A FISH AND WILDLIFE RESOURCE INVENTORY OF WESTERN AND ARCTIC ALASKA

1977

VOLUME 2 - FISHERIES

COMPILED BY THE ALASKA DEPARTMENT OF FISH AND GAME UNDER CONTRACT TO THE ALASKA COASTAL MANAGEMENT PROGRAM - DIVISION OF POLICY DEVELOPMENT AND PLANNING

VOLUME II STUDY TEAM

ROBERT F. MCLEAN KEVIN J. DELANEY

CARTOGRAPHIC STAFF

SUSIE M. ELSNER PAMELA D. JOSEPH
CAROL J. RIEDNER SUZANNE J. STARR

1977

THIS PROJECT WAS SUPPORTED, IN PART, BY THE FEDERAL COASTAL ZONE MANAGEMENT PROGRAM DEVELOPMENT FUNDS (P.L. 92-583, SEC. 305), GRANTED TO THE STATE OF ALASKA BY THE OFFICE OF COASTAL ZONE MANAGEMENT, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, U.S. DEPARTMENT OF COMMERCE.

TABLE OF CONTENTS

Page

Page

Page

TABLE OF TABLES

KUSKOKWIM RIVER AREA SALMON FISHERIES

YUKON RIVER AREA SALMON FISHERIES

NORTON SOUND AREA SALMON FISHERIES

KOTZEBUE AREA SALMON FISHERIES

KUSKOKWIM RIVER AREA SUBSISTENCE FISHERIES

YUKON RIVER AREA SUBSISTENCE FISHERIES

NORTON SOUND AREA SUBSISTENCE FISHERIES

KOTZEBUE AREA SUBSISTENCE FISHERIES

WESTERN-ARCTIC ALASKA SUBSISTENCE HERRING FISHERIES

KUSKOKWIM RIVER AREA SPORT FISHERIES

YUKON RIVER AREA SPORT FISHERIES

TABLE OF FIGURES

INTRODUCTION

The State of Alaska has recently become the focal point of major decisions concerning marine and land resources. Many of the decisions which must be made will have national significance and will have a lasting impact on the future of Alaska and its resources. It is very important that comprehensive and accurate natural resource data be collected and made available to form the basis for developing sound planning for the State of Alaska.

The Alaska Department of Fish and Game has, since statehood, accumulated an abundant amount of data concerning the distribution, life history, habitat requirements and human uses of many species of fish and game.

This volume presents a compilation of existing commercial, sport and subsistence fishery information for the Western-Arctic Alaska areas. The report is divided into two primary sections: (1) a written narrative and (2) a portfolio of mapped data. The written narrative includes characterizations of each fishery and tabularization of statistical data. Historical catch, effort, economic value and escapement statistics are included. The map section includes distribution mapping for all significant finfish and shellfish species. Major fishing areas are delineated for all commercial species. Critical salmon and shellfish spawning areas are indicated, by species, where known. Shellfish rearing areas, by species, have also been noted where known.

It is imperative that those who use this report recognize that fish populations are a dynamic, ever-changing resource. The information contained within this report is as up to date as possible, but changing land tenure, human use and development, and a multitude of natural factors require that data be continuously gathered and updated.

Most of the information in this report was obtained from Alaska Department of Fish and Game biologists, much of it unpublished before now. Additional contributions were made by other staff members and from members of other resource agencies. These contributions are greatfully acknowledged.

KUSKOKWIM RIVER AREA SALMON FISHERIES

INTRODUCTION

The Kuskokwim River area includes all waters of the Kuskokwim River and its tributaries and all coastal waters between Cape Newenham, including Nunivak Island and St. Matthew Island, northward to Cape Romanzoff. (Figure 1). The Kuskokwim River is one of the largest rivers in the state, second only to the Yukon in size and length. The main river originates in central interior Alaska near Medfra, flows southwest for approximately 850 miles through the Kuskokwim Mountains and empties into the Bering Sea. It is heavily laden with silt throughout most of its length. Most of the major tributaries enter from the south and east. These include the Aniak, Holitna, Stony, Swift and Big Rivers. The headwaters include the North, East, South and Nixon forks of the Kuskokwim. The Takotna River drains an area northwest of the Kuskokwim near McGrath. The area extends from the coastal Yukon-Kuskokwim lowland in the west to the central Alaska Range in the east. The Kuskokwim River valley is a wide, flat basin with numerous small ponds and lakes. Edging the Kuskokwim River valley to the west are the Kuskokwim Mountains. The Holitna lowland occupies the central portion of the basin between the Alaska Range and the Kuskokwim Mountains, with the Taylor Mountains-Nushagak Hills on the south. The lowlands of the upper Kuskokwim are an extension of the Tanana lowlands.

For management and regulatory purposes, the Kuskokwim area is divided into four subdistricts. These include: lower Kuskokwim River (335-10), from Eek Island to Mishevik Slough near Tuluksak; middle

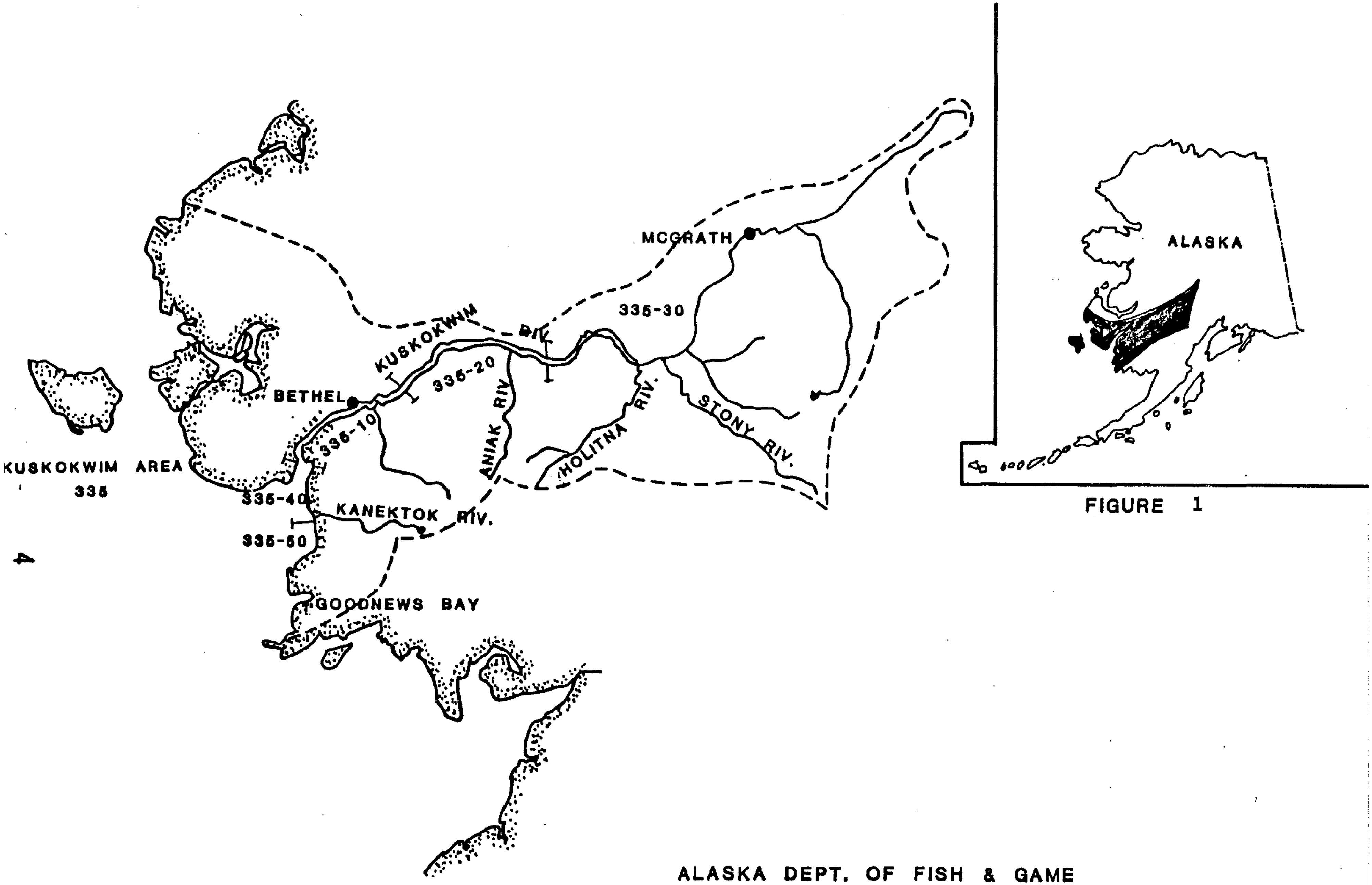


FIGURE 1

ALASKA DEPT. OF FISH & GAME
DIVISION OF COMMERCIAL FISHERIES
KUSKOKWIM AREA

Kuskokwim River (335-20), from Mishevik Slough to Kolmakoff River above Aniak; Quinhagak (335-40), approximately five miles of shoreline adjacent to the village of Quinhagak located at the mouth of the Kanektok River; Goodnews Bay (335-50); and the upper Kuskokwim River (335-30), above the Kolmakoff River (Figure 1). The upper Kuskokwim River subdistrict has been closed to commercial salmon fishing since 1966.

COMMERCIAL FISHERIES

Description

All five species of North American Pacific salmon are indigenous to the area. Chum salmon are the most abundant, followed in descending order of abundance by coho, king, sockeye and pink salmon. All five species are present in the Kuskokwim, Kanektok and Goodnews River drainages. Chum and pink salmon occur in most of the coastal streams and chum salmon are found in most of the streams on Nunivak Island.

Commercial salmon fishing in the Kuskokwim area dates back to 1913 or earlier (Table 1). The fishery prior to 1961 was often poorly documented, sporadic in nature and generally small. Since 1961 the commercial salmon fishery has expanded considerably in terms of harvest, effort and efficiency of the fishing fleet. The expansion of the commercial fishery was made possible through increased marketing potential and by improvements in tendering facilities. The product is primarily fresh or fresh-frozen.

The average annual salmon harvest for the Kuskokwim area from 1960 to 1974 is approximately 163,000 fish, which represents less than one percent of the total statewide salmon catch for the same period

(Table 1). Since 1960 coho salmon have accounted for 35 percent of the Kuskokwim area salmon harvest, followed by chum (32 percent), king (22 percent), pink (7 percent) and sockeye (4 percent).

In addition to salmon, commercial catches of whitefish and sheefish have been recorded in the Kuskokwim area since 1967 (Table 2). There has been a limited sale or barter of freshwater species in this area for many years. Most of the catches shown in the table are fish sold only to stores in Bethel. The majority of whitefish and sheefish catches are incidental harvests made during the coho fishing season.

Most of the commercial catch in the Kuskokwim area is dressed, iced and shipped elsewhere for further processing or sale. In the Quinhagak district floating processing ships are used. In recent years, the production of salmon roe for food and bait has been increasing and this product is becoming more important.

Timing

In the lower Kuskokwim subdistrict, the king salmon run begins just after break-up in late May and extends to the end of June, peaking sometime in mid-June. Since 1971 the Department has allowed a bonafide commercial chum salmon fishery in the lower Kuskokwim subdistrict immediately after the king salmon season. The fishery is open from June 25 until July 31; however, it generally closes in mid-July. Only gill nets of six inches or smaller mesh size can be operated, and the area is restricted to the lower 49 miles of the river below Napakiak. Chum salmon appear in this subdistrict around the first week of June, peak in late June and early July and continue to run until mid-August. Very few sockeye are harvested in the lower Kuskokwim in most years. Those taken are incidental to the king and chum salmon fisheries. The actual sockeye harvest, however, is often largely unknown due to incorrect species identification by buyers and fishermen. The sockeye run usually occurs in the lower Kuskokwim from the first week of June to the middle of July. Coho salmon begin to appear in this subdistrict in mid to late July and continue to run into September and October. Many subsistence fishermen do not fish the month of August due to poor weather conditions, moose hunting and other food gathering activities, but commercial effort has been strong in recent years.

Timing of the salmon runs in the middle Kuskokwim subdistrict coincides closely to those of the lower Kuskokwim, although fish appear slightly later.

In the Quinhagak subdistrict king salmon are bound for the Kanektok River which receives a later run than does the Kuskokwim River. The commercial fishing season is opened later to accommodate the later arrival of local stocks. King salmon usually appear in the fishery the second week of June and continue to run until the beginning of July. Recent management efforts have resulted in bonafide fisheries for sockeye, pink and chum salmon. These runs usually commence the third week of June and extend through the month of July. Coho salmon runs begin in early August and continue until mid or late September. Fishing effort varies greatly during the coho season due to variable weather conditions and the length of time processing ships remain in the area.

In the Goodnews subdistrict the king salmon run coincides with that in the Quinhagak subdistrict. The commercial fishing season generally sockeye are harvested in the lower Kuskokwim in most years. Those taken are incidental to the king and chum salmon fisheries. The actual sockeye harvest, however, is often largely unknown due to incorrect species identification by buyers and fishermen. The sockeye run usually occurs in the lower Kuskokwim from the first week of June to the middle of July. Coho salmon begin to appear in this subdistrict in mid to late July and continue to run into September and October. Many subsistence fishermen do not fish the month of August due to poor weather conditions, moose hunting and other food gathering activities, but commercial effort has been strong in recent years.

Timing of the salmon runs in the middle Kuskokwim subdistrict coincides closely to those of the lower Kuskokwim, although fish appear slightly later.

In the Quinhagak subdistrict king salmon are bound for the Kanektok River which receives a later run than does the Kuskokwim River. The commercial fishing season is opened later to accommodate the later arrival of local stocks. King salmon usually appear in the fishery the second week of June and continue to run until the beginning of July. Recent management efforts have resulted in bonafide fisheries for sockeye, pink and chum salmon. These runs usually commence the third week of June and extend through the month of July. Coho salmon runs begin in early August and continue until mid or late September. Fishing effort varies greatly during the coho season due to variable weather conditions and the length of time processing ships remain in the area.

In the Goodnews subdistrict the king salmon run coincides with that in the Quinhagak subdistrict. The commercial fishing season generally opens at the same time. Sockeye salmon are usually available to the fishery from mid-June through July, peaking around the first 10 days of July. Chum salmon become available around the third week of June, peak the first 10 days of July and extend through July. The coho salmon run generally begins in earnest during the first week of August and continues until mid-September. Commercial fishing time during the coho run is frequently extended by emergency order to compensate for lost fishing time due to severe storms.

Effort

Legal salmon gear in the Kuskokwim area includes set and drift gill nets in all subdistricts. The upper Kuskokwim subdistrict has been closed to commercial salmon fishing since 1966.

Commercial fishing effort in the Kuskokwim River has been steadily increasing since 1960. The average number of licensed commercial fishermen from 1960 to 1974 is 442, with a low in 1960 of 91 and a high of 1,138 in 1974 (Table 3). Drift gill nets account for the majority of the salmon harvest in this area. The 15-year average of registered drift gill nets is 338, with a low of 28 in 1960 to a high of 853 in 1974. For the same period, 1960 to 1974, registered set nets have averaged 40 licenses, with a low of 9 in 1966 to a high of 76 in 1970.

Economic Values

Although the annual commercial harvest in the Kuskokwim area is small in comparison to those in other areas of the state, economically the area's commercial fisheries are extremely important to the local economy. The average annual value to the fishermen of the salmon harvest since 1964 is approximately $361,000 (Table 4). In recent years increased harvests and higher prices have resulted in annual values to the fishermen of one million dollars.

ESCAPEMENT AND SPAWNING

Introduction

Due to the large size of the area and turbid water conditions, it is extremely difficult to obtain accurate escapement data that can be used for in-season management of the commercial fisheries. Presently there is only one counting tower located on the Kogrukluk River, which is a tributary to the Holitna River system. Indices of escapements are made by aerial survey estimates of a few selected streams, but variable weather and stream conditions make results difficult to interpret. The main stem of the Kuskokwim River serves as a migratory corridor for salmon bound for spawning tributaries along its course. No spawning has been observed along the main river itself.

In the Kuskokwim River subdistricts, king salmon spawn in the tributaries of the Kuskokwim River. Some of the more important spawning tributaries include the Kwethluk, Kisaralik, Tuluksak, Aniak, Salmon, Kipchuk, Holitna, Kogrukluk, Hoholitna and Chukowan Rivers. At this time, the value of the upper Kuskokwim as a contributor to escapements is still under evaluation. The bulk of the king salmon passing through the Quinhagak subdistrict fishery spawn in the Kanektok River. Kanektok River spawner densities are among the highest observed in the region. King salmon have also been observed spawning in the Arolik River. A special tag and recovery study conducted by the Department in 1969 and

1970 indicated that the majority of king salmon taken in the Quinhagak subdistrict fishery are of local origin. Of 779 king salmon tagged and released in the area during both years, 0.5 percent were recovered in the Kuskokwim River, 0.5 percent in the Nushagak River in Bristol Bay and 33.8 percent were recovered either in the Quinhagak fishery or in the Kanektok River. Table 5 presents the estimated king salmon escapement of selected systems in the Kuskokwim area.

Valid escapement data for coho salmon stocks in the Kuskokwim area is lacking. The lateness of the run coincides with the end of the Department's field season. Little is known about specific spawning areas or escapement. Coho utilize many of the same systems as king salmon for spawning. Included in the known spawning systems are the upper portions of the Kwethluk, Aniak, Salmon, Kipchuk, Oskawalik and Kogrukluk Rivers. Coho salmon have also been observed spawning in the Arolik and Goodnews Rivers and in the inlet streams of Lake Kagati.

Limited numbers of sockeye salmon spawn in tributaries of the Kuskokwim River, including the Eek, Holokuk, Oskawalik, Holitna, Hoholitna, Kogrukluk, Stony and Chukowan Rivers. Sockeye salmon passing through the commercial fishing area of the Quinhagak subdistrict spawn in the Kanektok and Arolik River systems. Most spawn in Lake Kagati, located at the headwaters of the Kanektok River. Some also spawn in Arolik Lake. There are nine known sockeye spawning lakes in the Goodnews River system. One of the more important spawning areas is Goodnews Lake; others include Canyon and Kukaktlim Lakes. Table 6 presents estimated sockeye salmon escapement for several systems in the Kuskokwim area.

There is a minimum of 16 known chum salmon spawning tributaries in the Kuskokwim River system, several over 75 miles in length. Most of these streams cannot be surveyed annually due to adverse stream or weather conditions. Usually not more than three tributary streams can be adequately surveyed in any given season, but as many as 185,000 spawning chums have been counted. Good comparative escapement data is lacking for chum salmon stocks in the Quinhagak subdistrict. Chum salmon utilize most of the Kanektok River, the lower portion of the Arolik River, Jacksmith Creek, Cripple Creek and Indian River for spawning. Chum salmon do not appear to be as abundant in the Goodnews subdistrict as in the other subdistricts. Aerial survey counts made in the main Goodnews River have ranged as high as 8,500 fish.

In the Kuskokwim area pink salmon exhibit an even-odd year cycle, with the largest runs occurring during even years. Limited numbers of pink salmon spawn in tributaries of the Kuskokwim River. Spawning pink salmon have been observed in the upper portions of the Kwethluk and Holitna Rivers and in the lower portion of the Kogrukluk River. One million pink salmon were estimated to have spawned in the Kanektok River in 1968. In 1970 the Arolik River escapement was judged to range between 150,000 and 250,000 fish. More than 112,000 pink salmon were observed spawning in 1970 in the upper 10 miles of the Goodnews River.

Habitat, Migration and Timing

Spawning and rearing habitat preference for salmon stocks in the Kuskokwim area is essentially the same as outlined in the generalized life histories (Appendix). Sockeye and coho salmon which spawn in tributaries of the Kuskokwim River rear in deep holes and sloughs along the tributaries. The Goodnews and Kanektok Rivers sockeye runs appear to exhibit a five-year cycle of abundance. Pink salmon stocks in the Kuskokwim area are characterized by a dominant even-year cycle of abundance. Chum salmon stocks do not appear to be cyclic, although large fluctuations in run sizes do occur.

Timing of salmon spawning in the Kuskokwim area varies by species, system and season. In the Kuskokwim area, king salmon spawn from mid-July until late July; pink salmon through July; chum salmon from mid-July until mid-August; and coho salmon from mid or late September through much of October. In the Quinhagak and Goodnews subdistrict sockeye salmon spawning occurs from mid-August until late September.

Escapement Goals

Escapement goals have not been formulated for the salmon stocks in the Kuskokwim area due to the limited information available concerning spawning magnitude and distribution. In-season management of the commercial fisheries is based on analysis of comparative commercial, subsistence and test fishing catches which indicate relative magnitude of run size. The long range management goal is to maintain present harvest levels until future returns can be studied and additional escapement information obtained.

STATUS RELATED TO MAXIMUM SUSTAINED YIELD

Adequate information concerning escapement magnitude and spawner distribution is not available for the Kuskokwim area salmon stocks.

Consequently, estimation of maximum sustained yields (MSY) for these fisheries is extremely difficult. Preliminary estimates of MSY's are presented below by species for the lower Kuskokwim River subdistrict, the Quinhagak subdistrict and the Goodnews Bay subdistrict. The middle Kuskokwim River subdistrict is regulated by a quota of 2,000 king salmon and 2,000 sockeye, chum and coho salmon combined. The upper Kuskokwim River subdistrict is closed to commercial fishing; consequently, no MSY's have been developed.

Lower Kuskokwim River Subdistrict

Very few sockeye or pink salmon are commercially harvested in this subdistrict. No harvest goals have been developed because of the lack of information concerning escapement magnitude and spawner distribution of these species.

There is little information on which to estimate MSY for the king salmon stocks in this subdistrict. Until future returns can be studied and additional escapement information is obtained, commercial harvests should not exceed 15,000 to 20,000 fish annually. During peak years an additional 20 percent, approximately 4,000 fish, could be commercially harvested.

Commercial catches of coho salmon have been unpredictable due to extreme fluctuations in runs and effort. Virtually nothing is known about escapement magnitude or spawner distribution of coho salmon. Due to the lateness of the run, all escapement monitoring projects are terminated prior to spawning which occurs during freeze-up. No estimates of MSY have been developed.

There is insufficient information to accurately evaluate the MSY for chum salmon in this subdistrict. A harvest goal for the commercial fisheries is presently estimated to be 100,000 to 150,000 fish annually. The total utilization goal, commercial plus subsistence, for chum salmon is 400,000 fish annually.

Quinhagak Subdistrict

Until further studies of king salmon stocks in this subdistrict are conducted, recent commercial catch levels of 12,000 to 15,000 fish must be considered maximum. With the inclusion of subsistence catches, the MSY for king salmon is in the range of 15,000 to 20,000 fish annually.

Very little data has been collected concerning coho salmon in this subdistrict. Inclement weather often hinders valid observation and renders counts difficult to analyze. Until information is obtained regarding population size, annual commercial harvests should not be allowed to exceed 20,000 to 25,000 fish annually.

An MSY for the sockeye salmon fishery in this subdistrict has not been estimated due to the lack of biological data. However, a small harvestable surplus, compared to recent harvests of 3,000 to 5,000 fish, probably exists.

Great fluctuations occur in the annual abundance of pink salmon in this subdistrict. Good comparative escapement data is lacking. No estimate of MSY has been developed for this species. During especially large runs, such as occurred in 1968, in excess of 500,000 pink salmon could have been commercially harvested. However, maximizing harvests during years of extremely high abundance could jeopardize conservation of other species unless a selective means of harvest can be implemented.

No accurate MSY has been formulated for chum salmon; however, present levels of commercial harvests, 30,000 to 40,000 fish annually, could probably be maintained without damaging the run.

Goodnews Bay Subdistrict

The remoteness of this area and poor weather conditions have precluded gathering the required escapement information necessary to formulate any MSY's for this subdistrict fisheries. It is presently estimated that commercial harvests of king salmon in the Goodnews Bay subdistrict should not exceed 5,000 fish annually.

Table 1 . Commercial salmon catch, Kuskokwim area, by year, in numbers of fish, 1913-1974. 1/ 2/

Year	Total	King	Sockeye	Coho	Pink	Chum
1913	7,800	7,800	--	--	--	--
1914	2,667	--	2,667	--	--	--
1915	--	--	--	--	--	--
1916	949	949	--	--	--	--
1917	7,878	7,878	--	--	--	--
1918	3,055	3,055	--	--	--	--
1919	4,836	4,836	--	--	--	--
1920	34,853	34,853	--	--	--	--
1921	9,854	9,854	--	--	--	--
1922	15,064	8,944	6,120	--	--	--
1923	7,254	7,254	--	--	--	--
1924	34,487	19,253	900	7,167	--	7,167
1925	7,514	1,664	5,850	--	--	--
1926	--	--	--	--	--	--
1927	--	--	--	--	--	--
1928	--	--	--	--	--	--
1929	--	--	--	--	--	--
1930	9,963	7,515	2,448	--	--	--
1931	8,541	8,541	--	--	--	--
1932	9,399	9,399	--	--	--	--
1933	--	--	--	--	--	--

continued

1/ Source - INPFC, Historical Catch Statistics for Salmon of the North Pacific Ocean. 2nd Draft, July, 1974, and A.D.F.& G., Statewide Catch Statistics, Final IBM run.
2/ No commercial catch reported before 1913.

Table 1 (continued). Commercial salmon catch, Kuskokwim area, by year, in numbers of fish, 1913-1974.

Year	Total	King	Sockeye	Coho	Pink	Chum
1934	--	--	--	--	--	--
1935	14,744	6,448	--	8,296	--	--
1936	624	624	--	--	--	--
1937	480	480	--	--	--	--
1938	1,452	624	--	828	--	--
1939	134	134	--	--	--	--
1940	747	247	--	500	--	--
1941	861	187	--	674	--	--
1942	--	--	--	--	--	--
1943	--	--	--	--	--	--
1944	--	--	--	--	--	--
1945	--	--	--	--	--	--
1946	2,962	2,288	--	674	--	--
1947	5,356	5,356	--	--	--	--
1948	--	--	--	--	--	--
1949	--	--	--	--	--	--
1950	--	--	--	--	--	--
1951	4,210	4,210	--	--	--	--
1952	--	--	--	--	--	--
1953	--	--	--	--	--	--
1954	64	57	7	--	--	--
1955	--	--	--	--	--	--
1956	--	--	--	--	--	--
1957	--	--	--	--	--	--

continued

Table 1 (continued). Commercial salmon catch, Kuskokwim area, by year, in numbers of fish, 1913-1974.

Year	Total	King	Sockeye	Coho	Pink	Chum
1958	--	--	--	--	--	--
1959	3,760	3,760	--	--	--	--
1960	17,135	5,985	5,649	5,498	--	3
1961	49,815	23,462	2,308	5,090	91	18,864
1962	94,037	20,869	10,307	12,572	4,340	45,949
1963	35,041	18,581	1	16,458	--	1
1964	65,306	21,246	13,422	28,992	939	707
1965	42,823	24,428	1,895	12,191	37	4,272
1966	52,716	25,823	1,030	22,985	268	2,610
1967	97,111	29,986	652	58,239	--	8,234
1968	298,845	43,157	5,884	154,302	75,818	19,684
1969	237,240	64,777	10,362	110,473	1,251	50,377
1970	228,520	65,273	12,645	62,442	27,440	60,720
1971	160,432	44,936	6,054	10,006	13	99,423
1972	184,280	56,939	4,312	23,880	1,952	97,197
1973	393,758	51,374	5,224	152,408	634	184,207
1974	495,331	30,570	29,003	179,579	60,015	196,127

Table 2 . Commercial catches of whitefish and sheefish, Kuskokwim area, by year, in numbers of fish, 1967-1974 1/ 2/.

Year	Catch Whitefish	Catch Sheefish	Value to Fishermen
1967	2,817	1	1,260
1968	6,182	48	3,138
1969	6,393	140	3,302
1970	10,337	21	3,122
1971	12,214		6,107
1972	4,503	100	2,352
1973	5,910	637	4,910
1974	5,846	529	4,664

1) Source - A.D.F.&G., AYK Annual Management Reports.
2) The majority of harvests made in lower Kuskokwim River drainage with sales made in Bethel. No information available prior to 1967.

Table 3 . Commercial, vessel and gear licenses, Kuskokwim area, 1960-1974. 1/ 2/

Year	Commercial	Vessel	Drift Gill Net	Set Gill Net
1960	91	51	28	17
1961	178	170	159	15
1962	355	307	284	55
1963	173	157	136	27
1964	179	175	148	29
1965	268	224	213	24
1966	247	200	194	9
1967	324	256	239	17
1968	529	418	375	49
1969	601	482	441	76 3/
1970	600	479	447 4/	76
1971	589	532	501	71
1972	613	548	498	43
1973	746	558	554	25
1974	1,138	905	853	70

1/ Source - A.D.F.& G., Stock Status Report and AYK Annual Management Reports.

2/ Unless indicated, numbers reflect resident licenses only.

3/ Includes one non-resident set gill net.

4/ Includes one non-resident drift gill net.

Table 4 Value of commercial salmon catch to the fishermen, Kuskokwim River area, in dollars, 1964-1974 1/.

Year	Value of Salmon Catch to the Fishermen
1964	83,030
1965	90,950
1966	87,466
1967	138,647
1968	290,370
1969	297,233
1970	362,470
1971	371,220
1972	360,727
1973	827,735
1974	1,056,042

1) Source - A.D.F.&G., AYK Annual Management Reports.

Table 5 Estimated king salmon escapement, Kuskokwim area, by year, in numbers of fish, 1960-1974 1/ 2/.

Year	Kwethluk River	Kisaralik River	Aniak River 3/	Aniak River (above Salmon River 4/)
1960	1,320	1,104	1,881	
1961			497	
1962	248	327	925	
1963				
1964				
1965		194	646	
1966	516	204	2,184	485
1967				758
1968	800	487	1,420	783
1969				537
1970		531	1,231	592
1971				144
1972	68			93
1973		152		200
1974	88	4	196	57

continued

1) Source - A.D.F.&G., AYK Stock Status Report (unpublished), and 1974 AYK Annual Management Report.
2) All counts from aerial surveys and are peak counts, except Kogrukluk River tower counts.
3) Includes all of Aniak River.
4) Peak escapement count of Aniak River above Salmon River.
5) Weir count.

Table 5 (continued) Estimated king salmon escapement, Kuskokwim area, by year, in numbers of fish, 1960-1974.

Year	Salmon River	Kipchuk River	Chukowan River	Kogrukluk River		Kanektok River
				Aerial Count	Tower Count	
1960	223	513				6,047
1961				214		1,650
1962						1,516
1963						935
1964						627
1965						
1966	141	491	986	1,645		3,718
1967		200		1,033		2,605
1968		319	1,260	2,180		4,170
1969					2,980	119
1970	381	821	1,118	1,598	3,868	3,112
1971				636	42 5/	
1972	43		163	476	1,934	73
1973	100		229	610	1,725	
1974	35	73			3,724	

Table 6 Estimated sockeye salmon escapement, Kuskokwim area, by year, in numbers of fish, 1960-1974 1/ 2/.

Year	Goodnews Lake	Lake Kagati	Three Unnamed Lakes 3/
1960	3,400	77,000	--
1961	1,000	22,000	3,000
1962	--	18,564	--
1963	--	--	--
1964	--	80,000	--
1965	--	8,365	200
1966	818	11,305	920
1967	2,400	1,900	1,940
1968	7,310	19,400	2,800
1969	32,000	5,600	1,850
1970	800	9,475	1,400
1971	2,056	2,330	8,100
1972	--	6,800	175
1973	--	0	3
1974	1,075	7,500	500

1) Source - A.D.F.&G., AYK Annual Management Reports.
2) All counts from aerial surveys and are peak counts except Lake Kagati counts for 1961 and 1962, which were obtained by counting tower.
3) Three small lakes located approximately 3 miles downstream from Lake Kagati outlet.
-- No data available.

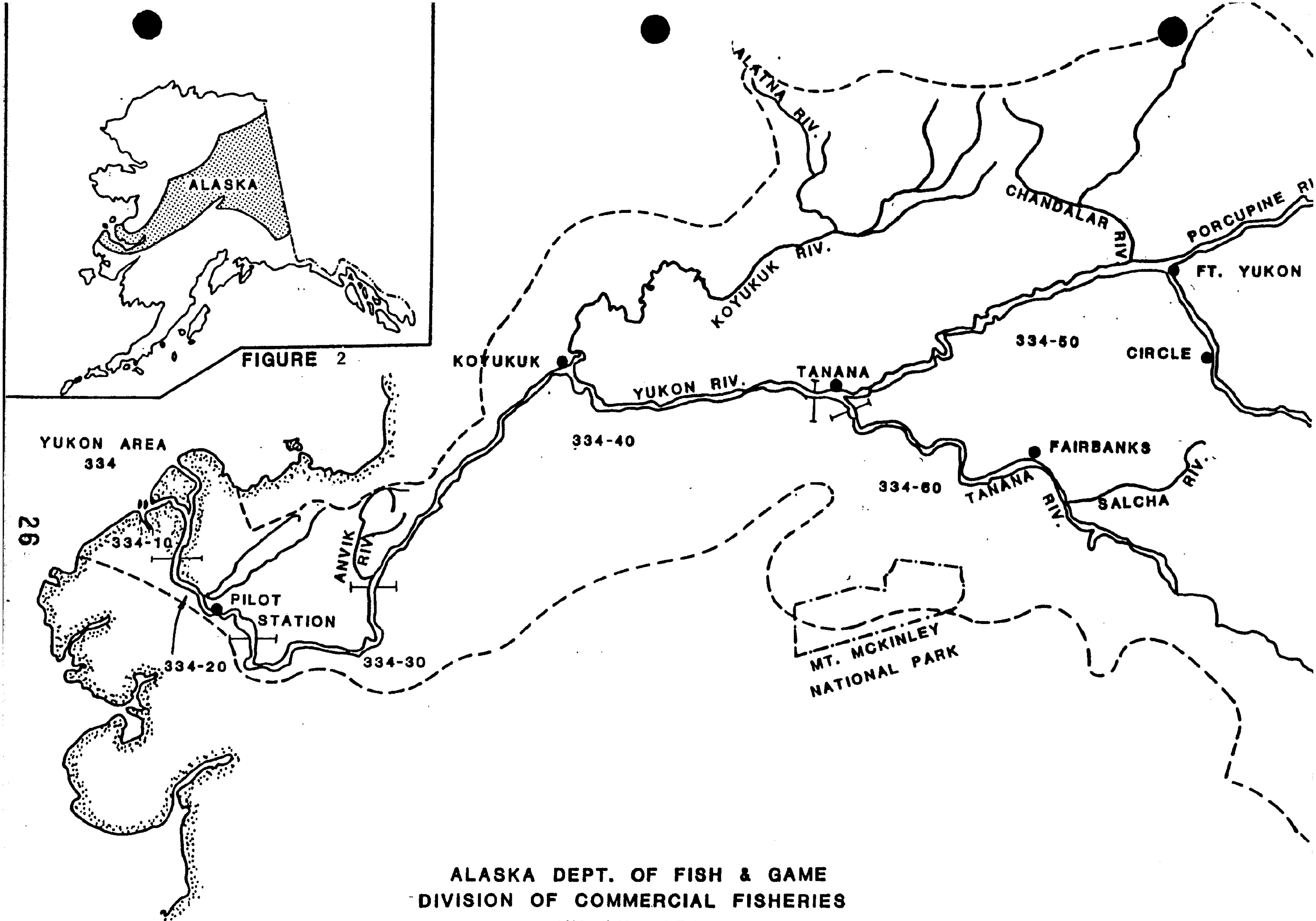
YUKON RIVER AREA SALMON FISHERIES

INTRODUCTION

The Yukon River area, the largest management district in Alaska, includes all waters of the Yukon River and its tributaries and all coastal waters from Canal Point light southward to Cape Romanzof (Figure 2). The Yukon River is the largest river in the State and the fifth largest in North America. It originates in British Columbia, Canada, within 30 miles of the Gulf of Alaska, and flows over 2,300 miles to its mouth on the Bering Sea, draining an area of approximately 330,000 square miles. Topographically, the area is extremely diverse, ranging from the flat, lake-dotted tundra of the Yukon River delta to the forested uplands of interior Alaska. The major rivers in the Alaskan portion of the drainage important to salmon production include the Andreafsky, Anvik, Innoko, Nulato, Rodo, Tozitna, Gisasa, Hogatza, Alatna, Koyukuk, Chandalar, Sheenjek, Porcupine, Black, Tanana, Toklat, Chatanika, Salcha, Chena, Delta and Goodpaster Rivers. Numerous small tributaries and short coastal streams also contribute substantially to salmon production. The Yukon River is primarily utilized as a migratory corridor to distant spawning areas, many of which are located in the Yukon Territory, Canada.

For management and regulatory purposes, the Yukon River area is divided up into six districts: the Yukon River delta, two in the lower Yukon River, the middle Yukon River, the upper Yukon River and the Tanana River (Figure 2).

FIGURE 2



ALASKA DEPT. OF FISH & GAME
DIVISION OF COMMERCIAL FISHERIES
YUKON AREA

COMMERCIAL FISHERIES

Description

All five species of North American Pacific salmon are indigenous to the area, with chum salmon begin the most abundant. King salmon rank second in abundance, followed in order by coho, pink and sockeye salmon. Pink and sockeye salmon are present in limited numbers only, and there is no significant fishery for them.

Although commercial salmon fishing in the area dates back to 1918, major commercial utilization of all species has only existed since 1961. This relatively recent development and expansion of the commercial salmon fisheries has enabled many area residents to obtain a cash income when other employment is often sporadic or non-existent. Nearly all of the area's commercial fishermen are resident Eskimos and Indians, as are the vast majority of processing plant workers.

The major commercial fisheries are found in the lower 150 miles of the Yukon River, although limited commercial fishing is widely dispersed over 1,200 river miles of the upper Yukon and lower Tanana Rivers. Tributary streams of the Yukon and Tanana Rivers are closed to commercial fishing. With the possible exception of a few fish harvested at the Yukon River mouth or adjacent coastal villages, only salmon of Yukon River origin are harvested in the area.

The majority of the commercial catch is frozen by floating processing ships. The remainder of the catch is either canned, mild cured, hard salted or sold fresh. In recent years, the production of salmon roe for food and bait has been increasing and is gradually becoming quite important.

Timing

The commercial fisheries in the lower Yukon River for king salmon and a few incidentally caught summer run chum salmon generally begin in early June, depending on breakup of the river ice. The majority of fishermen use large mesh gill nets (8 1/2-inch stretched mesh) which are selective for king salmon. Commercial fishing is closed in late June-early July to insure adequate king salmon escapement. After a short closure, the season is usually reopened to fishing with small mesh gill nets (less than 6-inch stretched mesh) which maximizes the catch of the more abundant summer chums and minimizes the catch of the late king run. The fisheries continue through August with predominantly fall chum and coho salmon runs. The timing of the upper Yukon River salmon fisheries is variable as it is basically regulated by quota.

Effort

Since 1960, fishing effort, as indicated by the number of licensed fishing vessels, has more than tripled (Table 8). The 15-year average (1960-1974) of licensed commercial fishermen is 598 annually. Although the use of drift gill nets is steadily increasing, set gill nets account for approximately 75 percent of the present commercial harvest. Since 1960, an average of 212 drift gill nets and 469 set gill nets have been licensed annually (Table 8). In addition, more than 100 fishwheels are used annually in the upper Yukon River. Most commercial fishermen utilize small (16 to 20-foot) outboard powered skiffs without net rollers or power reels of any type.

Economic Value

In terms of total State salmon harvest, the Yukon River area is a minor producer, averaging approximately 300,000 fish annually, which represents less than one percent of the total statewide harvest (Table 7). However, economically the area's commercial fisheries are extremely important to the local economy and provide a much needed cash income. The average annual value to the fishermen of the salmon fisheries since 1961 is $682,221 (Table 9). In recent years, increased catches and higher prices have resulted in annual values to the fishermen in excess of one million dollars. The 1974 salmon fisheries were worth nearly two million dollars to the fishermen.

ESCAPEMENT AND SPAWNING

Introduction

The Yukon River area (330,000 square miles) is too extensive for complete escapement survey coverage during any given year. In addition, poor survey conditions and turbid water often make escapement estimates difficult. Presently, escapement surveys are conducted primarily by aerial reconnaisance for king, coho and chum salmon in selected key "index" streams. Limited ground and boat surveys are also conducted. A king and summer run chum salmon counting tower has operated on the Anvik River since 1972. Tabular escapement data for the major systems is presented at the end of this area summary.

With the exception of the Anvik River tower counts, all escapement counts reflect peak live estimates and do not indicate total escapement. Consequently, annual escapements are only comparable on a relative basis. The lengthy migrations between the fisheries and the spawning grounds (often exceeding two months) for many of the up-river stocks preclude the practical use of escapement surveys for inseason management. The fisheries are managed by analyzing comparative commercial and test fishing catch data. Adjustments in fishing time and enactment of fishing season closures are made based on the apparent abundance of salmon as indicated by catch data.

Despite efforts in recent years to expand escapement survey coverage, large areas still remain unsurveyed. Each year, previously undocumented spawning areas are generally found. In 1974, large concentrations of spawning fall run chum salmon were documented for the first time in the Toklat, Sheenjek and Chandalar Rivers. As time, money and manpower permits, additional escapement surveys are needed for this area.

Habitat, Migration and Timing

Pink and sockeye salmon are present in nominal numbers and are present only in the lower Yukon River drainages. Management and research effort is limited on these species and little is known about their specific life histories. It is assumed that their life histories basically follow that outlined in the generalized life histories (Appendix).

King Salmon

King salmon are present in nearly all of the major tributaries throughout this area, extending into upper tributaries in the Yukon

Territory, Canada. Spawning and rearing habitat preference is essentially the same as outlined in the generalized life history (Appendix). The run generally first appears off the Yukon River mouth in late May and extends into mid-July. Upriver king salmon are generally first reported as follows: Galena (mid-June), Rampart (late June), Eagle (early July); Tanana River drainage, Nenana (late June, early July), Chena River (late July), Salcha River (late July). Migration timing from the Yukon River mouth to its upper tributaries normally requires approximately 60 days.

Peak of spawning for stocks utilizing lower Yukon River tributaries is generally from early to mid-July. Middle river spawners (Salcha River, Tanana River) normally peak from early to mid-August.

Coho Salmon

The coho salmon run normally first enters the Yukon River in late July. This run is characteristically about one week behind the fall chum salmon run. Spawning generally occurs in October and often extends into mid-November. Spawning and rearing habitat preference is essentially the same as that outlined in the generalized life history (Appendix).

Chum Salmon

There are two distinct major runs of chum salmon entering the Yukon River: summer run chums and fall run chums. Summer chums are chiefly characterized by an earlier run timing (early June, mid-July), more rapid maturation in freshwater, smaller size (6-7 pounds) and larger population. Fall chums are mainly distinguished by later run timing (mid-July, early September), a more uniform robust body shape and bright, silvery appearance, larger size (7-8 pounds) and smaller population. Summer run chums generally utilize spawning areas in the lower and middle portion of the Yukon River watershed, whereas fall chums primarily spawn in tributaries of the upper watershed. Spawning and rearing habitat preference for both the summer and fall chum salmon runs is essentially the same and parallels that described in the generalized life history (Appendix).

Peak of spawning for summer chums utilizing spawning areas in the lower Yukon River is generally from early to mid-July. These stocks typically move into tributary streams, spawn and die much quicker than other chum salmon stocks in this area. Spawning of summer chums utilizing spawning areas in the middle Yukon River (Salcha River, lower Tanana River) generally peaks from early to mid-August.

Fall run chum salmon spawn much later in the year, extending from September to mid-November. Stocks spawning in upper Yukon River tributaries (Sheenjek River, Porcupine River) generally peak in late September. Those utilizing the lower Tanana River and Toklat River generally spawn from early to mid-October. Peak of spawning in the upper Tanana River extends from early to mid-November. The extreme distance of these spawning areas from the Yukon River mouth often requires upstream migrations in excess of 60 days.

Escapement Goals

Due to the lack of extensive escapement surveys and escapement-return relationships, optimum escapement goals have not been defined for any species or stock of salmon in this area. In recent years, however, efforts have been made to upgrade and increase escapement surveys, primarily for king and chum salmon. Estimated escapement goals, at least for the major systems, should be defined in the not too distant future.

STATUS RELATED TO MAXIMUM SUSTAINED YIELD

Current stock assessment and escapement information is not adequate to estimate maximum sustained yield (MSY) for this area's fisheries. However, preliminary estimates are available and are presented by species. Since there are no significant sockeye or pink salmon fisheries, no MSY's have been estimated.

The Yukon River area king salmon stocks are probably being harvested at or near the maximum rate by the present commercial and subsistence fisheries. Until future returns can be studied and additional escapement information obtained, commercial harvests should not normally exceed 70,000 to 80,000 fish annually. With the inclusion of subsistence catches, the maximum sustained yield (MSY) is considered to be in the range of 86,000 to 96,000 fish annually.

The present level of coho salmon catches, 15,000 to 20,000 fish annually, probably represents the MSY. Future expansion of the fishery appears unlikely.

Summer chum salmon population magnitudes based on tag recovery programs were estimated at 3.6 million in 1970 and 1.6 million in 1971. Aerial survey of the Andreafsky and Anvik Rivers during most years have indicated mimimum escapements of 500,000 summer chum salmon in these two streams combined. Additionally, chum salmon have either been observed or reported spawning in at least 60 other tributary streams. Since commercial harvests of summer chum salmon since 1969 have averaged only 124,435, it is apparent that greater commercial harvests could occur. It is presently estimated that the summer chum salmon run can sustain a commercial harvest of at least 500,000 fish annually. This harvest level may be substantially increased in years of exceptional abundance.

There is very little information on which to accurately estimate an MSY for the fall chum salmon run. Recent commercial harvest levels of approximately 250,000 fish annually should be considered the MSY until additional information becomes available.

Table 7 Commercial salmon catch, Yukon River area, by year, in numbers of fish, 1918-1974 1/ 2/.

Year	Total	King	Sockeye	Coho	Pink	Chum
1918	112,304	12,239	--	26,144	--	73,921
1919	469,790	104,822	--	37,070	--	327,898
1920	214,122	58,467	--	--	--	155,655
1921	181,744	69,646	--	1,000	--	111,098
1922	16,825	16,825	--	--	--	--
1923	13,393	13,393	--	--	--	--
1924	27,375	27,375	--	--	--	--
1925	--	--	--	--	--	--
1926	--	--	--	--	--	--
1927	--	--	--	--	--	--
1928	--	--	--	--	--	--
1929	--	--	--	--	--	--
1930	--	--	--	--	--	--
1931	--	--	--	--	--	--
1932	4,739	4,739	--	--	--	--
1933	8,829	8,829	--	--	--	--
1934	25,365	25,365	--	--	--	--
1935	7,265	7,265	--	--	--	--
1936	20,963	20,963	--	--	--	--
1937	6,226	6,226	--	--	--	--
1938	13,727	13,727	--	--	--	--

continued

1) Source - INPFC, Historical Catch Statistics for Salmon of the North Pacific Ocean. 2nd Draft, July, 1974 and A.D.F.&G., Statewide Catch Statistics, Final IBM run.
2) No commercial catch reported before 1918.

Table 7 (continued) Commercial salmon catch, Yukon River area, by year, in numbers of fish, 1918-1974.

Year	Total	King	Sockeye	Coho	Pink	Chum
1939	9,987	9,987	--	--	--	--
1940	18,053	18,053	--	--	--	--
1941	29,905	29,905	--	--	--	--
1942	22,487	22,487	--	--	--	--
1943	27,650	27,650	--	--	--	--
1944	14,232	14,232	--	--	--	--
1945	19,727	19,727	--	--	--	--
1946	22,782	22,782	--	--	--	--
1947	54,026	54,026	--	--	--	--
1948	33,842	33,842	--	--	--	--
1949	36,379	36,379	--	--	--	--
1950	41,808	41,808	--	--	--	--
1951	56,278	56,278	--	--	--	--
1952	49,505	38,637	--	10,868	--	--
1953	64,836	58,859	--	--	--	5,977
1954	78,920	64,545	--	--	--	14,375
1955	55,925	55,925	--	--	--	--
1956	72,951	62,208	51	1	--	10,691
1957	63,623	63,623	--	--	--	--
1958	63,735	63,735	--	--	--	--
1959	78,370	78,370	--	--	--	--
1960	67,597	67,597	--	--	--	--
1961	165,096	119,664	--	2,855	116	42,461
1962	171,842	94,736	12	23,339	32	53,723
1963	122,623	117,048	3	5,572	--	--

continued

Table 7 (continued) Commercial salmon catch, Yukon River area, by year, in numbers of fish, 1918-1974.

Year	Total	King	Sockeye	Coho	Pink	Chum
1964	104,364	93,587	--	2,430	--	8,347
1965	141,886	118,014	--	661	--	23,211
1966	183,627	93,315	--	19,254	13	71,045
1967	189,889	129,430	2	11,047	201	49,209
1968	187,204	106,526	--	13,303	--	67,375
1969	298,378	90,720	--	15,076	--	192,582
1970	439,837	79,301	--	13,188	255	347,093
1971	412,395	110,507	1	12,203	--	289,684
1972	402,917	92,840	--	22,233	--	287,844
1973	630,029	75,353	--	36,641	101	517,934
1974	994,877	98,091	--	16,792	--	879,994

Table 8 Commercial, vessel and gear licenses, Yukon River area, 1960-1974 1/.

Year	Commercial	Vessel	Drift Gill Net	Set Gill Net	Fish Wheels
1960	307	229	46	244	Not Available
1961	412	350	103	338	Not Available
1962	533	490	177	436	13
1963	451	413	114	383	3
1964	487	451	159	409	7
1965	539	486	164	420	20
1966	577	516	189	468	17
1967	607	549	249	431	Not Available
1968	585	510	223	410	13
1969	590	498	252	437	11
1970	625	546	254	490	16
1971	715	633	295	571	26
1972	765	660	319	634	25
1973	872	739	335	679	60
1974	900	771	298	684	85

1) Source - A.D.F.&G., AYK Stock Status Report and AYK Annual Management Reports.

Table 9 Value of commercial salmon catch to the fishermen, Yukon River area, in dollars, 1960-1974 1/.

Year	Value of Salmon Catch to the Fishermen
1960	Not Available
1961	437,000
1962	361,900
1963	412,300
1964	354,400
1965	542,300
1966	454,500
1967	606,400
1968	535,000
1969	519,200
1970	623,100
1971	783,000
1972	784,000
1973	1,217,000
1974	1,921,000

1) Source - A.D.F.&G., AYK Annual Management Reports.

Table 10 Estimated king salmon escapement, Yukon area, by year, in numbers of fish, 1960-1974 1/ 2/.

Year	Andreafsky River East Fork	Andreafsky River West Fork	Anvik River	Salcha River	Nisutlin River	Whitehorse Dam Fishway
1960	1,020	1,220	1,950	1,660		660
1961	1,003		1,226	2,878		1,068
1962	675 3/	762 3/		937		1,500
1963						484
1964	867	705		450		587
1965		355 3/	650 3/	408		903
1966	361	303	638	800		563
1967		276 3/	336 3/			533
1968	380	383	297 3/	735	407	407
1969	231 3/	274 3/	296 3/	461 3/	105	334

continued

1) Source - A.D.F.&G., AYK Stock Status Report (unpublished), and 1974 AYK Annual Management Report.
2) With exception of Whitehorse fishway counts, the data was obtained from aerial surveys which were made only on the main stem of each of the rivers listed and represent peak counts.
3) Incomplete survey or poor survey conditions resulting in a very minimal count.
4) Tower count and aerial survey estimates.
5) Tower count.
6) Source - Canadian Department of Fisheries survey.

Table 10 (continued) Estimated king salmon escapement, Yukon area, by year, in numbers of fish, 1960-1974.

