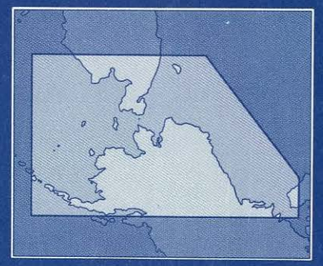
Bering, Chukchi, and Beaufort Seas

Coastal and Ocean Zones Strategic Assessment: Data Atlas



United States Department of Commerce
National Oceanic and Atmospheric Administration
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Bering, Chukchi, and Beaufort Seas

Coastal and Ocean Zones Strategic Assessment: Data Atlas

Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
of the
National Oceanic and Atmospheric Administration
UNITED STATES DEPARTMENT OF COMMERCE

Pre-publication Edition
November 1987

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Sea Ice Structure—Gary L. Hufford, National Environmental Satellite Service, NOAA, Anchorage, and Michael S. Blouin, Department of Biology, University of Florida, Tallahassee.
Phytoplankton Productivity—Frank E. Müller-Karger, Horn Point Environmental Laboratory, University of Maryland, Cambridge, and Charles R. McClain, National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Maryland.
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Caribou—Peggy J. Kuropat, University of Alaska, Alaska Cooperative Research Unit, Fairbanks.
Oil and Gas Lease Areas and Activities—Thomas K. Bundtzen, Division of Geological and Geophysical Surveys, Alaska Department of Natural Resources, Anchorage.

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Oceanographic Maps—Zygmunt Kowalik and H. Joseph Niebauer, Institute of Marine Science, University of Alaska, Fairbanks; Harold O. Mofjeld and James D. Schumacher, Pacific Marine Environmental Laboratory, NOAA, Seattle; Knut Aagaard and Lawrence K. Coachman, Department of Oceanography, University of Washington, Seattle; and William A. Brower, Jr., National Climate Data Center, NOAA, Asheville, North Carolina.
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Preface

No coastal and oceanic region of the USA has captured the attention of public and private decision-makers more over the past two decades than Alaska and its adjacent waters, particularly the region defined by the waters and coastal areas of the Bering, Chukchi, and Beaufort seas. Trade-offs between increased economic development, particularly hydrocarbon and mineral extraction, and long-standing renewable resource uses and environmental quality remain timely and important issues. The region supports one of the world's richest commercial fisheries, is home to the largest marine mammal and seabird populations outside the Antarctic, holds much of the Nation's remaining recoverable oil, and is a strategically important military operating area.

Decisions about use of the Nation's coastal and oceanic resources are made regularly in Congress, in state legislatures, in executive agencies at all levels of government, in corporate boardrooms, and by individual citizens. These decisions concern activities over a wide range of spatial and temporal scales from site-specific to national policies and programs affecting the Nation or entire regions, such as coastal Alaska and the Bering, Chukchi, and Beaufort seas. As the complexity of resource-use issues and the decisionmaking processes to resolve them continue to increase, syntheses of information and assessment capabilities of many types and quality are required for resource-use decisions throughout this range of scales.

Several recent developments make this data atlas—a major synthesis of regional information—timely. Public awareness and political attention have been focused on the region, especially since the establishment of the United States Exclusive Economic Zone (EEZ) in 1983 that expanded national jurisdiction over the rich resources in 456,700 square nautical miles of the Bering, Chukchi, and Beaufort seas. Many of these resources are exploited heavily by U.S. and foreign interests. The passage of the Arctic Research and Policy Act of 1984 and the establishment of the Arctic Research Commission to assess regional research needs, policies, and priorities has focused attention on the region even further. Central to national concern about this region is the need to develop comprehensive and consistent region-wide information syntheses and assessment capabilities to guide the management of resource uses and to help resolve conflicts in the region as well as throughout the Nation's other coastal and oceanic regions.

The *Bering, Chukchi, and Beaufort Seas Data Atlas* is the most recent in a series of National Oceanic and Atmospheric Administration (NOAA) strategic assessment data atlases designed to fill gaps in the information and assessment capabilities available for making decisions about resource use in the Nation's coastal and oceanic areas. At least four gaps exist: 1) between the large amounts of detailed data that exist for a relatively few well-studied areas and the partial or incomplete data that exist throughout large regions of the EEZ; 2) between the knowledge base of the scientific and technical communities and the information available to and used by decisionmakers; 3) between the proliferation of certain types of data generated by technology, especially remote sensing, and current capabilities to synthesize and direct them toward the information needs of decision-makers; and 4) between the incompatibilities of various scales, formats, and content of data developed among various scientific disciplines and public agencies.

This atlas is a beginning toward filling these important gaps. However, neither it nor others in the NOAA series can meet the needs for all decisions; no single source can. The series does provide access to a wide range of previously unavailable information, organized consistently and systematically for a subset of resource-use issues that are affected by decisions at State and Federal levels. The series is intended to demonstrate how to make maximum use of existing data, information, and knowledge that reside in a wide variety of institutions, in personal files and collections, in the formal and informal literature, and—most importantly—in the "experience base" that scientists and other professionals working in these areas have acquired over the years. We believe this data atlas and the assessment capabilities developed from it are an important step toward improving decisions about resource uses in this economically and environmentally important region of the Nation's EEZ.

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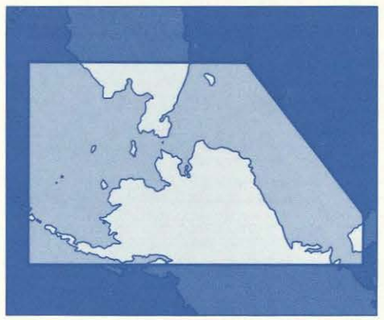
Introduction

The resources of the Nation's coastal areas and Exclusive Economic Zone (EEZ) are being used increasingly to generate a variety of goods and services such as crude oil, natural gas, hard minerals, fish and shellfish, transportation, recreation, and waste disposal. Inevitably, this trend is leading to increased conflicts among users whenever the use of one resource precludes or adversely affects the use of others. What historically have been relatively simple decisions made by individual groups about the use of single resources are now becoming increasingly complex, involving many users and multiple uses.

Determining the best mix of goods and services to be produced over time from any resource area is difficult at best, given the uncertainty of available information. Despite enormous strides over the past decade in data gathering and information processing, our understanding of how physical, chemical, biological, economic, legal, and political information should be considered in decisions for the use of coastal and oceanic resources remains limited. Consequently, decisions are always made on the basis of incomplete information.

The *Bering, Chukchi, and Beaufort Seas Data Atlas* synthesizes available information about important characteristics of the entire arctic region of the USA. It is the third of four National Oceanographic and Atmospheric Administration (NOAA) strategic assessment data atlases covering the Nation's major coastal and oceanic regions. It offers new and improved possibilities for multiple-use resource planning in the Bering, Chukchi, and Beaufort seas. Portraying the best information available, its 107 maps present a comprehensive perspective of the region's coastal and oceanic resources, their uses, and other related characteristics. It improves the information base for decisionmaking and provides direction for future assessments and research.



Study Area

The Region

Far from the lifeless, barren wasteland that too many people still think it is, the Bering, Chukchi, and Beaufort seas region contains some of the most valuable natural resources within the Nation's EEZ and its adjacent coastal areas (see Study Area map). The region supports one of the world's major commercial fisheries and the largest marine mammal and bird populations in the USA. While the region is sparsely populated, Native people have existed there for thousands of years, supporting themselves through a hunting and fishing subsistence economy. During the last century and early into this one, whales, walruses, sea otters, and seals were commercially exploited, some nearly to extinction. Although exploitation of some of these species continues, improved management and changing economic conditions have resulted in the recovery of many species. Changes in fish populations have also occurred with recent exploitation. Other than changes like these, the region remains relatively unaltered by human activities.

Several characteristics combine to make the region unique. The continental shelf area underlying the Bering, Chukchi, and Beaufort seas is the Nation's largest, accounting for about 74 percent of the total shelf area in the EEZ. This expanse of shallow water is well supplied with nutrients from the North Pacific carried by currents into the Bering Sea, from upwelling, and from terrestrial runoff. These nutrients fuel a level of primary productivity as high as any in the world oceans despite a short growing season. The result is a region very rich in living marine resources, including exploitable fishes and invertebrates. This productivity, however, is strikingly seasonal as much of the shelf area is ice-covered during winter. Large areas are ice-free for only six months in the Bering Sea and two to three months in the Chukchi and Beaufort seas. The distributions of ice-inhabiting and ice-avoiding species and their accessibility for harvest vary with sea-ice movements and conditions throughout the region.

The relatively undisturbed nature of the region may soon change. The onshore and offshore areas of the region are thought to contain much of the remaining recoverable oil in the USA. About one-fifth of the Nation's oil production comes from one relatively small area of the region, Prudhoe Bay. Despite early disappointments in offshore exploratory drilling in the Beaufort and Bering seas, the oil and gas industry continues to maintain high interest in exploration activities. Development of oil fields and the evaluation of transportation alternatives are also taking place in the Canadian Beaufort Sea.

To understand the region and the potential effects of mineral exploration better, NOAA has, since 1973, managed (recently through the Alaska Office of the Office of Oceanography and Marine Assessment) one of the largest arctic marine science research efforts ever undertaken, the Outer Continental Shelf Environmental Assessment Program (OCSEAP). Operated with funds transferred from the Minerals Management Service, OCSEAP has made major contributions toward understanding the effects of oil and gas activities on the offshore and coastal environments of Alaska. Other research activities, especially those of NOAA's Northwest and Alaska Fisheries Center, the U.S. Fish and Wildlife Service, the National Science Foundation, the U.S. Geological Survey, the Minerals Management Service, the Alaska Department of Fish and Game, and several universities and private groups, have added to our knowledge of this important region. However, despite some efforts to synthesize information and knowledge for specific purposes, such as oil and gas lease sales, much of it remains poorly organized. This atlas synthesizes and organizes such information and knowledge across individual programs and disciplines so that it can be applied in an effective and timely manner to planning and decisionmaking about the use of arctic resources.

NOAA's Program of Strategic Assessments

NOAA's Strategic Assessment Program is being conducted by the Ocean Assessments Division of the Office of Oceanography and Marine Assessment, National Ocean Service, NOAA. Its objective is to organize and synthesize existing information and knowledge concerning important characteristics of the Nation's coastal and oceanic regions and to communicate it clearly to decisionmakers and institutions, both in the public and private sectors, who inevitably must deal with multiple-use issues. The assessments are characterized as "strategic" because they develop information of a nature and at space and time scales that are appropriate for: 1) setting and modifying national or large-scale regional objectives for coastal and oceanic resource development and conservation; 2) identifying various means to achieve these objectives; and 3) evaluating the effects of their implementation. These assessments complement and do not replace, the necessary "tactical" analyses for site-specific decisions.

Strategic assessment activities bring together four general types of information relevant to resource use decisionmaking: 1) physical and chemical characteristics of resources and their surrounding environment; 2) biological characteristics, including species distribution abundance, life history, and habitat; 3) economic characteristics, including resource extraction and production, marine recreation, and land use; and 4) environmental quality, including pollutant discharges, ambient water quality, and hazardous materials disposal.

One of the most important products of NOAA's Strategic Assessment Program is a series of atlases. Three distinctly different types of atlases are being developed, each presenting information for different decisionmaking requirements. First is a series of thematic atlases of the Nation's most heavily used coastal and ocean regions. The *Bering, Chukchi, and Beaufort Seas Data Atlas* is the third of four in this series. Data atlases for the East Coast and Gulf of Mexico regions have already been completed; an atlas of the West Coast of North America is in production and will be published in 1989. Second is an atlas series on nearly 100 estuaries throughout the contiguous USA that presents consistent and compatible information on the nation's estuarine resource base. Third is a folio series of national maps that presents comprehensive information on the use and health of coastal waters.

The process of developing atlases of thematic maps for each region provides a focus for organizing and synthesizing, in a systematic manner, what is currently known about important characteristics of the marine environment and how it is used. The maps presented in each data atlas are an essential component of each strategic assessment. Almost 600 thematic maps of important characteristics of the Nation's coastal and oceanic regions have been or are being developed: 127 for the East Coast; 163 for the Gulf of Mexico; 107 for the Bering, Chukchi, and Beaufort seas; and 150 for the West Coast of North America. The maps can be used to structure, simplify, and convey large amounts of data. Atlases of thematic maps have no equal in communicating complex information on relationships between human activities and the natural environment. They can be powerful assessment tools when used properly.

While the data atlases are an important part of the Strategic Assessment Program and an important means of presenting and communicating information, they represent only the first step in the continuous process of developing an operational capability for assessing multiple resource-use conflicts in a given region. This process includes analyzing and synthesizing data, digitizing mapped data, completing and formatting data bases, and developing operational capabilities for interactive use. Since the data atlases represent only a 'snapshot' of what is known at any one time, the data bases are continually updated and improved. Many of the data sets used for the *Bering, Chukchi, and Beaufort Seas Data Atlas* are now being merged with data from other regions to form a comprehensive national assessment capability.

Making the Data Atlas

The Bering, Chukchi, and Beaufort seas project began in late 1980. Most of the data, however, were collected and organized between 1982 and 1985, although on some topics, data collection continued late into 1986. Cartography was completed from 1985 to 1987.

As the third in NOAA's series of strategic assessment data atlases, the *Bering, Chukchi, and Beaufort Seas Data Atlas* has incorporated many of the lessons learned in previous efforts. Consequently, it is more complex than its predecessors, has significantly greater content, and has incorporated new features and themes. All of this made it more difficult to produce than earlier data atlases. Not only was the cartography more complex, but the process of checking, review, and inevitable revision was also more extensive. Four important aspects of this process are described below.

The Base Map. A standard base map at a scale of 1:4,000,000 (one inch = approximately 64 miles) was selected for data presentation. This relatively small scale was chosen so that various categories of information could be shown on a base map covering a single page of the atlas. For example, the life history of a marine mammal that moves hundreds of miles within and outside the study area can be presented on a single map. Use of a base map makes comparing maps easier and facilitates digital transformation of data into an automated geographic information system.

A modified transverse Mercator map projection was selected because of its minimum distortion of geographic features in high latitudes. It is the standard projection used by the U.S. Geological Survey and the State of Alaska for this region. The base map was then compiled from the best available sources, with particular attention given to portraying the bathymetry accurately. In some parts of the region, bathymetric contours were compiled directly from soundings data (Map 1.1). The standard base map is used for all maps in the atlas, except in a few cases. In these cases, smaller inset maps, also based on the modified transverse Mercator projection, but at a smaller scale, have been used to illustrate complex relationships or to emphasize points made in the text accompanying each map.

Information Content. No single data atlas can cover adequately all features that are necessary to assess and resolve the range of potential conflicts among the multiple uses of the region's resources. Depending on the context, scale, and scope of the resource issues under consideration, the type, amount and detail of the information required will vary. Consequently, the content, organization, and specificity contained in this or any other data atlas will always be a compromise between various decisionmaking needs. However, regardless of the resource issue, certain categories of information must always be considered in making resource decisions. These categories are: *physical environments*, *biotic environments*, *living marine resources*, *economic activities*, *jurisdictions*, and *environmental quality*. Compared to others in the series, this atlas has relatively small sections on economic activities and jurisdictions and no section on environmental quality. Relative to other coastal regions, human activity levels and associated environmental effects are limited.

Several criteria were used to determine the themes for which maps would be prepared within the five categories. First, the theme had to be relevant to the assessment of known or perceived resource-use compatibilities or conflicts. Second, the data available had to be geographically comprehensive, i.e., cover at least a significant portion of the Bering, Chukchi, and Beaufort seas area. Third, the available data had to be of relatively high quality and accessible within the time constraints and production schedule of the project. Last, an effort was made to select themes that contributed to providing as complete a view as possible of the region's natural systems. Generally, themes were selected for their importance in determining living marine resource patterns of distribution, movement, productivity, and/or biomass, as well as the human activities associated with their harvest and use.

Data Collection and Review. Data were collected and organized from a wide variety of sources such as Federal, State, and local agencies; universities; other research institutions; private industry; trade associations; and individuals. In some cases, data were transferred directly from existing maps; in others, data were collected from published or unpublished reports, or from personal communications with individuals or institutions. In several cases, new or original work was necessary. For example, data were gathered and new analyses performed for Phytoplankton Productivity (Map 2.2), Marine Surficial Sediments (Map 1.2), Sea Ice Structure (Map 1.9) and Subsistence Resource Use (Maps 4.3-4.5). Knowledge of the spatial and temporal characteristics of these conditions is fundamental to understanding the region's natural systems. A more complete description is included in the introduction to each section and in the description accompanying each map.

Review of the working maps was a lengthy, repetitive process. Maps were checked and rechecked against original sources and with individual experts. Some maps were eliminated, others were added, and still others had to be fundamentally redone as new information became available. Additionally, new presentations were developed from raw data because previous interpretations were inadequate for the purposes of the atlas. Overall, the validation process for this atlas represents a significant improvement over past efforts, largely due to a more detailed iterative peer review process.

Because of the large number of sources used to develop and review each map, care was taken to separate the reference list at the end of each section into three parts to provide a clear audit trail for users. The three parts include: references used to prepare the description of each map; references used to develop the maps; and communications with individuals who assisted in map development and review.

The Maps. Each map is a synthesis of published and unpublished data portraying spatial, temporal, and other components. The mapped information is generally qualitative and non-quantitative. Every effort has been made to standardize the maps and make them consistent in design and organization with those in previous data atlases. Legend notes clarify important features on each map and must be used to interpret the maps correctly.

Proper interpretation of the maps requires understanding the limitations of the data presented. In addition to data quality and inclusiveness, natural variability also has to be considered to interpret the maps correctly. For example, the living marine resources maps present average or generalized distributions that cannot account for year-to-year variations, which can be considerable. Consequently, physical factors that influence these variations, such as sea ice (Map 1.8), must also be considered when interpreting certain features on the maps.

Perhaps one of the most useful features is the addition of an "Information Content and Quality Table" in the section on living marine resources. This table provides an evaluation of the data elements on each living marine resource map.

Data Categories

The five categories are briefly described below, along with a general discussion of their content. The introduction to each section describes each category, its importance, the rationale for map selection, and provides additional overview information. A comparison of maps and information among the different categories allows for the identification of relationships among region-wide patterns of distribution and use of living and non-living resources. Ultimately, such comparisons can aid decisionmakers in the development and evaluation of management strategies for the region.

Physical Environments. This section contains nine maps and descriptions presenting information on the physical oceanographic and environmental characteristics of the region. Typical of arctic and subarctic areas, the physical environment is highly complex and defined by the interactions of powerful atmospheric and oceanographic forces including ice formation, tidal currents, wind stress, and strong advective current flows. Emphasis has been placed on mapping those features that most affect the human population and economic activities of the region, or that are principal determinants of the distributions of living marine resources.

Biotic Environments. Five maps and accompanying descriptions present information on the patterns of distribution of important biological associations and groups of co-occurring species in terms of productivity or biomass. The patterns of distribution reflect the influences of circulation, bottom sediment types, bathymetry, and oceanographic fronts that separate many marine subregions. The maps primarily consider large-scale patterns.

Living Marine Resources. Special emphasis has been given to developing this section because of the region's high concentration of living marine resources, their importance to Native subsistence activities, and how resources will be affected by increasing development. Seventy-seven maps and descriptions present the spatial and temporal distributions and important characteristics of 91 marine and coastal species. The section is organized into four subsections: 31 invertebrates; 21 fishes; 25 birds; and 14 mammals. Each subsection contains an introduction that explains briefly the characteristics of each species group and subgroup and their overall distributions, movement patterns, and habitats.

Species were selected based on their commercial or subsistence use; their endangered, threatened, or protected status; or their "ecological importance"—a term loosely defined to include species that are either a major food source for an important species or group of species, a major component of their own ecosystem, or a major competitor with an important species for food.

Life history information for a species is presented for its adult, juvenile, and reproductive stages. Each species has been mapped following a consistent format to facilitate digital entry into a NOAA computer mapping and automated analysis system. The consistent format allows for comparisons of individual or composite distributions. Other information, such as abundance, migrations and movements, haulout areas, and foraging areas, is presented as appropriate to each species. The overall introduction to the section includes a "Species Life History Table" that summarizes important life history attributes for each species, including habitat type, distribution, and salinity range; feeding and reproduction types; and biogeography. The section introduction also includes three computer-generated maps that combine attributes for 37 species to illustrate the computer mapping and assessment capabilities developed in parallel with atlas preparation.

Considerable scientific judgment was required to infer and/or extrapolate the spatial and temporal distributions of many of the species from existing data and available literature. But even the most informed judgment is far from perfect, and the comprehensiveness of the knowledge base varies from species to species, among life stages, and among areas of the region. Consequently, the certainty of the distributions shown on individual maps varies. A special effort to assess and codify this uncertainty has been made by the addition of the Information Content and Quality Table. To capture the variation of data, the table divides the study area into offshore and coastal areas (see inset maps in section introduction). The distributions of individual species within each area are evaluated on a five-point scale, ranging from reasonably certain to highly speculative. The study areas are further divided into an evaluation of three life-stage distributions for each species: adult distribution areas, reproduction areas, and areas of adult abundance. In general, data quality is best for intensively studied commercial species and easily observed species, but less reliable for many noncommercial species of ecological importance.

Economic Activities. This section contains 12 maps and descriptions presenting information on the major onshore and offshore economic activities distributed throughout the region that affect coastal and marine environments and/or the living resources they support. Compared to other coastal and oceanic areas of the USA, the Bering, Chukchi, and Beaufort seas region is sparsely populated and undeveloped.

Three criteria were used to select activities: 1) importance as a user of land and other resources; 2) importance to local and regional economies; and 3) importance as a source of pollutants or modifier of the natural environment.

The maps selected represent four dominant economic activities in the coastal and oceanic areas of the region: 1) oil and gas exploration and development, which generates about half the employment and personal income of Alaska; 2) other resource extraction activities, notably sand, gravel, coal, and strategic minerals such as platinum and tungsten, which are not extensively developed because of the harsh arctic environment and the resulting costs; 3) commercial fishing, Alaska's largest employer in the extractive industries and a multinational activity, with large, distant water fleets from Asia and Europe active in the region; and 4) subsistence activities (e.g., hunting and fishing), an integral part of the Native culture and the economic base of Native villages.

The mapping of subsistence resources depicts the location, timing, and magnitude of subsistence use by resource category. The study area is divided into four regions (inset map, Maps 4.3 - 4.5) to demonstrate how resource use differs among them. The map then allows for cross-referencing of subsistence resource use by region as well as by location, timing, and magnitude. This cross-referencing is valuable in revealing patterns of existing or potential resource conflict.

Jurisdictions. Jurisdictions are an important element of the institutional framework and affect almost all resource-use decisions, including the harvest and use of living marine resources. The two maps in this section depict jurisdictional boundaries of the region. Information is presented on international, Federal, State, and local governmental units that have jurisdiction in the region and the areas over which they preside. Although the study area encompasses only the coastal portion of the State, jurisdictional divisions are complex and include those of local boroughs, Native corporations, and numerous State and Federal agencies that are responsible for the large managed and protected areas within the State. In addition, the USA currently is disputing boundary claims with both Canada and the USSR. As in the Nation's other coastal and oceanic regions, jurisdictional boundaries do not necessarily correspond to resource distributions and present a significant challenge for multiple-use management.

Uses and Planned Applications

The *Bering, Chukchi, and Beaufort Seas Data Atlas* offers new and improved opportunities to synthesize information for multiple resource-use decisions and provides direction for future assessments and research in this important coastal and oceanic area. It can be used to understand better the many spatial and temporal relationships among coastal and oceanic resources . The atlas can be a valuable tool for analysts, managers, and other interested parties in the public and private sectors, as well as a useful source of data for scientists and field technicians.

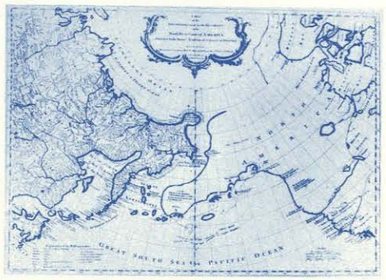
The maps provide a synthesis of available information on specific topics. The graphic portrayal permits straightforward comprehension of the most significant features and allows visual comparisons among topics across disciplines, for example, the comparison of species distributions with physical parameters such as sea ice or marine sediments. Individual maps can also be used to pose questions and identify future research and monitoring needs to fill data gaps, or used collectively, for comparative analyses through overlay techniques or other methods. These analyses and related examination of other data sets can reveal patterns and specific relationships indicative of existing or potential conflicts.

Simple manual comparisons, however, can be cumbersome. Consequently, the maps have been digitized and entered into a NOAA automated geographic analysis system. This increases considerably the range and complexity of the comparisons and relationships that can be examined. Plans are to develop these capabilities further and provide selected users with digital data and a custom, "user friendly" mapping and analysis package for microcomputers.

Since the knowledge of the topics that these maps depict is changing constantly, publication of this atlas is not the final task. Rather, its publication is seen as the beginning of a process to organize and apply the best available information and to develop an operational capability to assist people who make decisions about resource uses in this region.

Preparation of NOAA's atlases of the Nation's coastal and oceanic regions has generated new ideas for investigation by identifying specific categories of information for which few consistent and comprehensive data exist. Since this information is essential to strategic assessments, projects to fill several of these information gaps are underway. Comments on this atlas or questions about current or future activities should be addressed to:

Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
National Oceanic and Atmospheric Administration
11400 Rockville Pike
Rockville, MD 20852



"A Map of the Discoveries Made by the Russians on the Northwest Coast of America," *published by the Royal Academy of Sciences at St. Petersburg (Leningrad), Russia.*

This English version, printed in 1771 for Carrington Bowles of London, is based on a map by Gehard Friedrich Müller, a German historian and geographer and permanent secretary of the Royal Academy of Sciences. The Müller map, showing the voyages of Bering and Chirikov, was originally published in 1753 to refute claims of a French cartographer, Joseph Nicholas De l'Isle. It is the most common pre-Captain Cook map of the region. The North American coast shown on the map is pure conjecture, based on only a few observations; Alaska appears in the shape of a turtle. Two hundred and fifty years later, satellite-based sampling and computer-based analysis can provide scientists with millions of new observations every day to improve understanding of the region (see Map 2.2).

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
National Oceanic and Atmospheric Administration

Study Area

Description

The Bering, Chukchi, and Beaufort seas are shallow, ice-stressed waters. Together they cover the area known as Beringia, which as recently as 20,000 years ago formed the land bridge between Asia and the Americas. The strategic assessment of the Bering, Chukchi, and Beaufort seas focuses on the area between 55°N to 75°N latitude and 120°W to 175°E longitude, which includes the Canadian Beaufort Sea as far as Banks Island, as well as a portion of the eastern Siberian Peninsula. The entire continental shelf and coastline of Alaska that is affected by ice is within the study area.

The presence of ice is the single most important feature of the arctic marine environment (maps 1.8, 1.9). Its seasonal formation, movement, and degradation continuously influence other physical and biological aspects of the environment, including exploration for resources as well as subsistence activities of the Native peoples (Selkregg, 1975).

The arctic coastal plain of Alaska continues with little break onto the continental shelf. Broad lobes of sediments extend many miles onto the continental shelf beyond the major river deltas, and chains of barrier islands span many miles, paralleling the coastline and enclosing lagoons with numerous shoals. Occasional remnants of tundra cut off from the mainland by thermal erosion spot the coast, and permafrost underlies the entire land area (Selkregg, 1975).

The study area is unique in its large number of jurisdictional boundaries: two international boundaries, one between the USA and Canada and the other between the USA and USSR, provide special interest with respect to sovereignty, marine resource exploitation, and management. Disputed maritime claims between the USA and Canada are particularly important given oil and gas discoveries in the Beaufort Sea. Fishery and mineral resources, pollution control, and navigation through international straits are key issues and sources of potential conflict given the recent declaration of a 200-mile Exclusive Economic Zone by the USA (Map 5.1).

Physical Characteristics

The **Bering Sea** is the largest, the most complex, and the richest of these arctic seas. It encompasses approximately 2,500 kilometers (km) of coastline which includes numerous bays, points, and capes, as well as several islands, of which Nunivak and St. Lawrence are the largest and most important. The Bering Sea has three major embayments—Bristol Bay, Norton Sound, and the Gulf of Anadyr. The Yukon, Kuskokwim, and Kvichak rivers, which drain much of central Alaska, discharge large quantities of glacial meltwaters and runoff into the Bering Sea. From the head of Bristol Bay to Norton Sound, shoals and banks formed by deposits from these rivers extend many miles from the mainland.

The Bering Sea is isolated from the currents of the North Pacific Ocean by the Alaska Peninsula and from the Arctic Basin by the narrow Bering Strait. The environment is basically subarctic. Ice cover is present and expands seaward beginning in October, reaching a maximum in April and largely disappearing by June. Air surface and coastal water temperatures are not unlike those along the coast of Washington.

The **Chukchi Sea** extends west to Wrangel Island off Siberia in the Soviet Union and east to Point Barrow, Alaska. It consists of 1,750 km of irregular coastline and covers 580,000 km^2. In summer, the Chukchi is supplied with relatively warm water through the Bering Strait, resulting in ice-free conditions over 50-100% of its area by late summer (Stringer, Barrett, and Schreurs, 1980).

The **Beaufort Sea**, extending from Point Barrow north to the Canadian Archipelago, is encompassed by 750 km of irregular coastline characterized by numerous bays, points, capes, barrier bars, and lagoons. The Beaufort Sea is ice-free only briefly in the summer and has a narrow shelf dominated inshore by the input of several large rivers. Offshore, the Beaufort Sea is poor in primary production and nutrients. Its productivity appears to depend upon coastal detritus and nutrients from its tributary rivers, although some evidence suggests that productivity in the Beaufort may be related also to upwelling of bottom waters from the Arctic Basin.

The coasts of the Beaufort and Chukchi seas are generally low and flat with occasional bluffs and sea cliffs reaching up to 15 meters (50 feet). The region's larger tributary rivers terminate in deltas, especially along the Beaufort Sea.

Living Marine Resources

Living resources of the Bering, Chukchi, and Beaufort seas are adapted to characteristics of the ice-dominated, cold-water continental shelf and slope, and to habitats found in adjacent water bodies and on nearby coastal plains. These areas are nesting grounds for vast colonies of sea birds and waterfowl which are dependent upon the sea for food (Maps 3.41-3.63). Anadromous fishes, like salmon (Maps 3.22-3.26), spend most of their lives at sea, but return to the rivers to spawn. The region's living resources are generally varied, widely dispersed, and highly migratory over vast areas. Seasonal influences are strong. Assessment of the impacts of economic activities requires consideration of all these special features.

The arctic/subarctic environment is a critical habitat for several species of mammals including the polar bear, northern fur seal and gray whale (Maps 3.64-3.77). Both marine and terrestrial mammals are important to Native subsistence, although the historical commercial exploitation of many species, including whales and seals, has reduce stocks to the extent that regulation is necessary to prevent further declines in stock populations.

Many species of waterfowl and shorebirds use arctic Alaskan nearshore waters and coastal estuaries for foraging and resting during the periods of ice-free, open water. Nearshore waters are also important navigation routes for subsistence hunters and fishermen with small boats, as well as for numerous barges that transport materials and supplies up the Yukon River.

Population

Most of the region's human population, 74% of which is Native Alaskan, is widely scattered in the coastal zone of the region (Alaska Department of Labor, 1982). As of 1980, Bethel was the only community in the study area with a population that exceeded 2,500 people. The population of Barrow has increased significantly since the 1980 census and is estimated to exceed 2,500. Major settlements along the Bering Sea coast include Unalakleet, Bethel, Cape Newenham, Dillingham, King Salmon, Naknek, and Cape Sarichef (Stringer, Barrett, and Schreurs, 1980). Nome is the largest population center along the Bering Sea coast; Kotzebue the largest along the Chukchi Sea coast. Permanent human habitation along the Beaufort Sea is sparse; the largest permanent settlements there are Nuiqsut, an Alaskan Native village east of Barrow in the Coleville River Delta, three military installations, the Prudhoe Bay oil fields population, and Kaktovik village, a community on Barter Island east of Prudhoe Bay.

Commerce centers around small settlements such as Barrow and Kotzebue along the Chukchi Sea and Bethel, Dillingham, and Nome along the Bering Sea. In contrast, major population and industrial centers such as Fairbanks and Anchorage lie outside the study area (Map 4.1).

Commercial Fishing

Commercial fishing is an important part of the regional economy, particularly in the Bering Sea (Maps 4.10-4.11). In 1983, the USA commercial fish catch in the Bering and southern Chukchi seas was worth $216.3 million. Important species include salmon, snow (tanner) crab, and king crab (Division of Commercial Fisheries, 1984). The disposal of organic wastes from fish processing, which for crabs is up to 80% of landed tonnage, is a major source of marine pollution along the Bering Sea coast. In 1983, the reported catch of foreign fisheries in the Bering Sea and Aleutian Islands was 2.5 billion pounds, 77% of which was caught by the Japanese. Alaska pollock was the dominant fish, accounting for 79% of the total foreign catch (National Fishery Statistics Program, 1984).

Oil and Gas Development

Oil and gas exploration and development is now the dominant economic activity in the region. This industry has been expanding rapidly since the discovery of oil in Prudhoe Bay in 1968, although oil exploration has taken place in Alaska since 1900 and the Naval Petroleum Reserve-Alaska was established on the North Slope in 1923. Reserves at Prudhoe Bay are presently estimated at 9.6 billion barrels of oil and 265 trillion cubic feet of gas—about one-third of the known petroleum reserves in the USA. Oil is currently being produced at Prudhoe Bay and pumped 800 miles south to Valdez through the Trans-Alaska Pipeline System (TAPS) at a rate of 1.5 million barrels each day (Alaska Geographic, 1982).

The study area contains several offshore sedimentary basins where outer continental shelf oil and gas leasing is scheduled or has already taken place. (Maps 1.5, 4.6). According to a 1979 estimate of the U.S. Geological Survey, these outer-shelf areas contain 43% of the total energy equivalent of USA offshore oil and gas reserves. The areas of the Chukchi and Beaufort seas account for an estimated one-third of total offshore reserves.

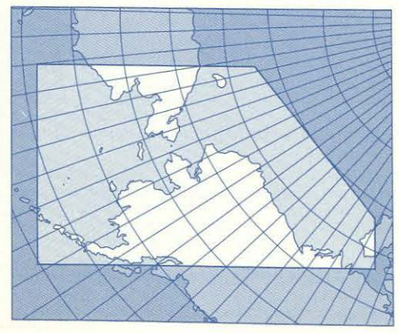
Mineral resources are also potentially important to the regional economy, although the industry is relatively undeveloped because of the remoteness of mining sites and the high cost of production. While few metal deposits are found in the Arctic, large quantities of coal (90% of Alaska's identified onshore coal resources of 141 billion tons) are known to exist north of the Brooks Range (Alaska Geographic, 1982). Oil shale, phosphates, sand, and gravel also exist there, sand and gravel being particularly important for the construction of offshore islands for oil and gas exploration. Also, gold has been mined steadily since 1898 from over 200 small-scale placer mines in the Nome area. Other mining in the Bering Sea coastal zone includes copper, lead, zinc, gypsum, platinum, uranium, and tungsten (Maps 4.7-4.9).

Legend

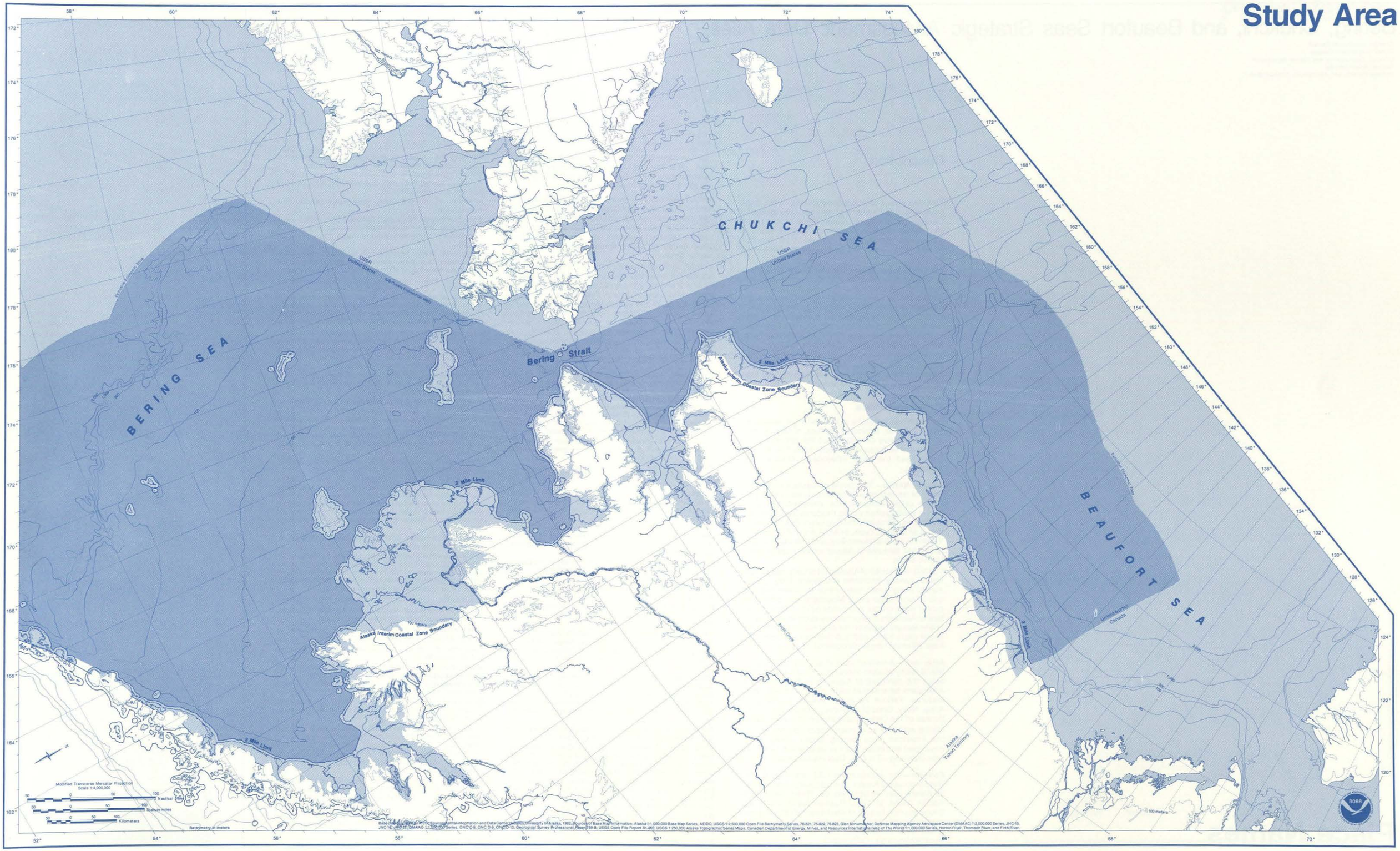
- Study Area
- U.S. Exclusive Economic Zone

Map References

U.S. Department of State, 1977; Alaska Coastal Policy Council, 1979; Alaska Office of Coastal Management, 1979; National Advisory Committee on Oceans and Atmospheres, 1984; Alaska Map Service, 1984.



Study Area


BERING SEA
CHUKCHI SEA
BEAUFORT SEA
USSR
United States
U.S./Russia Convention Line
Bering Strait
3 Mile Limit
Alaska Interim Coastal Zone Boundary
100 meters
150 meters
200 meters
Arctic Circle
United States
Canada
Alaska
Yukon Territory
Modified Transverse Mercator Projection
Scale 1:4,000,000
Nautical miles
Statute miles
Kilometers
Bathymetry in meters
NOAA

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
National Oceanic and Atmospheric Administration

Description

This map shows selected communities, rivers, lakes, bays, and other water and land features in Alaska, Canada, and the Soviet Union. Place names reflect the Native Alaskan, American, and Russian influences in the region. Explorers from America, Russia, and Great Britain named many Alaskan features.

For example, the Bering Sea was at one time known as the Sea of Kamchatka. In 1822, it was re-named by Captain Vasili Golovnin of the Imperial Russian Navy (IRN) for Vitus Bering (1680-1741), a Dane sailing in the service of the IRN. Bering had been selected in 1724 by Peter the Great, Tsar of Russia, to explore eastern Asia and western America. His mission was to find where Asia was joined to America. Bering finally reached Alaska in 1741 (Orth, 1967).

The map displays only some of the major features and places in the region. Many other towns, Native villages, rivers, lakes, bays, and lagoons, are identified on other maps in the atlas.

Origin of Names

Place names in Alaska originated from several different cultures. Explorers, Natives, miners, settlers, and others have contributed to the identification of places and features in the study area. The following groups had the most influence in Alaskan place naming.

Alaskan Native—The names of Alaska's villages and many of its marine and terrestrial features have a Native origin. However, the interpretation of the Native spelling often varies. Features shown on maps and charts are usually the English or Russian derivation of an Inupiat, Yupik, or Aleut word or phrase. The Yukon River, Kuskokwim Bay, and Nunivak Island are prominent features in Alaska whose names have a Native origin.

The Native peoples of Alaska historically had a unique way of naming landforms and rivers. They typically named many small, even minor landmark features, and ignored large ones. Mountains are often overlooked while creeks and ponds have specific names. Native Alaskans also commonly apply several names to one feature based on the characteristics of its particular parts (Orth, 1967). A river, for example, could have different names throughout its course.

American—American naming activity first began in the 1840s by whalers operating off the Alaskan coast. Since the purchase of Alaska from Russia in 1867, Americans have named many of Alaska's geographic features. Various Federal agencies, including the Army, Navy, Geological Survey, Coast Survey, and Bureau of the Census have identified Alaska places.

Mining activities have been responsible for much of the American place naming. Some mining camps developed into cities, the names of which reflect the type of mining—Tin City, Coal Harbor, and Platinum.

Russian—For approximately 83 years, until 1867, Russia occupied Alaska. The first Russian settlement in Alaska was established on Three Saints Bay, Kodiak Island, in 1784. Russian explorations continued up until the sale of Alaska to the USA and were primarily confined to the Aleutians and southcentral areas, with some exploration up the Yukon and Kuskokwim rivers (Orth, 1967).

Russian names for coastal features in Alaska still exist. The city of Kotzebue, Shishmaref Inlet, Golovnin Bay, the Pribilof Islands, and Etolin Strait are all named after Russian explorers.

British—British activity in the region began with the third and last voyage of Captain James Cook in 1778 and continued for approximately 80 years (Orth, 1967). Cook was responsible for naming many of the coastal features in Alaska's northern areas including Cape Prince of Wales, Bristol Bay, Icy Cape, and Norton Sound.

In 1826, arctic explorer Sir John Franklin (1786-1847) traveled by small boat down the Mackenzie River to its mouth and along the arctic coast of Alaska. He had planned to meet Captain Frederick W. Beechey (1796-1856), of the British Royal Navy (RN) and a fellow English explorer, around Point Barrow. Weather stopped him at Beechey Point, which Franklin named for his friend. Both Franklin and Beechey named many landmarks along their routes.

History of Selected Names

Alaska—The name was originally applied only to the southwestern end of the Alaska Peninsula and probably derived from the Aleut word, "Alyeska," or "the great land." Alaska was proposed as the official name of the State's lands in 1867 by William H. Seward (U.S. Secretary of State), Charles H. Sumner (U.S. Senator and Chairman of the Committee on Foreign Relations), and General H. W. Halleck (Commander of the Military Division of the Pacific).

Amundsen Gulf—Named for Roald Amundsen (1872-1928), Norwegian explorer, discoverer of the Northwest Passage in 1906 and the South Pole in 1911.

Banks Island—Named for Sir Joseph Banks (1743-1820), English naturalist and president of the British Royal Society from 1778-1820.

Beaufort Sea—Named in 1826 by Sir John Franklin (1786-1847), RN, for his friend Captain (later Admiral) Sir Francis Beaufort (1774-1857), hydrographer of the British Admiralty.

Bethel—Originally the site of an Inupiat village and trading post, Mantevilleq, meaning "site of many caches." Bethel was named in 1884 by Moravian missionaries. In Hebrew, Bethel means "house of God."

Big and Little Diomede Islands—Discovered by Vitus Bering, IRN, on August 16, 1728, the day of Saint Diomede.

Bristol Bay—Discovered by Captain James Cook (1728-1799), RN, in 1778 and named by him in honor of the Admiral, Earl of Bristol.

Brooks Range—Named in 1925 by the U.S. Geological Survey for geologist Alfred Hulse Brooks, chief geologist of the USGS from 1903-1924.

Cape Prince of Wales—Named by Captain Cook in 1778.

Colville River—Named in 1837 by Peter Dease and Thomas Simpson, officers of the Hudson's Bay Company, to honor Andrew Colville, governor of the Hudson's Bay Company, 1852-1856.

Chukchi Sea—Named for the Chukchi natives of Siberia.

Dillingham—Named in 1904 for William Paul Dillingham, Governor of Vermont, 1888-1890, and U.S. Senator, 1903-1922. In 1903 Dillingham conducted the first comprehensive Congressional tour of Alaska with his Senate subcommittee.

Dutch Harbor—Named by the Russians who believed that a Dutch vessel was the first to enter the harbor.

Etolin Strait—Discovered in 1821 by Captain Adolph K. Etolin, IRN, who originally named it "Cook Strait" for Captain James Cook, RN. It was later named for its discoverer and governor of the Russian American colonies from 1841-1845.

Fairbanks—Named after Charles Warren Fairbanks, U.S. Senator and later Vice President under Theodore Roosevelt. Founded in 1901 as "Barnettes Cache," a local trading post, the town name changed in 1902 to Fairbanks.

Gambell—Named in 1898 in honor of Mr. and Mrs. Vene C. Gambell, Presbyterian missionaries on Saint Lawrence Island from 1894-1898, who were lost at sea on their return from a leave of absence.

Harrison Bay—Named by Dease and Simpson in 1837 to honor Benjamin Harrison, the Deputy Governor of the Hudson's Bay Company, 1835-1839.

Icy Cape—Named by Captain Cook in 1778 "...because it was so much encumbered with ice."

Kaktovik—An Alaskan native place name meaning "the seining place."

Kotzebue Sound—Named by Lieutenant Otto von Kotzebue (1787-1846), IRN, for himself after discovering the bay in 1816. Kotzebue was on an exploratory mission to find a northwest passage.

Kuskokwim River—According to Moravian missionaries, "Kuskokwim" is a native name whose last syllable means "river," but the meaning of the rest of the name is unknown.

Mackenzie River—Named for Sir Alexander Mackenzie (1764-1820), a Canadian trader and explorer, and the first white man to reach the river and cross the northern part of the North American continent to the Pacific Ocean. Originally Mackenzie named the river "the River of Disappointment" because it took him to the Arctic Ocean instead of the Pacific.

Nome—Originally a gold mining town known as "Anvil City." By 1899 the town gradually was referred to as Nome after the nearby cape. The name "Nome" is generally attributed to a British Admiralty draftsman's misinterpretation of the word "name" on a manuscript chart of 1850-1852.

Norton Sound—Discovered by Captain Cook, RN, in 1778 and named by him in honor of Sir Fletcher Norton, Speaker of the House of Commons.

Nuiqsut—An Alaskan Native place name meaning "area from where you can begin siting along the coast."

Nunivak Island—Discovered on July 21, 1821, by Captain Lieutenant Mikhail N. Vasiliev, IRN, and originally named for his ship Otkritie (Discovery). The Inupiat word "Nounivak" or "Nunavak" was commonly used on early charts and means "walrus on the ice."

Peard Bay—Named by Captain Frederick William Beechy, RN, in 1826 for his first lieutenant, George Peard.

Point Barrow—Named by Captain Beechy, RN, in 1826 to honor Sir John Barrow, Second Secretary of the Admiralty and founder of the Royal Geographic Society, as well as to mark the progress of northern discovery. The Inupiat word for Point Barrow is "Nuvuk," meaning "point of land." The Inupiat word for the town of Barrow is "Utqiagvik," or "a high place for viewing."

Port Moller—Named in 1828 by Captain Mikhail N. Staniukovich, IRN, after his sloop.

Pribilof Islands—The Pribilofs were named for Gerassim G. Pribilov, a master in the IRN, who discovered the breeding place of the fur seals in 1786. The Pribilof Islands of Saint Peter and Saint Paul were first seen by Russian hunters on June 29, 1787, the dedicated day of those two apostles.

Prudhoe Bay—Named by Sir John Franklin, RN, in 1828.

Saint Lawrence Island—Discovered by Bering on August 10, 1728, and named by him for Saint Lawrence Day.

Saint Matthew Island—Discovered in 1766 and named by Lieutenant Sind (Synd), IRN, on or about Saint Matthew Day.

Savoonga—An Alaskan Native place name meaning "the prow (of something)".

Seward Peninsula—In 1898 Governor John Green Brady suggested the peninsula be named after William Henry Seward (1801-1872), U.S. Secretary of State from 1861-1867, who negotiated the purchase of Alaska.

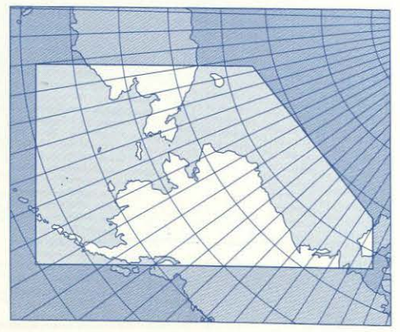
Shishmaref—Named in 1816 by Lieutenant Kotzebue, IRN, for Captain Lieutenant Glieb S. Shishmaref, who accompanied him on his expedition.

Teller—Derived from the nearby Teller Reindeer Station established in 1892. The station was named for Henry Moore Teller, U.S. Senator (1876-1882 and 1885-1909), and Secretary of the Interior (1882-1885).

Unalakleet—An Alaskan Native place name meaning "place where the south wind blows."

Wainwright—Named by Captain Beechy, RN, in 1826 for Lieutenant John Wainwright, astronomical observer and officer under Beechey's command. The Inupiat name for the village is Olgonik.

Yukon—The name was established by Hudson's Bay Company traders in 1847 who explored the upper river in the interior of Alaska. The name "Yukon" is believed to be an Athabaskan word meaning "Big River."



Place Names

Place Names



Dezhnev Bay
Koryak Range
Khatyrka
Anadyr
Anadyr Range
Anadyr River
Amguema River
DeLong Strait
Wrangel Island
Cape Schmidt
Herald Island
Cape Navarin
Ugol'Noi Bay
Anadyr Gulf
Kresta Bay
Chukchi Peninsula
Kolyuchin Island
Kolyuchin Bay
CHUKCHI SEA
ARCTIC OCEAN
USSR
United States
Providenlya Bay
Cape Serdtse Kamen
Arakamchechen Island
Mechigmenan Bay
St. Lawrence Bay
Cape Krigugon
Uelen
Cape Dezhnev
Bering Strait
Big Diomede Island
Little Diomede Island
Cape Prince of Wales
Point Hope
Cape Lisburne
Ledyard Bay
Point Lay
Kasegaluk Lagoon
Icy Cape
Wainwright
Point Franklin
Peard Bay
Barrow
Point Barrow
Plover Islands
Bease Inlet
Smith Bay
Teshekpuk Lake
Harrison Bay
Simpson Lagoon
Nuiqsut
Jones Islands
Prudhoe Bay
Deadhorse
Colville River
North Slope Range
Camden Bay
Barter Island
Kaktovik
Beaufort Lagoon
Demarcation Point
Herschel Island
Phillips Bay
Mackenzie Bay
Mackenzie River Delta
Tuktoyaktuk
Tuktoyaktuk Peninsula
Cape Dalhousie
Inuvik
Northwest Territories
Yukon Territory
Banks Island
Amundsen Gulf
Yukon Flats
Fairbanks
Tanana River
Alaska Range
Alaska Yukon Territory
Kotzebue Sound
Cape Krusenstern
Kotzebue
Goodhope Bay
Selawik Lake
Shishmaref
Shishmaref Inlet
Seward Peninsula
Teller
Nome
Safety Lagoon
Golovnin Bay
Norton Bay
Norton Sound
Stuart Island
Chamisso Island
Unalakleet
Sledge Island
King Island
Gambell
St. Lawrence Island
Savoonga
South Punuk Island
Shpanberg Strait
Hall Island
St. Matthew Island
BERING SEA
Otter Island
St. Paul Island
Pribilof Islands
St. George Island
Cape Romanzof
Nunivak Island
Etolin Strait
Nelson Island
Yukon-Kuskokwim Delta
Yukon River
Bethel
Kuskokwim
Kuskokwim Bay
Goodnews Bay
Security Cove
Cape Newenham
Cape Peirce
Shaiak Island
Hagemeister Island
Walrus Islands
Round Island
Kuskokwim Mountains
Dillingham
Nushagak Bay
Kvichak Bay
Bristol Bay
Alaska Peninsula
Aleutian Range
Port Heiden
Nelson Lagoon
Herendeen Bay
Cape Seniavin
Shumagin Islands
Augustine Island
Cook Inlet
Kenai Peninsula
Anchorage
Illiamna Lake
Bogoslof Island
Aleutian Islands
Butch Harbor
Unimak Pass
Rootok Island
Tigalda Island
Unalaska Island
Amak Island
Sea Lion Rock
Izembek Lagoon
Modified Transverse Mercator Projection
Scale 1:4,000,000
Nautical miles
Statute miles
Kilometers
Bathymetry in meters

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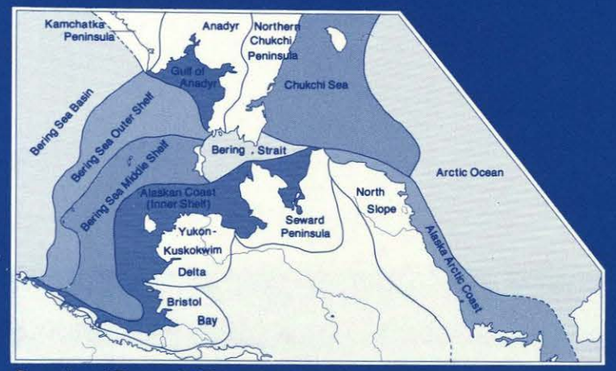
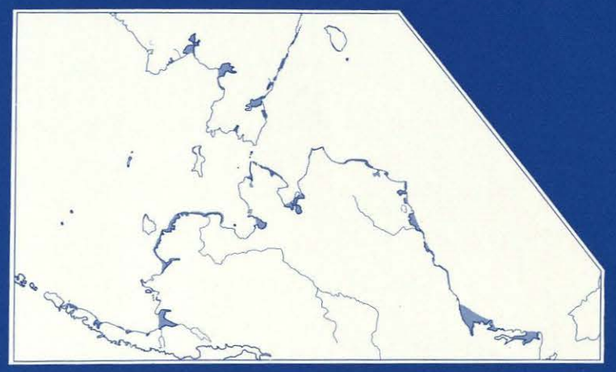
Physical Environments



Oceanic and Terrestrial Subregions.



Coastal Habitats.

Estuaries/deltas | Beaches | Cliffs | Barrier islands/lagoons

Introduction

This section presents information on the physical oceanographic and environmental characteristics affecting the distribution of living marine resources and the range of human activities in the region. The nine maps provide the physical setting for the atlas, especially for the Biotic Environments and Living Marine Resources sections. Several maps are first portrayals of newly compiled and analyzed information. Map 1.4, Marine Surficial Sediments, and map 1.9, Sea Ice Structure, present the spatial distributions of two important factors determining the distribution of living marine resources and the human activities associated with their harvesting and use. Other maps such as 1.2, Water Temperatures; 1.3, Tides; and 1.7, Mean Circulation, present existing information that relates more directly to resource distributions and associated human activities. When considered as a unit, these maps highlight several features of the Nation's only polar and subpolar environments that distinguish them from the rest of the Nation's coastal areas.

Continental Shelf—The broad continental shelf areas of the Bering and Chukchi seas (Map 1.1), combined with the extensive Alaska coastline and coastal plains, represent the Nation's largest coastal and shelf region. The region's shelf areas under U.S. jurisdiction account for almost 75 percent of the shelves in the entire U.S. Exclusive Economic Zone. The Bering Sea itself is the world's third largest semi-enclosed water body and includes both the shelf, with depths averaging 100 meters, and the Bering Sea Basin, an oceanic area with depths up to 4,000 meters. The relatively featureless Bering Sea shelf extends into the slightly shallower, but more topographically complex, Chukchi Sea via the 60-meter-deep Bering Strait, which has an irregular bottom. In contrast, the Beaufort Sea shelf is very narrow and falls off rapidly into the Arctic Basin.

Seasonal Variability—The region is noted for the strong seasonality of physical processes: solar radiation and heating, affecting water column stratification and biological processes; winds, affecting surface currents and mixing; tides, affecting bottom water movements and providing kinetic energy to the system; and ocean currents, affecting the distributions of physical characteristics and biological features. The high latitudes of the region result in low intensity and short periods of solar radiation, low temperatures, extended periods of sea ice coverage, and strong winds, serving to differentiate the area from the Nation's other coastal and oceanic regions. The interaction of these physical processes creates an environment that varies widely seasonally, annually, and geographically. For example, the high biological productivity of the southern Bering Sea shelf contrasts with the much less productive Beaufort Sea. The former has higher nutrient levels, longer periods of solar radiation, and far shorter periods of ice cover.

Sea Ice Dynamics—The marked seasonal variability and its dynamic nature are best illustrated by the annual formation, movement, and melting of sea ice (Map 1.8). This is perhaps the most important physical process in the region. Formation begins in the northern portion of the region in October and continues until March, when the maximum southern extent is reached, often covering most of the Bering Sea shelf. This cover is not continuous; there are leads and larger ice-free polynyas in various parts of the area. Retreat and melt begin in the south in March, the edge moving northward as the season progresses. Sea ice extent shifts over 1,000 km in latitude during a yearly cycle, the overall cover varying considerably among years. For most years, all of the Bering Sea, and considerable portions of the Chukchi and Beaufort seas, are ice-free by summer. Ice formation and melt are modified by interactions with winds and ocean currents.

The effects of sea ice on living resources and related human activities are profound. Ice-avoiding species, such as walleye pollock, Pacific herring, and most seabirds and cetaceans, are driven southward and far offshore during winter. In contrast, several pinniped species, which require the ice for parts of their life histories, associate with the ice in the Bering Sea during winter. The high primary productivity of the Bering Sea is greatly reduced until ice melt, when phytoplankton in the ice initiate the spring bloom, making the ice edge a region of very high productivity (Map 2.2). Similarly, human use of natural resources is both limited and enhanced by the presence of sea ice; it cuts off the commercial harvest of fishes and crabs, but gives Natives access to walrus and other pinnipeds. Sea ice movement also strongly affects oil and gas exploration and extraction.

Oceanographic Subregions

The region can be divided into nine distinctive subregions shown on the first inset map. Their characteristics are determined by the interactions of major processes including sedimentation (Map 1.4), riverine input of fresh water (Map 1.6), ocean currents (Map 1.7), sea ice dynamics (Map 1.8), tidal currents (Map 1.3), horizontal and vertical mixing, and wind stress. These subregions are also differentiated biologically by such characteristics as levels of primary productivity and presence of important species. Five of these subregions are south of the Bering Strait, and three are to the north. The boundaries in the Bering Sea, often referred to as fronts, are zones of steep gradients in physical characteristics such as temperature and salinity, and consequently, can vary spatially and temporally, often showing relatively predictable seasonal shifts in location.

Bering Sea Basin—This is the southern boundary of the study area. The waters of the Basin are oceanic, and it is bounded by the Aleutian Islands and the Bering Sea continental slope. Water depths range from 200-4,000 meters. Circulation is generally counterclockwise, with water from the North Pacific entering through passes in the Aleutians. Some of this water flows up onto the adjacent continental shelf and northward. Tides are similar to those of the North Pacific. Temperatures are always above freezing, and there is no ice cover. Salinities are the same as in the North Pacific, around 32.0. Sediments are poorly known.

Bering Sea Outer Shelf—This is the outer portion of the broad eastern Bering Sea continental shelf. It is bounded by slope water and the continental slope on the south and west, and by a temperature and a salinity front on the northeast at roughly 80-100 meters depth. Water depths range from 80-200 meters. Currents generally flow north to northwest. The water column is in two layers separated by a steep density gradient, or pycnocline, 30 meters down from the surface. The upper layer is mixed by winds and the lower layer by tidal currents. Tides are mixed and stronger toward the southeastern portion of the subregion. Summer water temperatures are relatively high, averaging 10°C at the surface, but bottom temperatures remain at 0° - 4°C all year. Salinities are around 32.0. The northern and western portions are covered with sea ice in winter and spring of most years, but the southern and eastern portions are usually ice free. Sediments are generally fine-textured and silty but variable.

Bering Sea Middle Shelf—This area lies between the fronts at 40-50 and 80-100 meter depths. Its waters have little net circulation and are divided into two layers. The lower layer forms during the winter and is mixed by tidal currents. The surface layer is wind mixed. Tides are strong and mixed. Summer surface temperatures average 9° - 10°C, and bottom temperatures range from 2° - 10°C, except for a residual layer that remains at 0°C. Winter temperatures are near freezing throughout. Salinities are 31.5-31.7, low for an oceanic area. Sea ice is present throughout the area in winter and spring; ice remnants remain through early June south of St. Lawrence Island. Sediment textures are medium to fine and generally not mixed, except for a poorly sorted area south of Unimak Island.

Alaskan Coast (Inner Shelf)—This subregion is bounded by the Alaska coastline and the inner front at 40-50 meters depth. Waters are vertically well mixed and flow northward through the Bering Strait. Tides are generally mixed, but semidiurnal in the Yukon-Kuskokwim area and diurnal in Norton Sound; they are strong and of high range in Bristol Bay and are reduced northward. Summer surface temperatures average 10° -14°C, and bottom temperatures range from 6° - 10°C. Winter temperatures are near freezing. Salinities are low, below 31.5, showing the influence of coastal rivers. Sea ice cover lasts through winter and spring, and shorefast ice can persist into summer. Sediments are highly variable.

Anadyr Subregion—This is essentially restricted to the Gulf of Anadyr, with depths ranging from 0-100 meters. Waters from the Bering Sea Basin and the outer shelf flow into this subregion and through the western side of the Bering Strait. Currents are strong, but tides are weak and of low range. Summer surface temperatures average 8° - 9°C, and bottom temperatures are 0° - 2°C. Winter temperatures are near freezing throughout. Salinities are high, typically exceeding 33.0. Sea ice covers the area from winter until early summer, and shorefast ice and sea ice remnants last even longer. Sediments are poorly known.

Bering Strait Subregion—This zone extends north from St. Lawrence Island into the southern part of the Chukchi Sea, with water depths between 40 and 50 meters. This zone serves as a mixing area for exchanges of water and sea ice between the Bering and Chukchi seas and is characterized by strong currents and weak tides. Wind forcing determines whether the exchanges are toward the north or the south.

Chukchi Subregion—This comprises most of the Chukchi Sea, with depths ranging from 0-100 meters. Circulation is determined primarily by Bering Sea water flowing northward through the Bering Strait; currents are moderate to strong. Tides are weak and of low range. Summer surface temperatures are usually below 12°C, averaging 8°C in the southwest and colder to the north; there is a residual pool of 0°C bottom water in the southcentral portion. Winter temperatures are near freezing throughout. Salinities are generally low, around 31.0. The northern portion of the region is ice covered throughout the year; the southern portion is ice free only during mid-summer and early fall. Sediments are mostly sandy to silty.

Alaska Arctic Coastal Subregion—This includes the narrow Beaufort Sea shelf and the adjacent nearshore Chukchi Sea from Cape Lisburne to Point Barrow. Water depths range from 0-100 meters along the Beaufort coast and to 30 meters in the Chukchi portion. Currents tend to flow northeastward and are variable in strength; flow close to the Beaufort coast changes direction seasonally. Tides are weak and of low range. Temperatures may reach 10°C along the Chukchi portion and 8°C along the Beaufort coast in summer but are near freezing in winter. Salinities are low, especially during periods of river runoff. The whole region is covered by sea ice much of the year; in late spring, an area of broken ice develops off the northwest Alaska coast, and a polynya forms off the Mackenzie River delta and the eastern Beaufort Sea. Sediments are patchy and highly variable.

Arctic Ocean Subregion—This forms the northern boundary of the study area and is poorly known. Depths range from 200-2,000 meters, or deeper. Circulation is generally clockwise. Temperatures are close to freezing throughout. Ice cover is permanent. Sediments are poorly studied.

Terrestrial Subregions

As with the oceanic area, the lands within the region can be divided into subregions. The first inset map shows the seven divisions, four in the USA and three in the USSR, based on topographic, hydrographic, and climatic features that give each its characteristic landscape. These physical features include tundra, lakes and ponds, river systems, estuaries, deltas, barrier islands and lagoons, beaches, cliffs and headlands, and poorly-to-well-drained uplands. In turn, these landscape features strongly influence the biota of the subregions. Coastal physical features important for living marine resources are shown on the second inset map.

North Slope—This area is characterized by extensive wet tundra underlain by thick permafrost. The terrain is flat, and drainage is poor, although numerous rivers and streams flow across the tundra into the Beaufort Sea. The surface is dotted with thousands of shallow lakes created during glacial thawing. The coastline is bounded extensively by barrier islands and lagoons, and deltas and estuaries at the river mouths.

Seward Peninsula—This area is a combination of moist tundra and well-drained hills and low mountains. The coastline has stretches of barrier islands and protected lagoons, for example, along the north coast of the Seward Peninsula proper, and areas of cliffs and rocky headlands. Rivers and streams are generally short in the peninsular areas, but the Kobuk River is large, with a well-developed delta. The lower tundra areas are dotted with lakes and underlain by permafrost.

Yukon-Kuskokwim Delta—This is an area of extensive deltaic deposits from two large rivers. It is almost entirely wet tundra, very poorly drained and dotted with thousands of lakes and ponds. Drainage is further impeded by a thick permafrost layer. The coastline is essentially tundra fronted by narrow beaches, although the mouth of the Kuskokwim River is estuarine, as are other smaller bays.

Bristol Bay—Bristol Bay and its associated smaller embayments make up the largest estuarine system in the study area. The land areas closest to the coast are mostly moist tundra with numerous small lakes, but the topography rises farther from the coast, changing to hills and mountains covered with alpine tundra. Sea cliffs and rocky headlands dot the northern coast of the bay, and lowland forested areas characterize the lower part of the Nushagak River drainage. The area is also noted for a number of lakes larger than those found elsewhere in coastal Alaska.

Kamchatka Peninsula, Anadyr, and Chukchi Subregions—The Kamchatka Peninsula area is mountainous, with a rugged coastline and some embayments. The Anadyr subregion is the drainage basin of the Anadyr River and is moist to wet, poorly drained tundra with permafrost. The coastline has several embayments and estuaries. The Chukchi subregion is of higher relief, with areas of both rocky headlands and low tundra along the coast. There are also some stretches of barrier islands and coastal lagoons.

The components of the physical environment are the major driving forces for the region, strongly affecting biological functions and human activities. These forces make data collection difficult, so that large portions of the study area remain poorly explored. The southeast Bering Sea and the Beaufort Sea are the best known, but there are considerable gaps in information even there. Other parts of the region have been studied far less, and for these areas, small numbers of samples have been used to infer actual conditions. Verification of these inferences awaits further studies.

Contents

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1.1 Bathymetry
1.2 Water Temperatures
1.3 Tides
1.4 Marine Surficial Sediments
1.5 Petroleum Hydrocarbon Basins
1.6 Rivers and Lakes
1.7 Mean Circulation
1.8 Sea Ice Dynamics
1.9 Sea Ice Structure
References

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
National Oceanic and Atmospheric Administration

Bathymetry
1.1

Description

Bathymetry is the measurement of depths of large water bodies and, therefore, describes the seafloor. On this map, depths are indicated by isobaths (contour lines connecting points of equal depth). The shape and configuration of the seafloor influence currents, temperature, salinity, and marine life. Water depth is an important determinant of habitat for many species of invertebrates and fishes in the study area.

The physiography of the arctic seafloor consists of three dominant features: the continental shelf, the continental slope, and the abyssal plain. The principal bathymetric feature of the Bering and Chukchi seas is the shallow continental shelf. This submerged platform, much of which was exposed during the most recent glacial advances, connects Asia with the North American continent. The deepest waters in the study area are in the basins of the Bering and Beaufort seas, where depths reach 4,000 meters.

Bering Sea

The Bering Sea is the world's third largest semi-enclosed water body, with a surface area of 2.3 million square kilometers (km^2), a volume of 3.7 million cubic meters (m^3), and a mean depth of 1,636 meters. At its eastern margin, Bristol Bay encompasses more than 150,000 km^2. The gradient for most of the Bering averages 1 foot per mile, creating a broad, relatively flat continental shelf up to the 100-meter isobath, where the slope increases abruptly to 4-5°. This shelf, part of the vast undersea plateau covering the eastern Bering Sea, extends north through the Bering Strait and into the Chukchi Sea (Stringer, Barrett, and Schreurs, 1980).

The Bering Sea is divided into a shelf zone (0-200 meter depths), the continental slope (200-1,000 meters), and an abyssal region (depths over 1,000 meters). The shelf and abyssal region are almost equal in size and account for 87% of its area. The continental slope dissects the Bering Sea northwest to southeast and is incised with many canyons. The abyssal region consists of a smooth, almost featureless floor (Hood, 1981).

The continental shelf of the Bering Sea can be divided into zones based on structure: an inshore zone, extending out to depths of 30 meters and about which little is known; a nearshore shelf, with depths of 30-45 meters, separated by relic beaches at 45-50 meters and 95-100 meter depths; a central shelf zone between 30 and 90 meters; and the outer-shelf region, where gradients increase dramatically. The inner and middle regions are characterized by gentle slopes (Selkregg, 1976).

Chukchi Sea

In contrast to the Bering, the Chukchi Sea is a uniformly shallow platform. Depths average between 40 and 60 meters, with a maximum depth of approximately 70 meters. Kotzebue Sound, the Chukchi's major embayment, is a wide, shallow bay approximately 20 meters deep. Barrow Canyon and Herald Canyon transect the outer continental margin of the Chukchi Sea and funnel warmer water north into the Arctic Ocean. The Herald Shoals dominate the north-central Chukchi seafloor (Sharma, 1974).

The Bering Strait has an irregular bottom with depths up to 60 meters. Strong north-flowing currents, ice scouring, and ancient riverine action are primary factors influencing the seafloor morphology. Islands rise abruptly from the sea bottom in this region. The prominent islands in this region are St. Lawrence Island, Little and Big Diomede Islands, and Fairway Rock. St. Lawrence Island, the largest of these, is approximately 30 km wide and 160 km long.

Sea ice is an important feature of the Chukchi Sea, as most of the area is covered from November to July (Map 1.8). The southern Chukchi is ice-free for longer periods due to the influence of warmer waters moving north through the Bering Strait. Two large spitlike shoals extend north from Cape Prince of Wales and Pt. Hope/Cape Lisburne peninsulas.

Beaufort Sea

The Beaufort continental shelf is relatively narrow, extending only 50-100 km off the coast and characterized by a gentle slope. Along much of the shoreline, the 20-meter isobath lies between 25 and 60 km offshore. The 80-meter isobath lies about 70 km offshore from Barrow to Demarcation Point, approximating the abrupt edge of the continental shelf. Depths increase rapidly along the shelf before it joins the Canada Basin of the Arctic Ocean (Stringer, Barret, and Schreurs, 1980).

Ice dominates the entire Beaufort Sea for 9 to 10 months of the year (Map 1.8). The resulting ice scour of the benthic environment has a severe impact on the productivity of the region. The morphology of the Beaufort Sea continental shelf consists of a series of linear shoals found slightly landward of the 20-meter contour. These shoals, known as stamukhi, interfere with the shifting ice pack. Their presence contributes to the formation of grounded ridges and affects seasonal ice zonation (Reimnitz and Kempema, 1984).

The Canada Basin is the most extensive abyssal plain in the Arctic Ocean, reaching depths of greater than 3,600 meters. Steep continental slopes surround most of its perimeter. Sediment thickness is greatest toward the center of the basin (Maps 1.4, 1.5).

Legend

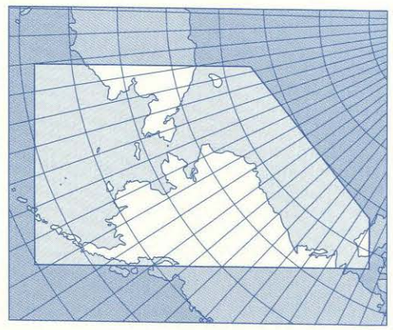
Water Depth in Meters

- 2,000 or greater
- 100 - 1,999
- 30 - 99
- 20 - 29
- 0 - 19

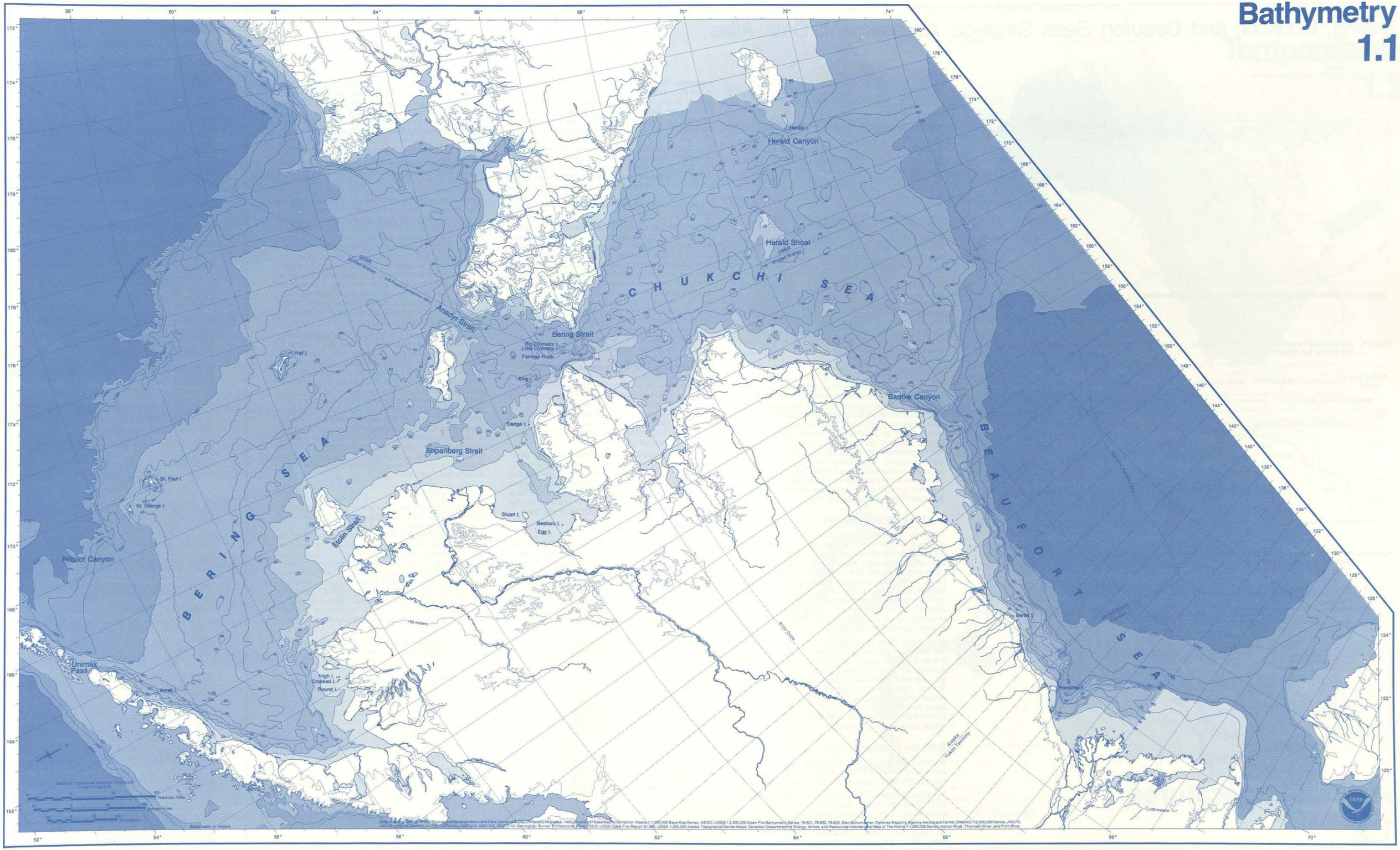
The missing bathymetry in the Canadian Beaufort Sea will be completed for the final atlas. Bathymetry in Soviet waters around Wrangel Island is unavailable. Bathymetry south of the Aleutian Islands is generalized since it is outside of the study area.

Map References

Hopkins et al., 1976; Schumacher, 1976a, b; Morley and Jones, 1981; National Ocean Service, Nautical Charts, 1981-1983, Bathymetric charts, 1982-1984; Ehm, 1983.



Bathymetry
1.1



Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

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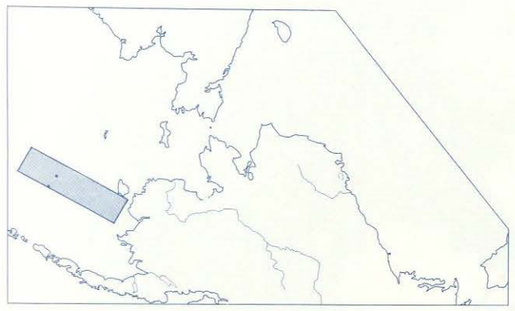
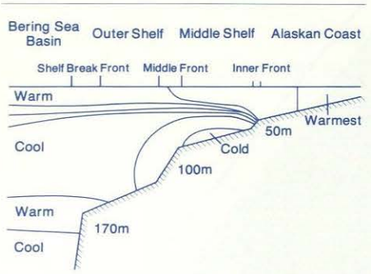


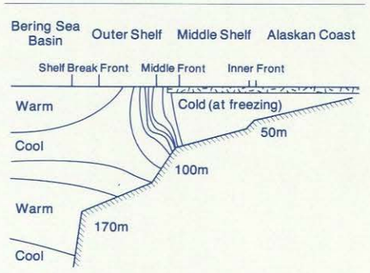
Location for Generalized Temperature, Salinity, and Cross-Sections.

Figure 1. Generalized Temperature Structure Across the Bering Sea Shelf in Summer.



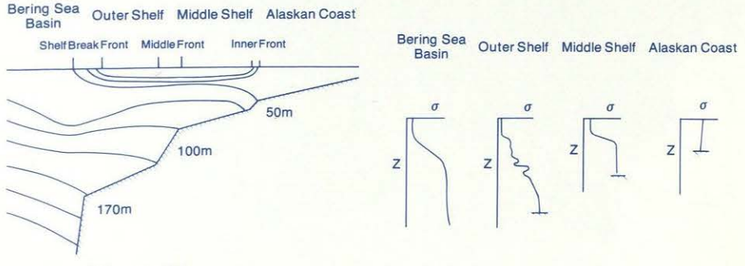
Sources: Kinder and Schumacher, 1981; Schumacher and Kinder, 1983.

Figure 2. Generalized Temperature Structure Across the Bering Sea Shelf in Winter.



Sources: Kinder and Schumacher, 1981; Muench, 1983.

Figure 3. Generalized Density Structure Across the Bering Sea Shelf in Summer. (Vertical profiles are shown at right.)



Source: Kinder and Schumacher, 1981.

Water Temperatures
1.2

Description

Water Temperatures

Water temperature is an important factor that limits the distribution of marine organisms. For the many cold-blooded marine animals, lower temperatures lead to decreases in metabolic rates, biological functions, and activities. Under extremely cold conditions, a near dormant state may exist in some marine organisms. Colder temperatures can also lead to a decline in species diversity. However, despite its cold waters, the Bering Sea supports a diverse and productive ecosystem.

Surface and bottom temperature characteristics, including average annual and record maximum surface temperatures, and extreme summer and winter bottom temperatures are shown. Temperature patterns depend on solar radiation, water and ice movements, river discharge, the freezing process of seawater, and vertical mixing. Temperature is just one of the parameters important to understanding marine ecosystems. Water density and salinity are two other parameters that determine the nature of the marine environment. The figures in this text provide simplified pictures of these other important characteristics.

Wind Effects

The rate at which heat is exchanged between sea and air has a significant effect on water surface temperature. Winds play an important part in this process. For example, cold air blowing from ice-covered areas to open water extracts heat from the sea. Conversely, warm, moist air moving over cooler areas will add heat to surface waters, primarily as precipitation. Waves generated by winds mix the upper layer of the water column, eliminating any stratification in temperature, salinity, or nutrients. Wind energy also influences the extent and nature of sea ice cover. In the lee of land, winds can break the ice cover, creating leads and polynyas (Maps 1.8, 1.9).

Surface Temperatures

The two surface temperature maps only show maximums. The map on the top left shows the warmest temperatures found in an average year. The map on the top right shows the warmest temperatures ever recorded. The data used to produce these maps come from historical observations (Brower, Searby, and Wise, 1977a, 1977b; Brower and Wise, 1987a, 1987b), and represent conditions found in late August and September. Minimum surface temperatures are not shown since most of the study area is covered by ice in winter.

Both maps show the influence of northward water movements, or advection of warmer Siberian and Alaskan coastal waters, as they surround the cooler waters of the northern Bering Sea around St. Lawrence Island. Another source of warm water is river discharge. This effect is noticeable at the mouth of the Mackenzie River in northwest Canada. Solar heating of shallow sheltered waters such as Bristol Bay, Norton Sound, and Kotzebue Sound also raises surface temperatures.

Bottom Temperatures

Bottom temperature maps are shown for summer and winter seasons. Both maps show that depth and topography affect the distribution of temperatures.

Summer Season—The range between the warmest and the coldest bottom waters is more than 10°C in the summer. The coldest temperatures are found in the Middle Shelf subregion of the Bering Sea shelf and on the central Chukchi Sea shelf. These areas have very little horizontal water movement. Cold temperatures are the result of cold water remaining in the area from the previous winter. These residual waters slowly increase in temperature throughout the summer through lateral and vertical diffusion, but typically remain below 0°C. The intensity and areal extent of these minimums vary from year to year. The warmest temperatures in the summer occur along the Alaskan coast. These coastal waters are influenced by solar heating, river discharge, and advection of warmer water from the south. Shelf break water in the Bering Sea is warmer than the water on either side in both summer and winter because of a warm subsurface water layer. Bottom water along the Arctic Ocean shelf break is at approximately 0°C throughout the year.

Figure 1 is a simplified cross-section of water temperatures in the Bering Sea. It shows: (1) the warmest water occurs in the Alaskan Coast subregion; (2) cold residual water on the shelf in the Bering Sea Middle Shelf subregion; and (3) warm shelf break water at the edge of the Bering Sea Outer Shelf subregion. The cross-section shown is representative of conditions along the area shown on the small inset map on this page. This area extends from near Nunivak Island out to and beyond the Pribilof Islands. The cross-section moves through four of the oceanic subregions discussed in the section introduction (Alaskan Coast (Inner-Shelf), Bering Sea Middle Shelf, Bering Sea Outer Shelf, and Bering Sea Basin).

Winter Season—As fall progresses, coastal bottom waters are cooled, until by winter all bottom water shallower than 60 or 70 meters depth has decreased to near-freezing temperature (approximately −1.5°C). As in the summer, the shelf break in the Bering Sea is an area of warmer water. Waters at greater and lesser depths are much colder. The shelf break in the Arctic Ocean maintains a temperature of about 0°C throughout the year.

Figure 2 is a winter cross-section along the same transect as Figure 1 and identifies the very cold water on the Bering Sea shelf and the warmer shelf break zone. A noticeable shift in temperature occurs as one moves from the Middle Shelf to the Outer Shelf. This is primarily caused by the presence of sea ice over the shelf (Map 1.8 shows the distribution of sea ice).

Density and Salinity

Summer Season—Figures 3 and 4 show cross-sections of water density and salinity in the summer. The shallowest subregion, the Alaskan Coast subregion, is vertically homogeneous as a result of tidal and wind mixing. Moving seaward, one finds a front separating the Alaskan Coast subregion from the Middle Shelf subregion. The Middle Shelf has two homogeneous layers: (1) a surface layer, typically 20 to 30 meters deep during the summer, kept well-mixed by winds, and (2) a bottom layer kept well-mixed by tides. The pycnocline separating these layers is intense and thin. The Outer Shelf subregion is separated from the Middle Shelf by a front and is comprised of three layers: (1) a well-mixed surface layer; (2) a thick pycnocline that contains fine structure; and (3) a well-mixed bottom layer. In the Bering Sea Basin the water column is vertically structured.

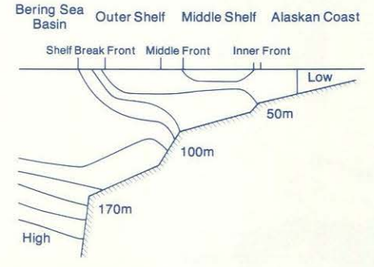
Winter Season—Figure 5 shows a cross-section of salinity for the Bering Sea in winter. During winter, the seawater freezing process determines the structure of the water column. As seawater is cooled, its density increases until the temperature reaches the freezing point. The freezing point of seawater is a linear function of salinity ranging from −1.3°C at 24 salinity units to −1.9°C at 36 units (Fofonoff and Millard, 1983). During freezing, ice crystals are reduced in salt content and the unfrozen water (brine) is enriched in salt. The floating ice is less dense than the parent water, while the brine is denser. However, both are at the same freezing temperature. The brine will sink until it reaches water of the same density. In this manner, the freezing process redistributes salt vertically in the water column, increasing the salinity of deeper waters and generating subsurface water at near-freezing temperatures.

During winter, most of the study area is covered by ice (Map 1.8) and the waters under the ice are at freezing temperatures (−1.5°C to −1.8°C). As shown in Figure 5, salinity is uniform with depth over the Middle and Inner shelves. This is caused primarily by intense wind mixing during the fall. This isohaline water column causes the temperatures to become isothermal at the freezing point of the surface in order to maintain stability. While the water column is well-mixed under the ice, a gradient across the Bering shelf remains. Sea ice is generally formed in northern areas and is advected towards the south where it is continually melting at its southern edge. In the vicinity of the ice edge the water column is usually stratified in the first several meters because of low density ice-melt water.

Arctic Ocean

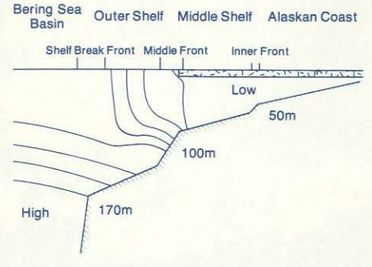
Although no cross-sections are shown for the Arctic Ocean, several general features can be described. It has four characteristic layers: (1) a cold (<0°C) surface layer of low salinity (<32) generated from ice melt; (2) a transition layer 200 to 400 meters thick in which temperatures remain cold but the salinity increases; (3) a deep, warm (>0°C) layer with high salinities (>34.8) that originates in the North Atlantic Ocean; and (4) very deep arctic bottom water that has the same high salinity but is colder (<0°C). Within the Chukchi Sea only the topmost layer and part of the second layer are present because of shallow depths (Aagaard, Coachman, and Carmack, 1981).

Figure 4. Generalized Salinity Structure Across the Bering Sea Shelf in Summer.



Sources: Kinder and Schumacher, 1981; Schumacher and Kinder, 1983.

Figure 5. Generalized Salinity Structure Across the Bering Sea Shelf in Winter.



Sources: Kinder and Schumacher, 1981; Muench, 1983.

Legend

Surface Temperature in Degrees Celsius

- 14.0 or greater
- 10.0 - 13.9
- 6.0 - 9.9
- 2.0 - 5.9
- Less than 2.0
- Pack Ice (greater than 5/8 coverage)
- Isotherm

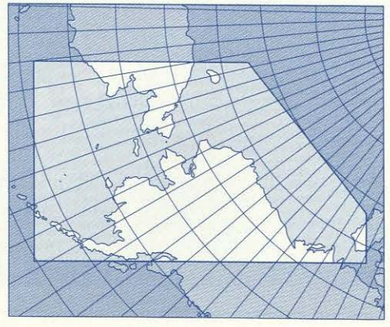
Bottom Temperature Regions

- Area of Coastal Maximums (4.0°C or greater)
- Area of Shelf Break Maximums (0.0-4.0°C)
- Cold Water Remaining through Summer (less than 0.0°C)
- Bottom Water at Freezing (−1.5°C)
- ⑭ Characteristic Bottom Temperature

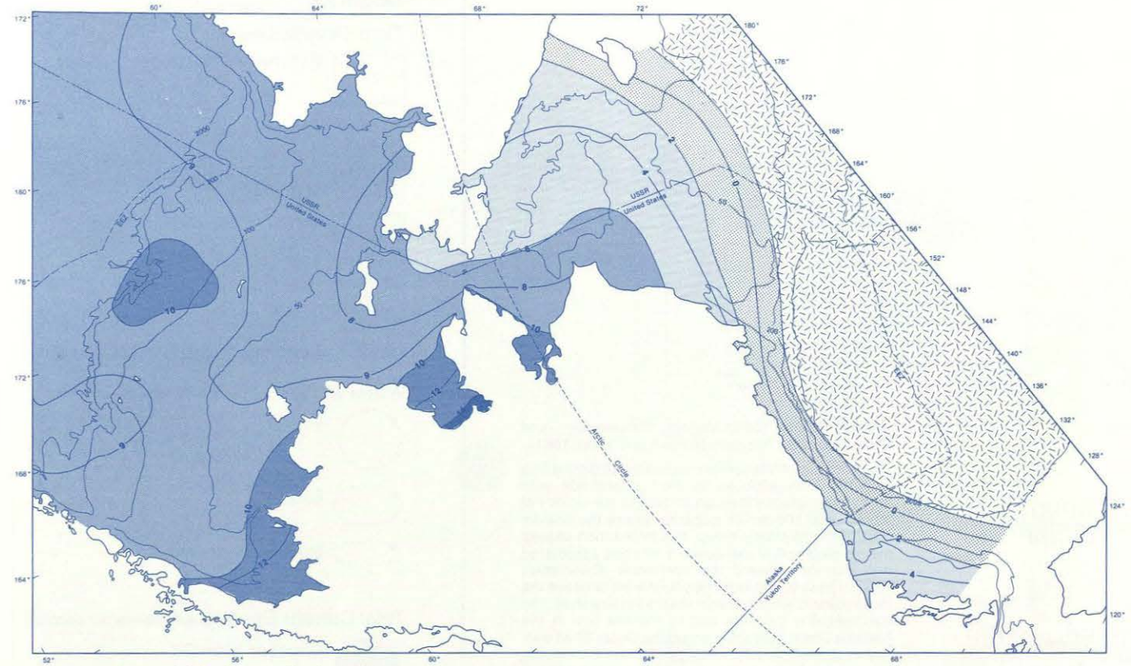
Data are sparse throughout the study area and are especially difficult to evaluate in ice-covered regions or waters bordering the Soviet Union. Coastal maximum bottom temperatures are found to about six meters depth in the Beaufort Sea and 10 meters depth in the Bering Sea. Shelf break maximum temperatures are found between approximately 150 and 200 meters depth. Residual minimum bottom temperatures in summer are cold bottom waters remaining from the previous winter. In winter, water at or near freezing may be present up to 40 meters depth. Pack ice in the areas shown covers at least 5/8 of the sea surface (Brower, Searby, and Wise, 1977a, 1977b). Regions shown are schematic.

Map References

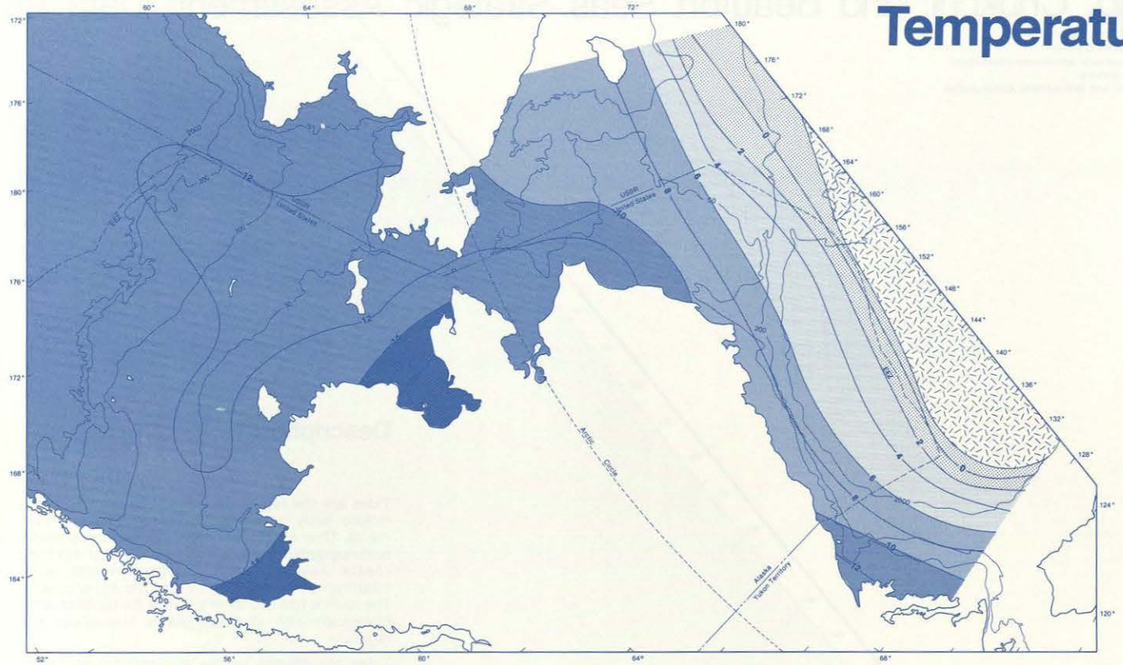
Coachman, Aagaard, and Tripp, 1975; Sayers, Aagaard, and Coachman, 1975; Brower, Searby, and Wise, 1977a, 1977b; Matthews, 1979; Aagaard, 1981; Aagaard, 1984b; and Coachman, 1986; Brower and Wise, 1987a, 1987b.



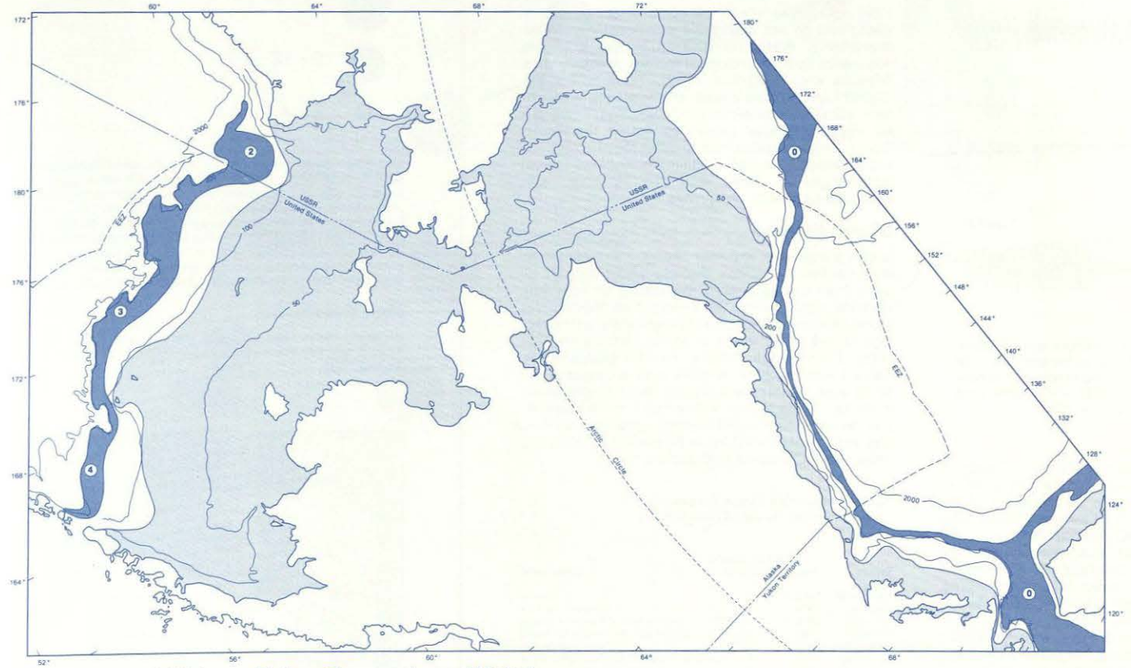
Water Temperatures 1.2



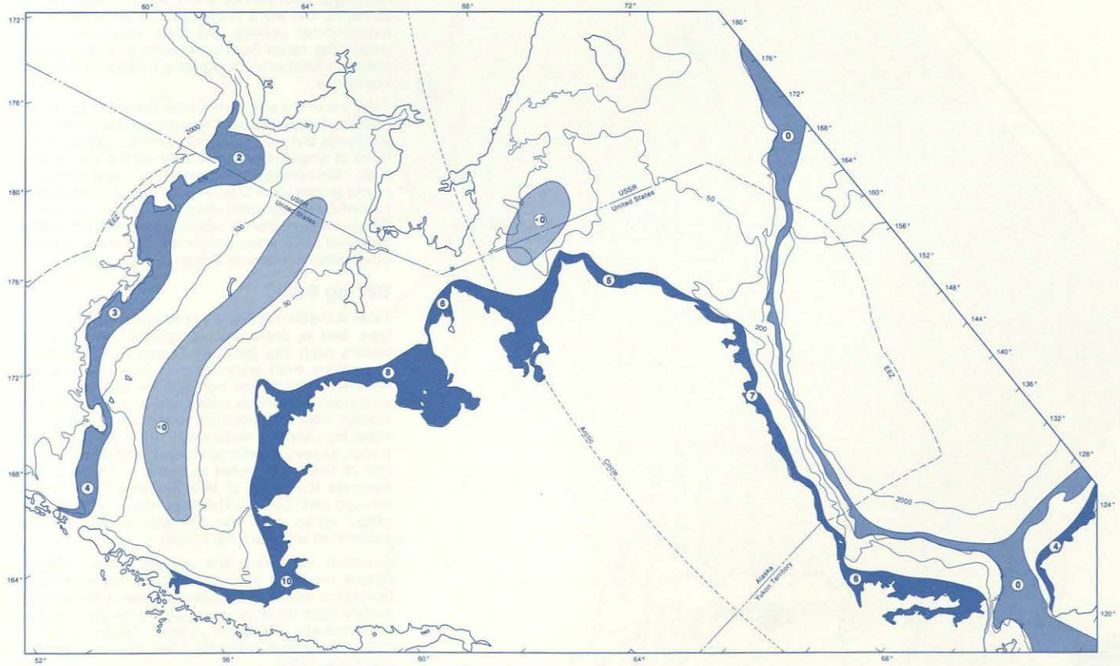
Average Annual Maximum Surface Temperatures



Recorded Maximum Surface Temperatures



Maximum and Minimum Bottom Temperatures (Winter)



Maximum and Minimum Bottom Temperatures (Summer)

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
National Oceanic and Atmospheric Administration

Tides
1.3

Description

Tides are the regular rise and fall of sea level and include both horizontal and vertical water movements. They are one of the most important physical oceanographic processes in the study area, affecting coastal navigation and construction and redistributing nutrients and salt within the water column. The routine rise and fall of water at the coast creates biologically rich intertidal zones throughout the region.

Tides are caused by the gravitational attraction between the Earth, Sun, and Moon. Tides are the sum of component waves, each having predefined periods, and amplitudes and phases that vary regionally. Tidal periods are typically between 4 and 35 hours, and are a function of the six fundamental astronomical periods and their harmonics. Tidal amplitudes range from millimeters to a few meters and are a function of topography, bottom friction, and resonance.

Tides enter the study area from the south as waves from the Pacific Ocean. Through multiple reflections off islands and coastlines, they form complicated patterns of amplitudes and phases on the Bering Sea shelf. Tidal ranges are highest at the heads of embayments (6 meters in Bristol Bay). This amplification is caused by topographic effects and local resonance. Relatively large diurnal ranges occur near the Bering Sea shelf break when compared to offshore areas in other oceans (National Ocean Service, 1983).

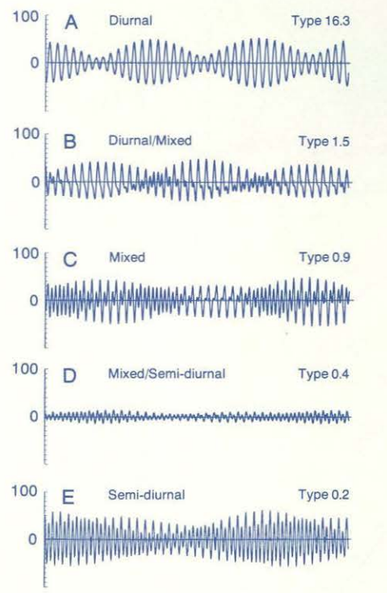
Bering Sea

Tides in the Bering Sea are predominantly of a mixed type, that is, there are two unequal high and low waters each day (National Ocean Service, 1983). Exceptions exist within Norton Sound, where the tides are diurnal (one high and low each day), and southeast of Nunivak Island and within the Gulf of Anadyr, where the tides are semi-diurnal (two nearly equal high and low waters each day). Selected tidal traces, showing predicted water elevation as a function of time, are shown in figure 1. These traces illustrate the range of tidal patterns from diurnal through semi-diurnal. They also show how the tidal range varies over the 14- and 28-day periods associated with the lunar month.

Seasonal variations are present, with extreme ranges occurring at the spring and fall equinoxes. During the winter, the presence of ice at the water's surface appears to increase slightly the semi-diurnal components (Mofjeld, 1984, 1986; Mofjeld, Schumacher, and Pashinski, 1984; Pearson, Mofjeld, and Tripp, 1981).

Associated with the tidal rise and fall of sea level are tidal currents. These currents are substantial, with typical peak speeds of 20-40 centimeters per second (cm/s) on the Bering Sea shelf, decreasing north of St. Lawrence Island to less than 15 cm/s. Tidal currents by themselves contribute only a very small net flow; however, they dominate the dynamics of the Bering Sea shelf. South of St. Lawrence Island, tides contribute more than 80 percent of the kinetic energy, increasing to more than 90 percent within the outer parts of Bristol Bay. This tidal energy keeps the bottom 30 meters of the water column well-mixed, contributing to the transport of bottom nutrients into the upper water column. These currents also generate a lateral diffusion of salt across the Middle Shelf subregion, maintaining the salinity gradient. Characteristic hodographs (circles and ellipses) of water movement during a tidal cycle are shown on the map. For example, within the Middle Shelf subregion, a water parcel may move 10 km during a semidiurnal tidal cycle before returning to its starting point (Mofjeld, 1984, 1986; Mofjeld, Schumacher, and Pashinski, 1984; Pearson, Mofjeld, and Tripp, 1981).

Figure 1. Example Tidal Traces.



The tidal traces shown indicate changes in water elevation (cm) over a period of 40 days at five locations. Tidal type numerics are the ratio of diurnal to semi-diurnal component amplitudes, (K1 + 01)/(M2 + N2). Data were provided by National Ocean Service, NOAA.

The influence of tides on circulation in the Bering Sea is significantly effected by their interaction with bottom topography through friction. In the vicinity of the 50- and 100-meter isobaths, where the bottom gradient is relatively steep, this interaction causes the development of two ocean fronts and associated drift currents toward the northwest (Coachman, 1986). These fronts form the boundaries between the three oceanic subregions on the Bering Sea shelf. The northwesterly currents add to the net flow in the Alaskan Coast subregion and in the Outer Shelf subregion (Maps 1.2, 1.7). Thus, tides in the Bering Sea are coupled to the mean water flow and the general distribution of hydrographic properties.

Chukchi and Beaufort Seas

Tidal amplitudes are small north of St. Lawrence Island and do not contribute significantly to water movements. Water movements in this area are dominated by meteorological factors, primarily wind (Kowalik and Matthews, 1982). Tides within the Chukchi and Beaufort seas are relatively independent from the tides within the Bering Sea. There are no significant tides generated within the Arctic Ocean. The small tides that do occur move across the Arctic Ocean from their origin in the Atlantic. Typical tidal ranges in these seas are 10-15 cm with associated currents of 10 cm/s.

Storm Surges

Storm surges are extreme changes in local water level caused by storms pushing water against or away from a coastal area. Depending on how they coincide with the local tides and the strength of the storm producing them, they can generate extremely high or low water levels. In areas with low coastal relief, storm surge flooding can be catastrophic. Table 1 lists some of the more severe surges in the study area within recent history. Most surges occur in the fall during storms with winds from the west or southwest in the Bering Sea, west in the Chukchi Sea, and west or northwest in the Beaufort Sea (Kowalik, 1984; Wise, Comiskey, and Becker, 1981).

Table 1. Selected Storm Surges within Recent Arctic History

Month	Year	Water Height (meters)*	Location(s)
September	1954	3	Barrow
October	1954	3	Wainwright/Barrow
October	1960	6	Norton Sound/Kotzebue Sound
October	1963	1-4	Wainwright/Barrow/Barter Island
September	1970	3	Barrow/Prudhoe Bay
November	1974	6	Kuskokwim Bay/Norton Sound/Kotzebue
November	1978	3	Kuskokwim Bay/Norton Sound
November	1979	2.5	Bristol Bay/Kuskokwim Bay

*Height above mean higher high water.

Source: Wise, Comiskey, and Becker, 1981.

Legend

Tidal Elevation (meters)

2.0 Estimated Corange

Type of Tide

- Diurnal
- Mixed
- Semi-diurnal
- E Tidal Trace Station Locations

Water Motion (arrow heads indicate rotation)

- Circular
- Elliptic
- Bi-directional

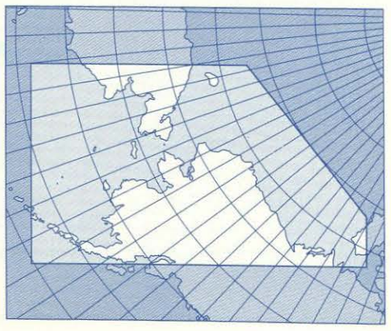
Tidal Current Speed (Centimeters per second)

- Greater than 20
- 13 - 20
- 5 - 12
- Less than 5

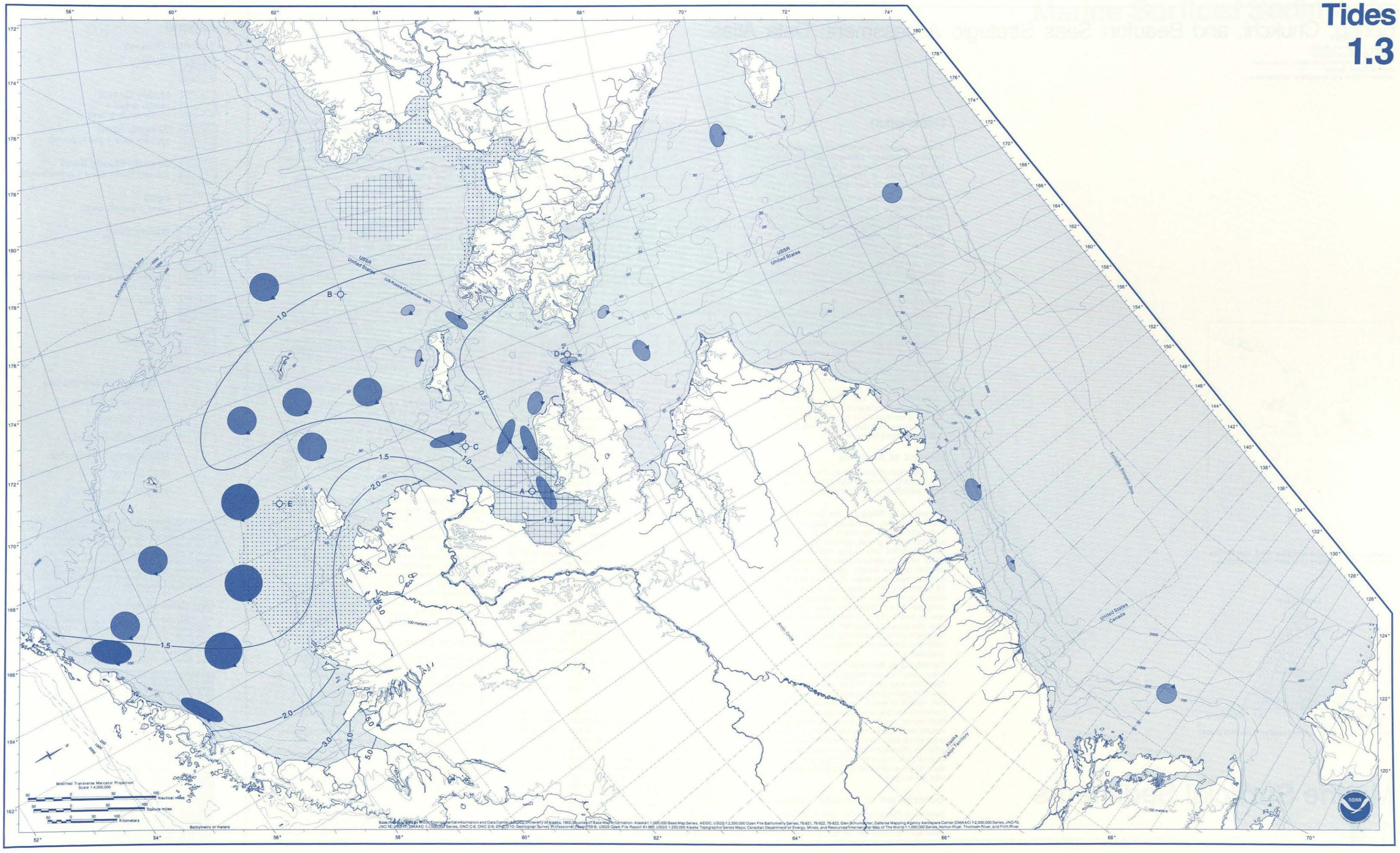
Tide type is based on the ratio of diurnal to semi-diurnal component amplitudes. Ratios of 2.0 and 0.3 were used to separate diurnal from mixed, and mixed from semi-diurnal, respectively. Tides off the coast of Siberia are based on modeling studies rather than direct observations due to the scarcity of data in the region. Water motion classes are determined by the ratio of minor to major axis for the longest harmonic component. The bounds for the elliptic class were 0.6 and 0.2. Tidal elevations north of the Bering Strait are less than 0.25 meters.

Map References

Aagaard, 1981; 1984; Pearson, Mofjeld and Tripp, 1981; Kowalik and Matthews, 1982; National Ocean Service, 1983; Mofjeld, 1984.

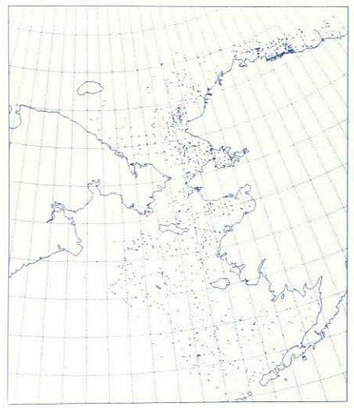


Tides
1.3

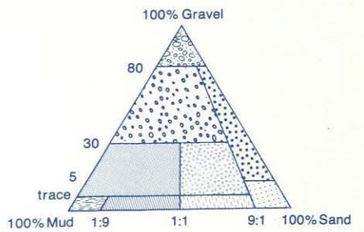

USSR
United States
(U.S.-Russia Convention 1867)
B
D
C
A
E
1.0
0.5
1.5
2.0
3.0
4.0
5.0
100 meters
Exclusive Economic Zone
Arctic Circle
United States
Canada
Alaska
Yukon Territory
Modified Transverse Mercator Projection
Scale 1:4,000,000
Nautical miles
Statute miles
Kilometers
Bathymetry in meters
NOAA

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
National Oceanic and Atmospheric Administration



Location of sediment samples from the Bering, Chukchi, and Beaufort seas continental shelves.



Classification of sediments modified from Folk (1954).

Marine Surficial Sediments 1.4

Description

The map depicts the spatial distributions of sediment types and sediment sorting for surficial sediments on the continental shelves of the Bering, Chukchi, and Beaufort seas. It represents the first complete bottom sediments map compiled for the region.

The characteristics and distribution of marine surficial sediments (sediments to a depth of 5-10 cm) have a significant effect on the distribution of benthic organisms, especially infauna, and to a lesser extent, their predators. Sediment characteristics are also important for assessing the effects of pollution and the quantity of organic matter that may be sequestered and resuspended. Because most sedimentary classification schemes do not lend themselves to correlations with benthic communities, a scheme that more closely presents sediment as related to benthic habitat has been used.

Two dominant properties that influence biota are mapped: sediment size and the degree to which the sediment grain size is sorted. Sediment size refers to the diameter of particles in the sample; sorting refers to the distribution of different particle sizes within the sample. Sorting is important because sediments are always composed of different grain sizes. When the particles in any sediment sample are composed of one or only a few different grain sizes, the sediment is considered to be well sorted. When a sediment sample consists of a wide spectrum of grain sizes, the sample is considered to be poorly sorted. The legend and accompanying diagrams provide additional information on these features.

Method of Analysis

The accompanying inset map shows the distribution of samples that were analyzed to construct the map. Both published and unpublished data sources were used.

Classifying by Texture—The basis for this classification was a triangular diagram devised by Folk (1954, 1968) for which the three end members are defined: 1) gravel, coarser than 2 mm; 2) sand, between 0.062 and 2 mm; and 3) mud, finer than 0.062 mm. The textural class of a sediment sample is defined by the weight percent of the three end member sediment sizes. On this basis, Folk defines 15 granulometric classes. All of the textural types except sand occur in the mapped area, but were collapsed into 9 classes (see inset diagram) because spatial distributions of some classes are not extensive, are generally disjunct, and would be difficult to delineate at the present map scale. Data for depicting sediment classes were based on over 2,300 sample analyses.

Classifying by Sorting—Sorting values were defined using Folk and Ward's (1957) method. Standard deviation was used to indicate the spread (assortment) of grain sizes in a sample. High standard deviation values, in which many different grain sizes are found in a sample, are indicative of poor grain sorting. Well-sorted sediments have low standard deviation values, as they are composed of one or a few different grain sizes. Sediment samples that were analyzed by other sorting schemes were recomputed from the original data to conform to Folk and Ward's specifications. In developing this parameter, about 2,000 samples were used.

Description of Surface Sediments

Sediment Textures—Considerable spatial variation in sediment types exists in the region. The patchy sediment distribution is thought to be typical of arctic-subarctic shelves. With the exception of the southeastern Bering Sea shelf (Sharma et al., 1972), the entire region is non-graded, that is, there is little progressive decrease in overall particle size from the coast across to the shelf break. Areas of glacial boulders and outcrops of hard or semi-hard, older sediments occur in the northern Chukchi Sea and parts of the Beaufort Sea. Samples from these substrates are lacking and are not represented here.

- *Southern Bering Sea shelf*—The Bering Sea shelf, from south of St. Lawrence Island to the western margin of Bristol Bay, is in the mid-stage of establishing a graded condition (Knebel and Creager, 1973); Bristol Bay is nearing a graded condition (Sharma, 1979). This is illustrated by the general, but broad, seaward change in the lithology of Bristol Bay from coarse materials such as gravelly muddy sand, to sand, to finer sandy mud (Sharma et al., 1972). However, occasional patches of relatively coarser substrate on the outer shelf of this region seem to preclude designation of Bristol Bay as a classical graded shelf (Gardner et al., 1979).
- *Northern Bering Sea and Chukchi Sea*—The substrate of the central Chirikov Basin, extending between St. Lawrence Island and Bering Strait, is characterized by muddy sand that laterally grades to gravelly muddy sand (Nelson and Hopkins, 1972; McManus et al., 1977). The strong currents and circulation pattern prevent burial and the typical wave-generated gradation from coarse nearshore to finer grained offshore. The substrate of the Chukchi Sea is predominately gravelly mud, sandy mud, and mud (McManus et al., 1969; Barnes, 1972). However, the inner shelf of the Chukchi Sea, the Bering Strait and vicinity, the area marginal to St. Lawrence Island and the Alaska Peninsula, and isolated shoals throughout the region are carpeted by relatively coarser material (e.g., muddy gravel, gravelly muddy sand, or gravelly sand). These are glacial remnants from which finer particles have been winnowed and carried north. Sands and silts from the Yukon River are found in Norton Sound.
- *Beaufort Sea*—An actively eroding shoreline provides the inner shelf of the Beaufort Sea with poorly sorted, coarser grained materials (sandy mud or muddy sand) out to about 30 feet from shore. The area beyond is characterized by overconsolidated sediments. The middle shelf is dominated by gravelly mud or sandy mud, and the outer shelf by mud. Extensive micro-relief found on the shelf is the result of ice scour.

Sediment Sorting—Sediments of the Beaufort, Chukchi, and northern Bering seas are generally poorly sorted. A large area of moderately well-sorted material occurs south of Nunivak Island. Relatively sheltered areas, such as Norton and Kotzebue sounds, Port Clarence, Prudhoe and Harrison bays, and Simpson Lagoon (see Place Names map), generally have muddy sand or gravelly mud substrates that are very poorly to poorly sorted. Other well-sorted sediments occur over small areas throughout the region.

The unique environmental setting of a relatively wide shelf area, sea ice cover, circulation patterns, geostrophic currents, and occasional storm surges, combined with a complex Pleistocene transgressive-regressive history, have shaped the distribution of surficial sediment types across the shelves of the Bering and Chukchi seas (McManus and Creager, 1965). The diverse sediment distribution in the Chukchi and Beaufort seas reflects the intense reworking of the sea bottom by ice gouging and the transport and deposition of mud and gravel by sea ice (Barnes, 1972; Naidu, 1974; Barnes et al., 1984). Many of the sediments north of St. Lawrence Island are glacially derived relicts, with little deposition under contemporary processes (Nelson and Hopkins, 1972). Strong geostrophic bottom currents flowing northward carry fine-grained sediments into the Chukchi Sea. Sheltered coastal water bodies are traps for terrigenous, i.e., land-based, debris. The presence of a near-graded shelf in the southeastern Bering Sea is attributed to tidal currents and wave energy that produce intense hydraulic sorting of sediments during frequent storms (Sharma et al., 1972).

The sources of sediments include rivers, coastal erosion, glaciers, and suspended sediments carried by currents and ice. Sedimentation rates have varied from 2 to 30 cm per 1,000 years and, in fact, the northern Chukchi Sea and portions of the Beaufort Sea may be eroding. Finer fractions of sediments may be winnowed from the seafloor by fast-moving currents for deposition downstream. In addition, the bioturbation caused by various organisms, especially marine mammals, can have significant effects, causing sediments to be more poorly sorted. Gray whales feeding in the northern Bering Sea to southern Chukchi Sea in summer can alter thousands of square kilometers of sediments (Johnson and Nelson, 1984). Walruses may have similar, and even more far-reaching effects (Ray, 1984). Human effects on surficial sediments in the study area are minor or absent except for relatively small areas.

Importance of Sediments to Biota

The data presented here are consistent with our general knowledge of the behavior and habitat requirements of most benthic organisms of the region. The presence or absence of a benthic species is reflected in part by the nature of the substrate over the long term, as relationships between sediment characteristics and biotic assemblages are recognized. Bottom sediments are ingested for the bacteria and detritus, which serve as the basis of the food chain.

There is a general tendency for deposit feeders (e.g., sea cucumbers and various worms) to dominate in silt-clay sediments and filter feeders (e.g., clams, sea pens, and fan worms) to dominate on sandy sediments (Mann, 1982). However, fine sediments support both filter and deposit feeders. Likewise, changes in substrate will precipitate a change in resident fauna. For example, ice, currents, and sedimentation disrupt filter feeders in shallow waters (Carey et al., 1974). Ice gouging produces local suspension and mixing, and also disrupts fauna. In summary, sediment type plays a vital role in many aspects of the ecology of marine resources of the Bering, Chukchi, and Beaufort sea shelves.

Persons Consulted

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Legend

Sediment Classes

- Gravel
- Muddy Gravel (muddy gravel + muddy sandy gravel)
- Gravelly Sand (gravelly sand + sandy gravel)
- Gravelly Muddy Sand (gravelly muddy sand + gravelly mud)
- Sand (sand + gravelly sand)
- Muddy Sand
- Gravelly Mud (gravelly mud + gravelly sandy mud + gravelly mud)
- Sandy Mud
- Mud

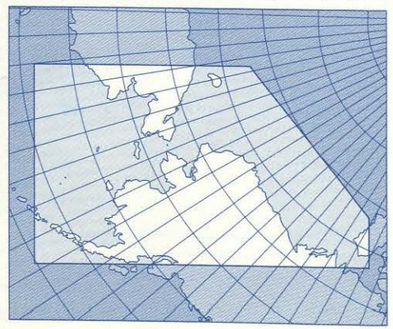
Sorting Values

1. Extremely Poorly Sorted
2. Very Poorly Sorted
3. Poorly Sorted
4. Moderately Sorted
5. Moderately Well Sorted
6. Well Sorted
7. Very Well Sorted

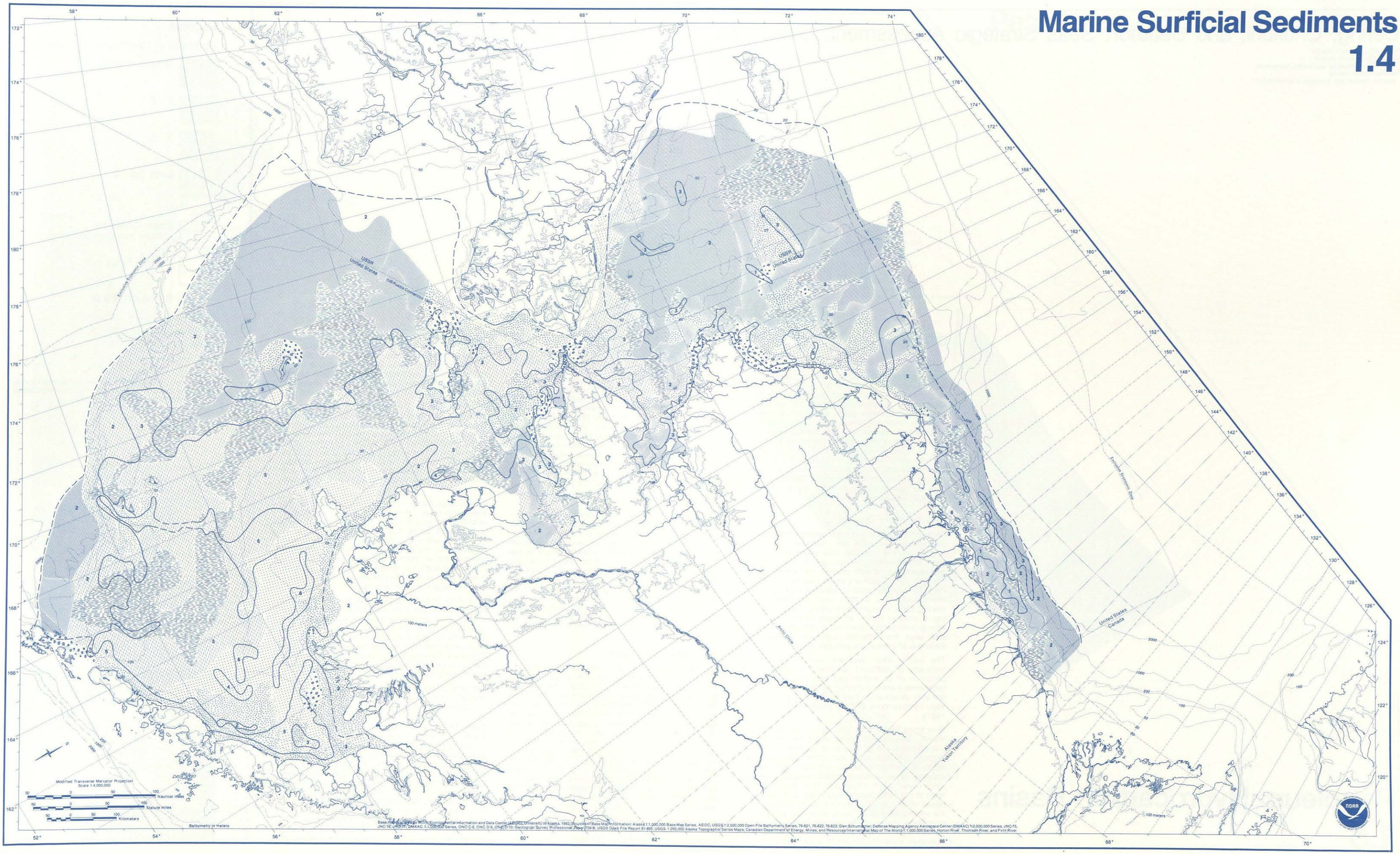
The classes shown are a combination of Folk's (1954) sediment classes (included in parenthesis). Sorting is a measure of the distribution of particle sizes in a sediment sample. A well sorted sediment contains only one or a few different particle sizes; a poorly sorted sediment is characterized by a wide range of particle sizes. Information shown is based on actual field samples. No extrapolation is made to unsampled regions, accounting for no information shown along the U.S.S.R. and the Canadian Beaufort coasts.

Map References

Folk, 1954, 1968; Folk and Ward, 1957; McManus and Creager, 1965; Burrell et al., 1970; Dygas et al., 1971; Barnes, 1972, 1974; Naidu and Sharma, 1972; Tucker, 1973; Naidu and Mowatt, 1974; Alexander et al., 1975; Naidu 1976; Roberts, 1976; Gardner et al., 1979; Naidu et al., 1980, 1982; Sweeney, 1984. Personal communications from Carey; Moore; Sharma.



Marine Surficial Sediments
1.4



Base map data courtesy of Environmental Information and Data Center (AEIDC), University of Alaska, 1982; Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17, DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-455; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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Petroleum Hydrocarbon Basins
1.5

Description

Determination of the presence and distribution of oil-bearing sedimentary strata is the most important element in assessing the petroleum potential of an area and in developing strategies for exploration. Almost all petroleum pools occur in sedimentary materials and are frequently found in basins. Sedimentary basins are geologically depressed areas formed by depositional or structural processes with the thickest sediments located in the center. The permeability of sedimentary strata allows petroleum to percolate into these natural reservoirs, where it is trapped and accumulates in pools. Therefore, areas such as basins and fault zones are the focus of petroleum exploration.

Sedimentary Basins

Sedimentary basins and other geologic features with oil-producing potential are identified through a lengthy process involving field work and observations, photographic surveys, gravity and magnetic measurements, seismic profiles, and eventually exploratory drilling. In many cases seismic surveying is the most important step in planning exploration in a frontier area and is often used to determine the starting point for exploration drilling. Seismic surveying, a process similar to sonar, broadcasts sound from ground surface down into a rock/sediment layer and uses the reflected signal to estimate the thickness of subsurface geologic formations.

The basin areas depicted contain sedimentary materials of sufficient thickness to suggest the presence of oil and/or gas reserves, with thicker sedimentary areas indicated by darker tones. Faults are also shown since they can provide a barrier that traps hydrocarbons in porous sediments (Levorsen, 1967).

Two types of contours, structural and isopach, are shown. Structural contours show the extent and vertical thickness of a layer of geological material. Isopach contours, which also show both extent and depth of geological strata, are also corrected for bedding angle. Isopach contours usually provide more useful depth information than structural contours of the same feature. Both types of contours are based on a reference bed of material that underlies the sedimentary strata being examined. Most of the formations shown on this map are from the Cenozoic period, with lesser amounts of Mesozoic and Paleozoic materials present in some areas.

Exploration in the Arctic

Collecting geologic data in many parts of Alaska, particularly the Arctic, is often more difficult than in other areas of the USA. One obvious problem is climate. In offshore areas in particular, exploration is a seasonal activity. Ice conditions make some types of exploration work difficult. The remoteness of most sites in Alaska presented problems for geologists until the advent of the helicopter. Now field crews can be dropped almost anywhere. The status of land ownership in Alaska also poses difficulties to exploration and development. Federal and state public lands, as well as lands granted to Alaska Native corporations, cover most of the state. Only about one percent of the state is privately owned (Alaska Northwest Publishing, 1982). Disruption of the seasonal migrations of birds and mammals must also be considered during exploration.

Oil and gas exploration and development are also underway in the Soviet and Canadian Arctic. In the USSR, all current arctic oil production takes place in the central and western parts of the country (outside the study region). Canadian activities occur in the Mackenzie Delta region, which contains oil and gas deposits that extend well out into the Beaufort Sea. Both Canada and the USSR estimate that significant quantities of hydrocarbons exist in their arctic territories, but development is hindered by the lack of transportation systems. Substantial undiscovered, recoverable petroleum is thought to lie in the vicinity of the USA-USSR international boundary, presently in dispute.

Resource Estimates

Federal OCS—The outer continental shelf (OCS) of Alaska is one of the more promising areas for future oil and gas development in the USA. The Minerals Management Service (MMS) estimates that one-fourth of the oil and one-fifth of the natural gas that have yet to be discovered in the OCS of the USA will be found in Alaska's offshore areas. MMS estimates the amount of undiscovered, economically recoverable hydrocarbons in the Alaska OCS at 3.3 billion barrels of oil and 13.9 trillion cubic feet of natural gas, ranking second only to the Gulf of Mexico region (6 billion barrels of oil and 60 trillion cubic feet of natural gas). The planning areas used by MMS to organize data on hydrocarbon reserves and other OCS activities are shown on map 4.6. Short descriptions of some of the planning areas follow:

- *Beaufort Sea*—The Beaufort Sea is considered the most likely of all the Alaskan offshore areas to produce commercial quantities of hydrocarbons. This is due in part to its proximity to the huge reserves located in the vicinity of Prudhoe Bay. MMS estimates the marginal probability (MP) of oil production for this region at 0.70. The mean volume of recoverable oil is estimated to be 2.7 billion barrels (Cooke, 1985), with production of as much as 100,000 barrels of oil per day as early as 1988.
- *Navarin Basin*—The marginal probability of this region becoming productive is 0.27, considerably lower than the Beaufort Sea. However, if commercial quantities of oil or gas are discovered, chances are that the volumes recovered will be somewhat higher. The estimated mean volume of oil that might be recovered from this area is 4.8 billion barrels. Evidence of numerous traps near potential source rocks is one reason for this relatively high conditional estimate.
- *St. George Basin*—This area is less likely than the areas previously mentioned to contain commercial quantities of hydrocarbons; its marginal probability is estimated to be 0.22. The mean estimate of 1.7 billion barrels of oil recovered is also lower than estimates for the Beaufort Sea and Navarin Basin areas. About two-thirds of this planning area is on the continental shelf; the remainder is located in much deeper water and is considered unlikely to produce commercial amounts of oil or gas.
- *Chukchi Sea*—MMS estimates that this area has about a one-in-five chance of containing commercial quantities of hydrocarbons. The estimated mean volume of oil in the area is 2.7 billion barrels. Estimates for this area are based in large part on work conducted in the western portion of the National Petroleum Reserve Alaska, which contains some of the same geologic formations that are productive in the Prudhoe Bay region.

The other planning areas in the study region are considered much less likely to produce commercial amounts of oil and gas.

State Lands and Waters—About one in every twenty-five barrels of recoverable American oil is in Alaska (including oil shales and sands). All the oil produced in Alaska in 1985 came from land or water areas leased from the state. Two basins, Cook Inlet and Colville, have produced almost all the oil ever pumped in Alaska. By late 1985, their cumulative production was over 5.3 billion barrels of oil and 7.1 trillion cubic feet of natural gas. Over 97% of all oil produced in Alaska comes from the North Slope fields at Prudhoe Bay and Kuparuk River (Alaska Oil and Gas Conservation Commission, 1985). Areas offered for leasing by the state are shown on map 4.6.

Legend

Thickness of Sediments in Kilometers

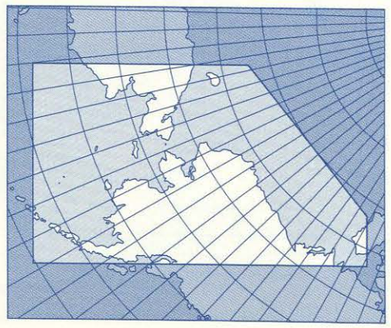
- Greater than 8
- 5 - 8
- 3 - 5
- Less than 3

- Basin Contours (Contour Intervals: 1 and 2 km)
- Normal Fault
- Strike-Slip Fault
- Hope — Basin Name

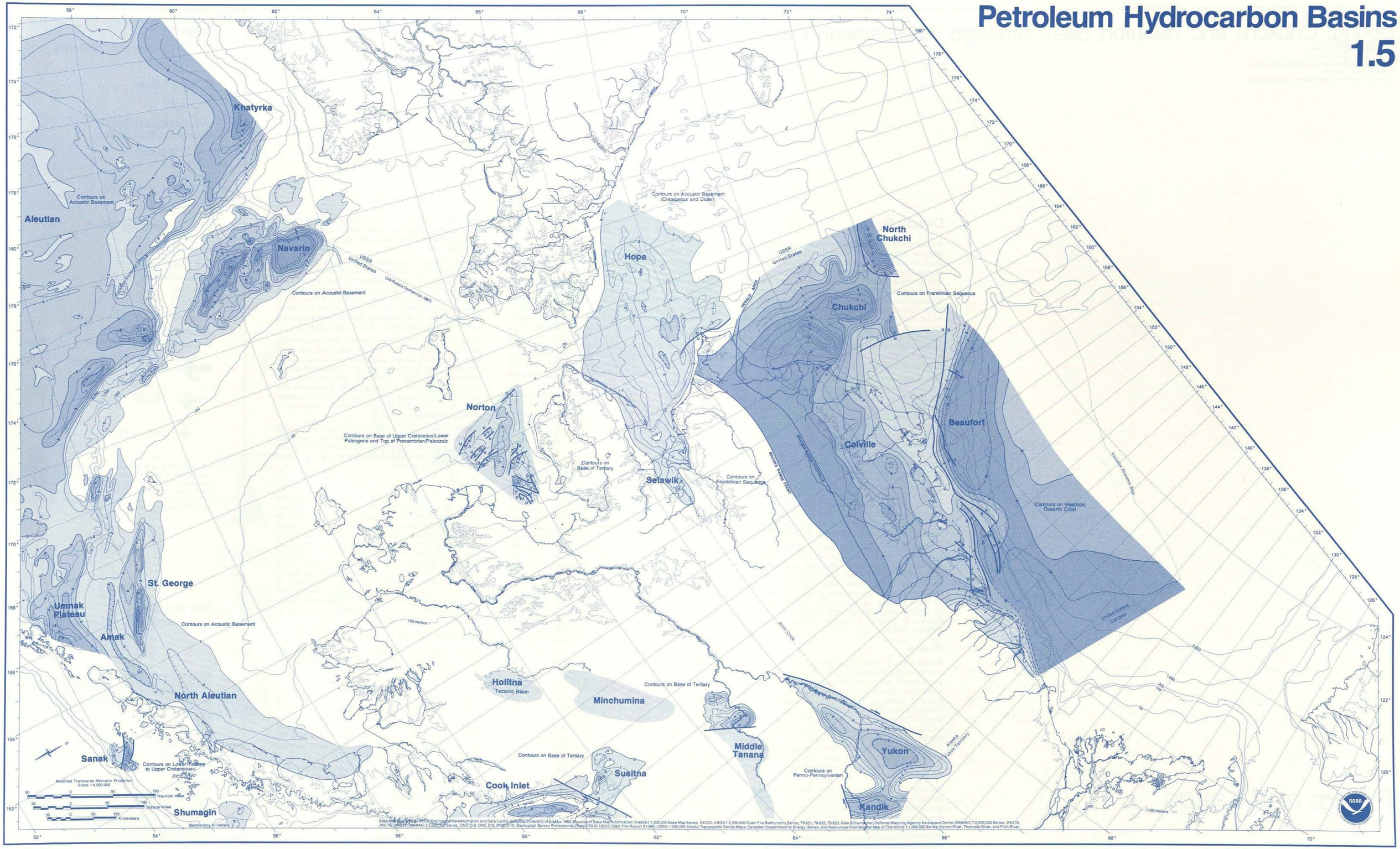
Isopach contours are shown in Bering Sea basins. All other basins have structural contours. No contours were available for Holitna and Minchumina basins.

Map References

Ehm, 1983.



Petroleum Hydrocarbon Basins
1.5



Base map data courtesy of the Environmental Information and Data Center (EIDC), University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher, Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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Rivers and Lakes
1.6

Description

Alaska is a land of abundant surface water resources, despite lacking large amounts of precipitation in much of the state. The cold climate through most of the year conserves moisture that would otherwise be lost to evaporation. The harsh climate also results in the presence of a layer of permafrost, or permanently frozen ground, which underlies much of the state. This layer minimizes percolation and restricts groundwater movement, allowing more water runoff into rivers and lakes. River flow in most areas is highly seasonal, especially in the far north. In the extreme environment of the Arctic, streams and ponds may be frozen to a six foot depth during winter months (U.S. Geological Survey, 1984).

Two major mountain ranges (Alaska and Brooks) channel runoff from snowmelt and rainfall into the state's broad interior lowland. This is drained by Alaska's two major rivers (the Yukon and Kuskokwim) which, in turn, flow into low-lying valleys and riverbeds and onto the coastal plains on their way to the sea. Most of Alaska's largest lakes are also located on these wide coastal plains. Much of the substructure of the coastal basins and plains is lined with unconsolidated glacial till, providing storage for an extensive groundwater system.

The Yukon, Alaska's dominant river, originates in Canada and flows west and south into the Bering Sea. Its drainage area covers more than one-third of the state. It ranks fourth in North America in length (1,875 miles) and fifth in drainage area (327,600 square miles) (Alaska Northwest Publishing,1982).

Alaska's largest lake, Lake Iliamna, which drains into Bristol Bay, has a surface area of 1,000 square miles and depths approaching 1,000 feet. Lakes Becharof (458 square miles), Teshekpuk (315 square miles), and Naknek (242 square miles) are the next largest (Alaska Northwest Publishing, 1982). Alaska has 95 lakes whose surface area is greater than 10 square miles. About one percent of Alaska's surface is covered by lakes (Moody, Chase, and Aronson, 1986).

Rivers

Alaska's many rivers differ greatly in physiographic characteristics such as channel configuration, length, width, depth, sediment carrying capacity, period of ice cover, flow volume, and associated geomorphological features such as braids and meanders. All are dominated by the effects of climate, particularly ice. Most of the rivers are covered with thick ice in winter until spring thaw, when the break-up of ice produces ice jams and flooding. River basins in the north have, on average, less than half the unit area runoff of those in the southcentral part of the state. This difference is most directly related to lower precipitation on the North Slope.

Periods of peak riverine flow are influenced by temperature and by the amount and timing of snowmelt. For rivers in the southcentral and southwestern portions of the state, peak flows occur in May-June, while rivers throughout the northwest and the North Slope peak later in the summer (June-July). Three general types of rivers are found in the study area: 1) rivers that flow year-round with extreme seasonality; 2) lake-regulated rivers; and 3) rivers with discontinuous flow.

Rivers With Seasonal Flow—These rivers occur mainly in the southcentral and southwestern portion of the state, but also include all rivers draining into the Bering Sea north of Bristol Bay, rivers draining into the Chukchi Sea between Icy Cape and Cape Krusenstern, and the Anderson River, which drains into the eastern Beaufort Sea. Although most of these rivers flow throughout the year, their volume varies considerably with time of year. Minimum flow generally occurs from February to April; maximum flow in June. Break-up of ice occurs around mid-May, and freeze-up, usually mid-October. Ice jam flooding results from rapid, unpredictable increases in water level from snowmelt and consequent rapid releases of floodwater.

Sediment discharge is seasonal and generally peaks during spring floods or heavy summer rains. The Yukon, Kuskokwim, and Anadyr rivers discharge the largest quantities of sediment into the Bering Sea, the Yukon discharging up to 500,000 tons of sediment per day from June through August (U.S. Geological Survey, 1985).

Lake-Regulated Rivers—Lake-regulated rivers, which predominate in the Bristol Bay region and thus discharge into the lower Bering Sea, usually flow year-round. Lake-regulated rivers are located along the Alaska Peninsula and include the Kvichak, Alagnak, Naknek, and Egegik rivers. The Mackenzie River, the major source of inflow and sediment into the Beaufort Sea, originates outside the study area. The Mackenzie's flow is regulated by Great Bear Lake, Great Slave Lake, and Lake Athabasca (all not shown), in Canada's Northwest Territories. It discharges over 1 million tons of sediment per day into the Beaufort Sea during summer months (Soil Conservation Service, 1980).

Water storage provided by large lakes moderates flow and decreases seasonal variability in these rivers. Minimum flow in lake-regulated rivers occurs typically during March-April; maximum flow is typically during May-June (June-July for the Mackenzie). Large ice jams are common on these rivers in the spring (U.S. Geological Survey, 1984).

Rivers With Discontinuous Flow—Rivers with discontinuous flow primarily include those draining the North Slope of Alaska into the Beaufort Sea and those flowing into the Beaufort Sea from the Yukon Territory and Banks Island. These rivers are characterized by lack of flow until break-up occurs in spring. The entire drainage area of these rivers usually lies within the area of continuous permafrost.

The Colville is the largest of these rivers. Its period of zero flow occurs from February-April, with maximum flow during June. Seawater penetrates 50-80 km upstream in the Colville River during winter. Ice break-up occurs from mid-May to early June; freeze-up from mid- to late October. Extreme flooding is common during break-up, and enhanced by the buildup of shorefast ice at river mouths.

Lakes and Ponds

Alaska's approximately three million lakes also exhibit seasonal freeze and thaw changes. Because most lakewater is derived from snowmelt and rainfall, water levels are generally low in early spring and rise to their highest levels during spring thaw and autumn rainy periods.

The abundance of lakewater in most of arctic Alaska is the result of low evaporation rates, reduced percolation due to permafrost, seasonal ice cover, and low relief. Alaska's lakes were either formed or modified by glaciation during the Pleistocene, and most lie at elevations less than 100 meters above sea level. Consequently, in some areas tidal influence extends as far inland as the outlet of the lowest lake.

Coastal lakes are influenced by the moderating effects of a milder maritime climate. They are more exposed to wind action, and therefore, some are ice-free over long periods in winter. Coastal lakes are shallower and have increased surface area and turbidity compared to interior lakes. Dissolved salt content, suspended sediment loads, and light attenuation levels are also higher in coastal lakes (U.S. Geological Survey, 1985).

Interior lakes, farther from the influence of a maritime climate, have shorter ice-free periods and are generally deeper than lakes nearer the coast. Since they become ice-free only in late spring, the use of these waters is limited.

Habitat

Rivers and lakes provide essential habitat for migrating and nesting birds, arctic mammals, and anadromous fish. Many Alaskan wildlife species such as bald eagles and brown bears range over large areas of the state. Five species of salmon, an important market resource for commercial fishermen and subsistence resource for Native Alaskans, are found in rivers and lakes throughout Alaska (Maps 3.22-3.26). River deltas, such as the Yukon-Kuskokwim, are especially important for waterfowl. Tens of millions of birds use these areas as breeding and staging areas during the brief Arctic summer. Some species journey from as far as South America to reach these grounds every year.

Economic Uses

Alaska's water resources are most heavily used around Anchorage, where more than one half of the state's population lives. Increasing demands upon water resources are expected as Alaska's population continues to grow, particularly in Anchorage, where the population more than doubled between 1970 and 1980 (Map 4.1). (U.S. Water Resources Council, 1979). Siltation and freezing temperatures preclude the use of surface water as the primary source of water in much of Alaska. In 1980, less than 40% of the residents received their water from surface supplies (Moody, Chase, and Aronson, 1986).

Rivers and lakes are also important for regional transportation (Map 4.12). Although much of Alaska's transportation is by aircraft, rivers provide a lower cost alternative for bulky goods that can be shipped by flat bottom boats in summer. Rivers and lakes are used as roads when frozen in winter.

Legend

Rivers and Tributaries

Lakes

U.S. Geological Survey Hydrologic Boundaries

Regional

Subregional

Cataloging Unit

U.S. Geological Survey Gaging Station

Mean Annual Flow in Cubic Feet Per Second

200,000 or greater

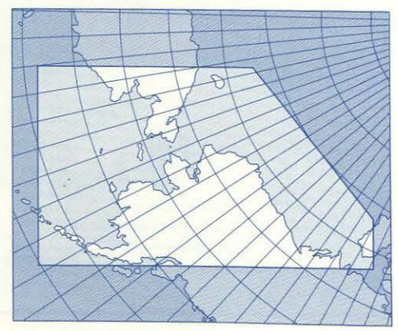
10,000 - 50,000

250 - 1,500

All streamflow data are mean gaged flow for the period of record. None of the rivers shown had mean annual flows between 1,500 and 10,000 cfs or 50,000 and 200,000 cfs. The major river in most cataloging units is gaged, except for the Colville River on the North Slope where the cataloging unit has no US Geological Survey gage.

Map References

U.S. Geological Survey, 1976; National Water Data Exchange, 1985.



Rivers and Lakes
1.6



Base map courtesy of Environmental Information and Data Center (AEIDC), University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher, Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC15, JNC16, JNC17, DMAAC 1:1,000,000 Series, ONC C-6, ONC D-9, ONC D-10, Geological Survey Professional Paper 258-B, USGS Open File Report 81-485, USGS 1:250,000 Alaska Topographic Series Maps, Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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Mean Circulation
1.7

Description

The circulation of waters in the Bering, Chukchi, and Beaufort seas is an important determinant of the distribution of living marine resources and human activities in the region. Circulation features directly affect distributions of plankton, sediments, sea ice, and therefore, influence the movements of most marine animals in the region, as well as the duration of the navigation season.

Circulation patterns are complex and highly variable, responding to both local winds and the extent of ice cover. This variablility is evident at all time scales, from days to years, and causes local currents to change by up to a factor of ten in speed and to make major changes in direction, including reversals. A schematic representation of mean currents is shown representing mean annual flow above the seasonal pycnocline. In the broadest terms, mean circulation is clockwise around Alaska; it follows the bathymetric contours along the Bering Sea shelf north through the Bering Strait into the Chukchi Sea. At Point Hope/ Cape Lisburne this northerly flow divides, part heading west out to the Arctic Ocean through the Herald Canyon and part continuing along the Alaskan coast to the Beaufort Sea through the Barrow Canyon.

Bering Sea

Circulation of the Bering Sea is dominated by tidal flows that account for more than 90 percent of the kinetic energy in the southern part of the study area. However, measurements indicate that there are mean flows that are significant even though they are an order of magnitude smaller than oscillatory tidal currents.

Three flow regimes are evident in the southeastern Bering Sea shelf that, for the most part, correspond to the oceanic subregions discussed in the section introduction and on map 1.2. A coastal regime shoreward of the 50-meter isobath has a northerly drift of 1-5 centimeters per second (cm/s). The water in this regime is characterized by warm summer temperatures and low salinities related to river discharge. A middle regime, bounded by the 50- and 100-meter isobaths, has minimal net flow and a flushing time in excess of one year. An outer regime, from the 100-meter isobath westward to the shelf break, has northwesterly flows of 1-5 cm/s. Along the shelf break, the Bering slope current regime flows counterclockwise around the deep basin with mean speeds of 10 cm/s. Numerous eddies of 100 km scale size are present in this current. (Kinder and Schumacher, 1981; Schumacher and Kinder, 1983)

There is northerly flow on both sides of St. Lawrence Island. Flow through Anadyr Strait (to the west) has water characteristics determined by coastal processes in the Gulf of Anadyr combined with those of the Bering Sea Outer Shelf subregion. Alaskan coastal water flows north through Shpanberg Strait (to the east) generally following the 30-meter isobath. This flow loops into the outer portion of Norton Sound to a variable degree, depending on the amplitude of its general northward flow; when the flow is weak, more water "backs up" into the Sound. (Coachman, 1986)

Bering Strait

The Bering Strait connects the Bering Sea with the Chukchi Sea. The northward movement of water into the Chukchi Sea is critical to the oceanography and biology of the Arctic Ocean. On average, 0.5 Sverdrups (Sv), or half a million cubic meters per second, of water flow through the Strait. However, day-to-day transport can be either to the north or the south, with a range of plus or minus three Sv. Major flow reversals can occur in only one or two days. The winter mean of 0-0.5 Sv is lower than the summer value of 1-1.5 Sv. The faster flows, occasionally in excess of 200 cm/s, are in the upper layers east of the Diomedes. The western channel has lower and more uniform speeds. Transport through the Strait is correlated with east-west atmospheric pressure differences across the Strait. The reversals that occur are episodic and coincide with strong north winds (blowing toward the south) over the Chukchi Sea. (Coachman and Aagaard, 1981; Aagaard, Roach, and Schumacher, 1985)

Chukchi Sea

Three distinct water types, each characterized by different salinity, flow northward through the Bering Strait into the Chukchi Sea. The most saline is the Anadyr water (>33) on the west, followed by the Bering shelf water in the center, and finally, the Alaskan coastal water (<31.5) on the east. The Anadyr water quickly mixes with the Bering shelf water and loses its identity soon after entry into the Chukchi Sea. The general flow then veers to the east, steered in part by bathymetry, and then accelerates north past Point Hope. During this passage, the low salinity of the Alaskan coastal water is reinforced by additions of less saline water from Kotzebue Sound. In the Point Hope/Cape Lisburne region, the flow divides, with most Bering shelf water flowing northwest following the Herald Canyon out into the Arctic Basin. Most of the Alaskan coastal water continues to flow toward the northeast.

An apparent "dead spot" exists in the southcentral Chukchi Sea (near 68° N. Latitude, 169° W. Longitude) where cold bottom water is residual from previous winters and has high oxygen demand (Map 1.2). The flow along the Alaskan coast is jetlike and responds to local wind forcing, occasionally reversing. Speeds of this jet often exceed 65 cm/s. Eddies are formed downstream of the prominent capes. The duration of ice cover in the Chukchi Sea is reduced by the general inflow of warm water from the south (Coachman, Aagaard, and Tripp, 1975; Aagaard, 1984a).

Beaufort Sea

From Point Barrow east, circulation can be divided into an inner and an outer regime, separated by the 40-or 50-meter isobaths. A third regime, located within the coastal lagoonal systems, is driven by runoff and winds during the ice-free summer and by brine rejection and convective flow during the winter.

The inner regime responds primarily to winds blowing from the east or west. Mean flow is toward the west at 0.1-0.3 cm/s west of Barter Island (143° W. Longitude) and toward the east, east of this island. Maximum current speeds are about 10 cm/s, primarily following isobaths. Some cross-shelf flow is driven by runoff, upwelling, and brine rejection during ice formation. Flow in this inner regime is suppressed during the winter when ice covers the region.

The outer regime is affected by the circulation of the Arctic Ocean and is also coupled to Bering Sea circulation through the Alaskan coastal flow that rounds Point Barrow. Both Alaskan coastal and Bering Sea water can be traced eastward across most of the Alaskan Beaufort Sea by their distinctive temperature and salinity. The currents are bimodal (predominantly east or west) in direction following isobaths, and although influenced by local wind, they appear to be part of the general counterclockwise circulation of the Arctic Ocean periphery, with mean flow toward the east. Typical currents have speeds of 5-10 cm/s with semi-diurnal tidal components of 1-3 cm/s. Maximum currents range from 30-70 cm/s. Upwelling (upslope flow) contributes to cross-shelf flow outside the 60-meter isobath. Farther offshore, beyond the slope, the deeper flow is also to the east. Sea ice off the Beaufort Sea coast is driven to the west by the mean regional winds (Aagaard and Anderson, 1981; 1984b).

Legend

Net Flow Characteristics

5-20 — Major Features (net speed in centimeters per second)

← — Flow Direction

w — Weak Flow (less than one centimeter per second)

Flow Boundaries

Constant

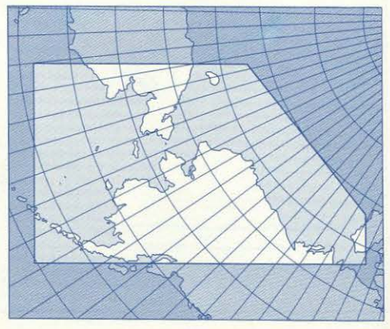
Variable

Continuous Ice

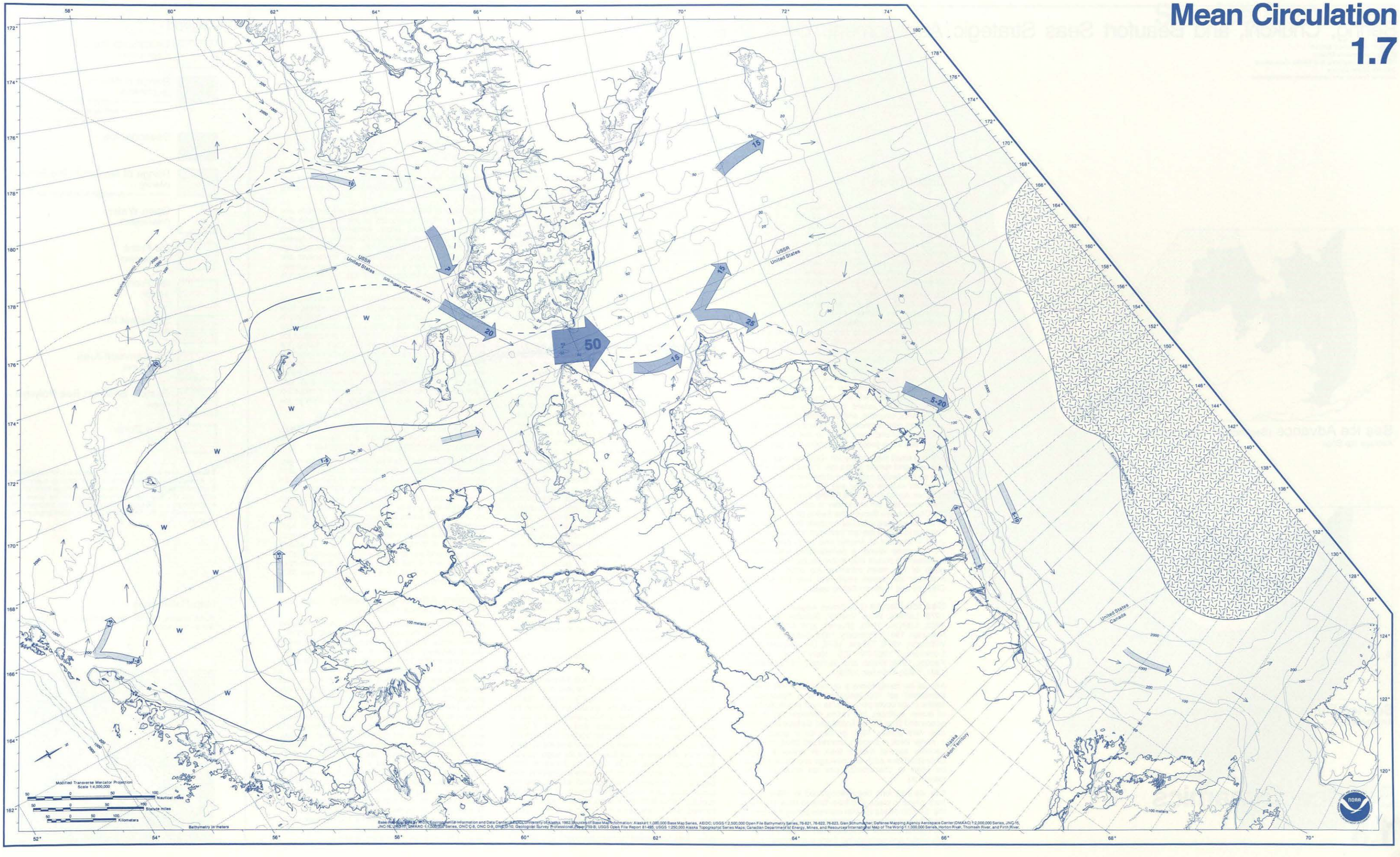
Although net circulation features in the Gulf of Anadyr are understood, detailed flow data are unavailable. Constant flow boundaries are controlled by bottom topography and are relatively permanent delimiters of areas of similar flow characteristics. Variable flow boundaries lack the stabilizing influence of bottom topography and are more readily altered. The continuous ice area shown represents the area north of the 100% probability minimum ice edge for September 15 (LaBelle et al, 1983). This area is generally ice covered throughout the year. For additional information on sea ice, see maps 1.8 and 1.9.

Map References

Coachman, Aagaard and Tripp, 1975; Aagaard, 1981, 1984a, 1984b; Coachman and Aagaard, 1981; Kinder and Schumacher, 1981; LaBelle et al, 1983; Schumacher and Kinder, 1983; Aagaard, Roach and Schumacher, 1985; Coachman, 1986.



Mean Circulation
1.7



Base map data sources: NOAA, Environmental Information and Data Center (EIDC), University of Alaska, 1982; Sources of Base Map Information: Alaska at 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Bohumulsky; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNG-15, JNC-16, JNC-17, DMAAC-1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-485; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

Strategic Assessment Branch
Ocean Assessments Division
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National Ocean Service
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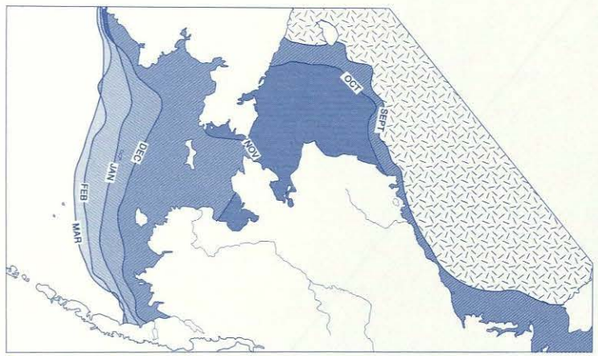
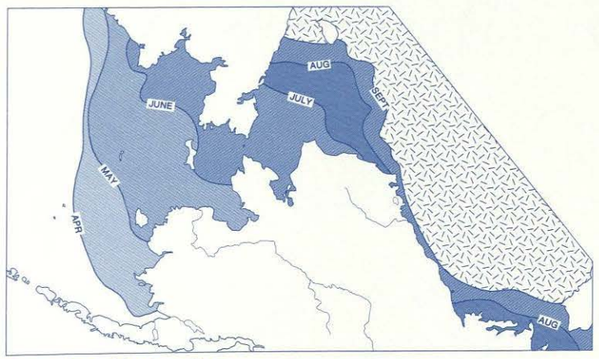


Sea Ice Advance (September 15-March 15)
Average Ice Edge



Sea Ice Retreat (April 15-September 15)
Average Ice Edge

Sea Ice Dynamics
1.8

Description

The annual formation and retreat of sea ice are dominant physical processes of the coastal and marine waters of the Arctic. Sea ice is a major determinant of distributions in time and space of living marine organisms. The presence of sea ice makes portions of the study area unsuitable for many species. Each year as ice advances these species are forced to move southward to ice-free waters. For other species sea ice provides important habitat.

For centuries people have also adapted to sea ice and its dynamics. Native people of the Arctic have associated the distribution and movements of the species on which they depend with sea ice characteristics. They have had to deal with the hazards of sea ice while hunting for ice-inhabiting species such as seals, walruses, bowhead whales, sea birds, and many others. This is true for industries that extract both living and nonliving resources from sea-ice-dominated seas. For example, one of the world's most valuable commercial fish is walleye pollock (Map 3.32), a species whose seasonal movements are to a great extent dictated by sea ice. The movements, structure, and dynamics of ice also have stimulated new technology for oil and gas exploration and development, particularly in the Beaufort Sea, where sea ice is present near shore and year-round.

The two small maps to the left show the mean annual advance and retreat of sea ice. These maps and the one on the facing page also show the maximum and minimum extents of the sea ice during winter and summer. About 97% of the Bering Sea's ice is formed there annually; the remainder is carried south from the Chukchi Sea through the Bering Strait. Over 60% of the Bering Sea's annual ice melts there, especially near the ice edge; the last (remnant) ice melts in May-June in the Gulf of Anadyr and north and south of St. Lawrence Island. A considerable proportion of multiyear ice occurs only in the central Beaufort Sea, north of the mean minimum ice edge; very little multiyear ice moves southward into the southern Chukchi and northern Bering seas.

Sea Ice Zones (Coachman, Aagaard, and Tripp, 1975; LaBelle, Wise, Voelker, Schulze, and Wohl, 1983; Lisitysu, 1960; Muench and Ahlnas, 1976; Niebauer, 1981b; Potocsky, 1975; Sater, Walsh, and Wittmann, 1974; Tabata, 1974; U.S. Department of Commerce, 1962-79; U.S. Navy Fleet Weather Facility, 1976; Walsh and Johnson, 1979; Webster, 1981, 1982; Wendler, 1973)

Annual ice rarely forms a continuous cover (usually expressed as "concentration" and described in tenths of ice cover per unit area over a specified area of ocean surface), but varies considerably in both space and time. Its thickness and surface roughness also vary greatly. Most annual ice is greater than 1 meter thick in smooth, unstressed floes, but it can become several meters thick in pressure ridges. Characteristics such as coverage and thickness can be used to characterize sea ice structural types (Map 1.9).

Sea ice has long been recognized to differ greatly from place to place and from time to time. However, the division of sea ice into discrete zones that can be identified as species' habitats is recent. The map on the right shows the most important of these zones. In late winter and early spring, there is a relatively stable belt of shorefast (ice attached to shore) along the coasts. Seaward, the floes are free-floating and separated by leads (fractures in the ice) and polynyas (lakelike or nonlinear openings in the ice). A well-defined ice "front" occurs between the open sea and the pack ice. It is defined, for our purposes, between the mean ice edge and the "five-tenths ice concentration boundary" for most times of year (September is shown on the map). During the time of maximum sea ice extent there is no clear difference between these boundaries. Therefore, the March-April front depicted on the map was determined by measuring the width of the "loose pack ice" (Map 1.9) as revealed by NOAA weather satellite imagery from 1973-1982; it averaged 77(±14) kilometers wide. The other notable zones shown on the map include the eastern Chukchi Sea flaw zone and the eastern Beaufort Sea polynya. The former comprises a passage of mostly open water between the shorefast and pack ice; and the latter is a large area of mostly open water that forms north and west of the MacKenzie Delta and the Canadian Archipelago in spring.

All of the zones shown on the map represent average conditions. They all vary considerably among and within years. As depicted here, they have been used to normalize the distributions of many ice-influenced species in this atlas; that is, distributions for species that are ice-dependent have been made consistent and comparable according to the sea ice characteristics shown here. For example, the importance of these zones is especially well illustrated by marine mammals, since these animals breathe air and must either find open water or break through relatively thin sea ice. Some (pinnipeds) also use sea ice to rest and to bear their young. The "front" zone is used by several species of seals that cannot break through heavy pack ice; the ringed seal is an exception and makes breathing holes and pupping lairs in both shorefast and sea ice. The heavier pack ice is used by walruses and bearded seals for hauling out. The bowhead whale winters in the pack ice of the southwest Bering Sea and migrates through the eastern Chukchi flaw zone in spring to the eastern Beaufort polynya to feed. The influence of sea ice on sea birds is also readily observed and relatively well known; the influence on fishes and invertebrates is less well known, but is undoubtedly important for many species. Sea ice also plays an important role in primary productivity.

Seasonal Variability (Konqhi and Saito, 1974; Leonov, 1960)

Sea ice extent varies over 1000 kilometers latitudinally from summer to winter. The maximum extent ("Average Maximum Ice Edge") occurs during March-April, after which the annual retreat from the Bering Sea begins. The disintegration of the ice is closely related to the location and extent of large water openings within the main body of the pack ice. The Bering Sea is essentially free of sea ice by early summer. As summer continues, the ice edge retreats northward into the Chukchi Sea. At the same time, the ice concentration in the eastern Beaufort Sea begins to decrease; disintegration of the sea ice accelerates as it retreats from the coast. As the ice retreats within both these seas, a continuous edge is formed, which reaches a maximum northward position ("Average Mimimum Ice Edge") during late September to early October. In some years, the ice edge does not retreat far from the coast, and belts or patches of ice may break from the main pack to block the channel of open water between land and the ice edge.

Beginning in October, the ice reverses direction and begins to move southward at the same time that freezing conditions occur. Mean ice drift during October and November is southwesterly from Alaska toward the Soviet Union. This seasonal advance reaches the Bering Strait region by November and continues until the ice reaches its maximum southerly extent (Average Maximum Ice Edge) in mid-March to mid-April.

The ice appears to retreat faster from the Bering Sea in spring than it advances in fall and winter. This difference is also observed in the rise and fall in seasonal cycles of sea surface and air temperatures and is probably related to very small amounts of ice movement (about 3%) onto the shelf during ice formation and a large Bering Sea off-shelf movement (about 37%) during melt. During the period of ice advance, there are at least two relatively minor retreats (late December-early January and late February-early March). These retreats last about 2-3 weeks and can result in a 5-20% reduction in ice cover.

Interannual Variability (Konishi and Saito, 1974; Leonov, 1960; McLain and Favorite, 1976; Niebauer, 1980, l981a, l981b; Rodgers, 1978).

The extent of sea ice can vary considerably from year to year. The range of this variation during periods of minimum and maximum ice cover is also shown on the map. For example, the years 1973-1976 were characterized by lower (and slightly falling) temperatures, greater than normal (and slightly increasing) ice extent, and stronger than normal (and slightly increasing) northerly surface winds. In April 1976, the ice extent was about 20% above normal. The years 1976-1981 were characterized by strong rises in air and sea temperatures, a precipitous fall in ice cover, and a fall in the northerly component of surface wind. In April 1979, the ice cover was 35% below normal.

Factors Affecting Variability (Kukla and Kukla, 1974; Leonov, 1960)

Most Bering Sea ice is formed along the south-facing coasts of land masses under prevailing northerly winter winds. These winds carry the ice southward like a conveyor belt, until it reaches water warm enough to melt it. This suggests that for much of the time there is increased water column stability at the ice edge, resulting from low-salinity melt water. This stability is an important factor in the high primary productivity observed in the marginal, or frontal, ice zone. The interaction of ocean swell and winds contributes to the nature of the ice at the edge. Variations on the order of years in duration are correlated with sea level pressure, air temperature, wind direction, and other meteorological factors. Light-ice summers have been related to more frequent southerly surface winds; winds are reversed in heavy ice summers. Observations of interannual variations have lead to the hypothesis that mean winter atmospheric circulation is the driving force behind the large fluctuations in sea ice extent. The higher rate of heating in spring is speculated to be related to strong ridging in the 700-millibar air pressure patterns and the associated northward flow of air over Alaska. It probably is also related to increased insolation in spring.

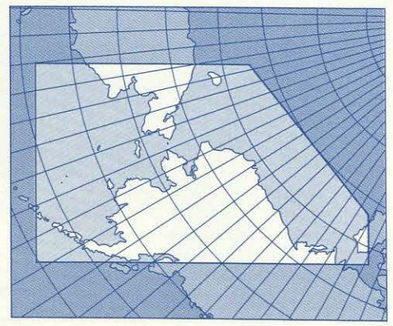
Legend

- Continuous Ice (Year-round)
- Range of Minimum Ice Extent (September)
  - —— – —— Average Minimum Ice Edge
  - — — — — Average Minimum Five-Tenths Ice Cover
- Seasonal Ice
- Range of Maximum Ice Extent (March)
  - —— —— Average Maximum Ice Edge
- Open Water (Year-round)
- Ice Front (September)
- Ice Front (March)
- Shorefast Ice (May)
- Ice Remnant Area (early June)
- Eastern Beaufort Sea Polynya (May)
- Flaw Zone (May)

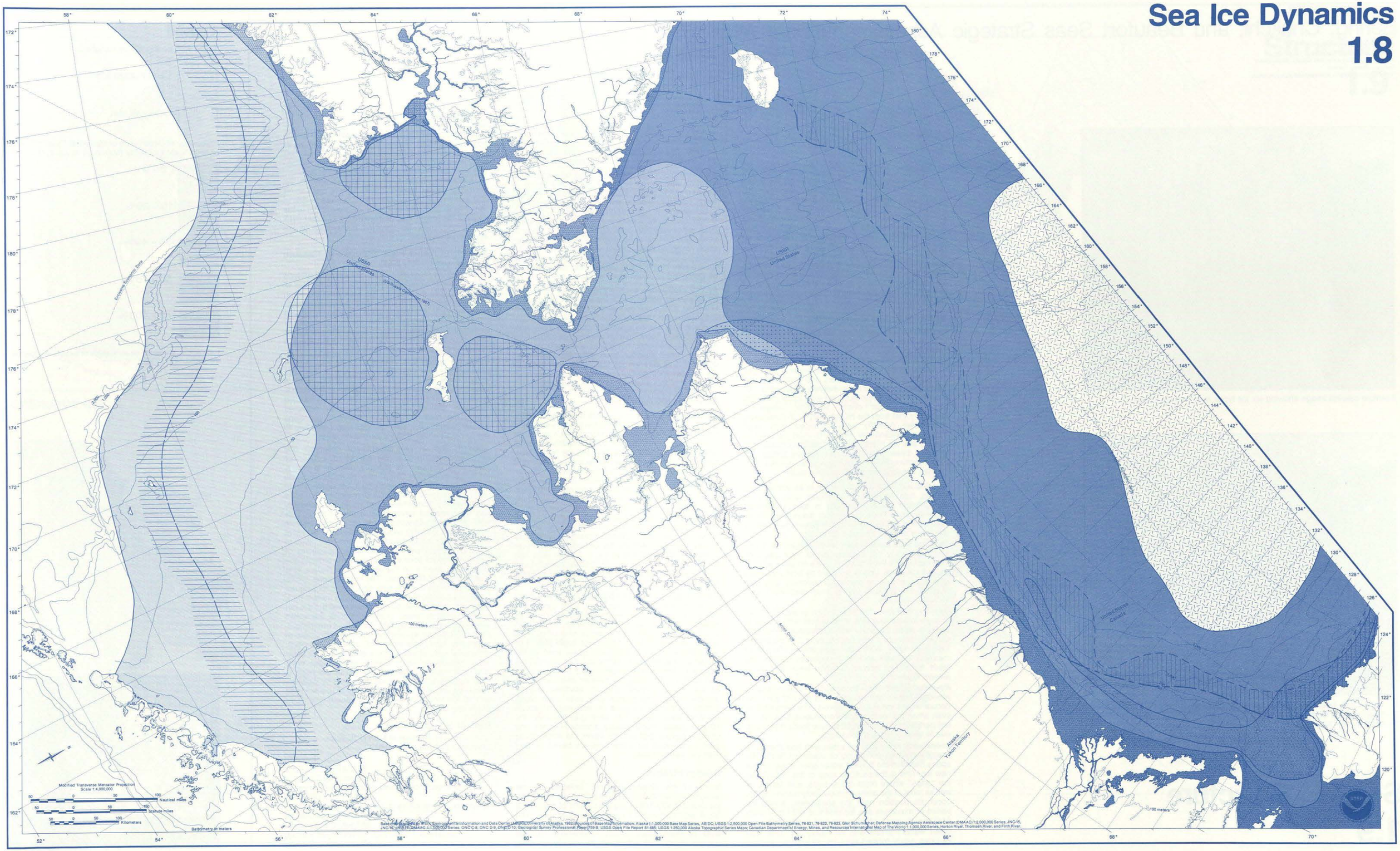
Seasonal ice is area within which there is a 100% probability of annual ice, i.e., ice formation and melting every year. September ice front is area between the average minimum ice edge and the average minimum five-tenths ice cover line. March ice front is the area corresponding to the average width of loose pack ice. Remnant ice is highly variable in extent and location.

Map References

Burns, Shapiro, and Fay, 1980; LaBelle, et al. 1983; Ray and Blouin, manuscript.



Sea Ice Dynamics
1.8



Base map data courtesy of the Environmental Information and Data Center (AEIDC), University of Alaska, 1982; Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-485; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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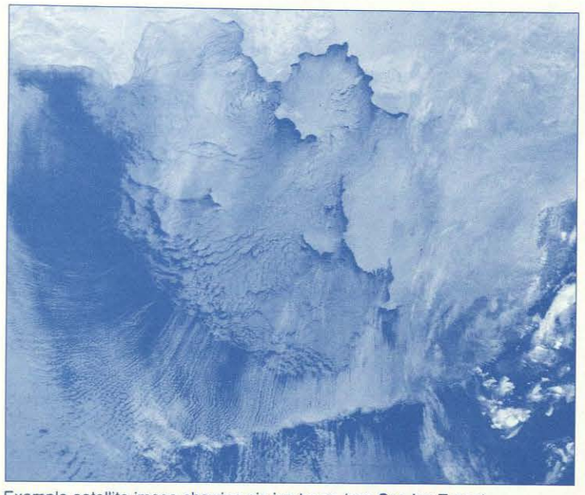
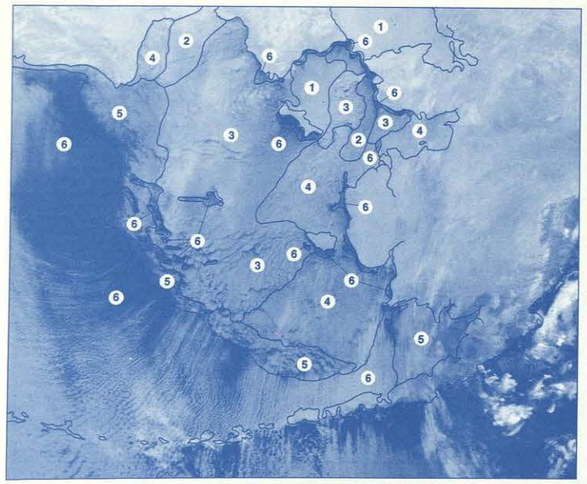


Example satellite image showing six ice types (see Sea Ice Types).



1 - Continuous pack ice
2 - Pack ice with leads
3 - Broken pack ice
4 - Rounded pack ice
5 - Loose pack ice
6 - Open water

Sea Ice Structure
1.9

Description

This map presents the results of an analysis of the spatial distribution of sea ice types during the March-April period of maximum sea ice extent for the Bering Sea and southern Chukchi Sea, using synoptic satellite imagery of annual sea ice within the region. As described in the previous map (Map 1.8, Sea Ice Dynamics), the distributions of structural differences of sea ice types may be used to formulate a first approximation of the distributions of ice-inhabiting species whose ice-type preferences are reasonably well known, for example, the walrus and bowhead whale. This analysis is for the period 1973 through 1982. Although these distributions can be used to infer the probabilities of sea ice types that may occur in a particular area, natural variability makes year-to-year prediction difficult.

Sea Ice Types (Burns, Shapiro, and Fay, 1980)

Quantifiable features of sea ice that can be used to infer habitats include: (1) sizes and shapes of floes (sheets of floating ice); (2) percent ice cover or concentration; (3) ice extent; (4) ice thickness; (5) density of leads (linear areas of open water), polynyas (nonlinear areas of open water), and number of lead intersections; and (6) ice surface roughness. Although synoptic methods do not exist for determining all of these at once, satellite imagery—especially that from the NOAA Very High Resolution Radiometer (VHRR) and Advanced Very High Resolution Radiometer (AVHRR)—can be used to classify sea ice into a number of visually discernible ice types, based generally on ice floe size, shape, and lead structure. Six structural types, as defined from satellite imagery, are shown on this map:

Continuous pack ice—ice cover is an almost continuous field of white to light gray tones with no recognizable leads. Gradients in tone sometimes imply separate floes, but distinct leads are absent. This type is not biologically well known; few marine mammals or birds inhabit this zone.

