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Living Marine Resources of the Shumagin Region:

A Resource Assessment for the Shumagin Oil and Gas Lease Sale 86

U.S. DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration
National Marine Fisheries Service

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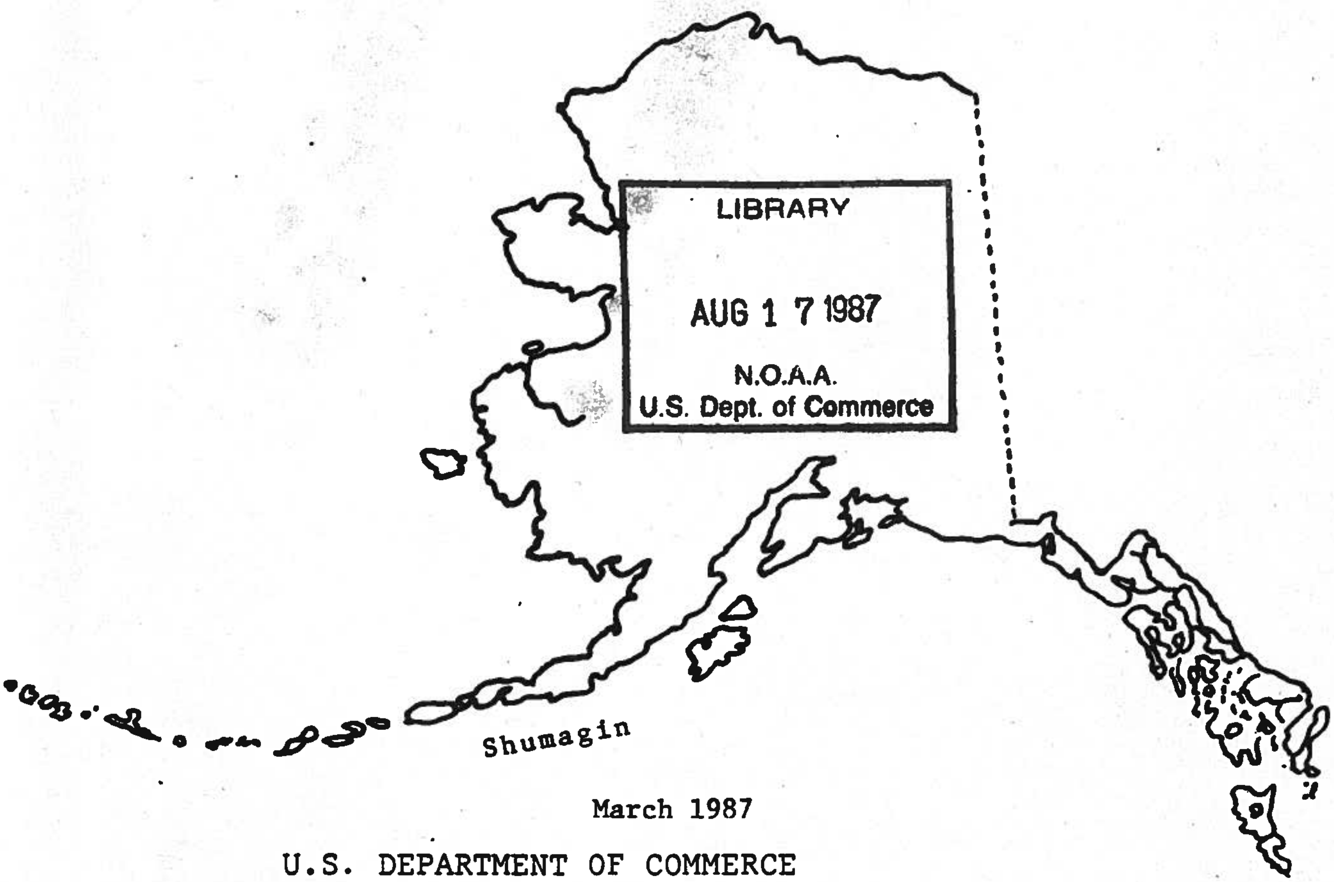
prepared by:

Byron F. Morris



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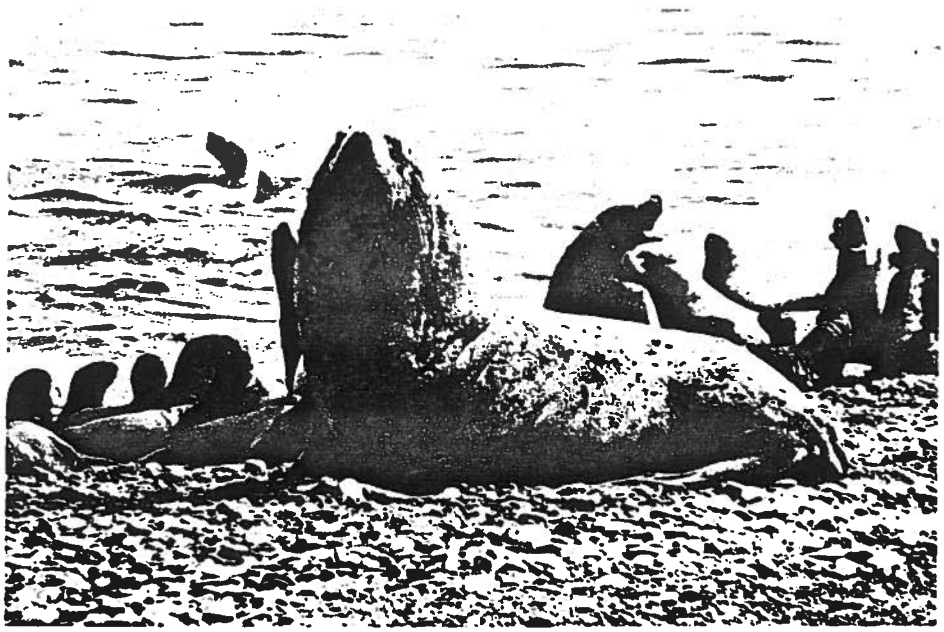

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Anchorage, Alaska

March 1987

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I. INTRODUCTION

The Minerals Management Service (MMS) of the Department of the Interior (DOI) has proposed an oil and gas lease sale in the Shumagin region of the western Gulf of Alaska. This sale is numbered Shumagin Lease Sale 86 and is proposed for December, 1987. As part of the pre-sale planning process, MMS issued a Call for Information and Nominations on November 8, 1985 to ensure that "all interests and concerns are communicated to the DOI for future decisions in the leasing process" (MMS, 1985). This call for information is an important first step is leasing, and is not a preliminary decision to lease in the area.

The Shumagin Planning Area is located south of the Alaska Peninsula and southwest of Kodiak Island (Figure 1.1). According to MMS (1985), the area contains 15,054 blocks encompassing approximately 83 million acres. Water depths range from 20 to 7,000 meters. Distance from shore ranges from 3 to 250 miles. Undiscovered recoverable resources are estimated at between 50 to 90 million barrels of oil and 500 billion to 2.65 trillion cubic feet of gas. The dollar amount expended on environmental studies in this area is approximately $450,000 (elsewhere reported as $750,000).

The NMFS is a branch of the National Oceanic and Atmospheric Administration (NOAA) with mandates to manage, conserve and protect living marine, estuarine, and anadromous resources and their habitats. In carrying out these responsibilities, NMFS acts under the following legislative authorities:

* <u>The Magnuson Fishery Conservation and Management Act</u> (MFCMA) of 1976 requires that fishery resources and their habitats within the 200-mile fishery conservation zone of the U.S. be managed and protected to provide sustained and renewable utilization.

* <u>The Marine Mammal Protection Act</u> of 1972 gives NMFS responsibility for protecting marine mammals and their habitats.

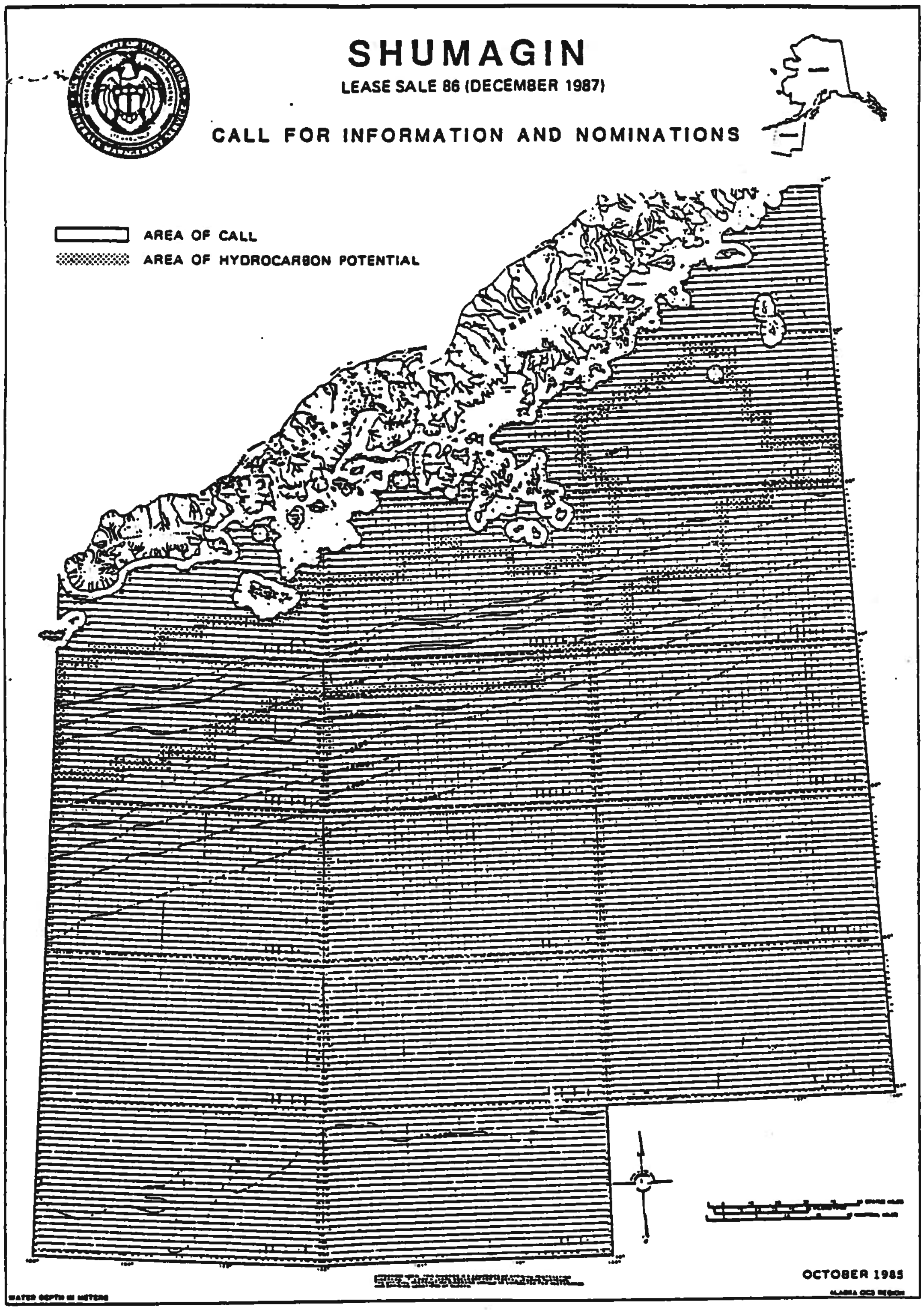

Figure 1.1. The location of the Shumagin Planning Area and area of hydrocarbon potential (from MMS, 1985).

* The Endangered Species Act of 1973 mandates NMFS to assure the continued existence of certain marine mammal species, primarily the great whales, whose populations are threatened with extinction as a result of man's past practices.

* The Fish and Wildlife Coordination Act of 1958 makes NMFS a cooperating agency in processing all Corps of Engineers permit applications for dredge and fill and construction on navigable waters, and Environmental Protection Agency permit applications for waste discharges.

In helping to fulfill these responsibilities, NMFS provides other Federal agencies with information on living marine resources and habitats that may be affected by a proposed activity and makes recommendations on how to avoid resource use conflicts. This report on "The Living Marine Resources of the Shumagin Region" has been prepared in response to the request from NMFS for information for proposed lease Sale No. 86.

This resource report provides information on the living marine resources and their habitats in the Shumagin Region of the western Gulf of Alaska that are within the management authority of the NMFS. The report contains a current review of the fishery resources and commercial fishing activities of the Shumagin region, and discusses the status of knowledge of marine mammal populations of the area. An overview of the physical and biological environment of this region is also included in this report.