Year	Andreafsky River East Fork	Andreafsky River West Fork	Anvik River	Salcha River	Nisutlin River	Whitehorse Dam Fishway
1970	665	574 3/	368 3/	1,882	615	625
1971	1,904	1,284		159 3/	640 6/	856
1972	798	582 3/	1,172	1,193	317	392
1973	825	788	613 4/	249	36 3/	228
1974		285	506 5/	1,857	48 3/	273

Table 11 Estimated chum salmon escapement, Yukon area, by year, in numbers of fish, 1960-1974 1/ 2/.

Year	Andreafsky River East Fork	Andreafsky River West Fork	Anvik River	Chena River	Salcha River	Tanana River	Delta River	Porcupine River
1960	3,830		11,110		670			
1961	8,110				1,152			
1962	18,040	19,530	20,600	402	1,161	862	46 4/	
1963				898				
1964		12,810	12-14,000 4/		250 4/			
1965		14,670 4/	100,000		2,375			
1966	25,619	18,145	37,500		2,200			
1967		14,495 3/	116,000					
1968	17,600 3/	74,600 3/	51,580 4/		3,790			
1969	119,000	159,500			425 4/			

continued

1) Source - A.D.F.&G., AYK Stock Status Report (unpublished), and 1974 AYK Annual Management Report.
2) Counts obtained from aerial surveys and represent peak counts.
3) Includes some pink salmon.
4) Poor survey conditions.
5) Combined tower and aerial survey estimates.
6) Tower counts.
7) Survey from Richardson Highway Bridge to Blue Creek.
8) Sheenjek River.

Table 11 (continued) Estimated chum salmon escapement, Yukon area, by year, in numbers of fish, 1960-1974.

Year	Andreafsky River East Fork	Andreafsky River West Fork	Anvik River	Chena River	Salcha River	Tanana River	Delta River	Porcupine River
1970	84,090	91,710 4/	232,780		7,879	800	800	
1971	98,095	71,745			306 4/			115,000+
1972	41,460	25,573	245,857 5/	670	947 4/	19,657	3,650	35,326 5/
1973	10,149 4/	51,835	86,665 5/		290	5,635 7/	7,971	1,175 4/8/
1974	3,215 4/	33,258	208,815 6/		8,040	4,567 7/	4,010	40,507 8/

NORTON SOUND AREA SALMON FISHERIES

INTRODUCTION

For purposes of this report two A.D.F.& G. management areas, the Norton Sound area and the Port Clarence area, are discussed under the Norton Sound area section. The Norton Sound area includes all waters from Cape Douglas south to Canal Point light, including St. Lawrence Island. The Port Clarence area includes all waters from Cape Douglas north to Cape Prince of Wales (Figure 3).

The areas consist largely of plateaus, highlands, low mountains and small areas of coastal plains. The topography in the highlands ranges from gently sloping uplands to rolling and steep, sloping mountains. The lowland is limited to the northwest part of the Seward Peninsula and to a few relatively small valleys along the coast of Norton Sound. The Norton Sound area is bordered to the north by the Kigluaik, Bendeleben and Darby Mountains and to the east by the Nulato Hills. The Brooks Range and Kougarok Mountains border the Port Clarence area in the north, and to the south are the Kigluaik Mountains. St. Lawrence Island lies southwest of the Seward Peninsula across from Norton Sound. The island is largely lowland, with some gentle to steep, sloping upland in the western part.

The principal salmon systems in the Norton Sound area include Unalakleet, Niukluk, Fish, Kachavik, Kwiniuk, Tubutulik, Shaktoolik, Koyuk and Boston Rivers. The important salmon systems in Port Clarence are the Pilgrim River-Salmon Lake complex, the Kuzitrin River and the Agiapuk River.

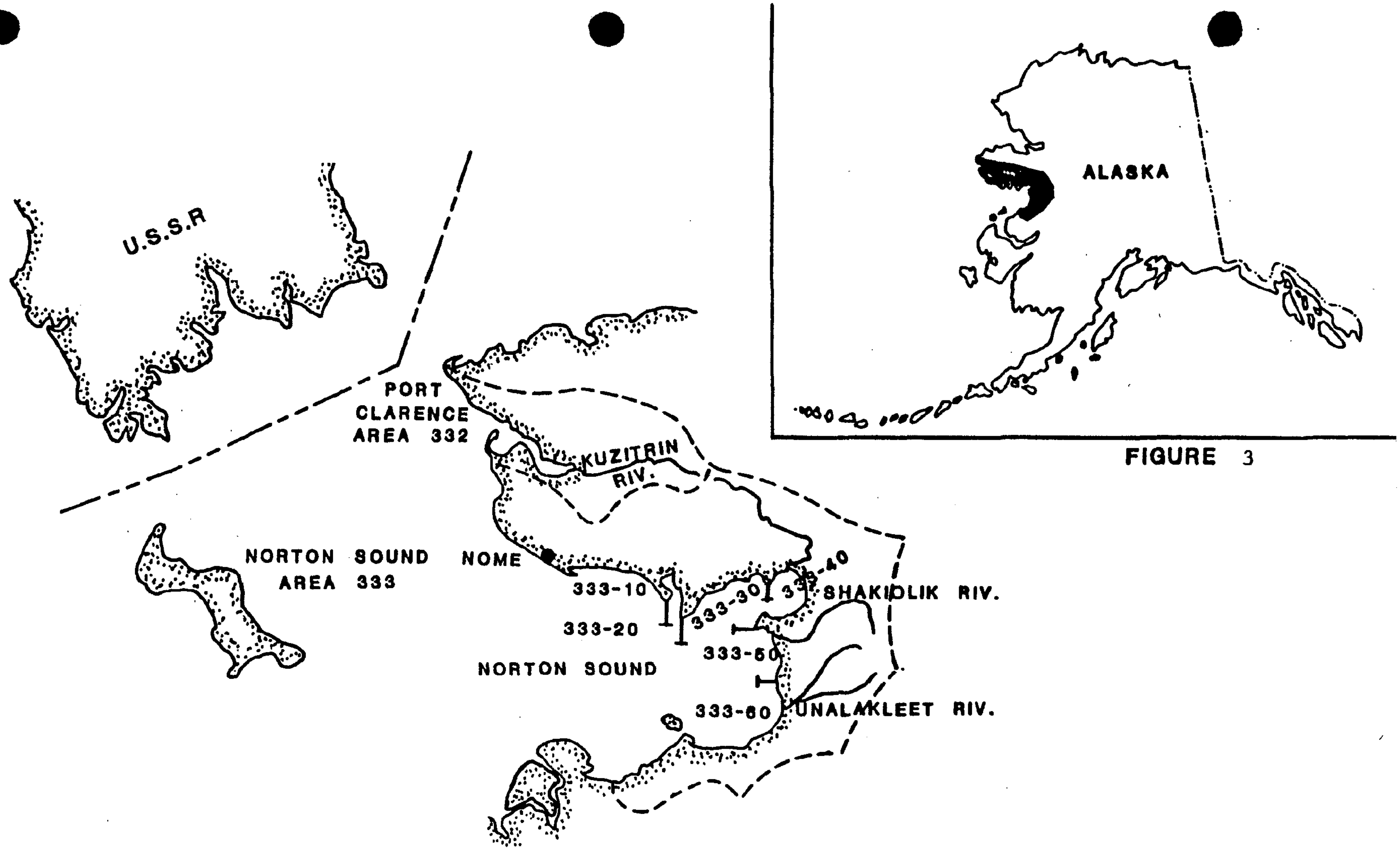


FIGURE 3

ALASKA DEPT. OF FISH & GAME
DIVISION OF COMMERCIAL FISHERIES
NORTON SOUND AREA

For management and regulatory purposes, the Norton Sound area is divided into six subdistricts: Nome (333-10), from Penny River to Topkok Head; Golovin Bay (333-20), from Rocky Point to Cape Darby; Moses Point (333-30), from Elim Point to Kwik River; Norton Bay (333-40), from the Kuiuktulik River to Island Point; Shaktoolik (333-50), from Cape Denbigh to Junction Creek, seven miles north of Egavik; and Unalakleet (333-60), from Junction Creek to Black Point (Figure 3).

COMMERCIAL FISHERIES

Description

All five species of North American Pacific salmon are indigenous to the Norton Sound area. Chum and pink salmon are the most abundant, followed in descending order by coho, king and sockeye salmon.

Commercial salmon fishing in the Norton Sound area first began in the Unalakleet and Shaktoolik subdistricts in 1961. Most of the early interest involved king and coho salmon which were flown in dressed condition to Anchorage for further processing. A single American freezership also purchased and processed chum and pink salmon during 1961. In 1962, two floating ships operated in the Norton Sound area and the commercial fishery was extended into the Norton Bay, Moses Point and Golovin Bay subdistricts. The peak in canning operations occurred during 1962 and 1963. In recent years the majority of salmon have either been flown fresh to Anchorage or handled by shore freezing or salting plants.

Until recently, the commercial fishery has been characterized by sporadic fishing effort as a result of the lack of processors and buyers or inadequate tendering service. The recent emergence of cooperatives and improved tendering facilities has helped to stabilize the fishery. The Unalakleet subdistrict is a relatively stable fishery in terms of fishing effort and has been fished each year since 1961.

The only documented commercial salmon fishery in the Port Clarence area was in 1966 when 1,216 salmon were taken in the Grantly Harbor-Tuksuk Channel area. A few salmon are traditionally sold or bartered each year in Teller and Nome. Commercial fishing in freshwater is prohibited in this area. A unique feature of the Port Clarence area is the Pilgrim River-Salmon Lake sockeye salmon run which is one of the northernmost occurrences of this species on the continent. Although there is little commercial fishing effort in this area, the subsistence fishery is important. Further discussion of the Port Clarence area will be presented in the following sections entitled "Subsistence" and "Escapement and Spawning."

Timing

Commercial salmon fishing commences June 15 and extends to September 30. This basic season has been in effect since 1963. Normally, the first commercial landings are not made until mid-June when king salmon arrive in sufficient numbers. The king salmon run continues until mid-July, at which time effort shifts toward chum, pink and coho salmon. The season normally ends when processors terminate their operations, usually sometime in August. Chum salmon are in the bays and available to the fishery from June 20-25 until July 20-25. The pink salmon run is considerably shorter, entering the bays around June 25 to July 1 and arriving on the spawning grounds by July 15-20. The coho salmon run is later and is found in the fishery from August 1 until about August 20.

Effort

Commercial fishing gear is restricted to set gill nets, with a maximum aggregate length of 100 fathoms allowed for each fisherman. There are no mesh or depth restrictions, but a majority of set gill nets operated are approximately 5 1/2-inch stretched measure. In the Unalakleet and Shaktoolik subdistricts, 8 1/2-inch stretched mesh set gill nets are commonly used during the king salmon run in June through early July, after which 5 1/2-inch mesh nets are used for chum, pink and coho salmon. Small mesh gill nets sized for pink salmon have been in evidence in Unalakleet and Golovin.

Since the Norton Sound fisheries began in 1961, gear registration has fluctuated, depending on the number of active subdistrict fisheries. The years of high fishing effort, 1962-1964, were followed by several years of low effort. Licensing has steadily increased since 1970 and reached a new high in 1974 with 271 registered commercial licenses, 228 registered vessels and 227 set net licenses (Table 13).

Economic Values

The average annual salmon harvest for the Norton Sound area since 1960 is approximately 158,377 fish, which represents less than one percent of the total statewide salmon catch for the same period (Table 12). Since 1960, chum salmon have accounted for 65 percent of the area's salmon harvest, followed by pink (29 percent), coho

(4 percent) and king (2 percent). Although the Norton Sound area is a minor producer in comparison to other areas, the area's commercial salmon fisheries are important to the local economy and provide a much needed cash income.

The average economic value to the fishermen of the Norton Sound area salmon fisheries since 1962 is approximately $123,000 annually (Table 14). Increased catches and higher prices in 1974 resulted in a value of approximately $437,000.

ESCAPEMENT AND SPAWNING

Introduction

Aerial surveys and two counting tower sites are used to monitor escapement in most of the Norton Sound area streams. Escapement counts obtained by aerial surveys are only indices of abundance and not total population estimates. Limiting factors such as weather conditions, type of aircraft, water conditions, bottom conditions, date of survey and efficiency of surveyor must be taken into account when interpreting these index counts. Kwiniuk River escapements have been obtained by a counting tower since 1965. Each of the six management subdistricts in the Norton Sound area contains at least one major salmon spawning stream, and the majority of fishing effort occurs in the ocean near the stream mouths. It is assumed that the majority of salmon caught in any one subdistrict are bound for streams in that subdistrict, although this assumption needs to be tested by tag and recovery studies.

Chum and pink salmon are the most abundant species in the area. Both species are found spawning in many of the same streams. Tables 15-20 presents the estimated salmon escapement for some of the more productive systems in the Norton Sound area. These systems include the Kachavik, Niukluk, Fish, Tubutulik, Kwiniuk and Unalakleet Rivers and Boston Creek. Chum salmon escapements exhibit annual fluctuations. Norton Sound pink salmon do not exhibit strong even-odd year fluctuations as do other pink salmon in more southerly latitudes. Pink salmon are often the most abundant species in the Norton Sound area. However, pink salmon runs do exhibit large annual fluctuations, apparently in response to climatic conditions.

King salmon escapement information for the Norton Sound area is limited. King salmon are only present in commercial quantities in the Unalakleet and Shaktoolik subdistricts. Studies are needed to identify the origin of king salmon taken in various Norton Sound coastal fisheries. There is a distinct possibility that Yukon River stocks contribute greatly to the Norton Sound fishery during some years. Known king salmon spawning systems in the Norton Sound area include the North, Unalakleet, Shaktoolik, Ungalik, Inglutalik, Kwiniuk and Tubutulik Rivers.

Little is known about the numbers and distribution of spawning coho salmon in the Norton Sound area. Field projects concerned with escapement monitoring are terminated prior to coho spawning activity. Coho runs appear to be small.

In the Port Clarence area, sockeye salmon are produced in the Pilgrim River-Salmon Lake complex which is one of the northernmost occurrences of this species. Spawning grounds for this run include Salmon Lake and the Grand Central River. The run is currently at low population levels, possibly as a result of overharvests by the subsistence fishery. The Salmon Lake sockeye salmon run has varied considerably in magnitude since 1963, with the 1969 run probably being the smallest. It is possible that the run has suffered such a significant decline that it cannot be restored to former levels unless a rehabilitation program is undertaken and subsistence fishing is sharply decreased. Table 21 presents the estimated sockeye escapement for Salmon Lake and Grand Central River.

Habitat, Migration and Timing

Spawning and rearing habitat preferences for salmon stocks in the Norton Sound area and the Port Clarence area are essentially the same as outlined in the generalized life histories (Appendix). These areas are among the most northern distribution range for king, sockeye, coho and pink salmon. Salmon stocks do not exhibit any apparent cycles as do stocks in more southern areas.

Timing of salmon runs in the Norton Sound and Port Clarence areas is presented in Table 22 . Salmon spawning activity in these areas is very late. Coho salmon have been observed spawning under the ice as late as January.

Escapement Goals

Escapement goals have not been formulated for salmon stocks in the Norton Sound area due to the limited information available concerning spawning magnitude and distribution. The Norton Sound area is managed on the basis of comparative catch data, escapement and weather conditions. A single factor or combination of factors may cause the curtailment or extension of fishing time.

STATUS RELATED TO MAXIMUM SUSTAINED YIELD

Adequate escapement and spawner distribution information is not available for Norton Sound salmon stocks. Consequently, estimation of maximum sustained yield (MSY) for these fisheries is extremely difficult. Preliminary estimates of MSY are presented below by species for the entire area. There is presently no commercial fishery in the Port Clarence area; therefore, no MSY's have been formulated.

Recent commercial harvests of king salmon in the Norton Sound area must be considered at or near maximum. A small increase in utilization may be possible in the Shaktoolik subdistrict. Commercial catches of king salmon for the entire area should not exceed 4,000 fish annually, with not more than 2,500 coming from the Unalakleet subdistrict.

An estimate of MSY for the coho salmon stocks has not been formulated due to a lack of good harvest data and escapement-return relationships. The coho runs appear to be small. Commercial harvests should not be allowed to increase over the recent levels of approximately 5,000 fish annually until further studies can be initiated.

An MSY for pink salmon stocks in the Norton Sound area has not been formulated. A conservative estimate is that commercial harvests ranging from 200,000 to 1,000,000 fish annually could have been taken in the past if all subdistricts received optimum effort.

It is estimated that the MSY for chum salmon for the entire area ranges between 170,000 and 270,000 fish annually during most years. This value is inclusive of both commercial and subsistence fisheries.

Commercial harvests of sockeye salmon are insignificant in this area. No estimate of MSY has been developed.

Table 12 . Commercial salmon catch, Norton Sound area, by year, in numbers of fish, 1961-1974. 1/ 2/

Year	Total	King	Sockeye	Coho	Pink	Chum
1961	101,711	5,300	35	13,807	34,237	48,332
1962	232,453	7,286	18	9,156	33,187	182,784
1963	233,863	6,613	71	16,765	55,625	154,789
1964	164,671	2,018	126	98	13,567	148,862
1965	40,524	1,449	30	2,030	220	36,795
1966	100,345	1,553	14	5,755	12,778	80,245
1967	74,818	1,804	--	2,379	28,879	41,756
1968	124,499	1,045	--	6,885	71,179	45,390
1969	178,972	2,392	--	6,836	86,949	82,795
1970	178,218	1,853	--	4,423	64,908	107,034
1971	141,977	2,593	--	3,127	4,895	131,362
1972	149,494	2,938	--	454	45,182	100,920
1973	176,797	1,918	--	9,282	46,499	119,098
1974	315,829	2,951	--	2,092	148,519	162,267

1/ Source - A.D.F.& G., AYK Annual Management Reports.

2/ No commercial catch reported before 1961.

Table 13 . Summary of commercial, vessel and gear license registration, Norton Sound area, 1960–1974. 1/ 2/

Year	Commercial	Vessel	Set Gill Net (Fathoms of Gear)
1960	--	--	--
1961	NA	62	80 (5,450)
1962	195	143	154 (14,850)
1963	196	144	146 (14,110)
1964	175	133	132 (13,050)
1965	92	78	77 (7,500)
1966	158	117	117 (11,300)
1967	102	79	79 (7,700)
1968	146	113	114 (10,150)
1969	171	149	149 (14,450)
1970	158	127	128 (12,450)
1971	180	145	150 (14,750)
1972	228	171	169 (16,600)
1973	263	219	217 (20,700)
1974	271	228	227 (21,700)

1/ Source - A.D.F.& G., AYK Stock Status Report and AYK Annual Management Reports.

2/ Numbers reflect resident licenses, no non-resident licenses issued.

Table 14 Value of commercial salmon catch to the fishermen, Norton Sound area, in dollars, 1961-1974 1/.

Year	Value of Salmon Catch to the Fishermen
1961	Not Available
1962	105,800
1963	104,000
1964	51,000
1965	21,483
1966	68,000
1967	44,038
1968	63,700
1969	95,297
1970	99,019
1971	101,000
1972	102,225
1973	308,740
1974	437,127

1) Source - A.D.F.&G., AYK Annual Management Reports.

Table 15 Estimated salmon escapement, Norton Sound area, Kachavik Creek, by year, in numbers of fish, 1963-1974 1/ 2/.

Year	Chum	Pink	Pink and Chum 3/
1963	16,000	16,000	
1964	5,284	3,675	
1965			
1966	758	1,788	
1967 4/			1,780
1968			
1969	600	4,525	
1970	500		
1971	10,000	5,323	
1972	3,100	16,950	
1973	10,325	22,275	
1974	1,645	2,723	

1) Source - A.D.F.&G., 1974 AYK Annual Management Report.
2) Data obtained from aerial surveys. Chum and pink salmon collectively taken as "high counts" for the season.
3) Surveyor unable to distinguish between the two species.
4) Poor survey conditions or partial survey.

Table 16 Estimated salmon escapement, Norton Sound area, Niukluk River, by year, in numbers of fish, 1962-1974 1/ 2/.

Year	King	Chum	Pink	Pink and Chum 3/
1962	11			27,879
1963		13,687	4,103	
1964		8,395	10,495	
1965				
1966		21,300	8,600	4,700
1967			20,546	
1968				85,125
1969		10,240	92,650	
1970		7,300	60,350	
1971		22,605	8,370	
1972 4/		10,500	22,600	
1973		15,156	14,326	
1974		13,684	9,210	

1) Source - A.D.F.&G., 1974 AYK Annual Management Report.
2) Data obtained from aerial surveys. King salmon count is the "high count" for the season, chum and pink salmon counts collectively taken as "high counts" for the season.
3) Surveyor unable to distinguish between the two species.
4) Poor survey conditions or partial survey.

Table 17 Estimated salmon escapement, Norton Sound area, Fish River, by year, in numbers of fish, 1961-1974 1/ 2/.

Year	King	Chum	Pink	Pink and Chum 3/
1961	1			14,100
1962	48			28,918
1963	21			25,728
1964		18,670	10,935	14,550
1965				
1966	7			17,955
1967	20			13,510
1968	10			164,000
1969		2,080	124,000	
1970	33	76,550	198,000	
1971	1	13,185	1,670	
1972 4/		3,616	13,050	
1973	31	6,887	14,364	
1974	3	10,945	15,690	

1) Source - A.D.F.&G., 1974 AYK Annual Management Report.
2) Data obtained from aerial surveys. King salmon count is the "high count" for the season, chum and pink salmon collectively taken as "high counts" for the season.
3) Surveyor unable to distinguish between the two species.
4) Poor survey conditions or partial survey.

Table 18 Estimated salmon escapement, Norton Sound area, Tubutulik River, by year, in numbers of fish, 1962-1974 1/ 2/.

Year	King	Chum	Pink	Pink and Chum 3/
1962	3			16,690
1963	9	16,069	4,355	
1964		15,469	10,043	3,420
1965				
1966		4,363	26,000	
1967	1			22,475
1968 4/				
1969	3	12,040	12,788	3,045
1970		53,290	136,590	
1971		16,820	7,500	5,065
1972 5/		8,070	21,100	
1973	131	5,383	15,665	
1974	136	9,560	17,940	

1) Source - A.D.F.&G., 1974 AYK Annual Management Report.
2) Data obtained from aerial surveys. King salmon count is the "high count" for the season, chum and pink salmon collectively taken as "high counts" for the season.
3) Surveyor unable to distinguish between the two species.
4) Count not obtained, but numbers believed to be similar to Kwiniuk River for the same year.
5) Poor survey conditions or partial survey.

Table 19 Estimated salmon escapement, Norton Sound area, Kwiniuk River, by year, in numbers of fish, 1962-1974 1/ 2/.

Year	King	Chum	Pink	Pink and Chum 3/
1962	3			23,249
1963	2	11,340	3,779	
1964		14,533		
1965	14	26,634	8,301	
1966	7	32,786	10,629	
1967	13	24,444	3,508	
1968	27	18,813	126,764	
1969	12	19,687	56,683	
1970		68,004	235,131	
1971	37	39,046	16,742	
1972	65	30,305	62,299	
1973	57	28,614	38,426	
1974	62	35,899	40,825	

1) Source - A.D.F.&G., 1974 AYK Annual Management Report.
2) Counts from 1962-1964 obtained from aerial surveys, king salmon count is the "high count" for the season, chum and pink salmon counts collectively taken as "high counts" for the season. Counts from 1965-1974 represent total counts obtained from counting tower.
3) Surveyor unable to distinguish between the two species.

Table 20 Estimated salmon escapement, Norton Sound area, Boston Creek, by year, in numbers of fish, 1963-1974 1/ 2/.

Year	King	Chum	Pink
1963	67	1,669	
1964	10	3,315	
1965			
1966 3/	153	761	
1967			
1968	7	2,500	2,500
1969	100	7,000	16,000
1970	246	8,200	12,900
1971	42	7,045	80
1972	56	4,252	3,950
1973	153	2,282	3,213
1974	225	2,201	749

1) Source - A.D.F.&G., AYK Annual Management Report.
2) Data obtained from aerial survey counts. King salmon count is the "high count" for the season, chum and pink salmon counts collectively taken as "high counts" for the season.
3) Poor survey conditions or partial survey.

Table 21 Comparative sockeye salmon aerial survey counts, Port Clarence area, by year, in numbers of fish, 1963-1974 1/ 2/.

Year	Salmon Lake	Grand Central River
1963	866	620
1964	76	590
1965	250	160
1966	1,120	370
1967	129	280
1968	830	645
1969	24	171
1970 3/		
1971	538	512
1972	680	300 4/
1973	1,747	607
1974	820	0

1) Source - A.D.F.&G., 1974, AYK Annual Management Report.
2) Counts represent peak counts from aerial surveys.
3) No survey conducted.
4) Boat survey.

Table 22 General salmon run timing information, Norton Sound and Port Clarence areas 1/.

Species	Present Bays and Estuaries	Spawning
King Salmon	June 15 to July 10-15	July 10 to August 5
Sockeye Salmon	June 25 to July 25	July 15 to September 10
Coho Salmon	August 1 to August 20	August 20 to September 30
Pink Salmon	June 25 or July 1 to July 15-20	July 15 to August 5
Chum Salmon	June 20-25 to July 20-25	July 10 to August 15

1) Source: A.D.F.&G., AYK area staff, personal communication, 1976.

KOTZEBUE AREA SALMON FISHERIES

INTRODUCTION

The Kotzebue district includes all waters from Cape Prince of Wales to Point Hope (Figure 4). With the exception of an experimental commercial fishery at Deering, salmon can only be taken in Kotzebue Sound east of a marker line placed from Aukoolak Lagoon in Sheshalik Spit to Cape Blossom on Baldwin Peninsula. The remaining large closed area is thought necessary to prevent establishment of another separate fishing area which would harvest mixed stocks, including salmon bound for the Noatak and Kobuk Rivers which are already exploited by the present fishery adjacent to the village of Kotzebue.

COMMERCIAL FISHERIES

Description

The salmon population entering this district is composed almost entirely of chum salmon bound for the Noatak and Kobuk River systems. Commercial catches have been strongly influenced by seasonal variations in abundance. These extreme fluctuations are probably normal since the Kotzebue area is in the northern range of North American chum salmon. Small numbers of sockeye, king and pink salmon are also present.

Two other species of fish, Arctic char and sheefish, are also harvested commercially. The Arctic char fishery is incidental to the commercial salmon fishery. The sheefish fishery is generally considered a winter fishery which is regulated by permit.

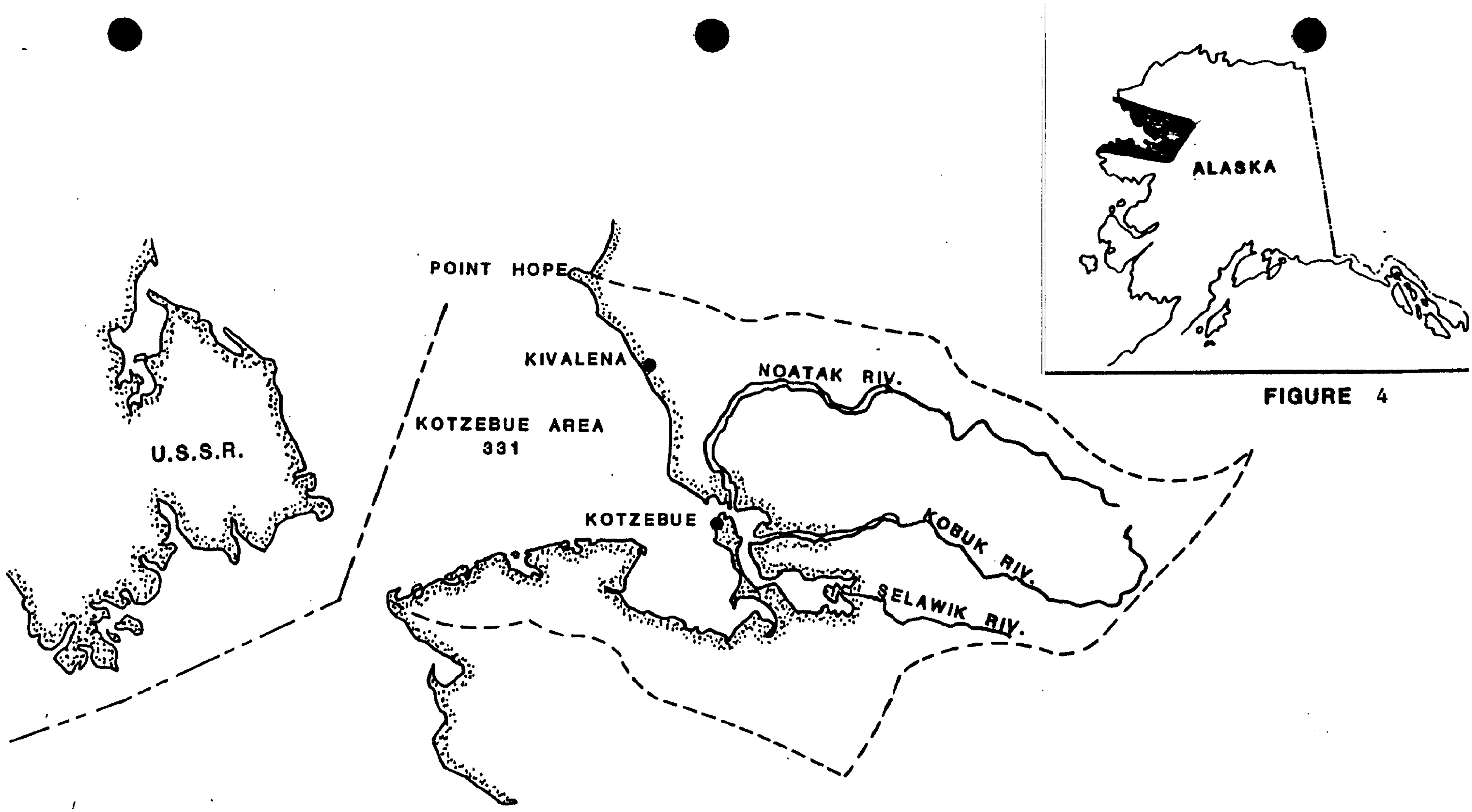


FIGURE 4

ALASKA DEPT. OF FISH & GAME
DIVISION OF COMMERCIAL FISHERIES
KOTZEBUE SOUND AREA

Timing

The Kotzebue commercial salmon season officially opens on July 1, but actual fishing does not commence until mid-July due to availability of fish. The weekly fishing period extends from 6 p.m. Monday to 6 p.m. Wednesday and from 6 p.m. Thursday to 6 p.m. Saturday. Prior to 1968, commercial fishermen could fish for subsistence purposes during the closed periods except for a six-hour period just before each open commercial fishing period. Beginning with the 1969 season, however, commercial fishermen were prohibited from subsistence fishing during all closed fishing periods throughout the commercial fishing season.

It has been determined that the bulk of the fish returning to this district are bound for the Kobuk and Noatak Rivers. Tagging studies indicate that the less abundant Kobuk River chum salmon arrive in this district first, peaking in the commercial fishery during July 17-28. The Noatak River run follows, peaking from August 10-24. With this in mind, the A.D.F.& G. has attempted to restrict fishing time for those years of low salmon abundance and/or increased fishing effort while the Kobuk River run is passing through the fishery.

Effort

All commercial fishing effort is concentrated near the village of Kotzebue. Fishermen can legally operate set gill nets of up to 150 fathoms. Small open skiffs, powered by outboard motors, are used to operate the fishing gear and deliver the fish to buyers.

Commercial fishing effort has increased rapidly in recent years. From 1972-1975 an average of 181 fishermen were actively involved in the fishery annually. There is no licensing registration deadline date, which results in the registration fluctuating with the size of the runs and resultant harvests. Table 24 presents the number of commercial, vessel and gear licenses for the Kotzebue area from 1962-1974.

Economic Value

Using 1974 prices, the average (1960-1974) value to the fishermen of the Kotzebue commercial chum salmon harvest is $432,000 annually. However, this average value is not a good reflection of what the fishery is worth since catches have increased substantially in recent years. The 1974 value of the commercial harvest was over 1.8 million dollars. In addition, sheefish and Arctic char are also sold commercially; however, no economic values are available. The annual value to the fishermen of the salmon fishery since 1960 is given in Table 25 .

ESCAPEMENT AND SPAWNING

Introduction

Due to extreme variations in annual chum salmon abundance, forecasting returns to the Kotzebue area has been difficult. Aerial surveys in this district are conducted on key tributaries, as well as on the main streams of the Kobuk and Noatak River systems and southern Kotzebue Sound. Peak counts of spawning chum salmon for the years 1960-1974 are presented in Table 26 . These counts are considered minimal since surveys were not always conducted under optimum conditions or on all spawning areas.

In August of 1960, biologists under contract to the Atomic Energy Commission conducted boat and aerial surveys of the Noatak River and estimated the chum spawning population at 930,000 fish. After observing this system since 1962, A.D.F.& G. biologists feel that the 1960 count was an overestimate. It is possible that large numbers of char and whitefish normally present were mistaken for chum salmon.

Habitat, Migration and Timing

Spawning and rearing habitat preferences for chum salmon in the Kotzebue area are essentially the same as outlined in the generalized life history (Appendix). Chum salmon runs in this area have fluctuated markedly since 1962. From comparisons of past escapement and harvest data, it appears that Kotzebue chum salmon stocks exhibit a five-year cycle of abundance.

As previously mentioned, the majority of chum salmon returning to the Kotzebue area are bound for the Kobuk and Noatak Rivers. The Kobuk River chum salmon run arrives first and spawning occurs from July 20 to August 25. The Noatak River run is later, with spawning occurring from July 27 through September 5, peaking around August 16-17.

Escapement Goals

Escapement goals have not been defined for chum salmon runs in the Kotzebue area due to insufficient information concerning spawning magnitude and distribution. In-season management of the fishery is based on analysis of comparative catch and catch per unit effort data, as well as on aerial escapement surveys and test fishing results. The duration of the fishing season and weekly fishing periods is occasionally changed by emergency order to compensate for either unusually large or small runs.

STATUS RELATED TO MAXIMUM SUSTAINED YIELD

Unrefined estimates of chum salmon returns have been made for Noatak and Kobuk River stocks. Estimates utilizing peak harvest and aerial survey counts range from 90,000 to 440,000 during the 1962-1972 period. Assuming a static subsistence harvest of about 30,000 fish, it is estimated that maximum allowable commercial harvest should range between 30,000 and 250,000 fish annually.

An improvement in escapement monitoring is required before accurate assessment of run magnitudes and MSY can be obtained. Due to large runs during several recent seasons, fishing time has been increased beyond the normal four days per week schedule. However, limited processing capability has prevented fishermen from taking full advantage of these time extensions. It is estimated that a minimum of 50,000 to 75,000 additional chum salmon could have been commercially harvested during each of the last three seasons (1972-1974).

The potential for a commercial fishery in southern Kotzebue Sound near the villages of Deering, Candle and Buckland is being investigated. Inquiries from local residents have recently been made regarding opening this area to commercial salmon fishing. Pink and chum salmon are known to occur in this area, but species composition, distribution and abundance are unknown.

Table 23 . Commercial salmon catch, Kotzebue area, by year, in numbers of fish, 1914-1974. 1/ 2/

Year	Total	King	Sockeye	Coho	Pink	Chum
1914	8,550	--	--	--	--	8,550
1915	4,750	--	--	--	--	4,750
1916	19,000	--	--	--	--	19,000
1917	44,612	--	--	--	--	44,612
1918	27,407	--	--	--	--	27,407
1962	130,075	12	7	1	107	129,948
1963	54,588	7	--	--	136	54,445
1964	76,504	--	--	--	5	76,499
1965	40,034	--	--	--	--	40,034
1966	31,981	1	93	--	131	31,756
1967	29,404	1	--	--	3	29,400
1968	30,384	--	--	--	--	30,384
1969	59,383	--	--	--	48	59,335
1970	159,664	--	--	--	--	159,664
1971	154,957	1	--	--	--	154,956
1972	169,667	3	--	--	--	169,664
1973	375,437	5	--	--	--	375,432
1974 3/	634,527	--	--	--	48	634,479

1/ Source - A.D.F.& G., AYK Annual Management Reports.

2/ No catch reported 1919-1961.

3/ Includes 6,567 chum salmon from Deering experimental commercial fishery.

Table 24 . Commercial, vessel and gear licenses, Kotzebue area, 1960-1974. 1/

Year	Commercial	Vessel	Set Gill Net
1960	--	--	
1961	--	--	
1962 2/	128	88 3/	102 (11,350 F.)
1963 4/	110	59	60 (8,550 F.)
1964	81	48	52 (5,550 F.)
1965	61	43	45 (5,450 F.)
1966	64	44	44 (4,650 F.)
1967	54	32 5/	30 (3,600 F.)
1968	90	59	59 (6,750 F.)
1969	77	52	52 (5,400 F.)
1970	160	82	82 (9,800 F.)
1971	198	87	91 (11,100 F.)
1972	202	87	101 (13,100 F.)
1973	390	136	156 (19,250 F.)
1974 6/	401	174	191 (26,500 F.)

1/ Source - A.D.F.& G., AYK Stock Status Report and AYK Annual Management Reports.
2/ Includes Norton Sound area fishermen and their gear who also fished in Kotzebue area before area registration established.
3/ Includes 4 tenders.
4/ Includes 2 tenders.
5/ Includes 2 tenders.
6/ Includes Deering experimental commercial fishery with 7 commercial, 4 vessel and 6 (300 fathoms) set gill nets.

Table 25 Value of commercial salmon catch to the fishermen, Kotzebue area, in dollars, 1962-1974 1/.

Year	Value of Salmon Catch to the Fishermen
1962	45,550
1963	9,140
1964	34,660
1965	18,000
1966	25,000
1967	28,700
1968	46,000
1969	71,000
1970	186,000
1971	200,000
1972	260,000
1973	925,735
1974	1,822,784

1) Source - A.D.F.&G., AYK Annual Management Reports.

Table 26 . Estimated chum salmon escapement, Kotzebue area, by year, in numbers of fish, 1962-1974. 1/ 2/

Year	Noatak River System	Kobuk River System
1962	178,898	62,977
1963	2,605 3/	8,940
1964	89,798	28,032
1965	7,332 3/	11,480
1966	102,222	8,164
1967	28,845	8,113
1968	45,271	13,306
1969	34,163 3/	16,934
1970	138,145	23,326
1971	41,064	30,667
1972	67,601 3/	52,354
1973	36,034	21,706
1974	138,834	94,287

1/ Source - A.D.F.& G., AYK Annual Management Reports.

2/ All counts made from aerial surveys and represent peak counts.

3/ Poor survey conditions or incomplete survey.

NORTHERN AREA SALMON FISHERIES

INTRODUCTION

The Northern area lies entirely north of the Arctic Circle and encompasses all of the drainages north of the Brooks Range from Point Hope eastward around the northern Alaska coast to the Canadian border at Demarcation Point (Figure 5). Topographically, the area ranges from the flat Arctic plain with a myriad of slow-moving rivers and shallow tundra ponds to the mountainous foothills of the northern Brooks Range.

Several major rivers flow through this area including the Kokolik, Utukok, Kukpouruk, Colville, Sagavanirktok, Kaparuk, Okpilak, Kongakut, Aichilik, Egaksaak, Hulahula and Canning Rivers. Although these watersheds are generally clear water systems, they are subject to summer flooding resulting from widespread showers on the watersheds. Most of the shallow tundra lakes in this permafrost region are not considered a suitable environment for fish production.

COMMERCIAL FISHERIES

Although pink and chum salmon are present in this area and have been found as far north as Point Barrow and in the Beaufort Sea adjacent to the mouth of the Sagavanirktok River, their population numbers are extremely limited. There is a paucity of information concerning species distribution primarily due to the lack of human habitation throughout much of the area. There is no bonafide commercial salmon fishing in this area.

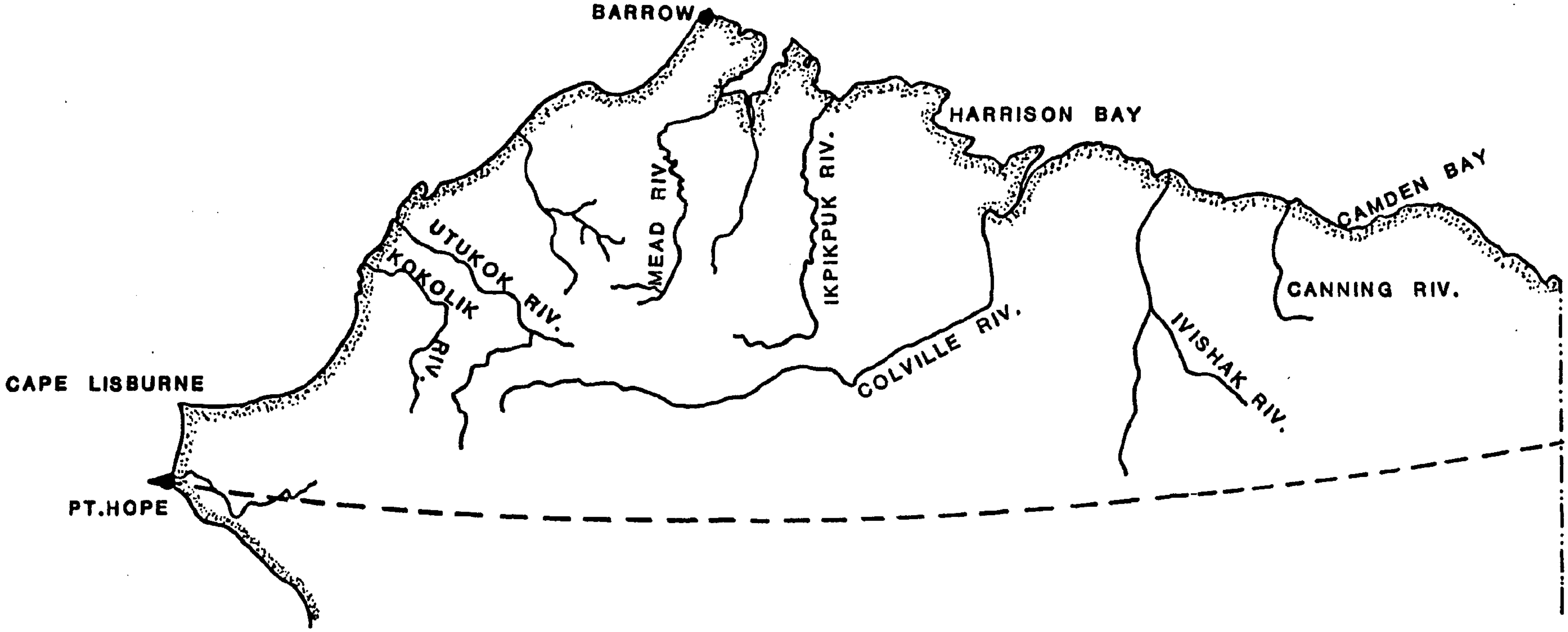
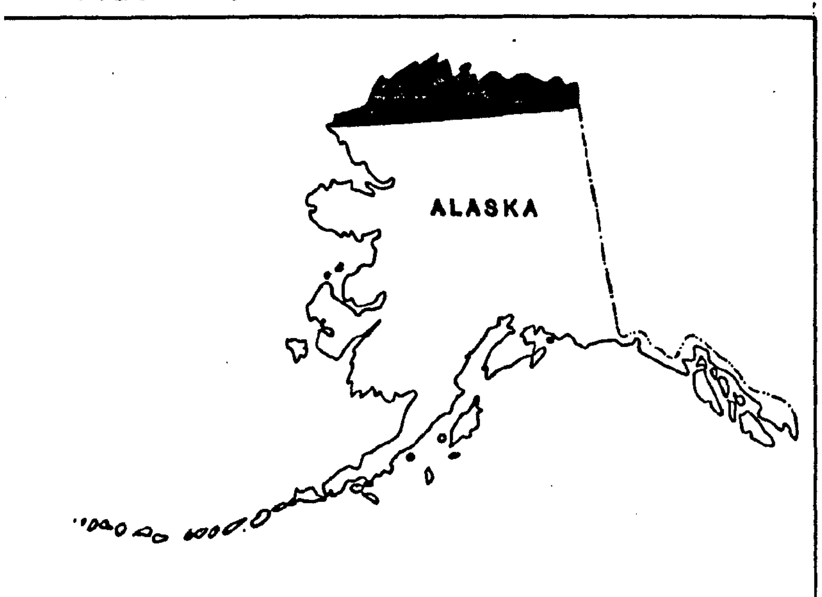


FIGURE 5



ALASKA DEPT. OF FISH & GAME
DIVISION OF COMMERCIAL FISHERIES
NORTHERN AREA

A commercial whitefish fishery has been conducted in the Colville River delta since 1960. Approximately 3,000 broad whitefish and 1,000 humpback whitefish are harvested annually during the summer fishery and 20,000 least cisco and 40,000 Arctic cisco during the fall fishery.

ESCAPEMENT AND SPAWNING

The Northern area represents the most northern range of Pacific pink and chum salmon. As a result, these species are existing at the outer limit of their environmental tolerances. Currently, data is unavailable for migrational patterns, run and spawning timing, and escapement levels.

STATUS RELATED TO MAXIMUM SUSTAINED YIELD

No estimates of maximum sustained yield (MSY) have been developed for the salmon resources in this area. Since the salmon stocks are extremely limited, it is unlikely that future development of a bonafide commercial fishery will occur. The extreme environmental parameters and the lack of suitable spawning areas that are not subject to winter freeze-up are considered overriding restrictions against major salmon production.

WESTERN-ARCTIC ALASKA AREA

HERRING FISHERIES

INTRODUCTION

For the purpose of this report, the Western and Arctic Alaska area includes all waters between Cape Newenham on the south and Demarcation Point on the north. Data for the commercial foreign fisheries, however, will include the entire Bering Sea as information is only available for the overall area.

Pacific herring, *Clupea pallasii*, as well as several species of smelt (Osmeridias), including capelin (*Mallotus villoseis*), are present within this area. Presently, only Pacific herring are utilized in a commercial fishery; there are no known commercial fisheries, either domestic or foreign, for smelt in this area. This report will deal only with the Pacific herring resource.

COMMERCIAL FISHERIES

Domestic Fisheries

There are presently no full-fledged domestic herring fisheries operating within this area. Adequate stocks appear to be available, and with improved market conditions and more efficient fishing techniques, a commercial fishery could be developed.

Foreign Fisheries

The major foreign fisheries for herring occur in the eastern Bering Sea. It is assumed that these fisheries exploit herring stocks originating from western Alaska. Fredin, in an INPFC Document, 1962, entitled Herring Fisheries and Resources of Eastern Bering Sea, states that:

> "There are three major fisheries for herring in the eastern Bering Sea, a Japanese trawl fishery, a Soviet trawl fishery, and a Japanese gill net fishery. The trawl fisheries operate along and inside the 100 fathom line between the Pribilof Islands and St. Matthew Island during the winter months, November to March. The gull net fishery operates off the Bering Sea coast of Alaska from Bristol Bay to Norton Sound during the Spring, April to June."

Japanese catches for both the gill net and trawl fisheries averaged 19,436 metric tons annually between 1967 and 1973, with a peak harvest of 38,639 metric tons in 1968 and a low of 1,911 metric tons in 1973. Soviet catches averaged 49,330 metric tons annually for the same period, with a peak harvest of 117,202 metric tons in 1970. The 1973 Soviet harvest was 34,361 metric tons. In addition to these fisheries, the Republic of Korea entered the Bering Sea herring fishery in 1973 with a harvest of 285 metric tons.

The future development of foreign herring fisheries in the Bering Sea will be closely tied to the recent passage of the Fishery Management and Conservation Act of 1976. Through this Act herring fishing by foreign fleets in the Bering Sea will be more formally regulated by the United States. Fishery management plans developed by regional management councils will set forth conditions under which all foreign nations fishing within 200 miles of the U.S. coast will have to comply.

Included in the fishery management plans is the determination of the total allowable catch for foreign vessels. These management plans are presently evolving and will determine to what extent foreign exploitation of the Bering Sea resource will occur.

DISTRIBUTION AND LIFE HISTORY

There has been little American biological research on the herring stocks in this area. Offshore marine distribution and migration is not known. Limited observations on inshore spawning areas, particularly as a result of the 1976 OCSEAP Southern Bering Sea Herring Spawning Survey, have been made, yet large areas remain unsurveyed. Ground checks on suspected spawning areas are needed throughout much of the area.

The 1976 OCSEAP Southern Bering Sea Herring Spawning Survey identified several areas as primary herring spawning areas (Figures 6, 7 and 8). This survey, however, extended only from Cape Sarichef on the northwest end of Unimak Island to the Yukon River mouth. Surveys are lacking north of the Yukon River and for the Bering Sea islands, although herring are known to be present on St. Lawrence Island and in Norton and Kotzebue Sounds. When the results of the 1977 survey, which included Norton and Kotzebue Sounds, are available, additional spawning areas will be identified.

Known spawning habitat in this area generally consists of beaches where the shoreline morphology includes cliffs or bluffs with large, jagged outcroppings. Where beaches occur in such areas, they are usually intertidal. Spawning substrate consists primarily of rocks covered with rockweed kelp (*Fucus* sp.). Ground surveys, however, indicate that almost any substrate (e.g., <u>Laminaria</u> sp., bare rocks, gillnets) may be used under conditions of dense spawning. A second type of herring spawning habitat consists of shallow bays, beaches or slough areas where eelgrass (<u>Zosteria</u> sp.) is common. The bottom substrate in these areas is usually mud and/or sand. Intertidal and subtital spawning generally occurs in water depths of less than two meters. This type of spawning habitat is the predominant form found north of Cape Newenham.

Specific life history information is lacking for this area. Additional data may be obtained in the generalized life history found in the Appendix.

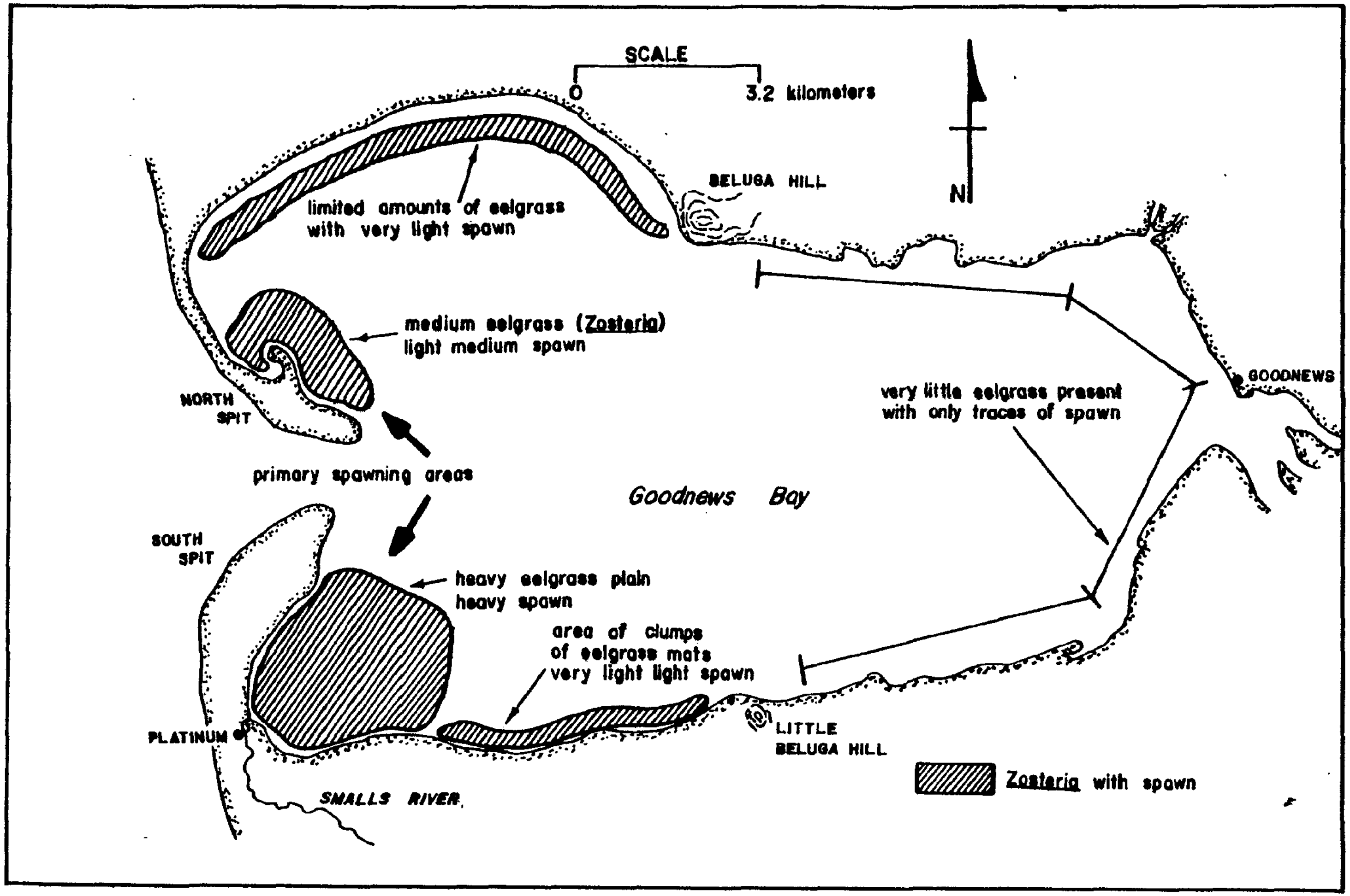


FIGURE 6 DISTRIBUTION OF EELGRASS (ZOSTERIA SP.) AND HERRING SPAWN, IDENTIFIED BY GROUND SURVEYS JUNE 10-13, IN GOODNEWS BAY, 1976.