Pack ice with leads—pack ice is crossed by leads, which generally are subparallel but may intersect. This represents the first stage of the breaking of continuous ice cover. Leads are used by both mammals and birds, and some primary productivity may also occur there, but this type is also relatively poorly known biologically.

Broken pack ice—identified by the presence of two or more intersecting sets of leads that outline floes of variable sizes, generally with an angular form. This stage represents a step beyond type 2 in the breaking of ice cover. Within this type occurs the bulk of marine mammals and birds, because intersecting leads mean that access between water and air is always available.

Rounded pack ice—floes appear predominantly rounded, rather than angular. This type of ice often occurs where ice is being formed. The term applies even when the ice is almost continuous. This type is not particularly hospitable, because leads may close due to wind or current conditions.

Loose pack ice—used for areas with less than 50% heavy ice cover, consisting of scattered floes. The space between the floes is either open water or thin new ice. This is the pack ice zone of the "front" and the "edge" where most seals, birds, and fishes, as well as most of the primary productivity within sea ice, occur. Its position near the shelf-break during the period of maximum sea ice extent in March or early April favors very high biomass and productivity.

Open water—areas with no heavy ice. This type includes newly formed gray ice which may appear uniform or fractured and is less than 20 cm thick. It also includes large polynyas adjacent to land masses or within the pack. All of the species that are not adapted to sea ice retreat to this type in winter.

Sea ice cover, or concentration (the ratio of sea ice area to total area), is not a significant factor in defining three of the six categories; pack ice with leads, rounded pack ice, and loose pack ice may vary in ice cover from about 50-90%. Continuous pack ice is restricted to sea ice cover greater than 90%, loose pack ice to less than 50% cover, and open water to either very thin ice or none at all. These percentages apply over relatively large areas as revealed by satellite imagery. For smaller areas, such as one sees from a ship or low-flying aircraft, sea ice cover may be perceived as much more variable.

As indicated above, each of these sea ice types may be viewed as equivalent to the habitat of a species. However, care must be taken in interpretation. First, the exact habitat requirements of the species must be known before sea ice type can be used as a predictor of distribution. Some species are very specific in their habitat requirements, but others are much less so. Second, most species have different habitat requirements at different life stages or even between the sexes. Examination of the species maps in Section 3 of this atlas will illustrate these points.

Methods of Analysis

The top photograph on the left is an example of the images used in the analysis. Below it is an example of how the ice types were delineated on each image. As can be seen, there is considerable spatial variation among the six types in the total sea ice field. Placement of boundaries between adjacent types is based on judgement, in which the experience of the investigator is an important variable. The open water areas within the sea ice field are polynyas that form on the southerly side of land masses during periods of northerly winds, which are often accompanied by clear weather. During periods of southerly winds, these polynyas are reduced or even absent. Obviously, satellite imagery presents a different picture from that seen on the ground; the maximum resolution of AVHRR imagery is 0.9 km, and this places a limit on interpretation. Thus, considerable care must be taken in interpreting imagery to coincide with observed surface conditions.

The six maps on the facing page depict the frequency of occurrence for each structural type during the years 1973-1982. The analysis was performed by selecting a single, relatively cloud-free image, or a composite of images, for the period of maximum ice extent, mid-March to mid-April, for each year. The occurrences of the specific ice types seen in the individual images were recorded on a one-degree latitude by two-degree longitude grid for the greater part of the total area; for greater resolution near St. Lawrence, Nunivak, and St. Matthew islands, one-degree by one-degree grid cells were used. Simple division by ten gave the frequency of occurrence of each ice type in each grid cell over the 10-year period. Due to clouds, distorted images, and satellite passes that did not cover the entire study area, frequencies for a few cells are based on less than ten years of data.

Interpretation

Some of the notable features revealed by the analysis follow. During the period of maximum sea ice extent (1973-1982), the area north of the Bering Strait was dominated by continuous pack ice. The single exception was the area immediately south and west of Point Hope, which experiences variable ice conditions with open water usually present. Continuous pack ice also was usually found on the north side of St. Lawrence Island. Open water occurred more than 50% of the time in Hooper and Kuskokwim bays, on the southern and eastern shores of the Gulf of Anadyr, to the south of Nunivak, St. Matthew, and St. Lawrence islands, and in the northeast part of Norton Sound. Mostly open water and loose pack ice occurred from Nunivak to Bristol Bay. The area east of St. Lawrence, from 57°N to the Seward Peninsula, was dominated by rounded pack ice. Broken pack ice occurred more often in the western Bering Sea.

Variability and Fine Structure (Niebauer, 1981; Webster, 1981, 1982)

The analysis indicated that predicting ice type composition is especially difficult for certain areas of the Bering Sea, for example, the area west and south of Cape Lisburn-Point Hope, and the area immediately south of the Bering Strait. Prediction is also difficult in the vicinity of the ice edge (south of 60°N) because of variability in the position of the ice edge from year to year, even though the width of the "front" is reasonably predictable (Map 1.8).

Using the results in a predictive mode requires the assumptions that conditions from year to year are independent, and that the period 1973 to 1982 is representative of conditions expected in the future. However, 1973-1982 may not have represented "average" conditions, or conditions to be expected during the next ten years. In addition, averaging across "warm" and "cold" periods may contribute to the unpredictability evident for certain areas.

This analysis is not capable of detecting fine structure within any of the ice types, largely for reasons of resolution of imagery, referred to above. For example, the ice "front" may be subdivided into three zones, each of which may be significant to marine organisms. The front is important because it is the boundary area where open water and seasonal sea ice meet and where most melting occurs. This has important consequences for water column stratification, primary productivity, and distributions of marine life. At the seaward edge of the front, there is a zone approximately 10 km wide, consisting of heavily rafted ice floes with ridges on the order of one meter high, depths on the order of five meters, and diameters of 10-20 meters. The second zone, which is approximately five km wide, consists of rectangular ice floes about 20 meters across and 0.5 meters thick that have been broken by the ocean swell but are not heavily rafted or ridged. In the third zone, the ocean swell propagates through the ice without fracturing it, so that the floes may have horizontal length scales of kilometers and thicknesses of about 0.3 meters. When the wind blows strongly off the ice, the outer zone, because of its increased aerodynamic drag, moves downward ahead of the rest of the pack to form the characteristic bands observed by satellite. These bands, which are on the order of one km wide and 10 km long, continue to move south into warm water and waves.

Persons Consulted

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Legend

Areas with no Significant Variability (March 15-April 15)

Continuous Ice

Open Water

Frequency of Occurrence of Structural Type in Areas of Significant Variability (March 15 to April 15)

0 - 9%

10 - 29%

30 - 49%

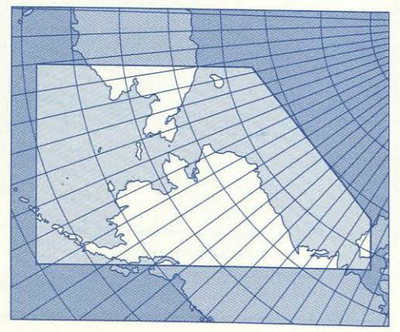
50 - 75%

76 - 100%

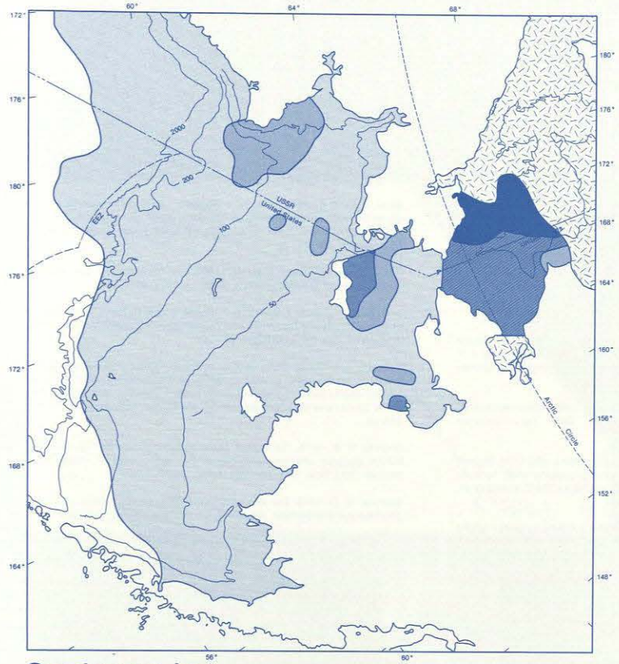
Frequencies are based on an analysis of satellite imagery for the period 1973 to 1982.

Map References

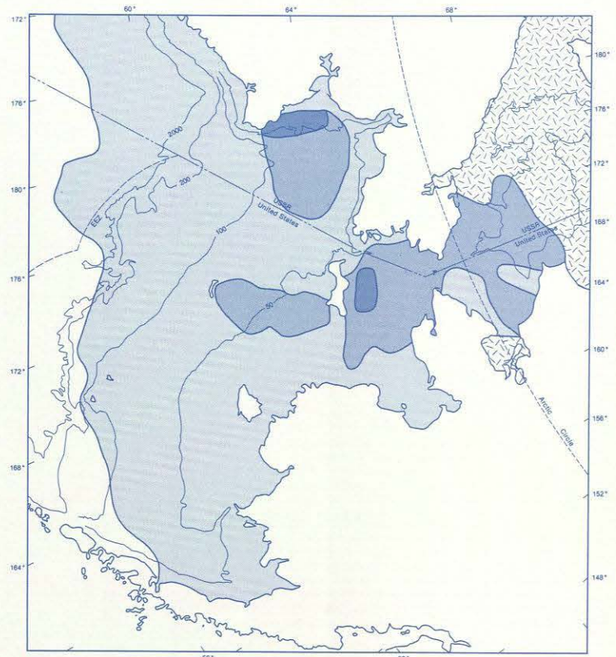
Burns, Shapiro, and Fay, 1980.



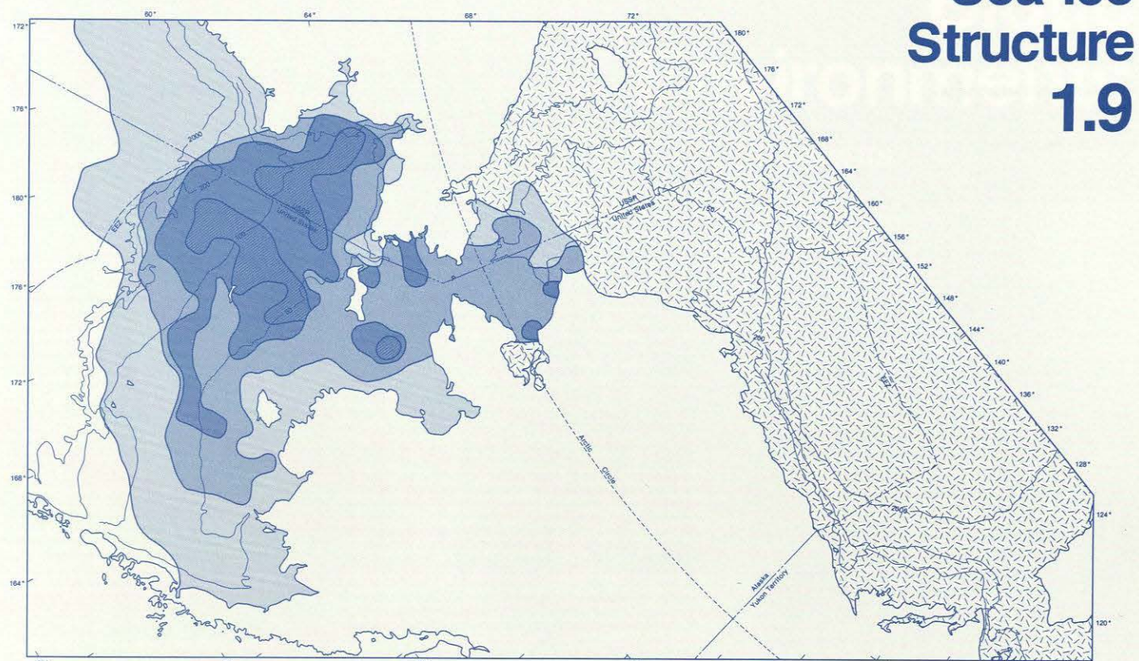
Sea Ice Structure 1.9



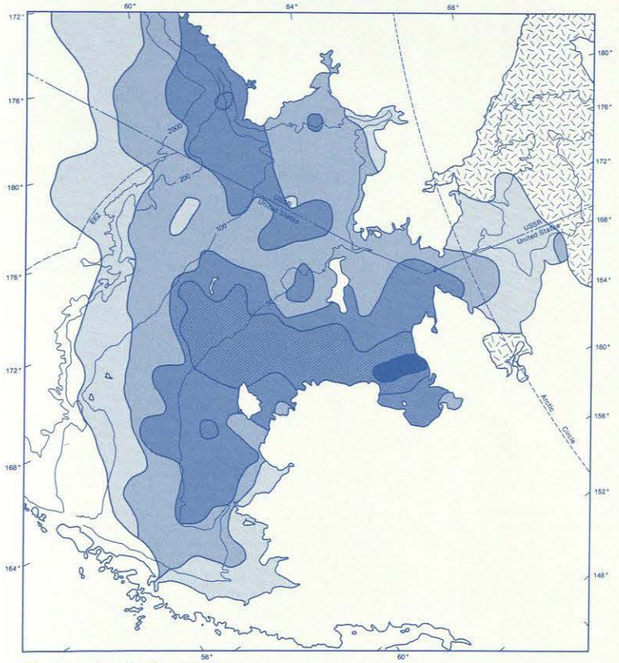
Continuous Ice



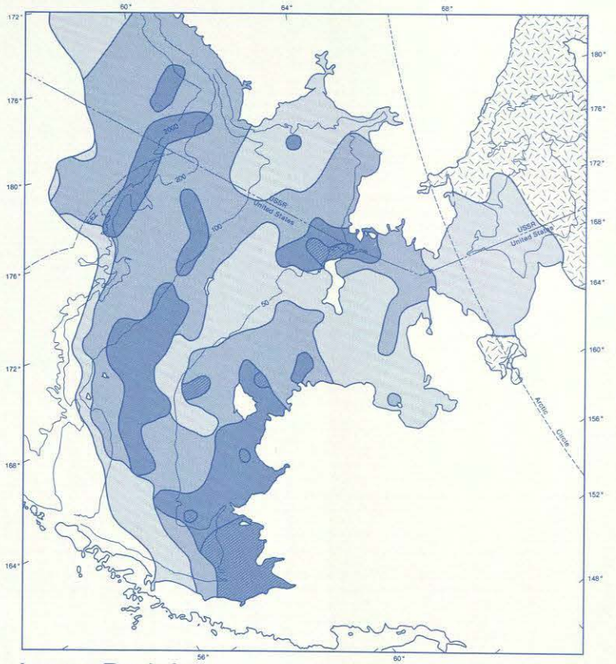
Pack Ice with Leads



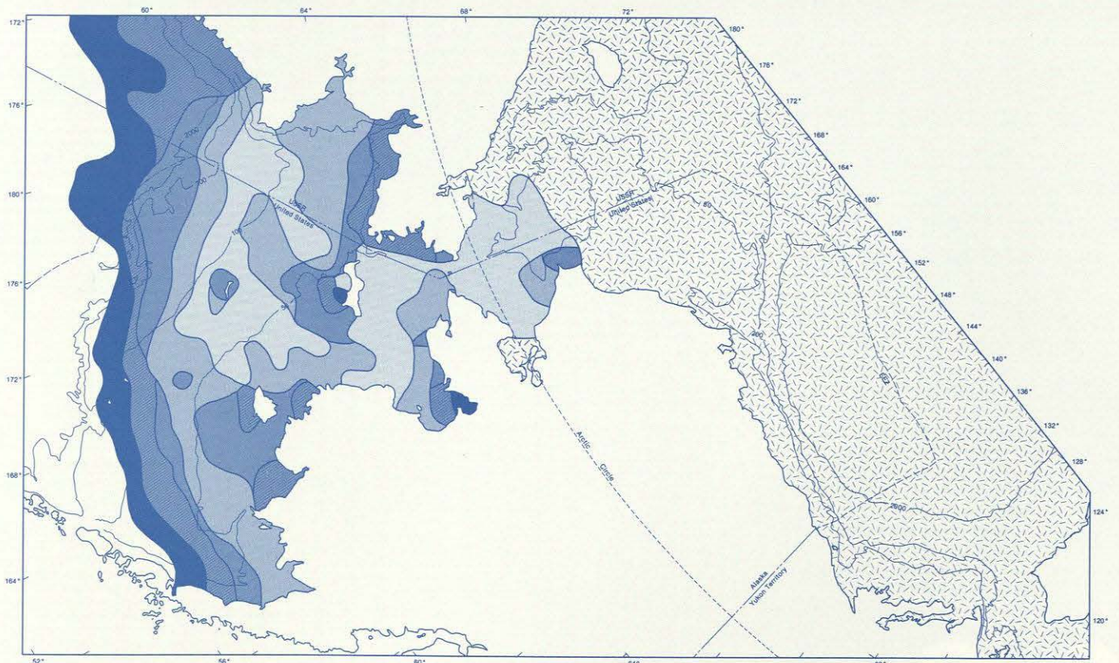
Broken Pack Ice



Rounded Pack Ice



Loose Pack Ice



Open Water

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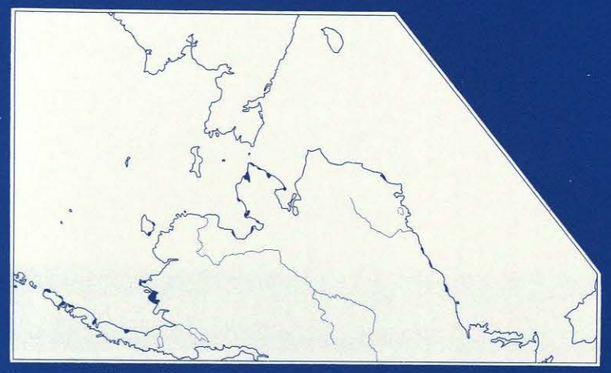
Biotic Environments



Important Kelp and Eelgrass Beds.

Introduction

This section presents information on the patterns of distribution of important biological associations and groups of co-occurring species, in terms of productivity (the rate of growth of a population) or biomass (the weight or volume of organisms present in a defined area). The distribution patterns of productivity and biomass reflect to varying degrees the influences of the physical oceanographic conditions of the region (Section 1). They also provide a bridge to the following section, which presents information on the distributions of living marine resources.

Of the five maps, only the first, Terrestrial Vegetation, is not a new compilation. This is also the only map showing patterns not determined by oceanographic conditions; the distribution of vegetation types is a result of the interplay of climate, precipitation, and soils. The patterns of productivity and abundance on the other four maps reflect the influences of circulation, bottom sediment types, bathymetry, and the oceanographic fronts that separate many marine subregions. Much of the information on these maps, especially north of the southeastern Bering Sea, is based on limited sampling, and some patterns have been inferred from knowledge of other factors. The maps primarily consider large-scale oceanic patterns.

Productivity—An important characteristic of the region is its high annual primary productivity (Map 2.2), or phytoplankton growth. Although values per unit area are similar to those for other subpolar shelf areas, the overall primary production of the region, primarily of the Bering Sea shelf and Bering Strait, is enormous due to the great expanse of continental shelf. This high production supports high standing stocks of zooplankton and benthic invertebrates, as well as fishes, seabirds, and marine mammals. Productivity and biomass levels fall off rapidly north of the Bering Strait. There is evidence that much of the benthic biomass in the Chukchi Sea is dependent on nutrients carried north from the Bering Sea.

Seasonal Variability—As noted in Section 1, Physical Environments, seasonal variability is strong across the region, illustrated by the annual north-south movement of sea ice that strongly affects species distributions and life histories. The advance of sea ice essentially cuts off phytoplankton productivity, causing the growth and activity of other organisms to slow down. Many species reduce their activity, or form resting stages, awaiting the spring breakup of the ice and the intense initial phytoplankton bloom initiated by algae growing in the ice and at the ice edge (Map 2.2). Other more mobile species apparently move in advance of the ice edge, although the degree of this is not known. The duration of sea-ice cover also determines to some extent the species present, especially sessile invertebrates such as clams. Sea-ice scour in intertidal and shallow inshore areas also severely limits benthic fauna annually; most species present are those that can recolonize these areas every spring.

Low temperature by itself is not a particularly important limiting factor, as evidenced by the high productivity and the relatively high species diversity (Section 3) in the Bering Sea, where nutrient levels are high. The Beaufort Sea, with far lower nutrient levels, has lower biomass and fewer species, although it is not significantly colder. The longer period of ice cover in the Beaufort Sea also contributes to its lower biomass by reducing the length of the growing season.

Large-Scale Offshore Biotic Patterns

Maps 2.2-2.5 present the patterns of productivity and biomass of four major species assemblages: phytoplankton, zooplankton, epifaunal (surface-living) benthic invertebrates, and infaunal (burrowing) benthic invertebrates. Productivity and biomass are strongly affected by the physical factors discussed in Section 1, especially currents, sea ice, and surficial sediment characteristics. Although quantitative relationships among planktonic and benthic species assemblages are not yet clear, the qualitative aspects of species interactions are better known, especially for the southeastern Bering Sea. These are not as well understood for the areas north of the Bering Strait.

Phytoplankton Productivity—The base of the food web for offshore communities is phytoplankton, composed of microscopic, free-floating algae. The most important factors influencing productivity are light, nutrients, water-column structure, temperature, sea-ice cover, and sea-ice melting. The satellite images of map 2.2 illustrate the variability of productivity patterns in time and space and show that the growing season in the Bering Sea may be longer than had been thought, extending from at least March into early September. The overall patterns of annual productivity, presented on the inset map on map 2.2, show high productivity over much of the Bering Sea shelf, Bering Strait, and southern Chukchi Sea, with low values along the Alaskan coast and in most of the Chukchi and Beaufort seas.

Zooplankton Productivity—The zooplankton community is composed of small animals with limited swimming ability that live in the water column. It contains species, primarily copepods, that eat phytoplankton. It also contains small carnivores and provides the link to higher levels in the food web. Zooplankton productivity is directly linked to phytoplankton productivity, but comparison of both patterns (Maps 2.2, 2.3) shows little correspondence. This may be due in part to limited coverage of sampling and inherent difficulties in estimating zooplankton abundance. Mostly, it is due to the markedly different zooplankton communities in outer and middle-to-inner shelf waters, where currents, water-column structure, and sea ice are quite different in nature. Temperature is also known to affect zooplankton growth rates and reproduction, but the relationships in the study area are unclear.

Map 2.2 shows considerable spatial variation of zooplankton productivity in the region; it is highest over the shelf break and lowest over the inner shelf and coastal areas. The pattern correlates with the oceanographic subregions described in the introduction to Section 1 and is reflected by the distributions of benthic biomass (Maps 2.4, 2.5). Zooplankton grazing over the outer Bering Sea shelf is believed to be high enough to consume most of the phytoplankton. Ungrazed phytoplankton production over the middle and inner shelf domains mostly sinks to the bottom and becomes available to benthic organisms.

Epifaunal Benthic Invertebrates—Epifaunal species biomass and distribution patterns differ from those of infauna. Most epifaunal species in the study area are fairly mobile; the most important are crabs, shrimp, sea stars, sea urchins, and brittle stars. The major influences on their distributions are predation, especially by fishes; distribution of food; bottom currents; bottom temperatures; and, for some species, bottom type, including sediment texture.

Observed spatial patterns (Map 2.4) have two important components, overall biomass and species composition, neither of which is uniform. The southeastern Bering Sea shelf is dominated by crustaceans (crabs and shrimp), whereas echinoderms (sea stars, sea urchins, and brittle stars) dominate in the Bering Strait and Chukchi Sea. The reasons for this are unclear, but may be due to the types of food available. Areas with similar biomass values correspond roughly to oceanographic subregions and to areas of differing phytoplankton and zooplankton productivity, with highest values in the Bering Strait and middle shelf of the Bering Sea.

Infaunal Benthic Invertebrates—Map 2.5 presents the spatial distribution of biomass and major species groups of infaunal invertebrates, the most important of which are bivalve mollusks (clams), polychaete worms, gastropod mollusks (snails), and amphipod crustaceans. These distributions are most strongly affected by sediment type, bottom temperature, salinity, depth, sedimentation rate, bottom-water movements, and amount of suspended particulate material. Species patterns vary over the region, although bivalves dominate throughout. There is also evidence of differing faunal assemblages in the inner, middle, and outer shelf areas of the Bering Sea. Biomass patterns in general reflect primary productivity patterns; biomass is highest in the Bering Strait and the Bering Sea middle shelf. The spatial linkages to primary productivity are not strong, however, suggesting other influencing factors, such as predation by mammals and fishes, flow and turbidity from coastal rivers, and sampling difficulties.

Nearshore and Coastal Habitats

In addition to the large-scale oceanographic patterns described above, coastal physical features (Section 1 Introduction) provide critical habitats for many marine and ocean-associated species and are important components of the overall ecosystem. Unlike the mostly non-migratory species that make up the assemblages discussed above, the species using these coastal habitats tend to move into them for specific parts of their life histories. The habitats support juvenile life stages and reproductive functions of many fishes and invertebrates. They also provide nest sites, roosts, and feeding areas for seabirds, waterfowl, and shorebirds, as well as rookeries and haulout sites for marine mammals.

Moist to wet tundra, the dominant coastal terrestrial vegetation type (Map 2.1), with large numbers of ponds, provides nest sites for a significant portion of North America's waterfowl and shorebird populations. The mainland and barrier island beaches are the major habitats for migratory shorebirds that feed on infauna and stranded zooplankton. Beaches and low rocky shores are used for haulouts and rookeries by thousands of marine mammals. Sea cliffs and talus slopes are the principal sites of seabird colonies that can contain hundreds of thousands of individuals.

The region's estuaries and lagoons, especially those not affected by ice scour, often support large populations of juvenile fishes and invertebrates, some of which have considerable commercial value, and are critical reproductive areas for many species. Estuaries with extensive muddy bottoms can have large populations of infaunal invertebrates tolerant of fluctuating salinities. They may have extensive beds of eelgrass, which provide cover for fishes and invertebrates, food for migrating waterfowl, and detritus for benthic organisms. Some eelgrass beds are critical staging areas for migrating waterfowl, Izembek Lagoon being particularly important. Subtidal rocky rubble and reef areas on the open coast are substrate for kelp beds. As with eelgrass beds, they provide structure and shelter, as well as food and detritus. In particular, the kelp beds in Bristol Bay are important spawning areas for Pacific herring. Both eelgrass and kelp beds have overall high productivity and higher species diversities than the adjacent sea bottom. The inset map shows the major areas of kelp and eelgrass beds. Kelp beds are distributed sparsely throughout the region, including the Beaufort Sea coast. Eelgrass beds are primarily in the Bristol Bay area and along the Alaska Peninsula.

Studies of the region's biotic environments have revealed key characteristics. The region is one of the world's richest, with high primary productivity and high standing stocks of invertebrates, fishes, birds, and marine mammals. Physical oceanographic characteristics are major driving forces for the large-scale distribution patterns of species groups, but certain coastal physical features provide critical areas for life history functions of many species.

Although it is unlikely that human activities will adversely affect large-scale offshore systems in the near future, the critical coastal habitats are susceptible to disruption or destruction due to their relatively small size and high accessibility. The relationships of coastal to offshore parts of the system require further study to ensure that man's activities do no irreparable damage to an area whose living marine resources are of such considerable importance.

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2.4 Epifaunal Invertebrate Biomass
2.5 Infaunal Invertebrate Biomass
References

2.0

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
National Oceanic and Atmospheric Administration

Terrestrial Vegetation
2.1

Description

The Alaskan coastal biome is unique and highly productive. Its plant life, particularly in the arctic region, is distinctly adapted to environmental extremes and is easily threatened, particularly by activities associated with energy production.

The geographic distribution of vegetation in Alaska is influenced by the availability of space, light, water, and nutrients. Factors such as topography, geographic location, climate, temperature range, and amount of precipitation also affect the types of vegetation that occur throughout the different regions of Alaska. In general, number of species, species diversity, individual plant size, productivity, and growth rates decrease at higher latitudes (Brown, 1984).

The principal ecosystem of coastal Alaska is tundra; cottongrass is the most widespread single species. Moist tundra, characterized by cottongrass, dwarf shrubs, and other sedges, occurs along foothills in northern Alaska, and on old beach faces. Wet tundra is found north of the Brooks Range and on the northern parts of the Seward Peninsula and the Yukon-Kuskokwim Delta, where mats of sedge and cottongrass are interspersed with woody and herbaceous plants. Alpine tundra, characterized by low mats of herbaceous and shrubby plants, occurs on exposed ridges in arctic and southwestern coastal areas. Dense to open stands of deciduous brush (particularly alder) are also common in coastal areas and along floodplains, in regions of muskegs and bogs (Joint Federal-State Land Use Planning Commission for Alaska, 1973).

Wildlife Habitat

Alaska's rather limited terrestrial vegetation types provide a variety of habitats for wildlife activities that include breeding, nesting, rearing of young, resting, escaping, and feeding (Alaska Department of Fish & Game, 1977). Some species, such as wolverines and ravens, are adaptable and have wide ranges. They may be found in either marshy or mountainous environments (Selkregg, 1975, 1977). But many Alaskan species require unique habitats. For example, muskrats live in marshy areas, and pikas are found in rocky, alpine habitats.

Some animals and birds are drawn to areas for food. Caribou are typically found in the arctic tundra and above treeline, but they are forced to migrate for food. In summer, they head down into forested regions to feed on willow and dwarf birches, grasses, sedges, and succulent plants; after the autumn frost sets in, lichens and dried sedges on higher grounds become their principal food source (Hemmings, 1970). Several species of marine birds depend on Alaska's terrestrial vegetation for food. Plovers, cranes, swans, Canada geese, and occasionally black brant and eiders consume unharvested grain from agriculture (Sellars, Timm, and Tankersley, 1982; Matthews, 1982, 1983; Paul, 1984; Timm, 1984a,b).

These limited varieties of vegetation are critical to maintaining Alaska's large and diverse wildlife populations. Thus, because activities associated with logging, mining, oil extraction, development, and urbanization destroy vegetation, they also disrupt habitats and can adversely affect wildlife populations.

Human Use

Plant materials and wood, along with other resources at hand, have traditionally been used by Native Alaskans for food, clothing, shelter, and commercial enterprise.

Commercial agricultural activity in Alaska is limited to the Anchorage, Fairbanks, and Kenai-Cook Inlet areas. In 1982, there were more than 25,000 acres of harvested cropland in the state. Most of this land is located in the Matanuska and Susitna valleys (Bureau of the Census, 1982a), where soil type and capability, temperature range, and amount and distribution of moisture are favorable. Hay and potatoes are Alaska's principal agricultural products, supplying local markets only (Selkregg, 1976b, 1977).

Indigenous berries and vegetables, traditional local food supplements, provide a source of vitamins and minerals otherwise lacking in the meat-and-fish diet of Native Alaskans. Some communities in remote sections of Alaska still demonstrate a dependency on gathering berries and vegetables as a primary food source.

Vegetation also provides raw materials for shelter and fuel. Traditional dwellings, which are still used to some extent, are constructed of driftwood, sod, and logs. Wood is also a primary fuel. Grasses are used by Natives for weaving insoles for mukluks (Native-made boots) and are woven with roots for baskets and other craft items.

Certain regions of Alaska's forestland also sustain a substantial timber industry. In 1977, there were approximately 119 million acres of forestland in Alaska (Bureau of the Census, 1982b), constituting 16% of all forested land in the USA. Of these vast Alaskan forestlands, 11.1 million acres are considered to be of commercial value. Approximately 63% of these acres are located outside the study area in coastal areas in southeastern and south-central Alaska, where virtually all of the state's pulp and lumber exports are produced.

By contrast, interior Alaska has 10 times more forestland than coastal Alaska; however, only 4.1 million of these acres are suitable for harvesting as commercial timber. Forests of the interior are generally inferior in quality to the coastal stands because their growth is stunted and short-lived. In addition, they are located in areas remote from markets where transport is feasible only on river systems. As a result, only small-scale, localized timber-harvesting has developed there (Forest Service, 1982). Nevertheless, interior Alaska forests are thought to have considerable potential for development despite their lower productivity potential. The predominant commercial timber species of the interior include white spruce, paper birch, aspen, and balsam poplar.

Effects of Fire

Fire is an important factor in shaping the character of plant communities in Alaska; it can set back plant succession and alter species composition over vast expanses. Crown fires and surface fires, both, reestablish pioneer conditions and initiate secondary succession, while peat burns convert forests to stagnant open areas (Smith, 1974).

In 1981, fires burned more than 758,000 acres of land in Alaska (Alaska Northwest Publishing, 1983). In interior Alaska in summer, low levels of precipitation and long hours of sunshine combine with high air temperatures and low humidity causing drying of mosses and lichens, which then become susceptible to fires that can burn off acres of forests, tundra, and brush (Selkregg, 1975, 1977). The consequences of uncontrolled fire can be far-reaching. Fires can convert a white spruce stand into a treeless herbaceous or shrub community of fireweed and grass or dwarf birch and willow, where growth is so thick that trees cannot become reestablished (Smith, 1974). Fire can expose soil to erosion, increasing runoff, ruining soil structure, and destroying both habitat and food for wildlife.

Fires can also have healthy effects. Human-induced, controlled fires—"prescribed burns"—are an effective management tool. These fires can prepare favorable seedbeds for certain species, eliminate disease and insects, remove undesirable vegetation, and provide open areas for wildlife. Wildfires also release nutrients bound up in the soil and produce habitat for plants that provide browse for wildlife (Selkregg, 1976a, 1977).

Environmental Threats

The vulnerability of the Arctic to environmental modification is significant. Tundra communities in permafrost areas are threatened by the compaction of snow by traffic, which reduces spring melt, inhibiting plant growth and diversity. Fruticose lichens, an important forage item for caribou, are affected by low sulfur concentrations associated with air pollution. Tundra lichens are susceptible to permanent damage by oil spills. In addition, regeneration is generally retarded in this region because of the limited sun and moisture. Planned development which considers environmental sensitivity as a key criteria is necessary to preserve and maintain the coastal Alaska biome (Brown, 1984).

Legend

Tundra Systems

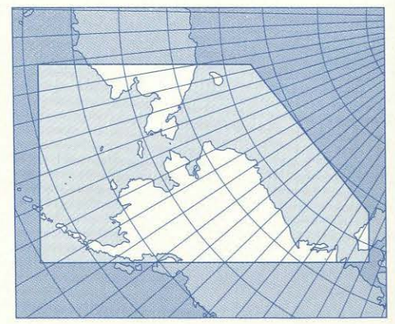
- Moist Tundra
- Wet Tundra
- Alpine Tundra

Coniferous Systems

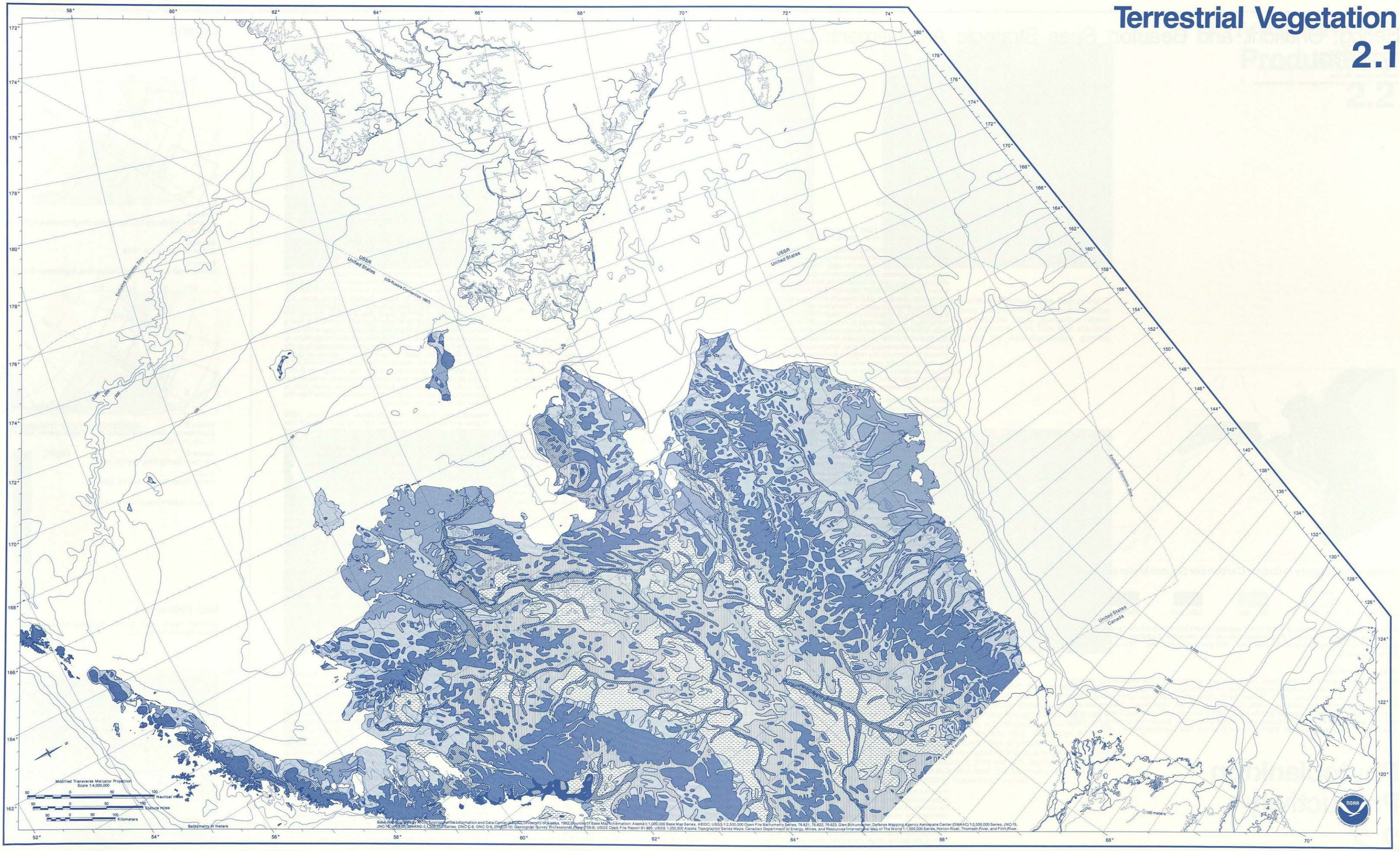
- Coastal Western Hemlock - Sitka Spruce Forest
- Bottomland Spruce - Poplar Forest
- Upland Spruce - Hardwood Forest
- Lowland Spruce - Hardwood Forest
- High Brush
- Low Brush, Muskeg - Bog

Map References

Joint Federal-State Land Use Planning Commission for Alaska, 1973.



Terrestrial Vegetation
2.1



Base map data source: National Environmental Information and Data Center (NEIDC), University of Alaska, 1992; Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

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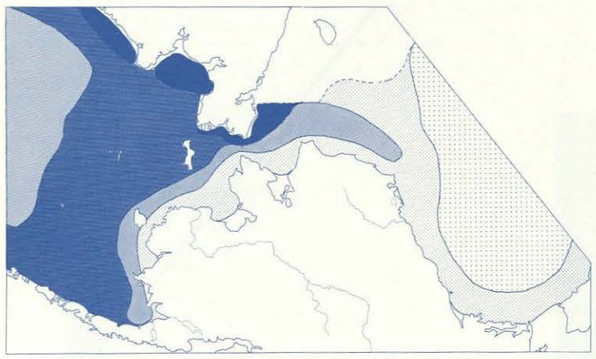

Primary Productivity in Grams Carbon per Square Meter per Year

Less than 1-15 | 10 - 75 | 50 - 150 | 100 - 350 | 200 - 500

Ranges of primary productivity are first-order approximations based on published and unpublished data. They assume the following annual production periods: central and southern Bering Sea - 130 days; northern Bering Sea and Chukchi Sea - 100 days; Beaufort Sea - 70 days; and Arctic Ocean - 30 days.

Map References

Dawson, 1965; Meguro and Fukushima, 1966; Matheke and Horner, 1974; Motoda and Minoda, 1974; Adams, 1975; Clasby, Alexander, and Horner, 1976; Grainger, 1975; Hsiao, 1976; Taniguchi et al., 1976; English and Horner, 1977; Horner, 1977; Hsiao, Foy, and Kittle, 1977; Carey, 1978; Hameedi, 1978; Saito and Taniguchi, 1978; Goering and Iverson, 1980; Hsiao, 1980; Kokur and Iverson, 1980; Niebauer, Alexander, and Cooney, 1980; Alexander and Chapman, 1981; Alexander and Niebauer, 1981; Cooney and Coyle, 1982; Schell et al., 1982; Sambrotto and Goering, 1983; Walsh, 1983; Müller-Karger, 1984; Sambrotto and Goering, 1984; Sambrotto et al., 1986.

Phytoplankton Productivity

2.2

Description

(Gordon and Clark, 1980; Alexander and Niebauer, 1981; Hovis, 1981; Gordon et al., 1983a, 1983b)

Phytoplankton is composed of microscopic plants that drift in open waters and convert solar energy and inorganic nutrients into living tissue by photosynthesis. These plants fuel most aquatic ecosystems. They are eaten by zooplankton (Map 2.3) which are in turn prey of fishes, birds, and baleen whales. The amount of phytoplankton biomass that is produced may be interpreted, therefore, as a measure of the overall productivity of the ecosystem it supports. The rate at which phytoplankton is produced is termed primary productivity and is expressed as the amount of carbon that is incorporated in phytoplankton under a unit area of ocean surface over a specified time period (e.g., grams of carbon per square meter per year: $gCm^{-2}\ yr^{-1}$). Knowledge of the spatial and temporal characteristics of primary productivity of a region is fundamental to understanding the ecological mechanisms of fishery yields and their natural variability. Primary productivity in shelf waters of the Bering and southern Chukchi seas is among the highest known for any ocean waters.

Oceanic phytoplankton productivity is affected by a number of oceanic processes and conditions, including upwelling of nutrient-rich bottom waters, stratification of surface waters due to solar heating, and water column mixing due to wind-induced current effects. In this region, the presence, structure, and movement of sea ice are important factors that affect the distribution and biomass of phytoplankton, particularly early in the growing season. As soon as sufficient sunlight to support photosynthesis becomes available in early spring, algae begin to grow on the undersurface of sea ice. These algae form a band of less than 1 cm to approximately 10 cm thick which colors the ice brown.

The sea-ice algae "seed" the water column as the ice decays, thus playing a role in setting the initial conditions for phytoplankton blooms after the ice retreats. Also, melting ice creates a stable surface layer of relatively low salinity that allows phytoplankton to remain in the upper water layers where they have greater exposure to sunlight. In this case, growth is enhanced to create an ice-edge bloom. In contrast, in years of reduced ice extent, stability of the water column is induced by solar heating. This leads to an open-water phytoplankton bloom which represents the major contribution to the region's annual phytoplankton productivity. In most years, a combination of the two conditions occurs.

Phytoplankton Biomass

The images on the facing page illustrate the distribution and variability of phytoplankton biomass of the southern Chukchi and Bering seas. The images were taken by the Coastal Zone Color Scanner (CZCS) on the NASA Nimbus-7 satellite. No images are shown for the northern Chukchi or Beaufort seas. Because of extensive cloud cover, relatively few images are available for these regions. In addition, low sun angles in these latitudes make CZCS imagery difficult to interpret.

The CZCS sensor measures ocean color. Pigments (i.e., chlorophyll and chlorophyll-like pigments) contained in phytoplankton in approximately the upper 15 meters of the water column affect these color measurements. A consistent color scale has been used for all of the images for comparative purposes. The cool colors (blues and greens) represent low concentrations of phytoplankton pigment; the warmer colors (reds and oranges) represent higher concentrations. In areas close to shore where color measurements are significantly affected by other suspended material, such as sediment, CZCS measurements may be poor indicators of phytoplankton pigment concentrations.

Images A and B are each composites of eight individual images of the southeastern Bering Sea taken on separate days during the springs of 1979 and 1980. The individual images have been combined by computer to produce an "average image" for each year. These "average" spring conditions illustrate that although phytoplankton productivity in this area is generally high in the spring, large variations occur from year to year. Surface concentrations over the outer shelf in the spring of 1979 were about an order of magnitude lower than in 1980. This was probably due to the unusually low winds (1-5 meters/second) that occurred during the first two weeks of May 1979. During periods of low wind conditions, less mixing occurs and phytoplankton in surface waters sink more quickly. Consequently, a high proportion of the phytoplankton produced during the spring of 1979 may have been deposited on the outer shelf and slope. In contrast, winds during 1980 were stronger and more frequent and variable, causing periodic disruptions of the surface water layer, a mixing of nutrients upward, and maintenance of phytoplankton near the surface. Subsequent solar heating and stratification resulted in secondary phytoplankton blooms. The high offshore concentrations may have been the result of phytoplankton-rich surface waters being transported offshore by strong winds blowing from the north and east.

The remaining four scenes (C through F) illustrate areas of the southern Chukchi and northern Bering seas. Each is for a single day of spring, summer, or early fall. The images are presented as approximations of the phytoplankton biomass only for the day the image was taken. These scenes illustrate further the distribution and variability of phytoplankton within the region. All six scenes are explained in the captions. Note that high biomass occurs well into September; this is longer than had previously been thought.

Phytoplankton Productivity

Accurately measuring phytoplankton productivity remains a problem for oceanographers, especially in this region because of its climatic variability both within and among years, and its relative inaccessibility. The map on this page summarizes present estimates of phytoplankton productivity throughout the region, revised upward because of the longer growing season revealed by CZCS imagery.

The map is divided into subregions on the basis of ranges of productivity. These ranges overlap considerably due to the dynamic nature of the marine environment and the relatively small number of measurements. The number of measurements is greatest for the southeastern Bering Sea and least for the southcentral Bering Sea, the western Bering and Chukchi shelves, and the Arctic Ocean basin.

Bering Sea (McRoy and Goering, 1974a, 1974b; Motoda and Minoda, 1974; Taniguchi et al., 1976; Saito and Taniguchi, 1978; Alexander, 1980; Niebauer, Alexander, and Cooney, 1980; Alexander and Chapman, 1981; Kinder and Schumacher, 1981; Coachman, 1982; Cooney and Coyle, 1982; Sambrotto and Goering, 1983; Walsh, 1983; Müller-Karger, 1984; Sambrotto et al., 1986)—The southeastern Bering Sea is by far the best understood of the subregions. Most of the discussion that follows applies to the area east of St. Lawrence and St. Matthew islands, including Bristol Bay. The annual primary productivity cycle begins in March with algal growth within thin ice floes and in brash ice. The contribution of ice algae to annual phytoplankton productivity is largely unknown; estimates range from less than 0.1 to 12 gCm^{-2}. Ice-edge communities may persist until about mid-May, but they are rapidly lost to the water as the ice breaks up.

An ice-edge bloom generally occurs as the ice breaks up in April and May. Where this bloom occurs, it is usually maintained for about 15-20 days, but its maximum duration is unknown. Influencing factors include the stabilization of the water column by low-salinity, sea-ice meltwater, and wind and tidal energy that mix the water column and determine the extent of sea ice. Increased sunlight in the summer enhances the stability of the water column by heat input, causing phytoplankton blooms that may be unrelated to the melting of sea ice. These blooms dominate the Bering Sea in years of reduced ice extent. Within a week or two of bloom onset, periodic nutrient depletion occurs near the surface. The dynamics of ice-edge and open-water blooms appear to be similar, and nitrogen may be the limiting nutrient in both cases.

A reasonable estimate for total annual primary productivity for this region is about 200-350 $gCm^{-2}\ yr^{-1}$. This comparatively high value is due to a relatively long growing season for the region, and to the concentrations of nutrients throughout the year. Two areas of very high productivity (200-500 $gCm^{-2}\ yr^{-1}$) occur in the western Bering Sea off the Kamchatka Peninsula and in the Gulf of Anadyr. These are areas where wind-induced upwelling and river discharge modify surface waters in a way favorable for phytoplankton growth. The large variabilities of light, winds, tides, and zooplankton consumption cause patchiness in time and space, as is evident from the satellite imagery.

Southern Chukchi Sea and Bering Strait (Dawson, 1965; Motoda and Minoda, 1974; Matheke and Horner, 1974; Aagaard and Coachman, 1975; Clasby, Alexander, and Horner, 1976; Hameedi, 1978; Sambrotto and Goering, 1984)—This area is complex and exhibits some of the highest rates of phytoplankton growth of any ocean area. The eastern portion receives turbid Yukon River water, which limits phytoplankton productivity to about 50-150 $gCm^{-2}\ yr^{-1}$. The southwestern Chukchi Sea supports very high productivity of about 400 $gCm^{-2}\ yr^{-1}$ or more. This is due to nutrient-rich waters from the Gulf of Anadyr that flow northward over a shallow shelf, where light is available over a large portion of the water column. The central Chukchi Sea has productivity of about 50-150 $gCm^{-2}\ yr^{-1}$. Waters there originate from the central Bering Sea (Map 1.7 and Scene F, opposite). Boundaries between water masses in this region may be sharp due to the different origins of waters that flow through the Bering Strait. However, these boundaries become less coherent further north. Phytoplankton distribution varies widely both in time and space due to variations in freshwater inflow from the Yukon River and other factors.

Beaufort Sea (Adams, 1975; Grainger, 1975; Hsiao, 1976; English and Horner, 1977; Horner, 1977; Hsiao, Foy, and Kittle, 1977; Atlas, 1978; Carey, 1978; Hsiao, 1980; Horner and Schrader, 1982, Schell et al., 1982; Schell, 1983)—The highest rates (30-50 $gCm^{-2}\ yr^{-1}$) occur in the summer in waters between the 20 meter isobath and the permanent ice pack. Much lower rates (0.5-15 $gCm^{-2}yr^{-1}$) occur shoreward of the 20-meter isobath. In the Beaufort Sea there is a slow, seasonal increase in phytoplankton concentration with a gradual depletion of nutrients, rather than the dramatic blooms observed in the Bering Sea. Nitrogen appears to be the limiting nutrient. Among the influencing factors are: input of organic and inorganic matter from rivers, especially the Mackenzie and Colville; organic matter input from shoreline erosion of tundra; the variable extent of sea ice cover among years; and snow depth on ice and sediment within ice, both of which decrease light penetration into the water column. Organic matter carried by rivers from the tundra may be a significant contributor of carbon to nearshore areas.

Arctic Ocean. Plant growth is severely limited by low light availability due to the large area covered by multiyear ice and to low summer sun elevations. Annual primary productivity appears to be less than 5 $gCm^{-2}\ yr^{-1}$. The dynamics of productivity for this ocean are very poorly understood.

Persons Consulted

Vera Alexander, Institute of Marine Science, University of Alaska, Fairbanks.
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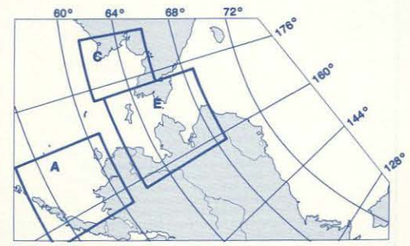
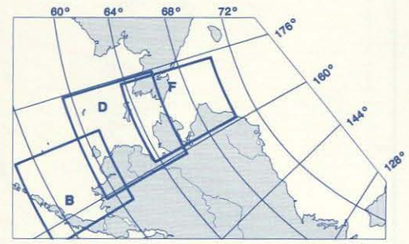
Legend



Scene A
Southeastern Bering Sea, composite of eight scenes, April 8 to May 24, 1979

Scene C
Gulf of Anadyr, July 6, 1979

Scene E
Bering Strait and southern Chukchi Sea, September 2, 1979



Scene B
Southeastern Bering Sea, composite of eight scenes, April 11 to July 18, 1980

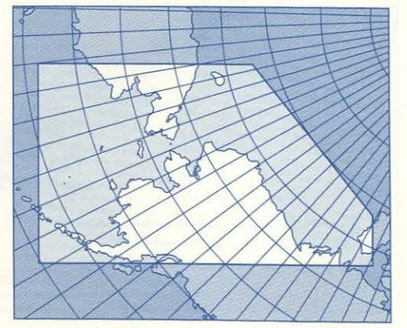
Scene D
Northern Bering Sea, May 19, 1980

Scene F
Bering Strait Region, July 18, 1980

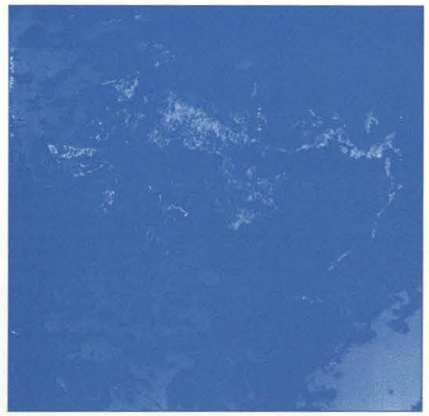
All scenes were taken near local noon.

Map References

Goddard Space Flight Center, National Aeronautics and Space Administration, n.d.



Phytoplankton Productivity 2.2



Scene A

Southeastern Bering Sea, composite of eight images, April 8 to May 24, 1979. The scene shows most phytoplankton biomass in the inner and middle shelf domains. The very high concentrations (red) in coastal areas may be suspended matter discharged by rivers, such as the Kuskokwim and Kvichak, rather than phytoplankton biomass.



Scene C

Gulf of Anadyr, July 6, 1979. The effect of discharge from the Anadyr River on phytoplankton biomass is clearly shown, especially in the outer regions of the river plume (yellow) where the effects of suspended sediments are minimal. Waters from this region are carried northward by coastal currents (Scenes E and F) where they contribute to the very high productivity of the Bering Strait region.



Scene E

Bering Strait and southern Chukchi Sea, September 2, 1979. This scene shows the generally high phytoplankton biomass found throughout this highly productive region. The western portion is especially rich. This high standing stock occurs throughout the June-September growing season.

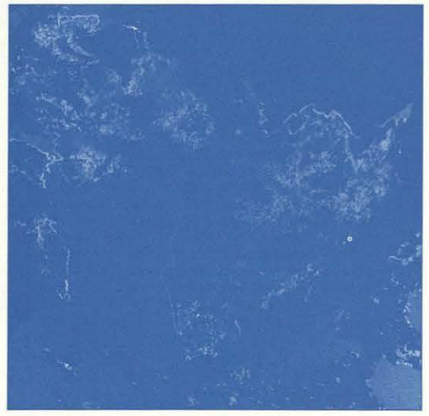
Phytoplankton Pigment Concentration



High

Low

Color Bar. Color scale represents phytoplankton pigment concentration ranging from low (blues and light green) to high (dark greens, yellow, red). Clouds are shown in gray, ice in white. It was not possible to affix absolute values to colors because of insufficient ground-truth measurements. Caution should be taken in interpreting high concentrations in coastal areas due to the presence of suspended and dissolved materials that may not be related to phytoplankton but that interfere with pigment measurements.



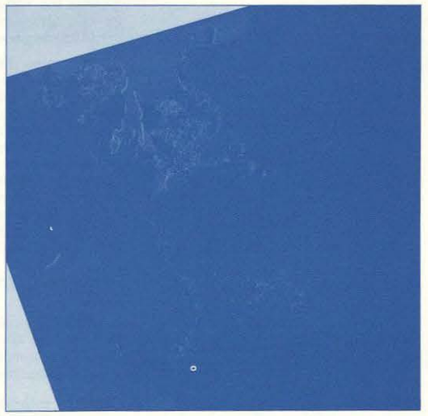
Scene B

Southeastern Bering Sea, composite of eight images, April 11 to July 18, 1980. In contrast to Scene A, high phytoplankton biomass occurs throughout the entire inner, middle, and outer shelf domains. The difference between Scenes A and B is due to greater wind mixing (i.e., observed higher wind velocities and more frequent storms) during 1980 (see description). The very high concentrations (red) in the middle and outer shelf domains (visible to a lesser degree in Scene A) are unexplained. The dramatic drop in biomass that occurs over the shelf break can be seen at the lower left.



Scene D

Northern Bering Sea, May 19, 1980. This scene was taken during the period of ice retreat. Sea ice (traced from the simultaneous near infrared [780 nm] CZCS image) is shown in white. Three features are notable. First, the effect of the Yukon River on coastal waters of the Yukon/Kuskokwim Delta is clearly evident as red areas (probably sediment) in the center right of the scene. Second, several of the areas of very high phytoplankton concentrations (red) occur near broken ice and are probably "ice melt" blooms. These are especially pronounced around St. Lawrence Island (upper center of scene) and in the outer Anadyr Gulf (upper left). Third, the dark red area in the upper center of the scene illustrates the very high phytoplankton biomass associated with polynyas (areas of open water surrounded by ice) during the active ice melt period.



Scene F

Bering Strait region, July 18, 1980. The scene shows the intrusion of three separate water masses into the Chukchi Sea from the south. In the center (blue/green), the movement of Bering Sea shelf water through the Bering Strait is unmistakable. On the left, a northward coastal flow carries nutrient-rich waters from the Gulf of Anadyr into the Chukchi Sea and causes high phytoplankton concentrations. Although these concentrations are generally lower than those in Scene E, they are still clearly visible. On the right, the warm colors near the Alaskan coast reflect the northward flow of Yukon River waters.

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

Strategic Assessment Branch
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National Ocean Service
National Oceanic and Atmospheric Administration

Zooplankton Productivity
2.3

Description

(Horner, Coyle, and Redburn, 1974; Redburn, 1974; Neimark, 1979; Cooney, 1981; Cooney and Coyle, 1982)

Short-term and annual averages of zooplankton growth rates are expressed as the amount of carbon incorporated per day or year. These averages are derived from several different methods including: 1) population dynamics, 2) metabolism as measured by respiration, and 3) carbon ingestion and gross growth efficiency. The values apply to zooplankton organisms retained by nets with mesh sizes no smaller than 0.20 mm.

The map shows daily and annual rates of zooplankton productivity for four distinct biological provinces: 1) oceanic, 2) shelf-break, 3) middle shelf, and 4) inner shelf and coastal. The oceanic community intrudes from the Bering Sea basin into the outer portion of the continental shelf in the east and occurs extensively over the shelf in the west. The shelf-break community occurs largely between 100 meters and 170 meters and is composed of both oceanic and shelf species. The middle-shelf community extends shoreward from 100 meters to 50 meters and lacks oceanic species, which apparently cannot cross the strong oceanographic front at the 100-meter isobath. The inner-shelf and coastal community occurs from about 50 meters' depth to the shore.

Growth rates obtained in the southeastern Bering Sea (see box on map) are from estimates of annual zooplankton production for the Bering Sea, April-August (Table 1). These rates were applied to shelf and coastal communities farther to the north and east (i.e., in areas not shown in box on map) to infer growth rates for those areas. This is justified by a general similarity of species in these widely separated but hydrographically connected regions. Table 2 lists species of these regions that are considered "dominant," that is, those constituting more than 20% of any one sample.

Variability (Heinrich, 1962; Ikeda and Motoda, 1978)

Spatial—In general, zooplankton productivity grades from high to low as one moves landward from the oceanic province. The shelf-break area has the highest productivity values. Some oceanic species occur there in great abundance, forming a band of high biomass. The oceanic community extends north across the shelf and through the Bering Strait because of cross-shelf transport, which advects ocean-derived species northward into the Chukchi Sea.

Temporal—The depiction of zooplankton productivity on the map lacks any strict sense of temporal variation. However, reduced daylight limits the production cycle in the northern North Pacific, including the Bering Sea, during 4-6 months of each year, depending on latitude. Also, nutrient limitation further restricts the production of food for zooplankton to approximately 5 months. Therefore, the measurements of annual zooplankton production presented are based on a 150-day production cycle beginning in May and continuing through September. This cycle is shorter northward.

Inclusiveness—The southeastern Bering Sea shelf is one of the most studied regions in the northern North Pacific Ocean. The data on zooplankton productivity there are probably as good as present methods permit. The shelf areas farther north (northern Bering/Chukchi) and east (Beaufort) are significantly less well known, and rates can only be inferred. Therefore, the productivity patterns shown here reflect a progressive lack of information northward from the southeastern Bering Sea and must be considered only as first-order approximations for the areas north of Bering Strait.

Table 1. Estimates of annual zooplankton production for the Bering Sea, April-August.

Region and source	grams carbon per square meter per year[a]	
Oceanic community		
Respiration relationship (Ikeda and Motoda, 1978)	6.0-18.2	(13.3)
Summer biomass (Ikeda and Motoda, 1978)	1.0-4.3	(3.3)
Primary production[b] (Ikeda and Motoda, 1978)	27.0	
Population dynamics (Heinrich, 1962)	7.8	
Ingestion[b] (Cooney, 1981)	16.1-23.3	(19.6)
Shelf-break community		
Ingestion (Cooney, 1981)	17.3-64.1	(32.8)
Middle-shelf community		
Ingestion (Cooney, 1981)	7.1-10.2	(7.9)
Inner-shelf and coastal community		
Ingestion (Cooney, 1981)	1.7- 5.7	(4.0)
Population dynamics (Heinrich, 1962)	0.7	

Source: Cooney, 1981.

[a] Assuming a 150-day production period; average values in parentheses.
[b] Production = 30% ingestion (Winberg, 1956).

Table 2. Commonly occurring representatives of zooplankton and micronekton communities in the Bering Sea region (Cooney, 1981).

	Southeast Bering Sea	Norton and Kotzebue Sounds	Beaufort Sea
Cnidaria			
Hydrozoa			
Aglantha digitale	■		■
Coryne princeps	■		
Obelia longissima		■	■
Bougainvillia superciliaris			■
Leuckartiara sp.			■
Perigonimus yoldia-arctica			■
Rathkea octopunctata			■
Mollusca			
Pteropoda			
Clione limacina	■		■
Limacina helicina	■		■
Gastropoda			
Unident. veligers		■	
Chaetognatha			
Eukrohnia hamata	■		
Sagitta elegans	■		
Sagitta elegans arctica			■
Arthropoda			
Copepoda			
Acartia longiremis	■	■	
Acartia bifilosa		■	
Acartia spp.			■
A. clausi		■	
Calanus glacialis	■		■
C. marshallae	■		
C. hyperboreus			■
Centropages abdominalis		■	■
Eucalanus bungii	■		
Eurytemora herdmani		■	■
E. pacifica		■	
Metridia pacifica (=*lucens*)	■		
M. longa			■
Neocalanus cristatus	■		
N. plumchrus	■		
Oithona similis	■		■
Pseudocalanus spp.	■	■	■
Tortanus discaudatus	■	■	
Cirripedia			
Balanus spp.		■	■
Cladocera			
Evadne sp.	■	■	
Evadne nordmanii			■
Podon sp.	■	■	
Podon leukarti			■
Cumacea			
Diastylis bidentata	■		
Amphipoda			
Parathemisto libellula	■		
P. pacifica	■		
Decapoda			
Chionoecetes spp.	■		■
Crangon sp. zoea		■	
Paralithodes sp.			■
Euphausiacea			
Thysanoessa inermis	■		
T. raschii	■		■
T. longipes	■		
Chordata			
Larvacea			
Fritillaria borealis			■
Oikopleura spp.	■		■

Influencing Factors

Natural—Year-to-year zooplankton productivity is influenced by a number of natural environmental factors: during warm years the growth rates of most species are enhanced, particularly in the middle-shelf domain where food is not a limiting factor. During warmer-than-average conditions, higher growth rates may result in more generations per year, yielding higher zooplankton standing stocks. Conversely, colder-than-average conditions inhibit growth rates, leading to lower standing stocks. Cooler years may also coincide with a longer period of sea-ice cover, which affects the production cycle by shading the water column. Under these conditions, the duration of the under-ice algal community, which develops prior to the spring melt, may be prolonged; the extent to which this early primary production augments the overall production cycle is not known. Later, as the ice melts, freshwater input stabilizes water at the surface, promoting a phytoplankton bloom that produces food for zooplankton populations. In some regions, this ice-melt bloom is followed by a second period of algal growth, promoted by thermal stratification and continuing until inorganic nutrients in the water column are exhausted. Thus light, temperature, and nutrients affect the primary production of organic matter, which in turn influences zooplankton growth rates.

Human-related Factors—Commercial and subsistence harvests of fishes, shellfishes, marine mammals, and birds represent the major human impacts on the environment. Eutrophication and pollutant impacts are negligible at present because the rivers that flow into these coastal and shelf regions drain relatively undeveloped areas.

Potential Impacts—Effects of industrialization associated with an enlarging scale of fossil fuel extraction (both exploration and development) pose some threats to the shelf and coastal zones of the region. However, these effects will likely be localized and episodic. The long-term damage to zooplankton communities is difficult to predict on the basis of present knowledge.

Persons Consulted

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Legend

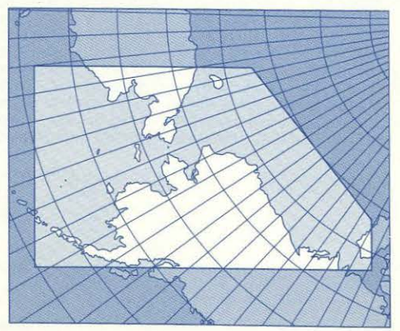
Productivity in grams carbon per square meter

- Inner-Shelf and Coastal Community
  Annual: mean, 4; range, 1-6
  Daily: mean, 0.03; range, 0.01-0.10
- Middle-Shelf Community
  Annual: mean, 8; range, 7-10
  Daily: mean, 0.05; range, 0.02-0.20
- Shelf-Break Community
  Annual: mean, 33; range, 17-64
  Daily: mean, 0.22; range, 0.05-1.0
- Oceanic Community
  Annual: mean, 20; range, 6-27
  Daily: mean, 0.13; range, 0.05-0.50
- Area of Direct Productivity Measurements

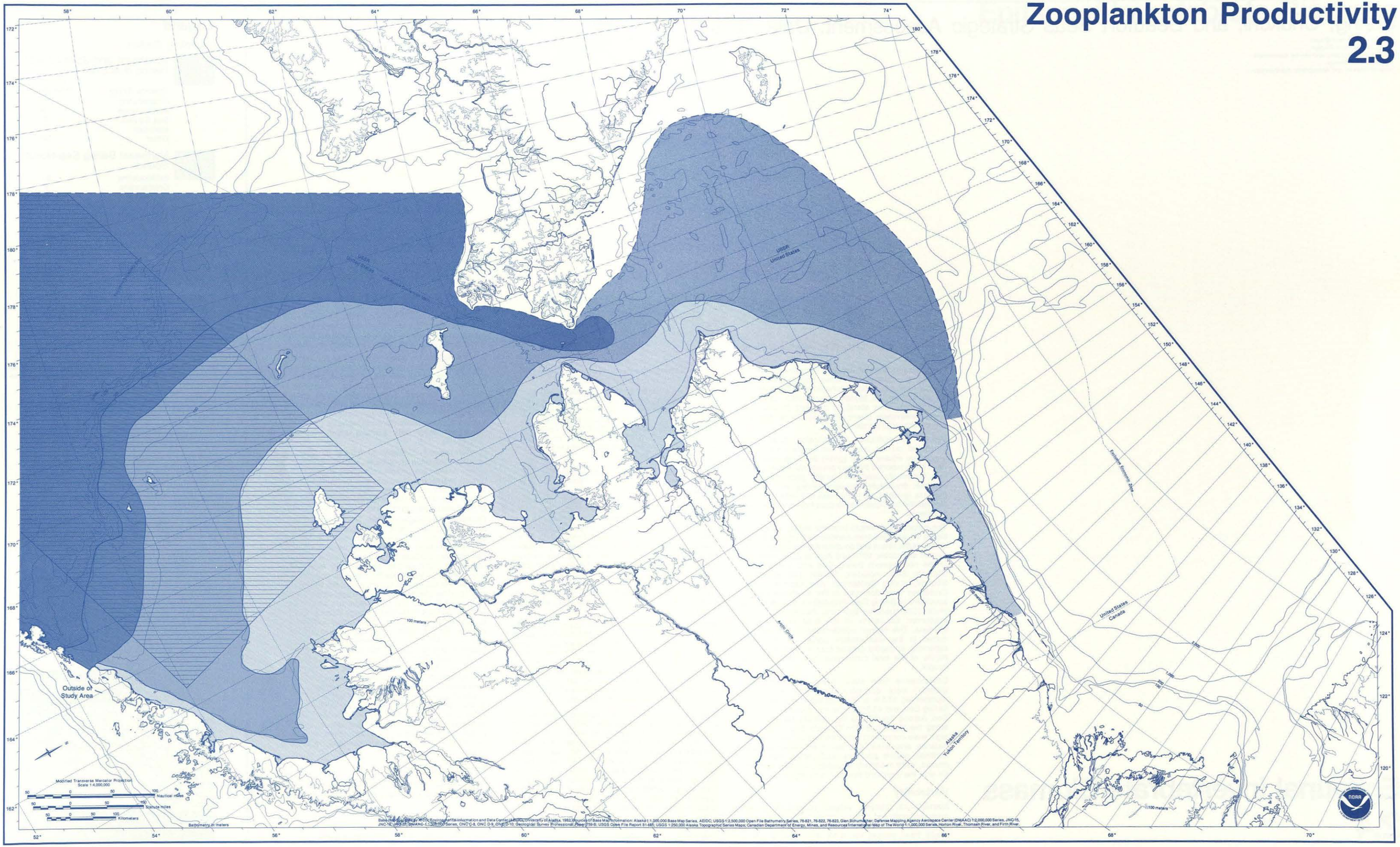
Annual mean productivity is daily mean productivity multiplied by 150, the approximate number of productive days in the region. Productivity values are inferred for areas outside area of direct zooplankton productivity measurements. Dashed lines indicate limits of areas for which suitable information was available.

Map References

Heinrich, 1962; Horner et al., 1974; Redburn, 1974; Ikeda and Motoda, 1978; Cooney, 1981; Cooney and Coyle, 1982.



Zooplankton Productivity
2.3



Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

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Epifaunal Invertebrate Biomass
2.4

Description

(Feder and Jewett, 1978, 1980; Jewett and Feder, 1981)

Epifaunal invertebrates are organisms that live on the bottom, as opposed to within bottom sediments. Epifauna usually reflect the character of the substrate on which they live. Modes of locomotion vary from slow movers (sea stars), to crawlers (crabs), and crawler-swimmers (many shrimps). Some epifauna are sessile (e.g., barnacles).

Values for epifaunal invertebrates have been presented on the map as wet-weight biomass in grams per square meter (g/m^2) because most data have been reported this way previously. Other values less commonly used are density ($individuals/m^2$), ash-free dry-weight biomass (g/m^2), and carbon biomass (g/m^2). Carbon biomass estimates are considered the best quantitative data from an ecological standpoint.

The mapped wet-weight biomass values (g/m^2) are based on samples from benthic trawling, conducted in the southeastern and southcentral Bering Sea from August to October 1975 and April to June 1976 and in the northeastern Bering Sea and southeastern Chukchi Sea, including Norton and Kotzebue Sounds, during September and October 1976. Crustacea were dominant in the southeastern and southcentral Bering Sea. Populations of commercial crabs (*Chionoecetes* spp. and *Paralithodes* spp.) accounted for 36.4% of the total eastern shelf biomass. The highest concentrations of crabs occurred in the southeastern portion of the shelf, especially at depths greater than 40 meters, where 96.1% of the total commercial crab biomass was caught.

Echinoderms (sea stars, brittle stars, and sea urchins) were dominant elsewhere: sea stars represented 67.5% of the biomass in the northeast Bering Sea and 45.3% in the southeastern Chukchi Sea. Among the 29 sea star species that occurred along the eastern Bering/Chukchi Sea shelf, only eight were common to the entire region; four of these, *Asterias amurensis*, *Evasterias echinosoma*, *Leptasterias polaris acervata*, and *Lethasterias nanimensis*, were especially abundant. *Asterias amurensis* was the dominant sea star in all regions.

Variability

Spatial—All plotted values represent actual measurements and probably range from good to very good in accuracy. Each value typically depicts a single trawl sample taken for a ½-hour duration. However, biomass values do not adequately reflect distribution of: 1) organisms that associate with hard/rough substrates where trawling is not possible; 2) small organisms that often escape through nets (9-cm mesh size in the net's cod end); and 3) highly mobile organisms, such as shrimps and some crabs, which can avoid the sampling net.

Temporal—Distribution and biomass of mobile epifauna change seasonally as these organisms respond to changes in bottom-water temperatures, food availability, and predators, or as they engage in reproductive activity. Predation is highly variable. For example, demersal fishes that feed on epifaunal species inhabit the colder portions of the Bering Sea shelf only during warm years.

Inclusiveness (Neiman, 1963; Semenov, 1964; Griffiths and Dillinger, 1981; Feder and Jewett, 1982)—Some data on epifauna exist from the Beaufort Sea coastline; however, these data are not included here because the reported values combine infauna with epifauna. Spatial gaps in mapped data represent areas where no data were available. Some data (e.g., Soviet) are available from waters of the western Bering Sea, but they are not included because they are cited in such a way that separate wet-weight values for infauna and epifauna cannot be extracted easily.

Influencing Factors (Jewett, 1978; Jewett and Feder, 1980; Stoker, 1981; Shimada and June, 1982; Somerton, 1982)

Natural—Environmental factors often govern epifaunal recruitment. The timing and extent of spring phytoplankton blooms determine success of larval recruitment of tanner crabs (*Chionoecetes*). Successful recruitment of *C. opilio* at the southern limit of its range in the southeastern Bering Sea is greatest during cold years when ice is prevalent; recruitment of *C. bairdi* is more consistent because of the regularity of the later ice-free bloom.

Predation is an important influence on epifauna. An exceptionally strong year-class (1977) of Pacific cod (*Gadus macrocephalus*) may be responsible, in part, for the recent decline of the red king crab (*Paralithodes camtschatica*) in the southeastern Bering Sea. The very successful 1977 year-class of cod may have resulted in greater predation pressure, and the cod may have supplemented their typical foods (e.g., gammarid amphipods, crangonid and pandalid shrimps, tanner crabs) with king crabs. Water temperature influences the geographic range within which benthic fishes feed. Low water temperatures on the northern shelf usually preclude invasion of benthic-feeding fishes; however, occasional warming trends may allow these fishes to forage in northern waters, where food is abundant, thereby resulting in increased predation pressure.

Sediments from the eastern Bering Sea display varying textures. Whereas some benthic species (e.g., *C.opilio,* crangonid shrimps, *A. amurensis*) exhibit somewhat ubiquitous distributions, inhabiting a variety of sediment environments, other species occur on specific substrates (e.g., the sea urchin *Strongylocentrotus droebachiensis*—gravel and cobble; the sea basket *Gorgonocephalus caryi*—silty sand; the brittle star *Ophiura sarsi*—nearshore muddy silt).

Human-related—Commercial fishing is the most important influence on epifauna. Crabs (and to some extent snails) are prominent in both domestic and foreign markets, and supply and demand influence fishing pressure on these organisms. In addition, habitat loss and/or the incidental catch of epifauna occur during dragging operations for demersal fishes.

Potential (Cunningham, 1969; Nelson-Smith, 1973; Karinen and Rice, 1974; Mecklenburg et al., 1976; Smith, Paulson, and Rose, 1978; Jewett and Feder, 1981)—Petroleum and mineral exploration and development are factors that may influence epifaunal organisms. Echinoderms are especially sensitive to any change in water quality; they are conspicuous members of the benthic community of the Bering Sea and could be affected by oil- or mineral-related activity there. Sea stars and brittle stars are often important components of the diets of large crabs and a few species of demersal fishes. Other typical components in diets of crabs are infaunal organisms (e.g., clams) that are known to accumulate hydrocarbons. Postmolt tanner crabs (*Chionoecetes bairdi*) lose most of their legs after exposure to Prudhoe Bay crude oil. Molting of king crabs (*Paralithodes camtschatica*) and coonstripe shrimp (*Pandalus hypsinotus*) larvae is permanently inhibited when larvae of each species are exposed for 72 hours to a concentration of 0.8-0.9 ppm of crude oil; larvae that failed to molt died in seven days, although the contaminated water had been replaced with clean water. Lower concentrations disrupted swimming and molting in the same period and ultimately resulted in death.

Persons Consulted

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North Pacific Research, Fairbanks, Alaska

Legend

Sampling Region

Southeast and Southcentral Bering Sea Shelf

Species Group	Percent of Total Biomass
Crustaceans	59
Echinoderms	19
Sea Squirts	7
Mollusks	5
Other	10

Northeast Bering Sea-Norton Sound

Echinoderms	81
Crustaceans	8
Mollusks	5
Other	6

Southeast Chukchi Sea-Kotzebue Sound

Echinoderms	60
Mollusks	13
Crustaceans	12
Sea Squirts	10
Other	5

Total Epifaunal Biomass

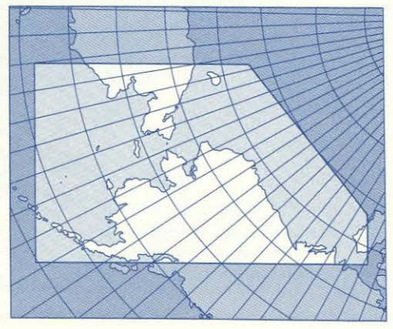
Station wet weight in grams per square meter

- Less than 6
- Greater than 6

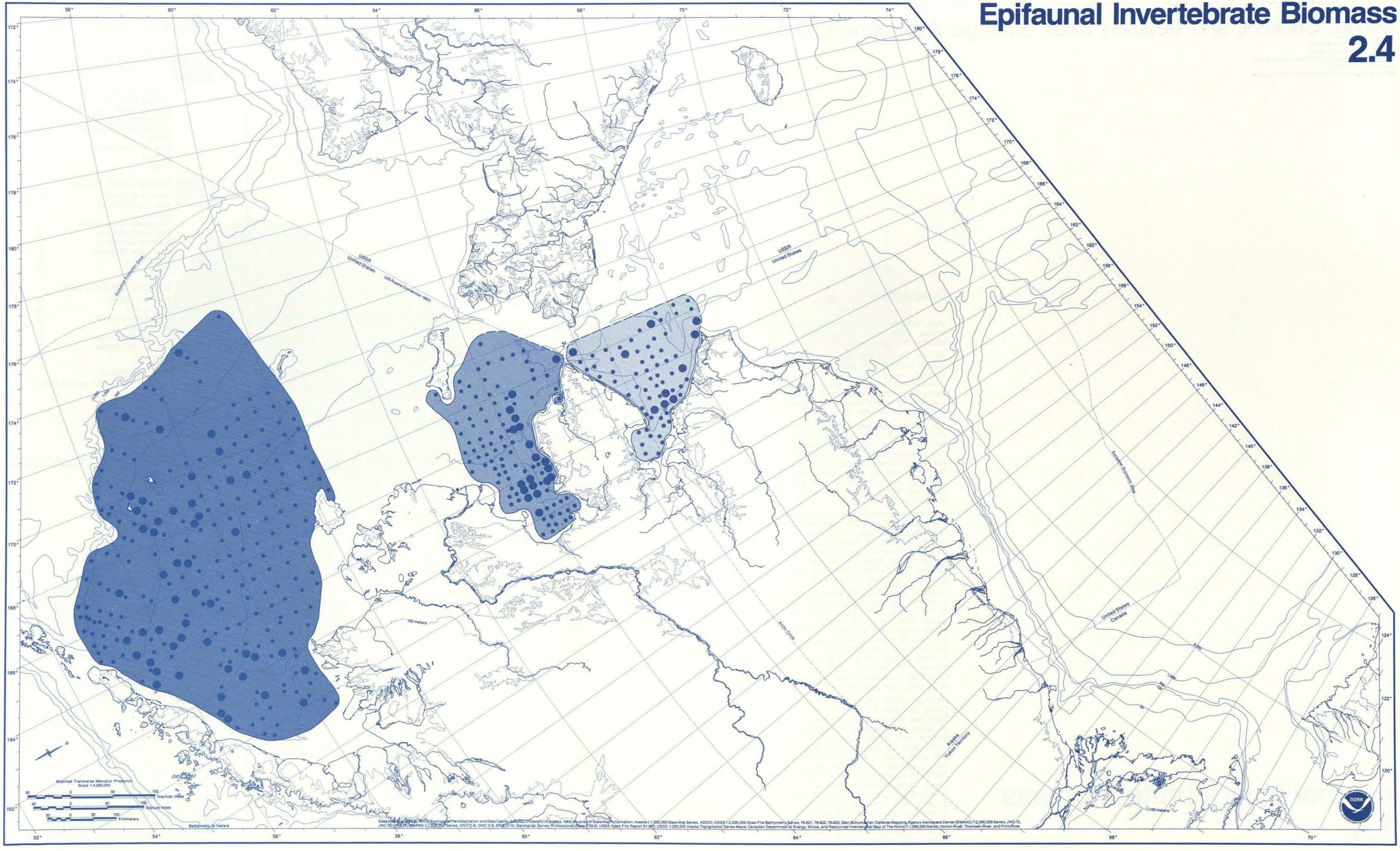
Areas depict extent of sampling programs, not faunal regions, which are undoubtedly greater in extent. Dashed lines indicate limits of suitable data.

Map References

Feder and Jewett, 1978, 1980; Jewett and Feder, 1981.



Epifaunal Invertebrate Biomass
2.4



Base map data courtesy of the Environmental Information and Data Center (EIDC), University of Alaska, 1982; Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-8, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
National Oceanic and Atmospheric Administration

Infaunal Invertebrate Biomass
2.5

Description

(Fay, Feder, and Stoker, 1978; Haflinger, 1978, 1981; Stoker, 1978, 1981; Feder, 1981; Hughes and Bourne, 1981; McDonald, Feder, Hoberg, 1981)

Infaunal invertebrates are organisms that live in bottom sediments, as opposed to on them. In the mapped region, the most ubiquitous infaunal invertebrates are polychaete annelids, bivalve mollusks, gastropod mollusks, and amphipod crustaceans: these groups constitute the greatest biomass and comprise the most species.

The map depicts wet-weight biomass of infaunal invertebrates in grams per square meter (g/m²) for over 250 stations within 0.5° latitude by 1.0° longitude sampling areas. Each plotted value represents the mean biomass, calculated from all data sources. For each station, most values reflect a single sampling, which is typically an average of five replicates. Some values are based on multiple occupations of a station.

For this map, three sources provide data collected by comparable methods for January-October, 1970-1980. Data from these sources have been combined into the three faunal regions depicted on the map: 1) the southeastern and southcentral Bering Sea, 2) the Bering Strait region, and 3) the eastern Chukchi Sea. Further subdivisions appear not to be justified on the basis of present data.

Feder et al. (1981) took samples from the southeastern Bering Sea (northwest of the Pribilof Islands) to the southeastern Chukchi Sea, near Kotzebue Sound. They found 647 infaunal species. Biomass values ranged from 14 g/m² at a station northwest of the Pribilofs to 649 g/m² at a station northeast of St. Lawrence Island. Stations with the highest biomass values (484 g/m² average) were located between St. Lawrence Island and Bering Strait. Dominant biomasses were of bivalve mollusks, amphipods, and sea urchins.

Haflinger (1978, 1981) sampled the southeastern Bering Sea from St. Matthew Island to the Alaska Peninsula and found 464 species; annelid worms, mollusks, and crustaceans dominated the samples. Station wet weights ranged from 9 g/m² to 2,420 g/m² but were generally low; values of over 200 g/m² occurred at only 14 stations. High values were generally found adjacent to the Alaska Peninsula. An exception was the middle-shelf region, where dense bivalve beds (mainly of the cockle, *Clinocardium ciliatum*) occurred. At least four faunal domains were apparent. An inshore infaunal community occurs in nearly all areas up to 50-meter depths, where a sharp transition from sand to silty sand is accompanied by a marked change to a middle-shelf community. A less obvious faunal change occurs at 100 meters, where an outer-shelf community begins. The fourth domain is at the head of Bristol Bay in gravel and sand substrates.

Stoker's (1978, 1981) sample encompassed the region between Bristol Bay and the northern Chukchi Sea; 472 species were identified. The least diverse station was off the east end of St. Lawrence Island; the most diverse was in the northern Chukchi Sea. The most ubiquitous groups were polychaete annelids, bivalve mollusks, gastropod mollusks, and ampeliscid amphipods. Major groups in average biomass were bivalve mollusks (115 g/m²), echinoids (56 g/m²), amphipods (34 g/m²), and polychaetes (29 g/m²). Major groups in mean density were amphipods (689 individuals/m²), polychaetes (190 individuals/m²), bivalve mollusks (152 individuals /m²), and ophiuroids (32 individuals/m²). The average infaunal standing stock over the eastern continental shelf of the Bering and Chukchi Seas was 300±51 g/m² (wet weight), with highest values between St. Lawrence Island and the vicinity of Bering Strait.

For all areas in general, high biomass values presumably result from: 1) high rates of primary productivity near Bering Strait in spring; 2) influx of terrestrial detritus from the Yukon River; 3) water-current structures of the Bering and Chukchi Seas; and 4) temperature effects on distributions of bottom-feeding predatory fishes.

Variability (Fay, Feder, and Stoker, 1978; Hughes and Bourne, 1981; Stoker, 1981)

Spatial—The values plotted on the map for infaunal distribution represent actual measurements and probably range from good to excellent in accuracy. At least seven physical factors influence species distribution: sediment particle size, bottom temperature, salinity, depth, sedimentation rates, circulation intensity, and amount of suspended particulates in near-bottom water. Probably because of variable substrate conditions, infaunal distribution in the region appears to be extremely patchy, especially in the central Bering shelf from St. Matthew and Nunivak Islands to just north of St. Lawrence Island. Limitations of the equipment precluded sampling of the large, deep-burrowing bivalves (*Mya* and *Spisula*), known to make up a large part of the diet of the Pacific walrus in the northern Bering Sea and Bering Strait region. Also, grab samples in shallow waters along the Alaska Peninsula did not reveal a preponderance of *Spisula* there, although 329,000±52,000 metric tons is the estimated biomass of whole clams (with shell) for this region, based on highly efficient hydraulic dredge sampling.

Temporal (Stoker, 1978, 1981)—There is probably little discernible seasonal or annual fluctuation in density of infaunal standing stock. However, the occurrence of predators, seasonally and interannually, is highly variable and probably influences infaunal density greatly.

Inclusiveness (Neiman, 1963; Semenov, 1964; Griffiths and Dillinger, 1981; Feder and Jewett, 1982)—Not all available data are incorporated here. For the Beaufort Sea coastal region, many data include combined infaunal and epifaunal values. Furthermore, these data are presented in the literature mainly as ash-free dry weight (g/m²) and/or as individuals per square meter. Soviet data, derived from ecological studies that have mostly considered only dominant species, are reported in such a way that separate wet-weight values for epifauna and infauna cannot be extracted easily.

Influencing Factors (Stoker, 1978, 1981)

Natural—Distribution of species correlates most directly with sediment type. Over the latitudinal extremes of the study area, both standing stock and diversity exhibit marked changes. In the southern Bering Sea, standing stock is probably reduced through predation, even though productivity and diversity are high as a result of lower physical environmental stress and higher food availability. In the northern Chukchi Sea, decreased availability of food and increased environmental stress may account for the relatively low standing stock (and probably for low productivity). The relatively high diversity observed in these northern extremes may reflect competition and replacement of boreal-Pacific forms by arctic and Atlantic forms, or it may indicate increased pressure of marine mammal predation.

Human-related—The fishing and mining industries may influence infauna through substrate disturbances and/or by removing predatory species. The southeastern Bering Sea receives the most fishing pressure. Substrate disturbance may be a less important factor than the removal (or absence) of predators.

Potential—Petroleum and mineral exploration and development may influence infaunal organisms. Bivalves are known to accumulate hydrocarbons, which not only affect them directly but are also passed on to animals that feed on them, for example, crabs and marine mammals. The Chukchi Sea system seems very dependent on the Bering Sea as a source of nutrients and possibly as a spawning ground providing recruitment. Therefore, altered water quality south of Bering Strait would likely result in altered biomass values northward.

Persons Consulted

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Legend

Faunal Region

Southeast and Southcentral Bering Sea

Species Group	Percent of Total Biomass
Bivalve Mollusks	62
Polychaete Worms	13
Gastropod Mollusks	5
Amphipod Crustaceans	4
Brittle Stars	4
Sea Urchins/Sand Dollars	4
Other	8

Bering Strait Region

Bivalve Mollusks	29
Sea Urchins/Sand Dollars	24
Amphipod Crustaceans	15
Polychaete Worms	8
Asteroid Starfishes	5
Gastropod Mollusks	4
Brittle Stars	4
Other	11

Eastern Chukchi Sea

Bivalve Mollusks	42
Sipunculids	19
Polychaete Worms	14
Brittle Stars	4
Gastropod Mollusks	3
Asteroid Starfishes	2
Other	16

Total Infaunal Biomass

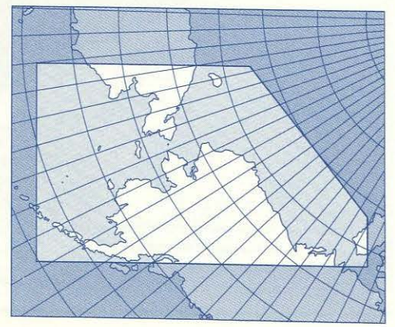
Station wet weight in grams per square meter

- Less than 200
- 200 to 1,000
- Greater than 1,000

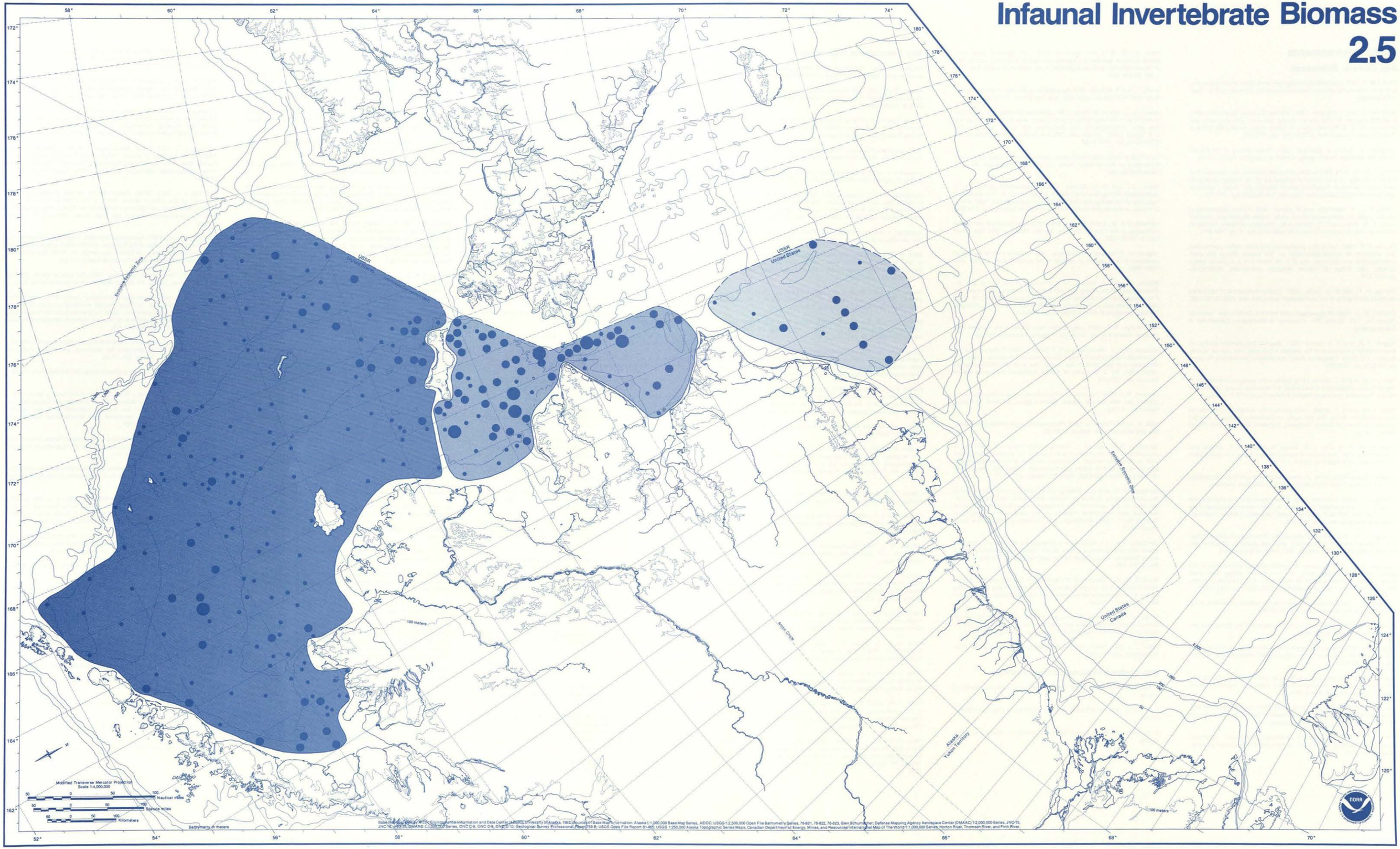
Faunal regions are derived from an analysis of station data; they are undoubtedly greater in extent. Dashed lines indicate limits of suitable data.

Map References

Feder et al., 1981; Haflinger, 1981; Stoker, 1981.



Infaunal Invertebrate Biomass
2.5



Base map by Bailey Smith, Environmental Information and Data Center (AEIDC), University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, and 1:3,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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Map Descriptions: Personal Communications

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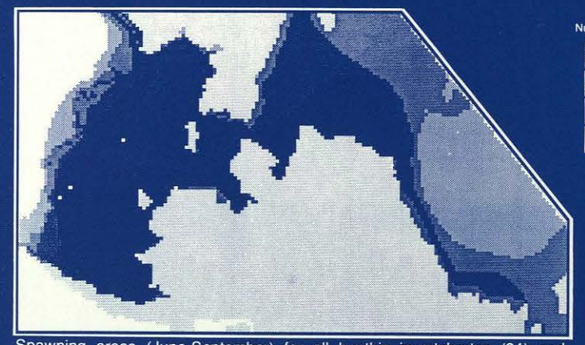
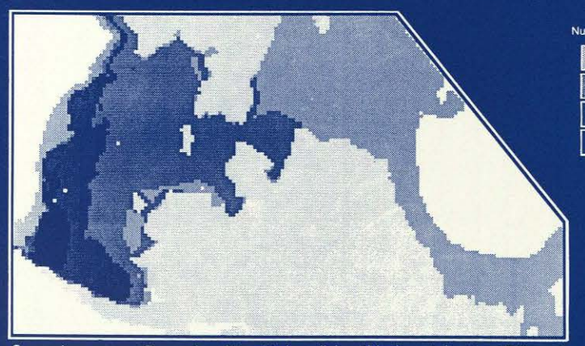


Spawning areas (June-September) for all benthic invertebrates (24) and demersal fishes (12) —No consideration of data quality

Subset of spawning areas (June-September) for benthic invertebrates (13) and demersal fishes (9) — Selection based only on "reasonably certain, moderately certain, and reasonable inference" data quality



Spawning areas (December-March) for all benthic invertebrates (24) and demersal fishes (12)—No consideration of data quality

Introduction

The 77 maps and descriptions in this section present the spatial and temporal distributions and important characteristics of 92 marine and coastal species. These species support most of the commercial and subsistence fishing and hunting activities in the region, account for much of the nonplanktonic marine biomass, and play important roles in their ecosystems. This section is organized into four subsections: invertebrates, with 31 species on 20 maps; fishes, with 21 species on 20 maps; birds, with 25 species on 23 maps; and mammals, with 14 species on 14 maps. Each subsection contains an introduction that explains briefly the characteristics of each species group and subgroup and their overall distributions, movement patterns, and habitats. Although the species considered are diverse, the maps and descriptions are presented in a consistent style that facilitates comparisons. Each map shows for each species the spatial and temporal distribution of its life history stages, areas of greater or lesser abundance, and where applicable, patterns of resource use.

The high primary productivity of the region, particularly of the Bering Sea, is reflected by the region's enormous populations of fishes, benthic invertebrates, seabirds, and marine mammals. An estimated 60 million seabirds and 2 million marine mammals, the largest concentrations in the northern hemisphere, occupy the area during the spring and summer, taking advantage of the high standing stocks of zooplankton and forage fishes. Summer residents fall into two groups. The first, including fur seals, sea lions, and seabirds (such as murres, kittiwakes, and auklets) migrates into the region to feed and reproduce. The second, including gray whales, fin whales, and oceanic birds (primarily shearwaters), occurs in the area only to feed; reproduction takes place elsewhere. The huge fish and benthic invertebrate populations are generally resident throughout the year, but many species move seasonally. Although reliable population estimates for many species are unavailable, the enormous commercial catches clearly indicate the abundance of marine life in the region. Demersal fish species, primarily walleye pollock, support one of the world's major fisheries; at the peak of foreign fishing in the early 1970's, annual catches averaged 2 million metric tons. King and tanner crabs were, until recent population declines, the basis for major invertebrate fisheries.

Seasonal Movements and Biogeography. Many species in the region move seasonally with the advance and retreat of sea ice (Map 1.8). Walrus and seals inhabit pack ice, and many fishes tend to move in response to ice retreat and advance. Movements of birds and mammals appear to anticipate sea ice dynamics. For example, black guillemots and bowhead whales move into the Bering Sea in fall well in front of the ice and return to the Beaufort Sea while the area is still ice covered, generally following leads and polynyas. Similarly, ice-avoiding species, such as murres, leave northern areas in late summer before the ice advances, but return via leads to breeding islands as soon as sufficient open water is available. However, sea ice is not the only determinant of movements. Other physical, biotic, and behavioral factors are important. The descriptions that accompany the maps help to explain these.

The study area is a transition region between two major faunas, or groups of co-occurring species—the North Pacific boreal (or cold-temperate), and the arctic. There is also a small group of species, the Beringian, that is restricted to the region. The boreal fauna, the richest in species and numbers, characterizes the Bering Sea and extends into the Chukchi Sea in summer. These species are also generally widely distributed throughout the North Pacific. Examples are fishes such as walleye pollock and Pacific herring, invertebrates such as king crabs, birds such as murres and kittiwakes, and marine mammals such as northern fur seal, northern sea lion, and gray whale. The arctic fauna, with far fewer species and lower numbers, characterizes the Beaufort and northern Chukchi seas and the Arctic Basin. Some of these species move into the Bering Sea during winter; many are circumpolar and occur in the North Atlantic. Typical species are Arctic cod, oldsquaw, white whale, and bowhead whale. The Beringian fauna is restricted to the study area and has the lowest number of species, although some can be found in abundance. Examples are saffron cod, spotted seal, and whiskered auklet.

The Species

Four criteria were used to select species: 1) inclusion of representatives from each of the four major groups of interest—invertebrates, fishes, birds, and mammals; 2) economic value—either commercial, sport, or subsistence; 3) endangered, threatened, or depleted status, legislatively protected or recently greatly reduced in number; and 4) ecological value, such as having high abundance, being a major food source, or competing with another important

species. These criteria were balanced against the adequacy of data for individual species.

Based on these criteria and other constraints, the species mapped present a reasonable representation of the diversity of species in the region. All major foreign and domestic commercial fishes and invertebrates are mapped, as well as over forty species harvested for subsistence (Section 4, Maps 4.3-4.5, 4.10, 4.11). The list includes the region's dominant marine mammals and seabirds, and ecologically important fishes, crustaceans, and mollusks. The species range from the southern Bering Sea to the Arctic Ocean and from the depths of the Bering Sea Basin to coastal cliffs. The *Species Life History Table* presents a summary, extracted from the maps and descriptions, of information on habitat, distribution, behavior, and human use, for each species. The table is a reference guide for quick comparisons of life history characteristics and for identification of particular species and maps with attributes of interest.

The Maps

Each map is a synthesis of published and unpublished information portraying spatial, temporal, and life history components of the distribution of a species, including human use where applicable. The information is generally descriptive and nonquantitative. The distributions portrayed are based primarily on sampling data and field observations. However, in areas where these data are lacking, distributions are inferred, using available information about preferred habitats and environmental constraints—a process balanced by extensive peer review. The life history information presented includes: overall distribution; areas of adult and juvenile abundance, often at several levels; and areas important for reproduction, such as nesting sites or spawning areas; migration and movement patterns; and areas important for other life history functions, such as haulouts, feeding areas, and staging areas for migrations. The temporal characteristics of each life stage or function are identified in the legend for each map.

Map presentations of life history stages are standardized. Adult areas are where sexually mature individuals occur or concentrate, juvenile areas are where immature stages occur, and reproductive areas are where reproductive activities such as mating, spawning, or giving birth occur. The juvenile and reproductive areas may not differ from adult areas; when this is the case, it is noted in the map legend. Legend notes also explain how some areas were delineated by use of spatial and temporal features such as sea ice boundaries. The descriptions accompanying the maps further explain these distributions and also provide important information not conducive to mapping. Topics include behavior, food and feeding, habitat requirements, community relationships, growth and reproduction, and management.

A special effort has been made to identify areas where a species is relatively more abundant than in other parts of its distribution. These areas are defined either by survey data or other documented observations. However, available data do not permit use of a simple rule quantitatively defining the levels of abundance equally for all species. Two levels of abundance are presented when appropriate. The lesser is called "major area," as in major adult area, and the greater is called "major concentration," as in major spawning concentration. Although used consistently, in some instances these designations require the help of the descriptions for interpretation. For example, densities may be greater in reproductive areas than in major adult areas or concentrations. In addition, the absence of designations on a map does not imply that the species is evenly distributed throughout its range, but rather, that information was not sufficient to identify such areas.

Using the Maps

The maps and accompanying descriptions can be used to identify and compare important distributional features in space and time for both individual species and groups of species. However, proper interpretation of the maps requires understanding the limitations of the data, which vary both within and among species. The *Data Content and Quality Table* codifies the uncertainty underlying the distributions on each map. For each species, information content is evaluated within each of 22 areas in the region by life history stage or function, using a simple five-point scale. In general, data quality is best for intensively studied commercial species such as salmon and pollock, and easily observed species such as marine mammals and seabirds, but is less reliable for poorly studied groups such as zooplankton and benthic mollusks.

In addition to data quality and inclusiveness, natural variability must be considered to interpret the maps correctly. The maps present average or generalized distributions that cannot account for year-to-year variations, which can be considerable. Consequently, physical factors that influence these variations, such as sea ice (Map 1.8), must also be considered when interpreting certain features on the maps. An example is the major adult area for murres around Wrangel Island (Map 3.60). This will exist only in warm years, when the summer ice edge is north of its average position; in many years, Wrangel Island is surrounded by ice all year long.

The maps can be used for several purposes. A single map can be used to pose questions and identify future research efforts to fill in data gaps. Because of consistent standards of data presentation, both temporal and spatial comparisons among species are possible either visually or by manual overlays. For example, using the maps and the two summary tables, one can consider all species sharing a set of common attributes, for example, boreal benthic invertebrates with summer reproductive periods. Similarly, single attributes can be extracted for all species to make simple composite maps showing, for example, important reproductive areas for fishes. Several of these composites are presented in the introductions to the subsections on invertebrates, fishes, and mammals.

Simple manual comparisons, however, can be cumbersome. Converting the mapped data to digital form for computer processing allows considerably more complex analyses by using any combination of species and species attributes, as well as information presented in other sections of the atlas. To facilitate such analyses, NOAA's National Ocean Service has digitized the species maps in this atlas. Three examples of composite maps generated from digitized data are shown.

In sum, the maps provide a synthesis of available information on the species selected. This graphic portrayal of information permits straightforward comprehension of the significant features of the distribution of a species. It allows visual comparisons among species, revealing areas important to the biota as a whole as well as to its individual components. This method of synthesis and communication provides comprehensive and complete information not only to biologists and resource managers, but also to a wider array of interested individuals and decisionmakers.

Living Marine Resources

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3.56 Glaucous Gull
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References

3.0

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
National Oceanic and Atmospheric Administration

		Legal Status			Use			Habitat																				Feeding Type				Reproduction										Range						
								Type				Distribution						Substrate				Salinity Range										Timing				Location						Study Area			Worldwide			
		Endangered/ Threatened	Federal/State Regulation	International Treaty	Commercial	Subsistence	Recreational	Benthic	Pelagic	Sea Ice	Terrestrial	Inland Tundra/Taiga	Coastal land/Islands	Inland Waters/ Estuaries	Inner Shelf	Middle Shelf	Outer Shelf/Oceanic	Mud (Silt/Clay)	Sand, Gravel, or Shell	Rocks, Reefs, or Solid Bottoms	Aquatic Vegetation	Freshwater (0-0.5 ppt)	Oligohaline (0.5-5 ppt)	Mesohaline (5-18 ppt)	Polyhaline (18-30 ppt)	Euhaline (30-40 ppt)	Hypersaline (> 40 ppt)	Grazing Herbivore	Filter/Suspension Feeder	Deposit Feeder	Carnivore/Omnivore	December-February	March-May	June-August	September-November	Inland Tundra/Taiga	Coastal Land/Islands	Inland Waters/ Estuaries	Inner Shelf	Middle Shelf	Outer Shelf/Oceanic	Bering Sea	Chukchi Sea	Beaufort Sea	Arctic Region	Boreal Region	Warm Temperate Region	Tropical Region
	Invertebrates																																															
3.1	Arrow Worm *Sagitta elegans*								●						●	●	●							●	●	●							●	●	●				●	●	●	●	●	●	●	●	●	
3.2	Euphausiids *Thysanoessa inermis*								●							●	●									●			●	●			●	●						●	●	●	●	●	●	●	●	
	Thysanoessa raschii								●						●	●	●									●			●	●			●	●					●	●	●	●	●	●	●	●	●	
3.3	False Calanus Copepods *Pseudocalanus* spp.								●						●	●	●							●	●	●			●		●		●	●	●				●	●	●	●	●	●	●	●	●	
3.4	Feathery Calanus Copepod *Neocalanus plumchrus*								●								●									●			●			●	●								●	●	●		●	●		
3.5	Dragonfly Amphipod *Themisto libellula*								●						●	●	●								●	●					●	●	●						●	●	●	●	●	●	●	●		
3.6	Common Two-spined Crangon *Crangon communis*							●								●	●	●							●	●					●		●	●	●					●	●	●	●			●		
	Ridged Crangon *Crangon dalli*							●							●	●		●							●	●					●		●	●	●				●	●		●	●		●	●		
	Sand Shrimp *Crangon septemspinosa*							●							●	●		●							●	●					●		●	●	●				●	●		●	●		●	●		
3.7	Large Crangonid Shrimp *Argis dentata*							●							●	●	●	●							●	●					●			●	●				●	●	●	●	●		●	●		
	Argis lar							●							●	●	●	●							●	●					●			●	●				●	●	●	●	●		●	●		
	Sclerocrangon boreas							●							●	●		●							●	●					●			●	●				●	●		●	●		●	●		
	Sabinea septemcarinata							●							●	●	●	●							●	●					●			●	●				●	●	●			●	●			
3.8	Northern Pink Shrimp *Pandalus borealis*		●		●	●		●							●	●	●	●	●							●				●	●			●	●				●	●	●	●				●		
3.9	Humpy Shrimp *Pandalus goniurus*				●	●		●							●	●	●	●	●							●					●				●				●	●	●	●			●	●		
	Yellow-legged Shrimp *Pandalus tridens*				●	●		●									●	●	●							●					●				●						●	●				●		
	Side-stripe Shrimps *Pandalopsis dispar*				●	●		●									●	●	●							●					●				●						●	●				●		
3.10	Opossum Shrimps *Mysis litoralis*							●	●						●	●		●	●		●		●	●	●	●			●		●	●	●	●	●				●	●		●	●	●	●	●		
	Mysis oculata							●	●						●	●		●	●		●		●	●	●	●			●		●	●	●	●	●				●	●		●	●	●	●	●		
	Mysis polaris							●	●						●	●	●	●	●		●					●			●		●	●	●	●	●				●	●	●		●	●	●			
	Mysis relicta							●	●					●				●	●		●		●	●	●	●			●		●	●	●	●	●			●				●	●	●	●	●		
3.11	Korean Hair Crab *Erimacrus isenbeckii*		●		●			●							●	●	●	●	●						●	●					●	●	●		●				●	●	●	●				●		
3.12	Red King Crab *Paralithodes camtschatica*		●		●	●		●							●	●	●	●	●	●	●					●					●	●	●	●					●	●		●				●		
3.13	Golden King Crab *Lithodes aequispina*		●		●			●									●	●	●	●						●					●	●	●	●	●						●	●				●		
3.14	Blue King Crab *Paralithodes platypus*		●		●	●		●							●	●	●	●	●	●						●					●	●	●	●					●	●	●	●	●		●	●		
3.15	Bairdi Tanner Crab *Chionoecetes bairdi*		●		●	●		●							●	●	●	●	●							●					●	●	●						●	●	●	●				●		
3.16	Opilio Tanner Crab *Chionoecetes opilio*		●		●	●		●							●	●	●	●	●							●					●	●	●						●	●	●	●	●		●	●		
3.17	Red Squid *Berryteuthis magister*		●		●				●							●	●									●					●	●	●								●	●				●		
3.18	Chalky Macoma *Macoma calcarea*		●					●							●	●	●	●	●						●	●			●	●				●					●	●	●	●	●	●	●	●		
3.19	Greenland Cockle *Serripes groenlandicus*		●					●							●	●	●	●	●						●	●			●				●	●					●	●	●	●	●	●	●	●		
3.20	Iceland Cockle *Clinocardium ciliatum*		●					●							●	●		●							●	●			●				●	●					●	●		●	●	●	●	●		
	Fishes																																															
3.21	Pacific Herring *Clupea harengus pallasi*		●		●	●			●					●	●	●	●		●	●	●			●	●	●			●		●		●	●				●	●			●	●		●	●	●	
3.22	Pink Salmon *Oncorhynchus gorbuscha*		●		●	●	●		●					●	●	●	●					●	●	●	●	●					●			●	●			●				●	●	●	●	●		
3.23	Chum Salmon *Oncorhynchus keta*		●		●	●	●		●					●	●	●	●					●	●	●	●	●					●			●	●			●				●	●	●	●	●		
3.24	Coho Salmon *Oncorhynchus kisutch*		●		●	●	●		●					●	●	●	●					●	●	●	●	●					●				●			●				●	●		●	●		
3.25	Sockeye Salmon *Oncorhynchus nerka*		●		●	●	●		●					●	●	●	●					●	●	●	●	●					●			●	●			●				●	●		●	●		
3.26	Chinook Salmon *Oncorhynchus tshawytscha*		●		●	●	●		●					●	●	●	●					●	●	●	●	●					●			●	●			●				●	●		●	●		
3.27	Capelin *Mallotus villosus*		●			●			●					●	●	●	●							●	●	●					●		●	●				●	●			●	●	●	●	●		
3.28	Eulachon *Thaleichthys pacificus*		●			●	●		●					●	●	●	●					●	●	●	●	●					●		●	●				●				●				●		
3.29	Rainbow Smelt *Osmerus mordax*		●			●	●		●					●	●	●						●	●	●	●	●					●		●	●				●	●			●	●	●	●	●		
3.30	Saffron Cod *Eleginus gracilis*					●		●	●					●	●									●	●	●					●	●							●			●	●		●	●		
3.31	Pacific Cod *Gadus macrocephalus*		●		●			●	●						●	●	●								●	●					●	●	●								●	●				●		
3.32	Walleye Pollock *Theragra chalcogramma*		●		●			●	●						●	●	●	●							●	●					●	●	●	●							●	●				●		
3.33	Yellowfin Sole *Limanda aspera*		●		●			●							●	●	●	●	●							●					●			●					●			●	●			●		
3.34	Alaska Plaice *Pleuronectes quadrituberculatus*		●		●			●							●	●	●	●	●							●					●		●	●					●	●	●	●	●			●		
3.35	Starry Flounder *Platichthys stellatus*		●			●		●						●	●	●	●	●	●			●	●	●	●	●					●		●	●					●			●	●			●	●	
3.36	Greenland Turbot *Reinhardtius hippoglossoides*		●		●			●								●	●	●								●					●	●	●							●	●	●				●		
3.37	Rock Sole *Lepidopsetta bilineata*		●		●			●							●	●	●	●	●							●					●		●	●							●	●				●	●	
3.38	Arrowtooth Flounder *Atheresthes stomias*		●		●			●									●	●								●					●	●	●								●	●				●		

Species Life History Table

No.	Species	Legal Status: Endangered/Threatened	Legal Status: Federal/State Regulation	Legal Status: International Treaty	Use: Commercial	Use: Subsistence	Use: Recreational	Habitat Type: Benthic	Habitat Type: Pelagic	Habitat Type: Sea Ice	Habitat Type: Terrestrial	Distribution: Inland Tundra/Taiga	Distribution: Coastal land/Islands	Distribution: Inland Waters/Estuaries	Distribution: Inner Shelf	Distribution: Middle Shelf	Distribution: Outer Shelf/Oceanic
	Fishes																
3.39	Flathead Sole *Hippoglossoides elassodon*		●		●			●							●	●	●
	Bering Flounder *Hippoglossoides robustus*		●		●			●							●	●	●
3.40	Pacific Halibut *Hippoglossus stenolepis*		●	●	●			●							●	●	●
	Birds																
3.41	Northern Fulmar *Fulmarus glacialis*		●	●					●		●		●		●	●	●
3.42	Short-tailed Shearwater *Puffinus tenuirostris*		●	●	●				●		●				●	●	●
	Sooty Shearwater *Puffinus griseus*		●	●	●				●		●				●	●	●
3.43	Tundra Swan *Cygnus columbianus*		●	●		●					●	●	●	●			
3.44	Emperor Goose *Chen canagica*		●	●		●	●				●	●	●	●			
3.45	Brant *Branta bernicla*		●	●		●	●				●	●	●	●			
3.46	Greater White-fronted Goose *Anser albifrons*		●	●		●	●				●	●		●			
3.47	Canada Goose *Branta canadensis minima*		●	●		●	●				●	●	●	●			
	Canada Goose *Branta canadensis parvipes*		●	●		●	●				●	●	●	●			
3.48	Oldsquaw *Clangula hyemalis*		●	●		●	●		●	●	●	●	●	●	●		
3.49	Common Eider *Somateria mollissima*		●	●		●	●			●	●	●	●	●	●		
3.50	King Eider *Somateria spectabilis*		●	●		●	●				●	●	●	●	●		
3.51	Bald Eagle *Haliaeetus leucocephalus*		●	●							●	●	●	●			
3.52	Peregrine Falcon *Falco peregrinus japonensis*		●	●							●	●	●	●			
	Falco peregrinus pealei		●	●							●	●	●	●			
	Falco peregrinus tundrius	●	●	●							●	●	●	●			
3.53	Western Sandpiper *Calidris mauri*		●	●							●	●	●	●			
3.54	Red Phalarope *Phalaropus fulicaria*		●	●					●		●	●	●	●	●	●	●
3.55	Glaucous-winged Gull *Larus glaucescens*		●	●					●	●	●		●	●	●	●	●
3.56	Glaucous Gull *Larus hyperboreus*		●	●					●	●	●	●	●	●	●	●	●
3.57	Black-legged Kittiwake *Rissa tridactyla*		●	●					●	●	●		●	●	●	●	●
3.58	Red-legged Kittiwake *Rissa brevirostris*		●	●					●		●		●	●	●	●	●
3.59	Arctic Tern *Sterna paradisaea*		●	●					●		●	●	●	●	●	●	●
3.60	Common Murre *Uria aalge*		●	●		●			●	●	●		●		●	●	●
	Thick-billed Murre *Uria lomvia*		●	●		●			●	●	●		●		●	●	●
3.61	Horned Puffin *Fratercula corniculata*		●	●					●		●		●		●	●	●
3.62	Parakeet Auklet *Cyclorrhynchus psittacula*		●	●					●		●		●		●	●	●
3.63	Least Auklet *Aethia pusilla*		●	●					●		●		●		●	●	●
	Mammals																
3.64	Caribou *Rangifer tarandus*		●			●	●				●	●	●				
3.65	Brown Bear *Ursus arctos*		●			●	●				●	●	●				
3.66	Polar Bear *Ursus maritimus*		●	●		●	●			●	●	●	●		●	●	●
3.67	Northern Fur Seal *Callorhinus ursinus*		●	●	●	●			●		●		●		●	●	●
3.68	Steller Sea Lion *Eumetopias jubatus*		●			●			●		●		●		●	●	●
3.69	Pacific Walrus *Odobenus rosmarus divergens*		●			●			●	●	●		●		●	●	●
3.70	Pacific Harbor Seal *Phoca vitulina richardsi*		●			●			●	●	●		●	●	●	●	
3.71	Spotted Seal *Phoca largha*		●		●	●			●	●	●		●	●	●	●	●
3.72	Ringed Seal *Phoca hispida*		●		●	●			●	●					●	●	●
3.73	Ribbon Seal *Phoca fasciata*		●		●	●			●	●					●	●	●
3.74	Bearded Seal *Erignathus barbatus*		●		●	●			●	●					●	●	●
3.75	Bowhead Whale *Balaena mysticetus*	●	●	●		●			●	●					●	●	●
3.76	Gray Whale *Eschrichtius robustus*	●	●	●		●			●						●	●	●
3.77	White Whale *Delphinapterus leucas*		●			●			●	●				●	●	●	●

No.	Species	Substrate: Mud (Silt/Clay)	Substrate: Sand, Gravel, or Shell	Substrate: Rocks, Reefs, or Solid Bottoms	Substrate: Aquatic Vegetation	Salinity Range: Freshwater (0-0.5 ppt)	Salinity Range: Oligohaline (0.5-5 ppt)	Salinity Range: Mesohaline (5-18 ppt)	Salinity Range: Polyhaline (18-30 ppt)	Salinity Range: Euhaline (30-40 ppt)	Salinity Range: Hypersaline (>40 ppt)	Feeding Type: Grazing Herbivore	Feeding Type: Filter/Suspension Feeder	Feeding Type: Deposit Feeder	Feeding Type: Carnivore/Omnivore
	Fishes														
3.39	Flathead Sole *Hippoglossoides elassodon*	●	●							●					●
	Bering Flounder *Hippoglossoides robustus*	●	●							●					●
3.40	Pacific Halibut *Hippoglossus stenolepis*	●	●							●					●
	Birds														
3.41	Northern Fulmar *Fulmarus glacialis*														●
3.42	Short-tailed Shearwater *Puffinus tenuirostris*														●
	Sooty Shearwater *Puffinus griseus*														●
3.43	Tundra Swan *Cygnus columbianus*				●							●			
3.44	Emperor Goose *Chen canagica*		●	●	●							●			
3.45	Brant *Branta bernicla*		●		●							●			
3.46	Greater White-fronted Goose *Anser albifrons*				●							●			
3.47	Canada Goose *Branta canadensis minima*				●							●			
	Canada Goose *Branta canadensis parvipes*				●							●			
3.48	Oldsquaw *Clangula hyemalis*		●												●
3.49	Common Eider *Somateria mollissima*		●	●											●
3.50	King Eider *Somateria spectabilis*		●												●
3.51	Bald Eagle *Haliaeetus leucocephalus*														●
3.52	Peregrine Falcon *Falco peregrinus japonensis*														●
	Falco peregrinus pealei														●
	Falco peregrinus tundrius														●
3.53	Western Sandpiper *Calidris mauri*	●	●												●
3.54	Red Phalarope *Phalaropus fulicaria*		●												●
3.55	Glaucous-winged Gull *Larus glaucescens*		●	●											●
3.56	Glaucous Gull *Larus hyperboreus*	●	●	●											●
3.57	Black-legged Kittiwake *Rissa tridactyla*			●											●
3.58	Red-legged Kittiwake *Rissa brevirostris*			●											●
3.59	Arctic Tern *Sterna paradisaea*		●	●											●
3.60	Common Murre *Uria aalge*			●											●
	Thick-billed Murre *Uria lomvia*			●											●
3.61	Horned Puffin *Fratercula corniculata*			●											●
3.62	Parakeet Auklet *Cyclorrhynchus psittacula*			●											●
3.63	Least Auklet *Aethia pusilla*			●											●
	Mammals														
3.64	Caribou *Rangifer tarandus*											●			
3.65	Brown Bear *Ursus arctos*														●
3.66	Polar Bear *Ursus maritimus*														●
3.67	Northern Fur Seal *Callorhinus ursinus*														●
3.68	Steller Sea Lion *Eumetopias jubatus*														●
3.69	Pacific Walrus *Odobenus rosmarus divergens*														●
3.70	Pacific Harbor Seal *Phoca vitulina richardsi*														●
3.71	Spotted Seal *Phoca largha*														●
3.72	Ringed Seal *Phoca hispida*														●
3.73	Ribbon Seal *Phoca fasciata*														●
3.74	Bearded Seal *Erignathus barbatus*														●
3.75	Bowhead Whale *Balaena mysticetus*												●		●
3.76	Gray Whale *Eschrichtius robustus*												●		●
3.77	White Whale *Delphinapterus leucas*														●

No.	Species	Reproduction Timing: December-February	Reproduction Timing: March-May	Reproduction Timing: June-August	Reproduction Timing: September-November	Reproduction Location: Inland Tundra/Taiga	Reproduction Location: Coastal Land/Islands	Reproduction Location: Inland Waters/Estuaries	Reproduction Location: Inner Shelf	Reproduction Location: Middle Shelf	Reproduction Location: Outer Shelf/Oceanic	Range Study Area: Bering Sea	Range Study Area: Chukchi Sea	Range Study Area: Beaufort Sea	Range Worldwide: Arctic Region	Range Worldwide: Boreal Region	Range Worldwide: Warm Temperate Region	Range Worldwide: Tropical Region
	Fishes																	
3.39	Flathead Sole *Hippoglossoides elassodon*	●	●						●	●	●	●				●		
	Bering Flounder *Hippoglossoides robustus*	●	●						●	●	●	●	●			●		
3.40	Pacific Halibut *Hippoglossus stenolepis*	●									●	●				●		
	Birds																	
3.41	Northern Fulmar *Fulmarus glacialis*		●	●			●				●	●	●	●	●	●	●	
3.42	Short-tailed Shearwater *Puffinus tenuirostris*	●			●							●	●	●	●	●	●	●
	Sooty Shearwater *Puffinus griseus*	●			●							●	●	●	●	●	●	●
3.43	Tundra Swan *Cygnus columbianus*			●		●						●	●	●	●	●	●	
3.44	Emperor Goose *Chen canagica*			●				●				●	●		●	●		
3.45	Brant *Branta bernicla*		●	●		●	●	●				●	●	●	●	●	●	
3.46	Greater White-fronted Goose *Anser albifrons*		●	●		●		●				●	●	●	●	●	●	
3.47	Canada Goose *Branta canadensis minima*			●		●		●				●	●	●	●	●	●	
	Canada Goose *Branta canadensis parvipes*			●		●		●				●	●		●	●	●	
3.48	Oldsquaw *Clangula hyemalis*		●	●		●	●	●				●	●	●	●	●	●	
3.49	Common Eider *Somateria mollissima*		●	●		●	●	●	●			●	●	●	●	●		
3.50	King Eider *Somateria spectabilis*		●	●		●						●	●	●	●	●		
3.51	Bald Eagle *Haliaeetus leucocephalus*		●	●		●	●	●				●	●	●	●	●	●	
3.52	Peregrine Falcon *Falco peregrinus japonensis*		●	●	●	●	●	●				●	●		●	●	●	●
	Falco peregrinus pealei		●	●	●	●	●	●				●	●		●	●	●	●
	Falco peregrinus tundrius		●	●	●	●	●	●				●	●	●	●	●	●	●
3.53	Western Sandpiper *Calidris mauri*			●		●						●	●	●	●	●	●	●
3.54	Red Phalarope *Phalaropus fulicaria*		●	●		●		●				●	●	●	●	●	●	●
3.55	Glaucous-winged Gull *Larus glaucescens*		●	●			●					●	●		●	●	●	
3.56	Glaucous Gull *Larus hyperboreus*		●	●		●	●	●	●			●	●	●	●	●		
3.57	Black-legged Kittiwake *Rissa tridactyla*		●	●	●		●		●	●	●	●	●	●	●	●	●	
3.58	Red-legged Kittiwake *Rissa brevirostris*			●			●				●	●				●		
3.59	Arctic Tern *Sterna paradisaea*		●	●		●	●	●	●			●	●	●	●	●	●	●
3.60	Common Murre *Uria aalge*		●	●			●		●	●	●	●	●	●	●	●	●	
	Thick-billed Murre *Uria lomvia*			●			●					●	●	●	●	●	●	
3.61	Horned Puffin *Fratercula corniculata*		●	●			●		●			●	●	●	●	●		
3.62	Parakeet Auklet *Cyclorrhynchus psittacula*		●	●	●		●		●	●		●	●		●	●		
3.63	Least Auklet *Aethia pusilla*		●	●	●		●		●	●		●	●		●	●		
	Mammals																	
3.64	Caribou *Rangifer tarandus*		●	●		●	●								●	●		
3.65	Brown Bear *Ursus arctos*	●				●									●	●		
3.66	Polar Bear *Ursus maritimus*	●					●		●			●	●	●	●	●		
3.67	Northern Fur Seal *Callorhinus ursinus*			●			●					●				●		
3.68	Steller Sea Lion *Eumetopias jubatus*		●	●			●					●				●	●	
3.69	Pacific Walrus *Odobenus rosmarus divergens*		●	●					●	●		●	●	●	●	●		
3.70	Pacific Harbor Seal *Phoca vitulina richardsi*			●			●					●				●	●	
3.71	Spotted Seal *Phoca largha*		●						●	●	●	●	●	●	●	●		
3.72	Ringed Seal *Phoca hispida*		●						●	●		●	●	●	●	●		
3.73	Ribbon Seal *Phoca fasciata*		●						●	●	●	●	●		●	●		
3.74	Bearded Seal *Erignathus barbatus*		●						●	●	●	●	●	●	●	●		
3.75	Bowhead Whale *Balaena mysticetus*		●	●					●	●		●	●	●	●	●		
3.76	Gray Whale *Eschrichtius robustus*											●	●		●	●	●	
3.77	White Whale *Delphinapterus leucas*		●	●	●			●	●	●		●	●	●	●	●		

Description

This table summarizes important life history attributes for the species described in this atlas. (See individual species maps for more complete information.) With few exceptions, the entries on the table are limited to the adult life stage. Most of the categories are self-explanatory. The following need clarification:

Habitat: Type. For invertebrates and fishes, the term "pelagic" means living within the water column; for birds and mammals the term "pelagic" means occurrence at sea, usually out of sight of land.

Habitat: Distribution: The boundaries for the divisions of the continental shelf are based on ecological and water mass characteristics rather than bathymetry. For the southeastern Bering Sea, the inner shelf extends from the coastline to the 40-50 meter isobaths, the middle shelf from 40-50 meters to 80-100 meters, the outer shelf from 80-100 meters to 200 meters, and oceanic waters from the 200-meter isobath seaward. Central and western Bering Sea waters are considered oceanic (see Introduction: Physical Environments). For the Chukchi and Beaufort seas, the inner shelf extends from the coastline to approximately the 20-meter isobath, the middle shelf from 20 meters to 100 meters, the outer shelf from 100 meters to 200 meters, and oceanic waters from the 200-meter isobath seaward.

Habitat: Salinity Range. The Venice System, a classification system widely accepted in oceanography, is used.

Feeding Types. These are defined as follows: a grazing herbivore actively consumes plant tissue by means other than filtering water; a filter/suspension feeder actively or passively strains or entraps suspended particles from the water column; a deposit feeder feeds actively, but not necessarily selectively, on material deposited on the sediment surface or in the sediment; a carnivore actively seizes living animal (invertebrate or vertebrate) prey; and an omnivore eats both plant and animal matter.

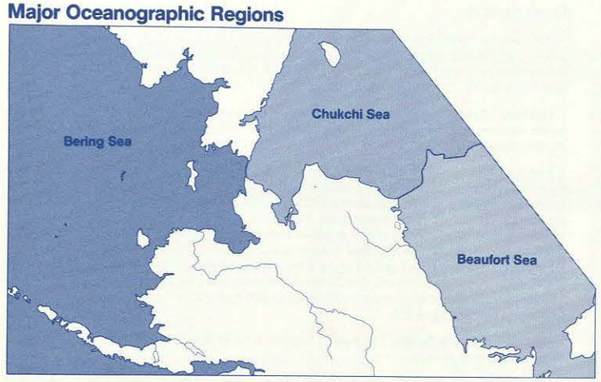
Reproduction. This category refers to the release of eggs, larvae, or juveniles from the adult.

Range: Worldwide. Divisions reference a classification system widely used in biogeography.

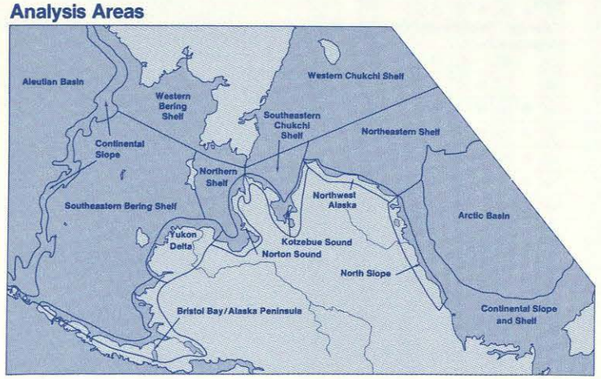
Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
National Oceanic and Atmospheric Administration

Major Oceanographic Regions



Analysis Areas

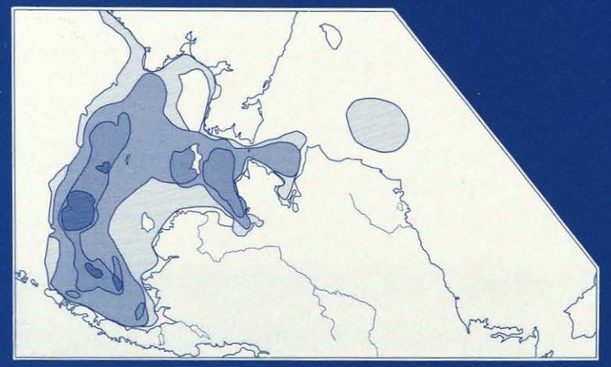


		Bering Sea																						Chukchi Sea												Beaufort Sea								
		Adults								Reproduction								Abundance						Adults				Reproduction				Abundance				Adults				Reproduction				Abundance		
		Oceanic/ Neritic				Nearshore			Terrestrial	Oceanic/ Neritic				Nearshore			Terrestrial	Oceanic/ Neritic				Nearshore			Terrestrial	Oceanic/ Neritic			Nearshore		Terrestrial	Oceanic/ Neritic		Nearshore		Terrestrial	Oceanic/ Neritic			Nearshore		Terrestrial	Oceanic/ Neritic		Nearshore		Terrestrial
		Aleutian Basin	Continental Slope	Western Shelf	Southeastern Shelf	Northern Shelf/ Bristol Bay/ Peninsula	Yukon Delta	Norton Sound	Bristol Bay/ Peninsula	Yukon Delta	Norton Sound	Aleutian Basin	Continental Slope	Western Shelf	Southeastern Shelf	Northern Shelf/ Bristol Bay/ Peninsula	Yukon Delta	Norton Sound	Bristol Bay/ Peninsula	Yukon Delta	Norton Sound	Aleutian Basin	Continental Slope	Western Shelf	Southeastern Shelf	Northern Shelf/ Bristol Bay/ Peninsula	Yukon Delta	Norton Sound	Southeastern Shelf	Western Shelf	Northeastern Shelf	Kotzebue Sound	Northwest Alaska	Kotzebue Sound	Northwest Alaska	Kotzebue Sound	Northwest Alaska	Southeastern Shelf	Western Shelf	Northeastern Shelf	Kotzebue Sound	Northwest Alaska	Kotzebue Sound	Northwest Alaska	Arctic Basin	Continental Slope and Shelf	North Slope	North Slope	Arctic Basin	Continental Slope and Shelf	North Slope	North Slope	Arctic Basin	Continental Slope and Shelf	North Slope	North Slope
	Invertebrates																																																				
3.1	Arrow Worm *Sagitta elegans*																																																		
3.2	Euphausiids *Thysanoessa inermis*																																																		
	Thysanoessa raschii																																																		
3.3	False Calanus Copepods *Pseudocalanus* spp.																																																		
3.4	Feathery Calanus Copepod *Neocalanus plumchrus*																																																		
3.5	Dragonfly Amphipod *Themisto libellula*																																																		
3.6	Common Two-spined Crangon *Crangon communis*																																																		
	Ridged Crangon *Crangon dalli*																																																		
	Sand Shrimp *Crangon septemspinosa*																																																		
3.7	Large Crangonid Shrimp *Argis dentata*																																																		
	Argis lar																																																		
	Sclerocrangon boreas																																																		
	Sabinea septemcarinata																																																		
3.8	Northern Pink Shrimp *Pandalus borealis*																																																		
3.9	Humpy Shrimp *Pandalus goniurus*																																																		
	Yellow-legged Shrimp *Pandalus tridens*																																																		
	Side-stripe Shrimp *Pandalopsis dispar*																																																		
3.10	Opossum Shrimps *Mysis litoralis*																																																		
	Mysis oculata																																																		
	Mysis polaris																																																		
	Mysis relicta																																																		
3.11	Korean Hair Crab *Erimacrus isenbeckii*																																																		
3.12	Red King Crab *Paralithodes camtschatica*																																																		
3.13	Golden King Crab *Lithodes aequispina*																																																		
3.14	Blue King Crab *Paralithodes platypus*																																																		
3.15	Bairdi Tanner Crab *Chionoecetes bairdi*																																																		
3.16	Opilio Tanner Crab *Chionoecetes opilio*																																																		
3.17	Red Squid *Berryteuthis magister*																																																		
3.18	Chalky Macoma *Macoma calcarea*																																																		
3.19	Greenland Cockle *Serripes groenlandicus*																																																		
3.20	Iceland Cockle *Clinocardium ciliatum*																																																		
	Fishes																																																		
3.21	Pacific Herring *Clupea harengus pallasi*																																																		
3.22	Pink Salmon *Oncorhynchus gorbuscha*																																																		
3.23	Chum Salmon *Oncorhynchus keta*																																																		
3.24	Coho Salmon *Oncorhynchus kisutch*																																																		
3.25	Sockeye Salmon *Oncorhynchus nerka*																																																		
3.26	Chinook Salmon *Oncorhynchus tshawytscha*																																																		
3.27	Capelin *Mallotus villosus*																																																		
3.28	Eulachon *Thaleichthys pacificus*																																																		
3.29	Rainbow Smelt *Osmerus mordax*																																																		
3.30	Saffron Cod *Eleginus gracilis*																																																		
3.31	Pacific Cod *Gadus macrocephalus*																																																		
3.32	Walleye Pollock *Theragra chalcogramma*																																																		
3.33	Yellowfin Sole *Limanda aspera*																																																		
3.34	Alaska Plaice *Pleuronectes quadrituberculatus*																																																		
3.35	Starry Flounder *Platichthys stellatus*																																																		
3.36	Greenland Turbot *Reinhardtius hippoglossoides*																																																		
3.37	Rock Sole *Lepidopsetta bilineata*																																																		

Data Content and Quality Table

| | | Bering Sea | | |

Invertebrates



Areas of Abundance for Selected Benthic Invertebrates

Number of Species

1 | 2,3 | 4,5 | 6,7,8

Species: Small Crangonid Shrimp *(Crangon communis. C. dalli)*, Large Crangonid Shrimp *(Argis dentata, Sclerocrangon boreas)*, Northern Pink Shrimp, Korean Hair Crab, Red King Crab, Golden King Crab, Blue King Crab, Bairdi Tanner Crab, Opilio Tanner Crab, Chalky Macoma, Greenland Cockle, Iceland Cockle

Areas indicate the number of species present, not necessarily the overall distribution of biomass.

Introduction

This subsection comprises 20 maps describing species, a small fraction of the region's diverse invertebrate fauna. The species are organized taxonomically and ecologically into three groups: six zooplankton species; 21 benthic crustaceans; and four mollusks. Zooplankton (small, weakly swimming animals) represent important links in the food web between phytoplankton and higher level consumers; they are generally the most abundant shelf species. Benthic crustaceans (crabs, shrimp, and their relatives) include species of considerable ecological and economic importance. The latter are the concern of several cooperative Federal-State regulatory programs. Mollusks (clams, snails, squid, and octopus) are also abundant in the region. They are important food sources for some fishes and marine mammals, but are not as yet intensively harvested. Cooperative studies to assess the economic potential of several clams and whelks are under way. Species of other invertebrate groups of ecological importance are not presented due to an overall lack of information. Maps 2.3-2.5 present the overall patterns of invertebrate distributions.

Adult invertebrates differ in their abilities to move, although most species have planktonic larvae that can be carried considerable distances by currents. Many zooplankton species may have good powers of locomotion over short distances, but their large-scale movements are generally controlled by currents. In contrast to these species, other invertebrates are powerful swimmers (such as squid) or walkers (such as large crabs); their movements are not determined directly by water motion. Still other species, such as infaunal worms and bivalve mollusks, either remain fixed in one location or move only short distances.

The inset map on this page is a composite of major adult areas and concentrations for benthic invertebrates for which such areas could be determined. The darker portions represent major areas or concentrations common to relatively higher numbers of species. Given the poor sampling coverage for many parts of the region and the relatively few species for which sufficient data are available, this map should be considered preliminary. Nevertheless, it probably indicates certain features of habitat and species diversity that deserve attention. For example, high densities of the largest numbers of species occur on the southern and eastern portions of the middle and outer shelves, the area north and south of St. Lawrence Island, and into the Norton Sound-Bering Strait region. These areas reflect the patterns of the two invertebrate biomass maps (Maps 2.4, 2.5) and the overall pattern of species diversity in the region; highest numbers of species for all invertebrate groups are in the Bering Sea, with diversity decreasing to the north. The single species area in the northeast Chukchi Sea is due to the presence of chalky macoma, a clam, and may indicate enhanced benthic productivity, possibly associated with the intrusion of warm Alaska coastal water from the Bering Sea to the Chukchi Sea.

The maps in this section must be viewed as first-order guides to the understanding of these animals. As shown in the *Data Content and Quality Table* (Section 3 Introduction), invertebrates (with the exception of commercially important crabs) are the most poorly known of the four groups of species presented in this atlas. Distributions in many cases had to be inferred from water masses, bathymetry, and other oceanographic characteristics. Additionally, the temporal and spatial patchiness of invertebrate distributions cannot be depicted at the atlas scale, although this patchiness is important ecologically, especially to predators. The complex life histories of these species and their poorly known habitat requirements have presented difficult management problems for species of commercial importance. For example, the recent decline in stocks of king crabs, which used to support a major fishery, may be due to several causes, including natural habitat variability, disease, and overfishing.

Zooplankton—These are small animals, usually less than 0.5 cm long, that live in the water column. Their movements are generally determined by currents. Zooplankton comprise an assemblage of considerable complexity and importance to marine food webs. This community of organisms includes larval forms and eggs of species that are not planktonic as adults, such as crabs, mollusks, and many fishes, as well as those whose whole life history is spent as plankton. Most permanent zooplankton species are crustaceans; they usually pass through a series of distinct life history stages that may differ from one another in food habits and structure.

Zooplankton organisms may be either primary consumers that feed directly on phytoplankton and particulate matter, or secondary consumers that feed on other zooplankton and even their own eggs and larvae. The first group includes the grazers of the sea that convert phytoplankton into animal matter. The most important grazers in the region are copepods and euphausiids (Maps 3.2-3.4). Copepods are the principal prey for several species of fishes, birds, and whales. The second group includes hyperiid amphipods (Map 3.5) and arrow worms (Map 3.1). These are voracious predators on other zooplankton; arrow worms alone probably account for the consumption of 10 percent of total zooplankton biomass in the Bering Sea. Other important groups include polychaetes, medusae, other amphipods, comb jellies, and tunicates (salps and larvaceans). All of these species may be extremely abundant, but estimating actual population size is difficult as their abundances vary widely in both time and space. As a result, most are also poorly known.

The importance of zooplankton to the distributions of other species in the region may be inferred from the patterns of zooplankton productivity shown on map 2.4. The assemblages illustrated on that map differ in their ability to consume phytoplankton. This appears to have a strong effect on benthic species composition and biomass. For example, much phytoplankton biomass over the inner and middle shelves of the Bering Sea might not be consumed by zooplankton, but might, instead, fall to the bottom to be consumed by benthic organisms such as worms, amphipods, and clams, which in turn, form the principal foods for bottom-feeding species such as crabs, flatfishes, and walrus. In contrast, zooplankton of the outer shelf consume phytoplankton more efficiently, leading to a pelagic, or water column food web, dominated by pelagic fishes, seabirds, and such marine mammals as fin whales and fur seals.

Benthic Crustaceans—These are the shrimps (Maps 3.6-3.10) and crabs (Maps 3.11-3.16) that live as adults on the bottom. They are strong swimmers, or walkers, capable of actively seeking out specific habitats and may undertake considerable seasonal movements. Many of these species have complex life histories, including planktonic larvae and a series of juvenile stages that may be semi-planktonic or benthic. Each life history stage usually has different habitat requirements and ecological relationships.

As with zooplankton, shrimps and crabs are usually aggregated and distributed in patches, making estimates of abundance difficult. The abundance of benthic organisms in the study area may be related to overall primary production (Map 2.2) and the proportion of this production not consumed by zooplankton. The effect of this on the distribution of benthic crustaceans is reflected by epifaunal biomass (Map 2.4), which is high over the southeastern Bering Sea shelf and lower farther north. Bottom type is also a major determinant of the distributions of both juveniles and adults of these species. Post-planktonic individuals generally seek the cover of rubble, submerged vegetation, and rocky bottoms, whereas adults may be more abundant on open sandy to muddy bottoms, due to their lower susceptibility to predation.

There are other benthic crustaceans of great ecological importance, including many species of amphipods and isopods, but their overall distributions are not well studied. The most notable of these are the tube-dwelling ampeliscid amphipods that are the major prey of gray whales in the Bering Strait region. Apparently, they are abundant in that area, but their overall distribution in the region and their life history are poorly known.

Mollusks—There are three main groups of mollusks in the region. Two of these, bivalves (including clams, cockles, and their relatives) and gastropods (including whelks and snails), are generally benthic and sessile, or slow-moving as adults. In contrast, cephalopods (including squid and octopus) swim or crawl and are highly mobile. Most mollusks have planktonic larvae, but some snails hatch directly from egg cases as miniatures of the adults.

Most benthic mollusks are infaunal. Bivalves (Maps 3.18-3.20) are usually buried in sediments with only their siphons extended for feeding and respiration. The predatory whelks hunt their prey by crawling on or through the sediment. Although it is difficult to sample and estimate the abundance of infaunal species, rough estimates of biomass (Map 2.5), combined with known distributions of major mollusk predators (such as walrus and bearded seal), suggest that the Bering Sea mid-shelf and the Bering Strait region support the greatest populations of mollusks in the region. As for benthic crustaceans, this may be correlated with the relatively low zooplankton abundances in this area. The more limited information on Chukchi and Beaufort sea distributions indicates that abundance and diversity are lower than in the Bering Sea. There is also evidence that some of the populations in those northern waters consist of non-reproducing adults that were carried as larvae from the Bering Sea.

Squids (Map 3.17) have entirely different habits from all other mollusks and behave more like fishes. Juveniles and adults are active predators. Most actively swim in schools and prey on fishes and larger invertebrates; they may never be associated with the bottom, except during egg deposition. Squids in this region are most abundant over the Bering Sea outer shelf and continental slope where their prey is concentrated, but are rare north of St. Lawrence Island. In general, squids are major components of invertebrate biomass, but are not well studied in the region.

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Sagitta elegans

3.2 Euphausiids
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3.3 False Calanus Copepods
Pseudocalanus spp.

3.4 Feathery Calanus Copepod
Neocalanus plumchrus

3.5 Dragonfly Amphipod
Themisto libellula

3.6 Small Crangonid Shrimps
Crangon communis, C. dalli, C. septemspinosa

3.7 Large Crangonid Shrimps
Argis dentata, A. lar, Sclerocrangon boreas, Sabinea septemcarinata

3.8 Northern Pink Shrimp
Pandalus borealis

3.9 Other Pandalid Shrimps
Pandalus goniurus, P. tridens, Pandalopsis dispar

3.10 Opossum Shrimps
Mysis litoralis, M. oculata, M. polaris, M. relicta

3.11 Korean Hair Crab
Erimacrus isenbeckii

3.12 Red King Crab
Paralithodes camtschatica

3.13 Golden King Crab
Lithodes aequispina

3.14 Blue King Crab
Paralithodes platypus

3.15 Bairdi Tanner Crab
Chionoecetes bairdi

3.16 Opilio Tanner Crab
Chionoecetes opilio

3.17 Red Squid
Berryteuthis magister

3.18 Chalky Macoma
Macoma calcarea

3.19 Greenland Cockle
Serripes groenlandicus

3.20 Iceland Cockle
Clinocardium ciliatum

References

3.1-3.20

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

Strategic Assessment Branch
Ocean Assessments Division
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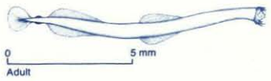


Arrow Worm

Sagitta elegans

3.1

Description

Category

Chaetognatha

Classification

Class—Sagittoidea
Order—Aphragmophora
Family—Sagittidae

Name

Arrow worm, *Sagitta elegans* (glass worm)

Legal Status

None.

Range (Bieri, 1959; Alvariño, 1965)

Worldwide—Panarctic. South to North Carolina, France, Korea, Japan, and Washington State.

Region of Concern—Throughout Bering, Chukchi, and Beaufort seas.

Distribution (Fraser, 1957; Sund, 1959; Alvariño, 1965; Kotori, 1972, 1976; Motoda and Minoda, 1974; Redburn, 1974; McConnell, 1976; Cooney, 1981)

Discrete Populations—Two subspecies in region of concern: *Sagitta elegans arctica* in polar basin and subarctic waters; *S. e. elegans* from polar basin to temperate waters. Distributions of both poorly known. Taxonomic status controversial: subspecies may be ecophenomorphs, probably caused by different temperatures during development.

Concentrations

- *Natural*—Greatest densities of both adults and juveniles in midshelf domain of southeastern Bering Sea. Also common in outer-shelf and deeper waters all year. Lowest densities in coastal domain.
- *Commercial*—Not taken commercially.

Habitat (Lea, 1955; Fraser, 1957; Bieri, 1959; Sund, 1959; Alvariño, 1965; Dawson, 1971; Sameoto, 1971; Kotori, 1972, 1976; Pearre, 1973; Motoda and Minoda, 1974; Cooney, 1981)

Type—Holoplanktonic; epipelagic.

Physical/Chemical—Arctic-boreal. Occur in ice-covered to ice-free waters near surface (less than 200 meters). Temperatures −0.5 to 21.0°C (primarily less than 12°C); salinities at depth of occurrence 10-35.5 ‰ usually greater than 25 ‰.

Life History

Social Behavior (Alvariño, 1965; Ghiradelli, 1968)—Swarming; otherwise unknown.

Biological Associations (Raymont, 1963; Alvariño, 1965)—Commonly with *Calanus* spp., *Oithona* spp., *Pseudocalanus* spp., *Acartia* spp., *Metridia* spp., and *Themisto* spp.

Nutrition (Reeve, 1966; Ghiradelli, 1968; Sameoto, 1971; Pearre, 1973; Barnes, 1974; Kotori, 1976)

- *Feeding type*—Predator.
- *Food*—Most important invertebrate predator in many northern waters. Foods of larvae and juveniles unknown, probably larval copepods. Adults eat copepod nauplii, juveniles, and adults, especially *Pseudocalanus*, *Oithona*, *Acartia*, and *Eurytemora*; also rotifers, polychaetes, euphausiids, amphipods, tintinnids, fish larvae, and other arrow worms. Estimated to consume 10% of secondary production on Bering Sea shelf.
- *Feeding behavior*—Follow swarms of copepods, capturing only actively moving individuals. Prey within 3 mm are detected by vibration. Grasp prey in teeth, then enclose with head spines. Feed day and night year-round; eat more in winter than in summer.
- *Feeding location*—Water column, generally in less than 200-meter depths, or over shelf in less than 50 meters.

Reproduction (Russell, 1932; Dunbar, 1962; Alvariño, 1965; Ghiradelli, 1968; Sherman and Schaner, 1968; Sameoto, 1971, 1973; Zo, 1973; Barnes, 1974; Kotori, 1976)

- *Mode*—Sexual; internal fertilization; monoecious (hermaphroditic).
- *Location*—Breed throughout shelf area and North Pacific Ocean.
- *Behavior*—Animals lie side-by-side, head-to-tail; mutually exchange spermatophores. Mating takes place at night.
- *Biology*—Reproduction is temperature dependent: up to 5 generations per year in warmer waters (south of study area); 3 per year in Bering Sea; one generation every 2 years in high arctic. May spawn all year in arctic regions (mainly June to September); late April to November at lower latitudes, possibly concurrent with peak copepod abundance. Sperm from spermatophores stored and eggs fertilized internally. Eggs released when embryo has developed. Adults die after spawning. Further development of embryo in floating eggs is temperature dependent. Reproductive success low, less than 2% survival from egg to adult.

Development (Russell, 1932; Dunbar, 1962; Sherman and Schaner, 1968; Sameoto, 1971, 1973; Zo, 1973; Kotori, 1976)—Embryos hatch at 1.2-1.4 mm, becoming motile larvae which resemble adults; larvae develop into juveniles (with head spines and anterior fins); juveniles develop into nonreproductive adults. Rate of development to maturity temperature dependent; generation times vary from 45 days in temperate zone to 2 years in arctic.

Growth (Dunbar, 1962; Marumo, 1966; Kotori, 1972, 1976; Barnes, 1974)—In Bering Sea, larvae average 1.2-2.2 mm; juveniles 2.2-7.9 mm; adults are at least 7.9 mm in length. Maximum lifespan 45 days in warmest waters, 2 years in coldest waters.

Movements (Dunbar, 1962; Sherman and Schaner, 1968; Kotori, 1972, 1976; Pearre, 1973)—Diel vertical migration occurs year-round. Adults migrate to near surface at night, to 150-200 meter depths during day; larvae remain near surface, start moving deeper during day with increasing age, size, and swimming speed. Thermoclines slow upward movement, accelerate downward movement. Adults move into deeper water to spawn.

Factors Influencing Populations

Natural (Russell, 1932; Alvariño, 1965; Reeve, 1966; Bédard, 1969; Pearre, 1973; Wing, 1976; Feder and Jewett, 1981)—Predators include pelagic polychaetes, pandalid shrimps, king crabs, hyperiid amphipods, flathead soles, plaice, herring (major predator), and least auklets. Probably taken extensively by fish larvae. Parasitized by nematodes and trematodes, which prevent maturation of gonads.

Human-related—Unknown.

Potential—Effects of marine pollutants unknown.

Population Size (Kotori, 1976)

Estimated to constitute 10% of total zooplankton biomass over Bering Sea shelf. Commonly 100-1,000 individuals per square meter over outer shelf; up to 6,000 over midshelf of southeastern Bering Sea.

Management

None.

Persons Consulted

R. T. Cooney, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
K. O. Coyle, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
B. L. Wing, Northwest and Alaska Fisheries Center, NMFS/NOAA, Auke Bay, Alaska.

Legend

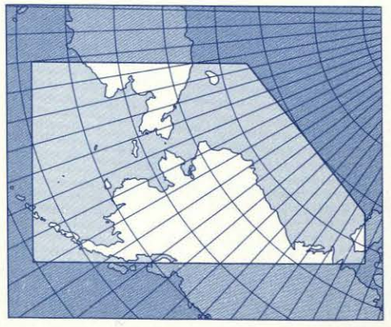
Adult Area
(Year-round)

Major Adult Area
(Year-round)

Spawning occurs April-November south of Bering Strait and June-September north of Bering Strait throughout adult areas. Juveniles occur year-round throughout adult areas. Distribution in western Bering Sea and Chukchi Sea is uncertain.

Map References

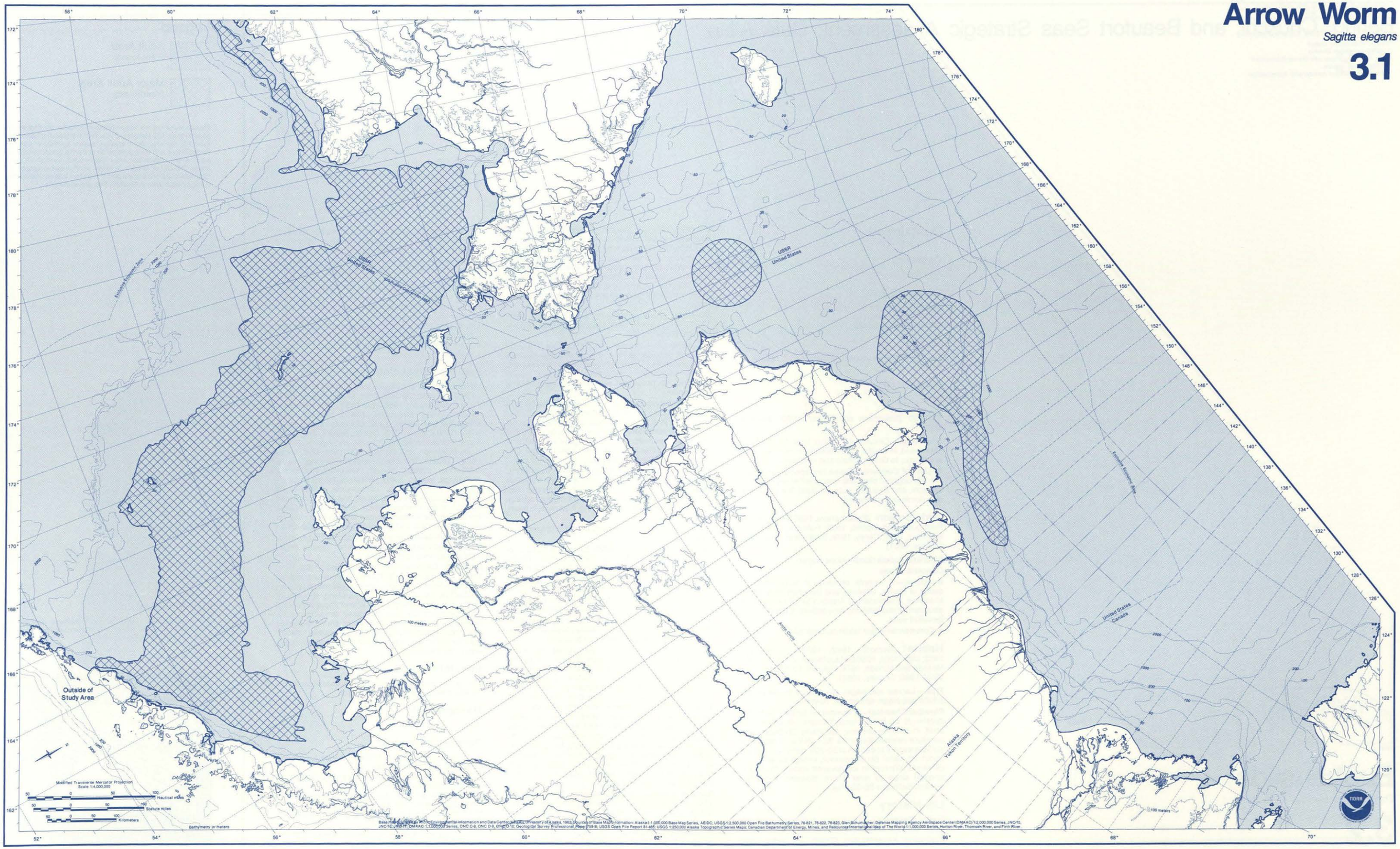
Alvariño, 1965; Redburn, 1974; Kotori, 1976; McConnell, 1976; Wing and Barr, 1977; Cooney, 1981.



Arrow Worm

Sagitta elegans

3.1



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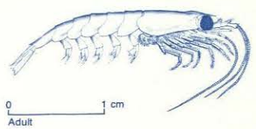


Euphausiids

Thysanoessa inermis, T. raschii

3.2

Description

Category

Arthropod

Classification

Class—Crustacea
Order—Euphausiacea
Family—Euphausiidae

Name

Euphausiids, *Thysanoessa inermis* and *T. raschii* (krill)

Legal Status

None.

Range (Mauchline and Fisher, 1969; Grainger, 1975)

Worldwide—Circumpolar. Occur from Arctic Ocean southward. In Pacific, from Korea to British Columbia; in Atlantic, to Great Britain and northeastern USA.

Region of Concern—These two species are dominant throughout shelf and near-shelf areas of Bering, Chukchi, and Beaufort seas. At least five other species dominant southward.

Distribution (Ponomareva, 1963, 1966; Geiger, Rodriguez, and Murillo, 1968; Fukuchi, 1977; Wing and Barr, 1977; Carey, 1978; Smith and Vidal, 1980; Cooney, 1981)

Discrete Populations—None known.

Concentrations

- *Natural*—*T. inermis* primarily in outer-shelf domains of Bering, Chukchi, and Beaufort seas and in shallower, cold waters of Anadyr Gulf; *T. raschii* most abundant in midshelf domains of Bering, Chukchi, and Beaufort seas.
- *Commercial*—Not taken commercially.

Habitat (Nemoto, 1962, 1966; Ponomareva, 1963; Mauchline, 1966a; Mauchline and Fisher, 1969; Motoda and Minoda, 1974; Fukuchi, 1977; Smith and Vidal, 1980; Cooney, 1981)

Type—Larvae epipelagic, planktonic; juveniles and adults epipelagic-epibenthic, nektonic.

Physical/Chemical—*T. inermis*: in surface waters to depths of 50-300 meters. Winters off continental shelf in ice-free waters; spawning probably temperature related. Salinities 32.1-34‰. *T. raschii*: in surface waters to depths of 20-200 meters, usually to about 20-meter depth contour, except as advected by winds. Winters in ice-covered waters from continental slope to near shore. Spawns in ice-free waters. Salinities 30-33.4‰.

Life History

Social Behavior—Gregarious; commonly occur in large, dense swarms.

Biological Associations (Smith and Vidal, 1980; Cooney, 1981)—*T. inermis* commonly occurs with *Calanus cristatus* and *C. plumchrus*, *Eucalanus b. bungii*, *Eukrohnia hamata*, *Metridia pacifica*, *Sagitta elegans*, *Themisto pacifica*, and *Thysanoessa longipes*. *T. raschii* occurs with *Acartia longiremis*, *Calanus glacialis*, *C. marshallae*, *Pseudocalanus* spp., *Sagitta elegans*, and *Themisto libellula*. Both occur frequently near areas of high primary productivity.

Nutrition (Paulsen, 1909; Ponomareva, 1954, 1955, 1959b, 1963; Lasker, 1966; Mauchline, 1966a; Mauchline and Fisher, 1969)

- *Feeding type*—Nauplii and metanauplii larvae do not feed; older larvae are omnivorous filter-feeders and predators. Juveniles mainly herbivores and detrital filter-feeders, secondarily predators. Adults are principally predators, also herbivores and detrital filter-feeders.
- *Food*—Calyptopis and furcilia larval stages take phytoplankton, diatoms, filamentous algae, dinoflagellates, and larval calanoid copepods. Juveniles and adults take mainly detritus, phytoplankton, and calanoid copepods; also dinoflagellates, diatoms, radiolarians, chaetognaths, echinoderm larvae, amphipods, and other crustaceans.
- *Feeding behavior*—Feed singly or in loose swarms. Juveniles and adults predatory at night in water column, filter-feed near seabed during day; select bioluminescent copepods. Feeding rate highest spring-summer, lowest in winter; in spring, feed most in evening and at night.
- *Feeding location*—Throughout water column, surface to epibenthos.

Reproduction (Lebour, 1926; Einarsson, 1945; Drobysheva, 1957; Nemoto, 1957, 1959; Zelikman, 1958a; Ponomareva, 1959a; Mauchline, 1966a; Mauchline and Fisher, 1969; Smith and Vidal, 1980)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Mainly in ice-free surface waters. *T. inermis* in outer shelf; *T. raschii* in midshelf region.
- *Behavior*—Spawn in surface swarms. High proportion of *T. raschii* population bioluminescent during January-July; believed related to breeding.
- *Biology*—Mate during spring phytoplankton bloom (April-June in Bering Sea, later to north). Eggs released in upper 25 meters of water column shortly after fertilization; slowly sink; hatch 5-7 days later. Fecundity 300-400 eggs per female per year. Breed at 1-2 years. Most production from first breeding age-class; few individuals in older age-classes.

Development (Einarsson, 1945; Nemoto, 1957, 1959; Ponomareva, 1959a, 1963; Mauchline, 1966a; Mauchline and Fisher, 1969)—Larvae hatch as nauplii; molt to metanauplii, then calyptopis, then furciliae. Reach juvenile stage at 2 months. In warmer waters, sexually mature at 1 year (length greater than 14 mm). In colder waters, mature at 2 years (length greater than 22 mm).

Growth (Lebour, 1926; Einarsson, 1945; Nemoto, 1957; Mauchline, 1966a; Mauchline and Fisher, 1969; Smith and Vidal, 1980)—Increase in size with periodic molts greatest in younger individuals. Greatest growth spring-early summer; rate slows in winter with low temperatures and/or low concentrations of phytoplankton. Length to 16 mm by end first summer; 24 mm by end second summer; 30 mm by end third summer. Maximum life duration 3 years.

Movements (Gardiner, 1934; Lacroix, 1961; Mauchline, 1966a; Nemoto, 1966; Mauchline and Fisher, 1969)—Adults, juveniles, and older larvae undergo diel vertical migrations, upward by night, downward by day. Movement slowed by strong thermoclines, not by salinity. Metanauplii generally sink to bottom; older larvae concentrate in upper 50 meters; late furcilia stages tend to move deeper again during day, with juveniles and adults. Most *T. inermis* move to deeper, off-shelf waters during winter; most *T. raschii* remain on shelf all year.

Factors Influencing Populations

Natural (Brook and Hoyle, 1888; Hartley and Fisher, 1936; Einarsson, 1945; Banner, 1954; Nemoto, 1957, 1959; Zelikman, 1958a,b, 1961; Ponomareva, 1959a,b, 1963; Mauchline, 1966b; Bedard, 1969; Mauchline and Fisher, 1969; Ogi and Tsujita, 1973; Mito, 1974; Carey, 1978; Ogi, Kubodera, and Nakamura, 1980; Wehle, 1980; Frost and Lowry, 1981a; Hunt, Burgeson, and Sanger, 1981; Ogi and Hamanaka, 1982)—Predators include herring, cods, rockfishes, capelin, pollock, sculpins, snailfishes, greenlings, skates, soles, flounders, fulmars, shearwaters, storm-petrels, cormorants, phalaropes, jaegers, gulls, kittiwakes, terns, murres, guillemots, auklets, puffins, ringed seals, and baleen whales. Parasitized by *Thalassomyces fagei*, which may reduce growth rate and prevent sexual development.

Human-related—Reduction of populations of predators by commercial fishing or other means might increase survival rate.

Potential (Nelson-Smith, 1973; Johnson, 1977; Rice, Short, and Karinen, 1977)—In crustaceans in general, oil pollution disrupts osmoregulation, alters reproductive behavior, reduces hatching success of eggs, reduces feeding activity, and impairs general locomotor activity; also increases larval mortality, especially during molt. Cold-water shrimps appear more sensitive to oil pollution than do closely related, warmer water species. These findings probably apply also to euphausiids.

Population Size

Unknown. Densities of adults and juveniles commonly 10-100 individuals per square meter.

Management

None.

Persons Consulted

R. T. Cooney, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
K. O. Coyle, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
R. H. Day, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
C. P. McRoy, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
B. L. Wing, Northwest and Alaska Fisheries Center, NMFS/NOAA, Auke Bay, Alaska.

Legend

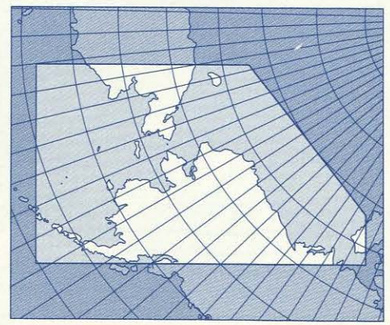
Adult Area
(Year-round)

Major Adult Area
(Year-round)

Thysanoessa inermis occurs primarily on outer shelf (at depths greater than 100 meters); *T. raschii* on midshelf (depths less than 100 meters). Both species spawn April-June south of Bering Strait and May-June north of Bering Strait throughout adult areas. Juveniles occur year-round throughout adult areas. Density of species in major adult areas averages 10-100 individuals per square meter. Western and northern limits of major adult area in Chukchi Sea are uncertain.

Map References

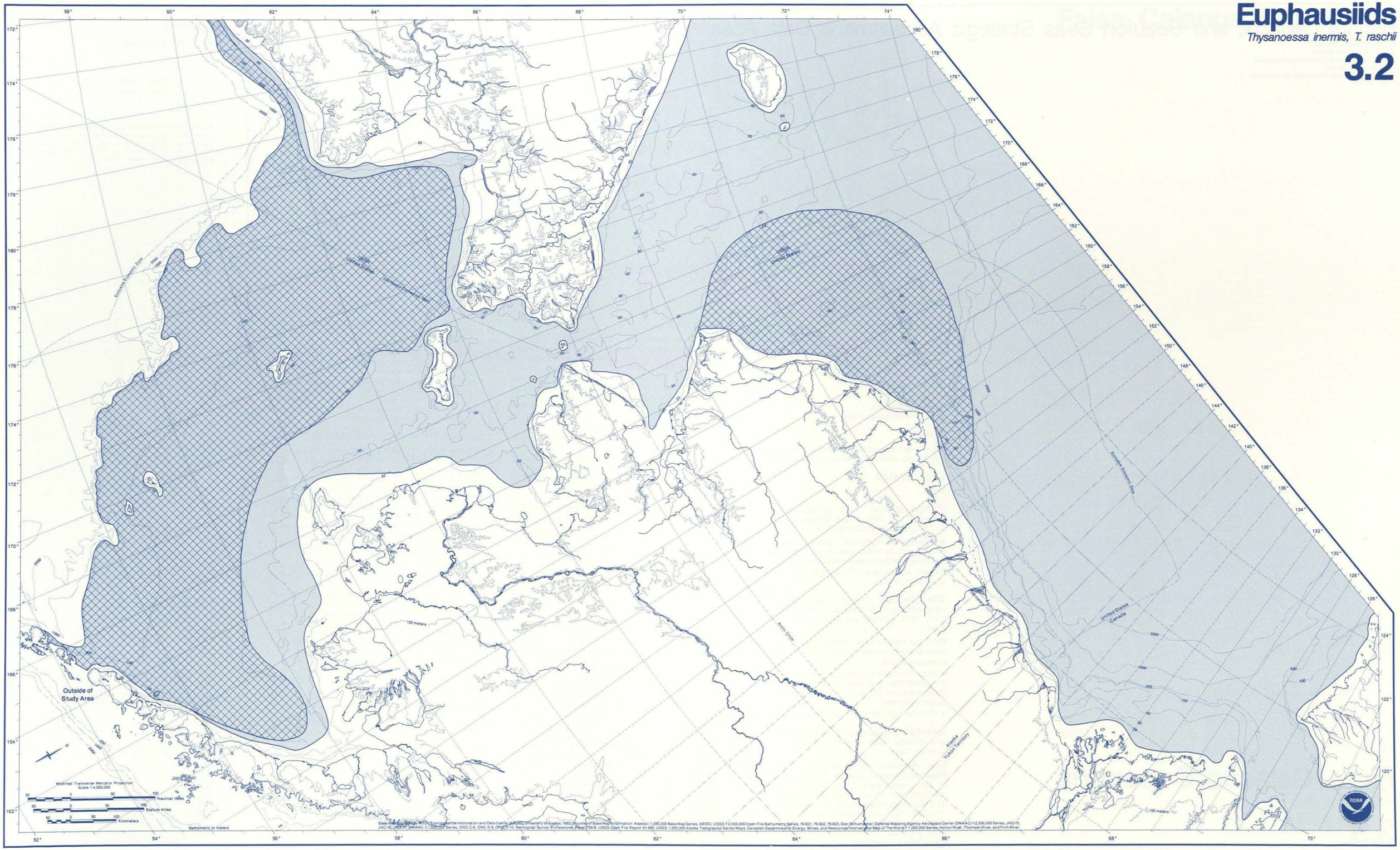
Ponomareva, 1963, 1966; Geiger, Rodriguez, and Murillo, 1968; Mauchline and Fisher, 1969; Motoda and Minoda, 1974; Wing and Barr, 1977; Cooney, 1981.



Euphausiids

Thysanoessa inermis, T. raschii

3.2



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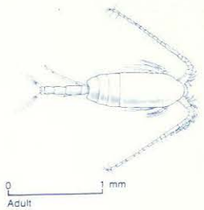


False Calanus Copepods

Pseudocalanus spp.

3.3

Description

Category

Arthropod

Classification

Class—Crustacea
Order—Copepoda
Family—Pseudocalanidae

Name

False calanus copepods, *Pseudocalanus* spp. (taxonomic status of species uncertain)

Legal Status

None.

Range (Brodskii, 1950; Johnson, 1953, 1956; Minoda, 1971; Motoda and Minoda, 1974; Corkett and McLaren, 1978; Cooney, 1981)

Worldwide—Circumpolar, arctic-subarctic. Polar basin, south to Korea and Japan, California, North Carolina, Mediterranean and Black seas.

Region of Concern—Throughout Bering, Chukchi, and Beaufort seas.

Distribution (Brodskii, 1950; Johnson, 1953, 1956; Minoda, 1971; Motoda and Minoda, 1974; Redburn, 1974; Corkett and McLaren, 1978; Cooney, 1981)

Discrete Populations—None known. Poorly differentiated multispecies complex.

Concentrations

- *Natural*—None recorded; densities slightly higher over shelf than over deep water. Dominant member of zooplankton community only in middle-shelf and coastal domains.
- *Commercial*—Not taken commercially.

Habitat (Johnson, 1953; Minoda, 1971; Motoda and Minoda, 1974; Corkett and McLaren, 1978; Cooney, 1981)

Type—Holoplanktonic; epipelagic.

Physical/Chemical—Depths generally 200 meters or less; occasionally to 4,000-5,000 meters; concentrate near thermoclines. Eurythermal (−1.8 to 24.5°C; usually in waters 13°C or less); reproduce at −1.8 to 16°C. Euryhaline (6-37‰); inhabit low salinities only in cold waters; do not reproduce in low-salinity waters. May withstand anoxic conditions for some time. Phototactic.

Life History

Social Behavior (Corkett and McLaren, 1978)—Commonly occur in large, dense swarms, several kilometers in diameter; one swarm estimated at 400 trillion individuals.

Biological Associations (Corkett and McLaren, 1978; Cooney, 1981)—Commonly with *Acartia longiremis*, *Calanus glacialis*, *C. marshallae*, *Oithona similis*, *Sagitta elegans*, *Themisto libellula*, and *Thysanoessa raschii*.

Nutrition (Corkett and McLaren, 1978)

- *Feeding type*—Primarily herbivorous filter-feeders; occasionally predatory.
- *Food*—Primarily diatoms (especially *Coscinodiscus* and *Thalassiosira*); also eat algae, algal detritus, humus particles, flagellates, coccoliths, radiolarians, crustaceans, and dinoflagellates. Occasionally cannibalistic.
- *Feeding behavior*—Prefer centric over pennate diatoms and solitary over chain-forming diatoms. In spring, feed mainly at night.
- *Feeding location*—Throughout water column, but mainly in upper layers.

Reproduction (Corkett and McLaren, 1978)

- *Mode*—Sexual; dioecious.
- *Location*—Unknown. Probably reproduce wherever they occur.
- *Behavior*—Courting in males probably induced by pheromones; swim in zigzag and figure-eight patterns around females.
- *Biology*—In Bering Sea, mate in spring and fall after plankton blooms begin; mate only in summer in Arctic Ocean. Multiple generations, especially in southern part of range. Females lay up to 35 eggs per clutch in one or more clutches; early clutches generally large, fertile; later clutches small and/or infertile. Fecundity directly proportional to size of female, food supply, and hatch of previous clutch. Female carries eggs 3-19 days until they hatch, then extrudes next clutch. Total egg-laying period up to 110 days. Males die after mating; females have postreproductive life of up to 100 days.

Development (Brodskii, 1950; Corkett and McLaren, 1978)—Temperature determines incubation period, which is shorter at higher temperatures. Nauplii undergo 3 naupliar, 3 metanaupliar, 5 copepodite stages; duration of each stage temperature dependent. Mature in 35-40 days at 12°C, 2 years at 0°C.

Growth (Corkett and McLaren, 1978)—Increase in size with each molt, growing more slowly and to larger size in colder waters. Food supply does not influence ultimate size, but does influence growth rate; adult male body length 1.1-2.0 mm, females 1.2-2.4 mm. Body size of each generation affected by size of parents. Maximum life duration of males 35 days to 2 years; females, 6 months to 2.5 years.

Movements (Corkett and McLaren, 1978)—Undertake diel vertical migrations. Hatching nauplii swim toward surface; metanaupliii and early copepodite stages stay at surface; older copepodite stages and adults swim to surface at night, then swim downward to 50-100 meters by day. Amount of diel migration decreases in winter. Overwintering stages and egg-laying females move to deeper waters.

Factors Influencing Populations

Natural (Wing, 1976; Corkett and McLaren, 1978)—Eaten by larval salmon, sardines, mackerel, sprats, haddock, whiting, plaice, hake, turbot, sand lances, and eelbennies; extremely important as food to herring, cods, and some baleen whales. Also eaten by euphausiids, hyperiid amphipods, ctenophores, chaetognaths, and hydromedusae. Parasitized by dinoflagellates (prevent sexual maturity, eat contents of eggs), ellobiopsids (prevent sexual maturity), trematodes and nematodes (use as intermediate host), sporozoites (effects unknown), and epicarid isopods (suck blood, use as intermediate host).

Human-related—Reduction of populations of any of these predators and parasites might increase rate of survival.

Potential (Nelson-Smith, 1973; Johnson, 1977; Rice, Short, and Karinen, 1977; Spooner and Corkett, 1979)—Oil has been shown to reduce feeding activity and impair general locomotor activity in this genus. Oil also disrupts osmoregulation, impairs reproductive behavior, decreases hatching success of eggs, and increases larval mortality of other crustaceans. Cold-water shrimps appear more sensitive to oil pollution than do closely related, warmer water species. These findings probably apply also to *Pseudocalanus* species.

Population Size (Corkett and McLaren, 1978)

Estimated to be the most abundant metazoans in the world.

Management

None.

Persons Consulted

R. T. Cooney, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
H. M. Feder, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
B. L. Wing, Northwest and Alaska Fisheries Center, NMFS/NOAA, Auke Bay, Alaska.