Where possible, this document uses metric system units. For ease of conversion, the following equivalents may be calculated:

1 centimeter (cm) = 2.54 inches
1 meter = 3.28 feet
1 kilometer (km) = 3281 feet
= 0.62 statute miles
1 nautical mile (nm) = 1.16 statute miles
1 kilogram (kg) = 2.205 pounds
1 metric ton (mt) = 2,205 pounds
1 knot (kt) = 51.4 cm/sec
= 1.15 miles per hour
1 hectare = 2.471 acres
1 square kilometer (km^2) = 0.384 square statute miles
= 0.292 square nautical miles
Degrees Centigrade (°C) = (°F - 32) x 0.56.

2. THE PHYSICAL ENVIRONMENT

2.1. GENERAL DESCRIPTION OF THE ENVIRONMENT.

The Shumagin planning area lies south of the Alaska Peninsula between longitudes 156°W and 165°W (see Figure 1.1). This area encompasses waters of the North Pacific Ocean ranging in depth from less than 10 meters in shallow nearshore areas of the continental shelf to over 6400 meters in the Aleutian Trench offshore. Much of the offshore area is over the broad abyssal plain of the North Pacific Ocean at depths of over 4000 meters. The shoreward northeastern boundary of this planning area is at the approximate location of Wide Bay between Cape Igvak and Cape Kayakliut along the southwest entrance of Shelikof Strait. The shoreward northwestern boundary lies at the eastern entrance to Unimak Pass. The southern boundary is at 50°N latitude in waters of the North Pacific Basin up to 280 nautical miles (nm) offshore.

A profile of the bathymetry in a cross-section of the lease area along 162°W is shown in Figure 2.1. Beginning in the north on the Alaska Peninsula, the sea floor descends gradually at first across the relatively narrow continental shelf. This shelf is irregularly punctuated with islands and shoal areas of the submerged land mass. About 50 nm from shore the bottom drops steeply from the shelf edge at about 200 meters, where the continental slope descends abruptly to seafloor depths over 4000 meters within the next 35 nm. The bottom then continues to descend to over 6400 meters depths in the eastern portion of the Aleutian Trench which extends through the lease area from 70 to 100 nm offshore. South of the Aleutian Trench, the bottom rises gradually to basement depths of about 4800 meters. Rising above this abyssal plain are scattered seamounts, including Pritchett Seamount (depth 3754 m) illustrated here.

2.1.1. The Coastal Environment.

The Alaska Peninsula is dominated by the mountainous and rugged Aleutian Range with many irregular and bold peaks of tectonic and volcanic origin reaching 600 to 2750 m elevation. The general topography of the southern coast of the peninsula consists of wave-cut platforms bordered by low sea cliffs, intensely

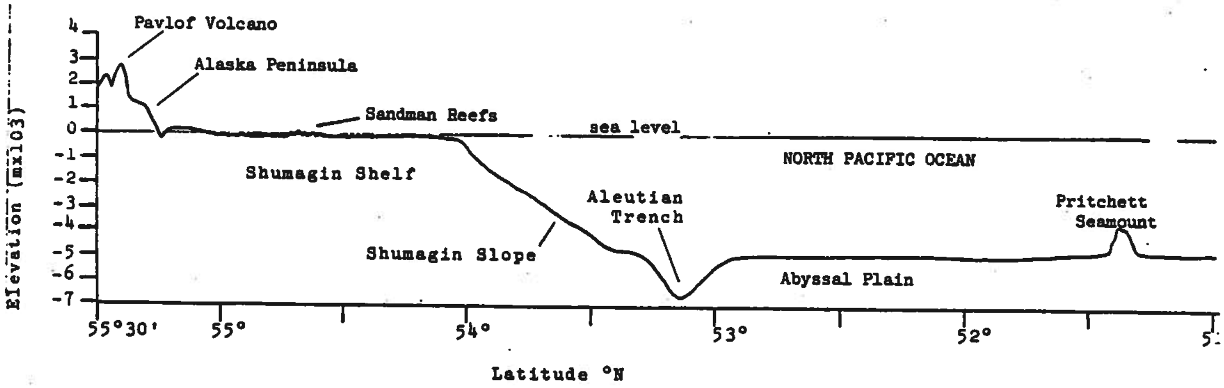

Figure 2.1. Topographic cross-section of the Shumagin Planning Area along 162°N.

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glaciated mountains indented by fjords and bordered by cliffs, and volcanic peaks of which the highest bear ice caps and small glaciers (Batten and Murray, 1982). Pavlof Volcano is the most prominent of several active volcanoes on the peninsula, rising to 2536 m in elevation. The high plateaus between mountain peaks often contain numerous lakes and sizeable streams. The rivers and streams flowing to the Pacific side of the Alaska Peninsula are generally short and have steep gradients, the relatively long and wide Chignik River being the notable exception.

The southern coast of the Alaska Peninsula, particularly in its eastern region, is irregular and broken by numerous bays and fjords set between wave-eroded capes and headlands. Many of the capes are high rugged cliffs with offshore rocks and reefs. Often these rock reefs are marked by extensive kelp beds and breakers, but these may not be apparent under certain wind and current directions. On exposed shores and capes, the shoreline is often composed of steep rock cliffs with high jagged ridges and steep peaks, generally covered in grass or alder brush. Waterfalls cascade down many of these cliffs. The intermittent beaches are narrow and boulder strewn or sandy. Along shore are often many sunken rocks, rock pinnacles, and small rock islets extending up to 500 m offshore. The bays and inlets generally offer a more gentle relief than the exposed coasts, many contain low-lying shores with shallow flats extending far out. The bays are usually very deep at their mouths and may remain deep for considerable distances inland.

Depending on wind directions, many of these bays act as natural funnels for winds passing over the peninsula, producing violent winds called "williwaws".

A detailed description of the coastal region is contained in United States Coast Pilot 9 (USDOC, 1985). Other useful descriptive references are ACMP (1978), AECRSA (1984), and BBCMP (1984). Many of these geographic features of the region are shown in Figure 2.2. Coastal features of note along this southern coast are briefly highlighted as follows, beginning from the northeast:

Cape Igvak is a conspicuous headland separating Portage Bay and Wide Bay. It represents the southern end of a ridge of 600 to 800 meter mountains which are covered in clouds most of the time.

Port Wrangell is a deep and narrow indentation of the coast with steep and rocky shores. The inner bay is one of the best anchorages along this part of the coast.

Lighthouse Rocks, 50 nm west of Chirikof Island has a large sea lion rookery.

Chignik Bay and Chignik Lagoon are important salmon fishing areas. The Chignik River system, emptying into the bay through Chignik Lagoon, is a unique hydrologic feature along the southern coast of the Alaska Peninsula. This watershed penetrates between the steep slopes of the coastal mountains on a northwest - southeast pass from the coastal plains of the northern peninsula. Chignik Village (pop. 178 in 1980) is a fishing settlement at the head of Anchorage Bay and there are salmon canneries nearby. Chignik Lagoon Village (pop. 48 in 1980) is located toward the head of the lagoon.

Kuiukta Bay extends over 26 km inland and has 11 arms or bays of various sizes and shapes. Its shores are precipitous cliffs. This bay is a natural funnel for winds and has a reputation as one of the windiest bays in Alaska. The water at its entrance is subject to tidal rips. The abandoned Indian village of Mitrofania is by the first arm on the west side of the bay.

Brother Islands are two flat-topped, cliff-faced islands, the more eastern of which is inhabited by thousands of seabirds.

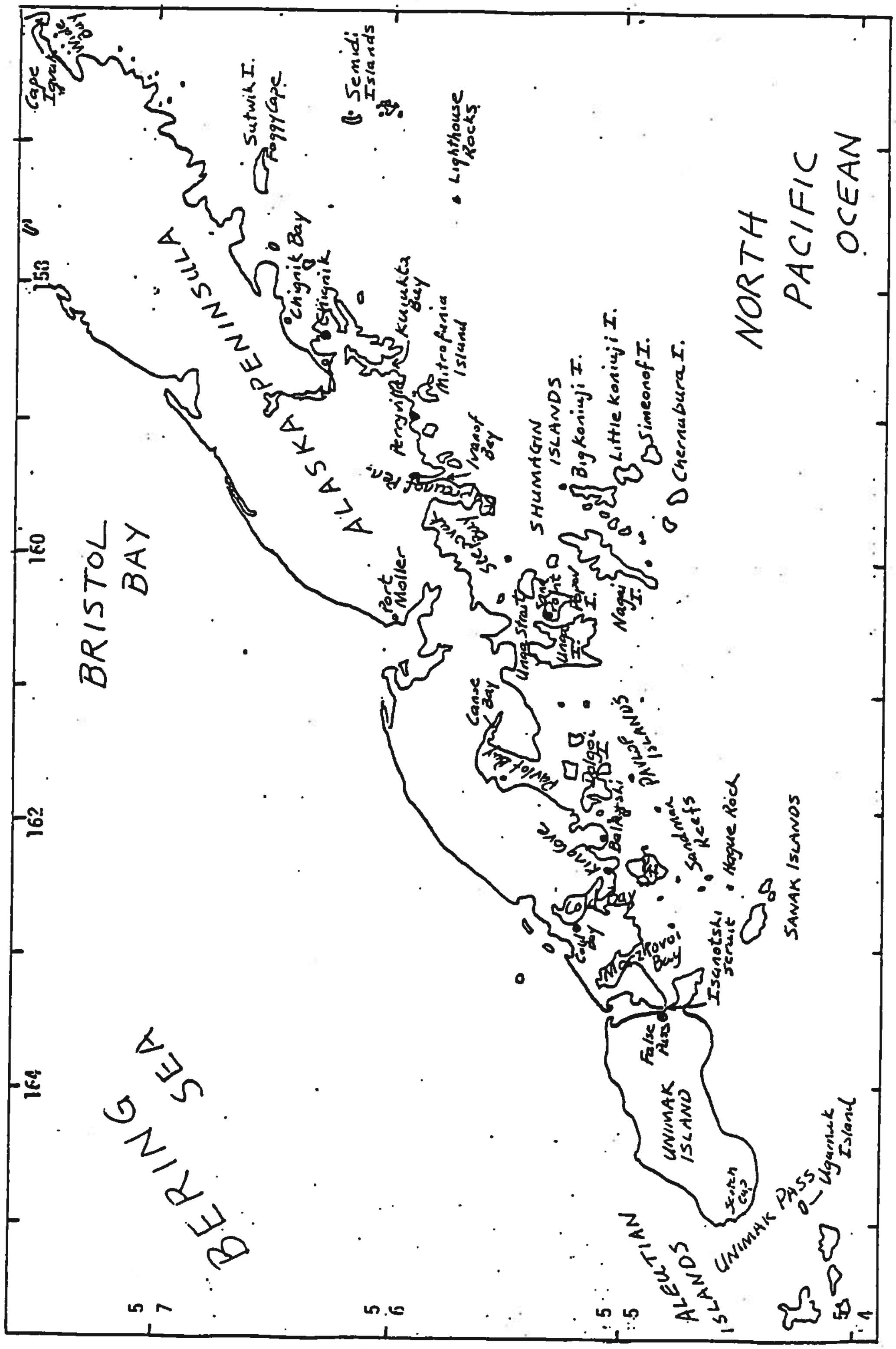

Figure 2.2. Principal geographic feature of the Shumagin region.

Perryville (pop. 111 in 1980) is a small native settlement on the coast midway between Mitrofania and Ivanof Bays.

Alexander Point is sheer and rocky and marks the end of the high cape bordering the east side of Ivanof Bay. This bay is bordered by bluffs and high ridges on both east and west shores, but at the head of the bay there is a low valley leading west across the Kupreanof Peninsula to Stepovak Bay. The village of Ivanof Bay (pop. 40 in 1980) is at the head of the bay. Remains of buildings of abandoned fox farms are found along the bay.

Kupreanof Peninsula is a 22 km long, bold ridge of land broken only by a few stretches of broad sand beaches and sandy coves. The western shore is mountainous with barren rocky peaks and grass and alder covered lower slopes.

Stepovak Bay lies on the west side of the Kupreanof Peninsula. It is a large and open bay with numerous smaller bays and coves indenting both the eastern and western shores. At the heads of each of these smaller bays are stretches of sand beach generally backed by lagoons and grassy flats. The northern shore of Stepovak Bay is a long stretch of wide sandy beach and grassy sand dunes. Beyond the dunes a belt of flat tundra extends across the Kupreanof Peninsula into Ivanof Bay. The western shore of Stepovak Bay is mountainous and very rugged, with snow and icefields covering the upper plateaus. This bay is an important fishing area during the salmon season.

San Diego Bay is a small bay west of Stepovak Bay that is used during the salmon season as an anchorage and as a fish transfer point.

Balboa Bay, known locally as Portage Bay, lies between Swedania Point to the east and Cape Aliaksin to the west . It is a deep bay at midchannel, and when the coal mine at Herendeen Bay was in operation, supplies were landed here and carried across the Alaska Peninsula by pack train, a distance of 25 km. The highest point on this trail is less than 200 meters.