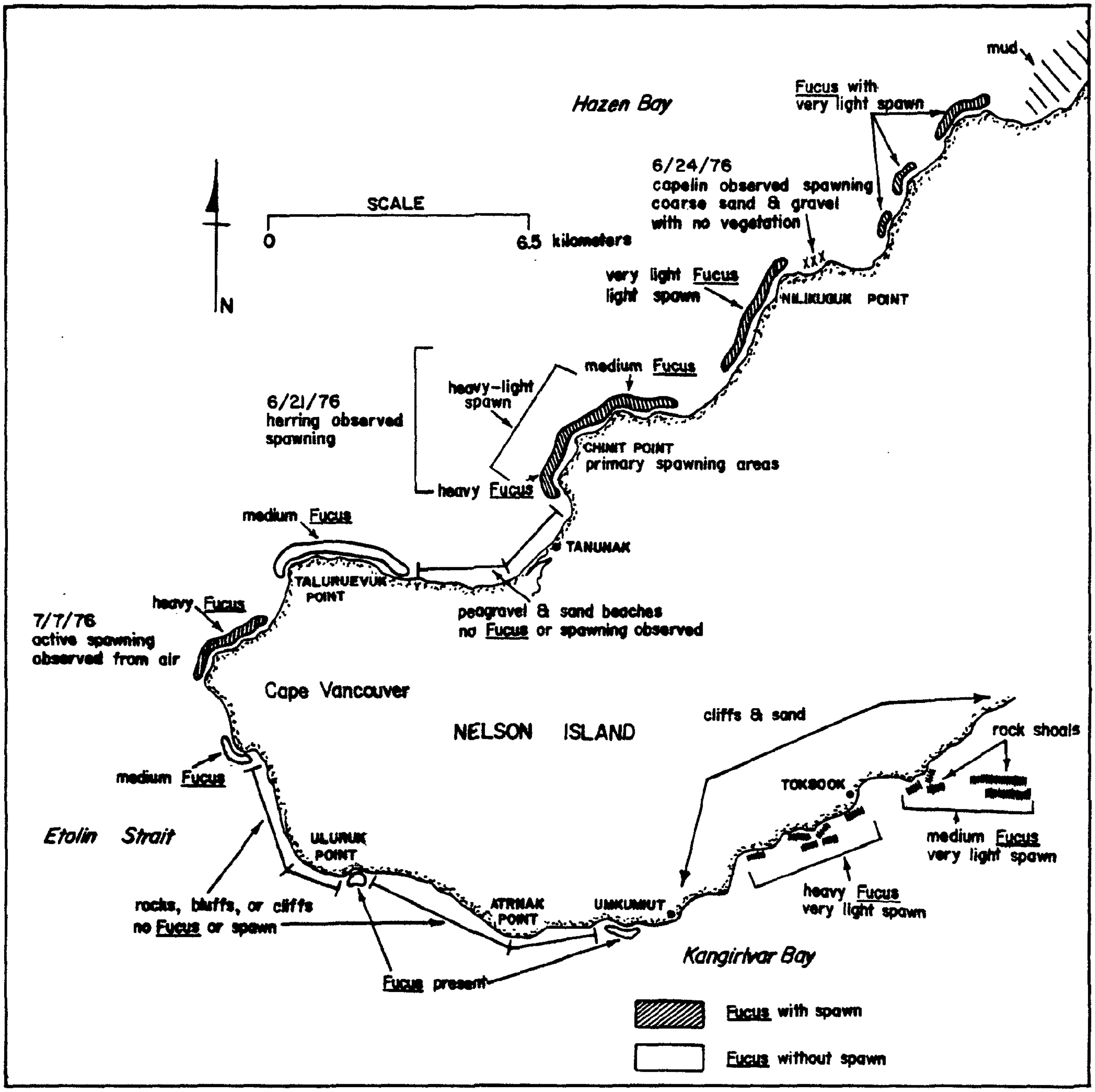


FIGURE 7 DISTRIBUTION OF ROCKWEED KELP (FUCUS SP.) AND HERRING SPAWN, IDENTIFIED BY GROUND SURVEYS JUNE 19-24 AND JULY 13-14 AT NELSON ISLAND, 1976.

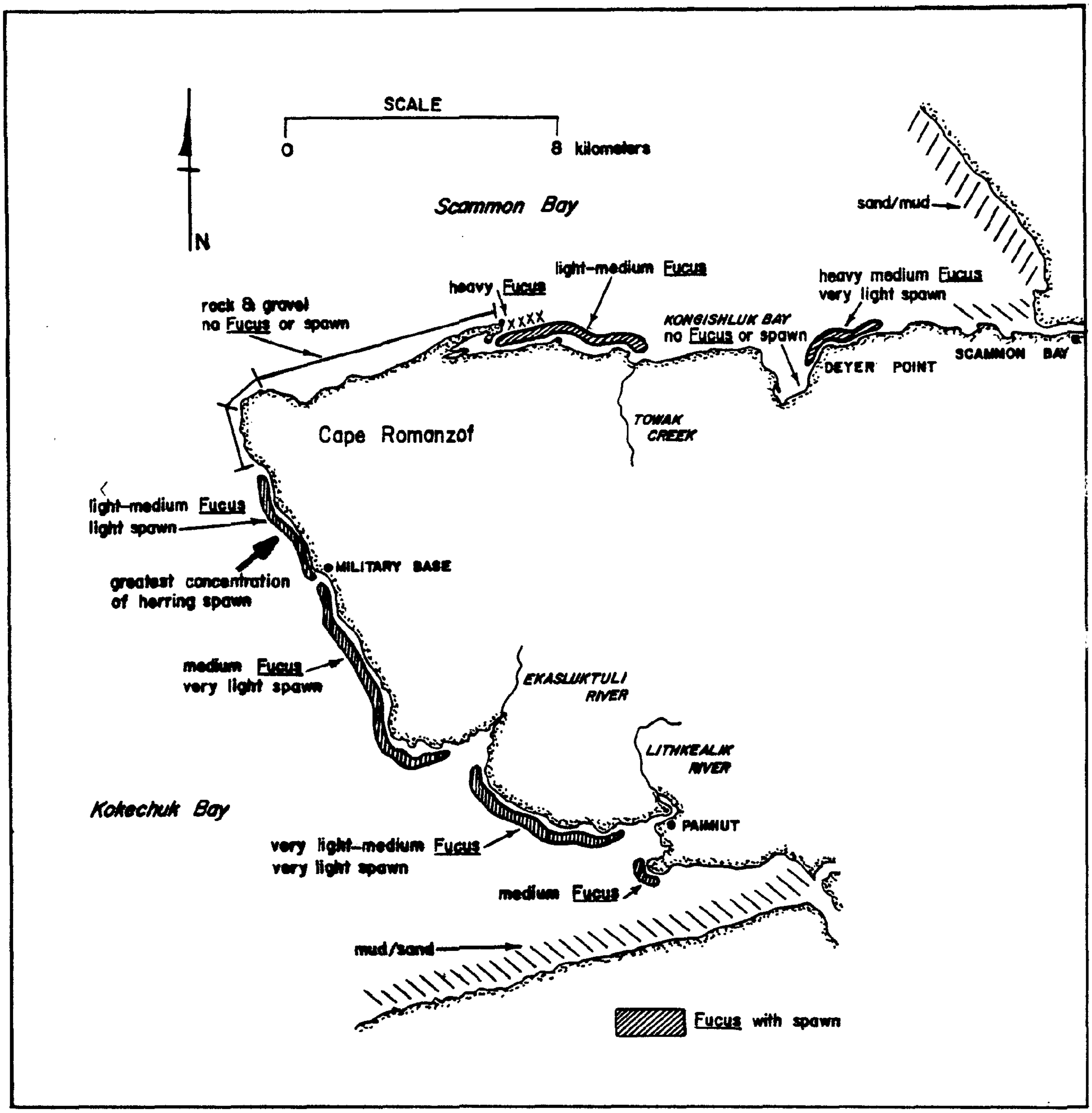


FIGURE 8 DISTRIBUTION OF ROCKWEED KELP (FUCUS SP.) AND HERRING SPAWN, IDENTIFIED BY GROUND SURVEYS JULY 4 - 8 IN KOKECHUK BAY AND SCAMMON BAY, 1976.

WESTERN-ARCTIC ALASKA AREA GROUNDFISH FISHERIES

Much of this study area lies outside of the productive Bering Sea groundfish fishing grounds which lie along the continental shelf and slope between the Aleutian Islands and Saint Lawrence Island. Few exploratory surveys have been conducted in the northern portion (north of Saint Lawrence Island); consequently distributional information and abundance estimates are largely unavailable. However, various groundfish species, including grey cod and several flounders, have been documented as present within the area. There is no commercial fishery for these species in the northern portion of the study area. Low level subsistence utilization does occur.

At the present time a major foreign groundfish fishery occurs along the continental shelf and slope within this area south of Saint Lawrence Island. Specific data on this fishery was reported on in a previous publication produced by this staff. Reference should be made to McLean, et al., 1977, A Fish and Wildlife Resource Inventory of the Alaska Peninsula, Aleutian Islands and Bristol Bay Areas. This report is one of a sequence of reports, inclusive of the present one, which has presented an inventory of the states coastal fishery resources for the Alaska Coastal Management Program.

WESTERN-ARCTIC ALASKA SHELLFISH FISHERIES

For the purpose of this report, the Western-Arctic Alaska area includes all of the waters of the Bering Sea north of 59°N. latitude, the Chukchi Sea and the Beaufort Sea. This area includes a portion of the productive Bering Sea king crab, tanner crab and shrimp fishing grounds north of the Pribilof Islands. Specific information on these fisheries may be found in McLean, et al., 1977, A Fish and Wildlife Resource Inventory of the Alaska Peninsula, Aleutian Islands and Bristol Bay Areas. This report is one of a sequence of reports, inclusive of the present one, which has presented an inventory of the state's coastal fishery resources for the Alaska Coastal Management Program.

King crab, tanner crab and shrimp have been reported as far north as the Chukchi Sea. Abundance, however, north of 60°N. latitude is low. The only documented fisheries have been of a subsistence nature.

Dungeness crab are not present within this study area.

Razor clams, *Siliqua patula*, are not present in this study area. However, a related but smaller species, *Siliqua alta*, has been reported with a range extending into the Arctic Ocean. There are no commercial fisheries for this species. Stock abundance is low and appears to support only a small subsistence fishery.

KUSKOKWIM RIVER AREA SUBSISTENCE FISHERIES

DESCRIPTION

The subsistence salmon fishery in the Kuskokwim district, especially in the Kuskokwim River, remains the largest and most intense of its kind in the state. King and chum salmon are the two most important species taken for subsistence purposes. Coho salmon are not heavily utilized due to the lateness of the run when most residents are returning to their villages. Additionally, rainy weather during this time prevents proper drying of the catch. One exception to this occurs in the village of Quinhagak. Here the greatest fishing effort occurs in the Kanektok River for coho salmon after the commercial fishing season. Although accurate data is lacking, observations by Fish and Game personnel indicate that the dependence on subsistence fishing in this village has declined considerably in recent years.

In addition to salmon, nearly all species of fish present are utilized for subsistence. Whitefish, northern pike, burbot, sheefish and herring represent the majority of the species harvested. It is estimated that 75 to 85 percent of this catch is utilized for human consumption.

ECONOMIC CONDITIONS IN THE AREA

Nearly all of the Kuskokwim area residents are dependent to varying degrees on the fish and game resources for their livelihood. Recent development and expansion of commercial salmon fisheries in this area of little industrialization has enabled many of the local residents to obtain a cash income. Other sources of income are limited to sporadic employment, such as firefighting and special welfare payments.

For many fishermen the need of a cash income from the sale of commercially caught salmon remains secondary to the need of gathering, preparing and storing of fish for subsistence purposes. In terms of money required to purchase a similar quantity of meat substitute, the subsistence catch may rival the value of the commercial catch during some years.

There is still a moderate sale or trading of dried salmon on the Kuskokwim River, but it is not documented. People from the coastal delta villages still bring seal oil to trade for dried fish. The dried fish from the lower river are now primarily being used for human consumption.

METHODS OF FISHING

The majority of subsistence caught salmon are currently taken with nylon gill nets. The use of the fishwheel, which historically harvested a considerable number of salmon in the Kuskokwim River, is slowly disappearing. Only 11 fishwheels were used along the survey route in 1974, compared to 30 in 1965 and 65 in 1960. The fishwheel is being replaced by the much more mobile gill net, which involves less time and effort to operate. The use of gill nets is a relatively new technique for most Kuskokwim River residents. The efficiency of the two types of gear is difficult to evaluate as large catches are often made with both.

Traps and fish weirs of various designs are used, mainly in the fall and winter months, to capture whitefish, sheefish, blackfish and burbot. Sheefish, pike, char and tomcod are frequently taken through the ice by jigging.

There has been no definite trend in the decline in total catches or numbers of participating fishermen since 1960, although the percentage of king salmon in the catch has increased. The number of fishwheels operated has steadily declined, but this has been more than compensated for by the increasing use of nylon gill nets. During the past few years the numbers of sled dogs have declined and numbers of snowmachines have increased, which may foretell decreases in effort. Table 27 shows the subsistence salmon catch in the Kuskokwim district for the years 1960 to 1974.

Accurate catch records are not available for species other than salmon, but a gross estimate is that 250,000 to 500,000 whitefish (0.5 to 1.0 million pounds), 90,000 pike and 10,000 burbot are harvested annually by subsistence fishermen in the lower Kuskokwim River drainage. In coastal areas it is estimated that up to 20,000 whitefish, 20,000 pike, 9,000 pounds of halibut and many tons of herring are harvested each year.

PROBLEMS

The coexistence of a commercial fishery and an intensive subsistence fishery in the Kuskokwim management area has created problems of user group allocation.

A recently evolved potential conflict concerns the newly-adopted legislation permitting the sale of salmon roe from subsistence caught fish. The sale of subsistence caught salmon roe is expected to enhance the economy in areas such as the upper Kuskokwim River where no commercial fishing is permitted. However, with the high value of salmon roe, subsistence fishing effort has increased, presumably for the purpose of roe extraction and sale. The Department of Fish and Game has implemented quotas and restrictions on the sale and production of salmon roe, but the net result remains to be seen.

Table 27 Subsistence salmon catch, Kuskokwim River area, in numbers of fish, 1960-1974 1/.

Year	Fishing Families Surveyed	King	Other Salmon 2/	Total
1960	247	20,361	327,297	347,658
1961	342	30,910	185,447	216,357
1962	349	14,642	165,626	180,268
1963	405	37,246	141,550	178,796
1964	394	29,017	189,660	218,677
1965	332	27,143	283,459	310,602
1966	492	49,606	174,660	224,266
1967	472	57,875	205,263	263,138
1968	567	30,230	260,023	290,253
1969	376	40,138	198,628	238,766
1970	514	69,204	245,550	314,754
1971	488	42,926	116,391	159,317
1972	576	40,145	120,316	160,461
1973	408	38,526	179,259	217,785
1974	596	26,665	277,170	303,835

1) Source - A.D.F.&G., AYK Annual Management Reports.
2) Includes mostly chum salmon.

Table 28 Comparative king salmon subsistence catch, Kuskokwim River area, by village, 1960-1974 footnotes.

1) Source - A.D.F.&G., AYK Annual Management Reports.
2) Included with other villages.
3) Does not include 1965 and 1974.
4) Estimates based on catch data through 1969.
5) Included with Eek.
6) Does not include 1964.
7) New village of Atmauthluak segregated in 1970 from parent village of Nunapitchuk.
8) Included with Lower Kalskag.
9) Does not include 1962 and 1963.
10) Included with Red Devil.
11) Data not available.
12) Includes Lime Village.

Table 28. Comparative king salmon subsistence catch, Kuskokwim River area, by village, 1960-1974 1/.

Village	1960	1961	1962	1963	1964
Kwigillingok, Kipnuk, Kongiganak	250	283	54	229	414
Eek	1,474 4/	2,238 4/	1,060 4/	2,697 4/	1,857
Tuntutuliak	226	2,226	842	2,853	1,826
Kasigluk	135	1,215	127	1,302	5/
Nunapitchuk	683	2,042	848	1,874	636
Atmauthluak 7/					
Napakiak	1,830	2,573	2,191	3,148	2,677
Oscarville	1,968	282	75	309	339
Napaskiak	536	1,258	759	1,569	2,201
Bethel	1,923	4,150	1,378	7,019	4,114
Kwethluk	2,692	3,763	2,329	5,050	3,262
Akiakchak	1,626	3,052	1,800	2,533	3,488
Akiak	1,865	3,159	906	2,869	2,495
Tuluksak	737	1,486	493	1,295	572
Lower Kalskag	961	571	805	2,661	710
Upper Kalskag	667	1,049	8/	8/	1,143
Aniak	1,057	688	185	602	1,104
Chuathbaluk	64	54	10	30	74
Napamute	20	16	44	52	134
Crooked Creek	747	518	561	859	1,358
Georgetown	11/	11/	11/	11/	11/
Red Devil	11/	40	144	228	314
Sleetmute	465	222	10/	10/	10/
Stony River	435	25	31	67	299
Total	20,361	30,910	14,642	37,246	29,017

continued

Table 28 (continued) Comparative king salmon subsistence catch, Kuskokwim River area, by village, 1960-1974.

Village	1965	1966	1967	1968	1969
Kwigillingok, Kipnuk, Kongiganak	0 2/	205	957	70	385
Eek	2,737	2,872	4,375	2,760	2,037
Tuntutuliak	1,978	3,061	3,338	2,026	2,195
Kasigluk	513	1,875	2,766	1,360	2,888
Nunapitchuk	490	2,875	1,926	1,360	2,279
Atmauthluak 7/					
Napakiak	1,670	3,592	3,922	2,317	3,546
Oscarville	678	301	1,327	393	457
Napaskiak	1,412	2,935	3,091	1,647	2,227
Bethel	3,342	7,604	11,772	4,900	7,472
Kwethluk	4,538	6,135	6,889	3,549	3,187
Akiakchak	3,952	4,957	5,543	3,415	2,602
Akiak	1,774	3,941	3,790	1,332	1,275
Tuluksak	1,019	1,559	1,710	1,048	1,131
Lower Kalskag	841	1,918	1,733	1,463	2,083
Upper Kalskag	719	1,333	1,699	1,404	1,623
Aniak	494	2,002	1,415	467	1,406
Chuathbaluk	29	139	217	40	180
Napamute	2	78	60	100	19
Crooked Creek	363	1,249	638	77	541
Georgetown	11/	12	11/	11/	9
Red Devil	11/	182	11/	111	142
Sleetmute	491	149	343	200	267
Stony River	101	632	364	191	2,187
Total	27,143	49,606	57,875	30,230	40,138

continued

Table 28 (continued) Comparative king salmon subsistence catch, Kuskokwim River area, by village, 1960-1974.

Village	1970	1971	1972	1973	1974
Kwigillingok, Kipnuk, Kongiganak	1,111	241	10	75	10/
Eek	2,065	1,882	1,969	1,981	2,356
Tuntutuliak	3,558	1,841	3,214	2,859	1,577
Kasigluk	3,931	1,645	1,292	1,864	1,411
Nunapitchuk	4,680	1,978	2,496	2,663	1,165
Atmauthluak	1,205	548	864	1,106	382
Napakiak	4,960	1,868	2,009	1,763	1,224
Oscarville	542	570	196	586	180
Napaskiak	3,446	1,916	1,578	2,048	900
Bethel	17,026	8,731	8,371	8,898	4,631
Kwethluk	7,932	5,564	5,137	3,444	2,694
Akiakchak	7,022	4,818	3,872	2,592	1,726
Akiak	3,290	2,688	1,899	1,895	1,292
Tuluksak	1,995	1,280	1,318	1,322	883
Lower Kalskag	2,146	2,355	2,604	1,309	1,586
Upper Kalskag	734	601	401	938	463
Aniak	2,136	1,076	2,105	1,030	1,952
Chuathbaluk	219	179	261	942	674
Napamute	22	17	20	13	6
Crooked Creek	684	291	183	269	650
Georgetown	2	0	0	0	10/
Red Devil	232	135	182	138	205
Sleetmute	161	181	69	504	269
Stony River	105	2,521 12/	95	287	439
Total	69,204	42,926	40,145	38,526	26,665

continued

Table 28 (continued) Comparative king salmon subsistence catch, Kuskokwim River area, by village, 1960-1974.

Village	1960-1974 Total	1960-1974 Average
Kwigillingok, Kipnuk, Kongiganak	4,284	330 3/
Eek	34,360	2,291
Tuntutuliak	33,620	2,241
Kasigluk	22,324	1,595 6/
Nunapitchuk	27,995	1,866
Atmauthluak	4,105	821
Napakiak	39,290	2,619
Oscarville	8,203	547
Napaskiak	27,523	1,835
Bethel	101,331	6,755
Kwethluk	66,165	4,411
Akiakchak	52,998	3,533
Akiak	34,470	2,298
Tuluksak	17,848	1,190
Lower Kalskag	23,746	1,583
Upper Kalskag	12,774	983 9/
Aniak	17,719	1,181
Chuathbaluk	3,112	207
Napamute	603	40
Crooked Creek	8,988	599
Georgetown	23	4
Red Devil	2,053	171
Sleetmute	3,321	277
Stony River	7,779	519
Total	554,634	36,976

Table 29 Comparative "other salmon" subsistence catch, Kuskokwim River area, by village, 1960-1974 footnotes.

1) Source - A.D.F.&G., AYK Annual Management Reports.
2) Catches include primarily chum salmon but also include small numbers of sockeye, coho, pink and small king salmon.
3) 1965 to 1972 catches do not include late coho salmon catches.
4) Estimate based on catch data through 1970.
5) Included with Eek.
6) Included with Lower Kalskag.
7) Data not available.
8) Included with Red Devil.
9) Included with Lime Village.

Table 29 Comparative "other salmon" subsistence catch, Kuskokwim River area, by village, 1960-1974 1/ 2/ 3/.

Village	1960	1961	1962	1963	1964	1965
Kwigillingok, Kipnuk, Kongiganak	1,430	3,279	1,990	2,562	2,323	0
Eek	4,094 4/	2,321 4/	2,072 4/	1,771 4/	3,151	2,898
Tuntutuliak	4,101	8,526	9,692	6,791	8,421	18,993
Kasigluk	1,400	3,657	1,705	1,020	5/	4,041
Nunapitchuk	2,743	4,868	7,474	2,462	1,171	4,251
Atmauthluak	—	—	—	—	—	—
Napakiak	19,888	5,789	6,167	3,711	12,312	12,928
Oscarville	3,948	1,680	1,723	1,025	487	8,010
Napaskiak	5,199	4,286	5,546	3,584	6,275	26,206
Bethel	12,972	12,845	8,470	8,623	15,623	19,099
Kwethluk	32,975	21,106	22,788	13,188	19,186	37,780
Akiakchak	15,932	12,518	10,521	6,725	10,096	25,138
Akiak	13,061	8,205	6,551	8,478	9,659	12,297
Tuluksak	19,261	7,928	8,526	10,289	9,777	12,820
Lower Kalskag	11,563	7,764	16,478	23,249	9,472	21,906
Upper Kalskag	38,398	27,149	6/	6/	11,391	11,970
Aniak	36,673	15,935	10,120	10,608	17,874	11,353
Chuathbaluk	22,370	2,922	3,784	2,629	5,059	6,507
Napamute	11,107	6,235	3,898	5,192	4,873	704
Crooked Creek	41,263	17,558	27,259	23,166	32,550	18,986
Georgetown	7/	7/	7/	7/	7/	7/
Red Devil	7/	1,350	9,007	5,367	5,706	7/
Sleetmute	17,259	6,884	8/	8/	8/	11,707
Stony River	11,750	2,642	1,855	1,110	4,254	15,865
Total	327,297	185,447	165,626	141,550	189,660	283,459

continued

Table 29 (continued) Comparative "other salmon" subsistence catch, Kuskokwim River area, by village, 1960-1974.

Village	1966	1967	1968	1969	1970	1971
Kwigillingok, Kipnuk, Kongiganak	680	2,846	2,800	2,481	3,937	1,110
Eek	1,324	1,922	3,503	3,436	4,855	2,213
Tuntutuliak	9,747	11,531	14,090	17,462	10,600	9,964
Kasigluk	3,058	2,309	4,311	3,308	5,731	2,043
Nunapitchuk	4,145	6,278	7,731	6,934	11,412	3,375
Atmauthluak	—	—	—	—	1,191	1,197
Napakiak	9,275	12,685	12,700	12,390	16,371	4,427
Oscarville	407	2,580	2,104	2,743	4,669	1,675
Napaskiak	8,743	8,585	12,409	11,655	11,169	7,039
Bethel	14,011	14,055	28,603	14,613	33,475	9,905
Kwethluk	18,707	23,872	36,645	23,462	27,702	13,941
Akiakchak	15,049	13,584	19,461	10,306	29,776	12,298
Akiak	10,622	9,332	13,775	9,854	13,003	9,264
Tuluksak	11,670	8,898	11,114	6,058	7,626	5,115
Lower Kalskag	10,346	16,108	8,114	8,468	11,158	3,509
Upper Kalskag	6,236	8,364	9,733	9,413	5,309	3,530
Aniak	12,484	16,788	17,341	15,127	10,030	4,933
Chuathbaluk	5,625	7,249	11,588	7,523	10,971	5,632
Napamute	3,704	5,750	1,774	1,453	1,224	1,862
Crooked Creek	19,467	14,365	12,704	6,810	9,216	3,094
Georgetown	70	7/	2,030	3,664	800	0
Red Devil	2,746	7/	2,400	1,130	2,454	1,067
Sleetmute	2,611	6,875	11,218	8,258	4,464	3,203
Stony River	3,933	11,377	13,875	12,080	8,407	5,995 9/
Total	174,660	205,263	260,023	198,628	245,550	116,391

continued

Table 29 (continued) Comparative "other salmon" subsistence catch, Kuskokwim River area, by village, 1960-1974.

Village	1972	1973	1974
Kwigillingok, Kipnuk, Kongiganak	1,284	807	7/
Eek	783	2,401	4,227
Tuntutuliak	11,103	13,572	28,321
Kasigluk	1,934	6,090	6,773
Nunapitchuk	5,600	7,663	12,498
Atmauthluak	947	2,818	4,585
Napakiak	5,191	8,461	21,494
Oscarville	498	3,081	5,617
Napaskiak	8,858	8,478	20,467
Bethel	16,885	33,930	34,892
Kwethluk	11,721	19,565	39,747
Akiakchak	9,266	9,864	15,108
Akiak	5,108	6,118	18,434
Tuluksak	5,145	5,946	13,261
Lower Kalskag	3,490	2,873	12,265
Upper Kalskag	1,460	5,607	9,631
Aniak	5,243	13,547	9,305
Chuathbaluk	8,509	14,171	4,287
Napamute	4,645	3,451	76
Crooked Creek	3,658	1,981	4,954
Georgetown	0	10	7/
Red Devil	1,695	2,782	2,688
Sleetmute	4,293	2,168	4,212
Stony River	3,000	3,875	4,328
Total	120,316	179,259	277,170

continued

Table 29 (continued) Comparative "other salmon" subsistence catch, Kuskokwim River area, by village, 1960-1974.

Village	1960-1974 Total	1960-1974 Average
Kwigillingok, Kipnuk, Kongiganak	27,529	1,966
Eek	40,971	2,731
Tuntutuliak	182,914	12,194
Kasigluk	47,380	3,384
Nunapitchuk	88,605	5,907
Atmauthluak	10,738	2,148
Napakiak	163,789	10,919
Oscarville	40,247	2,683
Napaskiak	148,499	9,900
Bethel	278,001	18,533
Kwethluk	362,385	24,159
Akiakchak	215,642	14,376
Akiak	153,761	10,251
Tuluksak	143,434	9,562
Lower Kalskag	166,673	11,112
Upper Kalskag	148,191	11,399
Aniak	207,361	13,824
Chuathbaluk	118,826	7,922
Napamute	55,858	3,724
Crooked Creek	237,031	15,802
Georgetown	6,574	939
Red Devil	38,392	3,199
Sleetmute	83,152	6,929
Stony River	104,346	6,956
Total	3,070,299	204,687

YUKON RIVER AREA SUBSISTENCE FISHERIES

DESCRIPTION

The subsistence salmon fishery in the Yukon district is one of the largest of its kind in the State. Although all five species of salmon are known to occur in the area, king and chum salmon are the two most important species taken for subsistence purposes. Kings are utilized for human consumption, while chums are mainly reserved for dog food. Only small numbers of pink and coho salmon are taken.

In addition to salmon, several other species of fish present in the area are utilized for subsistence purposes. Whitefish, northern pike, burbot, sheefish and herring represent the majority of these species harvested. It is estimated that 75 to 85 percent of this catch is utilized for human consumption.

Until recently, the summer chum salmon runs were reserved mainly for subsistence utilization. Commercial catch limitations were imposed by fishing season closures and by prohibition of small mesh gill nets. Due to recent declines in subsistence fishing effort and dependence, many of these restrictions have been liberalized to allow increased commercial utilization.

ECONOMIC CONDITIONS IN THE AREA

Although economic conditions in the Yukon district are similar to those of the Kuskokwim, residents of the area are not as dependent upon subsistence fishing. This is mainly due to an increase in commercial fishing effort in recent years. Like the Kuskokwim, other sources of cash income are limited to sporadic employment such as firefighting and special welfare payments.

METHODS OF FISHING

Several types of gear are used in the Yukon subsistence fishery, including gill nets, fishwheels, beach seines, traps, spears and gaffs. Gill nets are the most common type of gear. In the upper Yukon River area fishwheels are also used.

With the decreasing use of fishwheels, which are very effective in capturing chum salmon, there has been an associated reduction in the overall chum salmon harvest. Table 30 shows the subsistence salmon harvest in the Yukon area for the years 1960-1974. The recorded king salmon harvests have remained surprisingly stable throughout the period. Table 31 gives a breakdown of the king salmon catch by village in the Yukon River area for the years 1961-1974. A breakdown by village of other subsistence caught salmon (mostly chums) is presented in Table 32 .

PROBLEMS

Since problems with this fishery are identical to those of the Kuskokwim district, they will not be discussed again here. Refer to the Kuskokwim subsistence section for additional information.

Table 30 Subsistence salmon catch, Yukon area, by year, in numbers of fish, 1960-1974 1/.

Year	Fishing Families Surveyed	King	Other Salmon 2/	Total
1960	—	—	—	—
1961	624	23,719	407,814	431,533
1962	564	19,910	358,441	378,351
1963	597	32,656	421,625	454,281
1964	602	22,817	485,630	508,447
1965	541	19,723	458,379	478,102
1966	494	14,017	214,236	228,253
1967	471	19,661	288,595	308,256
1968	476	14,832	189,607	204,439
1969	459	14,946	213,725	228,671
1970	400	15,926	223,237	239,163
1971	429	24,755	200,568	225,323
1972	401	19,541	140,102	159,643
1973	463	22,215	186,179	208,394
1974	438	20,543	291,080	311,623

1) Source - A.D.F.&G., AYK Annual Management Reports.
2) Primarily chum salmon, includes small numbers of pink and coho salmon.
— No data available.

Table 31 Comparative king salmon subsistence catch, Yukon River area, by village, 1961-1974 [1/].

Village	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Sheldon's Point	180	116	893	52	42	127	755	30	728	1,093	731	462	165	265
Alakanuk	165	53	81	87	177	263	287	205	852	589	986	647	373	575
Emmonak	137	21	120	63	145	160	541	42	810	151	543	300	899	202
Lamont Slough	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2	0	94	3
Aproka Pass	171	180	268	73	281	645	959	147	238	23	NA	37	12	2
Kotlik	NA	35	195	53	131	47	162	53	551	394	315	366	714	394
Mt. Village	1,110	619	2,427	985	510	217	1,345	238	557	348	1,648	907	741	450
Pitka's Point	NA	391 [3/]	1,254 [3/]	521 [3/]	826 [3/]	499 [3/]	993 [3/]	168 [3/]	737 [3/]	188	346	203	391	234
St. Mary's	1,810	4/	4/	4/	4/	4/	4/	4/	4/	387	1,352	1,312	672	589
Pilot Station	753	219	801	237	502	440	1,534	784	367	647	1,120	1,513	1,303	467
Marshall	1,265	503	2,012	290	942	350	306	365	564	598	819	656	955	1,068
Russian Mission	1,563	641	1,392	1,185	1,393	800	2,019	2,170	707	993	849	914	1,126	1,170
Holy Cross	2,348	1,111	3,123	2,243	2,351	2,645	2,876	1,418	1,877	1,678	2,799	2,202	3,338	1,944

continued

1) Source - A.D.F.&G., AYK Annual Management Reports. Does not include Canadian catches.
2) Includes 200 kings taken by two families at the New Minto fish camp.
3) Includes St. Mary's.
4) Included with Pitka's Point.
5) Includes Manley Hot Springs.
6) Included with Minto.

Table 31 (continued) Comparative king salmon subsistence catch, Yukon River area, by village, 1961-1974.

Village	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Anvik	22	51	163	153	118	144	54	114	71	67	137	72	67	111
Grayling	NA	NA	NA	124	246	85	199	208	187	155	394	185	489	519
Kaltag	33	224	102	330	57	47	199	60	232	124	131	123	130	586
Nulato	513	171	835	355	305	218	578	209	771	734	418	364	281	1,037
Koyukuk	483	423	629	209	228	93	262	398	357	30	410	371	411	555
Galena	626	123	282	158	260	407	210	456	263	313	574	532	436	385
Ruby	1,060	226	1,514	2,555	1,843	887	820	881	1,619	1,313	2,275	1,110	2,098	2,319
Tanana	2,379	332	1,414	329	524	421	151	627	683	361	609	917	869	789
Rampart	605	1,438	1,231	990	1,041	869	368	922	321	150	1,071	1,236	1,609	370
Minto	17	86	325	468 5/	276 5/	146 5/	0	12	1	0	NA	NA	20	154
Steven's Village	650	831	1,073	325	910	620	534	787	350	851	450	1,002 2/	967	241
Beaver	185	442	491	710	480	31	210	495	458	773	680	241	307	23
Fort Yukon	2,958	1,822	2,831	2,098	2,747	1,074	692	632	75	1,019	647	520	536	883
Circle	496	393	250	1,200	NA	NA	NA	NA	NA	NA	NA	345	225	406
Eagle	875	400	500	17	100	NA	NA	NA	NA	NA	111	235	267	22
Huslia	NA	100	32	112	9	NA	7	35	16	12	2	1	29	60

continued

Table 31 (continued) Comparative king salmon subsistence catch, Yukon River area, by village, 1961-1974.

Village	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Hughes	NA	NA	47	18	NA	NA	65	82	10	116	315	27	32	7
Alatna	NA	NA	NA	NA	NA	NA	0	1	8	2	0	3	1	0
Allakaket	NA	0	85	NA	NA	NA	70	3	15	128	190	21	61	69
Nenana	310	115	213	194	157	NA	252	462	465	357	2,357	788	455	1,073
Manley	330	6	0	6/	6/	6/	NA	NA	75	138	7	99	NA	176
Fairbanks and vicinity	NA	NA	NA	NA	NA	NA	NA	NA	NA	132	98	220	26	38

Table 32 Comparative "other salmon" subsistence catch, Yukon River area, by village, 1961-1974 1/ 2/.

Village	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Sheldon's Point	12,683	10,899	30,798	8,701	9,851	3,007	2,757	8,693	5,573	4,238	1,680	3,514	2,267	5,857
Alakanuk	8,932	5,747	17,953	11,333	21,473	9,830	9,964	14,184	15,806	10,994	6,716	5,633	5,241	12,279
Emmonak	15,670	9,074	27,749	16,954	47,386	11,824	15,314	16,569	12,836	7,365	4,370	5,178	8,825	6,987
Lamont Slough	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	12	62	900
Aproka Pass	7,303	5,277	6,175	7,712	20,129	10,741	7,910	4,853	4,048	565	541	332	508	560
Kotlik	NA	5,362	9,942	4,076	4,728	3,003	7,251	1,709	6,391	4,878	4,583	4,824	5,061	6,098
Mt. Village	7,373	8,331	10,106	13,593	11,475	7,548	8,305	7,312	10,676	4,865	6,[illegible]49	5,923	6,142	11,408
Pitka's Point	NA	10,510 3/	7,001 3/	12,508 3/	14,130 3/	8,460 3/	9,790 3/	9,166 3/	11,586 3/	6,764	3,561	2,329	1,393	2,433
St. Mary's	8,771	4/	4/	4/	4/	4/	4/	4/	4/	7,840	7,988	8,803	6,962	10,491
Pilot Station	5,605	13,926	5,553	10,776	7,865	5,587	6,520	4,770	7,515	5,882	5,058	7,021	7,424	8,410
Marshall	5,922	6,595	8,023	10,125	6,631	3,640	3,070	3,530	6,606	4,910	5,455	4,743	4,400	6,763

continued

1) Source - A.D.F.&G., AYK Annual Management Reports. Does not include Canadian catches.
2) Catches are primarily chum salmon but also include small numbers of pink, coho and sockeye salmon.
3) Includes St. Mary's.
4) Included with Pitka's Point.
5) Includes Manley Hot Springs.
6) Included with Minto.

Table 32 (continued) Comparative "other salmon" subsistence catch, Yukon River area, by village, 1961-1974.

Village	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Russian Mission	4,098	9,994	5,354	10,069	4,888	2,707	4,897	3,836	3,668	3,114	2,378	2,737	1,997	4,461
Holy Cross	20,068	20,424	12,532	31,447	25,709	4,228	22,341	10,309	6,037	4,188	2,203	2,695	3,176	3,986
Anvik	61,406	43,404	28,064	34,341	37,179	14,239	20,793	10,020	8,925	9,925	7,309	3,362	20,850	29,261
Grayling	NA	NA	NA	23,784	36,436	11,436	22,852	8,225	18,037	12,548	6,537	6,428	12,105	25,978
Kaltag	23,395	25,824	23,193	35,961	29,382	21,729	27,028	12,090	9,942	12,465	9,133	3,543	20,243	14,174
Nulato	63,163	27,948	31,742	62,446	43,988	22,017	22,521	13,242	23,853	26,456	16,337	7,298	12,388	33,319
Koyukuk	13,544	6,282	7,966	36,167	11,232	7,443	4,613	3,541	3,359	3,789	3,125	1,575	1,428	13,770
Galena	10,585	1,673	6,731	3,100	2,741	8,296	2,650	1,079	2,422	3,179	4,710	1,184	3,922	4,531
Ruby	15,654	18,243	15,585	30,122	17,603	5,530	10,690	2,382	5,201	8,068	12,328	6,470	10,810	15,388
Tanana	12,775	7,245	16,646	15,348	14,855	10,421	11,938	13,406	12,455	23,017	21,663	7,713	9,715	12,447
Rampart	11,722	6,962	11,209	14,963	13,462	4,056	15,763	2,636	8,935	5,252	10,291	3,694	3,607	1,249
Minto	4,536	12,455	12,528	17,628 5/	11,358 5/	7,152 5/	22	740	130	500	NA	NA	2,020	2,720
Steven's Village	3,490	4,355	8,247	6,979	7,346	1,900	3,145	2,022	2,725	8,292	4,774	1,118	3,216	2,214
Beaver	2,975	2,334	12,119	11,359	3,274	4,135	4,292	3,619	1,965	2,378	1,636	3,057	1,176	1,055
Fort Yukon	13,252	10,255	31,219	19,407	19,399	3,960	8,983	6,564	3,338	6,354	3,207	1,597	2,732	122

continued

Table 32 (continued) Comparative "other salmon" subsistence catch, Yukon River area, by village, 1961-1974.

Village	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Circle	992	800	100	2,300	NA	NA	NA	NA	NA	NA	NA	752	642	1,266
Eagle	150	100	125	1,582	256	NA	NA	NA	NA	NA	490	391	1,687	22
Huslia	NA	16,000	5,455	13,913	5,101	NA	5,489	3,677	2,466	4,018	652	256	3,363	5,776
Hughes	NA	NA	767	559	NA	NA	5,837	2,237	3,112	6,367	14,084	2,777	2,541	8,786
Alatna	NA	NA	NA	NA	NA	NA	170	99	830	1,226	496	490	27	3,510
Allakaket	NA	few	1,972	NA	NA	NA	3,929	1,391	3,254	7,759	6,943	771	1,808	3,517
Nenana	6,426	13,821	13,599	11,129	7,363	12,023	3,517	6,055	3,247	11,398	19,007	18,546	9,436	19,755
Manley	1,950	4,773	2,965	6/	6/	6/	NA	NA	200	40	8	6	NA	20
Fairbanks and vicinity	NA	NA	NA	NA	NA	NA	NA	NA	NA	1,072	5,655	8,280	1,657	2,953

NORTON SOUND AREA SUBSISTENCE FISHERIES

Salmon are harvested almost exclusively for subsistence in the Port Clarence district except for a few fish that are bartered or sold each year in Teller and Nome. Teller and Brevig Mission subsistence fishermen take all species of salmon, mainly in the Grantley Harbor and Tuksuk Channel areas. Subsistence fishermen from Nome drive 36 to 60 miles north from Nome to fish for all species of salmon in the Pilgrim River and Salmon Lake areas under special permit. Table 33 gives subsistence catches in the Port Clarence area for the years 1963-1974.

Based on harvest and effort data, subsistence salmon fishing in the Norton Sound district is less significant than in most other districts in the Arctic-Yukon-Kuskokwim region. This is probably due to the commercial fishing operations that have existed in the area since 1961. Many of the residents use fish caught during the commercial season for personal consumption. Subsistence catches for the Norton Sound area are shown in Table 34 . A breakdown of these catches by village is presented in Table 35 .

Several species of fish other than salmon are also utilized for subsistence in the Port Clarence and Norton Sound districts, but catches have not been documented. These species include whitefish, northern pike, burbot, sheefish and herring. The set gill net is the gear most commonly used for all species of fish harvested in this area. A few beach seines are used in some rivers, although use of this type of gear seems to be declining.

Table 33 Subsistence salmon catch, Port Clarence area, in numbers of fish, 1963-1974 1/ 2/.

Location	No. of fishermen	Kings	Reds	Cohos	Pinks	Chums	Total
			1963				
Pilgrim River	7	0	303	0	805	419	1,727
Salmon Lake	9	0	3,283	25	0	0	3,308
Total	16	0	3,586	25	805	419	5,035
Teller	3	9	1,280	0	256	860	2,405
			1964				
Pilgrim River	14	17	1,266	174	312	986	2,755
Salmon River	8	0	209	53	59	63	384
Total	22	17	1,475	227	371	1,049	3,139
Teller - no survey							
			1965				
Pilgrim River	12	11	305	64	199	628	1,207
Salmon Lake	11	1	962	100	23	43	1,129
Total	23	12	1,267	164	222	671	2,336
Teller	6	24	537	475	1,632	931	3,599

continued

1) Source - A.D.F.&G., AYK Annual Management Reports.
2) Subsistence salmon catches not recorded prior to 1963.

Table 33 (continued) Subsistence salmon catch, Port Clarence area, in numbers of fish, 1963-1974.

Location	No. of fishermen	Kings	Reds	Cohos	Pinks	Chums	Total
			1966				
Pilgrim River	7	5	7	14	84	295	405
Salmon Lake	4	0	123	2	0	2	127
Total	11	5	130	16	84	297	532
Teller	13	2	702	785	645	2,393	4,527
Brevig Mission	2	3	168	95	130	185	581
Total	15	5	870	880	775	2,578	5,108
			1967				
Pilgrim River	4	7	51	4	5	21	88
Salmon Lake	9	0	286	2	0	0	288
Total	13	7	337	6	5	21	376
Teller	6	5	1,731	226	762	1,052	3,776
			1968				
Pilgrim River	3	3	34	4	7	19	67
Salmon Lake	3	0	73	1	0	0	74
Total	6	3	107	5	7	19	141
Teller	11	25	361	75	1,542	738	2,741
Brevig Mission	7	12	220	53	357	147	789
Total	18	37	581	128	1,899	885	3,530

continued

Table 33 (continued) Subsistence salmon catch, Port Clarence area, in numbers of fish, 1963-1974.

Location	No. of fishermen	Kings	Reds	Cohos	Pinks	Chums	Total
			1969				
Pilgrim River	3	0	4	0	10	0	14
Salmon Lake	4	0	51	0	0	0	51
Total	7	0	55	0	10	0	65
Teller	6	2	128	27	538	922	1,617
			1970				
Pilgrim River	3	0	32	0	2	25	59
Salmon Lake	4	0	30	6	23	30	89
Total	7	0	62	6	25	55	148
Teller	9	4	481	1,040	1,261	3,601	6,387
Brevig Mission	2	o	45	25	22	575	667
Total	11	4	526	1,065	1,283	4,176	7,054
			1971				
Pilgrim River	4	3	37	3	0	39	82
Salmon Lake	4	4	90	2	14	10	120
Total	8	7	127	5	14	49	202
Teller	12	23	688	899	1,155	3,605	6,370
Brevig Mission	2	1	35	55	2	115	208
Total	14	24	723	954	1,157	3,720	6,578

continued

Table 33 (continued) Subsistence salmon catch, Port Clarence area, in numbers of fish, 1963-1974.

Location	No. of fishermen	Kings	Reds	Cohos	Pinks	Chums	Total
			1972				
Teller	7	0	68	287	75	2,661	3,091
Brevig Mission	1	4	0	101	0	145	250
Total	8	4	68	388	75	2,806	3,341
			1973				
Teller	4	22	46	280	424	1,562	2,334
			1974				
Teller	7	0	0	62	12	1,455	1,529
Salmon Lake	4	0	28	0	0	0	28
Brevig Mission	2	0	0	0	2	1,208	1,210
Total	13	0	28	62	14	2,663	2,767

Table 34 Subsistence salmon catch, Norton Sound area, in numbers of fish, 1963-1974 1/ 2/.

Year	No. of fishermen Interviewed	King	Coho	Pink	Chum	Total
1963	44	5	118	16,607	17,635	34,365
1964	44	565	2,567	9,225	12,486	24,843
1965	71	574	4,812	19,131	30,772	55,289
1966	67	269	2,210	14,335	21,873	38,687
1967	119	817	1,222	17,516	22,724	42,279
1968	141	237	2,391	36,912	11,661	51,201
1969	131	436	2,191	18,562	15,615	36,804
1970	114	561	4,675	26,127	22,763	54,126
1971	136	1,026	4,097	10,863	21,815 3/	37,801
1972	115	804	2,319	14,158	13,966 4/	31,247
1973	79	392	520	14,770	7,185	22,867
1974	117	420	1,064	16,426	3,958	21,868

1) Source - A.D.F.&G., AYK Subsistence Fishery Report, Report to the Board of Fish and Game, April, 1973 and Annual Management Reports.
2) Catch figures do not include Port Clarence area.
3) Includes 197 sockeye salmon.
4) Includes 93 sockeye salmon.

Table 35 Subsistence salmon catch, Norton Sound area, by village, in numbers of fish, 1963-1974 1/.

St. Michael

Year	No. of fishermen Interviewed	King	Coho	Pink	Chum	Total
1963	NA	NA	NA	NA	NA	NA
1964	NA	NA	NA	NA	NA	NA
1965	NA	NA	NA	NA	NA	NA
1966	5	7	50	13	812	882
1967	5	62	155	74	1,132	1,423
1968	10	20	96	791	649	1,556
1969	8	51	368	60	2,169	2,648
1970	9	37	356	477	1,573	2,443
1971	4	47	55	36	691 2/	829
1972	7	307	62	10	1,168	1,547
1973		Included with Unalakleet				
1974		Included with Unalakleet				

continued

1) Source - A.D.F.&G., AYK Annual Management Reports.
2) Includes 75 sockeye salmon.
3) Includes 55 sockeye salmon.
4) Includes 2 sockeye salmon.
5) Includes 51 sockeye salmon.
6) Includes 2 sockeye salmon.
7) Inlcudes 12 sockeye salmon.
8) Includes 46 sockeye salmon.
9) Includes 2 sockeye salmon.
10) Includes 45 sockeye salmon.

Table 35 (continued) Subsistence salmon catch, Norton Sound area, by village, in numbers of fish, 1963-1974.

Unalakleet

Year	No. of fishermen Interviewed	King	Coho	Pink	Chum	Total
1963	NA	NA	NA	NA	NA	NA
1964	34	488	2,227	7,030	6,726	16,471
1965	30	521	4,562	11,488	8,791	25,362
1966	20	83	739	6,070	2,575	9,467
1967	43	428	329	9,890	2,951	13,598
1968	44	166	1,397	10,253	2,333	14,149
1969	38	273	1,115	4,170	2,027	7,585
1970	45	458	3,551	9,627	5,642	19,278
1971	46	864	3,082	2,194	6,382 3/	12,522
1972	38	336	1,756	3,122	2,964	8,178
1973	25	323	213	6,233	3,426	10,195
1974	41	313	706	7,341	588	8,948

continued

Table 35 (continued) Subsistence salmon catch, Norton Sound area, by village, in numbers of fish, 1963-1974.

Koyuk

Year	No. of fishermen Interviewed	King	Coho	Pink	Chum	Total
1963	12	--	--	5,097	4,171	9,268
1964	NA	NA	NA	NA	NA	NA
1965	7	4	22	252	3,032	3,310
1966	7	7	41	929	3,612	4,589
1967	13	12	14	1,097	2,945	4,068
1968	14	28	71	1,916	1,872	3,887
1969	18	59	189	2,115	3,655	6,018
1970	7	3	10	840	3,500	4,353
1971	12	5	47	92	2,619 5/	2,763
1972	20	30	44	2,089	2,022	4,185
1973	3	1	--	10	130	141
1974	4	--	--	17	900	917

continued

Table 35 (continued) Subsistence salmon catch, Norton Sound area, by village, in numbers of fish, 1963-1974.