Legend

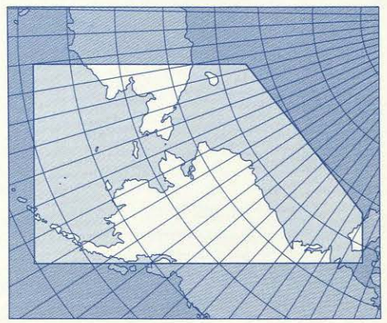
Adult Area (Year-round)

Major Adult Area (Year-round)

Spawning occurs April-May and September-October south of Bering Strait and May-June north of Bering Strait throughout adult areas. Juveniles occur year-round throughout adult areas. Western and northern limits of major adult areas in Bering and Chukchi seas are uncertain.

Map References

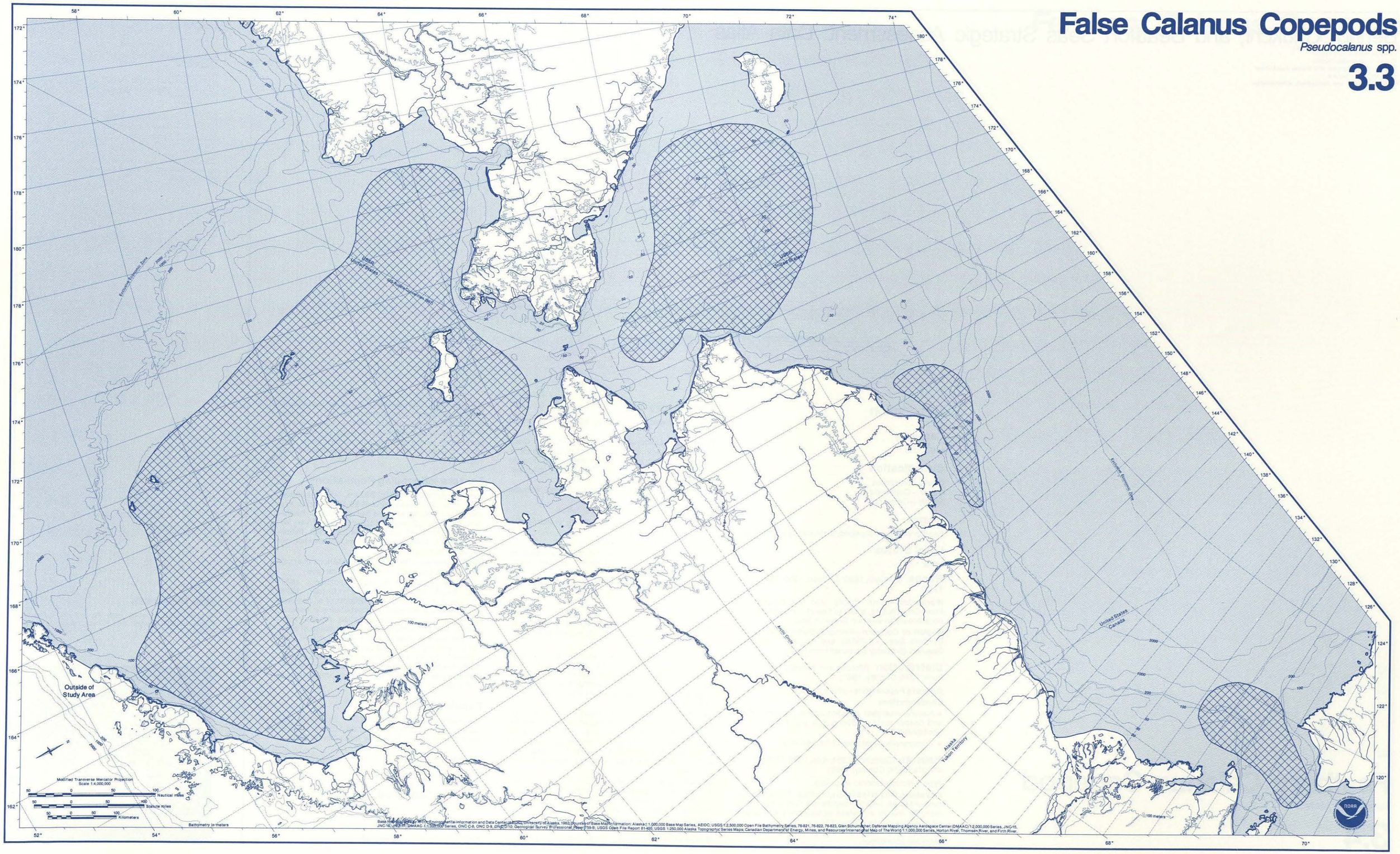
Brodskii, 1950; Johnson, 1953, 1956; Minoda, 1971; Motoda and Minoda, 1974; Redburn, 1974; Wing and Barr, 1977; Corkett and McLaren, 1978; Cooney, 1981.



False Calanus Copepods

Pseudocalanus spp.

3.3



Base map data courtesy of the Environmental Information and Data Center (AEIDC), University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-455; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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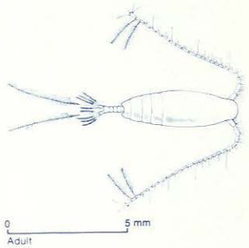


Feathery Calanus Copepod

Neocalanus plumchrus

3.4

Description

Category

Arthropod

Classification

Class—Crustacea
Order—Copepoda
Family—Calanidae

Name

Feathery calanus copepod, *Neocalanus plumchrus*

Legal Status

None.

Range (Brodskii, 1950; Johnson, 1953, 1956; Kos, 1972)

Worldwide—North Pacific and arctic-subarctic. From Chukchi Sea, south to Sea of Japan and 40°N; occasionally to western Beaufort Sea.

Region of Concern—Primarily Bering Sea; also in Chukchi Sea (to 73°N) and rarely to western Beaufort (probably advected from south).

Distribution (Motoda and Minoda, 1974; Redburn, 1974; Cooney, 1981)

Discrete Populations—None known.

Concentrations

- *Natural*—Largest concentrations on outer shelf and deeper parts of Bering Sea, especially around shelf-break.
- *Commercial*—Not taken commercially.

Habitat (Campbell, 1934; Kos, 1972; Motoda and Minoda, 1974; Cooney, 1981)

Type—Holoplanktonic; epipelagic.

Physical/Chemical—Salinities 30-34.2‰; temperatures 1-13°C; depths 0-1,000 meters (immatures mostly in waters of less than 80 meters; most adults in greater than 300 meters). Occurrence in upper water layers coincides with times of phytoplankton abundance.

Life History

Social Behavior—Swarming; behavior otherwise unknown.

Biological Associations (Cooney, 1981)—Commonly found with *Calanus cristatus*, *Eucalanus b. bungii*, *Eukrohnia hamata*, *Metridia pacifica*, *Sagitta elegans*, *Themisto pacifica*, *Thysanoessa longipes*, and *T. inermis*.

Nutrition (Campbell, 1934; Heinrich, 1962; Minoda, 1971)

- *Feeding type*—Herbivore; filter-feeder.
- *Food*—Young eat phytoplankton, primarily diatoms; adults do not feed.
- *Feeding behavior*—Unknown.
- *Feeding location*—Upper 200 meters of water column, especially upper 50 meters (where phytoplankton are most abundant).

Reproduction (Campbell, 1934; Brodskii, 1950; Heinrich, 1962; Minoda, 1971; Cooney, 1981)

- *Mode*—Sexual; dioecious.
- *Location*—Outer-shelf and oceanic waters, generally near shelf-break; mostly near surface (100-150 meters) where depth is 300 meters or more.
- *Behavior*—Unknown.
- *Biology*—Energy for reproduction derived from stored lipids. Mate shortly after final molt to adulthood, mid- to late winter; males die after mating, females after spawning. Fecundity averages 200 eggs per female. Eggs released into water column, hatch into naupliі.

Development (Campbell, 1934)—Incubation rate probably temperature controlled; factors affecting rate of development of naupliar and metanaupliar stages unknown; copepodite stages probably food controlled. Molt through 3 naupliar, 3 metanaupliar, and 5 copepodite stages over 3.5-4 months. Mature at 1 year.

Growth (Campbell, 1934; Omori, 1969)—Increase in size with periodic molts through copepodite stages I-V (juveniles) to stage VI (adult). First naupliar stage 0.28-0.30 mm; adults 4.5-5.0 mm. Males and females grow and molt at same rate. Maximum life duration 1 year.

Movements (Campbell, 1934; Vinogradov, 1968; Minoda, 1971; Cooney, 1981)—Diel vertical migrations controlled by light intensity, slowed by thermoclines. Immatures migrate daily; adults evidently migrate little. Last copepodite stage (V) moves to deep water in late summer; overwinters there, then molts to stage VI and returns to surface waters to spawn in spring.

Factors Influencing Populations

Natural (Brodskii, 1950; Bedard, 1969; Minoda, 1971; Kos, 1972; Kawamura, 1980; Frost and Lowry, 1981a; Hunt, Burgeson, and Sanger, 1981)—Predators include pollock, saury, mackerel, herring (very important), young of many planktophagous fishes, auklets, and some baleen whales. Information on parasites lacking.

Human-related—Reduction of populations of any of these predators might increase survival rate.

Potential (Nelson-Smith, 1973; Johnson, 1977; Rice, Short, and Karinen, 1977; Corner, 1978; Spooner and Corkett, 1979)—Effects of oil pollution on this species unknown. In crustaceans in general, oil pollution disrupts osmoregulation, impairs reproductive behavior, reduces hatching success of eggs, reduces feeding activity, and impairs general locomotor activity; also increases larval mortality, especially during molt. Cold-water shrimps appear more sensitive to oil pollution than do closely related, warmer water species. These findings probably apply to this species.

Population Size

Unknown. Reaches 100 to 1,000 individuals per square meter on outer shelf; 1,000-10,000 in deeper parts of Bering Sea, especially around shelf-break.

Management

None.

Persons Consulted

R. T. Cooney, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
B. L. Wing, Northwest and Alaska Fisheries Center, NMFS/NOAA, Auke Bay, Alaska.

Legend

Adult Area
(January-April)

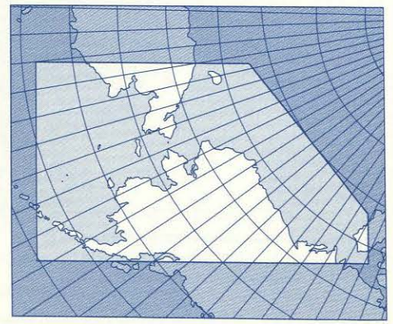
Juvenile Area
(February-October)

Juvenile Area
(May-September)
Expatriates

Spawning occurs January-April throughout adult area; adults die after spawning. Juveniles also occur year-round throughout adult area.

Map References

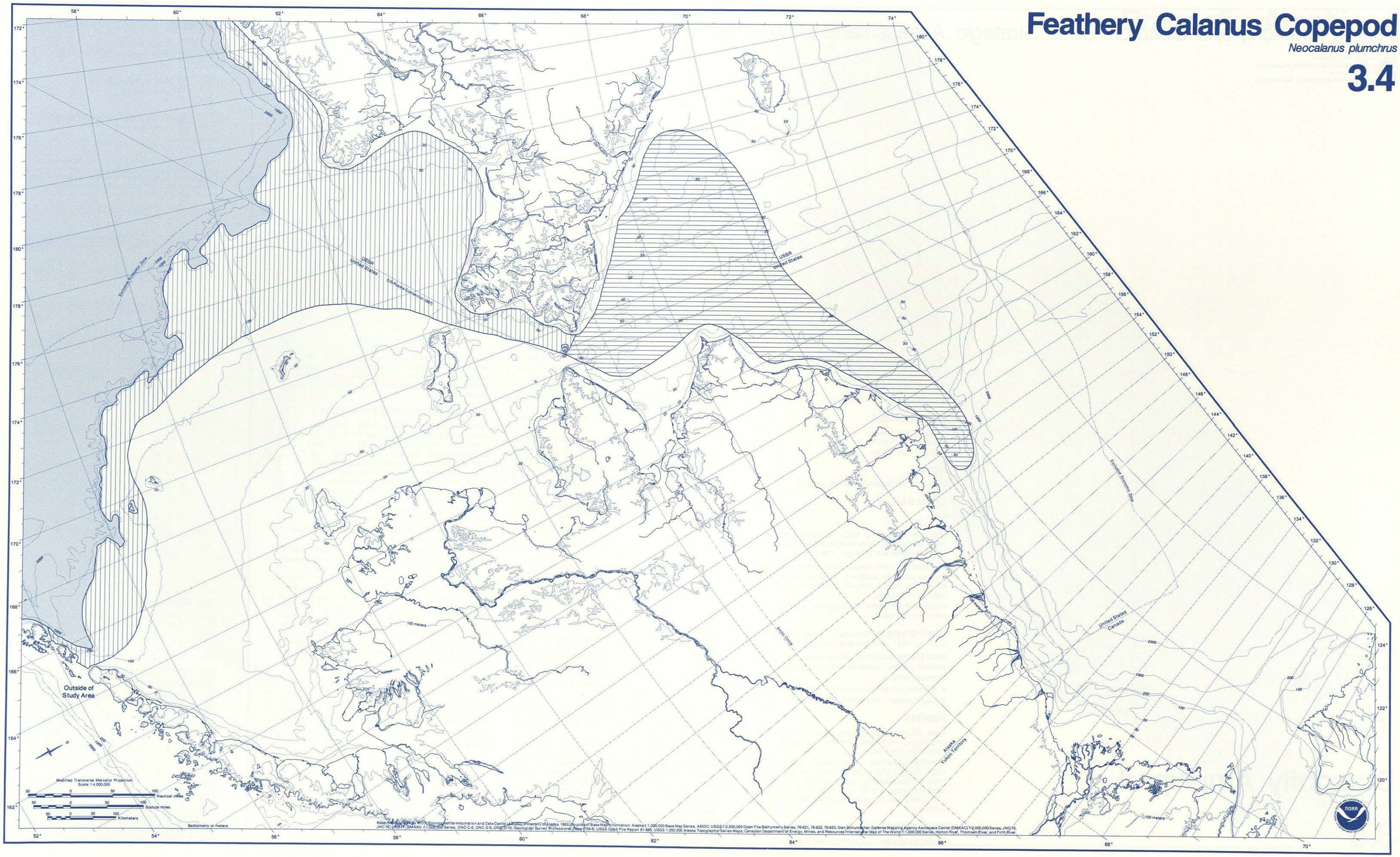
Brodskii, 1950; Johnson, 1956; Motoda and Minoda, 1974; Redburn, 1974; Cooney, 1981. Personal communication from Cooney.



Feathery Calanus Copepod

Neocalanus plumchrus

3.4



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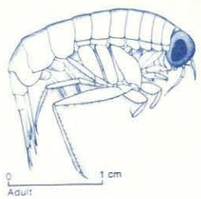


Dragonfly Amphipod

Themisto libellula

3.5

Description

Category

Arthropod

Classification

Class—Crustacea
Order—Amphipoda
Family—Hyperiidae

Name

Dragonfly amphipod, *Themisto libellula*

Legal Status

None.

Range (Bowman, 1960; Motoda and Minoda, 1974; McConnell, 1976; Wing and Barr, 1977; Cooney, 1981; Griffiths and Dillinger, 1981)

Worldwide—Circumpolar, arctic and subarctic. In Pacific, south to southern Okhotsk Sea and southeastern Alaska; in Atlantic, south to Gulf of St. Lawrence and Norway.

Region of Concern—Throughout Bering, Chukchi, and Beaufort seas.

Distribution (Bowman, 1960; Wing, 1976; Cooney, 1981; Griffiths and Dillinger, 1981)

Discrete Populations—None known, except southeastern Alaska population may be glacial relict.

Concentrations

- *Natural*—Greatest in middle-shelf domain.
- *Commercial*—Not taken commercially.

Habitat

Type (Dunbar, 1957; Wing, 1976)—Young juveniles epipelagic, planktonic; older juveniles and adults epipelagic, nektonic.

Physical/Chemical (Shoemaker, 1955; Dunbar, 1957; Wing, 1976)—Occur mostly to depths of 300 meters, occasionally 2,500 meters; commonly in temperatures to 8°C, with maximum probably 15-17°C; salinities 28-34‰. Mostly in areas of sea ice in winter.

Life History

Social Behavior—Swarming near surface.

Biological Associations (Cooney, 1981)—Commonly found with *Acartia longiremis*, *Calanus glacialis*, *C. marshallae*, *Oithona similis*, *Pseudocalanus* spp., *Sagitta elegans*, and *Thysanoessa raschii*.

Nutrition (Bigelow, 1926; Dunbar, 1941; Bowman, 1960; Wing, 1976)

- *Feeding type*—Predator; small juveniles occasionally herbivorous.
- *Food*—Small juveniles: mainly calanoid copepod nauplii, occasionally phytoplankton. Large juveniles and adults: mainly calanoid copepods (all stages); also euphausiids, amphipods, chaetognaths, polychaetes, larval fishes, cladocerans, cyclopids, and *Themisto pacifica*. Occasionally cannibalistic when young.
- *Feeding behavior*—No significant diel variation in rate of feeding. Copepods taken in proportion to their abundance. Cannibalism appears more common in cold waters.
- *Feeding location*—Throughout water column; primarily in upper 200 meters.

Reproduction (Dunbar, 1941, 1957; Bédard, 1969; Barnes, 1974; Wing, 1976; Griffiths and Dillinger, 1981)

- *Mode*—Sexual; dioecious; external fertilization.
- *Location*—Unknown; assumed to be in water column of middle and inner shelf.
- *Behavior*—Unknown.
- *Biology*—Reproductive periods poorly known, probably year-round, with maximum activity in late winter-early spring. Eggs brooded in marsupium; early juveniles brooded 3-8 weeks more before being released. Most males die shortly after reproduction, most females shortly after release of young. Fecundity about 40 eggs per female.

Development (Dunbar, 1957; Wing, 1976)—Incubation period of eggs and young temperature dependent. Mature at 2 years in cold waters, 1 year in warmer waters.

Growth (Dunbar, 1941, 1957; Bowman, 1960; Wing, 1976)—Young increase in size with periodic molts; juveniles about 2 mm long when released from marsupium; adult males about 20 mm in warm waters, 30 mm in colder waters; females about 23 mm in warm waters, 35 mm in colder waters; maximum length in arctic individuals, 60 mm.

Movements (Wing, 1976)—Diel vertical migrations: older juveniles and adults to 200-300 meters during day, less than 100 meters (most less than 50 meters) at night; young juveniles generally remain at depths less than 50 meters. Vertical migrations not influenced by weather, sea state, or cloud cover. In warmer waters, most older juveniles and adults stay below thermocline, even at night. Seasonal movements unknown.

Factors Influencing Populations

Natural (Dunbar, 1941, 1946; Grainger, 1953; Bédard, 1969; Mito, 1974; Wing, 1976; Ogi, Kubodera, and Nakamura, 1980; Frost and Lowry, 1981b; Hunt, Burgeson, and Sanger, 1981; Lowry and Frost, 1981a; Ogi and Hamanaka, 1982)—Predators include pasiphaeid shrimps, salmonids, pollock, rockfishes, Arctic cod, herring, shearwaters, kittiwakes, murres, auklets, puffins, ringed seals, and some baleen whales. Parasitized by ellobiopsid parasite *Thalassomyces marsupii*, which reduces growth rate and retards sexual development.

Human-related—Reduction of populations of any of these predators might increase survival rate.

Potential (Nelson-Smith, 1973; Linden, 1976; Johnson, 1977; Percy, 1977; Rice, Short, and Karinen, 1977)—Effects of oil pollution on this species unknown. In crustaceans in general, oil has been shown to disrupt osmoregulation, impair reproductive behavior, decrease hatching success of eggs, and increase larval mortality, especially during molt; also reduces feeding activity and growth rate, impairs general locomotor activity, and increases metabolic activity in amphipods. Cold-water shrimps appear more sensitive to oil pollution than do closely related, warmer water species. These findings probably apply to this species.

Population Size

Unknown. Densities in southeastern Bering Sea, 10-100 individuals per square meter; in Beaufort and Chukchi seas mean density about 0.25 individuals per square meter, but can be much greater in patches.

Management

None.

Persons Consulted

R. T. Cooney, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
K. O. Coyle, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
B. L. Wing, Northwest and Alaska Fisheries Center, NMFS/NOAA, Auke Bay, Alaska.

Legend

Adult Area
(Year-round)

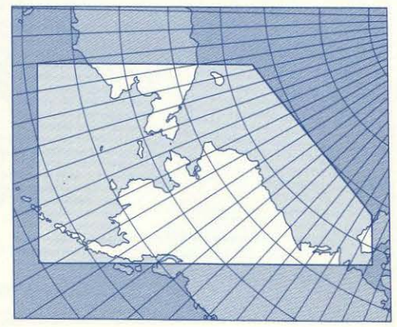
Major Adult Area
(Year-round)

Major Adult Concentration
(Year-round)

Spawning (February-April) and hatching (May) occur throughout adult areas. Juveniles occur year-round throughout adult areas. Distribution very patchy; density ranges from less than one to more than 100 individuals per square meter. Western limit of major adult area in Chukchi Sea is uncertain.

Map References

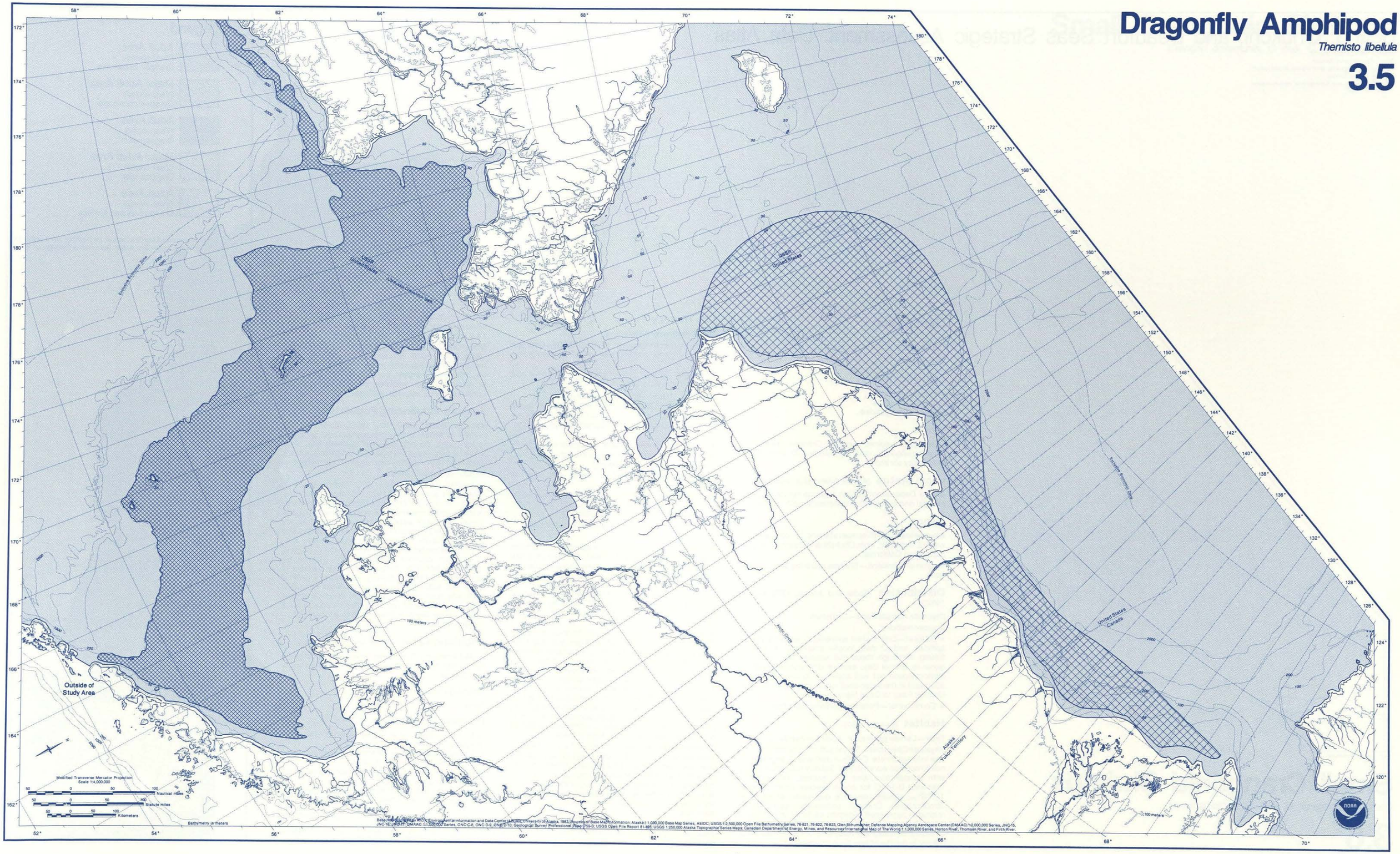
Bowman, 1960; Motoda and Minoda, 1974; McConnell, 1976; Wing, 1976; Wing and Barr, 1977; Cooney, 1981; Griffiths and Dillinger, 1981.



Dragonfly Amphipod

Themisto libellula

3.5



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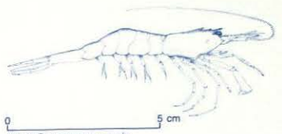

Adult, *Crangon communis*

Small Crangonid Shrimps

Crangon communis, C. dalli, C. septemspinosa

3.6

Description

Category

Arthropod

Classification

Class—Crustacea
Order—Decapoda
Family—Crangonidae

Name

Common two-spined crangon, *Crangon communis*; ridged crangon, *C. dalli*; sand shrimp, *C. septemspinosa* (gray shrimp)

Legal Status (Alaska Administrative Code)

Alaska Department of Fish & Game regulates commercial and subsistence fisheries in USA waters.

Range

Worldwide—North-temperate and boreal to arctic waters. In Pacific, from Chukchi and Beaufort seas to Japan and California.

Region of Concern—Shelves of Bering and Chukchi seas.

Distribution (Feder and Jewett, 1978; Butler, 1980)

Discrete Populations—Unknown.

Concentrations

- *Natural*—Distribution sporadic. *Crangon septemspinosa* and *C. dalli* locally abundant in Norton Sound. Although these two species are known to occur in Bristol Bay, inshore distribution south of Norton Sound not well known. *C. communis* locally abundant in the outer-shelf region of Bering Sea from Unimak Pass to Cape Navarin.
- *Commercial*—Potential commercial fishery.

Habitat (Butler, 1980)

Type—Larvae planktonic. Adults primarily benthic.

Physical/Chemical—Prefer soft, muddy bottom; burrow into substrate. *Crangon dalli* and *C. septemspinosa* reported eurythermal. Salinity tolerance varies with temperature, also with gender. Temperature tolerance 0-14°C for some species; salinity range 19-36‰; salinity tolerance depressed at extreme temperatures. *Crangon communis* restricted to middle to outer shelf in depths 46-327 meters; found mainly between 79 and 137 meters. Both *C. dalli* and *C. septemspinosa* are residents of inner-shelf area, mainly in depths of less than 55 meters.

Life History

Social Behavior—Unknown.

Biological Associations (Butler, 1980)—*Crangon communis* closely associated with *Pandalus borealis*.

Nutrition—(Tiews, 1970; Jeffries, 1974; Feder and Jewett, 1980; Rice, 1980)

- *Feeding type*—Scavenger, predator.
- *Food*—Crustaceans, polychaetes, small mollusks (e.g., *Nuculana*), diatoms, and detritus. Sediment is a frequent and significant component of stomach contents.
- *Feeding behavior*—These shrimps are "gulpers"; whole animals often found in stomach. Often sort through sediment while feeding.
- *Feeding location*—Adults feed primarily on bottom.

Reproduction (Lloyd and Yonge, 1947; Meredith, 1953; Schokaert, 1968; Haefner, 1969; Tiews, 1970; Couture, Corrivault, and Frechette, 1971)

- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Unknown.
- *Behavior*—As spawning time approaches, females retire to a sheltered position and do not eat. No copulatory organs; male's spermatophore applied to ventral side of female near genital opening. During spawning, female lies on side with abdomen bent under thorax; eggs pass back in chains from genital opening, assisted by first pair of abdominal appendages, then attach to abdominal appendages within 30 minutes.
- *Biology*—Sex differences not obvious in young. Females molt prior to mating. Eggs laid May-September within 2 days of molting, regardless of copulation. If copulation has not occurred, eggs fail to develop. Spawning time and frequency highly variable with location and environmental conditions. Spawn 1-3 times per year, usually 2; lowest frequency in coldest waters. Females may carry eggs throughout year. Fecundity varies with size of female. Clutch size to 4,300 eggs for some species; eggs 0.35-0.40 mm in diameter. Average fecundity (*C. communis*) in Bering Sea, 2,200 eggs per clutch; eggs 0.9 mm.

Development (Meredith, 1953; Tiews, 1970)—Developing eggs whitish; those ready to hatch usually greenish, ovate, and eyed. Incubation time more than 10 weeks at 6°C. Larvae approximately 2 mm at hatching, increasing to 4.7 mm by end of 5th (final) larval stage when animal becomes benthic. Planktonic period 5 weeks or more, depending on temperature.

Growth—*Crangon communis*: males to 21-mm carapace length, females to 24 mm in the study area. *C. dalli*: males to 18.0-mm carapace length, females to 15-mm carapace length in study area. *C. septemspinosa*: males to 15-mm carapace length, females to 14.5 mm.

Movements (Lloyd and Yonge, 1947; Meredith, 1953; Tiews, 1970; Makarov, 1976; Barsukov and Ivanov, 1979)—Seasonal migrations onshore in winter, offshore in summer, perhaps related to changes in salinity. Some evidence of vertical migration. Larvae also may migrate vertically.

Factors Influencing Populations

Natural (Butler, 1980; Rice, 1980)—Eaten by wide variety of fishes and macroinvertebrates including pollock, cod, snow crabs, and flathead sole. Also taken by bearded seals, walruses, and white whales. Parasitized by branchial isopods and rhizocephalans.

Human-related—Unknown.

Potential (Nelson-Smith, 1973; Johnson, 1977; Rice, Short, and Karinen, 1977; Edwards, 1978; Rice, 1980)—Hydrocarbons contaminate sediment-detritus food systems. Chronic exposure to low concentrations of water-soluble oil fractions causes disturbances in endocrine system, early molting, and unusual behavior in *Crangon crangon*; higher concentrations cause death. In crustaceans in general, oil pollution disrupts osmoregulation, impairs reproductive behavior, reduces hatching success of eggs, reduces feeding activity, and impairs general locomotor activity; also increases larval mortality, especially during molt. Cold-water shrimps appear more sensitive to oil pollution than closely related, warmer water species. These findings probably apply to these species.

Population Size (Feder and Jewett, 1980)

C. dalli found in 1/3 of survey trawls in the southeast Bering Sea, and *C. communis* in 1/4. Reliable population data lacking.

Management

None.

Persons Consulted

H. M. Feder, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
K. I. McCumby, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
R. L. Rice, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
C. I. Winiecki, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.

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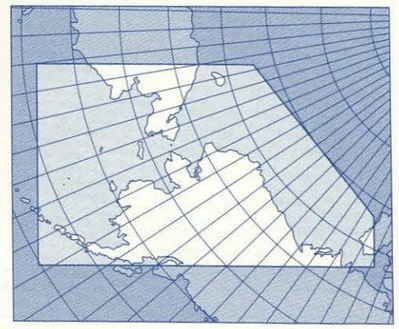
Legend

- Adult Area (Year-round) *Crangon communis*
- Major Adult Area (Year-round) *Crangon communis*
- Adult Area (Year-round) *Crangon dalli*
- Major Adult Area (Year-round) *Crangon dalli*
- Adult Area (Year-round) *Crangon septemspinosa*

Spawning occurs May-September throughout adult areas for each species. Juveniles occur year-round throughout adult areas.

Map References

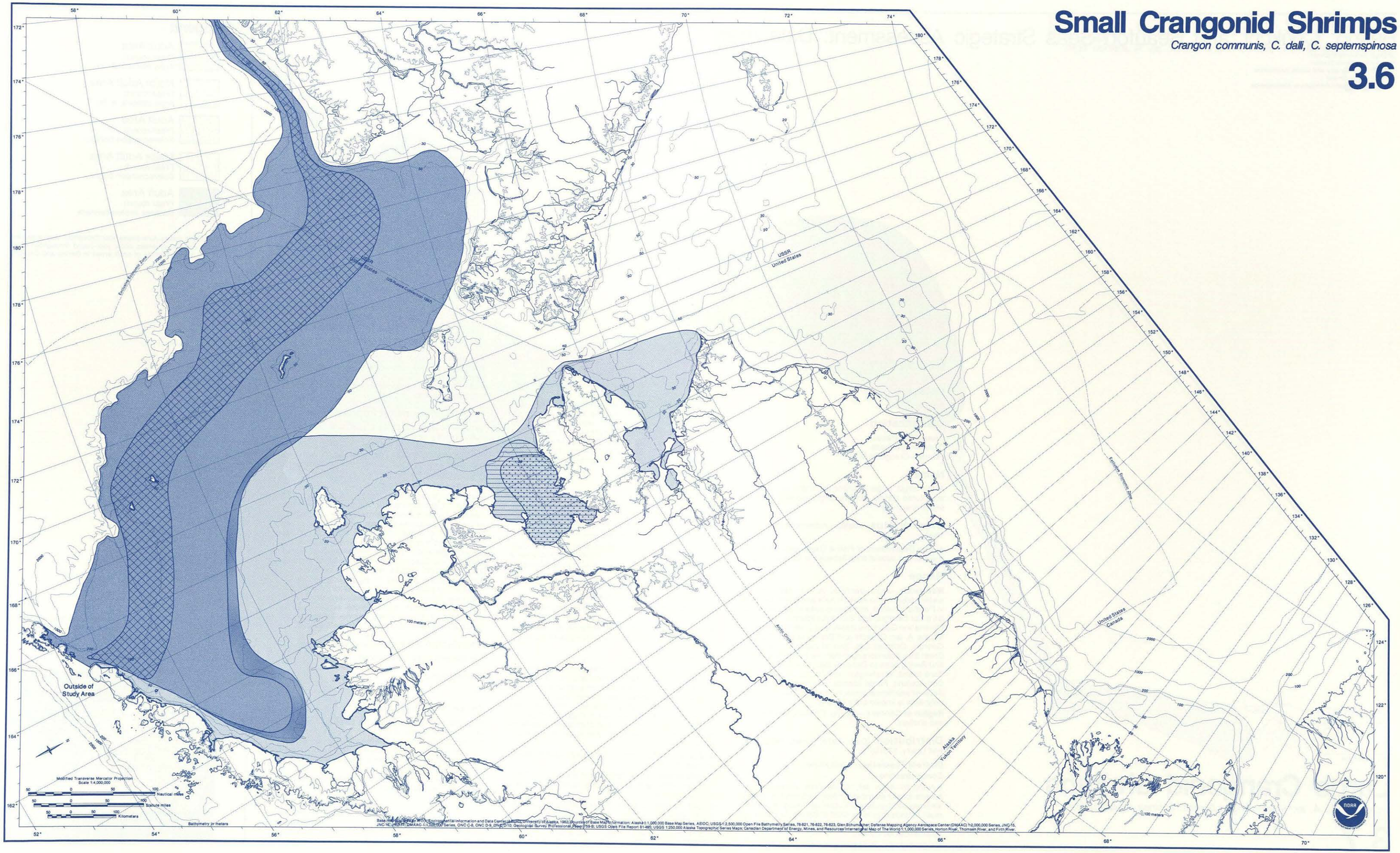
Feder and Jewett, 1978; Butler, 1980; Northwest and Alaska Fisheries Center, n.d. Personal communications from Frost; Jewett; Lowry.



Small Crangonid Shrimps

Crangon communis, C. dalli, C. septemspinosa

3.6



Base map prepared by ARCTIC Environmental Information and Data Center, UAA/APU, University of Alaska, 1982; Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17, DMAAC-1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-485; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

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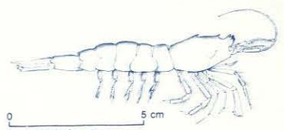


Adult, *Argis dentata*

Large Crangonid Shrimps

Argis dentata, A. lar, Sclerocrangon boreas, Sabinea septemcarinata

3.7

Description

Category
Arthropod

Classification
Class—Crustacea
Order—Decapoda
Family—Crangonidae

Name
Arctic argid, *Argis dentata*; northern argid, *A. lar*; sculptured shrimp, *Sclerocrangon boreas*; *Sabinea septemcarinata*

Legal Status (Alaska Administrative Code, 1984)
Alaska Department of Fish & Game regulates commercial and subsistence fisheries in USA waters.

Range
Worldwide—*Argis dentata*, *A. lar*: restricted to waters adjacent to eastern Asia and North America; in Pacific, Chukchi, and Bering seas to Sea of Japan, Strait of Georgia, and San Juan Islands; in Atlantic, Coronation Gulf, Foxe Basin, and Greenland to Nova Scotia. *A. lar*: Chukchi and Bering seas to Strait of Georgia; Okhotsk Sea, Sea of Japan, to Peter the Great Bay. *Sclerocrangon boreas*: in Pacific, Chukchi and Bering seas to Okhotsk Sea, Sea of Japan, and Bare Island, Washington; in Atlantic, south to Cape Cod, Iceland, Faroe Islands, and northern Norway. *Sabinea septemcarinata*: in Beaufort Sea shelf areas only; little is known of its biology.

Region of Concern—Bering, Chukchi, and Beaufort sea shelves.

Distribution (Cary, 1978; Butler, 1980; Frost and Lowry, 1981b)
Discrete Populations—Not known.

Concentrations

- *Natural*—*Argis lar*, *A. dentata*, *Sclerocrangon boreas* locally abundant in Norton Sound. *S. boreas* also may be abundant in Kotzebue Sound. *A. dentata* most abundant in inner shelf of Bering Sea. *Sabinea septemcarinata* found only in Beaufort Sea; local abundance not known.
- *Commercial*—Potential commercial fishery.

Habitat (Butler, 1980)
Type—*Argis* larvae planktonic. *Sclerocrangon* has direct development (lecitrophic), juveniles benthic. Adults primarily benthic.

Physical/Chemical—Prefer soft, muddy bottom; burrow into substrate. Both *Argis lar* and *A. dentata* found mainly in inner-shelf areas at depths of 11-68 meters; common in depths to 150 meters, but occasionally to 2,000 meters. *Sclerocrangon boreas* is also inner-shelf resident with the greatest numbers between 25 and 57 meters; depths range from 0 to 366 meters.

Life History
Social Behavior—Unknown.

Biological Associations (Butler, 1980)—Unknown.

Nutrition—(Feder and Jewett, 1980)

- *Feeding type*—Scavenger, predator.
- *Food*—Crustaceans, polychaetes, small mollusks (e.g., *Nuculana*), diatoms, and detritus. Sediment a frequent and significant component of stomach contents.
- *Feeding behavior*—Unknown.
- *Feeding location*—Adults feed on bottom.

Reproduction (Couture, Corrivault, and Frechette, 1971)

- *Mode*—Sexual, external fertilization, dioecious. Protandrous, in *Argis*; in *Sclerocrangon*, protandry is questionable.
- *Location*—Unknown.
- *Behavior*—As spawning time approaches, females retreat to a sheltered position and do not eat. No copulatory organs; male's spermatophore applied to ventral side of female near genital opening. During spawning, female lies on side with abdomen bent under thorax; eggs pass back in chains from genital opening, assisted by first pair of abdominal appendages, then attach to abdominal appendages within 30 minutes.
- *Biology*—Little known. Probably spawn spring through summer.

Development—Developing eggs greenish in *Argis* and *Sclerocrangon*; those ready to hatch greenish, ovate, and eyed.

Growth—*Argis lar* and *A. dentata* males found in the study area to 21.5-mm carapace length, females to 32-mm carapace length. *Sclerocrangon boreas* maximum recorded size 25-mm carapace length for males, 27-mm carapace length for females.

Movements (Lloyd and Yonge, 1947; Meredith, 1953; Tiews, 1970; Makarov, 1976; Barsukov and Ivanov, 1979)—Seasonal migrations, onshore in winter, offshore in summer; perhaps related to changes in salinity.

Factors Influencing Populations
Natural (Butler, 1980; Rice, 1980)—Predators include a wide variety of fishes and macroinvertebrates, including pollock, cod, snow crabs, and flathead sole. Also taken by bearded seals, walruses, and white whales. Parasitized by branchial isopods, rhizocephalans, and leeches.

Human-related—Unknown.

Potential (Nelson-Smith, 1973; Johnson, 1977; Rice, Short, and Karinen, 1977; Edwards, 1978; Rice, 1980)—Hydrocarbons contaminate sediment-detritus food systems. Chronic exposure to low concentrations of water-soluble oil fractions causes disturbances in endocrine system, early molting, and unusual behavior; higher concentrations cause death. In crustaceans in general, oil pollution disrupts osmoregulation, impairs reproductive behavior, reduces hatching success of eggs, reduces feeding activity, and impairs general locomotor activity; also increases larval mortality, especially during molt. Cold-water shrimps appear more sensitive to oil pollution than closely related, warmer water species. These findings probably apply to these species.

Population Size (Feder and Jewett, 1980)
Reliable population data lacking.

Management
None.

Persons Consulted
H. M. Feder, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
K. I. McCumby, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
R. L. Rice, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
C. I. Winiecki, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.

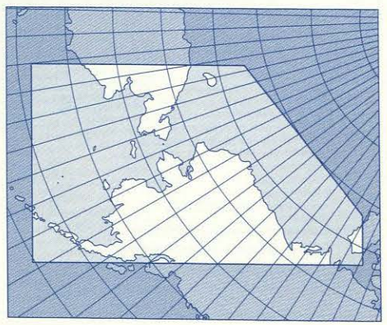
PAUL J. ANDERSON

Northwest and Alaska Fisheries Center, National Marine Fisheries Service, Kodiak, Alaska.

Legend
- Adult Area (Year-round) *Argis dentata, A. lar*
- Major Adult Area (Year-round) *Argis dentata, A. lar*
- Adult Area (Year-round) *Sclerocrangon boreas*
- Major Adult Area (Year-round) *Sclerocrangon boreas*
- Adult Area (Year-round) *Sabinea septemcarinata*

Spawning occurs June-September throughout adult areas for each species. Juveniles occur year-round throughout adult areas. Western limits of adult areas in Bering and Chukchi seas are uncertain.

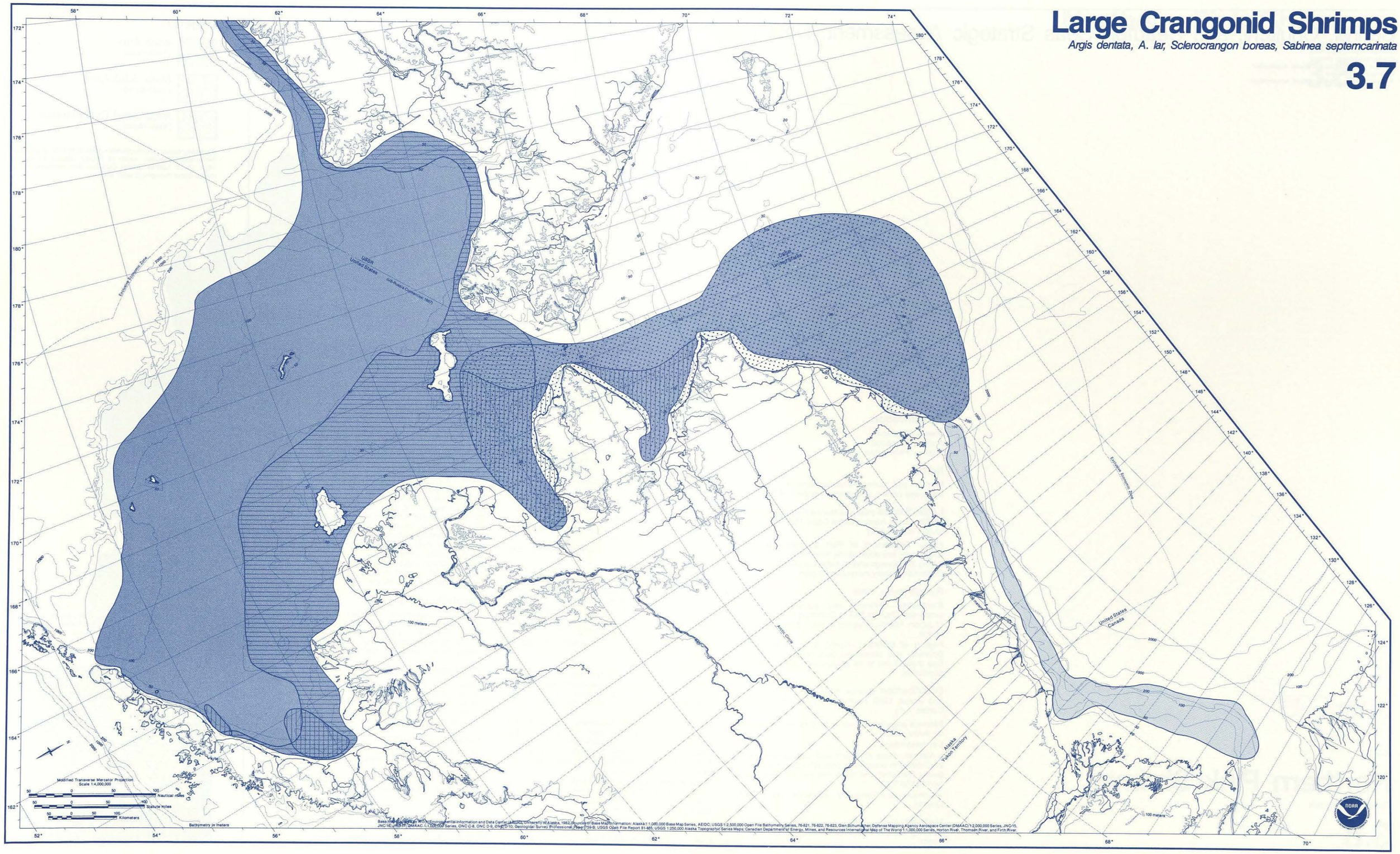
Map References
Carey, 1978; Butler, 1980; Frost and Lowry, 1981; Northwest and Alaska Fisheries Center, n.d. Personal communication from Jewett.



Large Crangonid Shrimps

Argis dentata, A. lar, Sclerocrangon boreas, Sabinea septemcarinata

3.7



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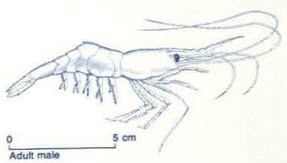


Northern Pink Shrimp

Pandalus borealis

3.8

Description

Category

Arthropod

Classification

Class—Crustacea
Order—Decapoda
Family—Pandalidae

Name

Northern pink shrimp, *Pandalus borealis*
(deep-sea prawn, pink shrimp, northern shrimp)

Legal Status (National Marine Fisheries Service, 1976b; Alaska Administrative Code, 1984, tit. 5, secs. 02.001 and 31.001)

Alaska Department of Fish & Game regulates commercial and subsistence fisheries in USA waters. Bering Sea foreign shrimp fishery prohibited under a preliminary fishery management plan.

Range (Butler, 1980)

Worldwide—Holarctic and subarctic to cold temperate. Chukchi Sea to Columbia River and Sea of Japan; Atlantic subarctic to North Sea and Gulf of Maine.

Region of Concern—Bering and Chukchi Seas. Sporadic and occasional occurrences in Chukchi Sea thought not to be contiguous with Bering Sea population.

Distribution (Ivanov, 1964, 1967, 1970; Feder and Jewett, 1980; Northwest and Alaska Fisheries Center, n.d.)

Discrete populations—May be only one population for entire area.

Concentrations

- *Natural*—Most abundant and concentrated near 2°C-isotherm boundaries between water masses on Bering Sea shelf and slope. Highest densities found north of 58°N.
- *Commercial*—Previously abundant off Pribilof Islands.

Habitat (Ivanov, 1964, 1967, 1970; Fox, 1972; National Marine Fisheries Service, 1976b; Butler, 1980)

Type—Larvae planktonic; adults primarily benthic. Prefer a smooth, soft, muddy to sandy bottom substrate. Organic content of sediment may influence distribution more than sediment type.

Physical/Chemical—Occasionally to 1,400 meters; mainly between 50 and 200 meters in study area. Temperatures from -1 to 11°C; mainly 1.5-4.5°C. Salinity 30-33‰.

Life History

Social Behavior—During mating season, all sizes and sexes mix; at all other times frequently segregate by size and sex.

Biological Associations (Ippolito, 1980)—In trawl catches with arrowtooth flounder, flathead sole, halibut, yellowfin sole, cod, walleye pollock, sand lance, capelin, and the common two-spined crangon.

Nutrition (Barr, 1970; Paul et al., 1979; Feder and Jewett, 1980; Rice, McCumby, and Feder, 1980; Stickney and Perkins, 1981)

- *Feeding type*—Predator, scavenger, detritus- and deposit-feeder.
- *Food*—Zooplankton, crustaceans, polychaetes, diatoms, detritus, and organic matter from sediment.
- *Feeding behavior*—Foraging. Some small clams and polychaetes swallowed whole.
- *Feeding location*—In water column and on bottom.

Reproduction (Ivanov, 1964; Fox, 1972; Alaska Department of Fish & Game, 1978)

- *Mode*—Sexual; external fertilization; monoecious, protandrous hermaphrodyte.
- *Location*—Unknown.
- *Behavior*—Female molts to breeding state; within 36 hours, male attaches spermatophores between last two pairs of female's pereopods. Fertilization and oviposition occur as eggs stream from oviducts and attach to pleopods.
- *Biology*—Spawn July-September north of Pribilof Islands, September-November to south. Timing related to temperature. Fecundity 500-2,500 eggs per clutch. Eggs carried until hatching, mainly March-April. Early larval stages found in or above spawning beds, not in surface waters.

Development (Butler, 1980)—Larvae planktonic for 2-3 months; molt 6 times to juvenile stage, then sink to bottom. Most mature as males at 1.5-2.5 years of age; transform to females at 3.5-4.5 years.

Growth—Males attain maximum of 25-mm carapace length; females reach 33.5 mm in the study area. Maximum lifespan at least 8 years, possibly longer.

Movements (Barr, 1970)—Circumstantial evidence suggests daily vertical movements: shrimp leave bottom at dusk and return at dawn.

Factors Influencing Populations

Natural (Fox, 1972; National Marine Fisheries Service, 1976b; Ippolito, 1980)—Heavy predation by demersal fishes. Reported to be parasitized by bopyrid isopods, rhizocephalans, and microsporidians.

Human-related—Commercial fishing.

Potential (Nelson-Smith, 1973; Johnson, 1977; Rice, Short, and Karinen, 1977; Rice, McCumby, and Feder, 1980)—Due to ingestion of sediment, potentially susceptible to hydrocarbon contamination of bottom. Juveniles and adults sensitive to sublethal levels of napthalene. In crustaceans in general, oil pollution disrupts osmoregulation, impairs reproductive behavior, reduces hatching success of eggs, reduces feeding activity, and impairs locomotor activity; also may cause suffocation and increased larval mortality, especially during molt. Cold-water shrimps appear more sensitive to oil pollution than closely related, warmer water species. These findings probably apply to pink shrimp.

Population Size

In 1979, population between Pribilofs and USA/USSR convention line estimated at 63,566 metric tons, with 80% confidence interval of 54,776-72,353 metric tons. Population data inadequate for before and after 1979.

Management

Management in eastern Bering Sea directed by a preliminary fishery management plan of the North Pacific Fishery Management Council and by state of Alaska statutes. Peak catches in 1963; over 30,000 metric tons harvested.

Persons Consulted

F.B. Hartsock, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, Kodiak, Alaska.
A.J. Ippolito, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.

PAUL J. ANDERSON
Northwest and Alaska Fisheries Center, National Marine Fisheries Service, Kodiak, Alaska.

Legend

Adult Area
(Year-round)

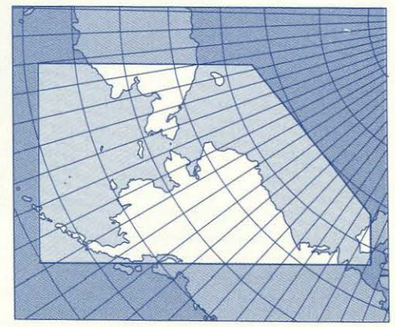
Major Adult Area
(Year-round)

Major Adult Concentration
(Year-round)

Spawning occurs July-September north of Pribilof Islands and September-November south of Pribilof islands throughout adult areas. Larvae (March-October) and juveniles (year-round) occur throughout adult areas.

Map References

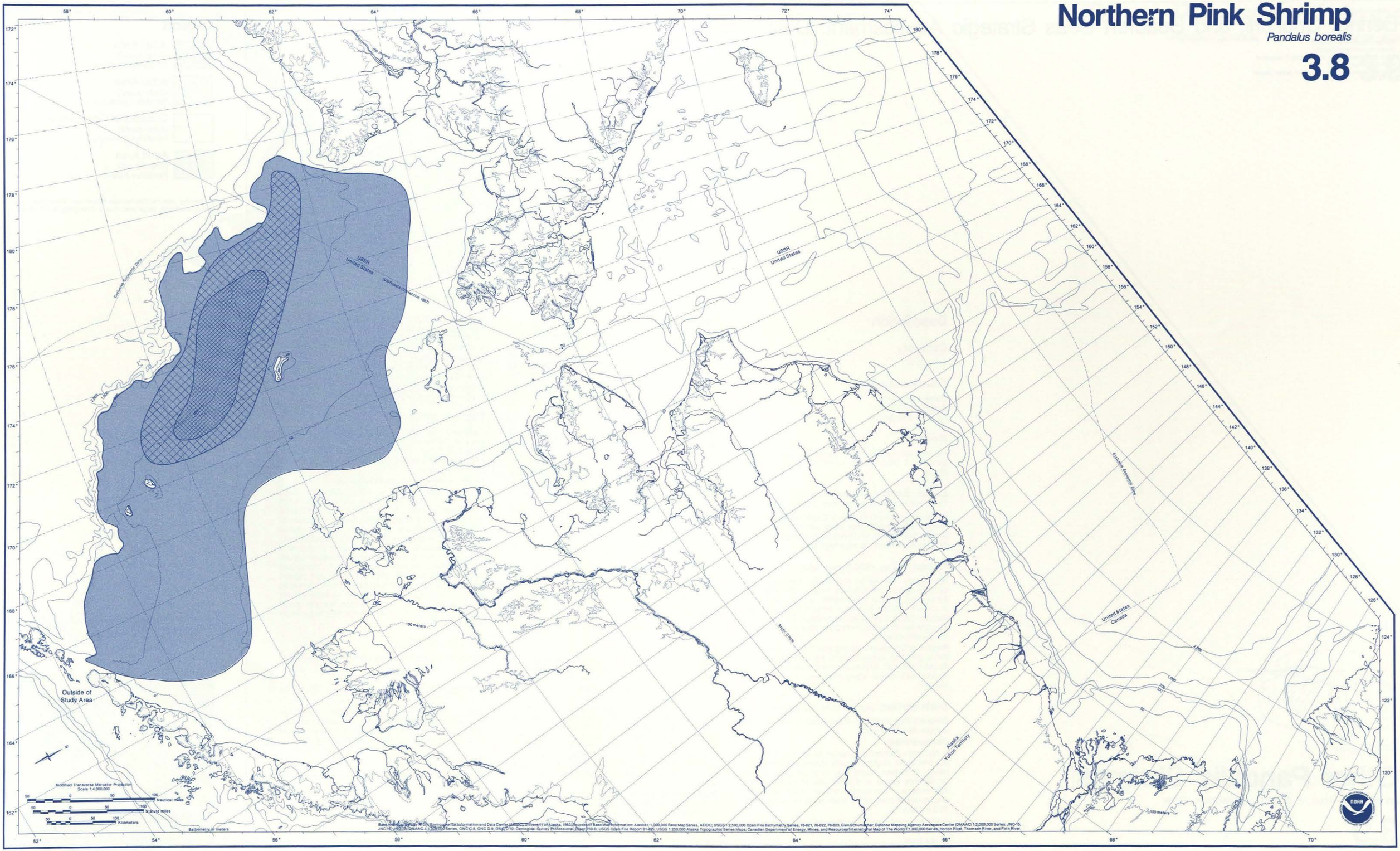
Ivanov, 1964, 1967, 1970; Butler, 1980; Feder and Jewett, 1980; Northwest and Alaska Fisheries Center, n.d. Personal communications from Anderson; Hartsock.



Northern Pink Shrimp

Pandalus borealis

3.8



Base map data derived from Environmental Information and Data Center (AEIDC), University of Alaska, 1982; Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-555; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

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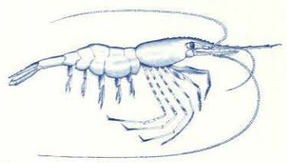


Adult, *Pandalopsis dispar*

Other Pandalid Shrimps

Pandalus goniurus, P. tridens, Pandalopsis dispar

3.9

Description

Category

Arthropod

Classification

Class—Crustacea
Order—Decapoda
Family—Pandalidae

Name

Humpy shrimp, *Pandalus goniurus*; yellow-legged pandalid, *P. tridens*; side-stripe shrimp, *Pandalopsis dispar*

Legal Status (Alaska Administrative Code, 1984; National Marine Fisheries Service, 1976b)

Alaska Department of Fish & Game regulates commercial and subsistence fisheries in USA waters. Bering Sea foreign shrimp fishery prohibited under preliminary fishery management plan.

Range (Carey, 1978; Butler, 1980)

Worldwide—Boreal to low arctic. *Pandalus goniurus*: Beaufort and Chukchi seas to Okhotsk Sea, Sea of Japan (near Vladivostok), and Puget Sound. *P. tridens*: Bering Sea near Pribilof Islands to San Nicolas Island, California. *Pandalopsis dispar*: Bering Sea and North Pacific from Cape Navarin to Manhattan Beach, Oregon.

Region of Concern—Bering and Chukchi seas. *Pandalus goniurus* occasionally to eastern Chukchi and Beaufort seas; *P. tridens* around Pribilof Islands only; *Pandalopsis dispar* along shelf edge north to Cape Navarin.

Distribution (Ivanov, 1974; Hartsock, n.d.)

Discrete Populations—Each species is apparently a discrete population.

Concentrations

- *Natural*—*Pandalus goniurus* found widely on middle and inner shelves; locally abundant throughout range. *P. tridens* found only in small area around St. George Island in the Pribilofs in depths of 83-128 meters. *Pandalopsis dispar* most abundant and concentrated along shelf edge in waters 170-700 meters.
- *Commercial* (Ivanov, 1974)—*Pandalus goniurus* formerly harvested in Gulf of Anadyr; stock currently at low level.

Habitat

Type—Larvae planktonic; adults primarily benthic.

Physical/Chemical—*Pandalus goniurus* occurs in depths of 20-150 meters and *Pandalopsis dispar* in 200-700 meters within the study area. All species prefer a smooth, soft, muddy to sandy bottom. Organic content of sediment may influence distribution more than sediment type. Temperatures −1 to 11°C; mainly 1.5 to 4.5°C.

Life History

Social Behavior—During mating season, all size and sex categories intermix. All other times of year, frequently segregated by size and sex in adult areas.

Biological Associations (Ippolito, 1980)—In trawl catches, associated with arrowtooth flounder, flathead sole, halibut, yellowfin sole, cod, walleye pollock, sand lance, and capelin.

Nutrition (Barr, 1970; Paul et al., 1979; Feder and Jewett, 1980; Rice, McCumby, and Feder, 1980; Stickney and Perkins, 1981)

- *Feeding type*—Predator, scavenger.
- *Food*—Zooplankton, crustaceans, polychaetes, diatoms, detritus, and sediment.
- *Feeding behavior*—Adults forage on bottom and in water column. Some small clams and polychaetes swallowed whole.
- *Feeding location*—Water column and on bottom.

Reproduction (Ivanov, 1964; Fox, 1972; Alaska Department of Fish & Game, 1978)

- *Mode*—Sexual; external fertilization; dioecious; protandrous.
- *Location*—Unknown.
- *Behavior*—Within 36 hours after female molts to breeding state, male attaches spermatophores between the last two pairs of female's pereiopods. Fertilization and oviposition occur as eggs stream from oviducts and attach to pleopods.
- *Biology*—Spawning takes place in September-November; probably earlier (June-July) in northern areas. Timing may be related to temperature. Fecundity 1,200-4,100 eggs per clutch for *Pandalopsis dispar*; 2,000 for *Pandalus goniurus*; no fecundity information available for *P. tridens*. Eggs carried until hatching, mainly March-April. Early larval stages found in or above spawning beds, not in surface waters.

Development (Butler, 1980)—Larvae planktonic, 2-3 months; 7 zoeal stages known for *Pandalus tridens* and *Pandalopsis dispar*; number of molts to juvenile stage unknown. *Pandalus goniurus* has 7 larval stages preceding juvenile stage. Age at maturity not reliably known.

Growth—*Pandalus goniurus* males attain 22.5-mm carapace length; females reach 25.6-mm carapace length in the Bering Sea. Adequate data on size not available for other species within the study area.

Movements (Barr, 1970; Ivanov, 1970; Barsukov and Ivanov, 1979)—Third larval stage spent in shallow water in summer; subsequently with adults in deeper water during first winter. Some daily vertical movements may be linked with feeding.

Factors Influencing Populations

Natural (Fox, 1972; National Marine Fisheries Service, 1976b; Ippolito, 1980)—Heavy predation by demersal fishes. Pandalid shrimps reported to be parasitized by bopyrid isopods, rhizocephalans, and microsporidians.

Human-related—Commercial fishing.

Potential (Nelson-Smith, 1973; Johnson, 1977; Malins et al., 1977; Rice, Korn, and Karinen, 1977; Rice, Short, and Karinen, 1977; Rice et al., 1979; Rice, McCumby, and Feder, 1980)—Due to ingestion of sediment, potentially susceptible to hydrocarbon contamination of bottom. Juveniles and adults sensitive to sublethal levels of napthalene. In crustaceans in general, oil pollution disrupts osmoregulation, impairs reproductive behavior, reduces hatching success of eggs, reduces feeding activity, and impairs locomotor activity; also increases larval mortality, especially during molt. Cold-water shrimps appear more sensitive than closely related, warmer water species to oil pollution. These findings probably apply to these species.

Population Size

Population size not adequately known in the study area.

Management (National Marine Fisheries Service, 1976b)

Open to commercial fishing. Management in eastern Bering Sea directed by preliminary fishery management plan of the North Pacific Fishery Management Council and pertinent state of Alaska statutes.

Persons Conulted

A. J. Ippolito, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.

PAUL J. ANDERSON

Northwest and Alaska Fisheries Center, National Marine Fisheries Service, Kodiak, Alaska.

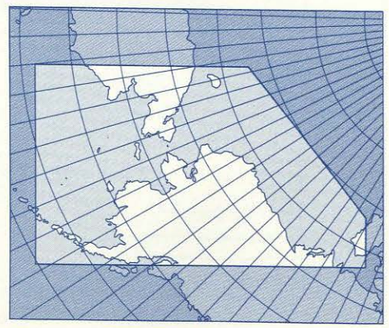
Legend

- Adult Area (Year-round) *Pandalopsis dispar*
- Adult Area (Year-round) *Pandalus goniurus*
- Occasional Occurrence (Year-round) *Pandalus goniurus*
- Adult Area (Year-round) *Pandalus tridens*

Spawning occurs September-November throughout adult areas. Juveniles occur year-round throughout adult areas.

Map References

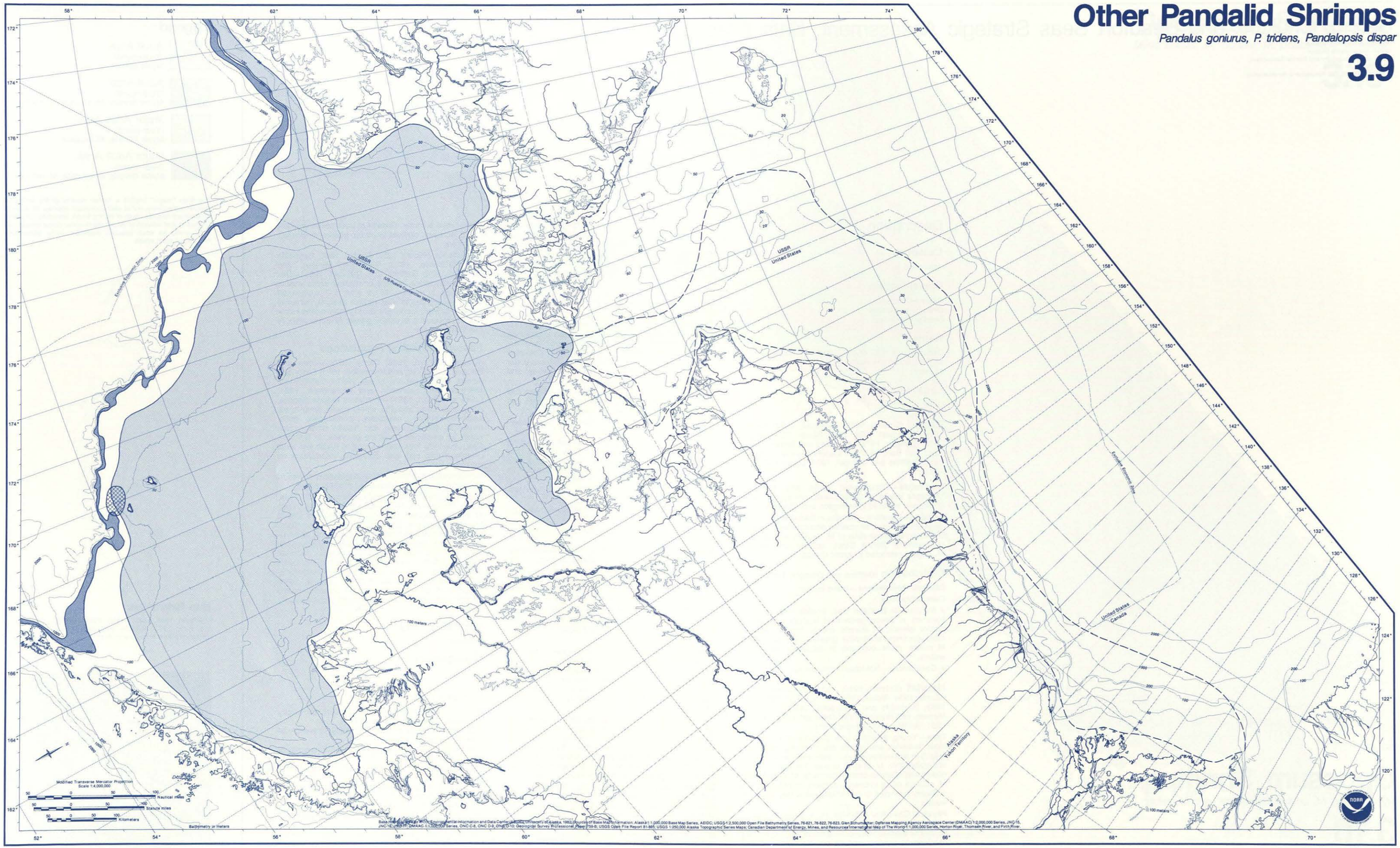
Ivanov, 1974; Hartsock, n.d. Personal communications from Frost; Lowry.



Other Pandalid Shrimps

Pandalus goniurus, P. tridens, Pandalopsis dispar

3.9



Base map by NOAA, Environmental Information and Data Center (AEIDC, University of Alaska, 1982) Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-621, 76-622, 76-623, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-16, JNC-17, JNC-18; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-555; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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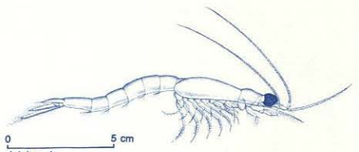


Adult male

Opossum Shrimps

Mysis litoralis; M. oculata; M. polaris; and M. relicta

3.10

Description

Category

Arthropod

Classification

Class—Crustacea
Order—Mysidacea
Family—Mysidae

Name

Opossum shrimps, *Mysis litoralis*, *M. oculata*, *M. polaris*, and *M. relicta*
(mysids)

Legal Status

None.

Range (Schmitt, 1919; Tattersall, 1933; Banner, 1954; Holmquist, 1958, 1963; Ricker, 1959; Geiger, 1969; Grainger, 1975; Mauchline and Murano, 1977; Wing and Barr, 1977; de Ladurantaye and Lacroix, 1980; Griffiths and Dillinger, 1981; Lowry and Frost, 1981)

Worldwide—Circumpolar, arctic and subarctic. *M. relicta* inland to Great Lakes, northern Eurasia. *M. litoralis* south to Washington and Quebec.

Region of Concern—Ranges in Bering and Chukchi Seas unconfirmed; all species occur in Beaufort Sea. Documented occurrence of *M. oculata* and *M. relicta* south of Bering Strait, latitude unconfirmed. *M. polaris* restricted to Arctic Ocean.

Distribution (Griffiths and Dillinger, 1981)

Discrete Populations—None known.

Concentrations

- *Natural*—In Beaufort Sea, mysids may be most common in deeper waters of lagoons, inshore of barrier islands; *M. litoralis* and *M. oculata* may be most common at depths greater than 30 meters; *M. relicta* more common in estuarine and fresh waters.
- *Commercial*—Not taken commercially.

Habitat (Schmitt, 1919; Juday and Birge, 1927; Banner, 1954; Ricker, 1959; Beeton, 1960; Holmquist, 1963; Reynolds and DeGraeve, 1972; Carpenter, Mansey, and Watson, 1974; Grainger, 1975; Cooney, 1981; Griffiths and Dillinger, 1981)

Type—Young juveniles are planktonic, epipelagic; older juveniles and adults are nektonic, epipelagic (night) to epibenthic (day); in very shallow waters, all are epibenthic. *M. polaris* occurs throughout open-ocean and offshore coastal domains. *M. litoralis* and *M. oculata* occur in coastal domain, and *M. relicta* is probably restricted to nearshore, estuarine, and fresh waters.

Physical/Chemical—Mysids as a group are euryhaline (0-70‰). Species exhibit salinity preferences: *M. relicta* fresh to marine, *M. litoralis* and *M. oculata* brackish to marine; and *M. polaris* marine. Some species eurythermal (-3.5 to 20°C, primarily less than 14°C). Muddy to stony bottom; prefer sand or gravel with large amounts of detritus and/or algae for concealment. Depths from shore to more than 200 meters. Some can withstand anoxic conditions for some time. Vertical migrations controlled by light.

Life History

Social Behavior (Barnes, 1974)—Frequently occur in large, dense swarms.

Biological Associations (Juday and Birge, 1927)—Commonly occur with other mysids and amphipods (*Monoculodes crassirostris, Monoculopsis longicornis, Pontoporeia affinis* and *P. femorata, Onisimus glacialis, Acanthostepheia incarinata, Boeckosimus affinis, Apherusa megalops, Aceroides latipes,* and *Acanthomysis pseudomacropsis*).

Nutrition (Lasenby and Langford, 1973; Bowers and Grossnickle, 1978; Broad et al., 1979; Cooper and Goldman, 1980; Griffiths and Dillinger, 1981)

- *Feeding type*—Omnivore-scavenger; also filter-feed, especially when young.
- *Food*—*M. relicta* eats primarily detritus derived from peat; *M. litoralis* takes primarily diatoms, but also copepods, cladocerans, algae, and pollen grains. Preferences of other species presumably similar to *M. litoralis'*. Individuals less than 6 mm long eat primarily algae, diatoms, and detritus. Occasionally cannibalistic.
- *Feeding behavior*—Benthic detritivores by day, carnivores/filter-feeders at night.
- *Feeding location*—Throughout water column to bottom.

Reproduction (Juday and Birge, 1927; Ricker, 1959; Holmquist, 1963; Lasenby and Langford, 1972; Reynolds and DeGraeve, 1972; Mauchline, 1973; Barnes, 1974; Carpenter, Mansey, and Watson, 1974; Morgan and Beeton, 1978; de Ladurantaye and Lacroix, 1980; Griffiths and Dillinger, 1981)

- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Mostly in shallow parts of inner shelf. *M. relicta* in lakes, estuaries, and lagoons.
- *Behavior*—Unknown.
- *Biology*—In marine waters, all species breed fall-early winter. Eggs held and hatched in marsupium; young incubated over winter, released in spring. Most females die 1-3 months after releasing young; 6% may reproduce again 4 months to 1 year later. Fec ındity 30-50 eggs per female in Arctic Ocean; about 90% hatch.

Development (Juday and Birge, 1927; Morgan and Beeton, 1978; de Ladurantaye and Lacroix, 1980; Griffiths and Dillinger, 1981)—Young brooded 2-5 months; independent thereafter. Some males reproduce by end of first summer, females and most males by second summer. Molt through four or five instars; all individuals mature by fourth instar.

Growth (Juday and Birge, 1927; Reynolds and DeGraeve, 1972; Morgan and Beeton, 1978; de Ladurantaye and Lacroix, 1980; Griffiths and Dillinger, 1981)—Juveniles 2-4 mm long when released from marsupium; increase in size with periodic molts. At high latitudes, reach 11 mm by end of first summer, 17 mm by end of second summer, 28 mm by end of third summer. Growth of both sexes greatest spring-summer, slowest in winter. Maximum lifespan 1-3 years.

Movements (Ricker, 1959; Beeton, 1960; Reynolds and DeGraeve, 1972; Carpenter, Mansey, and Watson, 1974; Griffiths and Dillinger, 1981)—Diel vertical migrations, except in shallow arctic waters (less than 5 meters). Move from 2-7 meters off bottom during day to near surface at night, but avoid surface in bright moonlight. Strong thermoclines slow rate of movement. In winter, generally move offshore into deeper water.

Factors Affecting Populations

Natural (Bedard, 1969; Carey, 1978; Ainley and Sanger, 1979; Craig and Haldorson, 1981; Feder and Jewett, 1981; Frost and Lowry, 1981a; Griffiths and Dillinger, 1981; Johnson and Richardson, 1981; Lowry and Frost, 1981)—Predators include ciscoes, Arctic char, cods, sculpins, soles, smelts, lumpfishes, eelpouts, cottids, oldsquaw, phalaropes, gulls, murrelets, auklets, seals, and baleen whales; also taken by amphipod *Onisimus glacialis*. In Beaufort Sea, especially important as food to Arctic and least ciscoes, Arctic cod, and oldsquaw. Information on parasites lacking.

Human-related—Reduction of populations of any of its predators probably increases mysid survival.

Potential (Nelson-Smith, 1973; Johnson, 1977; Rice, Short, and Karinen, 1977)—Oil contamination known to increase oxygen consumption in related mysid, *Mysidopsis almyra*. Effects of oil pollution on these species unknown. In crustaceans in general, oil pollution disrupts osmoregulation, impairs reproductive behavior, decreases hatching success, reduces feeding activity, and impairs general locomotor activity; also increases larval mortality, especially during molt. Cold-water shrimps appear more sensitive to oil pollution than do closely related, warmer water species. These findings probably apply to mysids.

Population Size

Unknown.

Management

None.

Persons Consulted

R.T. Cooney, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
K.O. Coyle, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
H.M. Feder, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
K.J. Frost, Alaska Department of Fish & Game, Fairbanks, Alaska.
L.F. Lowry, Alaska Department of Fish & Game, Fairbanks, Alaska.
J.B. Reynolds, Alaska Cooperative Fisheries Research Unit, University of Alaska, Fairbanks, Alaska.
B.L. Wing, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, Auke Bay, Alaska.

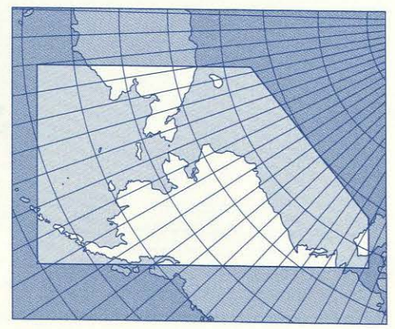
Legend

- Adult Area (Year-round) *Mysis polaris*
- Adult Area (Year-round) *Mysis litoralis, M. oculata, M. polaris*
- Major Adult Area (Year-round) *Mysis litoralis, M. oculata*
- Major Adult Area (Year-round) *Mysis litoralis, M. oculata, M. relicta*

The term "major" implies a higher density of the indicated species collectively, not of each individual species. *M. litoralis* is dominant species south of Bering Strait. Breeding (October-February) and release of young (April-June) occur throughout adult areas for each species. Juveniles occur year-round throughout adult areas.

Map References

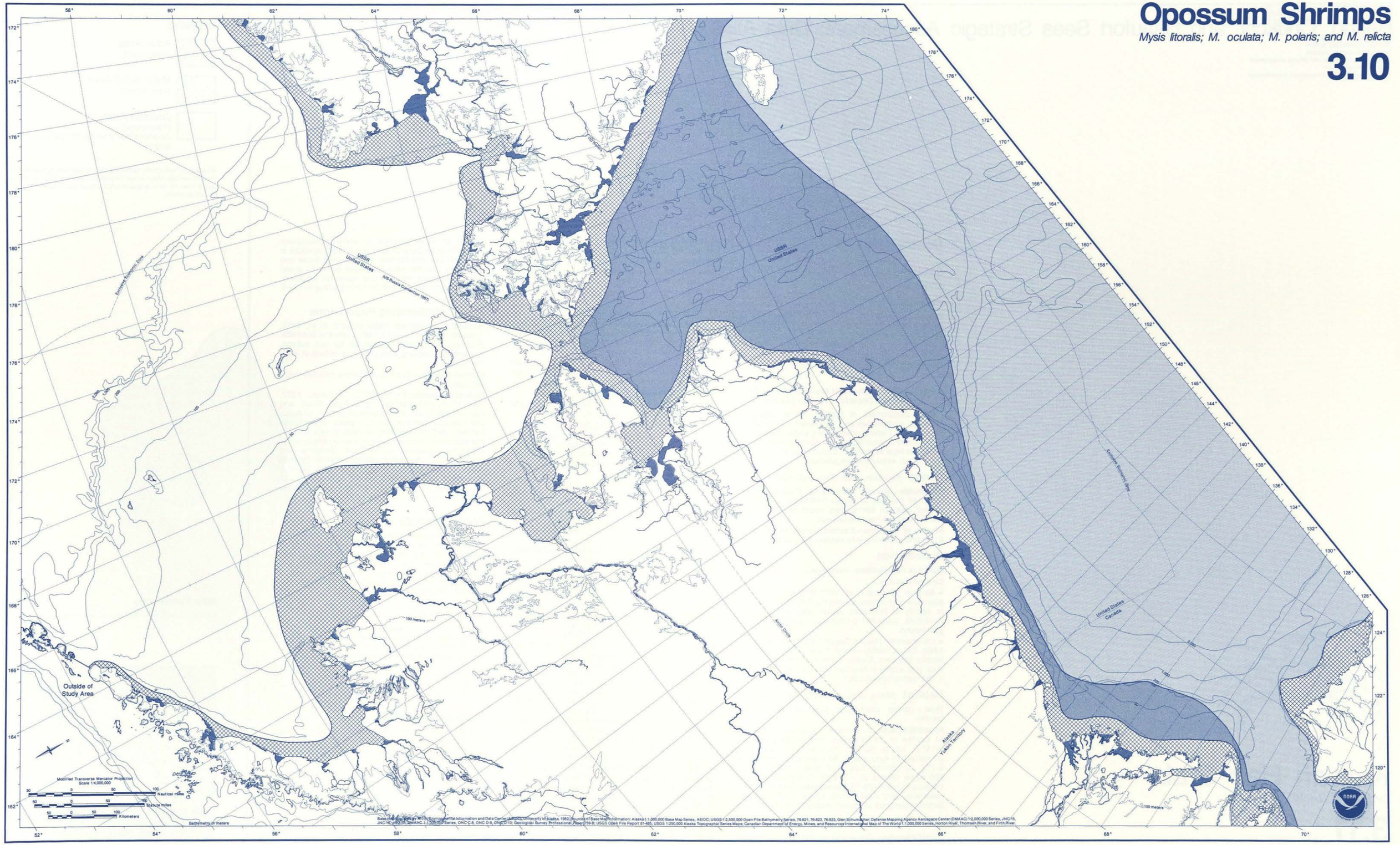
Holmquist, 1958, 1963; Geiger, 1969; Grainger, 1975; Wing and Barr, 1977; Griffiths and Dillinger, 1981. Personal communications from Lowry; Wing.



Opossum Shrimps

Mysis litoralis; M. oculata; M. polaris; and M. relicta

3.10



Base map prepared by the Arctic Environmental Information and Data Center, University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, and 1:5,000,000 DMAAC-1:5,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomson River, and Firth River.

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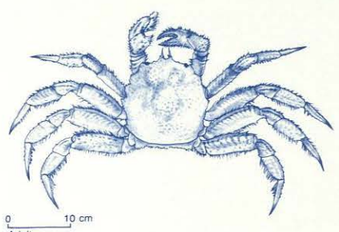

Korean Hair Crab

Erimacrus isenbeckii

3.11

Description

Category

Arthropod

Classification

Class—Crustacea
Order—Decapoda
Family—Atelecyclidae

Name

Korean hair crab, *Erimacrus isenbeckii* (horsehair crab)

Legal Status (National Marine Fisheries Service, 1976a; Alaska Department of Fish & Game, 1983)

Alaska Department of Fish & Game regulates domestic commercial and subsistence fisheries in USA waters. Federal government, under the Magnuson Fishery Conservation and Management Act of 1976, has legal authority in Exclusive Economic Zone but has not established regulations.

Range (Rathbun, 1930; Otto et al., 1983)

Worldwide—Boreal. Kamchatka Peninsula and south to the Sea of Japan (Hokkaido to eastern Korea); eastern Bering Sea, south of 61°N. Also found along the Aleutian Islands.

Region of Concern—Eastern Bering Sea south of 61°N and extending into eastern Aleutians.

Distribution

Discrete Populations—Not known.

Concentrations

- *Natural* (Sakurai et al., 1972; Otto et al., 1983)—Major concentrations around the Pribilof Islands and in vicinity of Hokkaido, Japan; also along Alaska Peninsula. Juveniles probably congregate inshore year-round.
- *Commercial* (Alaska Department of Fish & Game, 1983; Eaton, 1983)—Major fishery around Pribilof Islands in spring. Smaller fisheries off Alaska Peninsula and eastern Aleutian Islands. Highest catch 1,150 metric tons in 1981.

Habitat (Matui, 1970; Abe, 1977; Otto, 1983)

Type—Larvae planktonic; juveniles and adults benthic.

Physical/Chemical—Juveniles probably abundant at depths of 20-50 meters and temperatures of 5-15°C; adults occur from mean low water to 20 meters in April and to 90 meters in October at 2-7°C. In Bering Sea, hair crabs found in 20-250 meter depths at −1 to 12°C; highest concentrations in water 20-75 meters deep and 5-7°C. In Aleutians, near Adak Island, found to 401 meters. Salinity tolerance unknown. Muddy to sandy bottom.

Life History

Social Behavior (Sakurai et al., 1972)—Juveniles of both sexes congregate; adults apparently segregate by sex and size.

Biological Associations (Hirano, 1934)—Frequency and abundance of food organisms may govern growth, movements, and associations.

Nutrition (Hirano, 1934; Sakurai et al., 1972; Abe, 1973)

- *Feeding type*—Predator, scavenger.
- *Food*—Small crustaceans such as amphipods, isopods, decapods, and small bivalves are important food items. Polychaetes, mantis shrimps, brittle stars, and fish are of lesser importance.
- *Feeding behavior*—Feeding begins at dawn, peaks at midday, and stops around sunset when crabs apparently become inactive.
- *Feeding location*—On bottom.

Reproduction (Matui, 1970; Sakurai et al., 1972; Abe, 1977; Armetta and Stevens, in press)

- *Mode*—Internal fertilization; dioecious.
- *Location*—Males concentrate with primiparous females (usually 40-50 mm carapace length) in shallow waters (20-50 meters) and with multiparous females (usually 50 mm or more) in deeper waters (80-90 meters).
- *Behavior*—Male grasps female during her molt; female is still in soft shell when mating occurs. After mating, male injects into female's gonophores a liquid that congeals into a hard plug, which is carried until spawning. Females may mate with only one male every other year; males may mate with several females each year.
- *Biology*—In Bering Sea, soft-shelled females occur in June, July, and August (the majority in July); assumption is that mating occurs then also. (In Japan, mating is August-February; generally multiparous females mate in fall, primiparous in winter.) Both males and females mature at age 2, though males do not mate until age 4. Eggs extruded 4-10 months after breeding and carried for about one year before hatching. Average fecundity 40,000-50,000 eggs (maximum 160,000).

Development (Armstrong et al., 1983)—Zoeae pelagic. In Bering Sea, stages I, II, and III zoeae present in samples collected in April and May; stages IV and V present throughout June; and megalopae present in late June. First instars probably settle to the bottom during early August. No *Erimacrus* larvae present in October 1980 samples. (In Japan, eggs hatch March to May, and zoeae molt through the five zoeal stages in about three months.) Hair crabs molt eight times in the 18 months spent as juveniles and reach maturity at 40-50 mm carapace length. After reaching maturity, males molt annually until about 95 mm long, then molt biennially. Adult females molt biennially because of breeding cycle.

Growth (Abe, 1981; Armetta and Stevens, in press)—Adult males may grow 14-24% in each molt. In Bering Sea, males reach 145-mm carapace length and about 2,500 grams; females 115 mm and 1,200 grams. Crabs are smaller in Japan.

Movements (Hirano, 1934; Yamamoto, 1966; Sakurai et al., 1972; Abe, 1977)—Movements are in response to breeding cycle or water temperature fluctuations. In Japan, males are closest to shore in June and July and farthest offshore in October and November.) Males move to deeper water to breed with multiparous females and return to shallower waters in late fall to breed with primiparous females.

Factors Influencing Populations

Natural (Cunningham, 1969; Sakurai et al., 1972; Takeuchi, 1972; Abe, 1973, 1981; June and Shimada, in press)—Documented predation by cod, salmon, sculpins, and red king crab. Diseases include at least one virus.

Human-related—Commercial fishing reduces adult male population.

Potential (Nelson-Smith, 1973; Johnson, 1977; Rice, Korn, and Karinen, 1977; Rice, Short, and Karinen, 1977)—In crustaceans in general, oil pollution disrupts osmoregulation, impairs reproductive behavior, reduces hatching success of eggs, and impairs general locomotor activity; also increases larval mortality, especially during molt. Benzene and napthalene in sublethal concentrations depress heart rate and are potentially deleterious. Leg loss appears to be increased in brachyurans exposed to oil. Potential impact from oil contamination greatest in shallow waters, where juvenile crabs congregate.

Population Size (Otto et al., 1983)

Total 1983 eastern Bering Sea population estimated at 6.3 million crabs, of which 4.6 million were large males (greater than 89-mm carapace length), 0.8 million small males (less than 90 mm), and 0.9 million females. Total population estimate for 1983 represents a 74% decrease from 1979 population estimate of 24.1 million crabs.

Management

Catch quotas and season, area, sex, and gear restrictions are management tools. Fishermen restricted to use of pot gear and prohibited from retaining female crabs. Season currently year-round; crabs may be caught under permit issued by the Alaska Department of Fish and Game. Peak catch of 1,150 metric tons in 1981; grew rapidly from 3 metric tons in 1979 and has declined since.

Persons Consulted

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Legend

Adult Area
(Year-round)

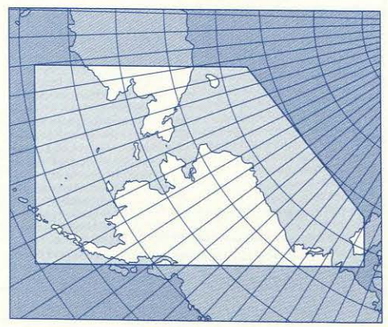
Major Adult Area
(Year-round)

Juvenile Area
(Year-round)
Juveniles less than 40-mm carapace length.

Mating (June-August), spawning (November-May), and hatching (November-May) occur throughout adult areas. Juveniles larger than 40-mm carapace length occur year-round throughout adult areas.

Map References

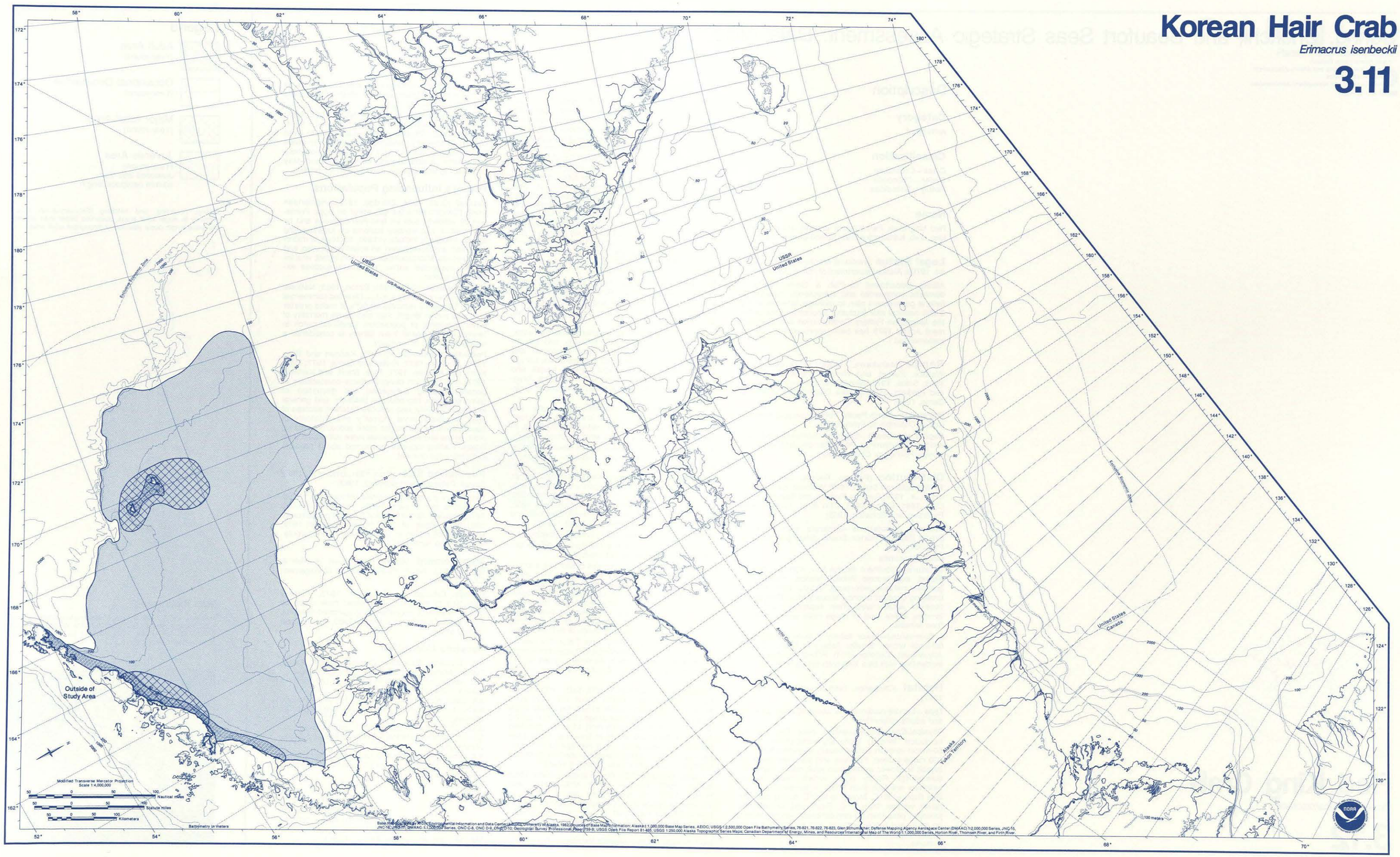
Otto et al., 1983; Northwest and Alaska Fisheries Center, n.d.



Korean Hair Crab

Erimacrus isenbeckii

3.11



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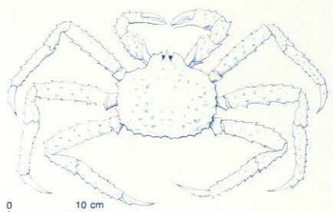

Red King Crab

Paralithodes camtschatica

3.12

Description

Category

Arthropod

Classification

Class—Crustacea
Order—Decapoda
Family—Lithodidae

Name

Red king crab, *Paralithodes camtschatica* (Alaska king crab, Kamchatka crab; *taraba-gani* in Japan)

Legal Status (National Marine Fisheries Service, 1976a; Alaska Department of Fish & Game, 1983)

Alaska Department of Fish & Game regulates domestic commercial and subsistence fisheries. A federal government plan to manage fisheries in the 3-200 nautical mile Exclusive Economic Zone under the Magnuson Fishery Conservation and Management Act of 1976 has been approved but not yet implemented.

Range (Marukawa, 1933; Makarov, 1938; Wallace, Pertuit, and Hvatum, 1949; MacGinitie, 1955; Sakai, 1971; Slizkin, 1974; Pereyra, Reeves, and Bakkala, 1976; Alaska Department of Fish & Game, 1978)

Worldwide—North Pacific from Japan and northern British Columbia to Point Barrow.

Region of concern—Eastern continental shelf from eastern Aleutians to Point Barrow. Not known in western Bering or Chukchi Seas.

Distribution (Pereyra, Reeves, and Bakkala, 1976; Rodin and Slizkin, 1977; Wolotira, Sample, and Morin, Jr., 1977; Pereyra, Reeves, and Bakkala, 1978; Otto, 1981; Eaton, 1983; Otto et al., 1983; Powell, Peterson, and Schwarz, 1983)

Discrete Populations—Separate populations in Bristol Bay and Norton Sound. Small population in Pribilofs.

Concentrations

- *Natural*—Southern Bristol Bay, northern Norton Sound, and around Pribilof Islands. Young congregate inshore year-round. Adults form inshore breeding concentrations February-May. Concentrations of adult males often separate from adult females. Males tend to range more widely offshore than females.
- *Commercial*—Major fishery in outer Bristol Bay, fall-early winter. Smaller fishery in Norton Sound, July-August. Catches from Pribilof Islands taken incidentally with blue king crab fall-early winter.

Habitat (Chebanov, 1965; Bright, 1967; Weber, 1967)

Type—Larvae planktonic for about 90 days; juveniles and adults epibenthic.

Physical/Chemical—Juveniles (less than 40-mm carapace length) generally nearshore within 50-meter isobath. Adults usually in waters less than 200 meters deep. Females and juveniles generally inhabit shallower waters than adult males, especially summer-fall. Rarely occur where mean bottom salinities are less than 30‰ or temperatures are less than −1.5°C. Mostly in 2-5°C during summer, rarely warmer than 7°C. First- and second-year juveniles (less than 30-mm carapace length) mostly on rocky and rubble bottoms with extensive macrophytes and epifauna. Older crabs usually on smoother bottoms.

Life History

Social Behavior (Bright, 1967; Weber, 1967)—First-year juveniles (less than 16-mm carapace length) solitary. Second- and third-year juveniles aggregate, frequently forming mound-shaped pods. Older juveniles aggregate in herdlike groups. Juvenile aggregations have approximately 1:1 sex ratios; mature individuals tend to aggregate by size and sex.

Biological associations (Hunter, 1969; Rodin, 1970; Walters and McPhail, 1982)—Densities highest in areas with abundant bivalves, ophiuroids, and polychaetes. Frequently trawled in close association with rock sole (*Lepidopsetta bilineata*), yellowfin sole (*Limanda aspera*), Alaska plaice (*Pleuronectes quadrituberculatus*), and sculpins (*Myoxocephalus* spp.). Snailfish (*Careproctus* spp.) lay eggs in crab's branchial chambers. Barnacles (*Balanus* spp.), leech (*Carcinobdella*) egg cases, bryzoans, hydroids, tube-forming polychaetes (*Spirorbis* spp.), and sponges commonly occur on exoskeleton.

Nutrition (Cunningham, 1969; Tarverdieva, 1976; Feder and Jewett, 1980, 1981; Paul and Paul, 1980)

- *Feeding type*—Predator and scavenger. Omnivorous in first year; become progressively carnivorous with growth.
- *Food*—Polychaetes, sand dollars, snails, bivalves, brittle stars, basket stars, barnacles, and crustaceans. Clams (*Nuculana, Nucula, Macoma*) and barnacles are dominant foods in some areas. Larvae eat diatoms, copepods, and various nauplii and zoeae. Newly settled juveniles eat diatoms, bryozoans, ostracods, harpacticoid copepods, polychaetes, and foraminiferans.
- *Feeding behavior*—Juveniles and adults are opportunistic foragers. Larvae are active predators. Newly hatched larvae must feed within 60 hours, or subsequent feeding ability is severely diminished.
- *Feeding location*—Zoeal larvae feed in water column. Glaucothoe larvae, juveniles, and adults benthic.

Reproduction (Marukawa, 1933; Wallace, Pertuit, and Hvatum, 1949; Fishery Agency of Japan, 1962; Powell and Nickerson, 1965; McMullen, 1967, 1969, 1970; Haynes, 1968; McMullen and Yoshihara, 1969, 1971; Powell and Hurd, 1972; Powell, Shafford, and Jones, 1973; Powell, James, and Hurd, 1974)

- *Mode*—Sexual; external fertilization, dioecious.
- *Location*—Mate mostly at depths up to 50 meters, occasionally as deep as 100 meters.
- *Behavior*—Males and females grasp one another by claws in precopulatory embrace of 1-16 days' duration; mate immediately after female molts. Male almost always larger than female partner. Females mated more than 3 days after molt unable to extrude eggs. Females mate with one male per year. Males may mate with up to six females before incurring possible reduction in size of clutch of fertilized eggs.
- *Biology*—Mate February-June. Fecundity related to carapace length: 20,000-400,000 eggs per female. Embryos average 1 mm in diameter; carried for 11-12 months. Larvae hatch about a month prior to next mating.

Development (Marukawa, 1933; Sato, 1958; Weber, 1967)—Egg eyespot visible about 100 days after fertilization; prezoeae visible at 150 days. Four zoeal stages prior to glaucothoe stage (total larval period about 100 days). Juveniles molt 11 times, reaching 10-12 mm carapace length in first year. Eight additional molts required to reach average 60-mm carapace length at 3 years; thereafter molting is annual (February-June) until maturity at 5-6 years.

Growth (Sakuda, 1958; Weber and Miyahara, 1962; Weber, 1967; Balsiger, 1976; McCaughran and Powell, 1977)—In Bristol Bay, males mature at 100-mm carapace length, females at 90 mm. Norton Sound females mature at 70 mm, males presumably similar. Mature male growth per molt averages 16 mm (12 mm in Norton Sound); female growth per molt averages 4 mm. Mature females molt annually, males less often. Average male weighs 1,949 grams at 135 mm. Maximum size for Bristol Bay males 205 mm; females 175 mm.

Movements (Fishery Agency of Japan, 1962, 1964; Hayes and Montgomery, 1963; Powell, 1964; Simpson and Shippen, 1968)—Larvae drift with current. First-year juveniles secretive; later juveniles wander during feeding with some inshore-offshore movements. Adults migrate inshore February-May for breeding and offshore June-August for feeding.

Factors Influencing Populations

Natural (Gray, 1964; Eldridge, 1972)—Nemertean worm (*Carcinonemertes* sp.) preys on eggs. Predation by yellowfin sole on first-year juveniles and by cod, halibut, and various sculpins on juveniles and adults. Infections include viruses, bacteria, a microsporidian, a rhizocephalan, an acanthocephalan, and a trematode. Microsporidian infection lethal; viral infection suspected lethal. Year-class success extremely variable.

Human-related (Otto, 1981; Eaton, 1983; National Marine Fisheries Service, n.d.)—Directed commercial fishery frequently removes 40-60% of males greater than 135 mm in length; may also cause mortality of other segments of population. Incidental catch in foreign and domestic trawl fishery is considered a negligible source of mortality.

Potential (Nelson-Smith, 1973; Karinen and Rice, 1974; Johnson, 1977; Krebs and Burns, 1977; Rice, Korn, and Karinen, 1977; Rice, Short, and Karinen, 1977)—Oil pollution directly affects crustaceans in general, causing suffocation and disruption of osmoregulation, reproductive behavior, and general locomotor activity; also reduces hatching success of eggs, increases larval mortality and autotomy of appendages. All life stages more susceptible during molt; larvae and early juveniles more vulnerable than adults. Fishing industry concerned about possible contamination of meat.

Population Size (Otto, 1981; Otto et al., 1983; Powell, Peterson, and Schwarz, 1983)

Bristol Bay population declined through the 1960s, reached a low in early 1970s, increased through 1970s, peaked 1977-1980, and declined precipitously 1981-1983. Peak of 365 million crabs in 1977; estimated 89 million in 1983. Norton Sound population has also fluctuated.

Management (Alaska Department of Fish & Game, 1983; North Pacific Fishery Management Council, 1983)

Foreign fisheries prohibited in 1976. Fishery restricted to harvest of legal-sized male crabs by means of pots or ringnets during specified seasons. Peak catch 59,900 metric tons in 1980; has declined to zero since.

Persons Consulted

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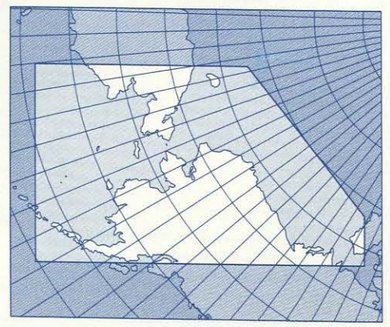
Legend

- Adult Area (Year-round)
- Occasional Occurrence (Year-round)
- Major Adult Area (Year-round)
- Juvenile Area (Year-round) Juveniles less than 40-mm carapace length

Mating, spawning, and hatching (February-June) occur primarily in major adult areas. Juveniles larger than 40-mm carapace length occur year-round throughout adult areas.

Map References

Makarov, 1938; Wallace, Pertuit, and Hvatum, 1949; Weber, 1967; Pereyra, Reeves, and Bakkala, 1976; Wolotira, Sample, and Morin, 1977; Otto, 1981; Otto et al., 1983. Personal communication from Otto.



Red King Crab

Paralithodes camtschatica

3.12



Base map sources: NOAA, Environmental Information and Data Center (EIDC), University of Alaska, 1982; Sources of Base Map Information: Alaska1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17, DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomson River, and Firth River.

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

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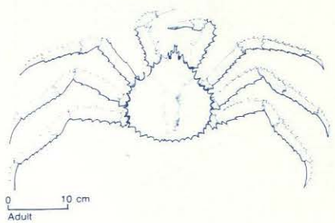

Golden King Crab

Lithodes aequispina

3.13

Description

Category

Arthropod

Classification

Class—Crustacea
Order—Decapoda
Family—Lithodidae

Name

Golden king crab, *Lithodes aequispina* (brown king crab; deep-water crab)

Legal Status (National Marine Fisheries Service, 1976a; Alaska Department of Fish & Game, 1983)

Alaska Department of Fish & Game regulates commercial and subsistence fisheries in USA waters. Federal government, under Magnuson Fishery Conservation and Management Act of 1976, has legal authority for management in Exclusive Economic Zone and is developing regulatory regime.

Range (Butler and Hart, 1962; Rodin, 1970)

Worldwide—Boreal. North Pacific Ocean from Bering Sea shelf edge and Sea of Okhotsk to Hokkaido and British Columbia.

Region of Concern—Continental shelf edge and slope along the Alaska Peninsula, Aleutian Islands, and eastern Bering Sea.

Distribution (Makarov, 1938; McBride, Fraser, and Reeves, 1982)

Discrete Populations—None known.

Concentrations

- *Natural*—Pribilof and Zhemchug canyons.
- *Commercial*—Continental shelf edge in Aleutians in winter; Bering Sea in summer-fall.

Habitat

Type—Larvae planktonic, adults benthic.

Physical/Chemical—Juveniles and adults generally found between 200 and 1,000 meters; rarely as shallow as 60 meters. Stenohaline. Prefer water temperatures of 3-5°C. Frequently occur in rocky areas; often with corals, but also on mud, sand, and cobble bottoms.

Life History (McMullen and Yoshihara, 1970)

Social Behavior—Habitat of juveniles generally the same as adults.

Biological Associations—Frequently found with deepwater species of tanner crabs (*Chionoecetes* spp.) and demersal fishes such as sablefish (*Anoplopoma fimbria*), snailfishes (*Careproctus* spp.), grenadiers (*Coryphaenoides pectoralis*), Greenland turbot (*Reinhardtius hippoglossoides*), and rockfishes (*Sebastes* spp. and *Sebastolobus* spp.). Snailfishes commonly lay eggs in crab branchial chambers, where they remain until hatching. Barnacles (*Balanus* spp.), tube worms (*Spirorbis* spp.), bryozoans, and sponges grow on exoskeleton, but less frequently than on other king crab species.

Nutrition

- *Feeding type*—Predator, scavenger.
- *Food*—Unknown.
- *Feeding behavior*—Unknown.
- *Feeding location*—Larvae pelagic, juveniles and adults benthic.

Reproduction (Rodin, 1970; Haynes, 1982)

- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Presumably at greater than 200-meter depths; some records shallower.
- *Behavior*—Grasping pairs observed, details unknown.
- *Biology*—Mating period unknown, probably year-round with peak from February to September in eastern Bering Sea. Fecundity 5,000-25,000 eggs per female (mean 12,000); varies with size of female. Egg diameter about 2.3 mm. Eggs carried for unknown length of time; probably about a year.

Development—Larvae large (7.3 mm). Four zoeal stages prior to glaucothoe stage (total larval period probably about 100 days).

Growth—Maximum size unknown.

Movements—Unknown.

Factors Influencing Populations (McMullen and Yoshihara, 1970)

Natural—Parasitized by the rhizocephalan *Briarsaccus callosus*, which interferes with reproduction, and by unidentified microsporidian protozoan, which is lethal. The extent of infection in population is unknown. Also infected by unidentified virus, dinoflagellate, and bacteria whose occurrence and effects are largely unknown.

Human-related—Rapidly developing fishery, especially in Aleutian Islands. This is the most common crab species in incidental catch of foreign trawlers and longliners.

Potential—(Nelson-Smith, 1973; Johnson, 1977; Rice, Korn, and Karinen, 1977; Rice, Short, and Karinen, 1977)—Oil pollution directly affects crustaceans in general, causing suffocation and disruption of osmoregulation, reproductive behavior, and general locomotor activity; also reduces hatching success of eggs, increases larval mortality and autotomy of appendages. All life stages are more susceptible during molt; larvae and early juveniles more vulnerable than adults. Fishing industry concerned about possible contamination of meat.

Population Size

Unknown.

Management (Otto, 1983)

Catch quota and season, area, size, sex, and gear restrictions are management tools. Fishery takes males only. Minimum legal size: carapace width of 140 mm (5.5 in) including spines. Difference in legal size based on differences in size at sexual maturity. Commercial catch 3,686 metric tons in 1982-1983 fishing season.

Persons Consulted

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Legend

Adult Area
(Year-round)

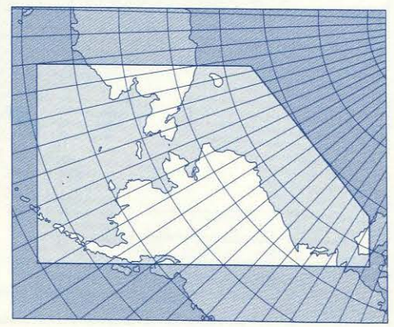
Occasional Occurrence
(Year-round)

Major Adult Area
(Year-round)

Mating, spawning, and hatching (year-round, peak period February-September) occur throughout adult areas. Juveniles occur year-round throughout adult areas.

Map References

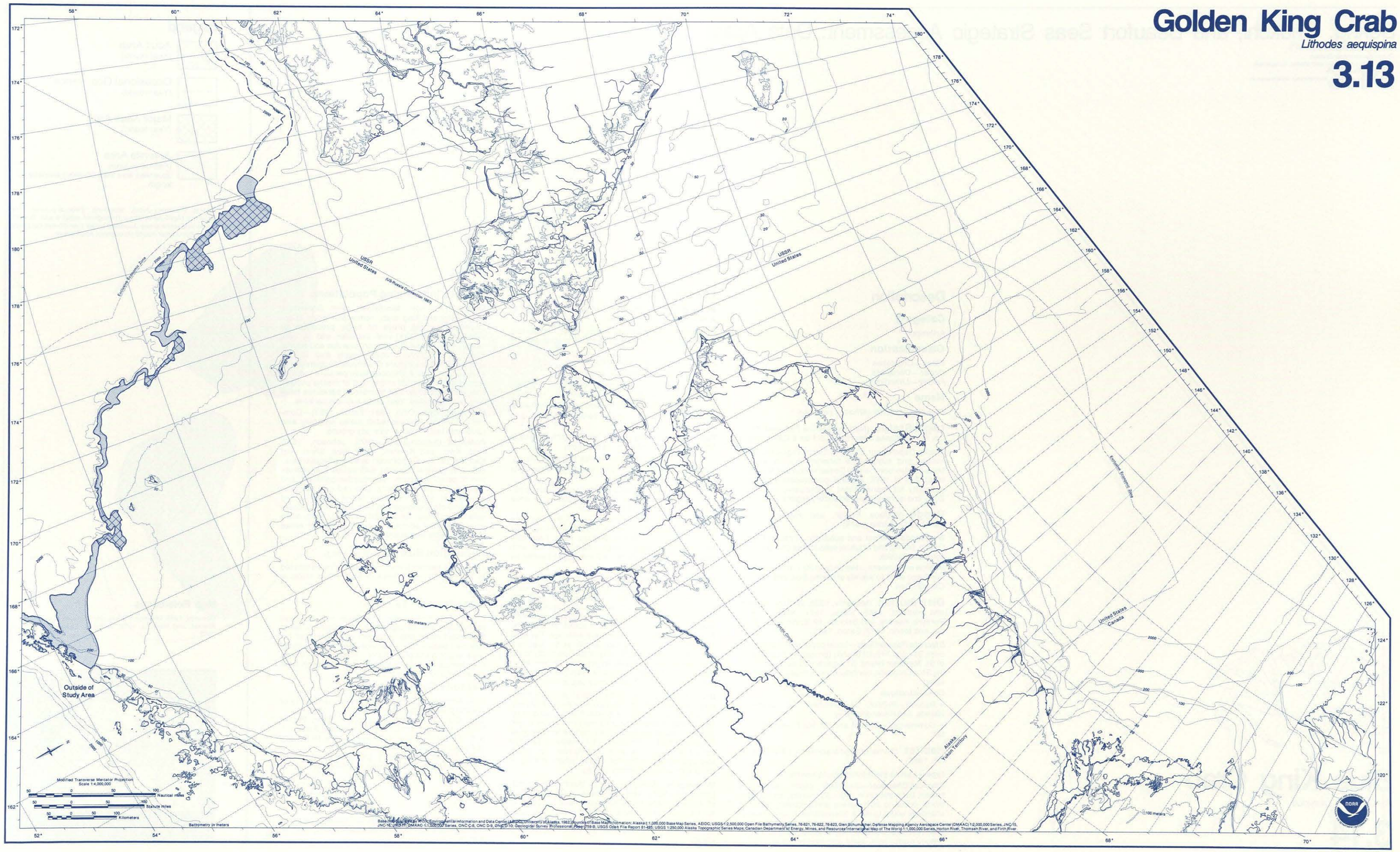
Makarov, 1938; McBride, Fraser, and Reeves, 1982.



Golden King Crab

Lithodes aequispina

3.13



Base map data derived from: Environmental Information and Data Center (EIDC), University of Alaska, 1983; Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-485; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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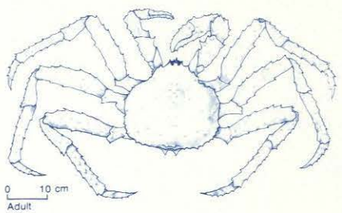

Blue King Crab

Paralithodes platypus

3.14

Description

Category

Arthropod

Classification

Class—Crustacea
Order—Decapoda
Family—Lithodidae

Name

Blue king crab, *Paralithodes platypus*

Legal Status (National Marine Fisheries Service, 1976a; Alaska Department of Fish & Game, 1983)

Alaska Department of Fish & Game regulates commercial and subsistence fisheries in USA waters. Under Magnuson Fishery Conservation and Management Act of 1976, Federal government has legal authority for management in Exclusive Economic Zone and is developing regulatory regime.

Range (Wallace, Pertuit, and Hvatum, 1949; Sakai, 1971; Slizkin, 1974)

Worldwide—Boreal and subarctic in North Pacific Ocean, Bering and Chukchi seas to Sea of Japan and southern Alaska.

Region of Concern—Herendeen Bay, in Bristol Bay, north and west to islands of Bering Sea, and north to Chukchi Sea.

Distribution (Makarov, 1938; Wallace, Pertuit, and Hvatum, 1949; Sakai, 1971; Slizkin, 1974; Pereyra, Reeves, and Bakkala, 1976; Wolotira, Sample, and Morin, 1977; Eaton, 1983)

Discrete Populations—Local populations at Herendeen Bay and Pribilof Islands (probably). Populations of St. Matthew Island, St. Lawrence Island, and Bering Strait probably continuous with those on Siberian coast.

Concentrations

- *Natural*—Pribilof, St. Matthew, St. Lawrence islands, and Herendeen Bay.
- *Commercial*—Pribilof and St. Matthew islands in fall.

Habitat (Somerton and MacIntosh, 1982; Somerton, 1985)

Type—Larvae planktonic; adults benthic.

Physical/Chemical—Juveniles' depth range not known, but common in about 60 meters; adults commonly occur to 200 meters and probably move to shallower water to mate. Stenohaline. Found in water temperatures −1 to 7°C. Juveniles prefer broken shell rubble and also rocks, to lesser extent. Adults occupy mainly rock, sand, and mud bottoms.

Life History

Social Behavior—No observed podding behavior in juveniles as in red king crab.

Biological Associations (Otto, 1981; Somerton, 1985)—Seldom found with red king crab in area of concern.

Nutrition (Tarverdieva, 1979)

- *Feeding type*—Predator, scavenger.
- *Food*—Take echinoderms (mostly sea urchins), polychaetes, bivalve mollusks, ophiurans.
- *Feeding behavior*—Dig for food on soft substrates.
- *Feeding location*—Larvae pelagic; juveniles and adults benthic.

Reproduction (Sasakawa, 1971, 1973, 1975a,b; Somerton and MacIntosh, 1982, 1985)

- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Probably near shore in waters of 65-meter depths or less.
- *Behavior*—Male usually grasps female prior to her molt. Extrusion of eggs and fertilization occur while female is in soft shell following molt.
- *Biology*—Mate February-June. Primiparous females mate early in season. Most females molt and mate in one season but skip the next. Fecundity 50,000-300,000 eggs (mean 150,000); varies with size of female. Egg length 1.2 mm. Eggs carried by female for about one year.

Development (Hoffman, 1968; Sasakawa, 1971; Armstrong et al., 1983)—Most eggs hatch April-June. Larvae have four zoeal stages and one glaucothoeal stage. All larval stages develop in a manner similar to red king crab. Actively swimming zoeae occupy water column for about four months. Frequency of molting decreases with age. Females mature at 80-mm carapace length at St. Matthew Island and 96 mm at Pribilof Islands. One study found spermatozoa in all males larger than 70 mm. Most mature females molt every other year; mature males molt once a year but sometimes skip a molt.

Growth (Sasakawa, 1975a; Otto et al., 1982; Somerton and MacIntosh, 1983a,b)—In Pribilof Islands, growth similar to that of Bristol Bay red king crab: large males increase about 16 mm in carapace length per molt. In western Bering Sea, mature females grow 7 mm per molt. In Pribilofs, adult males to 190-mm carapace length; females to 170 mm; for 1982, average weight in Pribilof Island fishery 3.4 kg; in St. Matthew Island fishery, 2.0 kg.

Movements (Somerton and MacIntosh, 1982; Somerton, 1985)—Not well known. In Olga Bay, Gulf of Alaska, crabs move inshore in late winter and spring, offshore in summer and fall. In Pribilofs, adult crabs are common in 65-meter depths, although depth range not well known for either summer or winter.

Factors Influencing Populations

Natural (Johnson, MacIntosh, and Somerton, 1985)—For red king crab, nemertean worm (*Carcinonemertes* sp.) preys on eggs; predation by yellowfin sole on first-year juveniles and by cod, halibut, and various sculpins on juveniles and adults. These observations probably apply also to this species. Diseases include *Chlamydia-Rickettsia* and at least one virus. A rhizocephalan parasite reduces reproductive potential in one Gulf of Alaska population. Microsporidian and trematode parasites have also been identified. Year-class success variable.

Human-related (Otto, 1981; Eaton, 1983)—Commercial fishing removes adult males and may also cause mortality in other size/sex groups.

Potential (Nelson-Smith, 1973; Johnson, 1977; Rice, Korn, and Karinen, 1977; Rice, Short, and Karinen, 1977)—Oil pollution directly affects crustaceans in general, causing suffocation and disruption of osmoregulation, reproductive behavior, and general locomotor activity; also reduces hatching success of eggs, increases larval mortality and autotomy of appendages. All life stages more susceptible during molt; larvae and early juveniles more vulnerable than adults. Fishing industry concerned about possible contamination of meat.

Population Size (Otto et al., 1983)

Total 1983 eastern Bering Sea population estimated at 21.8 million crabs. Peak of 58.1 million crabs in 1978.

Management (Eaton, 1983)

Catch quota and season, area, size, sex, and gear restrictions are management tools. Fishery takes legal-sized males only, with pots or ring nets, within specified season. Minimum legal size: 140-mm carapace length north of 58°39′N, 165 mm south of this line. Annual total Bering Sea catch has been from 3,500 to 6,200 metric tons since 1977.

Persons Consulted

D. A. Armstrong, College of Fisheries, University of Washington, Seattle, Washington.
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Legend

Adult Area
(Year-round)

Occasional Occurrence
(Year-round)

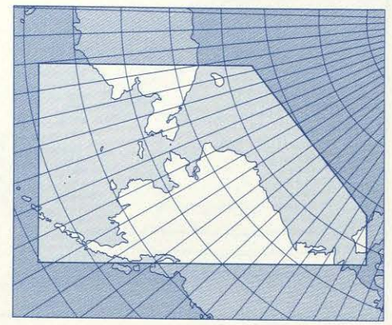
Major Adult Area
(Year-round)

Juvenile Area
(February-June)
Juveniles less than 60-mm carapace length

Mating (February-June), spawning (February-June), and hatching (April-June) occur throughout adult areas, but primarily in juvenile areas. Juveniles larger than 60-mm carapace length occur year-round throughout adult areas.

Map References

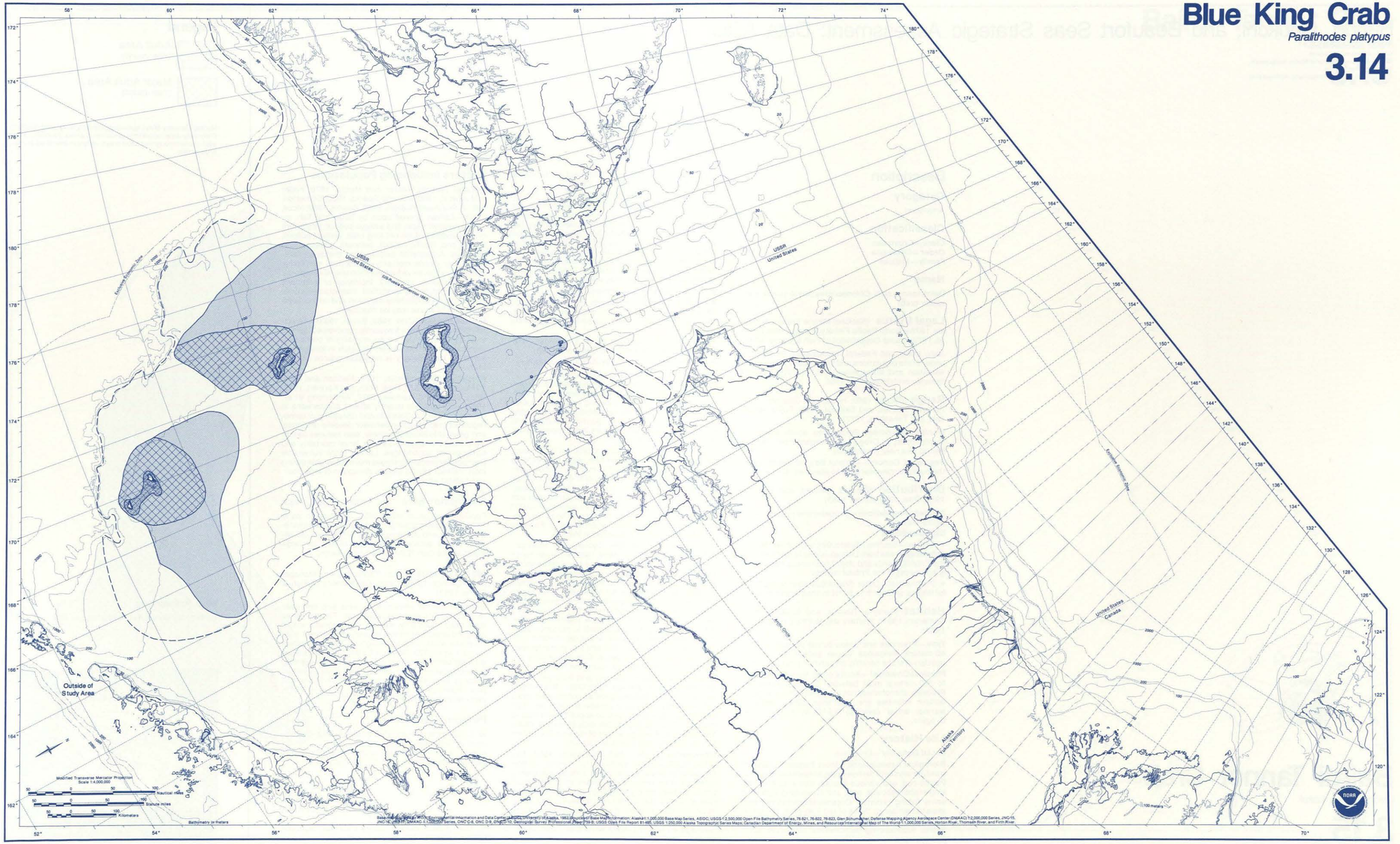
Makarov, 1938; Wallace, Pertuit, and Hvatum, 1949; Pereyra, Reeves, and Bakkala, 1976; Wolotira, Sample, and Morin, 1977.



Blue King Crab

Paralithodes platypus

3.14



Base map data courtesy of the Environmental Information and Data Center (EIDC), University of Alaska, 1982; sources of Base Map information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNG-15, JNC-16, JNG-17, DMAAC-1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

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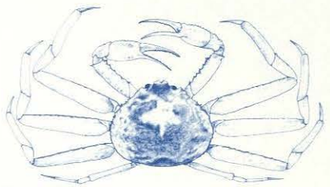
National Ocean Service
National Oceanic and Atmospheric Administration



Bairdi Tanner Crab

Chionoecetes bairdi

3.15

Description

Category

Arthropod

Classification

Class—Crustacea
Order—Decapoda
Family—Majidae

Name

Bairdi tanner crab, *Chionoecetes bairdi* (snow crab, spider crab)

Legal Status (National Marine Fisheries Service, 1976a; North Pacific Fishery Management Council, 1979; Alaska Department of Fish & Game, 1983)

Joint state and Federal management of fisheries under state regulations and Magnuson Fishery Conservation and Management Act of 1976. Foreign fisheries prohibited since 1980.

Range (Garth, 1958; Hosie and Gaumer, 1974; Pereyra, Reeves, and Bakkala, 1976; Fujita, Kawasaki, and Takeshita, 1977)

Worldwide—Boreal. Bering Sea south along the Pacific coast to Oregon. One record from western Bering Sea near Kamchatka.

Region of Concern—Bristol Bay northwest along the outer continental shelf to about 61°N.

Distribution (Pereyra, Reeves, and Bakkala, 1976; Otto, 1982; Eaton, 1983)

Discrete Populations—Probably one population for entire area.

Concentrations

- *Natural*—Southern Bristol Bay west of Port Moller; outer shelf areas from Unimak Island to and including the Pribilof Islands and shelf-break areas immediately northwest of the Pribilof Islands.
- *Commercial*—Outer Bristol Bay west to the Pribilof Islands and north to 59°N in shelf-break areas.

Habitat (Pereyra, Reeves, and Bakkala, 1976; Somerton, 1981c; Walters and McPhail, 1982; Incze, 1983)

Type—Prezoeae and zoeae larvae pelagic in upper 40 meters; megalopa larvae pelagic or benthic; postlarval crabs benthic, on sand and mud bottoms.

Physical/Chemical—Adults occur from littoral zone to 700 meters; most between 50 and 200 meters. Probably stenohaline; not in waters where average bottom salinities are less than 30‰. Occur in warmer water (average 4.5°C in August) than *C. opilio*.

Life History

Social Behavior—Unknown.

Biological Associations—Most frequently taken in trawl surveys with flathead sole, arrowtooth flounder, Pacific cod, and various skates; also with *C. opilio*, king crabs, yellowfin sole, and Greenland turbot on some fishing grounds. Organisms encrusting exoskeleton similar to those of red king crab: barnacles (*Balanus* spp.), leech (*Carcinobdella*) egg cases, bryzoans, tube-forming polychaetes (*Spirorbis* spp.), and sponges.

Nutrition (Tarverdieva, 1976; Paul et al., 1979; Feder and Jewett, 1981; Incze, 1983)

- *Feeding type*—Predator, scavenger.
- *Food*—Zoeae larvae believed dependent on zooplankton, although phytoplankton also taken. Threshold concentration of 80 zooplankton prey per liter required for successful first feeding of stage-I zoeae. In the eastern Bering Sea, dominant food groups of postlarval crab are mollusks, crustaceans, echinoderms, and annelids; juveniles feed on crustaceans, polychaetes, and mollusks. Polychaetes and echinoderms are major prey items of adults.
- *Feeding behavior*—Unknown.
- *Feeding location*—Prezoeae and zoeae larvae mostly in upper 40 meters of water column; megalopa larvae pelagic or benthic; juveniles and adults benthic.

Reproduction (Haynes et al., 1976; Hilsinger, 1976; Paul et al., 1983; Somerton and Meyers, 1983)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Throughout range.
- *Behavior*—Male grasps smaller female in precopulatory embrace up to 14 days prior to her primiparous molt (at maturity); mating and egg extrusion follow closely. Multiparous females grasped and mated without molting. Hybridization of *C. bairdi* and *C. opilio* common in areas where their ranges overlap (e.g., near Pribilof Islands).
- *Biology*—In eastern Bering Sea, mating occurs January through May. Females mate and extrude eggs shortly after final molt to maturity. Subsequent clutches fertilized by stored sperm or by additional mating. Eggs carried for about 1 year, hatching mostly February through June. Fecundity varies with size and spawning history of female: ranges from 50,000 to 400,000 eggs. Twenty percent of eggs lost between initial attachment and hatching. Females usually produce 3 or 4 clutches in lifetime.

Development (Donaldson, Cooney, and Hilsinger, 1981; Somerton, 1981b; Incze, 1983)—Larvae hatch mostly in March-May as prezoeae and immediately molt to first zoeal stage; two zoeal stages each last about 30 days. Megalops stage, which follows, more variable, but often lasts 60 days before molting to first juvenile instar. Juveniles molt 6 times in first year to reach 18-mm carapace width, twice in second year to reach 34 mm, and once yearly thereafter. Adult females have terminal molt to maturity; adult males may not molt annually. Males reach maturity at 105-115 mm carapace width and 5-6 years; females at 75-100 mm and 4-6 years. Size at maturity decreases from southeast to northwest within area.

Growth (Donaldson, Cooney, and Hilsinger, 1981; Somerton, 1981b; McBride, 1982; Otto, 1982)—Postlarval males and females grow at comparable rates until maturity; growth in carapace width per molt varies from 33% in first year to about 14% at molt to maturity. Average growth per molt of mature males 15% (21 mm). Average weight of males is 300 grams at 100 mm and 850 grams at 140 mm.

Movements (Bright, 1967; Donaldson, 1980; McBride, 1982)—Some evidence for diurnal vertical migration of larvae. Juveniles in schools apparently make random movements within relatively small areas. Inshore spring breeding migration occurs in Gulf of Alaska, but is unknown in Bering Sea. Maximum release-recovery distance for tagged males was 87 km (average, 73 km) in 1 year and 359 km (average, 80 km) in 2 years. Most movement was to south or southwest.

Factors Influencing Populations

Natural (Baross, Tester, and Morita, 1978; Feder and Jewett, 1980; Mix and Sparks, 1980; Somerton, 1981a; Smith and Walters, 1982; Sparks, 1982; Incze, 1983)—Larvae preyed upon by birds and fish, including yellowfin sole and walleye pollock. Predators on postlarvae include red king crab, walleye pollock, Pacific cod, Pacific halibut, eelpouts, sculpins, and flatfishes. A bacterial disease that damages carapace may cause mortality. Black-mat syndrome, caused by an invasive fungus (*Trichomaris invadens*), probably causes mortality. Incidence of infections and parasites poorly quantified. Year-class success variable; inshore-offshore transport and critical feeding period of larvae may be important.

Human-related (Otto, 1982; Eaton, 1983)—Directed commercial fishery frequently removes 40-60% of legal males; may also cause mortality of other segments of population. Incidental catch in foreign and domestic trawl fishery is negligible source of mortality.

Potential (Nelson-Smith, 1973; Karinen and Rice, 1974; Johnson, 1977; Rice, Korn, and Karinen, 1977; Rice, Short, and Karinen, 1977; Armstrong et al., 1983)—Oil pollution directly affects crustaceans in general, causing suffocation and disruption of osmoregulation, reproductive behavior, feeding response, and general locomotor activity; also reduces hatching success of eggs, increases larval mortality and autotomy of appendages. Larvae more vulnerable than postlarvae; all life stages more vulnerable during molt. Indirect effects include disruption of food chain and habitat alteration.

Population Size (Otto, 1982; Otto et al., 1983)

Population large in late 1960s, declining in early 1970s, increasing again in mid-1970s to approximately 0.8 billion, and declining since then to about 0.5 billion. Recent declines particularly severe for large males (more than 129-mm carapace width).

Management (North Pacific Fishery Management Council, 1979; Alaska Department of Fish & Game, 1983)

Catch quota and season, area, size, sex, and gear restrictions are management tools. Fishery takes legal-sized males only, with pots or ringnets, within specified season. Minimum legal size: 140-mm (5.5 in) carapace width. Average weight in fishery dropped from 1.1 kg in 1978-1981 to 1.0 kg in 1982-1983. Season may be closed early if desired exploitation is met, product quality is poor, mortality of crabs in vessel holds is excessive, or reproductive conditions are poor. Peak catch of 20,500 metric tons in 1979; declined to 2,400 metric tons in 1983.

Persons Consulted

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Legend

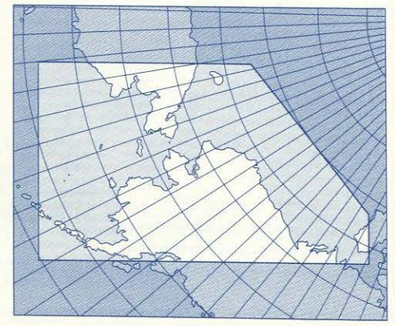
Adult Area
(Year-round)

Major Adult Area
(Year-round)

Mating (January-May), spawning (January-May), and hatching (February-June) occur throughout adult areas. Juveniles occur year-round throughout adult areas. Western limit of adult area is uncertain.

Map References

Garth, 1958; Pereyra, Reeves, and Bakkala, 1976.



Bairdi Tanner Crab

Chionoecetes bairdi

3.15



Base map data sources: ACADIC Environmental Information and Data Center, UAFDC, University of Alaska, 1962; Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 774-B; USGS Open File Report 81-455; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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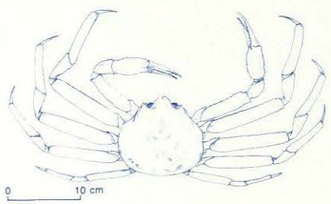

Opilio Tanner Crab

Chionoecetes opilio

3.16

Description

Category

Arthropod

Classification

Class—Crustacea
Order—Decapoda
Family—Majidae

Name

Opilio tanner crab, *Chionoecetes opilio* (snow crab, queen crab, spider crab)

Legal Status (National Marine Fisheries Service, 1976a; North Pacific Fishery Management Council, 1979; Alaska Department of Fish & Game, 1983)

Joint state and Federal management of fisheries under state regulations and Magnuson Fishery Conservation and Management Act of 1976. Foreign fisheries prohibited since 1980.

Range (Garth, 1958; Pereyra, Reeves, and Bakkala, 1976; Wolotira, Sample, and Morin, 1977; Otto, 1982; Otto et al., 1983)

Worldwide—Boreal to arctic. In Pacific, Bering, Chukchi, and Beaufort seas to Sea of Japan and Sea of Okhotsk; in Atlantic, from New Foundland to Gulf of Maine.

Region of Concern—Continental shelf of Bering and Chukchi seas to Beaufort Sea (occasional).

Distribution (Squires, 1969; Pereyra, Reeves, and Bakkala, 1976; Wolotira, Sample, and Morin, 1977; Otto, 1982; Eaton, 1983; Otto et al., 1983)

Discrete Populations—None known.

Concentrations

- *Natural*—Midshelf areas north of 56°N. Not common within 60 nmi of mainland and rare in shelf-break areas. Populations frequently patchy, and localized areas of abundance change from year to year. Larger males (greater than 95-mm carapace width) and females (wider than 65 mm) tend to occur along southern and western fringes of range.
- *Commercial*—Unimak Island, outer Bristol Bay, northwest to Pribilof and St. Matthew islands, and along the outer continental shelf in areas north of 60°N. Exploited over a small portion of range due to size-related differences in distribution.

Habitat (Somerton, 1981c; Incze, 1983)

Type—Prezoeae and zoeae larvae pelagic in upper 40 meters; megalopa larvae pelagic or benthic; postlarval crabs benthic, on sand and mud bottom.

Physical/Chemical—Adults occur at depths from 10 to 450 meters; most occur between 30 and 150 meters. In the eastern Bering Sea, found in perennially cold waters (late summer mean, 2.4°C).

Life History

Social Behavior—Unknown.

Biological Associations—Most frequently taken in trawl surveys with walleye pollock, yellowfin sole, Pacific cod, and eelpouts. Encrusting organisms similar to those of red king crab: barnacles (*Balanus* spp.), leech (*Carcinobdella*) egg cases, bryzoans, tube-forming polychaetes (*Spirorbis* spp.), and sponges.

Nutrition (Cunningham, 1969; Tarverdieva, 1976; Feder and Jewett, 1978, 1980; Incze, 1983)

- *Feeding type*—Predator, scavenger.
- *Food*—Zoeae larvae believed to be dependent on zooplankton although phytoplankton also taken. In eastern Bering Sea, dominant food groups of postlarval crabs are mollusks, crustaceans, echinoderms, and annelids. Polychaete worms and brittle stars (mainly *Ophiura* sp.) were most frequently consumed in one study. Dominant food in Norton Sound and southern Chukchi Sea is the bivalve *Nucula tenuis*.
- *Feeding behavior*—Unknown.
- *Feeding location*—Prezoeae and zoeae larvae in upper part of water column; megalopa larvae pelagic or benthic; juveniles and adults benthic.

Reproduction (Watson, 1972; Haynes et al., 1976; Wolotira, Sample, and Morin, 1977; Adams, 1979; Jewett, 1981; Incze, 1983; Paul et al., 1983)

- *Mode*—Sexual; dioecious.
- *Location*—Throughout range, but few adults in northern part of range.
- *Behavior*—Male grasps female in precopulatory embrace up to 14 days prior to her primiparous molt at maturity; mating and egg extrusion follow closely. Hybridization of *C. opilio* and *C. bairdi* common in areas where their ranges overlap (e.g., near Pribilof Islands).
- *Biology*—In eastern Bering Sea, mating occurs February through May. Females mate and extrude eggs shortly after final molt to maturity. Subsequent clutches fertilized by stored sperm and probably by additional mating. Eggs carried for about 1 year; hatching occurs March through May. Fecundity varies with female's size and spawning history: 28,000-75,000 eggs per female in eastern Bering Sea; fewer farther north where both size of fecund females and number of eggs produced by female of a given size decrease. Females usually produce 3 or 4 clutches in lifetime.

Development (Pereyra, Reeves, and Bakkala, 1976; Adams, 1979; Somerton, 1981b; McBride, 1982; Incze, 1983)—Larvae hatch in April as prezoeae and immediately molt to first zoeal stage. Two zoeal stages each last about 30 days. Megalops stage, which follows, is more variable, but often lasts 60 days before molting to first juvenile instar. Juveniles molt several times in first two or three years and once a year thereafter. Adult females have terminal molt to maturity; adult males may not molt annually. In the eastern Bering Sea, most females mature at 50-70 mm carapace width, while males mature at about 64 mm. Estimates of age at maturity, 5-7 years. Size at maturity decreases from south to north.

Growth (Ito, 1970; Miller and Watson, 1976; Adams, 1979; Somerton, 1981b; McBride, 1982)—Postlarval males and females grow at comparable rates until maturity; growth in carapace width per molt varies from high of 48% in the first year to about 18% and 15%, respectively, for males and females, at molt to maturity. Tagging studies in the eastern Bering Sea have shown a 14%-per-molt increase in carapace width for large males. Males weigh 192 grams at 78 mm (legal size) and 418 grams at 100 mm. In eastern Bering Sea, seldom larger than 140-mm carapace width for males and 80 mm for females.

Movements (Slizkin, 1974; Pereyra, Reeves, and Bakkala, 1976; Wolotira, Sample, and Morin, 1977; Somerton, 1981b; McBride, 1982; Incze, 1983)—Some evidence for diurnal vertical migration of larvae. Scarcity of large males (at least 110-mm carapace width) in northern and eastern portions of range and paucity of females relative to males in southeastern portion of range suggest considerable movement of males in a generally southerly direction. Females are apparently more sedentary. Tagging studies of males wider than 80 mm show a movement to the south or southwest. Cyclic annual movements have not been demonstrated.

Factors Influencing Populations

Natural (Feder and Jewett, 1980; Lowry and Frost, 1981b; Somerton, 1981a; Jewett, 1982; Smith and Walters, 1982; Incze, 1983)—Larvae preyed upon by birds and fish, including yellowfin sole and walleye pollock. Predators on postlarvae include red king crab, walleye pollock, Pacific cod, eelpouts, sculpins, and flatfishes. *C. opilio* is a major item in diet of bearded seal. A bacterial disease that damages carapace may also cause mortality. Nematodes and trematodes infect connective tissue. Highly variable year-class strength probably results from varying oceanographic effects on larval survival.

Human-related (International North Pacific Fisheries Commission, 1982; Otto, 1982; Eaton, 1983)—Directed commercial fishery removes large numbers of males. During the last 5 years, more than 90% of catch has been wider than 90 mm and typically averaged 105-118 mm or 500-700 grams. Exploitation rates have fluctuated with market conditions, but have been universally less than 20% of marketable stock. Incidental catch in foreign and domestic trawl fisheries is negligible cause of mortality.

Potential (Nelson-Smith, 1973; Karinen and Rice, 1974; Johnson, 1977; Rice, Korn, and Karinen, 1977; Rice, Short, and Karinen, 1977; Armstrong et al., 1983)—Oil pollution directly affects crustaceans in general, causing suffocation and disruption of osmoregulation, reproductive behavior, the feeding response, and general locomotor activity; also reduces hatching success of eggs, increases larval mortality and autotomy of appendages. Larvae more vulnerable than postlarvae; all life stages more vulnerable during molt. Indirect effects include disruption of food chain and habitat alteration.

Population Size (Otto, 1982; Otto et al., 1983)

Population large in late 1970s; steady decline since then to 8.6 billion crabs in 1980 and 3.8 billion in 1983.

Management (North Pacific Fishery Management Council, 1979; Alaska Department of Fish & Game, 1983)

Catch quota and season, area, size, sex, and gear restrictions are management tools. Fishery takes legal-sized males only, with pots or ringnets, within specified season. Minimum legal size: 78-mm (3.1 in) carapace width. Season may be closed early if desired exploitation is met, product quality is poor, mortality of crabs in vessel holds is excessive, or reproductive conditions are poor. Peak catch of 27,900 metric tons in 1979; declined to 11,850 metric tons in 1983.

Persons Consulted

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Legend

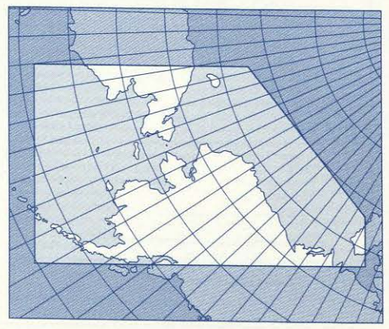
Adult Area
(Year-round)

Major Adult Area
(Year-round)

Mating (February-May), spawning (February-May), and hatching (March-May) occur throughout adult areas. Juveniles occur year-round throughout adult areas.

Map References

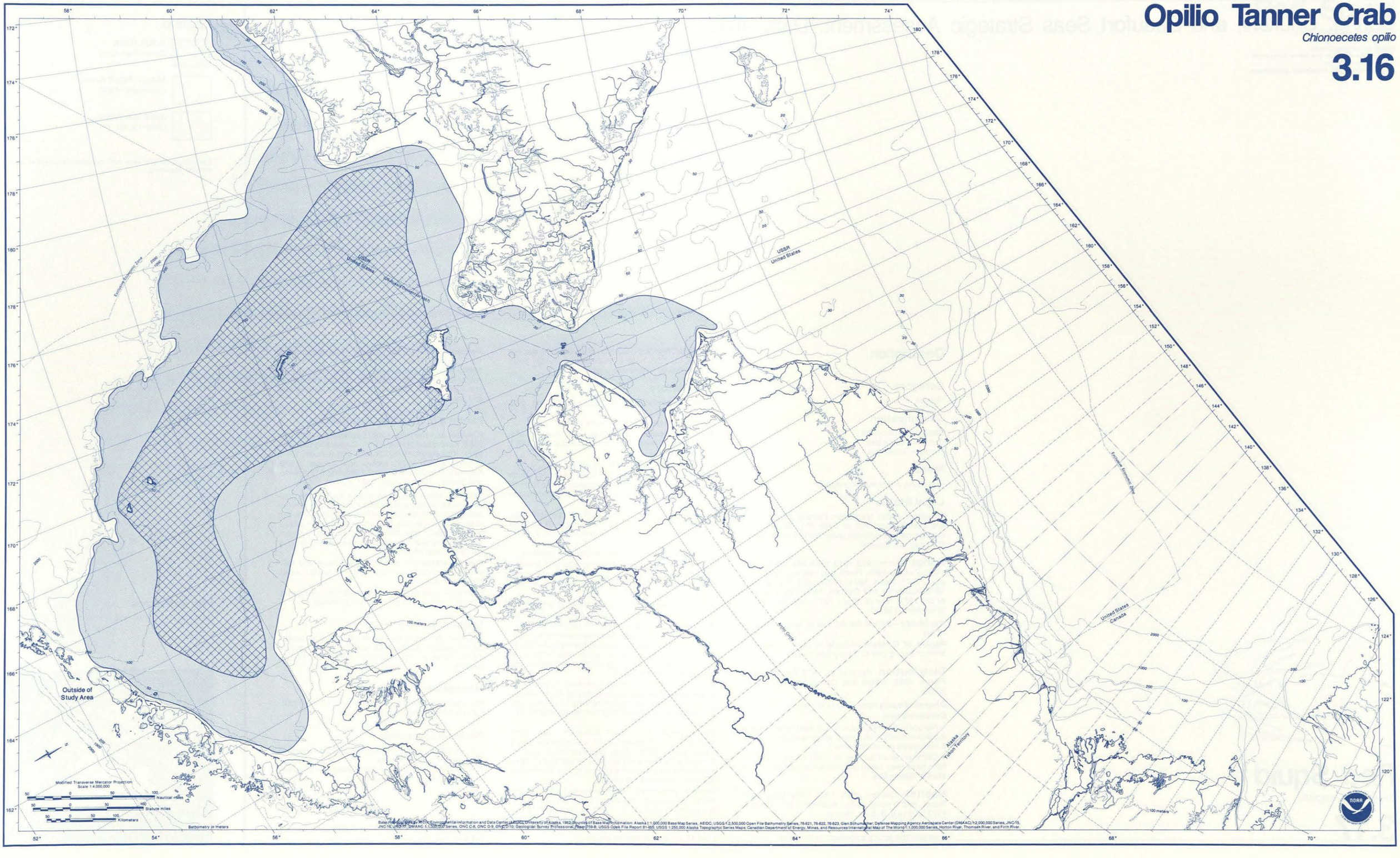
Squires, 1969; Pereyra, Reeves, and Bakkala, 1976; Wolotira, Sample, and Morin, 1977; Otto, 1982; Otto et al., 1983.



Opilio Tanner Crab

Chionoecetes opilio

3.16



Base map data from: NOAA, Environmental Information and Data Center (AEIDC), University of Alaska, 1992. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC16; JNC17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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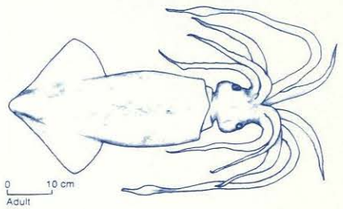


Red Squid

Berryteuthis magister

3.17

Description

Category

Mollusk

Classification

Class—Cephalopoda
Order—Teuthoidea
Family—Gonatidae

Name

Red squid, *Berryteuthis magister*

Legal Status

Protected under Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), with management jurisdiction under North Pacific Fishery Management Council.

Range (Berry, 1912, 1913, 1925; Pearcy and Voss, 1963; Pearcy, 1965; Fields and Gauley, 1971; Filippova, 1971; Nesis, 1971, 1972, 1973; Young, 1972, 1973; Kubodera and Okutani, 1977, 1981a,b; Naito et al., 1977; Pearcy et al., 1977; Bublitz, 1981a,b; Kristensen, 1981a)

Worldwide—Boreal. Bering Sea to Japan and California.

Region of Concern—Middle to outer continental shelf of Bering Sea to Bering Sea basin.

Distribution (Naito et al., 1977; Bublitz, 1981a; Fiscus, 1982; Wilson and Gorham, 1982; Jefferts, 1983)

Discrete Populations—None known.

Concentrations

- *Natural*—Continental slope of southeastern Bering Sea (density of immature specimens to more than 8 individuals per cubic meter).
- *Commercial*—Catches of 1-20 metric tons per hour have been taken on continental slope and deep shelf of Bering Sea.

Habitat (Okutani, 1966, 1968, 1969; Voss, 1967; Roper and Young, 1975; Kubodera and Okutani, 1977, 1981a,b; Bublitz, 1981a)

Type—Larvae planktonic in upper 100 meters; juveniles and adults epipelagic to demersal.

Physical/Chemical—Surface to about 1,200 meters, mainly 400-800 meters. Vertical distribution probably limited by temperature and light.

Life History

Social Behavior (Arnold, 1962)—Schooling possible.

Biological Associations—None known.

Nutrition (Nesis, 1964; Zuev and Nesis, 1971; Hurley, 1976; Naito, Murakami, and Kobayashi, 1977; Summers, 1981)

- *Feeding type*—Predator, carnivore.
- *Food*—Larvae eat zooplankton; juveniles, adults eat macroplankton, fishes, crustaceans, squids. Food choice appears related more to body size than to type of food.
- *Feeding behavior*—Prey captured by tentacles, secured and maneuvered to mouth by arms. Capture may be preceded by complex approach and orientation behavior.
- *Feeding location*—Water column and benthos.

Reproduction (Muus, 1956; Hamabe and Shimizu, 1966; Nesis, 1970; Young, 1973; Naito, Murakami, and Kobayashi, 1977; Kristensen, 1981b; Summers, 1981)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Copulate in water column; near bottom on outer continental shelf and on continental slope.
- *Behavior*—Copulation probably preceded by courtship ritual. Spermatophores transferred to female by male using arms and/or tentacles; spermatophores stored by female until egg-laying commences; egg masses attached to bottom.
- *Biology*—Gonads probably develop in fall-winter; spawn late winter-early spring. May be more than one spawning period; adults probably die after spawning. Fecundity about 10,000 eggs per female; egg mortality low.

Development (Voss, 1967; Summers, 1968, 1971; McMahon and Summers, 1971; von Boletzky, 1974, 1977; Nesis, 1979)—Eggs probably hatch after 1-2 months (temperature related) to planktonic larval stage. Mature just before spawning; age at maturity unknown, probably 1-2 years.

Growth (Kristensen, 1977; Kubodera and Okutani, 1977, 1981a; Naito, Murakami, and Kobayashi, 1977; Nishiyama and Bublitz, 1980; Summers, 1981)—Rapid growth until initiation of gonad development dependent on food and temperature. Adults to more than 45-cm dorsal mantle length.

Movements (Roper and Young, 1975; Naito et al., 1977; Pearcy et al., 1977; Nishiyama and Bublitz, 1980)—Larvae planktonic; juveniles and adults nektonic. Larvae undertake diel vertical migrations of about 50 meters. Movements unknown for juveniles and adults.

Factors Influencing Populations

(Okutani and Nemoto, 1964; LeBrasseur, 1966; Ito, 1969; Kanno and Hamai, 1971; Clarke and Stevens, 1974; Kawakami, 1976; Okutani and Kubota, 1976; Okutani et al., 1976; Ainley and Sanger, 1979; Kajimura, Fiscus, and Stroud, 1980; Hunt, Burgeson, and Sanger, 1981; Sanger, 1981; Fiscus, 1982)

Natural—Major predators include large fishes (particularly salmonids and sharks), marine mammals (fur seals, sea lions, harbor, spotted, ringed, and ribbon seals, Dall's porpoises, and white, sperm, and goosebeak whales), and seabirds (kittiwakes, fulmars, shearwaters, storm-petrels, murres, puffins, auklets, murrelets, and albatrosses).

Human-related—Direct fishing pressure and fisheries for predators and/or prey of squids affect population size.

Potential—Increase in high-seas fishery is probable. Effects of petrochemical pollution unknown.

Population Size (Laevastu, 1981)

Unknown. Annual consumption of squids by predators in eastern Bering Sea (estimated at 3 million metric tons) is attributable in large part to this species.

Management

Managed as incidental catch fishery by North Pacific Fishery Management Council.

Persons Consulted

J. H. Branson, North Pacific Fishery Management Council, Anchorage, Alaska.
T. Nishiyama, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.

CHRISTOPHER G. BUBLITZ

Sea Grant Program, University of Alaska, Fairbanks, Alaska.

Legend

Adult Area
(November-April)

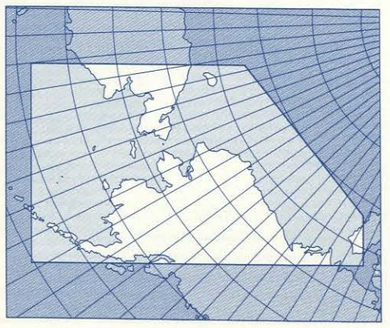
Major Adult Area
(November-April)

Juvenile Area
(Year-round)

Spawning occurs January-April throughout adult areas; adults die after spawning.

Map References

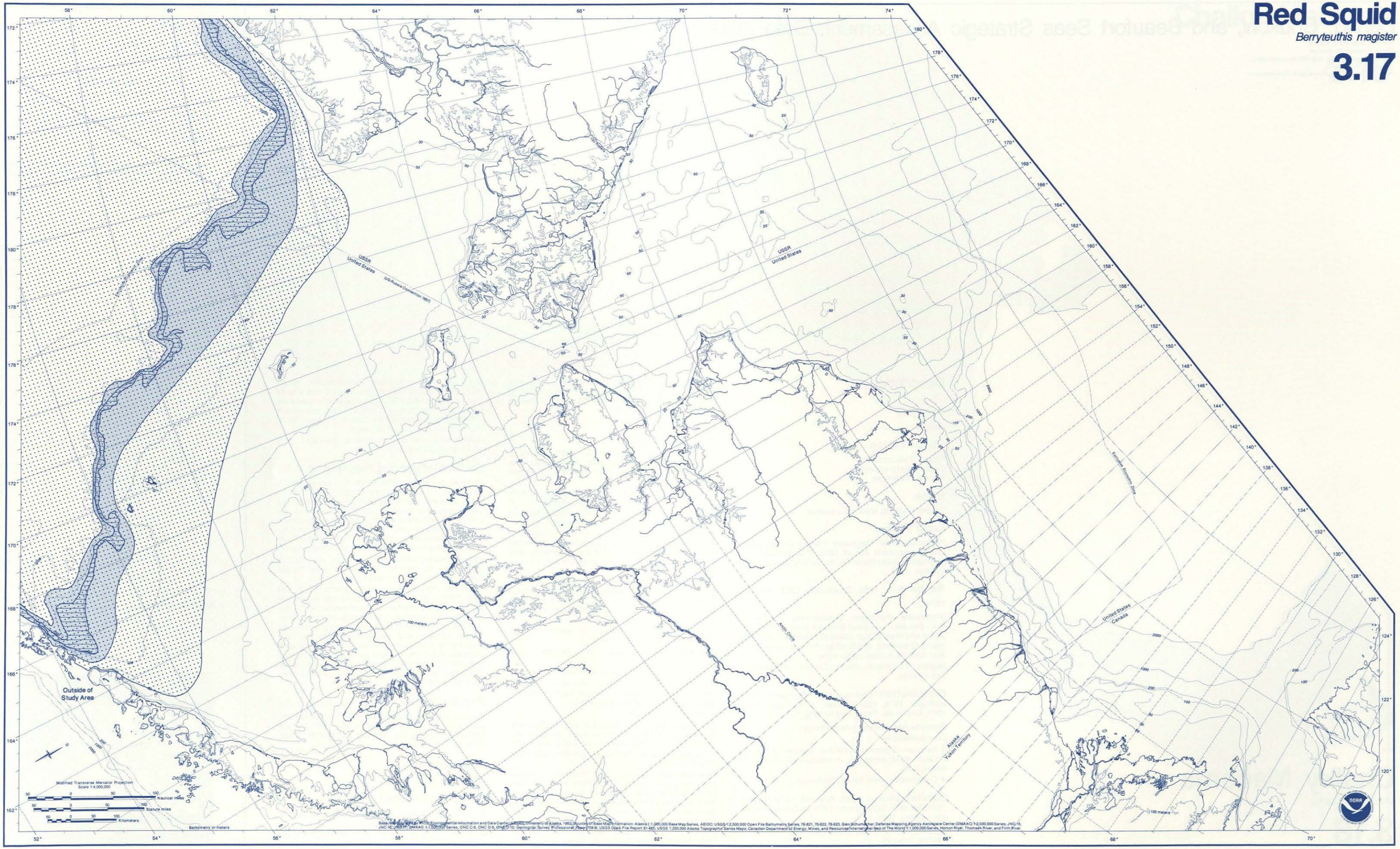
Naito et al., 1977; Wilson and Gorham, 1982.



Red Squid

Berryteuthis magister

3.17



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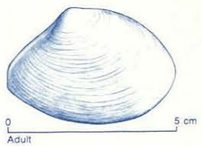


Chalky Macoma

Macoma calcarea

3.18

Description

Category

Mollusk

Classification

Class—Pelecypoda
Order—Heterodontida
Family—Tellinidae

Name

Chalky macoma, *Macoma calcarea*

Legal Status

Protected under Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), with jurisdiction under North Pacific Fishery Management Council.

Range (Ellis, 1960; Zenkevitch, 1963; Bernard, 1979)

Worldwide—Panarctic, circumboreal. In Pacific, from Beaufort and East Siberian seas to northern Japan and Washington State. In Atlantic, from Baffin Island, Greenland, and Svalbard to New Jersey, Norway, and the Azores (deep water).

Region of Concern—Bering, Chukchi, and Beaufort Sea shelves.

Distribution (Neiman, 1963; Semenov, 1964; Haflinger, 1978, 1981; Stoker, 1978; Feder et al., 1981; McDonald, Feder, and Hoberg, 1981)

Discrete Populations—None known.

Concentrations

- *Natural*—A dominant benthic species of Bering-Chukchi shelf, especially in middle-shelf domain of Bering Sea.
- *Commercial*—Not taken commercially.

Habitat (Neiman, 1963; Rowland, 1973; Stoker, 1978; Bernard, 1979; Foster, 1979; McDonald, Feder, and Hoberg, 1981)

Type—Larvae meroplanktonic; juveniles and adults benthic, infaunal.

Physical/Chemical—Depth range 2-590 meters, mainly 50-100 meters. Substrate fine silt-clay to gravel and stones; mainly very fine sand to medium silt. Avoid brackish water.

Life History

Social Behavior—Unknown.

Biological Association (Ellis, 1960; Rowland, 1973)—Commonly found with *Astarte borealis*, *Clinocardium ciliatum*, *Mya truncata*, *Serripes groenlandicus*.

Nutrition (Yonge and Thompson, 1976; Stoker, 1978; McDonald, Feder, and Hoberg, 1981)

- *Feeding type*—Unknown for larvae; juveniles and adults primarily deposit-feeders; may also suspension-feed.
- *Food*—Larvae eat small phytoplankton; juveniles and adults eat primarily detritus on sediments, also small phytoplankton. Select particles of about 20-μm diameter.
- *Feeding behavior*—Incurrent siphon extruded from sediment; sucks detritus from sediment surface. Material sorted by cilia on gills, passed to mouth by palps; indigestible material expelled via excurrent siphon.
- *Feeding location*—Larvae in water column; juveniles and adults on bottom.

Reproduction (Purchon, 1968; Barnes, 1974; Petersen, 1978)

- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Sperm released into water column, taken into mantle cavity of female; eggs fertilized in mantle cavity before being expelled.
- *Behavior*—Unknown.
- *Biology*—Spawn in midsummer after ice retreats. Fecundity unknown. Fertilized eggs released into water column. Annual mortality 16% at 5 years, 42% at 10 years; heaviest mortality in age-classes greater than 6 years.

Development (Barnes, 1974; Petersen, 1978)—Eggs hatch as trochophore larvae after unknown time; metamorphose to veliger larvae; veligers resemble juveniles and adults but are free-swimming; later settle to bottom as juveniles. Gonads develop at 3-4 years.

Growth (Neiman, 1964; Petersen, 1978; Stoker, 1978; Bernard, 1979; McDonald, Feder, and Hoberg, 1981)—Isometric, probably indeterminate. Mean rate 3 mm per year. Juveniles average 2 mm long at first settling; adults 13-17 mm at 5 years; maximum to 54 mm. Majority of Bering Sea population 3-8 years of age; some individuals to 11 years. Maximum life duration about 22 years.

Movements—Larvae planktonic; juveniles and adults essentially sessile.

Factors Influencing Populations

Natural (Petersen, 1978; Feder and Jewett, 1981; McDonald, Feder, and Hoberg, 1981; Fay, 1982)—Major prey of king and tanner crabs in southeastern Bering Sea; also taken by sea stars and walruses. Low densities in areas with high densities of flatfishes suggest predator-prey relationship. Parasitized by athecate hydrozoan, *Monobrachium parasiticum*, which slows growth rate and gonadal development.

Human-related—Reduction of crab and flatfish populations by commercial fisheries in southeast Bering Sea probably increases survival rate.

Potential (Nelson-Smith, 1973; Feder, Paul, and Paul, 1978)—Bottom-feeding habits and sessile life style predispose shellfish to oil contamination. Globular oil may be ingested in sediments, allowing movement of contaminants up food chain. Oil frequently causes narcosis and decreased feeding and respiratory movements of ctenidial cilia in clams, causing decrease in feeding rate and general decline in body condition. Conversely, oil contamination of water could decrease density of sea stars around clam beds, allowing higher survival rate.

Population Size (Neiman, 1963; Stoker, 1978)

Patchy; average about 50 to 200 individuals per square meter in Bering Sea middle-shelf domain. Estimated population on Bering/Chukchi shelf, 80 trillion individuals.

Management

None.

Persons Consulted

S. C. Jewett, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
D. W. Kessler, Northwest and Alaska Fisheries Center, NMFS/NOAA, Kodiak, Alaska.

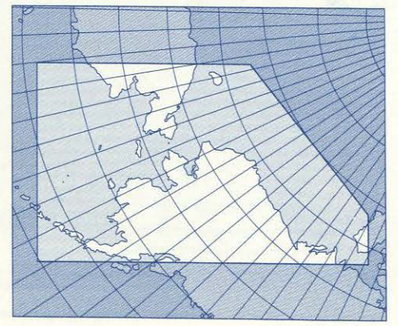
Legend

- Adult Area (Year-round)
- Major Adult Area (Year-round)
- Major Adult Concentration (Year-round)

Spawning occurs June-September in ice-free waters throughout adult areas. Juveniles occur year-round throughout adult areas. Distribution is very patchy.

Map References

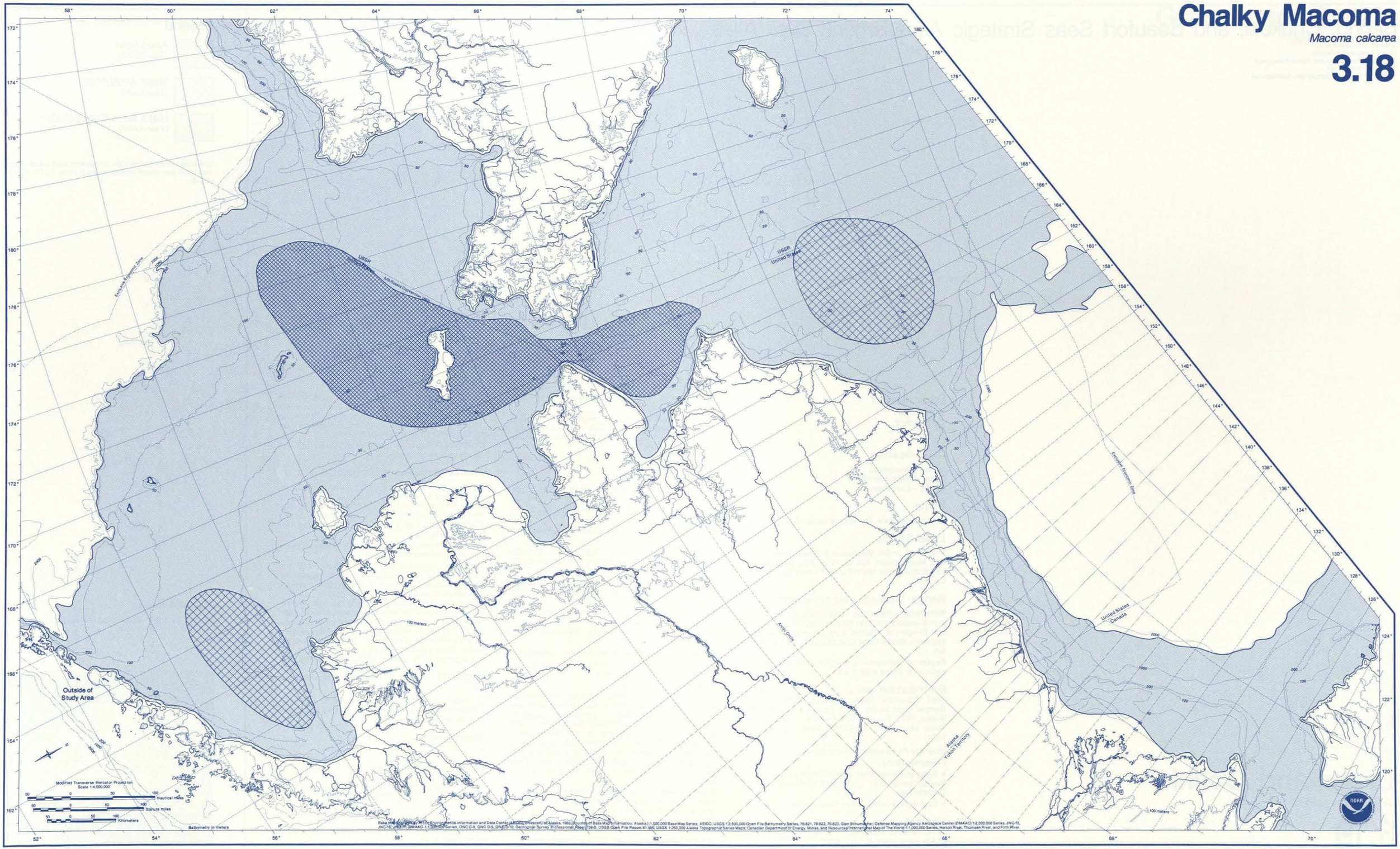
Haflinger, 1978, 1981; Stoker, 1978; Feder et al., 1981. Personal communication from Jewett.



Chalky Macoma

Macoma calcarea

3.18



Base map data courtesy of the Environmental Information and Data Center (EIDC), University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 79-B; USGS Open File Report 81-455; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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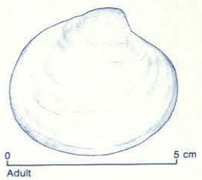


Greenland Cockle

Serripes groenlandicus

3.19

Description

Category

Mollusk

Classification

Class—Pelecypoda
Order—Heterodontida
Family—Cardiidae

Name

Greenland cockle, *Serripes groenlandicus*

Legal Status

Protected under Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), with jurisdiction under North Pacific Fishery Management Council.

Range (Zenkevitch, 1963; Bernard, 1979)

Worldwide—Panarctic, circumboreal. In Pacific, from Beaufort and East Siberian seas to Sea of Japan and Oregon; in Atlantic, from Greenland, Svalbard, and Kara Sea to Cape Cod, Norway, and Great Britain.

Region of Concern—Bering, Chukchi, and Beaufort seas; over entire shelf area.

Distribution (McLaughlin, 1963; Zenkevitch, 1963; Semenov, 1964; Rowland, 1973; Wolotira, Sample, and Morin, 1977; Haflinger, 1978, 1981; Stoker, 1978; Foster, 1979; Feder and Jewett, 1981; Feder et al., 1981; McDonald, Feder, and Hoberg, 1981)

Discrete Populations—None known.

Concentrations

- *Natural*—Inner-shelf domain from central Bristol Bay northwest to St. Lawrence Island; Norton Sound; Chukchi Sea.
- *Commercial*—Not taken commercially.

Habitat (Rowland, 1973; Petersen, 1978; Stoker, 1978; Bernard, 1979; Foster, 1979; McDonald, Feder, and Hoberg, 1981; Baxter, 1983)

Type—Larvae meroplanktonic; juveniles and adults benthic, infaunal.

Physical/Chemical—Depth range 0-2,200 meters; mainly less than 60 meters. Clay to gravel substrate. Avoid brackish water. Dead shells may be transported great distances.

Life History

Social Behavior—Unknown.

Biological Associations (Rowland, 1973)—Commonly with *Macoma calcarea*.

Nutrition (Barnes, 1974; Stoker, 1978; McDonald, Feder, and Hoberg, 1981)

- *Feeding type*—Larvae probably filter-feeders; juveniles and adults filter-feeders.
- *Food*—Larvae take small phytoplankton; juveniles and adults eat phytoplankton, other particulate foods, and suspended detritus.
- *Feeding behavior*—Water from incurrent siphon pumped across gills, where food is removed by cilia and moved to mouth.
- *Feeding location*—Larvae in water column; juveniles and adults on bottom.

Reproduction (Barnes, 1974; Petersen, 1978; Stoker, 1978)

- *Mode*—Sexual; external fertilization; monoecious.
- *Location*—Gametes released into water column, where fertilization takes place.
- *Behavior*—Unknown.
- *Biology*—Hermaphroditic, possibly protandrous. Spawning occurs late winter-early spring when sea ice may be present; spawning probably induced by phytoplankton being swept under ice by currents and does not appear to be related to light level or water temperature. Fecundity unknown. Adults may consume larvae and/or may "condition" substrate, preventing settlement of spat in colonized areas; larvae settle in single-age beds. Mortality averages 12% per year.

Development (Barnes, 1974)—Eggs hatch after unknown time to trochophore larvae, which metamorphose into veliger larvae; veligers resemble juveniles and adults but are free-swimming; later settle to bottom as juveniles. Age at maturity unknown.

Growth (Petersen, 1978; Stoker, 1978; Bernard, 1979)—Isometric, probably indeterminate. Growth rate 2.6-6.4 mm per year (mean 4.3 mm per year); decreases with increasing age. Shell length to 130 mm in Bering Sea; to 45 mm in Beaufort Sea. Maximum life duration about 25 years.

Movements—Larvae planktonic; juveniles and adults esentially sessile.

Factors Influencing Populations

Natural (Fay and Lowry, 1981; Feder and Jewett, 1981)—One of three main foods of walruses and major food of bearded seals in northern Bering Sea; also taken by king crab, Alaska plaice, starry flounders, and sea stars in eastern Bering and Chukchi seas.

Human-related—Reduction of any of these predators might increase survival rate.

Potential (Nelson-Smith, 1973; Feder, Paul, and Paul, 1978)—Filter-feeding habits and sessile lifestyle predispose shellfish to oil contamination. Oil emulsified in seawater may be ingested, allowing movement of contaminants up food chain. Oil frequently causes narcosis and decreased feeding and respiratory movements of ctenidial cilia in clams, causing decrease in feeding rate and general decline in body condition. Conversely, oil contamination of water could decrease density of sea stars in and around clam beds, allowing higher survival rate.

Population Size (Wolotira, Sample, and Morin, 1977)

Unknown. Average concentration 0.02 kg/km in Kotzebue Sound trawl survey is probably atypical of population as a whole.

Management

None.

Persons Consulted

D. W. Kessler, Northwest and Alaska Fisheries Center, NMFS/NOAA, Kodiak, Alaska.

STEPHEN C. JEWETT

Institute of Marine Science, University of Alaska, Fairbanks, Alaska.

Legend

Adult Area
(Year-round)

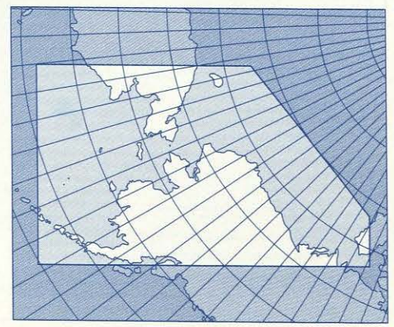
Major Adult Area
(Year-round)

Major Adult Concentration
(Year-round)

Spawning occurs March-June throughout adult areas. Juveniles occur year-round throughout adult areas. Distribution is patchy.

Map References

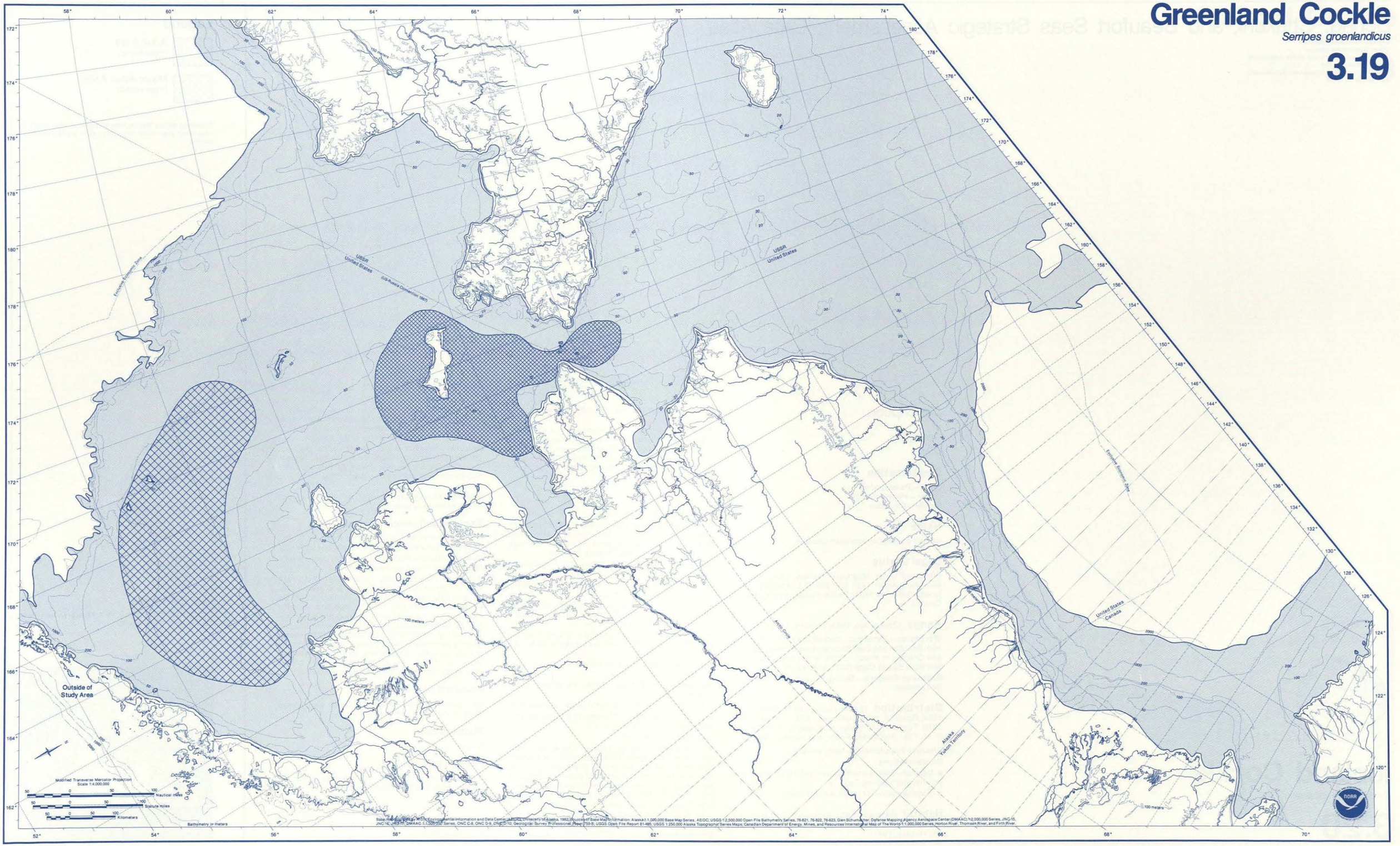
Haflinger, 1978, 1981; Stoker, 1978; Feder et al., 1981. Personal communication from Jewett.



Greenland Cockle

Serripes groenlandicus

3.19



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Iceland Cockle

Clinocardium ciliatum

3.20

Description

Category

Mollusk

Classification

Class—Pelecypoda
Order—Heterodontida
Family—Cardiidae

Name

Iceland cockle, *Clinocardium ciliatum*

Legal Status

Protected under Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), with jurisdiction under North Pacific Fishery Management Council.

Range (Zenkevitch, 1963; Bernard, 1979)

Worldwide—Panarctic, circumboreal. In Pacific, from Beaufort and East Siberian seas to Sea of Japan and Oregon; in Atlantic, from Greenland, Svalbard, and Kara Sea to Cape Cod and Great Britain.