Pavlof Bay is a large open bay with a landlocked arm named Canoe Bay on its eastern side. Dangerous rocks and small islands lie in the entrance to Pavlof Bay. The eastern shore of the bay is bold and strewn with rocks and reefs;

the interior is mountainous. The north shore consists of eroded bluffs 10 to 20 m high giving way to sand and ash beach near the entrance to Canoe Bay. The western shore of Pavlof Bay is comparatively low and rolling. Prevailing southerly winds draw up the bay in summer, often with considerable force, creating rough seas in the upper bay. In spring and fall, strong northwest winds sweep out of the bay with great force.

Canoe Bay is a landlocked arm of Pavlof Bay, connected by a 160 m channel between rocky entrance points. Often the tidal velocity through this entrance reaches seven knots. Violent northeasterly winter winds frequently sweep down the bay.

Belkofski, a former native settlement (pop. 7 in 1980) that was abandoned in 1976, is on the eastern side of Belkofski Point that separates Volcano Bay from Belkofski Bay.

King Cove (pop. 536 in 1983) is a cannery port and village west of Bold Cape and Belkofski Bay.

Cold Bay, indenting the coast west of King Cove, is a large and deep bay. The shore to Cold Bay is rocky and bold with many boulders, but gradually recedes to low bluffs and sand beaches backed by rolling tundra. The inner bay consists mostly of mudflats. The bay forms a natural draw through which strong winds often sweep, especially in the winter. The community of Cold Bay (pop. 228 in 1980), situated near the northwest portion of the inner bay, consists of an airfield and government and commercial buildings.

Morzhovoi Bay is the last bay indenting the southern coast of the Alaska Peninsula. The land bordering its entrance is very mountainous, but gives way to rolling tundra toward the head of the bay.

Isanotski Strait, known locally as False Pass, is a narrow passage that separates Unimak Island from the Alaska Peninsula, and connects Ikatan Bay on the southern side with Bechevin Bay on the Bering Sea side. Tidal currents that run through the strait can exceed seven knots. While the strait itself is deep, Bechevin Bay is practically closed by shoals at its entrance from the Bering Sea, and is filled with sand and mudflats with numerous blind channels.

The village and cannery of False Pass (pop. 70 in 1980) is located on Unimak Island at the upper end of Isanotski Strait. The abandoned village of Morzhovoi is located farther into Bechevin Bay on the Alaska Peninsula side.

Unimak Island, the northern- and easternmost island of the Aleutian Island chain, is about 80 km long and 37 km wide. The interior of the island is extremely mountainous, treeless and generally grass-covered. The higher peaks of Unimak Island, which descend steeply southward toward the Pacific coast, are often obscured by fogs and low-lying clouds, especially in the summer. Shishaldin Volcano (elev. 2857 m), cone-shaped and snowclad, and Isanotski Peaks (elev. 2480 m) rugged and barren rock, are the most notable of the higher peaks. The south coast of the island has cliffs in many places, with lower land and sand beaches between. This coast is fairly regular, with no embayments of any size. The unsheltered coast is exposed to the ocean swell, and there is generally a heavy surf along the shore. The water is deep to within 1.5 km of shore and is generally without the outlying rocks and islets of the nearshore areas to the east.

Scotch Cap, a precipitous cliff of rock 128 m high at the southwestern end of Unimak Island, marks the eastern entrance to Unimak Pass.

Unimak Pass is the first ship passage southwest of the Alaska Peninsula into the Bering Sea. It is about 16 km wide between the southwest end of Unimak Island and Ugamak Island to the west. Besides being the major eastern gateway to the Bering Sea, it is sometimes used as a shorter and preferred weather route across the North Pacific. On westward passages, this route avoids the prevailing head winds and heavy seas encountered south of the Aleutians. Unimak Pass averages 45 m in depth.

2.1.2. Island Groups of the Shumagin Area.

The continental shelf south of the Alaska Peninsula contains numerous island groups along its length. Some of these islands lie out to a distance of nearly 100 km from the coast. The main island groups along this area are the Semidi Islands, Shumagin Islands, Pavlof Islands, Sandman Reefs and the Sanak Islands.

Sutwik Island

This lone island is about 11 km off the Alaska Peninsula east of Cape Kumlik and about 145 km southwest of Kodiak Island. It is a moderately large island, 19 km long by 6.5 km wide. The northern shore of the island is generally steep with a flat grassy top, while the southern shore is low and marshy in places. There are many offshore rocks and islets surrounding the island. Foggy Cape is a prominence marking the eastern end of Sutwik Island.

The Semidi Islands

The Semidi Islands are an erosional remnant of a broad shoal of the Kodiak - Shumagin shelf, located about 145 km southwest of Kodiak Island, and about 30 km southeast of Foggy Cape. The two main islands are Aghiyuk Island, the northerly of the group, and Chowiet Island. Both islands have high rocky cliffs with elevations of 250 to 300 m. Moderate to strong tidal currents run between the island passages. Four smaller islands and several islets, all rocky and surrounded by pinnacle rocks, complete the group. The steep coastal cliffs on all the islands house large colonies of cliff-dwelling sea birds.

The Shumagin Islands

The Shumagin Islands, the dominant offshore island group along the Alaska Peninsula, consist of 15 sizeable islands and numerous smaller islets, sea stacks and rocks. These islands extend for a distance of up to 100 km offshore from the Alaska Peninsula, from which the group is separated by Unga Strait. In general, these islands have steep mountainous terrain and irregular shores that are broken in many places by inlets and capes. The shores are often rockbound and surrounded by rocky reefs and outcrops. Parts of the islands have some rolling topography. Fishing stations and camps are scattered throughout some islands of the group, and good fishing banks are offshore of them. Fox and cattle raising have been conducted to some extent in the past.

The main islands in the Shumagin group are Simeonof Island, the most easterly of the Shumagins, Little Koniuji, Big Koniuji, Chernabura - the most southerly of the group, Nagai Island, Popof Island and Unga Island - the largest and most westerly of the Shumagins. All these islands are relatively mountainous (to over 600 m elev.) and rugged. Their coasts are bordered by reefs, shoals, and thick kelp beds. Numerous inlets and embayments provide protected anchorages throughout the group. Williwaws can be expected in embayments when winds draw through them from certain directions.

The fishing port of Sand Point (pop. 903 in 1983) is on the east side of Popof Strait separating Popof and Unga Islands. On Unga Island is the old village of Unga, a former codfishing port, and there are several other seasonal fishing ports and abandoned canneries on the west side of the strait.

The Pavlof Islands

The Pavlof Islands consist of seven islands extending for over 25 km from the Alaska Peninsula coast south of Pavlof Bay. Much of the area between these islands is shallow and rocky and has not been surveyed. Covered and uncovered offshore rocks, submerged ledges, and breakers are common. These islands too are mostly high and mountainous, with rugged cliffs and rock-strewn shorelines. Dolgoi Island, 16 km across, is the largest of the group. Sandman Reefs.

The Sandman Reefs are a large area of hazardous seabed with numerous small islands, islets, and rocks, extending from the Pavlof Islands on the north almost to the Sanak Islands on the southwest. This area is generally avoided by vessels and has not been completely surveyed. Hague Rock, 14 m high, grass-covered and rocky, marks the southerly end of the reef group.

The Sanak Islands

The Sanak Islands are the southwesternmost group of islands along the Alaska Peninsula. The group consists of two large islands, and numerous small islands and rocks; all are bare of trees. Sanak Island, the largest, is mountainous (to 530 m elev.) at the northwest end, but low to the south. It is fringed with exposed rocks and extensive reefs along its shores, particularly along its southern coast. A number of small bays indent the coast. Pauloff Harbor is a small seasonal fishing port on the northeast side of the island. Caton Island to the southwest is rolling and grass covered, its coast formed by rocky ledges or boulder and gravel beaches.

2.1.3. The Offshore Region.

The Shumagin Planning Area extends to 450 km offshore. Beyond the coastal region with its numerous island groups, the continental shelf extends southward for 15 to 40 km to the shelf break. This shelf is widest (to 160 km from shore) at the eastern end of the planning area, and progressively narrows to the west (to about 65 km wide south of Unimak Island). The topography of the continental shelf is interrupted by isolated banks and shoals that rise abruptly from the surrounding bottom depths (Figure 2.3). The Sanak Bank, Davidson Bank, Shumagin Bank, and Chirikof Bank are uplifted areas along the shelf edge. Davidson Bank, the largest, is a productive marine area south of Unimak Island, extending along the shelf edge from the vicinity of Sanak Island to the southern entrance to Unimak Pass. The irregular and discontinuous relief of these banks, with their truncated bedrock and steep-sloped scarp features, suggest that they were subjected to subaerial erosion by streams or glaciers during periods of lower sea levels. Prominent depressions of this shelf region lie between the banks. These include the Shelikof Trough, Shumagin Gully, and Sanak Gully.

Beyond the shelf break at about 200 meters water depth, the continental slope descends rapidly to depths of over 6000 meters within as little as another 65 km (see Figure 2.1). Rock outcrops occasionally occur along the shelf edge and slope. Nautical charts for this area do not show any significant submarine canyons along the shelf edge and slope.

Sediments on the shelf are not well characterized but generally follow a graded pattern, reflecting wave and current interaction with the seabed. In shallower areas, the finer sediments are resuspended and carried to adjacent deep waters for deposition. Generally medium to coarse sediments predominate out to the 70 to 80 m bottom depth. Pebbles, gravel, and sand, with some shell fragments and volcanic materials from nearby islands are found on the banks. From these depths to the 120 to 150 m depths and in some of the shallower shelf depressions, finer sand and silt sediments occur. Near the shelf edge, intermittent concentrations of foraminifera are found and volcanic ash is common in the silt fractions. Deeper waters beyond 150 m and off the slope and deepsea basin progress to silt, mud, and fine clays.

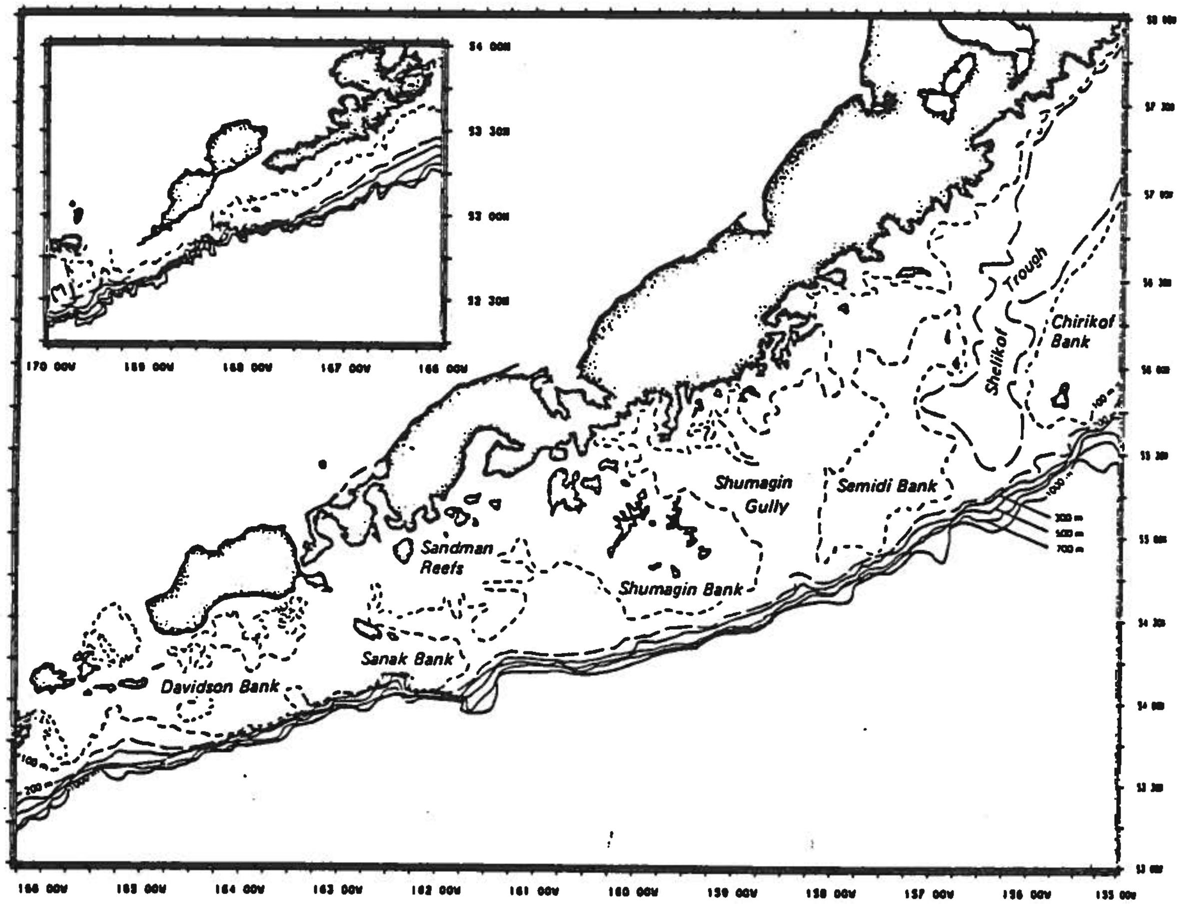

Figure 2.3. Bathymetric features of the Shumagin region.