Shaktoolik

Year	No. of fishermen Interviewed	King	Coho	Pink	Chum	Total
1963	NA	NA	NA	NA	NA	NA
1964	9	77	340	2,132	5,412	7,961
1965	8	31	107	3,763	3,420	7,321
1966	10	142	762	1,445	4,183	6,532
1967	13	262	387	2,010	4,436	7,095
1968	15	10	458	6,355	1,915	8,738
1969	16	40	193	4,018	3,439	7,690
1970	8	43	210	2,475	2,016	4,744
1971	8	87	329	494	5,060 4/	5,970
1972	8	64	235	939	3,399	4,637
1973	7	51	130	3,410	1,397	4,988
1974	12	93	353	1,901	358	2,705

continued

Table 35 (continued) Subsistence salmon catch, Norton Sound area, by village, in numbers of fish, 1963-1974.

Elim

Year	No. of fishermen Interviewed	King	Coho	Pink	Chum	Total
1963	18	5	221	5,808	8,316	14,350
1964	1	--	--	63	348	411
1965	8	16	72	1,325	9,857	11,270
1966	12	14	250	2,511	5,409	8,184
1967	15	39	116	1,322	9,913	11,390
1968	17	2	80	6,135	2,527	8,744
1969	15	9	109	1,790	1,303	3,211
1970	16	16	160	4,661	6,960	11,797
1971	14	16	271	1,046	2,227	3,560
1972	7	44	108	1,579	2,070 6/	3,801
1973	4	2	--	--	295	300
1974	10	3	--	2,382	1,723	4,108

continued

Table 35 (continued) Subsistence salmon catch, Norton Sound area, by village, in numbers of fish, 1963-1974.

Golovin

Year	No. of fishermen Interviewed	King	Coho	Pink	Chum	Total
1963	9	—	23	1,891	3,624	5,538
1964	NA	NA	NA	NA	NA	NA
1965	5	2	49	698	987	1,736
1966	10	4	58	1,037	1,996	3,095
1967	10	2	86	1,084	898	2,070
1968	9	2	41	1,555	104	1,702
1969	10	2	81	920	189	1,192
1970	6	—	62	1,090	627	1,779
1971	5	7	146	789	381 7/	1,323
1972	4	4	58	1,294	730 8/	2,086
1973	2	1	39	—	46	86
1974	5	1	—	665	180	846

continued

Table 35 (continued) Subsistence salmon catch, Norton Sound area, by village, in numbers of fish, 1963-1974.

White Mountain

Year	No. of fishermen Interviewed	King	Coho	Pink	Chum	Total
1963	6	--	195	3,811	5,695	9,701
1964	NA	NA	NA	NA	NA	NA
1965	5	--	--	825	2,860	3,685
1966	3	--	118	536	1,524	2,178
1967	9	1	99	1,690	3,905	5,695
1968	12	2	140	3,400	1,640	5,182
1969	10	--	109	1,840	2,325	4,274
1970	9	4	291	1,956	1,987	4,238
1971	7	--	45	755	1,555	2,355
1972	4	--	4	441	1,298	1,743
1973	2	--	9	9	28	46
1974	2	2	--	302	26	330

continued

Table 35 (continued) Subsistence salmon catch, Norton Sound area, by village, in numbers of fish, 1963-1974.

Nome

Year	No. of fishermen Interviewed	King	Coho	Pink	Chum	Total
1963	NA	NA	NA	NA	NA	NA
1964	NA	NA	NA	NA	NA	NA
1965	8	--	--	780	1,825	2,605
1966	22	12	192	1,794	1,762	3,760
1967	11	11	36	349	627	1,023
1968	20	7	108	6,507	621	7,243
1969	16	2	27	3,649	508	4,186
1970	14	--	35	5,001	458	5,494
1971	40	--	122	5,457	2,900 9/	8,479
1972	27	19	52	4,684	315 10/	5,070
1973	36	14	129	5,108	1,863	7,114
1974	43	8	5	3,818	183	4,014

KOTZEBUE AREA SUBSISTENCE FISHERIES

DESCRIPTION

Subsistence salmon fishing has long been an important food gathering activity for residents of the Kotzebue district. The harvest is comprised almost entirely of chum salmon. Nearly all of the catch is consumed as dried fish. All portions of salmon are utilized, e.g., the flesh is dried and the head and viscera fed to dogs.

Subsistence fishing occurs primarily in the Noatak and Kobuk Rivers. The Kobuk River run is more heavily utilized due to the greater number of villages on the river (Kobuk River, five villages; Noatak River, one village). Because of the large subsistence effort, commercial fishing regulations at Kotzebue are often made more restrictive in late July to early August in order to give added protection to the Kobuk River stocks.

Several other species of fish are important subsistence species, including sheefish, shortnose and longnose whitefish and Arctic char. Table 36 gives the subsistence chum salmon catch in the Kotzebue area by village for the years 1962-1974. Subsistence sheefish catches for the years 1966-1974 are presented in Table 37 along with the number of fishermen interviewed in each village.

ECONOMIC CONDITIONS IN THE AREA

Although adequate subsistence fishing effort data is not available, there is some indication that the dependence on subsistence fishing has declined in this area in recent years as a result of increased welfare payments and more employment opportunities. Snow machines have rapidly replaced sled dogs, reducing the need for subsistence fish.

Subsistence fisheries may prove to be more valuable (on a dollar basis) than commercial fisheries if the value of substitute protein food is considered. The number of salmon taken for subsistence in the Kotzebue Sound area has exceeded the commercial catch in some years. The NANA Native Corporation recently conducted a survey of subsistence harvests in the area. Using Anchorage prices, the study estimated the value of the 1973 subsistence fish harvest to be 1.9 million dollars. Village prices in this area are 25 to 125 percent higher than Anchorage prices.

METHODS OF FISHING

Subsistence fishermen presently use set gill nets and beach seines to catch salmon in the bays and rivers. Sheefish are taken with gill nets in the Kobuk River while ascending and descending the river on their spawning and post-spawning runs and by jigging through the ice on Hotham Inlet and Selawik Lake during the early spring months.

Subsistence fishing by Noatak villagers follows seasonal patterns. In the fall, char and whitefish are netted at the village and at fishing camps up river until freeze-up, at which time hook and line fishing through the ice is predominant. Ice fishing continues through the winter. In the summer, temporary camps are set up, primarily at Sheshalik, for seal and beluga whale hunting. At the end of the hunt, some villagers remain to fish for char and whitefish. During August, the area residents again return to the Noatak River to net salmon and dry it for later use.

In the fall, residents living near Shungnak fish for whitefish using nets or traps under the ice. Burbot are taken through the ice during the winter for immediate consumption. After breakup, seine and gill net fishing for sheefish, whitefish and grayling occurs. This continues until the chum salmon run begins. Beginning in June, chum salmon are obtained in quantity by seining and gill netting. Fish camp sites are scattered along the Kobuk River above and below the village. Some salmon are used fresh during the season, but most of the catch is dried for later use.

Whitefish, an important subsistence fish in all villages, are captured with beach seines and gill nets. Arctic char, which are a major food source in the villages of Noatak and Kivalina, are taken by jigs, seines and gill nets.

PROBLEMS

No real problems currently exist with this fishery. Minor problems that do exist concern balancing commercial and subsistence harvests to meet escapement goals, particularly in light of the large natural fluctuations in salmon abundance which occur in this area.

Table 36 Subsistence chum salmon catch, Kotzebue area, by village, in numbers of fish, 1962-1974 1/ 2/.

Village	1962	1963	1964	1965	1966	1967	1968	1969
Noorvik	15,934	4,304	2,167	5,596	3,141	2,350	2,424	1,301
Kiana	3,139	1,973	783	1,598	433	1,489	2,488	2,458
Ambler	3/	755	2,142	1,340	912	679	457	3,525
Shungnak	3/	1,240	3,134	2,160	899	1,500	1,600	2,550
Kobuk	2,321	200	1,020	877	625	175	1,030	1,655
Kobuk River Total	21,393	8,472	9,246	11,571	6,010	6,193	7,999	11,489
Noatak River Total 4/	48,890	16,762	12,763	5,671	19,700	26,512	5,490	14,458
Kotzebue	--	5,835	7,753	8,058	3,640	4,032	4,324	1,768
Deering	--	--	--	5,200	6,238	3,098	2,838	1,897
Buckland	--	--	--	--	--	162	37	--
Candle	--	--	--	--	--	11	89	200
Shismaref	--	--	--	--	--	100	37	--
Area Total	70,283	31,069	29,762	30,500	35,588	40,108	20,814	29,812

continued

1) Source - A.D.F.&G., AYK Annual Management Reports.
2) Subsistence salmon catches not recorded by the Alaska Department of Fish and Game prior to 1962.
3) Not surveyed.
4) Represents catches of the village of Noatak.

Table 36 (continued) Subsistence chum salmon catch, Kotzebue area, by village, in numbers of fish, 1962-1974.

Village	1970	1971	1972	1973	1974
Noorvik	6,077	7,144	1,774	2,312	6,809
Kiana	3,457	5,177	1,435	4,470	2,726
Ambler	2,899	2,299	1,469	1,529	1,651
Shungnak	3,450	2,653	2,665	4,406	6,243
Kobuk	600	1,931	2,119	1,917	2,251
Kobuk River Total	16,483	19,204	9,462	14,634	19,680
Noatak River Total 2/	4,120	9,919	741	216	4,330
Kotzebue	6,184	1,737	1,151	1,172	3/
Deering	1,242	763	369	1,098	1,880
Buckland	344	155	59	1,722	639
Candle	113	50	15	--	3/
Shismaref	--	131	29	100	200
Area Total	28,486	31,959	11,085	18,942	26,729

Table 37 Subsistence sheefish catch, Kotzebue area, by village, in numbers of fish, 1966-1974 1/ 2/.

Village	1966-1967 Fishermen Interviewed	1966-1967 # of Sheefish	1967-1968 Fishermen Interviewed	1967-1968 # of Sheefish	1968-1969 Fishermen Interviewed	1968-1969 # of Sheefish
Noorvik	28	3,792	35	1,910	20	1,324
Kiana	19	925	25	766	22	409
Ambler	11	194	14	559	20	554
Shungnak	11	166	13	837	17	530
Kobuk	7	99	5	270	11	553
Kobuk River Total	76	5,176	92	4,342	90	3,370
Selawik	29	7,164	38	5,080	35	4,140
Kotzebue	30	10,060	48	21,871	19	4,362
Area Total	135	22,400	178	31,293	144	11,872

continued

1) Source - A.D.F.&G., AYK Annual Management Reports.
2) Catch data recorded by seasonal years from 1966-1969; from 1970-1974 catches recorded by calendar year. No catch data available prior to 1966.

Table 37 (continued) Subsistence sheefish catch, Kotzebue area, by village, in numbers of fish, 1966-1974.

	1970		1971		1972	
Village	Fishermen Interviewed	# of sheefish	Fishermen Interviewed	# of sheefish	Fishermen Interviewed	# of sheefish
Noorvik	46	7,126	32	5,975	21	2,213
Kiana	25	790	25	1,060	17	307
Ambler	12	125	13	711	6	350
Shungnak	19	608	20	671	10	639
Kobuk	4	158	5	1,068	7	12
Kobuk River Total	106	8,807	95	9,485	61	3,521
Selawik	29	1,601	27	3,416	--	--
Kotzebue	33	3,520	33	682	18	311
Area Total	168	13,928	155	13,583	79	3,832

continued

Table 37 (continued) Subsistence sheefish catch, Kotzebue area, by village, in numbers of fish, 1966-1974.

	1973		1974	
Village	Fishermen Interviewed	# of sheefish	Fishermen Interviewed	# of sheefish
Noorvik	19	4,384	21	519
Kiana	25	--	15	51
Ambler	5	83	10	257
Shungnak	9	195	7	127
Kobuk	7	226	5	108
Kobuk River Total	65	4,888	58	1,062
Selawik	--	--	--	--
Kotzebue	6	--	--	--
Area Total	71	4,888	58	1,062

NORTHERN AREA SUBSISTENCE FISHERIES

Subsistence fisheries are known to exist throughout the area, however, subsistence catch records are not available. Although a few pink and chum salmon are probably taken each year for subsistence, whitefish and Arctic char are the most important subsistence fish harvested. Known major subsistence fishing sites include Oliktok (in the Colville River delta), the north side of Brownlow Point, Shaviovik River, Imiat, the headwaters of the Anaktuvuk River, Hulahula River and the saltwater lagoons adjacent to Barter Island.

The Hulahula River and the saltwater lagoons adjacent to Barter Island are fished by residents of Kaktovik. The Hulahula River is fished from mid-April to the end of May in its upper drainage. Catches are made by hook and line through the ice for small resident char and grayling. During July and August subsistence fishing effort by Kaktovik villagers shifts to the saltwater lagoons adjacent to Barter Island. Catches, primarily made by gill net, consist of anadromous Arctic char during July and Arctic cisco during August. Arctic cisco are preferred by the area inhabitants and are caught in abundance during this period. Kaktovik residents may take several hundred pounds of fish from these areas annually.

Subsistence fishing effort by Kaktovik residents is partly dependent on the abundance of caribou in the area. During years when game is more plentiful, fishing effort declines. Alternately, subsistence fishing is more prevalent in years when caribou are more scarce in the area, such as in 1973. Fishing is also partly influenced by the pressure of a DEW line site in the village. Those residents employed at the DEW line still fish on their one day off per week, primarily because of its cultural importance.

Harvest records, fishery timing and the role of subsistence fishing in the lifestyle are not presently available for the rest of this area.

WESTERN-ARCTIC ALASKA SUBSISTENCE HERRING FISHERIES

INTRODUCTION

Pacific herring are normally among the first species of fish to appear along the coast after ice breakup. Dependence upon them as a subsistence item varies along the coast by area and village, apparently as a result of village location. Village inhabitants who reside in areas where herring stocks far outnumber salmon, such as at Nelson Island, utilize herring more extensively as a subsistence item. Villages located where large runs of adult salmon occur supplement their subsistence needs with herring, with most effort directed towards salmon. A typical village of this type is Hooper Bay. Inland or coastal villages where large concentrations of herring or salmon are not common rely more heavily on pike, smelt, blackfish and whitefish species.

SUBSISTENCE FISHERY

Subsistence herring fishery data for this area is not available for its entirety. However, subsistence surveys were conducted in 1975, 1976 and 1977 as part of the Outer Continental Shelf Assessment Program (OCSEAP). At the time of this writing, the 1977 survey results, which included Norton and Kuskokwim Sounds, were not available. Consequently, this discussion will report only on the 1975 and 1976 surveys which were conducted between Cape Newenham and the Yukon River mouth.

The 1975 survey included only four coastal villages in the Yukon-Kuskokwim River delta region representing 133 fishing families. Reported herring catches in numbers of fish were as follows: Tanunak, 87,130;

Umkumiut, 131,795; Toksook, 136,810; and Hooper Bay, 11,085. The total reported harvest was 366,820 herring for the four villages.

Fourteen villages were surveyed from the Yukon River delta to Cape Newenham in 1976. A total subsistence herring harvest of 181,285 pounds (82.2 mt) was reported by local residents (Table 38). The 14 villages surveyed included Scammon Bay, Hooper Bay, Chevak, Newtok, Mekoryuk, Tanunak, Umkumiut (Nightmute), Toksook, Chefornak, Kipnuk, Kwigillingok, Kongiganak, Quinhagak and Goodnews. There was no subsistence herring harvest reported at Kongiganak. A total of 185 fishermen were contacted and/or returned subsistence catch forms, representing approximately 149 fishing families. From these returns and contacts only 133 fishermen, representing an estimated 114 families, reported herring catches. These estimates suggest an approximate harvest of 1,590 pounds of herring per fishing family.

Villagers at Hooper Bay, Tanunak, Umkumiut and Toksook reported a harvest of 140,935 pounds (63.9 mt), or about 78 percent of the total 1976 harvest (181,285 pounds [82.2 mt]) reported by the 14 villages surveyed. The 1976 OCSEAP survey revealed no subsistence use of herring in the village of Quinhagak.

Additional subsistence surveys are needed to adequately assess the utilization of the Bering Sea herring resource for subsistence purposes. Determination of the importance and economic value of this subsistence fishery is also needed.

Table 38 . Subsistence survey results for 14 villages from Cape Newenham to the Yukon River Delta, 1976. 1/ 2/

Village	Herring	Smelt	Capelin	Tomcod	Whitefish	Irish Lord	Sole	Trout	Blackfish	Pike
Scammon Bay	1,390# 3/			79 4/	235	4	16			
Hooper Bay	6,007#			215	780	2	19			
Tanunak	30,593#			20						
Umkumiut (Nightmute)	18,660#		1,140#	30						
Toksook Bay	85,675#	125#	600#		150		40#			
Mekoryuk	2,360#					3		5		
Newtok	300#				174				10#	1,484
Chevak	1,400#			730	215	200	8			
Kipnuk*	1,500#				100#					
Kwigillingok	21,350#				300					
Kongiganak										
Chefornak	12,050#									
Quinhagak		6,450								
Goodnews Bay*										
Estimated Totals	181,285#	6,500	1,740#	1,074	2,000	209	75	5	10#	1,484

1/ Source - A.D.F.& G., OCSEAP Bering Sea Herring Studies.
2/ With the exception of herring, capelin, pike and blackfish, the exact species of other fishery resources utilized for subsistence purposes could not be verified by the subsistence surveyor. Common names were given by local residents; however, it is believed that smelt refer to boreal smelt, tomcod refer to saffron cod, whitefish refer to *Coregonus* sp. and trout refer to char. Subsistence use of adult salmon by species was monitored by A.D.F.& G. management personnel.
3/ Represents pounds of fish.
4/ Represents numbers of fish.

* Indicates villages of poor response.

Table 39. Subsistence use of herring by fishing family in 14 villages from Cape Newenham to the Yukon River Delta, 1976. 1/

Village	Village population 2/	Herring fishing families 3/	Number returns 4/	Herring catch (pounds)	Pounds of herring per family 5/
Scammon Bay	166	4 6/	4	1,390	348
Hooper Bay	490	28	35	6,007	215
Chevak	387	9	12	1,400	156
Newtok	114	1	1	300	300
Mekoryuk	249	7	8	2,360	337
Tanunak	274	14	18	30,593	2,185
Umkumiut (Nightmute)	127 7/	6	7	18,660	3,110
Toksook	257	22	22	85,675	3,894
Chefornak	146	12	15	12,050	1,004
Kipnuk 9/	325	3	3	1,500	500
Kwigillingok	148	8	8	21,350	2,669
Kongiganak	190	--	--	0	--
Quinkagak 8/	--	0	--	0	--
Goodnews 9/	--	--	--	?	?
Total	2,873	114	133	181,285	1,590

1/ Source - A.D.F.& G., OCSEAP Bering Sea Herring Studies, 1976.
2/ Total population, 1970 census, University of Alaska, Institute of Social, Economic and Governmental Research, Sept., 1973, Vol. X, No. 2.
3/ Estimated number of families that fished for and utilized herring for subsistence purposes in 1976.
4/ Number of fishermen contacted and/or returning catch forms who captured herring.
5/ Estimated poundage of herring utilized by herring fishing families.
6/ When surveyed, most villagers were commercial fishing for salmon at Black River.
7/ Population estimate for the village of Nightmute.
8/ This village does not utilize herring for subsistence.
9/ Poor response from these villages on subsistence herring catches.

KUSKOKWIM AREA SPORT FISHERIES

Kuskokwim area includes all systems draining into Kuskokwim Bay from Cape Newenham to Cape Avinof. The entire Kuskokwim River lies within this area.

The Kuskokwim River is the second longest river in Alaska. It stretches over 800 miles from headwaters in the Alaska Range to its mouth in Kuskokwim Bay. The mainstem Kuskokwim carries heavy loads of silt in the summer months and is marginal habitat for most fish species.

The Kuskokwim mainstem does, however, serve as an important migratory corridor and overwintering area.

Clearwater tributaries of the Kuskokwim and rivers flowing directly into Kuskokwim Bay are the most productive systems in the study area.

The climate, influenced by the cold Bering Sea, varies from maritime transitional to continental. Precipitation averages 20" per year, coming mostly as rain in the summer months.

Freeze up varies within the study area. The mainstem Kuskokwim at Bethel is ice covered by October 15. The Kanektok River freezes over about five days later. Many of the higher elevation lakes freeze over by October 1. Most systems are free of ice by mid-May.

The fish species covered in this report are rainbow trout, *Salmo gairdneri* (Richardson), Arctic char, *Salvelinus alpinus* (Linnaeus), lake trout, *S. namaycush* (Walbaum), sheefish, *Stenodus leucichthys* (Guldenstadt), Arctic grayling, *Thymallus arcticus* (Pallus), northern pike, *Esox lucius* (Linnaeus), burbot *Lota lota* (Linnaeus) and several species of whitefish, round whitefish, *Prosopium cylindraceum* (Pallas), broad whitefish, *Coregonus nasus* (Pallas), humpback whitefish, *C. pidschian* (Gmelin), least cisco, C. sardinella (Valeniciennes), and Bering cisco, C. laurettae (Bean). A discussion of distribution within the study area, area specific life history and sport fisheries is included. Salmon, Oncornynchus species sport fisheries will also be discussed. Additional information on the salmon species is included in the Commercial Fisheries component.

Along with this narrative, a series of maps are furnished showing the known distribution of the species listed and related life history information. The information shown on the maps is not complete. Where surveys have been conducted or public interest exists, distributions are fairly well defined. Little data is available for portions of the study area.

The Kuskokwim area is not linked to the present Alaskan road system. Travel is restricted largely to riverboat and aircraft. Sport fisheries tend to be multispecies in nature. Sportsman, fishing the same gear, will commonly catch rainbows, Arctic char, grayling, northern pike and salmon on a single outing.

A substantial fishery resource exists. This resource plays an important role in the recreational needs of area residents.

RAINBOW TROUT

Distribution

Rainbow trout populations occur only in the southern part of this area. Their distribution is closely allied with the distribution of larger runs of salmon. Major drainages include the Goodnews, Kanektok, Kisaralik, Kivethluk, Arolik, Kasigluk and Aniak rivers. They seldom occur in the mainstem Kuskokwim. Rainbow trout are not present between the Kuskokwim and Yukon rivers (Baxter, pers. comm.). Occasionally rainbows are found as far up the Kuskokwim drainage as Sleetmute, at the mouth of the Holitna River (Alt, unpublished, 1976).

The majority of rainbow trout inhabit the middle reaches of rivers, below the moutainous headwaters and above those slower stretches with mud bottoms. Kuskokwim area rainbow trout do not normally move into lakes (Alt, unpublished, 1976).

Sport fish maps show known distribution of rainbow trout by quadrangle.

Life History

Spawning takes place in the spring. Dates are variable, but most spawning activity occurs in June. Spawning sites are typically gravel bars in the rivers and their side channels. Immature rainbows rear near the spawning sites and in tributary creeks (Alt, 1976). Kuskokwim area rainbows overwinter in the deep holes of rivers they are resident to.

Sport Fishery

Rainbow trout are the most sought after sport species in the study area.

Sport fishermen from Bethel frequently travel to the Kweethluk, Kasigluk, Kisaralik and Aniak rivers, all tributaries of the Kuksokwim. Sport effort in these systems is moderate. Non-resident fishermen occasionally visit the area. Kanektok and Goodnews river rainbows also receive sport fishing effort.

Most sport fishing takes place in the summer months.

ARCTIC CHAR

Distribution

To understand the distribution of Arctic char in the Kuskokwim area it is necessary to understand the diversity of this species. Although all the same species, three morphological varieties of char occur.

A stunted, resident race exists in many mountainous lakes and streams. These fish reach maturity at a length of approximately six inches. These dwarf char are usually found in upstream reaches, above where anadromous fish are commonly found. Because of their small size they are not sought as sport fish.

Large resident char inhabit tributaries to the Kuskokwim river and many lakes. The largest resident char are found in lakes. These fish may reach weights of four to six pounds. They are resident within the systems and seldom venture into the mainstem Kuskokwim River. It is not unusual to find these large resident char in high, mountainous headwater reaches as long as ample food supplies exist.

For the purpose of mapping distribution, it is impossible to separate these differences. Too much overlap occurs, not only in the larger, mature fish, but also in the fry and rearing stages.

Anadromous Arctic char occur in the streams and rivers of Kuskokwim Bay. No anadromous Arctic char are known to occur in the Kuskokwim river.

Sport fish maps show known distribution of Arctic char by quadrangle.

Life History

Kuskokwim area Arctic char spawn during August and September (Alt, 1976). All spawning and overwintering takes place in freshwater. Anadromous char outmigrate in the spring, shortly after breakup. These anadromous fish spend the summer months foraging for food in the salt water. Anadromous char re-enter the rivers of Kuskokwim Bay from July to September.

Anadromous char grow more rapidly and attain a larger maximum size than char resident to lakes or streams.

Sport Fishery

Populations of Arctic char in the study area provide an important resource for area residents. Char are sport harvested along with other species from nearly all clearwater tributaries of the Kuskokwim River and Kuskokwim Bay. Many area lakes support mixed bad sport fisheries which include Arctic char.

SHEEFISH

Distribution

Sheefish inhabit the mainstem Kuskokwim from the intertidal zone to Highpower Creek. Tributaries known to contain sheefish above their confluence with the Kuskokwim are the Holitna, Hoholitna, Aniak, Gweek, and Johnson rivers. Sheefish can occasionally be found feeding in the lower reaches of other streams tributary to the lower Kuskokwim.

Sport fish maps show the distribution of sheefish by quadrangle and document known critical areas.

Life History

Sheefish life history investigations have been conducted in the Kuskokwim River system (Alt, 1976). These studies provide information on spawning and migration movements.

In the Kuskokwim, one spawning site may serve the entire sheefish population. After intensive investigation, the only site discovered to date is located in Highpower Creek, 800 miles from the mouth of Kuskokwim. Spawning occurs in the lower 220 yards of this creek during the fall, with the peak in early October. Spawning activity takes place in the evening. This spawning population is apparently quite small and any interference to this site or spawning population could result in, at the very least, a year class failure. Permanent disturbance to this site would undoubtedly have serious effects on the Kuskokwim sheefish population.

Post spawning downstream migrations are at least partially under the ice in the lower Kukskokwim. Some fish are in the vicinity of Bethel by November. Not all sheefish participate in this downstream migration.

Sport Fishery

Because of their size, limited distribution, fighting ability and relative inaccessability, the sheefish are gaining popularity as a trophy sport fish. In the Kuskokwim area the majority of subsistence utilization comes from local residents (see subsistence report). Non-resident sport fishing effort is becoming more substantial. In 1971 a creel census was conducted on the Holitna River from the month of June through August to provide estimates of catch and effort (Table 40).

Commercial sport fishing guides now bring clients to the Holitna River from their base camps in Bristol Bay. Their primary interest is in sheefish.

GRAYLING

Distribution

Grayling are widely distributed throughout the Kuskokwim area. The clear water streams provide ideal habitat, and a majority of the grayling are located in them. Few grayling are found in the Kuskokwim except during winter months when they inhabit deep holes near the mouths of creeks.

Many of the delta waters are marginal habitat; however, grayling are known to be present there also.

The sport fish maps show the known distribution of grayling in this region.

Life History

Refer to appendix for general life history information.

Sport Fishery

The sport fishery for grayling in this region is essentially undeveloped. Some sport harvest of grayling, along with rainbow trout and Arctic char, occurs in nearly clearwater tributaries of the lower Kuskokwim.

Grayling are also caught in the multispecies sport fishery of the Holitna River. Arctic grayling are available for harvest throughout this region.

Overall pressure is low at this time.

LAKE TROUT

Distribution

Sport fish maps document the known location of lake trout stocks in this region. All of these populations occur south of the mainstem Kuskokwim River. The Kanekotok, Arolik, Kisaralik, Aniak and Goodnews drainages all contain populations of lake trout. Other populations do exist. As elsewhere in their range, these lake trout inhabit the first three or four miles of river below the outlet of lakes. Goodnews system lake trout are found throughout the course of the river to within three miles of saltwater.

Sport Fishery

An active lake trout fishery exists in this region. The majority of effort takes place in Aniak, Arolik, Kisaralik, Goodnews, Kagati and numerous other high country lakes where lake trout are harvested together with Arctic char. Lake trout are the most abundant sport fish found in these lakes, easiest to catch, and a very important sport species.

Life History

Kuskokwim lake trout reach maturity at age nine or ten. Most fish mature by age twelve (Alt, unpublished).

Lake trout are both consecutive and nonconsecutive spawners.

WHITEFISH

Distribution

Those whitefish species known to occur in the Kuskokwim area are round whitefish, broad whitefish, humpback whitefish, least cisco, and Bering cisco. As a group they are the most widely distributed species in the region.

Not all whitefish species are found together in these waters. Humpback whitefish, broad whitefish and the ciscos are most commonly found in the lowland lakes, sloughs and the mainstem rivers. Round whitefish are occasionally found in the lowlands, but of all the whitefish species, only round whitefish venture further upstream into the mountainous headwaters. Only round whitefish are found in Kuskokwim Bay drainages.

Life History

Whitefish generally spawn in gravel tributary streams during September and October. Some humpback whitefish have been observed spawning near Bethel as late as November. Refer to appendix for general life history information.

Sport Fishery

There is virtually no sport utilization of whitefish species in this region. See subsistence component for additional information.

BURBOT

Distribution

The distribution of burbot is not well defined. Burbot are known to inhabit the mainstem Kuskokwim river and throughout the delta area. Sport fish maps show waters known to have populations.

Life History

The lower Kuskokwim population of burbot is present in the Bethel area about mid-October when the ice forms. These fish are migrating upstream to spawning grounds that include the Aniak and Okawalik rivers. This migration lasts until mid-November at Bethel. Around Aniak these fish are present until January.

Spawning generally occurs in January.

Sport Fishery

Burbot are harvested in the lower Kuskokwim River by area residents during their fall spawning migration. This fishery takes place through the ice.

NORTHERN PIKE

Distribution

Northern pike are common through the Kuskokwim River drainage. The lakes and sloughs of these lowlands provide ideal spawning and rearing habitat. Northern pike are not found in that part of the Kuskokwim drainage south of the Ek River. With the exception of one pike taken in Goodnews Lake this species is not known to be present in systems flowing into Kuskokwim Bay.

Sport fish maps show northern pike distribution by quadrangle.

Life History

In this study area northern pike spawn during the latter part of May. Refer to appendix for additional life history information.

Sport Fishery

A northern pike sport fishery occurs within this region. Some important locations include the Holitna and Aniak rivers, and those areas surrounding the communities of Bethel and McGrath.

SALMON

Introduction

All five species of North American Pacific salmon can be found in this region. A discussion of salmon life history, distribution, commercial and subsistence fisheries can be found in the Commercial Fisheries Component.

Sport Fishery

The commercial and subsistence fisheries are the principal users of the salmon stocks in this region. A sport fishery does take place, concentrating primarily upon chinook, *O. tshawytscha* (Walbaum), and coho, *O. kisutch* (Walbaum), salmon and to a lesser extent chums, *O. keta* (Walbaum). Bethel, being the population center of the region is the source of much sport fishing effort. Coho salmon are the most commonly sought species in the Kuskokwim systems.

The Goodnews, Kanektok and all clearwater tributaries to the Kuskokwim offer good sport fishing for salmon. The Kanektok River is particularly attractive becuase of its large king salmon.

Table 40. Creel Census Results, Holitna River, June to August, 1971. 1/

No Angler Hours	952
Sheefish Catch	304
Catch/Hour	0.3

1/ Alt, K. T., 1972.

YUKON RIVER AREA SPORT FISHERIES

The Yukon River area includes the entire Yukon watershed within Alaska and the coastal area extending from Cape Avinof to Pastol Bay. The Koyukuk, Tanana and Porcupine rivers, all major tributaries of the Yukon, lie within this study area.

Geographic variations occur along the length of the Yukon. Four basic habitat types exist: the Yukon River Delta, the Flats, the Foothills, and the Interior Mountain Ranges. The Yukon River Delta consists of brackish and freshwater lakes, interconnecting waterways and the lowest reaches of the mainstem Yukon River. Flats, a common name for low lying swampland and lake complexes adjacent to mainstem rivers, occur discontinuously along the Yukon. The Yukon Flats, near Ft. Yukon, and the Minto Flats northwest of Fairbanks, are noteworthy examples of this habitat type. Most of the Yukon River area's numerous lakes are present in the delta and on the various flats.

Rising out of the flats and mainstem river valleys, the Foothills form a transitional habitat. Rivers are usually swift and clear. Few lakes are present. The Interior Mountain Ranges, the Brooks Range to the north and the Alaska Range to the south, form north-south boundaries for the eastern half of this large area. Systems originating in the glacial Alaska Range are often very silty during the summer season. Clearwater tributaries predominate in the Brooks Range. Cold, deep, clearwater lakes are occasionally present in the Interior Mountains.

The Yukon River drainage is extremely large, covering almost one fourth of the land within Alaska, but it is sparsely populated. Fairbanks, located on the Tanana River is the populations center of the study area.

Numerous small villages exist along the mainstem Yukon and tributary systems.

Sport fishing takes place to some degree over the entire study area. Intensive sport fisheries occur mostly in the Tanana River drainage, because of its proximity to larger human populations and greater access provided by state highways. Fishery resources provide for important recreational and nutritional needs of residents throughout the Yukon drainage. In addition to area residents, visitors from other parts of Alaska and outside the state frequently enjoy sport fishing opportunities the Yukon area has to offer.

Native fish species discussed in this report include sheefish, Stenodus leucichtys (Guldensladt), northern pike, Esox lucius (Linnaeus), Arctic grayling, Thymallus arcticus (Pallas), lake trout, Salvelinus namaycush (Walbaum), Arctic char, Salvelinus alpinus (Linnaeus), burbot, Lota lota (Linnaeus), and several species of whitefish, round whitefish, Prosgsium cylindraceum (Pallas), broad whitefish, Coregonus nasus (Pallus), humpback whitefish, C. pidschian (Gmelin), least cisco, C. sardinella (Valenciennes), arctic cisco, C. autumnalis (Pallas), and Bering cisco, C. laurettae (Bean). Rainbow trout, Salmo gairdneri (Richardson) are included, although they are not native to the Yukon drainage. Numerous lakes, stocked with rainbow trout, presently support active sport fisheries.

The distribution, area specific life history and sport fisheries are outlined for each species. Maps accompanying this narrative show the known distribution and critical habitat sites by 1:250,000 scale quadrangles.

In addition, a narrative description of salmon, Oncorhynchus species, sport fisheries included. Salmon distribution and life history data are presented in the Commercial Fisheries Component.

SHEEFISH

Distribution

Sheefish are present along the entire length of the Yukon River in Alaska. Major Yukon tributaries containing sheefish are the Koyukuk, Tanana and Porcupine rivers.

There are probably three separate populations of sheefish in the study area. These are the lower Yukon River-Koyukuk River, Upper Yukon and Mints Flats populations (Alt, 1975).

Sheefish remain primarily in the mainstem river, but are occasionally present as a feeding visitor in the lower reaches of both tributary streams and delta areas.

Sport fish maps show known distribution and descrete spawning areas by quadrangle.

Life History

Yukon River area sheefish populations are both estuarine anadromous and freshwater resident. Sheefish of the lower Yukon River-Koyukuk River population are anadromous. Upper Yukon River and Minto Flats sheefish are believed to remain in freshwater year round (Alt, 1975).

Anadromous sheefish of the lower Yukon arrive at spawning grounds in the fall from late August to early October. Spawning sites are documented in the Koyukuk, Yukon and Alatna rivers. See Sport Fish maps. Spawning takes place in late September and early October followed by a rapid postspawning downstream migration. These sheefish overwinter in the lower reaches of the Yukon River and into the brackish water at the mouth.

Upstream movement begins under the ice in April and May. In June and July the fish are widely distributed. Most nonspawners and immature fish remain in the lower section of the Yukon River to feed (Alt, 1975).

Sheefish of the lower Yukon population have the largest recorded migrations in Alaska. The distance from the Yukon River mouth to spawning grounds in the Alatna River is 1,000 miles.

The sheefish found in the Upper Yukon River are believed to be a separate population and nonanadromous. They are slower growing than lower Yukon River sheefish (Alt, 1973).

The Minto Flats sheefish, constituting a the third discrete population, are also nonanadromous (Alt, 1975). Spawning adults of the Minto Flats sheefish populstion begin migrating up the Chatanika River in late June and reach the area of the spawning grounds located approximately 75 miles up the Chatanika River in late August and September. Spawning occurs in late September and early October. A postspawning downstream migration follows. It is believed that Minto Flats sheefish overwinter in the lower Tolovana and Tanana rivers. These fish re-enter the Minto Flats in late May after breakup. Minto Flats is the main summer feeding and rearing area.

Sport Fishery

The lower Yukon River-Koyukuk River sheefish population supports the most active sport fishery in the study area. Effort levels are light. Fishing takes place along the Yukon River near the Melozitna, Hess, Ray and Dall rivers during July and in the Koyukuk River near

Hughes in September.

Sheefish are occasionally caught by sport fishermen on the upper Yukon River, the Porcupine River, and in the Minto Flats during the summer and fall. Most of this catch is incidental to other sport fisheries.

NORTHERN PIKE

Distribution

Northern pike are present throughout the lowland lakes, sloughs and mainstem rivers in the Yukon River area. Many, if not most, lakes in the interior that are deep enough to overwinter fish have pike populations. The largest populations are found in meandering river-slough areas usually referred to as "flats". The Minto and Yukon Flats are good examples of these. Populations of northern pike can be found in lakes and streams of both the Alaska Range and Brooks Range foothills.

Sport fish maps show distribution of northern pike by quadrangle and document known critical areas.

Life History

Northern pike life history investigations have been carried out in the Minto Flats northwest of Fairbanks (Alt, 1968, 1969 and Cheney, 1971). Life history and timing information are from those studies.

The Minto Flats drain into the Tanana River via the Tolovana River. Northern pike are present in the Minto Flats before ice is out of the larger rivers and lakes. Northern pike begin spawning in the Minto Flats in mid-May and are completed by mid-June. Spawning habitat is described by Cheney (1971) as having the following characteristics: shallow with emergent aquatic vegetation and depths from three inches to two feet, little or no current, ice free before the main rivers, and mud bottom covered with vegetation mat. These areas are subject to rapidly fluctuating water temperatures.

Winter movements of Minto Flats are largely unknown. Much of the area becomes totally frozen to the bottom or is subject to oxygen depletion (Roguski, L967). Pike probably move out of these low oxygen waters into the lower reaches of the Tolovana River and possibly the Tanana River (Cheney, 1971). Due to the vastness of the Yukon River area results of northern pike life history studied in the Minto Flats may vary from other, unstudied populations along the Yukon. Many area lakes are sufficiently deep to overwinter pike. These populations remain in the alke they are resident to year round.

Sport Fishery

Sport fishing for northern pike is becoming increasingly popular in the Yukon drainages. Most systems are accessible only by aircraft or riverboat. This is a year round fishery, but most activity takes place during the summer months.

The Minto Flats and portions of the upper Tanana River drainage because of their proximity to Fairbanks, receive the most concentrated pressure from sport fishermen. Northern pike are harvested with sport fish gear along the entire length of the Yukon River area by village residents, military personnel, workers and tourists. Overall, effort levels are low and pressure quite dispersed.

Subsistence report contains additional harvest information.

ARCTIC GRAYLING

Distribution

Arctic Grayling occur along the entire length of the Yukon River area. Clearwater tributary streams and high country lakes provide the most suitable habitat and contain the largest populations. Lesser numbers of grayling are present in the flats along the mainstem Yukon River and out into the Yukon-Kuskokwim delta.

Larger rivers such as the Yukon and Tanana are often unsuitable grayling habitat during summer months due to the large loads of silt being carried downstream. In the winter, these same rivers run silt free, and provide stable overwintering habitat for many fish species, including Arctic grayling.

In addition to native grayling populations, a number of Tanana Valley lakes have been stocked with grayling fry hatched at Fire Lake hatchery. These lakes are listed in Tables 41 and 42 and are shown on the sport fish maps.

Sport fish maps show the known distribution of Arctic grayling by quadrangle for the Yukon River area.

Life History

Grayling life studies have been carried out by the Alaska Department of Fish and Game in the Chena River of the Tanana drainage (Van Hulle, 1968), (Roguski and Winslow, 1969), (Roguski and Tack, 1970), (Tack, 1971 through 1976). Due to the vastness of the Yukon River area, life cycle data is certain to vary somewhat from site to site. The following data is resulted from studies previously cited.

Chena River grayling overwinter slough areas of the lower Chena

River and deeper pools of the mainstem Chena. These fish begin moving toward spawning sites in the Chena River during April. Grayling were observed spawning along the Chena River on May 12, 1976 (Tack, 1976).

Post spawning movement may consist of both up and downstream migrations. Pearse (1974) describes movements of up to 144 km. for other Tanana River drainage grayling. Rearing takes place throughout the general distributions including streams not associated with spawning (Pearse, 1974).

General life history data pertaining to Arctic grayling can be found in the Appendix.

Sport Fishery

Sport fisheries for grayling exist in some degree throughout the Yukon River area. The most important are streams with good access located in the Tanana River drainage. Among the most popular are the Chena River, Salcha River, Chatanika River, Goodpaster River, Delta River, and Tangle Lakes.

The majority of sport fishing effort takes place immediately after the ice goes out in spring and continues through the summer months. Float trips are popular on many of these systems. The more remote systems, lying between the White Mountains and the Brooks Range, receive only occasional sport fishing effort.

The Trans-Alaska Pipeline runs north-south through the Yukon River area. This construction corridor provides additional access to remote fish populations. Fishing effort is limited, however, by a regulated closure extending five miles to either side of the pipeline north of the Yukon River.

The Alaska Department of Fish and Game has monitored grayling sport fisheries on the Chena River in the Tanana Valley (Roguski and Winslow, 1969), (Roguski and Tack, 1970), (Tack, 1971 through 1974), (Tack, 1976). Badger Slough, 35 km. up the Chena River from its confluence with the Tanana River is the site of an intensive spring grayling fishery. A creel census has been conducted there most years since 1968. Data from those creel censuses are presented in Table 44

A creel census is conducted along that portion of the Chena River accessible by road during the summer months. The area covered by this census is divided into three sections, the Chena River adjacent to Fairbanks and Fort Wainwright, Bailey Bridge and the upper Chena River adjacent to Chena Hot Springs Road. The 1975 results of this census are presented in Table 43

WHITEFISH

Distribution

As a group, whitefish are the most widely distributed species in the Yukon River area of Alaska.

This report deals with five whitefish species: broad whitefish, humpback whitefish, round whitefish, least cisco, Bering cisco and Arctic cisco. Distribution differs somewhat between species. Broad whitefish, humpback whitefish and least cisco have the most universal distribution, being common in brackish and freshwater lakes and both slow and fast moving streams. Bering cisco are primarily a coastal species. Round whitefish are usually stream dwelling fish and not found in an estuarine situation.

Sport fish maps show known distribution of whitefish species as a group by quadrangle.

Life History

The vast Yukon River area of Alaska contains both resident and anadromous races of whitefish. Anadromous whitefish of the Yukon-Kuskokwim Delta spend the summer months feeding in brackish waters. These fish spawn and overwinter primarily in freshwater.

Resident whitefish exhibit seasonal movements while staying entirely in freshwater. All whitefish are fall spawning fish. Least cisco and humpback whitefish were observed spawning in the Chatanika River from September 24 to October 13 in 1972. The peak of spawning activity was the last week of September (Kepler, 1973). After spawning, whitefish migrate to suitable overwintering sites usually larger rivers or deep spring fed pools in their resident stream. Summers are spent feeding throughout their range including many shallow lakes and sloughs.

Spawning times and duration may vary slightly within the Yukon River area.

It is important to note that least cisco are a very important item in the diet of pike, lake trout, burbot and sheefish.

Sport Fishery

Whitefish are sport harvested in portions of the Yukon River area. Most notable of whitefish sport fisheries is the Chatanika River fall spear fishery. A creel census was conducted October 1-16 of 1972 (Kepler, 1973). Most spearfishing took place near road accesses from 8:00 p.m. to 12:00 midnight. The calculated total catch was 701 whitefish including 433 least cisco, 197 humpback whitefish and 71 round whitefish.

Sport catches of whitefish occasionally come from roadside tributaries of the upper Tanana River.

The most substantial whitefish harvest comes from the subsistence fishery. This is essentially a gill net fishery that is carried out year round in the Yukon River area. See subsistence report for additional information.

RAINBOW TROUT

Distribution

There are no native rainbow trout anywhere in the Yukon River area. All existing populations are the direct result of enhancement programs. Lakes stocked with rainbow trout are listed in Tables 41 and 42. Sport fish maps designate stocked lakes.

Life History

Rainbow trout stocked in Interior Alaska lakes are reared at the hatchery facilities near Eagle River, Alaska. Rainbows are stocked as fingerlings and allowed to reach catchable size in the respective lakes. Once stocked they are essentially nonreproductive, owing to the lack of spawning habitat in most enhanced lakes. Stocking rates and frequency vary and are based on yearly investigations of population status. Most lakes receive additional fish at least every other year.

Sport Fishery

The rainbow trout lake stocking program provides accessible sport fisheries for the more highly populated locations in the Tanana River drainage. These are year round fisheries although most rainbow trout are harvested during the ice free months. A creel census was conducted on the Birch Lake rainbow trout fishery from May 29 through September 6, 1971 (Peckham, 1972). The 1971 estimate of effort was 23,776 angler hours. Quartz Lake located along the Richardson Highway is another important stocked rainbow trout sport fishery. Effort rates vary between locations and from year to year, but these censuses are valuable because they document a substantial amount of angler interest in lake stocking programs.

BURBOT

Distribution

Burbot are widely distributed throughout the Yukon Delta, the mainstem Yukon River including the various flats and in many waters located in the foothills. Burbot prefer lakes, sloughs and the slower reaches of rivers and will enter brackish water.

Sport fish maps show distribution of burbot by quadrangle for the Yukon River area.

Life History

No area specific life history information is available. Refer to the Appendix for generalized life history.

Sport Fishery

Burbot are occasionally sought, as a sport fish, over most of the Yukon River area. One of the most active burbot sport fisheries take place in the upper Tanana River valley at the mouth of Moose Creek near

Northway during spring and fall migrations. Popular fisheries occur at the confluence of many other tributaries to the Tanana River. Winter fishing is common in many of the larger lakes where burbot exist.

SALMON

Introduction

All five species of North American Pacific salmon, king (chinook) salmon, *O. tshawytscha* (Walbaum), chum salmon, *O. keta* (Walbaum), silver (coho) salmon, *O. kisutch* (Walbaum), sockeye salmon, *O. nerka* (Walbaum) and pink salmon, *O. gorbuscha* (Walbaum) are indigenous to the Yukon River area with chum salmon the most numerous. King salmon rank second in abundance followed in order by coho, pink and sockeye. Pink and sockeye salmon are present in limited numbers only.

Additional information pertaining to salmon may be found in the Commercial Fisheries component of this report.

Sport Fishery

The Yukon River area as a whole receives very limited sport fishery effort directed toward the salmon species. Within the study area, the most active salmon sport fisheries take place in the Tanana River Valley. Clearwater tributaries to the Tanana such as the Salcha River are among the most popular locations. King, coho and chum salmon are the most commonly harvested species.

In addition to the native salmon runs, coho salmon have been stocked into many Tanana Valley lakes. These are landlocked populations and provide high use sport fisheries. Coho are actively sought through the ice, during the winter months. Coho bite much better than stocked rainbow trout at this time of year.

Tables 41-42 list lakes containing landlocked populations of stocked coho salmon.

LAKE TROUT

Distribution

Lake trout are present in many of the deeper lakes found in the Interior Foothills and mountains. These fish utilize the lake and to some extent the inlet and outlet streams.

Sport fish maps document known populations of lake trout in the Yukon River area.

Life History

Lake trout spawn in the fall. They are a long living, slow growing fish. Refer to the Appendix for generalized life history information.

Sport Fishery

Most sport fishing activity comes from fly in anglers and takes place during the summer months. Only in the southern portion of this area, particularly near Fielding and Tangle lakes, are lake trout populations accessible by public road. The Trans-Alaska pipeline haul road may, in the future, provide additional access, but it is currently closed to public use.

Villagers in the vicinity of lake trout populations will occasionally sport fish for the species. Big game hunters also sport fish lake trout when it is possible.

Sport Fishery

Only a limited amount of sport fishing activity takes place in the Yukon River area due to the remoteness of most char stocks. The most attractive sport fisheries exist on tributaries of the lower Yukon during the summer months.

Table 41 . Yukon River Area, Fairbanks District Stocked Lakes. 1/

Lake	Location	Species Currently Stocked
Sansing Lake	Clear AFS	RT
Engineer Hill Lake	Eielson AFB	GR
Harding Lake	Richardson Hwy, 45 Mile	SS
Little Harding Lake	Richardson Hwy, 45 Mile	SS
Lost Lake	Richardson Hwy, 55 Mile	SS
Nenana Pond	Nenana	SS
Ottos Lake	Parks Hwy, 120 Mile	GR
31 Mile Pit	Richardson Hwy, 31 Mile	GR
Johnson Road Pits	Richardson Hwy, 33 Mile	GR
Birch Lake	Richardson Hwy, 55 Mile	SS & RT
Koole Lake	Fly-in 8 Mile S.E. of Birch Lake	RT
Dune Lake	Fly-in 25 Mile S.W. of Nenana	GR
Roy Lake	Fly-in 7 Mile W. of Central	SS
Hidden Lake	Eielson AFB	GR
Grayling Lake	Eielson AFB	GR
Birch Lake Pit	Richardson Hwy, 55 Mile	GR
Bathing Beauty Pit		GR
TarKettle Lake	Eielson AFB	GR
Borrow Pits	Steese Hwy, 30.6 Mile, 34.6 Mile, 35.8 Mile	GR

1/ Source - On file, Alaska Department of Fish and Game, Division of Sport Fish, Fairbanks, Alaska.

Table 42. Yukon River Area, Upper Tanana District Stocked Lakes. 1/

Lake	Location	Species Currently Stocked
Bolio	Ft. Greely	SS
Mark	Ft. Greely	RT
North Twin	Ft. Greely	RT
South Twin	Ft. Greely	SS
Chet	Ft. Greely	GR
"J"	Ft. Greely	GR
Nickel	Ft. Greely	GR
Ft. Greely #2	Ft. Greely	RT
Donnelly	East of Donnelly Dome	SS
Rapids	Richardson Hwy	RT
Donna	Alaska Hwy	RT & SS
Little Donna	Alaska Hwy	RT
Craig	Alaska Hwy	RT & SS
Lisa	Alaska Hwy	RT & SS
Jan	Alaska Hwy	RT & SS
Four Mile	Taylor Hwy	SS
Quartz	Alaska Hwy	RT
Rainbow	Richardson Hwy, Fly-in	RT
81 Mile Pit	Richardson Hwy	GR
Crystal	Richardson Hwy	RT

1/ Source - On file, Alaska Department of Fish and Game, Division of Sport Fish, Delta Junction, Alaska.

Table 43. Chena River Grayling Sport Fishery, 1975 Angler Effort Data. 1/ 2/

Month	Fairbanks Ft. Wainwright	Bailey Bridge	Chena Hot Springs Road	Total
June	855	1,927	5,844	8,626
July	1,369	615	12,525	14,509
August	5,720	401	4,288	10,409
TOTAL	7,944	2,943	22,657	33,544

1/ Tack, 1976.

2/ In angler hours.

Table 44 . Yukon River area, Chena River, Badger Slough creel census results, 1968 to 1975.

Year	Inclusive dates of census	Total angler hours	Total grayling harvest
1968	4/17 - 5/31	8,970	7,355
1969	4/12 - 5/31	6,929	5,542
1970	5/01 - 5/31	6,206	2,669
1971	No Census		
1972	4/08 - 5/24	7,174	6,170
1973	4/05 - 5/31	8,511	9,958
1974	No Census		
1975	4/09 - 5/31	5,947	5,639

Source - Tack, 1976.