Region of Concern—Bering, Chukchi, and Beaufort Sea shelves.

Distribution (Zenkevitch, 1963; Semenov, 1964; Rowland, 1973; Haflinger, 1978, 1981; Stoker, 1978; Foster, 1979; Feder and Jewett, 1981; Feder et al., 1981; McDonald, Feder, and Hoberg, 1981)

Discrete Populations—None known.

Concentrations

- *Natural*—Middle-shelf domain (40-100 meters) of southeastern Bering Sea.
- *Commercial*—Not taken commercially.

Habitat (Rowland, 1973; Petersen, 1978; Stoker, 1978; Bernard, 1979; Foster, 1979; McDonald, Feder, and Hoberg, 1981)

Type—Larvae planktonic; juveniles and adults benthic, infaunal.

Physical/Chemical—Depth range in the southeast Bering Sea is mainly 50-100 meters; maximum depth 105 meters. In the northeast Bering and southeast Chukchi seas, occur at depths less than 50 meters. Substrate mainly very fine sand to medium silt. Avoid brackish water.

Life History

Social Behavior—Unknown.

Biological Associations (Rowland, 1973; Haflinger, 1981)—Commonly with the mollusks *Axinopsida serricata, Macoma calcarea, Nuculana pernula, Solariella varicosa*, and *Thyasira flexuosa*.

Nutrition (Barnes, 1974; Stoker, 1978; McDonald, Feder, and Hoberg, 1981)

- *Feeding type*—Larvae probably filter-feeders; juveniles and adults filter-feeders.
- *Foods*—Larvae take small phytoplankton; juveniles and adults eat phytoplankton, other particulate foods, and resuspended detritus.
- *Feeding behavior*—Water from incurrent siphon pumped across gills, where food is removed by cilia and moved to mouth.
- *Feeding location*—Larvae in water column; juveniles and adults on bottom.

Reproduction (Barnes, 1974; Petersen, 1978; Stoker, 1978)

- *Mode*—Sexual; external fertilization; monoecious.
- *Location*—Gametes released into water column, where fertilization takes place.
- *Behavior*—Unknown.
- *Biology*—Protandrous hermaphrodite. Spawn in late winter-early spring when sea ice may be present. Spawning probably induced by phytoplankton being swept under ice by currents and does not appear to be related to light level or water temperature. Fecundity unknown. Adults may consume larvae and/or may "condition" substrate, preventing settlement of spat in colonized areas; larvae settle in single-age beds. Mortality averages 20% per year.

Development (Barnes, 1974)—Eggs hatch after unknown time into trochophore larvae, which metamorphose into veliger larvae; veligers resemble juveniles and adults but are free-swimming; later settle to bottom as juveniles. Age at maturity unknown.

Growth (Petersen, 1978; Stoker, 1978; Bernard, 1979)—Isometric, probably indeterminate. Growth rate: 1.7-10.4 mm per year (mean, 6.8 mm per year); decreases with increasing age. Shell length to 70 mm.

Movements—Larvae planktonic; juveniles and adults essentially sessile.

Factors Influencing Populations

Natural (Feder and Jewett, 1981; Fay, 1982)—Primary prey for king crabs, yellowfin sole, and sea stars.

Human-related—Reduction of any of these predators might increase survival rate.

Potential (Nelson-Smith, 1973; Feder, Paul, and Paul, 1978)—Filter-feeding habits and sessile lifestyle predispose shellfish to oil contamination. Oil emulsified in seawater may be ingested, allowing movement of contaminants up food chain. Oil frequently causes narcosis and decreased feeding and respiratory movements of ctenidial cilia in clams, causing decrease in feeding rate and general decline in body condition. Conversely, oil contamination of water could decrease density of sea stars in and around clam beds, allowing higher survival rate.

Population Size

Unknown. Reaches 2,800 individuals per square meter in southeastern Bering Sea.

Management

None.

Persons Consulted

D. W. Kessler, Northwest and Alaska Fisheries Center, NMFS/NOAA, Kodiak, Alaska.

STEPHEN C. JEWETT

Institute of Marine Science, University of Alaska, Fairbanks, Alaska.

Legend

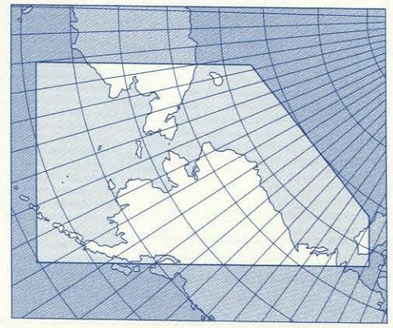
Adult Area
(Year-round)

Major Adult Area
(Year-round)

Spawning occurs March-June throughout adult areas. Juveniles occur year-round throughout adult areas. Distribution is patchy.

Map References

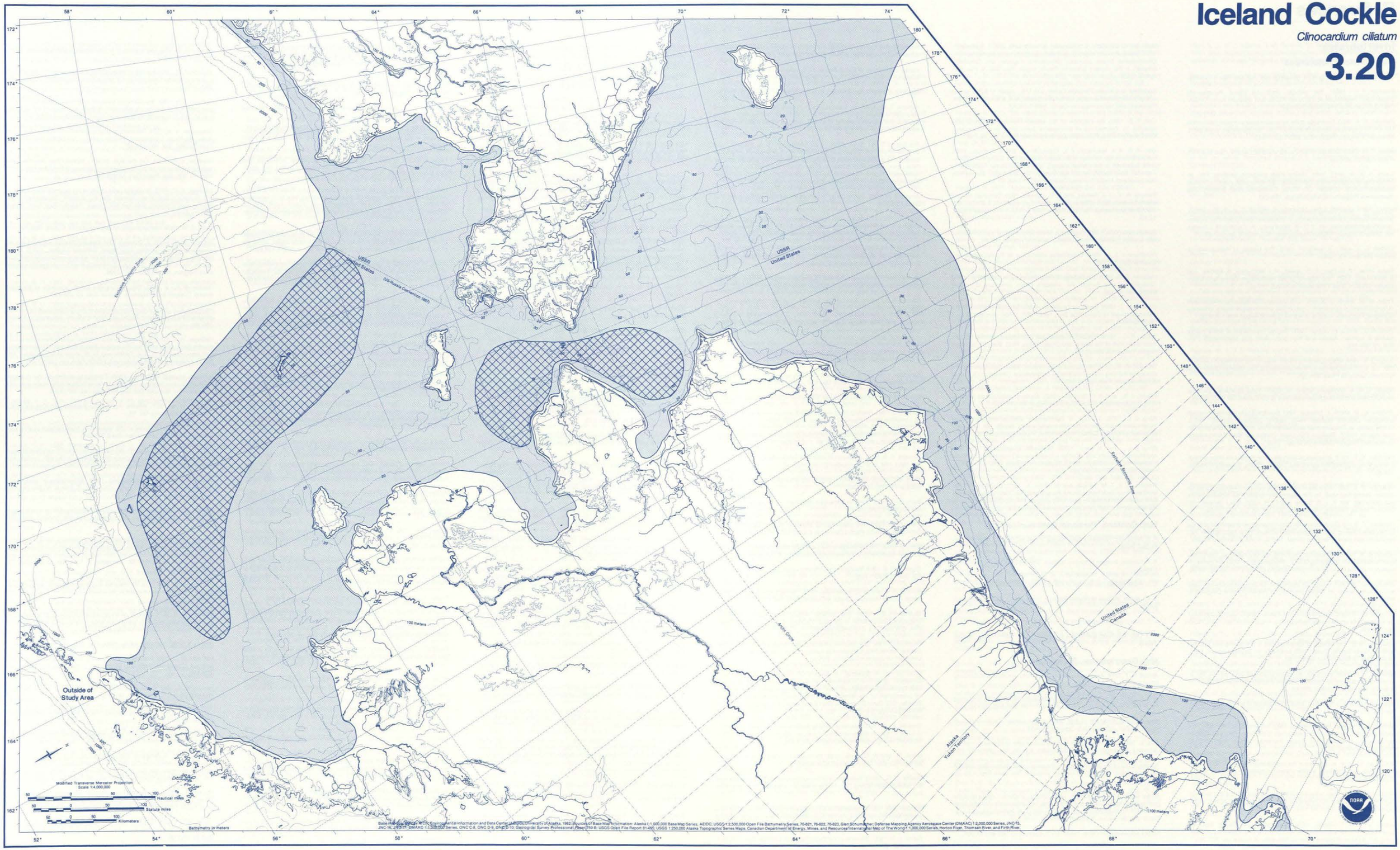
Haflinger, 1978, 1981; Stoker, 1978; Feder et al., 1981. Personal communication from Jewett.



Iceland Cockle

Clinocardium ciliatum

3.20



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Fishes



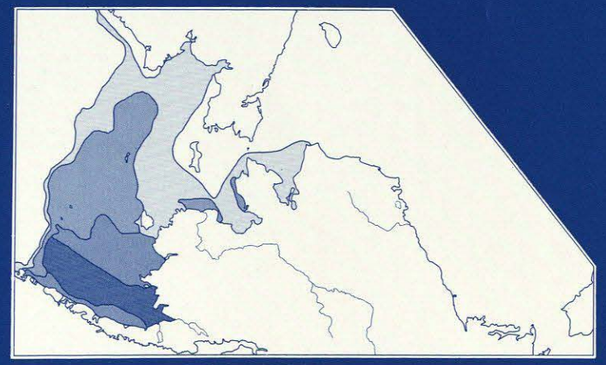
Areas of Reproductive Abundance for Selected Fishes

Number of Species

1 2 3 4 5,6

Species: Pacific Herring, Pink Salmon, Chum Salmon, Coho Salmon, Sockeye Salmon, Chinook Salmon, Capelin, Eulachon, Rainbow Smelt, Saffron Cod, Pacific Cod, Walleye Pollock, Yellowfin Sole, Rock Sole, Arrowtooth Flounder, Flathead Sole, Pacific Halibut

Areas indicate the number of species present, not necessarily the overall distribution of biomass.



Areas of Abundance for Selected Fishes

Number of Species

1,2 3,4 5,6 7,8

Species: Pacific Herring, Pink Salmon, Chum Salmon, Coho Salmon, Sockeye Salmon, Chinook Salmon, Capelin, Eulachon, Rainbow Smelt, Saffron Cod, Pacific Cod, Walleye Pollock, Yellowfin Sole, Alaska Plaice, Rock Sole, Arrowtooth Flounder, Flathead Sole, Pacific Halibut

Areas indicate the number of species present, not necessarily the overall distribution of biomass.

Introduction

This subsection comprises 20 maps of 21 species of fishes in three categories: 12 demersal species; one pelagic species; and eight anadromous species. Although comprising less than 10 percent of the species in the region, the 21 species mapped probably account for most of the region's fish biomass and include most of those that are commercially and ecologically important. The most abundant are walleye pollock, Pacific cod, the five salmon species, Pacific halibut, and yellowfin sole. These species support one of the world's largest commercial fish harvests. They also support, along with forage fish species (such as the smelts and Pacific sandlance), the largest populations of seabirds and marine mammals in the northern hemisphere from spring through fall. Fish population sizes have fluctuated widely in the region over the past century, partly from natural causes and partly from overfishing. For example, Pacific herring are depleted, Pacific halibut are recovering from low levels, and walleye pollock and the salmons are still abundant although heavily exploited. All the species considered here are managed either singly or cooperatively by the State of Alaska, the Federal government, or an international commission.

Most of the fishes in the region are carnivorous and fall loosely into three groups based on habitat and life history. Demersal species are those associated with the bottom. They may spend most of the time either in the water column somewhat above the bottom (as do walleye pollock and Pacific cod)and feed on pelagic and benthic organisms, or live and feed on the bottom (as do most of the flatfishes). Most commercial fish species of the region are in this group. Pelagic species, such as Pacific herring, spend most or all of their lives in the water column, with some species using the bottom for spawning. Anadromous species are those that live in marine waters as juveniles and adults but enter fresh water to spawn. This group includes salmon, which are pelagic and oceanic, and smelt, which are coastal. Anadromous species are generally pelagic feeders.

Although only a few species apparently account for most of the individuals, as many as 300 species occur in the region, most of which are small in size. Most fishes in the region fall into two geographic groups, the boreal (or cold-temperate) and the arctic. Most are boreal and are found in the Bering Sea and much of the North Pacific subarctic. This group includes the major commercial and forage species already mentioned. The Beaufort and Chukchi seas support an arctic fauna, some of which enters the Bering Sea during colder months. This group includes Arctic cod, polar cod, and a number of other poorly known species. Their abundance is far lower than that of the boreal species. A third group, the Beringian, is restricted to the Bering Sea and contains the smallest number of species. This group includes saffron cod and Bering flounder.

Seasonal distributions of the major species groups generally correlate with sea ice (Maps 1.8, 1.9). The boreal species avoid the ice, moving southward off the inner and middle Bering Sea shelf into deeper water during winter. They are replaced by the arctic species moving south from the Chukchi Sea with the sea ice advance. In summer, the arctic species move north out of the Bering Sea and the boreal species return to shallower water, taking advantage of the high summer productivity. The boreal species are not uniformly distributed over the Bering Sea shelf. Bottom-feeding flatfishes are most abundant on the southeastern shelf, whereas species feeding in the water column, such as walleye pollock and Pacific cod, are concentrated over the outer shelf and slope. This distribution pattern corresponds to that of the preferred prey of each fish species; for example, flatfishes concentrate where benthic biomass (Maps 2.4, 2.5) is high, and other species occur where zooplankton biomass (Map 2.3) is high.

The two inset maps illustrate the importance of different parts of the region to the fishes included in the atlas, even though they reflect the current and incomplete state of knowledge about the region. The maps are composites of major areas and concentrations for all times of year for the species indicated in the legend. Both maps highlight the southeastern Bering Sea/Bristol Bay area. The first map shows that two areas are most important for reproduction: the outer shelf and slope of the Bering Sea, especially the canyon areas, for demersal species; and the coastal and freshwater areas of Bristol Bay for anadromous species. The second map shows the areas important to non-breeding adults, primarily the southeastern Bering Sea shelf. These maps should be considered preliminary for two reasons: they reflect our incomplete knowledge of the region and are based only on the mapped species.

As shown in the *Data Content and Quality Table* (Section 3 Introduction), the distributions and life histories of the species mapped are reasonably well understood, having been well studied because of their commercial and ecological importance. The information is as good as that for birds and mammals. However, other ecologically important species, such as Pacific sandlance, Arctic cod, and several sculpins, have not been included because of paucity of detailed information. The importance of sea-ice movement in affecting distributions required standardizing seasonal positions of the ice edge for mapping purposes. This has been noted in the legends for those species where the standard lines were used to define distributions.

Demersal Fishes—These species (Maps 3.30-3.40) account for most of the fish biomass in the region. Their high abundance is due to the high primary productivity of the region and the large, relatively shallow area of the Bering Sea shelf. They feed in the water column and on the bottom, exploiting both pelagic and benthic food sources that range from zooplankton to worms, including smaller fishes. They are primarily year-round residents, but they move away from the sea-ice advance into deeper water in winter. They include major prey species for seabirds and marine mammals and the majority of the commercial species. Important forage species include Pacific sandlance, juvenile walleye pollock, and Pacific cod, several sculpins, and Arctic cod. The most important commercial species are walleye pollock, Pacific cod, yellowfin sole, and Pacific halibut. Pacific halibut harvests are managed by the International Pacific Halibut Commission and the remaining species by the State of Alaska and the National Marine Fisheries Service through the North Pacific Fishery Management Council.

Pelagic Fishes—This atlas includes only one pelagic shelf species, Pacific herring (Map 3.21); most pelagic species occur in the Bering Sea Basin, outside the area. Pacific herring lives in the water column, except when spawning, and feeds on zooplankton. It enters Bristol Bay and other shallow areas with extensive kelp or seagrass beds to spawn in dense aggregations. At other times, it is most abundant over the inner and middle shelves from spring to fall, but moves offshore as the sea ice advances. It is a major prey species for larger fishes, seabirds, and marine mammals. It has high commercial value, both as whole fish and for its roe, but intensive fishing has depleted the stocks. Other species that are pelagic feeders include the anadromous salmons and smelts (discussed below). Some of the demersal species, especially walleye pollock and Pacific halibut, also feed pelagically.

Anadromous Fishes—This category includes smelts (Maps 3.27-3.28) and the five salmon species (Maps 3.22-3.26). All enter fresh water to spawn with the exception of capelin, a beach spawner. An unusual feature of their life cycles is the high mortality after spawning; most of the smelts and all of the salmon die. In the marine environment, they are all pelagic feeders, consuming zooplankton, squid, and smaller fishes. Salmons spend most of their life histories in the North Pacific; they are present in the region when maturing adults return to spawning streams (which they locate by smell), and when juveniles leave the streams to enter the North Pacific. As the five species of salmons are in the region at somewhat different times, presence of salmon is spread out from May through October. Smelts are year-round residents of the region, generally living close to shore in marine and estuarine waters.

Anadromous species are important ecologically and economically. Salmons are major oceanic predators and are among the most valuable commercial and recreational species in the world, as well as being important subsistence species. They are heavily fished at sea and during spawning runs. Their harvests are managed by the State of Alaska within limits imposed by various international agreements. Smelts are important prey species for larger fishes, seabirds, and marine mammals, but only one—the eulachon—is used for Native subsistence.

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References

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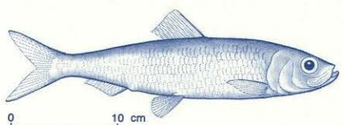
Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
National Oceanic and Atmospheric Administration



Pacific Herring

Clupea harengus pallasi

3.21

Description

Category

Fish

Classification

Class—Osteichthyes
Order—Clupeiformes
Family—Clupeidae

Name

Pacific herring, *Clupea harengus pallasi*

Legal Status

Protected under Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), with management jurisdiction under North Pacific Fishery Management Council.

Range (Svetovidov, 1952; Morrow, 1980; Wespestad and Barton, 1981)

Worldwide—Arctic-subarctic and North Pacific, from Bathurst Inlet (Canada) and Lena River (USSR) to Baja California and northern Korea.

Region of Concern—Coasts and shelves of Bering, Chukchi, and Beaufort Seas.

Distribution (Barton and Wespestad, 1980; Melteff and Wespestad, 1980; Wespestad and Barton, 1981)

Discrete Populations—Three discrete populations identified; two are migratory: one winters northwest of Pribilof Islands; the other east of northern Kamchatka in the western Bering Sea. The third population is resident in Kotzebue Sound.

Concentrations

- *Natural*—Spawning concentrations mainly in (1) northern Bristol Bay (Nushagak Peninsula to Cape Newenham), (2) waters on the north side of Alaska Peninsula, (3) Goodnews Bay-Security Cove, (4) waters off Cape Romanzof, (5) Norton Sound (St. Michael, Golovnin Bay), (6) Grantley Harbor, (7) waters near Shishmaref, (8) Kotzebue Sound, and (9) Gulf of Anadyr.
- *Commercial*—Formerly, a major commercial fishery based on Pribilof and western Bering Sea wintering concentrations; largest fishery at present based on northern Bristol Bay spawning concentration.

Habitat (Henderson, Lucas, and Fraser, 1936; Shaboneev, 1965; Reid, 1972; Barton and Wespestad, 1980; Morrow, 1980; Wespestad and Barton, 1981)

Type—Nektonic; outer shelf-pelagic (winter), to inner shelf-coastal (summer).

Physical/Chemical—Northwest of Pribilofs, occur in waters 2-4°C, depths about 10-40 meters. Spawn at 5-12°C in clear, ice-free waters. Salinity 4-33‰; optimum salinity for larvae and juveniles about 25‰.

Life History

Social Behavior (Henderson, Lucas, and Fraser, 1936; Shaboneev, 1965)—School year-round and at all life stages.

Biological Associations (Barton and Wespestad, 1980; Morrow, 1980; Wespestad and Barton, 1981)—Spawn in and deposit eggs on submerged vegetation.

Nutrition (Svetovidov, 1952; Barton and Wespestad, 1980; Morrow, 1980; Wespestad and Barton, 1981)

- *Feeding type*—Larvae omnivorous; juveniles and adults carnivorous.
- *Food*—Larvae eat mainly copepod nauplii, invertebrate eggs, small invertebrates, and diatoms; juveniles eat copepods, euphausiids, amphipods, cladocerans, and decapod and mollusk larvae; adults eat large zooplankton (mysids, large copepods, euphausiids, arrow worms), fish fry (including pollock, smelt, capelin, sand lance, other herring), and fish eggs.
- *Feeding behavior*—Feed mainly May-October and during seasonal migration; do not feed in winter.
- *Feeding location*—Primarily in water column, rarely on or near bottom; apparently mostly in coastal waters and on outer shelf.

Reproduction (Svetovidov, 1952; Reid, 1972; Barton, 1979; Barton and Wespestad, 1980; Morrow, 1980; Wespestad and Barton, 1981)

- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Sheltered intertidal and subtidal areas of rocky headlands, bays, lagoons, and, occasionally, estuaries; eggs deposited on algae, eelgrasses, occasionally on brush, pilings, or rocks.
- *Behavior*—School in thousands to millions of individuals. Females deposit eggs; males release milt in dense concentrations over spawning area. Spawning period lasts several days to several weeks.
- *Biology*—Spawn late April-early June south of Yukon River, June-July between Yukon River and Bering Strait, and July-August in Kotzebue Sound; older fish spawn first. Fecundity greater at higher latitudes and increases with size and age of female; 12,600-122,800 eggs per female; average 20,000. Eggs adhere to substrate. Incubation 10-21 days depending on temperature.

Development (Schaefer, 1937; Stevenson, 1962; Rumyantsev and Darda, 1970; Wespestad and Barton, 1981)—Hatch as yolk-sac larvae; yolk absorbed in about 2 weeks. Juveniles remain inshore 6-10 weeks, then move offshore. Mature at 2-6 years, predominantly 3-4 years; maturation faster in warmer waters.

Growth (Rumyantsev and Darda, 1970; Barton and Steinhoff, 1980; Morrow, 1980; Wespestad and Barton, 1981)—Yolk-sac larvae about 8 mm at hatching; juveniles to 100 mm by first fall; adults 160-290 mm. Maximum lifespan about 15 years.

Movements (Shaboneev, 1965; Rumyantsev and Darda, 1970; Barton and Wespestad, 1980; Wespestad and Barton, 1981)—Diel vertical migrations in deep waters; extent diminishes in winter. Adults summer in spawning areas, winter on outer shelf; juveniles generally winter in shallower, fresher waters than adults. Pribilof wintering stock migrates across shelf to summer spawning areas, then moves in fall nearer shore to wintering area.

Factors Influencing Populations

Natural (Outram, 1958; Taylor, 1971; Laevastu and Favorite, 1978; Ainley and Sanger, 1979; von Westernhagen et al., 1979; Barton and Wespestad, 1980; Morrow, 1980; Frost and Lowry, 1981a; Lowry and Frost, 1981)—Natural egg and larval mortality 50-99%; affected by poor weather, predators, unfavorable oceanic circulation, or lack of food at critical times. Predators of eggs include snails, crabs, fishes (especially yellowfin sole), sea ducks, large gulls, and ravens. Predators of larvae include comb jellies, arrow worms, hyperiid amphipods, and fishes (especially walleye pollock). Juveniles and adults eaten by squids, fishes (numerous species), loons, grebes, cormorants, gulls, murres, puffins, some seals and baleen whales, killer and white whales, and porpoises. Thick egg masses have higher embryonic mortality because of oxygen depletion and build-up of excess metabolic wastes. Heavy intraspecific competition for food in larval and early juvenile stages.

Human-related (Barton and Wespestad, 1980; Skrade, 1980; Fried, Whitmore, and Bergstrom, 1981)—Subsistence fishing takes 70-100 metric tons per year in coastal villages between Yukon and Kuskokwim Rivers. Overfishing and loss of spawning habitat through pollution and coastal development seriously affect populations.

Potential (Nelson-Smith, 1973; Patten, 1977)—Herring larvae appear to have high mortality rates in oil-contaminated water. In fishes, oil contamination can cause blockage or destruction of chemoreceptors, a respiratory "cough" response, loss of metabolic control, muscular/neural narcosis, and impairment of locomotor ability, equilibrium, and schooling behavior; also, increased egg mortality and larval deformities, decreased growth and development of embryos and young, decreased feeding rate, tainting of flesh, and death. Oil emulsified by rough seas or surfactants causes erosion of gill epithelium, depression of respiratory functions, and adherence of oil droplets to mucus layer of the fish. Emulsification also may allow oil to be swallowed more readily by fishes trying to maintain ionic/osmotic balance. In general, light petroleum fractions are highly toxic and cause almost instantaneous death even at low concentrations.

Population Size (Laevastu and Favorite, 1978; Barton and Wespestad, 1980)

Large population fluctuations common; equilibrium biomass in eastern Bering estimated recently at about 100,000-200,000 metric tons.

Management (North Pacific Fishery Management Council, 1979; Barton and Wespestad, 1980; Skrade, 1980; Fried, Whitmore, and Bergstrom, 1981)

National Marine Fisheries Service manages harvest within 200-nautical mile Exclusive Economic Zone. Alaska Board of Fisheries manages harvest within the 3-mile state coastal zone; annual catch managed at 10-20% of estimated spawning biomass through emergency closure orders. Current fishery for sac-roe (15,000-25,000 metric tons), roe-on-kelp (150-225 metric tons), and bait (less than 100 metric tons); rapidly expanding in Bristol Bay and Norton Sound. Roe-on-kelp harvest in Bristol Bay managed at exploitation rate of 10% of estimated available *Fucus* (algal) biomass. Studies on kelp regeneration are presently being conducted.

Persons Consulted

L.H. Barton, Alaska Department of Fish & Game, Fairbanks, Alaska.
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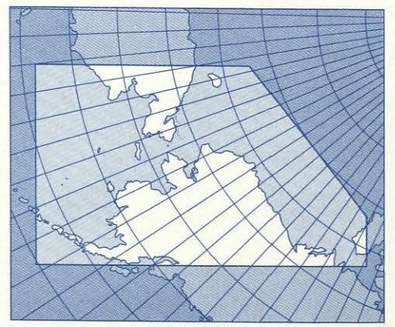
Legend

- Adult Area (Year-round)
- Adult Area (April-October)
- Adult Area (November-March)
- Occasional Occurrence (April-October)
- Major Adult Area (November-March)
- Spawning Area (April-August)
- Major Spawning Area (April-August)
- Juvenile Area (April-October) Juveniles younger than 10 weeks
- Major Juvenile Area (April-October) Juveniles younger than 10 weeks
- Major Juvenile Area (April-October) Juveniles older than 10 weeks
- Migration (April-May) Prespawners
- Migration (September-October)

Spawning occurs July-August north of Bering Strait; June-July between the Bering Strait and the Yukon River; and April-June south of the Yukon River. Spawning areas are also areas of major adult concentrations during spawning season. Juveniles younger than 10 weeks occur July-October north of Bering Strait; June-September between the Yukon River and the Bering Strait; and April-August south of the Yukon River. Older juveniles occur throughout adult areas during same times of year.

Map References

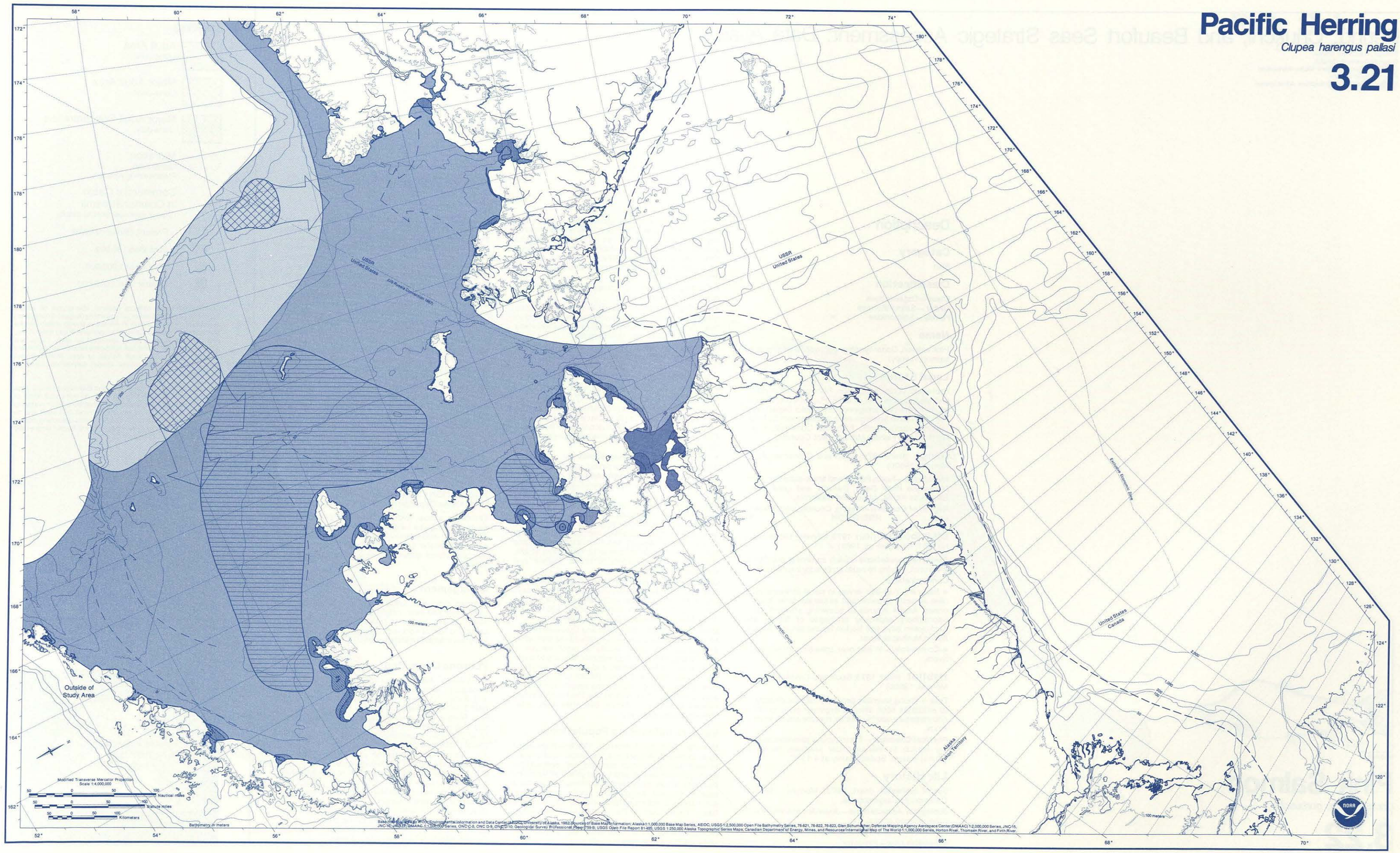
Melteff and Wespestad, 1980; Wespestad and Barton, 1981. Personal communication from Wespestad.



Pacific Herring

Clupea harengus pallasi

3.21



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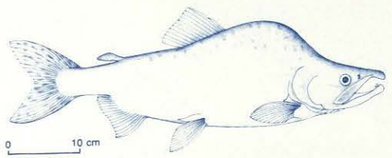

Pink Salmon

Oncorhynchus gorbuscha

3.22

Description

Category

Fish

Classification

Class—Osteichthyes
Order—Salmoniformes
Family—Salmonidae

Name

Pink salmon, *Oncorhynchus gorbuscha* (humpback salmon, humpy)

Legal Status

Protected under Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended, with coastal management by Alaska Department of Fish & Game and high-seas management by International North Pacific Fisheries Commission and North Pacific Fishery Management Council.

Range (Hart, 1973; Scott and Crossman, 1973; Morrow, 1980b)

Worldwide—North Pacific and arctic-subarctic, from Mackenzie River Delta, Canada, and Lena River, Siberia, to Korea, Japan, and California.

Region of Concern—Bering, Chukchi, and Beaufort seas.

Distribution (Hart, 1973; Morrow, 1980b; Straty, 1981; Takagi et al., 1981)

Discrete Populations—Each spawning population is distinct, moving to natal stream for reproduction.

Concentrations

- *Natural*—Yolk-sac larvae in natal streams; juveniles in natal streams and estuaries, later in open ocean. Adults in area of spawning streams (July-September), especially drainages of Bristol and Kuskokwim bays and Norton Sound; largest population in Nushagak River.
- *Commercial*—In and near spawning streams and rivers.

Habitat (Hart, 1973; Scott and Crossman, 1973; Morrow, 1980b)

Type—Young juveniles generally migrate directly into estuaries soon after emergence; older juveniles and immature adults oceanic; mature adults anadromous.

Physical/Chemical—Fresh (young juveniles, spawning adults) to marine (older juveniles, immature adults) waters. Spawn mainly at 4-11°C.

Life History

Social Behavior (Hart, 1973; Morrow, 1980b)—Commonly in large schools.

Biological Associations—Juveniles associate with other salmon at sea.

Nutrition (Hart, 1973; Morrow, 1980b)

- *Feeding type*—Predator.
- *Food*—Young juveniles usually feed only a short time in fresh water. Estuarine juveniles eat mainly copepods and tunicate larvae (*Oikopleura*); oceanic juveniles eat amphipods, euphausiids, and various fishes (herring, eulachon, hake, pricklebacks, gobies); adults eat euphausiids, copepods, amphipods, squid, and various fishes.
- *Feeding behavior*—Unknown at sea. Spawning adults do not feed.
- *Feeding location*—Primarily in and near surface waters. Juveniles feed in spawning streams and in nearshore waters when small; feed in warm surface waters of the open sea as they grow.

Reproduction (Hart, 1973; Scott and Crossman, 1973; Reiser and Bjornn, 1979; Morrow, 1980b; Straty, 1981)

- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Generally in lower reaches of coastal streams. Spawn in gravel.
- *Behavior*—Both sexes promiscuous. Females prepare nest by lashing tail to displace sand and gravel; nest defended by male, occasionally also by female. Female may make more than one nest; covers nest by digging upstream.
- *Biology*—Spawn August-September. Generally have strong runs in alternating years. Fecundity 800-2,000 eggs per female; eggs 6-mm diameter. Large individuals are more fecund. Adults die after spawning.

Development (Hart, 1973; Scott and Crossman, 1973; Morrow, 1980b)—Duration of incubation is temperature dependent; eggs hatch midwinter to early spring. Yolk-sac larvae remain in gravel until spring. Young move to sea soon after emergence from gravel (May-June); spend 12-18 months at sea, then return to freshwater to breed. Mature and spawn at 2 years.

Growth (Hart, 1973; Scott and Crossman, 1973; Morrow, 1980b)—Growth rate rapid in first 40 days at sea, slower thereafter until final year. Yolk-sac larvae 20-30 mm; adults average about 500 mm (1-3 kg). Maximum lifespan 2 years (rarely 3).

Movements (Hart, 1973; Scott and Crossman, 1973; Morrow, 1980b)—Juveniles migrate to sea soon after emergence from nest, usually at night; remain in coastal areas through first summer, migrate to outer shelf in fall. Older juveniles and immature adults in Bering Sea basin and North Pacific until spawning time. Spawning migration begins second summer; on shelf June-July. Pink salmon are the fourth salmon species to appear in Bering Sea shelf area (after chinook, chum, sockeye).

Factors Influencing Populations

Natural (Hart, 1973; Morrow, 1980b)—Eggs killed by extremes of temperature, low amounts of oxygen in nest, and streambed scouring and dessication. Eggs, yolk-sac larvae, and young juveniles eaten by caddisfly larvae, dolly varden, cutthroat trout, coho salmon, sculpins, mergansers, kingfishers, dippers, and muskrats. Adults eaten by marine mammals and bears. Parasitized by Pacific and Arctic lampreys, protozoans, trematodes, leeches, and crustaceans.

Human-related—Fished commercially and for subsistence. Sport-fish take insignificant.

Potential (Nelson-Smith, 1973; Servizi and Martens, 1974; Hawkes, 1977; Patten, 1977; Rice et al., 1979)—Chlorinated sewage effluent has been shown to be highly toxic to pink salmon. Exposures of various species of salmonids to various petroleum compounds have resulted in inflammation and lesion of gills, depletion of liver glycogen, slower growth rates, softening of eye lenses, increased destruction of red blood cells in spleen, increased oxygen consumption, lower hatching success and survival of eggs and young, and an increase in time young fish spend at surface of water. In fishes, oil contamination can cause blockage or destruction of chemoreceptors, a respiratory 'cough' response, loss of metabolic control, muscular/neural narcosis, and impairment of locomotor ability, equilibrium, and schooling behavior; also, increased egg mortality and larval deformities, decreased growth and development of embryos and young, decreased feeding rate, tainting of flesh, and death. Oil emulsified by rough seas or surfactants causes erosion of gill epithelium, depression of respiratory functions, and adherence of oil droplets to mucus layer of fish. Emulsification also may allow oil to be swallowed more readily by fishes trying to maintain ionic/osmotic balance. In general, light petroleum fractions are highly toxic and cause almost instantaneous death, even at low concentrations. These findings probably apply to this species.

Population Size (Straty, 1981; Middleton, 1983; Alaska Department of Fish & Game, 1984)

Estimated annual average runs (for 1974-1983) in eastern Bering Sea—6.9 million fish (even years) and 220,000 fish (odd years)—account for about 8% of all salmon in eastern Bering Sea. Nushagak population constitutes about 70% of eastern Bering pink salmon.

Management

Average even-year catch of 2.7 million fish (1974-1982) and odd-year catch of 100,000 fish (1975-1983) constitute 3% of total Alaska pink salmon catch and 10% of world catch. Goal of management is to achieve optimum escapement.

Persons Consulted

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Legend

- Adult Area (June-July)
- Major Adult Area (June-July)
- Major Adult Concentration (June-July)
- Migration (June-July) Prespawning Adults

Commercial Catch in Coastal Streams (5-year average, annual catch)

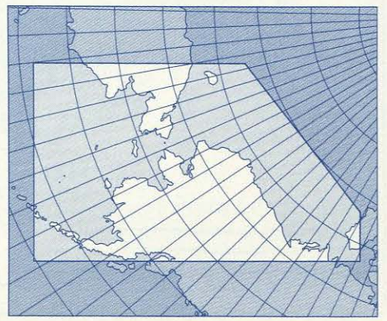
- Present; little or no catch
- Less than 100,000
- 100,000 to 1,000,000
- Greater than 1,000,000

Commercial catch reflects general abundance of adults migrating (July-September) or spawning (August-September) in coastal streams. Catch in Alaska is shown within Alaska Department of Fish & Game Management Areas (bold lines), and Districts (dashed lines) identified on map. Tones are extended 20 miles inland, but symbolize total catch in all rivers and streams draining each district or area. Norton Sound fishery may be underutilized. Soviet commercial catch is estimated.

Species has two-year cycle in Bristol Bay region; major runs occur in even years. Adults generally do not occur north of Bering Strait until July. Juveniles move from fresh water to estuaries and coastal waters May-June of first year, and to outer shelf during summer (migratory paths unknown); depart study area September-November for North Pacific, where they remain for about one year.

Map References

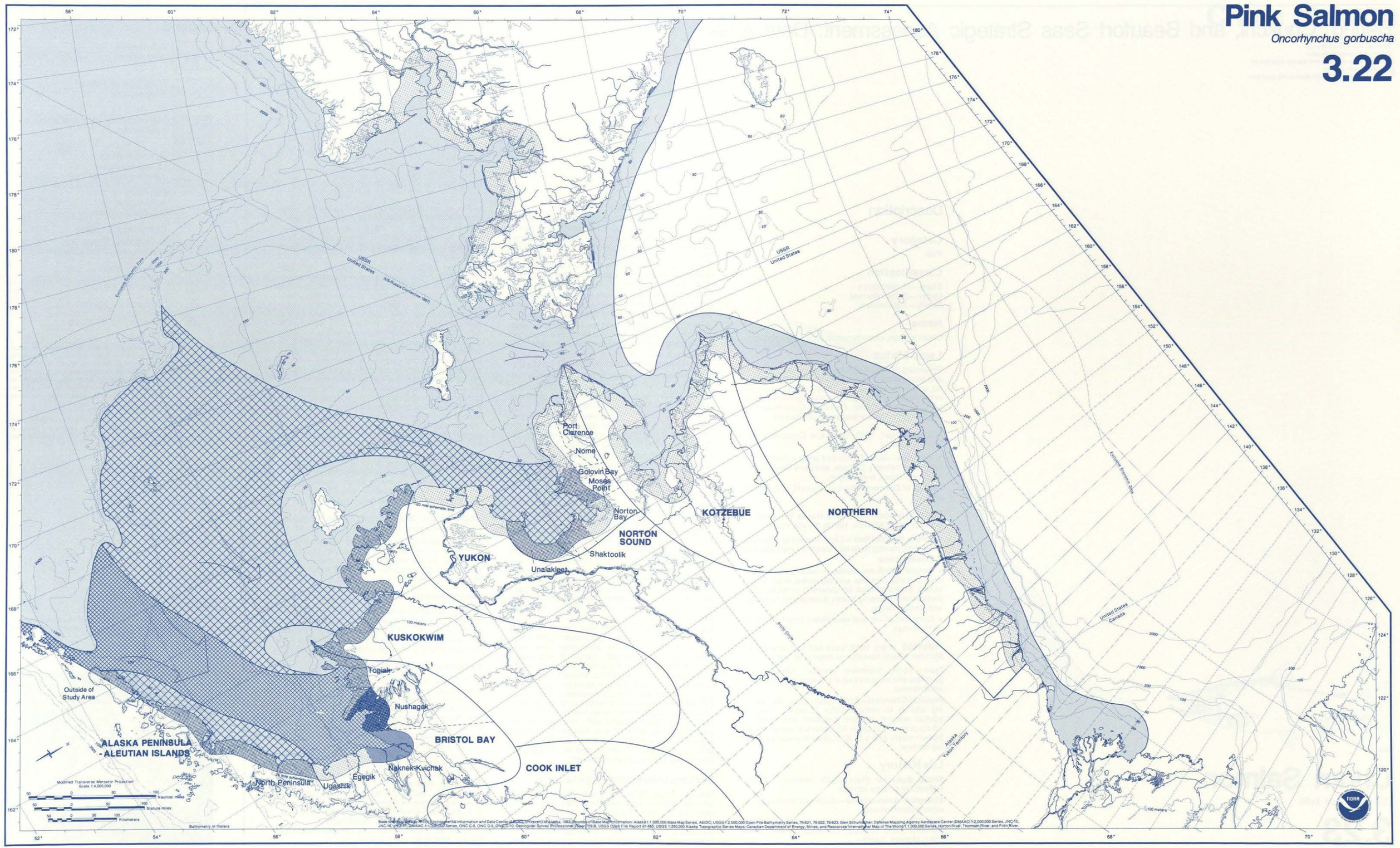
Straty, 1981; Middleton, 1983; Alaska Department of Fish & Game, 1984a, b, c, d, e. Personal communications from Nishiyama; Rogers; Straty.



Pink Salmon

Oncorhynchus gorbuscha

3.22



Base maps provided by the Geophysical Information and Data Center (GEIDC), University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-621, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:3,000,000 Series, ONC C-8, ONC D-8, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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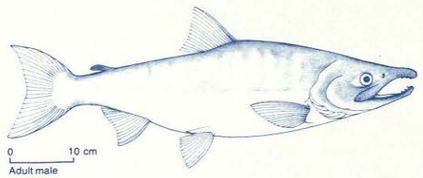

Chum Salmon

Oncorhynchus keta

3.23

Description

Category

Fish

Classification

Class—Osteichthyes
Order—Salmoniformes
Family—Salmonidae

Name

Chum salmon, *Oncorhynchus keta* (dog salmon)

Legal Status

Protected under Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended, with coastal management by Alaska Department of Fish & Game and high-seas management by International North Pacific Fisheries Commission and North Pacific Fishery Management Council.

Range (Hart, 1973; Scott and Crossman, 1973; Morrow, 1980b)

Worldwide—North Pacific and arctic-subarctic, from Northwest Territory, Canada, and Lena River, Siberia, to Korea, Japan, and Oregon.

Region of Concern—Bering, Chukchi, and Beaufort seas.

Distribution (Hart, 1973; Neave, Yonemori, and Bakkala, 1976; Morrow, 1980b; Straty, 1981)

Discrete Populations—Each spawning population is distinct, moving to natal stream for reproduction.

Concentrations

- *Natural*—Yolk-sac larvae in natal streams; juveniles in natal streams and estuaries, later in open ocean; adults in area of spawning streams (June-September), primarily Yukon, Kuskokwim, Nushagak, and Anadyr rivers.
- *Commercial*—In and near rivers listed above and on high seas.

Habitat (Hart, 1973; Scott and Crossman, 1973; Morrow, 1980b; Merritt and Raymond, 1983)

Type—Young juveniles limnetic, littoral; older juveniles and immature adults oceanic; mature adults anadromous.

Physical/Chemical—Fresh (young juveniles, spawning adults) to marine (older juveniles, immature adults) waters; oceanic juveniles and immature adults primarily in upper 60 meters of water column. Spawn mainly at 2.5-12.8°C, often in areas of upwelling springs.

Life History

Social Behavior (Hart, 1973; Morrow, 1980b)—Commonly in large schools.

Biological Associations—Juveniles associate with other salmon at sea.

Nutrition (Scott and Crossman, 1973; Neave, Yonemori, and Bakkala, 1976; Loftus and Lenon, 1977; Morrow, 1980b)

- *Feeding type*—Predator.
- *Food*—Young juveniles in fresh water eat chironomids, plecopterans, and ephemeropterans (larvae and adults), and cladocerans (*Daphnia*, *Bosmina*). Estuarine juveniles eat harpacticoid and calanoid copepods, tunicates (*Oikopleura*), terrestrial insects, and young herring. Oceanic juveniles and adults eat copepods, amphipods, tunicates, euphausiids, pteropods, squid, and fishes.
- *Feeding behavior*—Not known at sea. Diel vertical migrations in ocean believed to be result of following migration of prey. Spawning adults do not feed.
- *Feeding location*—Adults feed primarily in upper 60 meters of ocean. Juveniles feed both on bottom and in water column in shallow waters in June.

Reproduction (Hart, 1973; Scott and Crossman, 1973; Reiser and Bjornn, 1979; Morrow, 1980b)

- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Spawn as far as 3,200 km upstream, in coarse gravel (sometimes bedrock and boulders), often in areas of upwelling springs.
- *Behavior*—Both sexes promiscuous. Females prepare nest by lashing tail to displace sand and silt; males defend nest. Female may make more than one nest; covers nest by digging upstream.
- *Biology*—Two runs during August-September: one earlier in more coastal regions and the other, later, farther upstream. Fecundity 2,000-4,300 eggs per female; larger fall salmon more fecund. Eggs average 6-8 mm diameter. Adults die after spawning.

Development (Hart, 1973; Scott and Crossman, 1973; Morrow, 1980b)—Duration of incubation is temperature dependent; hatch midwinter. Yolk-sac larvae remain in gravel until juveniles' seaward migration, May-July. Mature at 4-6 years.

Growth (La Lanne, 1971; Scott and Crossman, 1973; Morrow, 1980b; Straty, 1981)—Growth rate slow in fresh water, rapid in first year at sea, then slower until final year. Yolk-sac larvae about 20-30 mm; juveniles entering estuaries about 35-70 mm; 2-year-old fish to 600 mm. Adults average 600-700 mm (4.5-6.0 kg); maximum 1,020 mm (15 kg). Maximum lifespan 6 years.

Movements (Dunn, 1969; Hart, 1973; Morrow, 1980b; Straty, 1981)—Young juveniles migrate downstream immediately after emergence from nest; usually migrate nocturnally; remain in estuaries a variable length of time, depending on growth, before migrating seaward; peak of out-migration from rivers is mid-June; move to surface waters of open sea in July. Juveniles and immature adults in Bering and Chukchi seas migrate as far west as 173°E and occur widely in Bering Sea in summer; overwinter in Gulf of Alaska and central North Pacific. Undergo diel vertical migrations while at sea. Spawning migration begins in spring-early summer, on shelf June-July; chum are the second salmon species to appear in Bering Sea shelf area (after chinook).

Factors Influencing Populations

Natural (Hart, 1973; Scott and Crossman, 1973; Morrow, 1980b)—Eggs killed by extremes of temperature, low amounts of oxygen in nest, and fluctuating water flows. Eggs and young eaten by stonefly larvae, sheefish, trout, dolly varden, silver salmon, sculpins, mergansers, kingfishers; adults by ospreys, eagles, bears. At sea, juveniles consumed by marine birds, mammals, and predatory fishes.

Human-related (Hart, 1973; Morrow, 1980b)—Large numbers taken for commercial and subsistence use in western Alaska. Sport-fishing catch insignificant.

Potential (Nelson-Smith, 1973; Hawkes, 1977; Patten, 1977)—Exposures of various species of salmonids to various petroleum compounds have resulted in inflammation and lesion of gills, depletion of liver glycogen, slower growth rates, softening of eye lenses, increased destruction of red blood cells in spleen, increased oxygen consumption, lower hatching success and survival of eggs and young, and an increase in time young spend at surface of water. In fishes, oil contamination can cause blockage or destruction of chemoreceptors, a respiratory "cough" response, loss of metabolic control, muscular/neural narcosis, and impairment of locomotor ability, equilibrium, and schooling behavior; also, increased egg mortality and larval deformities, decreased growth and development of embryos and young, decreased feeding rate, tainting of flesh, and death. Oil emulsified by rough seas or surfactants causes erosion of gill epithelium, depression of respiratory functions, and adherence of oil droplets to mucus layer of fish. Emulsification also may allow oil to be swallowed more readily by fishes trying to maintain ionic/osmotic balance. In general, light petroleum fractions are highly toxic and cause almost instantaneous death, even at low concentrations. These findings probably apply to this species.

Population Size (Straty, 1981; Middleton, 1983; Alaska Department of Fish & Game, 1984)

Average annual run is about 9 million fish, with runs of 2.5 million in the Anadyr, 2.1 million in the Yukon, 1.2 million in the Nushagak, and 1 million in the Kuskokwim. Chum salmon constitute about 15% of all salmon in the eastern Bering Sea.

Management

Average annual catch is about 3.3 million fish in USA waters (1974-1983) and about 1 million in Soviet waters. Average USA catch in Bering Sea is 42% of total Alaska chum catch and 7% of world catch. Goal of management is to achieve optimum escapement.

Persons Consulted

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H. W. Jaenicke, Northwest and Alaska Fisheries Center, NMFS/NOAA, Auke Bay, Alaska.
J. L. Landingham, Northwest and Alaska Fisheries Center, NMFS/NOAA, Auke Bay, Alaska.
C. P. Meacham, Alaska Department of Fish & Game, Anchorage, Alaska.
T. Nishiyama, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
D. E. Rogers, Fisheries Research Institute, University of Washington, Seattle, Washington.
R. R. Straty, Northwest and Alaska Fisheries Center, NMFS/NOAA, Auke Bay, Alaska.

Legend

- Adult Area (May-August)
- Major Adult Area (May-August)
- Major Adult Concentration (May-August)
- Juvenile Area (June-September) Juveniles older than 1 year
- Migration (May-August) Prespawning adults

Commercial Catch in Coastal Streams (5-year average, annual catch)

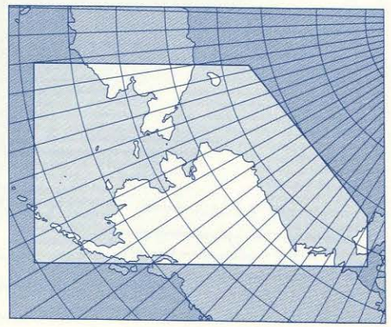
- Present; little or no catch
- Less than 100,000
- 100,000 to 1,000,000
- Greater than 1,000,000

Commercial catch reflects general abundance of adults migrating (July-September) or spawning (August-September) in coastal streams. Catch in Alaska is shown within Alaska Department of Fish & Game Management Areas (bold lines), and Districts (dashed lines) identified on map. Tones are extended 20 miles inland, but symbolize total catch in all rivers and streams draining each district or area. Soviet commercial catch is estimated.

Juveniles leave fresh water May-June of first year, and move to middle and outer shelf July-September (migratory paths unknown); remain in Bering Sea basin and North Pacific 3-5 years.

Map References

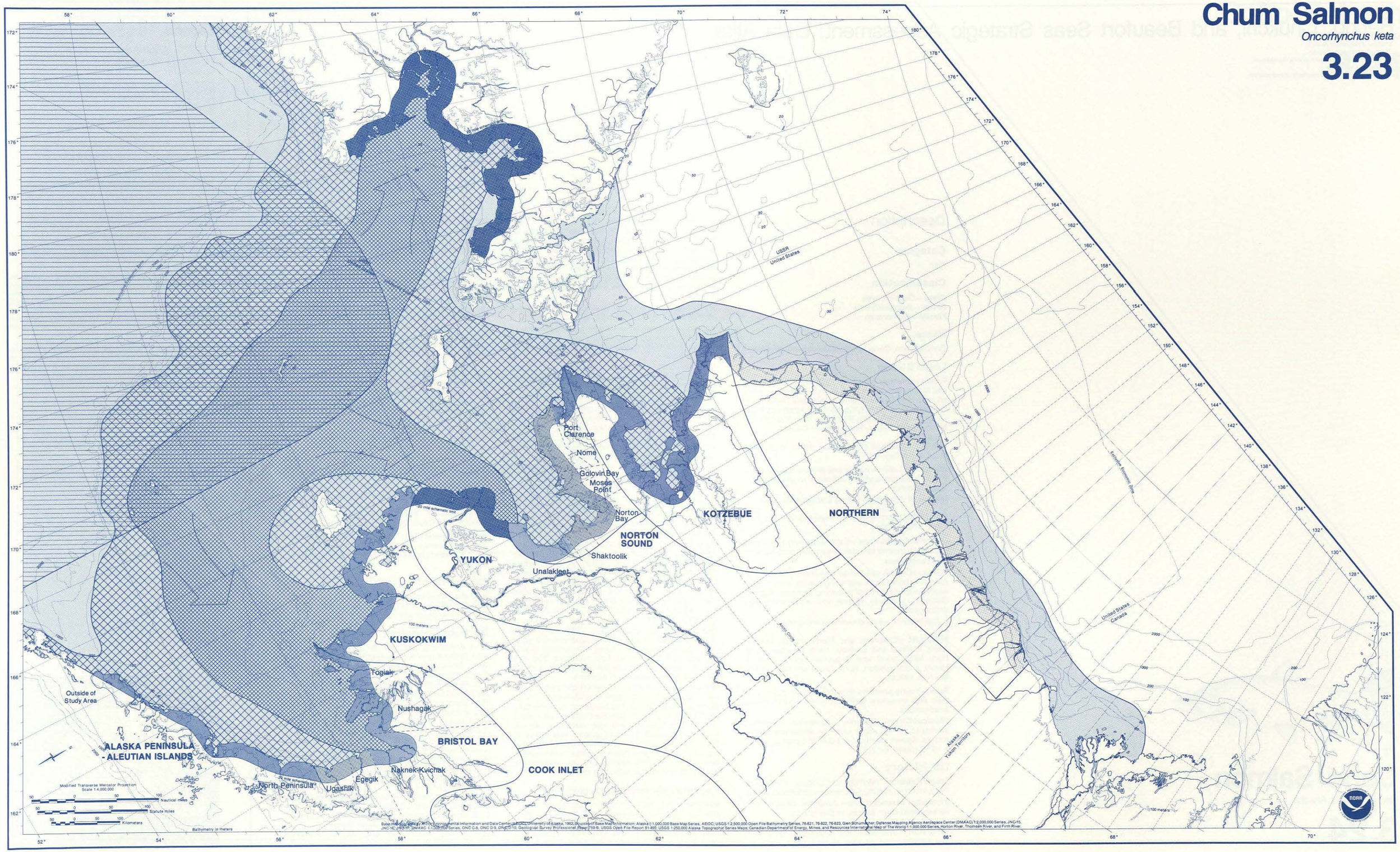
Straty, 1981; Middleton, 1983; Alaska Department of Fish & Game, 1984a, b, c, d, e. Personal communications from Arvey; Nishiyama; Meacham; Rogers; Straty.



Chum Salmon

Oncorhynchus keta

3.23



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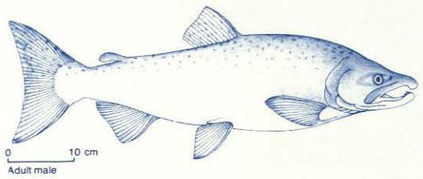

Adult male

Coho Salmon

Oncorhynchus kisutch

3.24

Description

Category

Fish

Classification

Class—Osteichthyes
Order—Salmoniformes
Family—Salmonidae

Name

Coho salmon, *Oncorhynchus kisutch* (silver salmon)

Legal Status

Protected under Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended, with coastal management by Alaska Department of Fish & Game and high-seas management by International North Pacific Fisheries Commission and North Pacific Fishery Management Council.

Range (McPhail and Lindsey, 1970; Hart, 1973; Morrow, 1980b)

Worldwide—North Pacific and arctic-subarctic, from Pt. Hope, Alaska, and Gulf of Anadyr, to Japan, Korea, and California.

Region of Concern—Bering and Chukchi seas.

Distribution (Godfrey, Henry, and Machidori, 1975; Straty, 1981)

Discrete Populations—Each spawning population is distinct, moving to natal stream for reproduction.

Concentrations

- *Natural*—Yolk-sac larvae in natal streams; juveniles in natal streams and along coasts, later in open ocean; adults in area of spawning streams (August-October), primarily Bristol and Kuskokwim Bay drainages.
- *Commercial*—In and near spawning rivers.

Habitat (Chapman and Bjornn, 1969; Mundie, 1969; McPhail and Lindsey, 1970; Drucker, 1972; Hart, 1973; Scott and Crossman, 1973; Godfrey, Henry, and Machidori, 1975; Crone and Bond, 1976; Morrow, 1980b)

Type—Young juveniles limnetic, littoral; older juveniles and immature adults oceanic; mature adults anadromous.

Physical/Chemical—Fresh (juveniles, spawning adults) to marine (older juveniles, immature adults) waters. Spawn mainly at 4.9-9.4°C; occur at sea at 3-16°C (prefer 8-12°C).

Life History

Social Behavior (McPhail and Lindsey, 1970; Hart, 1973; Morrow, 1980b)—Commonly in schools at sea.

Biological Associations—Juveniles caught with sockeye and chum salmon in Bristol Bay.

Nutrition (Mundie, 1969; McPhail and Lindsey, 1970; Hart, 1973; Scott and Crossman, 1973, Morrow, 1980b)

- *Feeding type*—Predator.
- *Food*—Juveniles in fresh water eat terrestrial insects (dipterans, hymenopterans, trichopterans, coleopterans) spiders, oligochaetes, and sockeye salmon fry; in salt water, eat copepods, amphipods, euphausiids, sand lance, herring, and chum and pink salmon fry. Adults eat mainly sand lance and herring, but also take squid, capelin, black cod, anchovies, and crustaceans.
- *Feeding behavior*—Young territorial in freshwater feeding areas. Spawning adults do not feed.
- *Feeding location*—Freshwater juveniles feed near surface in slack water, pools, and eddies of streams. Marine juveniles, immature adults feed primarily in surface waters.

Reproduction (McPhail and Lindsey, 1970; Hart, 1973; Scott and Crossman, 1973; Reiser and Bjornn, 1979; Morrow, 1980b)

- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Usually in short coastal streams; may spawn upstream in spring-fed tributaries of Yukon River. Spawn in swifter waters of shallow, gravelly areas.
- *Behavior*—Both sexes promiscuous. Females prepare nest by lashing tail to displace sand and silt; dominant male defends nest. Female may make more than one nest; covers nest by digging upstream.
- *Biology*—Entry into fresh water by adults triggered by rise in water level and possibly also by temperature of streams. Spawn September-October. Fecundity 1,440-5,700 eggs per female (average 2,500-3,000); eggs 4.5-6.0 mm diameter. Adults die after spawning.

Development (McPhail and Lindsey, 1970; Drucker, 1972; Hart, 1973; Scott and Crossman 1973; Morrow, 1980b)—Duration of incubation is temperature dependent; eggs hatch in spring. Yolk-sac larvae remain in gravel 3-4 weeks, then emerge as free-swimming juveniles. Spend 1-2 years in fresh water, mature during 12-18 months at sea, then return to fresh water to breed. Usually mature and spawn at 3 years, sometimes 4.

Growth (McPhail and Lindsey, 1970; Hart, 1973; Morrow, 1980b; Straty, 1981)—One-year-old juveniles migrate to sea when about 100 mm long. Adults average 550-700 mm (3 kg); maximum 960 mm (14 kg). Maximum lifespan 3-4 years. Coho salmon have highest growth rate of salmons.

Movements (Manzer et al., 1965; McPhail and Lindsey, 1970; Hart, 1973; Scott and Crossman, 1973; Morrow, 1980b; Straty, 1981)—Juveniles migrate to sea at night in spring or summer of second year (third year in Yukon River system); stay near shore until fall, when they move offshore and spend 1 year at sea. In North Pacific, circumnavigate Alaska gyre, completing one circuit per year. Spawning migration begins in late summer on shelf, July-August; coho salmon are the last of Bering Sea salmon to spawn.

Factors Influencing Populations

Natural (Hart, 1973; Scott and Crossman, 1973; Morrow, 1980b)—Juveniles eaten by trout, dolly varden, sculpins, loons, mergansers, and small mammals. Adults eaten by seals, killer whales, bears, and large birds. Parasitized by protozoans, trematodes, nematodes, acanthocephalans, and crustaceans.

Human-related—Fished commercially and for subsistence. Sport-fish catch is small. The least utilized Bering Sea salmon.

Potential (Nelson-Smith, 1973; Hawkes, 1977; Patten, 1977)—Exposures of various species of salmonids to various petroleum compounds have resulted in inflammation and lesion of gills, depletion of liver glycogen, slower growth rates, softening of eye lenses, increased destruction of red blood cells in spleen, increased oxygen consumption, lower hatching success and survival of eggs and young, and an increase in time young fish spend at surface of water. In fishes, oil contamination can cause blockage or destruction of chemoreceptors, a respiratory "cough" response, loss of metabolic control, muscular/neural narcosis, and impairment of locomotor ability, equilibrium, and schooling behavior; also, increased egg mortality and larval deformities, decreased growth and development of embryos and young, decreased feeding rate, tainting of flesh, and death. Oil emulsified by rough seas or surfactants causes erosion of gill epithelium, depression of respiratory functions, and adherence of oil droplets to mucus layer of fish. Emulsification also may allow oil to be swallowed more readily by fishes trying to maintain ionic/osmotic balance. In general, light petroleum fractions are highly toxic and cause almost instantaneous death, even at low concentrations. These findings probably apply to this species.

Population Size (Straty, 1981; Middleton, 1983; Alaska Department of Fish & Game, 1984)

Average annual run of 1.2 million fish (1974-1983) is 3% of all salmon in eastern Bering Sea. Coho are most abundant in upper Bristol Bay and Kuskokwim area.

Management

Average annual catch in eastern Bering Sea of about 590,000 fish (1974-1983) constitutes 22% of total Alaska coho catch and 5% of world catch.

Persons Consulted

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R. L. Burgner, Fisheries Research Institute, University of Washington, Seattle, Washington.
W. R. Heard, Northwest and Alaska Fisheries Center, NMFS/NOAA, Auke Bay, Alaska.
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C. P. Meacham, Alaska Department of Fish & Game, Anchorage, Alaska.
T. Nishiyama, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
D. E. Rogers, Fisheries Research Institute, University of Washington, Seattle, Washington.
R. R. Straty, Northwest and Alaska Fisheries Center, NMFS/NOAA, Auke Bay, Alaska.

Legend

Adult Area
(July-August)

Major Adult Area
(July-August)

Migration
(July-August)
Prespawning adults

Commercial Catch
in Coastal Streams
(5-year average, annual catch)

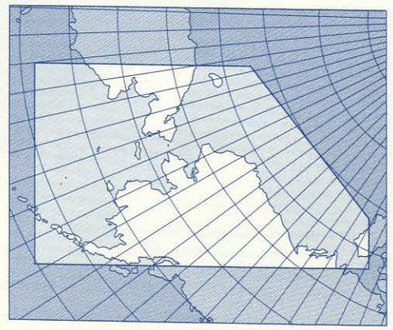
- Present; little or no catch
- Less than 10,000
- 10,000 to 100,000
- Greater than 100,000

Commercial catch reflects general abundance of adults migrating (August-October) or spawning (September-October) in coastal streams. Catch in Alaska is shown within Alaska Department of Fish & Game Management Areas (bold lines), and Districts (dashed lines) identified on map. Tones are extended 20 miles inland, but symbolize total catch in all rivers and streams draining each district or area. Soviet commercial catch is estimated.

Juveniles spend 1-2 years in fresh water; leave May-July and move to outer shelf during summer (migratory paths unknown); depart study area September-November for North Pacific, where they usually remain one year.

Map References

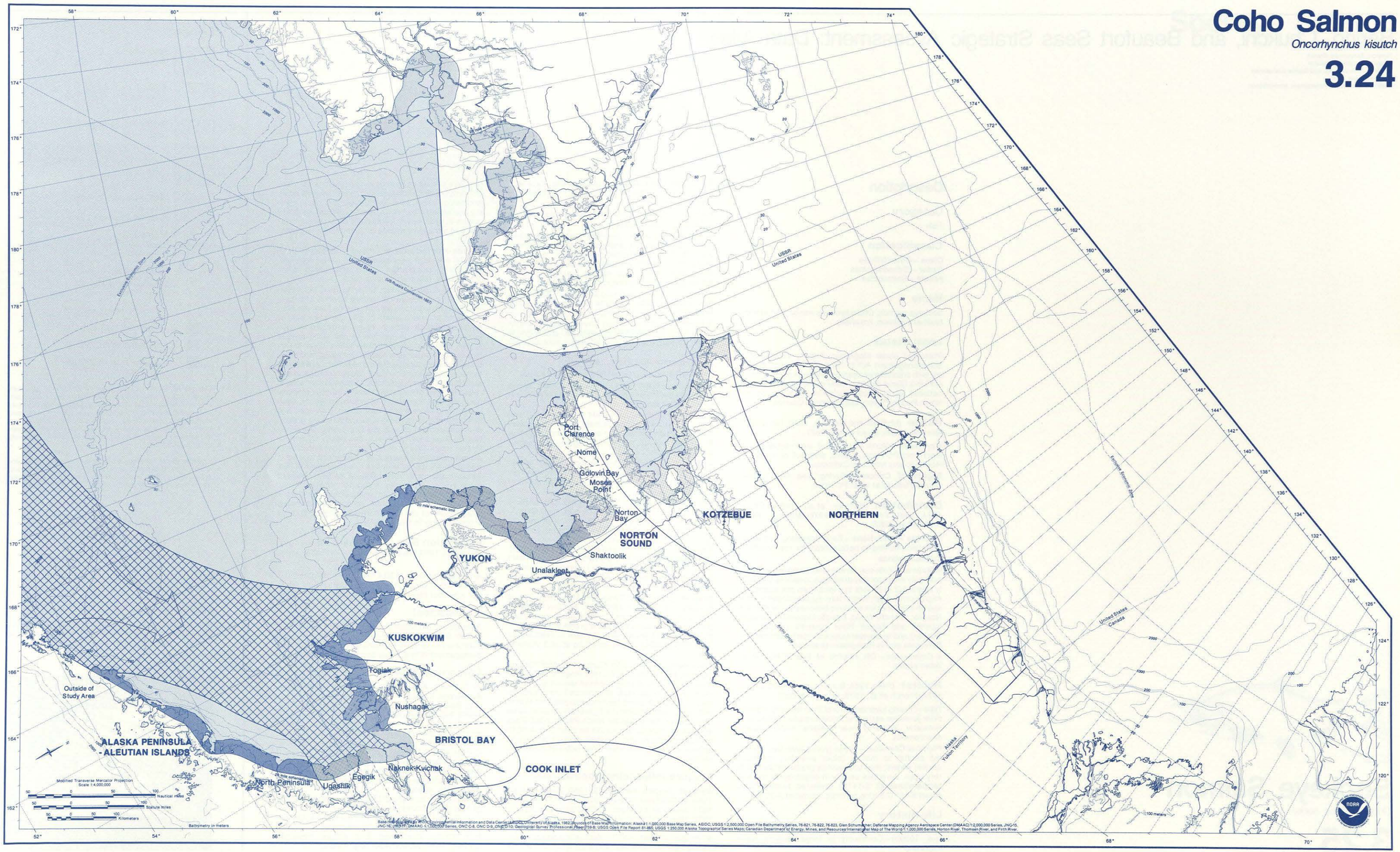
Straty, 1981; Middleton, 1983; Alaska Department of Fish & Game, 1984a, b, c, d, e. Personal communications from Arvey; Meacham; Nishiyama; Rogers; Straty.



Coho Salmon

Oncorhynchus kisutch

3.24



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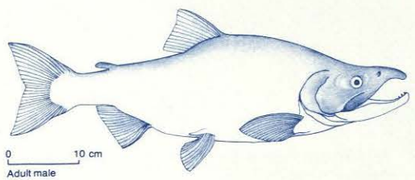


Sockeye Salmon

Oncorhynchus nerka

3.25

Description

Category

Fish

Classification

Class—Osteichthyes
Order—Salmoniformes
Family—Salmonidae

Name

Sockeye salmon, *Oncorhynchus nerka* (red salmon, blueback salmon, kokanee)

Legal Status

Protected under Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended, with coastal management by Alaska Department of Fish & Game and high-seas management by International North Pacific Fisheries Commission and North Pacific Fishery Management Council.

Range (McPhail and Lindsey, 1970; Hart, 1973; Morrow, 1980b; Shaul et al., 1982)

Worldwide—North Pacific and arctic-subarctic, at least from Pt. Hope, Alaska, and Gulf of Anadyr to Hokkaido and northern California.

Region of Concern—Bering Sea and eastern Chukchi Sea to at least Pt. Hope.

Distribution (Burgner et al., 1969; Straty, 1974, 1981; French et al., 1976; Morrow, 1980b; Shaul et al., 1982)

Discrete Populations—Each spawning population is distinct, moving to natal stream for reproduction.

Concentrations

- *Natural*—Yolk-sac larvae and juveniles in lakes, primarily in Bristol Bay drainages; juveniles commonly spend 1-2 summers in a lake, then one summer in migration through Bristol Bay. Adults concentrate to spawn in tributaries and lake beaches of the Kvichak, Naknek, Branch, Wood, Egegik, Ugashik, Nushagak, Igushik, and Togiak River systems (August-September), and to a lesser extent on north side of Alaska Peninsula and in Kuskokwim drainage.
- *Commercial*—Off mouths of Bristol Bay rivers listed above.

Habitat (Pella, 1968; Burgner et al., 1969; Straty, 1974; French et al., 1976; Morrow, 1980b)

Type—Young juveniles littoral then limnetic in lakes; older juveniles estuarine; immature adults oceanic in midwater, primarily near surface; mature adults anadromous.

Physical/Chemical—Fresh (young juveniles, spawning adults) to marine (older juveniles, immature adults) waters; may use salinity gradients as migratory cues. Juveniles usually in oligotrophic lakes at temperatures of 3-14°C; preferred temperatures about 8-12°C during summer; spawn at 3-10°C.

Life History

Social Behavior (Rogers, 1968; Straty, 1974; Morrow, 1980b)—Commonly in large schools when migrating.

Biological Associations—Juveniles associate with threespine stickleback in lakes and with other immature salmon at sea.

Nutrition (Rogers, 1968; Straty and Jaenicke, 1980)

- *Feeding type*—Predator.
- *Food*—Freshwater juveniles eat cladocerans, ostracods, copepods, and insects. Marine juveniles and adults eat copepods, amphipods, decapods, ostracods, barnacle larvae, euphausiids, squids, sand lance, myctophids, and various young and larval fishes. Spawning adults do not feed.
- *Feeding behavior*—Young juveniles in littoral zone feed diurnally; older juveniles and immature adults feed primarily during evening and early morning.
- *Feeding location*—Young juveniles feed in water column, epibenthos; older juveniles and adults feed in water column, near surface. Spawning adults do not feed.

Reproduction (Mathisen, 1962)

- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Primarily in streams and rivers flowing into lakes and on lake beaches, usually where there is groundwater upwelling.
- *Behavior*—Female digs redd (nesting area) and usually mates with only one male. Males may spawn with more than one female. Female defends redd only from other females; male defends against both sexes, but mostly other males.
- *Biology*—In Bristol Bay region, usually spawn August-September. Fecundity 2,000-6,000 eggs per female. Eggs 5-6 mm diameter. Adults die after spawning.

Development (Olsen, 1968; McPhail and Lindsey, l970; Scott and Crossman, 1973; Morrow, 1980b)—Duration of incubation is temperature dependent (500-700 degree days); hatch midwinter to early spring. Yolk-sac larvae leave gravel and become free-swimming juveniles in early spring (March-June). Young go to sea after 0-3 years in lake (1-2 years most common). Mature after 1-4 years at sea (2-3 years most common). Most mature at 5 years (range 3-7).

Growth (Lander and Tanonaka, 1964; McPhail and Lindsey, 1970; Rogers, 1973, 1980; Morrow, 1980b)—Highly variable; influenced by population density and temperature. Usually average 6 grams after 1 year in fresh water, 11 grams after 2 years in fresh water, 2 kg after 2 years at sea, and 3 kg after 3 years at sea.

Movements (Pella, 1968; Dunn, 1969; McPhail and Lindsey, 1970; Straty, 1974, 198l; Rogers, 1978; Morrow, 1980b)—Young migrate from spawning areas to nursery lakes soon after emergence from gravel; remain in lakes 1-3 years, then move to sea (mid-May to mid-July), toward outer shelf (peak abundance June-July). Leave Bering Sea for North Pacific in fall. Peak abundance of returning adults on shelf, mid-June to mid-July; sockeye are the third salmon species to appear in Bering Sea shelf area (after chinook and chum).

Factors Influencing Populations

Natural (Rogers, 1968, 1973, 1980; Burgner et al., 1969; McPhail and Lindsey, 1970; Hart, 1973; Straty, 1974; Ainley and Sanger, 1979; Straty and Haight, 1979; Morrow, 1980b; Straty and Jaenicke, 1980)—Eggs killed by extremes of temperature, low amounts of oxygen in nest, and by fluctuating water flows. Young may compete with threespine stickleback for food; are preyed on by dolly varden, Arctic char, rainbow trout, lake trout, Arctic tern (and other seabirds), and beluga whale. In streams, migrating and spawning adults eaten by brown bears. Greatest mortality occurs in fresh water during early life stages; predation on juveniles by marine birds may also be significant.

Human-related—Major impact through both coastal and high-seas commercial gillnet fisheries, which are size selective. Some subsistence catch; sport fishing relatively unimportant.

Potential (Nelson-Smith, 1973; Hawkes, 1977; Patten, 1977)—Exposures of various species of salmonids to various petroleum compounds have resulted in inflammation and lesion of gills, depletion of liver glycogen, slower growth rates, softening of eye lenses, increased destruction of red blood cells in spleen, increased oxygen consumption, lower hatching success and survival of eggs and young, and an increase in time young fish spend at surface of water. In fishes, oil contamination can cause blockage or destruction of chemoreceptors, a respiratory "cough" response, loss of metabolic control, muscular/neural narcosis, and impairment of locomotor ability, equilibrium, and schooling behavior; also, increased egg mortality and larval deformities, decreased growth and development of embryos and young, decreased feeding rate, tainting of flesh, and death. Oil emulsified by rough seas or surfactants causes erosion of gill epithelium, depression of respiratory functions, and adherence of oil droplets to mucus layer of fish. Emulsification also may allow oil to be swallowed more readily by fishes trying to maintain ionic/osmotic balance. In general, light petroleum fractions are highly toxic and cause almost instantaneous death, even at low concentrations. These findings probably apply to this species.

Population Size (Rogers, 1978; Straty, 1981; Middleton, 1983; Alaska Department of Fish & Game, l984)

Average annual run of 30.4 million fish (1974-1983) is about 72% of all salmon in eastern Bering Sea. Sockeye are most abundant in Bristol Bay.

Management

Average annual catch in eastern Bering Sea of 15.9 million fish (1974-1983) constitutes 69% of total Alaska sockeye catch and 45% of world catch. Goal of management is to achieve optimum escapement.

Persons Consulted

W. D. Arvey, Alaska Department of Fish & Game, Anchorage, Alaska.
J. E. Bailey, Northwest and Alaska Fisheries Center, NMFS/NOAA, Auke Bay, Alaska.
R. L. Burgner, Fisheries Research Institute, University of Washington, Seattle, Washington.
H. W. Jaenicke, Northwest and Alaska Fisheries Center, NMFS/NOAA, Auke Bay, Alaska.
J. L. Landingham, Northwest and Alaska Fisheries Center, NMFS/NOAA, Auke Bay, Alaska.
C. P. Meacham, Alaska Department of Fish & Game, Anchorage, Alaska.
T. Nishiyama, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
D. E. Rogers, Fisheries Research Institute, University of Washington, Seattle, Washington.
R. R. Straty, Northwest and Alaska Fisheries Center, NMFS/NOAA, Auke Bay, Alaska.

Legend

- Adult Area (May-June)
- Adult Area (June-July)
- Major Adult Area (June-July)
- Major Adult Concentration (June-July)
- Major Juvenile Area (May-July) Juveniles less than 1 year
- Migration (June-July) Prespawning adults

Commercial Catch in Coastal Streams
(5-year average, annual catch)

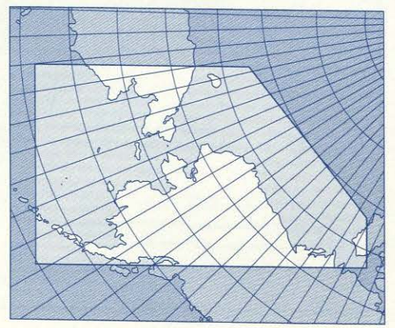
- Present; little or no catch
- Less than 1,000,000
- 1,000,000 to 10,000,000
- Greater than 10,000,000

Commercial catch reflects general abundance of adults migrating (July-September) or spawning (August-September) in coastal streams. Catch in Alaska is shown within Alaska Department of Fish & Game Management Areas (bold lines), and Districts (dashed lines) identified on map. Tones are extended 20 miles inland, but symbolize total catch in all rivers and streams draining each district or area. Soviet commercial catch is estimated.

Juveniles spend 1-3 years in fresh water; leave May-July and move to outer shelf during summer (migratory paths unknown); depart study area September-October for North Pacific, where they usually remain 2-3 years.

Map References

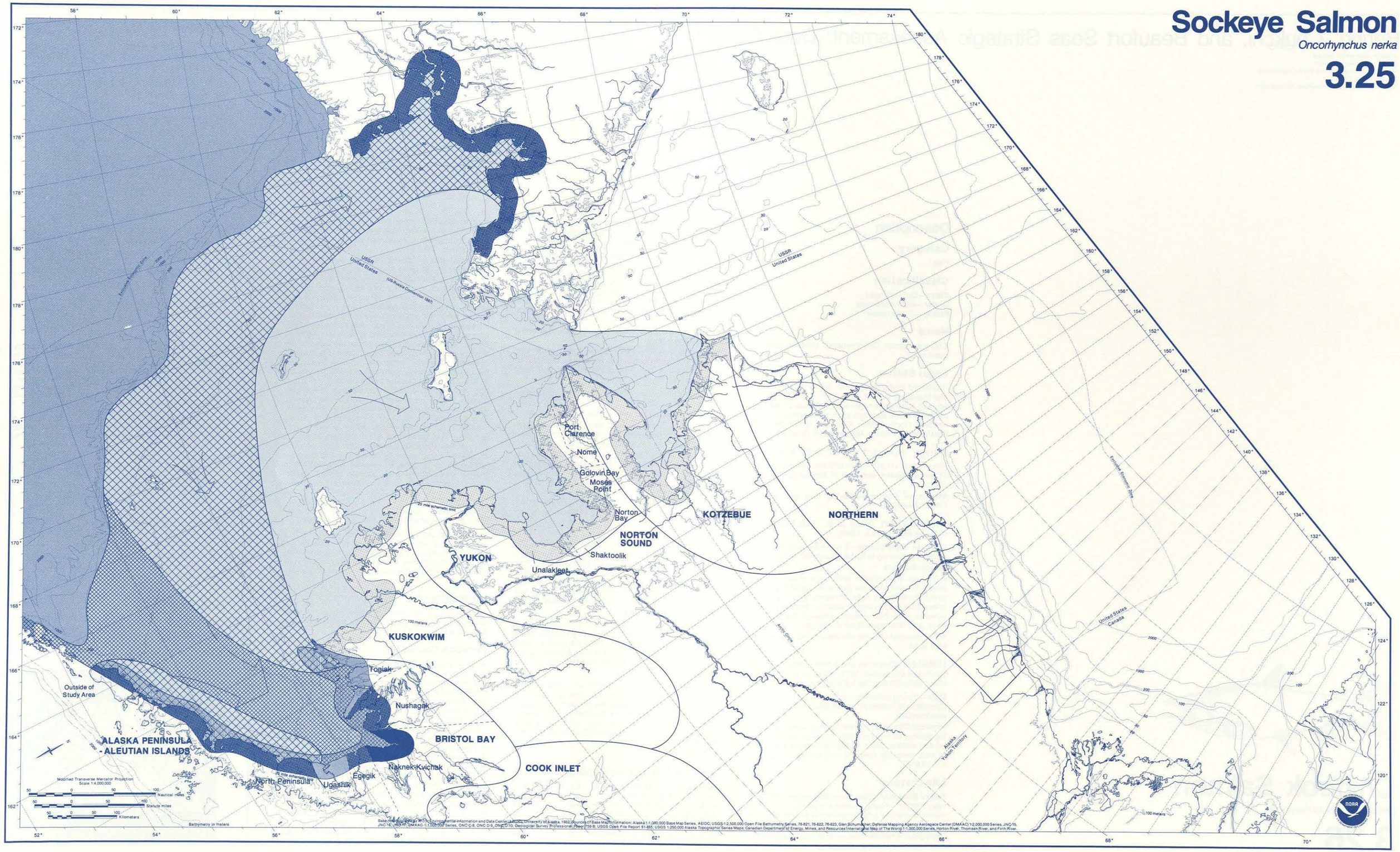
Straty, 1981; Middleton, 1983; Alaska Department of Fish & Game, 1984a, b, c, d, e. Personal communications from Arvey; Meacham; Nishiyama; Rogers; Straty.



Sockeye Salmon

Oncorhynchus nerka

3.25



Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

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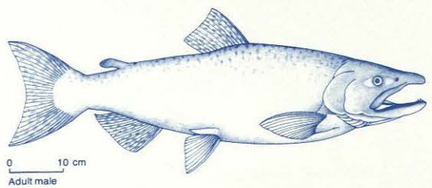

Chinook Salmon

Oncorhynchus tshawytscha

3.26

Description

Category

Fish

Classification

Class—Osteichthyes
Order—Salmoniformes
Family—Salmonidae

Name

Chinook salmon, *Oncorhynchus tshawytscha* (king salmon)

Legal Status

Protected under Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended, with coastal management by Alaska Department of Fish & Game and high-seas management by International North Pacific Fisheries Commission and North Pacific Fishery Management Council.

Range (Hart, 1973; Morrow, 1980b; Straty, 1981)

Worldwide—North Pacific and arctic-subarctic, from Pt. Hope, Alaska, and Gulf of Anadyr to Japan and California.

Region of Concern—Bering Sea and southern Chukchi Sea to Pt. Hope.

Distribution (Major et al., 1978; Straty, 1981; McBride and Wilcock, 1983)

Discrete Populations—Each spawning population is distinct, moving to natal stream for reproduction.

Concentrations

- *Natural*—Associated with large rivers. Yolk-sac larvae in natal streams that are tributaries to large rivers; juveniles in natal streams, lakes, and estuaries, later in open ocean; adults in area of spawning streams (May-September), primarily Yukon, Kuskokwim, and Nushagak River drainages.
- *Commercial*—In and off rivers listed above and on high seas.

Habitat (Chapman and Bjornn, 1969; Hart, 1973; Scott and Crossman, 1973; Major et al., 1978; Morrow, 1980b; Straty, 1981; McBride and Wilcock, 1983)

Type—Young juveniles in rivers, rarely in lakes; older juveniles and immature adults oceanic; mature adults anadromous.

Physical/Chemical—Fresh (young juveniles, spawning adults) to marine (older juveniles and immature adults) waters. Occur over broad temperature range at sea, generally stay above thermocline; spawn at 5.6-13.9°C.

Life History

Social Behavior (Scott and Crossman, 1973; Morrow, 1980b)—Young juveniles are territorial in fresh water. Immature adults commonly scattered at sea, not in large schools.

Biological Associations—Juveniles associate with other salmon at sea.

Nutrition (Chapman and Bjornn, 1969; Hart, 1973; Loftus and Lenon, 1977; Morrow, 1980b)

- *Feeding type*—Predator.
- *Food*—Freshwater juveniles eat chironomids, corixids, caddisflies, and other aquatic insects; also mites, spiders, and young crustaceans. Marine juveniles near shore eat mostly herring, sand lance, insects, crustaceans, and mollusks. Seasonal shift, in some areas, from euphausiids in spring to fishes in summer. Adults eat herring, sand lance, pilchard, euphausiids, and squid.
- *Feeding behavior*—Unknown at sea. Spawning adults do not feed.
- *Feeding location*—Juveniles in fresh water feed throughout water column. Oceanic juveniles and immature adults feed from surface waters to deep waters off shelf.

Reproduction (Hart, 1973; Scott and Crossman, 1973; Morrow, 1980b)

- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Coarse gravel beds in major streams and rivers; occasionally on gravel shoals in lakes. Spawn as far as 1,900 km upstream from ocean.
- *Behavior*—Both sexes promiscuous. Females prepare nest by lashing tail to displace sand and silt; nest defended by female, dominant male. Female may make more than one nest; covers nest by digging upstream.
- *Biology*—Spawn July-September. Fecundity 2,600-13,600 eggs per female, varying with size of female and latitude; eggs 6-7 mm diameter. Adults die after spawning.

Development (Hart, 1973; Scott and Crossman, 1973; Morrow, 1980b)—Duration of incubation is temperature dependent; eggs hatch in spring. Yolk-sac larvae remain in gravel 2-3 weeks, then emerge as free-swimming juveniles. Spend l-3 years in fresh water, mature after 1-6 years (usually 2-4) at sea, then return to fresh water to breed. Usually mature and spawn at 5-6 years.

Growth (Hart, 1973; Scott and Crossman, 1973; Morrow, 1980b)—Growth rate highly variable, but is especially high in final year before spawning. One-year-olds average 100-150 mm long. Adults average 750-800 mm (7-9 kg); maximum 1,040 mm (57 kg). Maximum lifespan 8 years.

Movements (Hart, 1973; Morrow, 1980b)—Juveniles migrate to coast in spring, moving offshore in early summer. Oceanic juveniles and immature adults circumnavigate Alaska gyre, but also occur in deeper waters off shelf year-round; also on outer shelf in summer. Spawning migration begins in early summer, on shelf May-July. Chinook are the earliest Bering Sea salmon to spawn.

Factors Influencing Populations

Natural (Hart, 1973; Scott and Crossman, 1973; Morrow, 1980b)—Young eaten by dolly varden, coho salmon, squawfish, sculpins, mergansers, kingfishers. Adults eaten by marine mammals, bears. Adults compete with coho salmon for food. Parasitized by Pacific lamprey, protozoans, trematodes, cestodes, nematodes, leeches, crustaceans, and mollusks.

Human-related—Important commercial fish because of high market value and demand. Also sport-fished intensively. Subsistence catch substantial in some areas.

Potential (Nelson-Smith, 1973; Hawkes, 1977; Patten, 1977)—Exposures of various species of salmonids to various petroleum compounds have resulted in inflammation and lesion of gills, depletion of liver glycogen, slower growth rates, softening of eye lenses, increased destruction of red blood cells in spleen, increased oxygen consumption, lower hatching success and survival of eggs and young, and an increase in time young fish spend at surface of water. In fishes, oil contamination can cause blockage or destruction of chemoreceptors, a respiratory "cough" response, loss of metabolic control, muscular/neural narcosis, and impairment of locomotor ability, equilibrium, and schooling behavior; also, increased egg mortality and larval deformities, decreased growth and development of embryos and young, decreased feeding rate, tainting of flesh, and death. Oil emulsified by rough seas or surfactants causes erosion of gill epithelium, depression of respiratory functions, and adherence of oil droplets to mucus layer of fish. Emulsification may also allow oil to be swallowed more readily by fishes trying to maintain ionic/osmotic balance. In general, light petroleum fractions are highly toxic, causing almost instantaneous death, even at low concentrations. These findings probably apply to this species.

Population Size (Straty, 1981; Middleton, 1983; Alaska Department of Fish & Game, 1984)

Average annual run of 750,000 fish (1974-1983) is about 2% of all salmon in eastern Bering Sea; 33% of total chinooks from Yukon, 29% from Nushagak, and 25% from Kuskokwim. Togiak and Anadyr have runs of less than l00,000. Populations in other rivers, less than l0,000.

Management

Average annual catch in eastern Bering Sea of about 340,000 fish (1974-1983) constitutes 50% of total Alaskan catch and 8% of world catch.

Persons Consulted

W. D. Arvey, Alaska Department of Fish & Game, Anchorage, Alaska.
J. E. Bailey, Northwest and Alaska Fisheries Center, NMFS/NOAA, Auke Bay, Alaska.
R. L. Burgner, Fisheries Research Institute, University of Washington, Seattle, Washington.
W. R. Heard, Northwest and Alaska Fisheries Center, NMFS/NOAA, Auke Bay, Alaska.
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T. Nishiyama, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
D. E. Rogers, Fisheries Research Institute, University of Washington, Seattle, Washington.
R. R. Straty, Northwest and Alaska Fisheries Center, NMFS/NOAA, Auke Bay, Alaska.

Legend

- Adult Area (May-June)
- Major Adult Area (May-June)
- Juvenile Area (Year-round) Juveniles older than 2 years
- Juvenile Area (May-September) Juveniles older than 2 years
- Migration (May-June) Prespawning adults

Commercial Catch in Coastal Streams (5-year average, annual catch)

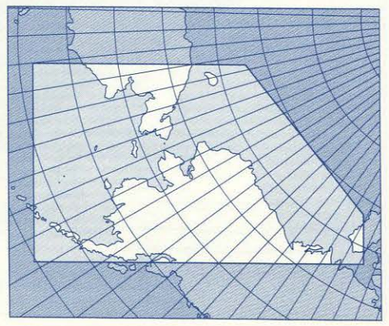
- Present; little or no catch
- Less than 10,000
- 10,000 to 100,000
- Greater than 100,000

Commercial catch reflects general abundance of adults migrating (June-September) or spawning (July-September) in coastal streams. Catch in Alaska is shown within Alaska Department of Fish & Game Management Areas (bold lines), and Districts (dashed lines) identified on map. Tones are extended 20 miles inland, but symbolize total catch in all rivers and streams draining each district or area. Soviet commercial catch is estimated.

Juveniles spend 1-3 years in fresh water; leave May-June and move to outer shelf during summer (migratory paths unknown); usually remain in Bering Sea basin and North Pacific 2-4 years.

Map References

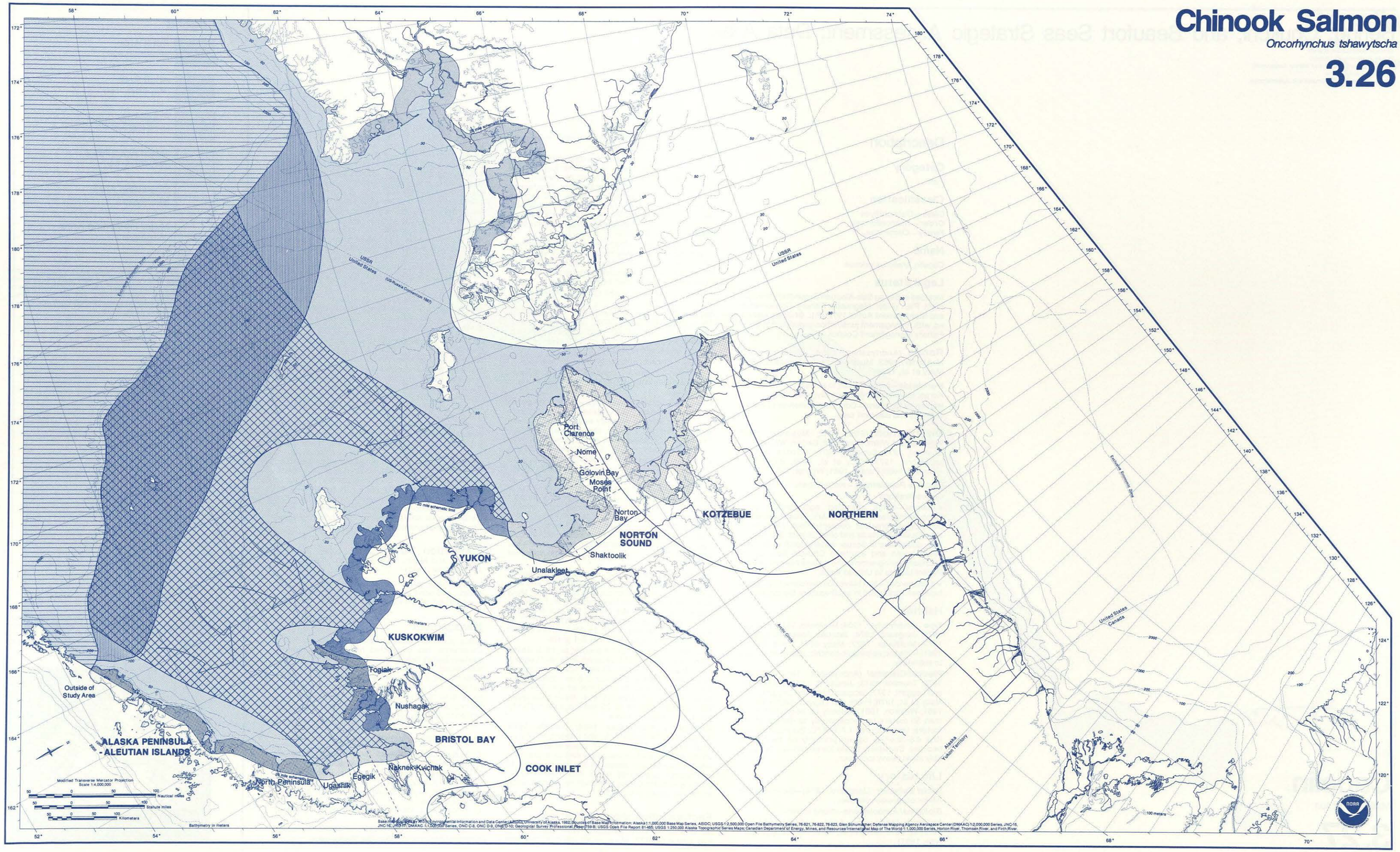
Straty, 1981; Middleton, 1983; Alaska Department of Fish & Game, 1984a, b, c, d, e. Personal communications from Arvey; Meacham; Nishiyama; Rogers; Straty.



Chinook Salmon

Oncorhynchus tshawytscha

3.26



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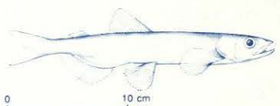


Capelin

Mallotus villosus

3.27

Description

Category

Fish

Classification

Class—Osteichthyes
Order—Salmoniformes
Family—Osmeridae

Name

Capelin, *Mallotus villosus*

Legal Status

Included in Bering Sea-Aleutian Groundfish Management Plan under Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended, with management jurisdiction under North Pacific Fishery Management Council.

Range (Andriyashev, 1954; Walters, 1955; McAllister, 1963; Musienko, 1970; Jangaard, 1974; Macy et al., 1978)

Worldwide—Arctic Ocean, to at least 76°N, south to Korea, British Columbia, Norway, and Maine.

Region of Concern—Continental shelves of Bering, Chukchi, and Beaufort seas.

Distribution (Ellis, 1962; Musienko, 1963; Alverson and Wilimovsky, 1966; Barton, Warner, and Shafford, 1977; Bendock, 1977; Wolotira, Sample, and Morin, 1977; Macy et al., 1978; Barton and Steinhoff, 1980; Pahlke, 1981; Warner, 1981)

Discrete Populations—None known.

Concentrations

- *Natural*—Large spawning aggregations occur along Bering Sea shores May-July; Chukchi-Beaufort, July-August; greatest concentrations along north side Alaska Peninsula and outer Bristol Bay. In summer, adults also in deeper waters north of St. Lawrence Island and southern Chukchi Sea. Larvae abundant spring-summer from Cape Newenham and Pribilof Islands to Unimak Pass.
- *Commercial*—Not taken commercially; test-fishing has been conducted in southeastern Bering Sea.

Habitat

Type (Andriyashev, 1954; Musienko, 1970; Fedorov, 1973; Jangaard, 1974; Jacquaz, Able, and Leggett, 1977; McAllister, 1977; Macy et al., 1978; Pahlke, 1981)—Neritic, epipelagic-benthic; spawn intertidally to subtidally.

Physical/Chemical (Andriyashev, 1954; Fedorov, 1973; Trumble, 1973; Jangaard, 1974; Bailey, Able, and Leggett, 1977; Jacquaz, Able, and Leggett, 1977; Macy et al., 1978; Frank and Leggett, 1981a; Pahlke, 1981; Waldron, 1981)—Mostly on inner shelf in less than 50 meters but occasionally to depths of 280 meters; temperatures 1.7-14.4°C. Euryhaline (salinities 4.8-32.6‰). Spawn primarily on sand-gravel beaches. Sensitivity to sea ice not known, but probably avoid heavy ice cover.

Life History

Social Behavior (Jangaard, 1974)—Schooling; behavior otherwise unknown.

Biological Associations—None known.

Nutrition (Andriyashev, 1954; Jangaard, 1974; Kendel et al., 1975; Macy et al., 1978; Vesin, Leggett, and Able, 1981)

- *Feeding type*—Filter-feeder; larvae omnivorous, juveniles and adults carnivorous.
- *Food*—Larvae eat mainly copepods (all life stages), invertebrate eggs, and diatoms; juveniles eat mainly small copepods (all stages), euphausiids, appendicularians; also invertebrate eggs, crustacean nauplii, euphausiid eggs and larvae, and mollusk larvae. Adults eat mainly copepods (all life stages), adult euphausiids, amphipods, and appendicularians; also eat cumaceans, decapod larvae, mysids, polychaetes, and small fishes.
- *Feeding behavior*—Daily peaks of feeding activity in late morning and evening in spring-fall, midday in fall-winter. Adults feed little in winter, more in spring, not while spawning, and much in postspawning period to late fall. Juveniles feed actively all year.
- *Feeding location*—In water column over continental shelf.

Reproduction (Andriyashev, 1954; Trumble, 1973; Jangaard, 1974; Bailey, Able, and Leggett, 1977; Macy et al., 1978; Frank and Leggett, 1981a,b, 1982a,b; Pahlke, 1981; Waldron, 1981; Warner, 1981; Warner and Shafford, 1981)

- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Primarily intertidal on sand-gravel beaches; occasionally subtidal to 75 meters, rarely to 280 meters.
- *Behavior*—Males school close to shore, females in deeper water. Both move shoreward at or just after high tide, at night or in cloudy weather. Each female accompanied by 1-2 males; spawn in surf on beach. Females depart area; males remain close to spawning beaches during entire 1-5 week spawning period.
- *Biology*—Spawn May (Bristol Bay) to August (Pt. Barrow). Eggs laid on beach, buried to 15-cm depths by waves, currents; fecundity 6,000-22,000 eggs per female in Bering Sea, varying with size of female and geographic location. Large, older females spawn earlier than small, younger ones; postspawning mortality usually greater than 90% in males, greater than 80% in females. Eggs hatch 10-55 days after spawning; yolk-sac larvae uncovered by surf; begin to school with juveniles and adults in late fall. Strength of spawning runs highly variable from year to year.

Development (Ellis, 1962; Jangaard, 1974; Barton, Warner, and Shafford, 1977; Jacquaz, Able, and Leggett, 1977; Wolotira, Sample, and Morin, 1977; Macy et al., 1978; Craig and Haldorson, 1981; Frank and Leggett, 1981a,b; Pahlke, 1981)—Duration of incubation is temperature dependent (10 days at 18°C, 55 days at 1°C), usually about 15 days; larvae absorb yolk-sac in 5-8 days. Mature at 2-4 years.

Growth (Jangaard, 1974; Kendel et al., 1975; Bailey, Able, and Leggett, 1977; Jacquaz, Able, and Leggett, 1977; Macy et al., 1978)—Growth slower in northern populations. Yolk-sac larvae 3-6 mm long; to 20-40 mm by fall, and up to 60 mm at end first year. Adults 60-210 mm; after first year, males grow faster than females and are 10-25 mm longer at maturity. Maximum lifespan 4 years.

Movements (Andriyashev, 1954; Trumble, 1973; Jangaard, 1974; Bailey, Able, and Leggett, 1977; Jacquaz, Able, and Leggett, 1977; Macy et al., 1978)—Juveniles and adults undergo diel vertical migrations, near surface at night, deeper by day. During winter, all age-classes apparently move into deeper water, possibly to outer Bering Sea shelf; return to shallow waters to spawn in summer.

Factors Influencing Populations

Natural (Ellis, 1962; Jangaard, 1974; Bailey, Able, and Leggett, 1977; Macy et al., 1978; Ainley and Sanger, 1979; Divoky, 1981; Feder and Jewett, 1981; Frank and Leggett, 1981a,b, 1982a,b; Frost and Lowry, 1981a; Harry and Hartley, 1981; Hunt, Burgeson, and Sanger, 1981; Lowry and Frost, 1981b)—Eggs eaten by bottomfishes. Larvae eaten by flounders, cods, herring, chaetognaths, jellyfishes, ctenophores, decapod larvae, and amphipods. Juveniles and adults eaten by spiny dogfish, cods, flounders, salmon, plaice, pollock, mackerel, herring, shearwaters, gulls, kittiwakes, terns, murres, puffins, seals (fur, ribbon, spotted, harbor), baleen whales, white and killer whales, and porpoises. Parasitized by larval nematodes (*Contracaecum*). Egg mortality in proportion to density, especially at high-tide levels. Release of egg-sac larvae from sediment dependent on surf at proper time.

Human-related (Pahlke, 1981)—Commercial fishery catch will reduce stock size. Small subsistence catch of spawning adults in western Alaska. Reduction of populations of any predators might increase survival.

Potential (Nelson-Smith, 1973; Barton, Warner, and Shafford, 1977; Patten, 1977; Warner, 1981)—Oil pollution of spawning substrates (especially beaches) will decrease survival of eggs and yolk-sac larvae. In fishes, oil contamination can cause blockage or destruction of chemoreceptors, a respiratory "cough" response, loss of metabolic control, muscular/neural narcosis, and impairment of locomotor ability, equilibrium, and schooling behavior; also, increased egg mortality and larval deformities, decreased growth and development of embryos and young, decreased feeding rate, tainting of flesh, and death. Oil emulsified by rough seas or surfactants causes erosion of gill epithelium, depression of respiratory functions, and adherence of oil droplets to mucus layer of fish. Emulsification also may allow oil to be swallowed more readily by fishes trying to maintain ionic/osmotic balance. In general, light petroleum fractions are highly toxic, causing almost instantaneous death, even at low concentrations. These findings probably apply to this species.

Population Size

(Trumble, 1973; Wolotira, Sample, and Morin, 1977; Laevastu and Favorite, 1978; Pahlke, 1981)

Unknown. Biomass of pelagic forage fishes (including capelin and sand lance) in eastern Bering Sea estimated at 4.3 million tons.

Management

Office of Fishery Development, U.S. Department of Commerce, has conducted test-fishing in southeastern Bering Sea. Fishery Board, State of Alaska, has issued policy statement (1981), giving Alaska Department of Fish & Game the directive to limit by-catch of herring by regulating capelin fishery (no more than 20% by-catch of herring after close of herring season). Sport-fish catch (of all "smelts") limited to 200 fish per day per person.

Persons Consulted

R. G. Bakkala, Northwest and Alaska Fisheries Center, NMFS/NOAA, Seattle, Washington.
L. H. Barton, Alaska Department of Fish & Game, Fairbanks, Alaska.
K. A. Pahlke, Alaska Department of Fish & Game, Juneau, Alaska.
D. C. Whitmore, Alaska Department of Fish & Game, Anchorage, Alaska.
V. G. Wespestad, Northwest and Alaska Fisheries Center, NMFS/NOAA, Seattle, Washington.

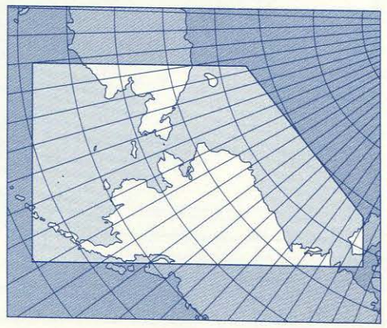
Legend

- Adult Area (November-April)
- Adult Area (May-November)
- Adult Area (June-September)
- Major Adult Area (May-November)
- Spawning Area (May-August)
- Major Spawning Area (May-August)

Spawning occurs along gravel beaches, July-August north of Bering Strait, May-June south of Bering Strait. Spawning areas are also areas of major adult concentrations during spawning season. Juveniles occur year-round throughout adult areas. Sensitivity to sea ice not known; probably move to deeper shelf waters during winter.

Map References

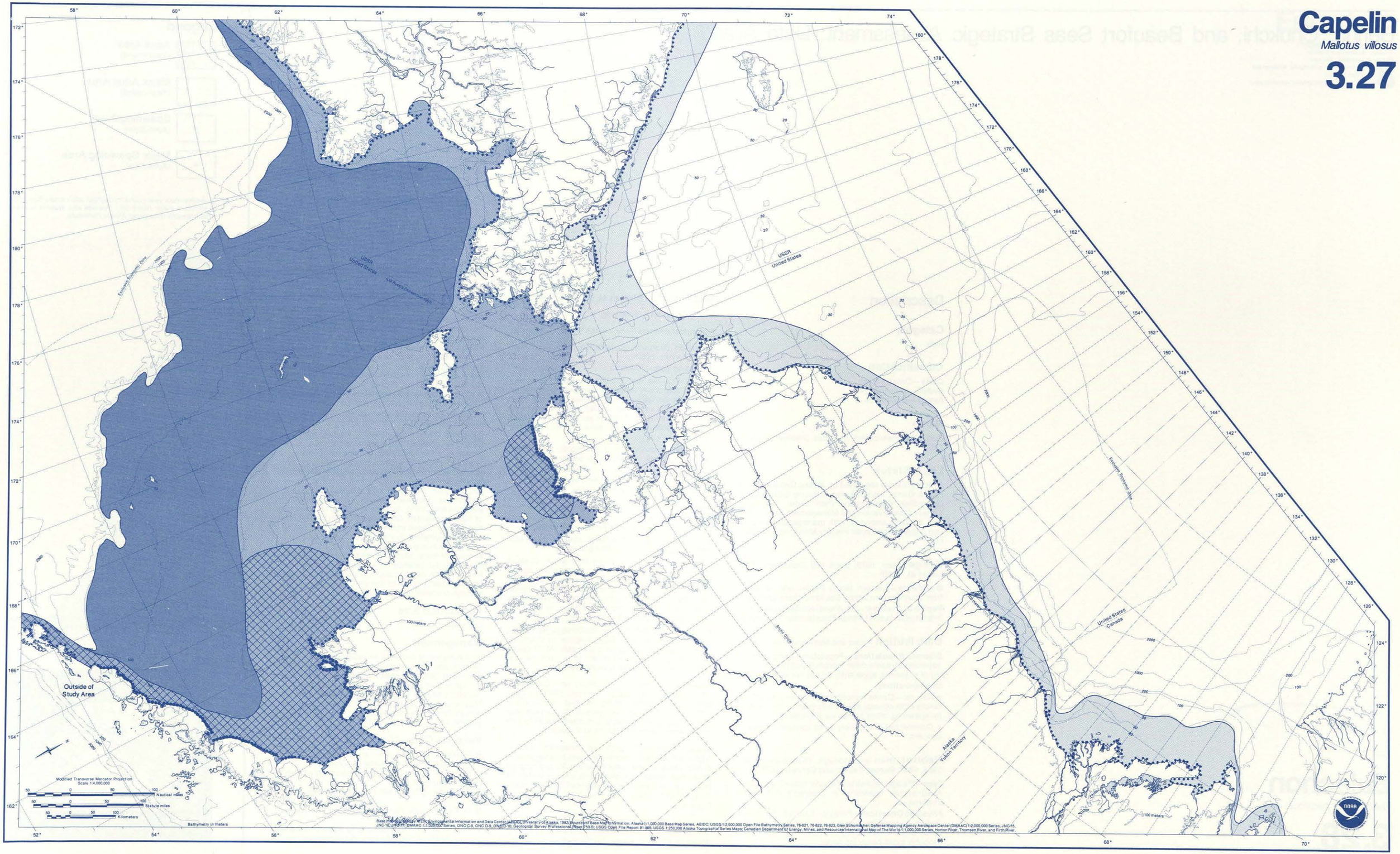
Andriyashev, 1954; Walters, 1955; McAllister, 1963; Musienko, 1970; Jangaard, 1974; Barton, Warner, and Shafford, 1977; Bendock, 1977; Divoky, 1978; Macy et al., 1978; Springer and Roseneau, 1978; Hunt, Burgeson, and Sanger, 1981; Pahlke, 1981. Personal communication from Pahlke.



Capelin

Mallotus villosus

3.27



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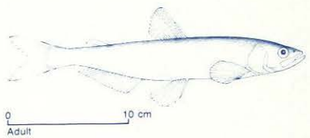


Eulachon

Thaleichthys pacificus

3.28

Description

Category

Fish

Classification

Class—Osteichthyes
Order—Salmoniformes
Family—Osmeridae

Name

Eulachon, *Thaleichthys pacificus* (hooligan, candlefish)

Legal Status

Catch in Alaska regulated by Alaska Department of Fish & Game. Also included in Bering Sea-Aleutian Groundfish Management Plan under Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended, with management jurisdiction under North Pacific Fishery Management Council.

Range (Hart, 1973; Scott and Crossman, 1973; Lee et al., 1980)

Worldwide—Eastern North Pacific and subarctic from southeastern Bering Sea to northern California.
Region of Concern—Southeastern Bering Sea from Pribilof Islands and Unimak Pass to inner Bristol Bay.

Distribution (Hart and McHugh, 1944)

Discrete Populations—Populations using different spawning streams differ morphologically and in timing of spawning; apparently do not mix extensively.
Concentrations

- *Natural*—Dense concentrations move short distances from coastal waters into freshwater streams for spawning, often just as ice is breaking up.
- *Commercial*—Relatively minor species in region of concern.

Habitat (Hart and McHugh, 1944; Barraclough, 1964, 1967; Barner, Taylor, and Bennett, 1979)

Type—Pelagic; midwater outside spawning season. Anadromous, spawning in mainland rivers and streams.
Physical/Chemical—Pelagic habitat unknown. Spawn in clear freshwater, 4.4-7.8°C, on coarse, sandy bottom. Sensitivity to sea ice not known, but probably avoid heavy ice cover.

Life History (Macy et al., 1978; Morrow, 1980b)

Social Behavior—Schooling.

Biological Associations—None known.

Nutrition (Barraclough, 1967; Scott and Crossman, 1973; Morrow, 1980b)

- *Feeding type*—Predator.
- *Food*—Larvae and postlarvae (25-50 mm long) eat phytoplankton, copepods, copepod eggs, mysids, ostracods, barnacle larvae, cladocerans, and polychaete larvae, as well as smaller larvae of their own species. Juveniles and adults eat primarily euphausiids, copepods, and cumaceans. Do not feed while spawning.
- *Feeding behavior*—Feed in schools, presumably moving vertically in circadian pattern with food supply.
- *Feeding location*—Midwater to surface, near shore and off mouths of large rivers.

Reproduction (Hart, 1973; Scott and Crossman, 1973; Morrow, 1980b)

- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Mostly in coastal streams upstream from estuaries, at depths to 7.6 meters.
- *Behavior*—Spawning migrations when streams are ice-free; southern populations generally spawn earliest. Runs in adjacent streams can be several months apart. Some streams have more than one run per year, probably of different populations. Males predominate early in run; females arrive later. No nest; eggs scattered and abandoned.
- *Biology*—Fecundity about 25,000 eggs per female, depending on her size. Eggs irregular in shape, 8-10 mm diameter, adhere to coarse sand. Most adults die after spawning; a few return to sea and may reenter streams to spawn a second time.

Development (Hart, 1973; Scott and Crossman, 1973; Macy et al., 1978; Morrow, 1980b)—Eggs hatch in 2-3 weeks. Newly hatched larvae about 4-5 mm long, slender, transparent, closely resemble young herring; swim feebly, drift downstream to sea shortly after hatching. Mature at 3 years.

Growth (Hart, 1973; Scott and Crossman, 1973)—Growth of larvae in nearshore areas less rapid than at sea. Young at sea in April average 23 mm long; by December, 46-51 mm. Move into deeper water as they grow. At 3 years, average about 165 mm; maximum length about 220 mm. Maximum lifespan 5 years.

Movements (Macy et al., 1978; Morrow, 1980b)—Schools move into mainland streams April-June for spawning. Other movements unknown.

Factors Influencing Populations

Natural (Outram and Haegele, 1972; Hart, 1973; Scott and Crossman, 1973; Ainley and Sanger, 1979; Kajimura, Fiscus, and Stroud, 1980)—Eaten by spiny dogfish, white sturgeon, salmon, halibut, Pacific cod, Pacific hake, eagles, gulls, kittiwakes, murres, puffins, harbor seals, northern sea lions, northern fur seals, Dall's porpoises, and fin and killer whales. Late breakup of ice in coastal streams appears to delay spawning runs and further concentrate schools, leading to more intense predation. Mild winters allow longer spawning periods and reduced predation.
Human-related—Overharvesting can depress breeding stocks.
Potential (Nelson-Smith, 1973; Patten, 1977)—In fishes in general, oil contamination can cause blockage or destruction of chemoreceptors, a respiratory "cough" response, loss of metabolic control, muscular/neural narcosis, and impairment of locomotor ability, equilibrium, and schooling behavior; also, increased egg mortality and larval deformities, decreased growth and development of embryos and young, decreased feeding rate, tainting of flesh, and death. Oil emulsified by rough seas or surfactants causes erosion of gill epithelium, depression of respiratory functions, and adherence of oil droplets to mucus layer of fish; also may allow oil to be swallowed more readily by fishes trying to maintain ionic/osmotic balance. In general, light petroleum fractions are highly toxic, causing almost instantaneous death, even at low concentrations. These findings probably apply to this species.

Population Size

Unknown.

Management

Within region of concern, no closed season. Alaska Department of Fish & Game regulations do not differentiate "smelt" species. Unknown quantity taken for sport and subsistence; sport-fish catch (of all "smelts") limited to 200 fish per day per person. Maintenance of water quality in spawning streams, prevention of overharvesting, and preservation of genetic stocks are important concerns.

Persons Consulted

R. G. Bakkala, Northwest and Alaska Fisheries Center, NMFS/NOAA, Seattle, Washington.
G. A. Brogle (retired), Alaska Department of Fish & Game, Yakutat, Alaska.
S. J. Kessler, U.S. Forest Service, Natchez, Washington.
S. M. Patten, U.S. Fish & Wildlife Service, Bethel, Alaska.
V. G. Wespestad, Northwest and Alaska Fisheries Center, NMFS/NOAA, Seattle, Washington.

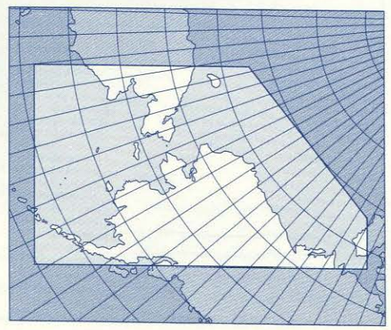
Legend

- Adult Area (Year-round)
- Major Adult Area (Year-round)
- Spawning Area (April-June)
- Major Spawning Area (April-June)

Juveniles occur year-round throughout adult areas. Spawning is shown in major rivers only. Species also spawns in many small streams throughout Alaska Peninsula.

Map References

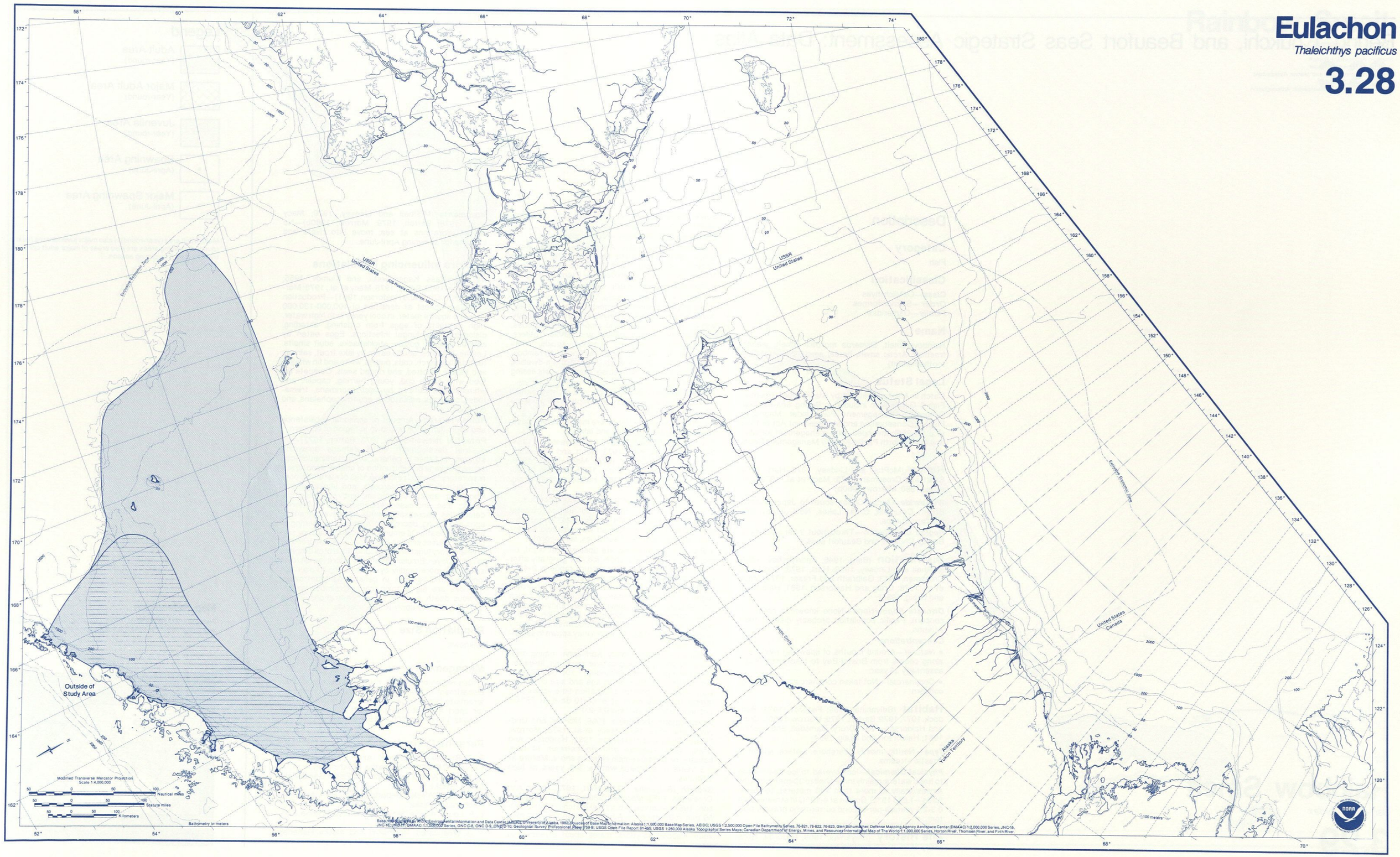
Carl, Clemens, and Lindsey, 1967; Hart, 1973; Scott and Crossman, 1973; Macy et al., 1978; Morrow, 1980; Lee et al., 1980.



Eulachon

Thaleichthys pacificus

3.28



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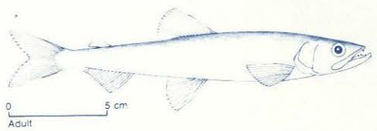


Rainbow Smelt

Osmerus mordax

3.29

Description

Category

Fish

Classification

Class—Osteichthyes
Order—Salmoniformes
Family—Osmeridae

Name

Rainbow smelt, *Osmerus mordax* (smelt, leefish, frostfish, Arctic smelt, boreal smelt, cucumberfish, toothed smelt)

Legal Status

Catch in Alaska regulated by Alaska Department of Fish & Game. Also included in Bering Sea-Aleutian Groundfish Management Plan under Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-256), amended, with management jurisdiction under North Pacific Fishery Management Council.

Range (McPhail and Lindsey, 1970; Hart, 1973; Scott and Crossman, 1973; Macy et al., 1978; Lee et al., 1980; Morrow, 1980b)

Worldwide—Arctic Ocean south to Japan, Korea, British Columbia, Great Lakes, New Jersey, and western Europe.

Region of Concern—Throughout inner shelves of Bering, Chukchi, and Beaufort seas.

Distribution (Berg, 1948; Andriyashev, 1954; McPhail and Lindsey, 1970; Hart, 1973; Scott and Crossman, 1973; Galbraith and Fraser, 1974; Macy et al., 1978; Craig and Haldorson, 1981; Haldorson and Craig, 1984)

Discrete Populations—None known in region of concern. Pacific population probably distinct from Atlantic.

Concentrations

- *Natural*—Around mouths of spawning rivers and along coasts from Bristol Bay to Mackenzie River, essentially all year.
- *Commercial*—Not taken commercially in region of concern.

Habitat (Belyanina, 1969; Fedorov, 1973; Bendock, 1977, 1979; Barton, 1979; Morrow, 1980b; Craig and Haldorson, 1981; Drury, Ramsdell, and French, 1981; Haldorson and Craig, 1984)

Type—Neritic, mostly nearshore, waters; spawn in coastal streams.

Physical/Chemical—Ice-covered to ice-free marine to fresh waters; mainly inner shelf to 30-meter depths (occasionally to more than 100 meters); temperatures –1.8 to 15°C. Spawn at 4-12°C in streams with 0.3-2.0 meters-per-second current and gravelly bottom.

Life History (Belyanina, 1969; Fedorov, 1973; Macy et al., 1978; Barton, 1979)

Social Behavior—Mainly schooling; only old, large adults swim and forage alone.

Biological Associations—None known.

Nutrition (Berg, 1948; Andriyashev, 1954; Belyanina, 1969; Percy, 1975; Neimark, 1979; Neimark, Cooney, and Geist, 1979; Wolotira, Sample, and Morin, 1979; Drury, Ramsdell, and French, 1981)

- *Feeding type*—Predator; rarely scavenger.
- *Food*—Fry eat mysids, chironomid larvae, copepods, cladocerans, rotifers, eggs, and algae. Juveniles and adults eat mysids, marine and freshwater copepods, gammarid amphipods, ostracods, cladocerans, aquatic insects and larvae, rotifers, polychaetes, cumaceans, isopods, squids, small clams, salmon eggs, young fishes (including rainbow smelt), other zooplankton, and bottom-dwelling crustaceans. Also eat refuse near fish-processing plants.
- *Feeding behavior*—Feed day and night; greatest during upward migration of zooplankton in early afternoon, evening.
- *Feeding location*—Nearshore marine waters, bays, estuaries, rivers, streams, and lakes.

Reproduction (Berg, 1948; Andriyashev, 1954; Belyanina, 1969; Hart, 1973; Scott and Crossman, 1973; Bendock, 1977, 1979; Macy et al., 1978; Wolotira, Sample, and Morin, 1979; Morrow, 1980b; Craig and Haldorson, 1981; Haldorson and Craig, 1984)

- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Clear rivers and larger coastal streams, usually 2-20 km (rarely to 1,000 km) from salt water; rarely in brackish water behind barrier beaches, littoral zone of estuaries, lake shores.
- *Behavior*—Adults migrate upstream at night, on high tide, occasionally under ice, but generally after breakup, when water temperature range is 2-4°C; males first, females follow. Nocturnal spawning initiated by sex ratio of 4 males per female. Fish crowd together, headed upstream; contact between males and females induces spawning over sandy-gravel to rocky bottom or on submerged vegetation. Before water reaches 15°C, adults drift downstream; many (especially males) die; survivors may spawn in subsequent years.
- *Biology*—Spawn mostly April-June; timing triggered by spring breakup of river ice. Older, larger individuals spawn first; fecundity 1,700-69,000 eggs per female, in proportion to age and size of female; eggs adhere to bottom. Incubation time varies with temperature (29 days at 6°C, 10 days at 15°C); average hatching success 0.5-2.0%.

Development (Belyanina, 1969; McPhail and Lindsey, 1970; Hart, 1973; Macy et al., 1978; Morrow, 1980b; Craig and Haldorson, 1981; Haldorson and Craig, 1984)—Larvae drift downstream to lake, estuary, or ocean; remain close to shore. Mature at 2-3 years in southern waters, 5-8 years at high latitudes.

Growth (Belyanina, 1969; Hart, 1973; Scott and Crossman, 1973; Morrow, 1980b; Craig and Haldorson, 1981)—Larvae 5-6 mm at hatching, reach 40-60 mm in 3-4 months. Adults average 160-200 mm; largest 356 mm. Females grow faster, larger. Maximum lifespan 15 years; males about 2 years less than females.

Movements (McPhail and Lindsey, 1970; Macy et al., 1978; Barton, 1979; Morrow, 1980b)—No known migrations at sea; move into rivers and streams for spawning April-June.

Factors Influencing Populations

Natural (Rass, Kagamovskii, and Klumov, 1955; Belyanina, 1969; Percy, 1975; Macy et al., 1978; Morrow, 1980b; Craig and Haldorson, 1981)—Production of larvae highest at densities of 100,000-130,000 eggs per square meter, in cool years with high water. High mortality of eggs from crushing, abrading, dislodging, and fungal infections. Eggs eaten by aquatic insects, gobies, sticklebacks, adult smelts. Larvae, juveniles, adults eaten by lake trout, salmon, turbot, pike, perch, cods, puffins, white and fin whales, and harbor, spotted, and ringed seals. Compete for food with Arctic cod, young herring, capelin, and whitefish. Parasitized by microsporidians, trematodes, cestodes, nematodes, acanthocephalans, and copepods.

Human-related—Amount of seasonal subsistence and sport-fish catch unknown in region of concern.

Potential (Nelson-Smith, 1973; Patten, 1977)—Industrial development could damage spawning streams. In fishes in general, oil contamination can cause blockage or destruction of chemoreceptors, a respiratory "cough" response, loss of metabolic control, muscular/neural narcosis, and impairment of locomotor ability, equilibrium, and schooling behavior; also, increased egg mortality and larval deformities, decreased growth and development of eggs and young, decreased feeding rate, tainting of flesh, and death. Oil emulsified by rough seas or surfactants causes erosion of gill epithelium, depression of respiratory functions, and adherence of oil droplets to mucus layer. Emulsification may also allow oil to be swallowed more readily by fishes trying to maintain ionic/osmotic balance. In general, light petroleum fractions are highly toxic, causing almost instantaneous death, even at low concentrations. These findings probably apply to this species.

Population Size

Unknown.

Management

Within region of concern, no closed season. Alaska Department of Fish & Game regulations do not differentiate "smelt" species. Unknown quantity taken for sport and subsistence; sport-fish catch (of all "smelts") limited to 200 fish per day per person.

Persons Consulted

R. G. Bakkala, Northwest and Alaska Fisheries Center, NMFS/NOAA, Seattle, Washington.
J. J. Burns, Alaska Department of Fish & Game, Fairbanks, Alaska.
D. S. Lloyd, Alaska Department of Fish & Game, Anchorage, Alaska.
L. F. Lowry, Alaska Department of Fish & Game, Fairbanks, Alaska.
V. G. Wespestad, Northwest and Alaska Fisheries Center, NMFS/NOAA, Seattle, Washington.

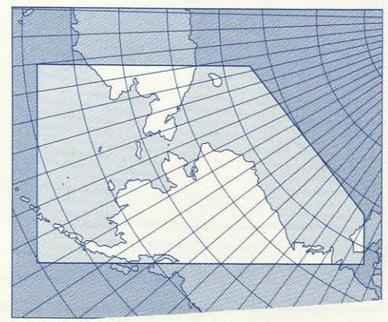
Legend



Major adult area (year-round) is also major juvenile area (year-round). Spawning areas are also areas of major adult concentrations during spawning season.

Map References

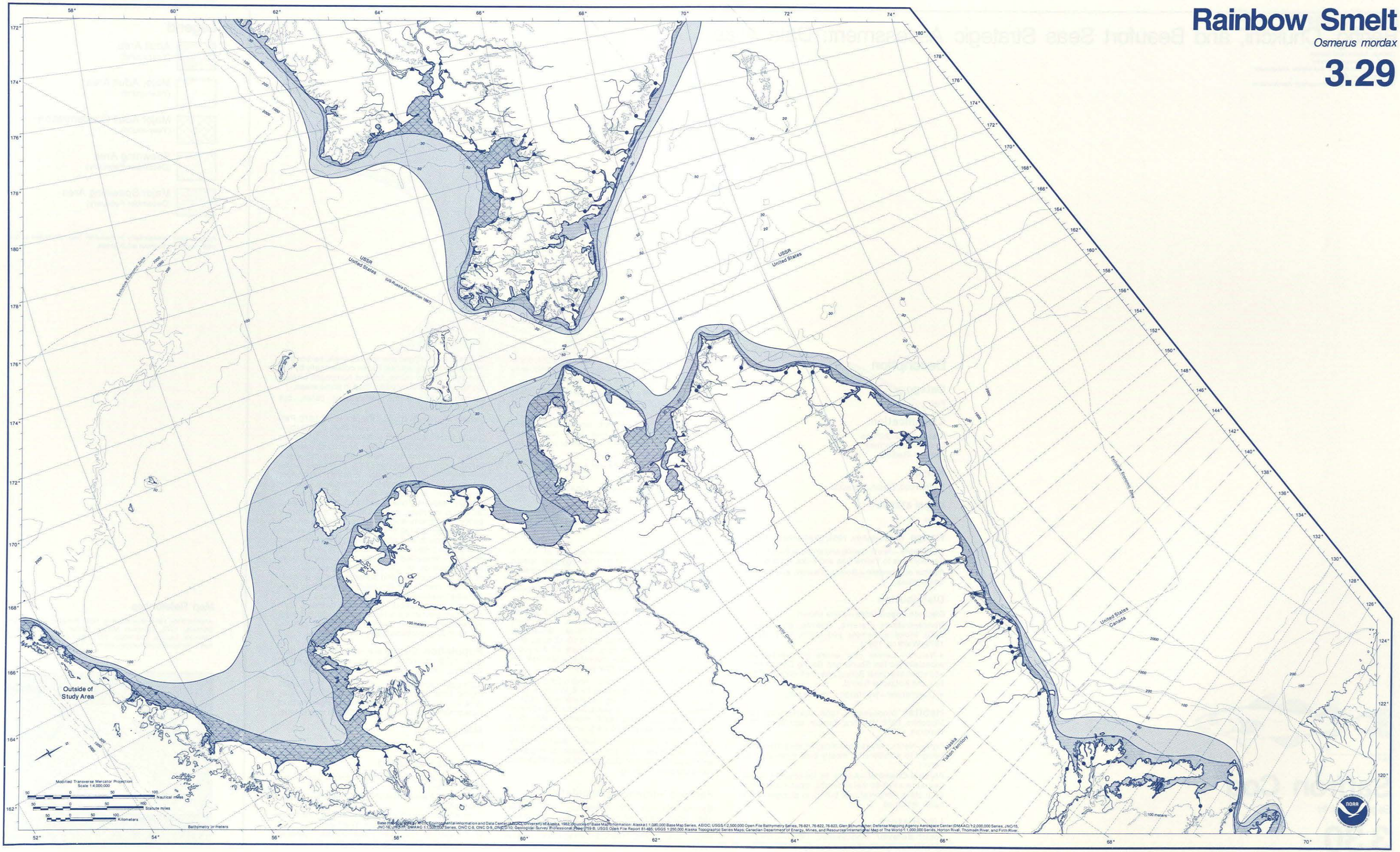
Fedorov, 1973; Macy et al., 1978; Lee et al., 1980; Haldorson and Craig, 1984. Personal communication from Bakkala.



Rainbow Smelt

Osmerus mordax

3.29



Base map data provided by Environmental Information and Data Center (EIDC), University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAG 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 259-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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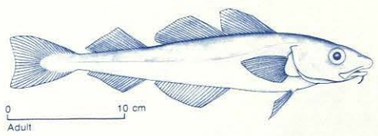


Saffron Cod

Eleginus gracilis

3.30

Description

Category

Fish

Classification

Class—Osteichthyes
Order—Gadiformes
Family—Gadidae

Name

Saffron cod, *Eleginus gracilis*

Legal status

None.

Range (Andriyashev, 1954; Mukhacheva, 1959)

Worldwide—North Pacific and arctic-subarctic, from Beaufort Sea to Yellow Sea and Sitka, Alaska.
Region of Concern—Bering, Chukchi, and Beaufort Sea shelves.

Distribution

Discrete Populations—None known.
Concentrations (Pereyra, Reeves, and Bakkala, 1976; Wolotira, Sample, and Morin, 1977; Barton, 1979; Waldron, 1981)

- *Natural*—Larvae over entire continental shelf, especially Norton Sound and Bering Strait. Adults abundant over inner Bering Sea shelf, north to Chaun Bay and Kotzebue Sound.
- *Commercial*—Not taken commercially.

Habitat (Andriyashev, 1954; Mukhacheva, 1959; Musienko, 1970; Wolotira, Sample, and Morin, 1977; Waldron, 1981)

Type—Neritic; larvae planktonic, adults and juveniles pelagic to semibenthic; mostly over inner-shelf domain.
Physical/Chemical—Adults in ice-covered to ice-free waters in 0-60 meter depths, mostly in less than 40 meters; temperatures 5-8°C in summer. Enter outer estuaries.

Life History

Social Behavior (Andriyashev, 1954)—Schooling, at least during nearshore spawning runs.

Biological Associations (Andriyashev, 1954; Alverson and Wilimovsky, 1966)—Larvae frequently cluster under bells of jellyfishes (*Cyanea* spp.).

Nutrition (Andriyashev, 1954; Percy, 1975; Craig and Haldorson, 1981; Frost and Lowry, 1981b)

- *Feeding type*—Predator.
- *Food*—Crangonid shrimps, amphipods, isopods, decapods, and mysids; also take polychaetes, pelecypods, and fish fry (including other saffron cod).
- *Feeding behavior*—Unknown.
- *Feeding location*—Demersal and undersurface of ice.

Reproduction (Andriyashev, 1954; Mukhacheva, 1959)

- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—On clean sand/gravel bottom, under ice, with strong tidal currents.
- *Behavior*—Unknown.
- *Biology*—Spawn December-February at −1.7 to −1°C. Fecundity 25,000-210,000 eggs per female. Eggs demersal; incubation 36-47 days, temperature dependent. Larvae planktonic by April, remaining at surface 2-3 months before descending to deeper water July-August.

Development (Svetovidov, 1948; Andriyashev, 1954; Mukhacheva, 1959; Musienko, 1970; Lowry, Frost, and Burns, 1981b)—Yolk-sac larvae 3.5-3.9 mm long; yolk-sac absorbed in 10-12 days, when larvae are 4.8-5.2 mm long. Mature at 2-3 years; probably spawn annually thereafter. Maximum lifespan unknown, probably 12+ years.

Growth (Svetovidov, 1948; Andriyashev, 1954; Pereyra, Reeves, and Bakkala, 1976; Wolotira, Sample, and Morin, 1977; Craig and Haldorson, 1981)—Greatest growth in first 3 years; adults 200-450 mm, 300-350 grams. Males reach maximum size more rapidly than females, but grow to smaller overall size.

Movements (Andriyashev, 1954; Barton, 1979; Craig and Haldorson, 1981)—Seasonal migration shoreward September-December to spawning areas; move offshore in spring.

Factors Influencing Populations

Natural (Springer and Roseneau, 1978; Wehle, 1980; Drury, Ramsdell, and French, 1981; Frost and Lowry, 1981a,b; Lowry and Frost, 1981b; Lowry, Frost, and Burns, 1981a,b)—Predators include sculpins, Arctic char, sheefish, other saffron cod, kittiwakes, murres, ringed and spotted seals, harbor porpoises, and white whales. Eaten occasionally by ribbon seals and by minke, fin, and humpback whales. Compete with Arctic cod for food in some areas.
Human-related—Some subsistence catch, but amount unknown.
Potential (Nelson-Smith, 1973; De Vries, 1976; Patten, 1977; Lowry, Frost, and Burns, 1981b)—Adults tested were killed within 24 hours by soluble fractions of crude oil at concentrations of less than 2 ppm at 3°C; toxicity increased with increasing water temperature, at least to 8°C. Pelagic larvae may be particularly susceptible to spillage of oil under ice. In fishes, oil contamination can cause blockage or destruction of chemoreceptors, a respiratory "cough" response, loss of metabolic control, muscular/neural narcosis, and impairment of locomotor ability, equilibrium, and schooling behavior; also increased egg mortality and larval deformities, decreased growth and development of embryos and young, decreased feeding rate, tainting of flesh, and death. Oil emulsified by rough seas or surfactants causes erosion of gill epithelium, depression of respiratory functions, and adherence of oil droplets to mucus layer of fish. Emulsification also may allow oil to be swallowed more readily by fishes trying to maintain ionic/osmotic balance. In general, light petroleum fractions are highly toxic, causing almost instantaneous death, even at low concentrations. These findings probably apply to this species.

Population Size (Pereyra, Reeves, and Bakkala, 1976; Wolotira, Sample, and Morin, 1977; Wolotira, 1985)

Estimated biomass for Chukchi Sea 1,200-1,800 metric tons, Norton Sound 12,000-65,000 metric tons; for remainder of eastern Bering Sea (north of Kuskokwim River Delta), 38,000-78,000 metric tons.

Management

None.

Persons Consulted

K. J. Frost, Alaska Department of Fish & Game, Fairbanks, Alaska.
L. F. Lowry, Alaska Department of Fish & Game, Fairbanks, Alaska.
T. M. Sample, Northwest and Alaska Fisheries Center, NMFS/NOAA, Seattle, Washington.
R. J. Wolotira, Northwest and Alaska Fisheries Center, NMFS/NOAA, Seattle, Washington.

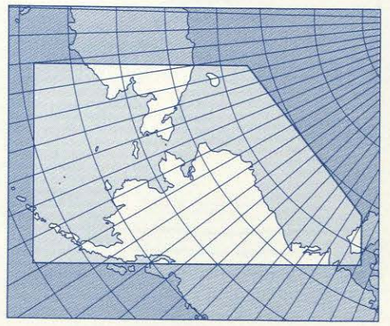
Legend

- Adult Area (Year-round)
- Major Adult Area (Year-round)
- Major Adult Concentration (Year-round)
- Spawning Area (December-February)
- Major Spawning Area (December-February)

Adults occur occasionally in Beaufort Sea. Juveniles occur year-round throughout adult areas.

Map References

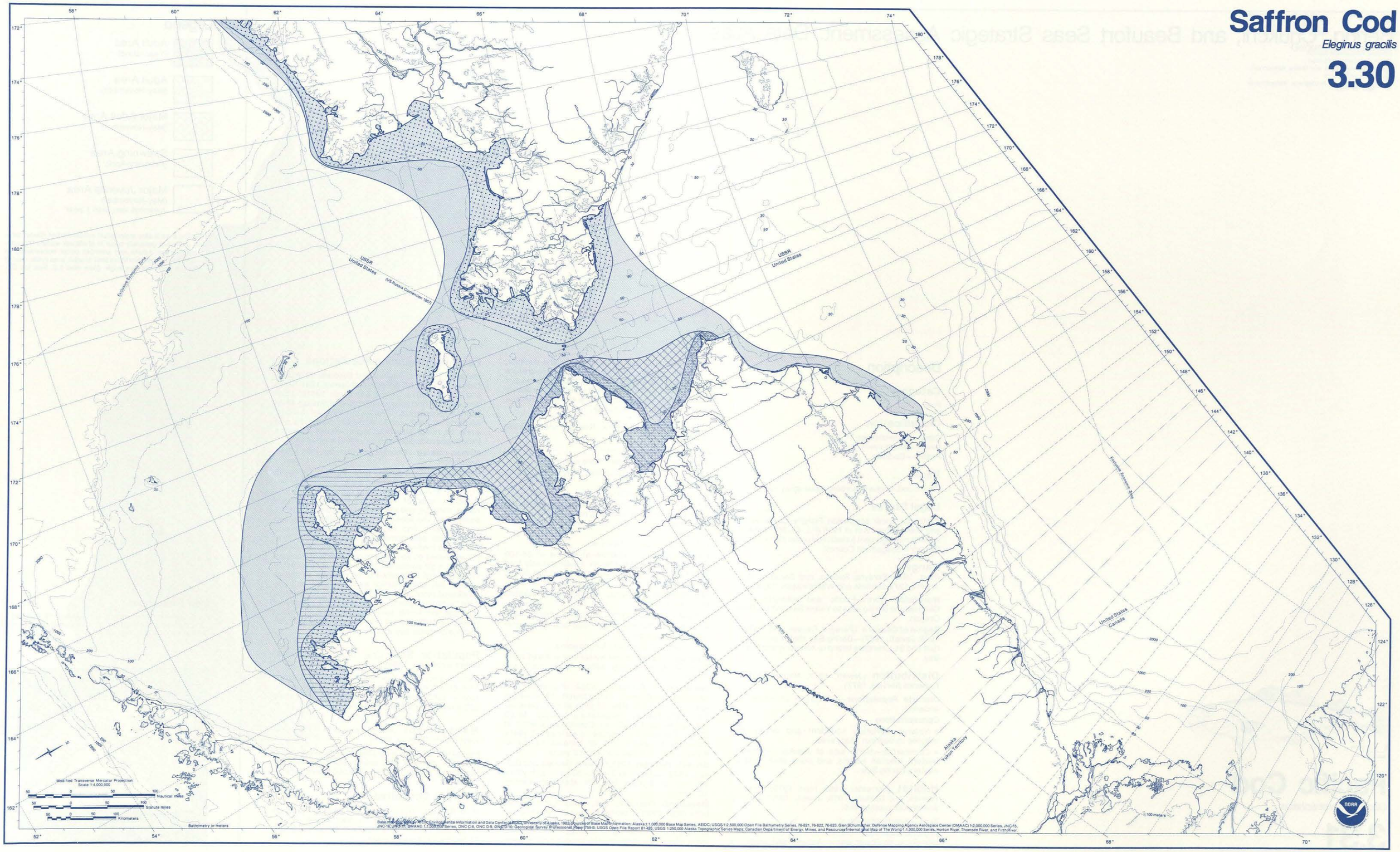
Andriyashev, 1954; Mukhacheva, 1959; Pereyra, Reeves, and Bakkala, 1976; National Marine Fishery Service, 1977; Wolotira, Sample, and Morin, 1977; Barton, 1979; Waldron, 1981. Personal communications from Sample; Wolotira.



Saffron Cod

Eleginus gracilis

3.30



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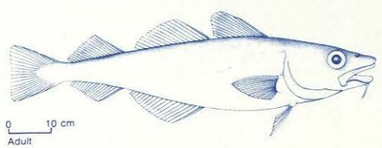


Pacific Cod

Gadus macrocephalus

3.31

Description

Category

Fish

Classification

Class—Osteichthyes
Order—Gadiformes
Family—Gadidae

Name

Pacific cod, *Gadus macrocephalus* (gray cod)

Legal Status

Protected under Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended, with management jurisdiction under North Pacific Fishery Management Council.

Range

(Hart, 1973; Pereyra, Reeves, and Bakkala, 1976; Jewett, 1977; Bakkala and Wakabayashi, 1985)

Worldwide—North Pacific and subarctic, from Okhotsk and Bering seas to Yellow Sea and southern Oregon.

Region of Concern (Pereyra, Reeves, and Bakkala, 1976; Jewett, 1977)—Bering Sea shelf, from Anadyr Gulf and St. Lawrence Island to Aleutians and Bristol Bay.

Distribution (Jewett, 1977; National Marine Fisheries Service, 1977)

Discrete Populations—Population structure unknown.

Concentrations

- *Natural*—Generally abundant and evenly distributed throughout study area.
- *Commercial*—North side of Alaskan Peninsula, eastern Aleutian Islands, and along shelf edge of eastern Bering Sea.

Habitat (Forrester, 1969; Hart, 1973; Pereyra, Reeves, and Bakkala, 1976; Jewett, 1977; Bakkala and Wakabayashi, 1985)

Type—Benthic/demersal.

Physical/Chemical—Depths 35-500 meters, occasionally in shallower water. Autumn and winter in deep water (100-300 meters); spring and summer, shallower water (36-250 meters). Temperature range 0-9°C; spawn in 0-5°C. Typically euhaline, but can tolerate somewhat lower salinities. Probably avoid sea ice. Eggs thought to be stenothermal and tolerant of wide oxygen range.

Life History (Pereyra, Reeves, and Bakkala, 1976)

Social Behavior—Unknown.

Biological Associations—None known.

Nutrition (Moiseev, 1953; Hart, 1973; Jewett, 1978; Feder and Jewett, 1980)

- *Feeding type*—Predator.
- *Food*—Young (20 mm) eat copepods. Adults eat worms, tanner crabs, mollusks, pandalid and crangonid shrimps, herring, sand lance, walleye pollock, and flatfishes.
- *Feeding behavior*—Unknown.
- *Feeding location*—Larvae at depths of 25-105 meters; feed in water column. Adults actively feed demersally in shallow shelf waters, but not during spawning.

Reproduction (Pereyra, Reeves, and Bakkala, 1976; Jewett, 1977)

- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Primarily spawn near bottom in water 108-250 meters deep.
- *Behavior*—Congregate for spawning.
- *Biology*—Spawn in late winter, below mixed layer. Eggs demersal, slightly adherent. Fecundity unknown.

Development (Forrester, 1964; Forrester and Alderdice, 1966; Hart, 1973; Jewett, 1977)—Eggs about 1 mm; hatch after 17 days at 5°C. Development affected by temperature, salinity. Newly hatched larvae 3.3-4.5 mm. Considered juvenile at 25 mm. Females may mature as early as 2-3 years, especially to south; 50% of females mature at 5 years; 50% of males mature at 2 years.

Growth (Moiseev, 1953; Pereyra, Reeves, and Bakkala, 1976)—Length at 2 years, 300 mm; at 5 years, 540 mm; at 9 years, 840 mm. Maximum lifespan 12 years.

Movements (Moiseev, 1956, 1960)—Local populations make short seasonal migrations (300-500 km) between deeper waters in winter for spawning and shallow waters in spring for feeding. Extent and timing of migrations stimulated by temperature change.

Factors Influencing Populations

Natural (Pereyra, Reeves, and Bakkala, 1976; McCain et al., 1978, 1979; Feder and Jewett, 1981; Frost and Lowry, 1981a; Lowry and Frost 1981b)—Environmental conditions, predators, and disease all influence population. Predators include halibut, northern fur seals, sea lions, harbor porpoises, and white, fin, minke, killer, and sperm whales. Diseases include pseudobranchial tumors and skin ulcers.

Human-related—Commercial fishing decreases population.

Potential (Nelson-Smith, 1973; Patten, 1977)—In fishes, oil contamination can cause blockage or destruction of chemoreceptors, a respiratory "cough" response, loss of metabolic control, muscular/neural narcosis, and impairment of locomotor ability, equilibrium, and schooling behavior; also, increased egg mortality and larval deformities, decreased growth and development of embryos and young, decreased feeding rate, tainting of flesh, and death. Oil emulsified by rough seas or surfactants causes erosion of gill epithelium, depression of respiratory functions, and adherence of oil droplets to mucus layer of fish. Emulsification also may allow oil to be swallowed more readily by fishes trying to maintain ionic/osmotic balance. In general, light petroleum fractions are highly toxic, causing almost instantaneous death, even at low concentrations. These findings probably apply to this species.

Population Size (Low, 1974; Jewett, 1977; Bakkala and Low, 1984)

Eastern Bering shelf population range estimated from 65,000 metric tons in 1975 to 1 million metric tons in 1982. Total Bering Sea population in 1970 estimated at 1 million metric tons.

Management (Wolotira, 1974; Pereyra, Reeves, and Bakkala, 1976)

Population abundance very high in early 1980s due to presence of strong 1977 year-class. Recommended equilibrium yield in 1983 was 298,000 metric tons.

Persons Consulted

R. G. Bakkala, Northwest and Alaska Fisheries Center, NMFS/NOAA, Seattle, Washington.
S. C. Jewett, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.

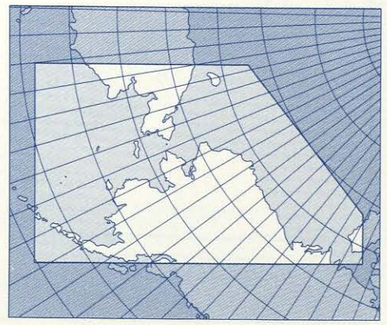
Legend

- Adult Area (Year-round)
- Adult Area (May-November)
- Major Adult Area (May-November)
- Spawning Area (February-April)
- Major Juvenile Area (May-November) Juveniles less than 1 year

Spawning area is also major adult concentration (December-April). Juveniles generally occur in shallower waters throughout adult areas. Adults and juveniles occur occasionally in northern Bering Sea. Northern limit of adult area (year-round) is average maximum ice edge. (See map 1.8, Sea Ice Dynamics.)

Map References

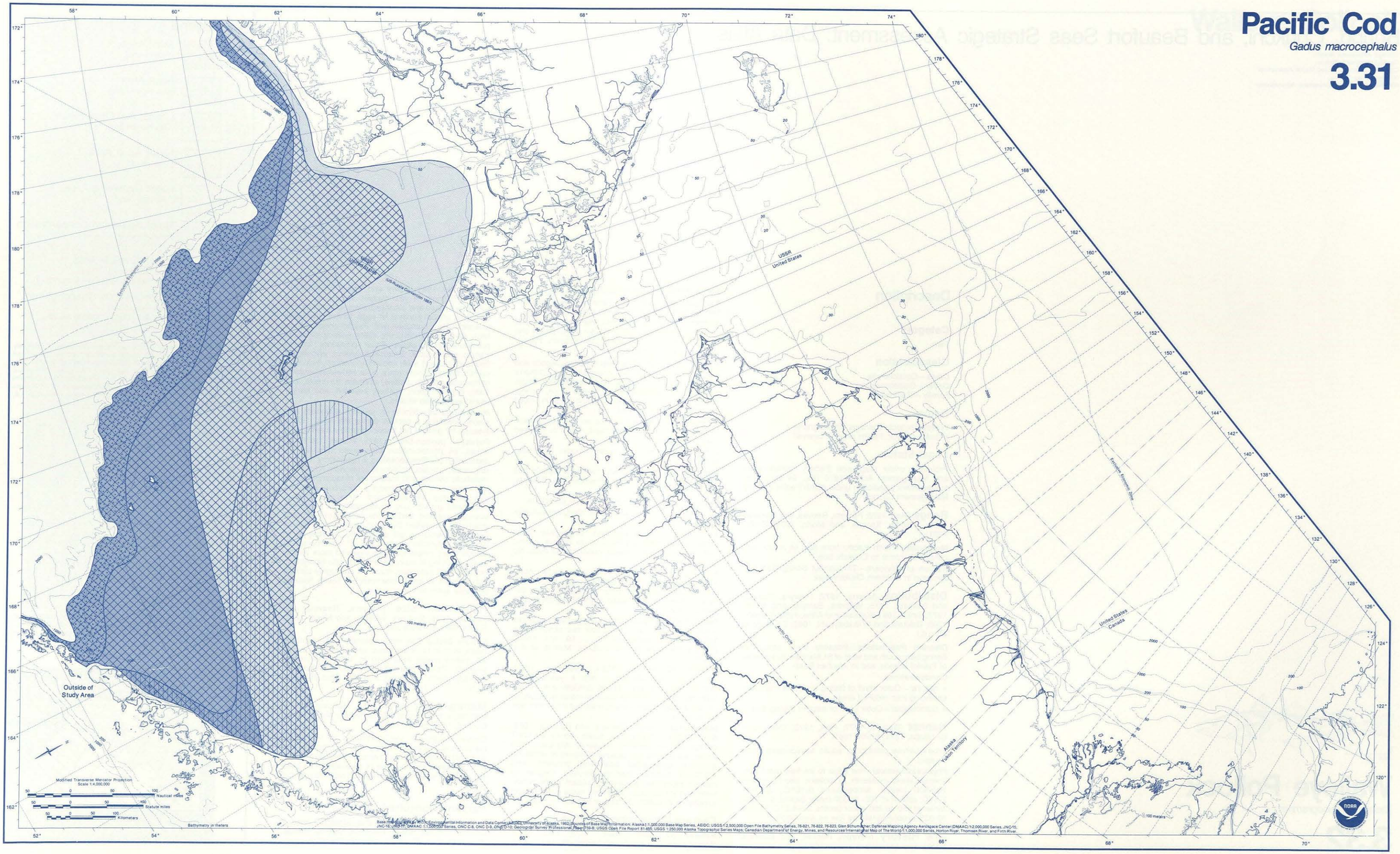
Pereyra, Reeves, and Bakkala, 1976; Jewett, 1977; Bakkala, 1984; Bakkala and Wakabayashi, 1985; Ocean Assessments Division (NOS/NOAA), in press.



Pacific Cod

Gadus macrocephalus

3.31



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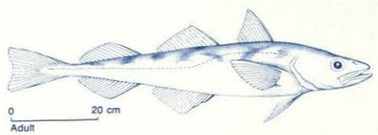


Walleye Pollock

Theragra chalcogramma

3.32

Description

Category

Fish

Classification

Class—Osteichthyes
Order—Gadiformes
Family—Gadidae

Name

Walleye pollock, *Theragra chalcogramma*
(Alaska pollock, Pacific pollock, bigeye)

Legal Status

Protected under Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), with management jurisdiction under North Pacific Fishery Management Council.

Range (Hart, 1973; Pereyra, Reeves, and Bakkala, 1976; Wolotira, Sample, and Morin, 1977; Smith, 1981)

Worldwide—North Pacific from Sea of Japan and central California to Chukchi Sea.

Region of Concern—Throughout Bering Sea; uncommon in southern Chukchi Sea.

Distribution (Maeda, 1972; Pereyra, Reeves, and Bakkala, 1976; Wolotira, Sample, and Morin, 1977; Smith, 1981; Bakkala and Alton, 1983; Traynor, 1983; Bakkala and Wakabayashi, 1985; Shimada et al., n.d.)

Discrete Populations—Possibly three stocks in Bering Sea: south and west of St. Matthew Island, east of Pribilof Islands, and in Aleutian Basin.

Concentrations

- *Natural*—Outer shelf of Bering Sea, in some years extending into midshelf areas.
- *Commercial*—Outer shelf of eastern Bering Sea.

Habitat (Reeves, 1972; Hart, 1973; Mito, 1974; Serobaba, 1974; Smith, 1981)

Type—Larvae planktonic; adults semidemersal and pelagic.

Physical/Chemical—Ice edge to ice-free outer continental shelf, middepth to bottom; depths mainly 100-300 meters; temperatures 0-10°C, optimum 2-5°C; spawn at 100- to 300-meter depths, 0-3.3°C; winter at 150- to 280-meter depths, 2.5-4.5°C. Salinity 30-33‰; occasionally as low as about 20‰.

Life History (Pereyra, Reeves, and Bakkala, 1976)

Social Behavior—School during all life stages.

Biological Associations—Taken in trawls with flatfishes, Pacific cod, and Tanner crabs.

Nutrition (Andriyashev, 1954; Hart, 1973; Pereyra, Reeves, and Bakkala, 1976; Clarke, 1978; Bailey and Dunn, 1979; Feder and Jewett, 1980; Smith, 1981)

- *Feeding type*—Predator.
- *Food*—Young (4-22mm) eat mainly copepods and their eggs. Juveniles eat copepods (e.g., *Oithona* spp.), mysids, euphausiids, and small fishes. Adults eat crustaceans and fishes, e.g., sand lance, herring, young salmon, young pollock, and capelin. Food choice mainly size-related.
- *Feeding behavior*—Juveniles school near bottom by day, feed near surface at night. Adults do not feed during spawning.
- *Feeding location*—In water column and near bottom.

Reproduction (Andriyashev, 1954; Yamaguchi and Takahashi, 1972; Pereyra, Reeves, and Bakkala, 1976; Smith, 1981)

- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Primarily along outer shelf, from Unimak Pass westward.
- *Behavior*—Spawning fish segregate from nonspawning. Mating presumed to involve pairing and broadcasting of pelagic, nonadhesive eggs. No parental care.
- *Biology*—Spawn February-July, peak April. Average fecundity about 437,000 eggs per female, varying geographically. Eggs planktonic, near surface. Females may release eggs all at once or in multiple pulses.

Development (Yusa, 1954; Haryu, 1980)—Larvae hatch in 12 days at 6-7°C; yolk sac absorbed by 7.0-mm length; planktonic up to 10 mm. Young become demersal before maturity. Mature at 3-4 years.

Growth (Gorbunova, 1954; Zverkova, 1969; Serobaba, 1977)—Rapid in first 4 years; reach 90-110 mm first year. Males predominate among juveniles; sex ratio about equal at maturity. Adults to 72 cm, 2.5 kg. Usually short-lived, but maximum age to 15 years.

Movements (Pereyra, Reeves, and Bakkala, 1976; Smith, 1981)—Young and adults mostly on shelf during ice-free seasons. Seasonal migrations late winter, spring, and fall between deep-water wintering grounds, outer-shelf spawning grounds, and shallower summer feeding grounds. Degree of inshore movement apparently related to ice conditions and temperature. Juveniles make daily vertical migrations to bottom by day, to surface by night.

Factors Influencing Populations

Natural (Ogi and Tsujita, 1973; Mito, 1974; Somerton, 1978; Frost and Lowry, 1981a,b; Harry and Hartley, 1981; Lowry and Frost, 1981; Smith, 1981)—Strength of year-classes apparently varies with temperature and other hydrologic conditions that influence annual survival of eggs, larvae, and early juveniles. May compete with Pacific ocean perch. High level of cannibalism; older pollock principal predators on juveniles. Other predators include Pacific cod, halibut, Greenland halibut, arrowtooth flounder, flathead sole, sablefish, snailfish, eelpouts, cottids, fulmars, cormorants, gulls, kittiwakes, murres, guillemots, auklets, puffins, northern fur seals, sea lions, ringed, ribbon, spotted, bearded, and harbor seals, and baleen whales.

Human-related—Stocks at present abundant and stable, following a decline during the early 1970s. Reason for decline not known: possibly overfishing.

Potential (Nelson-Smith, 1973; Patten, 1977)—In fishes, oil contamination can cause blockage or destruction of chemoreceptors, a respiratory "cough" response, muscular/neural narcosis, loss of metabolic control, and impairment of locomotor ability, equilibrium, and schooling behavior; also, increased egg mortality and larval deformities, decreased growth and development of eggs and young, decreased feeding rate, tainting of flesh, and death. Oil emulsified by rough seas or surfactants causes erosion of gill epithelium, depression of respiratory function, adherence of oil droplets to mucus layer; Emulsified oil is ingested more readily by fishes trying to maintain ionic/osmotic balance. In general, light petroleum fractions are highly toxic to fishes, even at low concentrations. These findings probably apply to this species.

Population Size (Pereyra, Reeves, and Bakkala, 1976; Wolotira, Sample, and Morin, 1977; Smith, 1981; Bakkala and Low, 1984)

Eastern Bering Sea stock estimated at 11 million metric tons in 1979 from trawl and acoustic surveys, 9.5 million metric tons (net) in 1980 from cohort analysis. Pollock constituted about two-thirds of standing stock of Bering Sea demersal fishes in 1979.

Management (Alton and Bakkala, 1976; Serobaba, 1977; North Pacific Fishery Management Council, 1979; Smith, 1981)

Current equilibrium yield estimated at 1.1 million metric tons. Fishery operating near equilibrium yield, with 1977-1981 catches averaging 988,000 metric tons per year. Average age of population has been reduced by fishery; principal ages in catches now 2-4 years.

Persons Consulted

R.G. Bakkala, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, Seattle, Washington.

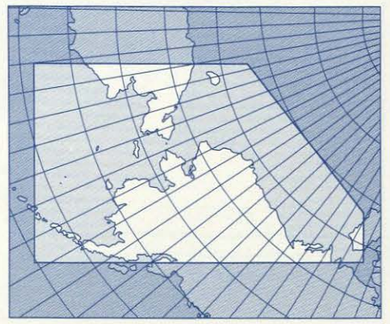
Legend

- Adult Area (Year-round)
- Adult Area (May-November)
- Occasional Occurrence (May-November)
- Major Adult Area (Year-round)
- Major Spawning Area (February-July)
- Major Spawning Concentration (February-July)
- Major Juvenile Area (May-November) Juveniles younger than 8 months
- Major Juvenile Concentration (May-November) Juveniles younger than 8 months

Spawning and juvenile areas shown are areas of relatively high abundance. Spawning generally occurs throughout slope and shelf waters of adult areas from February to July. Juveniles younger than eight months occur throughout shallower, ice-free shelf waters of Bering Sea. Older juveniles occur throughout adult areas. Northern limit of adult area (year-round) is average maximum ice edge. (See map 1.8, Sea Ice Dynamics.)

Map References

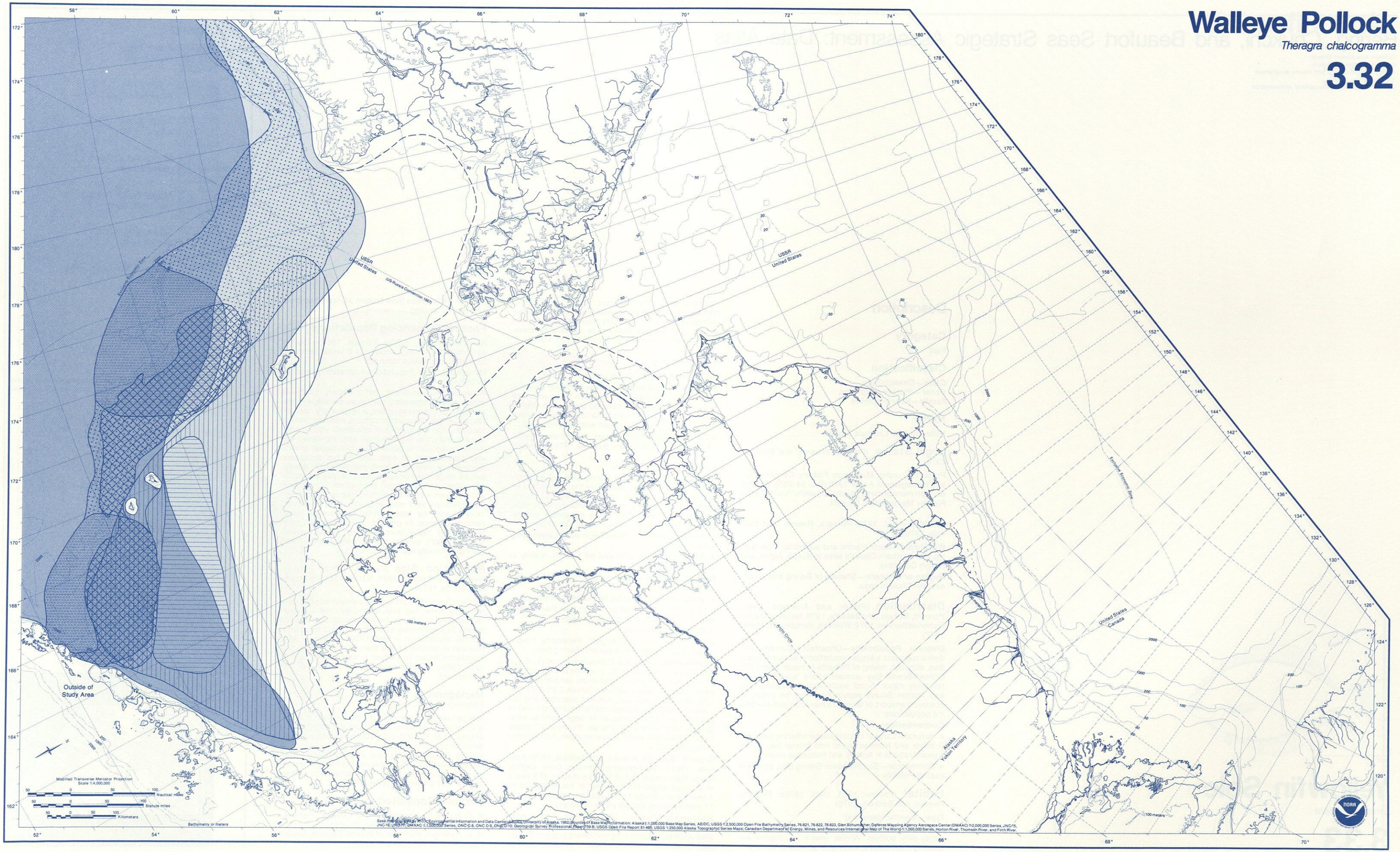
Maeda, 1972; Wolotira, Sample, and Morin, 1977; Smith, 1981; Bakkala and Alton, 1983; Traynor, 1983; Bakkala and Wakabayashi, 1985; Shimada et al., n.d. Personal communication from Bakkala.



Walleye Pollock

Theragra chalcogramma

3.32



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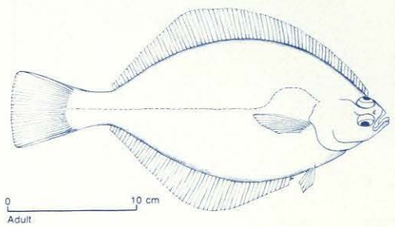


Yellowfin Sole

Limanda aspera

3.33

Description

Category

Fish

Classification

Class—Osteichthyes
Order—Pleuronectiformes
Family—Pleuronectidae

Name

Yellowfin sole, *Limanda aspera*

Legal Status (Pereyra, Reeves, and Bakkala, 1976)

Protected under Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended, with management jurisdiction under North Pacific Fishery Management Council.

Range (Hart, 1973; Pereyra, Reeves, and Bakkala, 1976)

Worldwide—North Pacific and subarctic, from Bering and southern Chukchi seas to Korea, Japan, and British Columbia.

Region of Concern—Shelves of Bering and southeastern Chukchi seas.

Distribution (Pruter and Alverson, 1962; Pereyra, Reeves, and Bakkala, 1976; National Marine Fisheries Service, 1977; Wolotira, Sample, and Morin, 1977)

Discrete Populations—Uncertain. Current evidence suggests a single population in eastern Bering Sea, although mixing of Pribilofs-Nunivak Island and Unimak-Bristol Bay concentrations appears to be relatively minor. Small southeastern Chukchi Sea and Norton Sound populations may be result of oceanic transport of larvae, rather than self-sustaining populations.

Concentrations

- *Natural*—Largest in southeastern Bering Sea from Pribilofs and Nunivak Island into Bristol Bay. Small concentrations in Norton and Kotzebue sounds.
- *Commercial*—Southeastern Bering Sea, primarily east of Pribilofs.

Habitat (Fadeev, 1963, 1965, 1970a; Pereyra, Reeves, and Bakkala, 1976)

Type—Benthic/demersal.

Physical/Chemical—Depths 5-360 meters, over sandy-silty bottom. Winter mainly at depths exceeding 100 meters, moving to shallower waters in spring-summer. Temperature range of 1.5-13°C. Wintering concentrations mainly at 2-6°C; summer temperatures 0-13°C. Adults probably avoid sea ice; young juveniles are exposed to subzero temperatures on shelf in winter. Salinity range 31.4-33.3‰.

Life History

Social Behavior—Unknown.

Biological Associations (Novikov, 1964; Pereyra, Reeves, and Bakkala, 1976)—Often taken with rock sole, Alaska plaice, and flathead sole, which may be competitors. Prey-predator relationship with halibut; halibut distribution correlated with yellowfin sole.

Nutrition (Skalkin, 1963; Hart, 1973; Wakabayashi, 1974; Pereyra, Reeves, and Bakkala, 1976; Feder and Jewett, 1980)

- *Feeding type*—Predator.
- *Food*—In southeastern Bering Sea, eat primarily *Clinocardium ciliatum*; also, more than 50 kinds of invertebrates and fishes, including hydroids, worms, mollusks, brittle stars, mysids, euphausiids, shrimps, capelin, and smelts. Diet varies seasonally and regionally. Size of food increases with size of sole.
- *Feeding behavior*—Feed little in winter, intensively spring-summer.
- *Feeding location*—On and off bottom, mainly in less than 60 meters.

Reproduction (Fadeev, 1963, 1970b; Musienko, 1963, 1970)

- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Inner-shelf domain in less than 50 meters, from Nunivak Island to Bristol Bay.
- *Behavior*—Unknown.
- *Biology*—Spawn July-August. Fecundity 1.3-3.3 million eggs per female in eastern Bering Sea.

Development (Pertseva-Ostroumova, 1961)—Eggs hatch after 4 days at 13°C. Duration of incubation is temperature dependent; minimum incubation temperature 4°C. Newly hatched larvae 2.25-2.80 mm long; have large yolk-sac; yolk-sac absorbed and larvae begin to feed at 3.8 mm; partly metamorphosed to juveniles at 17 mm; believed to begin benthic existence at this size or slightly larger. Young of 0-3 years remain in shallow water a year or more. Annual mortality about 25%.

Growth (Pereyra, Reeves, and Bakkala, 1976; Bakkala, 1981)—Slow-growing; females grow slightly faster than males. Half of females mature at 9 years at average length of 24 cm; half of males mature at 4 years and average 14 cm. Maximum lifespan about 17 years (males) and 19 years (females).

Movements (Fadeev, 1965, 1970b)—Move from outer shelf to shallower waters of middle and inner shelf April-May, continuing northward and into Bristol Bay in summer to spawn. Return to outer shelf in autumn-winter. Rise from bottom at night, but probably not for feeding.

Factors Influencing Populations

Natural (Fadeev, 1970a; Bakkala, 1981)—Halibut eat adults and young. Variations in water temperature affect year-class strength.

Human-related—Populations dramatically depleted by fishing in 1960s.

Potential (Nelson-Smith, 1973; Patten, 1977)—In fishes, oil contamination can cause blockage or destruction of chemoreceptors, a respiratory "cough" response, loss of metabolic control, muscular/neural narcosis, and impairment of locomotor ability, equilibrium, and schooling behavior; also, increased egg mortality and larval deformities, decreased growth and development of eggs and young, decreased feeding rate, tainting of flesh, and death. Oil emulsified by rough seas or surfactants causes erosion of gill epithelium, depression of respiratory functions, and adherence of oil droplets to mucus layer of fish. Emulsification also may allow oil to be swallowed more readily by fishes trying to maintain ionic/osmotic balance. In general, light petroleum compounds are highly toxic, causing almost instantaneous death, even at low concentrations. These findings probably apply to this species.

Population Size (Fadeev, 1970b; Pereyra, Reeves, and Bakkala, 1976; National Marine Fisheries Service, 1977)

Eastern Bering Sea population considered one population by some, two populations by others. In late 1950s, prior to intense fishery, biomass in eastern Bering Sea estimated at 2 million metric tons; after intense exploitation in late 1950s to early 1960s, biomass estimated at less than 1 million metric tons. Population began to recover in early 1970s, and by early 1980s, biomass estimated to exceed 2 million metric tons.

Management (Fadeev, 1965; National Marine Fisheries Service, 1977)

May be taken by fishery at age 4 years. Stock currently in excellent condition. Maximum sustainable yield estimated at 150,000-175,000 metric tons per year. Because of abundance, equilibrium yield estimated to exceed 200,000 metric tons in early 1980s. International North Pacific Fisheries Commission establishes time-area closures of trawl fisheries to protect halibut, also protecting yellowfin sole.

Persons Consulted

R. G. Bakkala, Northwest and Alaska Fisheries Center, NMFS/NOAA, Seattle, Washington.
K. E. Haflinger, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.

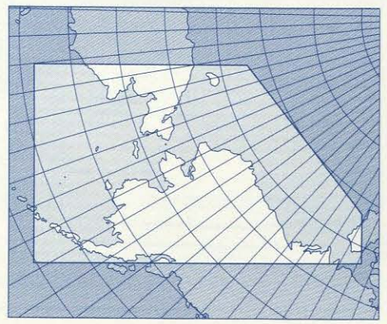
Legend

- Adult Area (Year-round)
- Adult Area (November-April)
- Adult Area (May-October)
- Major Adult Area (May-October)
- Major Adult Area (November-April)
- Spawning Area (July-August)
- Major Spawning Area (July-August)
- Movement (April-May)
- Movement (October-November)

Juveniles less than 3 years old generally occur in coastal and nearshore waters. Older juveniles occur throughout adult areas.