The Aleutian Trench, which begins off Cape St. Elias in the Gulf of Alaska, parallels the Alaska Peninsula and the Aleutian Islands for more than 3500 km. The east-west axis of the trench is 145 to 260 km offshore of the Alaska Peninsula in water depths that range to over 7400 meters. The trench is seismically active.

Beyond the Aleutian Trench, the sea floor of the abyssal plain very gradually rises to bottom depths of about 4800 meters at the southern boundary of the planning area. Numerous seamounts rise from the ocean floor, the Sirius Seamount being the shallowest at 2817 meters.

2.2. PHYSICAL OCEANOGRAPHY.

The waters of the Shumagin Planning Area are part of the general circulation of the Subarctic Region of the North Pacific Ocean. Two main currents, the Alaskan Stream and the Subarctic Current bound the Alaskan Gyre within this area (Figure 2.4; Dodimead, 1968). The Alaskan Stream is a strong westward flowing current bordering the shelf south of the Alaska Peninsula. This permanent, relatively warm current originates in the Gulf of Alaska under the influence of land configurations and hydrodynamic imbalances rather than winds (NWAFC, 1985). The Alaskan Stream current is continuous to the end of the Aleutian Island Chain (near 170°W) where it divides, sending one branch north into the Bering Sea, and another southwestward to recirculate in the eastward flowing Subarctic Current. The Alaskan Stream forms the northern boundary of the Alaska Gyre, an eddy that accompanies the general eastward drift of the Subarctic Current across the North Pacific south of latitude 50°N.

The Alaskan Stream is of considerable strength and constancy, with highest velocities (greater than 40 cm/sec or 0.8 knots) reported in the winter. As the current follows the coast to the western Aleutian Islands, it penetrates the Bering Sea through Unimak Pass and other deep passes between the Aleutian Islands. During summer, flow reversals in Unimak Pass may occur that allow Bering Sea waters to flow into the Gulf of Alaska (Schumacher and Moen, 1983). The relatively warm waters of the Alaskan Stream keep the southern side of the Alaska Peninsula warmer that the Bering Sea side, and give the islands a milder climate than the mainland.

A common, but underestimated feature of the westward flow of the Alaskan Stream in the western Gulf of Alaska and Aleutians is breakouts of southerly and southeasterly surface flows that extend hundreds of kilometers into the oceanic regime and rejoin the Subarctic Current (NWAFC, 1985). These "ejections" from the Alaskan Stream are believed to be associated with the dynamics of the flow and by coastal runoff, but are probably also influenced by the strong southwesterly surface winds in winter. At times this feature can be identified as a major divergence of the flow of the Alaskan Stream (Favorite et al., 1977) and has been called the Aleutian Current. As much as one-third of the flow in the upper 1000 m of the water column is estimated to

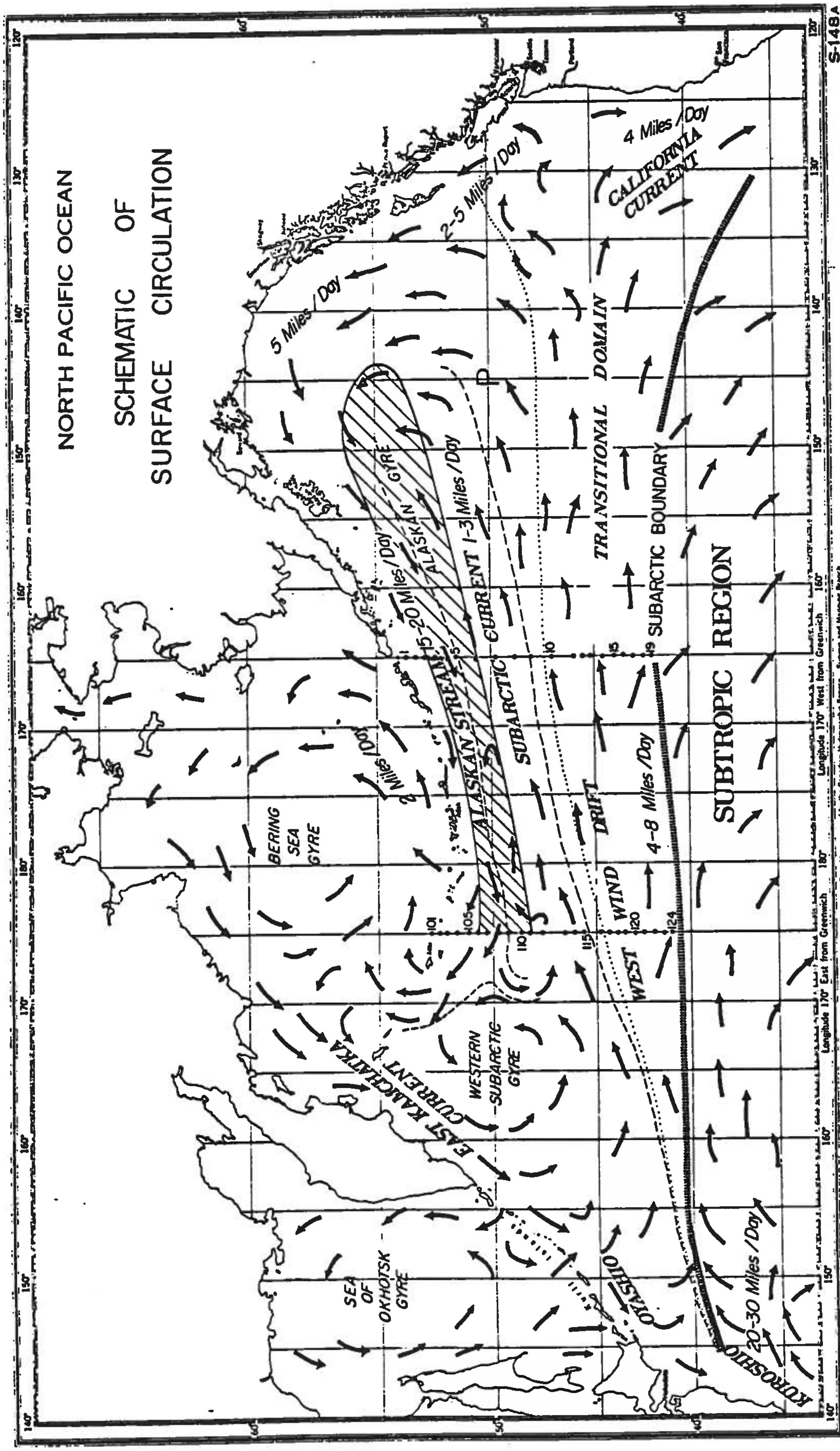

Figure 2.4. Major current systems of the North Pacific Ocean (from Dodimead, 1968).

turn southward and recirculate around the Alaskan Gyre. This flow (Figure 2.5) is of interest to both the transport of biota and pollutants in directions contrary to the popular concepts of the Alaskan Gyre. For example, of three drogued buoys released at the shelf edge off Kodiak Island in July, 1978, and transported southwestward with the Alaskan Stream, two subsequently turned southeastward and then northward, returning to the head of the Gulf of Alaska in December and back to Kodiak Island in January (Figure 2.6).

The Alaskan Gyre represents the shear zone between the Alaskan Stream and the Subarctic Current, encompassing the relatively slower-flowing westward and eastward portions of these two systems. A region of vertically upward divergence of deep water, called the Ridge Domain (Favorite et al., 1977) underlies the Alaskan Gyre and separates the westward flowing Alaskan Stream from the eastward flowing Subarctic Current. The waters of the Ridge Domain are characterized by high salinities, low temperatures, and low dissolved oxygen concentrations.

The Subarctic Current is a comparatively cold, low-salinity, weak eastward flowing current. It originates in the western North Pacific and extends eastward into the Gulf of Alaska. It is formed by the confluence of the warm Kuroshio and cold Oyashio Currents northeast of Japan. The direction of surface flow and strength of this current is more strongly influenced by winds than is the Alaskan Stream (NWAFC, 1985). Strong westerly winds in the winter strengthen this current, resulting in greater onshore transport with subsequent downwelling in the eastern Gulf of Alaska, and an increased westward geostrophic flow of the Alaskan Stream (McClain et al., 1979).

Coastal currents on the Shumagin shelf have not been well studied. Local currents can be strong and unpredictable, often moving counter to general trends in many places. Across the shelf, the Alaskan Stream finds all passages, large and small, between and around the offshore islands. In some straits and passages the current may show considerable strength, reaching 1.5 to 2 knots with strong winds in areas such as the West Nagai Strait. Generally, the current is strengthened by northeast winds and weakened by west winds. Both Isanotski Strait and Unimak Pass permit a limited exchange of waters between the North Pacific and Bering Sea.

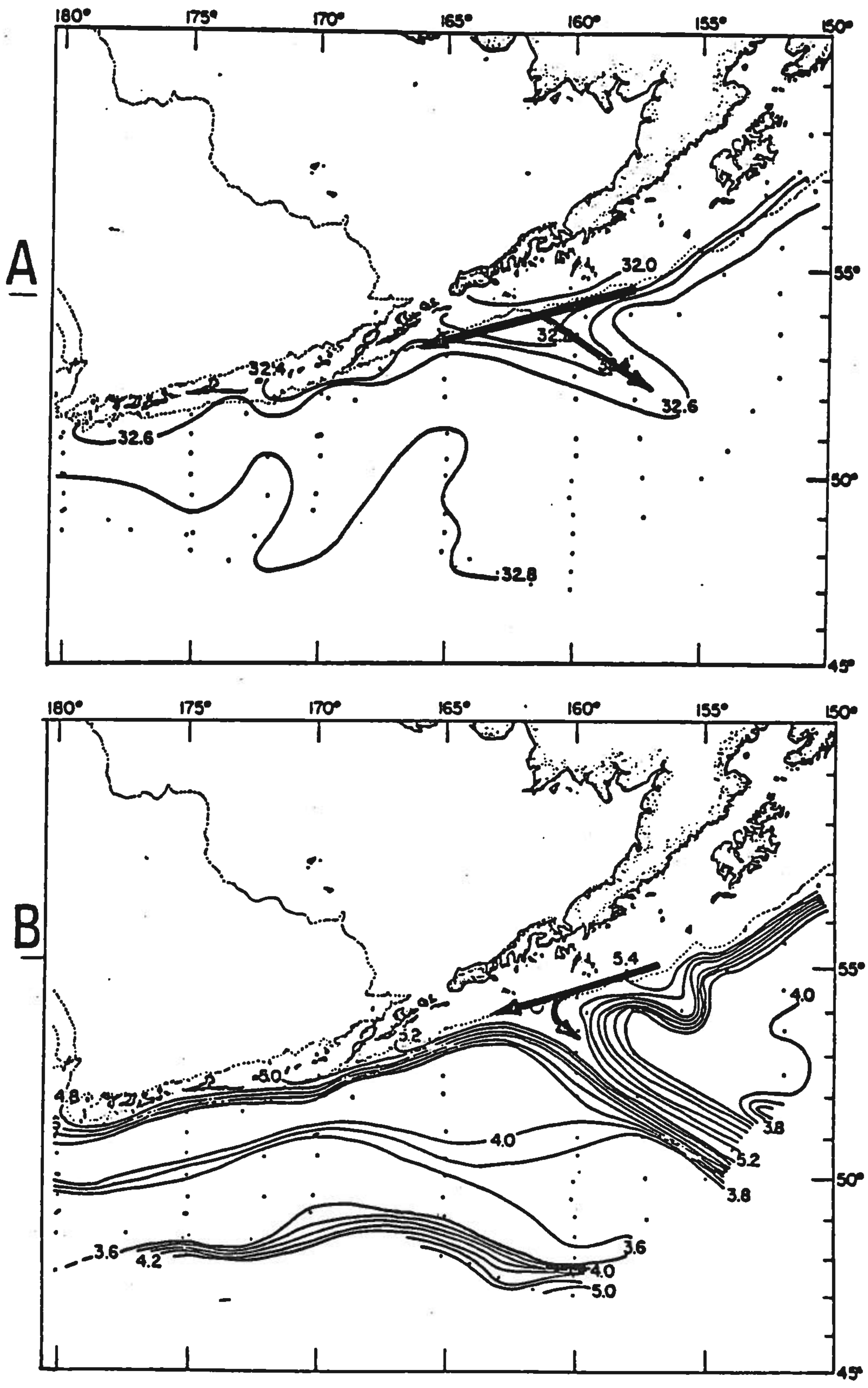

Figure 2.5. Horizontal distribution of surface salinity (A) and temperature (B) at approximately 200 m in the summer of 1959, indicating the recirculation of coastal flow eastward around the Alaskan Gyre; arrows simulate flow (from Favorite, 1964).