NORTHWEST AREA SPORT FISHERIES

The Northwest area is bounded on the north by the Brooks Range on the south and east by the Yukon River drainage, and on the west by Norton Sound, Kotzebue Sound and the Bering Straits. It includes all coastal streams from Pastol Bay to Cape Lisburne.

The largest watersheds are those of the Noatak and Kobuk rivers. Rivers in the study area are usually clear and moderately fast flowing. Drainage is good in most of the Northwest area.

Cold Bering Sea waters influence the climate. Rivers freeze in September and October. Spring break up takes place in June.

Nome and Kotzebue, as well as many smaller communities lie within the study area. Sport fishing is an important recreational pastime to area residents. In addition to the resident fishermen, the Northwest is becoming increasingly popular with non-resident sportsmen looking for unique fishing experiences.

The Northwest area of Alaska is not connected to the Alaska Highway system. Nearly all access into the area is gained by flying. A road system exists within the area, connecting Nome to other communities on the Seward Peninsula. Roadside streams support the most active sport fisheries. Aircraft and riverboats are popular means of travel among area residents.

The fish species discussed in this report are sheefish, Stenodus leucichthys, Arctic char, Salvelinus alpinus (Linnaeus), northern pike, Esox lucius (Linnaeus), Arctic grayling, Thymallus arcticus (Pallas), lake trout, Salvelinus namaycush (Walbaum), burbot, Lota lota (Linnaeus), and several whitefish species, Coregonus sp. and Prosopium cylindraceum

(Pallas).

The map component of this report shows known distribution of selected species by quadrangle for Northwest Alaska. Known critical areas are documented.

A discussion of salmon, Oncorhynchus sp., sport fisheries is included in this narrative. Additional information related to salmon can be found in the Commercial Fisheries component.

SHEEFISH

Distribution

Three rivers in Northwest Alaska contain spawning populations of sheefish. These are the Kobuk River, draining into Hotham Inlet, Selawik River, draining into Selawik Lake and the Koyuk River, draining into Norton Bay. Sheefish found in the Kobuk and Selawik drainages constitute a single population (Alt, 1976). The Koyuk population is much smaller than the Kobuk-Selawik.

Sport fish maps show distribution by quadrangle and document known critical areas.

Life History

Sheefish spawn during late September and early October. Spawning activity occurs in the late afternoon and evening. Optimum spawning habitat is described by Alt (1969) as differentially sized, coarse gravel with no silt and some sand. Suitable spawning grounds are present in the Kobuk, Selawik and Koyuk rivers.

Sheefish undertake rapid downstream migrations after spawning. Overwintering takes place in the lower reaches of rivers, brackish lakes, bays and inlets.

Upstream movement of Kobuk and Selawik prespawning sheefish begins just after ice out, usually in late May. The fish arrive in the vicinity of the spawning grounds in late August and early September. Spawning population counts were made in 1971 on both the Kobuk and Selawik rivers. Approximately 5,000 spawners were present in the Kobuk River and 1,020 were counted in the Selawik River (Alt, 1971).

Sheefish movements other than those related to spawning include summer feeding movements into the sloughs of the lower Kobuk and Selawik rivers and fall movement into Selawik Lake (Alt, 1976).

Age at maturity for Kobuk-Selawik sheefish is seven to nine years for males and nine to twelve years for females. Kobuk-Selawik sheefish are the slowest growing and longest lived of Alaskan sheefish (Alt, 1973).

Koyuk River sheefish life history is believed to be similar to that for Kobuk-Selawik fish with the exception that they are faster growing and do not reach the same large size of Kobuk-Selawik sheefish. According to the local Koyuk residents, this sheefish population overwinters in Koyuk Bay and moves upstream after breakup. Sheefish have been taken from the lower Koyuk River in late July (Alt, 1971).

Sport Fishery

An active sport fishery exists in Northwest Alaska. Most activity occurs in the Kobuk-Selawik area. Participation comes from both local residents and fly-in fishermen. A sport fishing lodge located at Kiana, on the Kobuk River is visited by approximately thirty to sixty anglers per year (Alt, pers. comm. 1976).

Sport fisheries take place year round, but most effort occurs in the summer months as sheefish move upstream to spawn. April and May are popular months for ice fishing in Hotham Inlet and Selawik Lake.

ARCTIC CHAR

Distribution

Arctic char are present in nearly every coastal stream in Northwest Alaska. Sport fish maps show distribution of Arctic char by quadrangle and document known critical areas.

Life History

The majority of Arctic char in Northwest Alaska are anadromous. These fish enter freshwater systems in the early fall during the months of August and September. Spawning takes place in August and September. Arctic char overwinter in freshwater then outmigrate shortly after the ice goes out of the rivers in spring. Summer months are spent feeding in saltwater.

Arctic char are non-consecutive spawners. These fish enter freshwater in the fall as nonspawners. Following the winter, they remain in rivers rather than outmigrating to saltwater. Spawning takes place the second autumn, one year after entering freshwater. After spawning and overwintering in the river these fish drop out into saltwater, putting their total freshwater stay at approximately 18 months (Alt, pers. comm.).

Arctic char from portions of Northwest Alaska become quite large in comparison with other char populations in the state. One specimen taken from the Wulik River weighed 17.5 pounds (Winslow, 1969).

Sport Fishery

The most active sport fishery in Northwest Alaska is centered around Nome and the Seward Peninsula road system. Char are an important sport fish, especially in the spring and late summer when they are present in most streams.

The Wulik and Kivalina rivers have excellent sport fishing potential. The Alaskan record Arctic char (17.5 pounds) was taken in the Wulik. Both of these rivers have relatively large char populations. Due to their remote locations, comparatively few sport fishermen have fished these rivers. A lodge now operates on the Wulik River. Guests at this lodge spend an estimated 400 man days per summer fishing for Arctic Char (Alt, pers. comm.).

Subsistence report contains additional harvest information.

NORTHERN PIKE

Distribution

Northern pike are widely distributed in the lowland lakes, sloughs and river systems of Northwest Alaska.

Sport fish maps show distribution of northern pike by quadrangle.

Life History

No area specific life history information is available.

Sport Fishery

A northern pike sport fishery occurs in Northwest Alaska. Effort levels are light (Alt, pers. comm.). Most participation comes from residents of the Nome area and takes place during the summer months along the road system in the lower Kuzitrin and Pilgrim rivers and in Fish River.

WHITEFISH

Distribution

As a group whitefish are the most widely distributed species in Northwest Alaska. Five species are present in the study area: round whitefish, *P. cylindraceum*, broad whitefish, *Coregonus nasus* (Pallas), humpback whitefish, *C. pidschian* (Gmelin), least cisco, *C. sardinella* (Valenciennes), and Bering cisco, *C. laurettae* (Bean). Almost all whitefish are found in brackish and freshwater lakes and both slow and fast moving streams. The round whitefish is usually a stream fish and not found in an estuarine situation (Alt, 1971).

Sport fish maps show distribution of whitefish species, as a group, by quadrangle.

Life History

Whitefish species exists as both anadromous and land locked populations. All whitefish spawn in freshwater during September and October. Following the spawning season whitefish will overwinter in the freshwater. Outmigration of the anadromous fish occurs in the spring and is closely related to ice out. Anadromous whitefish spend the summer months feeding in brackish deltas, sloughs and inlet areas. These fish re-enter freshwater in the fall.

Sport Fishery

No sport fishery exists at this time. See subsistence report for additional information.

ARCTIC GRAYLING

Distribution

Arctic grayling are widely distributed in Northwest Alaska. Moderately fast flowing, clearwater streams provide the most suitable habitat. Arctic grayling are only occasionally present in lowland lakes and poorly drained slough areas. Sport fish maps show grayling distribution by quadrangle.

Life History

No area specific life history information is available.

Sport Fishery

Grayling are harvested by sport fishermen in Northwest Alaska. Much of this activity takes place in the waters along the Nome road system during the summer months. Many grayling are caught incidental to char, lake trout and salmon. Miners and hunters occasionally take grayling from more remote areas.

LAKE TROUT

Distribution

Lake trout are present in many of Northwest Alaska's higher elevation lakes. Their distribution is limited to the deeper, gravel bottomed lakes and to a limited degree the inlet and outlet streams associated with those lakes.

Sport fish maps show known distribution by quadrangle for Northwest

Alaskan lake trout.

Life History

No area specific life history information is available. See Appendix for general life history.

Sport Fishery

A limited sport fishery occurs in Northwest Alaska. Most lake trout are taken during the summer months. Sport fishermen will fly into lakes from Nome, Kotzebue or even as far away as Fairbanks. Hunting guides and their clients harvest lake trout from lakes near their camp during the late summer. Overall effort is light.

BURBOT

Distribution

Burbot have a limited distribution in Northwest Alaska. They are probably most abundant in Kotzebue Sound drainages and possibly the Imuruk Basin area. At the present time, survey work, documenting burbot distribution is incomplete. Sport fish maps show known populations.

Life History

No area specific information is available.

Sport Fishery

Burbot are occasionally taken during winter ice fisheries.

SALMON

Introduction

All five species of North American Pacific salmon are present in

Northwest Alaska. Distribution, life history, commercial and subsistence fisheries are discussed in the Commercial Fisheries component.

Sport Fishery

Streams along the Nome road system support the largest salmon sport fisheries in the region. Pink salmon, O. gorbuscha (Walbaum), and chum salmon, O. keta (Walbaum) are the most plentiful. Coho, O. kisutch (Walbaum), and an occasional sockeye, O. nerka (Walbaum), or chinook, O. ts hawytscha (Walbaum), are also harvested. Effort levels are high at some locations along the roadway.

The Unalakleet River, flowing into Norton Sound, supports a small chinook salmon fishery. Kobuk River chum salmon also receive a small amount of sport fishing effort.

NORTH SLOPE AREA SPORT FISHERIES

The North Slope area includes all lakes and rivers lying north of the Arctic divide. This study area extends from Cape Lisburne east to the Canada border.

The North Slope is characterized by extreme climatic conditions. Break up varies, but rivers are usually free of ice in early June and frozen over again by October. Ice forms solid to the bottom of most streams and lowland lakes. Nearly all discharge has ceased by mid-winter. Running water remains only near groundwater springs and in the deep pools of larger rivers. Lakes are free of ice only from late June through mid-September.

Three major geographic division are present on Alasks's North Slope; the Arctic Coastal plain, the Foothills and the Arctic Mountains. The Arctic Coastal plain is somewhat rolling in the east. To the west it becomes more level, containing extensive marshes and lakes. Drainage is poor in much of the Western Arctic Coastal plain.

The Foothills rise slightly in elevation from the plain and have moderately rolling relief. Drainage is good in the Arctic Foothills. Many small lakes are present.

The Arctic Mountains are made up of the rugged Brooks Range. These mountains contain groundwater spring systems that are at the headwaters of most important North Slope rivers.

It is difficult and expensive to gain access to most North Slope sport fisheries. Those anglers not living or working in the study area must fly in nearly all cases.

The Trans-Alaska Pipeline, orginating at Prudhoe Bay, runs north-south through the North Slope area. An existing haul road, servicing the pipeline and related projects, is presently closed to public use. If this roadway is opened it will provide access to much of Arctic Alaska. This access will undoubtedly increase the amount of sport fishing activity.

Species of fish discussed in this report are Arctic char, *Salvelinus alpinus* (Linnaeus), Arctic grayling, *Thymallus arcticus* (Pallas), lake trout, *Salvelinus namaycush* (Walbaum), burbot, *Lota lota* (hinnaeus), and several species of whitefish, *Coregonus sp.* and *Prosopium cylindraceum* (Pallas). The distribution of these species is shown by quadrangle on the sport fish maps. There is no sport fishery on the salmon species in the study area. The Commerical Fisheries component contains additional information on salmon.

ARCTIC CHAR

Distribution

Arctic char can be found in nearly all North Slope rivers and many lakes. The eastern Arctic, from the Sagavanirktok River to the Canada border, provides the most suitable habitat. Larger rivers of the eastern Arctic such as the Sagavanirktok, Canning, Hulahula, Aichilik and Kongakut, headwater in the Brooks Range and contain numerous groundwater springs. These springs appear to be a controlling factor in Arctic char distribution (Craig and McCart, 1974). They provide running water year round.

Arctic char are occasionally present throughout the Colville River drainage and the remainder of the western Arctic. Larger areas exist on the North Slope where survey work is incomplete. Arctic char are known to be present in many of these areas, but their distribution is largely undefined.

Arctic char additionally inhabit the nearshore saltwater as they forage for food during the summer months.

Sport fish maps show distribution of Arctic char by quadrangle and document known critical areas.

Life History

Anadromous and resident races of Arctic char inhabit portions of the North Slope area. Resident char are most often lake dwellers, spawning and overwintering in those lakes in which they reside. Little is known of the biology of these resident char. Anadromous char inhabit the flowing water of rivers during the freshwater periods of their life cycle.

Anadromous char, found on the North Slope spawn during September and October (Terry Bendock, pers. comm. 1976). Spawning sites are typically braided, gravel bottomed stream channels in the vicinity of groundwater springs (Craig and McCart, 1974). Young of the year emerge from the gravel in April or May. After a variable number of years young char migrate seaward. Outmigration of both adult and juvenile char takes place during May and June. Summer months are spent feeding in nearshore saltwater.

Arctic char re-enter freshwater beginning in August. Spawners enter first followed by nonspawning mature and immature fish. Most Arctic char are nonconsecutive spawners (Terry Bendock, pers. comm. 1976). Overwintering takes place near spring areas where water flow is assured.

Some small, stream dwelling char remain in freshwater throughout their lives. These are referred to by area residents as "old man fish". They are primarily male fish from the anadromous population that fail to outmigrate.

Sport Fishery

Sport fishing for Arctic char occurs on a limited basis in the North Slope area. Construction workers from the Trans-Alaska Pipeline project and Prudhoe Bay form a large population of potential sport fishermen. Their effort is restricted by five mile sport fishing closure on each side of the pipeline. Workers are allowed to sport fish in Prudhoe Bay and the lower Sagavanirktok River delta.

Sport fishermen occasionally fly into North Slope lakes where they catch char in addition to lake trout and grayling. Most sport effort takes place in the summer months of July and August.

ARCTIC GRAYLING

Distribution

Arctic grayling are widely distributed in the North Slope area of Alaska. They are resident to nearly all area streams and higher elevation lakes. Although grayling seldom enter saltwater, they are known to venture into river deltas shortly after breakup when those reaches are made up primarily of freshwater effluent.

Sport fish maps show distribution of Arctic char by quadrangle and document known critical areas.

Life History

North Slope area Arctic grayling spawn during and just after spring breakup in the months of May and June. Once mature grayling appear to spawn every year (Bruyn and McCart 1974).

Grayling rear in the calm, shallow water of lakes and flowing systems.

It appears that grayling associated with lakes may move into streams associated with those lakes to spawn.' Fry and juveniles remain in the stream during the summer while mature fish move back into the lake.

Arctic grayling overwinter in deeper lakes, deep pools in rivers and near groundwater springs.

Sport Fishery

A small amount of sport fishing takes place for grayling in the North Slope area. Most of this effort comes from fly in fishermen and big game hunters. The construction workers of the Trans-Alaska Pipeline project are limited by the five mile sport fishing closure each side of the pipeline.

Most sport fishing occurs during the ice free summer months.

LAKE TROUT

Distribution

Lake trout are present in many of the larger deep gravel bottomed lakes of the Arctic Foothills and Mountains. Populations of lake trout seldom occur in the coastal plain (Alt, pers. comm. 1976). Sport fish maps show known distribution of lake trout by quadrangle.

Life History

Lake trout are fall spawning fish. Kogl (1971) found rearing lake trout in Ikagiak Creek which drains into Chandler Lake, indicating that small tributary streams are important rearing areas in the Chandler Lake system.

Spawning sites have not been documented. Lake trout overwinter in those lakes in which they reside.

Sport Fishery

Sport fishing is done largely by hunters at North Slope guide camps. Occasionally fishermen will fly in to such lakes as Peters, Chandler, Schrader and Itkillik. This fishery takes place during the ice free summer months.

BURBOT

Distribution

Burbot are present in many North Slope systems. The lower reaches of Arctic rivers appear to be the most suitable habitat. Sport fish maps show known distribution of burbot by quadrangle.

Life History

No area specific life history information is available.

Sport Fishery

There is no active sport fishery at this time.

WHITEFISH

Distribution

As a group, the whitefish are the most widely distributed species in Alaska's North Slope rivers and lakes. Five species of whitefish are present in the study area, round whitefish, P. cylindraceum, broad whitefish, Coregonus nasus (Pallas), humpback whitefish, C. pidschian (Gmelin), lease cisco, C. sardinella (Valenciennus), and Arctic cisco,

C. autumnalis (Pallas). With the exception of round whitefish, these species occupy brackish deltas, nearshore saltwater and the waters of the Arctic Coastal plain during the summer months. Round whitefish prefer freshwater and are distributed along the length of many North Slope systems.

Sport fish maps show distribution of whitefish species, as a group, by quadrangle and document known critical areas.

Life History

Both anadromous and resident whitefish species occur in this area. All whitefish species spawn during late September and October. All overwintering takes place in freshwater. After spawning and overwintering, humpback whitefish, broad whitefish, least cisco and Arctic cisco outmigrate into saltwater summer feeding grounds. This outmigration closely concides with breakup in May and June. Rearing takes place in both fresh and saltwater.

Round whitefish remain in freshwater year round.

Sport Fishery

There is no sport fishery at this time.

LITERATURE CITED

Alt, K. T. 1969. Taxonomy and ecology of inconnu, Stenodus leucichthys nelma, in Alaska. Biol. Pap. Univ. Alaska. 12:61 pp.

1971. A Life History of Sheefish and Whitefish in Alaska. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress 1970-1971. Project F-9-3.

1973. Age and growth of inconnu, Stenodus leucichthys, in Alaska. T. Fish. Res. Board Can. 30:457-459.

1976. Inconnu, Stenodus leucichthys, Migration Studies in Alaska. 1961-1974.

Bruyn, M. de., and P. McCart. 1974. Life History of the Grayling (Thymallus arcticus) in Beaufort Sea Drainages in the Yukon Territory. Arctic Gas Biological Report Series, Vol. 15. 40 pp.

Cheney, W. I. 1971. Life history investigations of northern pike in the Tanana River drainage. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress 1970-1971. Project F-9-3.

Craig, P. and P. J. McCart. 1974. Fall Spawning and Overwintering Areas of Fish Populations along routes of proposed pipeline between Prudhoe Bay and the Mackenzie Delta. Arctic Gas Biological Report Series. Vol. 15. 37 pp.

Kepler, P. 1973. Population studies of northern pike and whitefish in the Minto Flats complex with emphasis on the Chatanika River.

Kogl, D. R. 1971. Monitoring and evaluation of Arctic water with emphasis on the North Slope drainage: Colville River Study. Alaska Department of Fish and Game. Federal Aid to Fish Restoration, Annual Progress Report, Project F-9-3, pp. 23-61.

Roguski, E. A. 1967. Inventory and cataloging of the sport fish and sport fish waters in the interior of Alaska. Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Annual Report of Progress, 1966-1967, Project F-5-R-8, 8:231-246.

Roguski, E. A. and P. C. Winslow. 1969. Investigations of the Tanana River and Tangle Lakes grayling fisheries: migratory and population study. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1968-1969, Project F-9-1, 10:333-351.

Roguski, E. A. and S. L. Tack. 1970. Investigations of the Tanana River and Tangle Lakes grayling fisheries: migratory and population study. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1969-1970, Project F-9-2, 11:303-319.

Tack, S. L. 1971. Distribution, abundance, and natural history of the Arctic grayling in the Tanana River drainage. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1970-1971, Project F-9-3, 12(R-I) 35 pp.

1972. Distribution, abundance, and natural history of the Arctic grayling in the Tanana River drainage. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1971-1972, Project F-9-4, 13(R-I) 36 pp.

1973. Distribution, abundance, and natural history of the Arctic grayling in the Tanana River drainage. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1972-1973, Project F-9-5, 14(R-I) 34 pp.

1974. Distribution, abundance, and natural history of the Arctic grayling in the Tanana River drainage. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1973-1974, Project F-9-6, 15(R-I) 52 pp.

1975. Distribution, abundance, and natural history of the Arctic grayling in the Tanana River drainage. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1974-1975, Project F-9-7, 16(R-I) 35 pp.

1976. Distribution, abundance, and natural history of the Arctic grayling in the Tanana River drainage. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1975-1976, Project F-9-8, 17(R-I) 27 pp.

Van Hulle, F. D. 1968. Investigations of the fish populations in the Chena River. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1967, 1968, Project F-5-R-9, 9:287-304.

Winslow, P. C. 1969. Investigations and Cataloging of Sport Fish and Sport Fish waters in Interior Alaska - Char in Northwestern Alaska. Alaska Department of Fish and Game. Federal Aid in Fish Restoration. Annual Report of Progress. 1968-1969. Project F-9-1.

APPENDIX

LIFE HISTORY - KING SALMON

Taxonomy

King salmon (Oncorhynchus tshawytscha) are members of the family Salmonidae, and are the largest of the five Pacific salmon. Local names vary to location. In Washington and Oregon king salmon are called "chinook," while in British Columbia they are surnamed "spring salmon." Other local names are "quinnat," "tyee," " tule," and "blackmouth."

Distribution

King salmon range in western North America from Ventura River in southern California to Point Hope, Alaska, adjacent to the Chuckchi Sea. In Asia they range from Hokkaido, Japan, north to the Anadyr River in Siberia.

Physical Description

A mature king salmon averages 40 inches in length and 40 pounds in weight, however, a 126-pounder was taken near Petersburg, Alaska in 1949.

Adult king salmon are distinguished by the black irregular spotting on the back, dorsal fins and on both sides of the caudal fin. They are also characterized by a black pigment along the gum line. In the ocean, the king salmon is a robust, deep-bodied fish. It has a blue-green coloration on its back, fading to a silvery color on the sides with white on the belly.

Depending upon location and degree of maturation, spawning colors vary from red to copper to almost black. Males are more deeply colored than females. Males are also distinguished by their "ridgeback" condition and their hooked upper jaw.

In fresh water, juvenile king salmon are recognized by well developed parr marks which are bisected by the lateral line.

Life History

Like all species of Pacific salmon, king salmon are anadromous. They hatch in fresh water, spend part of their life in the ocean, then return to fresh water to spawn.

King salmon may become sexually mature between their second and seventh years. As a result, fish in any spawning run may vary greatly in size. For example, a mature three-year-old generally weighs less than four pounds, while a mature seven-year-old may exceed 50 pounds. Females are usually older than males at maturity. With the exception of six and seven-year age groups, male spawners generally outnumber female spawners. Small king salmon that mature after spending only one winter in the ocean are commonly referred to as "jacks". These are ususally males.

In Alaska, mature king salmon start to ascend larger rivers from May through July and often make lengthy freshwater spawning migrations to reach their home streams. Spawners destined for the Yukon River headwaters in Canada are known to travel more than 2,000 miles in a 60-day period.

King salmon do not feed during the freshwater migration, causing their physical condition to gradually deteriorate. During this period they utilize stored body material for energy and for the development of reproductive products.

King salmon may spawn immediately above the tidal limit, but most travel upstream. Spawning generally occurs in the main channels of larger streams. Optimum substrate composition is 55 to 95% medium and fine gravel (no more than 15cm in diameter) with less than 8% silt and sand. Optimum stream discharge is 0.5 to 2.0 ft^3/sec.

The spawning act is essentially the same for all five species of Pacific salmon. The female selects a spawning site, usually a riffle area, and digs the nest or redd by turning on her side and beating with her tail. Redd size varies from 1.2 to 9 meters in diameter. Usually a dominant and several accessory males are in attendance.

When the redd is completed and the female is ready to spawn, she swims across the redd and lowers her anal fin into it. The dominant male comes alongside the female and quivers. The eggs from the female and sperm (milt) from the male are released simultaneously. After egg deposition, the female digs upstream from the redd and covers the eggs with gravel. A female may dig several redds and spawn with more than one male. Males may also spawn with several females. Females may contain from 3,000 to 14,000 eggs. The eggs are comparatively large (six to seven millimeters in diameter) and are orangish-red in color. Shortly after spawning activity ceases, the adult king salmon die.

Dependent upon water temperatures, the eggs hatch in about seven to nine weeks. The newly hatched fish, called alevins, remain in the gravel for two to three weeks while they gradually absorb the food in the attached yolk sac. Fry emerge from the gravel by early spring. Following emergence they school, but soon become territorial. Juvenile king salmon predominately migrate to the ocean after hatching but may remain in freshwater one or two years before migrating.

During the freshwater stage they feed largely on plankton, aquatic insect larvae and terrestrial organisms. In the ocean king salmon consume a wide variety or organisms, including: herring, pilchard, sandlance, rockfish, eulachon, amphipods, copepods, euphausiids and larvae of crabs and barnacles. King salmon grow rapidly in the ocean, often doubling their body weight during a summer season. King salmon feed in marine waters for a period of one to six years before returning to spawn in freshwater.

Selected References

Clemens, W.A. and G.V. Wilby. 1961. Fishes of the Pacific coast of Canada. 2nd ed. Bull. Fish. Res. Bd. Canada 68. 443 p.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Bd. Canada. Bull. 180. 740 p.

McPhail, J.D. and C.C. Lindsey. 1970. Freshwater fishes of north western Canada and Alaska. Bull. 173. Fish. Res. Bd., Canada. 1970. 381 p.

LIFE HISTORY - SOCKEYE SALMON

Taxonomy

Sockeye salmon (*Oncorhynchus nerka*) is a member of the family Salmonidae, which includes Pacific salmon, Atlantic salmon, trout, Dolly Varden and Arctic char. Common names for sockeye salmon are "red salmon" and "bluebacks." The majority of sockeye salmon are anadromous. However, some individuals become "lake-locked," completing their life cycle in fresh water. These individuals are known as "kokanee."

Distribution

Sockeye salmon are native to practically all temperate and sub-arctic waters of the North Pacific Ocean.. The distribution along the North American coastline occurs from Point Hope, Alaska (adjacent to the Chukchi Sea) south to the Klamath River in California. On the Asiatic side, they have been reported from Cape Chaplina in the northern portion of the Bering Sea southward around Kamchatka Peninsula to the northern shore of the Okhotsk Sea off Siberia.

Coastal distributions of sockeye salmon are well known because of the historical concentration of fishing effort along the coast and river esturaries. However, how far they move offshore and to what areas of the high seas they frequent during their one to five years of ocean residence is poorly understood. Investigations into the high seas distribution of sockeye by Davidson and Hutchinson (1938) and Fleming (1955) indicate that sockeye salmon are found where summer surface temperatures range from five to 16 degrees Centigrade, and where the summer surface salinities are generally less than 32.2 percent.

Forrester (1968) indicates that salmon normally occupy the upper 60-100 feet strata. These ranges were calculated from gill net catches of the Japanese high seas fishery and from Canadian and United States Exploratory fishing vessels.

Description

Anadromous sockeye may reach (33 inches) in length and weighing up to 15.5 pounds. However, the average is 24 inches in length and six to nine pounds in weight. The nonanadromous form (Kokanee) seldom exceed 16 inches and one pound in weight.

During their marine life adult sockeye salmon are metallic, greenish-blue on the dorsal surface with fine black specklings. In fresh water, mature breeding males develop a humped back, hooked upper jaw and brilliant red on the back which eventually blends to a deep, dark red on the sides. The head is olive-green, and the lower jaw and underside are pale white. The breeding female lacks the characteristic humped back and hooked jaw of the male. It generally has greenish-yellow patches on its dark red sides.

Juvenile sockeye salmon have dark, mottled green backs blending to an iridescent green and silver on the sides. They are distinguishable by the six to 10 dark oval parr marks on the sides. The parr marks are about the same width as the eye, barely extend below the lateral line and are irregularly spaced along the side of the body.

Life History

Differential distribution of anadromous sockeye salmon coincides with specific stages in its life cycle. Each spring sexually mature sockeye salmon leave their feeding grounds in the north Pacific Ocean and migrate over the continental shelf, eventually finding the spawning rivers from where they emerged. Sockeye salmon reach the spawning stage at varying ages. They may spend from one to five years in marine waters, thus reaching sexual maturity at ages ranging from two to seven years. Sockeye salmon undergo many morphological changes as they near fresh water in preparation for spawning. Feeding discontinues and their digestive systems become nonfunctional and degenerate. Nourishment is derived from the fat and protein sources of their flesh, skeletal structures and scales. As sockeye salmon enter freshwater, they begin developing the characteristic spawning coloration.

In Alaska, the spawning season for sockeye salmon extends from late July to early October, depending upon the geographic location. Spawning rivers usually have lakes in their systems. Spawning occurs in inlet and outlet streams and along the gravel shoals of lakes, often to a depth of 100 feet. In general, spawning coincides with water temperatures of 40 to 50 degrees Farenheit.

Fish breeding in lakes or in their outlets spawn later than those in streams. This is because lake waters generally cool off more slowly in late summer than do runoff waters in lake tributaries.

Factors determining the selection of spawning sites are variable. They include stream gradient, water depth and velocity, and size of streambed materials. Spawning sites are usually selected where there is good waterflow through the gravel, enabling the eggs to receive the essential amount of oxygen. Optimum substrate composition is fine-medium gravel with no more than 1% of the gravel being 15cm or more in diameter. The nest, or redd, generally averages $1.75m^2$ in diameter, although they are usually larger and more irregular in lake spawning areas. Kokanee redds are considerably smaller.

After egg deposition and fertilization, the female covers the eggs with a layer of material from the streambed. This act is similar in all species of Pacific salmon. The total number of eggs found in samples of North American female sockeye ranges from 2,200 to more than 4,500. The average is approximately 3,500. Fecundity depends primarily upon the size of the female.

The egg incubation period depends primarily upon the temperature of water flowing through the nest, or "redd." Under normal conditions the period may vary from 80 to 140 days. When the eggs hatch, the young (alevins) remain in the gravel for three to five weeks. During this time they derive nourishment from the attached yolk sac. Full formed and free-swimming fry emerge from the gravel in early spring (April and May).

After emergence into lake tributaries, fry move downstream into the lake. Those hatched in lake outlets must move upstream into the lake. In some river systems, "races" of sockeye salmon exist which spawn in streams without associated lakes. In these cases, fry drop down directly to the sea, or rear in backwater streams or eddies.

When fry first enter a nursery lake they work along the shore for a few weeks. They soon move out into deeper water of the lake and concentrate in the top 10 to 20 meters. Fry have been found at depths greater than 40 meters.

Food during the nursery period consists primarily of insects and their larvae (in shallow water). Later they feed primarily on Cladocera, copeods and amphipods. In addition to competing with their own species for food, sticklebacks, whitefish and other freshwater species are significant competitors. Predators of sockeye fry include Dolly Varden, Arctic char, squawfish (*Ptychodheilus oregonensis*), rainbow trout, coho salmon and prickly sculpin (*Cottus asper*).

Sockeye fry may remain in freshwater for a period from one to four years. When surface waters in nursery lakes approach 39 to 45 degrees Farenheit, the young salmon, now called "smolts", begin their seaward migration. Depending upon genetic makeup and freshwater growth factors, sockeye smolt range from three to six inches in length.

Upon reaching saltwater the smolt generally remain inshore in estuarial areas. Food at this stage consists of insects, crustaceans such as copepods, amphipods, decopods, barnacle larvae, astrocods and euphausiids. Smolt also feed upon young fishes and larvae such as sandlance, bigeye, whiting, rockfishes, eulachon, starry flounder, herring, prickleheads and hake.

Sockeye salmon remain in ocean feeding areas from one to four years. With the onset of sexual maturity, they begin migrating back to coastal waters and finally their native streams.

Selected References

Clemens, W.A. and G.V. Wilby. 1961. Fishes of the Pacific coast of Canada. 2nd ed. Bull. Fish. Res. Bd. Canada 68. 443 p.

Davidson, F.A. and S.J. Hutchinson. 1938. The geographical distribution and environmental limitations of the Pacific salmon (genus Oncorhynchus). Bull. Bur. Fish., 48:667-692. (Bull. No.26.)

Fleming, R.H. 1955. Review of the oceanography of the North Pacific. Intern. North Pacific Fish. Comm., Bull. No.2, 43 p.

Foerster, R.E. 1968. The sockeye salmon. Bull. 162, Fish. Res. Bd. Canada. 422 p.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Bd. Canada. Bull. 180. 740 p.

Hartman, Wilbur L. 1971. Alaska's fishery resource - the sockeye salmon. U.S. Dept. of Commerce, Nat. Oceanic and Atmospheric Admin., NMFS leaflet 636.

McPhail, J.D. and C.C. Lindsey. 1970. Freshwater fishes of northwestern Canada and Alaska. Bull. 173. Fish. Res. Bd., Canada. 1970. 381 p.

LIFE HISTORY - COHO SALMON

Taxonomy

Coho salmon (*Oncorhynchus kisutch*) is a member of the family Salmonidae, which includes the rest of the Pacific salmon, Atlantic salmon, trout, char and Dolly Varden. In common usage, coho salmon are generally referred to as "silver salmon."

Distribution

Coho salmon are distributed in western North America from Monterey Bay, California, north to Point Hope, Alaska. In northeastern Asia they range from Hokkaido, Japan, north to the Anadyr River in Siberia. In Alaska cohos are abundant from the Dixon Entrance (Southeastern Alaska) north to the Yukon River. Evidence suggests cohos are rare north of Norton Sound.

Physical Description

The average weight of a mature coho salmon is from six to 12 pounds. The average length at maturity is 29 inches. During ocean residency adults are metallic blue on the dorsal surface, silvery on the sides and ventral surface and caudal peduncle. Irregular black spots are present on the back and usually on the upper lobe of the tail. Spots and gums are not as darkly pigmented as in king salmon. The caudal peduncle is unusually broad, and a silvery plate is evident on the tail. During the spawning phase, both sexes turn dark, with a maroon-reddish coloration on the sides. The male developes an extremely hooked snout and its teeth become enlarged. The male also developes a "humped" back, but it is not as extreme as those found in spawning sockeye or pink salmon males. Occasionally males return to spawn after only three to six months at sea. These small "jacks" resemble adults, but possess more rounded tail lobes.

Juvenile coho have parr marks evenly distributed above and below the lateral line. The parr marks are narrower in width than the interspaces. No black spots are visible on the dorsal fin. The anal fin has a long, leading edge usually tipped with white. All other fins are frequently tinged with orange.

Life History

In Alaska, coho salmon enter spawning systems from August through November, usually during periods of peak high water. Actual spawning occurs between September and January. Although spawning may occur in main channels of large rivers, locations at the head of riffles in shallow tributaries or narrow side channels are preferred. Optimum substrate composition is small-medium gravel. However, coho salmon are extremely adaptable and will tolerate up to to 10% mud. Optimum stream discharge is 3.4 $ft.^3$sec. Nest, or redd, site is generally larger than that for sockeye salmon and averages 2.8 m^2 in the Columbia River basin.

Fecundity ranges from 2,400 eggs to 5,000 eggs in larger females. Eggs are orangish-red in color and smaller than most other salmon eggs, ranging from four to six millimeters in diameter.

Eggs in the gravel develop slowly during the cold winter months, hatching in about six to eight weeks. The sac-fry remain in the gravel and utilize the yolk material until emerging two to three weeks later (May-June). Upon emergence the fry school in shallow areas along the shores of the stream. These schools break up rather quickly as fry establish territories. The fry defend these "territories" from other juvenile coho with aggressive displays. This territory is usually along the shoreline or behind a log or boulder. From such a location the young fish do not have to fight the current, and can dart out to feed on surface insects or drifting insect larvae.

Juvenile coho grow rapidly during the early summer months, and spend the winter in deeper pool areas of spring-fed side ponds. Coho salmon also rear in ponds or lakes, where they feed along shoreline areas. Rearing also occurs in brackish, lagoon areas.

In the spring of their second, third or fourth year, coho smolts migrate to the sea. They remain inshore and near the surface during the first few months, feeding on herring larvae, sandlance, kelp, greenling, rockfish, eulachon, insects, and various crustaceans such as copepods, amphipods, barnacles. They also feed on crab larvae and euphausiids. After several months inshore, they move out into the open ocean where their principal foods are squid, euphausiids and various species of small fish.

Information concerning the coho's ocean residency is scant. However, tagging in the Gulf of Alaska has indicated that a large number of southeast Alaska coho move north along the coastline until reaching the Kodiak Island vicinity. This movement corresponds with the Alaskan Gyre, which is a counterclockwise pattern of ocean currents moving across the North Pacific to the coast of British Columbia, northwest along the coast to the Gulf of Alaska and then southwest toward the Alaska Penninsula. Other species of Pacific salmon are thought to follow this counterclockwise pattern during ocean residency. Coho salmon spend from one to three years in marine waters before returning to spawn in their native streams.

Selected References

Clemens, W.A. and G.V. Wilby. 1961. Fishes of the Pacific coast of Canada. 2nd ed. Bull. Fish. Res. Bd. Canada 68. 443 p.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Bd. Canada. Bull. 180. 740 p.

McPhail, J.D. and C.C. Lindsey. 1970. Freshwater fishes of northwestern Canada and Alaska. Bull. 173. Fish. Res. Bd., Canada. 1970. 381 p.

LIFE HISTORY - PINK SALMON

Taxonomy

Pink salmon (Oncorhynchus gorbuscha) are members of the family Salmonidae, which also includes the genera Salmo (Atlantic salmon and trout) and Salvenlinus (char and Dolly Varden). Pink salmon have also been called "humpy"or "humpback" salmon because of the enlarged hump that develops on the back of the spawning male.

Distribution

Pink salmon occur in streams from northern California to the Arctic Ocean in North America, and from the Arctic Ocean south to Hokkaido Island of northern Japan in Asia. Their oceanic distribution extends from North America to Asia north of the 40th parallel through the Bering Strait into the Arctic Ocean. Although several attempts have been made to transplant pink salmon to waters outside their natural range, no new fishery has been established to date.

Physical Description

The average length of a mature pink salmon is from 16 to 22 inches, with an average weight of four pounds. Adults have large black spots on the back, adipose and both lobes of the caudal fin. The spots on the caudal fin are oval. The largest of these spots are at least as large as the eye diameter.

Fry have a general silvery appearance and their backs are often deep blue to green. A lack of parr marks easily distinguishes them from other salmon fry. During the first three months after the fry's entry into the ocean, they have a silvery color common to all salmon. Pink salmon fry can also be readily distinguished by small and numerous scales, with subtle differences in scale shape, color and internal structure.

Spawning adult males develop an elongated and hooked snout, enlarged teeth and a pronounced hump behind the back. The back and sides of the fish become dark, with green-brown blotches on the sides. Spawning females do not develop these characteristics as distinctly.

Life History

In Alaska mature pink salmon begin migration to spawning streams from mid-June to late September, usually ascending streams only short distances. In British Columbia and California, some pink salmon have been known to migrate more than 200 miles, and in Asia migrations have been reported up to 400 miles from the sea.

In Alaska, pink salmon spawn in the lower reaches of short, coastal streams. Some prefer intertidal areas of these streams, where eggs are alternately bathed by fresh and brackish waters. Spawning areas with medium size gravel are preferred. Optimum stream flow is 0.03m/sec. or greater.

Spawning generally begins in August or September when stream temperatures are approximately 50 degrees F. Pink salmon tend to spawn earlier in colder streams and later in warmer ones. Because pinks are smaller than the other salmon, the nest, or redds, dug by the female are not as large. In Southeast Alaska, redd size averages $1.1m^2$ in diameter and 9.3cm deep. The egg deposition and fertilization process is similar to the other species of Pacific salmon. The mature female usually carries between 1500 and 2000 eggs, which are orangish-red in color and roughly six millimeters in diameter. From the time of spawning to the fry's emergence from the gravel, less than 25 percent of the deposited eggs survive. This heavy mortality is caused by digging in the redds by other females, poor oxygen supply to the eggs, poor water circulation in the streambed, dislodgement of eggs by flooding and scouring, freezing of eggs during severe and prolonged cold, and predation by other fish.

The developmental period of the egg is critically affected by water temperature. Hatching normally occurs from December through February. Alevins remain in the gravel for several weeks and emerge in April or May. The fry migrate downstream to estuaries immediately after hatching, migrating at night and hiding in the gravel by day. Migrating fry generally do not feed, but if the distance is great they may consume larval insects.

Fry form large schools in estuarine areas, remaining inshore throughout their first summer. In September they move into deeper water. In April and June their principal food consists of copepods. By July, increased growth enables them to supplement their diet with larger organisms such as insects, and small fishes. In the estuaries of southeastern Alaska, fry may reach six to nine inches before migrating into the open ocean.

Maturing pink salmon remain in ocean feeding grounds until the following summer. Growth is rapid during the last spring and summer in the sea and throughout most of the spawning migration through coastal waters.

Pink salmon reach sexual maturity when they are 14 to 16 months old and average 16 to 22 inches in length. Little data concerning estuarial and ocean survival is available. Evidence suggests that roughly three-fourths of the fry entering estuary waters die before reaching the ocean. Of those entering the ocean, approximately three-foruths die before reaching sexual maturity. Predation is believed to be the principal cause of these mortalities.

Pink salmon have the shortest and simplest life history of any Pacific salmon. With a two year cycle they have two genetically distinct stocks. These stocks are called "odd" or "even" year, and are based upon the year adults spawn. Differences in the number and size of fish in the two stocks have been the subject of speculation for many years. In some areas of Alaska, only one stock spawns in significant numbers. In general, odd-year runs predominate in the Fraser River and in southern British Columbia. Even-year runs predominate in northern British Columbia and the Queen Charolette Islands. Switches from odd-year to even-year dominance have been recorded in Asian streams to a significant extent. Puget Sound and Southeastern Alaska odd-year runs dominate, while in Kodiak, Cook Inlet and Bristol Bay, even-year runs are in the majority. Long term averages in Prince William Sound indicate a higher abundance of even-year stocks, however, odd-year stocks have periodically sustained several years of high abundance.

Selected References

Baily, Jack E. 1969. Alaska's fishery resource - the pink salmon. U.S. Dept. of Int., Fish and Wildlife Service, Bureau of Comm. Fisheries. Leaflet 619.

Clemens, W.A. and G.V. Wilby. 1961. Fishes of the Pacific coast of Canada. 2nd ed. Bull. Fish. Res. Bd. Canada 68. 443 p.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Bd. Canada. Bull. 180. 740 p.

Helle, J.H. 1962-63. Biological characteristics of intertidal and freshwater spawning pink salmon at Olsen Creek, Prince William Sound, Alaska. Special scientific report no. 602. U.S. Dept. Fish and Wildlife Serv. 1970.

Helle, J.H., Richard S. Williamson, and Jack E. Bailey. 1964. Intertidal ecology and life history of pink salmon at Olsen Creek, Prince William Sound, Alaska. Special scientific report no. 483. U.S. Dept. of Interior, Fish and Wildlife Serv. 1964.

McNeil, W.J. 1969. Survival of pink and chum salmon eggs and alevins, page 101-117. D.W. Chapman and T.C. Bjornn, distribution of salmonoids in streams, with specific reference to food and feeding, page 153-176, in symposium on salmon and trout in streams, U. of British Columbia. H.R. MacMillan lectures in fisheries, 1969.

McPhail, J.D. and C.C. Lindsey. 1970. Freshwater fishes of northwestern Canada and Alaska. Bull. 173. Fish. Res. Bd., Canada. 1970. 381 p.

Prince William Sound Aquaculture Corp., 1975. Salmon culture program (unpublished).

LIFE HISTORY - CHUM SALMON

Taxonomy

Chum salmon (*Oncorhynchus keta*) are members of the family Salmonidae and sub-order Salmonoidea. Chum salmon are commonly referred to as "dogs" or "dog salmon." This name can be attributed to the hooked snout and protruding teeth of spawning males.

Distribution

Chums are the most widely distributed of the five Pacific salmon and second to the pink salmon in abundance. In western North America they range from California north to the Bering Strait and east to the MacKenzie River. In northeast Asia they run from near Pusan, Korea, north along the Asian coast to the Arctic Ocean. They also range west along the Arctic coast to the Lena River of Siberia. Primarily, distribution is above latitude 46°N in the colder waters of the subarctic region.

Physical Description

Adult chum salmon have been recorded as large as 40 inches in length and weighing as much as 33 pounds. The average is 30 inches long and eight pounds in weight. In marine waters they are metallic blue on dorsal surfaces with occasional black speckling. The pectoral, anal and caudal fins have dark tips. In fresh water maturing chums show reddish or dark streaks (or bars) and large blotches, with white tips on the pelvic and anal fins. The spawning male develops an elongated, hooked snout, and its teeth become enlarged.

Chum salmon fry have six to 14 short parr marks that rarely extend below the lateral line. The back is mottled green, while the sides and belly are silvery with a pale green iridescence.

Life History

From July through September, sexually mature chum salmon leave ocean feeding grounds and migrate to freshwater spawning habitat. These habitats may range from tidal flats of short, coastal streams to springs in the headwaters of large river systems. The longest known spawning migration occurs in the Yukon River, where chum salmon swim more than 1,500 miles upstream from the Bering Sea.

Spawning usually occurs in riffle areas, with gravel size comparable to that used by pink salmon. Spawning also occurs in coarser gravel and even in bedrock area atop loose rubble. Chum salmon generally avoid areas where there is poor circulation of water through the streambed. Optimum stream flow is 0.1-1.0 m/sec. Nest, or redd, size is considerably larger than that for pink salmon and has average $2.25m^2$ in diameter in the Columbia River basin. Optimal size is considered $3m^2$ in diameter.

Females produce an average of 3,000 orangish-red eggs approximately six to seven millimeters in diameter. Hatching occurs from December through March. Experiments have revealed that at a constant temperature of 50 degrees Farenheit, eggs hatch in about 50 days. Alevins emerge from the gravel from April through May to begin their seaward migration.

When fry reach the estuary they are usually about one and one-half inches long. They feed near shore for several months and migrate to open sea in September. Growth during the first months of marine residence is rapid, with juveniles reaching lengths of six to nine inches in their first year. The diets of maturing chum salmon is similar to that of other Pacific salmon.

Chum salmon return to spawn after spending two to four years at sea. Counting freshwater growth, they are between three and five years old when they leave the ocean.

Selected References

Clemens, W.A. and G.V. Wilby. 1961. Fishes of the Pacific coast of Canada. 2nd ed. Bull. Fish. Res. Bd. Canada 68. 443 p.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Bd. Canada. Bull. 180. 740 p.

McNeil, W.J. 1969. Survival of pink and chum salmon eggs and alevins, page 101-117. D.W. Chapman and T.C. Bjornn, Distribution of salmonoids in streams, with specific reference to food and feeding, page 153-176, in symposium on salmon and trout in streams, U. of British Columbia. H.R. MacMillan lectures in fisheries, 1969.

McPhail, J.D. and C.C. Lindsey. 1970. Freshwater fishes of northwestern Canada and Alaska. Bull. 173. Fish. Res. Bd., Canada. 1970. 381 p.

Merrell, Theodore, R. Jr. 1970. Alaska's fishery resource - the chum salmon. U.S. Dept of Int., Fish and Wildlife Service, Bureau of Comm. Fisheries. Leaflet 632.

Prince William Sound Aquaculture Corp., 1975. Salmon culture program (unpublished).

LIFE HISTORY - PACIFIC HERRING

Taxonomy

The Pacific herring is a member of the order Clupeiformes. Its family, Clupidae, is characterized by an elongate, compressed body. In general, all Pacific herring have similar characteristics, but minor differences may exist between the herring in Alaska and those in other areas.

Physical Description

The species can grow to lengths of 33 centimeters (13 inches), but an average large specimen is nine to 10 inches long, weighing about 1/3 pound. They are bluish-green dorsally and silvery on the ventral side, having relatively large scales. Herring are fast swimmers and occur in schools of up to one million or more fish. They feed principally on planktonic crustaceans and store large quantities of oil in their bodies. The common maximum life is about nine years, although some fish may live more than 15 years. They attain sexual maturity in their third or fourth year of life and spawn each year thereafter.

Distribution

Pacific herring occur all around the North Pacific rim, in the Bering Sea, and along the shores of the Arctic Ocean. In Alaska, the largest commercial quantities occur around Kodiak Island, Prince William Sound and in much of southeastern Alaska. Recent developments in fishing techniques and gear have resulted in the discovery of additional concentrations of Pacific herring in the Bering Sea, where thousands of tons are now taken annually by Soviet and Japanese trawlers.

Life History

The life history of Pacific herring from the time adults spawn until the developing juveniles move from inshore waters is well documented, but little is known about what occurs in the 2 1/2 years while herring are maturing.

Adult Pacific herring usually mature at about age three or four years in Alaska at a size of about 150 to 200 mm. However, this may vary somewhat between areas. Spawning occurs throughout the spring months, late April through mid-June, slightly earlier in more southern areas. Water temperatures appear to be one of the main factors that influence spawning timing, and spawning usually begins when water temperatures reach approximately 39.5°-40.0° F.

A female can produce about 10,000 eggs when she is three-years-old and as many as 59,000 when she is eight. The older and larger females produce more eggs than the younger ones, but approximately 20,000 eggs per spawning is average. The eggs are adhesive, and the female deposits them on solid surfaces rather than broadcasting them loosely in the water. The generally preferred surface for spawning is living plants. Those plants most often used are eel grass (*Zostera*), rockweed (*Fucus*) and girdle (*Laminaria*).

A spawning female makes physical contact with the substrate and deposits her eggs in narrow bands upon it. The male herring does not pair off with any particular mate, but wanders among the spawning females extruding milt (sperm) at random. The thousands, or perhaps millions, of fish spawning on a beach usually produce so much milt that the water becomes discolored.

A heavy spawning does not always result in more adult herring. In some cases, mortality caused by crowding of the eggs may actually produce fewer young herring than more moderate spawning. Moreover, if many of the eggs of a heavy spawning hatch successfully, high mortality may result as the millions of larvae compete for a limited food supply.

The eggs of the Pacific herring are small (1.0 to 1.5 millimeters in diameter). They are spherical, slightly heavier than seawater, and adhesive. The incubation time is governed by the temperature of the water, and ranges between 12 and 20 days. Higher temperatures accelerate development. Even under ideal conditions, millions of eggs fail to hatch and mortalities in the egg stage can range from 50% to as high as 99%. During the incubation period, eggs laid within the intertidal area are alternately exposed and covered by tides. In warm weather, great numbers of eggs may dehydrate and die when exposed by low tides. Severe mortality may also result from coastal storms if the egg-covered eel grass or kelp is torn from the bottom and cast up on the beach. The alternatve exposing and covering of the eggs by the tide makes them available to both aquatic and terrestrial predators.

Upon hatching, a larva receives nourishment from a small quantity of yolk that remains in the egg. When the yolk has been utilized the larva begins to feed. The herring larva is almost transparent and about six millimeters (1/4 inch) long. The transition from yolk subsistence to active feeding is perhaps one of the most critical periods in the herring's life. If water currents are unfavorable, thousands of larvae may be swept out to sea or to areas without proper food. The larvae are constantly exposed to predation by marine animals such as arrow worms, comb jellies and other fish.

The change from a larva to a scaled juvenile takes place from six to eight weeks after the egg is hatched. At this stage the herring is approximately 65 millimeters (2 1/2 inches) long. The young collect in small schools and gradually move seaward toward the mouths of bays and inlets in which they were hatched. By early fall they are about 100 millimeters (4 inches) long and consolidate into large schools of perhaps one million fish or more. Most of the schools move into deep or offshore water by late fall. They return 2 1/2 years later as mature adults ready to spawn for the first time.

Selected References

Clemens, W.A., and G.V. Wilby. 1961. Fishes of the Pacific coast of Canada. 2nd ed. Bull. Fish. Res. Bd. Canada 68. 443 p.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Bd. Canada. Bull. 180. 740 p.