Map References

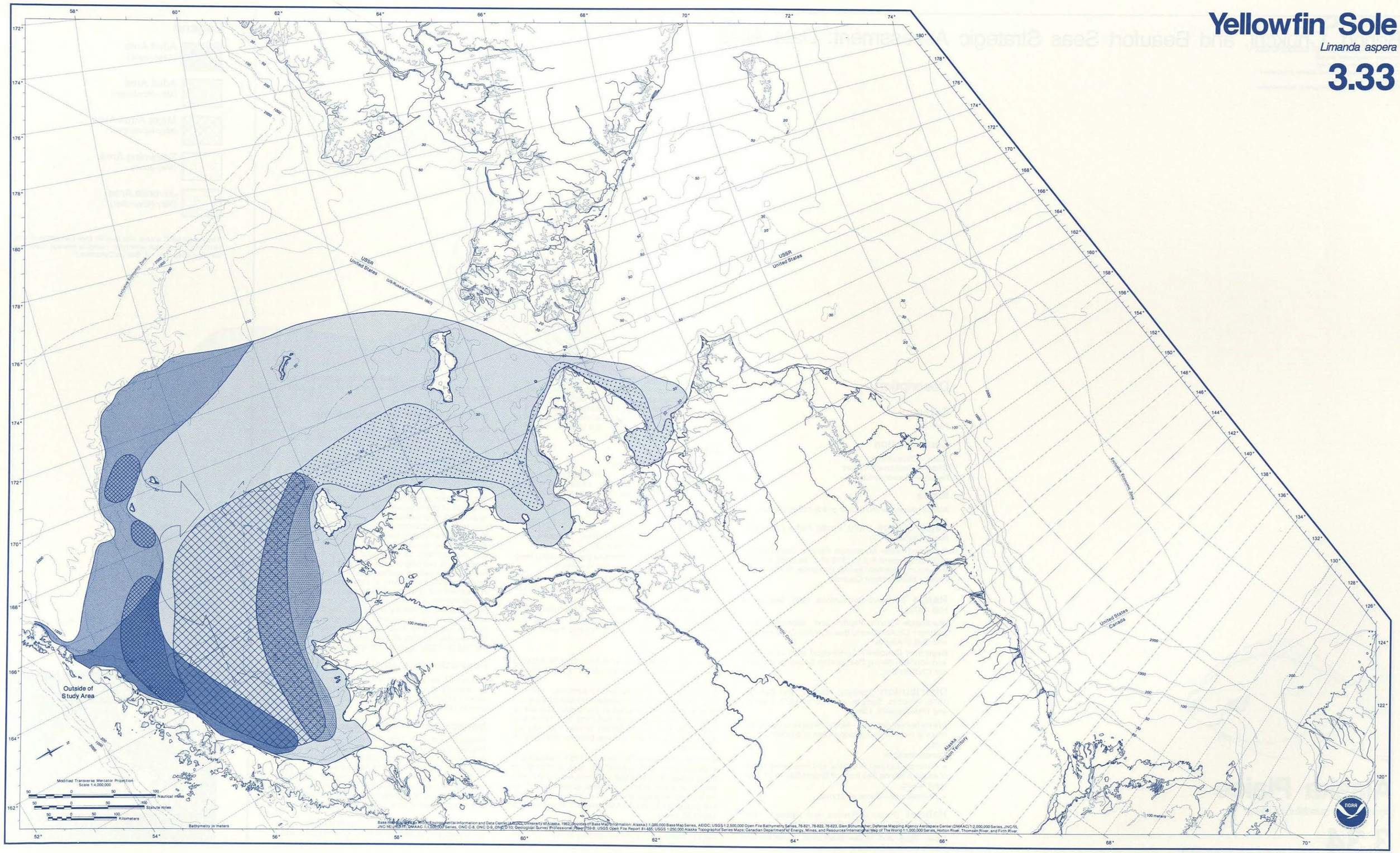
Pereyra, Reeves, and Bakkala, 1976; Bakkala, 1981; Bakkala, Wespestad, and Low, 1982; Bakkala and Wakabayashi, 1985.



Yellowfin Sole

Limanda aspera

3.33



Base map data courtesy of the Environmental Information and Data Center (EIDC), University of Alaska, 1982; Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17, DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-455; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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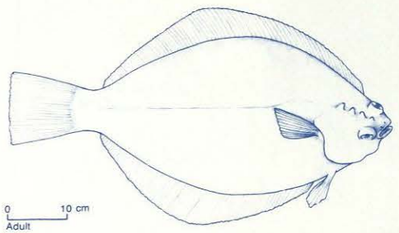

Alaska Plaice

Pleuronectes quadrituberculatus

3.34

Description

Category

Fish

Classification

Class—Osteichthyes
Order—Pleuronectiformes
Family—Pleuronectidae

Name

Alaska plaice, *Pleuronectes quadrituberculatus*

Legal Status (North Pacific Fishery Management Council, 1979)

Protected under Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended, with management jurisdiction under North Pacific Fishery Management Council.

Range (Pertseva-Ostroumova, 1961; Quast and Hall, 1972)

Worldwide—North Pacific and subarctic, from southern Chukchi Sea to Sea of Japan, Okhotsk Sea, and Gulf of Alaska.

Region of Concern—Continental shelf of eastern and northern Bering Sea, Norton Sound, and southern Chukchi Sea.

Distribution (Pereyra, Reeves, and Bakkala, 1976; Wolotira, Sample, and Morin, 1977; Bakkala and Wakabayashi, 1985)

Discrete Populations—No evidence to suggest that there is more than one population in eastern Bering Sea.

Concentrations

- *Natural*—Largest in central and inner-shelf region of eastern Bering Sea from off Bristol Bay to St. Matthew Island.
- *Commercial*—Same as above.

Habitat (Pereyra, Reeves, and Bakkala, 1976; Waldron, 1981; Smith and Bakkala, 1982)

Type—Eggs and larvae planktonic, juveniles and adults benthic/demersal.

Physical/Chemical—Depths nearshore to about 130 meters, mainly over sandy-silty bottom. Undergo seasonal cross-shelf migrations, with main concentrations between 20 and 100 meters in summer and between 90 and 130 meters in winter. Probably avoid sea ice. Temperature range −0.8 to 13°C.

Life History

Social Behavior—Unknown.

Biological Associations (Smith and Bakkala, 1982; Walters, 1983)—Distribution similar to that of yellowfin sole; also occur most commonly with rock sole and sculpins (*Myoxocephalus*).

Nutrition (Skalkin, 1963; Mineva, 1964)

- *Feeding type*—Predator.
- *Food*—Principally polychaetes, mollusks, amphipods, ascidians, and shrimps.
- *Feeding behavior*—Intensive postspawning feeding in early summer; no feeding in winter.
- *Feeding location*—Mainly benthic over inner shelf.

Reproduction (Fadeev, 1965; Musienko, 1970; Waldron, 1981)

- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Broad areas of eastern Bering Sea shelf from nearshore to 200 meters; mainly within 100 meters.
- *Behavior*—Unknown.
- *Biology*—Spawn May-June. Fecundity 56,000 eggs per female 28-30 cm in length and 313,000 for 50-cm fish. Eggs pelagic.

Development (Pertseva-Ostroumova, 1961)—Eggs taken from Alaska plaice from Kamchatka and incubated at 6°C hatched in 15-18 days. Larvae at hatching relatively large (5.6 mm) and more fully developed than other flatfish larvae. Yolk-sac absorbed at 6.0-7.5 mm. Larvae become demersal at 13-17 mm.

Growth (Pertseva-Ostroumova, 1961; Bakkala and Wakabayashi, 1985)—Relatively fast, with average length about 32 cm at age 10 years; reach maximum length of about 60 cm. Females grow faster than males and average about 3 cm longer. Mature at 4-6 years (20-21 cm) in Asian waters. Maximum age about 20 years.

Movements (Fadeev, 1965; Smith and Bakkala, 1982)—Move from summer feeding areas on middle and inner shelf to middle and outer shelf of eastern Bering Sea in winter, apparently in response to advancing ice cover. Inshore migration begins in April-May.

Factors Influencing Populations

Natural—Factors unknown, but predation, competition, and other environmental influences undoubtedly affect year-class strength.

Human-related (Bakkala and Low, 1984)—Population underexploited throughout history of fishery in eastern Bering Sea.

Potential (Nelson-Smith, 1973; Patten, 1977)—In fishes, oil contamination can cause blockage or destruction of chemoreceptors, a respiratory "cough" response, loss of metabolic control, muscular/neural narcosis, and impairment of locomotor ability, equilibrium, and schooling behavior; also, increased egg mortality and larval deformities, decreased growth and development of eggs and young, decreased feeding rate, tainting of flesh, and death. Oil emulsified by rough seas or surfactants causes erosion of gill epithelium, depression of respiratory functions, and adherence of oil droplets to mucus layer of fish. Emulsification also may allow oil to be swallowed more readily by fishes trying to maintain ionic/osmotic balance. In general, light petroleum compounds are highly toxic, causing almost instantaneous death, even at low concentrations. These findings probably apply to this species.

Population Size (Bakkala and Low, 1984)

Demersal trawl survey data indicate that population is currently at a high level and has increased from about 127,000 metric tons in 1975 to 745,000 metric tons in 1983.

Management (Bakkala and Low, 1984)

Alaska plaice, rock sole, flathead sole, and other miscellaneous species of small flounders managed collectively as species complex. Maximum sustainable yield for Alaska plaice estimated at 45,100-70,000 metric tons and for complex, 88,100-150,200 metric tons. Equilibrium yield in 1983 estimated to be 70,000 metric tons for Alaska plaice and 150,200 metric tons for the overall complex.

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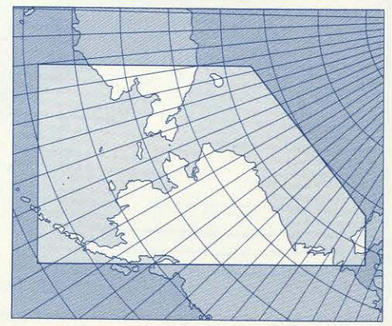
Legend

- Adult Area (Year-round)
- Adult Area (May-November)
- Major Adult Area (May-November)
- Spawning Area (May-June)
- Juvenile Area (May-November)

Year-round adult area is also juvenile area (December-April). Northern limit of adult area (year-round) is average maximum ice edge. (See map 1.8, Sea Ice Dynamics.)

Map References

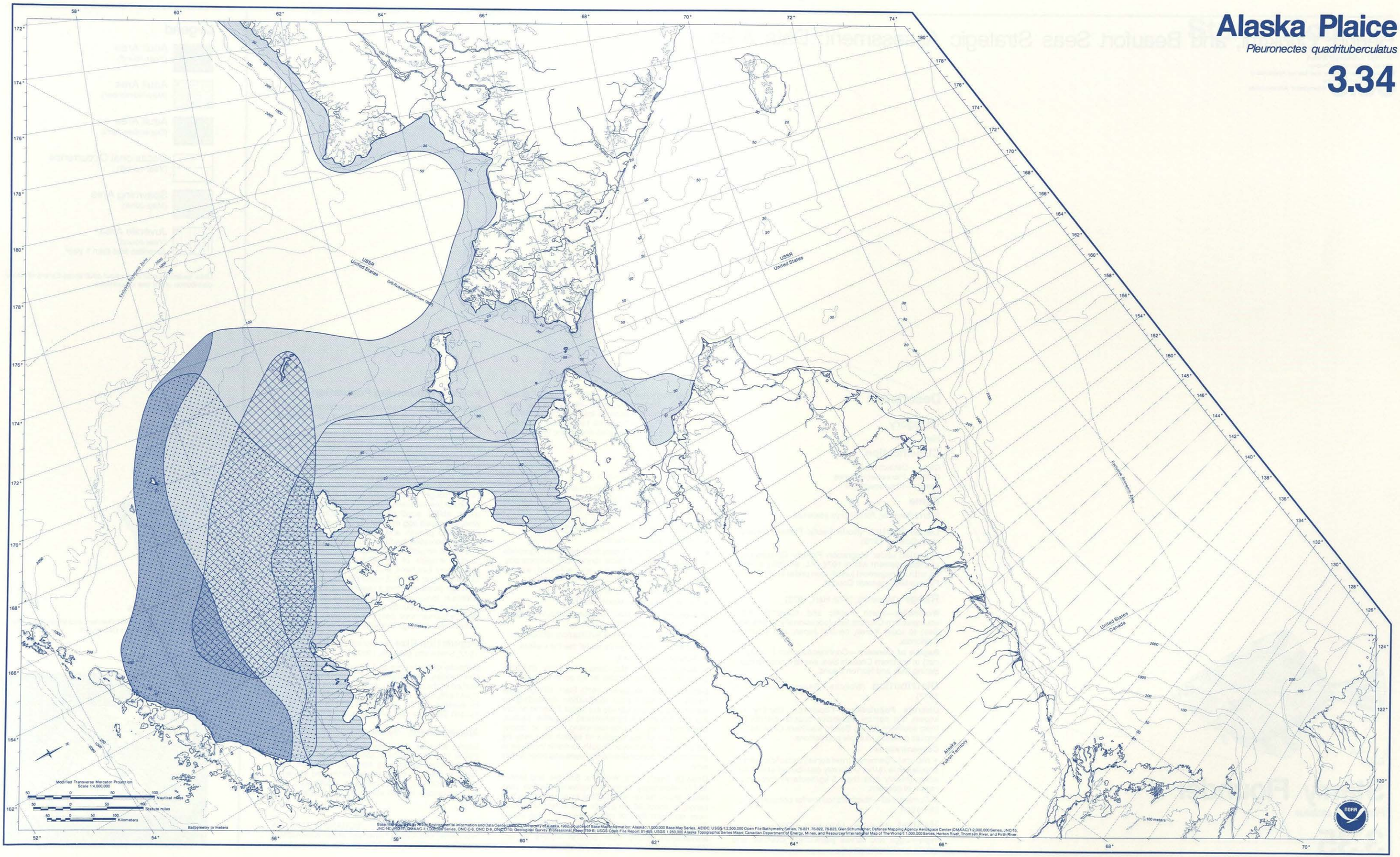
Northwest and Alaska Fisheries Center, n.d.



Alaska Plaice

Pleuronectes quadrituberculatus

3.34



Base map data courtesy of the Environmental Information and Data Center (EIDC), University of Alaska, 1982; Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC/15, JNC-16, JNC-17, DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-405; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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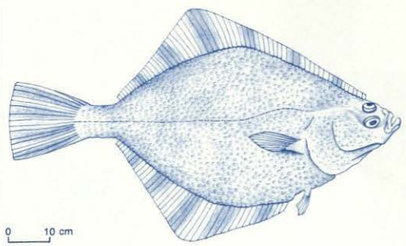

Starry Flounder

Platichthys stellatus

3.35

Description

Category

Fish

Classification

Class—Osteichthyes
Order—Pleuronectiformes
Family—Pleuronectidae

Name

Starry flounder, *Platichthys stellatus*

Legal Status (North Pacific Fishery Management Council, 1979)

Protected under Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended, with management jurisdiction under North Pacific Fishery Management Council.

Range (Musienko, 1970; Hart, 1973)

Worldwide—North Pacific and subarctic, from southeastern Chukchi Sea (occasionally to Beaufort Sea) to south Korea, central Japan, and southern California.

Region of Concern—Continental shelf (mainly inner) of southern Chukchi Sea, eastern and northern Bering Sea, and Norton Sound.

Distribution (Wolotira, Sample, and Morin, 1977)

Discrete Populations—Population identity unknown, but narrow, extensive coastal distribution from southern Bering Sea to southern Chukchi Sea implies possible multiple populations.

Concentrations

- *Natural*—Demersal trawl survey data indicate that population is rather uniformly distributed at low densities (mainly less than 5 kg/hectare) throughout region of concern.
- *Commercial*—Numbers too low for commercial exploitation.

Habitat (Musienko, 1970; Hart, 1973)

Type—Eggs and larvae planktonic; juveniles and adults benthic/demersal.

Physical/Chemical—Mainly silty to sandy gravel bottom in Bering Sea, from nearshore to over 100-meter depths. Mainly in less than 50 meters in summer, but extend to about 150 meters in winter. Commonly found in estuaries and rivers; tolerate low salinities.

Life History

Social Behavior—Unknown.

Biological Associations (Smith and Bakkala, 1982; Walters and McPhail, 1982)—Most commonly taken with longhead dab, Alaska plaice, red king crab, and yellowfin sole.

Nutrition (Hart, 1973; Jewett and Feder, 1980)

- *Feeding type*—Predator.
- *Food*—Young (5-12 mm) feed mainly on copepods and their nauplii, barnacle larvae, and cladocerans. Adults feed on polychaete and echiuroid worms, mollusks, brittle stars, crabs, and tunicates.
- *Feeding behavior*—Unknown.
- *Feeding location*—Mainly benthic.

Reproduction (Fadeev, 1965; Musienko, 1970; Frey, 1971; Garrison and Miller, 1982)

- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Probably in coastal marine waters.
- *Behavior*—Unknown.
- *Biology*—Spawn May-June. Fecundity 914,000-2,500,000 eggs for females 38-40 cm in length.

Development (Musienko, 1970; Hart, 1973)—Eggs hatch 10-30 days after fertilization, depending on water temperature. Larvae are about 2 mm at hatching and are initially symmetrical, like other flatfish. Metamorphose to side-swimming form at about 10 mm. One of few species of flatfish that may be either right- or left-eyed. South-to-north increase in proportion of population having eyes and color on left side.

Growth (Hart, 1973; Wolotira, Sample, and Morin, 1977)—Relatively large, fast-growing flatfish that reach about 34 cm at age four in southern part of range; to about 30 cm at age nine in Norton Sound near northern limit of range. Maximum age about 20 years; maximum length 91 cm.

Movements—Move from coastal waters in fall. Winter distribution under sea ice unknown.

Factors Influencing Populations

Natural—Factors unknown, but predation, competition, and other environmental influences undoubtedly affect year-class strength.

Human-related—Because of nearshore distribution and low density, species has been essentially unexploited by commercial fisheries.

Potential (Nelson-Smith, 1973; Patten, 1977; Rice et al., 1979)—In fishes, oil contamination can cause blockage or destruction of chemoreceptors, a respiratory "cough" response, loss of metabolic control, muscular/neural narcosis, and impairment of locomotor ability, equilibrium, and schooling behavior; also, increased egg mortality and larval deformities, decreased growth and development of eggs and young, decreased feeding rate, tainting of flesh, and death. Oil emulsified by rough seas or surfactants causes erosion of gill epithelium, depression of respiratory functions, and adherence of oil droplets to mucus layer of fish. Emulsification also may allow oil to be swallowed more readily by fishes trying to maintain ionic/osmotic balance. In general, light petroleum compounds are highly toxic, causing almost instantaneous death, even at low concentrations. These findings probably apply to this species.

Population Size (Wolotira, Sample, and Morin, 1977; Smith and Bakkala, 1982)

Because of nearshore and estuarine distribution of this species, demersal trawl surveys sample only a portion of the population. Based on limited trawl data from 1976, estimated biomass was 9,300 metric tons in eastern Bering Sea and 5,400 metric tons in Norton Sound to southern Chukchi Sea.

Management (Bakkala and Low, 1984)

Starry flounder managed collectively with Alaska plaice, rock sole, flathead sole, and other species of small flatfish as species complex. Maximum sustainable yield for this complex estimated to range from 88,100-150,200 metric tons. Equilibrium yield for the complex in 1983 estimated at 150,200 metric tons.

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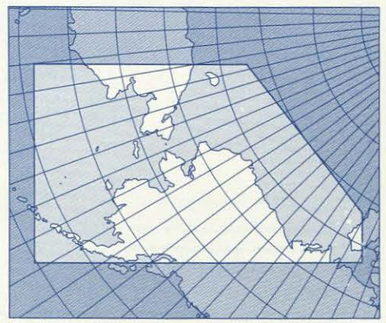
Legend

- Adult Area (Year-round)
- Adult Area (May-November)
- Adult Area (December-April)
- Occasional Occurrence (Year-round)
- Spawning Area (May-June)
- Juvenile Area (Year-round) Juveniles less than 1 year

Older juveniles occur throughout adult areas. Extent of winter distribution under sea ice unknown.

Map References

Frey, 1971; Lee et al., 1980; Garrison and Miller, 1982; Northwest and Alaska Fisheries Center, n.d.



Starry Flounder

Platichthys stellatus

3.35



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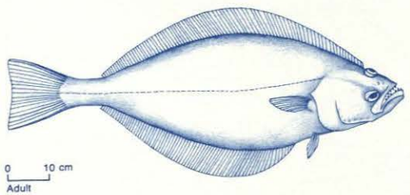

Greenland Turbot

Reinhardtius hippoglossoides

3.36

Description

Category
Fish

Classification
Class—Osteichthyes
Order—Pleuronectiformes
Family—Pleuronectidae

Name
Greenland turbot, *Reinhardtius hippoglossoides* (Greenland halibut—official name adopted by the American Fisheries Society)

Legal Status (North Pacific Fishery Management Council, 1979)
Protected under Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended, with management jurisdiction under North Pacific Fishery Management Council.

Range (Hubbs and Wilimovsky, 1964; Shuntov, 1965; Hart, 1973)
Worldwide—North Pacific and North Atlantic oceans; apparently different races of same species occupy the two oceans. In Pacific Ocean, range from Okhotsk and Bering seas to northeastern coast of Honshu Island, Japan, and northern Baja California. In eastern Pacific, only rare, sporadic occurrences observed south of Bering Sea.
Region of Concern—Shelf and slope of northern and eastern Bering Sea.

Distribution (Bakkala and Wakabayashi, 1985)
Discrete Populations—No evidence to suggest that there is more than one population in eastern Bering Sea.
Concentrations
- *Natural*—Juveniles rather uniformly distributed over broad areas of shelf; highest catch rates west of St. Matthew and St. Lawrence islands. Adult concentrations on slope at 200-700 meters in summer, 600-900 meters in winter, and 400-700 meters in spring.
- *Commercial*—Continental slope of eastern Bering Sea.

Habitat (Shuntov, 1965, 1970; Bakkala and Wakabayashi, 1985)
Type—Bathypelagic.
Physical/Chemical—Depths 14 meters to more than 1,000 meters over silty to muddy bottom; juveniles mainly less than 200 meters, adults mainly greater than 200 meters. Temperature range: 1.8°C to about 10°C; most abundant 3-4°C. Probably avoid sea ice.

Life History
Social Behavior—Unknown.
Biological Associations (Smith and Bakkala, 1982; Walters and McPhail, 1982)—Most closely associated with pollock, Pacific cod, flathead sole, tanner crabs, skates, and eelpouts.
Nutrition (Mikawa, 1963; Mito, 1974; Smith, Paulson, and Rose, 1977)
- *Feeding type*—Predator.
- *Food*—Mostly pelagic prey; mainly pollock in eastern Bering Sea, but also herring and squid.
- *Feeding behavior*—Feed mainly at night; feed year-round, but less in winter.
- *Feeding location*—Adults feed off bottom over continental slope.

Reproduction (Shuntov, 1966; Bulatov, 1983)
- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Continental slope, mainly in southeastern Bering Sea.
- *Behavior*—Unknown.
- *Biology*—Spawn February-March, according to occurrence of eggs in plankton. In Okhotsk Sea, females begin maturing at about 50 cm; 75% mature at 70 cm, and all mature at 80 cm. All males are mature at 70 cm.

Development (Andriyashev, 1954; Shuntov, 1970; Bulatov, 1983; Bakkala and Wakabayashi, 1985)—Time to hatching unknown. Larvae absorb yolk-sac at about 17-mm body length, move to benthic habitat at about 70-80 mm. Most remain in continental shelf waters until age three or four (30-40 cm), then move to continental slope.
Growth—Fast-growing flatfish: reach about 45 cm at age five years; maximum lengths exceed 100 cm.
Movements (Pereyra, Reeves, and Bakkala, 1976; Shuntov, 1970)—Both juveniles and adults move to shallower water in summer and deeper water in winter. Movements to shallower water most intense in May; return to deeper water in October or later.

Factors Influencing Populations
Natural—Largely unknown, but predation, competition, and other environmental factors probably affect year-class strength.
Human-related (Bakkala and Low, 1984)—Adults are a target species of commercial fisheries. Juveniles incidentally taken on continental shelf by fisheries for other species such as pollock and yellowfin sole. Fluctuations have been observed in stock size, but it is unknown whether these are due to fishery or to environmental causes.
Potential (Nelson-Smith, 1973; Patten, 1977)—In fishes, oil contamination can cause blockage or destruction of chemoreceptors, a respiratory "cough" response, loss of metabolic control, muscular/neural narcosis, and impairment of locomotor ability, equilibrium, and schooling behavior; also, increased egg mortality and larval deformities, decreased growth and development of eggs and young, decreased feeding rate, tainting of flesh, and death. Oil emulsified by rough seas or surfactants causes erosion of gill epithelium, depression of respiratory functions, and adherence of oil droplets to mucus layer of fish. Emulsification also may allow oil to be swallowed more readily by fishes trying to maintain ionic/osmotic balance. In general, light petroleum compounds are highly toxic, causing almost instantaneous death, even at low concentrations. These findings probably apply to this species.

Population Size (Bakkala and Low, 1984)
Based on demersal trawl survey data, estimated biomass of population has ranged from about 304,000 metric tons in 1979 to 125,000 metric tons in 1982. Biomass may be underestimated by trawl surveys.

Management (Bakkala and Low, 1984)
Greenland turbot managed as a species complex with arrowtooth flounder. Maximum sustainable yield estimated at 72,000 metric tons for Greenland turbot and 24,200 metric tons for arrowtooth flounder, for a total of 96,200 metric tons. Equilibrium yield in 1983 estimated at 47,500 metric tons for Greenland turbot and 20,000 metric tons for arrowtooth flounder, for a total of 67,500 metric tons.

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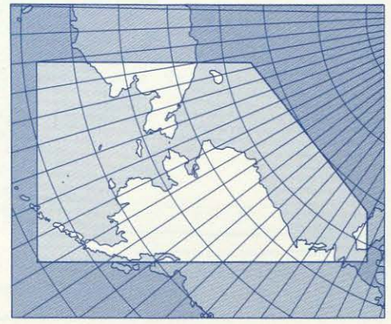
Legend
- Adult Area (Year-round)
- Juvenile Area (Year-round)
- Juvenile Area (May-November)
- Major Juvenile Area (May-November)

Spawning (February-March) occurs throughout adult area. Adults occur occasionally throughout juvenile areas.

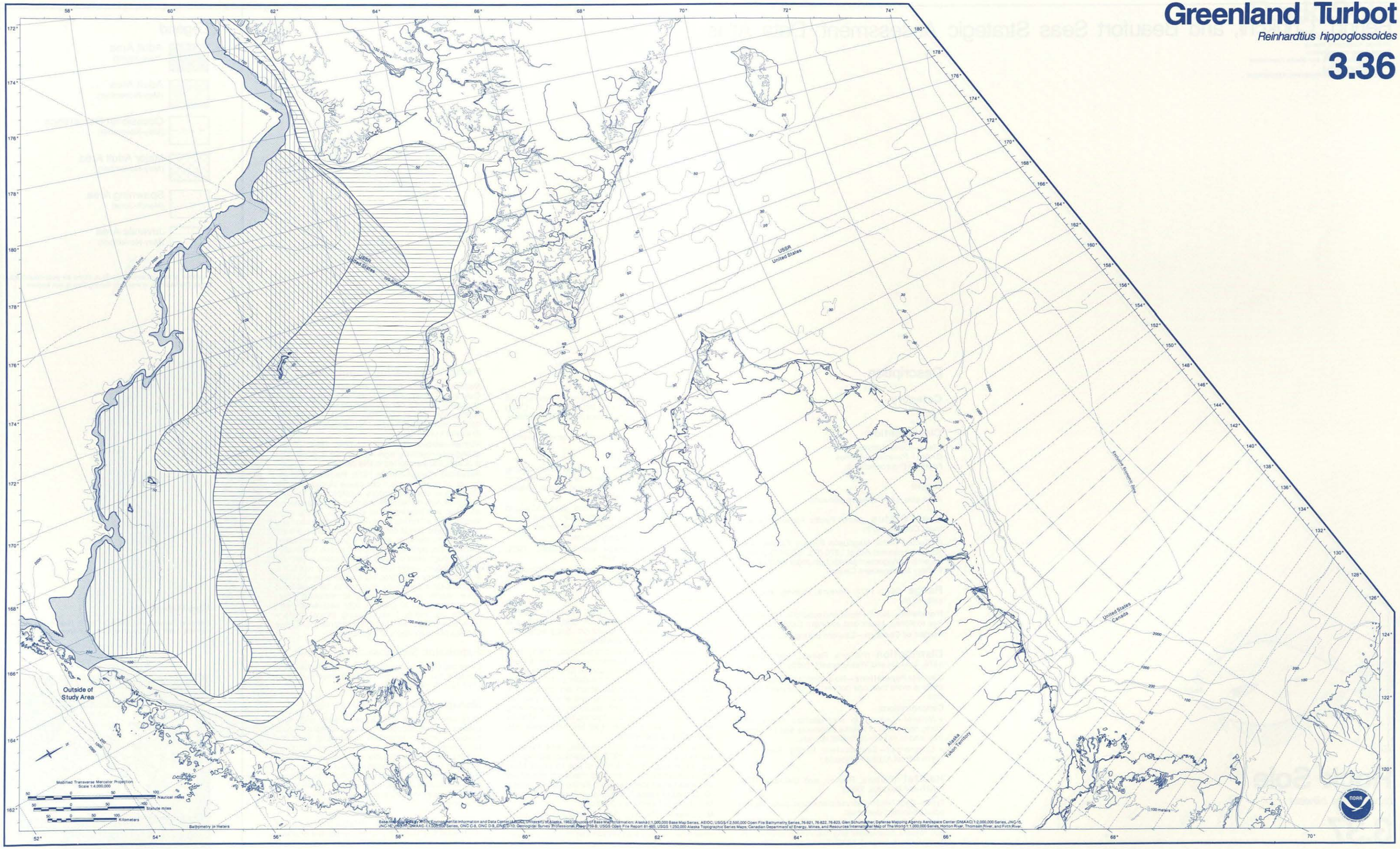
Map References
Bakkala and Wakabayashi, 1985; Northwest and Alaska Fisheries Center, n.d.



Greenland Turbot

Reinhardtius hippoglossoides

3.36



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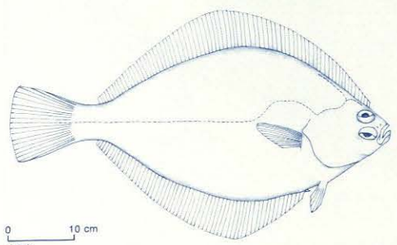

Rock Sole

Lepidopsetta bilineata

3.37

Description

Category

Fish

Classification

Class—Osteichthyes
Order—Pleuronectiformes
Family—Pleuronectidae

Name

Rock sole, *Lepidopsetta bilineata*

Legal Status (North Pacific Fishery Management Council, 1979)

Protected under Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended, with management jurisdiction under North Pacific Fishery Management Council.

Range (Hart, 1973; Pereyra, Reeves, and Bakkala, 1976)

Worldwide—North Pacific and subarctic, from Bering Sea to Korea, Japan, and southern California.
Region of Concern—Eastern Bering Sea shelf.

Distribution (Pereyra, Reeves, and Bakkala, 1976; Bakkala and Wakabayashi, 1985)

Discrete Populations—No evidence to suggest that there is more than one population in eastern Bering Sea.
Concentrations

- *Natural*—Largest in southeastern Bering Sea along north side of Alaska Peninsula and off Bristol Bay, and in vicinity of Pribilof Islands.
- *Commercial*—Southeastern Bering Sea along north side of Alaska Peninsula.

Habitat (Pereyra, Reeves, and Bakkala, 1976; Smith and Bakkala, 1982)

Type—Eggs benthic, larvae planktonic, juveniles and adults benthic/ demersal.
Physical/Chemical—Depths nearshore to about 200 meters, mainly over silty to sandy-gravel bottom. Temperature range 0-12°C. Probably avoid sea ice.

Life History

Social Behavior—Unknown.
Biological Associations (Pereyra, Reeves, and Bakkala, 1976; Walters and McPhail, 1982)—Often taken with yellowfin sole, Alaska plaice, flathead sole, and Pacific cod.
Nutrition (Skalkin, 1963; Shubnikov and Lisovenko, 1964; Mito, 1974)

- *Feeding type*—Predator.
- *Food*—Principally benthic invertebrates including polychaete worms, mollusks, brittle stars, and crustaceans (including shrimp and tanner crabs). Fishes are a minor component.
- *Feeding behavior*—Diet varies seasonally and regionally. Feed during daylight hours. Most active feeding in spring and summer, least in winter.
- *Feeding location*—Mainly benthic.

Reproduction (Shubnikov and Lisovenko, 1964; Fadeev, 1965; Waldron, 1981)

- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Outer shelf of southeastern Bering Sea.
- *Behavior*—Unknown.
- *Biology*—Spawn March-June. Fecundity 152,000 eggs per female at 22-24 cm body length and 404,000 per female at 40-42 cm. Eggs adhere to substrate and develop demersally.

Development (Pertseva-Ostroumova, 1961; Forrester, 1964, 1969)—Laboratory experiments (with fish caught off Kamchatka and off British Columbia) indicate that eggs hatch in 6.4 days at 11°C and in 25 days at 2.9°C. Larvae, which are pelagic, are about 5 mm long at hatching and absorb yolk-sac after 10-14 days. Metamorphose to side-swimming form at about 20 mm. Small young remain in shallow water one year or more; older juveniles move into somewhat deeper water.
Growth (Shubnikov and Lisovenko, 1964; Pereyra, Reeves, and Bakkala, 1976)—Relatively slow-growing; reach about 30-cm length at age 10 years. Maximum length about 49 cm, and maximum age about 18 years for females in eastern Bering Sea; for males, 40 cm and 17 years. Females grow faster than males. Mature at 5-7 years or 20-26 cm.
Movements (Pereyra, Reeves, and Bakkala, 1976; Smith and Bakkala, 1982)—Move from mid- and inner-shelf feeding areas in summer to outer shelf and near Alaska Peninsula in winter.

Factors Influencing Populations

Natural (Pereyra, Reeves, and Bakkala, 1976; McCain et al., 1978)—Factors unknown, but predation, competition, and other environmental factors may influence strength of year-classes. Skin tumors (epidermal papillomas) found in 1% of population in 1975. Predators unknown.
Human-related (Bakkala and Low, 1984)—Stock abundance relatively high in early 1980s; population probably underexploited in this period.
Potential (Nelson-Smith, 1973; Patten, 1977)—In fishes, oil contamination can cause blockage or destruction of chemoreceptors, a respiratory "cough" response, loss of metabolic control, muscular/neural narcosis, and impairment of locomotor ability, equilibrium, and schooling behavior; also, increased egg mortality and larval deformities, decreased growth and development of eggs and young, decreased feeding rate, tainting of flesh, and death. Oil emulsified by rough seas or surfactants causes erosion of gill epithelium, depression of respiratory functions, and adherence of oil droplets to mucus layer of fish. Emulsification also may allow oil to be swallowed more readily by fishes trying to maintain ionic/osmotic balance. In general, light petroleum compounds are highly toxic, causing almost instantaneous death, even at low concentrations. These findings probably apply to this species.

Population Size (Bakkala and Low, 1984)

Demersal trawl survey data indicate that population biomass has ranged from 170,000 metric tons in 1975 to 870,000 metric tons in 1983.

Management (Bakkala and Low, 1984)

Rock sole, flathead sole, Alaska plaice, and other species of small flounders managed collectively as a species complex. Maximum sustainable yield for this complex estimated to range from 88,100 to 150,200 metric tons. Equilibrium yield in 1983 estimated at 150,200 metric tons for the overall complex. Time-area closures to protect Pacific halibut (*Hippoglossus stenolepis*) and red king crab (*Paralithodes camtschatica*) in southern Bering Sea also protect rock sole.

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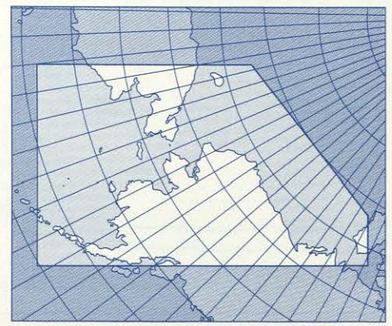
Legend

- Adult Area (Year-round)
- Adult Area (May-November)
- Occasional Occurrence (May-November)
- Major Adult Area (May-November)
- Spawning Area (March-June)
- Juvenile Area (May-November)

Juvenile area (December-April) is same as year-round adult area. Distribution in western Bering Sea is not known.

Map References

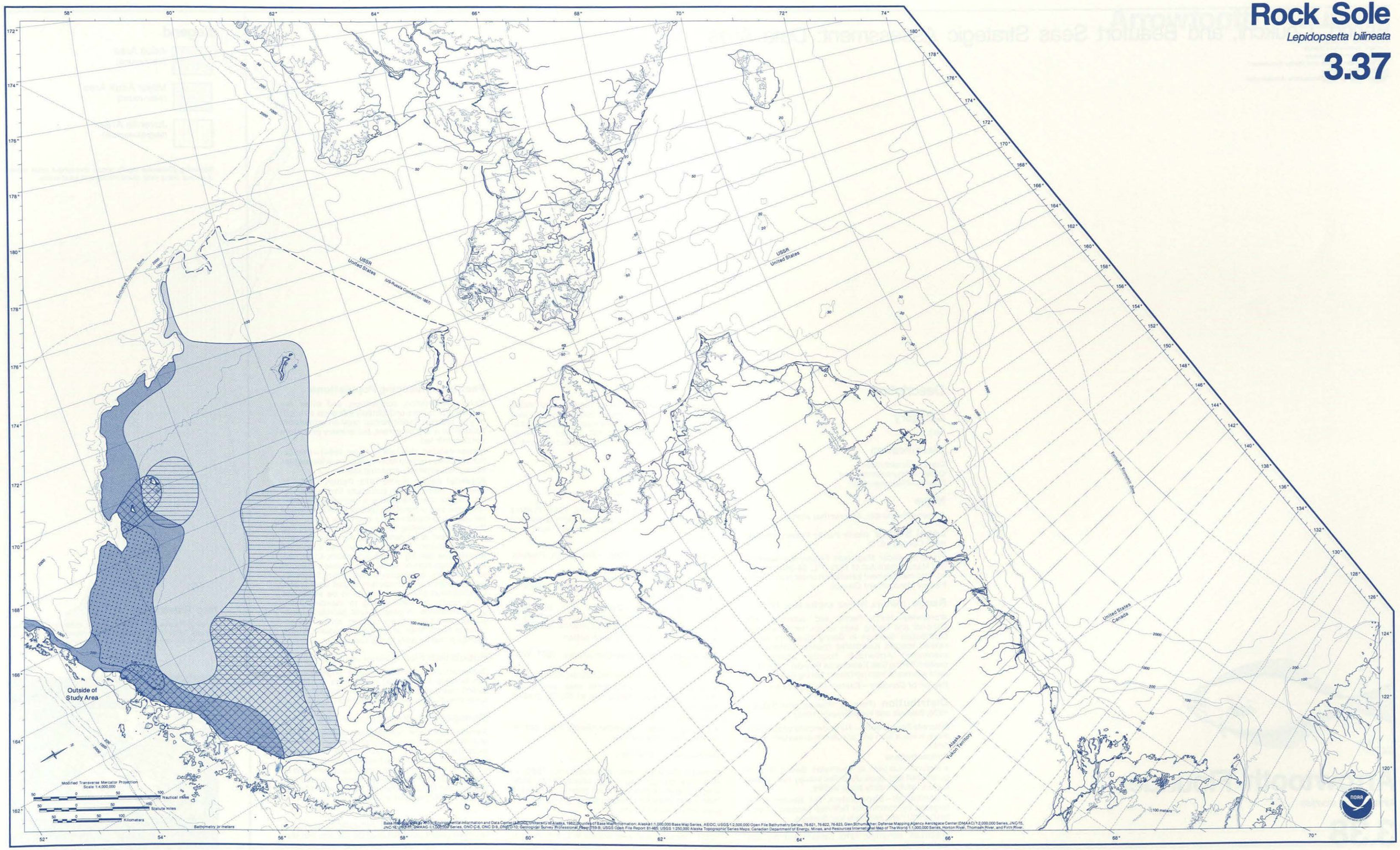
Pereyra, Reeves, and Bakkala, 1976; Bakkala and Wakabayashi, 1985; Northwest and Alaska Fisheries Center, n.d.



Rock Sole

Lepidopsetta bilineata

3.37



Base map data: NOAA, NGDC, Environmental Information and Data Center (EIDC), University of Alaska, 1982; Sources of Base Map Information: Alaska1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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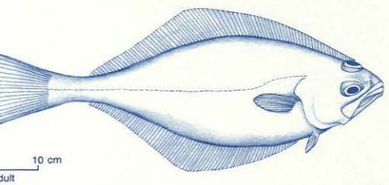

Arrowtooth Flounder

Atheresthes stomias

3.38

Description

Category

Fish

Classification

Class—Osteichthyes
Order—Pleuronectiformes
Family—Pleuronectidae

Name

Arrowtooth flounder, *Atheresthes stomias*

Legal Status (North Pacific Fishery Management Council, 1979)

Protected under Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended, with management jurisdiction under North Pacific Fishery Management Council.

Range (Pereyra, Reeves, and Bakkala, 1976)

Worldwide—North Pacific and subarctic, from Okhotsk and Bering seas to southern California. Distribution overlaps in Bering Sea with closely related species, Kamchatka flounder (*Atheresthes evermanni*). Arrowtooth flounder abundant in eastern Bering Sea; Kamchatka flounder more abundant westward from northwest Bering Sea.

Region of Concern—Eastern Bering Sea shelf.

Distribution (Pereyra, Reeves, and Bakkala, 1976; Bakkala and Wakabayashi, 1985)

Discrete Populations—No evidence to suggest that there is more than one population in eastern Bering Sea.

Concentrations

- *Natural*—Largest in southeast Bering Sea on outer shelf and slope. Juveniles occupy mainly shelf waters, adults mainly slope waters.
- *Commercial*—Slope waters, but species is not targeted by commercial fisheries because of poor flesh quality and relatively low numbers.

Habitat (Shuntov, 1970; Bakkala and Wakabayashi, 1985)

Type—Benthic/demersal.

Physical/Chemical—Juvenile depth range mainly 50-200 meters; adults mainly 200-500 meters over silty to muddy bottom. Adults mainly at 200-400 meters in summer and 300-500 meters in winter. Temperature range 0-9°C, with highest concentrations at 3-4°C.

Life History

Social Behavior—Unknown.

Biological Associations (Novikov, 1964; Walters and McPhail, 1982)—Often taken with Greenland turbot, Pacific ocean perch, flathead sole, and skates.

Nutrition (Shuntov, 1965, 1970; Smith, Paulson, and Rose, 1977)

- *Feeding type*—Predator.
- *Food*—Crustaceans and fish; mainly pollock in eastern Bering Sea.
- *Feeding behavior*—Demersal and off-bottom forager, mainly off-bottom. Feed most actively in summer and fall; feeding reduced in winter and spring.
- *Feeding location*—On and off bottom.

Reproduction (Pertseva-Ostroumova, 1961; Waldron, 1981)

- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Outer continental shelf and slope; mainly in southeast Bering Sea at depths greater than 200 meters.
- *Behavior*—Unknown.
- *Biology*—Spawn December-March. Eggs bathypelagic. Fecundity unknown.

Development—Unknown.

Growth (Bakkala and Wakabayashi, 1985)—Relatively fast-growing, reach about 38-cm body length at age five years. Females grow slightly faster than males. Maximum lifespan about 15 years; maximum length about 80 cm.

Movements (Shuntov, 1970; Smith and Bakkala, 1982)—Move to shallower waters in spring, deeper waters in fall or winter.

Factors Influencing Populations

Natural—Predation, competition, and other environmental factors undoubtedly influence strength of year-classes. Pacific halibut prey on arrowtooth flounder to a limited extent, but primary predators not documented.

Human-related (Bakkala and Low, 1984)—Population relatively stable in recent years; no evidence that fishery has adversely impacted stock.

Potential (Nelson-Smith, 1973; Patten, 1977)—In fishes, oil contamination can cause blockage or destruction of chemoreceptors, a respiratory "cough" response, loss of metabolic control, muscular/neural narcosis, and impairment of locomotor ability, equilibrium, and schooling behavior; also, increased egg mortality and larval deformities, decreased growth and development of eggs and young, decreased feeding rate, tainting of flesh, and death. Oil emulsified by rough seas or surfactants causes erosion of gill epithelium, depression of respiratory functions, and adherence of oil droplets to mucus layer of fish. Emulsification also may allow oil to be swallowed more readily by fishes trying to maintain ionic/osmotic balance. In general, light petroleum compounds are highly toxic, causing almost instantaneous death, even at low concentrations. These findings probably apply to this species.

Population Size (Bakkala and Low, 1984)

Demersal trawl survey data indicate range in population biomass from 58,000 metric tons in 1979 to 89,000 metric tons in 1982; estimates assumed to be lower than the true population biomass.

Management (Bakkala and Low, 1984)

Arrowtooth flounder managed as a species complex with Greenland turbot. Maximum sustainable yield estimated at 24,200 metric tons for arrowtooth flounder and 72,000 metric tons for Greenland turbot, for a total of 96,200 metric tons. Equilibrium yield in 1983 estimated at 20,000 metric tons for arrowtooth flounder and 47,500 metric tons for Greenland turbot, for a total of 67,500 metric tons.

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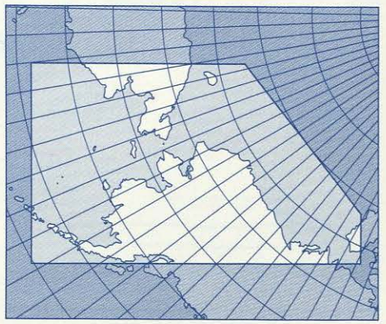
Legend

- Adult Area (Year-round)
- Major Adult Area (Year-round)
- Juvenile Area (May-November)

Spawning (December-April) occurs throughout adult areas. Juveniles occur year-round throughout adult areas.

Map References

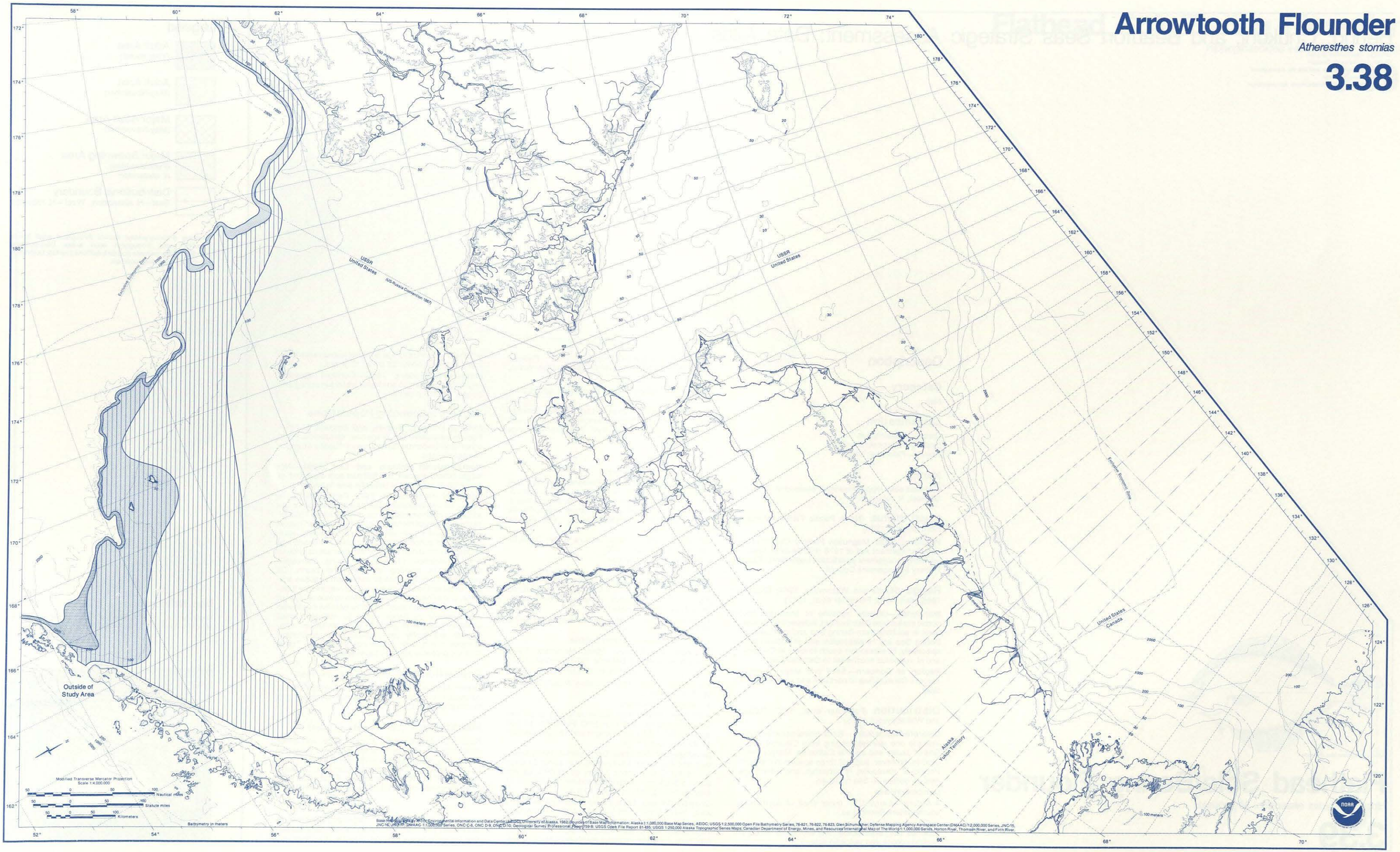
Pereyra, Reeves, and Bakkala, 1976; Bakkala and Wakabayashi, 1985; Ocean Assessments Division (NOS/NOAA), in press; Northwest and Alaska Fisheries Center, n.d.



Arrowtooth Flounder

Atheresthes stomias

3.38



Base map data: 1982, NOAA, Environmental Information and Data Center (EIDC), University of Alaska. 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17, DMAAC 1:1,000,000 Series, ONC-C-8, ONC D-9, ONC-D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-455; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

Strategic Assessment Branch
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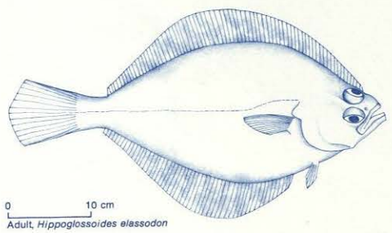

Adult, *Hippoglossoides elassodon*

Flathead Sole/Bering Flounder

Hippoglossoides elassodon, H. robustus

3.39

Description

Category
Fish

Classification
Class—Osteichthyes
Order—Pleuronectiformes
Family—Pleuronectidae

Name
Flathead sole, *Hippoglossoides elassodon*; Bering flounder, *H. robustus*

Legal Status (North Pacific Fishery Management Council, 1979)
Protected under Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended, with management jurisdiction under North Pacific Fishery Management Council.

Range (Hubbs and Wilimovsky, 1964; Shuntov, 1965; Hart, 1973; Forrester et al., 1977)
Worldwide—Unclear because of uncertain taxonomic status (see Distribution). Independent populations in southeastern Bering Sea and northwestern Bering Sea are *H. elassodon* and *H. robustus*, respectively; *H. elassodon* south to central California, and *H. robustus* southwest to Okhotsk Sea.
Region of Concern—Shelf and slope of southeastern Chukchi Sea to northern and eastern Bering Sea.

Distribution (Forrester et al., 1977; Bakkala and Wakabayashi, 1985)
Discrete Populations—Biochemical genetic studies indicate one species ranging from Chukchi Sea to Sea of Japan and central California. Morphometric studies, however, suggest three species in the North Pacific: *H. elassodon, H. robustus*, and a third species, *H. dubius*, in Sea of Japan.
Concentrations
- *Natural*—Largest on outer shelf of northern to southeastern Bering Sea.
- *Commercial*—Not a target species of commercial fisheries, but taken incidentally with other fishes, including pollock and yellowfin sole.

Habitat (Pertseva-Ostroumova, 1961; Fadeev, 1965; Hart, 1973; Eschmeyer, Herald, and Hammann, 1983)
Type—Eggs pelagic, larvae planktonic, adults benthic/demersal.
Physical/Chemical—Over soft bottom, nearshore to about 400-meter depths (younger fish in shallower waters); mostly on outer shelf. Temperature range about 0-12°C.

Life History
Social Behavior—Unknown.
Biological Associations (Pereyra, Reeves, and Bakkala, 1976; Walters and McPhail, 1982)—Associated with yellowfin sole, rock sole, Greenland turbot, Alaska plaice, walleye pollock, tanner crabs, Pacific cod, arrowtooth flounder, skates, and eelpout (*Lycodes palearis*).
Nutrition (Skalkin, 1963; Mineva, 1964; Pereyra, Reeves, and Bakkala, 1976)
- *Feeding type*—Predator.
- *Food*—Principally benthic invertebrates: sea cucumbers (*Ophiura sarsi*), crustaceans (shrimp, amphipods, hyperiids, euphausiids), and mollusks (*Yoldia*). Fish are minor component. Diet varies seasonally and regionally.
- *Feeding behavior*—Most active feeding in spring and summer, least in winter.
- *Feeding location*—Mainly benthic.

Reproduction (Fadeev, 1965; Musienko, 1970; Pereyra, Reeves, and Bakkala, 1976; Waldron, 1981)
- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Within shelf boundary, mostly in depths of 50-150 meters.
- *Behavior*—Unknown.
- *Biology*—Spawn from winter to spring at bottom temperatures of –0.4°C to 2°C. Fecundity 51,000 eggs per fish 22-24 cm in length and 160,000 per fish 40-42 cm. Eggs pelagic.

Development (Pertseva-Ostroumova, 1961; Alderdice and Forrester, 1974)—Hatch in about 21 days at 2.4-4.0°C and about 7 days at 10.7°C. Larvae about 5.3-6.9 mm at hatching and metamorphose to side-swimming form at about 10.6 mm.
Growth (Mineva, 1964; Pereyra, Reeves, and Bakkala, 1976; Smith and Bakkala, 1982)—Relatively slow-growing; females exhibit slightly faster rate. High proportion of fish mature around 29-cm body length (6-7 years). Females reach lengths of 50 cm, which corresponds to age l9 years; males reach maximum length of about 36 cm at 15 years.
Movements (Fadeev, 1965)—Conduct seasonal migrations, shifting to shallower waters in spring and deeper waters in winter.

Factors Influencing Populations
Natural (Pereyra, Reeves, and Bakkala, 1976)—Factors unknown, but predation, competition, and other environmental factors may influence strength of year-classes.
Human-related (Bakkala and Low, 1984)—Not target fishery species, but flathead sole exploited as by-catch of pollock and yellowfin sole fisheries.
Potential (Nelson-Smith, 1973; Patten, 1977)—In fishes, oil contamination can cause blockage or destruction of chemoreceptors, a respiratory "cough" response, loss of metabolic control, muscular/neural narcosis, and impairment of locomotor ability, equilibrium, and schooling behavior; also, increased egg mortality and larval deformities, decreased growth and development of eggs and young, decreased feeding rate, tainting of flesh, and death. Oil emulsified by rough seas or surfactants causes erosion of gill epithelium, depression of respiratory functions, and adherence of oil droplets to mucus layer of fish. Emulsification also may allow oil to be swallowed more readily by fishes trying to maintain ionic/osmotic balance. In general, light petroleum compounds are highly toxic, causing almost instantaneous death, even at low concentrations. These findings probably apply to these species.

Population Size (Bakkala and Low, 1984)
Demersal trawl survey data indicate that population biomass has ranged from 113,000 metric tons in 1975 to 279,000 metric tons in 1983.

Management (Bakkala and Low, 1984)
Rock sole, flathead sole, Alaska plaice, and other miscellaneous species of small flounders managed collectively as a species complex. Maximum sustainable yield for this complex estimated to range from 88,000 to 150,200 metric tons. Equilibrium yield in 1983 estimated at 150,200 metric tons for overall complex.

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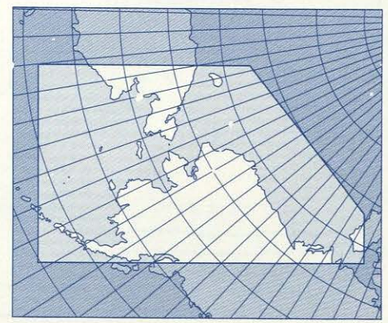
Legend
- Adult Area (Year-round)
- Adult Area (May-November)
- Major Adult Area (May-November)
- Major Spawning Area (February-May) *H. elassodon*
- Distributional Boundary East—*H. elassodon*, West—*H. robustus*

Spawning (February-May) occurs throughout adult areas. Juveniles occur throughout adult areas. Distributional boundary is approximate and distributions overlap; taxonomic status of species are uncertain.

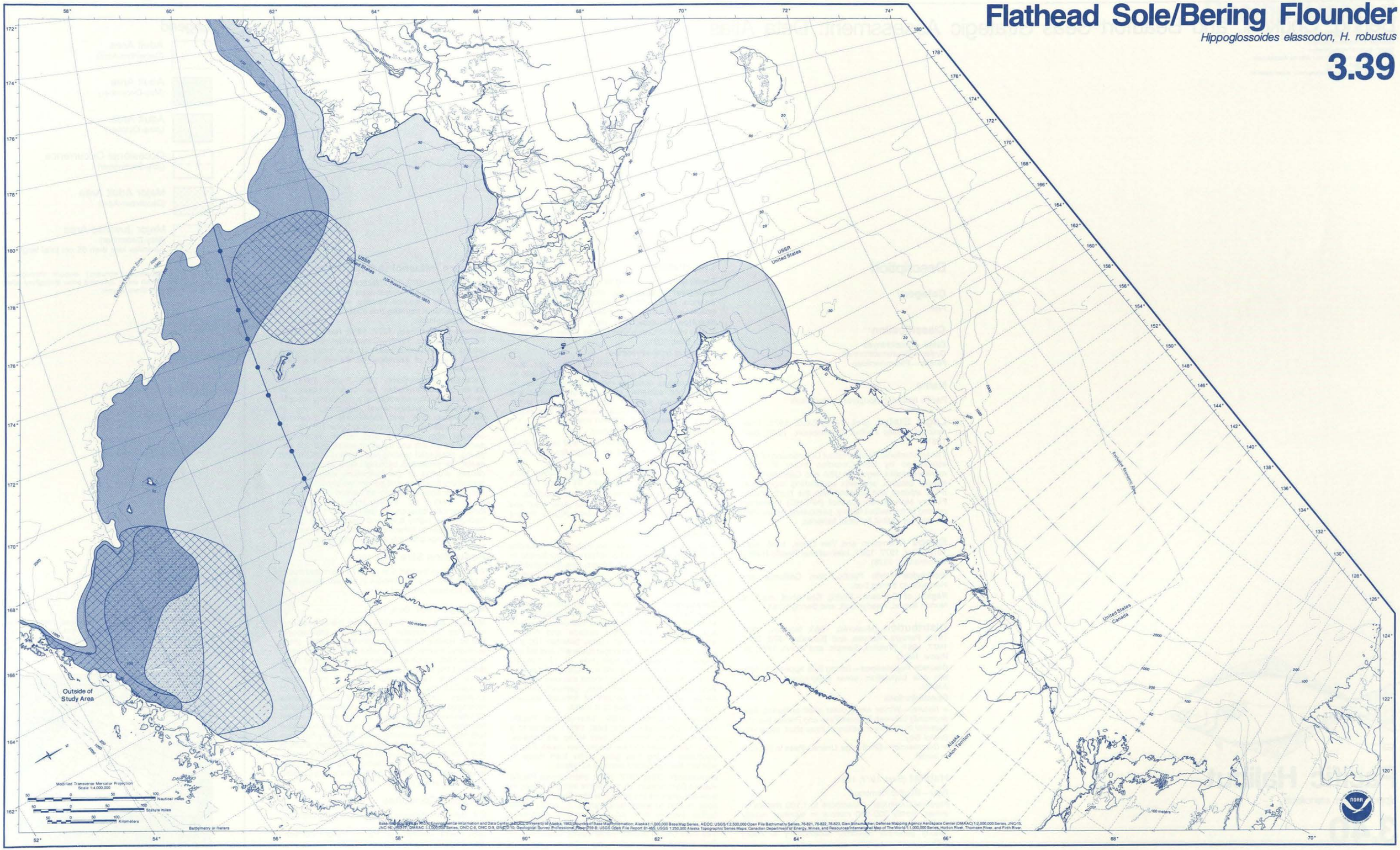
Map References
Forrester et al., 1977; Bakkala and Wakabayashi, 1985; Northwest and Alaska Fisheries Center, n.d.



Flathead Sole/Bering Flounder

Hippoglossoides elassodon, H. robustus

3.39



Base map data provided by NOAA Environmental Information and Data Center (AEIDC), University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 259-B; USGS Open File Report 81-455; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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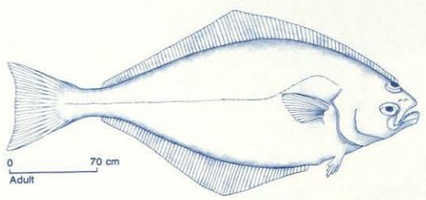


Pacific Halibut

Hippolgossus stenolepis

3.40

Description

Category

Fish

Classification

Class—Osteichthyes
Order—Pleuronectiformes
Family—Pleuronectidae

Name

Pacific halibut, *Hippoglossus stenolepis*

Legal Status (Bell, 1969; Skud, 1975; International Pacific Halibut Commission, 1978; Best, 1981)

The International Pacific Halibut Commission (IPHC), established by USA-Canadian treaty in 1924, monitors stocks, regulates USA and Canadian commercial catches, and sets sportfishing regulations. IPHC advises and consults with the North Pacific Fishery Management Council (NPFMC) in matters relating to the halibut fishery, particularly the incidental catch of halibut by other fisheries.

Range (Thompson and Van Cleve, 1936; Hart, 1973; Best, 1977, 1981; International Pacific Halibut Commission, 1978)

Worldwide—North Pacific, from California and Hokkaido to Bering Sea.

Region of Concern—Bering Sea shelf, north to Norton Sound, Anadyr Gulf, and Bering Strait.

Distribution (Musienko, 1963; Novikov, 1964, 1970; Pereyra, Reeves, and Bakkala, 1976; Best, 1977, 1981; Wolotira, Sample, and Morin, 1977; St. Pierre, 1984)

Discrete Populations—Bering Sea appears to contain one population; some emigration to Gulf of Alaska.

Concentrations

- *Natural*—Winter along outer shelf of Bering Sea, especially between Unimak Pass and Pribilof Islands. Summer in shallower waters of inner shelf, especially Bristol Bay.
- *Commercial*—Shelf edge, Unimak Pass to Pribilofs in winter.

Habitat (Best, 1977, 1981)

Type—Benthic/demersal.

Physical/Chemical—Nearshore to 1,100 meters; in winter, mostly 300-500 meters; in summer, mostly 40-200 meters. Primarily in temperatures of 2-8°C; salinity generally 30-33‰ occasionally to about 20‰.

Life History

Social Behavior—Young tend to school.

Biological Associations (Pereyra, Reeves, and Bakkala, 1976)—Often in trawls with yellowfin sole, pollock, rock sole, Alaska plaice, and flathead sole.

Nutrition (Novikov, 1964; Hart, 1973; International Pacific Halibut Commission, 1978; Feder and Jewett, 1980; Best, 1981)

- *Feeding type*—Predator.
- *Food*—Larvae eat plankton. Young less than 300 mm (1-3 years) eat small crustaceans, fishes. As size increases, consume more crabs and fishes, including cod, sablefish, rockfish, sculpin, turbot, and other flatfishes. Also eat octopus, clams, sand lance, and smaller halibut. Halibut over 600 mm feed extensively on pollock and yellowfin sole.
- *Feeding behavior*—Unknown.
- *Feeding location*—Primarily on and near bottom, but leave bottom to feed on pelagic fishes such as herring.

Reproduction (Thompson and Van Cleve, 1936; Novikov, 1964; Best, 1977, 1981; St. Pierre, 1984)

- *Mode*—Sexual; external fertilization; dioecious.
- *Location*—Spawning grounds on outer shelf and along shelf break, principally Unimak Pass to Pribilof Islands.
- *Behavior*—Unknown.
- *Biology*—Spawn December-February. Fecundity in Bering Sea averages 1.3 million eggs per female, in proportion to size. Eggs 3-3.5 mm, free-floating at 90- to 180-meter depths, drift in deep currents, rise to surface with increase in size. Eggs and larvae pelagic 5-6 months.

Development (Thompson and Van Cleve, 1936)—Eggs hatch in 20 days at 5°C. Larvae about 11 mm at hatching. Specific gravity of larvae decreases with age; larvae move toward surface and drift to shallower waters on shelf, mainly between 100 and 200 meters. Yolk sac no longer apparent, and left eye begins to migrate to right side at 18 mm. At 30 mm (6 months) resemble adults and become benthic. Smaller individuals inhabit shallower waters. With increasing age and size, generally inhabit deeper waters. Fifty percent of females sexually mature at 14 years, males at 8 years.

Growth (Hardman, 1969; International Pacific Halibut Commission, 1978; Best, 1981)—Adults to 3 meters, 315 kg. Nearly all over 45 kg are females, which grow faster and live longer than males. Fish in southeast Bering Sea grow faster than those in western Bering. Oldest females 42 years.

Movements (Best, 1977, 1981; International Pacific Halibut Commission, 1978)—Move inshore to feed in summer, offshore to spawn in winter. Extent of migrations related to water temperature. Juveniles move farther inshore than adults. Extensive east/west migrations (to 1,600 km). Some juveniles enter Bering Sea from Gulf of Alaska; some adults move back to Gulf of Alaska.

Factors Influencing Populations

Natural (Best, 1977, 1981; National Marine Fisheries Service, 1977)—Environmental conditions (e.g., temperature) influence relative strength of year-classes. Natural mortality rate about 20% per year for overall population.

Human-related (Best, 1977, 1981; National Marine Fisheries Service, 1977)—Commercial fishery takes adults; high incidental catch (11,519 metric tons in 1971), mainly of juveniles, by Bering Sea trawl fisheries.

Potential (Nelson-Smith, 1973; Patten, 1977)—In fishes, oil contamination can cause blockage or destruction of chemoreceptors, a respiratory "cough" response, muscular/neural narcosis, loss of metabolic control, and impairment of locomotor ability, equilibrium, and schooling behavior; also, increased egg mortality and larval deformities, decreased growth and development of embryos and young, decreased feeding rate, tainting of flesh, and death. Oil emulsified by rough seas or surfactants causes erosion of gill epithelium, depression of respiratory functions, and adherence of oil droplets to the mucus layer of the fish; emulsified oil is ingested more readily by fishes trying to maintain ionic/osmotic balance. In general, light petroleum fractions are highly toxic and cause almost instantaneous death to fishes, even at low concentrations. These findings probably apply to this species.

Population Size (Best, 1981)

Trawl surveys by NMFS in 1975-76 estimated nearly 3,100 metric tons of juveniles in eastern Bering Sea. Adult biomass unknown.

Management (Best, 1981)

Managed beginning in 1924 under the International Fisheries Commission (renamed the International Pacific Halibut Commission [IPHC] in 1953). IPHC estimated maximum sustainable yield at 2,268 metric tons in 1963; catch exceeded this in 1962 and 1963, declined thereafter. Total 1962 set-line catch 14,315 metric tons; 1975 set-line catch 317 metric tons. Population also depressed by incidental catch of juveniles. Time/area closures of trawl fisheries (arranged by the International North Pacific Fisheries Commission) in 1974 saved an estimated 1.5 million fish. Improvement of stock in recent years correlated with reduction in incidental catch. Recovery has been slow. Bering Sea subdivided into regulatory areas to distribute fishing effort: open periods vary with areas. The 1984 catch in the Bering Sea and Aleutian Islands was 1,430 metric tons. Minimum legal size, 81 cm (5-7 years old), set in 1974.

Persons Consulted

E.A. Best, International Pacific Halibut Commission, Seattle, Washington.
G.St. Pierre, International Pacific Halibut Commission, Seattle, Washington.

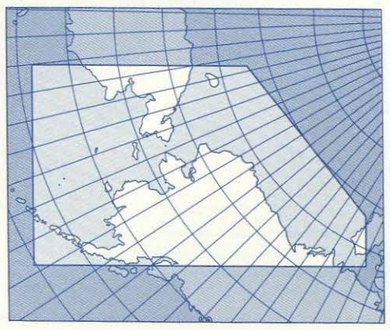
Legend

- Adult Area (December-April)
- Adult Area (May-December)
- Adult Area (June-October)
- Occasional Occurrence (July-September)
- Major Adult Area (December-April)
- Major Juvenile Area (May-December) Juveniles less than 65 cm total length

Spawning (December-February) occurs throughout December-April adult areas. Juveniles occur throughout adult areas during same times of year.

Map References

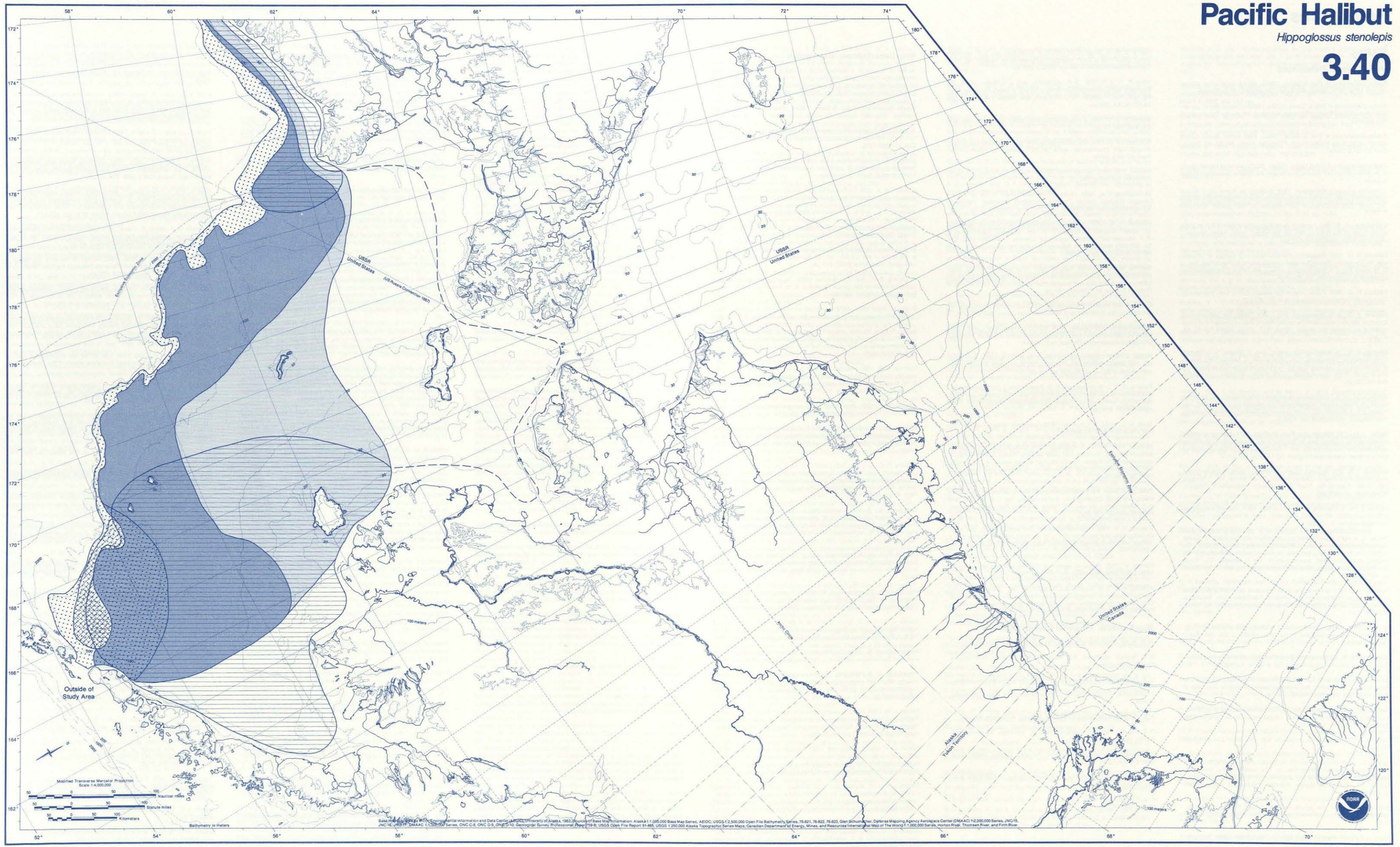
Thompson and Van Cleve, 1936; Musienko, 1963; Novikov, 1964, 1970; Pereyra, Reeves, and Bakkala, 1976; Wolotira, Sample, and Morin, 1977; International Pacific Halibut Commission, 1978; Best, 1981; St. Pierre, 1984. Personal communications from Best; St. Pierre.



Pacific Halibut

Hippoglossus stenolepis

3.40



Base map by Research Unit for Environmental Information and Data Center (ARDC), University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10, Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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Fishes

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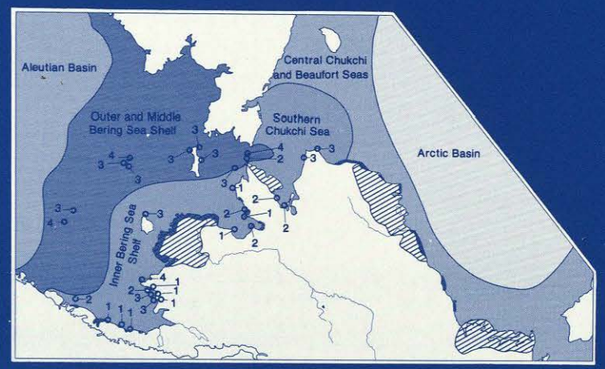
Birds



Areas of Abundance for Birds

Major Seabird Nesting Colonies—Numbers of Individuals

1. 1,000 - 10,000
2. 10,000 - 100,000
3. 100,000 - 1,000,000
4. >1,000,000

Seabird Pelagic Abundance—Approximate Average Summer Densities in Birds per Square Kilometer

Less than 1 | 1 to 10 | 10 to 50 | Greater than 50

Waterfowl and Shorebirds

Major Breeding Area | Major Coastal Concentrations—Staging and Molting

Introduction

This subsection comprises 23 maps describing 25 bird species with marine or major coastal distributions. The species are divided into four groups: 13 seabirds; eight waterfowl; two shorebirds; and two raptors. These are a representative sample of the region's approximately 45 species of seabirds, 34 waterfowl and loons, and 50 shorebirds. Considering both species diversity and total numbers, the area supports one of the largest assemblages of marine and coastal birds in the world. Over 60 million seabirds inhabit this region in spring and summer. Ten million are northern hemisphere breeding species, 9 million of which breed in the US EEZ. The remaining 50 million are short-tailed shearwaters that migrate to the Bering Sea to feed. Coastal tundra and lagoons support an additional 12 million waterfowl and 2 million shorebirds.

The high mobility of marine birds and their ability to exploit a wide range of marine and terrestrial food sources make them among the best indicators of biological productivity (Map 2.3). The inset map shows the importance of marine and coastal areas of the US portion of the region to seabirds, waterfowl, and shorebirds from spring to fall. Major breeding colonies, breeding areas, and staging areas (where birds prepare for breeding or migration) occur throughout the region from the western Alaskan Peninsula to the North Slope. Most major seabird colonies and pelagic concentrations are in the Bering Sea. This area also supports major waterfowl staging areas on the north side of the Alaskan Peninsula and a major waterfowl breeding and staging area on the Yukon/Kuskokwim Delta. The more northern part of the region is less important to seabirds, but has major waterfowl and shorebird breeding areas on the North Slope. In addition, important shorebird and waterfowl staging areas occur along the Chukchi and Beaufort coasts.

The maps incorporate distributions of the land portions of the study area, including the entire coastal plain. For seabirds, individual colonies too close together to be mapped individually are grouped into a single colony location. Maps of colonial seabirds include parental foraging areas, where breeding birds feed and gather food for chicks. For other species, additional distributional features are shown as appropriate. Much information on birds is available, and data reliability is generally good, as evidenced in the *Data Content and Quality Table* (Section 3 Introduction).

All birds in this atlas are protected under the Migratory Bird Treaty Act. Regulated hunting of most waterfowl species is permitted, with limits based on estimated population size and breeding productivity. Most of the major seabird colonies in this region are in wildlife refuges. No birds are considered endangered or threatened in the region, although some goose populations have been depleted recently, apparently due to subsistence hunting on breeding grounds and recreational hunting in wintering areas.

Seabirds—Seabirds (shearwaters and petrels, cormorants, gulls, terns, and alcids: Maps 3.41-3.43, 3.55-3.63) are usually associated with the marine environment for the entire year and have specialized adaptations for marine life. They typically come to land only to breed, usually in colonies, and with few exceptions, are found over waters deeper than 20 meters. They feed on a variety of fishes and zooplankton that inhabit the continental shelf and oceanic waters. At sea, they are most abundant in areas where frontal systems and upwelling lead to increased abundance and availability of prey. For breeding, they require isolated nesting localities, such as mainland cliffs and nearshore or offshore islands, adjacent to areas where prey populations are sufficient to raise young successfully. Tundra-nesting seabirds breed on islands in tundra ponds and rivers. The region supports major breeding concentrations of 18 species of colonial nesting seabirds and large numbers of non-colonial nesters, nonbreeding residents, and southern hemisphere migrants. The total numbers of nesting seabirds in the region represent about 33 percent of the total North American seabird population.

Seabird distributions and numbers are generally determined by coastal physical features that provide nesting sites and by oceanographic features that affect their prey. Six subregions, defined by combinations of these features, are shown on the inset map. They can be characterized by the types and numbers of bird species occupying them.

The Bering Sea area is most important to birds of the region. **The Bering Sea Basin** has low densities of pelagic species common to deep, oceanic waters. Although this area is ice-free throughout the year, available prey are too scarce to support large bird populations. Highest bird densities are over the continental slope. Lack of islands in this area precludes nesting. The principal species are oceanic surface feeders, such as northern fulmar (Map 3.41) and fork-tailed storm petrel. **The outer and middle Bering Sea shelf area** includes four major islands or island groups: the Pribilofs, St. Matthew, St. Lawrence, and the Diomedes. These offer habitat for breeding colonies of over 7 million birds, mostly auklets, murres, and black-legged kittiwakes (Maps 3.57, 3.60, 3.62, and 3.63). High copepod productivity supports large numbers of auklets, and walleye pollock populations support murres and black-legged kittiwakes. This area also contains the majority of the 50 million shearwaters (Map 3.42) that prey principally on euphausiids and forage fishes. **The inner Bering Sea shelf** is more strongly influenced by nearshore processes. Large populations of forage fishes, primarily sand lance and capelin, provide food for over 2 million breeding birds, principally murres, kittiwakes, and several million shearwaters.

The more northern portions of the region have considerably lower densities of birds. **The southern Chukchi Sea** is a major transition area from subarctic to arctic waters and is strongly influenced by the intrusion of warm Alaska coastal water from the Bering Sea (Maps 1.2, 1.7). The marine bird fauna is similar to that of the Bering Sea inner shelf, but numbers of breeding birds are lower—approximately 0.5 million— probably due in part to the scarcity of coastal cliffs for nest sites. **The central Chukchi and Beaufort seas** have extensive ice cover from seven to nine months of the year, limiting marine productivity and prey availability. Except for isolated small colonies on cliffs in Siberia and Canada, breeding seabirds are limited to fewer than 4,000 gulls, terns, and guillemots (Maps 3.55, 3.56, and 3.59) relying on sand and gravel bars. Pelagic densities are low, except within the Alaska coastal water intrusion. Tundra-breeding migrants, mostly gulls and terns, are dominant. Arctic cod and gammarid amphipods are the principal prey. **The Arctic Basin** has extensive ice cover during all seasons, with little available food and few nest sites. Bird densities are consequently very low.

Waterfowl and Loons—Unlike seabirds, waterfowl (ducks, geese, and swans: Maps 3.43-3.50) and loons breed principally in freshwater habitats. However, during the non-breeding seasons they depend on marine systems, using nearshore waters and the littoral zone. Waterfowl feed on a wide range of nearshore food resources, primarily benthic invertebrates and saltmarsh grasses; loons feed on nearshore fishes and invertebrates.

This group does not show the same geographic distribution pattern as seabirds. Major staging and breeding areas occur throughout the region. Unlike seabirds, which are most concentrated when breeding, waterfowl are most concentrated during migration and on wintering grounds. Bristol Bay is a major wintering area for eider and other sea ducks and is most important in spring and fall when large concentrations of waterfowl gather in small lagoons on the north side of the Alaska Peninsula, particularly geese in Izembek Lagoon. The wet tundra of the Yukon-Kuskokwim Delta supports one of the world's largest aggregations of breeding waterfowl and is an important staging area in spring and fall. The Chukchi Sea north of Cape Lisburne has major lagoons and coastal areas that support large numbers of post-breeding molting waterfowl in late summer and fall. Major areas of coastal wet tundra from Point Barrow to western Canada support breeding waterfowl. The lagoons and nearshore areas of the northern Chukchi and Beaufort seas are most important to molting eiders and oldsquaw, respectively.

The estimated Bering Sea waterfowl population represents 11 percent of the total for North America. This estimate does not include those waterfowl on the coasts of the Chukchi and Beaufort seas that migrate through the Alaska interior or through the Mackenzie River drainage basin.

Shorebirds—Shorebirds (sandpipers, plovers, and phalaropes: Maps 3.53, 3.54), like waterfowl, breed in freshwater habitats, but migrate and winter to a great extent in marine habitats. Also like waterfowl, they are most concentrated during migration and on wintering grounds. While most marine shorebirds are present in the littoral zone, where they feed on infaunal and epifaunal invertebrates, the phalaropes occupy pelagic and nearshore habitats during the nonbreeding season and feed on zooplankton. Substantial numbers of shorebirds use wet tundra and coastal lagoons throughout the region. Of the more than 50 species known in the region, only the red phalarope and western sandpiper are mapped. However, this region is exceedingly important to many species of shorebirds of the Pacific Basin.

The wet tundra areas of the Yukon-Kuskokwim Delta and the North Slope are the principal shorebird breeding areas in this region. The beaches along the Alaska Peninsula and Yukon-Kuskokwim Delta are important staging areas for spring and fall migrant sandpipers and post-breeding adults and juveniles. Phalaropes are abundant from spring through fall in pelagic and nearshore areas that have high zooplankton concentrations.

Raptors—These are birds of prey, represented in this atlas by the bald eagle (Map 3.51) and peregrine falcon (Map 3.52). While both have inland populations, they also have extensive contacts with the marine environment. Both breed near seabird colonies and prey on breeding seabirds. At all times of year, bald eagles are found on beach habitats where they scavenge for a wide variety of food, especially spawning salmon. Peregrine falcons prey on shorebirds and waterfowl that occupy nearshore waters and the littoral zone.

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References

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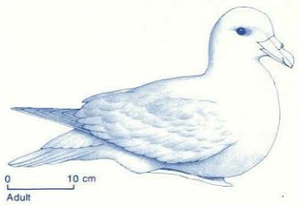
Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
National Oceanic and Atmospheric Administration



Northern Fulmar

Fulmarus glacialis

3.41

Description

Category

Bird

Classification

Class—Aves
Order—Procellariiformes
Family—Procellariidae

Name

Northern fulmar, *Fulmarus glacialis*

Legal Status

Protected under Migratory Bird Treaty Act of 1918 (P.L. 65-186), amended.

Range

Worldwide (Fisher, 1952; A.O.U., 1957)—Holarctic. In summer, arctic and subarctic seas. In winter, subarctic and north temperate seas, south to Japan, Baja California, and northern France.

Region of Concern (Gabrielson and Lincoln, 1959; Sowls, Hatch, and Lensink, 1978; Gould, 1980)—In summer, breed on Bering Sea islands and southern Chukchi Peninsula. Nonbreeders to northern Chukchi and extreme western Beaufort. In winter, inhabit open water regions south of pack ice in southern Bering Sea.

Distribution (Gabrielson and Lincoln, 1959; Portenko, 1972; Sowls, Hatch, and Lensink, 1978; Gould, 1980; Hunt, Eppley, and Drury, 1981)

Discrete Populations—Large breeding colonies on St. Matthew, Hall, and St. George islands; small colonies on St. Paul Island and in Provideniya Bay, Siberia.

Concentrations

- *Natural*—Outer-shelf domain and shelf-break. At St. Matthew, Hall, and Pribilof breeding colonies and in Akutan and Unimak passes in summer.
- *Commercial*—Not taken commercially.

Habitat (Gabrielson and Lincoln, 1959; Sowls, Hatch, and Lensink, 1978; Hatch, 1979; Gould, 1980; Hunt, Eppley, and Drury, 1981; Hunt et al., 1981a,b)

Type—Pelagic, but occasionally nearshore. Breed on sea cliffs.

Physical/Chemical—Feed in outer-shelf and oceanic domains. Nest in crannies and on ledges, especially those with protective overhang; on island cliffs with at least 50° *slope.*

Life History (Fisher, 1952; Gabrielson and Lincoln, 1959; Sowls, Hatch, and Lensink, 1978; Hatch, 1979; Gould, 1980; Hunt, Eppley, and Drury; 1981 Hunt et al., 1981b)

Social Behavior—Colonial nesters. Feed, migrate in loosely aggregated flocks.

Biological Associations—Usually nest near large colonies of other cliff-nesting birds. Feed with gulls, kittiwakes, shearwaters, and albatrosses.

Nutrition (Fisher, 1952; Hunt, Burgeson, and Sanger, 1981)

- *Feeding type*—Predator and scavenger.
- *Food*—Squids (especially *Gonatidae*), crustaceans, small fishes, jellyfishes, animal carcasses, and fish offal.
- *Feeding behavior*—Surface-seizing; also plunge-dive and pursue prey underwater to 3.5 meters. Thought to feed mainly at night. Congregate near fish-processing ships and dead whales.
- *Feeding location*—Open offshore waters; occasionally inshore if large amounts of food available.

Reproduction (Hatch, 1979; Gould, 1980; Hunt, Eppley, and Drury, 1981)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Island cliffs, often on highest portions. Nest sites irregularly clumped according to terrain, in crannies and shallow caves facing sea and on overhung ledges of cliffs.
- *Behavior*—Strong pair bond; monogamous; colonial. Both sexes incubate egg, feed chick.
- *Biology*—Single egg laid early June. Incubation period averages 53 days; hatching occurs from late July to mid-August; fledge in September. Hatching success averages 60%. Fledging success averages 80%.

Development (Dunnet and Ollason, 1978; Hatch, 1979; Gould, 1980; Hunt et al., 1981b)—Chicks fledge at approximately 50 days; fed until 3-5 days before fledging; independent thereafter. Age at first breeding, 9 years. Average reproductive life, 20-25 years.

Growth (Hatch 1979; Gould, 1980; Dunnet, 1982)—From hatching (mean 65 grams) to peak weight (878-965 grams), chicks gain about 20 grams per day. Adults average 620 grams. Maximum lifespan more than 50 years.

Movements (Gabrielson and Lincoln, 1959; Hunt et al., 1981b)—Large portion of Bering population remains there all year; others probably move into North Pacific in winter. General southward dispersal begins August, heaviest October; northward movement begins March, heaviest April. No specific migratory pathways.

Factors Influencing Populations

Natural (Gabrielson and Lincoln, 1959; Hatch, 1979)—Major predators on adults are bald eagles and peregrine falcons; gulls and ravens prey on eggs and chicks. Foxes prey on eggs, young, and nesting adults.

Human-related (Sowls, Hatch, and Lensink, 1978; Hatch, 1979; Day, 1980; Hunt, Eppley, and Drury, 1981; Hunt et al., 1981a)—Disturbance of colonies by aircraft and human intrusion can result in loss of eggs and chicks. Availability of offal from fishing fleets may increase survival, especially of first-year birds. Numbers in some Atlantic and Pacific fishing areas have increased dramatically in past 200 years. Plastic particles found in 58% of Alaskan birds; effect on birds unknown.

Potential (King and Sanger, 1979; Gould, 1980; Hunt et al., 1981b)—Ranked 43rd of 176 species in northeast Pacific in oil vulnerability index. Moderately susceptible to oiling. Increasing pollution from ship discharges or spills, release of toxins from mining or drilling operations, and ocean dumping of urban and industrial wastes may be threats. Pollution in immediate vicinity of ships may foul plumage; nonbiodegradable products may be ingested. Toxic chemicals may affect reproductive success. Increased availability of offal from fishing fleets may lead to population growth.

Population Size (Sowls, Hatch, and Lensink, 1978; Gould, 1980; Hunt et al., 1981b)

Total Alaska population estimated at 2 million; about one-half in region of concern.

Management

Nongame species.

Persons Consulted

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S. A. Hatch, U. S. Fish & Wildlife Service, Anchorage, Alaska.

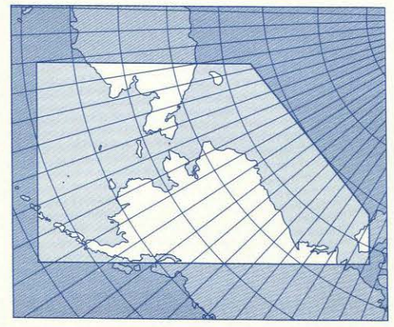
Legend

- Adult Area (Year-round)
- Adult Area (April-December)
- Adult Area (June-October) Primarily nonbreeders
- Major Adult Area (Year-round)
- Nesting Colony (June-September) Number of individuals
  - Less than 10,000
  - 10,000 to 100,000
  - Greater than 100,000
- Parental Foraging Area (June-September)
- Major Parental Foraging Area (June-September)
- Migration (April-May)
- Migration (October-November)

Eggs are laid early June; they hatch in July to mid-August. Young fledge August-September. Juveniles occur throughout adult areas. Winter range extends throughout subarctic and temperate North Pacific.

Map References

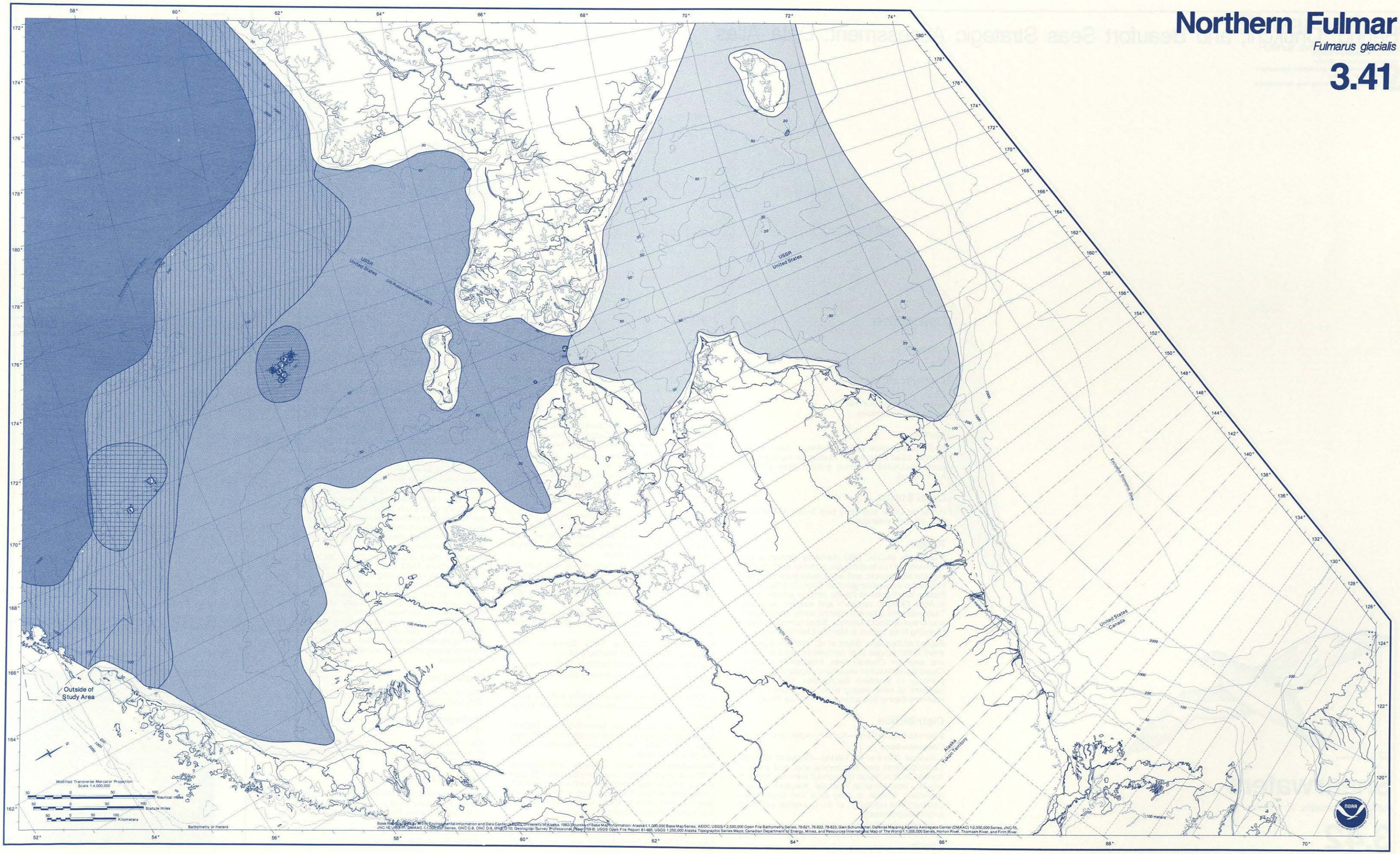
Gabrielson and Lincoln, 1959; Portenko, 1972; Sowls, Hatch, and Lensink, 1978; Hunt et al., 1981; Gould, Forsell, and Lensink, 1982.



Northern Fulmar

Fulmarus glacialis

3.41



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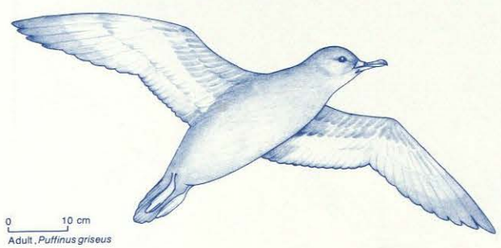


Adult, *Puffinus griseus*

Shearwaters

Puffinus tenuirostris, P. griseus

3.42

Description

Category

Bird

Classification

Class—Aves
Order—Procellariiformes
Family—Procellariidae

Name

Short-tailed shearwater, *Puffinus tenuirostris* (slender-billed shearwater, Tasmanian mutton-bird); sooty shearwater, *Puffinus griseus* (New Zealand mutton-bird)

Legal Status

Protected under Migratory Bird Treaty Act of 1918 (P.L. 65-186), amended.

Range

Worldwide (A.O.U., 1957; Serventy, Serventy, and Warham, 1971)—In spring and summer, both species migrate to subarctic and arctic seas from Southern Hemisphere breeding grounds. Sooty in Atlantic and Pacific; short-tailed in Pacific only. In winter, breed in New Zealand, southern and eastern Australia, Tasmania, and adjacent islands; sooty shearwaters also breed off South America. Small numbers of nonbreeding birds remain in Northern Hemisphere.

Region of Concern (Hunt et al., 1981b)—Summer: short-tailed ranges over continental shelf of Bering and southern Chukchi seas, irregular in northern Chukchi and Beaufort seas. Sooty apparently limited primarily to southern Bering Sea. Winter: small numbers of nonbreeding birds are present in the southern Bering Sea adjacent to Unimak Pass.

Distribution

Discrete Populations—None in region of concern.

Concentrations

- *Natural* (Hunt et al., 1981b)—Flocks of 100,000-1,000,000 birds over continental shelf and slope in Bering-Chukchi region throughout summer. Areas of regular concentration include Aleutian passes (especially Unimak in May-June and September-October) and northeast of St. Lawrence Island (in August-September).
- *Commercial* (Serventy, Serventy, and Warham, 1971)—Taken commercially only on breeding grounds.

Habitat

Type—Pelagic. Breeding: burrows on Southern Hemisphere islands.

Physical/Chemical—Short-tailed mainly in inner-shelf domain, sooty mainly in oceanic/outer-shelf domains. Northern distribution appears limited to surface water temperature of 6°C for sooty, colder for short-tailed.

Life History

Social Behavior (Serventy, Serventy, and Warham, 1971; Hunt et al., 1981b)—Colonial breeders. Highly gregarious; migrate and feed in large mixed flocks.

Biological Associations—Mutually gregarious; often form mixed flocks at sea.

Nutrition (Serventy, Serventy, and Warham, 1971; Brown, Bourne, and Wahl, 1978; Ogi, Shimazaki, and Nakamura, 1980; Brown et al., 1981; Hunt, Burgeson, and Sanger, 1981)

- *Feeding type*—Predator, scavenger.
- *Food*—Primarily euphausiids, squids, planktonic amphipods, and larval and juvenile fishes; also copepods, shrimps, and shelled pteropods. Scavenge fish offal at processing ships.
- *Feeding behavior*—Surface-seizing and pursuit-plunging and diving to 5-meter depths. Forage in large, unevenly distributed flocks. Prey of short-tailed generally smaller (14-32 mm) than that of sooty (80-137 mm).
- *Feeding location*—Principally pelagic; rarely near-shore. Short-tailed principally in waters less than 50 meters; sooty, deeper.

Reproduction (Richdale, 1963; Serventy, 1967; Serventy, Serventy, and Warham, 1971)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Burrows on offshore islands of Southern Hemisphere.
- *Behavior*—Strong nest-site fidelity and pair bond. Sensitive to disturbance, especially during early incubation.
- *Biology*—Eggs laid late November-early December; 1 egg per nest. Incubation period 52-56 days; eggs hatch late January-early February; chicks fledge late April-May.

Development (Serventy, Serventy, and Warham, 1971)—Chicks develop very slowly over 86-108 days in nest. Adults desert chicks for northward migration. Short-tailed obtains 150%, and sooty, 100% of adult weight in nest. Both fledge at adult weight. Females mature at 5-7 years, males at 5-8 years.

Growth (Richdale, 1963; Serventy, 1967; Serventy, Serventy, and Warham, 1971; Hunt, Burgeson, and Sanger, 1981)—Chicks exceed adult body weight while being fed; decline in weight before leaving nest. Adults in Bering Sea average 700 grams for short-tailed, 790 grams for sooty. Maximum age to more than 14 years.

Movements (Richdale, 1963; Serventy, Serventy, and Warham, 1971; Hunt et al., 1981b)—Trans-equatorial migration. Large numbers of short-tailed shearwaters enter Bering Sea in May-June, Chukchi Sea in August-September, depart September-October. Some nonbreeding birds remain in southern Bering and North Pacific through northern winter.

Factors Influencing Populations

Natural (Serventy, Serventy, and Warham, 1971; Ogi, Kubodera, and Nakamura, 1980; Hunt, Burgeson, and Sanger, 1981)—High-density food patches important to large flocks. Competition with sockeye salmon may reduce food supply in Bristol Bay.

Human-related (Serventy, Serventy, and Warham, 1971; Day, 1980)—Nestlings harvested in Australia, New Zealand. In study area, harvest of competitors such as sockeye salmon may increase food supply for adults. Plastic particles found in 43% of sooty and 84% of short-tailed shearwaters from Alaska; effect on birds unknown.

Potential (King and Sanger, 1979; Ogi, Kubodera, and Nakamura, 1980; Hunt, Burgeson, and Sanger, 1981)—Slowly reproducing, long-lived birds with low annual adult mortality; populations will take a long time to recover from drastic population declines. Short-tailed ranked 53rd and sooty ranked 60th of 176 species in northeast Pacific in oil vulnerability index. Moderately susceptible to oiling. Reduction in numbers of competitors by fisheries may increase carrying capacity for adults. Fish offal from high-seas fish-processing ships may provide significant artificial food source.

Population Size (Hunt et al., 1981b)

Approximately 9-20 million in Bering Sea in summer; 90% short-tailed, 10% sooty.

Management (Serventy, Serventy, and Warham, 1971)

Short-tailed chick harvest regulated by governments of Australia and New Zealand; adults and eggs protected from exploitation.

Persons Consulted

R. H. Day, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
D. S. Lloyd, Alaska Department of Fish & Game, Anchorage, Alaska.
I. J. Skira, Tasmanian National Parks and Wildlife Service, Sandy Bay, Tasmania.

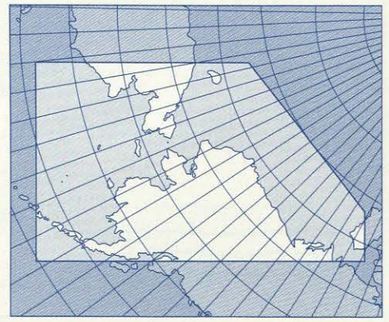
Legend

- Adult Area (June-November)
- Major Adult Area (June-November)
- Major Adult Concentration (May-June)
- Major Adult Concentration (June-September)
- Major Adult Concentration (October-November)
- Migration (May-June)
- Migration (September-October)

Study area population is 90% *P. tenuirostris* (short-tailed shearwater) and 10% *P. griseus* (sooty shearwater). Adults occur July-September north of Bering Strait. Both species breed in Southern Hemisphere, November-May. Small numbers of nonbreeders remain in Unimak Pass during breeding season. Juveniles occur throughout adult area.

Map References

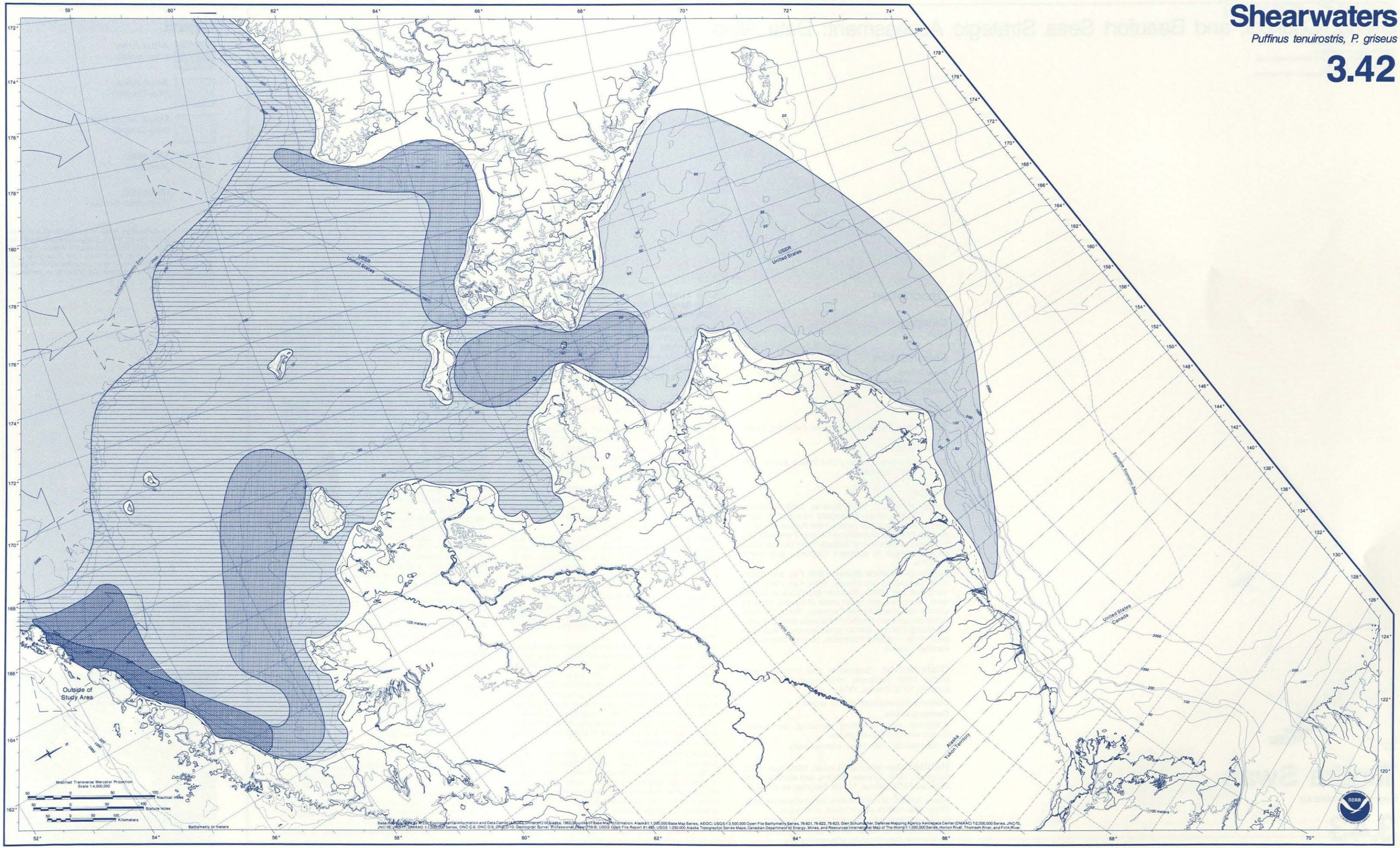
Hunt et al., 1981; Gould, Forsell, and Lensink, 1982. Personal communication from Gould.



Shearwaters

Puffinus tenuirostris, P. griseus

3.42



Base map data sources: NOAA Environmental Information and Data Center (NEIDC), University of Alaska, 1982; Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey: Professional Paper 759-B; USGS Open File Report 81-486; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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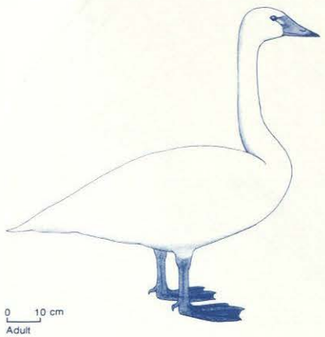


Tundra Swan

Cygnus columbianus

3.43

Description

Category

Bird

Classification

Class—Aves
Order—Anseriformes
Family—Anatidae

Name

Tundra swan, *Cygnus columbianus* (whistling swan)

Legal Status

Protected under Migratory Bird Treaty Act of 1918 (P.L. 65-186), amended.

Range

Worldwide (A.O.U., 1957; Godfrey, 1966; Portenko, 1972; Sladen, 1973)—Principally nearctic. In summer: breed on coastal tundra from Kodiak Island to Hudson Bay; also probably on Chukchi Peninsula and Wrangel Island. Winter principally in temperate North America, south to southern California and North Carolina.

Region of Concern (Bailey, 1948; Fay and Cade, 1959; Gabrielson and Lincoln, 1959; Fay, 1961; Hall, 1972; Bellrose, 1976)—Summer: Banks Island, Northwest Territories, and arctic coast of Alaska, south to Unimak Island and Alaska Peninsula. Small numbers breed on northern Chukchi Peninsula, probably also on Wrangel Island. Winter: small numbers (less than 300) at tip of Alaska Peninsula, Unimak Island, and Izembek Lagoon.

Distribution (Gabrielson and Lincoln, 1959; Irving, 1960; Bartonek, 1969; King, 1970, 1977; Lensink, 1973; Pitelka, 1974)

Discrete Populations—None known.

Concentrations

- *Natural*—High breeding densities on Yukon-Kuskokwim and Colville deltas.
- *Commercial*—Not taken commercially.

Habitat (Gabrielson and Lincoln, 1959; Hall, 1972; Bergman, 1974; Johnson, Adams, and Morrell, 1975; Bellrose, 1976; Palmer, 1976b; Bergman et al., 1977)

Type—Littoral; brackish estuarine bays and lagoons. Breed near tundra ponds, lakes, and rivers.

Physical/Chemical—Tundra lakes, ponds, and rivers; fresh to brackish water, usually greater than 1.8 meters deep. Nest on adjacent tundra.

Life History (Bent, 1925; Fay, 1961; Sladen, 1973; Bergman, 1974; Johnsgard, 1975; Bellrose, 1976; Palmer, 1976a)

Social Behavior—Solitary breeders; extremely gregarious at other times. Families and pairs are social units in flocks. Migrating and wintering flocks may contain hundreds to thousands of individuals.

Biological Associations—None in region of concern; on wintering grounds, associate with Canada geese.

Nutrition

- *Feeding type*—Mainly herbivore; omnivore in winter.
- *Food*—Aquatic plants, such as widgeon grass (*Ruppia spiralis*), bur reed (*Sparganium*), buckwheat (*Polygonum*), tubers of arrowhead (*Sagittaria*), horsetails (*Equisetum*), rushes (*Eleocharis, Scirpus*). In Alaska, pondweed (*Potamogeton*). Also take bivalves in wintering areas.
- *Feeding behavior*—Grazers, dabblers, bottom-feeders. Occasionally dig out roots of sedges.
- *Feeding location*—Shallow tundra ponds, coastal marshes, salt and fresh water, estuaries, river mouths, deltas, agricultural fields.

Reproduction (Bent, 1925; Bailey, 1948; Fay and Cade, 1959; Gabrielson and Lincoln, 1959; Irving, 1960; Fay, 1961; King, 1970, 1977; Hall, 1972; Portenko, 1972; Bergman, 1974; Gollop and Richardson, 1974; Pitelka, 1974; Bellrose, 1976; Palmer, 1976a; Scott, 1977; Spindler, 1978a,b)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Near shallow lakes, ponds, and rivers in tundra on coastal plain. Nest is mound of mosses, grasses, sedges, 0.3-0.6 meters high, often on edge of lake or estuary.
- *Behavior*—High mate fidelity; potentially lifelong. Male defends mate, expelling intruders. Copulate in water. Nesting pairs strongly territorial; greatest nesting density 12 pairs per square kilometer. Female usually incubates; male guards nest.
- *Biology*—Eggs laid shortly after arrival on breeding grounds, late May-early June. Clutch size 4-5 eggs; incubation period 30-32 days; hatch late June-early July. Hatching success generally less than 90%; fledging success low because of predation on young and adverse weather.

Development (Lensink, 1973; Sladen, 1973; Bellrose, 1976; Palmer, 1976a; Biderman et al., 1978)—Young and adults remain within 250 meters of nests on tundra or nearby waters for about 85 days after hatching, then begin to flock with non-breeders for fall migration. Age at first breeding unknown; probably 3 years or more.

Growth (Johnsgard, 1975; Bellrose, 1976; Palmer, 1976a)—Males increase from about 0.2 kg at hatching to 5.6 kg within 70 days; females slightly smaller. Fledge at 60-75 days. Adults average 6.5 kg, 125 cm long. Maximum lifespan 15-20 years.

Movements (King, 1970, 1977; Sladen, 1973; Koski, 1975, 1977a; Spindler, 1978b)—Spring migration in region of concern late April-late May, mainly via Yukon, Tanana, and Mackenzie valleys. Siberian birds cross Bering Sea via St. Lawrence Island and Bering Strait. Fall migration late September-early October via same routes.

Factors Influencing Populations

Natural (Johnsgard, 1975; Bellrose, 1976; Palmer, 1976a)—Predation on young by foxes, otters, mink; adverse weather during migration or at breeding grounds reduces breeding success; fowl cholera causes mortality on wintering grounds.

Human-related (Gabrielson and Lincoln, 1959)—Small subsistence take by Alaskan Natives. Suffer lead poisoning on wintering grounds. Hunted in some states.

Potential (Bartonek, 1969; Bergman et al., 1977; King, 1977; King and Sanger, 1979)—Ranked 63rd of 176 species in northeast Pacific in oil vulnerability index. Moderately susceptible to oiling. Modification of coastal wetlands by petroleum and hydroelectric development could destroy some nesting habitat. Colville Delta concentration potentially most threatened. Detrimental effect of increasing wintering populations on agricultural lands and commercial clam beds may result in initiation of hunting in Alaska and Atlantic states.

Population Size (Sladen, 1973; King and Dau, 1981)

About 75,000 in region of concern; nearly one-half of USA wintering population.

Management

Completely protected in most areas; several states allow experimental hunting. Possibility of harvest considered in Alaska and eastern USA because of increasing swan populations and resulting damage to agriculture and clamming industries on wintering grounds.

Persons Consulted

J. G. King, U. S. Fish & Wildlife Service, Juneau, Alaska.
R. J. King, U. S. Fish & Wildlife Service, Fairbanks, Alaska.
C. J. Lensink, U. S. Fish & Wildlife Service, Anchorage, Alaska.
W. J. L. Sladen, Department of Pathobiology, School of Hygiene and Public Health, The Johns Hopkins University, Baltimore, Maryland.
D. E. Timm, Alaska Department of Fish & Game, Anchorage, Alaska.

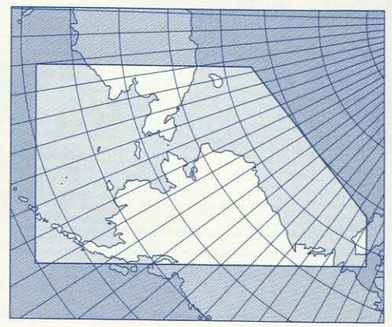
Legend

- Adult Area (Year-round)
- Adult Area (May-October)
- Major Adult Area (May-October)
- Migration (April-May)
- Migration (September-October)

Adults occur June-October north of Bering Strait and May-September south of Bering Strait. Breeding (May-September) occurs throughout adult areas and interior Alaska. Eggs are laid late May-early June; they hatch late June-early July. Young fledge in August-September. Juveniles occur throughout adult areas. Wintering areas are primarily in temperate North America.

Map References

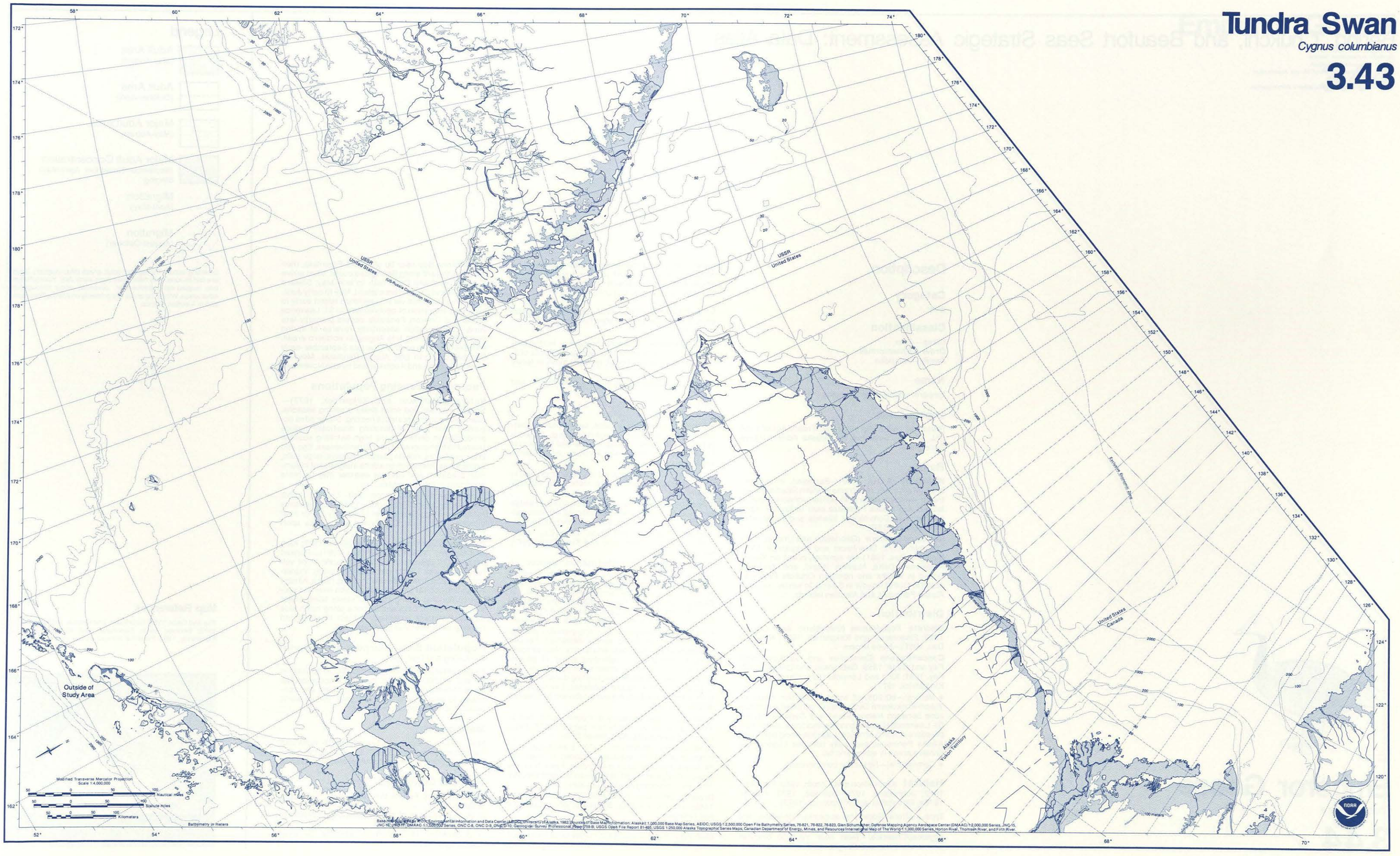
Fay and Cade, 1959; Portenko, 1972; Bellrose, 1976; Palmer, 1976a; Drury, Ramsdell, and French, 1981. Personal communication from J. King.



Tundra Swan

Cygnus columbianus

3.43



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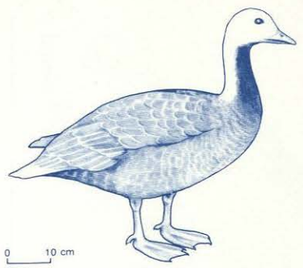


Emperor Goose

Chen canagica

3.44

Description

Category

Bird

Classification

Class—Aves
Order—Anseriformes
Family—Anatidae

Name

Emperor goose, *Chen canagica*

Legal Status

Protected under Migratory Bird Treaty Act of 1918 (P.L. 65-186), amended, and Alaska Administrative Code, 1984.

Range

Worldwide (A.O.U., 1957)—Beringian. In summer, breed in subarctic of extreme eastern Siberia and extreme western Alaska. In winter, inhabit Aleutian Islands and Alaska Peninsula east to Kodiak Island and west to Commander Islands and Kamchatka Peninsula in USSR.

Region of Concern (Gabrielson and Lincoln, 1959; Portenko, 1972; Eisenhauer and Kirkpatrick, 1977; King and Dau, 1981)—In summer, breed on Yukon-Kuskokwim Delta, Nunivak Island, and Kotzebue Sound in Alaska and northern Chukchi Peninsula south to Gulf of Anadyr in Siberia. In winter, found on Alaska Peninsula and Aleutian Islands.

Distribution

Discrete Populations (Gabrielson and Lincoln, 1959; Eisenhauer and Kirkpatrick, 1977; King and Dau, 1981)—None known.

Concentrations (Dement'ev and Gladkov, 1952; Fay and Cade, 1959; Gabrielson and Lincoln, 1959; Fay, 1961; King and Lensink, 1971; Eisenhauer and Kirkpatrick, 1977)

- *Natural*—80-90% of world population nests on Yukon-Kuskokwim Delta; mainly confined to coastal zone between Nelson Island and Cape Romanzof. St. Lawrence Island is principal molting area for nonbreeders in North America. Lagoons along north side Alaska Peninsula, especially Izembek Lagoon, are primary areas in spring and fall.
- *Commercial*—Not taken commercially.

Habitat (Gabrielson and Lincoln, 1959; Portenko, 1972; Johnsgard, 1975; Bellrose, 1976; Palmer, 1976a; Eisenhauer and Kirkpatrick, 1977)

Type—Littoral. Rocky shores (primarily in winter) and brackish lagoons. Breed on coastal wetlands.

Physical/Chemical—Nest near fresh to brackish ponds, streams, and sloughs, seldom far from tidewater; also on wet meadows with low relief. Molting congregations on brackish lagoons and deltas. Principally marine and brackish environments in winter, including reefs, rocks, and shoal waters.

Life History (Bent, 1925; Bailey, 1948; Delacour, 1954; Johnsgard, 1965; Headley, 1967; Portenko, 1972)

Social Behavior—Solitary breeders; mildly gregarious at other times of year. Migrate in flocks of 2-15 individuals. Highly social; typically move in family groups.

Biological Associations—Often with brant and Canada geese.

Nutrition

- *Feeding type*—Omnivore.
- *Food*—Summer-fall: grasses, sedges, tundra berries, submerged aquatic vegetation (e.g., *Potamogeton*). Winter and molting: marine and freshwater algae, mollusks (especially *Mytilus*), crustaceans, and insects.
- *Feeding behavior*—Graze and dabble singly and in small groups, occasionally to more than 50 individuals.
- *Feeding location*—Summer: coastal tundra, sedge and mud-flats, and intertidal beaches. Winter: eelgrass beds, salt-marshes, and rocky marine shores.

Reproduction (Fay and Cade, 1959; Fay, 1961; Mickelson, 1973; Eisenhauer and Kirkpatrick, 1977; Kistchinski, 1980)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Coastal Bering and Chukchi seas: in Alaska, from Kotzebue Sound to Kuskokwim estuary, including St. Lawrence and Nunivak islands; in Siberia, from Kolyma River to Bering Strait, southward through Anadyr to Cape Navarin and Khatyrka. Nest on elevated sites on lowland tundra near water.
- *Behavior*—Monogamous; strong, probably lifelong, pair bond. Mate during spring migration. Female selects nest site; high nest-site fidelity. Nest as scattered territorial pairs, defending about 14 square meters around nest site; males more aggressive than females in territorial defense. Nesting density typically 18-27 pairs per square kilometer. Laying begins when site is snow-free; female incubates; both sexes defend nest site.
- *Biology*—Eggs laid early-late June; clutch size 3-11 eggs (mode 5); incubation period 22-26 days. Hatching success 66-80% (mean 75%).

Development (Mickelson, 1973; Eisenhauer and Kirkpatrick, 1977)—Goslings brooded in nest 12-24 hours, then led away by parents. Feed in family groups. Fledge at 50-60 days. Mean fledging success 78%. First breeding at about 3 years.

Growth (Delacour, 1954; Gabrielson and Lincoln, 1959)—Adults 2.7-3 kg, 66-68 cm long. Maximum age unknown.

Movements (Eisenhauer and Kirkpatrick, 1977)—In early April, migrate eastward in Aleutians, westward from Kodiak, to Alaska Peninsula. Most apparently enter Bering Sea near tip of Alaska Peninsula, then move northward along Bering Sea coast. Most arrive Yukon-Kuskokwim Delta mid- to late May; Seward Peninsula and St. Lawrence Island, May to early June. Siberian birds cross via St. Lawrence Island early to mid-June. Migration of nonbreeders to St. Lawrence Island and Chukchi Peninsula occurs primarily late June. Fall migration essentially reverse of spring migration, beginning late August in northern areas, mid-September in south. Arrive late September-early October on north side Alaska Peninsula. Move to Aleutian Islands and Kodiak Island by late November.

Factors Influencing Populations

Natural (Eisenhauer and Kirkpatrick, 1977)—Severe weather and snow delay breeding seasons. Meltwater flooding restricts nesting. Storm tides occurring near peak of hatching drastically reduce production in certain years. High hatching success related to high degree of nest attentiveness. Egg and chick predators include parasitic jaegers, large gulls, Arctic foxes. Predation on adults insignificant in summer; predation and adverse weather may be more important in fall and winter.

Human-related (Gabrielson and Lincoln, 1959; Eisenhauer and Kirkpatrick, 1977)—Subsistence hunting and egging significant mortality factor near villages. Fewer than 5,000 killed annually by sport hunters.

Potential (Eisenhauer and Kirkpatrick, 1977; King and Sanger, 1979; King and Dau, 1981)—Ranked 19th of 176 species in northeast Pacific in oil vulnerability index. Highly susceptible to oiling. Vulnerable to oil pollution in coastal breeding range. Almost all nesting habitat just above mean sea level and subject to flooding during periodic storm tides. Major staging areas in bays and lagoons along north side Alaska Peninsula potentially subject to oil-related development, alteration, and spills.

Population Size (Eisenhauer and Kirkpatrick, 1977; King and Dau, 1981)

Earlier estimates varied from 175,000 to 200,000 in fall and 140,000 to 160,000 in spring. Population has since declined drastically to 71,000 in 1984 and continues to decrease at 10% per year. Entire world population in region of concern.

Management

May be taken legally in season. North American harvest managed by U.S. Fish & Wildlife Service and Canadian Wildlife Service; totally protected in USSR.

Persons Consulted

C. P. Dau, U. S. Fish & Wildlife Service, Cold Bay, Alaska.
F. H. Fay, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
C. J. Lensink, U. S. Fish & Wildlife Service, Anchorage, Alaska.

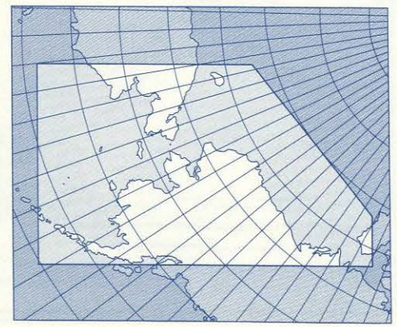
Legend

- Adult Area (May-August)
- Adult Area (October-April)
- Major Adult Area (May-August)
- Major Adult Concentration (September-November, April-May) Staging
- Migration (April-May)
- Migration (August-October)

Breeding occurs throughout adult areas (May-August). Eggs are laid in June; they hatch late June-early July. Young fledge late August-early September. Juveniles occur throughout adult areas. Wintering areas are primarily on Alaska Peninsula and in Aleutian Islands.

Map References

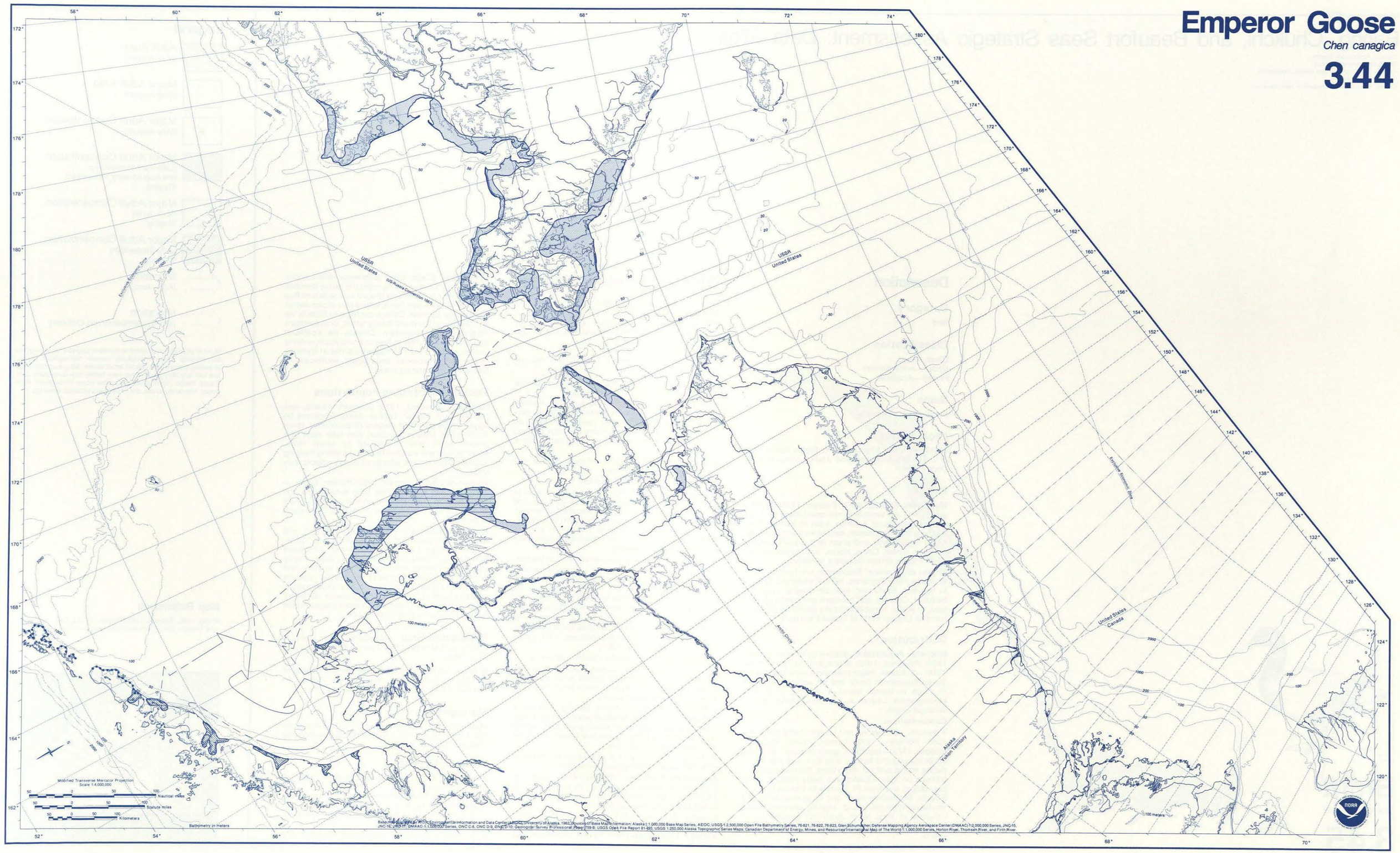
Fay and Cade, 1959; Gabrielson and Lincoln, 1959; Portenko, 1972; Bellrose, 1976; Eisenhauer and Kirkpatrick, 1977; Kistchinski, 1980. Personal communication from Bartonek.



Emperor Goose

Chen canagica

3.44



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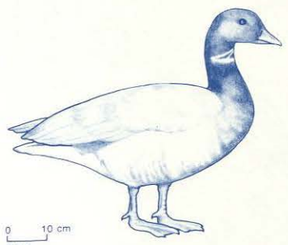


Brant

Branta bernicla

3.45

Description

Category

Bird

Classification

Class—Aves
Order—Anseriformes
Family—Anatidae

Name

Brant, *Branta bernicla*

Legal Status

Protected under Migratory Bird Treaty Act of 1918 (P.L. 65-186), amended, and Alaska Administrative Code, 1984.

Range

Worldwide (A.O.U., 1957; Palmer, 1976a; Johnsgard, 1978)—In summer, arctic coast of eastern Asia and western North America, west to Yenisei River and New Siberian Islands, east to western Canadian Arctic Archipelago, and south to Yukon-Kuskokwim Delta. In winter, China, Korea, and Japan; coastal North Pacific; British Columbia to Mexico.

Region of Concern (Gabrielson and Lincoln, 1959; Einarsen, 1965; Portenko, 1972; Kistchinski, 1980)—In summer, breed and molt on coastal tundra of Beaufort, Chukchi, and northern and central Bering seas. In winter, variable numbers (less than 5,000) at Izembek Lagoon at tip of Alaska Peninsula.

Distribution

Discrete Populations (Gabrielson and Lincoln, 1959; Portenko, 1972; Johnsgard, 1975; Bellrose, 1976)—In Alaska, major breeding concentrations on Yukon-Kuskokwim Delta and on arctic coast from Pt. Hope to Barter Island; in Siberia, at Kresta, Mechigmensk, Lawrence, and Chaun bays, and on Wrangel Island.

Concentrations

- *Natural* (Gabrielson and Lincoln, 1959; Einarsen, 1965; Portenko, 1972; Palmer, 1976a; King and Hodges, 1979)—Izembek Lagoon (Alaska Peninsula) major staging and feeding area for entire population during spring and fall migrations. Breeding concentrations on Yukon-Kuskokwim Delta (50% of world population) and from Pt. Barrow to Colville Delta. In Siberia, at Mechigmensk and Lawrence bays and southern Wrangel Island. Molting concentrations (10-20% of total North American population) at Teshekpuk Lake (west of Colville Delta) and Wrangel Island.
- *Commercial*—Not taken commercially.

Habitat (Gabrielson and Lincoln, 1959; Einarsen, 1965; Palmer, 1976a)

Type—Littoral. Brackish marshes and estuaries. Breeding: coastal tundra.

Physical/Chemical—Intertidal shallows. Water generally above freezing temperatures and of high salinity.

Life History (Johnson, Adams, and Morrell, 1975; Palmer, 1976a)

Social Behavior—Solitary to loosely colonial nesters. Gregarious in other seasons.

Biological Associations (Portenko, 1972; Palmer, 1976a)—Flock with Canada and emperor geese; nest on Wrangel Island with snow geese, St. Lawrence Island with common eiders. Move to sedge (*Carex*) meadows after breeding; winter in eelgrass (*Zostera marina*) lagoons.

Nutrition (Johnsgard, 1975; Johnson, Adams, and Morrell, 1975; Palmer, 1976a)

- *Feeding type*—Grazer; predator.
- *Food*—Eelgrass (*Zostera marina*) major food in migration and winter; also take sea lettuce (*Ulva*) and small amounts of fish eggs (especially herring), crustaceans, and mollusks. Young brant feed on larval insects, small crustaceans, and tender parts of sedges (*Carex*). Adults in breeding season take annual grasses and sedges.
- *Feeding Behavior*—Graze in small flocks at low tide.
- *Feeding location*—In summer, soft muddy islands with short annual grasses and sedges in river deltas and estuaries, occasionally with tundra perennials and taller grasses. In winter and during migration, tide pools, sloughs, lagoons, channels, and eelgrass beds.

Reproduction (Bent, 1925; Bailey, Brower, and Bishop, 1933; Manning, Höhn, and Macpherson, 1956; Gabrielson and Lincoln, 1959; Hansen, 1961; Jones and Jones, 1966; Barry, 1967)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Nest is depression lined with down, on wet to well-drained coastal tundra and deltas, just above high-tide line; also on low islands in tundra lakes and on dry inland slopes.
- *Behavior*—Strong, probably lifelong, pair bond. Nesting territories established when habitat snow-free. Colonial nesting, in small groups of two to several hundred pairs. Aggressive toward young as families disperse in October.
- *Biology*—Clutch size 4-5 eggs; incubation period about 24 days; hatching success 0-80%.

Development (Palmer, 1976a)—After hatching, young led to edges of tidal flats to feed; fledge at 45-50 days. Both parents guard young. About 10% breed at 2 years, most at 3 years.

Growth (Einarsen, 1965; Palmer, 1976a)—Adult males average 1.5 kg (maximum 1.8 kg); females average 1.3 kg (maximum 1.8 kg). Maximum age more than 8 years.

Movements (Cade, 1955; Gabrielson and Lincoln, 1959; Irving, 1960)—Spring migrants arrive Izembek Lagoon late April; move northward across Bristol Bay to Yukon-Kuskokwim Delta, where part of population remains for summer. Others continue to Siberia via St. Lawrence Island and Bering Strait, or to northern Alaska and northwestern Canada via Kotzebue Sound and major river valleys to arctic slope, arriving late May-early June. Fall migrants arrive at Izembek in September-October and depart southward in November to wintering areas.

Factors Influencing Populations

Natural (Johnsgard, 1975; Johnson, Adams, and Morrell, 1975; Palmer, 1976a)—Major predators on eggs include gulls and jaegers (*Stercorarius* spp.); Arctic foxes (*Alopex lagopus*) also take eggs and chicks. Nests often destroyed by storm tides, flooding; cold, wet weather reduces hatching, fledging success. Winter food (*Zostera*) supply affects survival.

Human-related (Einarsen, 1965; Palmer, 1976a)—Large number of mortalities from subsistence and sport hunting. This species constitutes up to 10% of coastal subsistence take of waterfowl in some areas.

Potential (Einarsen, 1965; Johnson, Adams, and Morrell, 1975; Jones and Jones, 1966; Palmer, 1976a; King and Sanger, 1979)—Ranked 19th of 176 species in northeast Pacific in oil vulnerability index. Highly susceptible to oiling. Hunting, inclement weather, and winter food supply (*Zostera*) apparently regulate population. Oil spills and habitat alteration, especially in areas such as Colville Delta (Kuparuk oil fields), Yukon-Kuskokwim Delta, and Izembek Lagoon could depress productivity and population.

Population Size (Johnsgard, 1975; Johnson, Adams, and Morrell, 1975; Palmer, 1976a; King and Dau, 1981)

Western North American population has averaged 150,000 in autumn, but recently has declined to 121,000. All decline is in region of concern.

Management

May be hunted legally in season. North American harvest managed by U.S. Fish & Wildlife Service and Canadian Wildlife Service.

Persons Consulted

J. C. Bartonek, U. S. Fish & Wildlife Service, Portland, Oregon.
F. H. Fay, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
C. J. Lensink, U. S. Fish & Wildlife Service, Anchorage, Alaska.
C. P. McRoy, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.

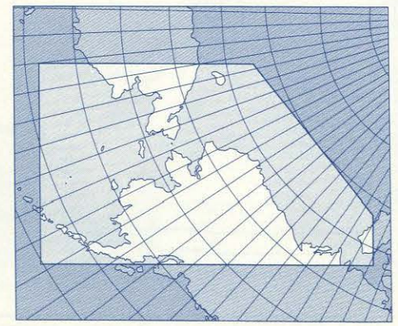
Legend

- Adult Area (May-August)
- Major Adult Area (May-August)
- * Major Adult Concentration (May-August)
- Major Adult Concentration (Late April to mid-May; late August-early November) Staging
- Major Adult Concentration (May-June) Staging
- Major Adult Concentration (July-September) Molting
- Migration (April-June)
- Migration (Mid-September to mid-October)

Most of population present in Izembek Lagoon for spring and fall staging; some individuals remain throughout winter. Breeding occurs throughout adult areas (May-August). Eggs are laid late May-early June; they hatch late June-early July. Young fledge July-August. Juveniles occur throughout adult areas. Wintering areas are in temperate North America.

Map References

Irving, 1960; Bellrose, 1976; Palmer, 1976a; Drury, Ramsdell, and French, 1981. Personal communication from Bartonek.



Brant

Branta bernicla

3.45



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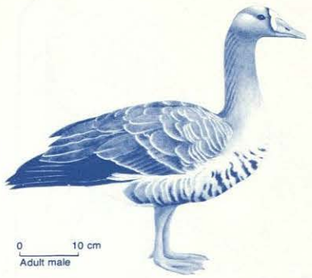


Greater White-fronted Goose

Anser albifrons

3.46

Description

Category

Bird

Classification

Class—Aves
Order—Anseriformes
Family—Anatidae

Name

Greater White-fronted goose, *Anser albifrons*

Legal Status

Protected under Migratory Bird Treaty Act of 1918 (P.L. 65-186).

Range (Johnsgard, 1978; Palmer, 1976a)

Worldwide—Holarctic. Arctic (except for northeastern Canada) in summer. Temperate inland valleys (Yukon Delta subspecies) and coastal marshes (arctic and interior populations) in winter.

Region of Concern—Mainland tundra, where summer breeding occurs.

Distribution (Portenko, 1973; Bellrose, 1976; Palmer, 1976a; Johnsgard, 1978)

Discrete Populations—Two North American populations: Yukon-Kuskokwim Delta and interior Alaska.

Concentrations

- *Natural*—High breeding densities on Yukon-Kuskokwim Delta, interior Kotzebue Sound, North Slope of Alaska, and MacKenzie Delta.
- *Commercial*—Not taken commercially.

Habitat (Palmer, 1976a; Johnsgard, 1978)

Type—Brackish lagoons, tidal flats, salt marshes, and coastal tundra. Breed on a wide range of marsh and tundra habitats.

Physical/Chemical—Occupy a wide variety of tundra habitats; more frequently associated with freshwater than with marine habitats.

Life History (Palmer, 1976a; Johnsgard, 1978)

Social Behavior—Gregarious except during breeding season; nesting usually occurs in solitary pairs. Flocks are unstable, but majority of persistent groups are families and paired birds.

Biological Associations—Associate with Canada goose during migration.

Nutrition

- *Feeding type*—Primarily herbivorous.
- *Food*—Largely vegetation, especially grasses, sedges, aquatic plants, and berries. Small quantities of insects and mollusks.
- *Feeding behavior*—Grazing and gleaning.
- *Feeding location*—Coastal tundra and marshes; agricultural fields in winter.

Reproduction

- *Mode*—Sexual; internal fertilization.
- *Location*—Primarily in coastal tundra habitats, but occupy a wide range of habitats in both coastal and interior locations.
- *Behavior*—High degree of mate fidelity, potentially lifelong. Usually nest in solitary pairs. Females incubate; males defend territory.
- *Biology*—Eggs laid shortly after arrival on breeding grounds, late May-early June. Clutch size 4-7 eggs. Incubation period 23-28 days.

Development—Young leave nest when they are dry, soon after hatching. After a week move with parents to molting areas (marshy areas or wet tundra), where food is abundant. Remain in family groups in fall, winter, and spring. Age at first breeding usually 3 years.

Growth—Young fledge at 45-55 days. Adult males average 2.8 kg; females 2.5 kg. Average life expectancy about 4 years. Maximum age 16 years.

Movements—Spring migration in region of concern late April-early June. Fall migration late August-early September. Yukon-Kuskokwim Delta birds fly over and next to Gulf of Alaska in spring and fall. Winter in Oregon and interior locations in western USA. Interior population moves to southern Alberta and Saskatchewan and winters on coast of western Gulf of Mexico.

Factors Influencing Populations

(Palmer, 1976a; Johnsgard, 1978; King and Sanger, 1979)

Natural—Parasitic jaeger, glaucous gull, and other nest predators prey on eggs. Weather influences overall breeding success.

Human-related—Hunting pressure in western USA during fall migration and winter, coupled with spring and summer hunting on breeding grounds and egging by Native Alaskans, has reduced populations.

Potential—Limited contact with marine habitats should minimize impacts from oil spills. Oil-related activities on tundra breeding grounds and molting areas could displace and/or decrease populations. Ranked 108th of 176 species in northeast Pacific in oil vulnerability index.

Population Size (Bellrose, 1976; Palmer, 1976a)

Estimates from 1982 of late summer populations include 250,000 in Alaska and 50,000 in western and central Canadian arctic. Breeding population of the Yukon-Kuskokwim Delta declined from early 1970s to early 1980.

Management

May be taken legally in season. North American harvest managed by U.S. Fish & Wildlife Service.

Persons Consulted

R.L. Garrett, U.S. Fish & Wildlife Service, Bethel, Alaska.

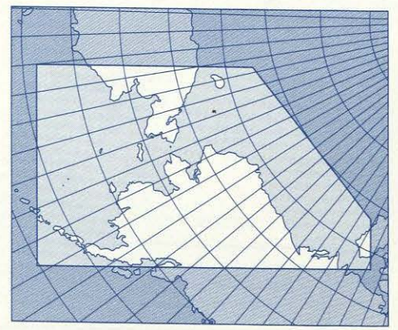
Legend

- Adult Area (May-October)
- Adult Area (June-August)
- Major Adult Area (May-October)
- Major Adult Area (June-August)
- Migration (late April-early June)
- Migration (August-September)

Breeding occurs throughout adult areas. Eggs are laid late May-early June; they hatch June-early July. Young fledge mid- to late August. Juveniles occur throughout adult areas.

Map References

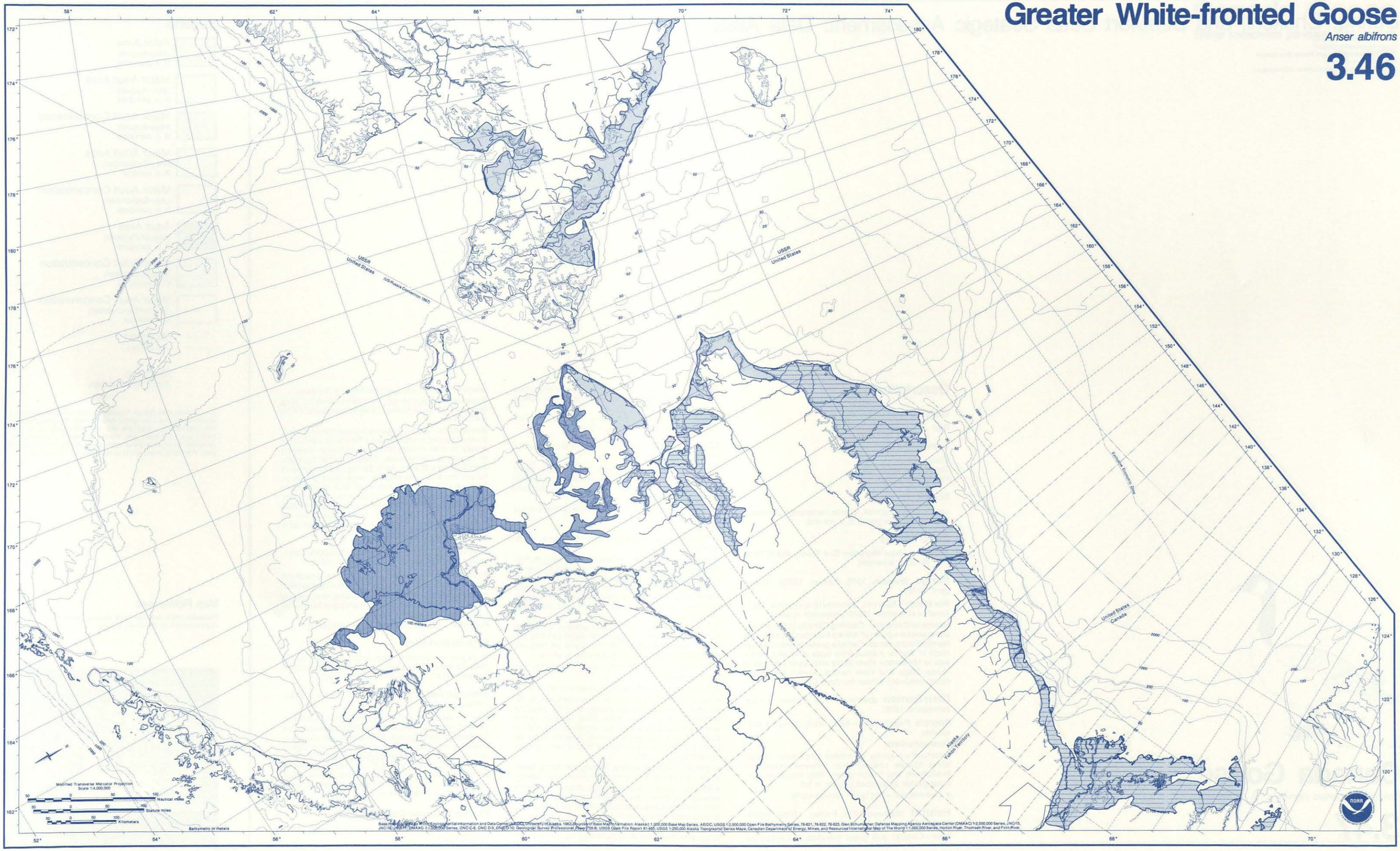
Portenko, 1973; Bellrose, 1976; Palmer, 1976a. Personal communication from Bartonek.



Greater White-fronted Goose

Anser albifrons

3.46



Base map data prepared by MMC Environmental Information and Data Center (AEIDC), University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC/15, JNC/16, JNC/17, DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-405; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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Adult, *Branta canadensis*

Canada Goose

Branta canadensis parvipes, B. c. minima

3.47

Description

Category

Bird

Classification

Class—Aves
Order—Anseriformes
Family—Anatidae

Name

Lesser Canada goose, *Branta canadensis parvipes*; cackling Canada goose, *B. c. minima*

Legal Status

Protected under Migratory Bird Treaty Act of 1918 (P.L. 65-186), amended.

Range (Bellrose, 1976; Palmer, 1976a; Johnsgard, 1978)

Worldwide—Nearctic. Temperate and arctic North America in summer. North temperate in winter.

Region of Concern—Cackling Canada goose breeds along western coast of Alaska from Nushagak Bay to Norton Sound. Lesser Canada goose breeds through much of interior Alaska, from base of Alaska Peninsula to Mackenzie River delta and upper reaches of Yukon Delta and from central Alaska and arctic coast, eastward across northern Canada.

Distribution (Bellrose, 1976; Palmer, 1976a; Johnsgard, 1978)

Discrete Populations—See distributions of subspecies.

Concentrations

- *Natural*—Majority of *minima* population occurs along 10-mile coastal strip between mouths of Kuskokwim and Yukon rivers. Fifty thousand *parvipes* gather at Izembek Lagoon in fall.
- *Commercial*—Not taken commercially.

Habitat (Bellrose, 1976; Palmer, 1976a; Johnsgard, 1978)

Type—Coastal: salt grass marshes and estuaries. Breeding: in coastal and interior tundra and other freshwater habitats. Winter: in interior river valleys and coastal estuaries.

Physical/Chemical—Primarily associated with freshwater habitats, but also estuarine.

Life History (Bellrose, 1976; Palmer, 1976a; Johnsgard, 1978)

Social Behavior—Gregarious; strong pair bond; have strong fidelity to specific migration routes and wintering grounds, which results in highly localized populations.

Biological Associations—Associate with brant and emperor geese.

Nutrition

- *Feeding type*—Predominantly herbivore; occasionally carnivore.
- *Food*—Shoots of marsh grasses and sedges, berries, aquatic plants and seeds, clover, and cultivated grain. Agricultural crops are mainstay during migration in temperate areas and on wintering grounds, but also eat grasses. Known to eat insects, crustaceans, mollusks, perhaps taken with plant food; fish occasionally ingested.
- *Feeding behavior*—Principally grazing. Daily feeding flights may be in large, loose aggregations, but families usually maintain identity. Make morning and evening feeding flights up to 30 miles in winter.
- *Feeding location*—Edges of ponds and fields.

Reproduction

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Typically nest in dense marshes, fields, on small islands, less commonly on cliffs, elevated platforms, or in trees. Nest sites variable within species, but mostly in drier and slightly elevated locations. *Minima* subspecies mainly selects islets on pond-studded tundra of coastal Yukon Delta, choosing wet, sedgy tundra.
- *Behavior*—Monogamous; lifelong pair bond. Nesting territory defended by male. High nest-site fidelity.
- *Biology*—Clutch size 4-7 eggs; incubation period averages 26 days. Time of egg-laying in region of concern late May-early June, but is highly variable at any locality depending on earliness or lateness of season.

Development—Young leave nest with parents 24 hours after hatching. Broods remain near nest sites; fledge in 45-50 days. Typically breed at 3 years.

Growth—Average weight for *minima* males is 1.5 kg, females 1.25 kg; *parvipes*, 2.7 kg for males and 2.4 kg for females.

Movements—Cackling goose leaves Yukon-Kuskokwim Delta and crosses Alaska Peninsula and Gulf of Alaska to area of Columbia River before proceeding to interior wintering areas. Departs wintering areas from February to early April. Spring route reverse of fall but more inshore. Majority of *parvipes* gather at Izembek Lagoon in fall and cross Gulf of Alaska to Skagit Bay before moving to interior wintering areas. Spring migration is in interior river valleys of British Columbia and Alaska. Both subspecies arrive on breeding grounds in region of concern in May-early June.

Factors Influencing Populations (Bellrose, 1976; Palmer, 1976a; Johnsgard, 1978)

Natural—Weather conditions and fox predation most important factors in reducing breeding success.

Human-related—Subsistence hunting and egging on breeding grounds, and sport hunting in fall migration and on wintering grounds.

Potential—Oil pollution, coastal development.

Population Size

In region of concern, population of *parvipes* in 1984-85 estimated at 100,000; *minima* estimated at 26,000 in 1983, down from 380,000 in 1965.

Management (Bellrose, 1976; Palmer, 1976a; Johnsgard, 1978)

May be taken legally in season. North American harvest managed by U.S. Fish & Wildlife Service and Canadian Wildlife Service. Due to dramatic decline in *minima* population, subsistence harvest and egging on Yukon-Kuskokwim Delta is being reduced through cooperation of local Native groups and Federal and state agencies. Sport hunting during fall migration and on wintering grounds is being severely reduced by U.S. Fish & Wildlife Service.

Persons Consulted

J. C. Bartonek, U. S. Fish & Wildlife Service, Portland, Oregon.

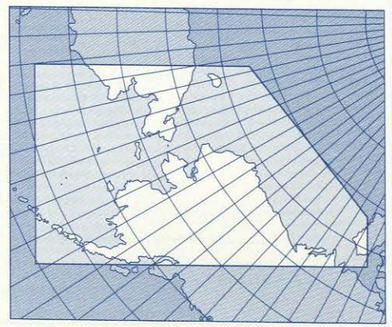
Legend

- Adult Area (May-August) *B. c. parvipes*
- Major Adult Area (May-August) *B. c. parvipes*
- Major Adult Concentration (May-August) *B. c. parvipes*
- Major Adult Area (May-September) *B. c. minima*
- Major Adult Concentration (July-September) *B. c. parvipes*
- Adult Area (August-October) *B. c. parvipes*
- Major Adult Concentration (August-October) *B. c. parvipes*
- * Major Adult Concentration (September-October) *B. c. minima*
- Migration (April-May)
- Migration (September-October)

B. c. minima also occurs August-October on Nunivak Island. Breeding occurs throughout adult areas (May-August and May-September). Eggs are laid late May-early June; they hatch late June-early July. Young fledge early-late August. Juveniles occur throughout adult areas during same times of year. Wintering areas are in temperate North America.

Map References

Portenko, 1972; Bellrose, 1976; Palmer, 1976a. Personal communications from Bartonek; J. King.



Canada Goose

Branta canadensis parvipes, B. c. minima

3.47



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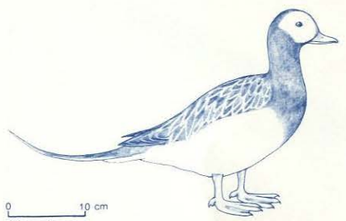


Oldsquaw

Clangula hyemalis

3.48

Description

Category

Bird

Classification

Class—Aves
Order—Anseriformes
Family—Anatidae

Name

Oldsquaw, *Clangula hyemalis* (long-tailed duck)

Legal Status

Protected under Migratory Bird Treaty Act of 1918 (P.L. 65-186), amended, and Alaska Administrative Code, 1984.

Range

Worldwide (A.O.U., 1957; Palmer, 1976b)—Holarctic. In summer, principally high arctic, south to Bristol Bay in western arctic and Labrador in eastern arctic. In winter, from open water in and south of Bering Sea pack ice, south to Japan, Washington State, and Virginia.

Region of Concern (Fay and Cade, 1959; Gabrielson and Lincoln, 1959; Fay, 1961; Portenko, 1972; Palmer, 1976b; Kistchinski, 1980)—In summer, breed on coastal tundra of mainland and islands of Bering, Chukchi, Beaufort seas. In winter, occupy Bering Sea nearshore to open waters in and south of pack ice.

Distribution (Fay and Cade, 1959; Gabrielson and Lincoln, 1959; Fay, 1961; Bartonek, 1969; Portenko, 1972; Palmer, 1976b; Richardson and Johnson, 1981)

Discrete Populations—None known.

Concentrations

- *Natural*—St. Lawrence Island, southern Chukchi Peninsula, Kuskokwim and Bristol bays in winter; also Koryak coast. Major staging areas of migrant and molting birds include Phillips Bay, Herschel Island, Simpson Lagoon, Jones Islands, Elson Lagoon, and Wrangel Island July-September.
- *Commercial*—Not taken commercially.

Habitat (Fay and Cade, 1959; Gabrielson and Lincoln, 1959; Fay, 196l; Johnsgard, 1975; Johnson, Adams, and Morrell, 1975; Bellrose, 1976; Palmer, 1976b)

Type—Marine: littoral to pelagic. Breed on coastal tundra, interior river valleys, and lakes.

Physical/Chemical—Water depths to 50 meters; fresh to marine. Leads in pack ice to ice-free sea; lakes and rivers in summer. Nest mainly on well-drained tundra near lakes and lagoons; also near inland lakes above timberline and in Yukon River valley.

Life History (Fay and Cade, 1959; Fay, 1961; Palmer, 1976b; Divoky, 1978a)

Social Behavior—Solitary breeders, but gregarious in other seasons.

Biological Associations—Occasionally nest among colonies of Arctic terns and near or among common eiders.

Nutrition (Johnsgard, 1975; Johnson, 1979)

- *Feeding type*—Predator. Occasionally omnivore.
- *Food*—Crustaceans, especially amphipods (*Gammarus*, *Caprella*), euphausiids (*Thysanoessa*), mysids (*Mysis*), as well as mollusks (*Mytilus edulis*, *Lacuna*, *Littorina*, and chitons). Insects, small fishes, and vegetation also important in summer.
- *Feeding behavior*—Pursuit-divers and bottom-feeders on benthic crustaceans and mollusks. In winter, forage during day, sometimes remaining on feeding grounds after dark on clear, calm nights. Tend to feed inshore.
- *Feeding location*—Nearshore, on or near bottom.

Reproduction (Brandt, 1943; Johnsgard, 1975; Johnson, Adams, and Morrell, 1975; Bellrose, 1976; Derksen, Rothe, and Eldridge, 1981)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Coastal tundra and islands of central and northern Bering, Chukchi, Beaufort seas; also in Yukon River valley and alpine areas. Most frequently near shallow lakes on coast. Nest is down-lined depression.
- *Behavior*—Annual pair bond. Not colonial nesters. Pair formation begins in wintering areas as early as December; nearly 70% of birds paired by May. Social displays and copulation on water. Female selects nest site. Nearly two-thirds of nests within 30 meters of nearest neighbor. After incubation begins, drakes usually leave females for molting areas. Females and young move to molting areas in August-September.
- *Biology*—Clutch size 5-10 (usually 6-8) eggs. Incubation period 24-26 days; begins when clutch completed (June-early July).

Development (Johnsgard, 1975; Bellrose, 1976)—Ducklings led to fresh water (sometimes salt water) ponds when only a few days old. Gradually move to large lakes and marine waters, where broods often coalesce. Swim well from beginning; fledge at 5 weeks. Age at first breeding 2 years.

Growth (Johnsgard, 1975)—Adult males average 500 grams, females 630 grams. Maximum age 10 years.

Movements (Johnson, Adams, and Morrell, 1975; Johnson, 1979; Richardson and Johnson, 1981; Woodby and Divoky, 1982)—Northward along shores of Bering-Chukchi seas May and early June; eastward through Beaufort Sea May-June. Some overland flights from southeastern and western Alaska toward upper Yukon and Mackenzie river drainages. First flocks almost exclusively males, later ones mixed. Peak numbers in Bering Strait late April, Pt. Barrow mid-May, Yukon-Beaufort late May. Drakes and non-breeders begin to move westward in Beaufort by mid-July. Migration by females with young begins late August; peaks at Pt. Barrow in September. Move southward toward wintering areas mid-October to December, as ice forms.

Factors Influencing Populations

Natural (Fay, 1961; Uspenskii, 1964; Palmer, 1976b)—Principal predators include snowy owls (*Nyctea scandiaca*), gulls, jaegers, gyrfalcons (*Falco rusticollis*), ravens (*Corvus corax*), Arctic foxes (*Alopex lagopus*). Fowl cholera has taken heavy toll on wintering concentrations in Atlantic.

Human-related (Palmer, 1976b)—Mass mortality of wintering concentrations from oil spills in Baltic and North seas. Hunting pressure low.

Potential (Palmer, 1976b; King and Sanger, 1979)—Ranked 28th of 176 species of marine birds from northeast Pacific in oil vulnerability index. Highly susceptible to oiling. Oil spills and fowl cholera may cause mass mortality in wintering areas.

Population Size (Fay, 1961; King and Lensink, 1971; Barry, 1974; Johnson, Adams, and Morrell, 1975; Palmer, 1976b; Johnson, 1979; Richardson and Johnson, 1981)

Total population unknown. Over 1.1 million migrated past Cape Dalhousie, Northwest Territories, in May-June 1972. At least 400,000 molt in coastal Beaufort Sea. About 500,000 estimated to winter near St. Lawrence Island. Westward migration past Pt. Barrow in fall at least 240,000 birds.

Management

May be taken legally in season. North American harvest managed by U.S. Fish & Wildlife Service and Canadian Wildlife Service.

Persons Consulted

F. H. Fay, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
S. R. Johnson, LGL Alaska Research Associates, Fairbanks, Alaska.
C. J. Lensink, U. S. Fish & Wildlife Service, Anchorage, Alaska.

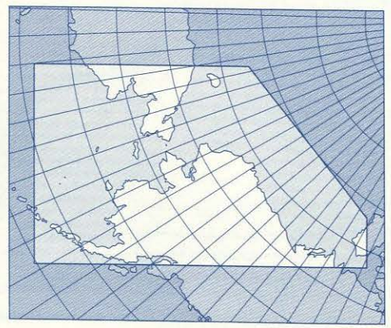
Legend

- Adult Area (Year-round)
- Adult Area (December-April)
- Adult Area (May-November)
- Major Adult Area (July-September) Molting
- Breeding Area (May-September)
- Migration (May-June)
- Migration (September-November)

Adults occur June-October north of Bering Strait. Eggs are laid June-early July; they hatch late July-early August. Young fledge late August-early September. Juveniles occur throughout adult areas. Wintering range extends to subarctic and temperate North Pacific.

Map References

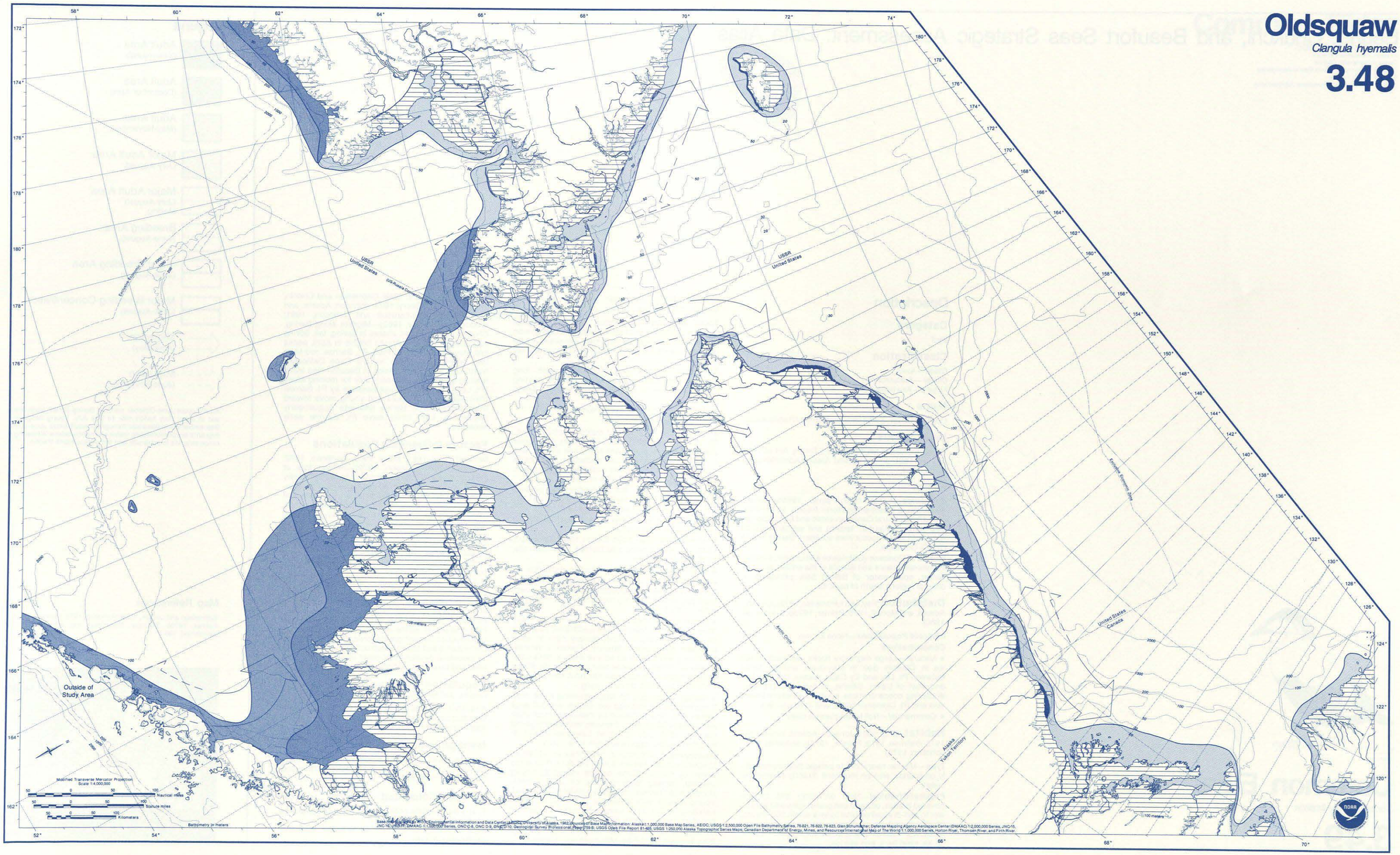
Gabrielson and Lincoln, 1959; Irving, 1960; Barry, 1974; Johnsgard, 1975; Bellrose, 1976; Palmer, 1976b; Johnson, 1979; Drury, Ramsdell, and French, 1981; Richardson and Johnson, 1981.



Oldsquaw

Clangula hyemalis

3.48

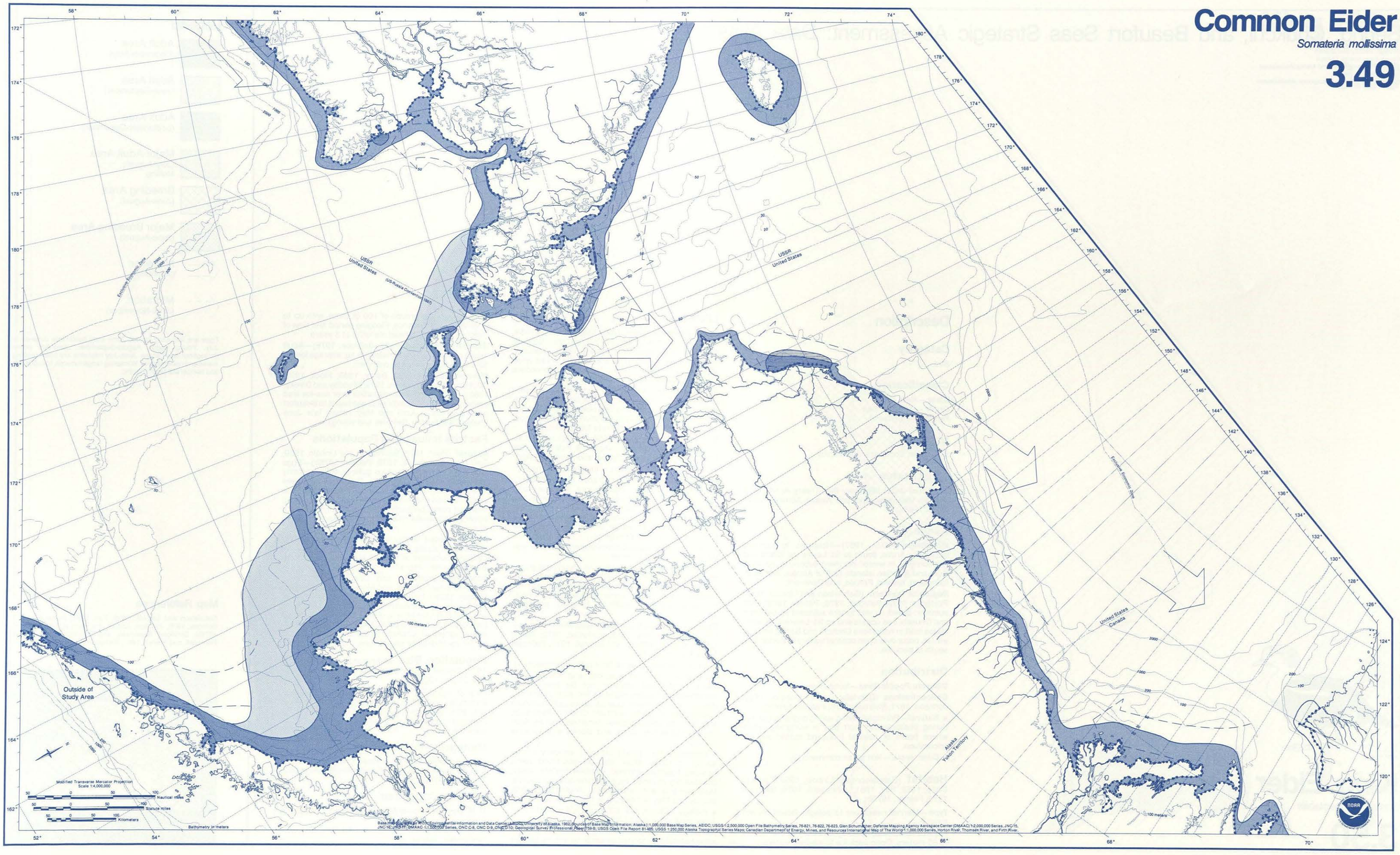


Base map data courtesy of the Environmental Information and Data Center (AEIDC), University of Alaska, 1982. Sources of Base Map Information: Alaska at 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Bohumsucher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17, DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

Common Eider

Somateria mollissima

3.49



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King Eider

Somateria spectabilis

3.50

Description

Category

Bird

Classification

Class—Aves
Order—Anseriformes
Family—Anatidae

Name

King eider, *Somateria spectabilis*

Legal Status

Protected under Migratory Bird Treaty Act of 1918 (P.L. 65-186), amended, and Alaska Administrative Code, 1984.

Range

Worldwide (A.O.U., 1957)—Holarctic. In summer, principally Arctic, south to St. Lawrence Island and Hudson Bay. In winter, northern subarctic, south to Kuril and Aleutian islands, Gulf of Alaska, and Newfoundland, Iceland, Faroes, and Denmark.

Region of Concern (Gabrielson and Lincoln, 1959; Portenko, 1972; Bellrose, 1976; Palmer 1976b)—In summer, breed on wet tundra adjacent to Beaufort and Chukchi Sea coasts and on St. Lawrence Island. Males molt in nearshore Chukchi and Bering seas. In winter, occur over open coastal waters of Bering Sea south of pack ice.

Distribution

Discrete Populations—None known.

Concentrations (Gabrielson and Lincoln, 1959; Johnson, 1971; Bellrose, 1976; Palmer, 1976b)

- *Natural*—Principally along spring migration routes during postbreeding molt and in wintering areas, where flocks of several thousand individuals not uncommon.
- *Commercial*—Not taken commercially.

Habitat

(Gabrielson and Lincoln, 1959; Fay and Cade, 1959; Fay, 1961; Johnsgard, 1975; Bellrose, 1976; Palmer, 1976b)

Type—Marine: nearshore to pelagic. Breed on wet tundra.

Physical/Chemical—Mainly shallow marine waters to 60 meters. Open pack ice to ice-free waters.

Life History

Social Behavior (Bent, 1925; Fay and Cade, 1959; Fay, 1961; Bellrose, 1976; Palmer, 1976b)—Solitary breeders, but gregarious during other seasons, especially during migration and staging; flocks up to 10,000-15,000. Adult males flock with nonbreeders after incubation begins.

Biological Associations (Fay, 1961; Derksen, Rothe, and Eldridge, 1981)—Flock and migrate with common eiders. Pendent grass (*Arctophila fulva*) is a key stimulus for nest-site selection, serving as food, protective cover, and substrate for aquatic prey.

Nutrition (Fay and Cade, 1959; Gabrielson and Lincoln, 1959; Fay, 1961; Bellrose, 1976; Palmer, 1976b; Divoky, 1978b; Derksen, Rothe, and Eldridge, 1981)

- *Feeding type*—Predator; omnivore in summer.
- *Food*—Mussels (*Mytilus*), razor clams (*Siliqua*), crustaceans (*Cancer*, *Dermaturus*, *Saduria*), and especially sea urchins and sand dollars; also sea stars, brittle stars, and sea cucumbers. Eelgrass (*Zostera*) taken when available; females and young feed in summer on midge larvae and freshwater plants, especially pendent grass.
- *Feeding behavior*—Bottom-feeders (to 54 meters); also graze in summer.
- *Feeding location*—Females and young pass entire summer in freshwater wetlands, especially with dense stands of pendent grass. Adult males and nonbreeders in summer, whole population in winter, forage at sea from sublittoral to about 60-meter depths.

Reproduction (A.O.U., 1983; Gabrielson and Lincoln, 1959; Godfrey, 1966; Portenko, 1972; Barry, 1974; Johnson, Adams, and Morrell, 1975; Bellrose, 1976; Palmer, 1976b)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Nest on tussocks and knolls along lakes, ponds, and streams, not far from coast; sometimes just above high-tide line. Nest is shallow, down-lined depression. Low densities along western Alaskan arctic coast, northern Chukchi Peninsula, and Wrangel Island; highest densities from Pt. Barrow to Mackenzie Delta and Banks and Victoria islands.
- *Behavior*—Pair bonds renewed annually during spring courtship. Most nest as scattered pairs; nearest neighbor several hundred meters away; occasionally in dense aggregations on river islands. Male remains with female until incubation begins, usually late May or early June, then departs.
- *Biology*—Clutch size 4-7 eggs, laid early to mid-June; incubation period 22-24 days.

Development (Bellrose, 1976; Palmer, 1976b)—After hatching, brood led to water by female; broods often merge into groups of 100 or more, with up to 9 females in attendance. Fledging period and time of fledging unknown. Sexual maturity at 3 years.

Growth (Johnsgard, 1975; Bellrose, 1976)—Adult males average 1.8 kg, females 1.6 kg; average length 53-58 cm. Maximum age unknown.

Movements (Hill, 1923; Barry, 1968; Flock, 1973; Gill, Handel, and Petersen, 1979; Woodby and Divoky, 1982)—Mass northward migration over sea-ice lead system of Bering-Chukchi seas eastward to Beaufort nesting areas in April and May; return late June (males), September (females and young).

Factors Influencing Populations

Natural (Bent, 1925; Gabrielson and Lincoln, 1959; Barry, 1968; Bellrose, 1976; Palmer, 1976b)—Eggs lost to Arctic foxes, glaucous gulls; juvenile mortality from jaegers, gulls, and foxes. Predation increases when lemming (*Lemmus*, *Dicrostonyx*) populations crash. Massive die-offs recorded in spring along Beaufort coast, probably related primarily to sea-ice cover, which results in lack of food, and secondarily to disease.

Human-related (Barry, 1968, 1974; Johnson, 1971; Johnson, Adams, and Morrell, 1975; Palmer, 1976b)—Subsistence take by Natives about 1% of Bering-Beaufort migrants.

Potential (Gabrielson and Lincoln, 1959; Barry, 1974; Johnson, Adams, and Morrell, 1975; King and Sanger, 1979; King and Dau, 1981)—Ranked 20th of 176 species in northeast Pacific in oil vulnerability index. Highly susceptible to oiling. Oil spilled in leads in Bering, Chukchi, or Beaufort seas in spring, nearshore waters of Chukchi in summer or Bering in winter could deplete populations.

Population Size

(Johnsgard, 1975; Bellrose, 1976; Palmer, 1976b; King and Dau, 198l; Woodby and Divoky, 1982)

One of the most abundant ducks in the region. Estimated population in North America about 2 million, 90% of which migrate through and winter in region of concern. About one million pass Pt. Barrow each fall.

Management

May be taken legally in season. North American harvest managed by U. S. Fish & Wildlife Service and Canadian Wildlife Service.

Persons Consulted

R. H. Day, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
C. J. Lensink, U. S. Fish & Wildlife Service, Anchorage, Alaska.

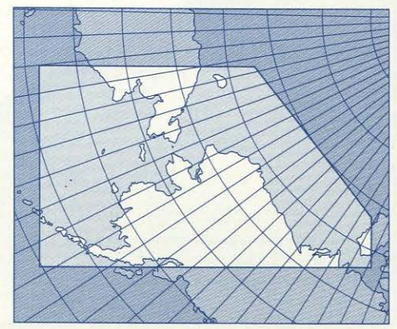
Legend

- Adult Area (December-May)
- Adult Area (June-September)
- Adult Area (September-December)
- Major Adult Area (July-August) Molting
- Breeding Area (June-August)
- Major Breeding Area (June-August)
- Migration (April-May)
- Migration (June-November)

Eggs are laid early to mid-June; they hatch late June-early July. Young fledge August-September. Juveniles occur throughout adult areas. June-July migrants are postbreeding males and nonbreeders. Wintering range extends to subarctic and temperate North Pacific.

Map References

Gabrielson and Lincoln, 1959; Fay, 1961; Portenko, 1972; Bellrose, 1976; Johnson, Adams, and Morrell, 1975; Palmer, 1976b; Springer, Roseneau, and Johnson, 1979; Drury, Ramsdell, and French, 1981; Richardson and Johnson, 1981.