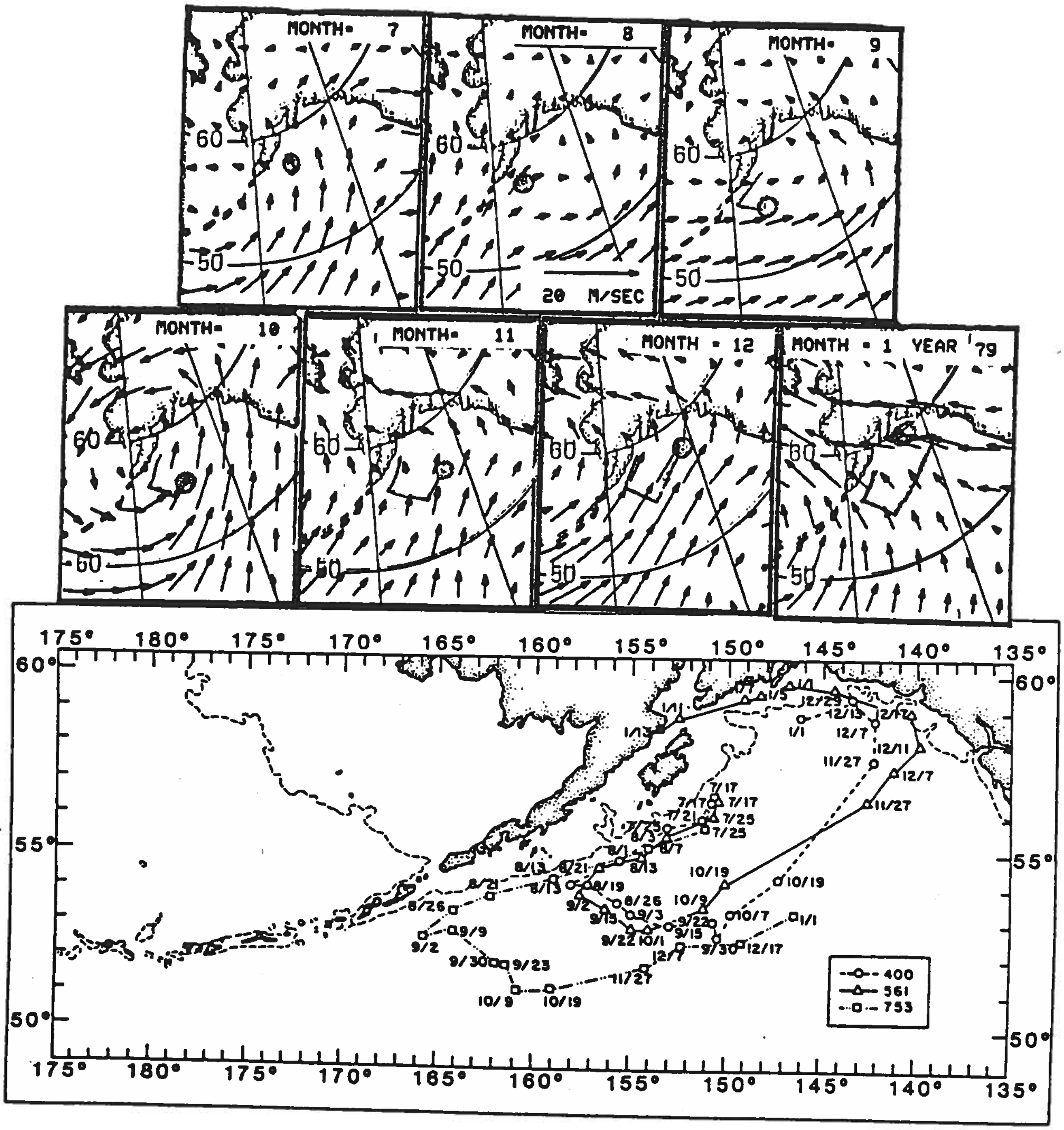

Figure 2.6. Tracks of three satellite tracked, drogued buoys from July 17, 1978 to January, 1979, and monthly mean wind fields during this period (from NWAFC, 1985).

Tides are generally mixed semi-diurnal (two unequal high and low tides each lunar day) along the coast with an average range of about 2 meters and a maximum range of 3.5 meters. Tidal currents, although generally weak in the offshore waters, may be strong along the coast in many of the constricted passages, such as the entrance to Cold Bay where current velocities may exceed 4 knots. In Unimak Pass, the tidal currents are strongest on the eastern side between Scotch Cap and Ugamak Island. At peak strength during flood and ebb, the tidal velocity averages about 3.5 knots (Brower et al., 1977), but the maximum may exceed this speed considerably during tropic tides when flows reach 6 knots or more.

The temperature and salinity structure of the Gulf of Alaska follows seasonal patterns (Figure 2.7). The surface layer over the shelf and slope exhibits winter cooling accompanied by turbulent mixing due to winter storms, resulting in a uniformly cold (about 4°C) water layer in the upper 100 m. During the summer, with higher air temperature and solar heating accompanied by reduced winds and turbulent mixing, the surface layer stratifies and may warm to temperatures exceeding 12°C. The surface waters of the region are distinctive in their low salinity. At no place in the region do surface salinities exceed 34 ppt.

Along the Shumagin shelf edge, upwelling, as a result of the offshore transport of surface waters, occurs from April to December. This is the most prolonged period of upwelling anywhere in the Gulf of Alaska (Favorite et al., 1977). There are three separate peak upwelling periods in April, August, and December. These upwellings replenish nutrients to surface waters of the shelf and promote increased biological productivity.

Beyond the shelf, the vertical structure of the ocean waters of the subarctic North Pacific is characterized by salinity features, with a salinity minimum at the surface and increase with depth. There is a permanent halocline between 100 and 200 meters, above which a seasonal thermocline develops in summer and dissipates in winter (Dodimead et al., 1962). The mixed surface layer is shallowest toward the Alaska coast (40 to 80 meters) and deepens offshore. Sea surface temperatures offshore are coldest in late winter at the end of the cooling season (less than 4°C in March) and warmest in late summer at the end of the heating season (to 12°C in August).

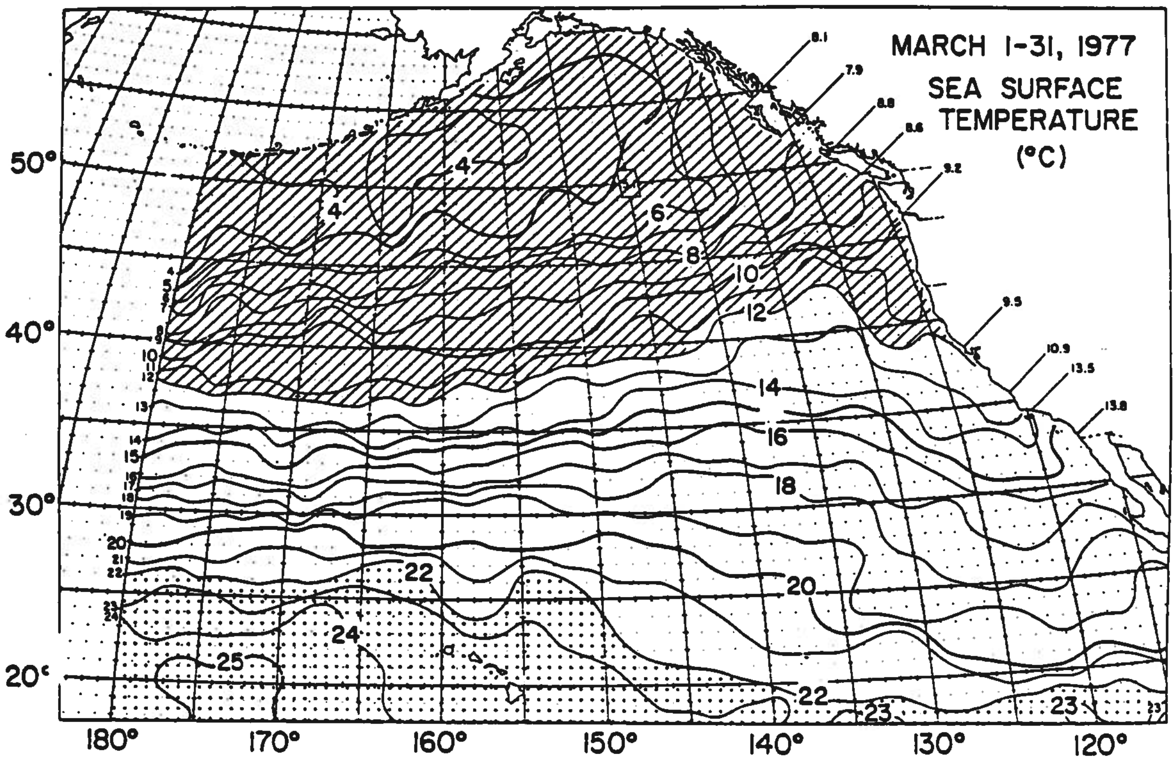

Figure 6.—Sea surface temperature for the eastern North Pacific during March 1977 (upper) and September 1977 (lower), adapted from *Fishing Information*.

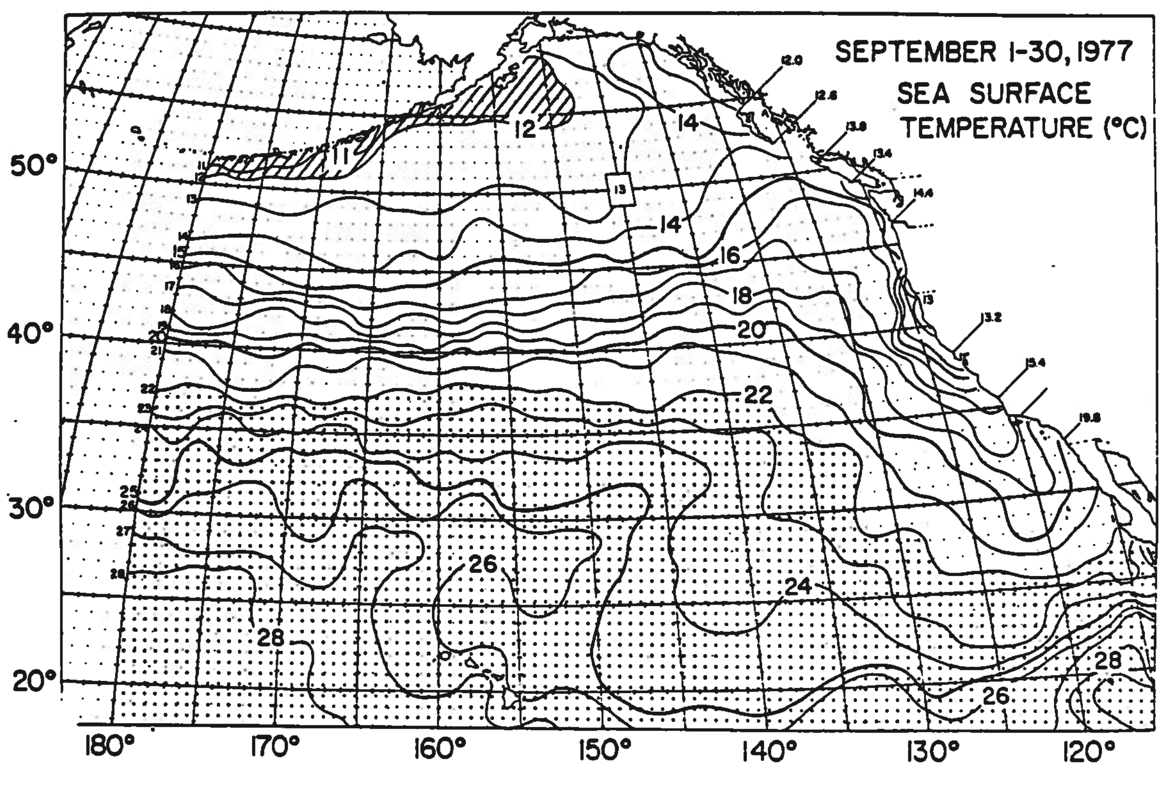

Figure 2.7. Sea surface temperatures for the eastern North Pacific during the months of March and September (from Ingraham, 1979).

2.3. CLIMATE AND WEATHER.

The climate of the Shumagin area is classified as Maritime, being characterized by heavy precipitation, cool summers, warm winters, and persistently strong surface winds. The major climatic influences are the ocean currents and the high frequency of cyclonic storms that cross the North Pacific Ocean and Bering Sea (AEIDC, 1976). To quote from USDOC (1964), "With the exception of an occasional fine summer, the weather of the Alaska Peninsula can be classified as bad, and the difficulties of navigation are many." Selected weather data is presented in Table 2.1 and discussed below. Detailed weather data is available only for Cold Bay.