McPhail, J.D. and C.C. Lindsey. 1970. Fresh water fishes of northwestern Canada and Alaska. Bull. Fish. Res. Bd. Canada 173. 381 p.

Reid, Gerald M. 1972. Fishery facts - 2, Alaska's fishery resources - the Pacific herring. U.S. Dept. Comm., NMFS, U.S. Government printing office, Wash., D.C. 20 p.

LIFE HISTORY - HALIBUT

Taxonomy

The Pacific halibut, Hippoglossus stenolepis (Schmidt), is a member of the order Pleuronectiformes, which includes such species as flounders, sole and brill. Until 1904, halibut were regarded as a circumpolar species common to the Atlantic and Pacific Oceans. The Atlantic form is now recognized as Hippoglossus hippoglossus (Linneaus).

Physical Description

The order Pleuronectiformes is characterized by a greatly compressed body which is somewhat rounded on the eyed side and flat on the blind side.

In young flatfish the body is upright and symmetrical with an eye on each side of the head. Very soon a metamorphosis occurs and one eye migrates to the opposite side of the head. Eventually, both eyes are on the upper or darker side. The fish then settle to the bottom and swim horizontally.

In the Pleuronectidae or flounder family, to which the halibut belongs, the eyes and colored surface are typically on the right side of the fish (dextral). The halibut mouth is large and symmetrical, with the maxillary extending to or behind the pupil of the eye. The teeth are developed on both sides of the jaws.

Halibut are the largest of all flatfishes and one of the larger fishes in the world. The adult male halibut may reach 4 feet 7 inches in length and attain an average weight of 40 pounds. An adult female may grow to 8 feet 9 inches. Females have been recorded weighing 470 pounds at an age of 35 years or more. The largest Pacific halibut on record was caught near Petersburg, Alaska, and weighed 495 pounds.

Habibut are dark brown and irregularly blotched with lighter shades on the eyed side and white on the blind side. By controlling the contraction and expansion of chromatophores of various colors, halibut and other flatfishes have the ability to change their external shades and color patterns to blend in with the immediate surroundings. These changes are activated by visual stimulation.

Distribution

The species range from Rosa Island off Santa Barbara in southern California to the Bering Sea, as far north as the southern Chukchi Sea. They are also distributed about halfway between St. Matthew and St. Lawrence Islands. On the Asiatic coast, they range from the Gulf of Anadyr in the north, as far south as Hokkaido, Japan. Halibut are found in very shallow waters and to depths of 600 fathoms. They generally range between 30 to 225 fathoms.

Spawning

Spawning takes place from November to January along the slopes of the continental shelf in depths from 125 to 250 fathoms.

Fecundity in females is proportionate to the size of the fish. A large female of 140 pounds may have as many as 2.7 million eggs. The eggs, or ova, are about 1/8-inch in diameter and bathypelagic, being laid and fertilized in proximity to the bottom but subsequently drifting in the middle to upper water levels. The eggs and larvae drift passively with the ocean currents at depths down to 375 fathoms. As development proceeds, they gradually rise toward the surface and drift into shallow water with the inshore surface currents.

The germinal disc of the egg goes through the normal processes of cell division to form the embryo that lives off the yolk. The yolk comprises the main mass of the egg. Eggs hatch after about 15 days, with the larvae living off nourishment from the yolk sac. After absorption of the yolk, post larvae must depend upon the external environment for their food. As with the eggs, the larvae and post-larvae continue to be free floating. They are transported many hundreds, if not thousands, of miles by the westward moving ocean currents.

The free floating stage lasts about six months. After rising to the surface water layers, they tend to be propelled by the prevailing winds toward the shallower sections of the continental shelf. The larvae undergo metamorphosis and begin their bottom existence as juvenile halibut far from the spawning grounds. Thus, the floating eggs, developing larvae and the post-larvae are dispersed far westward from the points where they were produced.

With advancing size and age, the young halibut move into deeper water. Females grow faster than males. The age of sexual maturity in females is from 8 to 16 years, averaging about 12 years.

Tagging operations have shown that immature halibut move within very restricted areas, whereas mature fish may migrate extensively to and from the spawning grounds. Some individuals have been known to migrate as far as 2,000 miles.

Halibut prey on a variety of animals, and their diet changes with age, season and area. Juveniles feed considerably on small crustaceans and shrimp. Older fish shift more to a fish diet, particularly of flounders (Novikov, 1964). Among flounders, yellowfin sole (Limanda aspera) is the halibut's principal prey in the southeastern Bering Sea, and there is a strong coincidence in the distribution of halibut and yellowfin sole during the summer (Novikov, 1964).

Pacific halibut feed year-round, but the intensity of their feeding is lower in winter than in summer. Young halibut seem to feed more during the winter, whereas large fish rarely feed at this time.

Selected References

Bell, H.F. 1972. The Pacific halibut - a managed resource. (In) A review of the oceanography and renewable resources of the Gulf of Alaska. Ed. Donald H. Rosenberg. IMS report R72-23.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Bd. Canada. Bull. 180. 740 p.

Novikov, N.P. 1964. Basic elements of the biology of the Pacific halibut (Hippoglossus hippoglossus stenolepis Schmidt) in the Bering Sea. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 49 (Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 51):167-207. (Transl. in Soviet Fisheries Investigations in the Northeast Pacific, Part II, p. 175-219, by Israel Program Sci. Transl., 1968, available Natl. Tech. Inf. Serv., Springfield, VA, as TT67-51204.)

LIFE HISTORY - POLLOCK

Taxonomy

The walleye or Pacific pollock, Theragra chalcogramma (Pallas), is a member of the family Gadidae. In common usage it is also often called the whiting or bigeye pollock.

Physical Description

The adult pollock is recognized by (1) three well-separated dorsal fins; (2) anus below space between the first and second dorsal fins; (3) minute or no barbel on the lower jaw; and (4) lower jaw slightly projecting.

Scales are small and cycloid, with the lateral line canal arching high anteriorly then sloping down to mid-body below the middle of the second dorsal fin. Adults are olive green to brown on the dorsal surface, silvery on the sides and dusky to black on the fins. In juveniles, two (occasionally three) narrow, light yellow bands are present along the sides.

Length may reach three feet (91 cm).

Distribution

Several populations of Theragra have been recognized as species or subspecies around the North Pacific Basin. Analysis led to the conclusion that such distinctions are not justified. In this account, only one species is recognized. Accordingly, the range is from Carmel, California, through the Bering Sea to St. Lawrence Island and on the

Asian coast to Kamchatka, Okhotsk Sea and southern Sea of Japan. Centers of abundance lie off Japan, Korea, the Kamchatka Peninsula, the eastern Bering Sea and in the western Gulf of Alaska.

Pollock inhabit the waters of the continental shelf and upper slope from the surface to depths of 200 fathoms. At 200 fathoms, it is suspected to be bathypelagic.

Life History

There is no apparent sexual dimorphism in pollock. Chang (1974) stated that size and age of maturation of pollock is closely related to the rate of growth and environmental factors. Krivobak and Tarkovskaya (1964) reported that female pollock from the southeastern Bering Sea attained sexual maturity at 40 cm and males at 32 cm. Serobaba (1971) reported that pollock from the same area reached maturity at lengths of 31 to 32 cm (three to four years of age), but that mature individuals were encountered at lengths of 24 cm.

Spawning is protracted, occurring between March and mid-July, peaking in May for Bering Sea stocks. Fertilization is external. The fertilized egg is planktonic and occurs at depths of 13 to 300 m, but rarely at greater depths. Eggs and larvae inhabit near-surface waters, but juveniles exhibit a distinct vertical movement, rising to the surface at night to feed and descending to mid- or bottom depths during the day (Kobayashi, 1963).

Yusa (1954) and Gorbunova (1954) described and illustrated the development of eggs and larvae of pollock. Yusa's work indicated that larvae hatched in 12 days at incubation temperatures of 6° to 7°C.

Gorbunova reared pollock eggs at average temperatures of 3.4°C (range 0° to 11.5°C) and 8.2°C (range 2.0° to 12.2°C). The development took 20.5 days at the lower mean temperature and 10 days at the higher temperature.

Hami, et al., (1971) studied the effect of temperature on the growth and mortality of early stages of pollock. These workers obtained the following relationship between development and temperatures:

$$\log 1/t = -\frac{m}{2}\frac{1}{T} + C, \text{ where}$$

t = time in days required for the eggs to reach a certain stage
T = the average absolute temperature
m = Arrhenius temperature characteristic (°Absolute)
C = constant

The incubation time from fertilization to 50 percent hatching was 10 days at 10°C, 13.8 to 14.4 days at 6°C and 24.5 to 27.4 days at 2°C.

According to Gorbunova (1954), newly hatched larvae (eggs incubated at 8.2°C) were 3.5 to 4.4 mm in length and apparently float upside down at the surface of the water due to the buoyancy of their large yolk sac (Yusa, 1954). The yolk sac is absorbed at about 7.0 to 7.5 mm. The actual time from hatching to transformation to the juvenile phase is not known, but according to Gorbunova (1954), pollock become demersal at lengths of 35 to 50 mm and reach 90 to 110 mm in the first year of life.

In the eastern Bering Sea, the growth of pollock is relatively rapid during the first 4 years of life. By age 1 pollock are about 170 mm long. From age 1 to 4 they may grow an average of 80 mm per year. Beyond age 4, the growth rate is much reduced.

After yolk sac absorption, larval pollock of 7 to 10 mm in length feed on diatoms, copepod eggs and nauplii. As the larvae grow, they feed primarily on zooplankton, and by 20 to 35 mm feed mainly on copepods. At 35 to 50 mm, pollock feed on pelagic copepods and euphausiids. Such organisms dominate stomach contents at least until pollock reach 117 mm in length (Gorbunova, 1954). Adult pollock feed on a variety of organisms, but predominant food items include pelagic or semi-pelagic crustaceans, particularly euphausids, copepods and amphipods. Takashashi and Yamaguchi (1972) observed that young pollock (0 to 1 year old) may constitute over 50 percent of the stomach content of pollock over 50 cm in length.

Literature Cited

Chang, S. 1974. An evaluation of eastern Bering Sea fisheries for Alaska pollock (Theragra chalcogramma, Pallas): population dynamics. Univ. Washington, Ctr. for Quant, Sc., NORFISH Rep. NL11, 313 p.

Gorbunova, N. N. 1954. The reproduction and development of walleye pollock (Theragra chalcogramma, Pallas). Adak. Nauk SSSR, Tr. Inst. Okeanol. 11:132-195. (Transl., Northwest Fish. Center, Seattle, WA).

Hamai, I., K. Kyuskin and T. Kinoshita. 1971. Effect of temperature on the body form and mortality in the developmental and early larval stages of the Alaska pollock (Theragra chalcogramma, Pallas). Hokkaido Univ., Fac. Fish. Bull. 22(1):11-29.

Kobayaski, K. 1963. Larvae and young of the whiting (Theragra chalcogramma, Pallas) from the North Pacific. Hokkaido Univ., Fac. Fish. Bull. 14(2):55-63.

Krivobok, M. N. and O. I. Taskovskaya. 1964. Chemical characteristics of yellowfin sole, cod and Alaska pollock of the southeastern part of the Bering Sea. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 49(Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 51):257-271. (Transl. in Soviet Fisheries Investigations in the Northeast Pacific, Part II, p. 271-286, by Isreal Program Sci. Transl., 1968, avail. Natl. Tech. Inf. Serv., Springfield, VA, as TT67-51204).

Serobaba, I. I. 1971. About reproduction of walleye pollock (Theragra chalcogramma, Pallas) in the eastern part of the Bering Sea. Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 75:47-55. (Transl. 1973, Fish. Res. Board Can. Transl. Ser. 2470, 20 p.)

Takahaski, Y. and H. Yamaguchi. 1972. Stock of the Alaskan pollock in the eastern Bering Sea. Bull. Jap. Soc. Sci. Fish 38(4):418-419.

Yusa., T. 1954. On the normal development of the fish (Theragra chalcogramma, Pallas) Alaska pollock. Bull. Hokkaido Reg. Fish. Res. Lab. 10, 15 p.

LIFE HISTORY - PACIFIC OCEAN PERCH

Taxonomy and Physical Description

Pacific Ocean perch, *Sebastes alutus* (Gilbert), are one of some 54 or more species in the genus *Sebastes* (previously placed in *Sebastodes*) occurring in the north Pacific Ocean (Major and Shippen, 1970; Amer. Fish. Soc., 1970). *Sebastes alutus* can be differentiated from closely related species by (a) a prominent forward-directed symphyseal knob and (b) a mouth color which is red. Phillips (1957), Barsukov (1964) and Hitz (1965) published keys to the identification of rockfish in the genus *Sebastes*.

Barsukov (1964) proposed that *Sebastes alutus* be divided into two subspecies: (1) *S. alutus alutus*, distributed from California to the Gulf of Alaska and along the Komandorskiy-Aleutian Arc; and (2) *S. alutus paucispinosus*, extending from the Pacific coast of Honshu Island into the Bering Sea. The subspecies were found to overlap in the region of the Aleutian and Komandorskiy Islands; therefore, Barsukov recognized the need for further study because this was a provisional division. Other workers (Hart, 1973; Quast and Hall, 1972; Chikuni, 1975) do not recognize subspecific differentiation.

Distribution

Pacific Ocean perch live along the eastern and northern rim of the Pacific Ocean from La Jolla, California, to Kamchatka and in the Bering

Sea. According to Alverson, et al. (1964), no fish of the genus Sebastes appear to have penetrated the Bering Strait.

Pacific Ocean perch are commonly found along the outer continental shelf and on the upper continental slope. Commercial quantities generally occur at depths between 100 and 500 meters (Quast, 1972). This species is common in and along gullies, canyons and submarine depressions of the upper continental slope. Adults occur in abundance over a variety of substrates, including clay and jagged rock, but their occurrence may be determined more by food and hydrographic factors than substrates (Quast, 1972).

Life History

Pacific Ocean perch are an oviparous species; eggs are fertilized internally and retained in the ovary during incubation. At present, controversy exists as to when actual fertilization of eggs occurs (see Lyubimova, 1963 and 1965; Snytko, 1971b; Pautov, 1972; and Gunderson, 1971).

Pacific Ocean perch spawn once a year, with actual mating time varying among regions. Chikuni (1975) suggested that copulation takes place during October to February, with spawning occurring in March to June. Moiseev and Paraketsov (1961) reported that spawning of ocean perch in the Bering Sea occurred at depths of about 360 to 370 meters. Spawning timing (from Major and Shippen, 1970) by region is shown below.

Area	Spawning Season	Water Temperature	Reference
		°C	
Bering Sea (south and southeast of the Pribilof Islands)	March-May	3.8-4.2	Paraketsov (1963)
Gulf of Alaska (north)	March-April	—	Lyubimova (1963)
Gulf of Alaska (south)	May-June	—	Lyubimova (1963)
Coastal waters off southwest Vancouver Island, B.C.	March	—	Westrheim, Harling and Davenport (1968)
Coastal waters off Washington-Oregon	January-March	6.0-8.0	Snytko (1968)

During the first year after birth, ocean perch are planktonic and their distribution is determined by the movement of the water into which they were born. Paraketsov (1963) reported that larvae are spawned in the Pribilof Islands area in spring and swept by currents toward the shores of the Aleutian Islands and the Alaska mainland. The age at which ocean perch become demersal is not known. Paraketsov (1963) stated that during their second year juvenile S. alutus take up life near the ocean bottom. Snytko (1971a) believed that young S. alutus of the Vancouver-Oregon region lead a pelagic life for the first two to three years and then switch to a benthopelagic life. Carlson and Haight (1976) suggested, however, that juvenile Pacific Ocean perch become demersal during their first year of life.

Following their change to a demersal existence, young ocean perch remain in waters from 125 to 150 meters deep until they reach the age of sexual maturity, according to Moiseev and Paraketsov (1961) and Paraketsov (1963). Young perch (under 36 centimeters) in the Vancouver-Oregon region were found at depths of 120 to 210 meters and mature specimens (over 36 centimeters) at depths of 170 to 300 meters (Snytko, 1971b).

Pacific Ocean perch are slow growing and have a long life span. Alverson and Westrheim (1961) reported that Pacific Ocean perch may live to age 30. Paraketsov (1963) reported that females from the Bering Sea matured at 6 to 7 years of age at lengths of 22 to 25 centimeters. Pautov (1972) reported that Bering Sea ocean perch reach sexual maturity at lengths of 26 to 31 centimeters and at ages of 6 to 9 years. He indicated that males matured earlier than females, the former maturing at 6 to 7 years and the latter at 8 to 9 years. Chikuni (1975) indicated that "fish in every stock" begin to mature at age 5 and all individuals finish their sexual maturation by age 9. He indicated that 50 percent of the stock matures at age 7.

Thompson (1915) reported _S. alutus_ as one of the important constituents in the diet of halibut, _Hippoglossus hippoglossus stenolepis_. Tomilin (1957) observed _Sebastes_ spp. in the stomachs of sperm whales.

The intensity of feeding by Pacific Ocean perch is apparently not the same throughout the year. Feeding intensity is apparently related to availability of food, temperature conditions and the physiological status of the perch (spawning). Lyubimova (1963) noted that the Gulf of Alaska population foraged near Unimak Island in May to September. She also contended that during the rest of the year the adult perch almost wholly abstain from feeding but that immature fish feed year-round. Perch captured during the winter were leaner than those taken during the foraging period, and their quality as food was inferior (Lyubimova, 1965). Pautov (1972) reported that the Bering Sea perch fed most intensively during the spring-summer period (April to September) and during the remainder of the year their food intake decreased. Syntko (1971a) considered spring, summer and fall as the prime feeding times for perch in the Vancouver-Oregon region. During mating (September to October), sexually mature males feed very lightly. The same behavior has been observed in females during spawning of larvae (February to March). Pautov (1972) reported that perch fed voraciously in morning and evening hours and that the frequency of feeding decreased at night.

Literature Cited

Alverson, D.L., A.T. Pruter and L.L. Ronholt. 1964. A study of demersal fishes and fisheries of the northeastern Pacific Ocean. H.R. MacMillan Lect. Fish., Inst. Fish., Univ. B.C., 190 p.

Alverson, D.L. and S.J. Westrheim. 1961. A review of the taxonomy and biology of the Pacific Ocean perch and its fishery. Cons. Perm. Int. Explor. Mer., Rapp. Proc.-Verb. 150:12-27.

American Fisheries Society. 1970. A list of common and scientific names of fishes from the United States and Canada (3rd ed.). Amer. Fish. Soc., Spec. Publ. 6, 150 p.

Barsukov, V.V. 1964. Interspecies variability of the Pacific Ocean perch (Sebastodes alutus Gilbert). Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 49 (Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 51):231-252. (Transl. in Soviet Fisheries Investigations in the Northeast Pacific, Part II, p. 241-267, by Israel Program Sci. Transl., 1968, avail. Natl. Tech. Inf. Serv., Springfield, VA, as TT67-51204.)

Carlson, H.R. and R.E. Haight. 1976. Juvenile life of Pacific Ocean perch, Sebastes alutus, in coastal fiords of southeast Alaska: their environment, growth, food habits and schooling behavior. Trans. Am. Fish. Soc. 105:191-201.

Chikuni, S. 1975. Biological study on the population of the Pacific Ocean perch in the North Pacific. Far Seas Fish. Res. Lab. Bull., 12:1-119.

Gunderson, D.R. 1971. Reproduction patterns of Pacific Oean perch (Sebastodes alutus) off Washington and British Columbia and their relation to bathymetric distribution and seasonal abundance. J. Fish. Res. Board Can. 28:417-425.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Board Can., Bull. 180, 740 p.

Hitz, C.R. 1965. Field identification of the northeastern Pacific rockfish (Sebastodes). U.S. Fish. Wild. Serv., Circ. 203, 58 p.

Lyubimova, T.G. 1963. Some essential features of the biology and distribution of Pacific Ocean perch (Sebastodes alutus Gilbert) in the Gulf of Alaska. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 48 (Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 50):293-303. (Transl. in Soviet Fisheries Investigations in the Northeast Pacific, Part I, p. 308-318, by Israel Program Sci. Transl., 1968, avail. Natl. Tech. Inf. Serv., Springfield, VA, as TT67-51203.)

______. 1965. The main stages of the life cycle of Pacific Ocean perch (Sebastodes alutus Gilbert) in the Gulf of Alaska. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 58 (Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 53):95-120. (Transl. in Soviet Fisheries Investigations in the Northeast Pacific, Part IV., p. 85-111, by Israel Program Sci. Transl., 1968, avail. Natl. Tech. Inf. Serv., Springfield, VA, as TT67-51206.)

Major, R.L. and H.H. Shippen. 1970. Synopsis of biological data on Pacific Ocean perch (Sebastodes alutus). U.S. Fish. Wildl. Serv. Circ. 347 (FAO Fisheries Synopsis No. 79): 38 p.

Paraketsov, I.A. 1963. On the biology of (Sebastodes alutus) in the Bering Sea. Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 48(Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 50):305-312. (Transl. in Soviet Fisheries Investigations in the North-eastern Pacific, Part I, p. 319-327, by Israel Program Sci. Transl., 1968, avail. Natl. Tech. Inf. Serv., Springfield, VA, as TT67-51203.)

Pautov, G.B. 1972. Some characteristic features of the biology of the Pacific Ocean perch (Sebastodes alutus) (Gilbert) in the Bering Sea. Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn, Khoz. Okeanogr. 81:91-117. (Transl. Bur., Dep. Sec. State, Canada, Transl. Ser. 2828.)

Phillips, J.B. 1957. A review of the rockfishes of California (Family Scorpaenidae). Calif. Fish and Game Fish. Bull. 104, 158 p.

Moiseev, P.A. and I.A. Paraketsov. 1961. Information on the ecology of rockfishes (family Scorpaenidae) of the northern part of the Pacific Ocean. Vop. Ikhtiol. 1[1(18)]:39-45. (Preliminary transl. Fish. Res. Board Can., Biol. Sta., Nanaimo, B.C., Fish. Res. Bd. Can. Transl. Ser. 358.)

Quast, J.C. 1972. Reduction in stocks of Pacific Ocean perch, an important demersal fish off Alaska. Trans. Am. Fish. Soc. 101:64-74.

Quast, J.C. and E.L. Hall. 1972. List of fishes of Alaska and adjacent waters with a guide to some of their literature. U.S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-658, 48 p.

Snytko, V.A. 1971a. Biology and pecularities of distribution of Pacific Ocean perch (Sebastodes alutus, G.) in Vancouver-Oregon region. Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 79:3-41. (Transl. Fish. Res. Bd. Can. Transl. No. 2805.)

Snytko. V.A. 1971b. Pacific Ocean perch (Sebastodes alutus) (Gilbert) of the Vancouver-Oregon region (commercial-biological characteristics). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 75:56-65. (Transl. Fish. Res. Bd. Can. Transl. Ser. 2431.)

Thompson, W.F. 1915. A new fish of the genus (Sebastodes) from British Columbia with notes on others. Rep. Comm. Fish. British Columbia 1914:120-122.

LIFE HISTORY - PACIFIC COD

Taxonomy

The Pacific cod (Gadus macrocephalus) is a member of the family Gadidae and the order Anacanthini. The scientific name Gadus macrocephalus is derived from the Latin gadus (codfish) and the Greek macros (large and cephalos (head). Common usage may continue to refer to this species as "plain" cod, "gray" cod or "true" cod to distinguish it from the other species currently referred to as varieties of cod. Other members of the family Gadidae are: the whiting (Theragra chalcogrammus), pacific tomcod (Microgadus proximus), and longfin cod (Antimora rostrata).

Physical Description

The Pacific cod has a brown to gray coloration on the dorsal surface, shading into lighter hues on the ventral surface. Brown spots are numerous on the back and sides, and are more or less dusky on the fins. The outer margin of all unpaired fins are white, and the white becomes wider on the anal and caudal fins. The Pacific cod is noted for three separate dorsal fins, with the anus below the second dorsal fin. The barbel below the lower jaw is as long or longer than the eye. This species may attain lengths up to 3 feet 3 inches.

Distribution

Pacific cod are mostly benthic, but are occasionally taken in quite shallow water. They have been caught at depths up to 300 fathoms

(550 meters). The species ranges from Santa Monica in southern California through Alaska and the Bering Sea to the Chukchi Sea. On the Asian side, they are distributed past the Kuril Islands to Kamchatka, Okhotsk Sea, Sea of Japan, off Honshu, Korea and in the Yellow Sea to Port Arthur. Toward the southern part of its center of abundance, cod occur in temperatures throughout the year between 6° and 9°C.

Life History

Spawning takes place in the winter. The eggs are slightly more than 1 mm in diameter and show no oil globule. The eggs are pelagic and slightly adhesive. They hatch in eight or nine days at 11°C and in 17 days at 5°C, but will take about four weeks at 2°C in northern waters. The hatching period for a batch of eggs lasts over several days. Egg survival is high at 5°C. Newly hatched larvae are approximately 4.5 millimeters in length. At 5°C, the yolk sac is absorbed in about 10 days. Young about 20 millimeters in length have been found to eat copepods.

Female cods sexually mature at approximately 40 centimeters of body length and two to three years of age. The length at which 50% of the females are sexually mature is 55 centimeters (Foerster, 1964). Half the males are mature at two years of age. At 60 centimeters, a female may produce 1.2 million eggs. At 78 centimeters, she may produce 3.3 million.

Cod generally move into deep water in the autumn and return to shallow water in the spring. Feeding includes a wide variety of invertebrates and fishes including: worms, crabs, molluscs and shrimps, herring, sand lance, walleye pollock and flatfishes.

Selected References

Clemens, W.A. and G.V. Wilby. 1961. Fishes of the Pacific coast of Canada. 2nd ed. Bull. Fish. Res. Bd. Canada 68. 443 p.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Bd. Canada. Bull. 180. 740 p.

LIFE HISTORY-LINGCOD

Taxonomy

The lingcod (Ophiodon elongatus), is a member of the family Hexagrammidae in the suborder Scorpaenoidea. The scientific name Ophiodon elongatus is from the Greek ophis (snake) and odons (tooth) and the Latin elongatus (elongate). It is often referred to as "cultus cod". Other members of the family Hexagrammidae found in Alaskan waters include the kelp greenling (Hexagrammos decagrammus), rock greenling (Hexagrammos lagocephalus), masked greenling (Hexagrammos octogrammus) and whitespotted greenling (Hexagrammos stelleri).

Physical Description

Reaching a length of five feet (152 centimeters), the lingcod is recognizable by its rounded and once-notched long dorsal fin, large mouth, large teeth, thoracic pelvic fins and small, smooth scales covering its body and head. Its coloration is variable, with bold, darker mottling on many shades of brown, gray, or green on the back and sides, depending upon the environment. Some smaller individuals are strongly green with the color permeating the flesh.

Distribution

The lingcod ranges from Baja in southern California north to Kodiak Island to the Shumagin Islands south of the Alaska Peninsula. It is common along the northeastern shore of the Pacific Ocean, with its center of abundance in waters of British Columbia. Its habitat is near the bottom of the intertidal zone down to at least 60 fathoms, among kelp beds and reefs, especially where there are strong tidal movements. When resting on the bottom, the fish supports its weight by resting on its pectoral and pelvic fins.

Life-History

Spawning takes place from December to March. Females deposit their eggs in crevices or under rocks in shallow water, sometimes in the intertidal zone. Newly maturing females produce 100,000 to 150,000 eggs. Larger females (40 inches in length) may produce upwards of 500,000 eggs. When water hardened, lingcod eggs are approximately 3.5 millimeters in diameter, and have tough membranous shells. They adhere strongly to each other, producing large, thick masses weighing up to 30 pounds, with a pinkish opalescent color. The male lingcod guards the eggs against intruders and fans them with his large pectoral fins.

Hatching is progressive, with eggs on the outside of the mass hatching first. Newly hatched young are seven to 10 millimeters long, have blue eyes, and a bright yellow oil globule near the liver. They sink to the bottom in intense light. The yolk sac is absorbed in about 10 days.

At one year of age, lingcod average about 10.5 inches in length. Growth in females is faster, averaging roughly 2.7 pounds per year, while males average only 1.7 pounds per year. Females reach 36 inches in length at 10 to 14 years old, with males seldom exceeding 36 inches. Males reach sexual maturity at about 18 inches. Females reach maturity at 27.5 to 30 inches.

Lingcod show two main patterns of movement. Some individuals are obviously quite sedentary, making few, if any, movements. Tagging has shown that fish were recaptured at the same location years after release, however, migratory populations have been known to exist.

Lingcod are voracious feeders, eating herring and sand lance, when available, and a variety of bottom forms such as flounders, hake, walleye pollock, cod and rockfishes. Lingcod also eat crustacea and octopus, and are definitely cannibalistic. Juveniles feed extensively on copepods and other small crustaceans.

Selected References

Clemens, W.A., and G.V. Wilby. 1961. Fishes of the Pacific Coast of Canada. 2nd ed. Bull. Fish. Res. Bd. Canada 68. 443 p.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Bd. Canada. Bull. 180. 740 p.

LIFE HISTORY - SABLEFISH

Taxonomy

The sablefish (*Anoplopoma fimbria*) is a member of the order Scorpaeniformes, which was originally established to include those fishes having a perch-like form of body. The order now includes many groups that are quite varied from the basic percoid character. One of these is the suborder Scorpoenoidea, to which the sablefish belongs. Within its family Anoplopomatidae or the skilfishes, sablefish are known to various names such as "skil", "coalfish" and "blackcod." However, the latter term is inappropriate since the fish is not a cod.

Physical Description

The body of the sablefish is long and slightly compressed, tapering into a long, slender, caudal peduncle. It is usually slaty black or greenish-gray on its dorsal surface and lighter on the ventral side. Males do not get as large as females, and reach maturity at an earlier age. Females may attain lengths of one meter or greater. It is estimated that a 40 inch sablefish is about 20 years old. Large individuals three feet in length and 40 pounds in weight have been captured on the halibut banks at depths down to 170 fathoms. Their food consists of crustaceans, worms and small fishes. In captivity, sablefish are indiscriminate feeders. They have been observed actively feeding on saury and blue lanternfish.

Distribution

The species ranges from Cedros Islands in southern California to the Bering Sea and is quite abundant in Alaskan and Canadian waters. On the Asian side of the North Pacific, they range from Hokkaido, Japan, north to the Kamchatka Peninsula off Siberia. Commercial quantities of adults are most abundant in water deeper than 200 fathoms and down to 500 fathoms. Although tagging studies have shown certain individuals to travel more than 1,200 miles, sablefish tend to be localized in most cases.

Life History

Sablefish spawn in the early spring with rising water temperatures and their eggs are pelagic, drifting with the current after fertilization. In late May, post-larval individuals have been found on the ocean surface at distances from 100 to 185 miles off the coast of Oregon. In the post-larval phase, sablefish are subject to heavy predation by larger organisms.

Selected References

Clemens, W.A., and G.V. Wilby. 1961. Fishes of the Pacific Coast of Canada. 2nd ed. Bull. Fish. Res. Bd. Canada 68. 443 p.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Bd. Canada. Bull. 180. 740 p.

McPhail, J.D. and C.C. Lindsey. 1970. Fresh water fishes of northwestern Canada and Alaska. Bull. Fish. Res. Bd. Canada 173. 381 p.

LIFE HISTORY - FLOUNDER

Taxonomy

The flounder family, Pleuronectidae, belongs to the order Heterosomata. This family includes demersal flatfishes such as halibut, sole and brill. Of 15 flatfish caught commercially in Alaskan waters, the arrowtooth flounder or turbot (*Atheresthes stomias*) was the most dominant species.

Physical Description

In flounders the eyes and colored surface are typically on the right side of the fish (dextral). The pelvic fins are symmetrically arranged, with one on each side of the abdominal ridge.

The family may be divided into two groups. In one, as exemplified by the halibuts and related species, the mouth is large and symmetrical, the maxillary extends to the pupil of the eye or behind, and the teeth are well developed on both sides of the jaws, associated with the habit of actively pursuing fishes for food. In the other group, the mouth is small and asymmetrical, the maxillary does not extend to the pupil of the eye, and the teeth are confined largely to the sides of the jaws on the unpigmented side of the head. This is associated with the habit of feeding upon invertebrates and small fishes of the sea bottom.

The body of the flounder is rather elongate, slender and much compressed. The arrowtooth flounder (*Atheresthes stomias*) has an average length of 2 feet 9 inches. The starry flounder (*Platichthys stellatus*) has an average length of 3 feet.

Distribution

Flounder range from southern California to the eastern Bering Sea. They are present in all regions and depth zones of the continental shelf and slope in the Gulf of Alaska. As a group, they historically dominated the catches in the Gulf of Alaska regions. They are most frequently encountered in the offshore regions. Flounder are most abundant on the continental shelf (less than 100 fathoms) decreasing as it extends beyond the 150 fathom contour.

Life History

Spawning generally occurs in late winter and early spring in a sandy substrate. In starry flounders (Platichthys stellatus), the eggs are pale orange, and their membranes have very fine vermiculate wrinkles, but no sculptured pattern. They have diameters between 0.89 and 0.94 millimeters, are slightly larger than sea water, and are non-adhesive upon hatching. Larvae are between 1.93 and 2.08 millimeters long. Like the other flatfishes, they are symmetrical. Young five to 12 millimeters long feed primarily on copepods and their nauplii, as well as barnacle larvae and Cladocera. The young are transformed to asymmetry at about 10.5 millimeters. Lengths corresponding to years of growth are: I, 105 millimeters; II, 310 millimeters and IV, 340 millimeters. Females are somewhat longer than males at higher ages and live longer.

Flounder consume crabs, shrimps, worms, clams and clam siphons, other small molluscs, small fishes, nemertean worms and brittle stars. At low water temperatures feeding stops. At this time, little digestion occurs and the stomach functions primarily as a food storage organ.

Selected References

Clemens, W.A., and G.V. Wilby. 1961. Fishes of the Pacific Coast of Canada. 2nd ed. Bull. Fish. Res. Bd. Canada 68. 443 p.

Hart, J.L. 1973. Pacific fishes of Canada. Fish. Res. Bd. Canada. Bull. 180. 740 p.

LIFE HISTORY - ATKA MACKEREL

Taxonomy

The Atka mackerel (Pleurogrammus monopterygius) is a member of the family Hexagrammidae, or greenlings.

Physical Description

The family Hexagrammidae is characterized by a head without spines or ridges but possessing cirri. Multiple lateral lines are also a characteristic of the family.

The Atka mackerel has five lateral lines, the first pair meeting on the occiput just before the origin of the dorsal. The second lateral line is smooth and does not curve before meeting the caudal peduncle. The first and fifth pair of lateral lines diverge and then reconverge on the caudal peduncle.

Color differs, depending on the specimen and the time of year. As a rule, the back and upper part of the body are an olive color but are sometimes black or light. The body has five broad, dark, vertical stripes of the same color as the back. The three anterior stripes on the ventral side are less distinct. The anterior stripe fades out on the abdomen, the second is more marked and the third even more distinct. The last two stripes pass from one side to the other, completely encircling the body and also passing onto the dorsal fin.

Adults generally reach a length of 380 to 420 mm, although some specimens have measured more than 450 mm. Adult weights fall between 1,500-1,800 g (3.3-4.0 lbs.) (Rass, 1962).

Distribution

Atka mackerel are distributed from the east coast of the Kamchatka Peninsula, through the southern Bering Sea and along the Aleutian chain, eastward to Kodiak Island. The species is not generally documented as present east of Kodiak Island, although one specimen was reported caught with rod and reel near Monterey Peninsula, California. The species is rarer in the eastern Bering Sea than along the Aleutians or western Bering Sea.

Life History

Eggs are deposited in June to July off the coast, usually in places with a stony bottom and Laminaria algae overgrowth in a powerful current which guarantees aeriation of the developing eggs. The eggs are sticky and adhere to the algae. Spawning occurs at a depth of 5 to 75 m.

In Alaskan waters, Atka mackerel are known to spawn in the stony-bottomed strait between Atka and Amlia Islands. Spawning lasts from mid-June to July 15-20. Spawning has also been observed off Attu Island at the entrance to Chichago Bay, off the northeast tip of the main island and among the small islets and reefs where tidal currents are strong and algae abundant. Atka mackerel first appear off Attu around May 1 and are actively spawning by mid-June. After late June, the spent fish gradually leave the shores. By August 1, most have moved back into offshore waters.

Little is known about the Atka mackerel's offshore life history. Pacific cod, sea lion and fur seals are known to feed on them.

Literature Cited

Rass, T. S. 1962. Greenlings, taxonomy, biology, interoceanic transplantation. Academy of Sciences of the USSR. Transaction of the Institute of Oceanology, Vol. 59. Translated from Russian by Israel Program for Scientific Translations. Jerusalem, 1970.

LIFE HISTORY - KING CRAB

Taxonomy

King crabs are anomuran crabs of the superfamily Paguridea found throughout the circum-arctic region of North America. Eldridge (1972) has described their taxonomy as follows:

Order:	Decapoda
Section:	Anomura
Superfamily:	Paguridea
Family:	Lithodidae
Subfamily:	Lithodinae
Genus:	*Paralithodes*

Of the three species found in Alaskan waters, "red" king crab (*Paralithodes camtschatica*) are the most abundant and commercially valuable. Although "blue" king crab (*Paralithodes platypus*) are not as abundant, they are morphologically similar to *Paralithodes camtschatica*. The Japanese have developed a modest fishery for this species in the Pribilof Island region of the Bering Sea. "Brown" or "golden" king crab (*Lithodes aequispina*) are found in the deeper waters (100 to 200 fathoms) of southeastern Alaska. The Japanese refer to the king crab as "taraba-gani", whereas the Russians often call it the "Kamchatka" crab. Americans usually reserve the name "king crab" for *Paralithodes camtschatica*. The term "king crab" will refer to *Paralithodes camtschatica* for the remainder of this report.

Distribution

Paralithodes camtschatica is abundant on both sides of the north Pacific Ocean. In Asian waters, it is found from the Sea of Japan northward into the Sea of Okhotsk and along the shores of the Kamchatka Peninsula; the northern limit on the Asiatic coast has been reported at Cape Olyutorskiy (60°N latitude). The species occurs throughout the Aleutian Islands and the southeastern Bering Sea where large fisheries exist. On the western coast of North America, the northern limit for king crab appears to be Norton Sound (65°N latitude) in the northeastern Bering Sea. King crab are also abundant in the Gulf of Alaska where major fisheries for them exist in Cook Inlet, Kodiak Island and the south Alaska Peninsula. Moderate numbers of king crab are found in Prince William Sound and southeastern Alaska. The southern limit of this species in the northeastern Pacific appears to be Vancouver Island, British Columbia (Butler and Hart, 1962).

During various life stages, king crab segregate from one another. In particular, males are separate from females except during the mating season and, in general, adults appear to inhabit different areas from those frequented by juveniles. Male king crab also may school by size.

King crab are distributed to depths of 1,200 feet, although the commercial fishery is generally confined to depths less than 600 feet. Females and smaller males appear to be most abundant in intermediate depths. Juveniles are most abundant in inshore waters and in relatively shallow waters, although they have been found to depths of 58 fathoms (Powell and Reynolds, 1965).

The favorite bottom habitat of king crab appears to be mud or sand. King crab are stenohaline and adapted to cold waters.

Maturity

King crab of both sexes reach sexual maturity when their carapace (back) length is approximately 100 mm (3.9 inches), or at an age of about 5 years. All females participate in breeding shortly after attaining sexual maturity. However, it appears that few males less than 120 mm in carapace length mate, possibly due to competition from larger males.

Mating

King crab follow distinct annual migration patterns associated with their mating season. During winter months they migrate to water depths of less than 50 fathoms along the shoreline and onto the offshore ocean banks. Young adults precede old adults; males precede females (Powell and Nickerson, 1965). Females molt and mate from February through May. Females normally, but not necessarily, molt while being grasped by a male. The precopulatory embrace (grasping) is an intrinsic behavior of adult king crab which serves to keep breeding adults together until subsequent mating has occurred. It additionally affords a protective mate to the female before and during the molt, and aides the female in molting.

Immediately after the female molts, the attendant male deposits spermatophore material around the female's gonopores and releases her. The female then ovulates into her abdominal pouch where eggs mix with the sperm mass and are fertilized. Fertile eggs are carried by the female for 11-12 months, hatching prior to the female's next annual molt. Female king crab not mating after molting will not extrude eggs.

Female king crab mate with only one male annually. Male king crab are polygamous.

Fecundity

The number of eggs each female carries varies with their size. Female king crab in Asiatic waters apparently carry less eggs than their counterparts in the northeastern Pacific. In this regard, Nakazawa (1912) reported that large females in Japanese waters could carry as many as 345,000 eggs, while the average female carried approximately 220,000 eggs. A later study (Sato, 1958) found that the number of eggs carried by females in Japanese waters varied between 15,000 and 204,000, with a mean of 102,000 eggs.

At Kodiak, small females have been reported to carry between 50,000 and 100,000 eggs, with large females carrying as many as 400,000 eggs.

Eggs and Larvae

The embryos develop into pre-zoea after about five months' growth and remain in this state while they are carried by the female. During this period, the embryos within the eggs become well developed and are easily visible. During hatching, which occurs between March and June, all of the eggs carried by an individual will hatch in about a five-day period. After hatching, the pre-zoea larva molts and assumes the first zoeal stage. During the pelagic phase, the larvae are active swimmers and feed primarily on diatoms. After the fifth molt, the larvae assume a benthic, or bottom, existence as glaucothoe larvae. In the next molt, which occurs during the first summer of life, they assume the first adult form.

Juveniles

During their first year of life, the juveniles assume a solitary, benthic existence. Larvae are quite abundant in waters close to shore in the Gulf of Alaska. In the Bering Sea, large concentrations of juveniles have been found in depths of 29 fathoms.

Two-year-old king crab are known to aggregate in large groups, commonly piling upon one another and moving as a conglomerate. The practice is known as "podding" and is a social behavior which affords the crab protection from predators. Aggregates, although constantly changing, are maintained by both sexes until they attain sexual maturity. At that point, crab segregate by sex and size.

Sculpins, cod and halibut have been reported to prey on juvenile king crab. In addition, Gray (1964a) has reported that halibut prey on king crab when they are in the soft shelled condition. Evidence suggests that once king crab attain sexual maturity, they are relatively immune to predation, except during the molting phase.

Growth

During each of the first several years of the king crab's life, growth is rapid, and it molts or sheds the hard outer shell several times in order to accommodate the increased body size. At the time of molting, the crab sheds the carapace, eyes, antennae, mouth, esophagus, stomach, calcerous teeth, gills and tendons. In other words, the entire outer body covering is molted. Juvenile male and female crab steadily increase in carapace length at a rate of 24 and 23 percent per molt, respectively, (Powell, 1967) until reaching sexual maturity.

After reaching sexual maturity, growth rates and molt frequency for male and female crab differentiate. Adult females molt annually and average 4 mm per molt. Adult males molt annually through the eighth year and average 20 mm per molt. After eight years, an increasing proportion molt biennially. Few male crab molt less frequently than biennially. Maximum size is reached at an average of 14 years of age. Growth rate for males decreases slightly following the eighth year.

Food Habits

King crab are omnivorous during both the juvenile and adult stages of life. In a study of food items found in the stomachs of king crab in the Bering Sea, the following occurred (in descending order of frequency): Mollusca (clams, etc.); Polychaeta (marine worms); algae (marine plants); other crustacea and Coelenterates (jellyfish). Other food organisms found less frequently were foraminiferans, nematode worms, tunicates, echiuroids and fish (McLaughlin and Hebard, 1959).

Diseases

Sindermann (1970) has reported that *P. camtschatica* and *P. platypus* from the eastern north Pacific are occasionally affected by "rust disease", which seems to result from action of chitin-destroying bacteria of the exoskeleton. However, this disease appears to be relatively rare. Sinderman (1970) has also reported that *P. platypus* from Alaskan waters are occasionally invaded by rhizcephalans.

Literature Cited

Butler, T.H. and J.F.L. Hart. 1962. The occurrence of the king crab, _Paralithodes camtschatica_ (Tilesius), and of _Lithodes aequispina_ (Benedict) in British Columbia. J. Fish. Res. Bd. Can. 19(3):401-408.

Gray, G.W., Jr. 1964. Halibut preying on large crustacea. Copeia 1964(3):590.

McLaughlin, P.A. and J.F. Hebard. 1959. Stomach contents of the Bering Sea king crab. U.S. Fish and Wildl. Serv. Spec. Sci. Rept.-Fish. n. 291.

Moore, J.P. and M.C. Meyer. 1951. Leeches (_Hirudinae_) from Alaskan and adjacent waters. Wasmann J. Biol. 9:11-17.

Nakazawa, K. 1912. Report on king crab, _Paralithodes camtschatica_. In experiment report of fisheries training school 8(6):21. Translation file, U.S. Dept. of Commerce, Nat. Mar. Fish. Serv. Biological Laboratory, Auke Bay, Alaska.

Powell, G.C. 1967. Growth of King Crabs in the vicinity of Kodiak Island Alaska. Alaska Dept. of Fish and Game Info. leaflet no. 92.

Powell, G.C. and R.B. Nickerson. 1965. Reproduction of King Crabs, _Paralithodes camtschatica_ (Tilesius). J. Fish. Res. Bd. Can. 22(1): 101-111.

Powell, G.C. and R.E. Reynolds. 1965. Movements of tagged king crabs. _Paralithodes camtschatica_ (Tilesius), in the Kodiak Island-Lower Cook Inlet region of Alaska. 1954-1963. Alaska Dept. of Fish and Game. Info. leaflet no. 55.

Sato, S. 1958. Studies of larval development and fishery biology of king crab, _Paralithodes camtschatica_ (Tilesius). Bull. Hokkaido Reg. Fish. Res. Lab. 17. 102 p.

Sindermann, C.J. 1970. Principal diseases of marine fish and shellfish. Acad. Press, New York. 369 p.

LIFE HISTORY - TANNER CRAB

Taxonomy

Tanner crab are members of the brachyuran crabs of the superfamily Oxyrhycha found throughout the circum-arctic region of North America. Garth (1958) has described their taxonomy as follows:

Order:	Decapoda
Section:	Brachyura
Superfamily:	Oxyrhyncha
Family:	Majidae
Subfamily:	Oregoniinae
Genus:	*Chionoecetes*

The genus of *Chionoecetes* may actually consist of two polytypic species, *C. opilio* and *C. angulatus*. *C. opilio* may have given rise to *C. opilio elongatus* and *C. bairdi*, while *C. angulatus* may have given rise to *C. tanneri* and *C. japonicus* (Garth, 1958). All of these species are present in the North Pacific.

Crabs of the genus *Chionoecetes* have been referred to as spider, tanner and snow crabs in English literature. In Japanese literature, this genus is referred to as zuwai crabs. In an attempt to capitalize on the excellent reputation of the king crab, American processors initially attempted to sell tanner crab under the trade name "Queen Crab". However, the U.S. Food and Drug Administration has since ruled that "Snow Crab" will be the official trade name for the tanner crab. In common usage, tanner crab has become the accepted name for the genus.

Distribution

Tanner crab belong to the subfamily Oregoniinae, which has a circum-arctic distribution extending into the temperate waters on the east and west coasts of North America and Eurasia. The genus' range is: the eastern Pacific from the Bering Strait and the Aleutian Islands to Cortex Bank, opposite the United States-Mexico boundary; western Pacific, from Kamchatka to off Kinkazan, Japan, and Oki Islands in the Japan Sea; Siberian, Alaskan and Canadian Arctic; and the Western Atlantic, from the west coast of Greenland to Casco Bay, Maine. Members of the genus are found in waters to depths of 1,625 fathoms (Garth, 1958). The greatest concentrations occur along the outer continental shelf and upper continental slope. Trawl surveys conducted by the International Halibut Commission indicate that tanner crab are quite abundant in the Gulf of Alaska and that they increase in abundance as one goes west toward the Bering Sea.

C. tanneri are typically found from the coast of Washington to the extreme southern edge of California. They occur from depths of 29 to 1,062 fathoms, with the greatest abundance in the 275 to 400-fathom interval. C. angulatus occur in the 49 to 1,625-fathom interval from the eastern edge of Kamchatka to the Pribilof Islands in the Bering Sea, south along the Aleutians and from British Columbia southward to Oregon. Because these two species occur in relatively deep water, intensive commercial exploitation is not feasible at this time.

C. bairdi inhabit waters from the littoral zone to depths of 259 fathoms and are the principal commercial species in the Gulf of Alaska. C. bairdi are distributed from Puget Sound, Washington, to the Aleutian Islands and the southeastern Bering Sea where they are reported to be the most common species in the commercial catch. C. opilio occur in the Bering Sea within the littoral zone and to depths of 85 fathoms. The greatest concentrations of *C. opilio* are north of latitude 58°N. *C. bairdi* comprise the bulk of the commercial tanner crab catch in both the Gulf of Alaska and Bering Sea.

Tanner crab distribution and abundance appear to be inversely related to that of king crab. Preliminary evidence indicates that king and tanner crab compete for space and food. Exploratory surveys in the southeastern Bering Sea indicate that both male and female tanner crab of all sizes are most abundant at depths where the abundance of male and female king crab is low. Although male tanner crab may overlap considerably with king crab of both sexes, female tanner crab are most abundant in areas where no female king crab are present (Haynes and Lehman, 1969).

Studies by Pereyra (1966) along the Oregon coast indicated a pronounced seasonal and sexual difference in the distribution of adult tanner crab, *C. tanneri*. *C. tanneri* were commonly present at depths ranging from 250 to 850 fathoms. Female tanner crab were concentrated principally between 350 and 375 fathoms throughout the year, and the relative abundance of male tanner crab changed seasonally by depth. During the spring and summer, males were most abundant at depths ranging between 275 and 300 fathoms. With the onset of fall, the male population shifted back into deeper water and mingled with the female population during the winter for the purpose of mating. Although specific observations are limited, the other species of tanner crab are believed to exhibit similar sexual and seasonal migrations.

Sexuality

Tanner crab are heterosexual and sexually dimorphic. There is considerable variation in morphology between male and female tanner crab, with the males being significantly larger than the females. Adult males have an acute and narrow abdomen, while adult females have a round and broad abdomen.

Maturity

Due to the difficulty of aging crustaceans, the age at which tanner crab reach sexual maturity is not known with certainty, although the size at maturity is known for most species. Alaska Department of Fish and Game tanner crab research has determined that the average male *C. bairdi* reaches maturity at 110 mm carapace width. The same research puts the size of 50 percent maturity for female *C. bairdi* at 83 mm (Donaldson, 1975). Studies conducted in the Japan Sea indicate that *C. opilio* reach sexual maturity after about the tenth molt, or six to eight years after hatching. Male and female *C. opilio* in Japanese waters reach sexual maturity at a size of approximately 50 to 65 mm in carapace width (Ito, 1970). Female *C. tanneri* off the Oregon coast reach sexual maturity at 75 to 126 mm in carapace width, while male *C. tanneri* mature at 103 to 181 mm in carapace width (Pereya, 1966).

Mating

As a genus, tanner crab appear to be polygamous. Initial mating is believed to take place in the spring or early summer shortly after the female has molted and grown to maturity. At the present time, it is suspected that female tanner crab can mate while hard-shelled. Some evidence is available which suggests that unlike king crab females, tanner crab females are capable of breeding while hard-shelled.

Hartnoll (1969) contends that only hard-shelled male tanner crab are successful at mating. Female tanner crab are apparently capable of producing more than one hatch of fertile eggs from one mating (Watson, 1970; Bright, 1967).

Fecundity

The number of eggs produced by female tanner crab is extremely varied. The range of 24,000 to 318,000 eggs per female C. bairdi (Hilsinger, 1975) compares with 20,000 to 140,000 and 6,000 to 130,000 eggs per female C. opilio in Canada (Watson, 1969) and Japan (Ito, 1963), respectively. The large egg number variation exists between females of both varying and similar sizes. Some of this variation can be accounted for by a decrease in clutch size in very old animals.