King Eider

Somateria spectabilis

3.50



Base map compiled with Environmental Information and Data Center (EIDC), University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC-C-6, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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Bald Eagle

Haliaeetus leucocephalus

3.51

Description

Category

Bird

Classification

Class—Aves
Order—Falconiformes
Family—Accipitridae

Name

Bald eagle, *Haliaeetus leucocephalus*

Legal Status (Bent, 1937; Gabrielson and Lincoln, 1959; Murphy, 1977)

Protected under Migratory Bird Treaty Act of 1918 (P.L. 65-186), amended, and Bald Eagle Protection Act of 1940. In compliance with Endangered Species Protection Act of 1973 (P.L. 83-205), listed as "threatened" in Minnesota, Wisconsin, Michigan, Oregon, and Washington, and as "endangered" in all other states except Alaska.

Range

Worldwide (A.O.U., 1957; Brown and Amadon, 1968)—Nearctic. In summer, breed from central and southwestern Alaska and Ungava and Newfoundland to Baja California and southern Florida. In winter, seek ice-free coastal areas of North America; also interior lakes and rivers in contiguous USA.

Region of Concern (Grinnell, 1900; Gabrielson and Lincoln, 1959; Murie, 1959)—In summer, breed in Aleutian Islands and Alaska Peninsula north along Bering Sea and southern Chukchi Sea coast to Noatak River. Vagrants on North Slope to Mackenzie River. In winter, occur in northeast Bristol Bay south along Alaska Peninsula, and on Aleutian Islands.

Distribution

Discrete Populations—None known.

Concentrations (Gabrielson and Lincoln, 1959; Murie, 1959)

- *Natural*—Coasts, streams where anadromous fish spawn, dumps, and fish-processing plants on Alaska Peninsula and Aleutian Islands.
- *Commercial*—Not taken commercially.

Habitat (Gabrielson and Lincoln, 1959; Murie, 1959; Patten, 1982)

Type—Coastal, littoral, and estuarine; lakes, rivers. Breed on cliffs and sea stacks.

Physical/Chemical—Fresh and salt water. Primarily along coast, rarely found at sea.

Life History

Social Behavior (Gabrielson and Lincoln, 1959; Murie, 1959)—Solitary nesters. Often in pairs in all seasons. Frequently congregate near food sources when not breeding.

Biological Associations (Gabrielson and Lincoln, 1959; Murie, 1959; Patten, 1982)—With other scavengers and piscivorous species such as gulls, ravens, herons, crows, magpies, mergansers, and brown bears. In Aleutian Islands, frequently nest near large seabird colonies.

Nutrition (Gabrielson and Lincoln, 1959; Murie, 1959)

- *Feeding type*—Predator, scavenger.
- *Food*—Primarily seabirds in Aleutian Islands and near other large seabird colonies (fulmars, cormorants, gulls, murres, auklets, puffins; also petrels, kittiwakes, shearwaters, guillemots, ducks, and ptarmigan). In areas of large rivers, primarily anadromous fishes, especially dead or dying salmonids; also, trout, smelts, herring. Mammalian prey include ground squirrels, rats, mice, young sea otters, and foxes. Carrion includes marine mammals, seabirds, fishes, and invertebrates.
- *Feeding behavior*—Patrol shorelines, lakes, rivers; in flight, catch live fishes at surface of water, seabirds near colonies, waterfowl from sea surface or land. Stoop-dive up to 100 meters, striking and grasping prey with talons; carry or drag prey to feeding site or to chicks at nest.
- *Feeding location*—Typically shorelines, nearshore waters, and beaches; also garbage dumps.

Reproduction (Bent, 1937; Gabrielson and Lincoln, 1959; Murie, 1959; Brown and Amadon, 1968; Sprunt, 1969; Sherrod, White, and Williamson, 1977; Newton, 1979)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Nest on cliffs, pinnacles, sea stacks; occasionally on low ground free of terrestrial predators. Bulky nest made of dried forbs (*Heracleum*, *Angelica* stalks), sticks, and other vegetation. In wooded areas, show strong preference for black cottonwood and spruce trees.
- *Behavior*—Monogamous; long-term pair bond; courtship flights before nesting. New nest constructed each year, often on top of old one. Both parents incubate, feed young.
- *Biology*—Eggs laid April-May; clutch size 1-3 eggs per nest. Incubation period 34-36 days. Aleutian Islands birds have highest reproductive success, 1.2-1.5 chicks fledged per nest.

Development (Bent, 1937; Murie 1959; Brown and Amadon, 1968; Sherrod, White, and Williamson, 1977; Newton, 1979; Clapp, Klimkiewicz, and Kennard, 1982)—Chicks stay in nest 72-74 days; fledge late July to September. After fledging, young may stay in vicinity of nest site 1-2 months. Have adult plumage at 5-6 years. Age at first breeding possibly influenced by food availability and/or competition.

Growth (Brown and Amadon, 1968)—Young as large as adults at fledging. Adult weight 4-6 kg; females larger than males. Maximum age more than 10 years.

Movements (Gabrielson and Lincoln, 1959; Murie, 1959; Murphy, 1977; Sherrod, White, and Williamson, 1977; Patten, 1982)—Migrate in fall from interior and from northern and western coasts to ice-free coasts (e.g., Aleutian Islands, Gulf of Alaska); Aleutian Islands population nonmigratory, with some inter-island movement.

Factors Influencing Populations

Natural (Snow, 1973; Sherrod, White, and Williamson, 1977)—Severe weather reduces foraging efficiency, decreases reproductive success, and may lead to starvation. Ravens, gulls prey on eggs and chicks. Probably limited by availability of food and nest sites.

Human-related (Sprunt, 1969; Snow, 1973; MacKenzie, 1977; Murphy, 1977; Sherrod, White, and Williamson, 1977)—Attracted to garbage dumps and offal around fish-processing plants, increasing winter survival. Subject to inadvertent trapping, deliberate shooting, occasional electrocution on power lines, entanglement in man-made structures. DDT and related biocides caused precipitous declines of populations in other states. In general, sensitive to disturbance, especially near nest sites.

Potential (Snow, 1973; Sherrod, White, and Williamson, 1977; King and Sanger, 1979)—Increased human population, commercial development may reduce population by habitat alteration and by intrusion into previously undisturbed nesting areas. Artificial food subsidies from garbage, fish offal may encourage growth of eagle populations in some areas. Ranked 39th of 176 species in northeast Pacific in oil vulnerability index. Highly susceptible to oiling.

Population Size

Approximately 50,000 birds in Alaska; an unknown number (probably greater than 5% of Alaskan total) are in region of concern.

Management

Nongame species.

Persons Consulted

R. H. Day, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
D. D. Gibson, University of Alaska Museum, Fairbanks, Alaska.
J. I. Hodges, U. S. Fish & Wildlife Service, Juneau, Alaska.
P. F. Schempf, U. S. Fish & Wildlife Service, Juneau, Alaska.

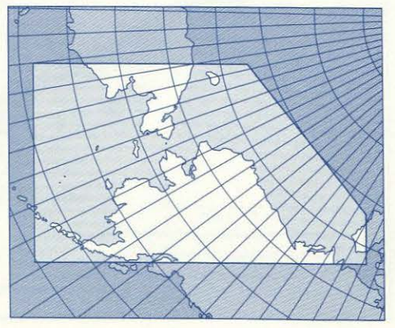
Legend

- Adult Area (April-October)
- Adult Area (May-September)
- Occasional Occurrence (June-September)
- Major Adult Area (October-November)
- Major Adult Area (October-March)

Breeding (April-September) occurs throughout adult areas. Eggs are laid April-May; they hatch May-June. Young fledge July-September. Juveniles occur throughout adult areas. Wintering range extends to Pacific Northwest.

Map References

Gabrielson and Lincoln, 1959; Murie, 1959; Portenko, 1972. Personal communications from Gibson; Roseneau; Schempf.



Bald Eagle

Haliaeetus leucocephalus

3.51



Base maps courtesy of the Environmental Information and Data Center (EIDC), University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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Adult, *Falco Peregrinus*

Peregrine Falcon

Falco peregrinus japonensis, F. p. pealei, F. p. tundrius

3.52

Description

Category

Bird

Classification

Class—Aves
Order—Falconiformes
Family—Falconidae

Name

Peregrine falcon, *Falco peregrinus japonensis*, *F. p. pealei*, *F. p. tundrius* (duck hawk)

Legal Status

Protected under Migratory Bird Treaty Act of 1918 (P.L. 65-186), amended. Subspecies *F. p. anatum* and *F. p. tundrius* listed as "endangered," according to Endangered Species Protection Act of 1973.

Range

Worldwide (A.O.U., 1957; Gabrielson and Lincoln, 1959)—In summer, arctic and subarctic. In winter, subarctic to Southern Hemisphere temperate.

Region of Concern (Gabrielson and Lincoln, 1959)—In summer, coasts of Bering, Chukchi, and Beaufort seas and interior river valleys where nesting sites available. In winter, Aleutians and north side of Alaska Peninsula.

Distribution

Discrete Populations (Cade, 1960; White, 1969, 1975; White and Cade, 1971, 1977; Portenko, 1972; Kistchinski, 1980)—Three races in region of concern: *F. p. tundrius* on tundra of northern North America; *F. p. pealei* on Aleutians and Alaska Peninsula (occasionally Pribilofs); *F. p. japonensis* throughout northeast Siberia.

Concentrations

- *Natural* (Kessel and Cade, 1958; Cade, 1960; White, 1969, 1975; White and Cade, 1971, 1977; White, Emison, and Williamson, 1971; White, Ray, and Sowl, 1977; Portenko, 1972)—In Alaska, highest densities of *tundrius* on Colville, Sagavanirktok rivers; *pealei* on Aleutian Islands, western Alaska Peninsula. No high densities of *japonensis* known in Siberia.
- *Commercial*—Not taken commercially.

Habitat (Cade, 1960; White, 1969, 1975; White and Cade, 1971, 1977; Portenko, 1972)

Type—Coastal in study area. Breed on coastal and interior cliffs.

Physical/Chemical—Breed on vegetated platforms on cliff faces, steep bluffs, offshore stacks; occasionally roost in trees; otherwise, mainly aerial.

Life History

Social Behavior (Bent, 1938)—Solitary or paired; sometimes with young (late in year); strongly territorial.

Biological Associations—Frequently breed near rough-legged hawks (*Buteo lagopus*).

Nutrition (Bent, 1938; Cade, 1960; White, 1969, 1975; White and Cade, 1971, 1977; Portenko, 1972)

- *Feeding type*—Predator.
- *Food*—Feed on large number of bird species. North Slope falcons take primarily shorebirds and passerines, especially plovers (*Pluvialis* spp.) and Lapland longspurs (*Calcarius lapponicus*); Bering Sea falcons take mostly small alcids and gulls.
- *Feeding behavior*—Birds taken in flight, occasionally on water. Stoop-dive, catching small prey in talons, striking larger birds on back.
- *Feeding location*—On coast, frequently forage around seabird colonies. Inland, forage along waterways and near nesting areas.

Reproduction (Bent, 1938; Gabrielson and Lincoln, 1959; Cade, 1960; White, 1969, 1975; White and Cade, 1971, 1977)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Nest in depressions on vegetated ledge of river bluffs, coastal cliffs, or sea stacks.
- *Behavior*—Long-term pair bond; pairs may form or remain together away from breeding sites. Aerial display and nest-site inspection first by male, then female. Nesting territory defended mainly by display, rarely by fatal combat. Copulate on nest or nearby perch. Male usually supplies food to female during egg-laying and early incubation; also may incubate or brood while female feeds or rests nearby.
- *Biology*—Eggs laid April-June; clutch size 3-7 eggs. Incubation period 32-34 days. Fledging success normally 1.5-2.5 young per nest.

Development (Bent, 1938; Gabrielson and Lincoln, 1959; Cade, 1960; White, 1969, 1975; White and Cade, 1971, 1977)—Fledge at 35-40 days (July-August), stay near nest 2-6 weeks more; independent thereafter. Age at first breeding normally 2 years, but may breed at age 1 year.

Growth (Bent, 1938; Brown and Amadon, 1968)—Young as large as adults at fledging; 690-1,600 grams, with females 50% larger than males. Maximum age 14 years.

Movements (Gabrielson and Lincoln, 1959; White, 1969, 1975; White and Cade, 1971, 1977; Portenko, 1972)—Fall migration of *F. p. tundrius* in September to southcentral USA, Central and South America; return in April-May. *F. p. pealei* resident mainly in Aleutians, Alaska Peninsula; *F. p. japonensis* to Commander Islands and Kamchatka; some winter along south coast of Chukchi Peninsula.

Factors Influencing Populations

Natural (Bent, 1938; Gabrielson and Lincoln, 1959; Cade, 1960)—Ravens prey on eggs; snowy and great-horned (*Bubo virginianus*) owls and bald and golden (*Aquila chrysaetos*) eagles prey on young.

Human-related (White, 1969, 1975; White, Emison, and Williamson, 1971; Ohlendorff and Kochert, 1977; White and Cade, 1977; White, Ray, and Sowl, 1977)—High levels of DDT, its metabolites, and other chlorinated hydrocarbons caused reproductive failure in populations of *F. p. tundrius* 15 years ago. Populations remain depressed, but partial recovery noted in many areas.

Potential (White, Emison, and Williamson, 1971; Olendorff and Kochert, 1977; White and Cade, 1977; White, Ray, and Sowl, 1977; King and Sanger, 1979)—Increased disturbance by humans may have negative effect on peregrine reproduction. Disturbances include general ones associated with oil development as well as accidental and illegal shooting, egg collecting, and illegal take by falconers. All populations vulnerable to further decline associated with organochlorine residues. Ranked 90th of 176 species in northeast Pacific in oil vulnerability index. Moderately susceptible to oiling. Effects of oil on prey probably more important.

Population Size (White and Cade, 1977)

Alaska population of *F. p. tundrius* was reduced to approximately 40% of original numbers, mainly due to chlorinated hydrocarbons. Population has recovered to 60% of original. Coastal/insular falcon populations in Alaska (*pealei*) and northeast Siberia (*japonensis*) have been relatively unaffected by hydrocarbons.

Management

Peregrine falcons migrating between USA and Mexico technically protected under convention between Mexico and USA, through an expansion of Annex to Migratory Bird Treaty Act. *F. p. tundrius* subspecies formally protected in USA under Endangered Species Protection Act.

Persons Consulted

R. H. Day, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
D. G. Roseneau, LGL Alaska Research Associates, Fairbanks, Alaska.
P. F. Schempf, U. S. Fish & Wildlife Service, Juneau, Alaska.
L. G. Swartz, Department of Biological Sciences, University of Alaska, Fairbanks, Alaska.

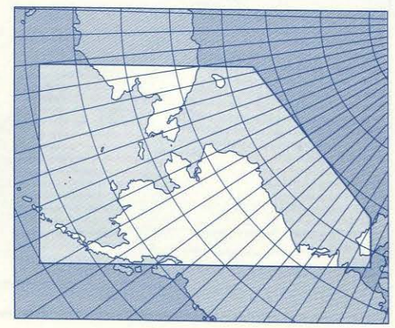
Legend

- Adult Area (September-April) *F. p. pealei*
- Adult Area (April-September) *F. p. pealei*
- Adult Area (April-September) F. p. tundrius
- Major Adult Area (April-September) *F. p. tundrius*
- Adult Area (October-April) *F. p. japonensis*
- Adult Area (April-September) *F. p. japonensis*
- Migration (April-May)
- Migration (September-October)

Distribution of *F. p. tundrius* extends into interior Alaska. Breeding (April-September), all subspecies, occurs throughout summer adult areas. Eggs are laid April-June; they hatch May-July. Young fledge June-September. Juveniles occur throughout adult areas. Wintering areas for *F. p. tundrius* are in tropical and south-temperate regions.

Map References

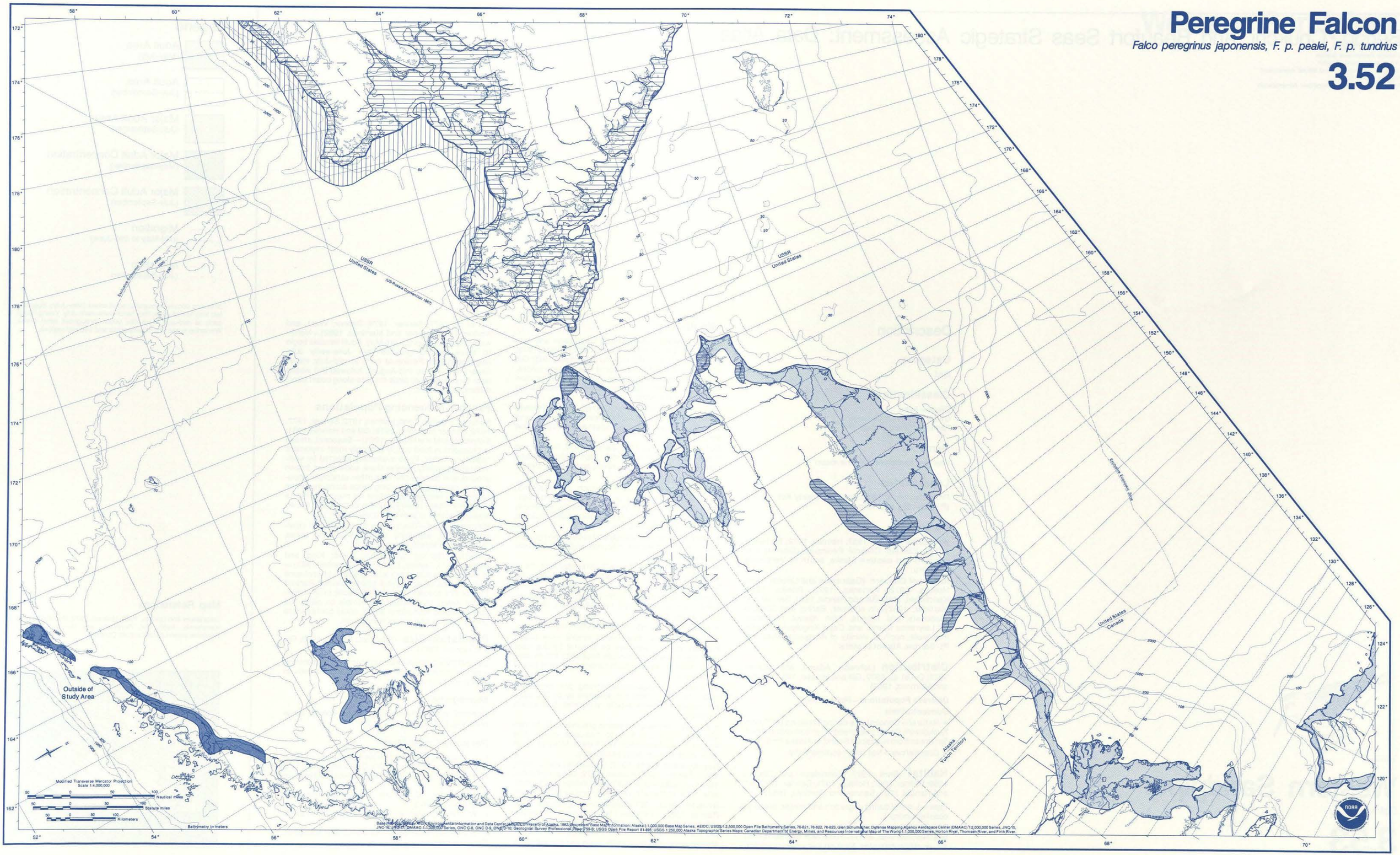
Gabrielson and Lincoln, 1959; Holmes, 1972; Portenko, 1972; Kistchinski, 1980; Gill, Petersen, and Jorgensen, 1981. Personal communications from Roseneau; Schempf.



Peregrine Falcon

Falco peregrinus japonensis, F. p. pealei, F. p. tundrius

3.52



Base map data courtesy of the Environmental Information and Data Center (EIDC), University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 78-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-455; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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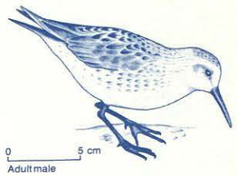


Western Sandpiper

Calidris mauri

3.53

Description

Category

Bird

Classification

Class—Aves
Order—Charadriiformes
Family—Scolopacidae

Name

Western sandpiper, *Calidris mauri*

Legal Status

Protected under Migratory Bird Treaty Act of 1918 (P.L. 65-186), amended.

Range

Worldwide (A.O.U., 1957; Holmes, 1972; Portenko, 1972)—Eastern Chukchi Peninsula (Siberia) and northern and western Alaska, south to Venezuela and Peru.

Region of Concern (Gabrielson and Lincoln, 1959; Holmes, 1972; Portenko, 1972; Pitelka, 1974; Kistchinski, 1980; Gill and Handel, 1981; Senner and Martinez, 1982)—In summer, Bering and Chukchi seacoasts and islands, from Alaska Peninsula, St. Lawrence Island, and Cape Kriguigun, Chukchi Peninsula, north to vicinity of Amguema River and Pt. Barrow. Absent in winter.

Distribution (Johnson, Adams, and Morrell, 1975; Gill et al., 1977; Gill and Handel, 1981; Senner and Martinez, 1982)

Discrete Populations—None known.

Concentrations

- *Natural*—Concentrate during breeding on Yukon-Kuskokwim Delta; postbreeding in salt-marsh/mud-flat areas from Kotzebue Sound to Alaska Peninsula.
- *Commercial*—Not taken commercially.

Habitat (Bent, 1927; Gabrielson and Lincoln, 1959; Palmer, 1967; Holmes, 1971; Senner, 1977; Gill and Handel, 1981; Senner and Martinez, 1982)

Type—Littoral during migration and winter; breed on coastal tundra.

Physical/Chemical—Feed on salt- to freshwater beaches, marshes, and intertidal flats with sand, mud, silt, or clay substrates. Nest on low, coastal tundra.

Life History

Social Behavior (Bent, 1927; Gabrielson and Lincoln, 1959; Brown, 1962; Palmer, 1967; Holmes, 1973; Isleib and Kessel, 1973; Gill and Jorgensen, 1979; Gill and Handel, 1981)—Territorial nesting on tundra, sometimes in high densities. Flocking in migration and winter, sometimes in very large flocks numbering hundreds of thousands.

Biological Associations (Recher, 1966; Pitelka, 1974; Senner, 1977)—Often winter, migrate, and breed in areas with dunlins and other small calidridine sandpipers.

Nutrition (Holmes, 1972; Senner, 1977; Senner and West, 1978; Gill and Handel, 1981; Schneider and Harrington, 1981; Senner, West, and Norton, 1981)

- *Feeding type*—Predator.
- *Food*—Intertidal bivalves, such as *Macoma*, *Mytilus*, *Mya*, and *Astarte*; also harpacticoid copepods and amphipods; on tundra, insects, especially dipteran larvae and adults (Chironomidae, Tipulidae, Muscidae, Ephydridae).
- *Feeding behavior*—Singly and in dispersed groups over tide flats, beaches, marshes, and tundra. Pecking and probing.
- *Feeding location*—Primarily intertidal flats, bays, estuaries, lagoons, ponds, and wetlands, including tundra marshes.

Reproduction (Bent, 1927; Brown, 1962; Palmer, 1967; Holmes, 1971, 1972, 1973; Portenko, 1972; Gill and Handel, 1981)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Low, dwarf-shrub tundra near coast. Highest nesting densities on coastal tundra near marshes that are occasionally flooded by storm tides in fall. Nest is depression in tundra lined with bits of dry vegetation.
- *Behavior*—Monogamous; strong pair bond and nest-site fidelity. Breed in densities up to 300 pairs per square kilometer in optimal habitat. Both adults incubate.
- *Biology*—Arrive on breeding grounds early to mid-May; lay eggs late May to mid-June; clutch size 4 eggs; incubation period 18-19 days. Move to coast after chicks fledge, early to mid-July.

Development (Bent, 1927; Gabrielson and Lincoln, 1959; Palmer, 1967; Holmes, 1972; Gill and Handel, 1981)—Chicks fledge at 30 days; independent thereafter. Age at maturity unknown, probably 1-2 years.

Growth (Bent, 1927; Gabrielson and Lincoln, 1959; Palmer, 1967)—Females slightly larger and heavier (30 grams) than males (28 grams) and have longer bill. Maximum age unknown, probably 8-9 years.

Movements (Godfrey, 1966; Isleib and Kessel, 1973; Gill et al., 1977; Senner, 1979; Senner, West, and Norton, 1981; Senner and Martinez, 1982)—Northward migration during April-May. Adult females begin to leave nesting grounds late June-early July, reaching Alaska Peninsula early to mid-July; males depart late July to mid-August, followed 2-3 weeks later by young. Most birds migrate along coast short distances at a time.

Factors Influencing Populations

Natural (Recher, 1966; Holmes, 1972; Senner, 1977, 1979; Senner and West, 1978; Gill and Handel, 1981; Schneider and Harrington, 1981)—Seasonal, annual fluctuations in food supply probably most important regulating factor. Food availability affected by sedimentation, salinity, temperature, snow cover, frozen ground, and competition with other sandpiper populations, especially at foraging stops along migration routes. Fat reserves important for migratory flights and early phase of reproductive cycle. Cold, snowy weather delays or prevents breeding.

Human-related—Destruction or alteration of intertidal habitat, especially migratory staging areas, reduces available foraging areas.

Potential (Senner and West, 1978; King and Sanger, 1979; Senner, 1979; Gill and Handel, 1981)—In western Alaska, highly susceptible to littoral zone disturbances, especially mid- to late summer. Ranked 71st of 176 species in northeast Pacific in oil vulnerability index. Moderately susceptible to oiling. Oil spills, coupled with storm surge, could contaminate critical feeding and breeding habitats.

Population Size (Isleib and Kessel, 1973; Gill and Handel, 1981)

Several million individuals; most common shorebird in western Alaska. Entire world population breeds in region of concern.

Management

National Wildlife Refuge System protects some breeding, staging areas.

Persons Consulted

P. G. Connors, Bodega Marine Laboratory, University of California, Bodega Bay, California.
R. E. Gill, U. S. Fish & Wildlife Service, Anchorage, Alaska.
C. M. Handel, U. S. Fish & Wildlife Service, Anchorage, Alaska.
D. W. Norton, Institute of Arctic Biology, University of Alaska, Fairbanks, Alaska.
S. E. Senner, Hawk Mountain Sanctuary, Kempton, Pennsylvania.

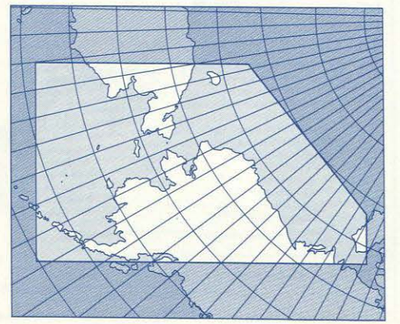
Legend

- Adult Area (May-July)
- Adult Area (July-September)
- Major Adult Area (July-September)
- Major Adult Concentration (May-September)
- Major Adult Concentration (July-September)
- Migration (mid-May to mid-June)
- Migration (July-September)

Breeding occurs throughout adult areas (May-July). Eggs are laid May to mid-June; they hatch June-early July. Young fledge early to mid-July. Juveniles occur throughout adult areas. Wintering areas are in temperate and tropical regions.

Map References

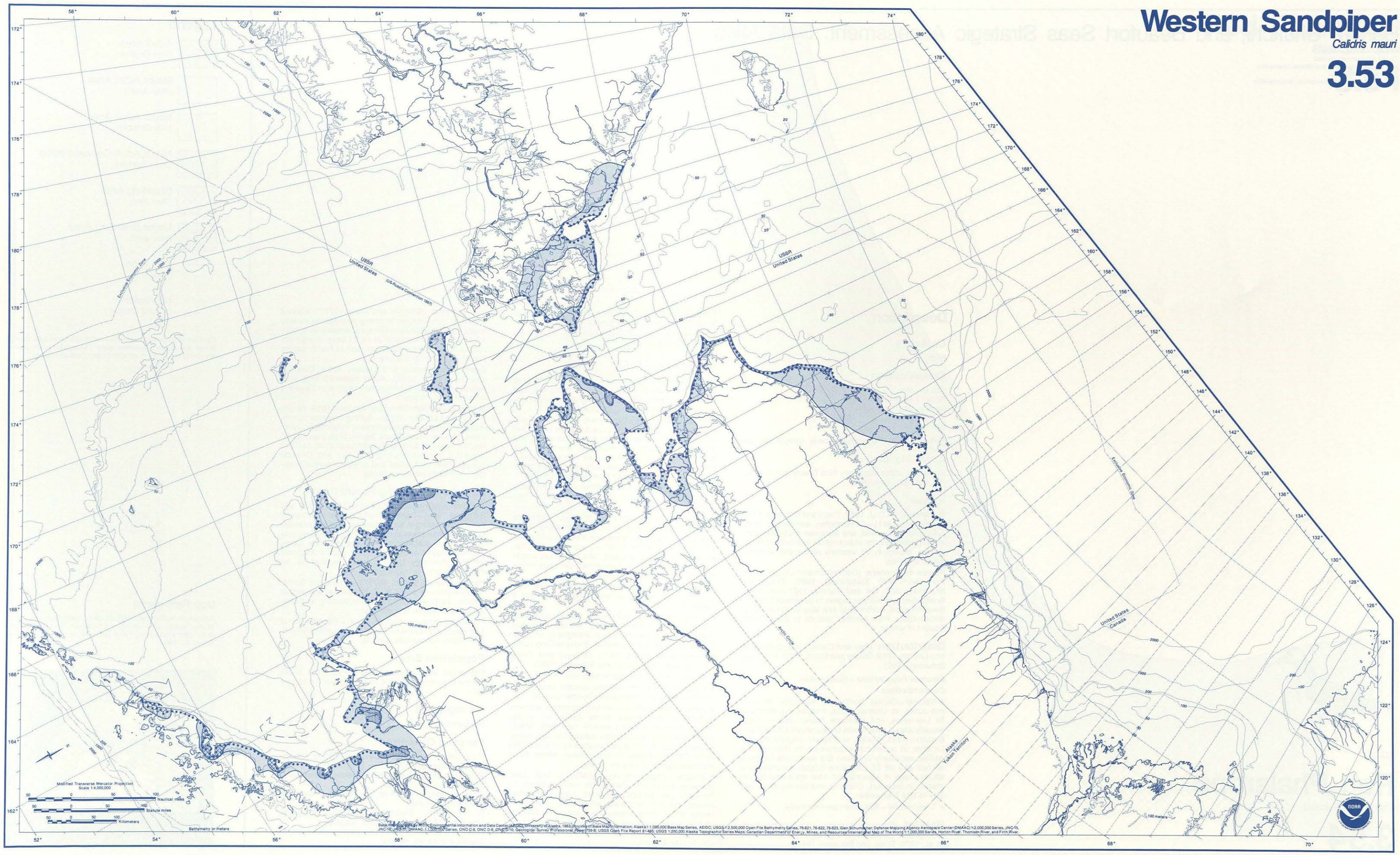
Gabrielson and Lincoln, 1959; Holmes, 1972; Portenko, 1972; Kistchinski, 1980; Gill, Petersen, and Jorgensen, 1981. Personal communication from Connors.



Western Sandpiper

Calidris mauri

3.53



Base map courtesy of the Environmental Information and Data Center (AEIDC), University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17, DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 758-B; USGS Open File Report 81-485; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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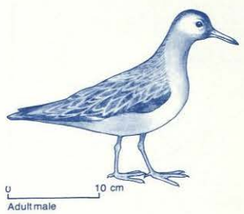


Adult male

Red Phalarope

Phalaropus fulicaria

3.54

Description

Category

Bird

Classification

Class—Aves
Order—Charadriiformes
Family—Scolopacidae

Name

Red phalarope, *Phalaropus fulicaria* (grey phalarope)

Legal Status

Protected under Migratory Bird Treaty Act of 1918 (P.L. 65-186), amended.

Range

Worldwide (A.O.U., 1957; Tracy and Schamel, 1980; Johnsgard, 1981)—Circumpolar; summer in North American, Greenland, and Eurasian arctic and subarctic regions; winter at sea mainly in Southern Hemisphere, especially off western Africa and southern South America.

Region of Concern (Gabrielson and Lincoln, 1959; Portenko, 1972; Kistchinski, 1980; Tracy and Schamel, 1980; Gill and Handel, 1981)—Northern Bristol Bay and Koryak region to coasts of Chukchi, Beaufort seas. Common at sea May and mid-July to mid-October, from Aleutian Islands to about 70°N. Absent in winter.

Distribution (Fay and Cade, 1959; Gabrielson and Lincoln, 1959; Divoky and Good, 1979; Tracy and Schamel, 1980)

Discrete Populations—None known.

Concentrations

- *Natural*—During northward migration (May to mid-June), in Unimak Pass, Pribilof, St. Matthew, St. Lawrence, and Diomede Island waters; occasionally also in open leads of nearshore Chukchi and Beaufort seas. During southward migration, July-October, at ocean convergence fronts, tide rips, and eddies, especially between Big and Little Diomede islands and off St. Lawrence Island. Juveniles and adults stage in lagoons and near spits and barrier islands in Beaufort, Chukchi, and Bering seas, late July to late September.
- *Commercial*—Not taken commercially.

Habitat (Connors, Meyers, and Pitelka, 1979; Divoky and Good, 1979; Johnson, 1979; Schamel et al., 1979; Tracy and Schamel, 1980)

Type—Littoral to pelagic during migration and winter; breed on low, wet coastal tundra.

Physical/Chemical—Loose pack ice to ice-free waters; fresh to marine.

Life History

Social Behavior (Schamel and Tracy, 1977; Mayfield, 1978; Harrison, 1979; Brown, 1980)—Solitary nesting on tundra; flocking in migration and during winter. Flocks up to many thousands.

Biological Associations (Brown, 1980)—Feed with Arctic terns, Sabine's gulls, black-legged kittiwakes, red-necked phalaropes along arctic shorelines; with kittiwakes, fulmars, storm-petrels, murrelets, auklets, gulls, murres, and oldsquaws in tide rips and at ice edge; occasionally flock with red-necked phalaropes. Follow feeding gray, bowhead whales.

Nutrition (Connors and Riseborough, 1978; Divoky, 1978b; Divoky and Good, 1979; Johnson, 1979; Tracy and Schamel, 1980)

- *Feeding type*—Predator; insectivore, planktivore.
- *Food*—In breeding season, eat chironomid larvae and adults, craneflies, stoneflies, beetles, and snails; also ostracods, water boatmen, spiders, caddisflies. At sea and along shorelines, take copepods, amphipods, euphausiids, small jellyfishes, decapod larvae, mysids, chaetognaths, and pteropods.
- *Feeding behavior*—Surface-feeders; locate prey visually while wading or swimming. Often feed in flocks of 10-100.
- *Feeding location*—In breeding season, at shallow marsh edges. After breeding, on lagoon edges, brackish ponds, and shorelines. Pelagically, at ocean fronts, ice edge, tide rips, eddies, and upwelling zones.

Reproduction (Höhn, 1971; Schamel and Tracy, 1977; Brown, 1980; Tracy and Schamel, 1980)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Nest on marshy coastal tundra with shallow ponds and temporarily flooded ground.
- *Behavior*—Sex roles reversed; females often more aggressive than males. Some paired on arrival, others soon after. Male selects nest site; female courts male and departs after mating and egg-laying. Not territorial. Females can produce up to 3 clutches (with different males) in one season. Males alone incubate eggs and care for young.
- *Biology*—Begin nesting mid-May to late June, following snowmelt. Density in best habitats to 70 nests per square kilometer. Egg-laying often begins less than one week after first arrivals; continues about three weeks. Four eggs per average clutch; incubation period 18-19 days. Male leaves nesting areas late June to late July; young leave late July to late August.

Development (Schamel and Tracy, 1977; Tracy and Schamel, 1980)—After hatching, young led by male to feeding areas. Male broods chicks, remains with them 12-14 days. Chicks fledge at 18-21 days; move from tundra to coast, then offshore. Age at first breeding unknown, probably 1-2 years.

Growth (Gabrielson and Lincoln, 1959; Connors and Risebrough, 1978)—Adult males 50-55 grams, females 60 grams. Maximum age estimated 15 years; average about 8 years.

Movements (Gabrielson and Lincoln, 1959; Gould, Forsell, and Lensink, 1982)—Spring migration northwestward through Unimak Pass to Pribilofs, St. Matthew, St. Lawrence islands, Bering Strait, and along leads in sea ice of Chukchi and Beaufort seas. Autumn migration westward along Beaufort and Chukchi coasts, then southward and offshore across Aleutians to Pacific wintering areas.

Factors Influencing Populations

Natural (Gabrielson and Lincoln, 1959; Tracy and Schamel, 1980)—Late melt-off sometimes delays or precludes nesting in arctic regions. Low water levels on tundra may lower prey availability, breeding success. Foxes, jaegers prey on eggs, chicks. Large numbers may starve at sea during storms. Availability of high-energy foods probably critical for fat deposition prior to migration.

Human-related (Bond, 1971; Connors and Smith, 1982)—Starving birds in California have ingested plastic particles. Negative correlation between amounts of plastic and body fat.

Potential (King and Sanger, 1979)—Ranked 41st of 176 species in northeast Pacific in oil vulnerability index. Highly susceptible to oiling.

Population Size

Estimated world-wide population 5 million birds; Alaska population 750,000 birds, all in region of concern.

Management

Nongame species.

Persons Consulted

P. G. Connors, Bodega Marine Laboratory, University of California, Bodega Bay, California.
R. H. Day, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
C. M. Handel, U. S. Fish & Wildlife Service, Anchorage, Alaska.
D. L. Schamel, Biological Sciences Program, University of Alaska, Fairbanks, Alaska.
D. M. Tracy, Institute of Arctic Biology, University of Alaska, Fairbanks, Alaska.

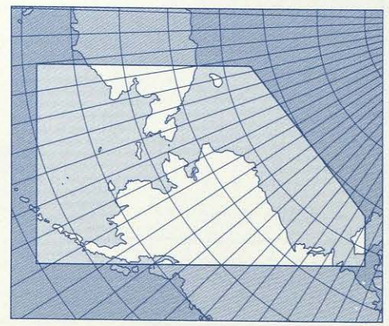
Legend

- Adult Area (May-October)
- Major Adult Area (May-June)
- Major Adult Area (July-October)
- Major Adult Concentration (July-October)
- Breeding Area (May-July)
- Major Breeding Area (May-July)
- Migration (May)
- Movement (August-October)

Eggs are laid late May-June; they hatch late June-July. Young fledge July-August. Juveniles occur throughout adult areas. Wintering areas are in temperate and tropical regions.

Map References

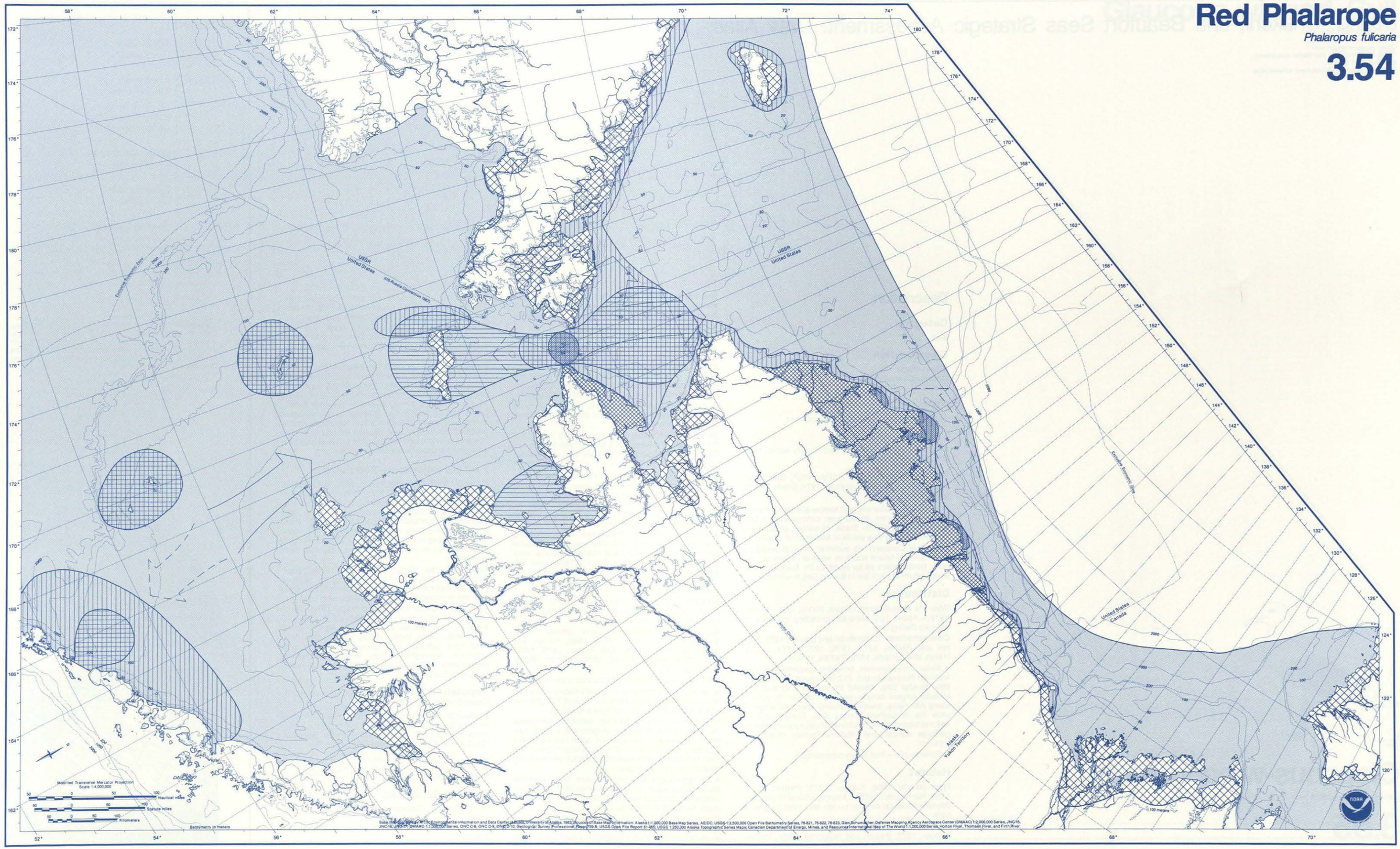
Gabrielson and Lincoln, 1959; Godfrey, 1966; Portenko, 1972; Weller, Norton, and Johnson, 1978; Gould, Forsell, and Lensink, 1980; Kistchinski, 1980; Satter et al., 1980; Tracy and Schamel, 1980.



Red Phalarope

Phalaropus fulicaria

3.54



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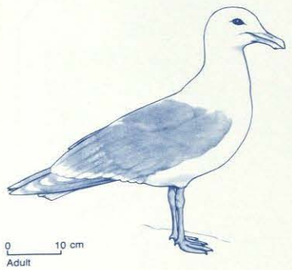


Glaucous-winged Gull

Larus glaucescens

3.55

Description

Category

Bird

Classification

Class—Aves
Order—Charadriiformes
Family—Laridae

Name

Glaucous-winged gull, *Larus glaucescens*

Legal Status

Protected under Migratory Bird Treaty Act of 1918 (P.L. 65-186), amended.

Range (Swarth, 1934; A.O.U., 1957; Gabrielson and Lincoln, 1959; Bystrak et al., 1974; Sowls, Hatch, and Lensink, 1978)

Worldwide—Subarctic and temperate North Pacific Ocean. In summer, breed from central Bering Sea south to Washington State. In winter, occur from southern Bering Sea south to Mexico and Japan.

Region of Concern—In summer, coastal breeders from Nunivak Island south to edge of region of concern; nonbreeders as far north as Pt. Barrow. Open water south of pack ice in Bering Sea in winter.

Distribution

Discrete Populations (Sowls, Hatch, and Lensink, 1978)—About 100 separate breeding colonies in eastern Bering Sea.

Concentrations (Gabrielson and Lincoln, 1959; Patten and Patten, 1975, 1976, 1977, 1978; Sowls, Hatch, and Lensink, 1978; Patten, 1980)

- *Natural*—In summer, breeding concentrations at western Nunivak Island, Pribilof Islands, Kuskokwim Bay, Bristol Bay, Alaska Peninsula, and Aleutian Islands; largest colony near Port Moller. In winter, along Aleutians, southern Bristol Bay, and edge of pack ice in eastern Bering Sea. Congregate at natural food sources, onshore fish-processing plants, garbage dumps, and offshore factory ships and trawlers.
- *Commercial*—Not taken commercially.

Habitat

Type (Moyle, 1966; Sanger, 1973; Patten, 1974, 1980; Harrington, 1975)—Marine: littoral to pelagic. Breed on coastal cliffs or slopes and sand or gravel bars.

Physical/Chemical (Gabrielson and Lincoln, 1959; Sanger, 1973; Patten and Weisbrod, 1974; Patten and Patten, 1975, 1976, 1977, 1978)—Open sea, shores, and river valleys. Avoid snow- and ice-covered areas inland in winter and do not range far onto pack ice.

Life History

Social Behavior (Swarth, 1934; Patten, 1974, 1980; Patten and Weisbrod, 1974; Strang, 1977; Hoffman, Wiens, and Scott, 1978)—Colonial breeders. Gregarious, especially at food sources; aggressive, exhibiting much inter- and intraspecific antagonism.

Biological Associations (Moyle, 1966)—Principally with other scavengers, such as other gulls, ravens, crows, and brown bears.

Nutrition (Gabrielson and Lincoln, 1959; Wilson and Baade, 1959; Vermeer, 1963; Moyle, 1966; Patten and Patten, 1976; Trapp, 1979; Wahl and Heinemann, 1979; Patten, 1980)

- *Feeding type*—Scavenger, predator; omnivore.
- *Food*—Scavenge dead fishes, invertebrates, birds, and mammals; also take garbage, sewage, and offal around fish-processing plants. Prey on small fishes, invertebrates, small mammals, eggs and chicks of other marine and coastal birds.
- *Feeding behavior*—Principally surface-feeding and surface-plunging. Individuals and small flocks patrol shoreline, rivers, and marine habitats, congregating at food sources. Feed in flocks over fish schools and floating offal. Can plunge several decimeters below surface of the water. Exhibit much intraspecific antagonism.
- *Feeding location*—From beaches to pelagic waters; also salmon streams, large rivers near coast, garbage dumps, sewage outfalls.

Reproduction (Gabrielson and Lincoln, 1959; Vermeer, 1963; Patten, 1974, 1980; Patten and Weisbrod, 1974; Patten and Patten, 1975, 1976, 1977, 1978; Hunt and Hunt, 1976; Hoffman, Wiens, and Scott, 1978)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Nest mainly on grassy slopes of islands; also steep, rocky cliffs, sand dunes, and flat, gravelly islets. Also will nest on rooftops and pilings.
- *Behavior*—Colonial nesting; establish territories as snow melts. Mainly monogamous; strong pair bond, renewed or initiated on open resting areas ("clubs") adjacent to colony; copulate there or on nest territory. Colony size up to 10,000 pairs; colony abandoned by late August.
- *Biology*—Eggs laid mid- to late May; average clutch size 3 eggs. Incubation period 26 days, beginning when clutch completed. Chicks hatch mid- to late June; hatching success 60-80%.

Development (Vermeer, 1963; Patten, 1974; Patten and Patten, 1975, 1976, 1977, 1978)—Chicks remain in nesting territory until fledged at 40-45 days; after fledging, disperse to club areas, where fed by parents. Fledged juveniles may accompany parents for brief period thereafter. Age at first breeding, 4 years.

Growth (Patten, 1980)—Nearly adult size and weight at fledging. Adult males average 1,200 grams, adult females 900 grams. Maximum age about 10 years.

Movements (A.O.U., 1957; Gabrielson and Lincoln, 1959; Bystrak et al., 1974; Patten and Patten, 1975, 1976, 1977, 1978; Patten, 1980)—Partly migratory; some populations shift southward in fall and winter from ice-covered areas. Juveniles disperse widely. Some adults and young remain in same areas throughout year. Common along ice edge, southwestern Bristol Bay and Aleutian Islands in winter. Third-year (nonbreeding) juveniles arrive at breeding colonies mid-June, when adults are nesting.

Factors Influencing Populations

Natural (Vermeer, 1963; Patten, 1974, 1980; Patten and Patten, 1975, 1976, 1977, 1978)—Natural infertility low; hatching success high. Aggressive territorial interactions, cannibalism, and cold, wet weather are principal causes of chick mortality. Principal nest predators include ravens, jaegers, other gulls, bald eagles, and foxes. Mortality of fledged juveniles high during first year, after dispersal from colonies.

Human-related (Wilson and Baade, 1959; Patten and Patten, 1975, 1976, 1977, 1978; Patten, 1980)—Populations increase rapidly with access to new food sources provided by garbage, sewage, and offal.

Potential (Patten and Patten, 1975, 1976, 1977, 1978; King and Sanger, 1979; Patten, 1980)—Ranked 44th of 176 species in northeast Pacific in oil vulnerability index. Highly susceptible to oiling. Artificial food supplies accompanying industrial and economic development may lead to increasing populations, with negative public health and public safety implications.

Population Size (Sowls, Hatch, Lensink, 1978; Gould, Forsell, and Lensink, 1982)

At least 31,000 breed on northern coast of Alaska Peninsula, northward to Nunivak and Pribilof islands; more than 27,000 on Aleutian Islands. Between 600,000 and 800,000 over eastern Bering Sea.

Management

Nongame species.

Persons Consulted

W. H. Drury, Jr., College of the Atlantic, Bar Harbor, Maine.
P. J. Gould, U. S. Fish & Wildlife Service, Anchorage, Alaska.

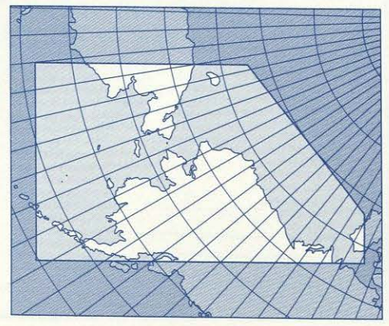
Legend

- Adult Area (Year-round)
- Adult Area (May-November)
- Major Adult Area (January-April)
- Major Adult Area (May-September)
- Breeding Area (May-August)
- Nesting Colony (May-August) Number of individuals
  - Less than 100
  - 100 to 1,000
  - Greater than 1,000

Eggs are laid mid- to late May; they hatch mid- to late June. Chicks fledge late July-early August. Juveniles occur throughout adult areas. Nonbreeders occur occasionally as far north as Pt. Barrow. Wintering range extends to Mexico. Northern limit of adult area (year-round) is average maximum ice edge. (See map 1.8, Sea Ice Dynamics.)

Map References

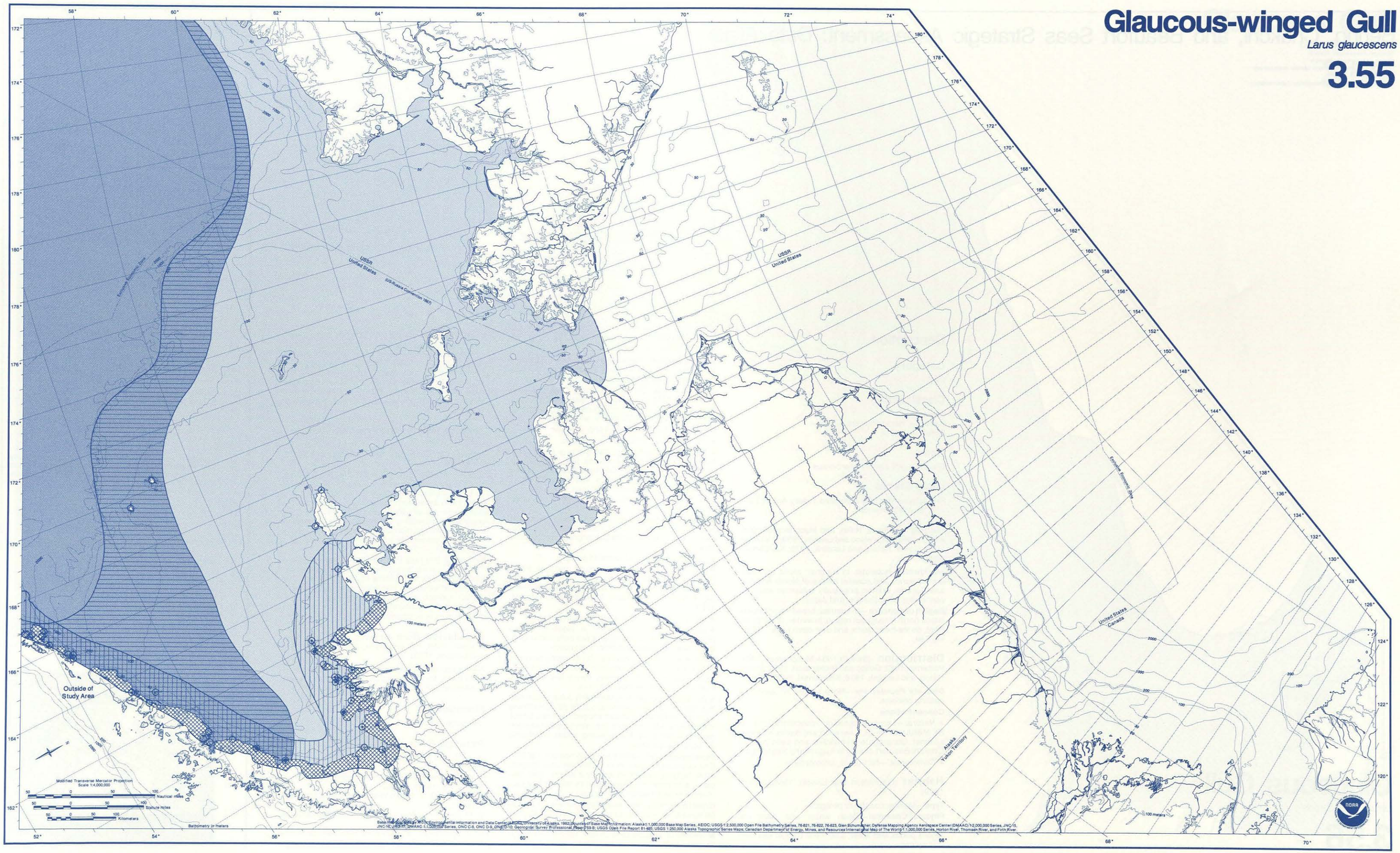
Gabrielson and Lincoln, 1959; Sowls, Hatch, and Lensink, 1978; Gould, Forsell, and Lensink, 1982; Nysewander et al., 1982.



Glaucous-winged Gull

Larus glaucescens

3.55



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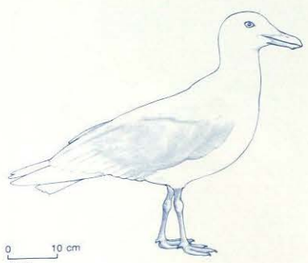


Glaucous Gull

Larus hyperboreus

3.56

Description

Category

Bird

Classification

Class—Aves
Order—Charadriiformes
Family—Laridae

Name

Glaucous gull, *Larus hyperboreus*

Legal Status

Protected under Migratory Bird Treaty Act of 1918 (P.L. 65-186), amended.

Range (Manning, Höhn, and Macpherson, 1956; A.O.U., 1957; Gabrielson and Lincoln, 1959; Portenko, 1973; Sowls, Hatch, and Lensink, 1978; Kistchinski, 1980)

Worldwide—Holarctic. In summer, arctic and subarctic islands and coastal tundra of North America and Eurasia. Winter: principally subarctic south to contiguous USA, Europe, and Japan.

Region of Concern—In summer, breed from Nunivak Island north throughout region. In winter, occur at ice front, on ice-free coasts, and over open water of Bering Sea.

Distribution (Swarth, 1934; Macpherson, 1961; Portenko, 1973; Gollop and Richardson, 1974; Sowls, Hatch, and Lensink, 1978; Kistchinski, 1980)

Discrete Populations—None known. At least 150 nesting colonies.

Concentrations

- *Natural*—Largest breeding concentrations at St. Matthew, Hall, St. Lawrence, and Banks islands in summer. Congregate on beaches and sand bars on Chukchi-Beaufort coasts in August and September.
- *Commercial*—Not taken commercially.

Habitat (Gabrielson and Lincoln, 1959; Divoky, 1979)

Type—Marine: coastal to pelagic.

Physical/Chemical—Open water and pack ice. Breed principally on nearshore islands and islands in tundra ponds and lakes; also, near tops of sea cliffs and stacks.

Life History (Gabrielson and Lincoln, 1959; Strang, 1976)

Social Behavior—Solitary to colonial nesters. Mildly gregarious for rest of year. Concentrate in large flocks at abundant food sources.

Biological Associations (Fay and Cade, 1959)—Frequently nest near colonies of seabirds and waterfowl. Associate with herring gulls, glaucous-winged gulls, black-legged kittiwakes in wintering areas.

Nutrition (Fay and Cade, 1959; Johnson, 1979)

- *Feeding type*—Predator, scavenger.
- *Food*—In summer, eggs and chicks of birds, small fishes, insects, and small rodents. Scavenge sea ice and coast for dead mammals, birds, and other animal matter; also garbage dumps and fish-processing plants for offal. In Beaufort Sea, take primarily Arctic cod, isopods, amphipods, copepods, birds, chaetognaths, and mysids.
- *Feeding behavior*—Primarily surface-feeders at sea. Individuals and small flocks patrol shoreline, rivers, and marine habitats, congregating at food sources.
- *Feeding location*—Coastal to pelagic.

Reproduction (Bent, 192l; Bertram and Lack, 1933; Bailey, 1948; Belopol'skii, 1957; Freuchen and Salomonsen, 1958; Fay and Cade, 1959; Smith, 1966; Ingolfsson, 1967; Parmelee, Stephens, and Schmidt, 1967)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Nest on islands in lagoons, tundra ponds, and lakes; also on top of sea cliffs and stacks. Bulky nests of moss and other vegetation.
- *Behavior*—Slightly colonial. On breeding territory before snow melts; breed when nest site snow-free. Nests usually widely spaced, hence few territorial interactions with neighboring pairs.
- *Biology*—Eggs laid late May-early June; clutch size 2-3 eggs; incubation period about 26 days. Hatching success 50-75%; 1-2 chicks fledged per nest. Lower intraspecific egg and chick predation than in smaller, more colonial gulls. Nonbreeding adults constitute 30-60% of population.

Development (Freuchen and Salomonsen, 1958)—Chicks usually remain in or near nest until fledged; after fledging, remain in vicinity 2 weeks, then disperse with parents; independent by mid- to late October. Sexually mature at 4 years.

Growth—Chicks near adult size and weight by 40-50 days after hatching. Largest gulls in North Pacific; average weight 1.5 kg.

Movements (Watson and Divoky, 1972; Barry, 1974; Divoky, 1979; Johnson and Richardson, 1981)—Move to Beaufort and Chukchi beaches and islands in late August. Move southward with and ahead of advancing ice and increasing snow cover in autumn, along coast and at sea. Some winter in open areas north to Pt. Hope; numerous at St. Lawrence, St. Matthew, Nunivak islands, and at ice edge; scattered elsewhere to south. Return northward March-May, moving along the coast and following open leads in ice.

Factors Influencing Populations

(Strang, 1976)

Natural—Probably food-limited. Some egg predation by jaegers.

Human-related (Day, 1980)—Plastic particles found in digestive tract of 3% of Alaskan birds; effects on birds unknown. Age structure of population suggests rapid expansion in some areas where garbage dumps are primary food source. Growth of human population, increasing commercial development in coastal areas, and high-seas fisheries generate large volumes of comestible waste, enhancing survival of juvenile gulls.

Potential (King and Sanger, 1979)—Ranked 79th of 176 species in northeast Pacific in oil vulnerability index. Moderately susceptible to oiling. Further commercial development and associated expansion of human population in coastal areas may lead to increased gull populations and increased impact by gulls on prey populations.

Population Size (Manning, Höhn, and Macpherson, 1956; Fay and Cade, 1959; Sowls, Hatch, and Lensink, 1978)

Alaska population estimated at 30,000. Largest colonies on St. Matthew, Hall, and St. Lawrence islands. Banks Island (NWT) population estimated at 20,000.

Management

Nongame species.

Persons Consulted

W. H. Drury, Jr., College of the Atlantic, Bar Harbor, Maine.
F. H. Fay, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
P. J. Gould, U. S. Fish & Wildlife Service, Anchorage, Alaska.
S. M. Patten, Jr., Alaska Department of Fish & Game, Bethel, Alaska.
M. A. Spindler, U. S. Fish & Wildlife Service, Arctic National Wildlife Range, Fairbanks, Alaska.

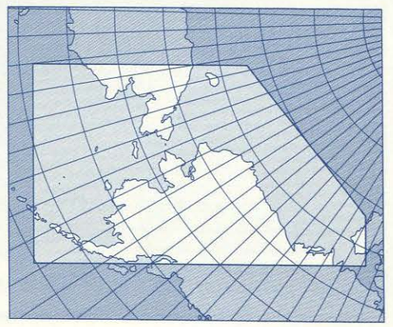
Legend

- Adult Area (Year-round)
- Adult Area (May-November)
- Adult Area (June-October)
- Major Adult Area (January-April)
- Major Adult Area (May-November)
- Major Adult Area (June-October)
- Breeding Area (May-August)
- Nesting Colony (May-August) Number of individuals
  - Less than 100
  - Greater than 100
- Migration (March-May)
- Migration (September-November)

Eggs are laid late May-early June; they hatch late June-early July. Young fledge in August. Juveniles occur throughout adult areas. Wintering range extends to north temperate regions. Northern limit of adult area (year-round) is average maximum ice edge. (See map 1.8, Sea Ice Dynamics.)

Map References

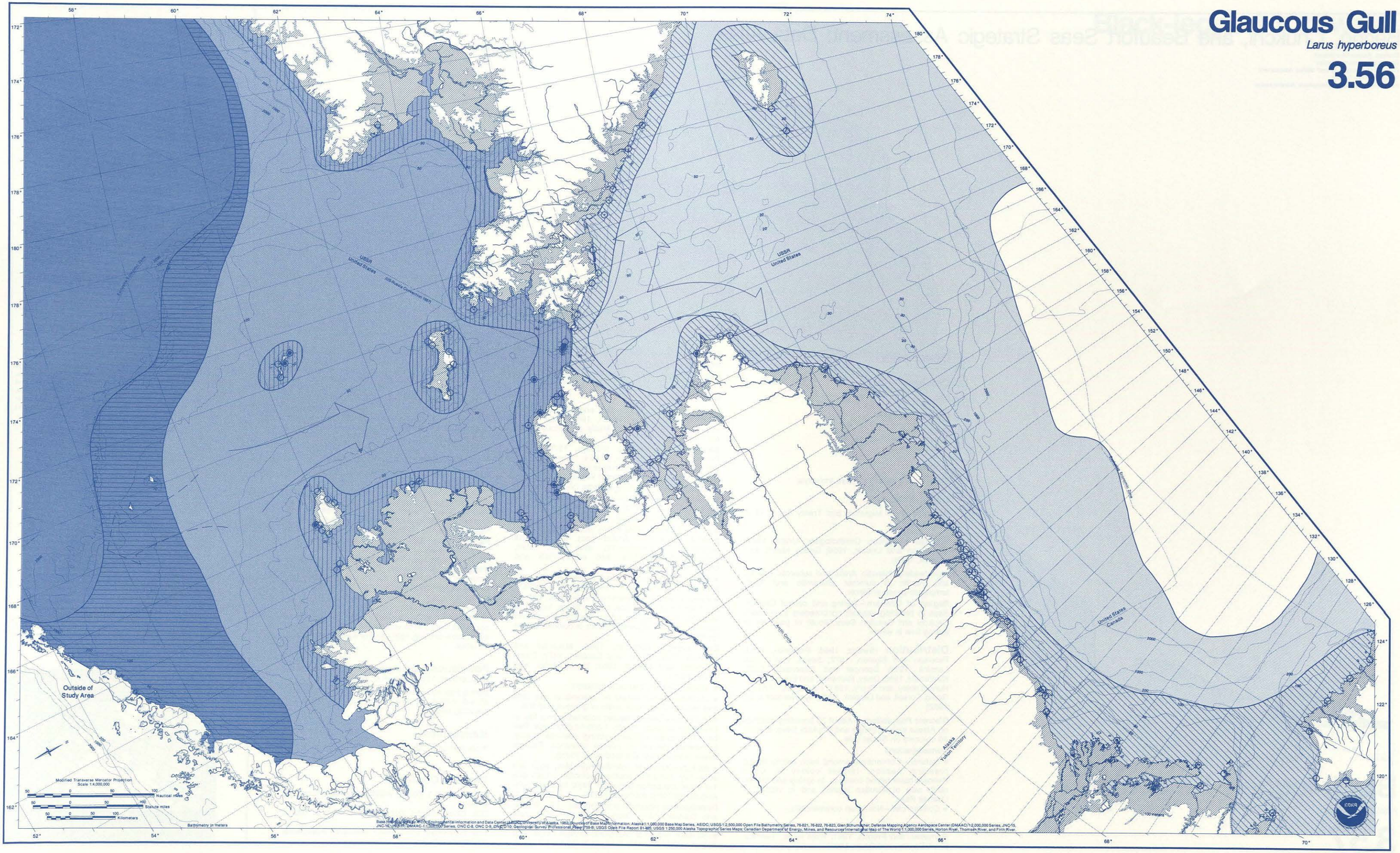
Manning, Höhn, and Macpherson, 1961; Portenko, 1973; Gollop and Richardson, 1974; Johnson, Adams, and Morrell, 1975; Divoky, 1978a, b; Sowls, Hatch, and Lensink, 1978; Spindler, 1978a, b; Kistchinski, 1980; Hunt, Eppley, and Drury, 1981.



Glaucous Gull

Larus hyperboreus

3.56



Base from Defense Mapping Agency, Environmental Information and Data Center (AEIDC, University of Alaska, 1982; Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

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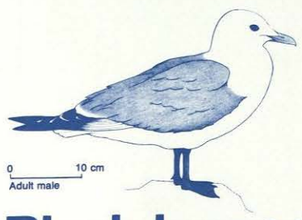
National Ocean Service
National Oceanic and Atmospheric Administration



Black-legged Kittiwake

Rissa tridactyla

3.57

Description

Category

Bird

Classification

Class—Aves
Order—Charadriiformes
Family—Laridae

Name

Black-legged kittiwake, *Rissa tridactyla*

Legal Status

Protected under Migratory Bird Treaty Act of 1918 (P.L. 65-186).

Range (American Ornithologists' Union, 1957; Gabrielson and Lincoln, 1959; Sowls, Hatch, and Lensink, 1978)

Worldwide—Holarctic. Arctic and subarctic Atlantic and Pacific in summer. Subarctic and north temperate zones in winter.

Region of Concern—Bering and central Chukchi Seas in breeding season; nonbreeders in northern Chukchi and Beaufort Seas. South of pack ice in Bering Sea in winter.

Distribution (Swartz, 1966; Portenko, 1973; Petersen and Sigman, 1977; Sowls, Hatch, and Lensink, 1978; Springer and Roseneau, 1978; Kischinskii, 1980; Drury, Ramsdell, and French, 1981; Hunt, Eppley, and Drury, 1981; Hunt et al., 1981a,b; Gould, Forsell, and Lensink, 1982; Nysewander et al., 1982)

Discrete Populations—About 75 breeding colonies on Alaska side of Bering and Chukchi Seas; at least 30 colonies on Soviet side.

Concentrations

- *Natural*—Concentrate around each colony during breeding season; largest colony is Cape Peirce/Shaiak Island complex. In spring and fall, on north side of Aleutian Islands and in vicinity of Unimak Pass.
- *Commercial*—Not taken commercially.

Habitat (Gabrielson and Lincoln, 1959; Drury, Ramsdell, and French, 1981; Hunt et al., 1981a,b; Hunt, Eppley, and Drury, 1981)

Type—Marine, nearshore to pelagic.
Physical/Chemical—Open sea to edge of pack ice. Nest on rock ledges of sea cliffs and stacks.

Life History

Social Behavior (Gabrielson and Lincoln, 1959; Drury, Ramsdell, and French, 1981; Hunt et al., 1981b)—Colonial breeder. Mildly gregarious when not breeding.

Biological Associations (Firsova, 1978; Drury, Ramsdell, and French, 1981; Hunt et al., 1981a)—Often nest near murres and fulmars; also in mixed colonies with red-legged kittiwakes.

Nutrition (Ainley and Sanger, 1979; Drury, Ramsdell, and French, 1981; Hoffman, Heinemann, and Wiens, 1981; Hunt et al., 1981a)

- *Feeding type*—Predator.
- *Food*—Primarily small fishes (sand lance, capelin, pollock, eulachon, Arctic cod), crustaceans (euphausiids, amphipods), and squid; also, polychaetes, shellfish, and offal. Fish and crustaceans fed to young.
- *Feeding behavior*—Surface-seizing, dipping, and plunging to water surface. Feed singly or in flocks.
- *Feeding location*—Nearshore in summer, pelagic in winter. Feed in tide rips, off headlands, local convergence fronts, and ice edges; occasionally at river mouths. Feed mostly within 25 km of colonies during reproduction.

Reproduction (Coulson, 1966; Maunder and Threlfall, 1972; Wooler and Coulson, 1977; Drury, Ramsdell, and French, 1981; Hunt, Eppley, and Drury, 1981)

- *Mode*—Sexual; internal fertilization.
- *Location*—Small ledges on precipitous sea cliffs and stacks. Small bulky nests of grasses and sod.
- *Behavior*—Colonial nester; colonies from a few to thousands of pairs, mostly 1,000-10,000 birds. Pair bonds renewed annually; strong nest-site fidelity. Somewhat tolerant of human presence. Parents share in incubation and feeding of young.
- *Biology*—Arrive at colonies April-May; eggs laid June-July, earliest in southern colonies. Clutch size 1-3 eggs; incubation period 27 days; hatching July-August. Hatching success 10-80%.

Development (Maunder and Threlfall, 1972; Wooler and Coulson, 1977; Drury, Ramsdell, and French, 1981; Hunt, Eppley, and Drury, 1981)—Chicks fledge at 35 days; remain at nest site 5-10 days longer. Age at first breeding usually 3 years; sometimes 2 years.

Growth (Swartz, 1966; Murphy et al., 1980; Hunt et al., 1981a)—Chicks grow at rate of 13-30 grams per day; attain adult size at fledging. Adult males 400-500 grams, females 350-450 grams. Maximum age exceeds 20 years.

Movements (Shuntov, 1972; Drury, Ramsdell, and French, 1981; Hunt et al., 1981a,b)—No distinct migration paths known. After breeding, widespread dispersal to sea and general southward shift to areas south of pack ice.

Factors Influencing Populations

Natural (Byrd and Tobish, 1978; Drury, Ramsdell, and French, 1981; Hunt, Eppley, and Drury, 1981; Hunt et al., 1981a)—Foxes, ravens, and large gulls prey on eggs and chicks. Inclement weather may destroy nests. Persistent ice may limit feeding. Productivity strongly influenced by food availability. Nestlings may kill siblings in times of food shortage.

Human-related (Day, 1980)—Plastic particles found in digestive tract of 5% of Alaskan kittiwakes; effect on birds unknown. Hunted in small numbers by Natives for subsistence. Disturbance by human presence and low-flying aircraft exposes eggs and chicks to predation and chill by driving adults off nests.

Potential (King and Sanger, 1979; Drury, Ramsdell, and French, 1981)—Ranked 64th of 176 species in northeast Pacific in oil vulnerability index. Moderately susceptible to oiling; light oiling of eggs or chicks may be lethal.

Population Size (Shuntov, 1972; Sowls, Hatch, and Lensink, 1978; Hunt et al., 1981b)

Bering Sea population in summer and fall estimated at 4-5 million, of which at least 1.1 million are breeding birds.

Management

Protected under Migratory Bird Treaty Act of 1918.

Persons Consulted

P.J. Gould, U.S. Fish & Wildlife Service, Anchorage, Alaska.
D.S. Lloyd, Alaska Department of Fish & Game, Anchorage, Alaska.
D.G. Roseneau, LGL Alaska Research Associates, Fairbanks, Alaska.

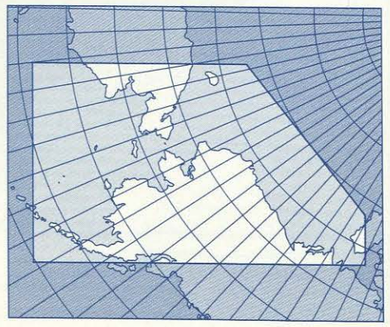
Legend

- Adult Area (Year-round)
- Adult Area (April-December)
- Adult Area (June-October) Primarily nonbreeders
- Nesting Colony (April-September) Number of individuals
  - Less than 10,000
  - 10,000 to 100,000
  - Greater than 100,000
- Parental Foraging Area (April-September)
- Major Parental Foraging Area (April-September)
- Major Parental Foraging Concentration (April-September)

Eggs are laid June-July; they hatch July-August. Young fledge August-September. Juveniles occur throughout adult areas. Most wintering areas are south of study area. Northern limit of adult area (year-round) is average maximum ice edge. Northern limit of adult area (June-October) is average minimum five-tenths ice cover. (See map 1.8, Sea Ice Dynamics.)

Map References

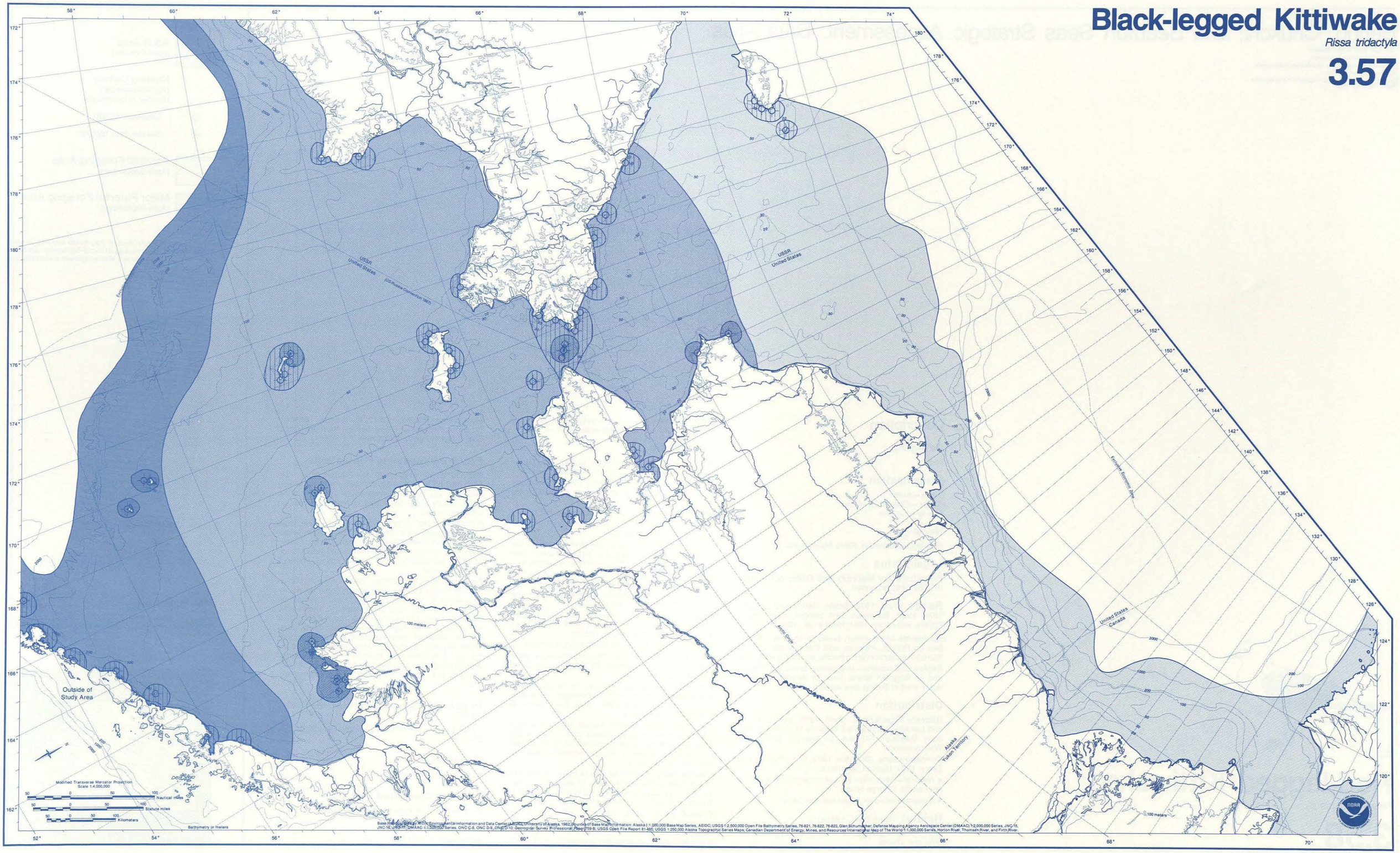
Sowls, Hatch, and Lensink, 1978; Drury, Ramsdell, and French, 1981; Hunt et al., 1981; Gould, Forsell, and Lensink, 1982; Nysewander et al., 1982. Personal communications from Lehnhausen; Quinlan.



Black-legged Kittiwake

Rissa tridactyla

3.57



Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

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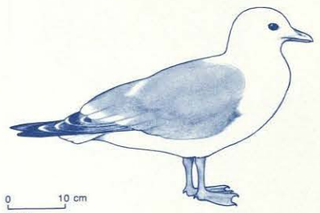


Red-legged Kittiwake

Rissa brevirostris

3.58

Description

Category

Bird

Classification

Class—Aves
Order—Charadriiformes
Family—Laridae

Name

Red-legged kittiwake, *Rissa brevirostris*

Legal Status

Protected under Migratory Bird Treaty Act of 1918 (P.L. 65-186), amended.

Range (Byrd, 1978; Sowls, Hatch, and Lensink, 1978; Hunt, Burgeson, and Sanger, 1981; Hunt, Eppley, and Drury, 1981; Hunt et al., 1981a)

Worldwide—In summer, breed in southern Bering Sea on Pribilof, Aleutian, and Commander islands. Winter in subarctic North Pacific, south of Bering Sea.

Region of Concern—In summer, breed on Pribilofs and on Bogoslof Island. Feed in pelagic waters of outer shelf of Bering Sea. Absent in winter.

Distribution

Discrete Populations (Byrd, 1978; Sowls, Hatch, and Lensink, 1978)—Five colonies in region of concern: Bogoslof, St. Paul, St. George, Otter, and Walrus islands.

Concentrations (Shuntov, 1972; Hunt, Eppley, and Drury, 1981; Hunt et al., 1981b)

- *Natural*—More than 95% of the world's population nest on St. George Island.
- *Commercial*—Not taken commercially.

Habitat (Hunt et al., 1981a)

Type—Marine, pelagic. Breed on rock ledges on sea cliffs and stacks.

Physical/Chemical—Outer-shelf domain, from 100-meter isobath to deeper ocean waters.

Life History

Social Behavior (Hunt, Eppley, and Drury, 1981)—Colonial nesters; feed singly or in small groups.

Biological Associations (Hunt, Eppley, and Drury, 1981)—Nest in mixed colonies with black-legged kittiwakes, murres.

Nutrition (Hunt, Burgeson, and Sanger, 1981; Hunt, Eppley, and Drury, 1981)

- *Feeding type*—Predator.
- *Food*—Predominantly small fishes, especially lantern fishes (Myctophidae); also pollock, capelin, sand lance, squids, euphausiids, planktonic amphipods.
- *Feeding behavior*—Surface-seizing, dipping, and surface-plunging; generally nocturnal.
- *Feeding location*—Almost entirely at shelf-break and deeper waters in frontal areas.

Reproduction (Kenyon and Phillips, 1965; Firsova, 1978; Sowls, Hatch, and Lensink, 1978; Hunt, Eppley, and Drury, 1981; Hunt et al., 1981a)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Nest on sea cliffs and stacks; in region of concern, only on Bogoslof, St. Paul, Walrus, Otter, and St. George islands.
- *Behavior*—Colonial nesters, in single-species aggregates or mixed with black-legged kittiwakes. Colony size 200 to 220,000 birds. Both sexes incubate and feed young.
- *Biology*—Arrive Pribilof Islands early April; eggs laid mid-June to July. Clutch size 1 egg; 2-egg clutches rare; incubation period about 29 days. Peak hatching late July-early August. Generally have high reproductive success.

Development (Hunt et al., 1981a; Hunt, Eppley, and Drury, 1981)—Chicks can fly at 37 days, but remain at nest 7-10 days longer. Adult plumage attained at 1 year; age at first breeding probably 2-3 years.

Growth (Hunt et al., 1981a)—Chicks gain 10-13 grams per day; fledge at 390 grams. Adults 350-450 grams; females slightly smaller than males. Maximum age unknown, probably greater than 10 years.

Movements (Shuntov, 1972; Hunt et al., 1981b)—No distinct migration. Disperse from southern Bering Sea to North Pacific in October.

Factors Influencing Populations

Natural (Hunt et al., 1981a)—Reproductive success may be limited by food supply. High winds may reduce productivity by decreasing foraging efficiency. Predation by foxes, large gulls is minimal, except on peripheral sites.

Human-related (Day, 1980)—Plastic particles found in digestive tract of 13% of Alaskan birds; effect on birds unknown. Disturbance of nesting areas lowers reproductive success; sustained subsistence hunting, particularly on St. Paul Island, reduces population size.

Potential (King and Sanger, 1979)—Oil pollution on or near Pribilof Islands could have a great impact on population, since more than 95% of world population breed there and feed along nearby shelf-break. Ranked 28th of 176 species in northeast Pacific in oil vulnerability index. Highly susceptible to oiling. Commercial fisheries may compete for food supply, especially pollock, although development of fisheries for myctophids does not appear imminent. Industrial development near colonies may depress productivity through disturbance, particularly by low-flying aircraft.

Population Size (Sowls, Hatch, and Lensink, 1978)

Total Alaska population estimated at 250,000 individuals.

Management

Nongame species.

Persons Consulted

P. J. Gould, U. S. Fish & Wildlife Service, Anchorage, Alaska.
D. S. Lloyd, Alaska Department of Fish & Game, Anchorage, Alaska.

Legend

Adult Area
(April-October)

Nesting Colony
(April-September)
Number of individuals

Less than 10,000

Greater than 100,000

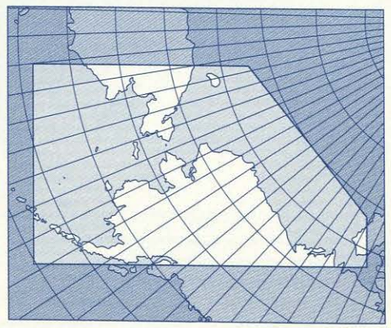
Parental Foraging Area
(April-September)

Major Parental Foraging Area
(April-September)

Eggs are laid mid-June to July; they hatch mid-July to early August. Young fledge mid-August to mid-September. Juveniles occur throughout adult areas. Wintering areas are in subarctic North Pacific.

Map References

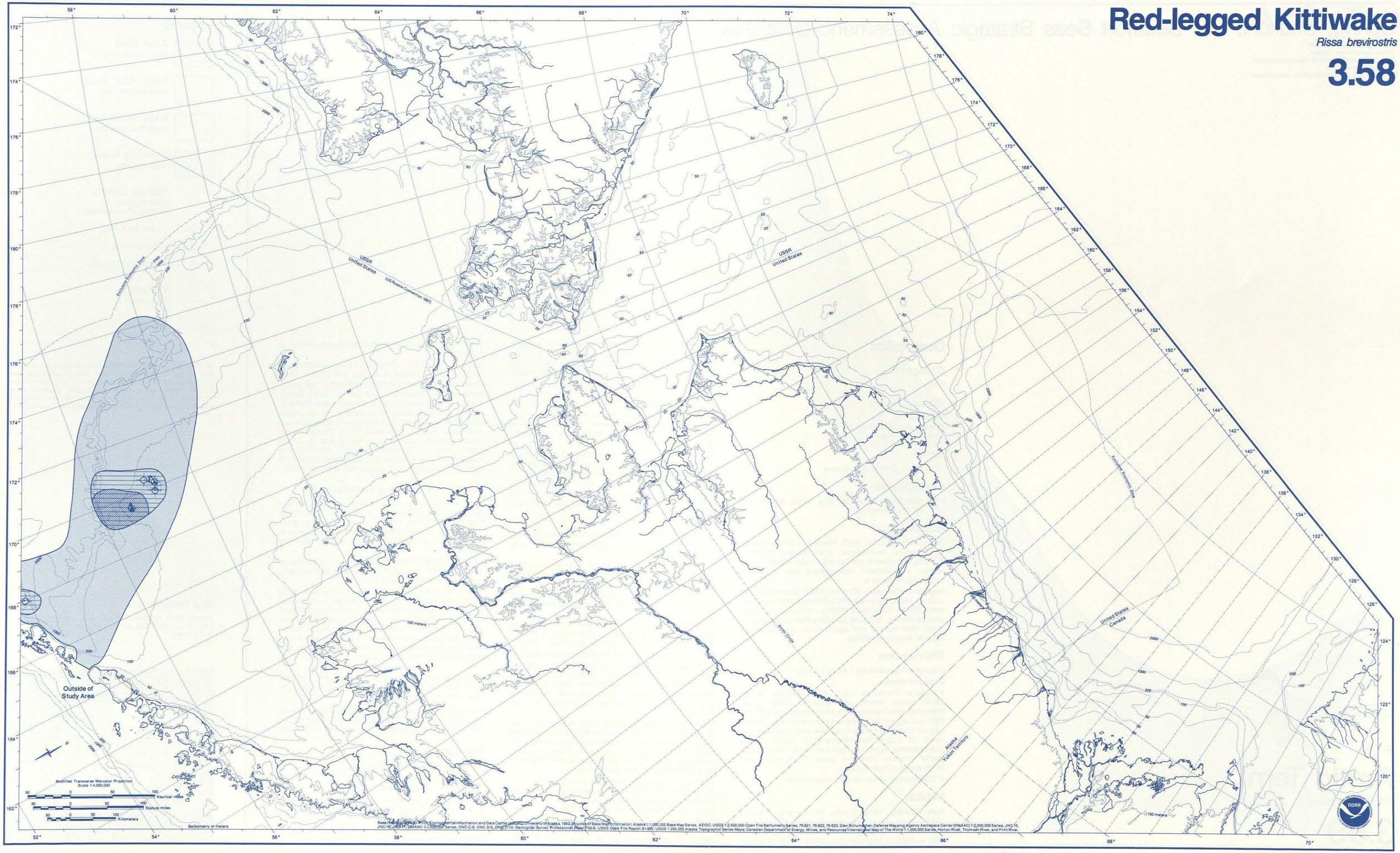
Byrd, 1978; Sowls, Hatch, and Lensink, 1978; Hunt, Burgeson, and Sanger, 1981; Hunt, Eppley, and Drury, 1981; Hunt et al., 1981.



Red-legged Kittiwake

Rissa brevirostris

3.58



Base map data sources: NOS, Environmental Information and Data Center (EIDC), University of Alaska, 1982; Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-485; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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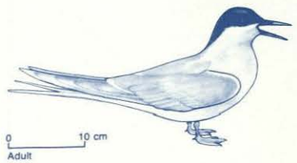


Arctic Tern

Sterna paradisaea

3.59

Description

Category

Bird

Classification

Class—Aves
Order—Charadriiformes
Family—Laridae

Name

Arctic tern, *Sterna paradisaea*

Legal Status

Protected under Migratory Bird Treaty Act of 1918 (P.L. 65-186), amended.

Range

Worldwide (A.O.U., 1957; Watson, 1975)—Holarctic breeders. In summer, from Alaska, northern Canada, Greenland, northern Eurasia to high Arctic. Winter in Southern Hemisphere and antarctic-subantarctic waters.

Region of Concern (Snyder, 1957; Gabrielson and Lincoln, 1959; Portenko, 1973; Sowls, Hatch, and Lensink, 1978; Kistchinski, 1980)—In summer, along coastal Bering, Chukchi, and Beaufort seas; also interior river valleys and alpine lakes of Alaska and Siberia. Absent in winter.

Distribution

Discrete Populations—None known.

Concentrations

- *Natural* (Portenko, 1973; 1976; Divoky, 1978a, 1979; Sowls, Hatch, and Lensink, 1978; Drury, Ramsdell, and French, 1981; Hunt, Eppley, and Drury, 1981)—Largest breeding concentrations at Nelson Lagoon (near Port Moller), Alaska, and Idlidlya Island (west of Cape Serdtse-Kamen), USSR. Large postbreeding migratory flocks at Plover Islands (extreme western Beaufort Sea), Pt. Barrow, and Pt. Franklin (Chukchi Sea).
- *Commercial*—Not taken commercially.

Habitat

Type (Divoky, 1976; Sowls, Hatch, and Lensink, 1978; Drury, Ramsdell, and French, 1981; Hunt, Eppley, and Drury, 1981; Johnson and Richardson, 1981)—Marine, nearshore to pelagic. Breed on gravel islands, beaches, spits, and interior rivers and lakes.

Physical/Chemical (Sowls, Hatch, and Lensink, 1978; Drury, Ramsdell, and French, 1981; Hunt, Eppley, and Drury, 1981)—Fresh to salt water. Generally nest on gravel islands, beaches, or spits.

Life History

Social Behavior (Gabrielson and Lincoln, 1959; Drury, Ramsdell, and French, 1981)—Solitary to colonial during breeding. Moderately gregarious during migration.

Biological Associations (Baird and Moe, 1978; Sowls, Hatch, and Lensink, 1978)—Nest in mixed colonies with Aleutian terns where ranges overlap.

Nutrition (Gabrielson and Lincoln, 1959; Serventy, Serventy, and Warham, 1971; Divoky, 1976; Day, 1980; Drury, Ramsdell, and French, 1981; Johnson and Richardson, 1981)

- *Feeding type*—Predator.
- *Food*—Crustaceans (especially euphausiids; also amphipods and mysids) and small fishes (e.g., sticklebacks, Arctic cod).
- *Feeding behavior*—Contact-dipping, hovering, and surface-plunging. Solitary or in small flocks. Rarely sit on salt water.
- *Feeding location*—Tundra lakes, lagoons, rivers, bays, inlets, beaches, tide rips, areas of upwelling, and oceanic fronts.

Reproduction (Gabrielson and Lincoln, 1959; Sowls, Hatch, and Lensink, 1978; Drury, Ramsdell, and French, 1981; Hunt, Eppley, and Drury, 1981)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Nest mainly on open beaches; also on cobbles, gravel patches on rocky shores, and wet or dry tundra. Avoid tall vegetation. Nest is shallow depression, sometimes lined with dried vegetation or ringed with bits of driftwood, stones, or other detritus.
- *Behavior*—Usually nest in small colonies or scattered pairs. Can exhibit low site fidelity. May relocate yearly in response to succession, disturbance, or predation. Strongly defend eggs and young, attacking predators and humans. Both male and female incubate, protect nest, and feed young.
- *Biology*—Arrive on breeding grounds late April-June; lay eggs late May to mid-June; clutch 1-3 eggs. Incubation period about 21 days. Eggs hatch mid-June to July. Hatching success 40-90%.

Development (Coulson and Horobin, 1976; Drury, Ramsdell, and French, 1981; Hunt, Eppley, and Drury, 1981)—Chicks fledge at 28 days. Age at first breeding averages 4 years, but may breed as early as 2 years.

Growth (Coulson and Horobin, 1976)—Adult size at fledging. Adult weight averages 115 grams. Maximum age more than 29 years; average 11-12 years.

Movements (Gabrielson and Lincoln, 1959; Drury, Ramsdell, and French, 1981; Johnson and Richardson, 1981)—Fall migration coastal in Arctic, otherwise offshore migrant. Fall migration begins late July and early August, westward along Beaufort and Chukchi coasts, then through Bering Sea to Gulf of Alaska, and on to western South America and Antarctica. Little information on spring movements in region of concern; may migrate over a broad front.

Factors Influencing Populations

Natural (Gabrielson and Lincoln, 1959; Baird and Moe, 1978; Drury, Ramsdell, and French, 1981; Hunt, Eppley, and Drury, 1981)—Foxes, jaegers, gulls, ravens, and weasels take eggs and young. Storms at hatching and during chick rearing reduce reproductive success.

Human-related—Sensitive to disturbance during nesting season; may abandon nest site permanently. Hunted off coast of South America.

Potential (King and Sanger, 1979; Ohlendorf et al., 1982)—Ranked 116th of 176 species in northeast Pacific in oil vulnerability index. Low susceptibility to oiling. Barrier island development and causeway construction may facilitate predation by Arctic foxes. Growth of gull populations from food provided at garbage dumps could depress tern reproduction and displace terns from colony sites.

Population Size (Sowls, Hatch, and Lensink, 1978; Drury, Ramsdell, and French, 1981; Hunt, Eppley, and Drury, 1981)

Bering, Chukchi, and Beaufort population on Alaska side estimated at 3,000-4,000 individuals. Fall migration past Pt. Barrow greater than 10,000 individuals.

Management

Nongame species.

Persons Consulted

P. A. Baird, University of California, Irvine, California.
P. J. Gould, U. S. Fish & Wildlife Service, Anchorage, Alaska.
S. M. Patten, Alaska Department of Fish & Game, Bethel, Alaska.

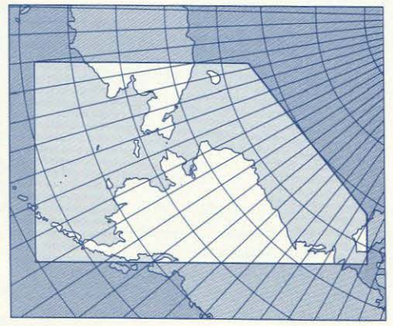
Legend

- Adult Area (May-September)
- Major Adult Area (May-September)
- Major Adult Area (August-September)
- Breeding Area (May-August)
- Nesting Colony (May-August) Number of individuals
  - Less than 100
  - 100 to 1,000
  - Greater than 1,000
- Migration (May-June)
- Migration (August-September)

Adults occur June-September north of Bering Strait. Breeding also occurs on barrier islands and throughout interior land areas. Eggs are laid late May to mid-June; they hatch mid-June to July. Young fledge mid-July to August. Juveniles occur throughout adult areas. Wintering areas are in subantarctic and antarctic regions. Migratory routes are not well known.

Map References

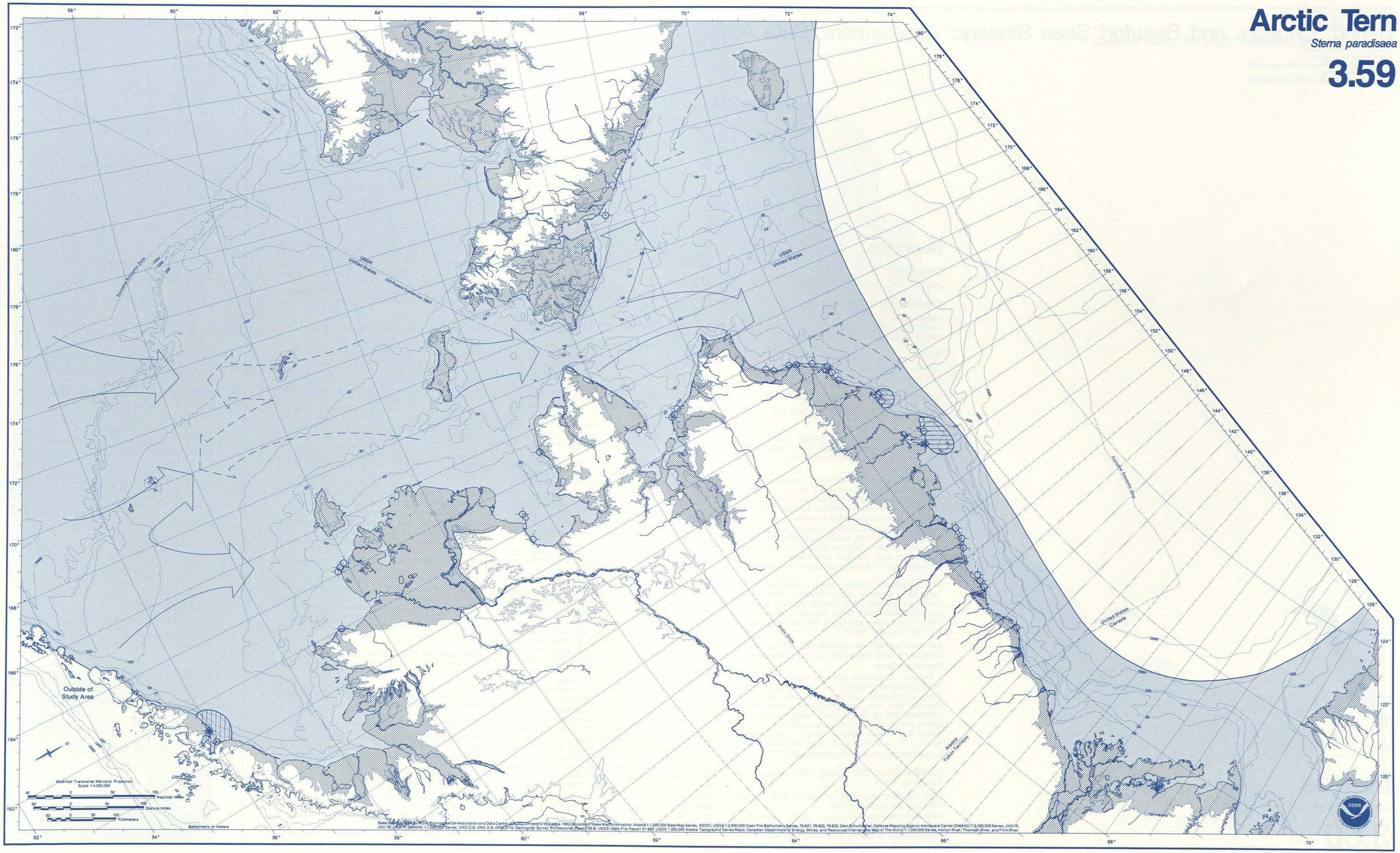
Snyder, 1957; Portenko, 1973; Sowls, Hatch, and Lensink, 1978; Drury, Ramsdell, and French, 1981; Hunt, Eppley, and Drury, 1981.



Arctic Tern

Sterna paradisaea

3.59



Base map by the Arctic Environmental Information and Data Center, University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17, DMAAC-1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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Adult male, *Uria aalge*

Murres

Uria aalge, U. lomvia

3.60

Description

Category

Bird

Classification

Class—Aves
Order—Charadriiformes
Family—Alcidae

Name

Common murre, *Uria aalge*, and thick-billed murre, *Uria lomvia*

Legal Status

Protected under Migratory Bird Treaty Act of 1918 (P.L. 65-186).

Range (American Ornithologists' Union, 1957; Gabrielson and Lincoln, 1959; Tuck, 1960; Sowls, Hatch, and Lensink, 1978; Hunt, Eppley, and Drury, 1981)

Worldwide—Holarctic. Common murre south to Spain, New York, California, and Japan in summer. Thick-billed murre south to southern Greenland, the Aleutians, and the Kuril Islands in summer. Both from subarctic to temperate zones in winter.

Region of Concern—Bering, Chukchi, and Beaufort Seas; Aleutian Islands, Alaska Peninsula, and Bristol Bay north to Cape Lisburne, Cape Parry (Northwest Territories), and Wrangel and Herald Islands in summer; south of ice edge to Aleutians in winter.

Distribution (Bailey, 1948; Uspenskii, 1958; Tuck, 1960; Udvardy, 1963; Portenko, 1973; Sowls, Hatch, and Lensink, 1978; Kistchinski, 1980; Springer and Roseneau, 1980; Drury, Ramsdell, and French, 1981; Hunt, Eppley, and Drury, 1981; Nysewander et al., 1982; Woodby, 1984)

Discrete Populations—At least 140 semi-isolated or isolated breeding populations in area of concern.

Concentrations:

- *Natural*—In summer, primarily within 100 km of nesting colonies in Bering and Chukchi Seas. Cape Parry, Northwest Territories, is only colony in Beaufort Sea. Also, throughout open waters of the southwest Bering Sea in much lesser numbers. In winter, concentrate at southern edge of pack ice from Bristol Bay westward and in areas of open pack ice south of St. Lawrence Island and in Kuskokwim Bay.
- *Commercial*—Not taken commercially.

Habitat (Tuck, 1960; Spring, 1971; Springer and Roseneau, 1980)

Type—Marine, nearshore to pelagic. Nest on sea cliffs and stacks; feed in sea.

Physical/Chemical—Species partly sympatric; overlapping habitat preferences. Common murre predominates in Bering Sea along mainland coast and nearshore islands, in waters 5-15°C, to 50 meters' depth. Thick-billed murre predominates in northern areas, on offshore islands, and in deeper waters at 0-10°C.

Life History

Social Behavior (Tuck, 1960; Springer and Roseneau, 1980)—Colonial breeders; feed and migrate singly and in small flocks. Large feeding flocks of thousands of birds are associated with high prey densities.

Biological Associations (Sowls, Hatch, and Lensink, 1978; Hunt, Eppley, and Drury, 1981)—Frequently nest near kittiwakes.

Nutrition (Springer and Roseneau, 1980; Hunt, Burgeson, and Sanger, 1981)

- *Feeding type*—Predator.
- *Food*—Mainly small fishes, some invertebrates. Common murre takes sand lance, capelin, Arctic cod, and small zooplankton; thick-billed murre takes stichaeids, pollock, large pelagic zooplankton (*Parathemisto*, other amphipods, euphausiids), and cephalopods.
- *Feeding behavior*—Pursuit diving; catch prey underwater. Early in nesting season, adults forage in large groups; later, singly. Feed during daylight hours.
- *Feeding location*—Summer: common murre usually forages within 10 km of colonies; thick-billed murre farther offshore, within 100 km of colonies. Winter: mainly near ice edge. South of ice edge, disperse over Bering Sea, especially along continental shelf.

Reproduction (Gabrielson and Lincoln, 1959; Tuck, 1960; Sowls, Hatch, and Lensink, 1978; Hunt, Eppley, and Drury, 1981)

- *Mode*—Sexual; internal fertilization.
- *Location*—Nest on sea cliffs and stacks. Common murre favors wide ledges and broad, flat areas; thick-billed murre nests on narrow ledges, in crevices, and on sloping cliffs.
- *Behavior*—Colonial; strong pair bond and high nest-site fidelity. Arrive at nesting areas mid to late May. Communally display on water; copulate on nest site. Nest closely together in dense concentrations. Colony size, a few to nearly a million pairs.
- *Biology*—Single egg laid early June to mid-July; incubation period 31-34 days; hatching success about 50%. Chicks hatch July-August. Will lay a second egg if first is lost early in season.

Development (Tuck, 1960; Springer and Roseneau, 1980; Hunt, Eppley, and Drury, 1981)—Chicks remain 18-24 days on nesting ledges, where they are fed and frequently brooded by adults. Before capable of flying, leave nest by jumping into water, usually at sunset. Adult males lead chicks away from colonies, and feeding by adults continues on the water. Duration of parental care at sea unknown. Probably mature at 2-3 years.

Growth (Tuck, 1960)—Chicks 70-90 grams at hatching, 175-275 grams when they go to sea. Adults average 950-1,100 grams; common murre averages 34-40 cm total length; thick-billed murre, 43-48 cm. Maximum age 30 years, average 11 years.

Movements (Tuck, 1960; Shuntov, 1972, Springer and Roseneau, 1980)—After breeding, widespread dispersal to sea and general southward shift. Most remain over continental shelf in ice-free areas and along ice edge. Some thick-billed murres winter in breeding range, notably Kuskokwim and Bristol Bays and south of St. Lawrence Island, where open water is available.

Factors Influencing Populations

Natural (Gabrielson and Lincoln, 1959; Tuck, 1960; Bailey and Davenport, 1972; Springer and Roseneau, 1980)—Principal predators on eggs and chicks are large gulls, ravens, and foxes. Cold weather and/or late sea-ice cover delay nesting, depress productivity. Mass mortalities ("wrecks") appear to result from starvation and adverse weather.

Human-related (Gabrielson and Lincoln, 1959; Ogi and Tsujita, 1973; King, 1975; Day, 1980; Springer and Roseneau, 1980)—Colonies easily disturbed by motor boats, gun shots, human intrusion, and low-flying aircraft (especially helicopters), which can cause eggs and chicks to be knocked from ledges or exposed to predation. Oiling has caused mass mortalities (up to 90,000 birds); even microliters of oil transferred to egg leads to embryonic death. Large direct mortality from high-seas, drift-net fisheries. Plastic particles found in digestive tract of 1% of Alaskan thick-billed murres; effect on birds unknown.

Potential (King and Sanger, 1979; Springer and Roseneau, 1980)—Ranked 20th of 176 species in northeast Pacific in oil vulnerability index. Blowouts and oil spills are major concerns, because birds are densely concentrated in proposed transport corridors and are highly susceptible to oil contamination. Oil spilled in, on, or under ice may accumulate in leads and polynyas used by birds. Depletion of forage fish stocks (especially pollock) by commercial fishing could depress populations. Increasing populations of large gulls, ravens, and foxes, stimulated by increasing garbage, could lead to greater mortality from predation.

Population Size (Tuck, 1960; Shuntov, 1972; Portenko, 1973; Sowls, Hatch, and Lensink, 1978; Hunt et al., 1981b)

Combined population in region of concern conservatively estimated at more than 10 million birds; about 75% in Bering Sea.

Management (Springer and Roseneau, 1980)

Protected under Migratory Bird Treaty Act of 1918; taking of eggs and adults by Native peoples for subsistence allowed in USSR and Alaska.

Persons Consulted

F.H. Fay, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
D.G. Roseneau, LGL Alaska Research Associates, Fairbanks, Alaska.
A.M. Springer, LGL Alaska Research Associates, Fairbanks, Alaska.

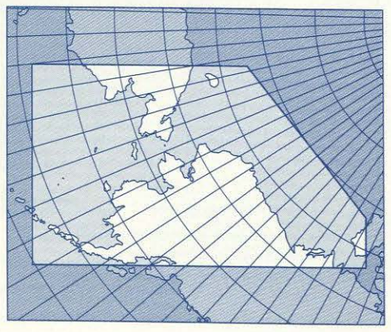
Legend

- Adult Area (Year-round)
- Adult Area (May-November)
- Adult Area (June-August)
- Nesting Colony (May-September) Number of individuals
  - Common Murre
    - Less than 100,000
    - Greater than 100,000
  - Thick-billed Murre
    - Less than 100,000
  - Both Species
    - Less than 100,000
    - 100,000 to 1,000,000
    - Greater than 1,000,000
- Parental Foraging Area (May-September)
- Major Parental Foraging Area (May-September)
- Major Parental Foraging Concentration (May-September)

Adult area (year-round) is also major adult area (January-April). Eggs are laid June to mid-July; they hatch July to mid-August. Young fledge August-September. Juveniles occur throughout adult areas. Northern limit of adult area (June-September) is average minimum five-tenths ice cover. (See map 1.8, Sea Ice Dynamics.)

Map References

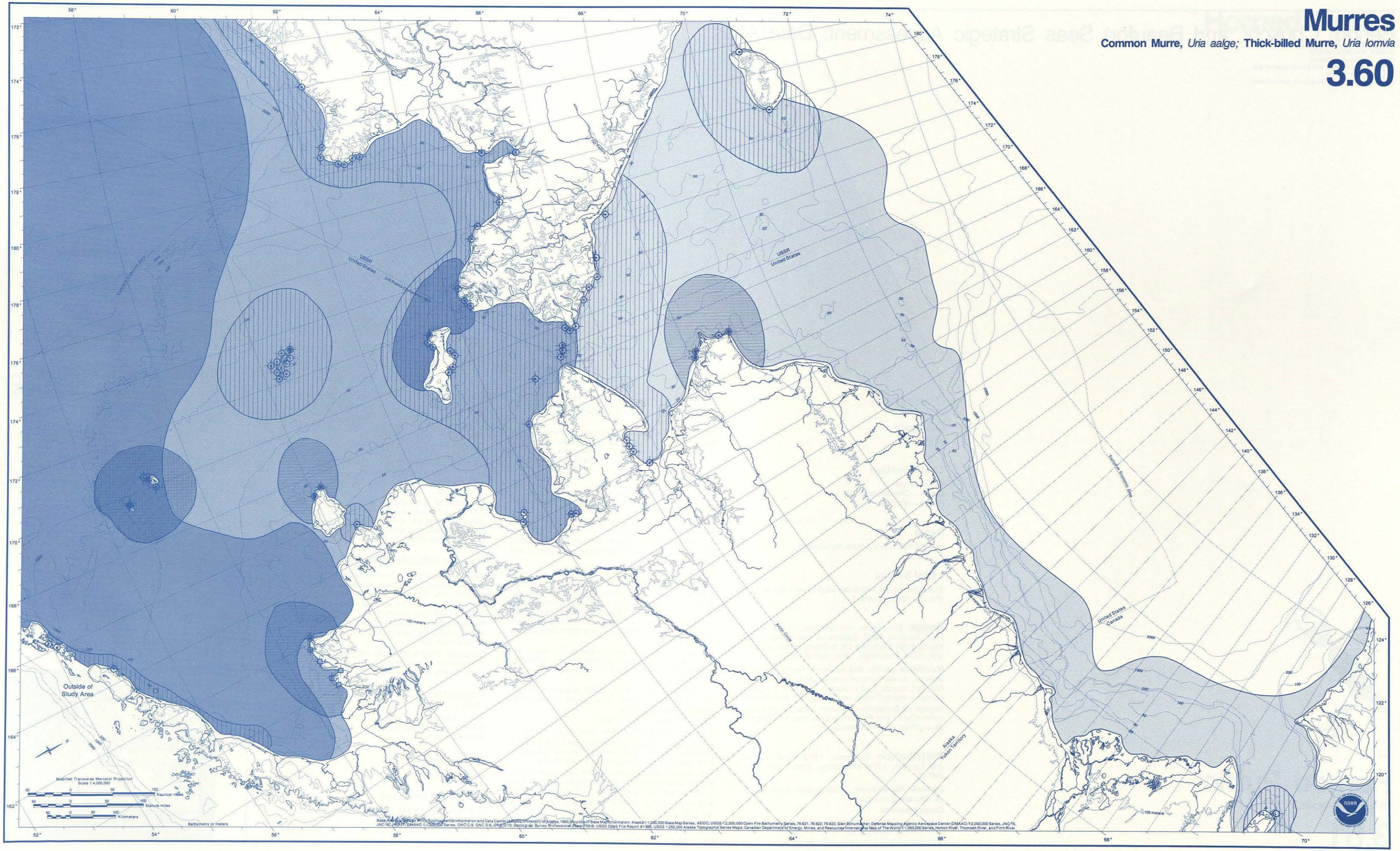
Bailey, 1948; Portenko, 1973; Sowls, Hatch, and Lensink, 1978; Kistchinski, 1980; Springer and Roseneau, 1980; Drury, Ramsdell, and French, 1981; Hunt, Eppley, and Drury, 1981; Nysewander et. al., 1982. Personal communications from Day; Fay.



Murres

Common Murre, *Uria aalge;* **Thick-billed Murre,** *Uria lomvia*

3.60



Base map data courtesy of the Environmental Information and Data Center (AEIDC), University of Alaska, 1982; Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-855; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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Adult

Horned Puffin

Fratercula corniculata

3.61

Description

Category

Bird

Classification

Class—Aves
Order—Charadriiformes
Family—Alcidae

Name

Horned puffin, *Fratercula corniculata*

Legal Status

Protected under Migratory Bird Treaty Act of 1918 (P.L. 65-186), amended.

Range (Dement'ev and Gladkov, 1951a; A.O.U., 1957; Kozlova, 1957; Gabrielson and Lincoln, 1959; Vaurie, 1965; Portenko, 1973; Sowls, Hatch, and Lensink, 1978; Kistchinski, 1980; Wehle, 1980)

Worldwide—Arctic and subarctic North Pacific. In summer, breed from central Chukchi Sea south to Aleutian Islands, Gulf of Alaska, and Gulf of Anadyr. Winter in North Pacific, south to Japan and Oregon.

Region of Concern—Summer: Wrangel and Kolyuchin islands and Pt. Barrow area, south throughout Bering Sea. Absent in winter.

Distribution (Portenko, 1973; Sowls, Hatch, and Lensink, 1978; Kistchinski, 1980; Hunt et al., 1981b)

Discrete Populations—Each breeding colony may be discrete population.

Concentrations

- *Natural*—Largest in region of concern at Little Diomede, St. George, and Chamisso islands.
- *Commercial*—Not taken commercially.

Habitat (Kessel, 1979; Wehle, 1980)

Type—Marine, nearshore to pelagic. Breed in cavities in cliffs and talus.

Physical/Chemical—Usually feed in waters less than 50 meters deep. Nest in cliffs and talus slopes, occasionally in rocky soil, rarely in burrows. Elevations 3 to more than 300 meters; slope angles 5-90°.

Life History

Social Behavior (Wehle, 1980)—Generally solitary or in low numbers (10-100 birds); gregarious in nearshore staging areas, where large flocks (to thousands) may occur. Congregate on rocks in colony, morning and evening.

Biological Associations (Wehle, 1980)—Often nest near pigeon guillemots (*Cepphus columba*) and parakeet auklets.

Nutrition (Wehle, 1980)

- *Feeding type*—Predator.
- *Food*—Adults take mainly sand lance, capelin, sandfish, cods, greenlings, sculpins, and squids; also, pelagic polychaetes, amphipods, and decapod larvae; rarely sponges and chitons. Subadults take more fish and squid than do adults. Young fed mainly capelin and sand lance.
- *Feeding behavior*—Pursuit-diving. Generally singly. Carry food to young 1-6 times per day, increasing in frequency as chicks get older, decreasing during severe weather.
- *Feeding location*—Pelagic and nearshore in summer. Greatest numbers about 2 km or less from colony; in winter, pelagic.

Reproduction (Wehle, 1980)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Copulate on water near colony; nest in cliff crevices; nest is on bare rock or soil, frequently with sparse lining of vegetation and feathers.
- *Behavior*—Monogamous; show strong pair bonding and nest-site fidelity. Both parents incubate, feed young. Circle in air over colonies, often in large flocks.
- *Biology*—Arrive nesting areas early May to mid-June; single egg laid mid-June to mid-July; incubation period 40-41 days. May renest if egg lost early in season. Overall reproductive success 0.29-0.78 young fledged per nest.

Development (Sealy, 1973; Wehle, 1980)—Chicks semiprecocial, fed by parents in nest; attain homeothermy at 5-7 days; fledge at 40-45 days, mainly at night; independent thereafter. Age at first breeding unknown, probably 4-5 years.

Growth (Sealy, 1973; Wehle, 1980; Hunt, Burgeson, and Sanger, 1981)—Chicks at fledging about 66% adult weight. Adults average 600 grams in northern Bering Sea; 560 grams in southern Bering Sea; males slightly heavier than females. Maximum age, probably 15-20 years.

Movements (Dement'ev and Gladkov, 1951a; A.O.U., 1957; Kozlova, 1957; Wehle, 1980)—Move offshore after nesting; shift southward in fall before ice forms, northward in spring during breakup; no migratory pathways known.

Factors Influencing Populations

Natural (Wehle, 1980)—Predators include foxes, eagles, falcons, snowy owls; eggs taken by large gulls, jaegers. Food for young stolen by gulls, jaegers; may decrease reproductive success. Shifting of talus can create or destroy nesting sites.

Human-related (Day, 1980)—Plastic particles found in digestive tract of 36% of Alaskan birds; effect on birds unknown.

Potential (King and Sanger, 1979)—Ranked 14th of 176 species in northeast Pacific in oil vulnerability index. Highly susceptible to oiling.

Population Size (Sowls, Hatch, and Lensink, 1978)

Total Alaska population estimated at 1.5 million birds; approximately 15% of world population in region of concern.

Management

Nongame species.

Persons Consulted

R. H. Day, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
P. J. Gould, U. S. Fish & Wildlife Service, Anchorage, Alaska.

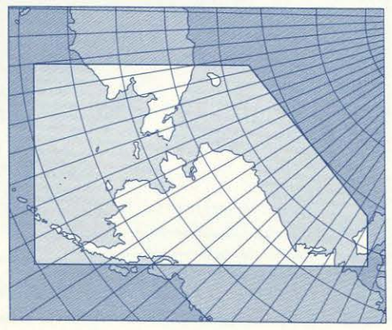
Legend

- Adult Area (May-November)
- Adult Area (June-September)
- Occasional Occurrence (May-November)
- Nesting Colony (May-August) Number of individuals
  - Less than 1,000
  - 1,000 to 10,000
  - Greater than 10,000
- Parental Foraging Area (May-September)
- Major Parental Foraging Area (May-September)
- Major Parental Foraging Concentration (May-September)

Eggs are laid mid-June to mid-July; they hatch late July to late August. Young fledge in September. Juveniles occur throughout adult areas. Wintering areas are in subarctic North Pacific.

Map References

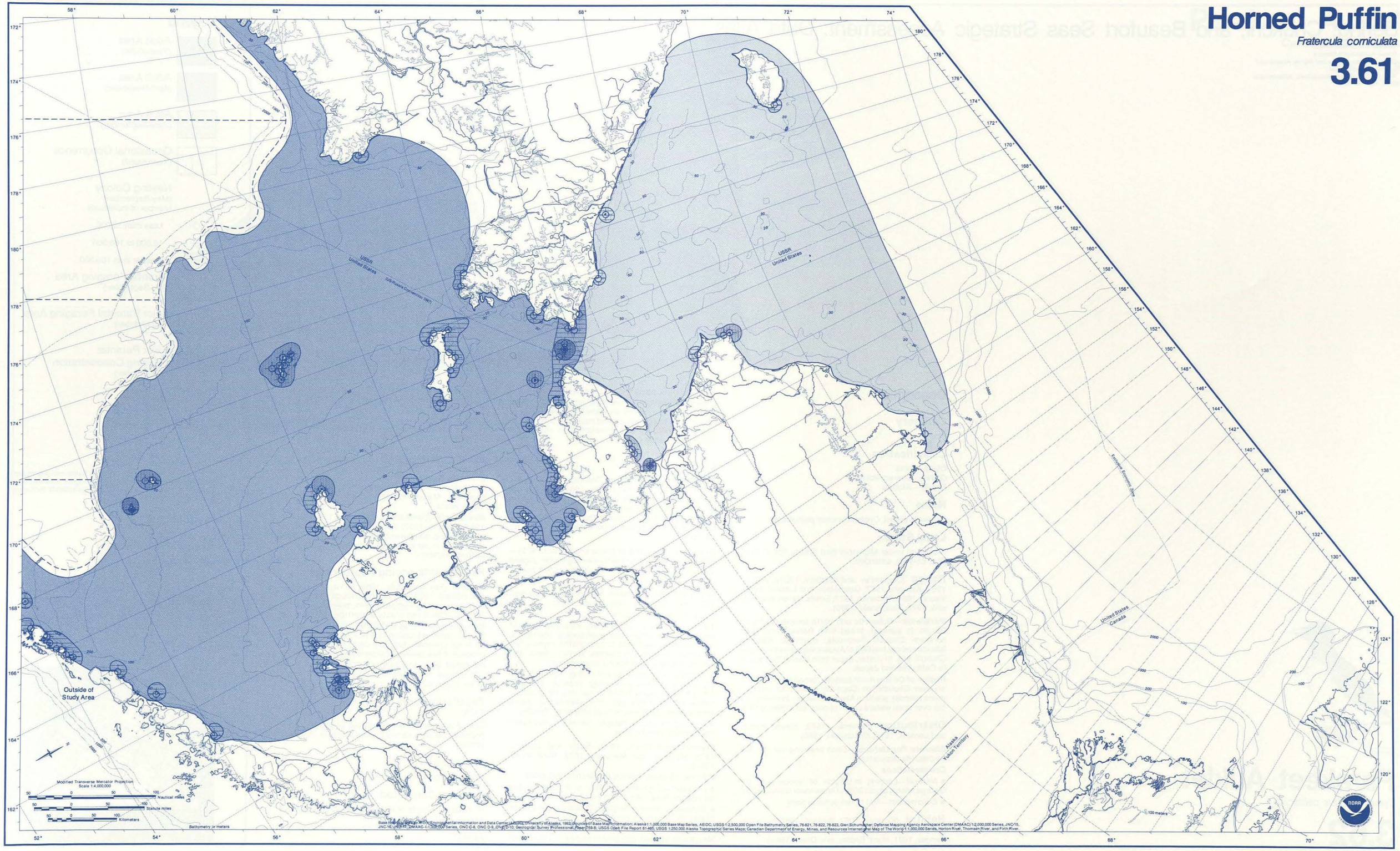
Portenko, 1973; Sowls, Hatch, and Lensink, 1978; Kistchinski, 1980; Gill, Petersen, and Jorgensen, 1981; Nysewander et al., 1982.



Horned Puffin

Fratercula corniculata

3.61



Base map data provided by ACCESS (Environmental Information and Data Center), UAIDC, University of Alaska, 1982; Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC/15, JNC16, JNC17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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Adult male

Parakeet Auklet

Cyclorrhynchus psittacula

3.62

Description

Category

Bird

Classification

Class—Aves
Order—Charadriiformes
Family—Alcidae

Name

Parakeet auklet, *Cyclorrhynchus psittacula*

Legal Status

Protected under Migratory Bird Treaty Act of 1918 (P.L. 65-186), amended.

Range (Dement'ev and Gladkov, 1951a; A.O.U., 1957; Kozlova, 1957; Gabrielson and Lincoln, 1959; Vaurie, 1965; Portenko, 1973; Sowls, Hatch, and Lensink, 1978; Kistchinski, 1980)

Worldwide—Subarctic and north temperate North Pacific. In summer, breed from Bering Strait and northern Chukchi Peninsula, south to Aleutian Islands and central Gulf of Alaska; vagrants to central Chukchi Sea. In winter, occur from Bering Sea south to California and Japan.

Region of Concern—In summer, breed from extreme southern Chukchi Sea (Cape Serdtse-Kamen and Diomede Islands), south to Aleutian Islands. In winter, occur over open waters south of pack ice in Bering Sea.

Distribution (Portenko, 1973; Sowls, Hatch, and Lensink, 1978; Kistchinski, 1980)

Discrete Populations—Each breeding colony may be discrete population.

Concentrations

- *Natural*—Largest in region of concern at St. George Island, about 20% of known world population.
- *Commercial*—Not taken commercially.

Habitat (Kozlova, 1957; Bédard, 1969a,b; Sealy and Bédard, 1973; Kessel, 1979; Hunt, Burgeson, and Sanger, 1981; Hunt, Eppley, and Drury, 1981)

Type—Marine, pelagic. Breed in crevices in rock.
Physical/Chemical—Inner-shelf to oceanic waters. Nest in crevices in cliffs, lava flows, boulder beaches, and talus slopes on islands and mainland; occasionally burrow in rocky soil; elevation 3 to more than 300 meters; slope 0-90°.

Life History

Social Behavior (Sealy and Bédard, 1973; Manuwal and Manuwal, 1979; Hunt et al., 1981a)—Generally solitary or in low numbers (10-100 birds); gregarious during breeding season in nearshore staging areas, where large flocks (to greater than 1,000 birds) may occur. Return to colony once a day, usually during daylight.

Biological Associations (Sealy and Bédard, 1973)—Often nest near other cavity-nesting alcids (pigeon guillemots, least and crested auklets [*Aethia cristatella*], and horned puffins).

Nutrition (Bédard, 1969a; Manuwal and Manuwal, 1979; Hunt, Burgeson, and Sanger, 1981)

- *Feeding type*—Predator.
- *Food*—Primarily zooplankton, including hyperiid and gammarid amphipods, euphausiids, pteropods, large calanoid copepods, chaetognaths, mysids, larval fishes, pelagic polychaetes, shrimp zoeae, and squids. Young fed planktonic crustaceans.
- *Feeding behavior*—Pursuit-diving. Generally singly, during afternoon-evening; possibly at night. Carry food to young 1-8 times per day, increasing in frequency as chicks get older, decreasing during severe weather. About 60% of time spent feeding.
- *Feeding location*—Pelagic. Generally midwater; occasionally near bottom.

Reproduction (Bent, 1919; Sealy and Bédard, 1973; Manuwal and Manuwal, 1979; Hunt et al., 1981a)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Copulate on water or in nest crevice; lay eggs on bare rock or soil in crevice.
- *Behavior*—Show strong pair bonding and nest-site fidelity. Both parents incubate egg, feed young.
- *Biology*—Arrive nesting areas mid-April to late May; single egg laid mid-June to early July. Incubation period 35 days. May renest if egg lost early in season. Hatching success 68%; fledging success 76%.

Development (Sealy, 1973; Sealy and Bédard, 1973)—Chicks semiprecocial, fed by parents in nest crevice; attain homeothermy at 4-5 days; fledge at 35 days, mainly at night; independent thereafter. Age at first breeding probably 2-3 years.

Growth (Sealy and Bédard, 1973)—Chicks at fledging about 77% adult weight. Adults average 290 grams in northern Bering Sea; 255-260 grams in southern Bering Sea; males slightly heavier than females. Maximum age unknown, probably 10-15 years.

Movements (Dement'ev and Gladkov, 1951a; A.O.U. 1957; Kozlova, 1957; Vaurie, 1965)—Move offshore after nesting, southward in fall before ice advances, northward in spring as ice retreats; no migratory pathways known.

Factors Influencing Populations

Natural (Fay and Cade, 1959; Murie, 1959; Sealy and Bédard, 1973)—Predators include Arctic foxes, bald eagles, rough-legged hawks, peregrine falcons. Shifting of talus can create or destroy nesting sites.

Human-related (Fay and Cade, 1959; Day, 1980)—Plastic particles found in 75% of Alaskan birds; effect on birds unknown, but may decrease ability to reproduce. A few taken by Eskimos and Aleuts for food.

Potential (King and Sanger, 1979)—Ranked 8th of 176 species in northeast Pacific in oil vulnerability index. Highly susceptible to oiling.

Population Size (Sowls, Hatch, and Lensink, 1978)

Total Alaska population estimated at 800,000 birds; probably 50-60% of world population in region of concern.

Management

Nongame species.

Persons Consulted

R. H. Day, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
P. J. Gould, U. S. Fish & Wildlife, Service, Anchorage, Alaska.

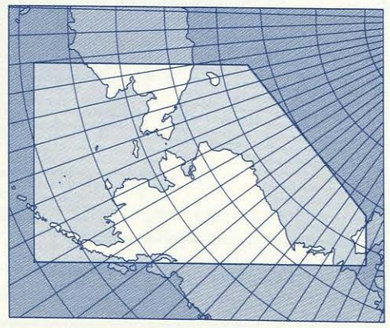
Legend

- Adult Area (Year-round)
- Adult Area (April-November)
- Adult Area (June-September)
- Occasional Occurrence (Year-round)
- Nesting Colony (May-September) Number of individuals
  - Less than 10,000
  - 10,000 to 100,000
  - Greater than 100,000
- Parental Foraging Area (May-September)
- Major Parental Foraging Area (May-October)
- Major Parental Foraging Concentration (May-October)
- Migration (May)
- Migration (October)

Eggs laid mid-June to early July; they hatch mid-July to early August. Young fledge late July to mid-August. Juveniles occur throughout adult areas. Wintering range extends throughout subarctic North Pacific.

Map References

Portenko, 1973; Sowls, Hatch, and Lensink, 1978; Kistchinski, 1980.



Parakeet Auklet

Cyclorrhynchus psittacula

3.62



Base map courtesy of the Environmental Information and Data Center (AEIDC), University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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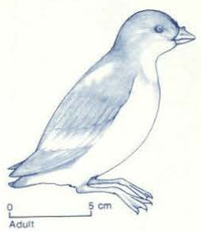

Least Auklet

Aethia pusilla

3.63

Description

Category

Bird

Classification

Class—Aves
Order—Charadriiformes
Family—Alcidae

Name

Least auklet, *Aethia pusilla*

Legal Status

Protected under Migratory Bird Treaty Act of 1918 (P.L. 65-186), amended.

Range (Dement'ev and Gladkov, 1951a; A.O.U., 1957; Kozlova, 1957; Gabrielson and Lincoln, 1959; Vaurie, 1965; Portenko, 1973; Sowls, Hatch, and Lensink, 1978)

Worldwide—Subarctic and northern temperate North Pacific. In summer, breed from Bering Strait south to Aleutian Islands and western Gulf of Alaska. In winter, inhabit open waters of Bering Sea and North Pacific south to Japan.

Region of Concern—Summer: breed on Big and Little Diomede, Arakamchechen, St. Lawrence, St. Matthew, and Pribilof islands. Uncommon vagrants in southern Chukchi Sea. Winter: uncommon in open water south of pack ice in Bering Sea.

Distribution (Portenko, 1973; Sowls, Hatch, and Lensink, 1978)

Discrete Populations—Each breeding colony may be discrete population.

Concentrations

- *Natural*—Largest in region of concern at Big and Little Diomede and St. Lawrence islands.
- *Commercial*—Not taken commercially.

Habitat (Dement'ev and Gladkov, 1951a; Kozlova, 1957; Bédard, 1969a,b; Kessel, 1979; Hunt et al., 1981a)

Type—Marine, pelagic. Breed on talus slopes and boulder beaches.

Physical/Chemical—Usually feed in waters more than 50 meters deep. Nest in cliffs, on boulder beaches, and on talus slopes; on talus slopes, nest among rocks 0.3-0.6 meters in diameter. Elevations 3-250 meters; slope angles 0-90°, mainly 5-45°.

Life History

Social Behavior (Bent, 1919)—Gregarious, colonial breeders. Swarm over nesting slopes morning and evening; stage on water near colonies, often bathing communally. Congregate on rocks in colonies morning and evening; much physical, vocal interaction. Less gregarious after breeding season.

Biological Associations (Bédard, 1969b)—Often nest near crested and parakeet auklets and horned puffins.

Nutrition (Bédard, 1969a; Searing, 1977; Hunt, Burgeson, and Sanger, 1981)

- *Feeding type*—Predator.
- *Food*—Mainly large calanoid copepods, hyperiid and gammarid amphipods, crab larvae; also, mysids, shrimps, cumaceans, chaetognaths, larval fishes, pelagic polychaetes, and pteropods. Young fed planktonic crustaceans.
- *Feeding behavior*—Pursuit-diving, generally singly. Carry food to young 2-8 times per day; increasing in frequency as chicks get older.
- *Feeding location*—Pelagic: midwater; in summer, more than 10 km from colony; in winter, farther offshore.

Reproduction (Bent, 1919; Sealy, 1968, 1970, 1973, 1975, 1981; Searing, 1977; Hunt, Eppley, and Drury, 1981; Hunt et al., 1981a; Knudtson and Byrd, 1982)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Copulate in nest crevice; lay egg on bare rock or soil in crevice.
- *Behavior*—Monogamous; high mate and nest-site fidelity. Both parents incubate egg, feed young. Swarming at colonies intensified prior to breeding; much chasing, wing-flapping on offshore staging areas; chasing, calling on rocks and in nesting crevices.
- *Biology*—Arrive nesting areas late April-May; single egg laid June. Incubation period approximately 31 days. May renest if egg lost early in season. Overall success, 0.34 young fledged per nest.

Development (Bédard, 1969a; Sealy, 1968, 1973, 1981)—Chicks semiprecocial, fed by parents in nest crevice; attain homeothermy at 4-5 days; fledge at 30 days, mainly at night; independent thereafter. Age at first breeding unknown, probably 2-3 years.

Growth (Sealy, 1968, 1981)—Chicks about 90% adult weight at fledging. Adults average 90 grams in northern Bering Sea; 83 grams in southern Bering Sea; males slightly heavier than females. Maximum age probably 10-15 years.

Movements (Dement'ev and Gladkov, 1951a; A.O.U., 1957; Kozlova, 1957; Vaurie, 1965)—Move offshore after nesting, southward in fall before ice advances, northward in spring as ice retreats; no migratory pathways known.

Factors Influencing Populations

Natural (Fay and Cade, 1959; Gabrielson and Lincoln, 1959; Murie, 1959; Sealy, 1968; Knudtson and Byrd, 1982)—Predators include foxes, eagles, rough-legged hawks, falcons, jaegers, large gulls. Displaced from some nesting sites by crested auklets. Shifting of talus can create or destroy nesting sites.

Human-related (Fay and Cade, 1959; Day, 1980)—Plastic particles found in digestive tract of 1% of Alaskan birds; effect on birds unknown. A few of this species taken by Eskimos and Aleuts for food.

Potential (King and Sanger, 1979)—Ranked 8th of 176 species in northeast Pacific in oil vulnerability index. Highly susceptible to oiling.

Population Size (Bédard, 1969b; Portenko, 1973; Hickey and Craighead, 1977; Day et al., 1978; Sowls, Hatch, and Lensink, 1978; Byrd, Day, and Knudtson, 1983)

At least 4.5 million birds estimated in Alaska, 3 million in USSR. Recent work suggests these are very conservative estimates; total world population may be closer to 15-20 million birds, 50-70% of them in region of concern.

Management

Nongame species.

Persons Consulted

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Legend

- Adult Area (Year-round)
- Adult Area (May-November)
- Adult Area (June-September)
- Nesting Colony (May-August) Number of individuals
  - Less than 100,000
  - Greater than 100,000
- Parental Foraging Area (May-August)
- Major Parental Foraging Area (May-August)

Eggs are laid in June; they hatch in July. Young fledge in August. Juveniles occur throughout adult areas. Wintering range extends throughout subarctic North Pacific.

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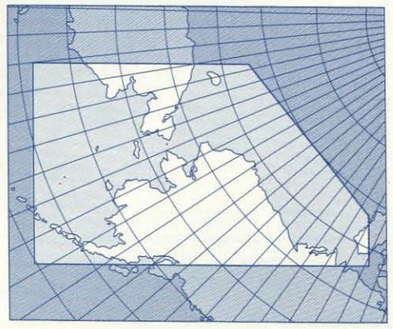
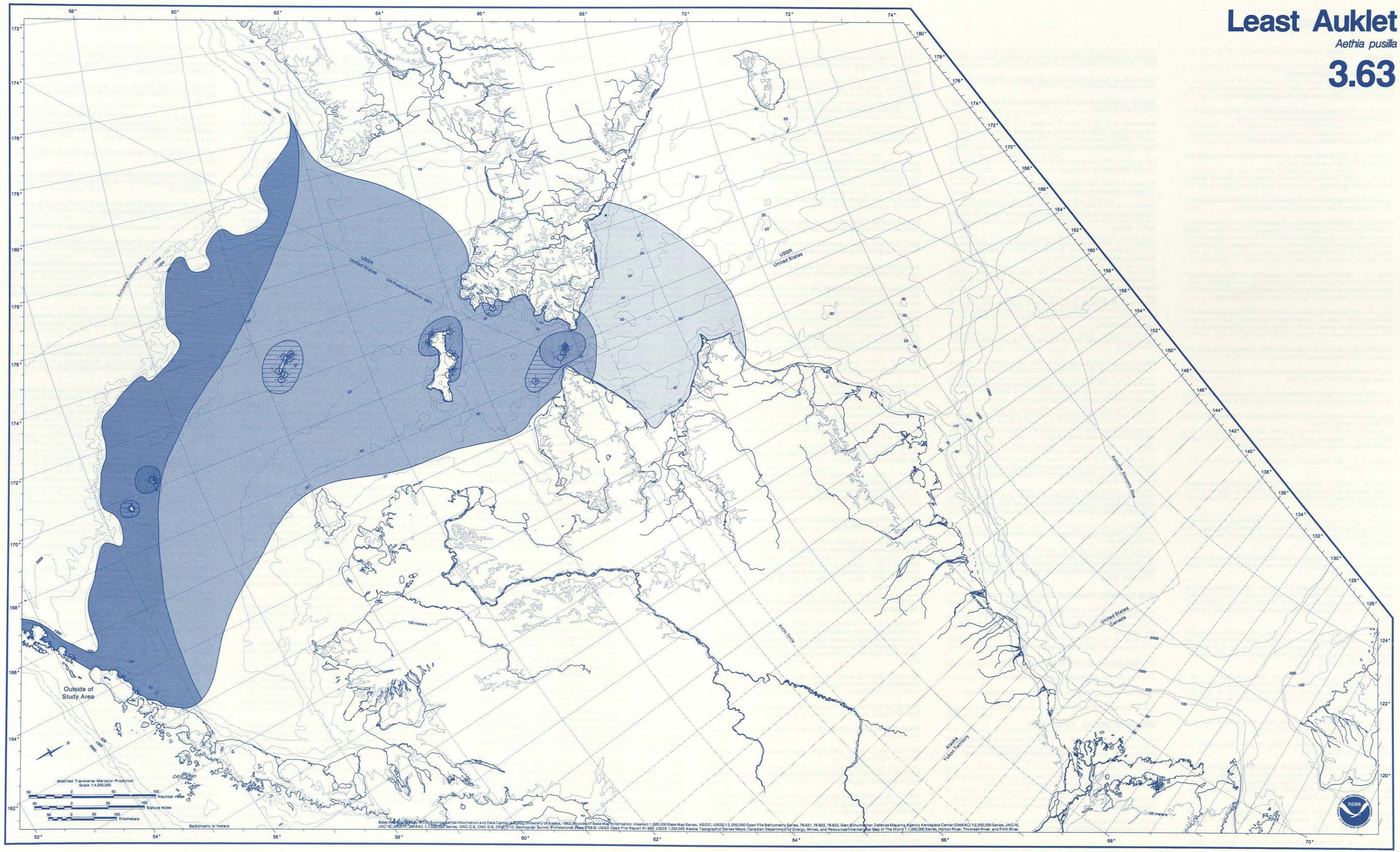
Dement'ev and Gladkov, 1951; American Ornithologists' Union, 1957; Kozlova, 1957; Gabrielson and Lincoln, 1959; Vaurie, 1965; Bédard, 1969; Portenko, 1973; Sowls, Hatch, and Lensink, 1978.



Least Auklet

Aethia pusilla

3.63



Base map data courtesy of the Environmental Information and Data Center (EIDC), University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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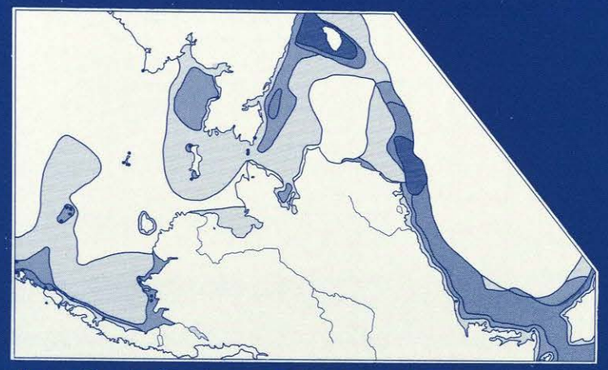
Mammals



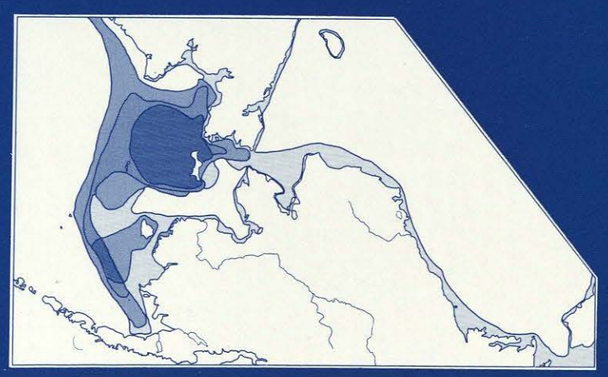
Areas of Summer Abundance for Selected Marine Mammals

Number of Species

1 2 3 4 ○ Major Rookeries and Haulouts

Species: Pacific Walrus, Pacific Harbor Seal, Ringed Seal, Bearded Seal, Northern Fur Seal, Northern Sea Lion, Gray Whale, Bowhead Whale, White Whale

Areas indicate the number of species present, not necessarily the overall distribution of biomass.



Areas of Winter Abundance for Selected Marine Mammals

Number of Species

1 2 3 4

Species: Pacific Walrus, Spotted Seal, Ringed Seal, Ribbon Seal, Bearded Seal, Bowhead Whale, White Whale

Areas indicate the number of species present, not necessarily the overall distribution of biomass.

Introduction

This subsection comprises 14 maps illustrating the distributions of 14 of the approximately 25 marine mammals found in the region. Included are eight regularly occurring pinnipeds, three of the most common cetaceans, and three terrestrial species—polar bear, caribou, and brown bear. All of these species are important either for subsistence or recreation, and several were harvested commercially in the past. All marine mammals within USA waters are legally protected and managed under the Marine Mammal Protection Act of 1972. The USA also participates in international agreements for the conservation and management of fur seal, polar bear, and the great whales.

Marine mammals of the region are abundant and highly visible. Numbering about two million individuals, they have enormous food requirements and play important roles as predators. Fish consumption in the Bering Sea by marine mammals, primarily seals, sea lions, and fur seals, is estimated to be twice the annual commercial catch. Major prey include fish species important to breeding seabirds. In addition, bottom-feeding mammals such as gray whale, bearded seal, and walrus disturb considerable areas of the seafloor and may have major effects on the species composition and abundance of benthic organisms. The intensity and distribution of predation vary during the year, as most of the marine species move seasonally. As for seabirds, marine mammal abundances vary during the year. In the Bering Sea, fur seals, sea lions, and gray whales are the most abundant species in summer; they migrate out of the area in winter and are replaced by walrus, ice associated seals, and bowhead and white whales that spend summer in the Chukchi and Beaufort seas.

The data used for the maps and descriptions are based on a limited number of surveys and inferences from knowledge of the natural history of the various species. *The Data Content and Quality Table* (Section 3 Introduction) shows that in general the information for marine mammals is reliable, although variable, with general distribution being the best. Northern fur seal, walrus, and bowhead whale are better studied than the others. Because of the importance of sea ice either as habitat or as an inhibitor to occurrence, standard ice distribution features are used to delimit marine mammal distributions. For example, the average position of the southernmost extent of sea ice is used to set the southern boundary of the winter distribution of walrus, although the actual position of this boundary varies from year to year with the actual position of the ice edge. Use of these features is noted in the map legends. Terrestrial species' distributions extend inland as appropriate.

Effects of Sea Ice—Sea ice in its various forms (Maps 1.8, 1.9) is perhaps the most important seasonal feature affecting marine mammal distributions. Most species in the region are ice associated. They are concentrated in the Beaufort and Chukchi seas in summer and in the Bering Sea in winter and spring, following the advance and retreat of the sea ice. Ice-associated species include walrus, most of the true seals, bowhead whale, white whale, and polar bear. For many of these, sea ice substitutes for land. For example, walruses use various components of sea ice, such as the broken pack, for resting, molting, giving birth, and nurturing young. Polar bears stalk seals, their primary prey, on pack ice. Bowhead and white whales are associated with polynyas and leads in the ice. However, even though intimately associated with pack ice, all of these species require access to open water for food. A smaller number of species, primarily fur seal and gray whale, tends to avoid the ice. These species are abundant in the Bering Sea in the summer, but migrate out of the region in winter.

The overall effect of sea ice on mammal distributions is illustrated in the inset maps. Each map is a composite of major adult areas and concentrations for selected species. The first inset map shows that in summer, most of the ice-associated species are concentrated in or near loose pack ice in the Beaufort and Chukchi seas. During this season, the Bering Sea is also occupied by large numbers of the two main ice-avoiding species that concentrate in feeding areas, rookeries, and haulouts. In contrast, the second inset map shows that in winter, concentrations of the ice-associated species have shifted south with the pack ice into the Bering Sea. When these species are entering the Bering Sea, the ice-avoiding mammals, birds, and fishes are moving to open water.

Pinnipeds

Pinnipeds ("fin-foot": seals and relatives) in the region fall into three taxonomic groups: 1) eared (otariid) seals, including northern fur seal and northern sea lion (Maps 3.67, 3.68); 2) true (phocid) seals, including harbor, ringed, spotted, ribbon, and bearded seals (Maps 3.70-3.74); and 3) Pacific walrus (Map 3.69). They are all amphibious in that they feed in the water, but also require access to air and availability of land or sea ice for breeding. They are active predators on a variety of invertebrates and fishes and have high food requirements, although they fast during periods of birth, nursing, and molting.

Distributions on land are restricted to areas with appropriate beaches or islands that are isolated to minimize risk from terrestrial predators. Sea ice, used by bearded, ringed, spotted, and ribbon seals and walrus, has some advantages over land, such as greater surface area, increased access to offshore food supplies, and reduced accessibility to terrestrial predators, perhaps offset somewhat by pack ice movements that can reduce access to water.

Populations in the region are the largest in the northern hemisphere, the most abundant species being northern fur seal, bearded seal, ringed seal, and walrus. These large populations have high food requirements. Walrus alone consume an estimated 1.5 million metric tons of shellfish annually in the Bering Sea, digging up a considerable portion of the continental shelf in the process. Northern fur seal consumption of walleye pollock and other demersal fishes may exceed the present commercial catch. These high levels of predation suggest that pinnipeds play an important role in their ecosystems by regulating prey abundance, disturbing and redistributing bottom sediments, and altering benthic species composition and distribution.

Declining fur seal, northern sea lion, and harbor seal populations have suggested that competition with commercial fisheries for walleye pollock and other species could be having deleterious effects on these populations due to reduced food supply. However, evidence is not sufficient to verify this. Drowning from entanglement in fishing gear is an increasingly recognized problem, but the extent of its effect on populations is unknown. Whether increased commercial fishing activities will affect pinniped populations is unclear, but competition for common resources suggests that the topic merits further study.

Cetaceans

Three species of cetaceans (whales and relatives) were chosen to represent the two major groups, which are distinguished from each other based on anatomy and feeding habits. The first group, toothed whales (including dolphins, porpoises, sperm whale, and white whale), actively pursue large prey such as squid and fishes. The only resident in the region and the most abundant representative of the group is the white whale (Map 3.77), an ice-associated species. Other toothed whales rarely enter the region, and then only in summer. The second group, baleen whales (including the great whales), are filter feeders, engulfing schools of copepods, euphausiids, and small forage fishes. Of these, only the bowhead (Map 3.75) is a year-round resident and is also associated with sea ice. Individuals of other species feed in the Bering Sea in summer. The most important of these is the gray whale (Map 3.76), most of whose entire population is in the region in summer, feeding on benthic amphipods. This activity involves plowing up a considerable portion of the bottom of the northern Bering and southern Chukchi sea shelves, with effects on the abundance, distribution, and species composition of the benthic biota.

Terrestrial Mammals

Three species are included in this atlas: polar bear, brown bear, and caribou. Of these, only the polar bear (Map 3.66) is directly associated with the marine environment. The largest terrestrial carnivore, it is a strong swimmer that spends considerable time on pack ice hunting seals and small walrus. It returns to land to breed, choosing denning sites on sloping ground near the ocean. Occasionally, dens are made in near-shore sea ice.

The other two species are often found in coastal areas and are important subsistence and sport species. The brown bear (Map 3.65) is nearly as large as the polar bear and is the major predator along the coast, preying heavily on salmon during spawning runs. Caribou (Map 3.64), an important subsistence species, migrates over considerable distances in the interior, but several large herds are found in coastal areas during summer, feeding in coastal tundra and along the shoreline.

Contents

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3.64 Caribou *Rangifer tarandus*

3.65 Brown Bear *Ursus arctos*

3.66 Polar Bear *Ursus maritimus*

3.67 Northern Fur Seal *Callorhinus ursinus*

3.68 Northern Sea Lion *Eumetopias jubatus*

3.69 Pacific Walrus *Odobenus rosmarus divergens*

3.70 Pacific Harbor Seal *Phoca vitulina richardsi*

3.71 Spotted Seal *Phoca largha*

3.72 Ringed Seal *Phoca hispida*

3.73 Ribbon Seal *Phoca fasciata*

3.74 Bearded Seal *Erignathus barbatus*

3.75 Bowhead Whale *Balaena mysticetus*

3.76 Gray Whale *Eschrichtius robustus*

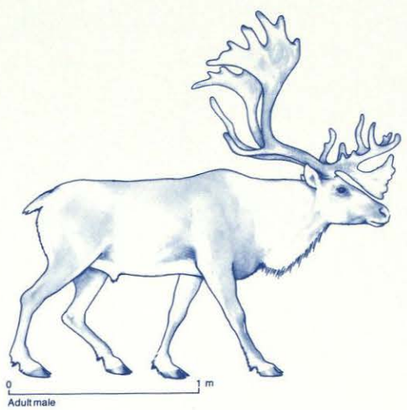
3.77 White Whale *Delphinapterus leucas*

References

3.64-3.77

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
National Oceanic and Atmospheric Administration



Caribou

Rangifer tarandus

3.64

Description

Category

Mammal

Classification

Class—Mammalia
Order—Artiodactyla
Family—Cervidae

Name

Caribou, *Rangifer tarandus*

Legal Status

Protected under Alaska Statutes and Alaska Administrative Code. Alaskan herds managed by Alaska Department of Fish & Game; Canadian herds managed under Department of Renewable Resources (Yukon Wildlife Branch and Northwest Territories Wildlife Service).

Range

Worldwide (Banfield, 1961)—Holarctic (including closely related reindeer): continental North America, Canadian Arctic Archipelago, Fennoscandia, subarctic and arctic Soviet Union, northern China.

Region of Concern (Scotter, 1972; Davis, 1980; Klein and Kuzyakin, 1982; Uspenski, 1984)—Alaska Peninsula northward along Bering and Chukchi Sea coasts to Pt. Barrow, Alaska; eastward across arctic North America. Reindeer introduced on Hagemeister, St. George, St. Paul, Nunivak, Stuart, and St. Lawrence islands, and Seward Peninsula; also, on Chukchi Peninsula and Wrangel Island and at the Reindeer Preserve on the Mackenzie River Delta, Northwest Territories, Canada.

Distribution

Discrete Populations—None recognized in region of concern.

Concentrations (Skoog, 1968; Scotter, 1972; Davis, 1980; Klein and Kuzyakin, 1982; Uspenski, 1984)

- *Natural*—Caribou in Alaska and Yukon Territory considered as one population because of herds' intermingling. In Alaska, 25 herds recognized by their repeated use of distinct areas as calving grounds, including: Alaska Peninsula herd, western arctic herd, Teshekpuk Lake herd, central arctic herd, and Porcupine herd.
- *Commercial*—Subsistence use by local residents. Sport hunting.

Habitat (Kelsall, 1968; Skoog, 1968; Klein, 1970)

Type—Arctic and alpine tundra, shrub tundra, riparian zone, coastal and delta areas, and forest-tundra ecotone.

Physical/Chemical—Air temperatures −50° to 30°C. Movements hampered by snow deeper than one meter. Extensive use of coastal areas and windswept ridges as insect-relief habitat during summer.

Life History

Social Behavior (Kelsall, 1968; Skoog, 1968)—Sexual segregation of groups during most of the year. Females congregate on traditional calving grounds just prior to parturition. Cow-calf and bull groups disperse over summer range in response to insect harassment and availability of preferred forage. All sex- and age-classes group together in fall and migrate to wintering grounds. During winter, pregnant females retain antlers, which may convey dominance to access of foraging sites.

Biological Associations (Skoog, 1968)—A principal prey of wolves (*Canis lupus*) and grizzly bears (*Ursus arctos*) throughout year; calves prey of golden eagles (*Aquila chrysaetos*) during calving period. Severe harassment during summer months by mosquitoes and oestrid flies (warble and nose bots). Parasitized by oestrid fly larvae during winter.

Nutrition (Kelsall, 1968; Skoog, 1968; Klein, 1970; Kuropat and Bryant, 1980; White and Trudell, 1980)

- *Feeding type*—Herbivore.
- *Food*—Preferred summer foods are willow and birch leaves, forbs, floral parts of cotton grasses, horsetails, and sedges. Preferred winter foods are lichens, particularly *Cladonia*, *Cetraria*, and *Usnea*. Frozen green sedges along lake margins are used preferentially during winter when available.
- *Feeding behavior*—At time of calving, flowers of cottongrass are predominant food. Subsequently, caribou switch to a diet primarily of newly emergent leaves of willow (particularly *Salix pulchra*) and dwarf birch (*Betula nana*), supplemented by floral parts of forbs, particularly legumes such as Arctic lupine (*Lupinus arcticus*) and wooly lousewort (*Pedicularis kaneii*), and mushrooms. As summer progresses, caribou move upward in altitude or northward in latitude, partially in response to availability of new growth of willow, birch, and forbs. In fall, intake of lichens increases, and in winter predominant foods are sedges and lichens, obtained by cratering through snow along lake margins.
- *Feeding location*—In summer, arctic and alpine tundra, shrub tundra, and riparian zone. In winter, arctic and alpine tundra and forest-tundra ecotone.

Reproduction (Kelsall, 1968; Skoog, 1968; Bergerud, 1978)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Tundra or forest-tundra ecotone.
- *Behavior*—Polygamous; males spar for dominance during fall rut.
- *Biology*—Breed in late September through mid-November. Polyestrous; gestation 227-229 days. Calves born mid-May through mid-June; 90% of young born during a 10-day period. Times of breeding and parturition vary among herds, but are quite consistent within a herd. Single calves born annually.

Development (Kelsall, 1968; Skoog, 1968)—Calves are precocial, able to walk within 1 hour of birth. Calves usually weigh 5-7 kg at birth; double weight within 10 days. Calf size and juvenile growth and weight reflect maternal winter nutrition and levels of parasitism. Both sexes antlered; antler growth begins during first summer. Antlers shed and regrown annually.

Growth (Kelsall, 1968; Skoog, 1968)—Most growth during summer. Strong sexual dimorphism: females reach adult size in three years and average 100 kg; males reach adult size in four years and average 190 kg. Growth influenced by nutrition and parasitism. Lifespan 10-12 years.

Movements (Kelsall, 1968; Skoog, 1968; Hemming, 1971)—Spring and fall migrations follow complex traditional routes. Spring migration is to traditional calving grounds. Fall migration is usually from upper latitudinal or altitudinal limit of summer range to wintering grounds in forest-tundra ecotone, but herds occasionally winter on summer ranges. Summer movements dictated by insect harassment and forage quality; local movements in summer to sites of insect relief (snowbeds, ridges, delta and coastal areas). Spring movement segregated by sex; females move northward or to higher altitude to calving grounds in advance of males. Fall migration not as strongly segregated.

Factors Influencing Populations

Natural (Skoog, 1968; Bergerud, 1978)—Predation by wolves, brown bears, Canada lynx (*Lynx canadensis*), and golden eagles. Diseases include brucellosis and rabies. Inclement weather can cause calf mortality in summer. Winter starvation can result from deep snow or severe icing.

Human-related (Bergerud, 1978; Klein, 1980)—Subsistence and sport hunting have been a major cause of localized caribou mortality, particularly since the introduction of modern rifles and snowmobiles into Native culture.

Potential (Klein, 1980; Cameron, Whitten, and Smith, 1983)—Increased development associated with natural resource extraction, e.g., oil field development, may result in obstruction of traditional migration routes, subdivision and decreased carrying capacity of caribou ranges, and subsequent herd declines. Winter seismic exploration may scatter caribou herds and increase energy expenditures by caribou. Disturbance on calving grounds may result in calf abandonment during critical maternal-bonding periods. Increased access to remote areas might result in increased harvest of caribou by hunters. Reindeer herding conflicts with caribou due to competition for rangelands. Reindeer joining caribou herds could result in increased pressure by reindeer herders to exclude caribou from grazing allotments; genetic mixing between reindeer and caribou could prove detrimental to caribou gene pools.

Population Size (Bergerud, 1978; Seward, 1985)

At present, 501,000 caribou (minimum estimate) in Alaska. Population estimates (1985) for individual herds: Alaska Peninsula herd—(north) 20,000, (south) 10,000; western arctic herd—212,000; Teshekpuk Lake herd—11,000; central arctic herd—13,000; and Porcupine herd—148,000. Numbers highest after summer calving. Herd sizes may fluctuate dramatically due to predation, hunting pressure, and emigration.

Management

Hunting season from July 1 to April 30, subject to local regulations and bag limits. Calving area of western arctic herd recognized as ecologically sensitive area by Naval Petroleum Reserve Production Act (1976). In 1983, Bureau of Land Management (BLM), U.S. Department of the Interior, discontinued oil and gas leasing in this area. BLM also restricts surface and aerial activity in calving area between May 15 and July 15. Porcupine herd rangelands protected under Alaska National Interest Lands Conservation Act (1980), which restricts mineral and petroleum exploration in areas used by caribou during calving and postcalving.

Persons Consulted

J. L. Davis, Alaska Department of Fish & Game, Fairbanks, Alaska.
D. R. Klein, Alaska Cooperative Wildlife Research Unit, University of Alaska, Fairbanks, Alaska.
F. L. Mauer, Arctic Wildlife Refuge, U.S. Fish & Wildlife Service, Fairbanks, Alaska.
K. R. Whitten, Alaska Department of Fish & Game, Fairbanks, Alaska.

PEGGY J. KUROPAT

Alaska Cooperative Wildlife Research Unit, University of Alaska, Fairbanks, Alaska.

Legend

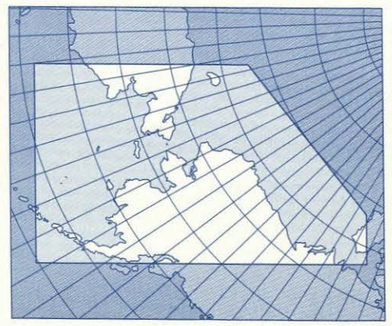
- Adult Area (Year-round)
- Adult Area (October-March)
- Adult Area (April-September)
- Occasional Occurrence (October-March)
- Calving Grounds (May-June)
- Major Adult Concentration (July-August) Insect relief
- Designated Herd Area

Mating occurs September-November throughout adult areas. Calving areas are also major adult areas during calving season. Herd areas are defined by calving grounds; herds may intermix when not calving. Central arctic and western arctic herds intermix October-March; boundaries for these herds in interior Alaska cannot be depicted. Juveniles occur throughout adult areas. Movements usually follow complex traditional migratory routes and often occur in groups segregated by sex.

Estimated populations for herds are: (1) western arctic herd, 212,000; (2) Teshekpuk Lake herd (nonmigratory), 12,000; (3) central arctic herd, 13,000; (4) Porcupine herd, 148,000; (5) southern Alaska Peninsula herd, 10,000; (6) northern Alaska Peninsula herd, 20,000. Andreafsky herd (south of Norton Sound and Yukon Delta, not shown) has very few animals, primarily feral reindeer.

Map References

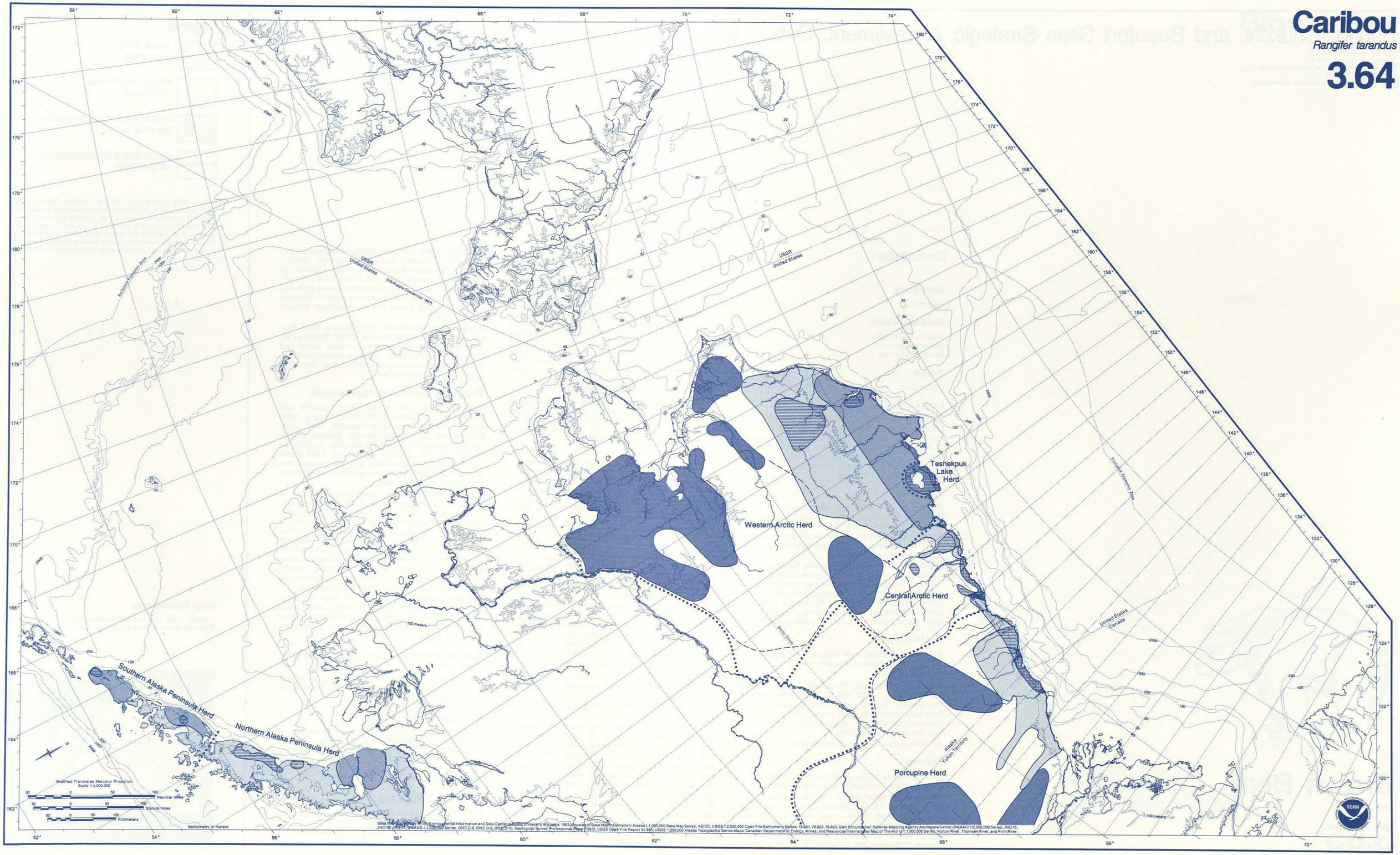
Hemming, 1971; Cameron, Whitten, and Smith, 1983; Valkenburg, Davis, and Karczmarczyk, 1983. Personal communications from Davis; Whitten.



Caribou

Rangifer tarandus

3.64



Base data courtesy of the Environmental Information and Data Center (EIDC), University of Alaska, 1982; sources of base map information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17, DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

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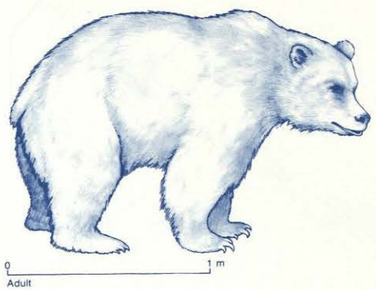


Brown Bear

Ursus arctos

3.65

Description

Category

Mammal

Classification

Class—Mammalia
Order—Carnivora
Family—Ursidae

Name

Brown bear, *Ursus arctos* (grizzly bear)

Legal Status

Listed in Convention on International Trade in Endangered Species of Wild Fauna and Flora as "threatened" in coterminous USA. Taking regulated in Alaska by Department of Fish & Game; in northwestern Canada by Department of Renewable Resources (Yukon Wildlife Branch and Northwest Territories Wildlife Service).

Range

Worldwide (Ellerman and Morrison-Scott, 1951; Heptner and Naumov, 1967; Herrero, 1972; Banfield, 1974)—Holarctic. Alaska and continental Canada south to Rocky Mountain states; Eurasian treeline, south to southern Scandinavia, Asia Minor, Tibet, northern China, and Hokkaido.

Region of Concern (Heptner and Naumov, 1967; Alaska Department of Fish & Game, 1973; Banfield, 1974)—Throughout mainland Alaska west to Unimak Island and Bering Strait (except Yukon-Kuskokwim Delta lowlands); Yukon and Northwest territories south of Banks and Victoria islands; in northeastern Siberia, southward from central Chukchi Peninsula.

Distribution

Discrete Populations (Rausch, 1963)—None recognized in region of concern.

Concentrations

- *Natural* (Kistchinski, 1972; Alaska Department of Fish & Game, 1973; Glenn and Miller, 1980)—Scavenging, feeding concentrations along Alaska Peninsula, May-July, and along salmon-spawning streams, July-October, especially on Alaska Peninsula and in Bristol Bay area.
- *Commercial*—Not taken commercially.

Habitat

Type (Herrero, 1972)—Open arctic and alpine tundra, subalpine brushlands, and river valleys.

Physical/Chemical (Murie, 1959; Lentfer et al., 1972; Harding, 1976; Reynolds, Curatolo, and Quimby, 1976; Jonkel, 1978)—Avoid direct sunlight and high temperatures. Winter dens usually in 20-40° slopes; also in steep banks of rivers or lakes and in natural rock caves and snowbanks.

Life History

Social Behavior (Erickson and Miller, 1963; Erickson, 1964; Craighead and Craighead, 1972; Herrero, 1972, 1978; Kistchinski, 1972; Pearson, l975; Egbert and Stokes, 1976; Glenn et al., 1976; Jonkel, 1978)—Solitary, except young remain with female 1.5-3.5 (rarely 4.5) years after birth and with siblings 1-2 years after leaving female. Loose congregations near marine mammal carcasses, salmon-spawning streams, garbage dumps. Dominance based on sex, age, size; females aggressive in defense of young. Limited cub adoption and mixed-age litters. Den separately in winter; females with young enter dens earlier and emerge later than do adult males.

Biological Associations—None known.

Nutrition (Clark, 1957; Kistchinski, 1972; Quimby, 1974; Pearson, 1975; Jonkel, 1978; Atwell et al., 1980; Berns, Atwell, and Boone, 1980; Glenn and Miller, 1980; Mealey, 1980; Reynolds, 1980; Murie, 1981; Spraker, Ballard, and Miller, 1981)

- *Feeding type*—Omnivore.
- *Food*—In spring, overwintered berries, carrion (including beached whales, seals, walruses), small mammals; in early summer, principally sedges, grasses, succulent forbs, and roots (especially legumes); in late summer-fall, horsetails (*Equisetum*), spawning salmon, other spawning fishes; also berries, roots, small mammals. Food is especially abundant in Bristol Bay and Alaska Peninsula areas; hence, bears attain greater size and density there.
- *Feeding behavior*—Graze plant shoots, stems, leaves; dig roots; browse berries. Low digestibility of most plant foods necessitates high feeding rate. Catch ungulates by pursuit or surprise; significant predation on calves in some areas. Dig marmots, voles, ground squirrels out of burrows.
- *Feeding location*—Along coasts and river valleys in spring; inland in early summer; along salmon-spawning streams, in uplands in late summer-fall.

Reproduction (Wimsatt, 1963; Craighead, Hornocker, and Craighead, 1969; Hensel, Troyer, and Erickson, 1969; Glenn et al., 1976; Herrero, 1978; Jonkel, 1978; Reynolds, 1980; Murie, 1981)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Mating locations variable; young born in winter dens.
- *Behavior*—Polygamous; transitory courtship and pair bond.
- *Biology*—Mate mid-May to mid-July; ovulation induced; pregnancy about 8 months, including 5-6 month delayed implantation. Cubs born January-February. Litter size 1-4; 3-4 years between litters.

Development (Erickson et al., 1968; Craighead, Hornocker, and Craighead, 1969; Hensel, Troyer, and Erickson, 1969; Pearson, 1975, 1976; Glenn et al., 1976; Reynolds, 1976, 1980, 1981; Jonkel, 1978)—Cubs suckle 4-5 months. Females sexually mature at 3.5-6.5 years in southwestern Alaska, 4.5-12.5 years in northern Alaska and Yukon. Males sexually mature at 4.5 years or later.

Growth (Erickson, 1965; Kistchinski, 1972; Pearson, 1975; Glenn, 1980; Reynolds, 1980; Bunnell and Tait, 1981; Kingsley, Nagy, and Russell, 1983)—Rapid to 2.5 years; sexual dimorphism apparent at 1.5 years. Females reach adult size at 4-6 years, males at 6-8 years in southwestern Alaska; probably later in northern areas. Maximum weight of Alaska Peninsula males about 600 kg. Maximum lifespan 25-30 years.

Movements (Kistchinski, 1972; Quimby, 1974; Ruttan, 1974; Curtolo and Moore, 1975; Atwell et al., 1980; Berns, Atwell, and Boone, 1980; Glenn and Miller, 1980)—In spring, from upland denning areas to river valleys, coastal plains, and beaches. Return to uplands in late summer-fall.

Factors Influencing Populations

Natural (Troyer and Hensel, 1962; Curatolo and Moore, 1975; Pearson, 1975, 1976; Rogers, 1976; Herrero, 1978; Jonkel, 1978; Reynolds, 1980, 1981; Bunnell and Tait, 1981)—Natality determined primarily by availability of food to females. Mortality up to 50% for cubs, decreasing with age. Adult males may kill cubs and other sex- and age-classes; this seems to be major population-regulation mechanism, especially on younger males.

Human-related (Alaska Department of Fish & Game, 1973; McCourt et al., 1974; Quimby, 1974; Jonkel, 1978; Harding and Nagy, 1980; Reynolds, 1980; Schallenberger, 1980; Bunnell and Tait, 1981)—Unregulated hunting and destruction of nuisance bears are main cause of adult mortality. Industrial development and human settlement generally have detrimental impact through habitat alteration, creation of artificial food sources, poaching, aircraft harassment, and den disturbance. Reaction to aircraft, especially helicopters, generally negative.

Potential (Alaska Department of Fish & Game, 1973; Pearson, 1975; Reynolds, 1980)—Wide-scale resource development and increased human habitation in previously undeveloped areas pose most serious threats.

Population Size (Alaska Department of Fish & Game, 1976a,b,c,d)

No estimates available. Most abundant on Alaska Peninsula; reduced in areas of human habitation and in some parts of northern Alaska.

Management

Alaska regulations allow each hunter one bear every 4 years; Yukon and Northwest territories allow one bear per year; all quotas exclude females with young. Protected in national parks and monuments, except for removal of nuisance bears and subsistence hunting by rural residents.

Persons Consulted

F. C. Dean, Department of Wildlife Management, University of Alaska, Fairbanks, Alaska.
H. V. Reynolds, Alaska Department of Fish & Game, Fairbanks, Alaska.

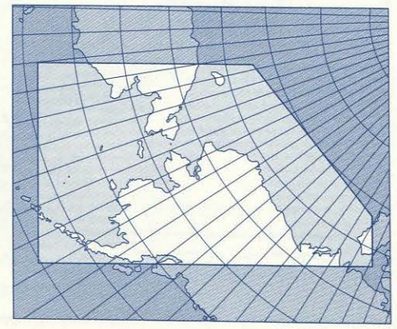
Legend

- Adult Area (Year-round)
- Major Adult Area (Year-round)
- Major Adult Concentration (March-July)
- Major Adult Concentration (June-August)

Mating (May to mid-July), birthing (January-February), and denning (December-April) occur throughout adult areas. Juveniles occur throughout adult areas. Density in areas of major adult concentration to 5 animals per 100 km^2; in major adult areas, 1-4 animals per 100 km^2; in adult areas, less than 1 per 100 km^2. Species will cross frozen lakes and rivers. Depiction of species is limited to study area; distribution extends into interior.

Map References

Rausch, 1963; Heptner and Naumov, 1967; Banfield, 1974. Personal communications from Dean; Glenn; Reynolds.



Brown Bear

Ursus arctos

3.65



Base map data by NOAA, Environmental Information and Data Center (AEIDC), University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-455; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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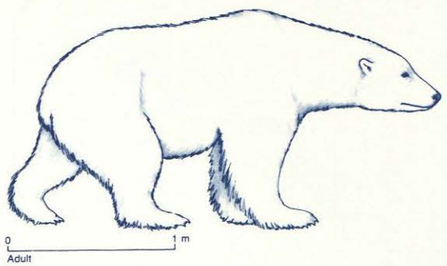


Polar Bear

Ursus maritimus

3.66

Description

Category

Mammal

Classification

Class—Mammalia
Order—Carnivora
Family—Ursidae

Name

Polar bear, *Ursus maritimus* (white bear, ice bear)

Legal Status

Listed in Convention on International Trade in Endangered Species of Wild Fauna and Flora as "potentially threatened." Protected under Marine Mammal Protection Act of 1972 (P.L. 92-522), amended, and under 1976 Agreement on the Conservation of Polar Bears between Canada, Denmark, Norway, USA, and USSR. Also, unilaterally protected by USSR.

Range

Worldwide (Heptner and Naumov, 1967; DeMaster and Stirling, 1981)—Circumpolar, arctic; polar ice cap south to Bering Sea, James Bay, Newfoundland, southern Greenland, Iceland, and Barents and Kara seas.

Region of Concern (Frame, 1972; Alaska Department of Fish & Game, 1973; Stirling et al., 1975; Burns, Shapiro, and Fay, 1981; DeMaster and Stirling, 1981; Lentfer, 1982)—In winter, throughout Beaufort and Chukchi seas, south in Bering Sea regularly to St. Lawrence Island; occasionally to St. Matthew Island and Cape Navarin. In summer, mainly in southern part of pack ice of Chukchi and Beaufort seas.

Distribution

Discrete Populations (Lentfer, 1974; Stirling et al., 1975; DeMaster and Stirling, 1981)—Two, with limited interchange, in region of concern: Wrangel Island-western Alaska (southwest of Pt. Lay) and northern Alaska-Canada (Pt. Lay eastward).

Concentrations (Harington, 1968; Lentfer, 1972; Uspenski and Kistchinski, 1972; DeMaster and Stirling, 1981)

- *Natural*—Maximum concentration areas of maternity denning occur in winter on southern Banks Island, Wrangel Island, and northern Chukchi Peninsula. Summer retreat of ice causes relative concentration of bears along southern edge of pack ice.
- *Commercial*—Not taken commercially.

Habitat

(Harington, 1968; Uspenski and Kistchinski, 1972; Lentfer, 1975; Stirling et al., 1975; Stirling, Cleator, and Smith, 1981; Lentfer and Hensel, 1980; DeMaster and Stirling, 1981)

Type—Pack ice and coastal areas; maternity dens mainly concentrated on islands and along mainland coast.

Physical/Chemical—Coastal flaw zones; persistent polynyas and areas of ice divergence, where ice movement causes frequent fracturing, refreezing. Maternity dens on mainland, offshore islands, shorefast ice, or (rarely) drifting sea ice; in deep snowdrifts of 10-40° slope on leeward sides of hills, cliffs, drainages, cut-banks, rough ice; 0-550 meters elevation; mostly within 8 km of coast; maximum 48 km inland.

Life History

Social Behavior (Stirling, 1974a; Stirling et al., 1975; Lentfer et al., 1980; DeMaster and Stirling, 1981; Latour, 1981; Lentfer, 1982)—Solitary, except cubs remain with mother up to 2.5 years, rarely longer. Dominance ranked by sex, age, size; females with young avoid adult males, which kill cubs.

Biological Associations—Often followed by Arctic foxes, which scavenge bear kills.