Seasonal climatic changes in this maritime area are not abrupt because of the moderating influences of the ocean waters (AECRSA, 1984). The beginning of spring is late May or early June and August is considered mid-summer. Fall begins in early October.

Sea level pressures at Cold Bay average 1007.8 mb, ranging from a mean low of 1001.4 in November to a mean high of 1014.9 in July (USDOC, 1985)

2.3.1. Winds and Waves.

The weather of the Shumagin Planning Area is characterized by high winds and often violent storms originating in the Aleutians or Bering Sea. During the winter the general region is under the influence of a barometric low pressure cell - the Aleutian Low, centered over the Aleutian Islands (Figure 2.8). This low is surrounded by two high pressure cells, the Siberian High and the North American Arctic High. Under the influence of this barometric pressure distribution, the predominant winds in winter are westerly and southwesterly in the Shumagin area. In summer, the Aleutian Low significantly weakens, and the area becomes under the influence of the North Pacific High (Figure 2.9), resulting in increased winds from the south and southwest.

The prevailing winds on the Shumagin shelf are from southwesterly directions in summer and from southerly directions in winter. Southwesterly gales occur during the fall through spring seasons. Ship observations reported south of

Table 2.1. Climate Means and Extremes at Selected Locations in the Shumagin Region (from various sources).

	Station		
Parameter	Cold Bay	Sand Point	Chignik
Temperature, °C			
Mean Annual Max/Min	6.7/0.8	6.8/1.7	6.8/-0.4
Record High/Low	25.6/-25.0	21.1/-17.2	24.4/-24.4
Precipitation, inches			
Average Annual	33.23	60.3	127.2
Greatest, Month/Day	10.0/4.9	11.8/3.4	35.7/7.2
Snowfall, inches			
Average Annual	51.9	40.5	58.5
Greatest, Month/Day	23.4/11.4	23.3/9.0	31.0/12.0
Snow Depth Max., inches	24	11	47
Surface Winds, knots			
Prevailing Direction	SSE	NW	--
Average Annual Speed	17.0	12	--
Fastest Direction	SSE	NW	--
Max. Sustained Speed	73	74	--

Unimak Island describe prevailing westerly winds during all months except December when they are northwesterly (USDOC, 1985).

High waves and rough seas are frequently encountered in the Shumagin region. Hazardous wave conditions with waves heights greater than 4 meters can occur year-round, but are most frequent from September through April (Brower et al., 1977).

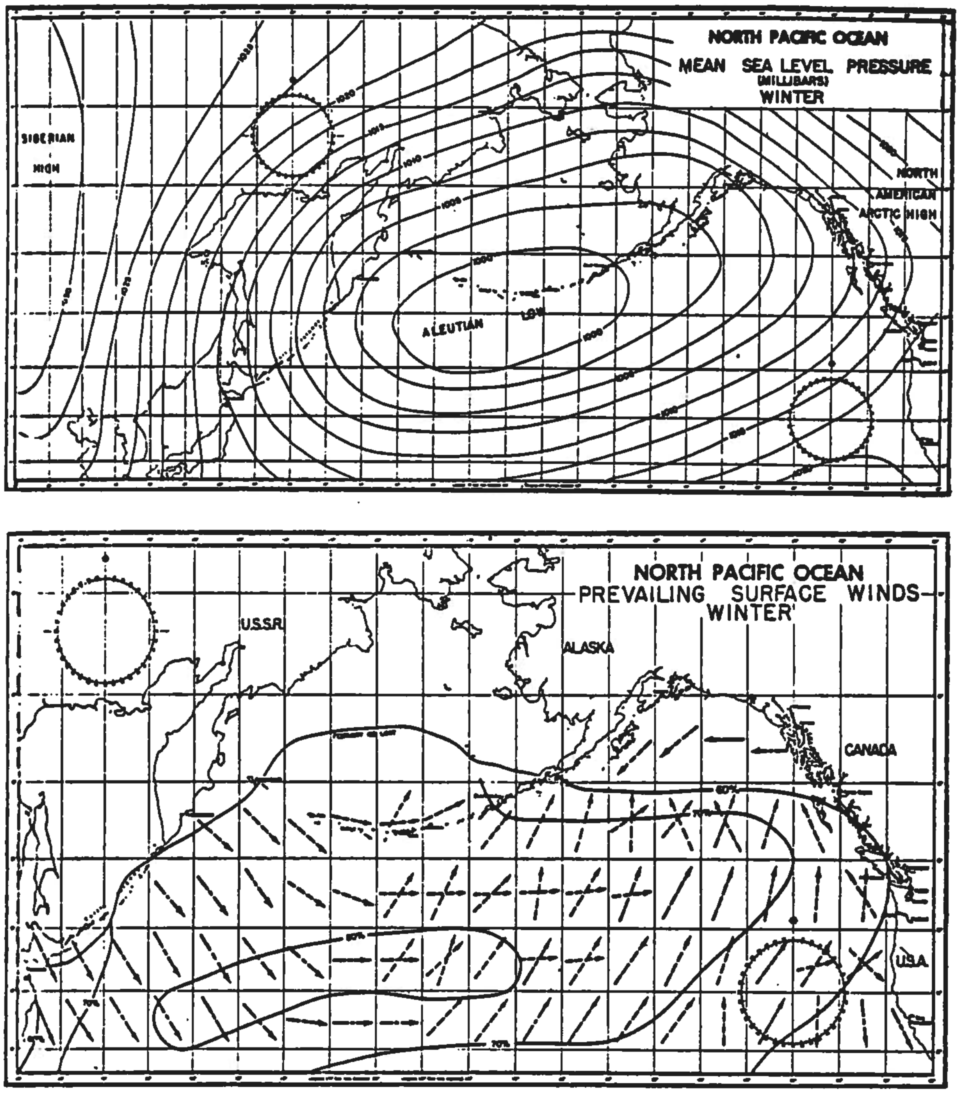

Figure 2.8. Mean sea level pressure (millibars) and prevailing surface winds during winter, with contours indicating the percentage of time the winds are Force 3 and less (from Dodimead et al., 1963).

Winds near the coast are greatly influenced by topography, and can be quite local and variable. At Chignik, on the upper Alaska Peninsula close to the eastern boundary of the Shumagin Planning Area, the winds are extremely variable. In early winter winds are from the northwest and west, while in January and February they are from the southeast. Winds shift frequently from southeast to southwest from March until September, and then shift back through

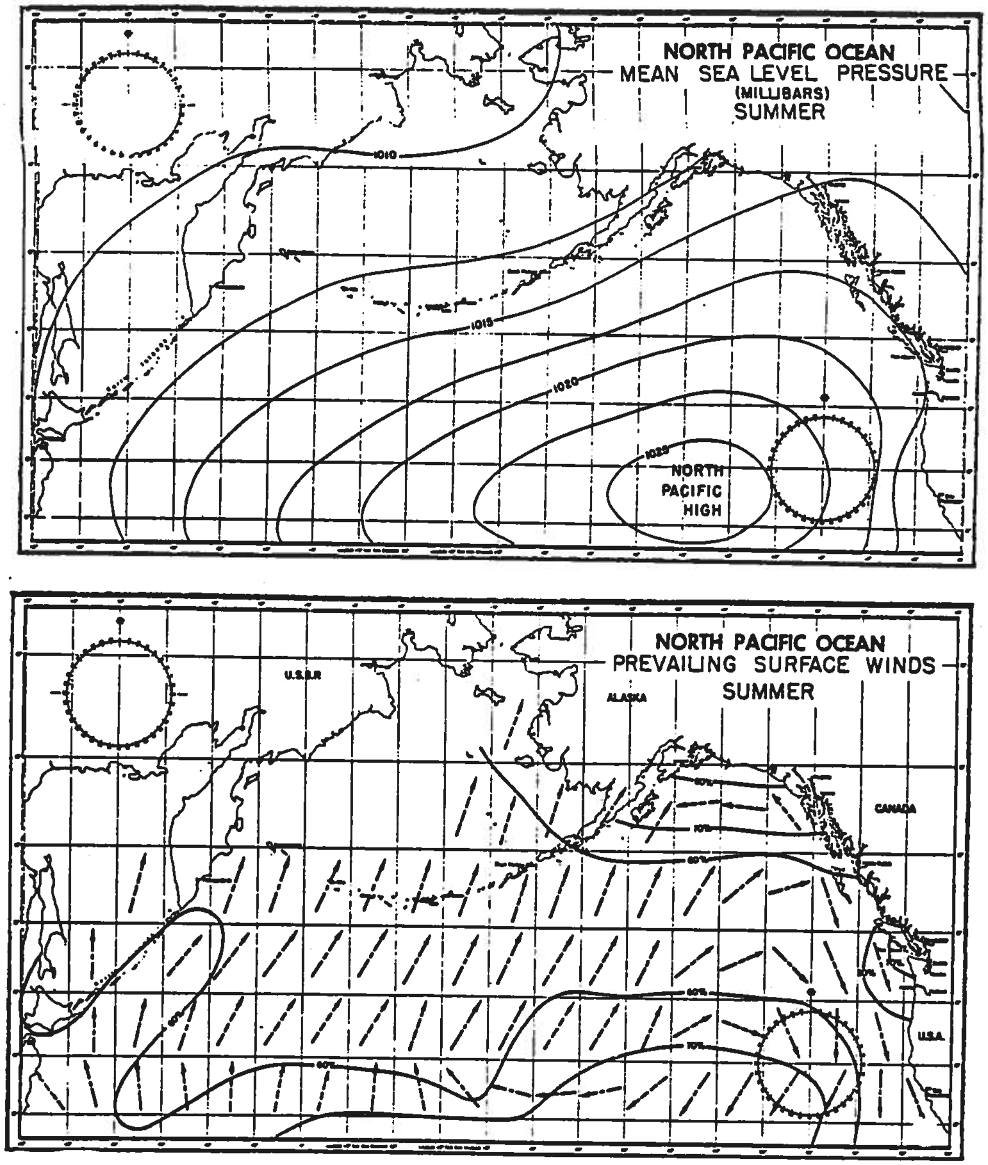

Figure 2.9. Mean sea level pressure (millibars) and prevailing surface winds during summer, with contours indicating the percentage of time the winds are Force 3 and less (from Dodimead et al., 1963).

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west to northwest by November. Gales are frequent along this part of the coast in winter when strong winds blow over the mountain passes from the Bering Sea.

Along the coast of the lower Alaska Peninsula, the strongest southeasterly winds are common all year. Northwesterly winds are frequent mainly during winter storms. In the summer, winds shift frequently from southeast to west northwest. Winds are frequently brisk, averaging 13 to 15 knots at Cold Bay during almost all months. During winter, winds exceed gale force (over 34 knots) 3 to 5 per cent of the time. Extreme sustained winds of 73 knots have been reported at Cold Bay. On Unimak Island the prevailing winds are also southeasterly in midwinter and generally from westerly and northwesterly directions during the other seasons. Off Unimak Island, gale force winds occur 10 to 14 per cent of the time from November through February. Wave heights greater than 3 meters are most common in February (at least 33 per cent of the days) and least common in June (6.5 per cent).

Generally, the strong northeast winds bring clear weather, and southeast or southwest winds are usually accompanied by rain and low clouds. Strong winds channel through the bays and inlets, often causing considerable changes in weather within short distances.

2.3.2. Precipitation.

The annual amount of precipitation along the coast of the Alaska Peninsula ranges from 100 to 250 cm (Brower et al., 1977; Glaspell, 1984a). Since most of the moisture laden winds are from the south, the prevailing northerly flow deposits the heaviest amounts of precipitation on the south side of the peninsula. Cold Bay averages 84 cm of total precipitation (rain and snow) annually, with measureable precipitation on 320 days per year, including 124 days of snow (USDOC, 1985). The least precipitation is in April (3.8 cm average), the most in October (10.9 cm). Annual precipitation is 122 cm at Coal Harbor on Unga Island, and 323 cm at Chignik. August through November are generally the wettest months. At Cold Bay, snow is the common form of precipitation from December through April, with rain more common May through November. Total annual snowfall is 132 cm in Cold Bay, 64 cm at Scotch Cap, 145 cm at Coal Harbor, 104 cm at Sand Point, and 150 cm at Chignik. Snow may fall at sea level from September until June, being most common from October through April. At Cold Bay, average monthly snowfall is highest in January (27 cm), and average winter snow depth is 51 cm (Brower et al., 1977).

An oceanographic feature of the Subarctic North Pacific, for which the Shumagin region is no exception, is that precipitation exceeds evaporation, and the area is thus a region of net dilution of surface waters (Dodimead et al., 1962).