Eggs and Larvae

After mating, the female lays a clutch of bright orange eggs. The eggs are attached to pleopods under the female's abdomen and are carried for approximately twelve months before hatching. A steady loss of eggs following fertilization has been documented for C. bairdi (Hilsinger, 1975) and C. opilio (Kon, 1974). The total loss may amount to as much as 45 percent. The decrease in egg number is attributed to death and disintegration of abnormal embryos and predation. Hatching of the eggs (larval release) appears to coincide with the plankton blooms. The free-swimming larvae molt and grow through several distinct stages before settling to the bottom as juveniles where they cover themselves with debris and begin feeding on detritus. The growth rate from larval to juvenile stage is dependent upon water temperature, with warmer temperatures producing faster growth. At water temperatures of 11° to 13°C, the free-swimming developmental period between the larval and juvenile stages may last approximately 63 to 66 days (Kon, 1970).

Plankton studies in the Japan Sea indicate that the free-swimming larvae of tanner crab undergo diurnal vertical migrations. This migration is a feeding response to the diurnal movements of plankton blooms.

Juveniles

There is very little published material concerning the habitat and distribution of juvenile tanner crab. Exploratory work in the Japan Sea indicates that juveniles settle along the sea bottom at depths ranging between 163 and 191 fathoms (Ito, 1968). Alaska Department of Fish and Game biologists in Kodiak have collected juvenile *C. bairdi* as small as 6.5 mm in 10 fathoms. The National Marine Fisheries Service has records of juvenile tanner crab as small as 12 mm caught in shrimp trawls off Kodiak in 30 to 80 fathoms. This information suggests that distribution of juvenile tanner crab is widespread and not depth dependent. The actual diet of the juveniles is uncertain, but they are believed to feed primarily on dead and decaying mollusks and crustaceans which accumulate in the detritus along the sea floor. Fish remains and small planktonic organisms are also ingested to a limited degree.

Adults

Adult tanner crab are intolerant and restricted in their distribution by low salinities and high temperatures. Laboratory experiments in

Canada have demonstrated that *C. opilio* will die within 24 hours if kept in salinities less than 22.5°/oo (anonymous, 1971). At a salinity of approximately 31°/oo to 32°/oo, McLeese (1968) determined that *C. opilio* reached the 50°/oo mortality point after 18.8 days when held at 16°C. Thus, it is reasonable to expect that the southern range of tanner crab distribution may be limited if water temperatures exceed 16°C.

Adult tanner crab appear to have few predators, although it is likely that during molting they may be vulnerable to large fish and perhaps other large crustaceans such as the king crab. In addition to predation, it is speculated that king and tanner crab may compete for food and space. The concept of competition between the king and tanner crab is interesting in that it poses the question of whether the populations of tanner crab are affected by the abundance of king crab. In this regard, the depletion of the larger male king crab by the present intensive fishery might have a favorable effect on the abundance of tanner crab.

Growth

Dimensional growth occurs in tanner crab when the hard exoskeleton is periodically cast off or molted. The animal is then able to take water into its tissues and increase in size before the rehardening occurs. Male and female crab display similar growth rates and molt frequently prior to reaching sexual maturity. Males continue to molt after becoming sexually mature, but the intervals between molts increase with age. Female crab normally do not molt after reaching sexual maturity. In females, the molt to maturity is considered the terminal molt. Growth may vary from one geographic location to another. The maximum age of tanner crab is probably 8 to 12 years, although this is not known with certainty.

Diseases

Brown (1971) reported a black encrustment on the carapace which has been labeled "shell syndrome". The meat of the crab is not affected by the "syndrome", but it may cause mortality in individuals which have undergone their terminal molt due to disablement of the mouth parts and eyes. There is some evidence that the indiscriminate dumping of wastes from crab processing plants may be a factor contributing to the spread of the disease.

Gordon (1966) reported that some polyclad Turbellaria are ectoparasitic on crabs. Specifically, *Coleophora chinonoecetis* has been found on the eggs of tanner crab.

Oka (1927) reported that the leech, *Carcinobdella kanibir*, is occasionally found on *C. opilio* in Asiatic waters.

Migration and Local Movement

Little is known concerning the migrations and local movements of tanner crab. However, tagging studies conducted by Canadian scientists (Watson, 1970) indicated that tagged male crab travel relatively little, with 85 percent of the returns recaptured within 10 miles of the release point. The farthest recapture in the study was a male that traveled 28 miles. A limited tagging experiment in Auke Bay, Alaska, concluded that tanner crab may return to a "home" area to mate and molt each year (anonymous, 1971).

Numerous trawl surveys conducted in the Gulf of Alaska and the Bering Sea indicate that tanner crab are more concentrated in some areas than others. These data indicate that tanner crab may school, but further work is needed for clarification.

Literature Cited

Anonymous. 1971a. Review 1969-1970. The Fisheries Research Board, Ottawa, Canada.

Anonymous. 1971b. Intern. N. Pacific Fish. Comm. Proc. of the Seventeenth Annual Meeting, 1970. Report of the subcommittee on King Crab and Tanner Crab. Appendix 5 (Doc. 1341). 247-257 p.

Bright, D.B. 1967. Life histories of the king crab and the "tanner" crab in Cook Inlet, Alaska. PhD. thesis. U. So. California 265 p.

Brown, R.B. 1971. The development of the Alaskan fishery for tanner crab, Chionoecetes species, with particular reference to Kodiak area, 1967-1970. Alaska Dept. of Fish and Game Info. Leaflet 153. 26 p.

Donaldson, W.E. 1975. Kodiak Tanner Crab Research, Tech. Rep. Natl. Oceanic and Atmosph. Adm., NMFS, Washington, D.C. 41 p.

Garth, J.S. 1958. Brachyura of the Pacific coast of America. Oxyrhyncha. Allan Hancock Pacific Expedition 21:854.

Gordon, I. 1966. Parasites and diseases of Crustacea. Mem. Inst. Fondam. Afrique Noire No. 77. 27-86 p.

Hartnoll, R.G. 1969. Mating in the Brachyura. Crustaceana 16:161-181.

Haynes, E. and C. Lehman. 1969. Minutes of the second Alaskan shellfish conference. Alaska Dept. Fish and Game Info. Leaflet 135. 102 p.

Hilsinger, J.R. 1975. Aspects of the reproductive biology of female snow crabs, Chionoecetes bairdi Rathbun, from Prince William Sound, Alaska. M.S. thesis, Univ. of Alaska 88 p.

Ito, K. 1970. Ecological studies on the edible crab, Chionoecetes opilio (O. fabricius) in the Japan Sea. III. Age and growth as estimated on the basis of the seasonal changes in the carapace width frequencies and the carapace hardness. Bull. Jap. Sea Reg. Fish. Res. Lab. 22:81-116.

Kon, T. 1970. Fisheries biology of the tanner crab. IV. The duration of planktonic stages. 1967. Fisheries of the United States. 1967. U.S. Fish and Wildlife Service, Bur. of Comm. Fish. C.F.S. No. 4700. Review (Crabs, king). xvii p.

McLeese, D.W. 1968. Temperature resistance of the spider crab, Chionoecetes opilio. J. Fish. Res. Bd. Can. 25(8):1733-1736.

Oka, A. 1927. Sur la morphologie esterne de Carcinobdella kanibir. Proc. Imp. Acad. (Tokyo) 3:171-174.

Pereya, W.T. 1966. The bathymetric and seasonal distribution of adult tanner crabs, Chionoecetes tanneri, Rathbun (Brachyura: Majidae) of the northern Oregon coast. Deep-Sea Res. 13(5)::1185-1205.

Watson, J. 1970a. Maturity, mating, and egg-laying in the spider crab, Chionoecetes opilio. J. Fish. Res. Bd. Can. 27:1607-1616.

Watson, J. 1970b. Tag recaptures and movements of adult male snow crabs, Chionoecetes opilio, (O. fabricius) in the Gaspe region of the Gulf of St. Lawrence. Fish. Res. Bd. Can. Tech. Rept. No. 204. 16 p.

LIFE HISTORY - DUNGENESS CRAB

Taxonomy

Dungeness crab, _Cancer magister_, are members of the brachyuran crabs of the family Cancridae. Mayer (1972) described their taxonomy as follows:

Phylum:	Arthropoda
Class:	Crustacea
Superorder:	Eucarida
Order:	Decapoda
Suborder:	Brachyura
Family:	Cancridae
Genus:	_Cancer_
Genotype:	_Cancer magister_ (Dana, 1852)

Crab of the species _Cancer magister_ have been referred to as market crab, common edible crab, Pacific edible crab, commercial crab, dungeness crab and dungeoness crab. At the present, dungeness crab is the accepted common name.

Distribution

Dungeness crab are found in the shallow, nearshore waters of the North Pacific along the western North American coast. They range from a northern limit of Unalaska to a southern limit in Monterey Bay, California (McKay, 1943). Crab inhabit bays, estuaries and open ocean near the coast from the intertidal zone to depths of approximately 50 fathoms. Favored substrate is a sand or sand-mud bottom, although dungeness crab may be found on almost any bottom substrate. Unlike king and tanner crab, dungeness crab inhabit shallow water most of the year. Juveniles are commonly associated with stands of eelgrass or, in the absence of eelgrass, with masses of detached algae, which are believed to afford them protection (Butler, 1956).

Water temperatures and salinity appear to be controlling factors in the seasonal distribution of dungeness crab. Studies by Cleaver (1949) indicate that crab abundance, as estimated from catch per unit effort data, increases with rising spring water temperatures and decreases with dropping fall temperatures. Changes in winter catch appear to be in response to fluctuating low salinities. McKay (1942) determined that adult dungeness crab migrate offshore during the winter and return to the nearshore in the early spring and summer.

Sexuality

Dungeness crab are heterosexual and sexually dimorphic. There is considerable variation in morphology between male and female crab, with males being significantly larger than females. Adult males have an acute and narrow abdomen, while adult females have a round and broad abdomen.

Maturity

According to Butler (1960), male dungeness crab from the Queen Charlotte Islands, British Columbia, reach sexual maturity at a carapace width of 110 mm, or at about three years of age. He found, however, that sexual activity was not appreciable until crab obtained a carapace width of 140 mm. McKay (1942) found by examination of gonads that male crab matured at a carapace width of about 137 mm.

Butler (1960) found mature female dungeness crab with a carapace width of 100 mm which were approximately two years old. Weymouth and McKay (1936) also determined that female crab reach sexual maturity at about 100 mm carapace width.

Mating

The mating of C. magister, as observed in aquaria, has been reported by Cleaver (1949), Butler (1960) and Snow and Nielsen (1966). No observations made under natural conditions have been reported. Crab copulate only after the female has recently molted. Premating activity begins with the male crab firmly grasping the female with both of his chelae. The male then holds the female crab beneath himself so that both sterna are in contact. The male crab continues to restrain the female during her ecdysis, but allows her to move into an upright position. Snow and Nielsen (1966) found that within 1 hour and 32 minutes after the female has molted, copulation took place. The female is again held with both sterna in contact. The abdominal flaps of both individuals are flexed in the copulatory position with the gonopods inserted in the spermathecae. Snow and Nielsen (1966) also reported the occurrence of a post-mating embrace which lasted for two days.

Fecundity

McKay (1942) found that a single egg mass contained 1,500,000 eggs and speculated that a single female dungeness crab may spawn three to five million eggs during a lifetime.

Eggs and Larvae

After mating, the female's oviduct is closed by a secretion which hardens in contact with sea water. The spermatozoa are sealed in the oviduct where they remain viable for several months. Upon extrusion, the eggs are fertilized (McKay, 1942). Egg-bearing occurs during October to June in British Columbia. Larvae emerge from the egg masses between December and April in Oregon waters (Reed, 1969). Egg and larvae development is dependent upon water temperature, with warmer temperatures producing faster growth. In California waters, Poole (1966) determined that the developmental period between egg and juvenile may last 128 to 158 days.

Predation and cannibalism are major causes of mortality among larval dungeness crab. Heg and Van Hyning (1951) found the larvae of C. magister as prey items in stomachs of chinook and silver salmon taken along the Oregon coast. McKay (1942) cites observations of C. magister larvae commonly found in the stomachs of salmon, herring and pilchard.

Reed (1969) investigated the effects of temperature and salinity on the growth of laboratory reared C. magister larvae. He found that optimum ranges of temperature and salinity for C. magister larvae are 10.0° to 13.9°C and 25°/oo to 35°/oo, respectively.

Juveniles

Juvenile dungeness crab are commonly associated with stands of eelgrass or, in the absence of eelgrass, with masses of detached algae, which are believed to afford them protection from predation (Butler, 1956). Butler (1954) reports the common occurrence of juvenile crab, about three-eighths of an inch, in the stomachs of adult crab.

The diet of juveniles is assumed to be similar to that of adults, with crustaceans and mollusks accounting for the principal food items.

Growth during the juvenile stage is fairly rapid, with crab reaching their eleventh or twelfth molt by age two.

Adults

After reaching sexual maturity at two to three years of age, dungeness crab continue to grow, with males obtaining their maximum size at age five. Female growth is similar to that of the male dungeness crab during the first two years of life, but decreases afterward (Butler, 1961). Butler (1960) concluded that the maximum age for *C. magister* is eight years. McKay and Weymouth (1935) felt that the maximum age was not more than ten years, with the average life expectancy being eight years.

The diet of adult dungeness crab is varied, consisting primarily of other crustaceans, mollusks, worms and occasionally seaweed (McKay, 1942). The cannibalism of juvenile and larval crab by adults is reported by Butler (1954).

Temperature tolerance for adult *C. magister* in Puget Sound, Washington, has been reported by Stober, Mayer and Salo (1971). In general, no mortality was observed at temperatures below 24°C.

Adult dungeness crab are subjected to heavy predation, particularly while in the soft-shelled condition following a molt. Waldron (1958) found ling cod, the great marbeled sculpin, wolf-eels, halibut, octopus and some rockfish to be voracious predators upon adult *C. magister*. Predation is particularly heavy on small, immature crabs, but is not exclusive of adults. McMynn (1951) observed two *C. magister*, which were 114 mm wide, and four smaller crabs in the stomach of one rockfish.

Diseases

A "black spot" or "rust spot" is occasionally found on the legs of *C. magister*. Although no discussion of this disease was found in the literature, it may be similiar to the chitininvrous bacteria-caused disease described for the European dungeness crab, *C. pagurus* (Sinderman, 1970).

The occurrence of a species of worm adhering to the carapace and among the egg masses was reported by McKay (1942). Sinderman believes the worms to have been a marine leech.

Migration and Local Movement

Little is known concerning the migrations and local movements of dungeness crab. However, Cleaver (1949) has divided the migration of *C. magister* into two types: (1) the onshore-offshore movements, and (2) coastwise. Cleaver concluded that adult crab migrate offshore during the winter months and return to the nearshore in the early spring and summer. This seasonal migration is apparently in response to seasonal changes in water temperatures. Furthermore, Cleaver observed that crab which were tagged in early winter moved northward with the approach of summer. Although he had no evidence of a return migration, he believed that one might exist in the deeper waters. Presumably, these migrations may also be in response to seasonal changes in water temperature.

Literature Cited

Butler, T.H. 1956. The distribution and abundance of early post-larval stages of the British Columbia commercial crab. Fish. Res. Bd. Can., Pac. Prog. Rept. 107:22-23.

Butler, T.H. 1960. Maturity and breeding of the Pacific edible crab, *Cancer magister* Dana. J. Fish. Res. Bd. Can. 17(5):641-646.

Butler, T.H. 1961. Growth and age determination of the Pacific edible crab, *Cancer magister* Dana. J. Fish. Res. Bd. Can. 18(5):873-891.

Cleaver, F.C. 1949. Preliminary results of the coastal crab (*Cancer magister*) investigation. Wash. State Dept. of Fish., Biol. Rept. 49A:47-82.

Heg, R. and J. Van Hyning. 1951. Food of the chinook and silver salmon taken off the Oregon coast. Fish. Comm. Oregon Res. Brief 3(2):32-40.

McKay, D.C.G. 1942. The Pacific edible crab, *cancer magister*. Bull. Fish. Res. Bd. Can. 62:32.

McKay, D.C.G. 1943a. The behavior of the Pacific edible crab, *Cancer magister* Dana. J. Comp. Psych. 36(3):255-268.

McKay, D.C.G. 1943b. Temperature and the world distribution of crabs of the genus *Cancer*. Ecology 24(1):113-115.

McMynn, R.G. 1951. The crab fishery off Graham Island, British Columbia to 1948. Bull. Fish. Res. Bd. Can. 91:1-21.

Poole, R.L. 1966. A description of laboratory-reared zoeae of *Cancer magister* Dana, and megalopae taken under natural conditions (Decapoda Brachyura). Crustaceana 11(1):83-97.

Reed, P.H. 1969. Culture methods and effects of temperature and salinity on survival and growth of Dungeness crab (*cancer magister*) larvae in the laboratory. J. Fish. Res. Bd. Can. 26(2):389-397.

Sinderman, C.J. 1970. Principal diseases of marine fish and shellfish. Academic Press: New York and London.

Snow, C.D. and J.R. Nielsen. 1966. Premating and mating behavior of the Dungeness crab (*Cancer magister* Dana). J. Fish. Res. Bd. Can. 23(9):1319-1323.

Stober, G.J., D.L. Mayer and E.O. Salo. 1971. Thermal effects on survival and predation for some Puget Sound fishes. Proceedings of Third National Symposium on Radioecology, May 10-12, 1971 (in press).

Waldron, K.D. 1958. The fishery and biology of the Dungeness crab (*Cancer magister* Dana) in Oregon waters. Fish. Comm. Oregon. Contr. 24:1-43.

Weymouth, F.W. and D.C.G. McKay. 1936. Analysis of the relative growth of Pacific edible crab, *Cancer magister*. Proc. Zool. Soc. Part 1 (1936).

LIFE HISTORY - SHRIMP

Commercial catches of shrimp in the north Pacific Ocean are made up of three families: Crangonidae, Hippolytidae and Pandalidae. The first species exploited by the west coast shrimp fisheries were members of the family Crangonidae in intertidal areas. Now, however, members of the Crangonidae and Hippolytidae are considered of little commercial value and are only taken incidental to catches of Pandalidae. Consequently, this life history report will consider only the pandalid shrimps.

Taxonomy

Fox (1972) defines the suprafamilial taxonomic relationships of the family Pandalidae as follows:

Phylum:	Arthropoda
Class:	Crustacea
Subclass:	Malacostraca
Order:	Decapoda
Suborder:	Natantia
Section:	Caridea
Family:	Pandalidae

Rathbun (1904) lists 14 species of pandalid shrimps found off the northwestern coast of North America which are divided between the two genera *Pandalus* and *Pandalopsis*. They are as follows:

*Pandalus borealis**	Kroyer
Pandalus danae	Stimpson
*Pandalus goniurus**	Stimpson
Pandalus gurneyi	Stimpson
*Pandalus hypsinotus**	Brandt
Pandalus jordani	Rathbun
Pandalus leptocerus	Smith
Pandalus montagui tridens	Rathbun
*Pandalus platyceros**	Brandt
Pandalus stenolepsis	Rathbun

Pandalopsis aleutica	Rathbun
Pandalopsis ampla	Bate
_Pandalopsis dispar_*	Rathbun
Pandalopsis longirostris	Rathbun

Only five, identified by asterisk above, of the fourteen species are caught by commercial fisheries in significant quantities in Alaskan waters. The remainder of this life history report will be devoted entirely to these five species.

Distribution

Shrimps of the family Pandalidae are found throughout the higher temperate and boreal latitudes of the world, with centers of concentration varying with the species. In the northeastern Pacific, shrimp are distributed in bays and on offshore banks. Their range extends from the Bering Sea to southern California with commercial fisheries occurring off every Pacific state. Specific distribution data for the five major shrimp species found in Alaskan waters is given as follows:

The northern pink shrimp, _Pandalus borealis_, has been found from the Bering Sea southward to the Columbia River in depths of 10 to 350 fathoms. It is the most abundant shrimp in the north Pacific Ocean and Bering Sea. The greatest concentrations occur from the southeastern tip of the Kenai Peninsula, Kodiak and Shumagin Island groups and along the south side of the Alaska Peninsula west to Unalaska Island. Small concentrations also occur along the eastern Kenai Peninsula, portions of Prince William Sound, Yakutat Bay and throughout southeastern Alaska. Optimum depth where the greatest commercial catches may be taken varies somewhat by area but is generally between 30 and 100 fathoms (Rathjen and Yesaki, 1966).

The "humpy" shrimp, Pandalus goniurus, has been caught from the Arctic coast of Alaska southward to Puget Sound, Washington, in depths of 3 to 100 fathoms (Rathjen and Yesaki, 1966). The greatest concentrations are off southeastern Kodiak Island and in the Shumagin Islands. Although overlapping in distribution, the "humpy" shrimp is not as abundant as the northern pink shrimp.

The coonstripe shrimp, Pandalus hypsinotus, has been found from the Bering Sea to the Strait of Juan de Fuca in depths of 3 to 100 fathoms, very similar in range to that of the "humpy" shrimp (Fox, 1972). High concentrations occur off Kodiak Island and in the Shumagin Islands. Coonstripe shrimp comprise a relatively small portion of the commercial catch, largely since they inhabit depths and bottom types that are seldom trawled. A small directed fishery for this species occurs in Kachemak Bay on the Kenai Peninsula. Coonstripe are often taken incidentally to pot fisheries for spot shrimp. The largest prawn size individuals are commonly retained and sold.

The spot shrimp, Pandalus platyceros, has been reported from Unalaska Island to San Diego, California, in depths of 2 to 266 fathoms (Fox, 1972). While the other pandalid shrimps are generally found in areas suitable for trawling, P. playtceros is found in rocky areas unsuitable for trawling. Consequently, areas of major concentration are not well known. Ronholt (1963) reported small quantities taken off Lapush, Washington, and in southeastern Alaska. In addition, pot fisheries are located in the Puget Sound-Vancouver Island area (Butler, 1964) and in scattered areas off central Alaska, principally Kachemak Bay (Barr, 1970a). There are indications from small commercial ventures that Kodiak Island and Alaska Peninsula waters may contain stocks as large as or larger than in other Alaskan waters (McCrary, 1977, personal communications).

The sidestripe shrimp, Pandalopsis dispar, is distributed from the Bering Sea, west of the Pribilof Islands, southward to Manhattan Beach, Oregon, in depths ranging from 20 to 351 fathoms (Fox, 1972). Next to the northern pink shrimp, it is the most abundant shrimp taken commercially in the north Pacific Ocean. The greatest concentrations occur off Kodiak Island and in the Shumagin Islands. The greatest concentrations of sidestripe shrimp are somewhat deeper than northern pink shrimp, generally from 60 to 120 fathoms (Ronholt, 1963).

Most pandalid shrimps are found on mud or sand and mud-mixed bottoms. However, they are not found in all areas where these types of bottoms occur. References to green mud bottoms in relation to large concentrations of the northern pink shrimp, P. borealis, and the ocean pink shrimp, P. jordani, have been made by many authors who infer that the organic content of the bottom is more important in determining distribution than bottom consistency. It should be noted, however, that most sampling has been conducted with trawls which work well only on the type of bottom described above. It is, therefore, inconclusive whether or not many pandalid shrimp concentrate on harder or rockier bottoms. P. platyceros and, to a lesser extent, P. hypsinotus are known to prefer coarse, rocky and coral-covered bottoms (Fox, 1972).

Sexuality

The reproductive life history of pandalid shrimps is rather unique among shellfish. Although reproduction is bisexual, pandalid shrimps exhibit protandric hermaphroditism.

Pandalid shrimps, to a large extent, mature first as males and then later in the life cycle transform into functional females. The morphological changes that accompany sex change usually occur within six to eight months. Individuals who the previous year spawned as a male will spawn the current year as a female. Once an individual has become a female, it remains so throughout the rest of its life.

The literature contains reports on a phenomenon called "primary" females. Primary females may be defined as those individuals who never function as males or, more strictly, as those individuals who mature directly as females, never being hermaphrodites. Dahlstrom (1970) reported primary females in _P. jordani_ off northern California, a few were found by Tegelberg and Smith (1957) off Washington and 47 of a sample by Butler (1964) off British Columbia were primary females. The production of early maturing (or primary) females may be environmentally related or may be a density dependent phenomenon. At any rate, the early maturation of females is a survival adaptation beneficial to the population. Primary females have also been noted in _P. borealis_ and _P. hypsinotus_ in British Columbia (Butler, 1964). Primary females have not been positively documented in Alaskan pandalid shrimp populations, and it is strongly indicated that their occurrence is rare.

A far more important sexual variation is that known as secondary female development. In this instance, male characteristics develop but are repressed before maturity. Sexual maturity and functioning for the remainder of life is as a female. Secondary females are common in southeastern Alaska populations of _P. borealis_, _goniurus_ and _hypsinotus_ but have not positively been shown to occur in other Alaskan areas.

McCrary (1977, personal communication) found some populations of females, especially P. borealis and goniurus, to be comprised of over half secondary females. Numerous authors have reported similar findings for P. jordani off the lower west coast states and British Columbia.

Maturity

The age at sexual maturity varies with the species and by geographical location within a species. The normal situation for pandalid shrimps is that they are protandric hermaphrodites, maturing first as males and then later transforming into functional females. P. danae and P. goniurus apparently mature as males during their first autumn and function again as males at 1 1/2 years in British Columbia (Butler, 1964). The age at first maturity as males is 1 1/2 years for P. borealis, P. hypsinotus, P. jordani, P. platyceros and Pandalopsis dispar (Butler, 1964; and Dahlstrom, 1970). Ivanov (1964a) estimates that P. borealis in the Pribilof Islands area of the Bering Sea do not mature as males until 2 1/2 years. McCrary (1971, personal communication) found the same to be true for P. borealis, Pandalopsis dispar and, to a lesser extent, P. goniurus and P. hypsinotus in Kodiak and Shumagin Island waters. The same author also found these pandalids and P. platyceros to mature at 1 1/2 years in certain southeastern Alaska populations.

The age at transition to functional female also varies with the species and by geographical location within the species. By and large, most shrimp function two years as a male before transforming to a female.

Mating

During summer and early fall eggs ripen in the ovaries of the females and the forming eggs may be seen as a greenish, blueish or yellowish-brown mass, depending on species, lying dorso-laterally under the carapace. Breeding and egg deposition occur from late September through mid-November. The male attaches a sperm mass to the underside of a female between the last two pairs of pereiopods (walking legs). This usually occurs within 36 hours after the female molts into breeding dress (Needler, 1931). Fertilization and oviposition occur as the eggs stream from the oviducts over the sperm masses and become attached to the forward four pairs of pleopods (abdominal appendages) and abdominal segments.

Fecundity

Pandalid shrimps have a high fecundity. The number of eggs per clutch ranges from 500 to 2,500 for *P. jordani* and *P. borealis* (Dahlstrom, 1970). McCrary (personal communication or unpublished A.D.F.& G. data) found 626 specimens of *P. borealis* to carry egg clutches ranging from 478 to 2117. In southeastern Alaska, the same author found full clutch sizes of *P. borealis* to range from 809-1642 (N=21); *P. dispar* 674-1454 (N=21); *P. goniurus* 971-3383 (N=11); *P. hypsinotus* 1083-4528 (N=25); and *P. platyceros* 4044-4528 (N=2). The number of eggs extruded is positively correlated with the size of the shrimp.

Eggs and Larvae

Females carry their eggs externally for about five to six months until hatching. Hatching occurs mainly from March through April for

P. borealis. *P. dispar*, however, often have ovigerous periods which overlap in the June-July period, meaning that the latest hatchers are present at the same time as the earliest egg layers (McCrary, 1977, personal communication). The lengths of spawning, carrying and hatching periods vary inversely with the water temperature, at least for *P. borealis* (Haynes and Wigley, 1969). In laboratory studies, Berkeley (1930) found that most larvae hatch at night during periods of vigorous pleopod movement by the female. Hatching an entire clutch of eggs may take as long as two days. The larvae remain planktonic for about two to three months, passing through six stages to become juveniles, and then settle, taking up a benthonic existence like the adults (Berkeley, 1930).

Juveniles

Little information is available on juvenile shrimp prior to their maturation as adult male shrimp. Differential rearing areas and migration patterns appear to exist between juvenile and adult shrimp. More specific information on this is available in the *Migration and Local Movement* section of this life history report.

Adults

Mortality rates are high for adult pandalid shrimps. *P. borealis* survive a maximum of four to seven years off the Pacific coast with growth decreasing and age increasing as one proceeds north and west. This is true for other pandalid species studied by A.D.F.& G. (McCrary, 1977, personal communication). Estimates of annual survival rates for

P. jordani off California range from 30 to 52 percent for the years 1960-1966 (Dahlstrom, 1970). These estimates were made in the presence of a fishery, so they represent both natural and fishing mortality.

The growth of pandalid shrimps may be generalized as follows: (1) the animal molts, ridding itself of a rigid exoskeleton; (2) water is absorbed, increasing the size of the animal; (3) a new exoskeleton is formed; and (4) the water is gradually replaced by new tissue. Growth in size, therefore, is a step function, increasing in increments at each molt but remaining constant between molting periods.

The most comprehensive study of the growth of Pacific pandalid shrimps is that of Butler (1964). He found that based on ultimate size P. platyceros becomes the largest, followed by Pandalopsis dispar and P. hypsinotus. However, until about two years of age, P. hypsinotus is larger than Pandalopsis dispar. Butler further reported that P. borealis and P. jordani both reach about the same size. Dahlstrom (1970) reports a somewhat faster growth rate for P. jordani off northern California and Oregon, but a slower growth rate off Washington. Studies by Ivanov (1969) indicate that the growth rate for P. borealis in the Bering Sea is slower than those of the western Gulf of Alaska or of British Columbia. A.D.F.& G. studies (unpublished, McCrary, 1969) show that the growth of P. borealis, P. dispar and P. goniurus around Kodiak Island and Shumagin Islands is slower than for these species in southeastern Alaska. Hence, it appears that the growth rate of P. borealis is dependent upon latitude and, consequently, upon water temperature. It is assumed that the other pandalid species exhibit similar growth characteristics.

Pandalid shrimps are carnivorous bottom feeders and feed both by scavengering dead animal material and by preying on living organisms such as amphipods, euphausiids, limpets, annelids and other shrimps.

Pandalid shrimps are subject to a high level of predation, both as planktonic larvae and as benthonic adults. Virtually any large fish in their vicinity is a potential predator. Those noted as feeding on shrimp include the Pacific hake, Pacific cod, sablefish, lingcod, arrowtooth flounder, petrale sole, yellowfin sole, rock sole, flathead sole, various rockfish, spiny dogfish, skates and rays, Pacific halibut, salmon and even harbor seals (Skalin, 1963; Barr, 1970a; Butler, 1970; and Dahlstrom, 1970).

Pandalid shrimp distribution and range is dictated, to a large degree, by temperature and salinity tolerances. On the basis of water temperature, P. borealis and P. jordani are diametrically opposed, with P. borealis being concentrated in colder water (Fox, 1972). The other pandalid species are not so easily delimited. P. goniurus, however, is not found in appreciable quantities off British Columbia or southward, yet it reaches its greatest abundance in the western Gulf of Alaska and Gulf of Anadyr on the Asian coast. P. goniurus is apparently selective toward colder waters. Butler (1964) reported finding all species but P. goniurus in temperatures of 7 to 11°C off British Columbia. Butler's data does not represent minima and maxima since Dahlstrom (1970) reports P. jordani from 5.6 to 11.5°C off northern California. Ivanov (1964b) found fishable concentrations of P. borealis down to 0.5°C in the Bering Sea and Allen (1959) reported specimens of P. borealis taken from water 1.68°C off Europe.

Salinity tolerances are more difficult to find in the literature, with P. jordani having the highest range, 28.7 to 34.6°/oo (Dahlstrom, 1970), and P. borealis the lowest, 23.4 to 30.8°/oo (Butler, 1964). Ivanov (1963), however, found P. borealis at 32.34°/oo off the Shumagins. The remaining ranges reported by Butler (1964) are P. hypsinotus, 25.9 to 30.6°/oo, P. platyceros, 26.4 to 30.8°/oo, and Pandalopsis dispar, 26.7 to 30.8°/oo. McCrary (1977, personal communication) found ranges to be similar to Butler's for southeast Alaska stocks, including P. goniurus.

Diseases

Little is known about the diseases and parasites of pandalid shrimps. Yevich and Rinaldo (1971) reported a condition in P. borealis off Maine termed the black spot gill disease. This disease results in the destruction of gill lamellae and in the formation of a chitinous growth over the damaged area producing a black spot. A similar condition was observed by Fox (1972) and A.D.F.& G. staff in a few specimens of P. borealis caught off Kodiak Island.

Butler (1970) reported the infestation of a male P. platyceros by a rhyocephalan, Sylon sp., in British Columbia waters. He stated that there are no records of isopod parasites on P. platyceros. However, Fox (1972) reports that most species of pandalid shrimps are parasitized to some degree by bopyroid isopods (Bopyrus sp.). McCrary, (1977, personal communication) has observed P. borealis and P. goniurus to be commonly infested by a rhyocephalon in southeast Alaska and bapyrid isopods to be common on P. dispar throughout the Gulf of Alaska. The isopods, a large female and the smaller male together, attach in the gill area. The shrimp's carapace then forms around them after molting and produces the characteristic "bubble".

Migration and Local Movement

Pandalid shrimps are known to undergo migrations onshore-offshore, coastwise and vertically in the water column. Extensive migrations in European waters are well documented (Mistakidis, 1957), but less so in the northeastern Pacific Ocean.

Migration associated with age has been documented by Berkeley (1930) for *P. borealis*, *P. hypsinotus*, *P. platyceros* and *Pandalopsis dispar*. Freshly hatched larvae were found around or near the vicinity of the spawned adults. At about the third stage of development, the larvae were found segregated in shallower water 5 to 35 fathoms deep where they spent their first summer. Later, during their first winter, the juveniles joined the adult population in deeper waters. Dahlstrom (1970), however, states that juvenile *P. jordani* are found among the adults throughout their life cycle. McCrary (1976, unpublished report) reported that *P. borealis* generally exhibits an inshore to offshore distribution by size, although adults and juveniles inhabit a wide range of depths, especially from late spring through early fall. McCrary further reported that adults of all ages are occasionally found in commercial quanties in the 15-25 fathom range, although it is generally smaller males (1+ and 2+ age groups) that frequent these relatively shallow waters. A.D.F.& G. sampling with try nets over a broad depth zone by season has indicated that during the first year of life, _P. borealis_ is primarily found at depths ranging from about 35 fathoms to over 120 fathoms. First year shrimp are most abundant at depths and in the areas where adults are found. Thus, it would appear that the larval stages are completed and post larval shrimp aggregate in areas near the points of larval release by adults. From one to two years of age, juveniles begin utilizing bottom habitats of 20 to 40 fathoms with increasing frequency, although dense aggregations are still found at depths of 50 to 70 fathoms. Utilization of shallower bottom habitats occurs primarily from spring through fall. During the winter, _P. borealis_ is generally absent from inner bay waters of less than 30 fathoms when bottom temperatures may be less than 2°C and ice cover may be present. At the same time, in middle and outer bays and gullies where northern shrimp are most concentrated, temperatures may range from 1 to 2°C warmer than innermost bays of comparable depth.

A general tendency that seems to hold for all pandalid shrimp encountered during A.D.F.& G. studies is that pandalids are distributed in one of two ways: (1) younger age groups shallower, older age groups deeper; and (2) older age groups offshore, younger age groups inshore. Reasons for this are suggested by the evidence with regard to salinity and temperature. Older sexually mature shrimp, especially ovigerous females, prefer deeper depth zones where these two parameters are more stable and less variable. Conversely, the younger individuals, particularly those prior to first sexual maturity, are tolerant of a broader range of salinities and temperatures and are often abundant in the shallower depth zones where these two parameters are generally more variable (McCrary, 1976, unpublished report).

Area migrations of the adult populations are less well documented. P. jordani off California are known to exhibit short spawning migrations during the winter into deeper water and short summer migrations, ostensibly in search of food (Dahlstrom, 1970).

Diel vertical migrations are common among some pandalids. Many P. borealis leave the bottom during late afternoon or evening and return to near, or on, the bottom about dawn in Kachemak Bay (Barr, 1970b). The period of time that the shrimp remained away from the vicinity of the bottom varied directly with the season's number of hours of darkness. Pearcy (1970) reported the same phenomenon for P. jordani off the coast of Oregon. He suggested that diel migrations are related to feeding behavior since the shrimp fed mainly on euphausiids and copepods which also make diel migrations. Pearcy also suggested that these movements may be evolutionary protection and dispersal mechanisms. Chew, et al., (1971) stated that P. platyceros exhibited a diel bathymetric distribution after finding high catches in shallow water at night in Dabob Bay, Washington, but in deeper water during the day.

Literature Cited

Ivanov, B.G. 1964b. Biology and distribution of shrimps during winter in the Gulf of Alaska and the Bering Sea. Trudy VNIRO, Vol. 53 (Soviet Fisheries Investigations in the Northeast Pacific, U.S. Dept. Int. Trans., 1968, 176-190 p.).

Ivanov, B.G. 1969. The biology and distribution of the northern shrimp (Pandalus borealis Kr.) in the Bering Sea and the Gulf of Alaska. FAO Fish. Rept. 57(3):800-810.

McCrary, J.A. 1971. Pandalid shrimp studies project, Ann. Tech. Rept. Comm. Fish. Res. Devel. Act. (Unpublished ms.)

Mistakidis. 1957. The biology of Pandalus montaqui Leach. Fishery Invest. (Gr. Britain), Ser. 2, 21(4):52.

Needler, A.B. 1931. Mating and oviposition in Pandalus danae. Can. Field Nat. 45(5):107-8.

Pearcy, W.G. 1970. Vertical migration of the ocean shrimp, Pandalus jordani: a feeding and dispersal mechanism. Calif. Fish and Game 56(4):125-129.

Pearcy, W.G. 1971. Diel changes in the behavior of pink shrimp. (Abstract) National Shellfish Assn., 63rd Ann. Conv. (Unpublished.)

Rathbun, M.J. 1904. Decapod crustaceans of the Northwest Coast of America. Harriman Alaska Series 10:1-210.

Rathjen, W.F. and M. Yesaki. 1966. Alaska shrimp explorations, 1962-64. Comm. Fish. Rev. 28(4):1-14.

Ronholt, L.L. 1963. Distribution and relative abundance of commercially important pandalid shrimps in the Northeastern Pacific Ocean. U.S. Fish. and Wildl. Serv., Spec, Sci. Rept.-Fish. No. 449. 28 p.

Skalin, V.A. 1963. Diet of flatfishes in the southeastern Bering Sea, Izvestiya TINRO, Vol. 51 (Soviet Fisheries Investigations in the Northeast Pacific, U.S. Dept. Int. Trans., 1968, P. 235-250).

Tegelberg, H.C. and J.M. Smith. 1957. Observations on the distribution and biology of the pink shrimp (Pandalus jordani) off the Washington coast. Wash. Dept. Fish. Res. Pap. 2(1):25-34.

Yevich, P. and R.G. Rinaldo. 1971. Black spot gill disease of Pandalus borealis (Abstract) Nat. Shellfish Assn., 63rd Ann. Conv. (Unpublished.)

Literature Cited

Allen, J.A. 1959. On the biology of Pandalus borealis Kroyer, with reference to a population off the Northumberland Coast. J. Mar. Biol. Ass. 38:189-220.

Barr, L. 1970a. Alaska fishery resources-the shrimps. U.S. Fish. Wildl. Serv., Fish. Leaflet 631. 10 p.

Berkeley, A.A. 1929. A study of the shrimps of British Columbia. Biol. Bd. Can., Prog. Rept. (Pacific) 4:9-10.

Berkeley, A.A. 1930. The post-embryonic development of the common pandalids of British Columbia. Contrib. Can. Biol. 10(6):79-163.

Butler, T.H. 1964. Growth, reproduction, and distribution of pandalid shrimps in British Columbia. J. Fish. Res. Bd. Can. 21(6):1403-1452.

Butler, T.H. 1968. The shrimp fishery of British Columbia. FAO Fish. Rept. 57(2):521-526.

Butler, T.H. 1970. Synopsis of biological data on the prawn Pandalus platyceros Brandt, 1851. FAO Fish. Rept. 57(4):1289-1315.

Chew, K.K., J.W. Wells, D. Holland, D.H. McKenzie and C.K. Harris. 1971. January size frequency distribution of Pandalopsis dispar and Pandalus platyceros trawled in Dabob Bay, Hood Canal, Washington from 1966 to 1971. (Abstract) Nat. Shellfish Assn., 63rd Ann. Conv. (Unpublished.)

Dahlstrom, W.A. 1970. Synopsis of biological data on the ocean shrimp Pandalus jordani Rathbun, 1902. FAO Fish. Rept. 57(4):1377-1416.

Fox, William W. 1972. Shrimp resources of the northeastern Pacific Ocean. Pages 313-337 in Donald H. Rosenberg. 1972. A review of the oceanography and renewable resources of the northern Gulf of Alaska. University of Alaska, Institute of Marine Science.

Haynes, E.B. and R.L. Wigley. 1969. Biology of the Northern Shrimp, Pandalus borealis, in the Gulf of Maine. Trans. Amer. Fish. Soc. 98(1):60-76.

Hynes, F.W. 1929. Shrimp fishery of southeast Alaska. U.S. Rept. Comm. Fish. 1929. 1-18 p.

Ivanov, B.G. 1964a. Results in the study of the biology and distribution of shrimps in the Pribilof area of the Bering Sea. Trudy VNIRO, Vol. 49 (Soviet Fisheries Investigations in the Northeast Pacific, U.S. Dept Int. Trans., 1968, 115-125 p.).

LIFE HISTORY - WEATHERVANE SEA SCALLOP

Taxonomy

The weathervane sea scallop, _Patinopecten caurinus_, is a member of the Lamellibranchia clams of the family Pectinidae. Keen (1963) described its taxonomy as follows:

Class: Pelecypoda
Subclass: Pteriomorphia
Order: Pteroconchida
Superfamily: Pectinacea
Family: Pectinidae
Genus: _Patinopecten_ [formerly known as _Pecten_ (Gould)]

Distribution

Although small numbers of weathervane sea scallops have been taken incidental to other fisheries from California to Alaska, the major commercial concentrations of this species are centered in the Kodiak Island and the Cape Fairweather to Cape Saint Elias area (Yakutat region) of the Gulf of Alaska (Hennick, 1970a). Trace amounts of scallops have also been dredged off the lower Kenai Peninsula, Shelikof Strait, and off Montague Island. Exploratory surveys in the Bering Sea and Alaska Peninsula area have revealed no extensive beds of scallops (Hennick, 1970b). Ronholt and Hitz (1968) reported that commercial quantities of weathervane sea scallops did not appear to be present in waters off Oregon. Thus, it appears that the Kodiak Island and Yakutat areas are the only regions that can support commercial exploitation of scallops in the Gulf of Alaska.

Exploratory surveys, largely conducted by the National Marine Fishery Service, have indicated that weathervane sea scallops are most abundant in depths of between thirty and seventy fathoms (Alverson, 1968). Gravel and sand, with some mud, is typical of Alaska scallop beds (Hennick, 1973).

The three major commercial scallop beds in Alaska may be described as follows (Hennick, 1973):

AREA 1	Yakutat, between Cape Saint Elias and Cape Spencer. Primarily mud-sand-clay or silt overburden. Productive areas between thirty and sixty fathoms in depth, twenty to forty miles offshore.
AREA 11	Westside Kodiak Island, between Cape Skolik to Afognak Island including that area of the Alaska Peninsula bordering Shelikof Strait adjacent to Kodiak Island proper. Primarily gravel-sand-mud or silt bottom. Productive areas twenty to seventy fathoms within three miles of shore.
AREA 111	Albatross, Marmot, Portlock Banks. Primarily rock, gravel, and sand bottoms. Productive areas between twenty-five to seventy-five fathoms, extending inshore and out to fifty miles or more offshore.

Sexuality

The weathervane sea scallop is heterosexual and sexually dimorphic. The sex of mature adult scallops can be distinguished by the characteristic white coloration of the testes and the bright orange of the ovaries (Hennick, 1970a). There are no superficial characteristics that indicate the sex.

Maturity

Scallops are aged by counting the growth rings, or annuli, on the shell. Although this method may not always provide the correct age, especially with older scallops, it gives a good estimate of age for younger scallops. Studies conducted in the Yakutat and Kodiak areas indicate that most weathervane sea scallops attain sexual maturity at age three and that all scallops at age four are mature (Hennick, 1970a). In addition, Hennick found that most scallops which exceed 100 mm in shell height are sexually mature.

Mating

Studies conducted by Hennick (1970a) indicate that weathervane sea scallops spawn only once annually. The spawning period normally occurs during June and early July and is apparently triggered by rising water temperatures. The sexes are separate and fertilization occurs externally. As the eggs and spermatozoa ripen, they are released through the kidney and are expelled into the water where fertilization is a random occurrence.

Fecundity

No information is available in the literature describing the fecundity of weathervane sea scallops.

Eggs and Larvae

After fertilization occurs in the open water, the eggs settle to the bottom and become attached to objects in the substrate. Hatching occurs within two to three days time (Hennick, 1973). Development is dependent upon water temperature, with higher temperatures producing faster growth. The larvae at this stage are capable of swimming and become planktonic, drifting with the tides and currents. During this planktonic stage, metamorphological changes take place and within two and one-half to three weeks the larvae settle to the bottom substrate and assume an adult form (Hennick, 1973).

Mortality is high during the larval stage, both from environmental factors and predation. Planktonic feeders, both fish and shellfish, including adult scallops, feed upon the drifting planktonic scallop larvae.

Juvenile

Complete basic studies on the life history cycle of weathervane sea scallops have not been conducted, especially in the juvenile stage. Hence, little information is available for this life stage. Based on studies of sea scallops elsewhere, however, the following observations can be made. After the larva settles to the bottom, the juvenile scallop may attach itself to the bottom, move around through the use of the foot appendage which later becomes residual, or swim. The juvenile at this stage is leptocephalus or transparent. Within a few months, pigmentation of the shell takes place and the animal appears identical to the adult form.

Adults

After reaching sexual maturity at about three to four years of age, weathervane sea scallops continue to grow. Studies conducted by Hennick (1973) indicate that growth is more rapid during the first ten to eleven years, then tends to slow as age advances. The meats of old, aged scallops actually tend to decrease in weight

(Hennick, 1973). In light of this growth phenomena, weathervane sea scallops should ideally be harvested between seven and eleven years of age, both from a biological and economic viewpoint.

There is little documented information on the longevity of weathervane sea scallops. Exploratory surveys and commercial catch data indicate a scarcity of scallops over 15 years of age. However, Hennick (1973) reported scallops recovered with as many as twenty-eight annual rings.

The growth rate of weathervane sea scallops is subject to regional differences. Based on Hennick's (1973) studies, the meats of scallops from the Yakutat area at a given age are much smaller than those from either of the Kodiak Island areas. Additionally, scallops from the Marmot, Albatross, and Portlock areas of Kodiak Island are the largest at any given age of all scallops in the Gulf of Alaska This phenomena is of great importance to the commercial fishermen as scallops from the Kodiak area have average meat weights nearly twice as large as those from the Yakutat area, meaning only half as many need be handled in order to obtain the same volume of salable product.

Weathervane sea scallops are planktonic filter feeders, consuming bottom detritus and drifting plankton. The opening and closing of the valves draws water into the mantle cavity. The circulation of water within the mantle cavity and gill areas provides a food source and enables respiratory functions to occur.

It is interesting to note that scallops are the only bivalve molluscs capable of swimming (Hennick, 1973). This is accomplished through relaxation of the adductor muscle, causing the valves to part and draw water into the mantle cavity. The scallop then rapidly contracts the large adductor muscle forcing water out. Rapid repetition of this function enables the scallop to rise off the bottom and essentially swim.

Predation is often high on weathervane sea scallops, with the major predators including cod, plaice, wolffish, and starfish.

Disease

Hennick (1973) reported the presence of marine boring worms on the shells of weathervane sea scallops from the Yakutat region. Nearly all of the scallops were heavily infected. However, infestation by marine boring worms in the Kodiak region is rare.

Migration and Local Movement

Little information is available concerning the migrations and local movements of weathervane sea scallops. Adult scallops are capable of independent movement but the extent or direction of any movement is not known.

Literature Cited

Alverson, D.L. 1968. Fishery resources in the northeastern Pacific Ocean. In The future of the fishing industry of the United States. Univ. of Wash. publications in fisheries-New Series. 4:96-97.

Hennick, D.P. 1970a. Reproductive cycle, size at maturity, and sexual composition of commercially harvested weathervane scallops, Patinopecten caurinus in Alaska. J. Fish. Res. Bd. Can. 27:2112-2119.

Hennick, D. 1970b. The weathervane scallop fishery of Alaska with notes on occurrence in Washington and Oregon. 22nd Ann. Rept. of the Pac. Mar. Fish. Comm. 1969. Appendix 3-Spec. Rept. 33-34.

Hennick, D. 1973. Sea scallop, Patinopecten caurinus, investigations in Alaska. Completion report, Commercial Fisheries Research and Development Act, Project No. 5-23-R.

Keen, M.A. 1963. Marine molluscan genera of western North America. Stanford Univ. Press. 126 p.

Ronholt, L.L. and C.R. Hitz. 1968. Scallop explorations off Oregon. Comm. Fish. Rev. 30(7): 42-49.

LIFE HISTORY - CLAMS

The clam resource of the Gulf of Alaska consists of approximately one hundred and sixty different species of clams, about twenty-eight of which can be utilized commercially (Baxter, 1965). The fishery is essentially supported by three species, the razor clam, (*Siliqua patula*), the butter clam (*Saxidomus giganteus*), and the cockle (*Clinocardium nuttalli*). Minor species, usually taken in the sports catch, include the Manila clam (*Venerupus japonica*), the little neck clam (*Protothaca staminea*), the horse clam (*Schizothaerus nuttalli*), and gapers (*Tresus nuttali* and *T. capax*). In addition, there appears to be substantial stocks of soft-shell clams (*Mya truncata*) at Cold Bay, Kachemak Bay, and Prince William Sound, Alaska (Kirkwood, 1967). Large populations of surf clams (*Spisula alaskana*) also occur subtidally in many areas of central Alaska. However, the importance, size and distribution of populations of minor clam species which may have a commercial potential is largely unknown.

In the following section, a summary of the taxonomy, distribution, and life history of the three principal commercial species, razor, butter, and cockle clams, in Alaska is given.

Razor clams

Taxonomy

The razor clam, *Siliqua patula*, is a member of the Lamellibranchia clams of the family Solenidae. Nosho (1972) described its taxonomy as follows:

Phylum: Mollusca
Class: Lamellibranchia
Family: Solenidae
Genus: *Siliqua*
Species: *S. patula*

Distribution

The razor clam is found from Pismo Beach, California, to the Bering Sea (Amos, 1966). It occurs in commercial quantities from Tillammok Head, Oregon, to the western end of the Alaska Peninsula. In Alaska, commercial stocks are found on the shores of Cook Inlet, Orcas Inlet, the Copper River delta near Cordova, and the mainland side of Shelikof Strait.

Razor clams are found intertidally to several fathoms in depth on the sandy ocean beaches of the open coast. Fine sand with some glacial silt, as found at Karls Bar located at Orcas Inlet near Cordova, is typical of Alaska clam producing areas (Weymouth and McMillan, 1931). Near Kodiak, the large beds at Swickshak and Hallo Bay consist of fine sand, volcanic ash and some glacial mud. In Cook Inlet, razor clams are found in substrata varying from almost entirely coarse white sand (Deep Creek area) to a fine sand-clay-gravel mixture at Clam Gulch (McMullen, 1967).

Razor clams may be found in the mouths of coastal harbors, but growth is usually inferior in these locations. They are not found in enclosed bodies of water.