Nutrition (Lønø, 1970; Freeman, 1973; Stirling, 1974a; Russell, 1975; Stirling and McEwan, 1975; Stirling et al., 1975; Heyland and Hay, 1976; Stirling and Archibald, 1977; Eley, 1978; Stirling and Latour, 1978; Smith, 1980; DeMaster and Stirling, 1981)

- *Feeding type*—Predator, scavenger, occasional omnivore.
- *Food*—Primarily ringed and bearded seals; also walruses and white whales. Scavenge marine mammal carcasses. Also take some kelp throughout year and eat grasses, berries, mosses, waterfowl, small mammals, and garbage when seals not available.
- *Feeding behavior*—Still-hunt for seals along leads, breathing holes, and lairs; also stalk seals on ice. In spring, dig out subnivean lairs of ringed seals. In Alaska and western Canada, greatest weight gains in summer. Begin feeding immediately after making kill; eat mainly skin and blubber. Forage for kelp along beaches or by diving (to 4 meters).
- *Feeding location*—Winter and spring hunting success highest in offshore ice and flaw zone. Lower on shorefast ice, due to difficulty of capturing seals in lairs.

Reproduction (Harington, 1968; Lønø, 1970; Lentfer, 1978, 1982; Lentfer et al., 1980)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Mate on sea ice April-June; young born in maternity den, usually on shore.
- *Behavior*—Polygamous; transitory courtship and pair bond only during estrus. Female alone prepares den, cares for cubs.
- *Biology*—Mate late March-June; ovulation induced; pregnancy about 8 months, including 6-month delayed implantation. Females den from late October-March. Cubs born December-January. Litter size 1-3; 3-4 years between litters.

Development (Harington, 1968; Lønø, 1970; Stirling et al., 1975; Blix and Lentfer, 1979; Lentfer et al., 1980; DeMaster and Stirling, 1981)—Cubs suckle up to 28 months, probably decreasing greatly by end of first summer; development affected by thermal protection in den. Females sexually mature at 3.5-7.5 years, males at 3.5-6.5 years.

Growth (Lønø, 1970; Stirling et al., 1975; Kingsley, 1979; Lentfer et al., 1980; DeMaster and Stirling, 1981)—Females reach full size at 4-6 years, males at 6-12. Adult females 180-200 cm long, 150-300 kg; adult males 200-250 cm long, 300-800 kg. Maximum lifespan 25-30 years.

Movements (Lentfer, 1972, 1984; Stirling, 1974b; Moore and Quimby, 1975; Stirling et al., 1975)—Beaufort Sea bears occupy annual activity areas of approximately 20,000 square nautical miles. Areas are strongly linear in east-west direction. Most year-round bear activity occurs between 0 and 100 nautical miles from shore. Bears do not frequent large open-water areas; they are generally onshore only when sea ice is nearby. Possibly some east-west movement from area between 150° and 141° longitude during winter and spring and back into that area in late spring and summer. Bears follow (at least generally) advance and retreat of sea ice.

Factors Influencing Populations

Natural (Lønø, 1970; Stirling, 1974a; Stirling et al., 1975; Stirling, Pearson, and Bunnell, 1976; Kiliaan and Stirling, 1978; Kingsley, 1979; Bunnell and Tait, 1981; DeMaster and Stirling, 1981)—Natality, cub survival controlled primarily by availability of food to females. Adult males kill other bears and displace them from food; number of males in population may be most important population-regulation mechanism. Large prey may wound or kill bears. Annual mortality up to 30% in cubs, 16% in subadults, 12% in adults.

Human-related (Jonkel, 1970, 1978; Stirling and Jonkel, 1972; Moore and Quimby, 1975; Belikov, 1976; Lentfer, 1976, 1978; Stirling, Archibald, and DeMaster, 1977; Lentfer and Hensel, 1980; Bunnell and Tait, 1981)—Unregulated hunting and destruction of nuisance bears are major mortality factors. Resource exploration and development result in den disturbance, creation of artificial food sources, increased human-bear encounters, and aircraft harassment.

Potential (Lentfer, 1972; Stirling et al., 1975; Lentfer and Hensel, 1980; Stirling and Kiliaan, 1980; Stirling, Cleator, and Smith, 1981)—Increasing oil and gas exploration and production along arctic coasts and offshore pose most serious threats. Besides known impacts of such development, marine oil pollution also could adversely affect bears through oil-fouling and reducing prey populations.

Population Size

(Larsen, 1972; DeMaster and Stirling, 1981)

World population estimated 20,000-40,000; about 3,000-5,000 in region of concern.

Management

(Lentfer, 1976; Schweinsburg, Furnell, and Miller, 1981; Yukon Wildlife Branch, 1981)

USA Federal regulations allow unrestricted take by Alaskan Natives; take in Yukon restricted to Eskimos by special permission from Department of Renewable Resources (Yukon Wildlife Branch); in Northwest Territories, quota system administered under Department of Renewable Resources (Northwest Territories Wildlife Service), with limitation on nonresident sport hunting and taking of females and cubs prohibited. All hunting banned in USSR.

Persons Consulted

S. C. Amstrup, U.S. Fish & Wildlife Service, Anchorage, Alaska.
J. J. Burns, Alaska Department of Fish & Game, Fairbanks, Alaska.
J. W. Lentfer, Juneau, Alaska.

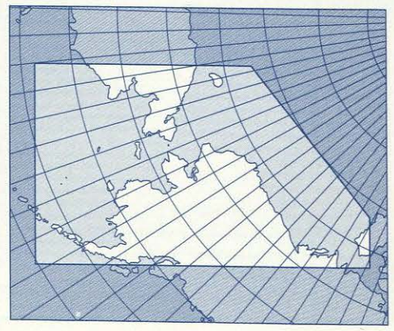
Legend

- Adult Area (Year-round)
- Adult Area (October-June)
- Adult Area (December-April)
- Occasional Occurrence (January-April)
- Major Adult Area (July-September)
- Maternal Denning Area (December-April)
- Major Maternal Denning Area (December-April)

Mating (March-June) occurs throughout adult areas; birthing (December-January) throughout denning areas. Juveniles occur throughout adult areas. Major adult area (July-September) primarily based on September ice front (map 1.8); may vary considerably within period indicated. Species will cross frozen lakes and rivers. Southern limit of adult area (year-round) is average maximum ice edge. (See map 1.8, Sea Ice Dynamics.)

Map References

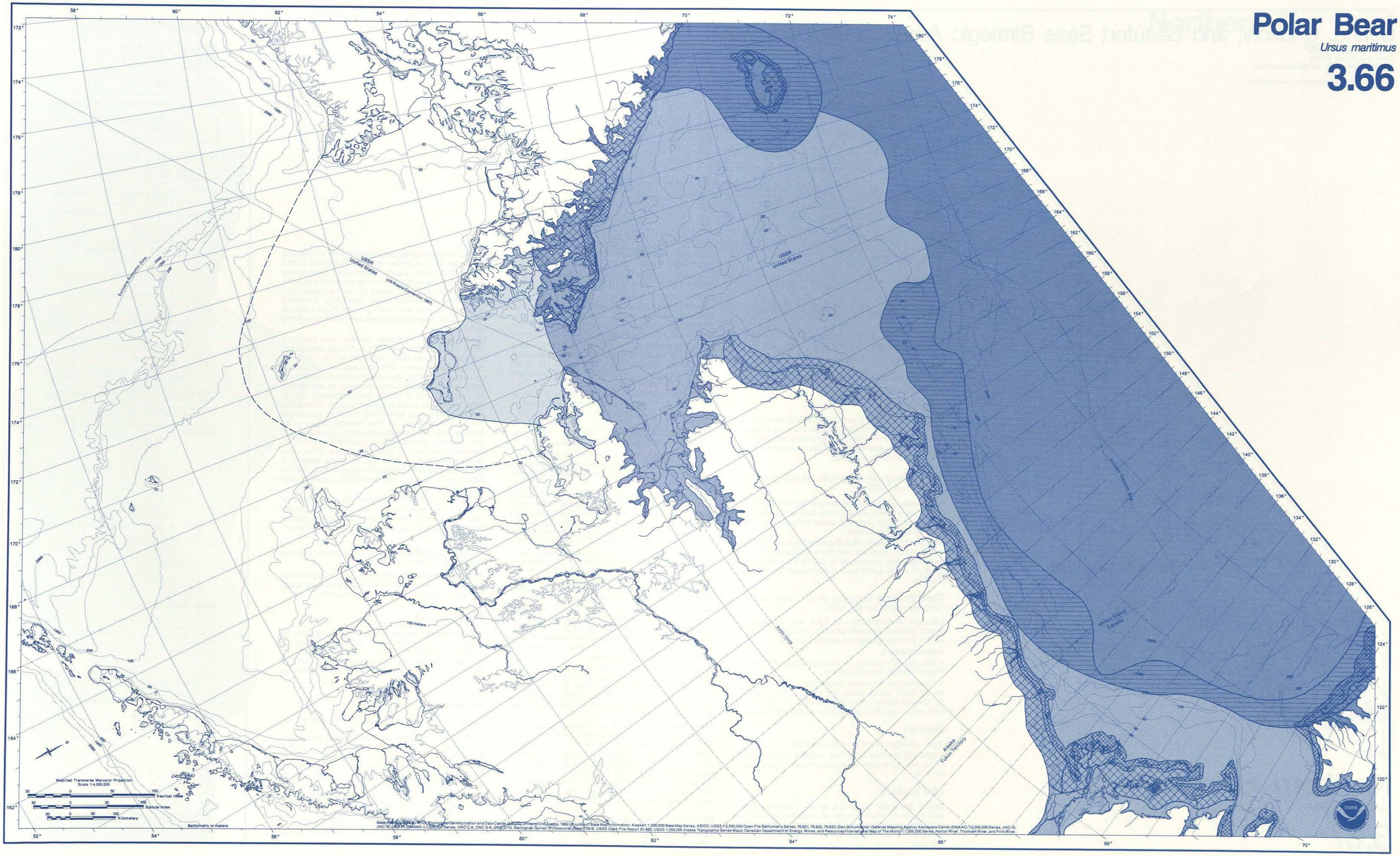
Harington, 1968; Alaska Department of Fish & Game, 1973; Moore and Quimby, 1975; Stirling et al., 1975; Lentfer and Hensel, 1980; DeMaster and Stirling, 1981. Personal communications from Amstrup; Burns; Lentfer.



Polar Bear

Ursus maritimus

3.66



Base map data source: NOAA, National Environmental Information and Data Center (Boulder), University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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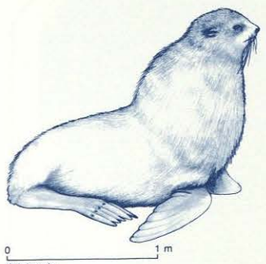


Adult male

Northern Fur Seal

Callorhinus ursinus

3.67

Description

Category

Mammal

Classification

Class—Mammalia
Order—Carnivora
Family—Otariidae

Name

Northern fur seal, *Callorhinus ursinus* (fur seal, Alaska fur seal)

Legal Status

Protected by North Pacific Fur Seal Convention of 1911, Fur Seal Act of 1966, Marine Mammal Protection Act of 1972 (P.L. 92-522), amended, and Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended.

Range (Kajimura et al., 1980; Harry and Hartley, 1981; Fiscus, 1983)

Worldwide—Subarctic to temperate North Pacific Ocean; in western Pacific from Sea of Okhotsk to latitude of Tokyo, Japan; in eastern Pacific south to California-Mexico border.

Region of Concern—Southern Bering Sea: Aleutian Islands to St. Matthew and Nunivak islands, May to November only. Irregularly to Bering Strait and into Chukchi and Beaufort seas to Northwest Territories, Canada.

Distribution (Kajimura et al., 1980; Griban, 1979; Harry and Hartley, 1981)

Discrete Populations—St. Paul and St. George Island populations semi-isolated; intermix to slight extent with populations in western Pacific.

Concentrations

- *Natural*—Principally in waters within 450 km of Pribilof Islands, May-November.
- *Commercial*—Juvenile males harvested annually on St. Paul Island rookeries since 1917; also on St. George Island until 1972. Before 1911, taken on land and at sea during migration to Pribilof Islands.

Habitat

Type—Pelagic; breed on rocky islands.

Physical/Chemical—Ice-free waters along shelf break and outer-shelf domain; surface temperatures 5-14°C.

Life History

Social Behavior (Kajimura et al., 1980)—Usually solitary or in small groups at sea; about 90% of sightings are groups of 1-5 animals. Highly gregarious on shore, in tight herds of several thousand animals.

Biological Associations (Lloyd, McRoy, and Day, 1981)—May haul out with other otariids.

Nutrition (Kooyman, Gentry, and Urquhart, 1976; Kajimura et al., 1980; Harry and Hartley, 1981)

- *Feeding type*—Predator.
- *Food*—In Bering Sea, primarily pollock and gonatid squids; also take herring, cod, bathylagid smelts, greenlings, salmonids, and flatfishes. In Unimak Pass, capelin and Atka mackerel are of major importance.
- *Feeding behavior*—Feed mainly at night and early morning; at depths mostly 20-80 meters (maximum, 190 meters). Swallow fishes and squids (to 40 cm long) under water; larger prey brought to surface and broken into smaller pieces by shaking.
- *Feeding location*—Primarily in waters of greater than 100-meter depths, and in greatest numbers between Pribilof Islands and Unimak Pass, May-November.

Reproduction (Craig, 1964; Peterson, 1968; Kajimura et al., 1980; Lloyd, McRoy, and Day, 1981)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Mainly St. Paul and St. George islands and Sea Lion Rock, Pribilof Islands; also small number on Bogoslof Island.
- *Behavior*—Polygynous; males territorial. Males arrive May, females June-July; pupping takes place about 2 days after females arrive; 30-40 pups born per harem bull. Females alternate feeding at sea (7-8 days) with nursing bouts (2 days) until pup is weaned, then depart southward, to eastern Pacific.
- *Biology*—Single pup born on shore late June to early August; adults mate usually 3-8 days following parturition; implantation delayed about 4 months. Females breed annually for 12 years or more; males hold territories (breed) average of 1.5 breeding seasons. Pregnancy rate about 60%.

Development (Peterson, 1968)—Pups precocial, can swim at birth; normally venture into water at 4 weeks; suckle 3-4 months; weaned October to mid-November, independent thereafter. Females mature at 4-5 years; males fertile at 5-6 years, become territorial and breed at 8-12 years.

Growth (Scheffer and Wilke, 1953; Johnson, 1968; Kajimura et al., 1980)—Pups 55-75 cm, 3-7 kg at birth; males slightly larger than females. Adult females 110-140 cm, 25-50 kg; males 185-215 cm, 140-280 kg. Maximum lifespan 17 years for males, 26 years for females.

Movements (Kajimura et al., 1980)—Females and juveniles older than 2 years arrive from North Pacific in Bering Sea in May and move onto rookery area in June-July. Depart Pribilof Islands October-November for Unimak Pass, Gulf of Alaska, then southward, offshore, to waters off British Columbia to California for winter. Almost all juveniles 1-3 years old occur south of study area, in North Pacific. Most adult males winter in southeastern Bering Sea and Gulf of Alaska.

Factors Influencing Populations

Natural (Scheffer, 1950; Keyes, 1965; Johnson, 1968; Gentry and Johnson, 1981)—Probably food-limited to some degree and space-limited on breeding rookeries. Pup mortality on Pribilof Islands 5-20% from malnutrition, trauma, parasitism, gastrointestinal infections, and predation by northern sea lions. Mortality of adults and young at sea from predation, starvation, parasitism, food poisoning, infectious diseases, storms, and fouling of fur. High turnover rate of adult males at rookeries as a result of breeding activities.

Human-related (Kooyman, Gentry, and Urquhart, 1976; Harry and Hartley, 1981)—Pelagic sealing and overharvesting on land from 1880 to 1911 reduced population by nearly 90%. Subsequent protection and regulation of harvest restored population to near preexploitation level. Some mortality at sea caused by entanglement in fishing gear, especially lost or abandoned nets and strapping material. Bering Sea pollock fishery may have some effect on population through competition for food source. Oiling of fur doubles thermal conductivity, which increases heat loss. Oiling of 10% of surface resulted in 1.5-fold increase in metabolic rate for two weeks. Oiled seals tend to haul out on land, thus reducing feeding; in females, this affects feeding of young as well. Tend to accumulate mercury and pesticides, possibly with adverse effects.

Potential—Oil spill in Pribilof area in spring-summer could kill high proportion of population and greatly reduce pup production. Competition with commercial fisheries for food may be ultimate controlling factor.

Population Size (Office of Protected Species and Habitat Conservation, 1985)

Worldwide population is declining. Estimated in 1985 at about 1.1 million animals; Pribilofs contain about 0.8 million (about 70% of world population).

Management

Research and management currently controlled by international convention. Annual harvest of immature males on Pribilof Islands regulated by U.S. National Marine Fisheries Service. Taking by Natives for subsistence also permitted; otherwise, protected.

Persons Consulted

J. J. Burns, Alaska Department of Fish & Game, Fairbanks, Alaska.
C. W. Fowler, National Marine Mammal Laboratory, Northwest and Alaska Fisheries Center, NMFS/NOAA, Seattle, Washington.
R. L. Gentry, National Marine Mammal Laboratory, Northwest and Alaska Fisheries Center, NMFS/NOAA, Seattle, Washington.
H. Kajimura, National Marine Mammal Laboratory, Northwest and Alaska Fisheries Center, NMFS/NOAA, Seattle, Washington.
A. E. York, National Marine Mammal Laboratory, Northwest and Alaska Fisheries Center, NMFS/NOAA, Seattle, Washington.

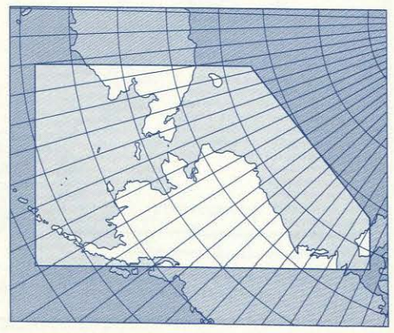
Legend

- Adult Area (Year-round) Males
- Adult Area (May-November) Nonbreeding males, 5 years and older
- Adult Area (Year-round) Females
- Major Adult Area (May-November) Females
- Occasional Occurrence (August-November) Males and nonbreeding females
- Rookery (June-November) Number of individuals
  - Less than 100
  - 100,000 to 200,000
  - 600,000 to 700,000
- Migration (October-November) Females
- Migration (May-June) Females

Pupping and mating (late June-early August) occur on rookeries. From December-April, some adult males, most adult females, and juveniles less than 3 years occur south of study area in North Pacific basin. Northern limit of adult area (year-round) is average maximum ice edge. (See map 1.8, Sea Ice Dynamics.)

Map References

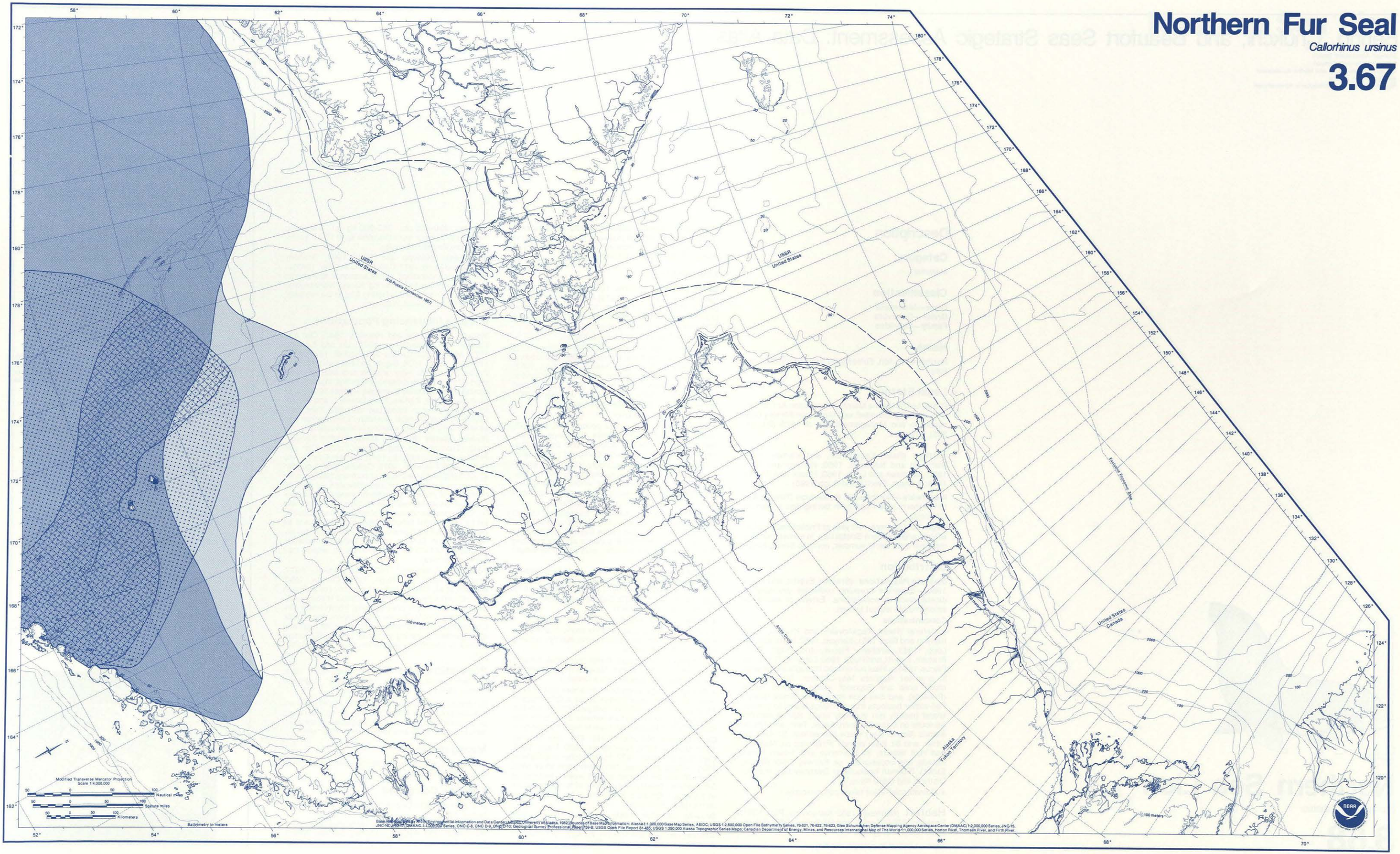
Bee and Hall, 1956; Johnson et al., 1966; Lentfer, 1973; Griban, 1979; Kajimura et al., 1980; Lloyd, McRoy, and Day, 1981; Fiscus, 1983; Kajimura, 1984; Office of Protected Species and Habitat Conservation (NMFS/NOAA), 1985; Ocean Assessments Division (NOS/NOAA), in press. Personal communications from Burns; Fay; Kajimura; Ray.



Northern Fur Seal

Callorhinus ursinus

3.67



Base map produced by the Environmental Information and Data Center (AEIDC), University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16; UNESCO, DMAAC 1:1,000,000 Series, ONC C-8, ONC D-8, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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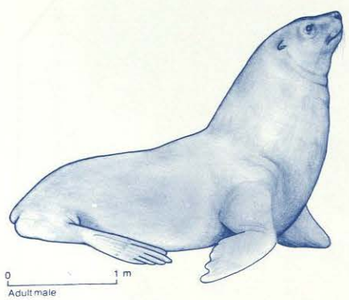


Northern Sea Lion

Eumetopias jubatus

3.68

Description

Category

Mammal

Classification

Class—Mammalia
Order—Carnivora
Family—Otariidae

Name

Northern sea lion, *Eumetopias jubatus* (Steller sea lion)

Legal Status

Protected by Marine Mammal Protection Act of 1972 (P.L. 92-522), amended, and Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended.

Range (Rass, Kaganovskii, and Klumov, 1955; Nishiwaki and Nagasaki, 1960; Kenyon and Rice, 1961; Mathisen and Lopp, 1963; Fiscus and Baines, 1966; Braham, Everitt, and Rugh, 1980)

Worldwide—North Pacific Ocean from Okhotsk Sea to northern Japan and from Bering Sea to central California.

Region of Concern—All year at Pribilof and Aleutian islands and southern Bristol Bay. In winter, north to marginal pack ice; in summer, north to Bering Strait.

Distribution

Discrete Populations (Braham, Everitt, and Rugh, 1980)—Separate breeding rookeries probably indicate discrete populations. Extent of exchange among rookeries not known.

Concentrations

- *Natural* (Rass, Kaganovskii, and Klumov, 1955; Kenyon and Rice, 1961; Kenyon, 1962; Mathisen and Lopp, 1963; Braham, Fiscus, and Rugh, 1977; Braham, Everitt, and Rugh, 1980; Loughlin, Rugh, and Fiscus, 1984)—Haul out on land throughout the year, in greatest numbers May-October. Rookeries in study area are Bogoslof Island, Walrus Island (Pribilofs), and Sea Lion Rock (near Amak Island). Fall-winter haulouts from Samalga Island to Unimak Island (mostly not in study area). Spring-summer haulouts on Cape Seniavin, Amak, Twin, and Round islands (Bristol Bay); Cape Newenham, St. George, Otter, and St. Paul islands (Pribilofs); St. Matthew and Hall islands; St. Lawrence and South Punuk islands; and occasionally on Fairway Rock (Bering Strait). Siberian haulouts at Dezhnev Bay (Koryak District) and Cape Navarin.
- *Commercial*—Not taken commercially.

Habitat (Mathisen, 1959; Kenyon and Rice, 1961; Spalding, 1964; Gentry and Withrow, 1978; Calkins and Pitcher, 1979)

Type—Littoral to pelagic; neritic.

Physical/Chemical—Coastal to 320 km offshore, marginal ice southward. Haul out, breed generally on rocky shorelines of isolated islands and exposed coasts. Occasionally haul out on sea ice.

Life History

Social Behavior (Gentry, 1970; Sandegren, 1970; Calkins and Pitcher, 1979)—Gregarious. Form groups of up to 2,000 at sea, 10,000 on land. Composition of herd varies seasonally. Adults segregated from juveniles in breeding season.

Biological Associations—None known.

Nutrition (Imler and Sarber, 1947; Kenyon, 1952; Wilke and Kenyon, 1952; Mathisen, 1959; Tikhomirov, 1959, 1964a,b; Mathisen, Baade, and Lopp, 1962; Spalding, 1964; Fiscus and Baines, 1966; Gentry, 1970; Sandegren, 1970; Mate, 1973; Calkins and Pitcher, 1977, 1978; Gentry and Johnson, 1981; Braham et al., 1982; Pitcher and Fay, 1982)

- *Feeding type*—Predator.
- *Food*—Adults eat walleye pollock, cod, sandfish, capelin, rockfish, herring, smelts, greenlings, salmon, halibut, other flatfishes, octopus, and squid; occasionally take bivalves, crustaceans, and young seals.
- *Feeding behavior*—Feed singly or in groups, mainly at night and early morning; depths to 180 meters. Fishes up to 2 kg swallowed whole under water; larger prey brought to surface and reduced to pieces by shaking. Congregate near fishing boats.
- *Feeding location*—Coastal to pelagic; up to 320 km offshore. Large groups (more than 100) tend to feed farther offshore (more than 50 km) than do smaller groups. Feeding excursions are one day long during breeding season; later, stay at sea for longer periods.

Reproduction (Scheffer, 1945; Mathisen, Baade, and Lopp, 1962; Thorsteinson and Lensink, 1962; Tikhomirov, 1964a; Gentry, 1970; Sandegren, 1970; Edie, 1977; Calkins, 1979; Calkins and Pitcher, 1979; Pitcher and Calkins, 1981)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Mate, give birth on shore in protected areas above high-tide splash zone, mainly on rocky islands, exposed coasts.
- *Behavior*—Polygynous; males territorial; females gregarious and aggressive. Males arrive at breeding areas in May, 1-2 weeks before females.
- *Biology*—Single pups born on shore late May to early July (peak second week June); adults mate 6-14 days later; implantation delayed about 4 months. Pregnancy rate for mature females 87%; birth rate 63% in Gulf of Alaska; unknown in region of concern.

Development (Scheffer, 1945; Orr and Poulter, 1967; Gentry, 1970; Sandegren, 1970; Mate, 1973; Calkins and Pitcher, 1977, 1978; Pitcher and Calkins, 1981)—Pups precocial, can swim soon after birth; taken to sea by females at 4-5 weeks; weaned at 3-6 months. Twenty-five percent of females mature at 3 years, 100% by 5 years; males fully mature and territorial at 8-12 years.

Growth (Scheffer, 1945; Mathisen, Baade, and Lopp, 1962; Mate, 1973; Calkins and Pitcher, 1978; Calkins, 1980)—Pups 100 cm, 20 kg at birth; weight doubles, length increases 25% in first 7 weeks. Females 230-250 cm, 250-300 kg at 5-8 years; males 285-300 cm, more than 800 kg at 10-13 years. Maximum lifespan 30 years.

Movements (Kenyon and Rice, 1961; Braham, Fiscus, and Rugh, 1977; Calkins and Pitcher, 1983)—Not clearly understood. Some seasonal movements from summering to wintering areas. Nonbreeding males move northward in Bering Sea as ice retreats; then move southward in autumn.

Factors Influencing Populations

Natural (Dougherty and Herman, 1947; Orr and Poulter, 1967; Sandegren, 1970; Liu and Edward, 1971; Mate, 1973; Calkins and Pitcher, 1977; Edie, 1977; Fay et al., 1978; Slijper and Harrison, 1979)—Predators include killer whales and sharks; other mortality caused by disease, parasites, injuries. Pup mortality on rookeries averages at least 10% due to premature birth, injuries, abandonment, and drowning during storms. Infectious diseases may contribute to high prenatal mortality. Earthquakes can alter rookery habitat, resulting in abandonment.

Human-related (Pike and Maxwell, 1958; Kenyon, 1962; Thorsteinson and Lensink, 1962; Orr and Poulter, 1967; Sandegren, 1970; Braham, Everitt, and Rugh, 1980; Fay et al., 1978; Calkins, 1980; Loughlin et al., 1983)—Harassment at rookery/hauling area can cause emigration or abandonment, as well as trampling of pups or permanent separation of cow and pup. Small harvests by Natives at Pribilof and St. Lawrence islands and, at present, larger incidental kill by commercial fisheries probably insignificant as regulating factors. Some injury and mortality from entanglement in flotsam (nets, strapping material). Availability of food from fish-processing vessels may enhance survival.

Potential (Craddock, 1977; Struhsaker, 1977; Braham, Everitt, and Rugh; 1980; Calkins, 1980; Braham et al., 1982)—Indirect effects of oil pollution and industrial development could occur through contamination of major prey species. Harassment (increased air, boat traffic) may have depressing effects. Competition with commercial fisheries for food and entanglement in fishing nets may become important factors in controlling population level and distribution.

Population Size (Kenyon and Rice, 1961; Braham, Everitt, and Rugh, 1980; Loughlin, Rugh, and Fiscus, 1984)

Estimated world population 250,000 animals; current Alaskan population about 200,000 (10-15% in region of concern). Eastern Aleutian population declined 50% between 1969 and 1976; cause uncertain.

Management

Taking by Natives for subsistence is permitted; otherwise, fully protected.

Persons Consulted

J. J. Burns, Alaska Department of Fish & Game, Fairbanks, Alaska.
T. R. Loughlin, National Marine Mammal Laboratory, Northwest and Alaska Fisheries Center, NMFS/NOAA, Seattle, Washington.

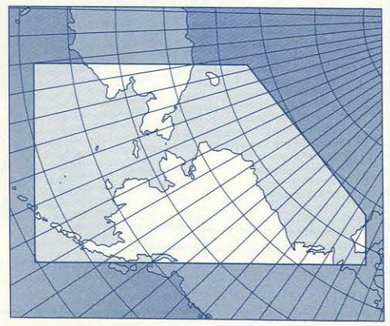
Legend

- Adult Area (Year-round)
- Adult Area (May-November)
- Major Adult Area (Year-round)
- Major Adult Area (May-October)
- Major Adult Concentration (May-October)
- Rookery (May-October)
  - Greater than 1,000 individuals
- Haulout (May-October) Number of Individuals
  - Less than 1,000
  - Greater than 1,000

Mating and pupping occur on rookeries (late May-early July). Juveniles occur throughout adult areas. Haulouts used later in northern areas and have greatest numbers of animals after reproductive period. Many other haulouts than shown may be used sporadically by small numbers of animals.

Map References

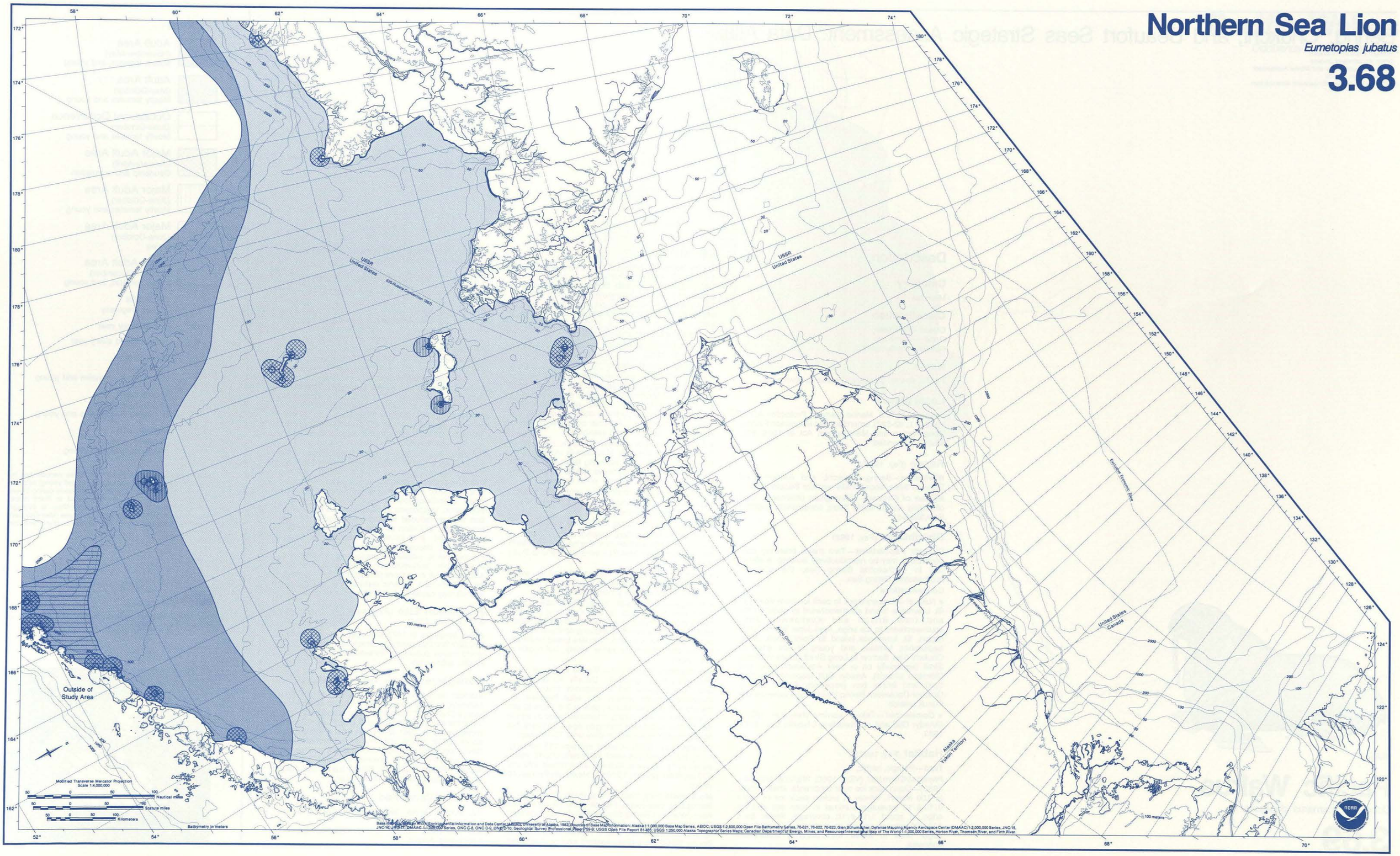
Rass, Kaganovskii, and Klumov, 1955; Gentry and Withrow, 1978; Loughlin, Rugh, and Fiscus, 1984. Personal communications from Burns; Fay; Loughlin.



Northern Sea Lion

Eumetopias jubatus

3.68



Base map produced by MMS Environmental Information and Data Center, AEIDC, University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17, DMAAC 1:3,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-365; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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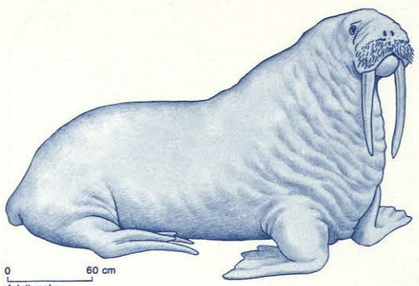


Adult male

Pacific Walrus

Odobenus rosmarus divergens

3.69

Description

Category

Mammal

Classification

Class—Mammalia
Order—Carnivora
Family—Odobenidae

Name

Pacific walrus, *Odobenus rosmarus divergens*

Legal Status

Protected by U.S. Marine Mammal Protection Act of 1972 (P.L. 92-522), amended, and Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended.

Range (Fay, 1982)

Worldwide—Bering, Chukchi, and eastern East Siberian Seas; occasionally western Beaufort Sea.

Region of Concern—Throughout continental shelf of Bering and Chukchi Seas; occasionally western Beaufort Sea.

Distribution (Fay, 1982)

Discrete Populations—Two major breeding concentrations may be reproductively isolated in winter: one in northcentral Bering Sea, the other in southeastern Bering Sea.

Concentrations

- *Natural*—January-April: In pack ice from vicinity of St. Lawrence Island southwestward to about 61°N, and from Bristol and Kuskokwim Bays southwestward to ice edge. April-June: Bering Strait region, St. Lawrence Island to Point Hope. June-September: females and young in ice edge of Chukchi Sea, Barrow to Long Strait; males in Bering Strait (especially on or near Arakamchechen and Diomede Islands), Anadyr Gulf (especially Rudder Spit), and Bristol Bay (especially Round Island). October-December: Bering Strait to St. Lawrence and Punuk Islands.
- *Commercial*—Taken commercially in USSR (Anadyr Gulf and northwestern Chukchi Sea) since 1982.

Habitat (Fay, 1982)

Type—Pelagic, neritic.

Physical/Chemical (Vibe, 1950; Wartzok and Ray, 1980)—Open pack ice over continental shelf; depths to 100 meters. Winter in broken pack ice of about 6/10-8/10 coverage; summer in open sea and ice edge of about 1/10-6/10 coverage. Prefer floes 100-200 square meters in summer; in winter use larger floes in areas with complex leads and polynyas.

Life History

Social Behavior (Miller, 1975; Estes and Gilbert, 1978; Wartzok and Ray, 1980; Fay, 1982)—Gregarious, vocal. Travel and feed mainly in groups of 1-20; haul out mostly in groups of 1-200 on ice, up to several thousand on shore. Sexes tend to segregate. Social rank a function of tusk and body size.

Biological Associations—None known.

Nutrition (Krylov, 1971; Ray, 1973, 1984; Fay, 1982; Oliver et al., 1983)

- *Feeding type*—Predator.
- *Food*—60-90% bivalve mollusks by weight (without shells); also anemones, polychaetes, echiurids, priapulids, sipunculids, snails, octopus, amphipods, shrimps, crabs, sea cucumbers, tunicates, and seals. Average daily requirement (by weight) estimated at 5-7% total body weight; highly variable with age, sex, and season.
- *Feeding behavior*—Benthic feeders, believed to dig with snout, like pigs. May take in most food by suction, simultaneously ingesting large quantities of bottom sediments. Adult males appear to fast during winter, but feed intensively in other seasons.
- *Feeding location*—Benthic, on continental shelf.

Reproduction (Ray and Watkins, 1975; Fay, 1982; Fay, Ray, and Kibal'chich, 1984)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Mate where concentrated in winter in northcentral and southeastern Bering Sea; give birth on ice floes mainly from St. Lawrence Island to Point Hope.
- *Behavior*—Polygynous. Males display in water alongside herds of females on ice. Probably copulate in water. Females very protective of calves.
- *Biology*—Adult males in rut December-March. Adult females in estrus January-February; pregnant 15-16 months, including 4-5 months' delayed implantation. Single calf born on ice during northward migration mid-April to mid-June. Females breed biennially or less often; fecundity varies widely, but peaks at 9-11 years.

Development (Fay, 1982)—Calves precocial, swim from birth, wean gradually. Usually suckle slightly less than 2 years, but occasionally much longer. Immature females remain with adult females; immature males leave female herds at 3-6 years to join all-male herds. About 70% of females breed by age 6; most males capable of mating by age 9-10 years, but not physically or socially mature until 15-16 years.

Growth (Fay, 1982)—Calves average 115 cm long, 65 kg at birth; females reach full growth at 9-10 years, males at 15-16 years. Average adult female 270 cm, 830 kg; male 320 cm, 1,210 kg. Maximum lifespan 40 years.

Movements (Fay, 1982)—Adult males stay mainly in Bering Sea year-round. Females and young migrate April-June from Bering Sea to Chukchi Sea, and from Chukchi to Bering October-December. Principal spring routes east and west of St. Lawrence Island to Bering Strait, then along eastern and southwestern Chukchi flaw zones. Autumn routes not well known, but generally reverse of spring.

Factors Influencing Populations

Natural (Tomilin and Kibal'chich, 1975; Fay and Kelly, 1980; Fay, 1982)—Polar bears and killer whales take mainly young. Some adults and young die on autumn haulouts, apparently due to trampling by other walruses. Cold stormy weather in spring may lead to deaths of large numbers of newborn calves, presumably from exposure.

Human-related (Fay, 1957, 1982; Loughrey, 1959; Tomilin and Kibal'chich, 1975; Salter, 1979)—Overhunting in late 19th and mid-20th centuries apparently diminished population by about 50%. Most disturbances cause only short-term displacement; ships, boats, and low-flying aircraft can cause stampedes, leading to abortion and to mortality of young due to trampling and abandonment. Females more sensitive to disturbance than males and more sensitive in winter than in summer.

Potential (North, 1967; Dow, 1975; Percy and Mullin, 1975; Renzoni, 1975; Gilfillan et al., 1976; Johnson, 1977; Geraci and St. Aubin, 1980; Kelley, 1980)—Population probably food-limited. Natural or anthropogenic decrease of bivalve supply, whether direct or indirect, probably would depress walrus population. Responses of bivalves to oil contamination include reduced feeding and growth, reduced productivity, inhibition of spat settlement, abnormal development, and increased mortality. Walruses' main prey, deposit-feeders, tend to concentrate hydrocarbons, possibly contributing to long-term hydrocarbon accumulation in walruses. Walruses also may take in oil more directly from sediments ingested with food. Chronic disturbance by ships and aircraft may cause abandonment of certain haulouts.

Population Size (Johnson et al., 1982; Estes and Gol'tsev, 1984)

Aerial censuses in 1975 and 1980 estimated about 200,000-300,000 animals, which is about 90% of world walrus population, including both Atlantic and Pacific subspecies.

Management (Krylov, 1968; Fay, 1982)

Alaskan Natives are allowed unlimited subsistence harvests; national quota in USSR, 5,000 animals per year, includes both commercial and subsistence take. Total harvest for both USA and USSR increasing in recent years; in 1981 and 1982, total retrieved take about 8,000; losses possibly an additional 5,000. Soviet regulations prohibit hunting at onshore haulout sites and shooting of animals in water; State of Alaska restricts access to Round Island and Cape Seniavin haulout areas in Bristol Bay.

Persons Consulted

J.J. Burns, Alaska Department of Fish & Game, Fairbanks, Alaska.
A.M. Johnson, U.S. Fish & Wildlife Service, Anchorage, Alaska.

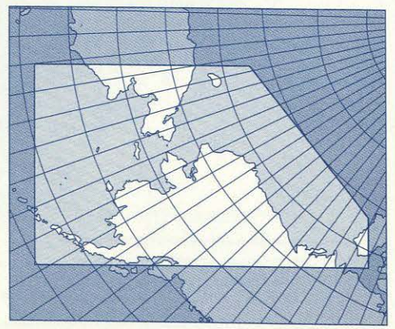
Legend

- Adult Area (November-May) — Males, females, and young
- Adult Area (May-October) — Mostly females and young
- Occasional Occurrence (June-October) — Mostly females and young
- Major Adult Area (January-April) — Courtship and copulation
- Major Adult Area (June-October) — Mostly females and young
- Major Adult Area (June-October) — Males
- Major Adult Area (October-December) — Males, females, and young
- Haulouts — used irregularly; used every year; major, used every year
- Movement (April-June) — M - males; F - females and young
- Movement (October-December) — M - males; F - females and young
- Movement (October-December) — Males, females, and young

Haulouts are used primarily during ice-free periods and by those animals (i.e. males and/or females and young) occupying the surrounding areas. Calving (May) occurs during movement, primarily from St. Lawrence Island to Point Hope. Southern limit of adult area (November-May) is average maximum ice edge. Northern limit of adult area (May-October) is average minimum five-tenths ice cover. (See: Sea Ice Dynamics)

Map References

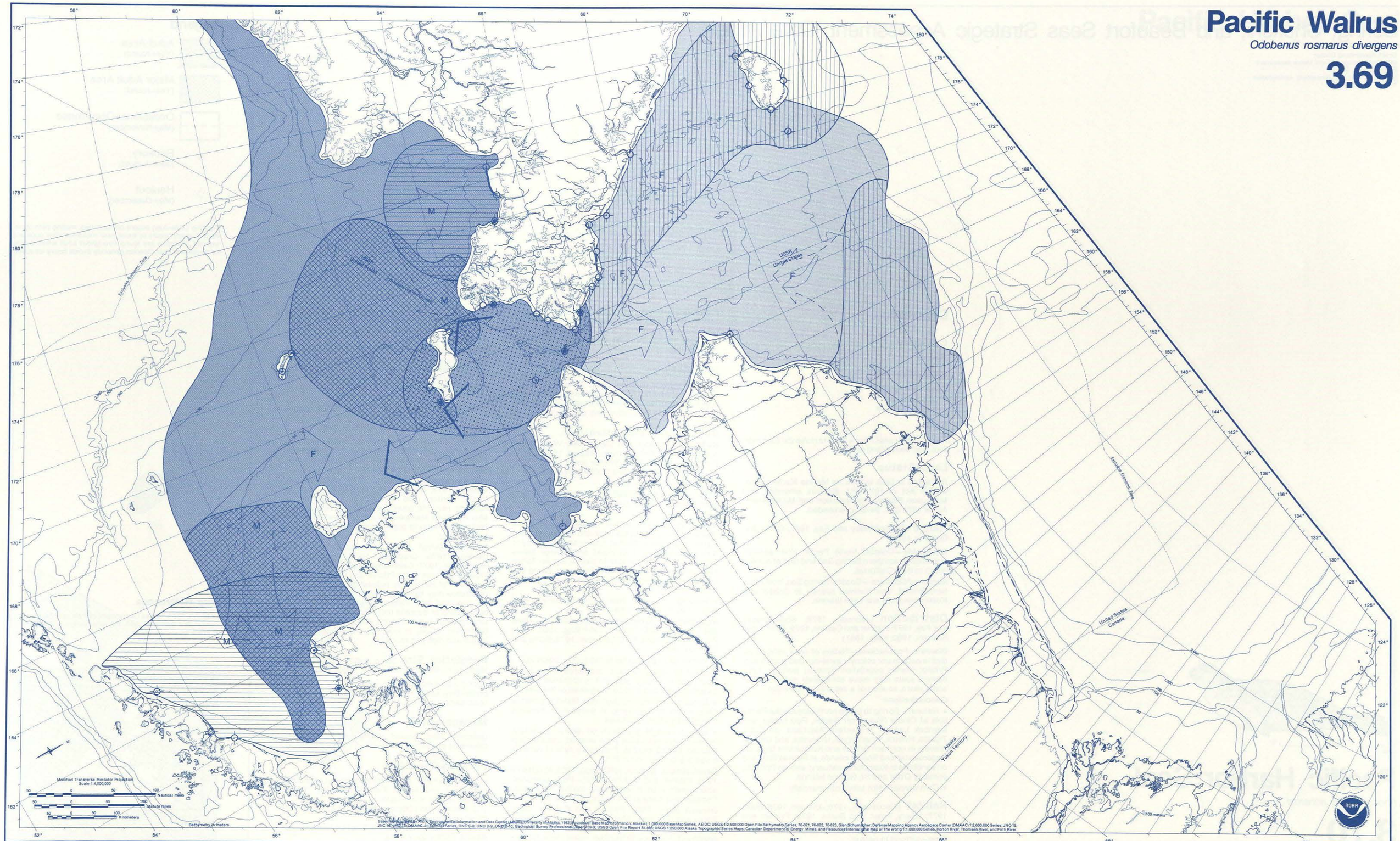
Fay, 1982. Personal communications from Burns; Fay; Johnson; Ray.



Pacific Walrus

Odobenus rosmarus divergens

3.69



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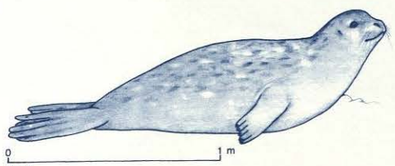


Pacific Harbor Seal

Phoca vitulina richardsi

3.70

Description

Category

Mammal

Classification

Class—Mammalia
Order—Carnivora
Family—Phocidae

Name

Pacific harbor seal, *Phoca vitulina richardsi* (common seal, hair seal, island seal)

Legal Status

Protected in USA waters by Marine Mammal Protection Act of 1972 (P.L. 92-522), amended, and Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended.

Range (Shaughnessy and Fay, 1977; Burns and Gol'tsev, 1984)

Worldwide—Coastal North Pacific from eastern Hokkaido to southern Bering Sea and Gulf of Alaska, south to Baja California.

Region of Concern—Coastal Bering Sea, from Aleutian, Pribilof, and Nunivak islands to Bristol and Kuskokwim bays and Lake Iliamna.

Distribution (Johnson, 1976; Shaughnessy and Fay, 1977; Pitcher and Calkins, 1979; Everitt and Braham, 1980; Kelly, 1981)

Discrete Populations—Ratios of color morphs indicate each major colony a semi-isolated population. Pribilof Islands population believed isolated; Lake Iliamna seals may move completely out of lake in some years, so are not a separate population.

Concentrations

- *Natural*—Spring to fall on north side Alaska Peninsula at Cinder River, Port Heiden, Port Moller, and Izembek Lagoon; in eastern Aleutians, on Baby, Tigalda, Rootok, Inner Signal, Unalaska, and Unimak islands; in northern Bristol and Kuskokwim bays, on Hagemeister and Shaiak islands, in Nanvak Bay, and on sandbars in Kuskokwim estuary; also on Pribilofs, primarily Otter and St. George islands.
- *Commercial*—Not taken commercially.

Habitat (Fiscus et al., 1976; Johnson, 1976; Wahl, 1977; Lowry, Frost, and Burns, 1979; Pitcher and Calkins, 1979; Everitt and Braham, 1980)

Type—Littoral to pelagic.

Physical/Chemical—Salt to brackish coastal waters and fresh waters; occasionally to 100 km offshore. Haul out on nearshore rocks, beaches, sand bars, mud bars, and sea ice, most often during low tides and fair weather.

Life History

Social Behavior (Bishop, 1967; Johnson, 1976)—Gregarious; haul out in groups of mixed age and sex. Some segregation of males and of adult females with pups. Travel and feed individually and in groups of up to 40.

Biological Associations—None known.

Nutrition (Scheffer and Slipp, 1944; Wilke, 1957; Spalding, 1964; Kenyon, 1965; Hazard, 1977; Lowry, Frost, and Burns, 1979; Pitcher and Calkins, 1979; Streveler, 1979; Burns and Gol'tsev, 1984)

- *Feeding type*—Predator.
- *Food*—In eastern Aleutians, Pribilofs, and Bristol Bay: pollock, Pacific cod, salmons, octopus, and capelin.
- *Feeding behavior*—Feed singly and in small groups. Slow movements back and forth in shallow waters; apparently also dart quickly and erratically or dive repeatedly in a localized area. Large fishes brought to surface and torn to pieces; smaller fishes swallowed whole under water. First-year young eat crustaceans and fishes less than 15 cm long; prey of adults up to 4.5 kg.
- *Feeding location*—Nearshore estuarine and sublittoral, midwater to benthic.

Reproduction (Scheffer and Slipp, 1944; Venables and Venables, 1957; Bishop, 1967; Bigg, 1969, 1973; Pitcher and Calkins, 1979; Streveler, 1979; Burns and Gol'tsev, 1984)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Mate in calm, protected areas away from pupping sites or adjacent to rookeries; pup on beaches, sand and mud bars exposed at low tide.
- *Behavior*—Probably polygynous. Males apparently seek mates by displaying in water near beaches occupied by estrous females.
- *Biology*—Single pup born on shore, June-July; females mate soon after pups weaned; implantation delayed 1.5-2.0 months. Pregnancy rate of females 8 years and older about 95%.

Development (Bishop, 1967; Bigg, 1969; Knudtson, 1974; Pitcher and Calkins, 1979)—Pups precocial, able to swim at birth; remain with mother 3-6 weeks. Females first mate at 3-4 years, males at 4-5 years.

Growth (Bigg, 1969; Pitcher and Calkins, 1979; Burns and Gol'tsev, 1984)—Pups more than double weight during suckling; double length in 5 years. Full grown at 7-10 years. Bristol Bay males about 160 cm and 90 kg; females 150 cm and 75 kg. Aleutian and Pribilof seals are larger: adult males about 175 cm and 115 kg; females 162 cm and 95 kg. Maximum lifespan 25-30 years.

Movements—Poorly understood. Some immature Bristol Bay seals migrate to Kuskokwim estuary and Nunivak Island in spring and return in late summer-fall. All probably move out of Bristol Bay in winter during extensive, heavy pack ice conditions (February-April).

Factors Influencing Populations (Scheffer and Slipp, 1944; Boulva, 1975; Fay et al., 1978; Braham et al., 1982; Pitcher and Fay, 1982)

Natural—Predators include killer whales, northern sea lions, and sharks. Lung worms, bacterial diseases, and starvation also cause mortality. Mortality of abandoned pups high, due to starvation.

Human-related (Johnson, 1976; Pitcher and Calkins, 1979; Matkin and Fay, 1980)—Taken by Native hunters and incidentally by commercial fisheries. Humans, small boats, surface vehicles, and aircraft cause stampedes into water, which sometimes cause injury to pups and premature separation from mother.

Potential (Arndt, 1973; Evans and Rice, 1974; DeVries, 1975; Craddock, 1977; Patten, 1977; Struhsaker, 1977; Calambokidis et al., 1978; Lowry, Frost, and Burns, 1979; Pitcher and Calkins, 1979)—Depletion of major prey populations by fisheries or pollutants may have significant impact. Increasing air, sea, and land traffic may displace some local populations or depress them through pup mortality. Chlorinated hydrocarbons and polychlorinated byphenyls (PCBs) in food may cause reproductive failure and high pup mortality.

Population Size (Bigg, 1969; Johnson, 1976; Mate, 1977; Everitt and Braham, 1980)

Bering Sea population at least 30,000, mostly in Bristol Bay. About 10% of world population in region of concern.

Management

Unlimited take allowed Natives for subsistence; otherwise protected.

Persons Consulted

H. W. Braham, National Marine Mammal Laboratory, Northwest and Alaska Fisheries Center, NMFS/NOAA, Seattle, Washington.
J. J. Burns, Alaska Department of Fish & Game, Fairbanks, Alaska.
F. H. Fay, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.

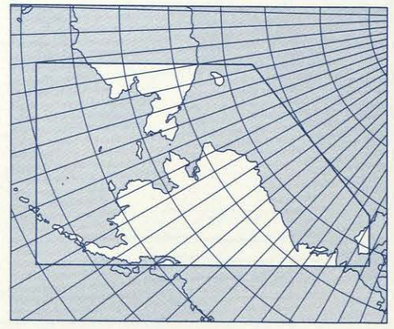
Legend

- Adult Area (Year-round)
- Major Adult Area (Year-round)
- Occasional Occurrence (May-November)
- Rookery (June-August)
- Haulout (May-December)

Pupping (June-July) occurs on rookaries; mating (late June-early August) occurs in water near rookeries after pups are weaned. Juveniles are found throughout adult areas during same times of year. Species generally avoids heavy ice cover.

Map References

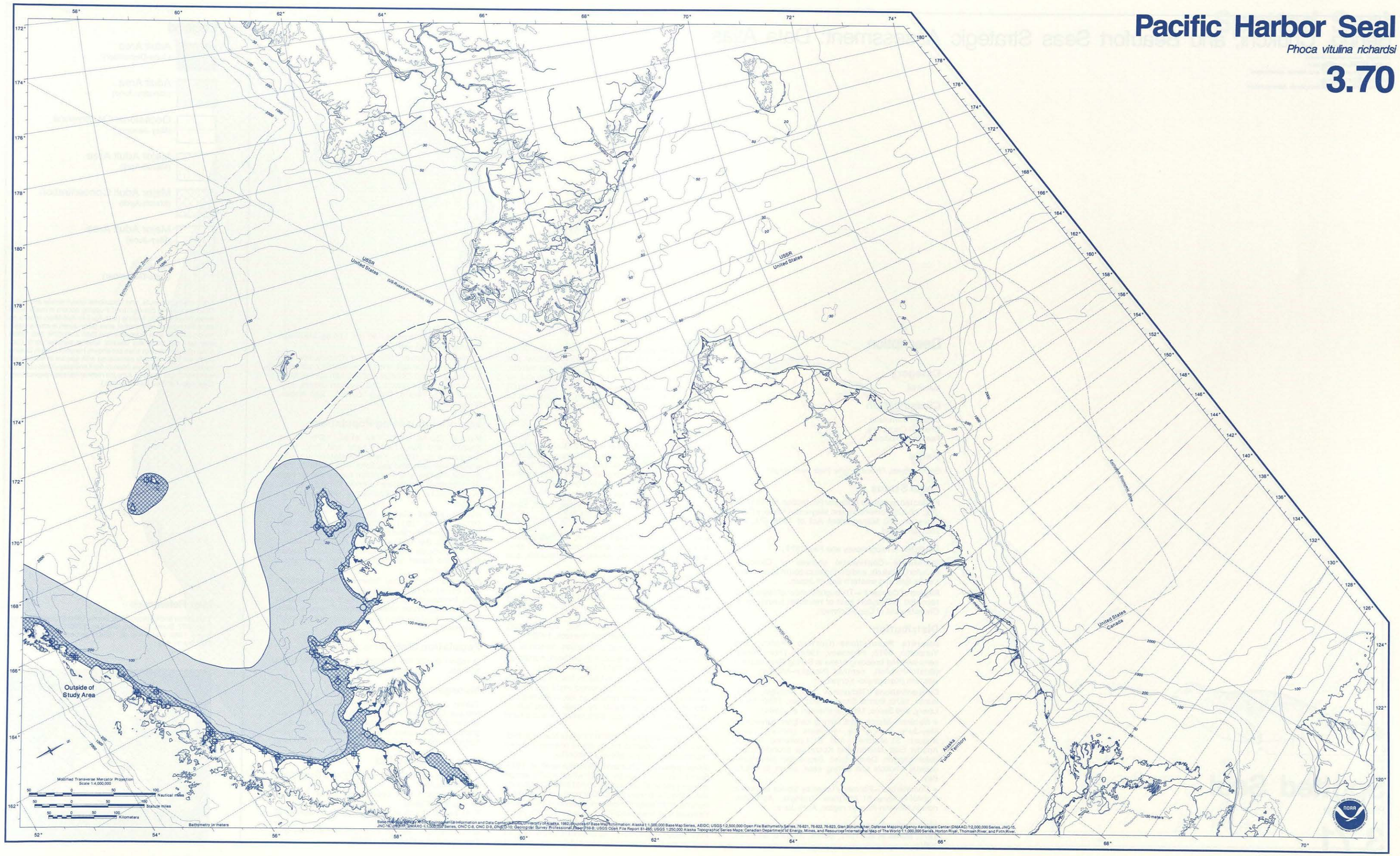
Johnson, 1976; Alaska Department of Fish and Game, 1978; Everitt and Braham, 1980. Personal communications from Burns; Fay.



Pacific Harbor Seal

Phoca vitulina richardsi

3.70



Base map data sources: NOAA Environmental Information and Data Center (AEIDC), University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 series, ONC C-8, ONC D-8, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-455; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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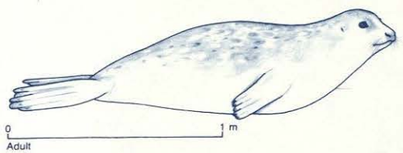


Spotted Seal

Phoca largha

3.71

Description

Category

Mammal

Classification

Class—Mammalia
Order—Carnivora
Family—Phocidae

Name

Spotted seal, *Phoca largha* (hair seal, larga)

Legal Status

Protected by Marine Mammal Protection Act of 1972 (P.L. 92-522), amended, and Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended.

Range (Shaughnessy and Fay, 1977)

Worldwide—Continental shelves of Okhotsk, Beaufort, Chukchi, and Bering seas south to northern Yellow Sea and western Sea of Japan.

Region of Concern—Throughout most of region; not recorded in Beaufort east of Herschel Island nor in Chukchi west of Cape Schmidt.

Distribution

Discrete Populations (Gol'tsev, Popov, and Yurakhno, 1975; Fedoseev, 1984)—Three major, semi-isolated breeding areas in Bering Sea: eastern (Bristol-Pribilof), central (Navarin-Anadyr), and western (Karaginski- Koryak).

Concentrations (Tikhomirov and Kosygin, 1966; Burns, 1970; Burns, Shapiro, and Fay, 1980; Frost, Lowry, and Burns, 1982; Braham et al., 1984)

- *Natural*—March-April: Bering ice front (breeding); May-June: Bering ice remnants (molting); July-August: St. Matthew and St. Lawrence islands, Anadyr Gulf, Norton and Kotzebue sounds, Kasegaluk Lagoon, Dease Inlet; September-November: coastal Chukchi and Bering seas, south to Bristol Bay.
- *Commercial*—Formerly taken by Soviet sealers in Pribilof-Nunivak-St. Matthew triangle, April-May; now in Navarin-Anadyr region, April-June.

Habitat (Tikhomirov and Kosygin, 1966; Burns, 1970; Burns et al., 1972; Burns, Shapiro, and Fay, 1980)

Type—Littoral to pelagic.

Physical/Chemical—November-June: ice-covered neritic waters; July-October: littoral-sublittoral and estuarine waters. Water depths 0-200 meters; temperatures −1.8 to 10°C. In spring, haul out on thick, snow-covered, outer front ice floes about 20 meters in diameter for pupping, molting; rest on gravel beaches, bars, and offshore rocks summer-autumn.

Life History

Social Behavior (Burns et al., 1972; Burns, 1973a)—Occur as isolated pairs with pup in breeding season; otherwise gregarious, hauling out on ice or land in large groups of mixed sexes and ages. Some tendency for age segregation of feeding groups.

Biological Associations—None known.

Nutrition (Gol'tsev, 1971; Lowry and Frost, 1981; Bukhtiyarov, Frost, and Lowry, 1984)

- *Feeding type*—Predator.
- *Food*—Primarily fishes (capelin, herring, pollock, Arctic and saffron cods, smelts, sculpins, and sand lance); also amphipods, shrimps, euphausiids, and octopus.
- *Feeding behavior*—Feed singly or in small groups. Prey swallowed whole, under water.
- *Feeding location*—Winter-spring: in and near Bering ice front; summer-autumn: near shore, including estuaries.

Reproduction (Tikhomirov, 1966; Burns et al., 1972; Burns, 1973a; Beier and Wartzok, 1979)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Bering ice front. Pups born, nursed on floes; adults probably mate in water nearby.
- *Behavior*—Pairs form in March, before birth; male stays with female until pup weaned; mate late April to mid-May. Pairs widely spaced on ice, indicating territorial defense, probably by male. Adoption of orphaned pups may occur. Both sexes vocal in air and under water.
- *Biology*—Single pup born on ice late March to mid-April; female ovulates, mates about one month later; implantation delayed about 3.5 months.

Development (Tikhomirov, 1966; Burns et al., 1972; Burns, 1973a)—Pups born with white, woolly lanugo pelage; precocial, but usually do not swim until lanugo shed, about 4-6 weeks later. During about 4 weeks of nursing, birth weight triples; independent thereafter. Females first breed at 3-4 years, males at 4-5 years.

Growth (Naito and Nishiwaki, 1972; Burns, 1973a)—Pups about 85 cm, 10-11 kg at birth. Length doubles by 6 years; full grown at 10 years. Adult males about 170 cm, 135 kg; females 160 cm, 115 kg. Maximum lifespan about 35 years.

Movements (Burns, 1970; Burns, Shapiro, and Fay, 1980)—From Bering ice front, principally northward and shoreward to Siberian and Alaskan coasts, May-June; then along Chukchi and Beaufort coasts, July-August. Southward along coasts, September-November.

Factors Influencing Populations

Natural (Burns, 1970; Fay et al., 1978; Burns, Shapiro, and Fay, 1981; Lowry and Fay, 1984; Braham et al., 1982)—Known predators are killer whales, walruses, and sea lions. Pup mortality from disease, injuries, and starvation appears to be high. Early breakup of pack ice believed to cause highest pup mortality, due to premature separation from mother.

Human-related (Galster and Burns, 1972; Burns, 1973a; Burrell, 1981)—Accumulations of pesticides and heavy metals have been reported, but in low concentrations. Bering Sea fisheries, which take pollock, herring, compete with this species for food. Alaskan Native and Soviet harvests of spotted seals about 7,000 per year.

Potential—Commercial fisheries, contaminants in food chain may reduce food supply, lowering productivity. Increased ship, aircraft traffic, and other human contact may cause abandonment of coastal haulouts, increased mortality of young in ice front through disturbance.

Population Size (Burns, 1973a)

In region of concern, estimated at 200,000-250,000 animals.

Management (Burns, 1973a)

Taking permitted in USA waters only by Alaskan Natives for subsistence, without regulation. Soviet harvests conservative, based on annual census of population, principally in Navarin-Anadyr region; disturbance and harvest prohibited on coastal haulouts.

Persons Consulted

J. J. Burns, Alaska Department of Fish & Game, Fairbanks, Alaska.
D. G. Calkins, Alaska Department of Fish & Game, Anchorage, Alaska.
F. H. Fay, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.
G. A. Fedoseev, Pacific Institute of Fisheries and Oceanography, Magadan, USSR.

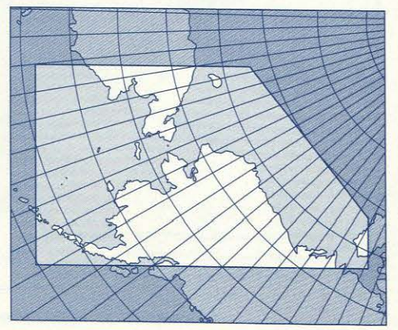
Legend

- Adult Area (June-December)
- Adult Area (January-June)
- Occasional Occurrence (May-January)
- Major Adult Area (March-April)
- Major Adult Concentration (March-April)
- Major Adult Area (May-June)
- Haulout (June-December)

Adult areas, haulouts, and occasional occurrences are June-October, north of Bering Strait. Pupping occurs in major adult areas (March-April). Mating (late April to mid-May) occurs on ice in Bering Sea. Major adult area (May-June) is also a major young juvenile area (juveniles less than 2 months old). Seals may haul out along any coastal area in summer; only consistently used haulout sites are shown. Haulout sites in Siberia unknown. Seals closely associated with sea ice in winter and spring; major adult areas (March-April and May-June) coincide with March ice front and June ice remnant areas, respectively. (See map 1.8, Sea Ice Dynamics.)

Map References

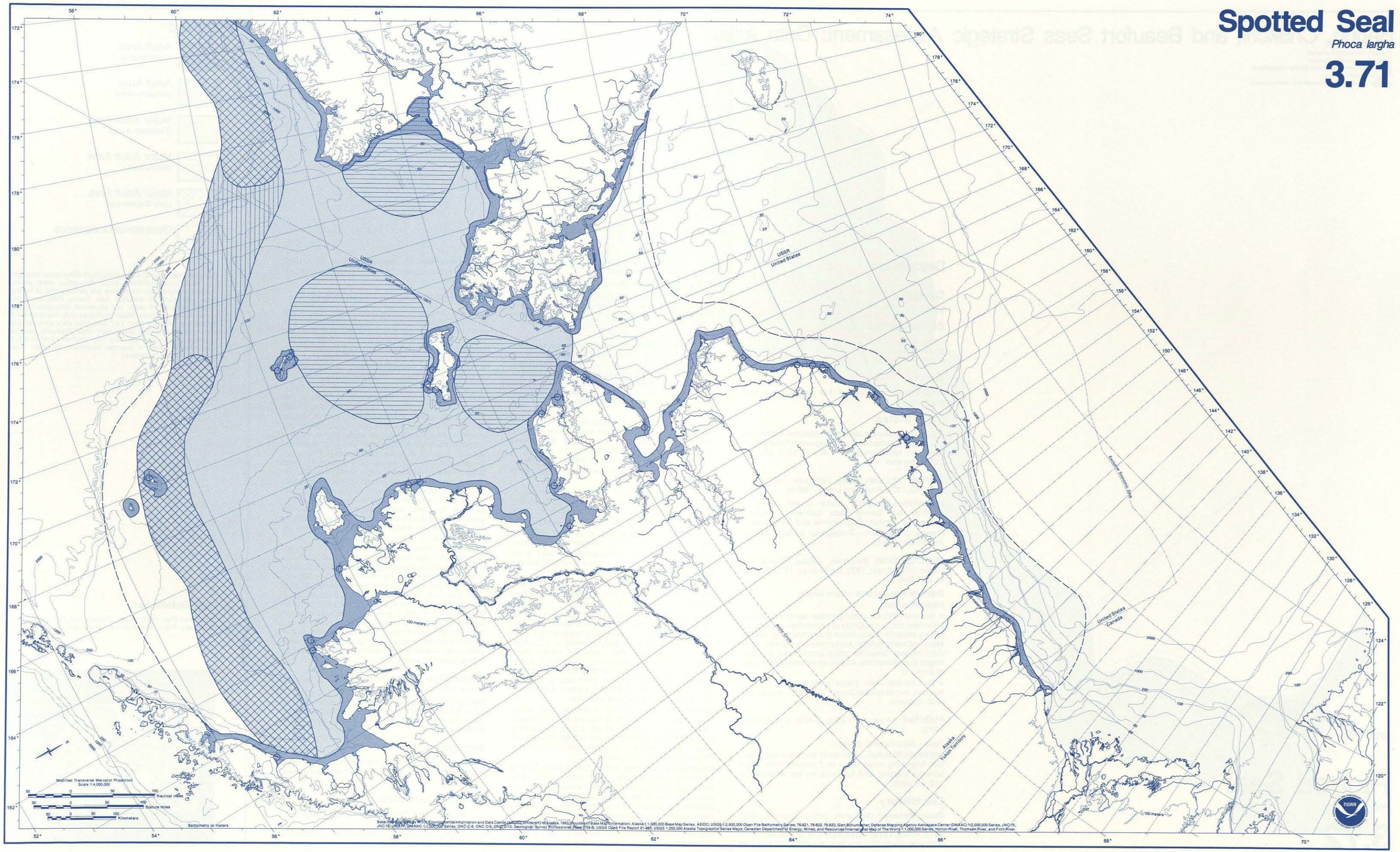
Tikhomirov and Kosygin, 1966; Burns, 1970; Shaughnessy and Fay, 1977; Burns, Shapiro, and Fay, 1980; Frost, Lowry, and Burns, 1982; Braham et al., 1984. Personal communications from Burns; Fay.



Spotted Seal

Phoca largha

3.71



Base map data courtesy of the Environmental Information and Data Center (EIDC), University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) h2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-6, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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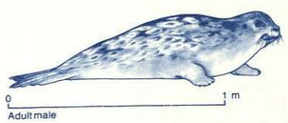


Adult male

Ringed Seal

Phoca hispida

3.72

Description

Category

Mammal

Classification

Class—Mammalia
Order—Carnivora
Family—Phocidae

Name

Ringed seal, *Phoca hispida* (hair seal, common seal, silver jar)

Legal Status

Protected by Marine Mammal Protection Act of 1972 (P.L. 92-522), amended, and Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended.

Range (McLaren, 1958a; Fedoseev, 1970; Burns and Eley, 1978; Frost and Lowry, 1981b)

Worldwide—Panarctic; Arctic Ocean, south to Okhotsk and Bering seas, Labrador, southern Greenland, northern Scandinavia, and Baltic Sea.

Region of Concern—Throughout Bering, Chukchi, and Beaufort seas.

Distribution (McLaren, 1958a; Burns and Harbo, 1972; Smith, 1973; Smith et al., 1978; Braham et al., 1984)

Discrete Populations—None known.

Concentrations

- *Natural*—Winter in ice; greatest density of seals in shorefast ice, but majority of population in heavy ice at sea. Majority of population during breeding (March-May) and molting (May-July) in heavy ice at sea. June-July: highest densities along cracks and pressure ridges in shorefast ice. August-November: along edge of pack ice.
- *Commercial*—Not taken commercially by USA hunters, but extensive Soviet, Canadian, and Greenland harvests.

Habitat (McLaren, 1958a; Smith and Stirling, 1975)

Type—Sublittoral to pelagic.

Physical/Chemical—Shorefast and pack ice. Maintain breathing holes in ice to 2 meters thick. Make lairs for pupping and haulouts on ice in snow 20-150 cm deep.

Life History

Social Behavior (McLaren, 1958a; Shustov, 1970; Smith, 1973; Smith and Stirling, 1975; Smith et al., 1978; Finley, 1979)—Generally solitary, except when with pup. Up to 25 (usually 1-2) individuals may use same breathing hole. Most active morning and evening; haul out at midday.

Biological Associations—None known.

Nutrition (McLaren, 1958a; Fedoseev, 1965; Johnson et al., 1966; Shustov, 1970; Lowry, Frost, and Burns, 1980; Frost and Lowry, 1981b; Lowry and Frost, 1981)

- *Feeding type*—Predator.
- *Food*—Pelagic and semidemersal fishes less than 20 cm long; pelagic, nektonic, and nektobenthic invertebrates: primarily Arctic and saffron cods, sculpins, mysids, euphausiids, shrimps, gammarid and hyperiid amphipods. In Bering Sea, young seals feed primarily on crustaceans, adults on fishes; in Chukchi-Beaufort, Arctic cod primary prey for all ages.
- *Feeding behavior*—Crepuscular; solitary or in loose aggregations. Swallow prey whole. Reduce feeding during breeding and molting. Not limited by water depths; benthic-feeding to depths of 90 meters, surface-feeding over greater depths.
- *Feeding location*—Sublittoral to benthic; pelagic in pack ice.

Reproduction (McLaren, 1958a; Johnson et al., 1966; Smith, 1973; Smith and Stirling, 1975; Stirling, 1977; Burns and Eley, 1978; Frost and Lowry, 1981b)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Pupping occurs in lairs on shorefast and stable pack ice; mating probably mainly in water.
- *Behavior*—Probably monogamous; males probably territorial. Pup born, nursed in subnivean lair; adults probably copulate in water nearby.
- *Biology*—Single pup born on ice late March-April; adults mate 2-4 weeks later; implantation delayed 3.5 months until late August.

Development (McLaren, 1958a; Johnson et al., 1966; Mansfield, 1967; Smith, 1973; Burns and Eley, 1978; Frost and Lowry, 1981b)—Pups precocial; born with white, woolly fetal coat, replaced by adult-type coat 2-4 weeks later. Pups nurse 5-7 weeks; abandoned by mother at ice breakup. Variation in age at weaning may account for variation in body size; pups weaned early may become small adults. Females mature at 5-7 years, males at 6-8 years. Annual molt late March-July; immatures molt first.

Growth (McLaren, 1958a; Fedoseev and Nazarenko, 1970; Smith, 1973; Fedoseev, 1975; Frost and Lowry, 1981b)—At birth, 65 cm, 4.5 kg; by weaning, 9-12 kg. Adults 115-140 cm, 50-100 kg; males 6-7% longer than females. Average life duration 15-20 years; maximum 40 years.

Movements (McLaren, 1958a; Smith, 1973; Stirling, Archibald, and DeMaster, 1977; Smith et al., 1978; Smith and Stirling, 1978)—Seals wintering in Bering Sea apparently move to Chukchi in May-June, return October-November. Others nonmigratory, except for inshore-offshore movements. Fast ice mainly inhabited by adults in winter-spring; immatures reside offshore, moving to fast and remnant ice for molt, late spring-early summer. Eastern Beaufort population shifted westward to Chukchi in winter 1974-1975, possibly in response to food and/or habitat shortage in Beaufort.

Factors Influencing Populations

Natural (McLaren, 1958a; Burns, 1970; Eley, 1976; Smith, 1976; Stirling, Archibald, and DeMaster, 1977; Smith and Stirling, 1978; Smith et al., 1978; Frost and Lowry, 1981b; Braham et al., 1982)—Pups born in unstable ice can be prematurely separated from mother. Predators include ravens, foxes, wolves, dogs, wolverines, and polar bears. Foxes prey exclusively on pups; bears catch adults and pups.

Human-related (Addison and Smith, 1974; Eberhardt, 1977; Geraci and Smith, 1977; Smith and Armstrong, 1978; Burns, Shapiro, and Fay, 1980; Frost and Lowry, 1981b)—Soviet and American Natives in Bering-Chukchi took 12,000-16,000 per year for subsistence use in early 1970s; current harvests believed 8,000-10,000 per year. Numbers reduced in areas of human habitation, probably due to disturbance; also along seismic survey lines. Organochlorine levels low; high levels of mercury in liver, especially in arctic Canada; effects unknown. Short-term exposure to crude oil resulted mainly in eye irritation and stress, also some liver and kidney damage. Improper waste disposal at oil camps attracts predators (foxes, bears), possibly enhancing their survival and productivity, with consequent impact on seals.

Potential (Geraci and Smith, 1977; Cowles, Hansen, and Hubbard, 1981)—Oil spilled under ice will accumulate in breathing holes and leads, possibly resulting in emigration by seals, premature separation of mother from pup, thermal-metabolic upset of pups. Eye, liver, kidney damage likely to be severe in prolonged contact with oil. Negative synergistic effects of oiling on sick, starved, or otherwise stressed seals may cause increased mortality. Acoustic and olifactory pollution in areas close to human habitation probably cause emigration. High underwater noise levels may interfere with communication, especially during breeding season.

Population Size (Bychkov, 1971; Frost and Lowry, 1981b)

Bering-Chukchi-Beaufort population estimated at 1-1.5 million animals; about 25% of world population. Most abundant north of Bering Strait, especially in Beaufort Sea.

Management

Unlimited taking by Native people for subsistence permitted in Alaska, USSR, and Canada; otherwise, protected.

Persons Consulted

J. J. Burns, Alaska Department of Fish & Game, Fairbanks, Alaska.
B. P. Kelly, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.

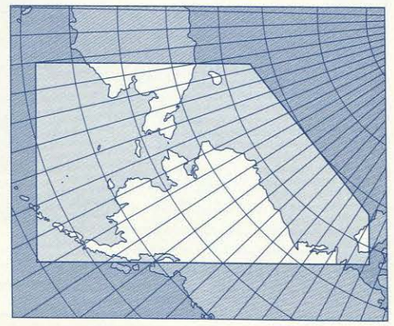
Legend

- Adult Area (Year-round)
- Adult Area (January-May)
- Major Adult Area (February-June)
- Major Adult Area (May-June)
- Major Adult Area (July-September)
- Occasional Occurrence

Pupping (March-April) and mating (April-May) occur throughout adult areas. Juveniles occur throughout adult areas. Periods of occasional occurrence are January-May in Bering Sea, year-round in Beaufort Sea. During February-June, largest numbers of seals are dispersed throughout adult areas on heavy pack ice. Major adult area (July-September) is September ice front (map 1.8); area may vary considerably within period indicated. Major adult area (February-June) is depicted as shorefast ice (map 1.8). Southern limit of adult area (January-May) is average maximum ice edge. (See map 1.8, Sea Ice Dynamics.)

Map References

Burns and Eley, 1978; Burns, Shapiro, and Fay, 1980; Frost and Lowry, 1981b. Personal communications from Burns; Fay.



Ringed Seal

Phoca hispida

3.72



Base map data sources: ARCTIC Environmental Information and Data Center (Alaska University of Alaska, 1982; Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-455; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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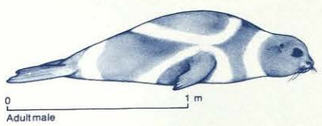


Ribbon Seal

Phoca fasciata

3.73

Description

Category

Mammal

Classification

Class—Mammalia
Order—Carnivora
Family—Phocidae

Name

Ribbon seal, *Phoca fasciata* (banded seal)

Legal Status

Protected by Marine Mammal Protection Act of 1972 (P.L. 92-522), amended, and Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended.

Range (Shustov, 1965; Burns, 1981a)

Worldwide—Continental shelves of Bering, Chukchi, and Okhotsk seas, south to northern Sea of Japan.
Region of Concern—Bering and Chukchi seas.

Distribution

Discrete Populations (Fedoseev, 1973; Burns, 1981a)—None in region of concern.

Concentrations (Burns, 1981a; Burns, Shapiro, and Fay, 1981; Braham et al., 1984)

- *Natural*—March-May: inner ice front of Bering Sea, especially westcentral part (breeding); May-July: Bering Sea ice remnants (molting), particularly Anadyr region.
- *Commercial*—Taken by Soviets in Cape Navarin-Anadyr Gulf region, April-July.

Habitat (Fay, 1974; Burns, 1981a; Burns, Shapiro, and Fay, 1981)

Type—Pelagic, neritic.

Physical/Chemical—Seasonal pack ice, November-May; pack ice remnants, May-July; pelagic, in ice-free waters, July-October. Water depths to 200 meters. Haul out on thick, snow-covered, inner front ice floes about 20 meters in diameter for pupping, molting.

Life History

Social Behavior (Burns, 1981a)—Solitary, except for females with pups.

Biological Associations—None known.

Nutrition (Arsen'ev, 1941; Frost and Lowry, 1980; Burns, 1981a)

- *Feeding type*—Predator.
- *Food*—Primarily fishes (especially pollock, capelin, eelpout, and Arctic cod) and octopus; also saffron cod, sculpins, herring, Greenland turbot, pricklebacks, amphipods, and mysids.
- *Feeding behavior*—Prey swallowed whole, underwater.
- *Feeding location*—Winter-spring: in and near Bering Sea ice front; summer-autumn: open waters of Bering and Chukchi seas.

Reproduction (Fedoseev, 1973; Watkins and Ray, 1977; Burns, 1981a)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Inner front of seasonal pack ice. Pups born and nursed on floes; adults probably mate in water nearby.
- *Behavior*—No evident pair formation; probably polygynous. Adults vocal under water.
- *Biology*—Single pup born on ice early to mid-April. Female ovulates, mates within one month after giving birth; implantation delayed about 3.5 months.

Development (Burns, 1970, 1981a; Fedoseev, 1973)—Pups born with white, woolly lanugo pelage; precocial, but do not swim until lanugo shed 3-4 weeks later. Nursed 3-4 weeks, during which weight more than doubles; independent thereafter. Females sexually mature at 2-4 years, males at 3-5 years.

Growth (Burns, 1973b, 1981a; Fedoseev, 1973)—Pups about 86 cm, 10.5 kg at birth. Both sexes fully grown by 7 years; average 150-155 cm, 70-80 kg; maximum size 180 cm, 140 kg; males slightly larger than females. Maximum lifespan approximately 30 years.

Movements (Burns, 1970, 1981a; Fay, 1974; Burns, Shapiro, and Fay, 1981)—Trend of northward migration in pack ice, May-June. Most, evidently, enter Chukchi Sea. Others may remain in Bering Sea during ice-free season; some of these may be from Okhotsk population. Associate with southward-advancing pack ice in late fall.

Factors Influencing Populations

Natural (Shustov, 1969; Burns, 1970; Fay et al., 1978; Burns, Shapiro, and Fay, 1981)—Pup mortality probably high from disease, injuries, starvation; early breakup of pack ice probably causes highest pup mortality through premature separation from mother. Predators include killer whales, sharks, and polar bears. Adult mortality probably also from disease, parasitism.

Human-related (Shustov, 1967; Galster and Burns, 1972; Burns, 1981a; Burrell, 1981)—Intensive commercial harvests by Soviets in 1960s significantly reduced population; reduced harvests have allowed population recovery. Present Soviet quota 3,000 animals per year; Alaskan Natives take 100-250 annually. Bering Sea pollock fishery competes with this species for food. Low-level heavy metal accumulations have been reported, probably pesticides also.

Potential (Cowles, Hansen, and Hubbard, 1981; Braham et al., 1982)—Population productivity could be lowered by reduction of prey populations from oil pollution, competition with commercial fisheries, accumulation of contaminants in food chain that may adversely affect reproduction, increased pup mortality through thermal upset (hypothermia) of nursing pups contacting oiled females, premature separation from females due to disturbance by ship and aircraft traffic. Organ damage, especially to eyes, kidneys, liver, likely to result from chronic oil pollution.

Population Size (Burns, 1981a)

Estimated at 90,000-100,000 animals in region of concern.

Management (Burns, 1981a)

Subsistence take permitted in USA waters only by Alaskan Natives. Soviet commercial harvest limited to 3,000 animals annually.

Persons Consulted

J. J. Burns, Alaska Department of Fish & Game, Fairbanks, Alaska.
F. H. Fay, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.

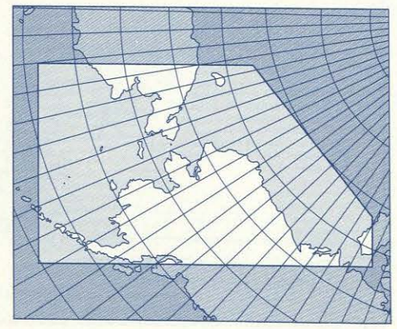
Legend

- Adult Area (January-June)
- Adult Area (June-December)
- Occasional Occurrence (January-June)
- Major Adult Area (May-June)
- Major Adult Area (June-December)
- Major Adult Area (March-April)
- Major Adult Concentration (March-April)

Pupping occurs throughout major adult areas (March-April); mating (April-May) throughout spring adult areas. Juveniles occur throughout adult areas. In Bering Sea, seals are closely associated with ice. During August-September, individuals from Okhotsk Sea (USSR) population may occasionally occur as far north as St. Lawrence Island. Major adult areas (March-April and May-June) are depicted as March ice front and June ice remnant areas, respectively. (See map 1.8, Sea Ice Dynamics.)

Map References

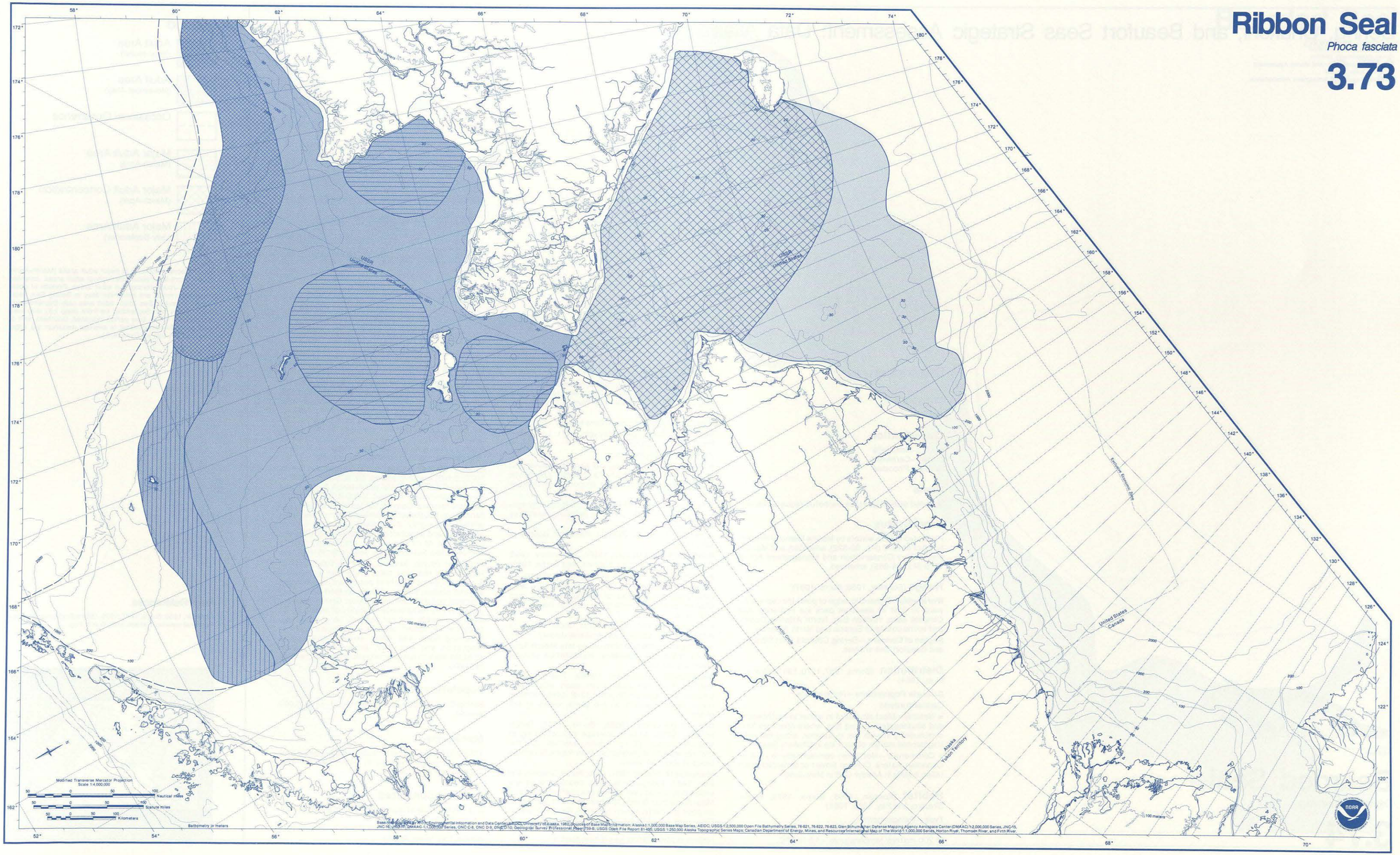
Ognev, 1931; Johnson et al., 1966; Burns, 1981a; Burns, Shapiro, and Fay, 1981; Braham et al., 1984. Personal communications from Burns; Fay.



Ribbon Seal

Phoca fasciata

3.73



Base map prepared by ADEC, Environmental Information and Data Center (EIDC), University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17, DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-455; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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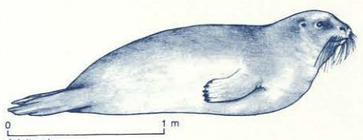


Adult male

Bearded Seal

Erignathus barbatus

3.74

Description

Category

Mammal

Classification

Class—Mammalia
Order—Carnivora
Family—Phocidae

Name

Bearded seal, *Erignathus barbatus* (square flipper)

Legal Status

Protected in USA waters by Marine Mammal Protection Act of 1972 (P.L. 92-522), amended, and Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended.

Range (Scheffer, 1958; Burns, 1967)

Worldwide—Panarctic; edge of polar ice cap southward to limit of seasonal pack ice in Bering and Okhotsk seas, Hudson Bay, North Atlantic Ocean, and arctic coasts of Eurasia and North America.
Region of Concern—Bering, Chukchi, East Siberian, and Beaufort Sea shelves.

Distribution (Burns, 1967, 1970, 1981b; Braham et al., 1984)

Discrete Populations—None known.
Concentrations

- *Natural*—Most abundant in winter in northcentral and southeastern Bering Sea, where openings form continuously in pack ice; in summer, along the wide, fragmented margin of pack ice in Chukchi Sea.
- *Commercial*—Not taken commercially in USA or Canadian waters. Current Soviet commercial catch taken mainly in Anadyr Gulf in May-June.

Habitat (Kosygin, 1966; Burns, 1970; Burns, Shapiro, and Fay, 1980, 1981)

Type—Pelagic; neritic.
Physical/Chemical—Pack ice; water depths, littoral to 200 meters; temperatures −1.8 to 5°C.

Life History

Social Behavior (Burns, 1981b)—Mainly solitary or in widely dispersed groups. On ice, several may lie on single floe, but at distance of several meters from each other.
Biological Associations—None known.
Nutrition (Burns, 1967; Kosygin, 1971; Lowry and Frost, 1981)

- *Feeding type*—Predator.
- *Food*—Principally crangonid shrimps, tanner and spider crabs, buccinid whelks, cockles, and Arctic cod. Young seals eat higher proportion of shrimps than do adults.
- *Feeding behavior*—Feed singly, in loose aggregations. Dive to bottom, probably ingesting most prey under water.
- *Feeding location*—Benthic, mainly at depths of 20-130 meters.

Reproduction (McLaren, 1958b; Tikhomirov, 1966; Burns, 1967, 1981b; Ray, Watkins, and Burns, 1969)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Mate in water; pup on heavy ice floes throughout shelf areas of Bering, Beaufort, and Chukchi seas, but primarily in central Bering Sea shelf area.
- *Behavior*—Males highly vocal under water in mating season, possibly as territorial display.
- *Biology*—Single pup born on ice late March-April; adults mate late April-May; implantation delayed about 2.5 months.

Development (McLaren, 1958b; Burns, 1967, 1981b)—Pups precocial, swim soon after birth; weaned and abandoned after 12-18 days. Females reach sexual maturity at 4-6 years, males at 6-7 years.
Growth (McLaren, 1958b; Burns, 1967; Benjaminsen, 1973)—At birth, average 130 cm, 34 kg; at weaning, about 90 kg. Adults average 220 cm, 250 kg; females slightly larger than males. Maximum lifespan about 30 years.
Movements (Burns, 1967, 1970; Burns, Shapiro, and Fay, 1980, 1981)—Unclear, as bearded seals are widely distributed over shelf areas at all times of year. Most move from Bering to Chukchi Sea in April-June, as pack ice melts; return to Bering Sea in October-December, as ice forms. Some remain in flaw zones of Beaufort and Chukchi seas during winter; some pups remain in open Bering Sea during summer.

Factors Influencing Populations

Natural (Zenkovich, 1938; Eley, 1976; Fay, Feder, and Stoker, 1977; Fay et al., 1978; Burns, 1979; Lowry and Frost, 1981)—Predators include polar bears, killer whales, and walruses. Parasitism of liver by liver flukes may be debilitating, possibly lethal, factor. Some competition with walruses for food. Death of full-term fetuses and newborn pups from trauma, probably during birth, may occur more frequently in bearded seals than in smaller seal species.
Human-related (Galster, 1971; Galster and Burns, 1972; Smith and Armstrong, 1978; Burns, 1979)—Combined annual Native subsistence harvest and Soviet commercial harvest 2,000-8,000, of which 55% are females. Commercial tanner crab and snail fisheries in southeastern Bering Sea may decrease winter food supply. At present, tissue burdens of pesticides and polychlorinated biphenyls (PCBs) are low. Levels of heavy metals are higher than in walruses, spotted and ribbon seals; effects unknown.
Potential (Burns, Shapiro, and Fay, 1980; Cowles, Hansen, and Hubbard, 1981; Braham et al., 1982)—Significant direct effects of petroleum development are improbable; indirect effects on food chain from chemical pollution are more likely. Some local displacement by disturbance in vicinity of development sites is possible, but not likely to be of great significance. Oil spilled under ice will accumulate in breathing holes and leads, possibly resulting in emigration and eye, liver, kidney damage; such stresses likely to have synergistic effects, increasing mortality.

Population Size (Burns, 1979)

Bering-Chukchi population estimated at 300,000 animals.

Management

Taking by Native people for subsistence is permitted; small commercial harvest in Soviet waters only. Otherwise, fully protected.

Persons Consulted

J. J. Burns, Alaska Department of Fish & Game, Fairbanks, Alaska.
F. H. Fay, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.

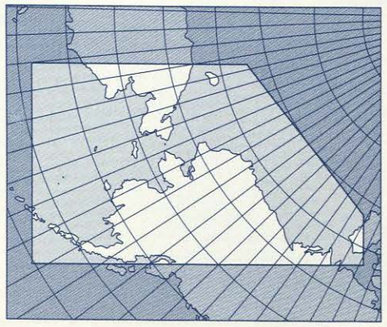
Legend

- Adult Area (Year-round)
- Adult Area (November-May)
- Occasional Occurrence
- Major Adult Area (March-April)
- Major Adult Concentration (March-April)
- Major Adult Area (July-September)

Pupping occurs primarily in major adult areas (March-April). Mating (April-May) occurs throughout adult areas. Juveniles occur year-round throughout adult areas. Periods of occasional occurrence are November-May in Bering Sea; year-round in Beaufort Sea. Major adult area (July-September) is taken in part from September ice front (map 1.8); may vary considerably within time period indicated. Southern limit of adult area (November-May) is average maximum ice edge. (See map 1.8, Sea Ice Dynamics.)

Map References

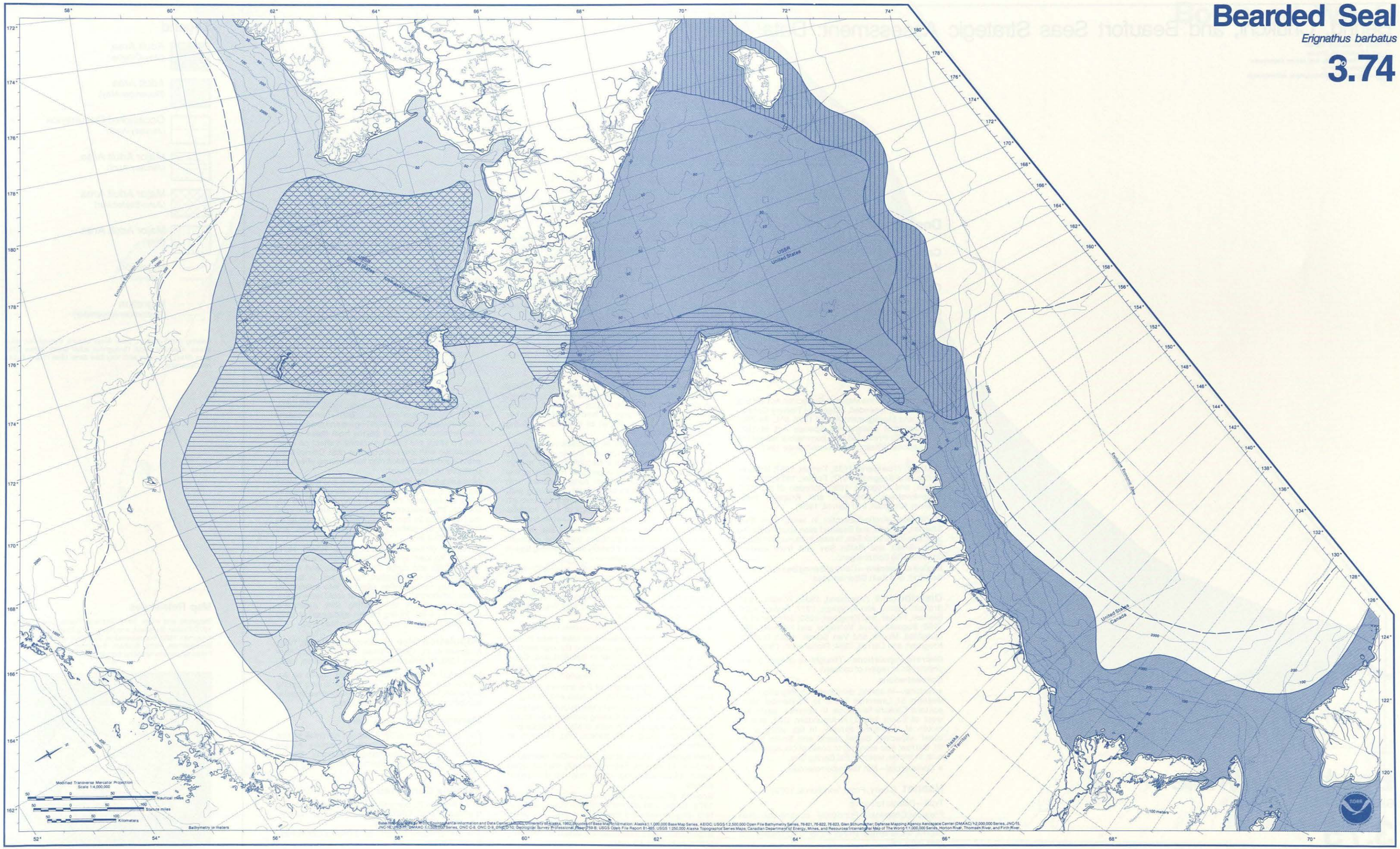
Scheffer, 1958; Burns, 1967, 1970, 1981b; Braham et al., 1984.
Personal communications from Burns; Fay.



Bearded Seal

Erignathus barbatus

3.74



Base map data sources: NOAA Environmental Information and Data Center, ABDIDU, University of Alaska, 1982; Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, ABEDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-NE, JNC-NW, DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10, Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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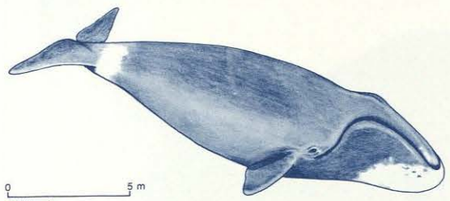


Adult male

Bowhead Whale

Balaena mysticetus

3.75

Description

Category

Mammal

Classification

Class—Mammalia
Order—Cetacea
Family—Balaenidae

Name

Bowhead whale, *Balaena mysticetus* (Greenland right whale)

Legal Status

Protected by Marine Mammal Protection Act of 1972 (P.L. 92-522), amended, Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended, and Endangered Species Act of 1973 (P.L. 83-205). Protected from commercial harvest by International Whaling Commission since 1947.

Range (Townsend, 1935; Tomilin, 1957; Braham, Fiscus, and Krogman, 1977; Fraker, 1979; Braham, Fraker, and Krogman, 1980; Johnson et al., 1980; Bogoslovskaya, Votrogov, and Krupnik, 1982; Braham, Krogman, and Carroll, 1984)

Worldwide—Arctic-subarctic; in west, from East Siberian, Chukchi, and Beaufort seas south to Bering Sea; also in Okhotsk Sea. In east, from Hudson Bay to Davis Strait and Baffin Bay and from eastern Greenland to Spitzbergen.

Region of Concern—Central Bering Sea to Chukchi, Beaufort, and East Siberian seas.

Distribution (Townsend, 1935; Tomilin, 1957; Braham, Fiscus, and Krogman, 1977; Fraker, 1979; Braham, Fraker, and Krogman, 1980; Johnson et al., 1980; Bogoslovskaya, Votrogov, and Krupnik, 1982; Ljungblad, Moore, and Van Schoik, 1983; Braham, Krogman, and Carroll, 1984; Richardson, 1985)

Discrete Populations—Thought to consist of one population in region of concern.

Concentrations

- *Natural*—In spring, principally on migration from western St. Lawrence Island to Pt. Barrow, along eastern Chukchi flaw zone. In summer, south and west of Banks Island, in Amundsen Gulf, and off mouth of Mackenzie estuary. In fall, along arctic coast, especially Barter Island and Smith Bay to Pt. Barrow; also along north coast of Chukchi Peninsula. In winter, westcentral Bering Sea.
- *Commercial*—Not taken commercially.

Habitat (Lowry, Frost, and Burns, 1979)

Type—Pelagic to neritic.

Physical/Chemical—Principally continental shelf waters to oceanic waters of less than 1,000-meter depths; water temperatures –2 to 10°C; usually in or near pack ice.

Life History

Social Behavior (Slijper and Harrison, 1979; Rugh and Cubbage, 1980; Würsig et al., 1985)—Social, usually travel in groups of 5-60. Emit sounds, presumably for social communication.

Biological Associations (Marquette, 1978; Fraker, 1979; Braham, Krogman, and Carroll, 1984)—In winter and spring, often with white whales; in summer, often followed by marine birds, especially glaucous gulls and phalaropes.

Nutrition (MacGinitie, 1955; Tomilin, 1957; Nemoto, 1959; Johnson et al., 1966; Mitchell, 1975; Lowry, Frost, and Burns, 1978; Marquette, 1978; Fraker, 1979; Slijper and Harrison, 1979; Carroll and Smithhisler, 1980; Marquette et al., 1982)

- *Feeding type*—Filter-feeder; carnivore.
- *Food*—Not well known. In autumn, appear to feed mainly on euphausiid *Thysanoessa raschii*; also, gammarid and hyperiid amphipods, copepods, mysids, and pteropods. Believed to feed mainly in summer and autumn, little or not at all in winter or during spring migration.
- *Feeding behavior*—Filter zooplankton by swimming through large patch with mouth partly open. Water and plankton pass through front of mouth; mouth then closed and organisms trapped in fine "hairs" of baleen. Also skim surface waters with mouth open and make short dives, breaching with mouth partly open and water streaming out through baleen. Feed in dispersed groups of 5-60 animals. Often create large sediment "clouds" while feeding.
- *Feeding location*—Shelf of Beaufort Sea (spring-summer), especially Amundsen Gulf, and northern Chukchi Sea (autumn). Possibly also in Bering Sea in winter, to a limited extent.

Reproduction (Scammon, 1968; Harrison, 1969; Braham and Krogman, 1977; Braham, Fiscus, and Krogman, 1977; Marquette, 1978; Everitt and Krogman, 1979; Carroll and Smithhisler, 1980; Rugh and Cubbage, 1980; Tillman, 1980; Ray, Wartzok, and Taylor, 1984; Nerini et al., 1984)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Mating believed to take place in late winter and during spring migration through eastern Chukchi Sea and in summer in Beaufort Sea. Calve before and during spring migration in Bering and Chukchi seas, possibly also in Beaufort in summer.
- *Behavior*—Observations of 2-6 animals rolling, in body contact, attributed to courtship and mating.
- *Biology*—Apparently mate March-June; gestation believed 13-14 months. Calving probably April to July or possibly August, with peak in May. Females produce single young 4-4.5 meters long, probably at 3-year intervals.

Development (Nerini et al., 1984)—Calf weaned at perhaps 13 months. Female sexually mature when about 14 meters long; male may be somewhat smaller.

Growth (Fiscus and Marquette, 1975; Marquette, 1978; Slijper and Harrison, 1979)—Young 4-5 meters long at birth; 8.5 meters at 1 year. Maximum length of adults about 18 meters; females slightly larger than males. Maximum life duration unknown; probably at least 40 years.

Movements (Sergeant and Hoek, 1974; Fraker, Sergeant, and Hoek, 1978; Fraker, 1979; Johnson et al., 1981; Marquette et al., 1982; Ljungblad, Moore, and Van Schoik, 1983; Braham, Krogman, and Carroll, 1984; Richardson, 1985)—April-June: occur mostly from vicinity of St. Lawrence Island through Bering Strait to vicinity of Pt. Hope, then along eastern Chukchi flaw zone to Pt. Barrow, and via offshore leads to Banks Island. June-September: evidently move southward to Amundsen Gulf, Mackenzie Delta, and westward to Smith Bay-Pt. Barrow area. September-November: thought to move generally westward along ice edge to Wrangel-Herald islands, then southward through Bering Strait. November-March: probably mostly in northern and westcentral Bering Sea in area of broken pack ice. (See map 1.9—Sea Ice Structure.)

Factors Influencing Populations

Natural (Lowry, Frost, and Burns, 1978; Marquette, 1978; Mitchell and Reeves, 1982)—Some deaths caused by entrapment in shifting ice and predation by killer whales. Number of deaths from these causes may be small, but have an unknown effect on small population with low reproductive rate. Competition with ringed seal for food may have limiting effect, but probably not significant.

Human-related (Fraker, Sergeant, and Hoek, 1978; Marquette, 1978; International Whaling Commission, 1984; Richardson, 1985)—Hunting by Natives believed to influence population growth; rate of removal may be close to recruitment rate. Reported to be frightened by some anthropogenic sounds and human activities.

Potential (Fraker, Sergeant, and Hoek, 1978; Cowles, Hansen, and Hubbard, 1981; Richardson, 1985)—Ship and barge traffic, seismic and drilling operations along migration routes and in feeding areas may force whales offshore into suboptimal areas. Offshore oil spill or blowout could have direct, short-term effects by irritating skin, eyes, and respiratory tract, fouling baleen, and possible long-term effects directly or indirectly on food web.

Population Size (Bockstoce and Botkin, 1982; Krogman et al., 1983; Tillman, Breiwick, and Chapman, 1983; International Whaling Commission, 1985)

Estimated in 1984 at 4,417 animals, based on extrapolations from counts at Barrow during spring migration; this is about 20-40% of estimated population before 19th-century exploitation.

Management (Tillman, 1980)

Fully protected since 1978, except for small Native harvest regulated by agreement among Alaska Eskimo Whaling Commission, National Marine Fisheries Service, and International Whaling Commission.

Persons Consulted

H. W. Braham, National Marine Mammal Laboratory, Northwest and Alaska Fisheries Center, NMFS/NOAA, Seattle, Washington.
J. J. Burns, Alaska Department of Fish & Game, Fairbanks, Alaska.

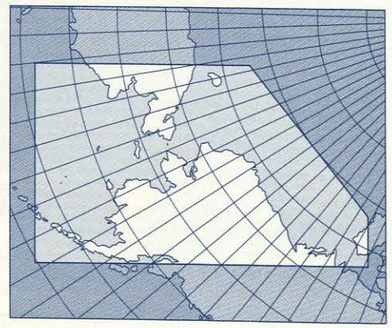
Legend

- Adult Area (May-October)
- Adult Area (November-May)
- Occasional Occurrence (January-April)
- Major Adult Area (January-April)
- Major Adult Area (June-September)
- Major Adult Area (May)
- Migration (April-June)
- Migration (September-November)

Calving (April-August, peak May) occurs throughout adult areas. Juveniles occur throughout adult areas. Major adult area (May) coincides with May flaw zone. (See map 1.8, Sea Ice Dynamics.)

Map References

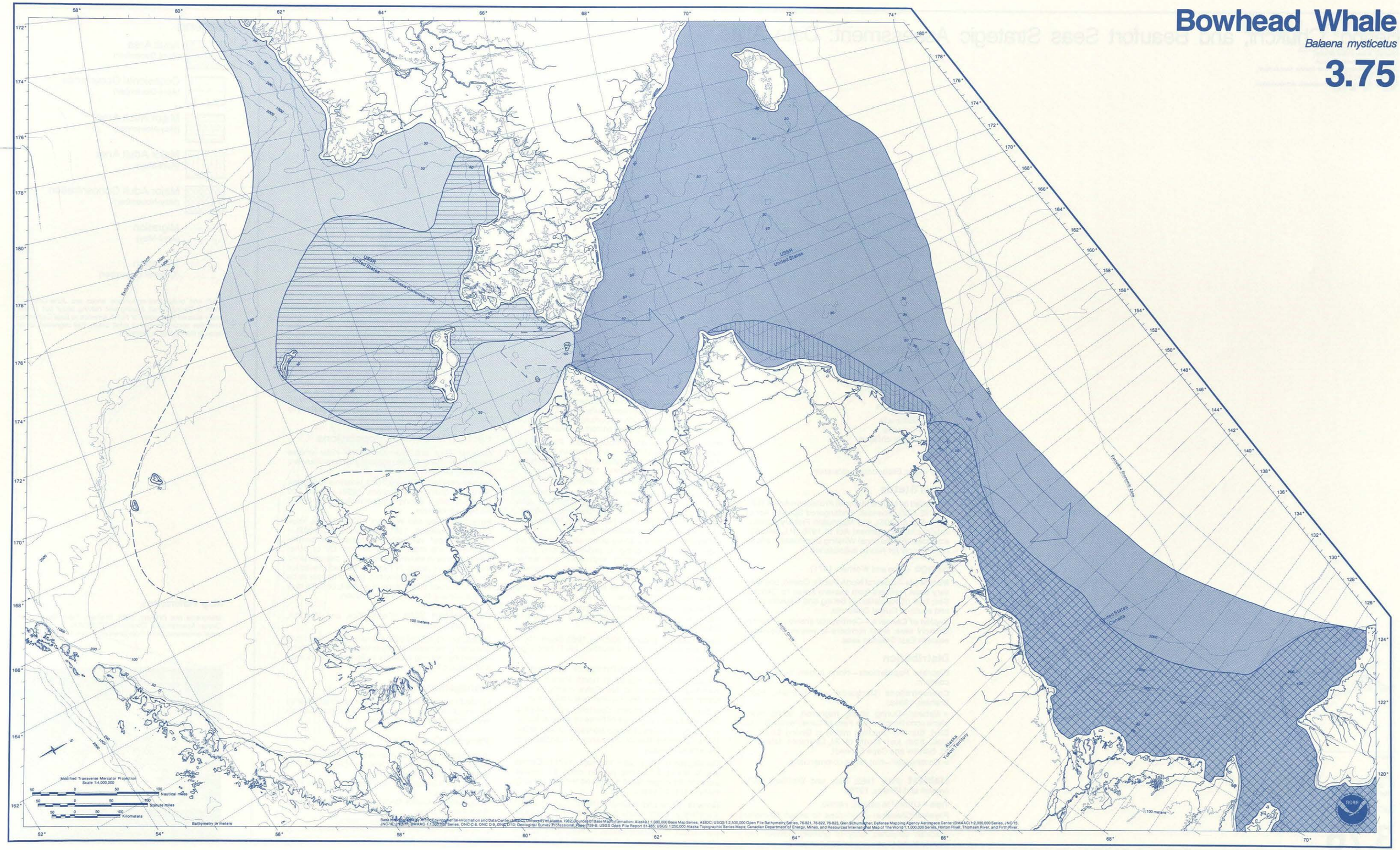
Sergeant and Hoek, 1974; Braham, Fiscus, and Krogman, 1977; Fraker, Sergeant, and Hoek, 1978; Braham, Fraker, and Krogman, 1980; Bogoslovskaya, Votrogov, and Krupnik, 1982; Brueggeman, 1982; Braham, Krogman, and Carroll, 1984. Personal communications from Braham; Burns.



Bowhead Whale

Balaena mysticetus

3.75



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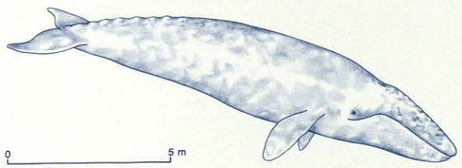

Gray Whale

Eschrichtius robustus

3.76

Description

Category

Mammal

Classification

Class—Mammalia
Order—Cetacea
Family—Eschrichtiidae

Name

Gray whale, *Eschrichtius robustus*

Legal Status

Protected by Marine Mammal Protection Act of 1972 (P.L. 92-522), amended, Endangered Species Act of 1973 (P.L. 83-205), and Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended. International Whaling Commission allows harvest only for Native subsistence.

Range (Rice and Wolman, 1971)

Worldwide—Coastal North Pacific Ocean; possibly, very small numbers from eastern Korea to Okhotsk Sea; bulk of population in Bering and Chukchi seas, and south to Gulf of California.

Region of Concern—Continental shelves of Bering, Chukchi seas; small numbers to western Beaufort, eastern East Siberian seas.

Distribution

Discrete Populations—None known in region of concern.

Concentrations (Marquette and Braham, 1982; Braham, 1984a)

- *Natural*—During spring migration, along nearshore zone from Unimak Pass to Cape Peirce (Bristol Bay). Summer (feeding) mainly in Bering Strait region, from just south of St. Lawrence Island to Pt. Barrow and Cape Schmidt.
- *Commercial*—Not taken commercially.

Habitat (Pike, 1962; Rice and Wolman, 1971; Ivashin and Mineev, 1978)

Type—Littoral to pelagic, neritic.

Physical/Chemical—Surf zone to about 60-meter depths, including major bays and lagoons, not brackish estuaries. Silty to gravelly bottom. Not usually found in sea ice, except near edge.

Life History

Social Behavior (Rice and Wolman, 1971)—Travel and feed singly, in cow-calf pairs, and in loosely aggregated groups of up to several thousand.

Biological Associations (Wilke and Fiscus, 1961; Harrison, 1979)—Sometimes followed by northern sea lions; also by phalaropes, gulls, terns, kittiwakes, and shearwaters, which opportunistically feed on organisms brought up from bottom by whales.

Nutrition (Wilke and Fiscus, 1961; Pike, 1962; Kasuya and Rice, 1970; Rice and Wolman, 1971; Ray and Schevill, 1974; Wellington and Anderson, 1978; Nerini and Oliver, 1983; Nerini, 1984)

- *Feeding type*—Filter-feeder; carnivore.
- *Food*—Principally benthic, infaunal, gammarid amphipods, especially *Ampelisca macrocephala*; also other small crustaceans, polychaetes, mollusks, cumaceans, ascidians, and holothurians. Ingest large amounts of sediment incidentally.
- *Feeding behavior*—Move slowly along bottom, on side, apparently sucking in sediments and small organisms, then expelling sediments and water through baleen. Organisms entrapped by baleen, then swallowed. Also feed by "surface skimming" with mouth partly open and "surface gulping" by rising open-mouthed from below.
- *Feeding location*—Benthic, nearshore to pelagic, mainly from St. Lawrence Island to Pt. Barrow and Cape Schmidt.

Reproduction (Houck, 1962; Fay, 1963; Sauer, 1963; Rice and Wolman, 1971; Zimushko, 1971; Baldridge, 1974)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Mate mainly in North Pacific during southward migration in fall. Calve mainly in Baja California in winter; also on southward migration.
- *Behavior*—Little known. Courtship and courtship play often occur in groups of three or more animals.
- *Biology*—Females ovulate biennially or less often. Mate November-March; pregnancy 13 months; birth December-January.

Development (Rice and Wolman, 1971)—Calves suckle about 7 months, remain close to mother 2-3 months longer. Most males and females sexually mature at 6-10 years.

Growth (Rice and Wolman, 1971)—Calves about 4 meters at birth; nearly double in length first year. Attain maximum size at 20-30 years; average adult male about 13 meters, female 14 meters. Maximum life duration unknown, probably about 70 years.

Movements (Marquette and Braham, 1982; Braham, 1984a)—Migrate from Baja California to Bering Sea in spring, through Unimak Pass, primarily in April-June. Most move alongshore, into and out of Bristol Bay, then north to St. Lawrence Island, Anadyr Gulf, Bering Strait, and Chukchi Sea. Move southward through eastern Bering Sea, directly to Unimak Pass in October-December, then coastally to Baja California.

Factors Influencing Populations

Natural (Rice and Wolman, 1971)—Killer whales take mainly young. Other regulating factors unknown; food may be limiting.

Human-related (Gilmore, 1978; Ivashin and Mineev, 1978; Marquette and Braham, 1982)—Up to 200 taken annually in Bering-Chukchi region, all for USSR Native subsistence.

Potential (Rice and Wolman, 1971; Cowles, Hansen, and Hubbard, 1981; Braham et al., 1982)—Probably most vulnerable to impact on benthic organisms, the main source of food. Oil or other contaminants in sediments may kill or displace prey, foul baleen, or result in hydrocarbon accumulation through ingestion of sediments. Do not appear to be much disturbed by shipping or aircraft, but this may vary according to season and location.

Population Size (Reilly, Rice, and Wolman, 1983; Reilly, 1984)

Estimated 15,000-16,000 animals. Population has apparently increased slowly since 1960s and may be nearing its carrying capacity in Bering-Chukchi seas and eastern Pacific.

Management

Limited harvest permitted by International Whaling Commission in Bering-Chukchi for Native subsistence; otherwise fully protected.

Persons Consulted

H. W. Braham, National Marine Mammal Laboratory, Northwest and Alaska Fisheries Center, NMFS/NOAA, Seattle, Washington.
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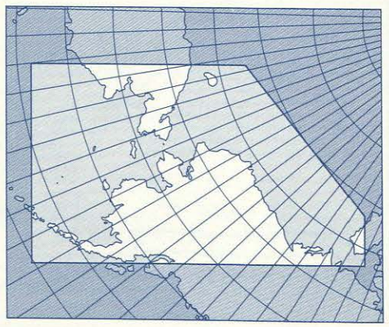
Legend

- Adult Area (April-December)
- Occasional Occurrence (April-December)
- Major Adult Area (May-November)
- Major Adult Area (April-May)
- Major Adult Concentration (May-November)
- Migration (April-May)
- Migration (October-December)

Adult and occasional occurence areas are June-October, north of Bering Strait. Mating and calving occur out of the study area off west coast of North America to Baja California. Juveniles occur throughout adult areas. Fall migration route through Bering Sea is unknown.

Map References

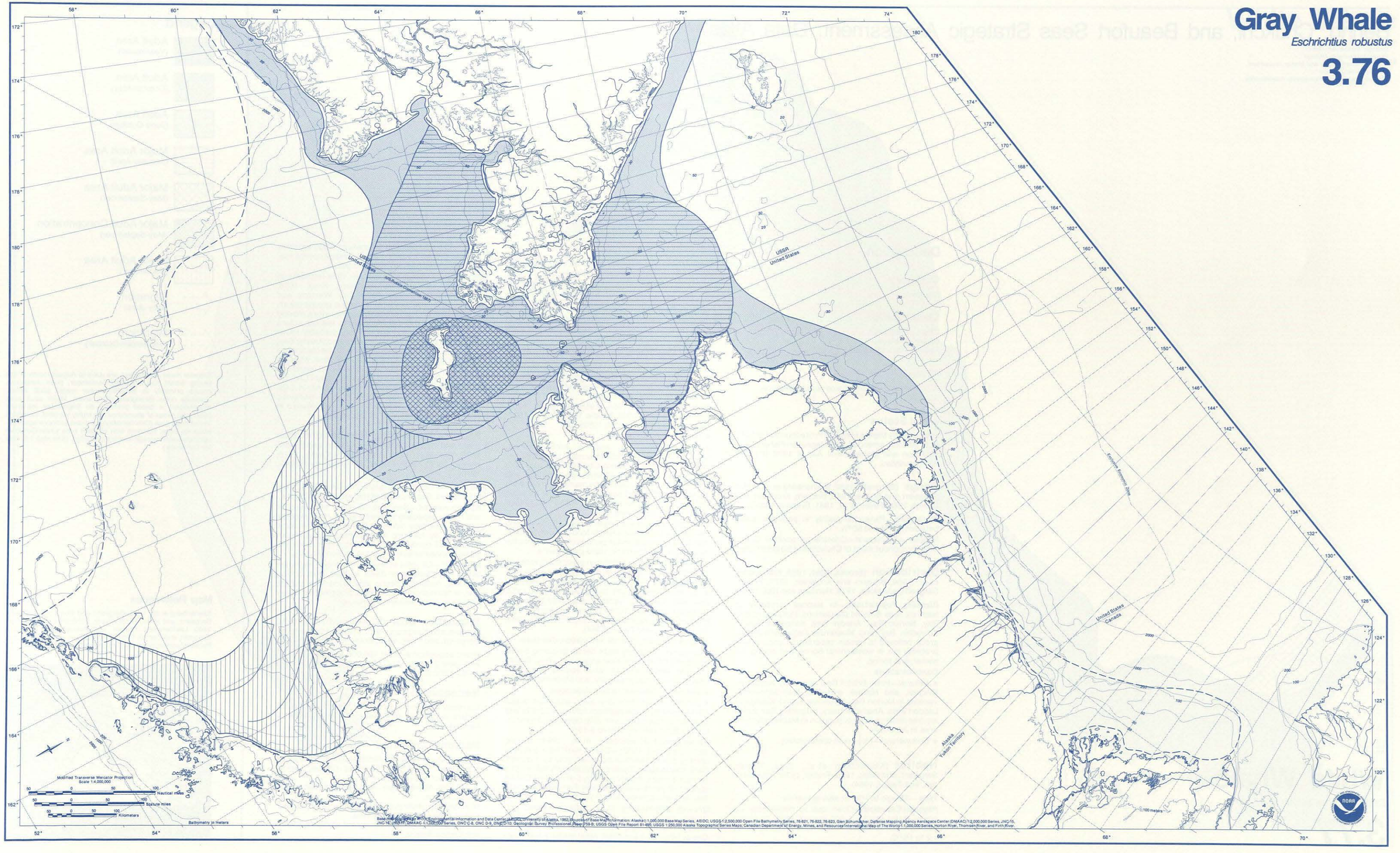
Marquette and Braham, 1982; Braham, 1984; Rugh, 1984; Ocean Assessments Division (NOS/NOAA), in press. Personal communications from Braham; Burns; Fay; Ray.



Gray Whale

Eschrichtius robustus

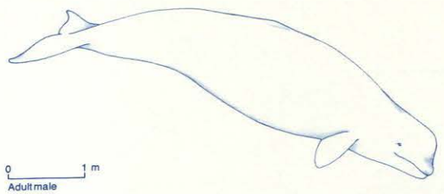
3.76



Base map compiled by ARCTIC Environmental Information and Data Center (AEIDC), University of Alaska, 1982. Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-455; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
National Oceanic and Atmospheric Administration



White Whale

Delphinapterus leucas

3.77

Description

Category

Mammal

Classification

Class—Mammalia
Order—Cetacea
Family—Monodontidae

Name

White whale, *Delphinapterus leucas* (belukha, beluga)

Legal Status

Protected by Marine Mammal Protection Act of 1972 (P.L. 92-522), amended, and Magnuson Fishery Conservation and Management Act of 1976 (P.L. 94-265), amended.

Range (Sergeant, 1962; Kleinenberg et al., 1964; Sergeant and Brodie, 1975; Braham, Krogman, and Carroll, 1984; Finley et al., 1981; Braham, 1984b)

Worldwide—Panarctic, mainly in pack ice areas between 56°N and 80°N.

Region of Concern—Continental shelf of Bering Sea; throughout most of Chukchi and Beaufort seas.

Distribution (Brooks, 1954, 1955; Kleinenberg et al., 1964; Braham and Krogman, 1977; Fraker, Sergeant, and Hoek, 1978; Harrison and Hall, 1978)

Discrete Populations—In summer, probably at least six semi-isolated populations, including Bristol Bay, Norton Bay, Anadyr Bay, Kotzebue Sound, Kolyuchin Bay, and Mackenzie Delta. Bristol Bay group believed to remain separate all year; others probably mix in westcentral Bering Sea during fall, winter, and spring.

Concentrations

- *Natural*—Inner Bristol Bay, especially Nushagak, Kvichak, and Naknek estuaries May-September; variable in Norton Bay, Kotzebue Sound, Kasegaluk Lagoon area, Anadyr estuary, Kolyuchin Bay during ice-free months; large population in Mackenzie Delta area in June-July.
- *Commercial*—Not taken commercially.

Habitat (Kleinenberg et al., 1964; Fraker, Sergeant, and Hoek, 1978; Fraker, 1979; Ray, Wartzok, and Taylor, 1984)

Type—Pelagic to littoral; also estuarine.

Physical/Chemical—Open sea to nine-tenths ice cover; water depths 1-500 meters; clear to turbid; salinity fresh to marine; water temperatures about −2 to 18°C.

Life History

Social Behavior (Kleinenberg et al., 1964; Sergeant and Hoek, 1974; Sergeant and Brodie, 1975; Finley et al., 1981; Ray, Wartzok, and Taylor, 1984; Braham, Krogman, and Carroll, 1984)—Gregarious. Usually travel in groups of 2-10 or more, often segregated by age, sex. Groups may coalesce; over 1,000 individuals may aggregate during migrations. Very vocal; produce wide variety of sounds, presumably for communication and echolocation.

Biological Associations (Sergeant and Hoek, 1974; Fraker, 1979; Johnson, 1979; Braham, Krogman, and Carroll, 1984)—Probably winter and migrate in spring in same habitat as bowhead whales. Often seen with marine birds and phocid seals; probably feed on same resources.

Nutrition (Brooks, 1954, 1955; Sergeant, 1962; Kleinenberg et al., 1964; Brodie, 1971; Fraker, 1977; Seaman, Lowry, and Frost, 1982)

- *Feeding type*—Predator.
- *Food*—Saffron cod, sculpins, herring, smelt, capelin, salmon, and Arctic char make up bulk of diet in spring-summer in Bering-Chukchi seas; also take octopus, squids, crabs, shrimps, clams, snails, and polychaetes. Arctic cod may be mainstay in northern Chukchi and Beaufort seas. Juveniles feed on same prey as adults, but smaller. Adult males tend to take larger prey than females do.
- *Feeding behavior*—Swallow prey whole. Sound may be used to locate, identify food in murky waters. In calving areas, alternate periods of relative inactivity with periods of erratic, rapid movements.
- *Feeding location*—Pelagic, in association with sea ice; also coastal, estuarine, and riverine waters.

Reproduction (Sergeant, 1962, 1973; Kleinenberg et al., 1964; Brodie, 1971; Sergeant and Hoek, 1974; Hay and McClung, 1976; Fraker, 1977; Fraker, Sergeant, and Hoek, 1978; Seaman and Burns, 1981; Braham, 1984b; Braham, Krogman, and Carroll, 1984; Ray, Wartzok, and Taylor, 1984)

- *Mode*—Sexual; internal fertilization; dioecious.
- *Location*—Probably mate before or during spring migration; calve in and near estuaries in inner Bristol Bay and Norton and Kotzebue sounds, Kasegaluk Lagoon area, Anadyr estuary, and Mackenzie Delta.
- *Behavior*—Believed to be polygamous.
- *Biology*—Mate February-June; gestation about 13-14 months. Single calf born from late April to late summer, but primarily June-July; calve at 2-3 year intervals. Birth rate estimated 8-13%.

Development (Kleinenberg et al., 1964; Brodie, 1971; Sergeant, 1973)—Calf at birth pale gray, becoming darker bluish or brownish gray by 1 month. Dark gray to about 2 years, progressively lighter gray for next 3 years, mostly white by 5 or 6 years. Calves suckle 1-2 years; wean gradually. Females may mate first at 5 years, males at 8-9 years.

Growth (Kleinenberg et al., 1964; Sergeant and Brodie, 1969; Fraker, Sergeant, and Hoek, 1978; Braham, 1984b; Ray, Wartzok, and Taylor, 1984)—Calf at birth 1.5-1.8 meters. Adult males 3.4-4.6 meters, 1,500 kg, maximum 6.7 meters, 2,300 kg; adult females 3.1-4.0 meters, 1,350 kg, maximum 6.4 meters. Maximum lifespan about 30 years.

Movements (Sergeant and Hoek, 1974; Braham and Krogman, 1977; Fraker, Sergeant, Hoek, 1978; Fraker, 1979; Johnson, 1979; Ray, Wartzok, and Taylor, 1984)—Movements of various groups uncertain. Bristol Bay herd probably nonmigratory, moving inshore and offshore in response to sea ice; others winter in westcentral Bering Sea; probably move northward March-June to Norton Sound, Anadyr Bay, Bering Strait, and Kotzebue Sound. Some continue to Beaufort Sea via eastern Chukchi flaw zone to Pt. Barrow and via offshore leads to Banks Island and Amundsen Gulf. Others may follow southern Chukchi flaw to Kolyuchin Bay and Wrangel Island. In September, Beaufort herds appear to move westward along ice edge to Chukchi Sea, then southward in open water to Bering Sea by December.

Factors Influencing Populations (Sergeant and Brodie, 1969, 1975; Addison and Brodie, 1973; Freeman, 1973; Hay and McClung, 1976; Fraker, 1977, 1979; Fraker, Sergeant, and Hoek, 1978)

Natural—Principal predators include killer whales, polar bears. Occasionally entrapped by shifting ice.

Human-related—Sensitive to noise from aircraft and boats, especially in calving areas. Hydroelectric development may have eliminated calving in some estuaries by lowering water temperatures. Accumulate DDT residues and mercury; effects unknown. Some accidental entrapment in salmon gill nets.

Potential—Oil spills in feeding areas and migration lanes may displace or divert animals from critical habitats, have depressing effects on food supply, and/or cause direct toxic effects. Shipping traffic may impede or divert whale movements.

Population Size (Sergeant and Hoek, 1974; Braham and Krogman, 1977; Fraker, 1977; Fraker, Sergeant, and Hoek, 1978; Braham, 1984b)

World population at least 100,000 animals. Beaufort and Bering seas about 3,500-7,000; Bristol Bay 1,000-3,000 animals.

Management

Currently protected in USA, Canada, and USSR waters, except for unregulated Native subsistence harvests.

Persons Consulted

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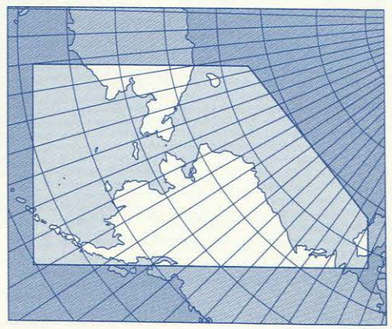
Legend

- Adult Area (Year-round)
- Adult Area (October-May)
- Adult Area (June-October)
- Major Adult Area (January-April)
- Major Adult Area (May-September)
- Major Adult Concentration (May-September)
- Major Adult Area (September)
- Migration (May-June)
- Migration (September-October)

Summer major adult areas are June to August, north of the Bering Strait. Calving (April-September, peak June-July) occurs primarily in May-September major adult areas. Juveniles occur throughout adult areas. Major adult area (September) is based primarily on September ice front (map 1.8). Areas of abundance are highly variable. Southern limit of adult area (October-May) coincides with average maximum ice edge; northern limit of adult area (June-October) coincides with average minimum ice edge. (See map 1.8, Sea Ice Dynamics.)

Map References

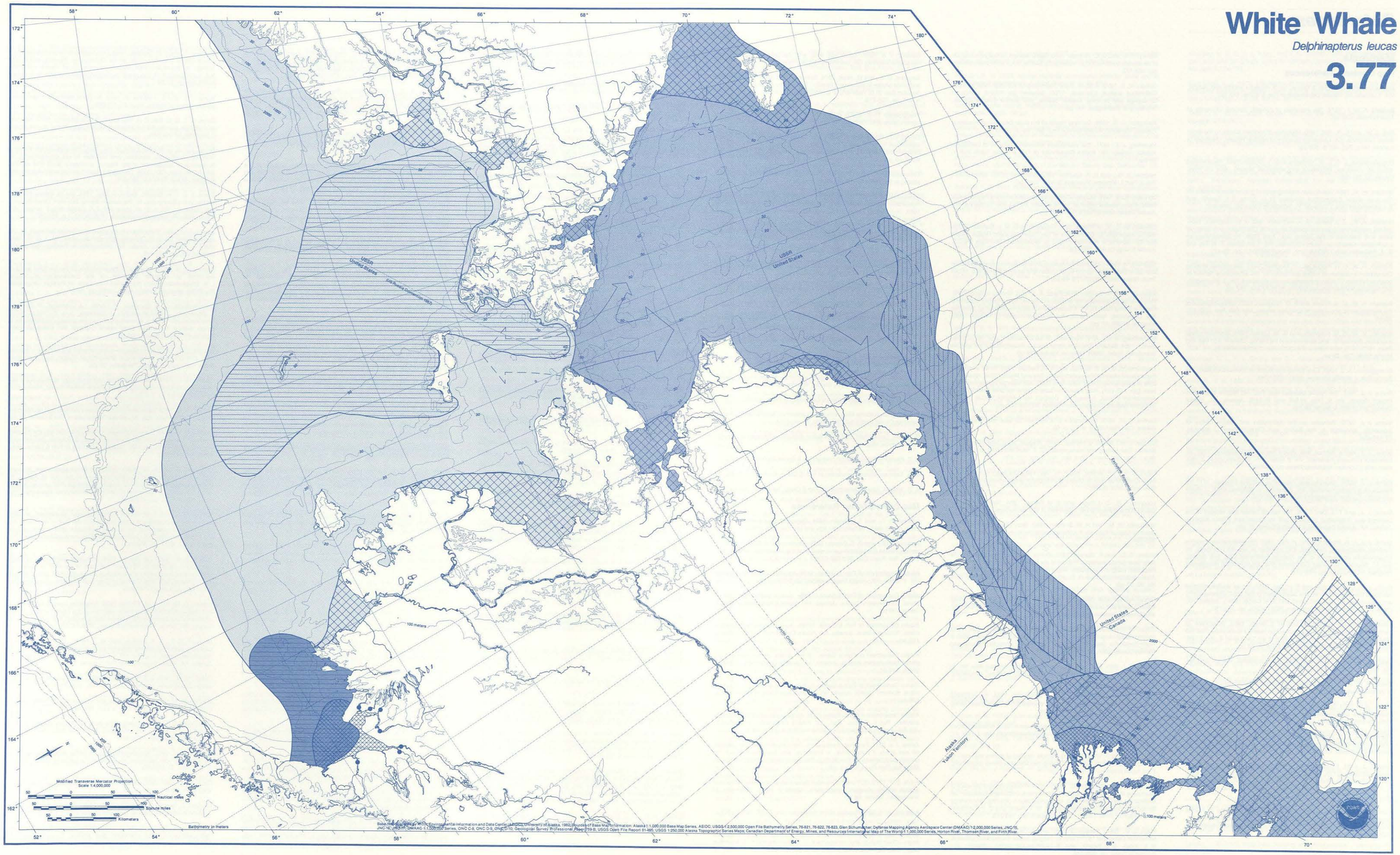
Kleinenberg et al., 1964; Sergeant and Hoek, 1974; Fraker, Sergeant, and Hoek, 1978; Fraker, 1979; Ray and Wartzok, 1980; Leatherwood, Bowles, and Reeves, 1983; Braham, Krogman, and Carroll, 1984; Ray, Wartzok, and Taylor, 1984. Personal communicatons from Braham; Burns; Seaman.



White Whale

Delphinapterus leucas

3.77



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Economic Activity

Introduction

The large size of the Bering, Chukchi, and Beaufort seas region, its sparse population, and its predominantly Native population in small villages and communities contrast dramatically with most other coastal areas of the USA. This region is remote and exposed to a severe climate. It is rich in resources only in terms of the high biological productivity of its seas, its hydrocarbon and coal reserves, and its strategic location for military operations. Its harsh environment makes the Bering, Chukchi, and Beaufort seas region an unfavorable place for most kinds of economic activity. For example, agricultural and manufacturing activities are not part of the coastal regional economy. Consequently, most of the coastal and oceanic areas of the region remain relatively free of the direct effects of humans although some economic activities do cause local environmental quality problems.

The twelve maps of this section provide information on the major economic activities of the region that affect environmental quality. No attempt has been made to map all activities. Three criteria were used to select themes: 1) the importance of an activity as a user of land and other resources; 2) the importance of an activity to local and regional economies; and 3) the importance of an activity as either a source of pollutants or modifier of the natural environment.

The distribution of both Native and non-Native Alaskans is presented on maps 4.1 and 4.2. The next three maps (Maps 4.3-4.5) portray Native subsistence hunting, fishing, and gathering activities. These maps are the first to synthesize information on subsistence activities for the entire region and are based on the results of intensive research conducted since 1979 by the Alaska Department of Fish and Game. They incorporate information from detailed field studies of the subsistence activities of over 35,000 people in 112 Native communities within the coastal areas of the Bering, Chukchi, and Beaufort seas.

Six other maps describe major economic activities: oil and gas production (Map 4.6); other mineral deposits and mining activities (Maps 4.7-4.9); and foreign and domestic fishing (Maps 4.10, 4.11). The last map (Map 4.12) shows transportation services and infrastructure.

Understanding the distribution in time and space of economic activities that use land or other resources, or that generate pollutants or modify habitats is critical to the identification and evaluation of management strategies. When information from the maps in this section is combined with that from maps in other sections, relationships among region-wide patterns of resource use, consumption, production, and living marine resources and their habitats can be identified.

Population

Largely because of the growth of the oil extraction industry, Alaska's population (Maps 4.1, 4.2) grew from 402,000 people in 1980 to 539,000 in 1985, nearly a 34 percent increase. Well over half of Alaska's population is located in Anchorage, Fairbanks, and Juneau. The rest is spread across the State in almost 400 small communities that average less than 500 people each. Many have fewer than 100 people.

In 1980, the total population of Alaska Natives was about 65,000 people. About 10,000 resided in Anchorage and 5,000 in Fairbanks. More than half of Alaska's Native population resided in the census areas of Bethel, Dillingham, Kobuk, Nome, North Slope, Wade Hampton, and Yukon-Koyukuk. In 1980, Barrow, a center of Native activity for centuries and one of the largest communities along the arctic coast, had a Native population of only 1,700 people and a non-Native population of about 500.

Subsistence Activities

Subsistence activities (Maps 4.3-4.5) remain important in most parts of the region. Subsistence is an economic system with producers, processors, and networks of distribution and exchange. It is an integral part of the culture of Native Alaskans and the economic base of Native villages. It involves nonmarket systems of local production and exchange based on the exploitation of renewable natural resources, including marine mammals, fish, invertebrates, large and small game, birds, eggs, and vegetation.

The harvest of living resources in arctic coastal communities is high, averaging about 670 pounds per person, over twice the mean per capita consumption of meat, fish, and poultry in the USA. Harvest levels range from 200 pounds per person in Naknek in Bristol Bay to over 1,300 pounds per person in Gambell on St. Lawrence Island. Subsistence activities include hunting, fishing, gathering and processing food, manufacturing tools and cultural artifacts, making clothing, bartering, and sharing.

Subsistence harvests vary by season with the distribution of animals. For example, from late spring to early fall, Bristol Bay and the Yukon-Kuskokwim Delta support some of the largest salmon populations in the world. Subsistence catch of salmon is a critical component of the subsistence economy of this area. However, along the coasts of the Chukchi and Beaufort seas, fish are much less important to Native subsistence.

Marine mammals are taken along the central and northern coasts of the region. Hunting is determined by the seasonal movements of these species. Walrus (Map 3.69) harvest occurs principally during the spring ice retreat when the animals are associated with pack ice. Similarly, hunting of most seals occurs during the spring when some species, such as the ringed seal (Map 3.72), are either on shorefast ice or on moving pack ice. The taking of northern fur seals (Map 3.67) from rookeries of the Pribilof Islands during the summer mating and pupping season is now considered a subsistence use, but started largely as a commercial activity in the mid-1700s.

Native people have used the living resources of the Arctic for thousands of years and strongly believe their interests in subsistence activities can best be managed through their own local governments. Natives are now participating increasingly in State, Federal, and international wildlife management regimes through new institutions like the Alaska Eskimo Whaling Commission, the International Porcupine Caribou Commission, and the Eskimo Walrus Commission.

Oil and Gas Activities

Unlike the diverse economies of many other states, the economy of Alaska is dominated by a single activity—the extraction of hydrocarbons (Map 4.6). The recent dramatic increases in Alaska's labor force, population, and personal income can be traced predominantly to development of the Prudhoe Bay oil field. Either directly or indirectly, oil generates about one-half of the employment and personal income of Alaska. For 1985, only 4 percent of the total state work force—about 8,800 workers—was directly employed in the oil extraction industry.

Alaska did not become a major oil-producing state until 1977, but by 1979, it had replaced Louisiana as the second largest, following only Texas. By 1981, direct State revenues from petroleum reached almost $4 billion or about $10,000 for each Alaskan resident. Alaska remains dependent on oil revenues to operate its State and local governments; about 84 percent of the State's revenues now comes from oil.

Costs of oil and gas development in the Arctic are enormous. While a 50 million-barrel field in the Gulf of Mexico would cost $100-200 million to develop, development of a comparable commercial field in the Arctic would cost about $6 billion in the Beaufort Sea and more than $10 billion in the Navarin Basin. In 1984, the average unit cost of a well in Alaska was $2.8 million compared to about $750,000 in Louisiana and about $320,000 in Texas. To be viable commercially, oil fields in the Arctic have to contain at least 1-2 billion barrels of oil.

Almost all of Alaska's oil production comes from the Prudhoe Bay field, an area of only about 200 square miles on the Beaufort Sea coast. In recent years, exploration for oil has moved offshore into the Bering, Chukchi, and Beaufort seas, presenting new challenges to the industry and increasing the risk to the living resources of these areas (see maps in Section 3). In general, the oil industry has used state-of-the-art technologies and operating procedures that have had minimum adverse effects on the Arctic environment.

However, a major controversy is now underway over whether to permit exploration in part of the Arctic National Wildlife Refuge (ANWR), the seasonal home of the Porcupine caribou herd (Map 3.64) and millions of waterfowl and shorebirds. The mean estimate of ANWR's conditional recoverable resources is 3.2 billion barrels with a 1-in-5 chance of finding commercial quantities of oil. The ANWR is one of the few remaining known prospects for significant discoveries of oil and gas in the USA. Proximity to the Trans-Alaska Pipeline also makes the ANWR attractive to industry.

Whether exploration in the ANWR will remain a controversy is uncertain, given the collapse of the world oil market in 1986. Exploration for oil throughout the Arctic has almost stopped. The industry has shut down its operations in the Canadian Beaufort Sea and reduced its offshore exploration budgets in Alaska. Boom and bust cycles are not new to the Alaskan economy; long before the current oil-bust economy, Alaska has experienced similar on-again, off-again resource exploitation of furs, gold, copper, and fish. Future predictable shortages and continued reliance on foreign supplies will restimulate arctic oil and gas exploration and development.

Other Resource Extraction Activities

Alaska's diverse mineral resources (Maps 4.7-4.9) include sand, gravel, coal, and strategic minerals such as platinum and tungsten. Half the Nation's estimated coal reserves and almost all of its platinum reserves are in Alaska. Its mineral wealth has created individual mining booms in the past. For example, gold accounts for approximately 90 percent of the historical mineral production in the Arctic and continues to be the principal metal produced by Alaska.

Most major mineral deposits are found in the interior. Notable exceptions include uranium, tin, and tungsten deposits on the Seward Peninsula, and platinum and mercury around Bristol Bay. Most sand and gravel mining occurs on the North Slope for use in road construction near the Prudhoe Bay complex. Over 700,000 cubic yards of gravel were used to construct the Shell Oil Company's artificial island, Seal Island, in the Beaufort Sea. Since arctic coastlines are unstable and subject to erosion, the effects of removing gravel for construction can have significant local, environmental effects. Gravel causeways built to offshore islands can be even more damaging if they interfere with along-shore migrations of fishes and mammals, as well as patterns of water circulation.

The most promising non-hydrocarbon mineral deposits in the Arctic are the world-class zinc/lead/silver deposits at Red Dog and Lik in the western Brooks Range, about 50 miles from the Chukchi Sea. The high cost of mining in the region, limited water supplies for use in extraction, poor transportation infrastructure, concerns about environmental effects, and land claims of Native peoples have limited mining to a few small operations. Annual revenues from all of these operations are considerably less than the revenues from a few weeks of oil production. Current market prices, remoteness from markets, and size and grades of deposits all combine to make large-scale mineral development projects in this area unlikely in the near future.

Commercial Fishing

Some of the world's richest fishing grounds are found off the coast of Alaska, especially in the Bering Sea (Maps 4.10, 4.11). Alaska leads all states in value of catch and is second only to Louisiana in weight of catch. Alaska also accounts for 92 percent of total foreign catch in the Exclusive Economic Zone of the USA. Walleye pollock (Map 3.32) alone comprised 73 percent of the total foreign catch in 1985. Japan takes almost 70 percent of the foreign catch; Korea about 19 percent.

The largest sockeye (red) salmon fishery (Map 3.25) in the world is in Bristol Bay. In 1985, Alaska landings of over 650 million pounds of salmon, valued at almost $370 million, accounted for 90 percent of the total salmon catch of the USA. For the same year, landings of king crab (Maps 3.12-3.14) in the Bering Sea and Aleutian Islands produced only about 15 million pounds, valued at about $39 million. Landings of king crab were the lowest since 1958, apparently the result of natural habitat variability, disease, and overfishing. Landings of snow (Tanner) crabs (Maps 3.15-3.16) taken in the Bering Sea and Aleutian Islands totalled about 40 million pounds, valued at $24 million. Boats formerly used to catch crabs by means of traps are being converted to trawlers for demersal fishing.

The bottomfish industry in the Bering Sea includes species such as Pacific cod (Map 3.31), flounders (Maps 3.33-3.40), walleye pollock (Map 3.32), and Pacific ocean perch. U.S. landings for 1985 were about 390 million pounds, valued at almost $71 million—an increase of 24 percent in quantity and 8 percent in value compared with 1984. Landings of pollock alone increased 287 percent, to almost 93 million pounds, significantly higher than the past 5-year average. Considerable product development for pollock, including surimi and formed product from fillets, also contributed to the increased demand for pollock. Alaska landings of Pacific cod increased 31 percent, to 105 million pounds, up from about 80 million pounds in 1984. Within the past 15 months, the wholesale price of most cod and pollock products has doubled.

Most fish caught in Alaskan waters are processed for export. At one time, over 80 percent of the total catch was canned locally. However, increasing demand for fresh fish and shellfish, particularly salmon, crab, shrimp, and halibut, has reversed this trend. Now approximately 75 percent of the catch is fresh frozen.

Commercial fishing is Alaska's largest employer in the extractive industries, with an estimated 15,000 people directly dependent on commercial fishing for their income. Recent developments in the Bering Sea, Aleutian Islands, and the Gulf of Alaska are changing the nature of fishing operations and the industry, including the previous dominance of Japanese and Korean fishing fleets. The Magnuson Fishery Conservation and Management Act of 1976, which legislated the eventual elimination of foreign fishing in the area, is responsible for this change. Already, in 1986, foreign fishing for the area has dropped to half the 1985 level, and foreign allocations for 1987 are down over one half million metric tons from 1986. Such restrictions have stimulated joint-venture fishing operations in which foreign vessels process fish from American ships. About 130 domestic vessels currently participate in such joint-venture processing, and approximately 60 percent of the 1987 catch is expected to be sold to foreign ships that process at sea. In addition to a rise in joint-venture fishing operations, allocations to domestic processors are double previous years. In 1985, five new catcher-processors and the first large mothership processor entered the American trawl fleet.

Transportation

Transportation in the Arctic is strongly influenced by the remoteness of the region, as well as by its geography and harsh climate. Only a limited network of land, sea, and air routes exists to service the region. Transportation along the arctic coast is by planes and boats in the summer and by planes and snow machines in winter. Dog teams, once a major means of moving goods and people locally, have been largely replaced by snow machines. Scheduled airlines, supplemented by charter planes, air taxis, and thousands of private aircraft, provide access to most parts of the region.

Marine transportation in the Arctic is more problematic. Ships can navigate unescorted by icebreakers along the Beaufort Sea coast for only a few months of the year. Once a year, a fleet of tug-pulled barges brings supplies and equipment to coastal villages and to the oil production complex at Prudhoe Bay. The lack of terminal facilities and deepwater ports limits the use of large marine vessels. Extension of the shipping season is possible by means of expanded icebreaker service, combined with improved weather and ice forecasting, search and rescue capabilities, and salvage and cleanup facilities. Presently, only the Soviet Union has the capability for extended arctic marine transportation through support of its 16-vessel icebreaking fleet.

Inland waterways provide some access to interior regions of the Arctic during both summer and winter seasons. In summer, rivers such as the Yukon and Kuskokwim are important routes for barges and shallow-draft vessels. These same rivers, when frozen (which is for much of the year), become highways for vehicular traffic. In the Canadian Arctic, the Mackenzie River is an important inland waterway between the port of Tuktoyaktuk and the Canadian heartland.

Land transportation is little developed and almost nonexistent in most areas, especially along the North Slope. In Alaska only one railroad, the Anchorage-Fairbanks Line, links the most northern part of the region with other population centers. Only the North Slope Haul Road connects Prudhoe Bay to the Yukon River—a distance of 350 miles.

The Future

Given the current state of world and domestic markets for hydrocarbons and nonfuel minerals, expectations for large-scale developments to extract these resources from the Arctic have now diminished. High costs of production and general economic conditions will limit large investments to develop most of these untapped resources for the near future. Nevertheless, managing existing resources and planning for future development of resources will require unprecedented collaboration among the Federal Government, the State of Alaska and its people, and the private sector.

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4.10 Domestic Commercial Fishing
4.11 Foreign Commercial Fishing
4.12 Transportation Systems
References

4.0

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

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Legend

Borough or Census Area Boundary

Number of Persons in 1980

Boroughs or Census Areas

- 170,000 or greater
- 25,000 - 55,000
- 7,500 - 24,999
- 1,000 - 7,499

Principal Population Centers

- 15,000 - 25,000
- 1,500 - 7,500

No population centers have between 7,500 and 15,000 inhabitants. Population centers with less than 1,500 persons are not shown. Data for Canada and the Soviet Union are estimates only.

1980 Population

4.1

Description

Wherever human populations occur, they inevitably affect the natural balance of the environment, and not always in beneficial ways. Consumption of resources, waste generation, and alteration of the landscape are examples of activities that can disturb the balance of environmental systems, causing contamination of land, air, and water. Population distribution is considered in order to determine where these stresses may be located and, if possible, mitigated.

The distribution of people in Alaska has two basic characteristics: (1) the state is sparsely populated; and (2) almost one-half of the population lives in three cities—Anchorage, Fairbanks, and Juneau. Scattered coastal cities and villages contain most of the remaining population. With the exception of Fairbanks, the interior of the state is largely unsettled.

Two types of areas are shown: boroughs and census areas. Boroughs are political units similar to counties (see Map 5.1). Census areas have been designated for statistical purposes by the Bureau of the Census for areas of the state where no organized boroughs exist.

Statewide Characteristics

Alaska has the fewest residents of all the states in the USA. The 1980 population was just over 400,000, a 33% increase from the 1970 level. By 1984 the population had grown to 500,000. The distribution of people in 1980 was similar to that of the previous decade. Alaska also has the lowest population density of any state—0.7 persons per square mile (throughout the USA, average population density in 1980 was 64 persons per square mile). The 1980 census recorded 64% of Alaska's population as "urban," up from 51% in 1970.

In 1980, as in 1970, Alaska had the lowest death rate (4 per 1,000) and the second highest birth rate (24 per 1,000) in the USA. The median age in 1980 was 26 years, making it the second youngest state. Alaska also has the highest ratio of males to females in the nation—112 males for every 100 females—and an average of 2.93 persons per household in 1980, the third highest in the nation (Bureau of the Census, 1983).

Growth

The discovery of gold near Sitka in southeast Alaska in 1872 led to the Klondike Gold Rush at the turn of the century. This discovery, together with the development of commercial fishing, the American military buildup, and oil, gas, and mineral extraction attracted many people to Alaska. The population surge during the decade between 1970 and 1980, however, was largely due to the North Slope oil boom.

Alaska has attracted people from all over the country since the discovery of vast oil reserves on the North Slope in 1968. More than 30% of Alaska's population over 5 years of age lived in another state prior to 1976. Migrants to Alaska are generally well educated. For example, 83% of Alaskans over 25 years old have high school diplomas and 21% have college degrees (Bureau of the Census, 1983).

Most of the non-Native citizens in the study area live in the boroughs of Fairbanks-North Star, Southeast Fairbanks, Matanuska-Susitna, Anchorage, and Kenai Peninsula. Anchorage and Fairbanks are the business and educational centers of the state. The Native population, composed of Aleuts, Eskimos, and Indians, is concentrated in western Alaska and along the North Slope. Alaska's population is expected to continue to grow, although at a declining rate, reaching more than 600,000 by the year 2000 (Bureau of the Census, 1983).

Employment

State and Federal governments are the leading employers in Alaska. In 1980, approximately one-third of Alaska's civilian labor force was employed by government; another 23,130 were active duty military personnel. Employment levels fluctuate seasonally in Alaska, with unemployment usually highest during the winter. Professional and related services—e.g., doctors, lawyers, engineers, scientists, and managers—is the second largest category of employment in the state. Alaska has the highest per capita income of any state; premium wages are paid to offset the high cost of living.

Cities, Towns, and Villages

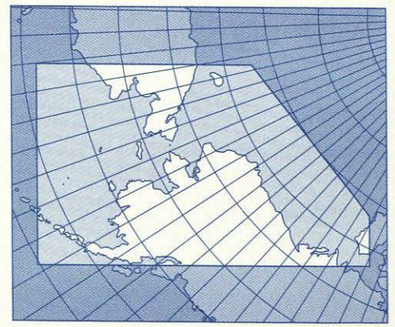
The rapid population growth in Alaska during the 1970s occurred primarily in bigger cities. During this period, the population of Anchorage, Alaska's most populous city with 174,431 persons, increased by 263%, the largest increase anywhere in the state. The population of Fairbanks, Alaska's second largest city, increased by 58%. Population density is greatest in Anchorage, where there are 101 persons per square mile. The population density of Fairbanks is only 7 persons per square mile (Bureau of the Census, 1982). Those cities with the largest populations in 1970 continued to be the major population centers in 1980, and their relative size ranking remained the same (Bureau of the Census, 1983).

Most population centers in arctic and northwestern Alaska have long traditions of Native use. For example, Barrow has been a center of Native activity for centuries. It is strategically located along migration paths of many birds, fishes, and marine mammals, which are essential for subsistence in much of the North. Barrow's population has grown steadily as its importance as a center of economic, social, and political activity has increased. The population of Barrow in 1980 was about 2,500.

Nome, on the other hand, has a much different history of settlement and development. Nome was a tent town of 250 miners at the turn of the century. With the discovery of gold in the early 1900s, its population grew to over 20,000, and businesses and services were established to serve the miners and their families. The gold rush was short-lived, however, and by 1910 Nome's population was less than 3,000. Disease and lack of employment further diminished the population level to less than 900 in 1922. The population of Nome today is distinctly Native.

Map References

National Foreign Assessment Center, 1978; Bureau of the Census, 1980, 1982; Alaska Northwest Publishing, 1983.



1980 Population
4.1

Meynypil'gyno
Anadyr
Sachterskij
Mys Shmidta
Beringovski
Egvekinot
Il'tin
Provideniya
Mechigmen
Uelen
Nome
Kotzebue
Barrow
Bethel
Dillingham
Inuvik
Fort Greely
Wasilla
Palmer
Soldotna
Kenai
College
Fairbanks
Eielson AFB

Nome Census Area
Wade Hampton Census Area
Bethel Census Area
Kobuk Census Area
North Slope Borough
Aleutian Islands Census Area
Yukon-Koyukuk Census Area
Dillingham Census Area
Bristol Bay Borough
Fairbanks North Star Borough
Matanuska-Susitna Borough
Anchorage Borough
Kenai Peninsula Borough
Southeast Fairbanks Census Area

USSR
United States
(U.S.-Russia Convention 1867)
Exclusive Economic Zone
Arctic Circle
United States
Canada
Alaska
Yukon Territory
100 meters
Bathymetry in meters

Modified Transverse Mercator Projection
Scale 1:4,000,000
Nautical miles
Statute miles
Kilometers

Base map data sources: NOAA, Environmental Information and Data Center (EIDC), University of Alaska, 1982; Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, and 1:5,000,000 Series, ONC C-8, ONC D-8, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-485; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

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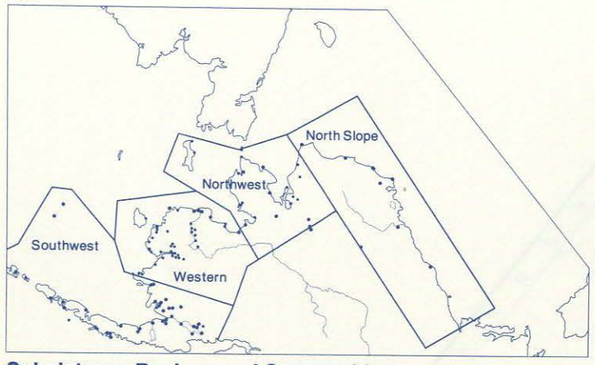
National Ocean Service
National Oceanic and Atmospheric Administration



Subsistence Regions and Communities

• Major Research • Limited Research

Fishes, invertebrates, and plant materials harvested for subsistence use.

Salmon	
Chum Salmon	*Oncorhynchus keta*
Chinook Salmon	*O. tshawytscha*
Coho Salmon	*O. kisutch*
Pink Salmon	*O. gorbuscha*
Sockeye Salmon	*O. nerka*
Other Fishes	
Alaska Blackfish	*Dallia pectoralis*
Burbot	*Lota lota*
Capelin	*Mallotus villosus*
Arctic Char (Dolly Varden)	*Salvelinus alpinus*
Arctic Cisco	*Coregonus autumnalis*
Least Cisco	*C. sardinella*
Arctic Cod	*Boreogadus saida*
Pacific Cod	*Gadus macrocephalus*
Saffron Cod	*Eleginus gracilis*
Arctic Flounder	*Liopsetta glacialis*
Starry Flounder	*Platichthys stellatus*
Arctic Grayling	*Thymallus arcticus*
Pacific Halibut	*Hippoglossus stenolepis*
Pacific Herring	*Clupea pallasi*
Northern Pike	*Esox lucius*
Sculpins	various cottids
Sheefish	*Stenodus leucichthys*
Smelt	*Osmerus mordax*
Nine-spined Stickleback	*Pungitius pungitius*
Longnose Sucker	*Catostomus catostomus*
Lake Trout	*Salvelinus namaycush*
Other Fishes (cont.)	
Rainbow Trout/ Steelhead	*Salmo gairdneri*
Broad Whitefish	*Coregonus nasus*
Humpback Whitefish	*C. clupeaformis*
Round Whitefish	*Prosopium cylindraceum*
Marine Invertebrates (partial listing)	
Chitons	various
Clams	various
Crab, Red King	*Paralithodes camtschatica*
Crab, Tanner	*Chionoecetes opilio*
Mussels	various
Octopus;	*Octopus dofleini*
Sea Cucumbers	various
Sea Urchins	various
Plant Material	
Blackberry	*Rubus spp.*
Blueberry	*Vaccinium* spp.
Hudson Bay Tea	*Ledum* spp.
Cranberry	*Vaccinium oxycoccus*
Crowberry	*Empetrum nigrum*
Sourdock	*Rumex* spp.
Wild Chives	*Allium* spp.
Willow Leaves	*Salix* spp.
Cloudberry	
Wild Celery	
Wild Potato	
Grass roots	
Wood	

Subsistence: Fishes, Invertebrates, and Vegetation 4.3

Description

This is the first in a series of three plates depicting the location, timing, and magnitude of subsistence resource use by resource category. The inset map shows the division of the study area into four regions for comparisons of resource use. Coastal communities where major and limited research has occurred are also shown.

This plate portrays the subsistence use of salmon, other fishes, invertebrates, and vegetation by Native communities in the study area. The locations of harvests of each of these four resource categories are shown on the maps. The inset table presents a list of the important species.

A histogram on the map plate shows the relative proportion of each resource category harvested by a representative community in each region for a base year. The bar chart shows the timing of primary and incidental harvest periods for each of the four regions.

Salmon

Salmon comprise a large proportion of the total subsistence harvest in western and southwestern Alaska (inset map and histogram on opposite page), where all five species are taken. Salmon account for over half the harvest by weight for most communities on Bristol Bay, and the Yukon and Kuskokwim rivers. Chum salmon are also an important part of the total harvest in some parts of northwest Alaska, although not the predominant resource. The fish are caught primarily in spawning rivers with gill nets, beach seines, gaffs, fish wheels, and rod and reel by extended families that maintain fishing camps at harvest locations during salmon runs.

Salmon and salmon products are preserved primarily for human consumption by drying, drying and smoking, burying and fermenting, and freezing. Some processed salmon are traded for other traditional foods. Prior to snowmobiles, half the salmon catch was used for dog food, but this has since declined. Fluctuations in salmon harvest have been due largely to changes in species abundance and distribution, with substitution of other fishes during low periods.

There are few restrictions on bag limits in the study area. However, salmon harvesting is often regulated by temporal closures, area closures, and gear restrictions to ensure escapement and to mesh with commercial catch management through voluntary reporting of catches.

In the past, subsistence harvest of salmon has suffered in competition with commercial harvests. While subsistence has legal priority now in areas under state jurisdiction, commercial fishing, including foreign catches in international waters, still influences the allowable harvest. Some competition also exists between upriver and downriver communities on the Yukon and Kuskokwim rivers. There is an agreement with Canada to ensure adequate escapement to the Canadian Yukon.

Other Fish Species

Of the many other fish species harvested, the most important are Alaska blackfish, Arctic char, Pacific herring, burbot, sheefish, and several species of whitefish. Other species listed on the inset table are also harvested regularly by area residents, although not in great quantities in most years.

Alaska blackfish are a main resource for residents of tundra lake communities in the Yukon-Kuskokwim Delta area and have been harvested extensively in other communities, especially when other sources fail. The fish are caught most frequently with traps, preserved frozen, and eaten either cooked or raw.

Herring is a primary resource for Bering Sea and Norton Sound communities, many of which were settled to take advantage of this seasonal resource. They are caught during spring runs from skiffs using gill nets and are split and dried for year-round consumption. Herring is often traded for other foods.

Both subsistence and commercial harvesting regulations contribute to management of the herring population. However, conflicts exist between subsistence harvesting and the recently established commercial fishery for herring roe. Critical management issues still have to be decided.

Arctic char are used throughout the region but are particularly important in parts of the Northwest and North Slope regions, where they are harvested in large quantities during early spring and fall migrations. They are caught with seines, gill nets, and rod and reel. Most are eaten fresh, but some are dried and smoked.

Burbot, sheefish, and the various whitefish and cisco species are harvested on most of the larger rivers in the study area. Most of the harvest occurs during major spring and fall migrations with gill nets set in open water or through ice. In the Northwest, significant numbers of sheefish are jigged through the ice, and burbot are trapped through river ice throughout the study area.

Many of the species are not harvested commercially. Test fisheries for sheefish and halibut have all proven to be spatially limited. Management issues are minimal, and current harvesting regulations have maintained population levels.

Marine Invertebrates

A diversity of marine invertebrates is harvested in the study area. Consumption data are missing from the histogram on the map plate because of the difficulty in documenting harvest quantities. Residents of Nome and other Norton Sound communities harvest king crab, and Aleutian Island communities use many species of chitons, clams, crabs, mussels, urchins, and sea cucumbers. These species account for a considerable part of the total subsistence harvest in some communities. Other communities make incidental use of marine invertebrates when conditions permit harvesting, such as when spring storms wash large numbers of clams onto beaches.

Of all the species harvested, only crabs have a managed harvest. The State of Alaska regulates the catch within three miles of the coast; beyond this, management is the responsibility of the North Pacific Fisheries Management Council. Competition exists between the commercial harvest and subsistence catch of king crab in Norton Sound.

There are no other commercial harvests of marine invertebrates in the region, and licensing or reporting requirements are not required for subsistence harvests. In the Aleutians, a recovering sea otter population that feeds in intertidal areas is presumed to reduce the availability of some invertebrates for subsistence use.

Plant Materials

Numerous species of plants are harvested for subsistence use throughout the study area. Berries, roots, and leaves are the main edible plant parts used from land plants. Some residents in the south use seaweed. Medicinal plants continue to be used to treat some illnesses. Basket grasses are used for crafts. Driftwood and forested wood carried to the coast during ice break-up and spring flooding are important fuel sources in some communities, as well as raw material for implements and crafts.

Most green plants are harvested early in the growing season. Berries ripen later in the season and most harvesting takes place before heavy frosts. Wood is cut as needed; most driftwood is gathered soon after break-up. Edible plants are collected in quantity and preserved by freezing, fermenting, and packing in oil. These food items are important sources of vitamins and minerals in rural diets and are necessary ingredients in traditional food preparations.

While many of the areas depicted for subsistence harvest of plant materials are near the communities that have been surveyed, area residents also travel to harvest these resources.

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Division of Subsistence
Alaska Department of Fish and Game
Juneau, Alaska

MICHAEL W. COFFING
Division of Subsistence
Alaska Department of Fish and Game
Bethel, Alaska

Legend

Invertebrates — Known / Probable

Salmon — Known / Probable

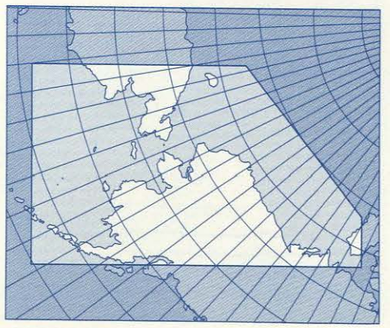
Other Fishes — Known / Probable

Vegetation/Wood — Known / Probable

The coastal subsistence patterns shown are approximate for the 1971-1986 period. The four communities and years chosen to represent per capita consumption are those for which harvest data are most complete. The resource categories shown are only those harvested during the base years selected. Timing of harvest is based on a combination of data from various communities in each region during the period.

Map References

Cooperative Parks Study Unit, various dates; Bane, 1975-1976; Division of Subsistence, various dates; Eisler, 1978; Pedersen, 1979; Veltre and Veltre, 1981, 1982, 1983; Wolfe, 1981, 1986; Nunam Kitlutsisti, 1982; Thomas, 1982; Andrews and Peterson, 1983; Braund and Burnham, 1983; Fienup-Riordan, 1983; Jorgensen, Maxwell, and Katchatag, 1984; Sobelman, 1984; Stickney, 1984; Wright, 1984; Division of Habitat, 1985, 1986a, 1986b; Magdanz and Olanna, 1985; Pedersen, Coffing, and Thompson, 1985. Personal communications from Behnke; Magdanz; Morris; Pete; Schroeder; Stern; Wolfe.



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Native Peoples and Languages
4.2

Description

Most archeologists agree that the ancestors of present-day Alaska Natives migrated into the region from Siberia across the Bering Land Bridge (Beringia), which linked Siberia and Alaska during the Wisconsin glacial period approximately 20,000 years ago. Northern Eurasian hunters are thought to be the ancestors of the Native peoples of Alaska, particularly the Eskimos.

The Native population is composed of three ethnic stocks: Eskimos, Aleuts, and Indians. While several differences distinguish these groups, Alaska Natives are in general culturally similar people, dependent upon subsistence hunting and fishing activities. At one time virtually the entire Native population was nomadic, moving between seasonal camps in search of food. Both coastal and inland Eskimos are hunters, fishers, and gatherers who have traditionally hunted caribou. Indians, who inhabit mainly the interior regions, are also hunters, although less dependent than the Eskimos upon caribou as a principal food source. Aleuts, by contrast, have depended primarily upon the sea for their livelihood. Their population has been drastically reduced from former levels.

This map shows the distribution of Native peoples and their languages within the study area.

Population Characteristics

Over 34,000 Eskimos, over 21,000 Indians, and about 8,000 Aleuts live within the study area. Native Alaskans constitute approximately 16% of Alaska's total population (Bureau of the Census, 1982). More than half of the state's total Native population (53%) live in the census areas of Bethel, Dillingham, Kobuk, Nome, North Slope, Wade Hampton, and Yukon-Koyukuk (Alaska Department of Labor, 1982).

This concentration of Native population is evident in the distribution and size of Native villages on the map. Most of the Native villages of western and northern Alaska are more sparsely settled than those in the southern and eastern portions of the state. The larger cities of Alaska have sizable Native populations. For example, the Native population of Anchorage is about 10,000 people and of Fairbanks about 5,000 people (Alaska Northwest Publishing, 1982).

The Eskimo population, which constitutes more than half of Alaska's Native population, is located mainly along major rivers of western Alaska and along the coastline bordering the Bering, Chukchi, and Beaufort seas. Alaskan Indians are found throughout the interior of the state. Aleuts inhabit primarily the Aleutian Islands.

During post-World War II development in Alaska, the Native population doubled to reach a total of over 70,000 persons. About the same number of Native Alaskans are alive today as were alive when the expedition of Vitus Bering arrived in 1741. The non-Native population has increased from 40,000 in 1940 to about 450,000 people (Schroeder, pers. comm.) as a result of the build-up of military forces, Alaska's admission to the Union, and the discovery of oil on the North Slope (Map 4.1).

Languages

The two major language families of Native Alaskans, the Eskimo-Aleut family and the Athabaskan-Eyak-Tlingit family, are composed of many dialects. The Eskimo-Aleut family is thought to be related linguistically to other Eurasian languages, while the Athabaskan-Eyak-Tlingit family is related more closely to other North American Indian languages. The latter is spoken by Indians of interior Alaska. Native dialects are not included on this map.

Speakers of the Eskimo branch of the Eskimo-Aleut family make up the largest Native language group. The two principal Eskimo languages occurring in the study area are Yupik, spoken south of the Bering Strait, and Inupiaq, spoken along the Chukchi and Beaufort seas (Woodbury, 1984). Central Yupik, a dialect of Yupik, has the largest number of speakers in the Eskimo-Aleut family. Two other Yupik dialects, Sugpiaq and Siberian Yupik, are also spoken along the Alaskan coast (Alaska Native Language Center, 1982).

Aleut, the primary language of the Aleut branch of the Eskimo-Aleut family, consists of two main dialects—Eastern Aleut and Western Aleut. These languages are spoken in the Aleutians, northwest and southwest Alaska, and the North Slope region (Alaska Native Language Center, 1982).

The distribution of languages in 1980 is largely unchanged from that at the time of the first European contacts, but the use of Native languages has been reduced (Woodbury, 1984).

Native Claims

Alaska has 12 Native regional corporations which were formed in 1971 when the US Congress passed the Alaskan Native Claims Settlement Act (ANCSA). The act divided the state into 12 regions based on geographic proximity and cultural similarities. A thirteenth Native corporation was later organized for Natives residing outside the state. Eight of the 12 regional corporations are occupied primarily by Aleut- or Eskimo-speaking people (Burch, 1984); nine of these corporations are included in the study area.

Under the guidelines of ANCSA, the responsibilities of the regional corporations include the distribution of Federal payments and land to Alaska Natives, supervision of the creation and operation of village corporations, ownership of mineral resources on or below their lands, regulation of the development and use of these resources, and the operation of at least one business for profit (Burch, 1984).

Slightly more than half of the land available under ANCSA, approximately 22 million acres, will be distributed to Native villages, based on their population. Any citizen who is at least one-quarter Alaskan Indian, Aleut, or Eskimo is entitled to participate under the terms of this act.

Village corporations created in response to ANCSA are smaller versions of the regional corporations. They are also able to receive and distribute land and money. Unlike the regional corporations, village corporations are organized for either profit or nonprofit purposes (Burch, 1984). Two hundred and three Native villages presently form these village corporations (Alaska Northwest Publishing, 1982). While the diversity of Native cultural families makes identification of social and cultural changes in village life uncertain, Alaska's Native population has successfully taken control over village and regional affairs (Burch, 1984).

However, the implementation of ANCSA has focused attention on the important issue of who should be allowed to hunt and fish. Native subsistence activities are an important aspect of this issue (see subsistence activities maps). Another part of this issue is whether responsibility for the control and regulation of hunting and fishing should be in the hands of the Federal government, the state government, or regionally based user groups. The debate over the development of Alaska's lands versus their preservation in a relatively pristine state also continues.