2.3.3. Temperature.

In general, temperatures in this area are mild and their range is small. Winter air temperatures of the southern coast of the Alaska Peninsula are moderated by the warm coastal current, and summer temperatures are cooled by the ocean waters. Daily temperature ranges average less than 6°C. The mean annual temperature ranges from 0° to 7°C. The average minimum temperature is -7° to -2°C in January (AECRSA, 1984). Occasionally a cold air mass from the Bering Sea will drop winter temperatures considerably, while sunny days in summer will heat sheltered locations to high temperatures. At Cold Bay (USDOC, 1985), the average annual temperature is 3.3°C. The average monthly high is 13°C in August, and the average low is -4.7°C in February. Extreme temperature at Cold Bay have ranged from -25° to 25.8°C. Ocean water temperatures are generally slightly warmer than air temperatures in winter and slightly lower in summer. The average dates of last and first frost are May 22 and October 8, giving an average of 135 frost-free days per year (AEIDC, 1976). The region is generally free of permafrost.

2.3.4. Sea Ice and Icing.

Ocean and coastal waters south of the Alaska Peninsula are free from ice year-round. The maximum extent of winter sea ice ends in the Bering Sea just north of Unimak Pass. Although some shore ice may form in various bays, all harbors and bays almost always remain ice free and open to navigation year-round. Any shore ice in a particular location usually forms and dissipates several times a winter. Ice formation has been observed in Cold Bay, Lenard Harbor, False Pass, Ikatan Bay, at the head of Volcano Bay, in Big Lagoon at the head of Morzhovoi Bay, and in Canoe Bay (AECRSA, 1984). The extent of icing varies from year to year. Winter ice has also been known to drift out of Bechevin Bay through Isanotski Strait and interfere with navigation in Ikatan Bay.

2.3.5. Visibility.

Weather conditions in this area can be quite local. Conditions of fog, low ceiling, and clear visibility can often be encountered within a distance of 30 km.

There is usually cloud cover over the area. Cloud-cover averages seven to nine-tenths year-round (AECRSA, 1984; BBCMP, 1984). The sky is overcast or obscured at least half the time. Overcast skies frequently are low enough to obscure most of the higher peaks and elevations along the coast and the larger islands. Thunderstorms have been reported at Cold Bay, but their occurrence is rare.

There is a considerable amount of fog over the area, with a decided maximum of occurrence in mid-summer. Fog can be expected along the coast at any time during June through September. Vast fog banks lie in the North Pacific during this season when warm Pacific air moves over the cooler Aleutian waters, and this sea or advective fog may be blown toward the coast by southeasterly winds. Often solar radiation does little to dissipate the fog, and it requires a change in wind direction to clear the area. Fog patches often hang at the headlands and entrances to bays while the upper part of the bays remain clear. At Chignik, fog is reported about 7 days per year. At Cold Bay, fog is most frequent during July and August (18 to 25 days per month), and least frequent in autumn and winter. Scotch Cap averages fog 11 per cent of the whole year, and 32 per cent during mid-summer. Least fog is encountered over water during the winter, averaging only 1 percent of the time at Scotch Cap during December and January; however, land fog and precipitation may reduce visibilities in many areas during this season.

2.4. GEOLOGY OF THE SHUMAGIN AREA.

The Alaska Peninsula and Aleutian Arc are located at the boundary between the oceanic crustal plate of the Pacific Ocean and the continental crustal plate of North America. At the margin between these two plates, the continental North American Plate extends outwards under the coastal waters as the continental shelf, and eventually meets the neighboring Pacific Plate of oceanic crust. Along the North Pacific margin of Alaska, seafloor spreading produces a zone of collision between the two plates. The oceanic crustal plate is subducted at the convergence boundary, creating a region of volcanism and high seismicity (Figure 2.10). Along this 8000 km margin, the oceanic crust is carried deep within the mantle of the Earth, where it melts and then rises as magma to form the volcanos and volcanic rocks. The Alaska Peninsula and Aleutian Islands represent a highly active volcanic arc which is flanked on the seaward side by the deep Aleutian Trench. Along this trench, the sea floor of the North Pacific is being subducted under the continental plate at a rate of about 5 to 8 cm per year.

Complex geologic structures are exposed in the coastal formations and islands of the Alaska Peninsula (Marlow et al., 1976). Interbedded volcanic and sedimentary rocks dating from the Paleozoic, Jurassic and Cretaceous, Tertiary and Quaternary, occasional intrusions of igneous rocks, as well as surficial deposits including volcanic ash and glacial drift may be found in various locations. The sedimentary rocks are mainly greywackes, siltstones, shales, and some limestone (BBCMP, 1984). Rocks of volcanic origin dominate the geology of the lower Alaska Peninsula (AECRSA, 1984). Volcanic deposits form soils over much of the area, being cinder-like close to volcanic cones, and sand or silt in texture on lower slopes. Major glacial activity occurred periodically throughout the area during Pleistocene time (until 10,000 years ago), and is responsible for most of the non-volcanic landforms of the area. Glacial deposits occupy most coastal lowlands and Unimak Island.

The Shumagin Islands are composed of deformed strata of continental origin that have been detached from the Alaska Peninsula by faulting and volcanism. Popof Island is of volcanic origin.

2.4.1. Seismicity.

The Alaska-Aleutian arc is one of the world's most active earthquake belts. About 7 per cent of the annual worldwide release of seismic energy occurs in the Alaska-Aleutian seismic belt (Dillon, 1977), making it the third highest region of great earthquakes worldwide. The primary cause of this seismic activity is the northeasterly motion of the Pacific tectonic plate at the rate of about 5 to 8 cm per year. Since the plate boundary is periodically subject to ruptures and their ensuing earthquakes as strain between the two plates is

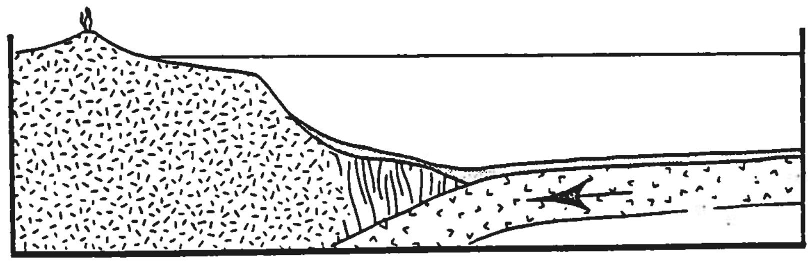

Figure 2.10. Idealized physiography of the Alaska margin colliding with the Pacific Plate (from Rowland, 1983).

released, gaps along the boundary that have not ruptured in the recent past are thought to have the greatest potential for earthquakes in the future. The frequency and magnitude of large earthquakes along the Aleutian Arc, based on historical data, indicates that about 13 earthquakes of Richter magnitude 7+ (M 7+) should occur during each 42-year interval, or one every 3.2 years (Dillon, 1977), and M 8+ earthquakes should occur once every 20 years.

The Shumagin area has not seen a major earthquake in recent years, and has been identified as the "Shumagin Gap", a high potential zone for a future great earthquake. Davies et al. (1976) have calculated the recurrence interval for M 8+ earthquakes in the Shumagin Gap as 52 years + 20. The last major earthquake (M 7.9+) to occur in the Shumagin area registered 8.7 in 1938 (Figure 2.11). Sykes et al. (1980) subsequently calculated that at least half of the Shumagin Gap was not ruptured by the 1938 earthquake and has not experienced a great earthquake for at least 77 years. They predict that one or more great earthquakes will rupture the Shumagin Gap by the year 2000. Dillon (1977) has predicted that the epicenter of this earthquake will be to the south of Kodiak Island where the aftershocks of the 1964 Good Friday Earthquake ended. More recently, an aseismic deformation event that may have occurred between 1978 and 1980 is believed to have increased the stress on the shallow locked portion of the plate boundary in the seismic gap, bringing it closer to rupture in a great earthquake (Beavan et al., 1983).

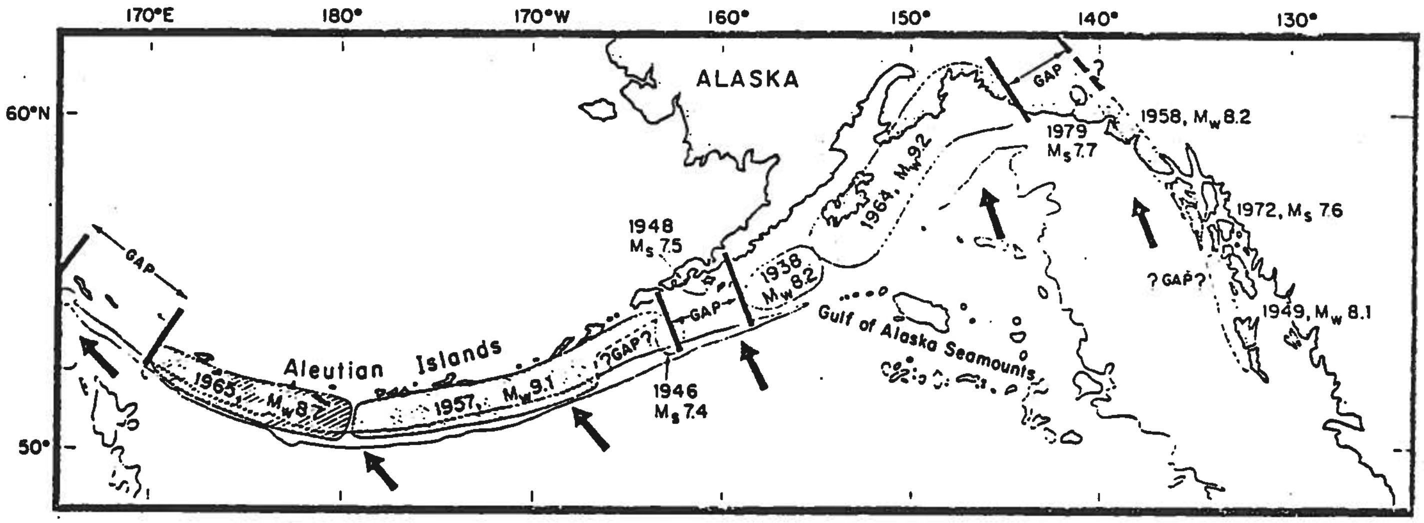

Figure 2.11. Rupture zones of large shallow earthquakes from 1930 to 1979 and seismic gaps along the plate boundary of Alaska. Heavy arrows indicate motion of the Pacific plate with respect to the North American plate (from Sykes et al., 198).

The area to the west of the Shumagin Gap has been suggested to be a possible seismic gap also. It has been called the Unalaska Gap. Should this area also release its energy simultaneously with the Shumagin Gap, some geologists have predicted a very great earthquake of M 9+ could result.

2.4.2. Tsunamis.

Tsunamis (often erroneously called tidal waves) are an infrequent yet serious hazard in seismically active areas of Alaska, including the Shumagin region. Tsunamis are moving ocean waves of great length and a long return period generated by ground disturbances caused by earthquakes in oceanic and coastal areas. Six tsunamis have occurred along the Alaska coast since 1899 causing damage, three of which claimed lives. The 1964 earthquake in Prince William Sound caused 119 fatalities and over $90 million in damage to property.

A tsunami wave at sea may have a crest to crest length of 150 km or more with a crest to trough height of about one meter. They may propagate at speeds over 600 knots. At sea they are unnoticeable, but as they enter shallow waters their speed is slowed and their wave height increases. Upon reaching land these waves can crest to 30 meters or more, and strike land with ensuing force and devastation.

Although tsunamis may arrive in Alaska from throughout the Pacific Ocean, their most serious threat is from local earthquakes. If an earthquake generated a tsunami close to Alaska shores, it could strike an area within minutes and without warning other than from the ground-motion from the earthquake itself. At Scotch Cap in 1947, a seismic disturbance along the Aleutian Trench caused a submarine landslide and generated a tsunami that reached a height of 35 m (155 ft) and destroyed a concrete lighthouse 28 m (92 ft) above sea level. The threat of an earthquake in the Shumagin Gap contains a high tsunami risk. A 10 to 30 meter wave is considered possible in the vicinity of Morzhovoi and Ikatan Bays (Davies and Jacob, 1981). The communities of Cold Bay, False Pass, King Cove and Sand Point have all been rated as tsunami hazard locations.

2.4.3. Volcanoes.

The many volcanos along the Alaska-Aleutian arc are generated by the subducting North Pacific tectonic plate. This active volcanism constitutes a major geophysical hazard in the Shumagin area. There are 12 active volcanoes on the Alaska Peninsula adjacent to the Shumagin area, six on Unimak Island alone (Figure 2.12). Mt. Veniaminof and Pavlof Volcano on the Alaska Peninsula, and Pogromni, Shishaldin, and Westdahl on Unimak Island are rated as high for eruption potential (Davies and Jacob, 1981).