Sexuality

The razor clam is hererosexual and sexually dimorphic. However, only through examination of the gonads is it possible to tell the sex of the clam. There are no superficial characteristics that indicate the sex. Examination of the contents of the gonads reveals a marked difference between sexes. The female ova have a granular appearance, in contrast to the viscous homogeneous mass in which the sperm is found.

Maturity

Razor clams are aged from growth rings on the shell. Although the method may not always provide the correct age, especially with older clams, it gives a good estimate of age for younger clams. In addition, accurate aging is hindered by the presence of summer growth checks (false annuli) on the shell which, it is believed, are caused by disturbed growth through tidal action.

Razor clams in the northwest Pacific reach sexual maturity after two or more years, or a shell length of approximately 100 mm (Nosho, 1972). Razor clams of the northern beds do not reach sexual maturity until much later. Clams of the Swikshak and Cordova beaches do not mature until their fifth and sixth years, respectively (Weymouth and McMillan, 1925). However, Cook Inlet clams appear to grow much faster, reaching maturity in their third year (McMullen, 1967).

Mating

Spawning occurs in the spring or summer when rising water temperatures reach 13°C (Nosho, 1972). In Alaska, this usually occurs in July. Studies conducted in Prince William Sound indicate that spawning timing can be computed by monitoring the cumulative maximum daily water temperature (Personal communication with Richard Nickerson, A.D.F.&G., Cordova, 1975). Razor clams spawning occurs when the cumulative maximum daily water temperature reaches 1,350 temperature units; with the cumulative total computed by suming the daily maximum degree units above or below 32°F from January 1 on. The 50% spawning level is generally reached when the cumulative total reaches 1,500 temperature units.

Spawning occurs for several weeks as eggs and sperm ripen and are discharged through the excurrent siphon. Fertilization occurs in the open water with surf action mixing the eggs and sperm.

Fecundity

The number of eggs carried by the female razor clam ranges between six to ten million eggs annually (McMullen, 1967).

Eggs and Larvae

After fertilization occurs in the open water, the eggs hatch into larvae within a few hours to a few days. Development is dependent upon water temperatures, with higher temperatures producing faster growth rates. The larvae exists as free swimming veligers (ciliated larvae) for five to sixteen weeks (Oregon Fish Commission, 1963). After the veliger stage, the young clams develop a shell and settle to the bottom where they "set" into the top layer of sand upon reaching an average shell length of 13 mm (Tegelberg, 1964). In years of heavy setting, as many as 1,000 to 1,500 young clams per square foot of beach may be found.

Mortality is extremely high during the larval stage. The pelagic larvae are subjected to a high level of predation by planktonic feeders. Unfavorable currents may also carry the larvae away from desirable habitat.

Juveniles

After settling to the bottom, juvenile growth is slow throughout the fall and winter. Growth accelerates during the spring and summer with warmer waters and increased food supply. After the first winter, young clams reach a length of about four-fifths of an inch in the Cordova district. An average length of four and one-half inches is attained in three and one-half years in the southern beds as compared to six and one-half years in the Cordova region (Amos, 1966).

The growth rate varies with locality. In Alaska, initial growth rate is slower than in the northwest states; however, after several years, the relative growth rate is higher (Weymouth and McMillan, 1931). Generally, razor clams have a larger final size and grow older in the northern beds than in the southern beds.

Adults

The maximum age for razor clams is highly variable with clams of the northern beds living longer than those of the southern beds. Clams collected at Pismo Beach, California, do not exceed five years in age, while Washington clams grow up to nine years. In Alaska, ages up to nineteen years have been recorded (Weymouth and McMillan, 1931).

Adult razor clams live in the intertidal zone where they lie buried in the sand with their necks, or siphons, protruding above the surface. During the low water stages, when the clams are exposed, their siphons are covered with a thin layer of sand which makes detection of the clams difficult. The clams can move through the sand very rapidly, averaging several feet per minute. Their unusual ability to move so fast is due to their foot, which is an effective burrowing organ. In digging, the foot of the clam is projected half the length of the shell and pushed into the sand. Below the surface the tip of the foot expands forming a strong anchor. Then the foot muscles contract pulling the clam downwards. The clam can repeat this movement in rapid succession. It has been observed that clams laid on the top of the sand have buried themselves completely in less than seven seconds (Loosanoff, 1947).

Razor clams are filter feeders, consuming bottom detritus and drifting plankton. Food particles are brought in along with water through the incurrent tube. Small hairlike structures (cilia) on the gills filter the food particles out. The food particles are then passed to the sensitive palps near the mouth for sorting, and are then ingested.

Predation is often high on razor clams, with the major predators including starfish, crabs, rays, octopus, and starry flounders.

Disease

As with all animals, razor clams are subject to disease. Marine bacteria and fungi are often injurious to clam larvae. In addition, razor clams are also subject to the problem of paralytic shellfish poisoning (PSP), as are all bivalve mollusks. PSP is associated with plankton blooms and is properly called *Gonyaulax* poisoning (Hayes, 1967). The causative organisms are believed to be the dinoflagellates *Gonyaulax catenella* and *G. acatenella*. The toxin is accumulated as a direct result of feeding on these organisms. PSP is extremely toxic and is one of the most potent materials known to man. The poison is a metabolic product of the dinoflagellate. It is believed that PSP directly affects the nerve and muscle membrane, blocking the passage of nervous impulses, and eventually resulting in paralysis of the diaphragm and death by suffocation if enough toxin is ingested.

Razor clams, unlike other mollusks, do not retain the toxin over a long period of time. The toxin is rapidly eliminated from the tissue by normal metabolic activity. In addition, the toxin does not build up to high levels in the tissue, but is concentrated in the digestive tract. Thorough cleaning and removal of the digestive tract will remove most, if not all, of the toxin.

Migration and Local Movement

Little is known concerning the migrations and local movements of razor clams. At the present, there is little evidence that razor clams move horizontally or migrate between areas. However, heavy surf action along exposed beaches is often responsible for the movement of razor clams laterally along the beach as well as onshore-offshore movements.

Butter Clams

Taxonomy

The butter clam, *Saxidomus giganteus*, is a member of the Lamellibranchia clams of the family Veneridae. Nosho (1972) described its taxonomy as follows:

Phylum: Mollusca
Class: Lamellibranchia
Family: Veneridae
Genus: *Saxidomus*
Species: *S. giganteus*

Clams of the species, *S. giganteus*, have been referred to as Washington clam, quahog, Coney Island clam, beef-steak clam, butter clam, and great Oregon clam. At the present, butter clam is the accepted common name.

Distribution

The butter clam is found from Humboldt Bay, California, northward to the Aleutian Islands. They are distributed from the lower levels of exposed tide flats out to depths of over thirty fathoms in some areas (Amos, 1966). Baxter (1971) indicated that the optimum habitat for butter clams is narrowly defined by tidal levels; primarily between mean low water and lowest low water. Butter clams appear to prefer a mixed gravel-sand-mud substratum, although they occasionally occur in sand bottoms. They generally occupy the upper twelve inches of the substratum, most commonly six to ten inches beneath the surface.

Sexuality

The butter clam is heterosexual and sexually dimorphic. However, only through examination of the gonads is it possible to determine the sex of the clam. The female ova have a granular appearance, in contrast to the viscous homogeneous mass in which the sperm is found.

Maturity

As are all clams, butter clams are aged from growth rings on the shell. Although this method may not always provide the correct age, especially with older clams, it gives a good estimate of age for younger clams.

The growth rate for butter clams is extremely slow in Alaskan waters. Baxter (1965) reported that butter clams may take from fifteen to twenty years to reach sexual maturity at a size of two and one-half inches in diameter.

Mating

Spawning occurs in the spring or summer when rising water temperatures reach 20°C (Breese and Phibbs, 1969). Unlike most clams, butter clams require fairly warm water to successfully spawn. For this reason, successful spawning and setting of butter clams is at best sporadic in the cool Alaskan waters. Amos (1966) reported certain British Columbia butter clam beds that have had only one major spawning and setting in twenty years. This inability to reproduce was attributed to low water temperatures.

When water temperature requirements are met, spawning will occur over several weeks as eggs and sperm ripen and are discharged through the excurrent siphon. Fertilization occurs externally in the open water with surf action mixing the eggs and sperm.

Fecundity

Little information is available in the literature describing the fecundity of butter clams. However, like all clams, the number of eggs carried annually by the female is quite large.

Eggs and Larvae

After fertilization occurs in the open water, the fertilized eggs develop into free swimming larvae. The larvae exist as free swimming veligers (ciliated larvae) for 20 to 30 days before developing a shell and settling to the bottom where they "set" into the top layer of the substrate. The rate of development is dependent upon water temperatures with higher temperatures producing faster growth rates.

Mortality is extremely high for butter clams during the larval stage. The pelagic larvae are subject to a high level of predation by planktonic feeders. Adult butter clams, as well as other bivalve mollusks, contribute heavily to the predation upon the pelagic larvae. In addition to predation, unfavorable currents, generated by storms, may carry the larvae away from desireable habitat.

Juveniles

Progressive growth for juvenile butter clams is extremely slow, particularly in Alaska. Baxter (1965) indicates that butter clams in Alaskan waters may take from fifteen to twenty years to reach a size of two and one-half inches or sexual maturity.

Predation is often quite high on juvenile butter clams, particularly at the "setting" stage. The young clams are concentrated in the upper layer of the substrate and are vulnerable to predation by crabs, starfish, and numerous demersal fishes.

Adults

Adult butter clams live in the intertidal zone where they lie buried in the sand with their necks, or siphons, protruding above the surface. Food particles, along with water, are brought into the siphon through the incurrent tube. The food particles are filtered out by small hairlike structures (cilia) on the gills and are then passed to the sensitive palps near the mouth for sorting and ingestion. Butter clams are filter feeders, consuming primarily bottom detritus and drifting plankton.

Adult butter clams, as are the other life stages, are also subject to predation. Crabs, particularly dungeness crab, star fish, octopus, and numerous other demersal fishes are the major predators.

Disease

There is little documentation in the literature as to the specific diseases of butter clams. However, marine bacteria and fungi are known to often be injurious to clam larvae in general. In addition, butter clams are also subject to the problem of paralytic shellfish poisoning (PSP), as are all bivalve mollusks (refer to razor clam life history - diseases for specifics on PSP poisoning). Unlike razor clams, PSP toxin in butter clams is concentrated and retained in primarily the siphon tissue. The toxin is eliminated very slowly by metabolic activity. This retention is particularly dangerous in the northern part of the butter clams' range, where colder waters slow down metabolic activity. Butter clams in these localities may still retain lethal concentrations of the toxin one year or more after the initial exposure to PSP.

Migration and Local Movement

Little is known concerning the migrations and local movements of butter clams. At the present, there is little evidence that butter clams move horizontally or migrate between areas. However, heavy surf action along exposed beaches may be responsible for movement laterally along the beach as well as onshore-offshore movements.

Cockles

Taxonomy

The cockle, *Clinocardium nuttalli*, is a member of the Lamellibranchia clams of the family Cardiidae. Nosho (1972) described its taxonomy as follows:

Phylum: Mollusca
Class: Lamellibranchia
Family: Cardiidae
Genus: <u>Clinocardium</u>
Species: <u>C</u>. <u>nuttalli</u>

Clams of the species, <u>C</u>. <u>nuttalli</u>, have been referred to as heart cockle, basket cockle, and cockerel. In common usage, the simple use of the name cockle is primarily used.

Distribution

The cockle is found from San Diego, California, northward to the Bering Sea. It is most abundant in British Columbia and in Puget Sound, Washington; although minor concentrations exist in the Kodiak Island and Cordova regions (Nosho, 1972). Cockles are generally found in both intertidal and deep water, one to three inches beneath the surface of the bottom and are often only partially buried. They appear to prefer a substratum of mixed sand and mud and are commonly found on eel-grass flats (Quayle, 1970).

Sexuality

The cockle differs from razor and butter clams, as well as most other clams, in that it is hermaphroditic (Amos, 1966). Individuals produce both sperm and eggs during the same season.

Maturity

Cockles, as are other clams, are aged from growth rings on the shell. Although this method may not always provide the correct age, especially with older clams, it gives a good estimate of age for younger clams. Amos (1966) indicates that cockles reach sexual maturity at the age of two years.

Mating

The mating behavior of cockles is quite different from most clams in that it is hermaphroditic, i.e., individuals produce both sperm and eggs. Unlike pandalid shrimp, which mature first as males and then later as females, cockles produce both sperm and eggs within the same season. Usually, the eggs are discharged first and the sperm later in the season, although both may be liberated simultaneously.

Spawning occurs in the summer with rising water temperatures and continues for some time. Fertilization occurs externally in the surrounding waters with surf and wave action mixing the eggs and sperm.

Fecundity

Little information is available in the literature concerning the fecundity of cockles. However, like all clams, the number of eggs discharged annually is quite large.

Eggs and Larvae

After fertilization occurs in the open water, the eggs develop into free swimming larvae, or veligers. The veligers remain planktonic until they develop a shell and settle to the bottom. The rate of development is dependent upon water temperature with warmer temperatures producing faster growth rates.

Mortality is extremely high for the pelagic larvae. Predation by other mollusks, including adult cockles, and numerous plankton feeding fishes is quite high. In addition, mortality may result from the movement of the larvae to undesireable habitat by unfavorable currents generated by storms.

Juveniles

Similar to razor clams, the progressive growth of juveniles cockles is faster in its southern range than it is in the northern portion of its range (Amos, 1966). Growth is slow during the fall and winter, but accelerates rapidly during the spring and summer with warmer waters and an increased food supply.

Cockles are particularly vulnerable at the "setting" stage to predation by crabs, particularly dungeness crab, starfish, starry flounder, and other demersal fishes. Tidal movements or heavy storm driven wave activity may relocate the young juveniles into undesireable habitat which will slow or stop the growth rate.

Adults

The maximum age for cockles is somewhat variable, with some indications that cockles in the northern beds grow older than those in the southern beds. However, generally, they live to be about eight years old; although Amos (1966) reports a cockle which was ten years old. The average size of commercially marketed cockles is usually three to four inches. Amos (1966) reported one specimen as four and three-fourth inches from hinge to edge and weighing 26 ounces.

Cockles are filter feeders, consuming bottom detritus and drifting plankton. Free swimming planktonic cockle larvae should also be included as a food item, for these are ingested along with other planktons.

Disease

There is little documentation in the literature as to the specific diseases of cockles. Most bivalve mollusks, however, are subject to infestation by marine bacteria and fungi. In addition, cockles are subject to the problem of paralytic shellfish poisoning (refer to razor clams life history - diseases for specifics on paralytic shellfish poisoning). The toxin is concentrated in the muscle tissue of cockles and is only slowly released by normal metabolic activity. Consequently, the clams may remain toxic year-round following a paralytic shellfish poisoning outbreak. This is particularly true in the northern range where cooler waters slow down the metabolic rate.

Migration and Local Movement

The migrations and local movements of cockles are poorly documented. At the present, there is little evidence that cockles move horizontally or migrate between areas. Baxter (1971), however, indicates that the cockle is the only species of hard-shell clam in Prince William Sound, Alaska, that is capable of changing postion in the adult stage. However, their movement appears to be limited and rarely exceeds twenty feet. Heavy surf and wave action along exposed beaches may be responsible for movement laterally along the beach as well as onshore-offshore movements.

Literature Cited

Amos, M.H. 1966. Commercial clams of the North American Pacific coast. U.S. Fish and Wildl. Serv. Circ. 237. 18 p.

Baxter, R. 1965. The clam resource of Alaska. Pages 3-4 in W.A. Felsing, Jr. 1965. Proceedings of joint sanitation seminar on North Pacific Clams, Sept. 24-25, 1965. U.S. Public Health Service and Alaska Dept. Health and Welfare.

Baxter, Rae E. 1971. Earthquake effects on clams of Prince William Sound. Pages 238-245 in The Great Alaska Earthquake of 1964, Biology volume. Published 1971 by the National Academy of Sciences.

Breese, W.P. and F.D. Phibbs. 1970. Some observations on the spawning and early development of the butter clam Saxidomus giganteus (Deshayes). Proc. Nat. Shellfish. Assn., 1969. 60:95-98.

Hayes, M. 1967. Review of the shellfish toxicity problem in Alaska waters. Page 2 in E. Haynes and J. McCrary. Minutes of the first Alaskan shellfish conference, May 23-26, 1967. Alaska Dept. Fish and Game, Info. Leaflet No. 106.

Loosanoff, U.L. 1947. Commercial clams of the Pacific coast of the United States. V.L. Bur. Fish and Wildl. Fish Leaflet No. 223.

McMullen, J.C. 1967. Some aspects of the life history of razor clams Siliqua patula (Dixon) in Cook Inlet, Alaska. Alaska Dept. Fish and Game, Info. Leaflet No. 110. 18 p.

Nosho, Terry, Y. 1972. The clam fishery of the Gulf of Alaska. Pages 351-360 in Donald H. Rosenberg. 1972. A review of the oceanography and renewable resources of the northern Gulf of Alaska. University of Alaska, Institute of Marine Science.

Oregon Fish Commission. 1963. Razor clams. Educ. Bull. 4, Portland, Ore. 13 p.

Quayle, D.B. 1970. Intertidal bivalves of British Columbia. British Columbia Prov. Mus. Dept. Educ., Hand. No. 17.

Tegelberg, H.D. 1964. Growth and ring formation of Washington razor clams. Wash. Dept. Fish., Fish Res. Papers 2(3):69:103.

Weymouth, F.W. and H.C. McMillan. 1931. Relative growth and mortality of the Pacific razor clam (Siliqua patula, Dixon) and their bearing on the commercial fishery. U.S. Bur. Fish., Bull. No. 46. 543-567 p.

Weymouth, F.W., H.C. McMillan and H.B. Holmes. 1925. Growth and age at maturity of the Pacific razor clam, Siliqua patula (Dixon) U.S. Bur. Fish., Bull. No. 41. 201-236 p.

ARCTIC CHAR

Description

Arctic char (Salvelinus alpinus) are members of the Salmonidae family. Color of Arctic char is extremely variable and differs with size, habitat and time of year. Typically, in fresh, sea run char the back is dark blue to green, with the sides and underparts white or dusky. Char are distinguished by large round, violet-pink colored spots usually greater in diameter than the pupil of the eye. Size in Arctic char is as variable as color. Sea run adults up to 25 pounds have been captured. In some non-migratory populations, mature adults are only six to eight inches long.

Distribution

Arctic char are circumpolar in their distribution and are found in inshore marine waters, lakes and streams of the northern hemisphere. In Alaska, they are found north of the Brooks Range and extend southeast along the Bering Sea to include the Aleutian Islands and the Alaska Peninsula. In the Kuskoswim and Yukon systems, scattered non-anadromous populations are found in lakes and clear rivers. A few non-anadromous Arctic char populations are also found in Cook Inlet on the Kenai Peninsula.

Biology

Arctic char may be either anadromous or non-anadromous. Little is known about the juvenile life stage of Arctic char. Anadromous char migrage to sea for the first time at two to seven years of age. Downstream migration occurs in June and early July. The fish usually remain near the estuary to feed, although tagged fish have been captured as far as 80 miles from their origin stream.

Anadromous char return to streams in July through September. Arctic char do not usually spawn every year (non-consecutive spawners) but may wait one or more years before spawning again. Both non-spawning char and spawning char enter the rivers during the fall migration. Spawners will later segregate out on the spawning grounds. The fish overwinter in lakes, deep river pools or spring areas in streams.

Growth is generally slow. Landlocked populations usually grow much more slowly than anadromous ones. The oldest reported char was 24 years old.

Arctic char mature between five and twelve years of age. Mature char begin their spawning migration in late July and spawn between late August and mid-November. Spawning takes place over gravel beds in lakes, pools below rapids in rivers and in spring areas.

The redd is constructed in small gravel in depths from 0.2 to 4.5 meters (m). A redd measured by Yoshihara (1973) was 1.2 m wide, 3.5 m long, with eggs deposited 10 centimeters (cm) deep. Water depth was 0.2 m and water velocity over the redd was 0.6 meters per second (mps). Spawning takes place during the day in water temperatures around 4°C.

The eggs remain in the gravel over winter and hatch in April. The eggs are exposed to temperatures of 0.0° to 2.2°C. They are killed by temperatures above 7.8°C. The alevins are thought to remain in the gravel until after ice break-up in June or July before emerging.

Arctic char are carnivorous. The adults feed mainly on small fishes, gastropods and chironomid larvae. Young char feed more heavily on amphipods and insect larvae.

ARCTIC GRAYLING

Description

Arctic grayling, _Thymallus arcticus_ Pallus, are members of the subfamily Thymallinae of the Salmonidae family.

Grayling are distinguished by a greatly enlarged dorsal fin. In adults the back is dark purple or blue and the sides grey with numerous black spots.

Distribution

Arctic grayling distribution is circumpolar in North America and Asia. In Alaska, they are found north of the Chugach Mountains to the Arctic Ocean and west to Port Heiden on the Alaska Peninsula. Grayling have been introduced into lakes of southeastern Alaska and Kodiak Island.

Biology

Grayling are found in clear, cold waters of large rivers, tributary streams and lakes. Spawning takes place between April and June. As the ice goes out in the small streams, adults migrate from ice-covered lakes and larger rivers to small gravel or rock bottom tributaries. Where no suitable small streams are available, spawning may take place in gravel bottomed areas of larger rivers.

On the spawning ground, the male establishes a territory in a riffle. No redd is dug, but small depressions sometimes result from spawning activity. Eggs are fertilized and extruded over the gravel where they settle and adhere. The female carries an average of 4,000 to

7,000 eggs, depending upon size. Grayling seem to prefer clear, moderately flowing waters about 15 inches deep with temperature between 40° to 43°F for spawning. The eggs hatch in 8 to 25 days, depending on stream temperatures. After spawning, the adults may migrate out to feed in another stream. Immature grayling rear in the tributary. All age classes will overwinter in larger rivers and lakes if conditions warrant.

Terrestrial insects form the most important summer food of grayling. When little terrestrial food is available, caddis and mayfly nymphs, cladocera, snails and small fish are common foods.

BURBOT

Description

Burbot, Lota lota, are the only members of the family Gadidae (cods) to live in freshwater. Burbot are also known as freshwater ling, lawyer and lush. The whiskerlike barbel on the tip of the chin and long, tapering body distinguish burbot. The back and sides of adults are olive green to dark brown, with irregular pale blotches. The underparts are usually a pale yellow, but occasionally are speckled. Adult burbot may reach 75 pounds in North American waters.

Distribution

Burbot occur in Siberia, northern Europe and northern North America from the Great Lakes basin and the northern Rocky Mountains to Alaska. In Alaska, they occur in the Copper River drainage north and west to the Arctic Ocean and the Bering Sea.

Biology

Burbot mature at four to seven years of age. Spawning occurs in late winter, usually under the ice. Lake spawning predominates through their entire range, but they also spawn in flowing water. The spawning site is on sand or gravel bottom in quiet waters less than 10 feet deep. No nest is made, eggs are extruded over the bottom. Spawning takes place at night. The number of eggs per female varies with the size of the fish, but is commonly in excess of 1,000,000. The young hatch early in spring.

Burbot prefer the cool, deep waters of lakes and can commonly be found in depths to 300 feet. They also occur in large rivers, small streams and ponds.

Burbot are voracious carnivores. Fish are their principal diet, with whitefish, stickleback and cottids commonly found in stomach analysis. Burbot also feed on Mysis, amphipod caddis larvae and other aquatic insects.

CUTTHROAT TROUT

Description

Cutthroat trout, Salmo clarki, are members of the family Salmonidae. Two forms of cutthroat trout are recognized, the coastal form (coastal cutthroat) and the interior form (Yellowstone trout), which are separated on basis of location and external appearance. The Alaska cutthroat are of the former variety.

Distribution

Cutthroat trout occur in fresh, brackish and saltwater areas of western North America from northern California to Alaska. In Alaska, cutthroat trout are found throughout southeast Alaska up into Prince William Sound.

Biology

Sexual maturity is reached by males as early as two years of age, and as late as five to six years of age for females. The average age of spawners is two to four years. Spawning usually occurs betewen February and May. Spawning takes place in small, gravelly streams, and the female digs one or more redds about one foot in diameter and four to five inches deep. The eggs are deposited in the redd, fertilized and covered with six to eight inches of gravel. Fecundity of the female ranges from 400 to 4,000 eggs (females 8 to 17 inches long), the average being 1,500 eggs. Spawning occurs primarily at night. Cutthroat trout may spawn more than once, but mortality is usually high.

After spawning, anadromous spawners will return to saltwater, but non-anadromous fish may remain in the tributary or drop down to a larger stream or lake. The eggs usually hatch in six to seven weeks, with the alevins remaining in the gravel several additional weeks.

Cutthroat trout may be anadromous or non-anadromous. Adult habitat may be coastal streams and lowland lakes, inland alpine lakes or inshore coastal areas. Hartman and Gill (1968) described cutthroat habitat in British Columbia in relationship to that of steelhead trout. Cutthroat predominated in small, short drainages (less than 13 km^2). In drainages less than 120 km^2, cutthroat were found in streams that contained sloughs in lower sections. In large streams where both steelhead and cutthroat trout occurred, cutthroat usually predominated in small tributaries and headwaters.

Non-anadromous populations may remain in their parent streams all their lives, remaining in a territory as small as 20 yards (Miller, 1957). Others may rear several years in small tributaries before moving into larger streams or into a lake.

Anadromous young fish rear in the spawning stream or connected lake two to four years before migrating to sea. Immature fish at sea may wander from stream to stream feeding during the summer, but usually remaining fairly close to the stream of outmigration. Overwintering at sea is uncommon, and in the fall both mature and immature cutthroat trout return to freshwater to overwinter in lakes or streams with deep holding areas. The fish may or may not overwinter in the same system every year (Armstrong, 1971; Jones, 1974).

Many cutthroat trout live only a few years and spawn only once. For others, spawning may be non-consecutive. Ten years is probably the maximum life expectancy, with four to seven years being more common.

Critical habitat for cutthroat trout consists of spawning, rearing and overwintering areas. Sloughs, side channels, deep pools and beaver pond areas constitute important rearing areas.

DOLLY VARDEN

Description

Dolly Varden char, Salvelinus malma (Walbaum), belong to the family Salmonidae. Dolly Varden may range in size from the largest known specimen which weighed over 30 pounds to dwarf fish weighing less than one-half pound when fully grown. No obvious differences exist between sexes except at spawning when anadromous male Dolly Varden display a hooked lower jaw (kype). Color is extremely variable. In fresh sea run adults the back is dark blue and the sides and underparts silvery. In non-migratory specimens the back is dark blue to olive green and the sides and underparts are white or dusky.

Distribution

Dolly Varden occur in eastern Asia and in western North America from northern California to Alaska. In Alaska, Dolly Varden distribution extends from southeast Alaska westward to the Aleutian Islands and into Bristol Bay. Occurrence of Dolly Varden has been reported in the Yukon River drainage, on the Seward Peninsula and as far north as the Noatak River, but confusion exists as to whether these fish are Dolly Varden or Arctic char.

Biology

Most Dolly Varden mature at age five or six. Mature fish migrate into their parent streams beginning in July and spawn from September to November. The female digs a nest (redd) in relatively uniform substrate of small to coarse gravel. The redd measures 12 to 24 inches in diameter and 6 to 8 inches deep. Blackett (1968) reported water velocities of 3 to 4 feet per second (fps) over the redd during construction, with water temperatures between 44° and 44°F. Females, depending on size, may deposit 600 to 6,000 eggs in the redd. The eggs are deposited in several pockets and each pocket is covered with gravel.

The eggs take about four to five months to hatch after fertilization, usually hatching in March. The alevins remain in the gravel until their yolk sacs are absorbed. Emergence usually occurs in April or May.

Dolly Varden may be either anadromous or non-anadromous. Most life history information available on Dolly Varden pertains to the sea run variety. Little is known concerning the habits of non-migratory Dolly Varden.

Young Dolly Varden rear in clear water streams from two to four years before their first migration to sea (anadromous form). The young fry keep to slow moving waters, remaining hidden on the bottom in pools, undercut banks and sloughs. They continue to remain bottom dwellers during their rearing stage, although the larger juveniles move out into riffles and faster moving areas in the stream. Small feeder tributaries, side channels and high water overflow areas also constitute important rearing habitat.

During the fall rearing fish apparently seek out areas in the stream to overwinter. Studies on Dolly Varden rearing ecology by Elliott and other workers in southeast Alaska have noted an upstream migration of Dolly Varden into spring-fed areas in the fall (Elliott and Armstrong, 1972; Elliott and Reed, 1974; Dinneford and Elliott, 1975). The fish overwinter there until late spring when they again redistribute themselves throughout the stream. The fall migration ceases when stream temperatures drop below 4°C, and the spring migration begins when stream temperatures increase above 4°C.

Anadromous Dolly Varden migrate to sea primarily as three and four-year-old fish, though some fish from lake systems migrate as two-year-olds. At this time they are about five inches long and are called smolts. This migration usually begins in March and peaks in May and June, with significant but smaller numbers migrating to sea in September and October. Once at sea, they begin a fascinating pattern of migration.

After their first seaward migration, Dolly Varden usually spend the rest of their lives wintering in and migrating to and from lakes. Those hatched and reared in a lake system carry on annual feeding migrations to sea in the spring and summer, returning to the lake each year for the winter. However, Dolly Varden originating from non-lake systems must seek a lake in which to winter. Recent research indicates that they find lakes by random searching, migrating from one stream system to another until they find one with a lake (Armstrong, 1974). Once a lake is found, these fish may also conduct annual seaward migrations in the spring, sometimes entering other stream systems in their search for food.

At maturity, Dolly Varden return to their parent stream to spawn. The fish possess the ability to find their "home" stream without randomly searching, as was the case in their original search for a lake. Those that survive the rigors of spawning return to the lake shortly thereafter. It is doubtful that much more than 50 percent of the Dolly Varden live to spawn a second time. A small number of them live to spawn more than twice. Some fish apparently spawn non-consecutively (Armstrong, 1974). Few Dolly Varden appear to live longer than eight years.

Critical Habitat

Critical habitat for Dolly Varden consists of rearing, overwintering and spawning areas. Blackett (1968) and Armstrong (1974) have discussed the importance of critical habitats in relationship to successful management. Non-lake systems are of primary importance for spawning and rearing, while anadromous lake systems and large rivers are important for overwintering. For five to nine months a year, each overwintering lake harbors fish from many streams over a wide area. Depletion of these fish could severely reduce populations from many systems.

Migrations between streams and lakes also complicates management. Heavy fishing on one system or one area may severely affect populations in other areas when these fish migrate into heavily fished areas. Spawners also remain in streams for much longer periods and would be more susceptible to the fishery. Spawning sites are quite specific and need to be identified and protected during spawning and egg incubation periods. Fishery closures may be used to protect spawning fish on the spawning grounds and on their migration to overwintering areas (October and November).

Rearing areas are often overlooked but are very critical. Side channels, undercut banks, sloughs, isolated pools and small tributaries provide critical rearing habitat. Land uses which disrupt or destroy these areas must be avoided. Overwintering rearing areas, such as springs or open water areas, are also critical.

EASTERN BROOK TROUT

Description

Eastern brook trout (*Salvelinus fontinalis*) are char of the family Salmonidae. Color is extremely variable, ranging from dark green on the back to silver or white on the sides and abdomen. Brook trout occurring in Alaska rarely exceed 12 inches in length.

Distribution

Brook trout are native to the eastern part of North America from the mountain streams in Georgia north to Hudson Bay. They have been widely introduced around the world, including Alaska. Numerous introductions were made in southeast Alaska in the 1920's and 1930's, but viable populations have survived only in a few lake and stream systems near Juneau, Ketchikan and Sitka.

Biology

Sexual maturity is usually attained by age three, but some individuals may mature by age two. Brook trout are fall spawners, with spawning occurring between September and December in Canada. Spawning time occurs earlier with increased latitude. Spawning occurs primarily in shallow headwaters of streams, but fish will spawn in lakes in gravel areas with upwelling groundwater. The usual site is a riffle area with a substrate of small gravel. Spawning takes place in the daytime. Females, depending on size, deposit from 100 to 5,000 eggs. The eggs are covered within the redd.

Egg incubation depends on temperature. At 41°F eggs hatch in 100 days, while at 50°F they hatch in 50 days. Young fry remain in the gravel until the yolk sac is absorbed.

Brook trout are found in cool, clear, well-oxygenated lakes and streams. Anadromous populations may occur, but none are known in Alaska. Brook trout tend to mature early and can quickly overpopulate a stream or small lake. Stunting of individuals is quite prevalent under these conditions. Brook trout are relatively short-lived, rarely living beyond five years and never beyond eight years.

LAKE TROUT

Description

Lake trout, *Salvelinus namaycush* (Walbaum), are not a true trout (genus *Salmo*) but are classed as char (genus *Salvelinus*). They are the largest of the chars, commonly weighing over 40 pounds. Lake trout are easily identified by their deeply forked caudal fin and irregular white spots on the back and sides. Adults vary in color, depending upon size and habitat, but usually the back is dark green to gray that gradually shades into pale yellow or white underparts.

Distribution

Lake trout are found only in North America and almost entirely within the limits of Pleistocene glaciation. In Alaska, they are found throughout the highland lakes of the Brooks Range. Lake trout are also found in Bristol Bay and the upper Susitna and Copper River drainages.

Biology

Lake trout are entirely freshwater dwellers. They prefer cold, deep lakes in the southern part of their range, but in Alaska and northern Canada they are also found in shallow tundra lakes and large, clear rivers.

Lake populations are found near the surface in the spring at the time of ice break-up. As the water warms in the summer, the fish move deeper to remain below the thermacline in the cold bottom waters, preferring temperatures between 40° and 50°F.

Lake trout generally mature at five to seven years of age and spawn in late summer and early autumn. Most lake trout are lake spawners, but river-spawning populations also exist. Lake trout may be non-consecutive spawners.

The male selects a spawning site over large boulders or rubble substrate in shoal areas. Suitable lake sites are often associated with windy areas. Unlike most salmonids, no nest is dug, but the site is cleaned of silt and mud by brushing and fanning motions. The eggs are fertilized and broadcast over the bottom to settle into crevices in the rocks. Large females may contain up to 18,000 eggs. Depth of spawning ranges from 6 inches to 200 feet, but spawning typically occurs in depths less than 40 feet. Optimum spawning temperature is about 48° to 50°F. Spawning almost always occurs at night. The eggs remain in the rocks over winter and hatch in the spring.

The young fish stay under cover until their yolk sacs are absorbed, and they remain on the bottom hiding from predators and feeding on plankton and bits of plant material. After growing to about six to eight inches in length, they leave the bottom and begin solitary wandering which continues, except for spawning periods, throughout life.

The food of adult lake trout consists of other fishes, bottom organisms, plankton and terrestrial insects. Small lake trout feed upon crustaceans, particularly Mysis where present.

NORTHERN PIKE

Description

Northern pike, Esox lucius, are members of the family Esocidae and are often referred to as pike or jackfish. They are distinguished by a long, flattened snout and large mouth with many teeth. Northern pike are typically dark green to dark brown on the back and sides, with light yellow spots arranged in vertical rows. The underside is usually a yellow-white. Pike in excess of 4 feet in length and over 40 pounds have been documented. There are no obvious external differences between the sexes.

Distribution

Northern pike are circumpolar in distribution in the freshwaters of Eurasia and America. In Alaska, they range from the Alaska Peninsula streams that feed into Bristol Bay, northward to the Arctic coast and throughout the interior. An isolated population is found in the Ahrlin River southeast of Yakutat, as well as in ponds in that area.

Biology

Pike generally prefer clear or brown-stained slow, vegetated rivers or warm, weedy bays of lakes. The young remain in the spawning area for several weeks after hatching. They then move out to establish territories where adequate food and cover exists. In general, pike are found in shallow water in spring and fall but move into deeper water in summer. Their winter movements are largely unknown. Much of the summer range dries up, freezes to the bottom or becomes oxygen depleted during the winter. Pike are assumed to move into the large river systems and lakes to overwinter. Generally, movement from overwintering areas to spawning areas is quite short.

Pike in southern Canada have been known to mature as early as age two. Maturity is delayed to age five or six in areas further north. Pike spawn in the spring, sometimes before ice break-up. They migrate under the ice from their wintering areas into shallow bays and sloughs along rivers or in lakes or ponds. They prefer quiet, shallow areas with mud bottoms and dense aquatic vegetation. Depth of spawning ranges from three inches to two feet. No spawning territory is established, nor is a nest built. Pike spawn by swimming through the vegetation and randomly dispersing eggs. The eggs are very adhesive and cling to the vegetation. Hatching takes place in 10 to 12 days at 50°F. The eggs can develop in temperatures from 35° to 73°F. The number of eggs deposited is high (average of 32,000 per female), but egg to fry survival is usually less than one percent. After spawning, the adults disperse to summer feeding areas.

Pike are known as voracious feeders, eating fishes of all available species, insects and even small birds and mammals.

RAINBOW TROUT

Description

Rainbow trout, Salmo gairdneri (Richardson), belong to the family Salmonidae. Anadromous rainbow trout are known as steelhead and are discussed separately. Mature rainbow trout vary in size from under 10-inch long dwarfs to over 4 feet in length. The largest rainbow trout on record purportedly weighed 52 pounds. It was taken from Jewel Lake, B.C. Rainbow trout derive their common name from their unique color combinations. The dorsal region is bluish green to brown, with the sides and underparts white or dusky. There is usually a lateral stripe that varies from light pink to red. The dorsal and pelvic fins commonly have white or orange leading edges.

Distribution

In North America, natural rainbow trout stocks are distributed in Pacific Ocean and Bering Sea drainages from northwestern Mexico to Alaska and on the east slope of the continental divide to the headwaters of the Peace and Athabasca Rivers. Rainbow trout may also occur in certain Asian rivers flowing in the Kamchatka and Okhotsk Seas.

In Alaska, rainbow trout are found throughout southeast Alaska west to the Alaska Peninsula and as far up the Kuskokwim River as Sleetmute. The clearwater lakes and streams draining into Bristol Bay provide suitable habitat. Rainbow trout occur naturally in the Susitna and Copper River drainages and have been transplanted to many interior Alaska lakes.

Biology

Rainbow trout prefer cool, clear lakes and streams. Distinct stream and lake populations exist throughout the natural range. In stream populations both spawning and rearing takes place in the riffle areas of spawning streams. Preferred adult habitat is areas of gravel bottom, moderate flow and pool-riffle configuration. Overwintering takes place in the deeper pools. Lake residents are usually found in deep, cool lakes. For lake populations to be self-sustaining, they must have access to inlet or outlet streams with good gravel bottom. Adult rainbow trout feed mainly on aquatic insect larvae, crustaceans, molluscs and occasionally small fishes. In Alaska, adult rainbow trout feed on salmon eggs and young salmon at certain times of the year.

Rainbow trout reach sexual maturity at three to five years of age, with males often maturing a year earlier than females. They spawn in the spring and generally exhibit a homing instinct for a specific spawning area. They usually spawn in smaller tributaries of the parent stream or the inlet or outlet streams of lakes. Spawning most often occurs in temperatures between 50° to 60°F.

The female chooses the spawning site and digs a redd approximately 4 to 12 inches deep and 15 inches in diameter. Preferred site is a bed of fine gravel in a riffle above a pool. The eggs are deposited in the redd, fertilized and covered with gravel. Total eggs range from 200 to 8,000, depending on size of female. Egg development requires several weeks to four months, depending on temperature. Rainbow trout may spawn up to five years consecutively, but very few actually survive to spawn even twice.

SHEEFISH

Description

Sheefish, Stenodus leucichthys, are the only members of the genus Stenodus in the whitefish family Coregonidae. Sheefish, also referred to as inconnu, normally have a dark silver color. Size varies greatly from one population to another, but sheefish weighing in excess of 50 pounds are documented (McPhail and Lindsey, 1970). Sheefish are distinguished by their length (up to five feet), wide mouth and projecting jaw.

Distribution

Sheefish are found in Eurasian arctic watersheds from the White Sea to Bering Strait and south to northern Kamchatka. In North America, sheefish occur in Bering Sea drainages south to the Kuskokwim River and east on Arctic Ocean drainages to Anderson River. Sheefish occur inland as far as Teslin Lake, B.C., headwaters of the Yukon River. A detailed account of Alaskan distribution is given in the text of this report.

Biology

Sheefish are most abundant in the large, muddy rivers and associated lakes. Adult sheefish are voracious and feed mainly on small fishes, particularly young whitefish, minnows, stickleback and lamprey ammocoetes (McPhail and Lindsey, 1970). Sheefish may occur as anadromous or freshwater resident populations.

A detailed regional account of spawning and related life history information is presented in the text of this inventory. Refer to individual chapters for additional data.

SMELT

Introduction

Five species of smelt are significant in Alaskan waters. These are *Mallotus villosus* (caplin), *Hypomesus olidus* (pond smelt), *Spirinchus thaleichthys* (longfin smelt), *Osmerus eperlanus* (boreal smelt) and *Thaleichthys pacificus* (eulachon). As the distribution and biological considerations of each of these species is unique, they will be dealt with individually.

Caplin, *Mallotus villosus*

Description

Caplin are noted for the high number of fine scales along the lateral line, the long adipose base, squared off adipose fin and the fan-like appearance of the pectoral and pelvic fins. They range in size from five to eight inches, with males being slightly larger than females. Caplin are olive green on the dorsal surface and silvery on the sides and ventral area.

Distribution

The worldwide distribution of caplin can best be described as circumpolar in the Northern Hemisphere. They are distributed throughout the Gulf of Alaska and into the Bering Sea.

Biology

Depending on location, caplin spawning may occur from April to October. Spawning is at high tide on beaches with fine gravel. Eggs are adhesive and stick to the gravel. Eggs hatch in two to three weeks to produce slender larvae. Female caplin can contain between 4,000 and 7,000 eggs.

Age structure of the caplin spawning population is not well known, but a majority of beach spawning fish are believed to be completing their first year of life. Caplin may live to be three years old. Caplin utilize euphausids and copepods as food and are themselves an important member of the food chain of larger fish and marine mammals.

Pond smelt, *Hypomesus olidus*

Description

Pond smelt are distinguished by the small mouth, absence of large canine teeth and large scales. Adults are light brown to olive green on the back and silvery white on the ventral surface, with a metallic silver band along the midlateral line. Pond smelt are usually about six inches in length.

Distribution

Pond smelt are found throughout drainages of the North Pacific and Arctic Oceans.

Biology

This species lives primarily in fresh water but ventures at times into brackish regions. Spawning takes place in spring from April to June in freshwater ponds. Pond smelt may live to three years of age.

Longfin smelt, <u>Spirinchus thaleichthys</u>

Description

Longfin smelt are named for the characteristicly long pectoral fins. Adults are dusky on the back and silvery below. Young are translucent. Longfins have a maximum size of about six inches.

Distribution

Longfin smelt are found along the west coast of North America from central California to Bristol Bay, Alaska.

Biology

Longfin smelt are anadromous, maturing at age two and spawning during the winter months. Females carry about 18,000 eggs. Longfin smelt may live up to three years but very few survive to spawn more than once.

Boreal smelt, <u>Osmerus eperlanus</u>

Description

Boreal smelt are most easily identified by the large mouth with large canine teeth. They are larger than the other smelt, with mature fish sometimes reaching 15 inches in length. Adults are a light olive green on the back and an iridescent silver below. The fins are normally immaculate, but some of the fin rays may have dusky speckling on them.

Distribution

Boreal smelt distribution is circumpolar in the Northern Hemisphere. They are found both in southeastern Alaska and in the drainages of the Bering Sea.

Biology

Boreal smelt are anadromous in some places, but landlocked populations occur throughout many parts of their range. Spawning takes place in the spring of the third or fourth year of life. Eggs are extruded over stones or gravel. Boreal smelt may live up to eight years.

Eulachon, *Thaleichthys pacificus*

Description

Eulachon commonly have a large mouth and short pectoral fins. Adults are brown to bluish black on the back, with whitish lower surfaces. Eulachon range up to 12 inches in length.

Distribution

Eulachon are found on the west coast of North America from northern California to the eastern Bering Sea. In Alaska, eulachon are commonly found in upper Cook Inlet and Bristol Bay.

Biology

Eulachon are anadromous fish that penetrate coastal rivers only a short distance during their spawning run. Spawning takes place in the spring of the third year of life. A few eulachon survive to spawn a second time. Most of their life is spent in inshore marine waters.

STEELHEAD TROUT

Description

Steelhead trout, Salmo gairdneri (Richardson), are the anadromous form of rainbow trout. They are covered separately since their life history is markedly different from that of rainbow trout. Steelhead trout are similar in appearance to the non-anadromous rainbow trout but are usually somewhat larger. There is no striking difference between the sexes.

Distribution

Steelhead originally occurred from southern California to Alaska, but the southern end of the range has been somewhat reduced. In Alaska, steelhead occur throughout the southeast region, in the lower Copper River drainages, on the lower Kenai Peninsula as far up as Ninilchik River and on the Alaska Peninsula.

Biology

Steelhead trout become sexually mature at three to five years of age, with males often maturing earlier than females. Spawning may occur in the fall, winter or spring, depending on run timing. In Alaska, steelhead spawn in the spring between March and May. Steelhead spawn in small to medium-sized streams or in suitable sections of mainstem rivers. Depth preference varies from 16 to 35 centimeters deep, and redd sites are chosen in areas that would rarely be exposed by lowering stream levels (Jones, 1975). The female prepares the redd in riffle areas or the tail end of pools, and spawning occurs as for rainbow trout except that steelhead redds are generally larger. Fecundity varies from 3,000 to 12,000 eggs.

After spawning, the spent fish move downstream and return to the ocean. Steelhead trout may spawn more than once, but initial spawning mortality is usually high. Egg incubation time varies with temperature but averages 50 days at 50°F.

After emerging from the gravel, the fry remain in shallow gravel areas to feed. They move out into deeper waters as they grow older and establish territories among rocky areas. Young steelhead trout rear two to four years before migrating out to sea as smolts. Growth and size appear to determine time of smoltification. Most outmigration occurs in April through June.

Immature steelhead trout migrate out into the ocean to feed for several years. Tagging studies indicate that steelhead ocean migration is similar to salmon as they apparently circulate around the Gulf of Alaska before returning to their home stream to spawn. Steelhead may remain at sea one to three years. After their ocean stage, steelhead return to their home stream, exhibiting a very strong homing ability. Maximum age reported for steelhead is eight years.

WHITEFISH

Description

Whitefish will be dealt with as a group because of their overlapping ranges and biology. Whitefish belong to the subfamily Coregoninae of the family Salmonidae. Three genera with seven species are discissed in this report. The genera Stenodus is represented by the sheefish S. Leucichthys, which is covered in another section. Genus Prosopium is represented by P. cylindraceum (round whitefish). Genus Corogonus is represented by C. clupaeformis (humpback whitefish), C nasus (broad whitefish), C. sardinella (least cisco), C. autumnalis (Arctic cisco) and C. laurettae (Bering cisco).

Distribution

Whitefish are widespread in the cooler parts of the Northern Hemisphere. In Alaska, ranges and characteristics of these fish sometimes overlap. They are found in the large rivers in southeast Alaska which drain interior British Columbia, in the Copper and Susitna River drainages and are widely distributed from Bristol Bay to the Arctic Ocean. They are also abundant in interior streams and lakes. The humpback whitefish is most widely distributed in Alaska, but broad and round whitefish are very common in the interior. Ciscos are very abundant along the Bering Sea and Arctic Ocean coast drainages.

Biology

Whitefish are generally fall spawners in Alaska. Spawning migrations begin as early as mid-July and run as late as December. Spawning areas vary with the habitat of the population, but in general whitefish prefer the shallows of small rivers, tributaries or river mouths, but may also use the shallows or shoals of lakes. Spawning takes place over sand, gravel or hard substrates. Stream temperatures during spawning vary from 42° to 32°F, and some fall spawning populations may spawn under ice. No nest or redd is built, so the eggs are dispersed more or less randomly to drift with the current.

After spawning, the adults leave the spawning grounds for feeding or wintering grounds. The eggs incubate during the fall and winter and hatch in March and April. By June the fry are dispersed to pools to rear.

Distribution, habits and habitat will be discussed separately by species.

Round Whitefish

Round whitefish primarily dwell in streams and lakes and are not found in estuaries. In rivers they may be found throughout the river, but they seem to prefer swift currents in the clear headwater regions. They are most abundant in gravel bottom streams throughout the interior and arctic regions, but are found down to the Taku River drainage in southeast Alaska.

Broad Whitefish

Broad whitefish are widely distributed in Arctic Alaska, western Alaska and in the Yukon and Kuskoswim River drainages. They are not found in the Copper or Susitna River drainages. They may be found in estuaries, rivers and lakes, but are most common in large rivers. They prefer slower moving waters. They may have mid-winter downstream migrations, and they overwinter in main river channels and in large lakes.

Humpback Whitefish

Humpback whitefish (lake whitefish) are the most widely distributed whitefish in Alaska, ranging from the Arctic coast down to the Alsek River near Yakutat. This includes the entire Yukon-Kuskoswim drainages, Bristol Bay, Susitna River and Copper River drainages. They are found in rivers, lakes and brackish areas and have both anadromous and non-anadromous forms. Like the broad whitefish, humpback whitefish prefer slower moving waters. In lakes the fish move into deep, cool waters in the summer, but come back into the shallows in the fall to spawn.

Arctic Cisco

In Alaska, Arctic cisco occur in the coastal areas from Demarcation Point through the Beaufort, Chuckchi and Bering Seas to the Bristol Bay area. Arctic cisco are anadromous and reside primarily in nearshore areas or estuaries. They leave this area in the spring and summer, ascend coastal rivers to spawn and then return to the sea again. They seldom are found very far inland from their home estuary. They overwinter in estuary or delta areas.

Least Cisco

Least cisco have the same general distribution as Arctic cisco, but are also found throughout interior Alaska. Both anadromous and non-anadromous populations are found. The anadromous populations behave similarly to Arctic cisco.

Bering Cisco

Bering cisco are known to occur only in Alaska, from Cook Inlet north to the mouth of the Colville River. Very little is known about their biology, but they are coastal and are probably anadromous.

APPENDIX BIBLIOGRAPHY

Armstrong, R.H. 1971. Age, food and migration of sea-run cutthroat trout, Salmo clarki, at Eva Lake, southeastern Alaska. Trans. Amer. Fish. Soc. 100(2):302-306.

Armstrong, R.H. 1974. Migration of anadromous Dolly Varden, Salvelinus malma, in southeastern Alaska. J. Fish. Res. Bd. Canada 31(4):435-444.

Blackett, R.F. 1968. Spawning behavior, fecundity and early life history of anadromous Dolly Varden, Salvelinus malma (Walbaum), in southeastern Alaska. Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Report of Progress, 1967-1968.

Elliott, S.T. and R.D. Reed. 1974. Establishment of guidelines for protection of the sport fish resources during logging operations. Fed. Aid in Fish Restoration, Annual Report of Progress, 1973-1974, Project F-9-6, Job D-I-A, Volume 15:1-43.

Jones, D.E. 1974. The study of cutthroat-steelhead in Alaska. Alaska Dept. of Fish and Game. Anadromous fish studies, Annual Progress Report, 1973-1974. Project AFS-42, 15:31.

McPhail, J.D. and C.C. Lindsey. 1970. Freshwater Fishes of Northwestern Canada and Alaska. Fish. Res. Bd., Canada, Bull. 173. 381 pp.

Miller, R.B. 1957. Permanence and size of home territory of stream-dwelling cutthroat trout. J. Fish. Res. Bd., Canada. 14(5):687-691.

Yoshishara, H.T. 1973. Monitoring and evaluation of Arctic waters with emphasis on the North Slope drainages, Alaska Dept. of Fish and Game. Fed. Aid in Fish Restoration, Annual Progress Report, Vol. 14.