Legend

Language Families

- Athabaskan - Eyak - Tlingit
- Eskimo - Aleut

Language Group

ANCSA Native Regional Corporation
(Alaska Native Claims Settlement Act)

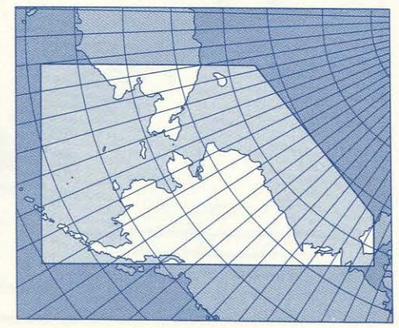
Native Villages (by Native population)

- ● 500 or greater
- • 250 - 499
- • 125 - 249
- · 1 - 124

Only villages with at least a 10% Native population are shown.

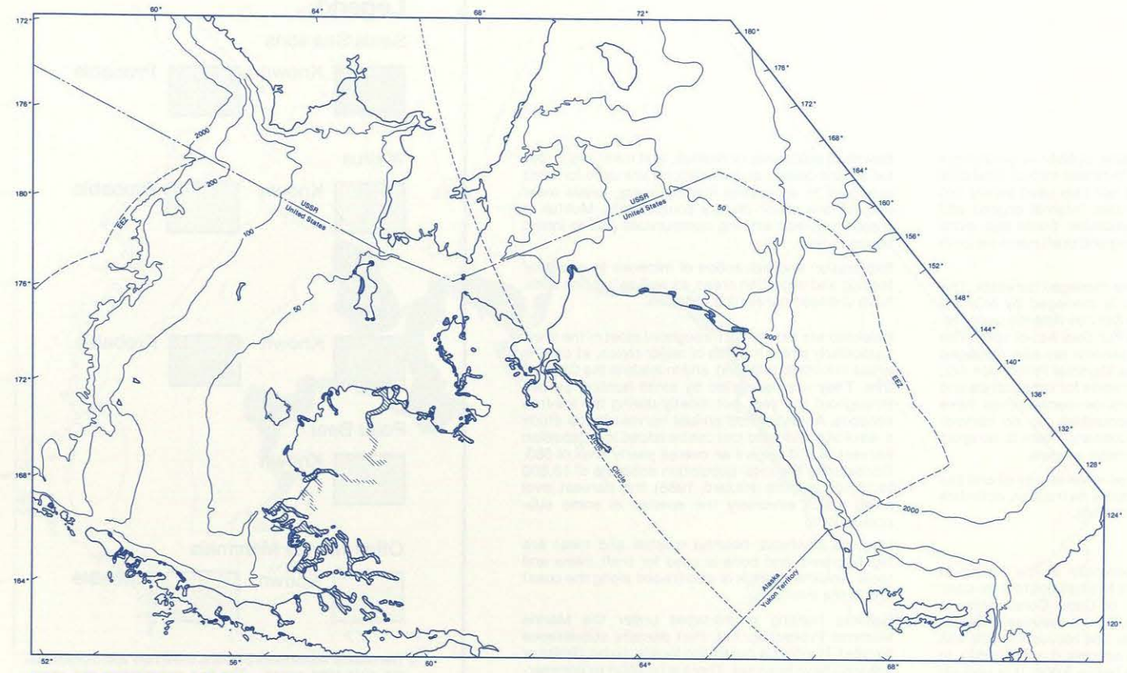
Map References

Bureau of Land Management, 1974; Alaska Geographic Society, 1979; Alaska Native Language Center, 1982; Alaska Department of Community and Regional Affairs, 1983.

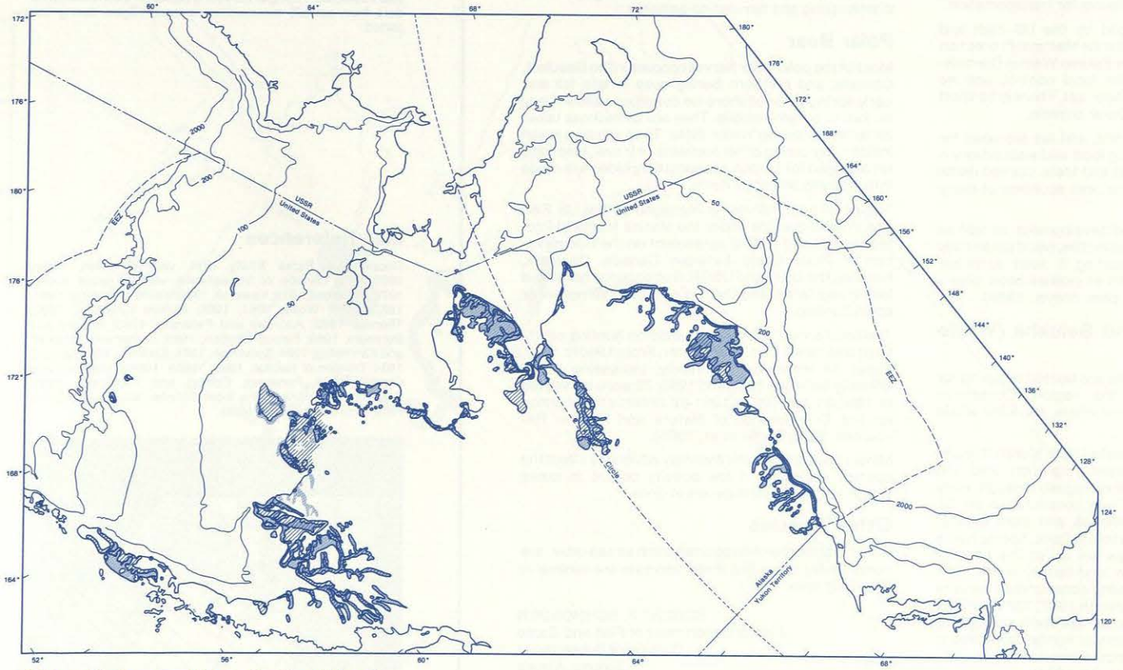


Subsistence: Fishes, Invertebrates, and Vegetation

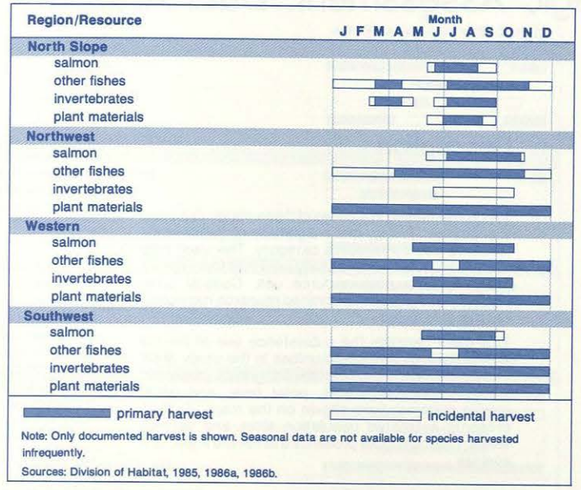
4.3



Invertebrates and Salmon



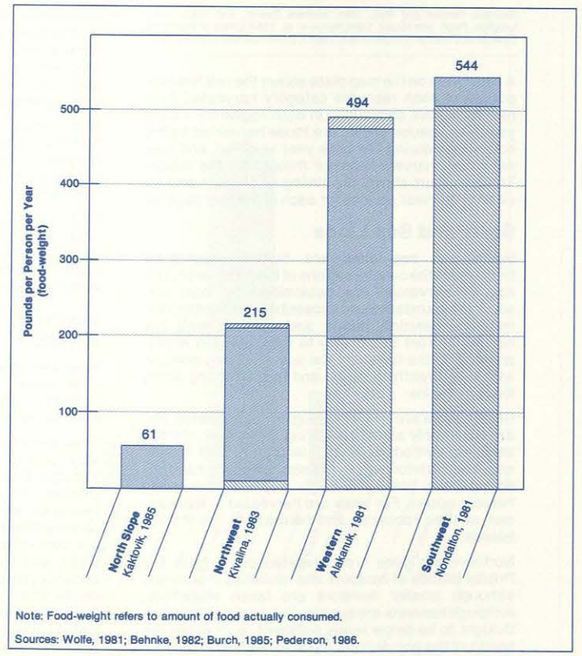
Other Fishes and Vegetation/Wood



Note: Only documented harvest is shown. Seasonal data are not available for species harvested infrequently.

Sources: Division of Habitat, 1985, 1986a, 1986b.

Timing of Subsistence Harvest



Note: Food-weight refers to amount of food actually consumed.

Sources: Wolfe, 1981; Behnke, 1982; Burch, 1985; Pederson, 1986.

Annual Per Capita Consumption

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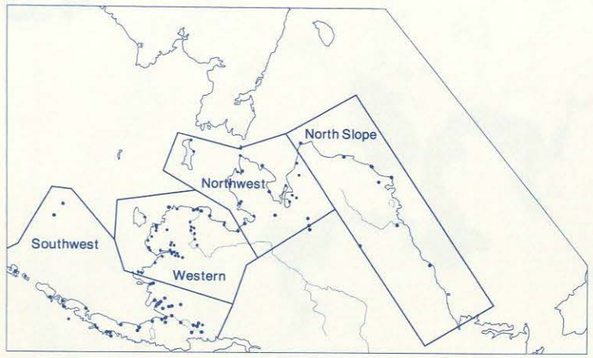

Subsistence Regions and Communitites

• Major Research • Limited Research

Marine mammals harvested for subsistence use.

Sea Otter	*Enhydra lutris*	Ringed Seal	*Phoca hispida*
Polar Bear	*Ursus maritimus*	Pacific Walrus	*Odobenus rosmarus*
Northern Sea Lion	*Eumetopias jubatus*	Killer Whale	*Orcinus orca*
Northern Fur Seal	*Callorhinus ursinus*	Belukha (White Whale)	*Delphinapterus leucas*
Bearded Seal	*Erignathus barbatus*		
Harbor Seal	*Phoca vitulina*	Gray Whale	*Eschrichtius robustus*
Spotted Seal	*Phoca largha*	Bowhead Whale	*Balaena mysticetus*
Ribbon Seal	*Phoca fasciata*	Minke Whale	*Balaenoptera acutorostrata*

Subsistence: Marine Mammals 4.4

Description

This is the second in a series of three plates depicting the location, timing, and magnitude of subsistence resource use by resource category. The inset map shows the division of the study area into four regions for comparisons of resource use. Coastal communities where major and limited research has occurred are also shown.

This plate portrays the subsistence use of marine mammals by Native communities in the study area. The locations of harvests of the five groups (seals and sea lions, walrus, whales, polar bear, and other marine mammals) are shown on the maps. Table 1 presents estimated population sizes and harvest levels. The inset table presents a list of the important species.

Table 1. Estimated harvest and population levels for seals and sea lion*

Species	Population	Harvest
Northern sea lion	20,000-30,000	n/a
Bearded seal	300,000	1,800
Harbor seal	30,000	n/a
Ribbon seal	90,000-100,000	250-1,100
Ringed seal	1-1.5 million	2,000-3,000
Spotted seal	200,000-250,000	2,400
Northern fur seal	800,000-900,000	3,384

* estimated from various base years and meant to provide a general indication of the overall magnitude of harvest.
n/a - not available

Sources: Kenyon and Rice, 1961; Braham, Everitt, and Rugh, 1980; Loughlin, Rugh, and Fiscus, 1984; Burns et al., 1985; Office of Protected Species and Habitat Conservation, 1985; Zimmerman and Letcher, 1985.

A histogram on the map plate shows the relative proportion of each resource category harvested by a representative community in each region for a base year. The species shown are those harvested by the community during the base year selected, and may not reflect harvest behavior throughout the region. The bar chart shows the timing of primary and incidental harvest periods for each of the four regions.

Seals and Sea Lions

Seals and sea lions are hunted intensively throughout the coastal regions of the study area. The species harvested are determined by local and seasonal abundance and accessibility to nearby communities. Bearded, ringed, and spotted seals are harvested from Bristol Bay to the Canadian Arctic, primarily in the fall along the advancing ice edge, in winter at breathing holes, and in late spring along leads in the ice.

Ribbon seals are hunted during the same period, but are taken only along the Bering Sea coast. Harbor seals are hunted in the Aleutian and Pribilof islands and from Bristol Bay to Nelson Island primarily in spring from boats, although a small year-round harvest occurs. Fur seals are harvested in the summer at their rookeries and haulouts in the Pribilof Islands.

Northern sea lions are harvested primarily in the Pribilof Islands at haulouts and rookeries in summer, although smaller numbers are taken elsewhere. Although harvests are substantial (to date), they are thought to be below levels sufficient to threaten the health of the populations. Prior to 1985, northern fur seal subsistence use was met by the 22,000 to 25,000 animals harvested for fur.

Almost all parts of the animal are used. The meat is generally preserved, usually by air drying or salting, for later human consumption. Seal oil, a major food item, is prepared by packing blubber in containers kept warm to allow the fat to render into oil. Seal oil is in such demand that it is not only used locally but traded to inland communities. Internal organs and flippers are considered delicacies. Some seal skins are used for making clothing and craft items for both local use and sale.

All seals and sea lions have managed harvests. The northern fur seal harvest is managed by NOAA's National Marine Fisheries Service (NMFS) under international treaty and the Fur Seal Act of 1966. The other seals and northern sea lion are also managed by NMFS under the Marine Mammal Protection Act, that permits continued harvests for subsistence and traditional crafts. Subsistence communities have continued to regulate themselves, so no harvest restrictions have been necessary. There is no sport or commercial harvest of these animals.

Harvesting could be affected adversely by oil and gas exploration or other resource extraction activities that could alter seal distributions.

Walrus

Walrus are harvested generally in the spring in broken pack ice by hunters in small boats from communities west and north of Cape Constantine in Bristol Bay and occasionally from the Alaska Peninsula and the Pribilof Islands. The harvest in 1982 was between 2,789 and 2,935 animals (Lowry, 1982). In general, annual levels are below 5,000. It is unlikely that the total population of 270,000-290,000 is adversely affected at this level of harvest (Burns et al., 1985). Harvest levels were higher when more residents maintained dog teams for transportation.

Walrus harvest is managed by the US Fish and Wildlife Service under the Marine Mammal Protection Act in consultation with the Eskimo Walrus Commission. Management is under local control, and no seasons or bag limits have been set. There is no sport or commercial hunting of these animals.

Walrus meat, internal organs, and fat are used for human consumption and dog food, and walrus ivory is used for carving craft items and tools. Carved items are an important part of the cash economy of many communities.

Oil and gas exploration and development, as well as other resource extraction activities, could potentially disrupt subsistence harvesting if such activities occur in critical habitat such as mollusk beds, where walruses feed (Schroeder, pers. comm., 1986).

Bowhead Whale and Belukha (White Whale)

Bowhead whale and belukha are hunted regularly for subsistence throughout the region. Occasional catches of gray whale, minke whale, and killer whale are also reported.

Bowhead whales are harvested from March through May during their northward migration into the Beaufort Sea, and from mid-August through early October on their return from communities on St. Lawrence and Diomede islands and from coastal communities from Kivalina to Kaktovik. Spring hunts are conducted from camps set up at the edge of leads, and fall hunts from land-based camps. The social organization of whaling communities centers on the hunt. From 1970 through 1977, 238 bowhead were taken and an additional 194 were struck and lost. At present, the total annual number of strikes is less—18 to 32—with strict allocation to specific villages (Armstrong and Braund, 1984).

Bowhead whale harvest quotas are set by the International Whaling Commission and the Alaska Eskimo Whaling Commission. Harvest is for subsistence use only.

Bowhead epidermis, or muktuk, and meat are prized foods, and baleen and whalebone are used for craft products. In successful hunting years, whale meat and fat are major dietary components. Muktuk is traded between whaling communities and to inland communities.

Exploration and extraction of minerals in and near feeding and migration areas, as well as hunting sites, have changed harvesting patterns.

Belukhas are harvested throughout most of the area, particularly at the mouths of major rivers, at calving areas in Kotzebue Sound, and in leads in the Chukchi Sea. They are harvested by small hunting parties throughout the year but mostly during the ice-free seasons. An estimated annual harvest in the study area of 356 killed and lost can be added to a Canadian harvest of 207 to give an overall yearly level of 563. Considering the total population estimate of 15,800 to 18,400 animals (Hazard, 1986), this harvest level could affect adversely the species in some subpopulations.

Like the bowhead, belukha muktuk and meat are highly prized, and bone is used for craft items and tools. Belukha muktuk is also traded along the coast and in the interior.

Belukha hunting is managed under the Marine Mammal Protection Act, that permits subsistence harvest. Hunting is controlled locally; no bag limits or seasons have been set. There is no sport or commercial harvest of Belukhas.

Like the bowhead, mineral exploration and extraction activities in sensitive areas have changed animal distributions and harvesting patterns.

Polar Bear

Most of the polar bear harvest occurs in the Beaufort, Chukchi, and northern Bering seas in late fall and early spring when offshore ice conditions allow travel on foot or by snowmobile. They are sometimes taken as far south as the Yukon delta. They are also taken incidentally during other harvests or travel. Meat and fat are used for human consumption; hides are made into clothing and craft items.

The polar bear harvest is managed by the US Fish and Wildlife Service under the Marine Mammal Protection Act and a 1976 agreement on the Conservation of Polar Bears between Canada, Denmark, Norway, the USA, and USSR. Subsistence hunting is locally regulated, and there is no legal commercial or sport hunting.

The total annual harvest depends on hunting conditions and varies from year to year. From 1960 to 1972, about 34 were taken annually, increasing to 86 annually between 1973 and 1980; 79 were harvested in 1980-81 and 106 in 1981-82 (International Union for the Conservation of Nature and Natural Resources, 1984; Burns et al., 1985).

Mineral extraction activities may adversely affect the species, especially if the activity occurs in areas where mothers and cubs are in dens.

Other Species

Other marine mammal species, such as sea otter, are occasionally taken, but these harvests are minimal in the study area.

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Legend

Seals/Sea lions — Known — Probable

Walrus — Known — Probable

Whales — Known — Probable

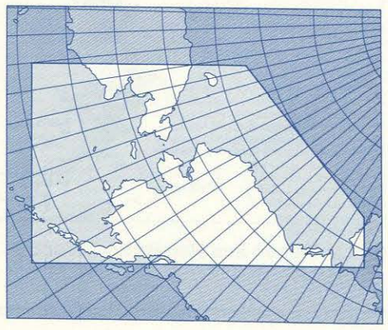
Polar Bear — Known

Other Marine Mammals — Known — Probable

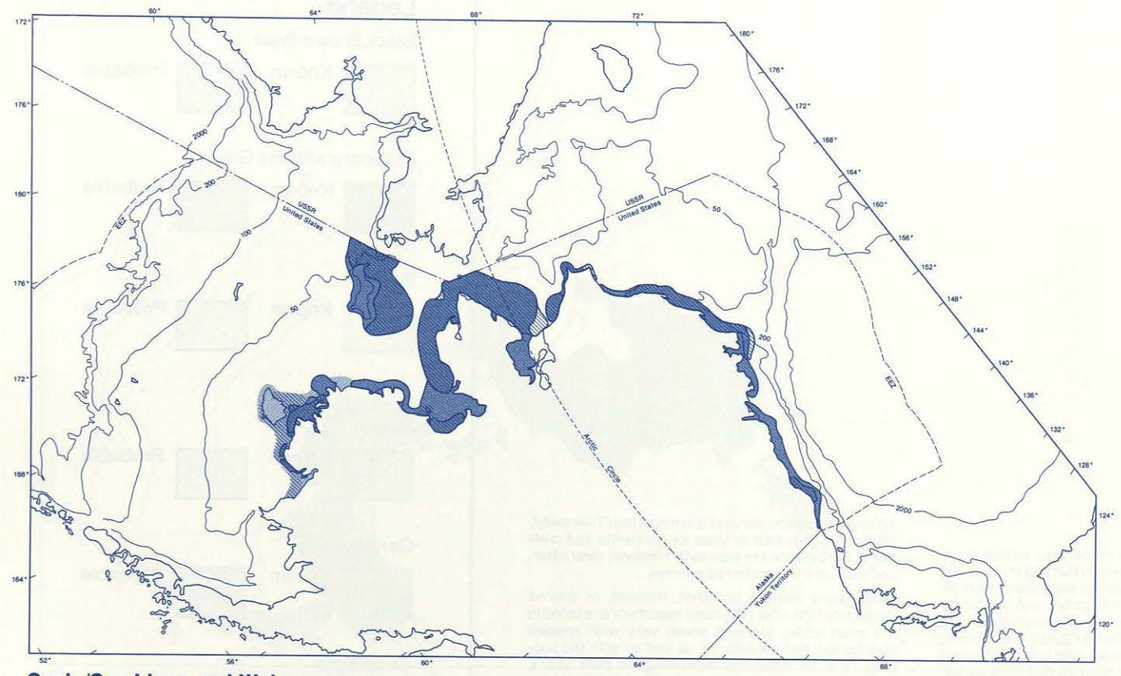
The coastal subsistence patterns shown are approximate for the 1971-1986 period. The four communities and years chosen to represent per capita consumption are those for which harvest data are most complete. The resource categories shown are only those harvested during the base years selected. Timing of harvest is based on a combination of data from various communities in each region during the period.

Map References

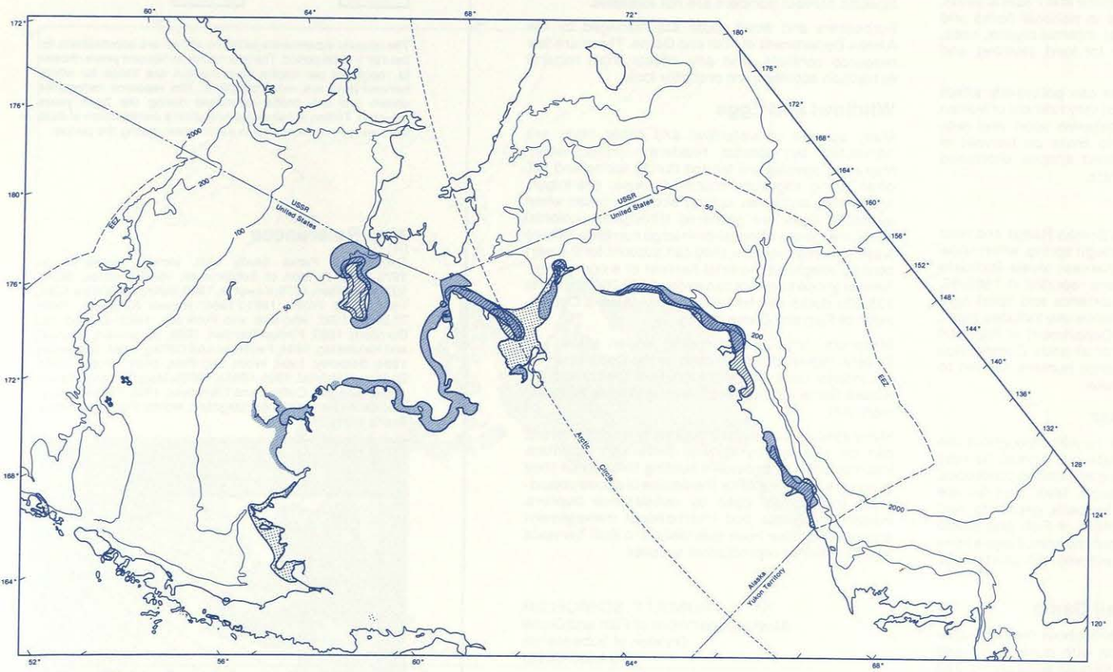
Cooperative Parks Study Unit, various dates; Bane, 1975-1976; Division of Subsistence, various dates; Eisler, 1978; Pedersen, 1979; Kawerak, 1980; Veltre and Veltre, 1981, 1982, 1983; Wolfe, 1981, 1986; Nunam Kitlutsisti, 1982; Thomas, 1982; Andrews and Peterson, 1983; Braund and Burnham, 1983; Fienup-Riordan, 1983; Jorgensen, Maxwell, and Katchatag, 1984; Sobelman, 1984; Stickney, 1984; Wright, 1984; Division of Habitat, 1985, 1986a, 1986b; Magdanz and Olanna, 1985; Pedersen, Coffing, and Thompson, 1985. Personal communications from Behnke; Magdanz; Morris; Pete; Schroeder; Stern; Wolfe.



Subsistence: Marine Mammals
4.4



Seals/Sea Lions and Walrus



Whales, Polar Bears, and other Marine Mammals

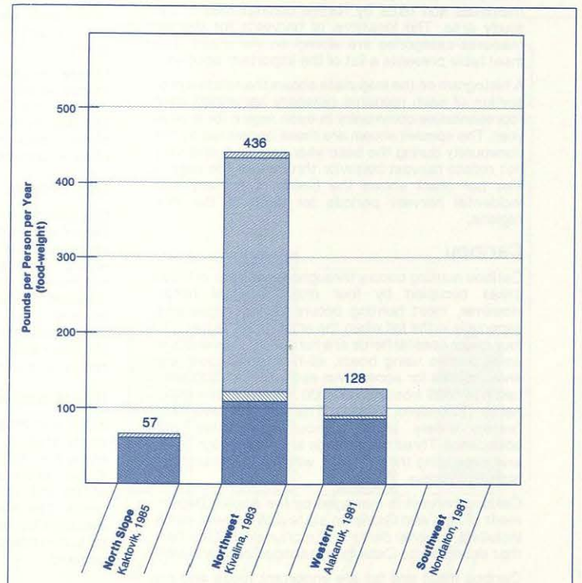
Region/Resource	Month J F M A M J J A S O N D
North Slope	
seals and sea lions	
walrus	
whales	
polar bears	
other marine mammals	
Northwest	
seals and sea lions	
walrus	
whales	
polar bears	
other marine mammals	
Western	
seals and sea lions	
walrus	
whales	harvested infrequently
polar bears	harvested infrequently
other marine mammals	
Southwest	
seals and sea lions	
walrus	
whales	harvested infrequently
polar bears	harvested infrequently
other marine mammals	

primary harvest incidental harvest

Note: Only documented harvest is shown. Seasonal data are not available for species harvested infrequently.

Sources: Division of Habitat, 1985, 1986a, 1986b.

Timing of Subsistence Harvest



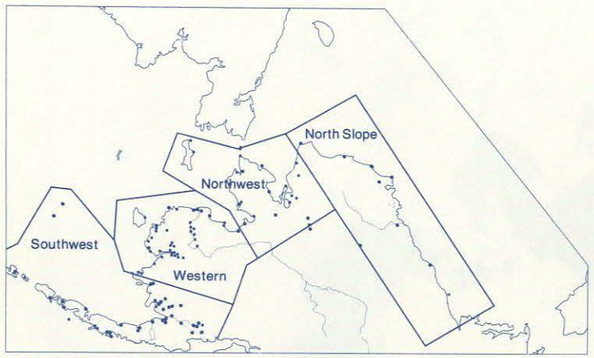
Note: Food-weight refers to amount of food actually consumed.

Sources: Wolfe, 1981; Behnke, 1982; Burch, 1985; Pederson, 1986.

Annual Per Capita Consumption

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
National Oceanic and Atmospheric Administration



Subsistence Regions and Communities

• Major Research • Limited Research

Land mammal and bird species harvested for subsistence use.

Big Game	
Caribou	*Rangifer tarandus*
Moose	*Alces alces*
Dall Sheep	*Ovis dalli*
Black Bear	*Ursus americanus*
Brown Bear	*Ursus arctos*
Furbearers	
Beaver	*Castor canadensis*
Muskrat	*Ondatra zibethicus*
Lynx	*Lynx canadensis*
Arctic Fox	*Alopex lagopus*
Red Fox	*Vulpes fulva*
Coyote	*Canis latrans*
Wolf	*Canis lupus*
River Otter	*Lutra canadensis*
Short-tailed Weasel	*Mustela erminea*
Least Weasel	*Mustela rixosa*
Mink	*Mustela vison*
Marten	*Martes americana*
Wolverine	*Gulo luscus*
Small Game	
Arctic Hare	*Lepus arcticus*
Snowshoe Hare	*Lepus americanus*
Small Game (cont.)	
Hoary Marmot	*Marmota caligata*
Porcupine	*Erethizon dorsatum*
Ground Squirrel	*Spermophilus undulatus*
Red Squirrel	*Tamiasciurus hudsonicus*
Game Birds	
Spruce Grouse	*Dendragapus canadensis*
Willow Ptarmigan	*Lagopus lagopus*
Rock Ptarmigan	*Lagopus mutus*
Seabirds	
Gulls	*Larus* spp.
Common Murre	*Uria aalge*
Thick-billed Murre	*Uria lomvia*
Kittiwakes	*Rissa* spp.
Sandhill Crane	*Grus canadensis*
Waterfowl	
Canada Goose	*Branta canadensis*
Emperor Goose	*Chen canagica*
White-fronted Goose	*Anser albifrons*
Black Brant	*Branta bernicla*
Swan	*Cygnus* spp.
Ducks	(various species)

Subsistence: Land Mammals and Birds 4.5

Description

This is the third plate in a series of three depicting the location, timing, and magnitude of subsistence resource use by resource category. The inset map shows the division of the study area into four regions for comparisons of resource use. Coastal communities where major and limited research has occurred are also shown.

This plate portrays the subsistence use of land mammals and birds by Native communities in the study area. The locations of harvests for the six resource categories are shown on the maps. The inset table presents a list of the important species.

A histogram on the map plate shows the relative proportion of each resource category harvested by a representative community in each region for a base year. The species shown are those harvested by the community during the base year selected, and may not reflect harvest behavior throughout the region. The bar chart shows the timing of primary and incidental harvest periods for each of the four regions.

Caribou

Caribou hunting occurs throughout the year in those areas occupied by four major coastal herds. However, most hunting occurs during migrations, especially in the fall when the animals are fattest. All four major coastal herds are hunted by individuals or small parties using boats, all-terrain vehicles, and snowmobiles for access. An estimated 12,000 were taken in 1985 from the 407,000 animals in the major herds (Townsend, 1986a). This harvest level fluctuates widely with caribou distribution and abundance. Three of the herds are now at high levels and expanding their ranges, with concomitant high hunting success.

Caribou harvest is managed by the Alaska Department of Fish and Game on state and Federal lands, including national parks and monuments. One herd that extends into Canada is managed cooperatively.

Caribou meat and fat are important foods and are eaten fresh or preserved by freezing or air drying for later use. Some skins and antlers are used for clothing and other traditional items.

Herds may be affected by activities associated with mineral exploration and extraction, especially if these occur on calving grounds or along migration routes. Sport hunting during low population periods or of smaller herds has been an issue of contention with subsistence hunters.

Moose

Although not as numerous as caribou, moose have been incorporated into seasonal hunting throughout the study area as the species has expanded its range northward. Moose are hunted in fall and winter by small groups travelling by boat or snowmobile. The 1984-85 harvest is estimated at 2,368 (Townsend, 1986b). Consideration of unreported and sport takes yields a higher estimate of 2,500 to 3,000 (Schroeder, 1986).

Moose harvests are managed by the Alaska Department of Fish and Game on state and Federal lands, including subsistence hunts in national parks and monuments. Moose meat, fat, internal organs, head, hooves, and hide are used for food, clothing, and crafts.

Mineral extraction activities can potentially affect moose, as the animals are not very tolerant of human disturbance. Competition between sport and subsistence hunters has led to limits on harvest in certain locations by controlled access, shortened season, and reduced bag limits.

Dall Sheep

Dall sheep are hunted in the Brooks Range and near Lake Clark from late fall through spring, when snow conditions permit. Annual harvest levels fluctuate widely; about 310 sheep were reported in 1985-86, but this is a combined subsistence and sport take (Townsend, 1986c). Subsistence use includes meat, fat, and hides. The Alaska Department of Fish and Game manages the harvest on all lands. Competition between sport and subsistence hunters has led to restrictions in season and take.

Black and Brown Bear

Black and brown bears are hunted throughout the study area in spring and late fall. Annual harvest levels are variable, depending on hunting conditions. Actual levels are not available. Meat and fat are eaten, and hides are used for pads, garments, and crafts. The Alaska Department of Fish and Game manages harvests throughout the area. Regulations for brown bear are restrictive due to high sport trophy demand.

Furbearers and Small Game

Furbearers are harvested throughout the study area on land and coastal sea ice with guns, traps, and snares mostly from late fall through early spring. The most important species are listed in the inset table. Harvest varies with species distribution and abundance, as well as fur prices. About 4,090 beaver, 1,080 river otter, 760 lynx, 450 wolves, and 230 wolverines were reported taken in the area in 1983-84, but some harvest is unreported (Townsend, 1986d,e). Fur is sold or used for garments and craft items. Furbearers are also eaten; beaver, river otter, and mink are the preferred species.

Small game species are shot, trapped, or snared throughout the area (the most important are listed in the inset table). Harvest levels vary with species distribution and abundance, as well as with the success of other resource harvesting. In poor years, small game may account for a high proportion of the subsistence take. In addition to food, some species, especially hare and squirrel, provide fur for clothing. Specific harvest numbers are not available.

Furbearers and small game are managed by the Alaska Department of Fish and Game. There are few resource conflicts, and any effects from mineral extraction activities are probably local.

Wildfowl and Eggs

Many species of waterfowl and other birds are harvested by coastal residents (inset table). Migratory species are hunted during spring and fall, often along migration routes. Grouse, ptarmigan, snowy owl, and other upland birds are taken when available. Eggs are gathered throughout; colonial seabird eggs are often taken in large numbers. Where waterfowl are available, they can account for 2-5 percent by weight of the total harvest of a community. Annual goose harvests can exceed 100,000, and over 135,000 ducks can be taken yearly (Alaska Department of Fish and Game, 1977).

Migratory birds are managed under state and Federal regulations developed by the Department of the Interior under the Migratory Bird Treaty Act, the Alaska Game Act, and the Fish and Wildlife Improvement Act.

Many species, particularly migratory tundra nesters, can be affected by mineral extraction activities. Habitat loss and excessive hunting throughout their range are responsible for the decline of goose populations traditionally used by subsistence hunters. Recent interstate and international management agreements have been established to limit harvests and to enhance reproductive success.

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Legend

Black/Brown Bear
Known Probable

Furbearers/Small Game
Known Probable

Sheep
Known Probable

Moose
Known Probable

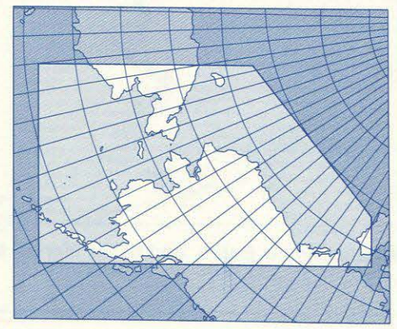
Caribou
Known Probable

Birds/Eggs
Known Probable

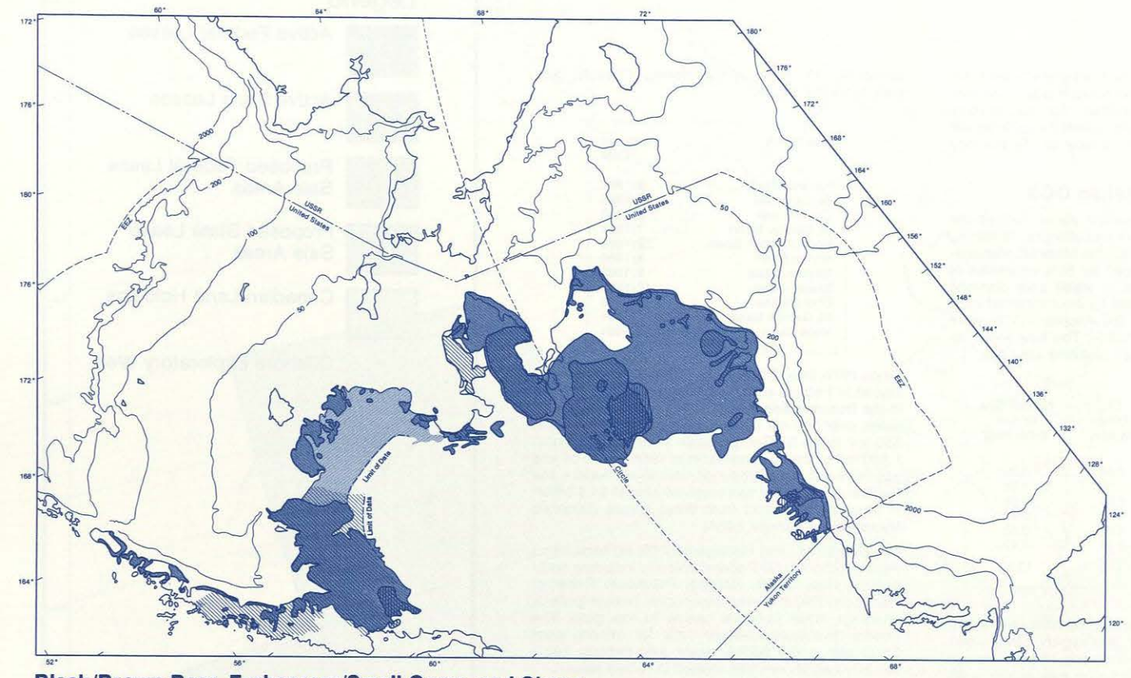
The coastal subsistence patterns shown are approximate for the 1971-1986 period. The four communities and years chosen to represent per capita consumption are those for which harvest data are most complete. The resource categories shown are only those harvested during the base years selected. Timing of harvest is based on a combination of data from various communities in each region during the period.

Map References

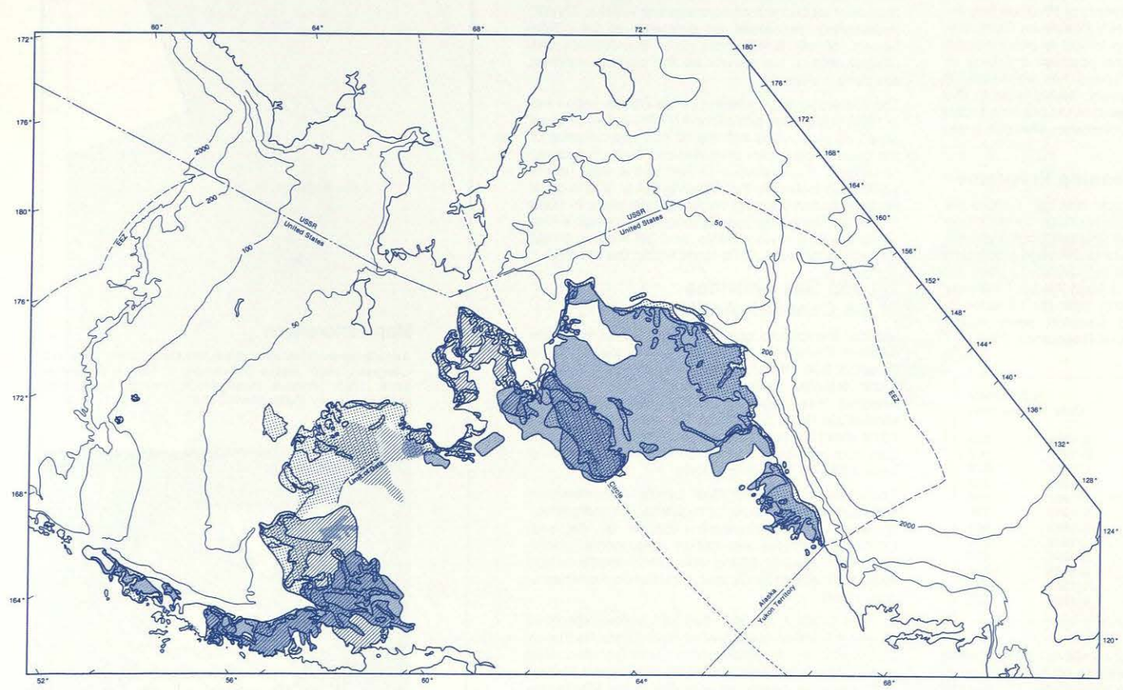
Cooperative Parks Study Unit, various dates; Bane, 1975-1976; Division of Subsistence, various dates; Eisler, 1978; Pedersen, 1979; Kawerak, 1980; Veltre and Veltre, 1981, 1982, 1983; Wolfe, 1981, 1986; Nunam Kitlutsisti, 1982; Thomas, 1982; Andrews and Peterson, 1983; Braund and Burnham, 1983; Fienup-Riordan, 1983; Jorgensen, Maxwell, and Katchatag, 1984; Pedersen and Coffing, 1984; Sobelman, 1984; Stickney, 1984; Wolfe and Pete, 1984; Wright, 1984; Division of Habitat, 1985, 1986a, 1986b; Magdanz and Olanna, 1985; Pedersen, Coffing, and Thompson, 1985. Personal communications from Behnke; Magdanz; Morris; Pete; Schroeder; Stern; Wolfe.



Subsistence: Land Mammals and Birds
4.5



Black/Brown Bear, Furbearers/Small Game, and Sheep



Moose, Caribou, and Birds/Eggs

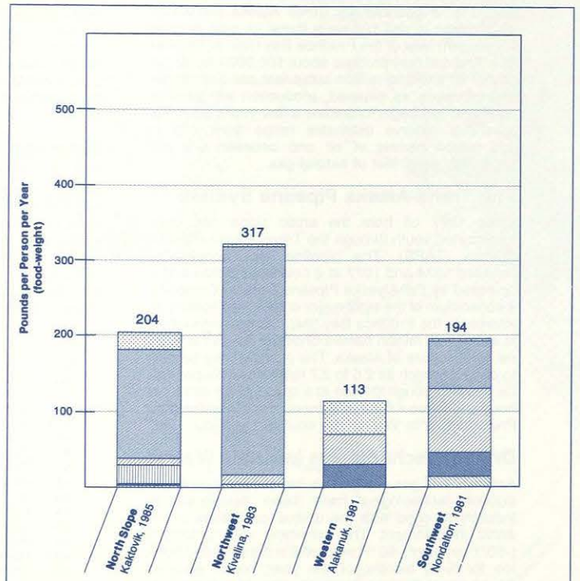
Region/Resource	Month J F M A M J J A S O N D
North Slope	
caribou	
moose	
sheep	
black/brown bear	
furbearers/small game	
birds/eggs	
Northwest	
caribou	
moose	
sheep	
black/brown bear	
furbearers/small game	
birds/eggs	
Western	
caribou	
moose	
sheep	not available
black/brown bear	
furbearers/small game	
birds/eggs	
Southwest	
caribou	
moose	
sheep	not available
black/brown bear	
furbearers/small game	
birds/eggs	

primary harvest incidental harvest

Note: Only documented harvest is shown. Seasonal data are not available for species harvested infrequently.

Sources: Division of Habitat, 1985, 1986a, 1986b.

Timing of Subsistence Harvest



Note: Food-weight refers to amount of food actually consumed.

Sources: Wolfe, 1981; Behnke, 1982; Burch, 1985; Pederson, 1986.

Annual Per Capita Consumption

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
National Oceanic and Atmospheric Administration

Oil and Gas Lease Areas and Activities

4.6

Description

Oil and gas production is the state of Alaska's dominant industry. In 1982 it generated at least half of the state's employment and income. Oil revenues made up almost all of Alaska's general revenues in the early 1980s (Tussing, 1984). About a fifth of all oil produced in the USA comes from Alaska.

Existing Production Activities

Almost all Alaskan oil is currently produced from the Prudhoe Bay field, which covers an area roughly 20 miles by 10 miles. The production of this one field exceeds that of all but one other American state and all but six foreign countries. The field is operated by Sohio Alaska Petroleum Co. and ARCO Alaska, Inc., and employs over 5,000 people. Since oil was discovered in 1968, over 500 wells have been drilled at Prudhoe Bay. Current production is about 1.5 million barrels of oil per day. While the production rate will begin to decline during the late 1980s, some production is expected to continue well beyond the year 2000. The present estimate of remaining recoverable oil reserves is 5.8 billion barrels.

The Kuparuk River field, approximately 40 miles west of Prudhoe Bay, is currently producing 120,000 barrels of oil per day. Its remaining reserves are estimated at 1.0 billion barrels. Kaparuk production should increase in the late 1980s, reach a peak of about 200,000 barrels per day, and begin to decline in the mid-1990s.

The Duck Island Unit of the Endicott reservoir, discovered in 1978 and the first arctic offshore field in the USA, is scheduled to begin production in 1988. This field, bordering the eastern side of the Prudhoe Bay Unit, is operated by Sohio Alaska Petroleum, which plans to drill 120 wells there. Its area borders the eastern side of the Prudhoe Bay Unit. At its peak rate, Endicott may produce about 100,000 barrels per day of oil and 250 million cubic feet per day of gas. If it proceeds as planned, production will peak in 1989 and will begin to decline a few years later. Recoverable reserve estimates range from 275 to 450 million barrels of oil and between 0.6 and 1.2 trillion cubic feet of natural gas.

The Trans-Alaska Pipeline System

Since 1977 oil from the arctic slope has been transported south through the Trans-Alaska Pipeline System (TAPS). The pipeline was constructed between 1974 and 1977 at a cost of $8 billion and is operated by the Alyeska Pipeline Service Company, a consortium of the eight major companies holding an interest in the Prudhoe Bay field. Current throughput is about 1.65 million barrels of oil per day, an amount set by the state of Alaska. The pipeline may be able to carry as much as 2.5 to 2.7 million barrels per day. Oil travels through the line at a speed of 7.5 miles per hour and takes 4.5 days to travel the 800 miles from Prudhoe Bay to Valdez, the southern terminus.

Drilling Technologies in Arctic Waters

Arctic oil and gas exploration, development, and production technologies have been developed by industry to cope with the unique conditions of the arctic environment. The extremely cold conditions (-50°F ambient; -90°F wind chill in the Beaufort Sea), ice for 5-10 months of the year, harsh weather, 24 hours of light or darkness, permafrost down to 2,000 feet, and general remoteness (the Navarin Basin is 400-750 miles from shore), all affect the selection of drilling technology in the Arctic.

Artificial, gravel islands are generally used in waters up to 50 feet deep. A reusable, mobile, concrete island drilling system (CIDS) was used for the first time by Exxon in 1984 in the Beaufort Sea. Drilling in Norton Sound waters (50-ft depths) is done from jackup rigs for exploration and from gravel islands for development. Activities in the Navarin Basin are conducted from semisubmersibles for exploration; gravity platforms or steel, pile-founded structures will be used for development (Office of Technology Assessment, 1985).

Reserves of the Alaskan OCS

Alaska was thought to contain about half of the recoverable oil, both onshore and offshore, remaining in the USA. However, in 1985 the Minerals Management Service (MMS) reduced by 55% estimates of undiscovered oil resources in lease sale planning areas throughout the Federal outer continental shelf (OCS). Oil estimates for the Alaskan OCS were reduced by 73% (Cooke, 1985). The new MMS resource estimates by Alaskan planning area are:

Planning Area	Oil (billion barrels)	Natural Gas (trillion cubic feet)
Beaufort Sea	0.89	3.93
Navarin Basin	1.30	1.58
Chukchi Sea	0.54	3.02
St. George Basin	0.37	3.47
Norton Basin	0.09	0.43
All Others	0.14	1.42
TOTAL ALASKA	3.33	13.85

Lower estimates for Alaska can be attributed to unsuccessful exploration in the region since 1981 (Office of Technology Assessment, 1985). Through the summer season of 1985 nine exploratory wells have been drilled in the Beaufort Sea. The only discovery to date has been at Shell's Seal Island, located about 15 miles northwest of Prudhoe Bay in 40 feet of water. Sohio Alaska Petroleum Company reportedly spent $140 million to drill its unsuccessful Mukluk exploration well—the costliest dry hole in history. Drilling in Norton Sound has consisted of seven wells without a discovery; twelve wells in the St. George Basin and four wells in the Navarin Basin have been drilled without a discovery (Palmer, pers. comm.).

State and Federal Leasing Programs

The Alaska Department of Natural Resources (ADNR) manages Alaska's subsurface hydrocarbon and mineral resources. Each year the Commissioner of Natural Resources submits to the state legislature a five-year schedule outlining ADNR's plan for leasing Alaska's land. The current Alaska Five-year Leasing Program (1985-1989) calls for 12 sales in the Bering, Chukchi, and Beaufort seas region (Alaska Department of Natural Resources, 1985).

Sale No.	Sale Name	Date	Approximate Area (mi²)
47	Kuparuk Uplands	5/1985	956
45A	North Slope	9/1985	307
48	Kuparuk Uplands	1/1986	816
52	Beaufort Sea	9/1986	288
51	Prudhoe Bay Uplands	1/1987	756
50	Camden Bay	5/1987	198
53	Icy Cape	9/1987	402
54	Kuparuk Uplands	1/1988	800
55	Demarcation Point	5/1988	468
56	Alaska Peninsula	9/1988	2,771
45	Hope Basin	5/1989	3,039
58	Offshore Icy Cape	9/1989	703

The Outer Continental Shelf Lands Act Amendments of 1978 require the Secretary of the Interior to prepare and maintain a 5-Year Outer Continental Shelf Oil and Gas Leasing Program. The U.S. Department of the Interior is currently preparing a program for mid-1986 through mid-1991 (Minerals Management Service, 1985). The proposed program has scheduled 11 sales in the Bering, Chukchi, and Beaufort seas region.

Sale Name	Proposed Date
Navarin Basin	9/1986
Beaufort Sea	12/1986
Chukchi Sea	5/1987
St. George Basin	7/1988
North Aleutian Basin	12/1988
Norton Basin	3/1989
Navarin Basin	9/1989
Beaufort Sea	12/1989
Chukchi Sea	3/1990
St. George Basin	4/1991
Hope Basin	6/1991

Since 1976, over 7,800 square miles (mi²) have been leased in Federal waters off Alaska—over 3,000 mi² in the Beaufort Sea leased in 1979, 1982, and 1984 sales; over 500 mi² in Norton Sound in 1983; almost 850 mi² in the St. George Basin in 1983; and almost 1,500 mi² in the Navarin Basin in 1984. While oil and gas have yet to be produced from these waters, the Federal government has received almost $4.4 billion in bonuses and rents from these leases (Minerals Management Service, 1984).

The Bureau of Land Management (BLM) conducts a leasing program for Federal uplands including competitive sales in the National Petroleum Reserve-Alaska (NPRA) and over-the-counter, noncompetitive openings in all potential basins in the state. The Federal five-year schedule calls for offering over 3,100 mi² in the NPRA every July through 1987. Industry has shown little interest in recent sales.

Industry's interest is increasing in the waters off the Arctic National Wildlife Refuge (ANWR), which occupies over 28,000 mi² of northeastern Alaska. ANWR hydrocarbon resources are estimated at 4.4 billion barrels of oil. Some geologists characterize the coastal strip of the ANWR as the biggest undrilled structure in Alaska.

The Alaska National Interest Lands Conservation Act of 1980 designates part of the ANWR as a wilderness area and also states that the oil and gas potential of the coastal plain can be assessed through seismic operations. Exploration is limited to the area (about 1,900 mi²) between the Canning River and Aichilik River (Beaufort Lagoon) on the coastal plain. In 1985 the Arctic Slope Regional Corporation, through a joint venture with Chevron, Sohio, and BP Alaska, drilled an exploratory well on its lands within the ANWR.

Oil and Gas Activities in the Canadian Arctic

Most of the oil and gas exploration activities in the western Canadian Arctic are taking place in the Beaufort Sea, the Mackenzie Delta region, and the Arctic Islands. Drilling activities in the Canadian Beaufort Sea began in 1972; exploration in the Mackenzie Delta dates from the early 1960s. Since 1972 about 30 wells have been drilled in the Beaufort Sea from artificial islands, a conical drilling unit, and from drillships in deeper waters.

The Canada Oil and Gas Lands Administration (COGLA) is responsible for regulating oil and gas exploration and development north of 60 degrees. COGLA negotiates exploration agreements, grants permits for specific drilling work, and inspects drilling operations (Canada Oil and Gas Lands Administration, 1984).

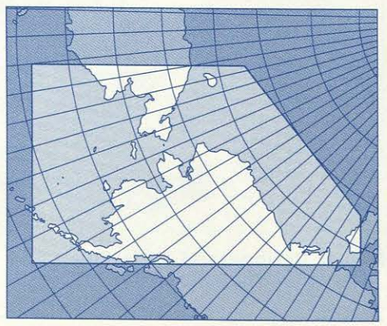
In 1984 COGLA reported that 820 million barrels of oil and 9.9 trillion cubic feet of natural gas had been discovered in the Mackenzie Delta-Beaufort Sea region. The latest estimate of the Geological Survey of Canada for petroleum potential in the Mackenzie Delta-Beaufort Sea is about 9.2 billion barrels of oil and 76 trillion cubic feet of natural gas. Small-scale commercial oil production is expected to begin in the Mackenzie Delta in the early 1990s.

Legend

- Active Federal Leases
- Active State Leases
- Proposed Federal Lease Sale Areas
- Proposed State Lease Sale Areas
- Canadian Land Holdings
- ○ Offshore Exploratory Well

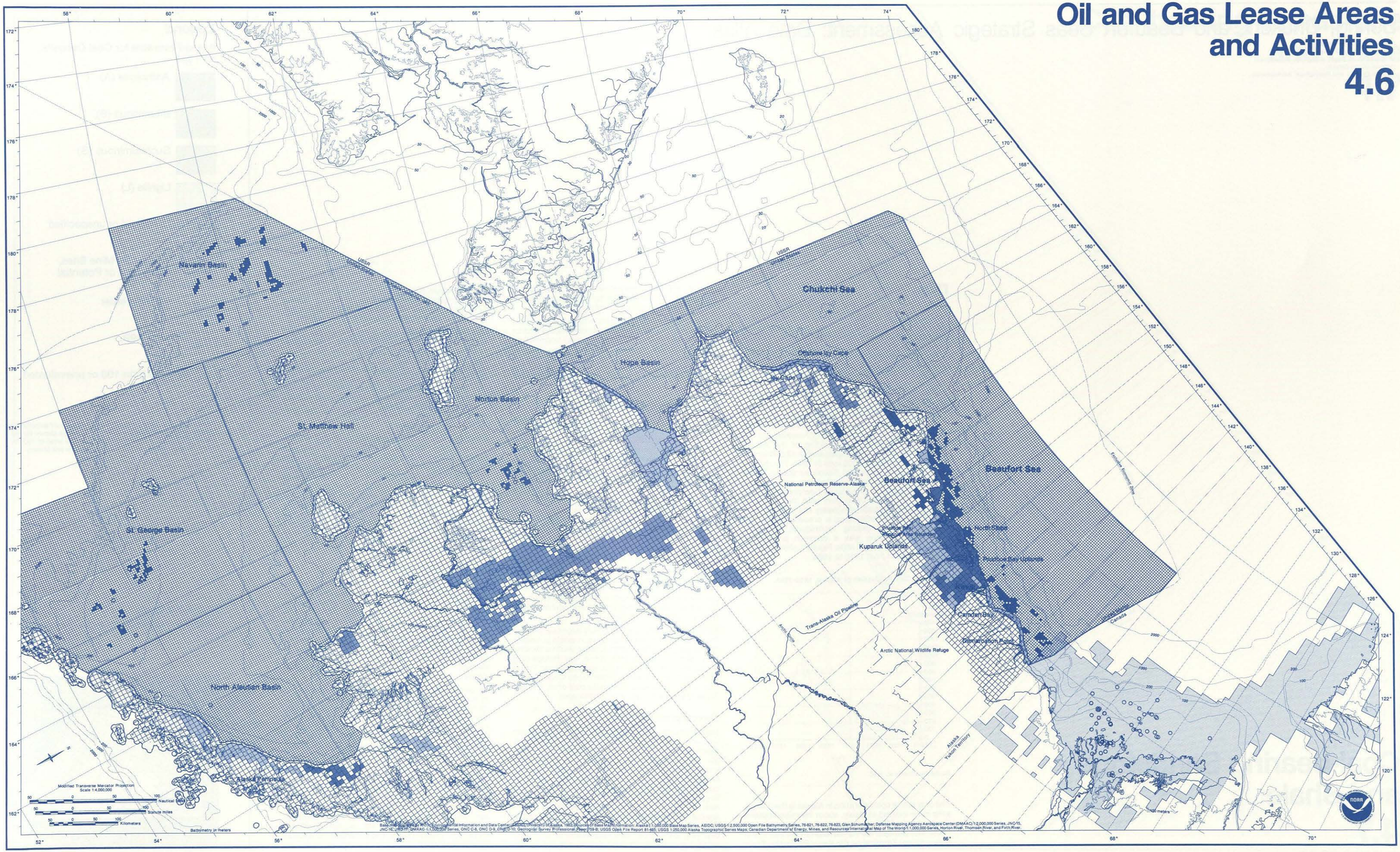
Map References

Arctic Environmental Information and Data Center, 1978; U.S. Congress, 1980; Alaska Department of Natural Resources, 1982, 1985; Minerals Management Service, 1984, 1985; MacLean Hunter Publications, 1985.



Oil and Gas Lease Areas and Activities

4.6



Base map data sources: Environmental Information and Data Center, University of Alaska, 1992; Sources of Base Map Information: Alaska | 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC/15, JNC-NE, JNC-17, DMAAC-L1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

Strategic Assessment Branch
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Coal-bearing Sandstone and Shale

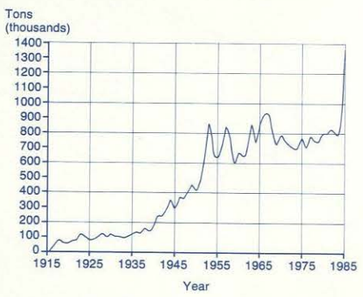
4.7

Description

Alaska has an enormous coal resource, totalling more than 5.5 trillion short tons or about one-half of the estimated coal resources in the USA (Merritt and Hawley, 1986). Although this portends significant development prospects, most Alaskan coal is difficult to exploit due to the harsh environment and lack of adequate transportation facilities. Currently, less than one percent of all American coal is mined in Alaska (Energy Information Administration, 1986).

Coal mining in Alaska was first recorded in 1855 when the Russian American Company mined coal at Port Graham on the Kenai Peninsula (Alaska Geographic Society, 1982). Large scale mining, however, did not occur until 1916 with the building of the Alaska Railroad. Mining increased from almost 13,000 tons in 1916 to more than 170,000 tons in 1940. The military buildup in Anchorage and Fairbanks during World War II resulted in further exploration and development of coal resources in Alaska. Coal production has gradually increased since then, with the 1985 production of 1,370,000 tons being the highest ever (Bundtzen et al., 1986). Coal is presently extracted through surface mining techniques. However, underground mining was a common practice in Alaska up to the early 1960s. Figure 1 shows Alaska coal production from 1915 to 1985.

Figure 1. Coal Production in Alaska, 1915-1985.



Source: Bundtzen et al., 1986.

The only active coal operation in Alaska is the Usibelli strip mine located at Healy, about 75 miles south of Fairbanks. In 1985, almost half of all coal mined at Healy was transported via the Alaska Railroad to the Seward Coal Terminal on the Kenai Peninsula. From Seward, the coal is loaded on 60,000-ton ships and transported to Korea. The terminal, completed in 1984, is Alaska's first deep water coal port.

Coal produced at the Usibelli mine is also used for military and municipal power plants in Alaska and for local home heating. Mining has also occurred, in smaller volumes, at sites along the Alaska Railroad near Nenana, Broad Pass, Costello Creek, and in the Little Susitna and Wishbone Hill areas of the Matanuska Valley (Alaska Geographic Society, 1982).

Types of Coal

Coal is classified and ranked in order of quality by the amount of heat generated during burning. Listed by increasing heat value, the types of coal are: lignite B, lignite A, subbituminous C, subbituminous B, subbituminous A, high volatile C bituminous, high volatile B bituminous, high volatile A bituminous, medium volatile bituminous, low volatile bituminous, semi-anthracite, anthracite, and meta-anthracite (Triplehorn, 1982).

Harder, more compact anthracite and low and medium bituminous coals are more difficult to ignite and are not acceptable for most uses. They are found in the Matunuska Valley and Broad Pass coal fields in southcentral Alaska.

High volatile bituminous coals are easier to ignite, release great quantities of heat, and are the most widely used coal types. This type of coal is found in very large amounts in the Arctic foothills, and in smaller amounts in the Kobuk coal field, the coal location north of Bettles, the Upper Yukon coal area, and the Herendeen Bay-Chignik area.

Subbituminous coal is found in very large quantities in the Arctic Coastal Plain coal area. It exists in smaller quantities in the Cook Inlet-Susitna Basin coal area (the Yentna, Little Susitna, Kenai, and Beluga coal fields), the Nenana coal fields, and the Upper Yukon coal area. Lignite is found in the Arctic Coastal Plain coal area, the Seward Peninsula coal area, and the Broad Pass lignite field near Anchorage.

Development Areas

Many of Alaska's coal-rich regions are remote, posing logistical difficulties for development. The North Slope, for example, may contain the world's largest coal province. However, it is also one of the least known and least probable for large-scale development. Access and transportation difficulties, in addition to the lack of a large local market, make large-scale development in this area unlikely in the near future. Small villages located near the resource are the most likely consumers of local coal mining. On the Arctic Coastal Plain, thick, wet tundra vegetation overlying permafrost generally restricts coal outcrops to areas along streams. Southward, toward the Brooks Range, high-quality coal is found in progressively greater quantities and increasing quality. Locations include the Corwin Bluffs, the Cape Beaufort area, and the Kukpowruk River valley.

The interior of Alaska (the area between the Alaska and Brooks ranges) contains several areas where coal-bearing rocks occur. Alaska's best-known field (the Healy Creek field) and only active mine are located in this part of the State. While the potential for further development in this area is good, exploration costs are high, and transportation difficulties, again, are limiting factors for development (Alaska Geographic Society, 1982).

Transportation

Large volumes of coal must be moved by ship or train. Transportation facilities for bulk products in Alaska are not very well developed (Map 4.12). The potential for developing the necessary facilities is decreased by severe climatic and geographic barriers, such as the Alaska and Brooks mountain ranges, hundreds of miles of tundra wetlands, intense cold for long periods of time, periods of total darkness, and seasonal fog. The icebound coast of the northern half of Alaska limits ocean access to Alaska's largest coal province on the North Slope. In addition, large coal carrier ships require very deep harbors, which are not present in much of the State.

Environmental Considerations

The environmental impacts of coal development include erosion, siltation, water quality degradation, and land disturbance. Erosion has severe effects on aquatic organisms through sedimentation of nearby waters. Excessive siltation of rivers and above-normal sediment loads in glacial streams, rivers, and lakes adversely affect the wildlife habitat. Salmon, for instance, are sensitive to increases in siltation. Chemical contamination results from substances leached from coal piles and other exposed surfaces in mines.

Large-scale coal development will create disruptions of large areas of land and result in temporary or permanent loss of habitat for a variety of species. Migration routes of animals such as caribou, moose, and migratory waterfowl could also be disrupted. Alteration of surface drainage and groundwater flow patterns by mining activities also has adverse effects on water quality and wildlife habitat.

The Future

The volume of coal production in Alaska is unlikely to increase significantly in the short term. However, as fuel demand and costs rise, exploitation of Alaska's vast coal resources becomes more likely. Development of these resources will require significant investment in an improved and expanded transportation infrastructure.

Legend

Areas Favorable for Coal Deposits, by Type

- Anthracite (A)
- Bituminous (B)
- Subbituminous (S)
- Lignite (L)
- Unranked or unspecified

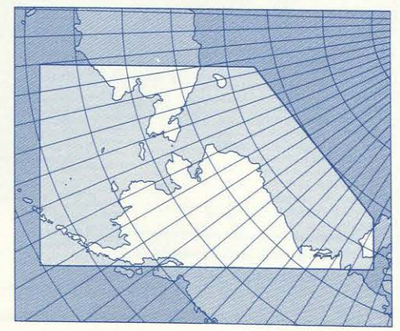
Existing or Potential Mine Sites, Million Tons of Past or Potential Production

- 500 or greater
- 100 - 499
- Less than 100 or unevaluated

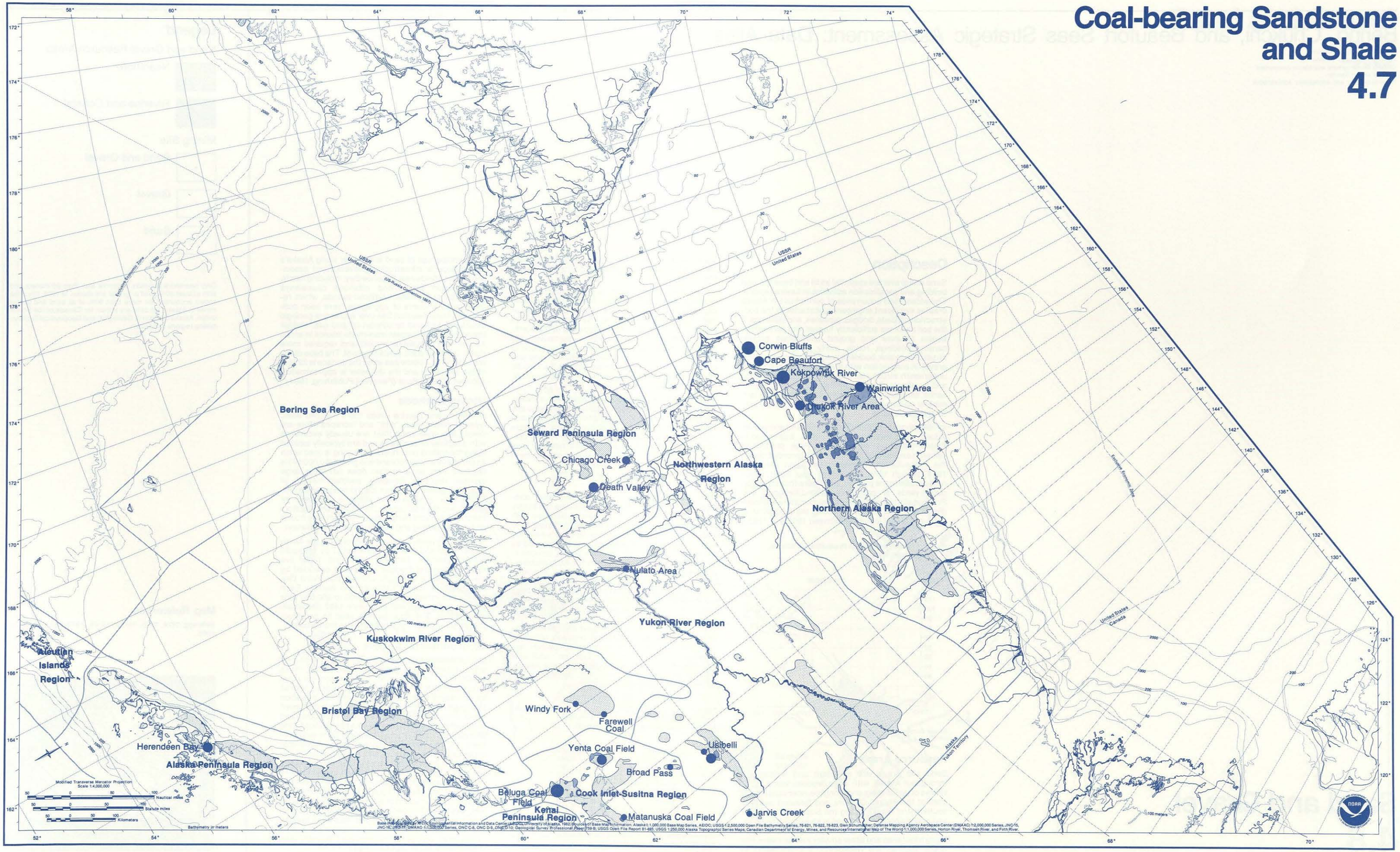
The Usibelli Mine, approximately 75 miles south of Fairbanks, is the only active coal mine in Alaska. No data are shown for the USSR or Canada or for the Aleutian Islands west of 162°W longitude. US Bureau of Mines mining regions are shown.

Map References

Arctic Environmental Information and Data Center, 1982.



Coal-bearing Sandstone and Shale
4.7



Base map sources: Arctic Environmental Information and Data Center (AEIDC), University of Alaska, 1982; Sources of Base Map Information: Alaska1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-8, ONC D-10; Geological Survey Professional Paper 739-B; USGS Open File Report 81-685; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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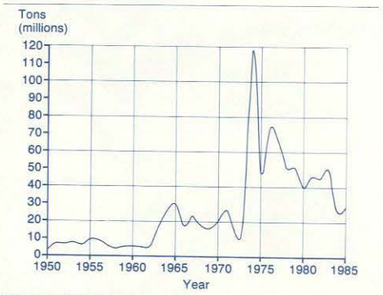
Sand and Gravel
4.8

Description

Sand and gravel are essential as fill and base for road building and construction activities in tundra regions. The widespread occurrence of permafrost in Alaska creates significant engineering obstacles in the construction of roads, bridges, pipelines, and buildings. If the soil becomes sufficiently heated, the permafrost begins to thaw and ground subsidence occurs, causing buildings, roads, utility poles, and other structures to sink, buckle or warp. However, sand and gravel, in conjunction with an insulating material laid underneath structures, prevent ground subsidence and its effects. Because of their engineering significance, sand and gravel are two of the most important mineral commodities in Alaska, ranking behind only oil and gas in value.

In 1985, more than 28 million tons of sand and gravel, valued at an estimated $112 million, was mined in Alaska (Bundtzen et al., 1986). Peak production values in excess of $200 million were recorded during the Trans-Alaska Pipeline construction period of 1974 through 1976. The Alaska Haul Road, which runs parallel to the pipeline, used more than 25 million cubic yards of gravel between Livengood and Prudhoe alone, a distance of approximately 450 miles (Robertson, 1981). Figure 1 shows the production of sand and gravel in Alaska between 1950 and 1985.

Figure 1. Sand and Gravel Production in Alaska, 1950-1985.



Source: Bundtzen et al., 1986.

Resource Areas

Sand and gravel are abundant and widespread throughout Alaska, with large deposits found in the valleys of major rivers and along the inner continental shelf of the Bering, Chukchi, and Beaufort seas. In southcentral Alaska, along the Susitna River, sand and gravel deposits are found in stream channels, on floodplains and terraces surrounding the river, and along tributaries and other smaller nearby rivers. For rivers such as the Kuskokwim and Nushagak in southwestern Alaska, the major source of sediment input are the glacial and stream deposits carried from the Alaska Range.

Large deposits of sand occur throughout the drainage basin of the Yukon River, with extensive deposits on the Yukon Delta, along the Yukon River near Fort Yukon, and along the Tanana River (a tributary of the Yukon) near Fairbanks. In the northwest, the Kobuk and Noatak rivers—particularly the mouth of the Kobuk—have major concentrations of sand and gravel. In the Arctic, significant sand and gravel deposits occur in areas east of the Colville River, along the Kuparuk, Shaviovik, Sagavanirktok, Kavik, and Canning rivers.

Areas presently supplying aggregate for development include glacio-fluvial deposits in Anchorage and the Matanuska Valley, gravel gold mine tailings and floodplain deposits near Fairbanks, and deposits along the North Slope. Other areas in Alaska providing sand and gravel supplies are typically local sources meeting needs for community development and highway construction projects.

Economic Development

Sand and gravel are high-bulk, low-value commodities. To be economically competitive, the supply source must be close to its market. Because both these mineral resources are widely distributed, sand and gravel mining in Alaska usually occurs near the area of demand. Site selection is also influenced by the quantity and quality of the material, amount of processing required, site preparation and rehabilitation requirements, and environmental concerns about the area. Sand and gravel are transported almost exclusively by barge and truck. They are used extensively in oil-related activities of the North Slope (Map 4.6) and for development in the cities of Anchorage and Fairbanks. Table 1 shows the average annual production of sand and gravel in the seven mining regions of Alaska between 1981 and 1985. The data shown for each region, however, are incomplete and do not include an additional 3.8 million tons mined each year throughout Alaska. Most of this additional production occurred in the northern and southcentral regions.

Table 1. Average Annual Sand and Gravel Production in Alaska Mining Regions, 1981-1985 (volume in thousands of tons).

Northern	25,507
Southcentral	6,266
Eastern Interior	1,263
Southeastern	297
Alaska Peninsula	134
Southwestern	69
Western	18
Other	3,837
Total	37,391

Sources: Bundtzen, Eakins and Conwell, 1982; Eakins et al., 1983; Bundtzen et al., 1984; Eakins et al., 1985; Bundtzen et al., 1986.

The principal use of sand and gravel along Alaska's North Slope is infrastructure development associated with oil fields near Prudhoe Bay, including roads, construction pads, and offshore causeways (Bundtzen et al., 1986). Artificial islands, which require large amounts of aggregate, have been constructed in the Beaufort Sea over submarine geologic structures believed to contain oil and gas. Mukluk Island, one of the largest man-made islands in arctic Alaska, was completed in 1983 and required more than 1.2 million cubic yards of gravel. The base of the island is 48 feet below sea level, the surface is 22 feet above sea level, and the diameter is approximately 350 feet at its surface (PennWell Publishing, 1984).

Mining Methods

In coastal and riverine areas there are two basic types of mining sites, "pits" and "scrapes." Pits are deeply dug open areas that are usually excavated with draglines or backhoes and are typically located along floodplains near rivers. Pit mining is used when an extensive amount of sand and gravel (50,000m³) is required from an area that does not have large exposed deposits. Scraping, another method of excavation, uses bulldozers to strip away thin surface layers over a large area within a floodplain or abandoned channel (Joyce, Rundquist, and Moulton, 1980). On the North Slope, gravel deposits are frozen and require drilling and blasting prior to excavation.

In selected rivers, bays, and lagoons on the North Slope, sand and gravel are extracted by hydraulic floating dredges. Between 1982 and 1985, five hydraulic floating dredges owned and operated by the North Slope Borough, worked near Point Lay, Wainwright, Atkasuk, Kaktovik, and Barrow. Each dredge has mined between 150,000 to 300,000 tons of sand and gravel each year since 1982 (Bundtzen et al., 1986). The aggregate is used to construct roads, runways, and other facilities in the borough.

Environmental Effects

Gravel removal can alter the environment in several ways. Effects from gravel scraping along rivers include the alteration of channel configuration, removal of bank and instream cover, loss of habitat for fish and wildlife, creation of potential migration blockages, development of potential fish entrapment areas, and increased turbidity (Joyce, Rundquist, and Moulton, 1980). When a stream is affected locally, the change often causes long- and short-term modifications to the stream channel for considerable distances, both upstream and downstream. During excavation, channel morphology and sedimentation patterns change. If the modification is extensive, stream channel readjustment may take several decades or may never occur. Impacts from dredging include the destruction of submerged bottom habitat and associated organisms, alteration of bottom topography, modification of the sediment budget, changes in the sediment character and water quality in the area dredged, and increased turbidity and resedimentation in adjacent areas.

Legend

Sand and Gravel Resource Areas

- Nearshore
- Riverine and Coastal

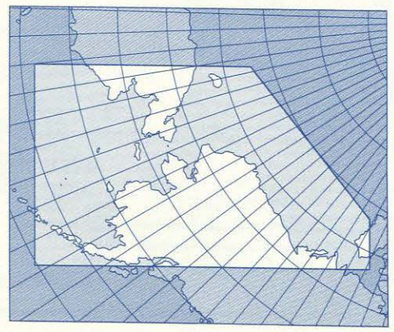
Mining Site

- Sand and Gravel
- Gravel
- Sand

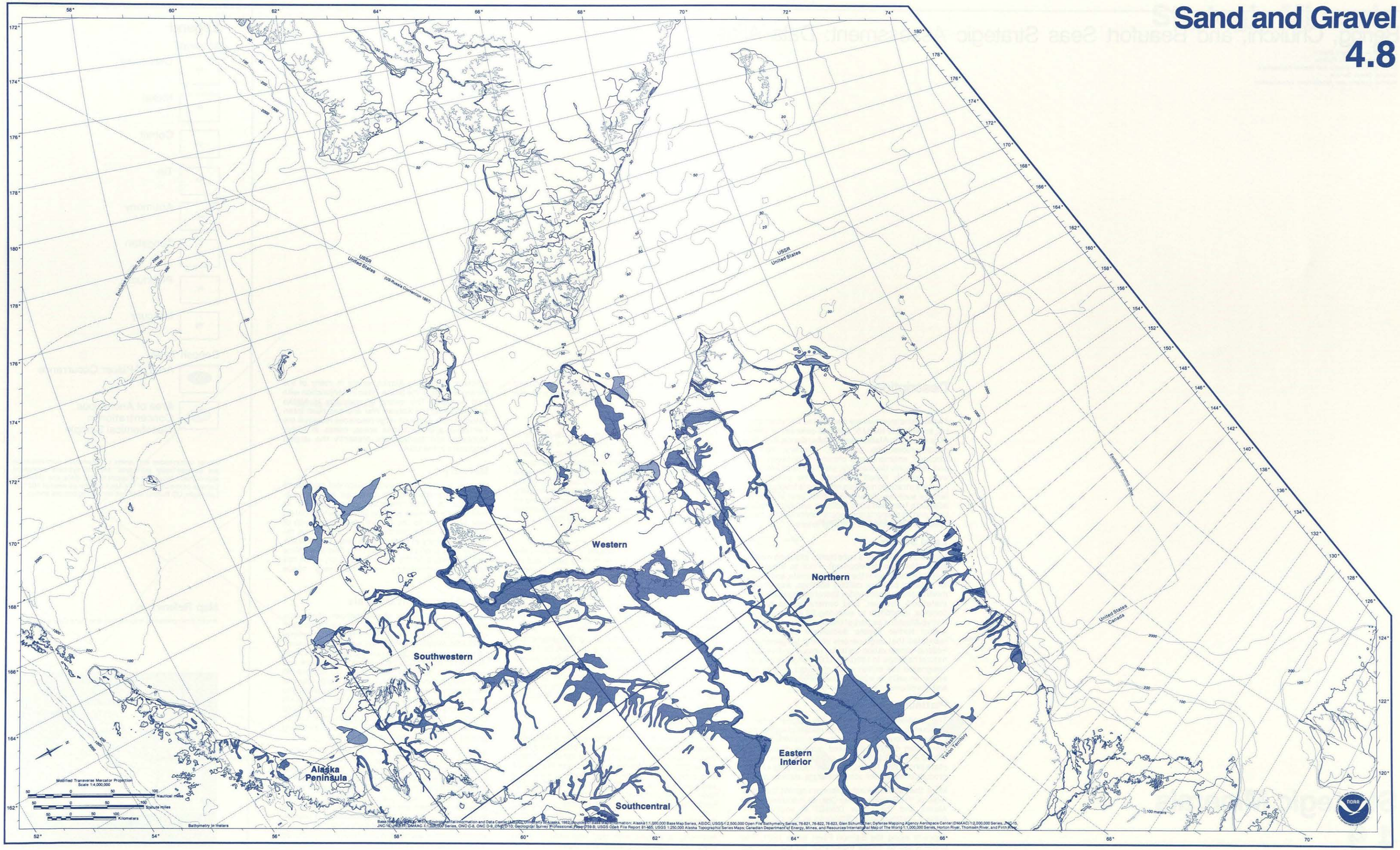
Only nearshore deposits in depths less than 20 meters and with at least 80% sand or gravel are shown. In 1985, the sites shown accounted for more than 90% of all sand and gravel mined in Alaska. No data are shown for Canada or the Soviet Union. Alaska Division of Geological and Geophysical Surveys mining regions are shown.

Map References

Selkregg, 1974, 1975, 1976a, 1976b, 1977; Bundtzen et al., 1986.



Sand and Gravel
4.8



Base map data sources: MMS Environmental Information and Data Center (AEIDC), University of Alaska, 1982; Source for data and information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, ONC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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Strategic Minerals
4.9

Description

Twenty-nine minerals are designated as "strategic", i.e., essential to the U.S. national defense. Of these, 18 are found in Alaska, many in abundance, including cobalt, nickel, tin, platinum, mercury, fluorine, tungsten, antimony, and chromium. Between 1980 and 1985, only tin, mercury, platinum, and antimony were actively mined in Alaska. The potential of Alaska's strategic minerals resource is favorable, but factors such as climate, unsettled land status, inadequate transportation facilities, and high production and transportation costs continue to make development unlikely in the near future.

Land Status

Land status has had a substantial effect on mineral exploration and development. Prior to statehood, most of Alaska was in the Federal domain, and except for national parks or military holdings, was open to mineral development under liberal mining laws. Since statehood, however, land ownership has become complex. In addition to awarding 22 million acres to Native Alaskans as part of their aboriginal rights, the Alaska Native Claims Settlement Act of 1971 mandated that large parcels of land be placed into Federal conservation units for unique and valuable natural heritage. In 1980, the U.S. Congress officially designated 104 million acres of Alaska land as conservation units, in which further mineral exploration and development is restricted (Map 5.2).

Platinum

The automotive industry is the largest user of platinum, a precious metal that resists chemical corrosion. Although no platinum was mined in 1985, more than 660,000 thousand ounces of platinum, valued at about $65 million, have been mined in the state since 1880. Platinum is often recovered as a by-product of mining for other minerals, such as gold.

More than 98% of Alaska platinum comes from two regions, the Goodnews Bay District in southwestern Alaska and the Hyder District in southeastern Alaska. Platinum was discovered in the Goodnews Bay District in 1926, and has been mined from placer deposits along the Salmon River since 1937. The prime areas for future exploration for platinum are located in mineral belts in southwestern Alaska, and in igneous rock complexes of southeastern Alaska (Alaska Geographic Society, 1982).

Chromium

The steel industry depends on a steady supply of chromium, an important metal used in producing alloys and in electroplating. Chromium deposits occur in at least six major mineral belts in Alaska, but the metal has been mined only on the Kenai Peninsula where production has been largely subsidized by the Federal Government (Alaska Geographic Society, 1982). The Red Mountain deposits near Seldovia on the Kenai Peninsula may contain one of the largest deposits of low-grade chromium in the Nation.

Tin

Tin is an important metal because of its anticorrosive properties, its relatively low melting point, and its malleability. Tin is used as a component in metal alloys and bronze and brass products, and for solder. Alaska is the largest primary source of tin in the USA, producing over 100,000 pounds of tin annually (Bundtzen et al., 1986). Tin mining occurs on the western Seward Peninsula near Nome and in the Manley area near Fairbanks.

The Lost River Mine on the Seward Peninsula contains the largest reserve of tin in the USA. Estimates for 1971 placed the tin capacity of the mine in excess of 124 million pounds (Alaska Geographic Society, 1982). Although the Lost River Mine only operated during the Korean War, exploration drilling near the mine and adjacent deposits continues (Bundtzen, 1983).

Tungsten

Tungsten has a high melting point, making it a valuable component in tools and other hardware. Modest amounts of tungsten were mined in Alaska during both World Wars and the Korean War. Since then, production has sharply declined, but significant tungsten resources have been located near the Lost River tin deposits, at the Stepovich Lode near Fairbanks, and at other scattered sites.

Antimony

Antimony is alloyed with lead and used in cable sheathings, battery plates, and pipes. Antimony, which is plentiful in Alaska, exists in many of the mining regions of the State, often in conjunction with gold deposits. The mining of antimony in Alaska peaked during the Korean War and has been intermittent since. Although large resources remain in the Fairbanks and Kantishna areas, mines in Idaho, Montana, and Nevada are presently the largest producers in the USA.

Mercury

Mercury is used in producing electrical equipment and in the preparation of chemicals and pharmaceuticals. A large mercury mining district in southwestern Alaska extends from Marsh Mountain near Dillingham to the Cripple Mountains north of McGrath. A dozen mines in this region have recovered mercury at various times since World War I. The largest producer has been the Red Devil Mine near Sleetmute on the Kuskokwim River, which has operated intermittently since the early 1940s (Bundtzen, 1983).

Other Important Minerals

Large mineral deposits of gold, copper, silver, iron, lead, molybdenum, uranium, and zinc have also been identified throughout Alaska. However, these mineral resources remain largely untapped because Alaska's climate and limited transportation systems (Map 4.12) have made mineral exploration slow and costly. Although these minerals are not designated as strategic, they are important in the manufacture of a wide variety of commodities, ranging from jewelry to steel. All have been mined to some extent in Alaska in spite of the many constraints to development. Gold mining in 1985 accounted for about $61 million, more than for any other non-fuel mineral (except sand and gravel) in Alaska (Bundtzen et al., 1986).

Strategic minerals in Alaska provide the USA with a valuable national resource. The development of Alaskan minerals is dependent primarily upon national and international demand and also limited by other factors such as climate, transportation costs, and unsettled land status. Although strategic minerals in Alaska are not currently in demand, the eventual development of these resources is seen by many Alaskans as a means of diversifying the state's economy and of decreasing USA reliance on imported mineral resources (Tuck, 1984).

Legend

Minerals

- Cr — Chromium
- Ni — Nickel
- Co — Cobalt
- Sn — Tin
- Sb — Antimony
- W — Tungsten
- Pt — Platinum
- Hg — Mercury

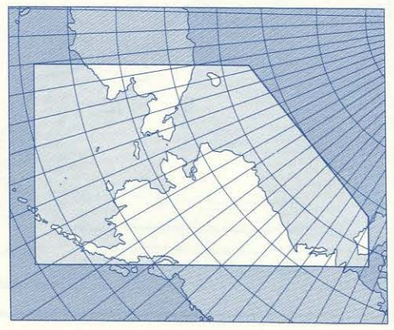
Deposit Type

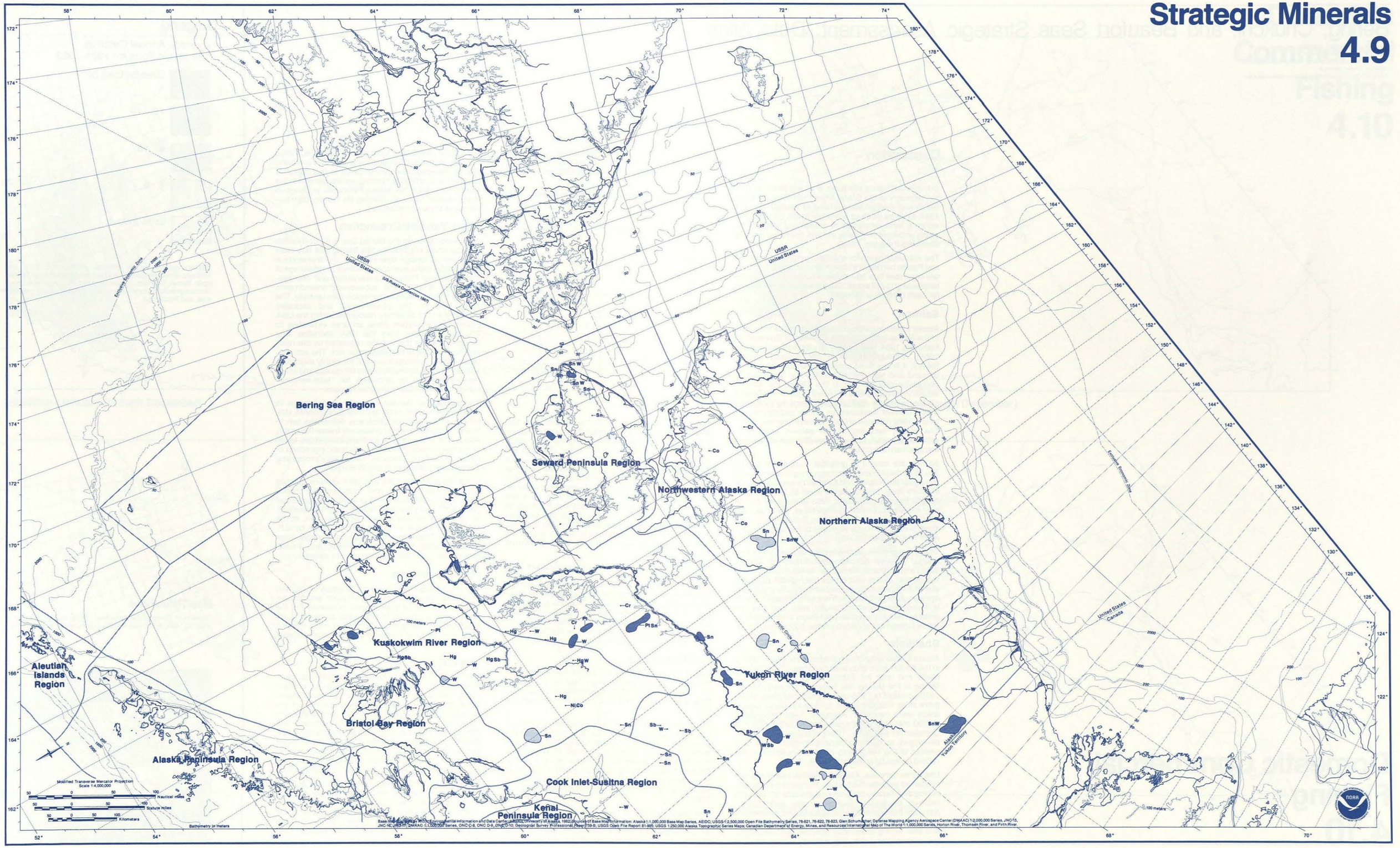
- Area of Placer Occurrence
- Area of Anomalous Concentration in Geochemical Sample

Placer occurrences and areas of anomalous concentration are schematically portrayed. Mineral symbols represent approximate locations of deposits. No data are shown in Canada or the USSR, or the Aleutian Islands west of 162° W. Longitude. US Bureau of Mines mining regions are shown.

Map References

Arctic Environmental Information and Data Center, 1982.





Base map data courtesy of the Environmental Information and Data Center (EIDC), University of Alaska, 1982.Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, JNC-17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-385; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
National Oceanic and Atmospheric Administration

Domestic Commercial Fishing
4.10

Description

Commercial fishing in Alaska is an important part of the economy of the State. More than $509 million in finfish and shellfish were landed at Alaskan ports in 1984, twice as much as any other state. Up to 25,000 workers were employed in processing and wholesaling activities in Alaska in 1985 (National Fishery Statistics Program, 1986).

The volume of catch for shellfish, groundfish, salmon, and Pacific herring are shown on four maps. The data are organized into 30-minute latitude by one-degree longitude grid cell areas. Seasonal ranges are shown for each of the four fisheries.

Salmon

Alaska's salmon catch accounted for more than 90% of the Nation's total in 1983 (Division of Commercial Fisheries, 1984; National Fishery Statistics Program, 1984). Although salmon is not Alaska's largest fishery, it is the most profitable because of its high demand and high market value. After low levels in population and harvest in the 1970s, the salmon industry has rebounded to record highs. From a catch of approximately 60,000 metric tons in 1974, the State harvest increased to about 282,000 metric tons in 1983 (Division of Commercial Fisheries, 1984). The recent recovery of the salmon industry is attributed, in part, to the implementation of fisheries management legislation.

Salmon are caught in greatest numbers in Bristol Bay, with the principal catch occurring in and near the mouths of the Naknek and Kvichak rivers. An average of more than 34,000 metric tons of salmon were caught between 1981 and 1983 in the area on the map at the mouth of the Kvichak River. Sockeye is the species caught most heavily in Bristol Bay, while chum is caught in large numbers to the north (Yukon River to Kotzebue Sound).

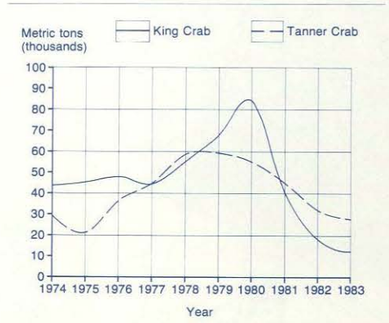
Of the five species (sockeye, chinook, pink, coho, and chum), sockeye typically constitutes the largest catch and produces the highest revenues. Chinook is the largest in size and brings the highest price per pound. Pink and coho, while commercially important, are also dominant sport fish in western Alaska. Chum is found throughout the study area, and has the greatest nutritional value. Life history distributions of these salmon are shown on maps 3.22 through 3.26.

Shellfish

Alaska's crab industry originated after World War II in the Kodiak area and spread westward, first for king crabs and later for Tanner crabs. Domestic crab fishing in the Bering Sea began in the early to mid 1970s, peaked in 1980, and has declined since. While more than 139,000 metric tons of king and Tanner crabs were caught in Alaska in 1980, only about 40,000 metric tons were recorded in 1983 (Division of Commercial Fisheries, 1984). Foreign crab fishing developed with the Japanese in the 1930s and peaked in the 1960s with catches approaching the record domestic levels of the late 1970s.

Like other fisheries, Alaska's shellfish resources are subject to periodic fluctuation. Population increases in king and Tanner crabs during the late 1970s were followed by drastic declines in the early 1980s. Although management strategies were implemented to reduce the allowable harvest for depressed stocks and limit fishing of severely affected fisheries, shellfish populations have only recently improved. The dramatic decline in the crab populations in the region is thought to be a function of several factors including fishing, parasitism, and climatic fluctuations.

Figure 1. King and Tanner Crab Catch in Alaska, 1974-1983.



Source: Division of Commercial Fisheries, 1984.

The shellfish included on the map are Korean hair (Map 3.11), bairdi Tanner (Map 3.15), opilio Tanner (Map 3.16), blue king (Map 3.14), golden king (Map 3.12), and red king (Map 3.13) crabs. Shellfish are caught throughout the year in the Bering Sea, with peak period of catch varying by species. With the enormous volume of gear currently available, most of the seasonal catch for king or Tanner crabs can be taken in a short time, from several days to a few weeks. For king crabs the largest catch occurs in September, in March for Tanner crabs, and between March and May for Korean hair crabs. The greatest catch of shellfish in the study area occurs east of the Pribilof Islands along the Bering Sea continental shelf.

Exploration for alternative crab resources has resulted in the harvest of golden king crab, mainly from the Bering Sea region. Substantial catches have also occurred in the central Aleutians from the Adak area, and around Dutch Harbor. Since the golden king crab is a deeper water species, conventional king crab fishing methods may be inefficient. New or modified fishing gear may promote the crab as a commercially viable resource (Browning, 1980).

Pacific Herring

Pacific herring have been caught commercially in Alaska for more than a century. Herring are caught for the valuable roe which is exported to Japan. The fishery is also exploited as a source for fish meal and oils.

The large market for herring roe makes the timing of the seasonal catch critical. Large schools of herring winter under the ice in the Bering Sea (Maps 1.8, 1.9) before spawning occurs from April through June. Herring catch occurs during these spring months. Recent Alaska herring seasons (1981-1983) have been productive, with annual catches exceeding 40,000 metric tons (Division of Commercial Fisheries, 1984).

The largest volume of herring are caught along the northern Bristol Bay coast, especially in Togiak Bay. An annual average of more than 11,000 metric tons of herring were caught between 1977 and 1982 in this area alone (Division of Commercial Fisheries, 1985). Another important herring fishing ground is in Norton Sound. However, the overall catch in this region is less than in Bristol Bay. Herring are also caught in the Bering Sea along the Alaska Peninsula, although in much smaller volumes. Herring life history distributions are shown on map 3.21.

Joint-Venture Groundfish

A growing fishery in the Bering Sea is for bottomfish or groundfish. Historically, the Bering Sea has been exploited by foreign operators for the tremendous groundfish stocks available. However, the passage of the Magnuson Fishery Conservation and Management Act of 1976 and subsequent amendments altered foreign fishing in the region substantially. The Act called for the conservation and exclusive management of all fishery resources within the USA Fishery Conservation Zone, an area extending to 200 nautical miles from the USA shoreline. Any foreign fishing in this zone is regulated by the rules and restrictions of the Magnuson Act. The Act protects fishery resources (except for highly migratory species of tuna) by instituting catch quotas and other restrictions, and by providing for "joint-venture" fishing opportunities with other nations.

The passage of the Act allowed U.S. fishermen to enter a new market. In the joint-venture process, U.S. fishermen harvest the catch and deliver the fish to foreign factory ships that process or freeze the catch. About 60% of the catch is sold to factory ships. Much of the fish is made into surimi, the basic ingredient of imitation seafood products. Two surimi processing plants have been built in Dutch Harbor.

Since the passage of the Act, joint-venture catches have increased every year, with walleye pollock (Map 3.32), yellowfin sole (Map 3.33), and Pacific cod (Map 3.31) being the most heavily caught groundfish. In 1980, U.S. fishermen took less than 10% of the catch; now almost all of the catch is taken by U.S. fishermen. Since domestic processing capabilities currently exist for salmon, shellfish, and Pacific herring, joint-venture fisheries are not necessary.

Fish Processing

The processing of fish takes place mainly at sea and at Alaskan ports such as Dutch Harbor and Akutan. The catch is sold as fresh, frozen, or canned and the roe of several species is processed as caviar. Less desirable fish and remaining parts are made into fish meal, fertilizer, and animal feed. Fish oil is retrieved for processing.

The Future

The development of Alaska fisheries has been influenced by economic factors such as interest rates, fuel costs, and competition. Of equal importance, however, are changes in abundance of the resource. For example, the Alaska fishing industry has been affected by the cyclical increases and decreases in major salmon runs and king crab stocks. Declining harvests of crabs have forced a major sector of that industry to consider alternate resources. Former crab vessel operators are converting to bottomfish joint ventures and cod production.

The price of pollock and cod products has doubled over the past several years. As many as 30 U.S. factory ships may be in operation by the end of 1987. The large increase in joint-venture production over the past several years is, in part, a result of the Magnuson Fishery Conservation and Management Act and its amendments.

Legend

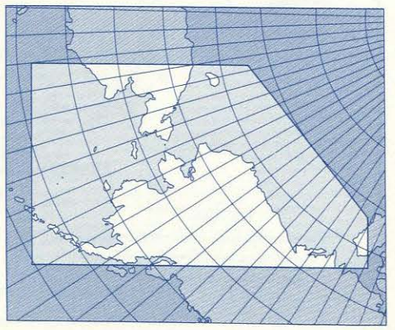
Average Annual Catch in 100 Metric Tons for 1981-1983

- Greater than 50
- 16 - 49
- 6 - 15
- 1 - 5
- Less than 1

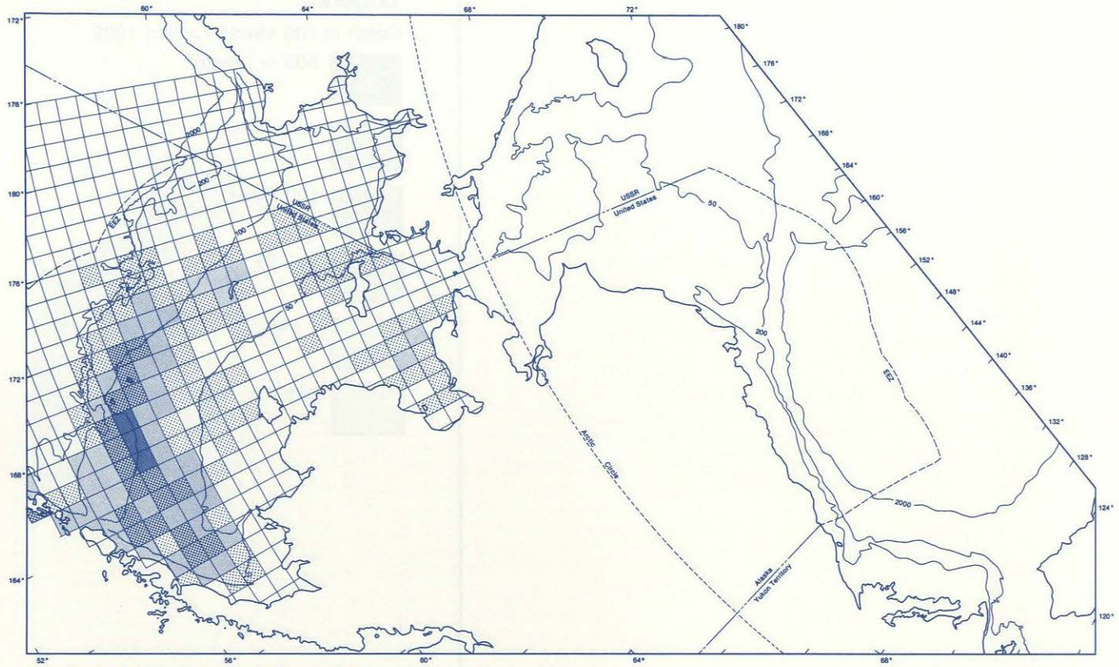
Salmon species include chinook, chum, coho, pink, and sockeye. Shellfish species include Korean hair, bairdi Tanner, opilio Tanner, blue king, golden king, and red king crabs. Joint-venture groundfish catch is primarily walleye pollock, yellowfin sole, and Pacific cod.

Map References

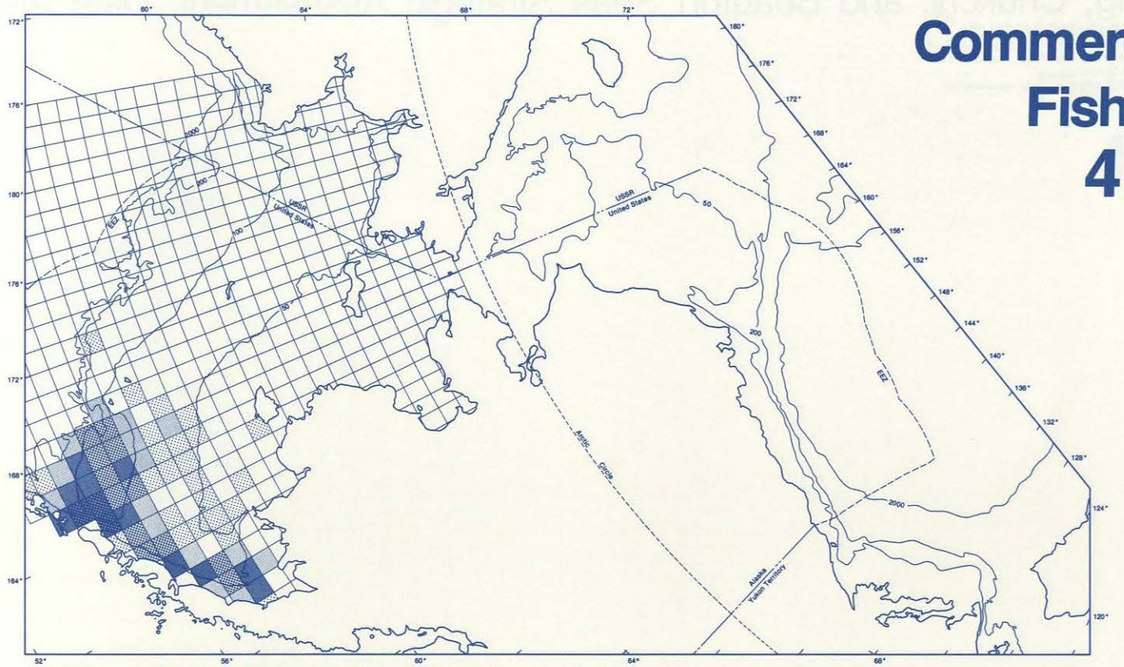
Division of Commercial Fisheries, 1985a, 1985b; Division of Habitat, 1985; Northwest and Alaska Fisheries Center, 1986.



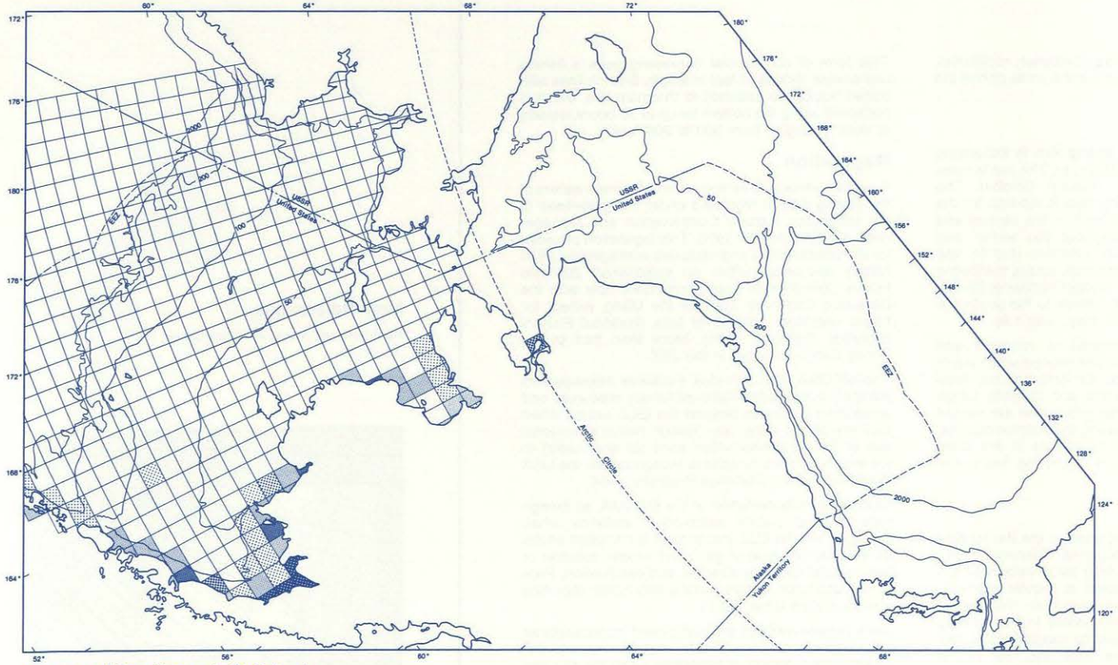
Domestic Commercial Fishing 4.10



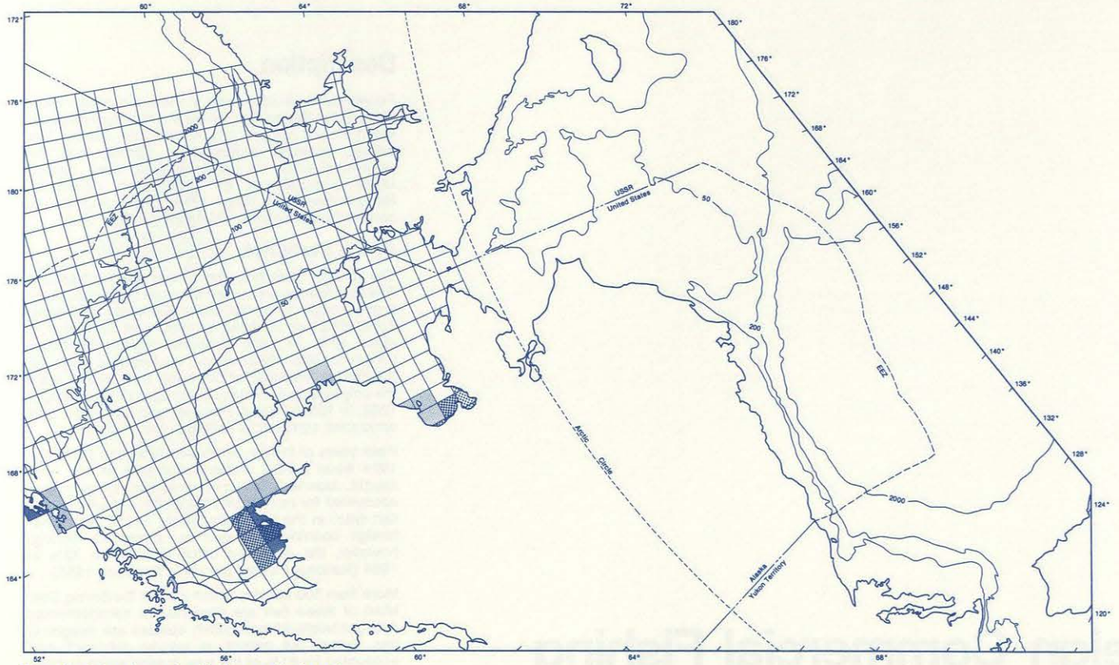
Shellfish (January through December)



Joint-Venture Groundfish (January through December)



Salmon (May through October)



Pacific Herring (April through June)

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Legend

Catch in 100 Metric Tons in 1982

- 500 or greater
- 250 - 499
- 100 - 249
- 50 - 99
- 1 - 49
- less than 1

Foreign Commercial Fishing
4.11

Description

Foreign commercial fishing in the arctic region takes place in the Bering Sea, where the mixing of relatively warm Pacific waters and nutrient-rich Bering Sea waters, seasonal extremes in climate, and the expansive nature of the continental shelf support large populations of groundfish (Bakkala, Hirschberger, and King, 1979). This map shows annual foreign commercial catch data for 1982.

Catch Statistics

The foreign catch from the eastern Bering Sea and Aleutian Islands accounted for more than 85% of the foreign catch from the entire Exclusive Economic Zone (EEZ) of the USA in 1982 and increased to about 87% in 1984 (National Fishery Statistics Program, 1983, 1985). Japan, the Republic of Korea, the Federal Republic of Germany, and Taiwan were the only foreign countries operating in these waters in 1982. In 1984, Poland, Portugal, and the USSR also conducted commercial fishing in this region.

Peak years of foreign catch were between 1971 and 1974 when 2.0-2.3 million metric tons of fish were caught. Japanese fishing operations historically have accounted for more than 75% of the annual groundfish catch in the Bering Sea (Low, 1981). With other foreign countries engaged in commercial fishing, however, the Japanese catch dropped to 72% in 1984 (National Fishery Statistics Program, 1985).

More than 300 species of fish inhabit the Bering Sea. Most of these fish are demersal or semidemersal. Approximately 31 groundfish species are caught in this region, but pollock is clearly dominant and accounted for 81% of the total foreign catch in 1982 and for 78% in 1984 (National Fishery Statistics Program, 1985). Other leading commercial species in the eastern Bering Sea and the Aleutians include flounders, yellowfin sole (Map 3.33), Pacific cod (Map 3.31), and Atka mackeral, Sablefish, rockfishes, and Pacific ocean perch represent a small part of the foreign fishery.

Ice Effects

Commercial fishing in the Bering Sea is influenced significantly by marine ice (Map 1.8). The sea is completely ice-free from July through October. The southern and western Bering Sea is ice-free for the entire year, while ice covers much of the eastern and northern Bering Sea throughout the winter and spring. Sea ice reaches its southern limit in late March, when the ice edge stretches across the Bering Sea from Bristol Bay to the southern coast of Siberia and approaches the Pribilof Islands to the south. Ice retreat begins in late April or May (Map 1.9).

Fishing activity is concentrated in southern and western waters during the colder months when warm Pacific Ocean currents and air temperatures keep this portion of the sea ice-free and fishable. Large numbers of pollock and other groundfish are caught in the eastern Bering Sea during the warmer months. Cool waters cause pollock to migrate to the outer continental shelf and slope of the Bering Sea in the winter months.

Fishing Methods

Trawling is the chief method used in the Bering Sea by foreign commercial fishermen (Hanley, 1984). With this method, vessels drag large nets near the seafloor and haul them aboard at regular intervals. Two types of trawlers are used in the Bering Sea—pair trawlers and stern trawlers. In pair trawling two vessels operate together by dragging one net. Stern trawlers work the net from the rear of the vessel. Service vessels that process and freeze the catch often accompany these trawling vessels.

Longline fishing, used to catch sablefish and Pacific cod, is a method used primarily by the Japanese. This form of commercial harvesting uses a fishing line several thousand feet in length. Branch lines with baited hooks are attached to the main line, which is anchored along the bottom for up to 30 hours, usually at depths ranging from 300 to 900 feet.

Regulation

Foreign commercial fishing within American waters of the Bering Sea is regulated under the guidelines of the Magnuson Fishery Conservation and Management Act (MFCMA) of 1976. This legislation provides for the conservation and exclusive management of all fishery resources within an established 200-mile fishery conservation zone (coincident now with the Exclusive Economic Zone of the USA), except for highly migratory species of tuna (National Fishery Statistics Program, 1984). More than half of the Bering Sea is included in the EEZ.

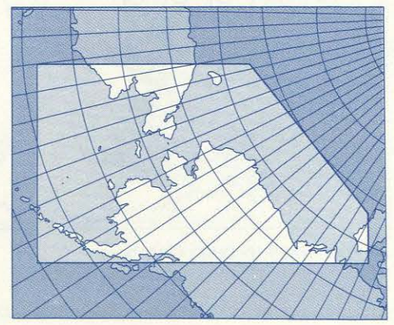
The MFCMA also provides exclusive management authority over continental shelf fishery resources and anadromous species beyond the EEZ, except when they are found within any foreign nation's territorial sea or fishery conservation zone (or equivalent) to the extent that sea or zone is recognized by the USA (National Fishery Statistics Program, 1984).

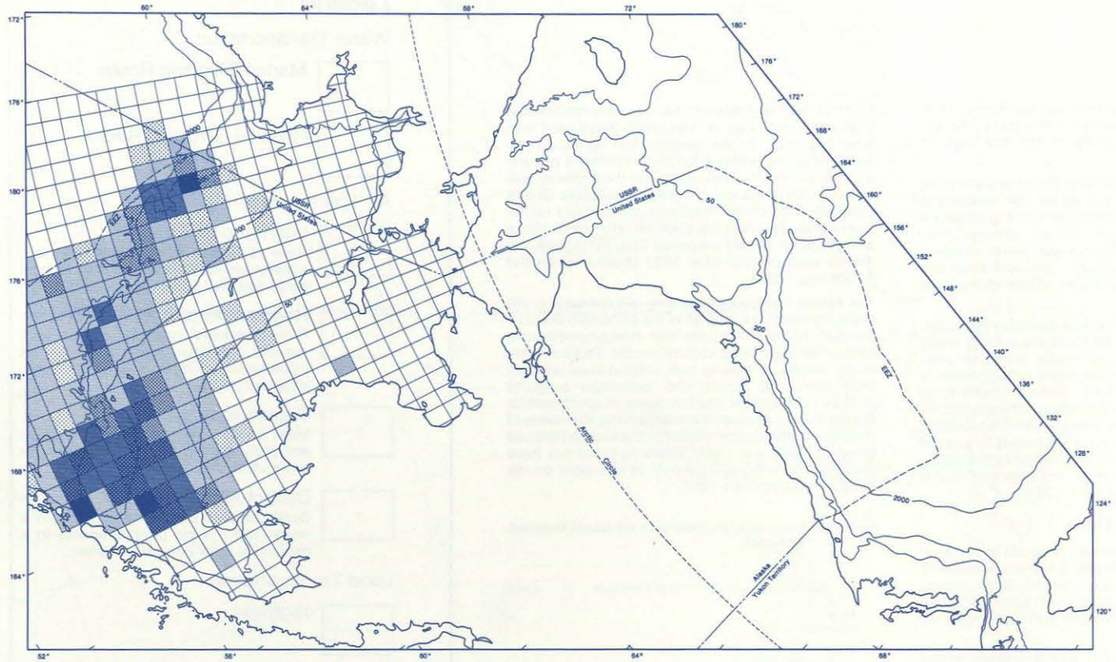
Since the implementation of the MFCMA, all foreign nations must submit catch-effort statistics when fishing within the EEZ. Information is compiled on the date of fishing, type of gear and vessel, location of fishing, total catch by species, and catch-effort. Prior to this legislation, Japan was the only nation reporting statistical data (Low, 1981).

Joint-venture catches are being used increasingly as a method of protecting USA fishery resources. In this arrangement, American fishermen catch the fish and load them onto foreign vessels. In 1983, joint-venture catches of trawl fish off Alaska more than doubled for the fifth consecutive year (National Fishery Statistics Program, 1984, 1985).

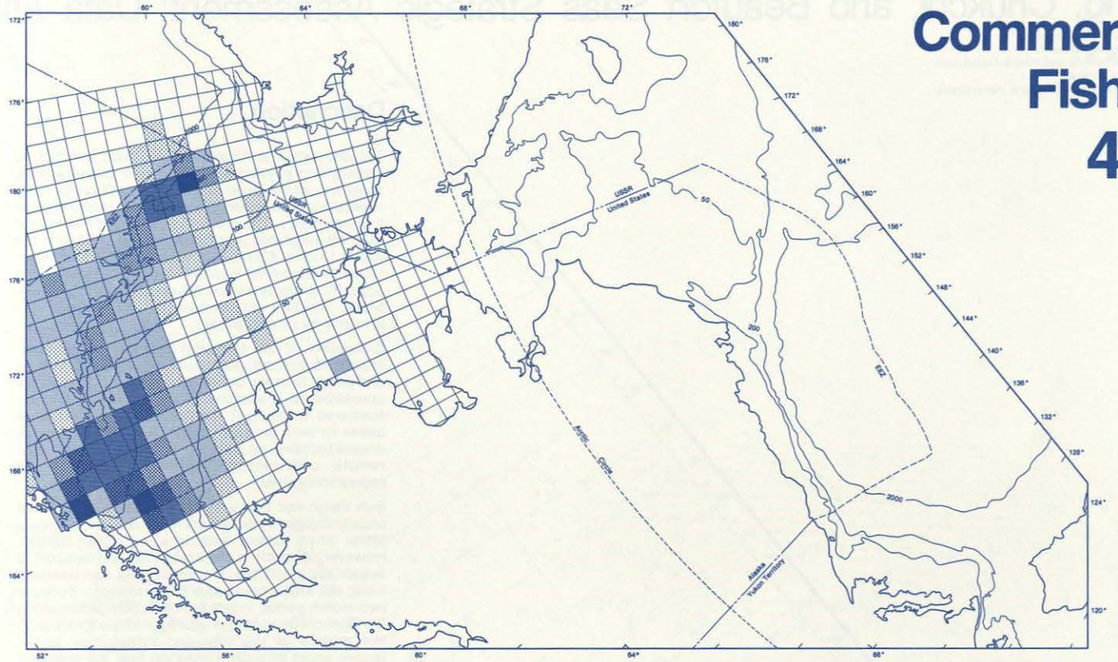
Map References

Northwest and Alaska Fisheries Center, n.d.

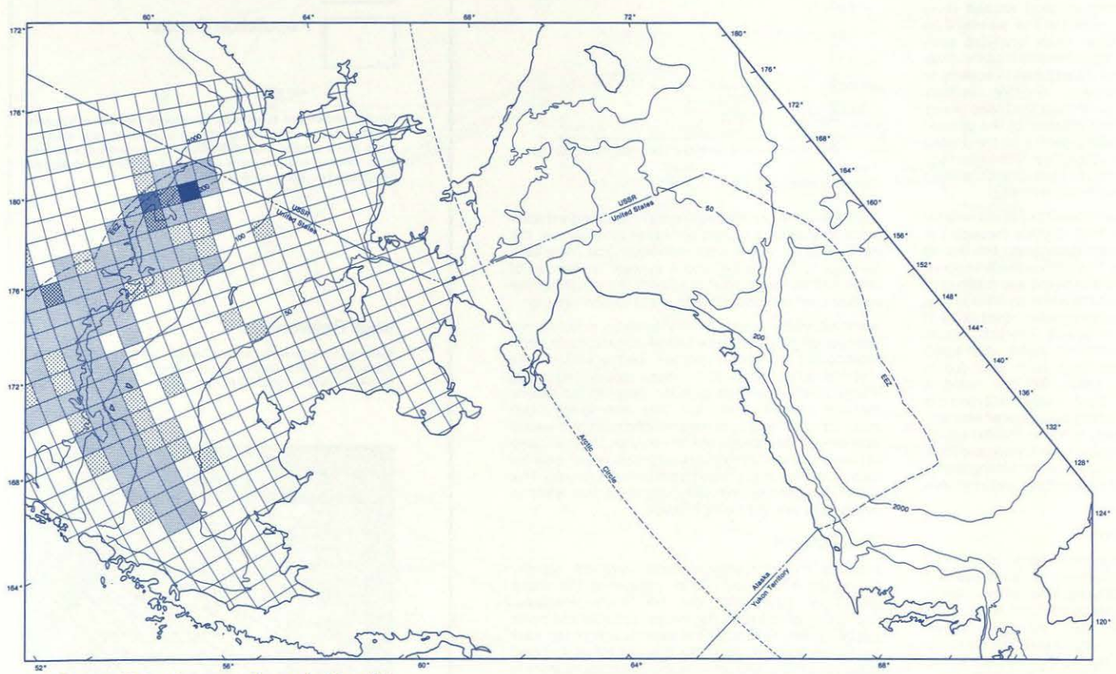




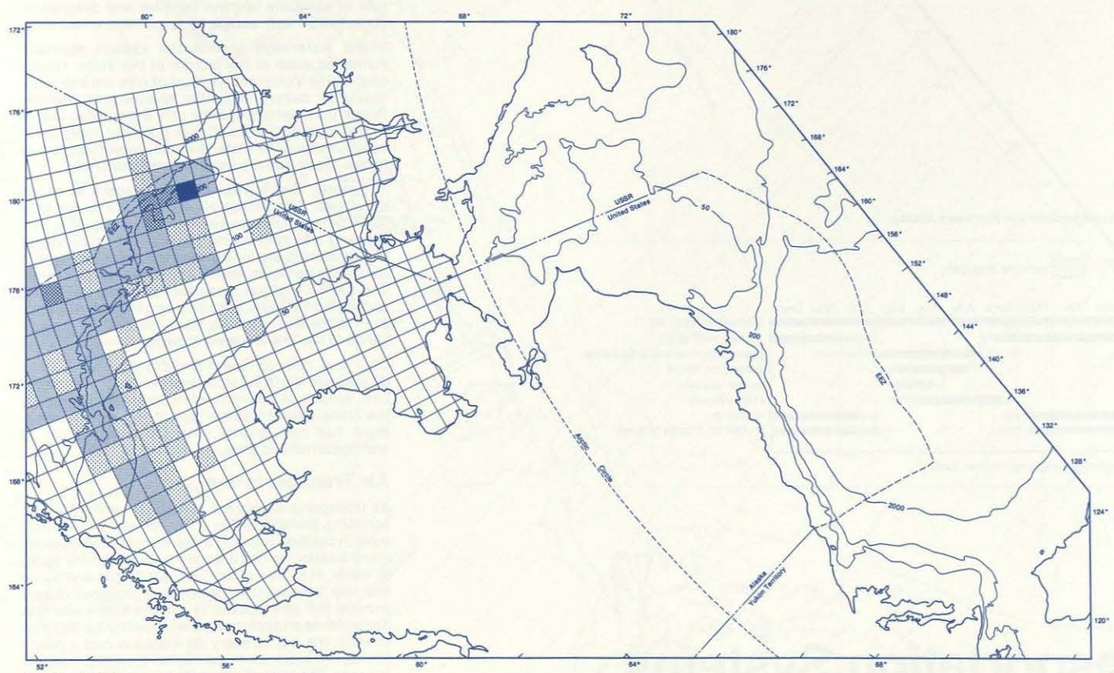
All Groundfish (January through December)



Pollock (January through December)



All Groundfish (January through March)



Pollock (January through March)

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

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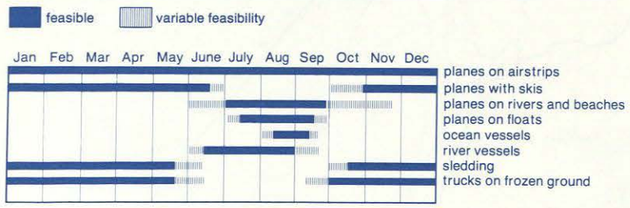
Transportation Feasibility in Northern Alaska



Source: National Foreign Assessment Center, 1978.

Transportation Systems
4.12

Description

Transportation in Alaska is very much affected by climate and physiography. Sub-zero temperatures, rough mountainous terrain, and permafrost all make special adaptations of common means of transportation necessary. The inset chart shows the seasonal restrictions placed on different modes of travel in the Arctic. Much of Alaska's air, water, and land transportation development is closely related to military and scientific projects and oil development on the North Slope. Alaska's connections to other areas are primarily by air and water.

Expansion of air transport has had substantial effects, facilitating year-round movement of people and goods to many places that were previously only accessible on a seasonal basis. Numerous airfields scattered throughout the Alaskan arctic serve as bases for both propeller and jet aircraft and provide access to towns, most larger Native settlements, and remote construction, industrial, research, and recreational sites.

Bulk cargo and heavy freight bound for Alaska are usually shipped by ocean-going vessels, such as container ships, ocean freighters, or ocean barges. However, in much of the state, marine transport is seasonally restricted. Marine vessels can navigate along the arctic coast east of Barrow only during a two-month period in late summer. Navigation along the Chukchi Sea coast is usually possible for three to five months of the year and increasingly longer farther south through the Bering Sea. Ice breakers could be used for access during freeze-up, but are prohibitively expensive given the quantity and value of the goods shipped. Shallow coastal waters and the lack of adequate terminal facilities and deep-water ports further limit access for large marine vessels.

Inland waterways provide the easiest approach routes to much of the interior of the state. Rivers, such as the Yukon and the Kuskokwim, are important routes for barges and other shallow draft vessels. Water transportation is the only economical way to move large quantities of bulk goods to most small communities in the state. In winter, some rivers act as frozen roads and are used for vehicular traffic.

In general, land transportation in Alaska is underdeveloped. The Alaska Highway is the major land route between Alaska and the rest of the USA. The Highway was built during World War II to provide a more secure route for the movement of supplies and personnel between Alaska and the lower 48 states. The Dalton Highway, the route between Fairbanks and the North Slope, is the only land link to the oilfields at Prudhoe Bay. It also is a service road for maintenance of the Trans-Alaska Pipeline.

Only one railroad line transects Alaska north of 60 degrees North latitude, the Anchorage-Fairbanks Line, which provided much of the logistical support for the Trans-Alaska Pipeline project. Highway development has had priority over the construction of additional railroad lines.

Air Transportation

Air transportation plays a special role in the Alaskan economy. Because of the harsh climate and the difficulty in building roads in a permafrost environment, many interior settlements are accessible only by air or water. In winter, when rivers are frozen and barge and ship movement is not possible, airplanes usually provide the only access to remote locations. This dependence on airplanes is evidenced by the fact that in 1981 one out of every 40 Alaskans had a pilot's license—a ratio six times higher than the national average. The ratio of one plane for every 54 Alaskans was 12 times the national average (Alaska Northwest Publishing, 1982).

The Alaska Department of Transportation and Public Facilities has developed a six-tiered classification system to describe the facilities and services at each of the more than 1,000 airfields in the state. The airports shown on the map fall in the four highest categories of air service.

Less than ten percent of the airports in the state have paved runways. Gravel and water (for seaplanes) runways are the most common, accounting for about two-thirds of all runways. Gravel runways predominate in the north of the state; water runways predominate in the south. Dirt, turf, and steel are other types of runway surfaces found at Alaskan airports.

Ownership of airports in Alaska also varies by region. In the south, almost one-fourth of the landing areas are in the public domain (primarily bases for seaplanes). In the north, less than ten percent of the fields are in the public domain. Federal ownership/operation of airports also is greater in the south than in the north (15 percent vs. nine percent). Statewide, about one-third of the airports are owned by private concerns and another third are owned by the state. Municipalities own fewer than three percent of the airports in the state (TRA/Farr, 1986).

Water Transportation

Unlike air travel, the movement of goods by water is very much limited by climate. Frozen coastal and ocean waters make passage difficult, if not impossible, for most of the year in northern Alaska. The sea ice maps (1.8, 1.9) show conditions in the study area throughout the year.

Port infrastructures are not well developed in the Arctic. Shallow waters make berthing of large ocean-going vessels impossible at most of the population centers shown. Sites where dredging or natural conditions permit the handling of large vessels have developed into shipping hubs for the surrounding communities. In these deeper water locations, such as Bethel and Dillingham, large vessels transfer their goods to smaller vessels for distribution to coastal or upstream population centers. Another delivery method employs lighterage vessels that take goods from large vessels anchored offshore to the coastal communities. The only docking facility on the Alaska Beaufort Sea coast is at Prudhoe Bay. Although many shipping routes are shown in the study area, traffic on most of these routes is extremely limited.

Unimak Pass is an important transit point, not only for the many marine species that migrate through the region, but also for ships going between the Bering Sea and the Pacific Ocean. The Pass is the first opening available to ships in the westward and northward movement of goods through the Aleutian Islands. It is on the great circle route between west coast ports of the USA and ports in the Orient. The U.S. Coast Guard estimates that between 3,000 and 4,000 vessels move through the Pass each year (Louis Berger and Associates, 1984). Besides being a shorter route to the Near East, traffic transiting the Bering Sea westward generally finds better weather conditions than ships using a North Pacific route. Traffic through the Pass includes the annual sea lift to the Beaufort Sea, foreign and domestic fishing fleets, and cargo ships visiting the Near East and northern and western Alaska.

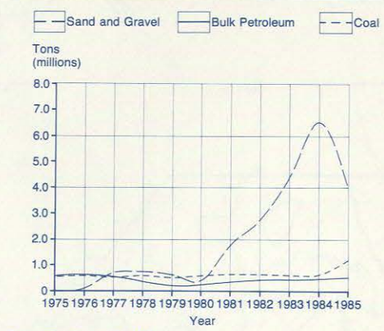
Land Transportation

Highway and railroad systems have played an important part in the development of resources and the delivery of services in Alaska. Most of the state is not accessible by automobile or train, but most of the larger population centers are linked by paved highways designed for year-round use. The distance by highway between the state's two largest cities, Anchorage and Fairbanks, is approximately 360 miles.

The Dalton Highway, also known as the North Slope Haul Road, connects Prudhoe Bay with Fairbanks and points south. This road, primarily gravel, was originally built to suppport oil and gas exploration and production activities on the North Slope, and was later important in the construction of the Trans-Alaska Pipeline, which it parallels. While the pipeline was under construction, access to the Highway was limited, but it is now open to the general public. Gravel roads, like the Dalton Highway, are the rule rather than the exception in the state as only one-fourth of all highways in Alaska are paved. The first highways in Alaska were completed in 1923 (Alaska Northwest Publishing, 1982).

The Alaska Railroad, one of only two railroads in the state, connects the interior of the state with ports on the Gulf of Alaska and Cook Inlet. It was completed in 1923, after eight years of construction. This line is the major means of moving bulk commodities such as coal, sand and gravel, and petroleum products between the interior and the coast of south-central Alaska. Figure 1 shows the trends in the shipments of the three leading commodities on the Alaska Railroad between 1975 and 1985. These commodities have made up more than 80 percent of all freight on the Alaska Railroad since 1981.

Figure 1. Commodity Shipments on the Alaska Railroad, 1975-1985.



Source: Bundtzen et al., 1986.

Travel on tundra requires specially adapted vehicles since depressions caused by normal tires will scar the landscape for years. One technique that minimizes damage to the fragile tundra surface is the use of large balloon-like tires that spread the weight of the vehicle over a broader surface and lessen sinking.

More traditional means of moving about in the Arctic, such as dogsleds, kayaks and skinboats, have been replaced by motorized vehicles like the snowmobile and the outboard engine. These modern forms of transportation provide greater mobility for Native hunters and fishermen, but they also have forced most, if not all, Native communities into a cash-based economy. Cash is required not only for the purchase of these forms of modern transportation, but also for their use (gasoline, oil) and maintenance (parts). The social and environmental impacts of this shift in technology are still being studied.

The Future

Alaska's transportation network evolved rapidly during the 1960s and 1970s, paralleling the sharp growth in population and the state economy. Expansion of railroads, highways, airfields and ports will be closely related to the exploitation of the vast resources found in the state. If prices for oil and gas, minerals, timber, and other resources in abundance in Alaska rise, the demand for transportation connections to the more remote parts of the state will increase. The presence of ice and other environmental conditions will continue to play an important role in any arctic transportation system.

Legend

Water Transportation

Marine Shipping Route

Riverine Shipping Route

Air Transportation

International Airport
Have scheduled international and interstate jet service and serve as statewide air cargo and mail distribution centers.

Regional Airport
Provide primary intrastate access to a regional population center of more than 1,000 persons and serve as primary transshipment points.

Transport Airport
Meet special needs to support regional and statewide economic development or other unusual circumstances.

District Airport
Serve as secondary access points in a region and provide primary access to a medium to large population center.

Land Transportation

Highway

Railroad

Population Center

Routes shown are schematic. Two lower classes of airports, community and local, are not shown. Community and local airports serve smaller population centers throughout the state. Nine hundred and forty nine of the 988 airports in Alaska fall into these two lower categories.

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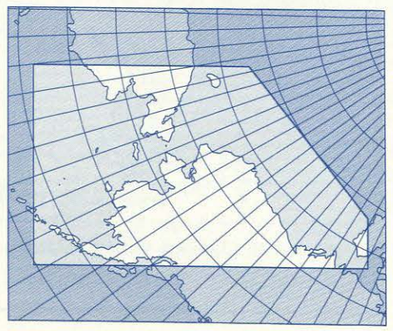
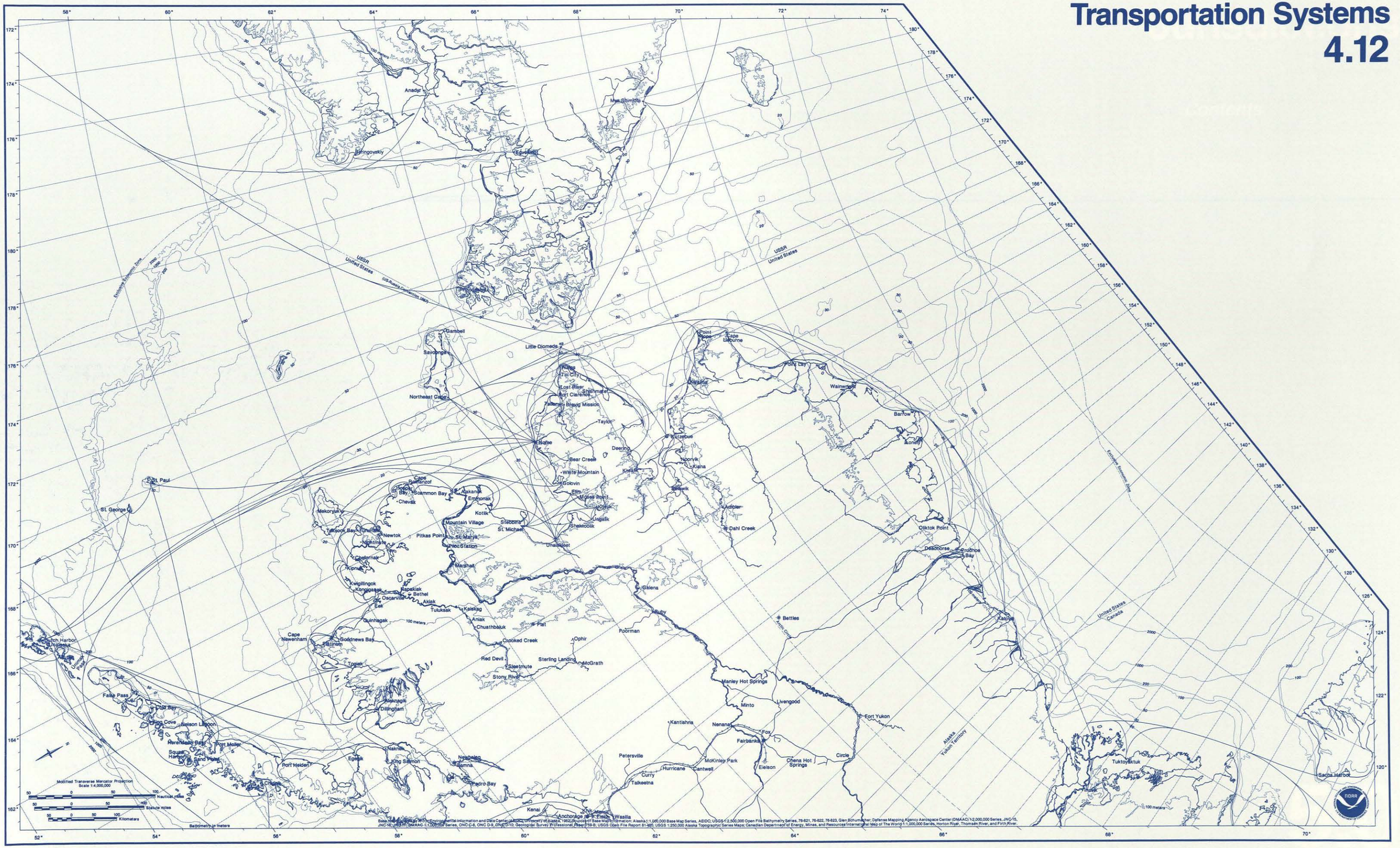


Transportation Systems
4.12



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Jurisdictions

Introduction

Understanding the range of international, national, and state jurisdictions and authorities, as well as their laws and regulations, is as important to effective management as understanding the complexities of the physical and biological environment. The two maps in this section depict jurisdictional boundaries within the study area. The first map shows political boundaries of the region, including marine waters, and the limits of Federal, State, and borough jurisdictions. The second map illustrates the extensive system of wildlife refuges, parks, reserves, and other protected areas within the State of Alaska. Jurisdictions are an important element of the institutional framework that affects almost all resource use decisions, including the harvest and use of living marine resources, which are particularly important in the study area.

The study area focuses primarily on the coastal areas of Alaska and adjacent waters and also includes lands and waters of the USSR and Canada. As elsewhere in the USA, specific authorities are divided among Federal, State, and local governments. Two important differences between Alaska and the rest of the USA are the extent of Federal protected areas and the considerable land holdings and subsistence-use rights of Native Alaskans. Specific Federal and State legislation relating to the requirements for management within certain areas—such as the Marine Mammal Protection Act and the Outer Continental Shelf Lands Act Amendments—are discussed in previous sections (Section 3, Mammals Subsection Introduction; Maps 3.66-3.77, 4.4, and 4.6).

Federal Government

The Federal Government has jurisdiction over 456,700 nautical square miles (nmi^2) of offshore waters from three miles offshore to the limits of the U.S. Exclusive Economic Zone (EEZ) in the Bering, Chukchi, and Beaufort seas. Outer continental shelf lands under Federal jurisdiction in this region cover 216,500 nmi^2, making it one of the largest oceanic areas to manage. The Federal Government also manages Federal lands, including national parks and preserves, wildlife refuges, and other protected areas within the State of Alaska.

The limits of the U.S. Exclusive Economic Zone (EEZ) and the sovereign rights that the U.S. exercises within that zone are based on the intent of the United Nations Law of the Sea Convention of 1982, which the U.S. has not yet ratified. The Magnuson Fishery Management and Conservation Act of 1972 defined U.S. rights to manage fishery resources within 200 miles of shore. A presidential proclamation of March 10, 1983 formally incorporated the waters of the newly established EEZ into law. Within this zone the U.S. claims sovereign rights to explore, manage, and exploit living and nonliving resources, manage construction of artificial structures, and protect the maritime environment. The Federal Government exercises sole jurisdiction within the EEZ, seaward of three miles from the coastal baseline; the State of Alaska has authority over the area from the baseline out to three miles.

The Federal Government has jurisdiction over more lands in Alaska than in any other state. Federal lands amount to about 225 million acres, or 60 percent of the State. The extent of these lands results primarily from Federal acquisitions prior to statehood in 1959 and from the Alaska National Interest Lands Conservation Act (ANILCA) of 1980. ANILCA placed more than 97 million acres of the State of Alaska into new and expanded national forests, parks, wildlife refuges, and wilderness areas. As map 5.2 shows, most of the coastal areas are included in one of these Federally protected categories. These lands, in combination with Federal authority in marine waters, make the Federal Government the principal in many development and resource use decisions about both the land and the marine portions of the study area.

State of Alaska

Within its three-mile marine boundary, the State of Alaska exercises sovereign jurisdiction over natural resources found in an area of almost 10,000 nmi^2. Particularly important has been the development of the Prudhoe Bay oil fields. Production from these fields increased the share of State revenues derived from oil and gas production to over 80 percent. The State has extensive lands within the study area; one half of the lands in the Alaska State Park System are located in the study area. Game refuges, sanctuaries, and critical habitat areas, also under the jurisdiction of State agencies, are located in the southwest portion of the study area.

Regional government plays a lesser role in resource use decisions in Alaska. The principal regional governmental units are boroughs. Three of the State's twelve boroughs—Bristol Bay, Northwest Arctic, and North Slope—cover extensive portions of the coastal region. The Northwest Arctic Borough, organized in June 1986, replaces the Kobuk census area.

Native Alaskans

Native Alaskans hold rights to considerable land areas within the State and are a major force in resource use decisions. The Alaska Organic Act of 1884 was the first legislation containing provisions recognizing the need to preserve aboriginal land rights. The Alaska Native Claims Settlement Act (ANCSA) of 1971 granted fee simple title to approximately 40 million acres of land in the State to Native peoples, including complete ownership of subsurface mineral resources. Many of these lands coincide with or border protected areas. Twelve Native corporations were established to manage these lands and the revenues they generate; their boundaries were drawn to reflect common cultures as closely as possible. Six of the the nine corporations in the study area cover extensive portions along the coast. The treatment of Native Alaskans contrasts with that of Indians from the lower 48 states, where tribes were moved to reservations and made wards of the Federal Government after their lands were taken by treaty.

Subsistence use (maps 4.3-4.5) of living resources is the dominant activity in areas controlled by Native Alaskans, but mineral and oil resource exploitation will undoubtedly play an important role in future resource use decisions. Several pieces of legislation give traditional Native subsistence uses priority over other uses of lands and waters under Federal or State jurisdiction, such as in wildlife refuges.

Regional Issues

At present, a boundary dispute exists concerning the limits of the EEZ between the USA and the USSR. The area in dispute is a portion of the Bering Sea lying between the U.S.-Russia Convention Line of 1867 and the limits of the EEZ as defined by the former U.S. Fishery Conservation Zone. A second dispute stems from Canada's claim of the 141st meridian as the international boundary in the Beaufort Sea versus the U.S. claim of an equidistant line. Both disputes involve areas that are thought to have oil and gas reserves. The dispute with the USSR also involves fishery resources.

Additionally, the State of Alaska has requested that it assume responsibility for the management of marine mammals in the study area, including Federal waters, as had been the case prior to passage of the Marine Mammal Protection Act of 1972. However, no agreement to turn this authority back to the State has been reached, primarily because of differing Federal and State perceptions about the value and use of marine mammals as resources.

Resource Relationships

Jurisdictions have their origins in history and politics. Although some have been established based on resource distributions, jurisdictional boundaries often conflict with natural boundaries (e.g., physiographic boundaries such as the continental slope) that determine resource distributions. The distribution of migratory fishes (e.g., salmons, Maps 3.22-3.26), birds (e.g., waterfowl, Maps 3.43-3.50), and mammals (e.g., gray whale, Map 3.76) are examples of the disparity between jurisdictions and resources. Management of these resources requires international, Federal, and State agency cooperation, as well as consultation with various Native Alaskan resource commissions.

Although many large State and Federal protected areas exist within Alaska, they cannot encompass the total range of species that migrates over considerable areas. For example, protected areas have not prevented the decline of geese in the Yukon-Kuskokwim Delta (Maps 3.44-3.47); the migratory nature of these birds and the different patterns of use and habitat alteration at the extremes of their ranges makes management and protection difficult. For the marine portion of the study area, there is no equivalent to these terrestrial protected areas.

Regional jurisdictions often do not coincide with subsistence use by Native peoples. Villages and regional corporations have disagreed over which lands should be selected for protection. Villages are interested in protecting the subsistence resources they depend upon, while regional corporations desire lands that are economically profitable. Additionally, land ownership under the corporations contrasts with traditional subsistence use patterns and social beliefs.

Management of oil and gas under the seafloor and of fisheries in the water column is often conducted in the same areas by different agencies. This creates conflicts that derive from specific agency responsibilities. Pollution management, for example, concerns different sets of agencies within different coastal and ocean zones, (e.g., Federal agencies in the EEZ), and others in State waters. However, there are several agencies involved in the management of living resources (e.g., crabs, salmons) whose authority crosses these jurisdictional boundaries.

The current relationship between jurisdictions and resource management is far from ideal. As resource exploitation continues to intensify in the Arctic, more cooperative agreements between State, Federal, and international interests will be required to address better the multiple uses of, and conflicts among, coastal and oceanic resources.

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5.0

Bering, Chukchi, and Beaufort Seas Strategic Assessment: Data Atlas

Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
National Oceanic and Atmospheric Administration

Political Boundaries and Maritime Zones

5.1

Description

The political boundaries and maritime zones of the region are complex. Many of these jurisdictions involve expanses of ocean and result in overlapping zones of interest and maritime activities.

International Boundaries

The United States regards its maritime boundary as the Line established by the 1867 U.S.-Russia Convention Ceding Alaska. This Line divides, among other things, fisheries and continental shelf resources. It extends from the Arctic Ocean, through the Chukchi Sea, Bering Strait, Bering Sea, and to the North Pacific Ocean. The United States and the Soviet Union currently are engaged in technical discussions over the interpretation and application of the Convention Line. The United States depicts the Line by arcs of great circles, which are the shortest distances between two points on a globe. The Soviet Union depicts the Line by rhumb lines, which are lines of constant direction used frequently by mariners. These differences result in areas in the Bering Sea which each country claims to be under its exclusive maritime resource jurisdiction.

The USA-Canada maritime boundary in the Beaufort Sea is also in dispute. Canada asserts that the boundary should continue seaward from the North Slope shoreline along the 141st meridian west, while the USA claims that this boundary runs northeast along a line equidistant from American and Canadian coasts (Couper, 1983). Substantial reserves of oil and gas are thought to occur in this area (Map 4.6).

A land boundary between the USA and Canada had been established originally in 1825 by Russia and Great Britain, the previous owners of Alaska and Canada. After the purchase of Alaska, however, a boundary dispute arose between the USA and Canada that was resolved in 1903 by an international tribunal, which upheld the American claim. The present USA-Canada international boundary along the 141st meridian west stretches over 600 miles from the Arctic Ocean to the Wrangell Mountains in Southeast Alaska (Alaska Northwest Publishing, 1982).

Coastal Zone Management Boundary

The state of Alaska has established an "interim coastal zone boundary" in response to section 305 of the Coastal Zone Management Act of 1972. This boundary was designed to reflect the various zones of coastal influence that are prominent in Alaska, rather than political or cultural boundaries which are more important in determining coastal zones in other states.

Alaska's coastal zone incorporates coastal regimes such as transitional and intertidal areas, salt marshes and wetlands, islands, and beaches, as well as geophysical factors such as water flow, salt water intrusions, tidal actions, erosion, wave fetch, salt spray, flooding, and storm surges. Biological processes such as wildlife migratory patterns and wildlife habitat were also considered in the delineation of this boundary.

The seaward boundary of Alaska's coastal zone is usually designated as 3 nautical miles (nmi) from the shoreline and coincides with the seaward limit of the territorial sea. The Alaskan coastal zone exceeds this limit around semienclosed water bodies such as Kotzebue Sound and Kuskokwim Bay. The landward boundary of the coastal zone approximates the 100-meter contour in many places.

Territorial Sea

The territorial sea includes all waters 3 nmi seaward of the coastal baseline, and thus coincides with the limits of state waters. In the territorial sea, Alaska exerts sovereign jurisdiction over natural resources and exclusive fishing rights, but cannot deny the right of innocent passage to foreign nations (Couper, 1983). A 12-mile territorial sea has replaced the historical 3-mile limit in many other countries, including both Canada and the USSR, and is the maximum limit under the 1982 Law of the Sea Convention (LOS).

Contiguous Zone

The contiguous zone extends 12 nmi from the territorial sea baseline (or 9 nmi from the seaward limit of the territorial sea). Established pursuant to the 1958 Geneva Convention on the Territorial Sea and Contiguous Zone, states are entitled to control of customs, fiscal, immigration, and sanitary regulations, and to punish any infringement of these regulations within 12 nmi of the coastal baseline. Foreign ships have the same right of passage that exists throughout the Exclusive Economic Zone or on the high seas.

Neither the USSR nor Canada claims a contiguous zone because their territorial seas are coincident with the 12-mile limit. Under the previously mentioned Law of the Sea Convention, the maximum limit for a contiguous zone was extended to 24 nautical miles. The USA has not adopted this change (Couper, 1983).

Prohibited Oil Pollution Zone

In 1973, the International Convention for the Prevention of Pollution from Ships (MARPOL) established that participating nations shall not permit operational oil discharges from tankers within 50 nmi of any land mass. Ships other than tankers and over 400 gross tons are restricted from discharging oil within 12 nmi of the nearest land.

Waters in the Canadian Beaufort Sea are affected by the Canadian Arctic Waters Pollution Prevention Act of 1970, which established a control zone to protect waters north of 60° from pollution out to 100 miles from the coastline (Couper, 1983).

Exclusive Economic Zone

The concept of the Exclusive Economic Zone (EEZ) was formalized at the United Nations Law of the Sea Convention of 1982, which, among other things, defined and established the EEZ as all waters 200 nmi from the baseline of the territorial sea. Although the USA did not sign the agreement, the basic intent of the convention has been achieved by Presidential Proclamation.

By Presidential Proclamation of March 10, 1983, the USA claims, as permitted by international law: (a) sovereign rights for the purpose of exploring, exploiting, conserving, and managing natural resources, both living and nonliving, of the seabed and subsoil and the superjacent waters and with regard to other activities for the economic exploitation and exploration of the zone, such as the production of energy from water, currents, and winds; (b) jurisdiction with regard to the establishment and use of artificial islands, and installation and structures having economic purposes; and (c) the protection and preservation of the maritime environment.

The United States also exercises within the EEZ, in conformity with customary international law as reflected in the 1982 LOS Convention, jurisdiction for the purpose of the protection and preservation of the marine environment. This includes jurisdiction to prevent pollution from land-based sources, from seabed activities subject to national jurisdiction, by dumping and from vessels. Customary international law is most developed with regard to coastal State vessel-source pollution prescriptive and enforcement jurisdiction, and the United States exercises its jurisdiction in the area in accordance with Part XII of the LOS Convention and in particularity with the international rules and standards established by the International Maritime Organization. U.S. prescriptive and enforcement jurisdiction varies within the EEZ depending on variables such as the nature and severity of the pollution incident, actual or potential, and the area within the EEZ in which it occurred.

The EEZ coincides with the USA Fishery Conservation Zone, which delimits exclusive rights to manage all fishery resources, except for migratory species (U.S. Department of State, 1977). Canada claims more limited rights in a 200-nmi "exclusive fishing zone," while the USSR also claims an EEZ.

Onshore Boundaries

Boroughs— In Alaska, the primary political subdivisions are boroughs, which are equivalent to counties in the contiguous USA and which generally provide services similar to most Alaskan cities. There are 12 boroughs in Alaska, whose primary responsibilities involve providing public education, planning, zoning, and assessing, levying, and collecting real and personal property taxes.

There are four classes of boroughs. A home-rule borough is a first-class borough which has adopted a home-rule charter. First- and second-class boroughs have mandatory powers over education and land-use planning, zoning, and tax assessment and collection. Otherwise, only the methods of acquisition of other powers differentiate the two classes. A third-class borough has mandatory power over the operation of public schools and the collection and assessment of taxes. In addition, a borough and all cities within it may unite in a single government called a "unified municipality" (Alaska Northwest Publishing, 1982). Sitka, Juneau, and Anchorage are unified municipalities. The North Slope Borough is the only home-rule borough; Northwest Arctic is the only first-class borough. Haines, in Southeast Alaska, is the state's only third-class borough (Alaska Department of Community and Regional Affairs, 1986). Portions of sparsely populated land outside organized borough boundaries compose the remainder of the state.

Native Regional Corporations—The Alaska Native Claims Settlement Act (ANCSA) of 1971 divides the state into regions based on geographical proximity and cultural similarities. Under the terms of ANCSA, $962.5 million and fee simple title to 40 million acres of land were given to Alaska Natives as settlement of all aboriginal land claims. Twelve business-like Native corporations (rather than traditional Native units) distribute benefits and implement Native settlement. All eligible Natives (USA citizens with a minimum of 1/4 Alaska Indian, Eskimo, or Aleut blood) can become shareholders in these corporations, whose stock cannot be sold nor corporation rights transferred for 20 years. A thirteenth corporation also exists for Natives residing outside Alaska.

The most important functions of Native corporations include (1) receipt of Federal and state compensation and mineral revenues, and disbursal of one-half of these moneys to village corporations; (2) ownership of the subsurface mineral resources on all 40 million acres; and (3) supervision of village incorporation, assistance in their land selection, and review of their spending plans (Bering Straits Native Corporation, 1981).

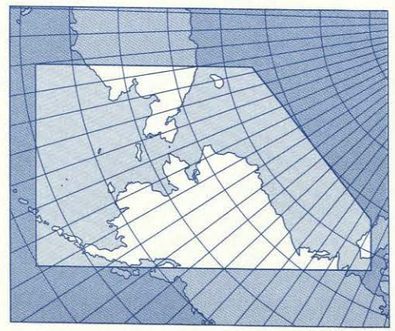
Legend

- International Boundaries
- 200-Mile Limit (Exclusive Economic Zone)
- 50-Mile Limit
  100-Mile Limit in Canada (Prohibited Oil Pollution Zone)
- 12-Mile Limit (Contiguous Zone)
- 3-Mile Limit (Territorial Sea)
- Alaska Interim Coastal Zone
- Corporation Boundaries
- Borough Boundaries
- Boroughs

The 3-mile limit is also the seaward boundary of the Alaska Interim Coastal Zone.

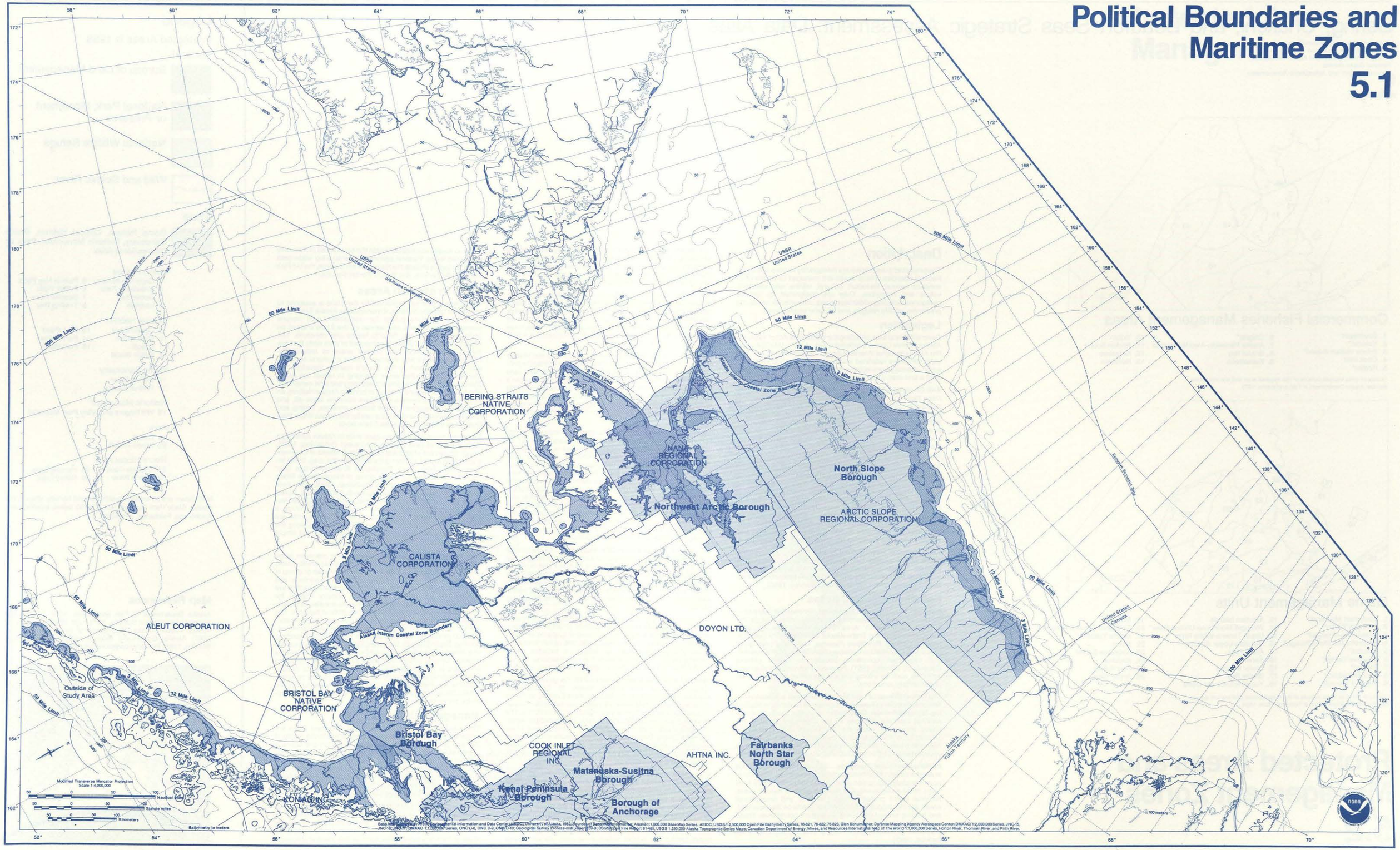
Map References

Bureau of Land Management, 1974; U.S. Department of State, 1977; National Foreign Assessment Center, 1978; Alaska Coastal Policy Council, 1979; Alaska Office of Coastal Management, 1979; National Advisory Committee on Oceans and Atmospheres, 1984.



Political Boundaries and Maritime Zones

5.1



Base information from AEIDC, Environmental Information and Data Center (AEIDC), University of Alaska, 1982; Sources of Base Mapping Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 78-821, 78-822, 78-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16, and 17; DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 759-B; USGS Open File Report 81-465; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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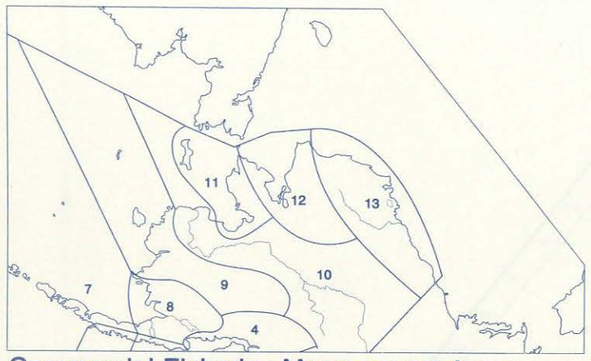
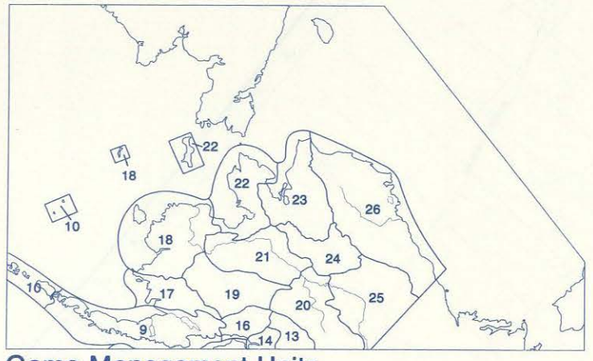


Commercial Fisheries Management Areas

1. Southeast*
2. Yakutat*
3. Prince William Sound*
4. Cook Inlet
5. Kodiak*
6. Chignik*
7. Alaska Peninsula-Aleutian Islands
8. Bristol Bay
9. Kuskokwim
10. Yukon
11. Norton Sound
12. Kotzebue
13. Northern

*Areas or units located outside of the mapped area and are not shown.
Source: Alaska Department of Fish and Game, 1978.



Game Management Units

1. Southeast Mainland*
2. Prince of Wales*
3. Petersburg-Wrangell*
4. Admiralty-Baranof-Chicagof*
5. Yakutat*
6. Cordova-Valdez*
7. Seward*
8. Kodiak-Shelikof*
9. Alaska Peninsula
10. Aleutian Islands
11. Wrangell Mountains-Chitina River*
12. Upper Tanana-White River*
13. Nelchina-Upper Susitna
14. Anchorage
15. Kenai*
16. Lower Susitna
17. Bristol Bay
18. Yukon-Kuskokwim Delta
19. McGrath
20. Fairbanks-Central Tanana
21. Middle Yukon
22. Nome
23. Kotzebue Sound
24. Koyukuk
25. Fort Yukon
26. Arctic Slope

*Areas or units located outside of the mapped area and are not shown.
Source: Alaska Department of Fish and Game, 1984.

Protected Areas and Management Zones

5.2

Description

The protected areas shown are managed by various State and Federal agencies. These areas are managed to preserve or enhance natural, historical, cultural, wildlife, and aesthetic values and resources. They are designated by various categories including wilderness areas, monuments, parks and preserves, wildlife refuges, and wild and scenic rivers.

Legislation

Several Federal laws, including the Wilderness Act of 1964, the Alaska Native Claims Settlement Act of 1971 (ANCSA), and the Alaska National Interest Lands Conservation Act of 1980 (ANILCA), have redefined land status, designating millions of acres of lands as protected areas. ANCSA and ANILCA represent a first step toward the protection of entire ecosystems.

ANILCA designated state lands for conservation by placing more than 104 million acres into new or expanded national parks and refuges (Cooley, 1984). The Act doubled the size of both the National Park System and the National Wildlife Refuge System. ANILCA also added 25 rivers to the Wild and Scenic River System. Of these lands, 56 million acres have been classified as wilderness areas, tripling the size of the National Wilderness Preservation System (Alaska Geographic Society, 1981).

The extensive land reclassification under ANILCA evolved from ANCSA, which authorized the Secretary of the Interior to place approximately 80 million acres of land in Alaska into the National Park, Forest, Wildlife Refuge, and Wild and Scenic Rivers Systems. ANCSA contributed to land conservation and management in a number of ways. Most importantly, in an effort to protect entire ecosystems, a continuous series of wildlife habitat land areas was created along the Alaska Peninsula, while in the Brooks Range, the protected habitat was extended from the Canadian boundary to near the Bering Sea.

Continuation of Native subsistence activities was provided in areas where hunting, fishing, and trapping are traditionally pursued. Certain areas known to be rich in oil and gas were exempted from protected status to permit resource exploration and development (National Park Service, 1985).

Federal Protected Areas

Bureau of Land Management Protected Areas—Bureau of Land Management protected areas include the Steese Conservation Area, White Mountains National Recreation Area, the Trans-Alaska Pipeline Utility Corridor, and the National Petroleum Reserve. They have been given protected classification because of landforms, wildlife habitat, and vegetation complexes peculiar to Alaska (Alaska Geographic Society, 1981). However, resource development activities such as mining are still permitted on these lands under certain conditions.

The largest Bureau of Land Management area in Alaska is the National Petroleum Reserve. Originally established in 1923 as the Naval Petroleum Reserve No. 4, it was the last of four national reserves managed by the U.S. Navy. In 1976, the Naval Petroleum Reserves Production Act transferred jurisdiction of the reserves to the Secretary of the Interior. With this transfer, the Department of the Interior assumed all environmental protection responsibilities for these reserves.

National Parks and Preserves—National Park Service lands in Alaska consist of national parks and preserves, comprising approximately 35.8 million acres in the study area (Study Area map). Most of the acreage is maintained in its natural state. National parks preserve scenic, wildlife, and recreational areas. Mining, logging, other forms of resource development, and hunting are not permitted within park boundaries. Traditional subsistence activities by Alaska Natives, however, are permitted in national parks and preserves (National Park Service, 1985).

The mission of the National Park Service is the preservation of nationally protected park lands and their availability to the public for use and enjoyment. All public uses are evaluated for their effect on the national park area. Presently, about 74 percent of all lands in the National Park System are in Alaska.

Ten of the 13 National Park Service units in Alaska are shown on the map. The three most extensive areas are the **Gates of the Arctic National Park and Preserve** and **Noatak National Preserve** in northwestern Alaska, and the **Denali National Park and Preserve** in interior Alaska. These three areas account for almost 40 percent of all National Park Service lands in the State.

National Wildlife Refuge System—The US Fish and Wildlife Service manages the National Wildlife Refuge System to protect the habitats of fish, birds, and mammals. Other land uses within the National Wildlife Refuge System may be permitted if they do not adversely affect habitat preservation. Wildlife refuges are open to hunting, fishing, and trapping under State and Federal regulations. Refuges may be opened to oil and gas leasing and exploration by a decision from the Secretary of the Interior.

More than 90 percent of all lands within the National Wildlife Refuge System are located in Alaska. Acreage reserved for national wildlife refuges in the State almost quadrupled with the implementation in 1980 of ANILCA. Covering over 76 million acres of Alaska, with approximately 18.5 million designated as wilderness, these refuges vary widely in size, depending upon the habitat requirements of a particular species. Human use of refuges, such as nature observation, boating, camping, hiking, and fishing, must be compatible with the goal of wildlife habitat protection. Native subsistence activities are allowed. In general, refuges are concentrated in northeast Alaska in a band along the south edge of the Brooks Range, in the Yukon and Kuskokwim Delta region, along the Alaska Peninsula, and across the Aleutians.

The three largest national wildlife refuges in Alaska are located in northeastern and southwestern Alaska. These refuges, the **Arctic National Wildlife Refuge**, the **Yukon Flats National Wildlife Refuge**, and the **Yukon Delta National Wildlife Refuge**, represent about 60 percent of all Federal wildlife refuge lands in the State. About 92 percent of all Federal wildlife refuge lands in the State are located in the 13 refuges shown.

Not shown on the map is the **Alaska Maritime National Wildlife Refuge System** that consists of about 3.5 million acres. This refuge system is composed of lands on or about islands, rocks, reefs, capes, headlands, and spires in coastal areas and adjacent seas of Alaska. It includes about 2,400 parcels of land and extends from the Seahorse Islands in the Chukchi Sea to Forrester Island in southeast Alaska.

National Wild and Scenic Rivers—ANILCA gave protected status as wild and scenic rivers to 25 rivers in Alaska—13 rivers within the National Park System, six rivers in the National Wildlife Refuge System, and two in the Bureau of Land Management Conservation and Recreation Units. The remaining five rivers are located outside designated preservation units. Twelve more rivers are designated for further study and possible wild and scenic river classification. Scenic features, wilderness characteristics, and recreational opportunities that would be impaired by alteration, development, or impoundment are protected.

Wilderness Areas—Under the Wilderness Act of 1964, wilderness is defined as an area extensive enough to sustain an ecosystem independent of activities in surrounding areas. It is also a place where humans are visitors, and where maintenance of the wilderness as such is the primary objective. Although wilderness areas are maintained in a natural state (i.e., without roads and other man-made structures), some uses and activities are permitted, among them recreational fishing and Native subsistence uses. All wilderness areas in Alaska are located within the boundaries of Federally protected lands. Federal agencies administering wilderness areas in Alaska include the National Park Service, the US Fish and Wildlife Service, and the US Forest Service.

State Protected Areas

Management of areas protected by the State is assigned to the Alaska Division of Parks. It manages the Alaska State Park System, administers grants for recreational and historic preservation purposes, and serves as the State's forum on park, recreational, and historic issues and concerns. The Alaska State Park System is composed of park units that are managed to preserve and protect areas of natural significance, preserve and interpret Alaska's cultural heritage, and provide support to the State's tourism industry. The Alaska State Park System is changing to reflect the larger changes occurring in the State's economy and land ownership. The transfer of millions of acres of lands to Alaska Natives, an influx of new residents and visitors from the lower 48, and increasing development of the State's minerals, fishing, and forest resources have created a role for the Alaska State Park System as a trustee of Alaska State lands.

Presently, there are 82 State park units in Alaska covering 3 million acres of land (Alaska Northwest Publishing, 1982). About 70 percent of all State park lands in Alaska are concentrated in four park system units shown on the map. In the interior, the Chena River Recreation Area comprises over 250,000 acres. The 1.4 million acres of Wood-Tikchik State Park lie north of Dillingham, in southwest Alaska. Two park units are located in the Matanuska-Susitna region: Denali State Park, with over 421,000 acres, which abuts Denali National Park and Preserve, and Nancy Lake Recreation Area, a small area of more than 22,000 acres. Most park units are small (one to several hundred acres), are located along the Alaska road system (Map 4.12), and have limited and simple facilities.

The Alaska Department of Fish and Game manages game refuges, game sanctuaries, and critical habitat areas. Game refuges are focused on a particular wildlife species or group of species. Human uses, including recreational pursuits and harvest of wildlife resources, are permitted as long as they are related or not detrimental to the primary reason for establishing the refuge. Game sanctuaries are also established to protect fish and wildlife and their natural habitats. The wildlife in these areas uses the land in exclusive ways. A sanctuary may be the only location where a certain population carries out some part of its annual life cycle, such as feeding, nesting, hauling out, or migration. Other uses of sanctuaries are closely controlled, or prohibited, to protect the wildlife species. Critical habitat areas are places where protective emphasis is on the environment in which wildlife occurs. Critical habitat areas may be complete ecosystems or partial systems, e.g., nesting or spawning areas. Management by the Alaska Department of Fish and Game is aimed primarily at providing protection for the habitat.

Management Zones

The management zones shown in the two inset maps are areas where specific State regulations apply to the taking of fish and game. The Alaska Department of Fish and Game is responsible for managing both of these areas. Thirteen commercial fisheries management areas were delineated by the State for regulating commercial fishing in Alaska. The length of the fishery season, type of gear allowed, vessel specifications, size and weight of hunts, and other restrictions apply to commercial fishermen in each of these areas.

Game management units are areas where regulations apply to subsistence and recreational hunting and trapping. The Alaska Department of Fish and Game has divided the State into 26 management units, 15 of which are in the study area. Most of the units have restrictions for hunting and trapping.

Legend

Protected Areas in 1986

Federal

- Bureau of Land Management
- National Park, Monument or Preserve
- National Wildlife Refuge
- Wild and Scenic River

State

- Game Refuge, Critical Habitat, Game Sanctuary, Historic Monument, Park or Recreational Area

Game Refuge
1 Cape Newenham
2 Creamer's Field
3 Goose Bay
4 Izembek
5 Palmer Hay Flats
6 Potter Point
7 Susitna Flats
8 Trading Bay

Critical Habitat
9 Cinder River
10 Clam Gulch
11 Egegik
12 Kalgin Island
13 Pilot Point
14 Port Heiden
15 Port Moller

Game Sanctuary
16 McNeil River
17 Walrus Islands

Historic Monument
18 Will Rogers and Wiley Post Memorial

Park
19 Denali
20 Wood-Tikchik

Recreational Area
21 Captain Cook
22 Chena River
23 Harding Lake
24 Nancy Lake

Not shown are 20 small recreational and historic sites in the Alaska State Park System, about 2,200 acres, located near Anchorage, Fairbanks, and Kenai.

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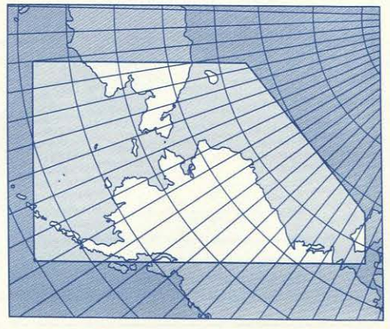
Alaska Department of Fish and Game, 1978, 1983, 1984; National Geographic Society, 1978; U.S. Geological Survey 1980a, 1980b; Alaska Department of Natural Resources, 1981; Alaska Geographic Society, 1981; National Park Service, 1985. Personal communication from Stephens.



Protected Areas and Management Zones

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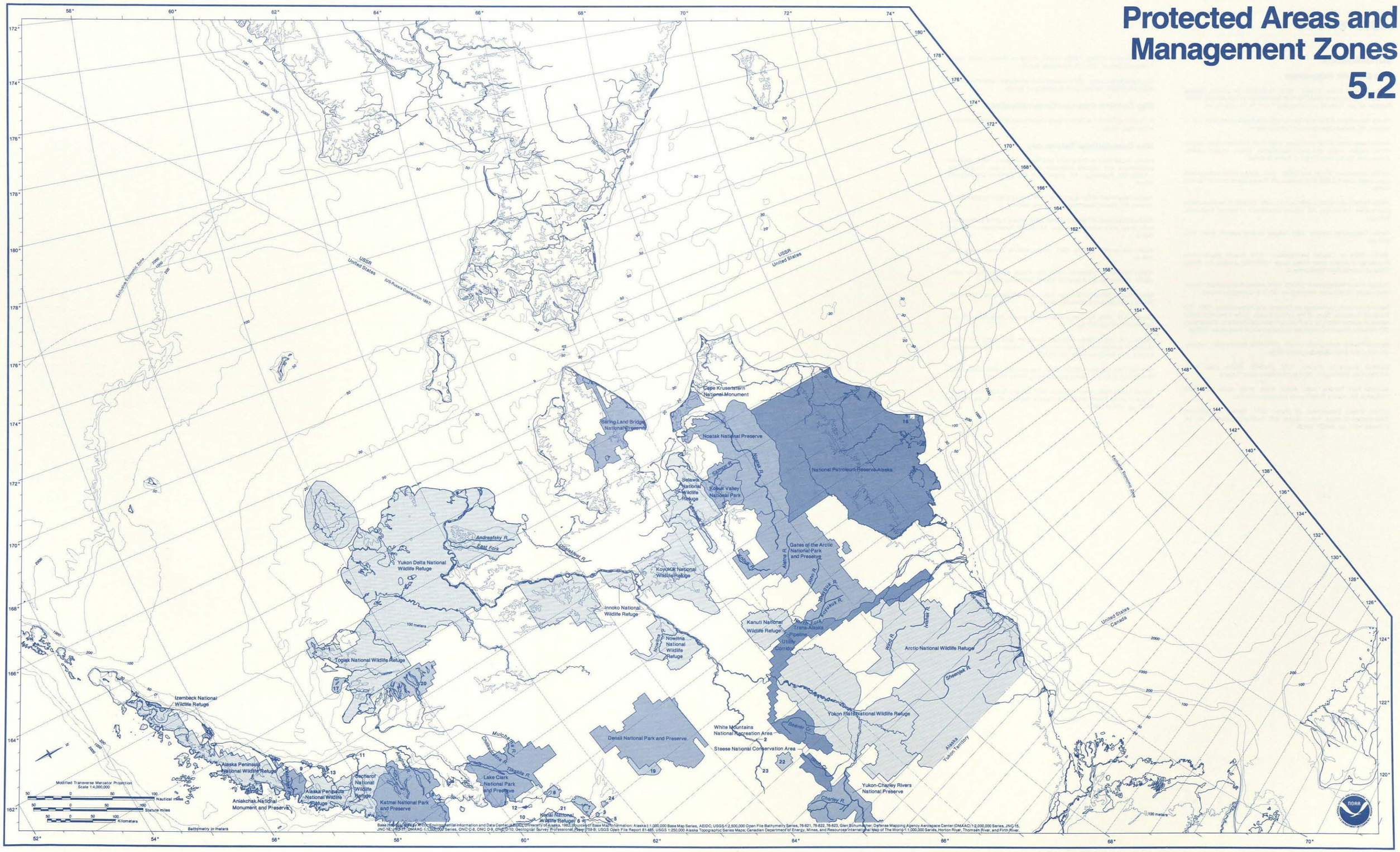

Base map data courtesy of the Environmental Information and Data Center (AEIDC, University of Alaska, 1982). Sources of Base Map Information: Alaska 1:1,000,000 Base Map Series, AEIDC; USGS 1:2,500,000 Open File Bathymetry Series, 76-821, 76-822, 76-823, Glen Schumacher; Defense Mapping Agency Aerospace Center (DMAAC) 1:2,000,000 Series, JNC-15, JNC-16; JNC-17, DMAAC 1:1,000,000 Series, ONC C-8, ONC D-9, ONC D-10; Geological Survey Professional Paper 259-B; USGS Open File Report 81-485; USGS 1:250,000 Alaska Topographic Series Maps; Canadian Department of Energy, Mines, and Resources International Map of The World 1:1,000,000 Series, Horton River, Thomsen River, and Firth River.

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