Most hazards from volcanic activity are associated with the eruption of lava and ash and the attendant earthquakes. The distribution of ash depends on the magma composition, character of the eruption event, wind speed and direction at the time of eruption, height of eruption, volume of material, and specific properties of the pyroclastic debris (Marlow et al., 1976). Eruptions from the large andesitic cones on the Alaska Peninsula and Aleutian Islands are mostly of the explosive-type and are likely to spread pyroclastic materials over large areas. The ground motion that often accompanies major eruptions,

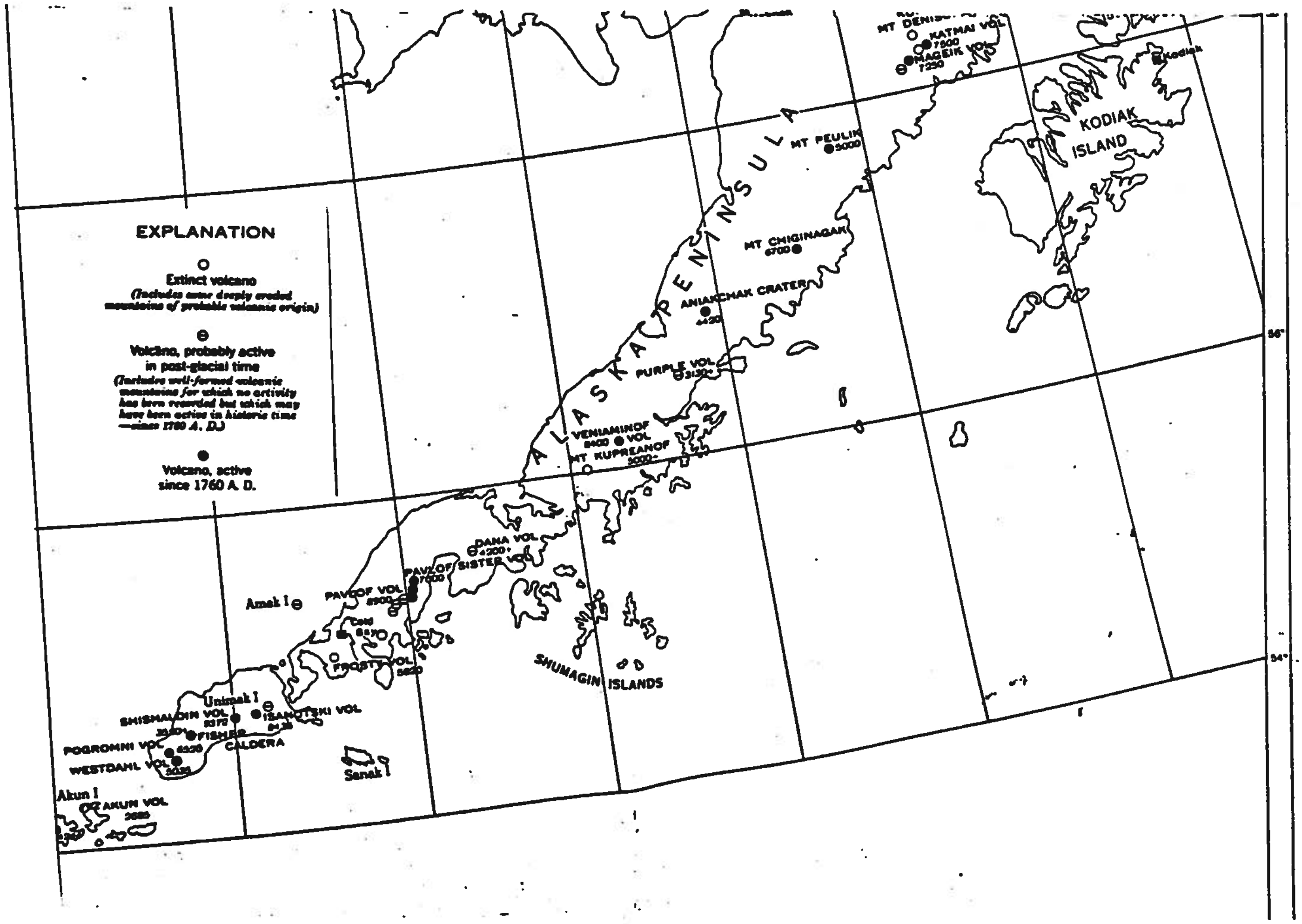

Figure 2.12. Locations of active and inactive volcanoes on the Alaska Peninsula, with outlines of general zones of high tsunami hazard (after Coats, 1950; AECRSA, 1984; BBCMP, 1984).

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including base surges from caldera eruptions, can affect man-made structures cause ground failure of underlying unstable or undercompacted sediments, and generate tsunamis.

Predictability of volcano activity may be partially related to earthquake activity. Beavan et al. (1983) have correlated the quiescence from 1977 to 1979 of Pavlof Volcano on the Alaska Peninsula to a decreased rate of seismic activity since 1973.

2.4.5. Petroleum Resources.

No offshore wells have been drilled in the Shumagin area to assess its petroleum resource potential. Based on seismic profiling, MMS has indicated that there are shallow sedimentary basins on the coastal shelf that may contain oil and gas (Figure 2.13). The recoverable oil and gas volumes that these reservoirs may contain, if oil bearing, are estimated as 50 million barrels of oil and 1.42 trillion cubic feet of gas (MMS, 1985). However, dredge samples taken within the area indicate poor source rock potential. Geological analysis for source rocks and reservoir rocks from the adjacent Kodiak Shelf suggests a low to moderate probability for the occurrence of commercial quantities of hydrocarbons in the Shumagin area.

Since 1902, 26 onshore wells have been drilled on the Alaska Peninsula (Figure 2.14). Those in the southern group, Sandy River to Cathedral River, found oil and gas shows of noncommercial quantities. It is believed that the formations

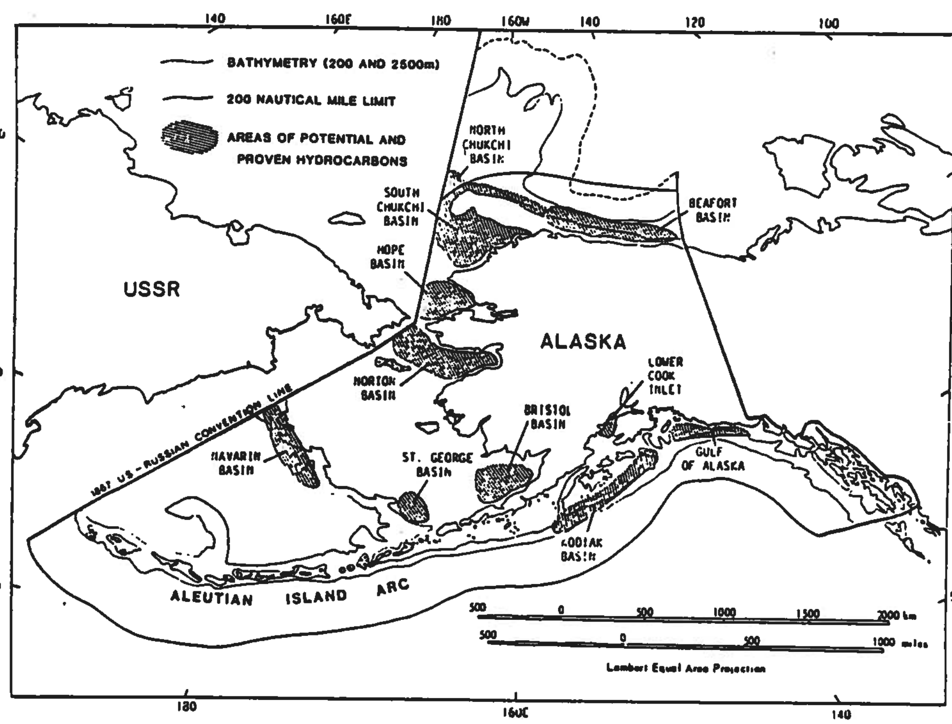

Figure 2.13. Location of sedimentary basins with oil and gas potential on the Alaska OCS (from Rowland et al., 1983).

in which these shows were encountered trend offshore toward Bristol Bay. The Mesozoic Province of sedimentary rocks extending along the southern shore of the Alaska Peninsula from Cook Inlet to the Aleutians may also contain hydrocarbon bearing formations. However, the volcanism and plutonism along the Alaska Peninsula are believed to have substantially disrupted and reduced the petroleum potential of these sedimentary formations along and to the south of the peninsula (Marlow et al., 1976).

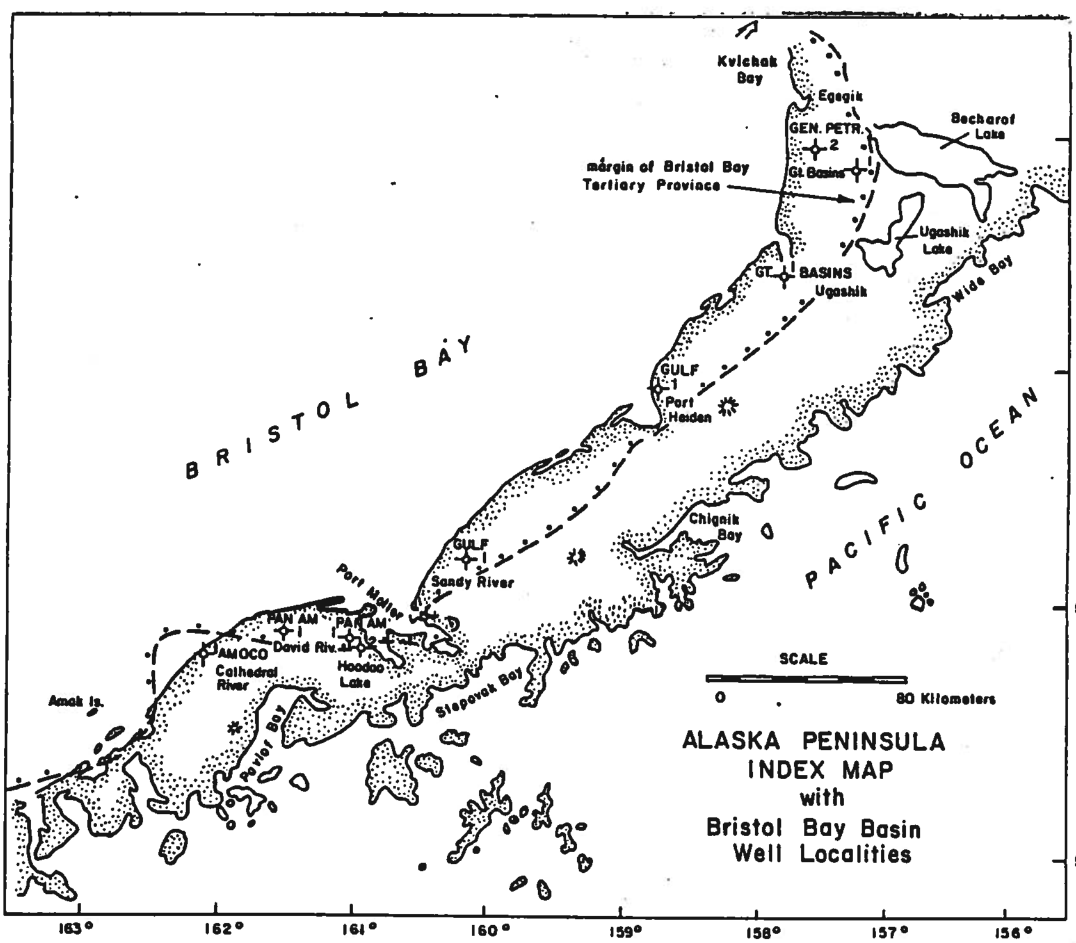

Figure 2.14. Map of the locations of onshore petroleum wells drilled on the Alaska Peninsula (from Marlow, 1976).

3. THE BIOLOGICAL ENVIRONMENT OF THE SHUMAGIN REGION

3.1. GENERAL DESCRIPTION OF HABITATS.

The Shumagin region contains a variety of marine and coastal habitats. The southern coast of the Alaska Peninsula is largely formed by steep mountains meeting the sea to form abrupt and intricate shorelines. Along these shores, long expanses of bedrock and sea cliffs intersperse with gravel, sand and boulder beaches. Tideflats and marshes form at the mouths of rivers and in sheltered bays. Eight of the coastal habitat categories contained in the Alaska Coastal Management Plan (ACMP 6AAC 80.130a) occur in this region (AECRSA, 1984; BBCMP, 1984). These habitat categories are: offshore areas; estuaries; barrier islands and lagoons; exposed high-energy coasts; rocky islands and sea cliffs; wetlands and tideflats; rivers, streams and lakes; and important upland habitat. The characteristics of these habitats in the Shumagin region are discussed individually below.

3.1.1. The Offshore Areas.

Offshore areas include the submerged lands and waters seaward of the coastline, beyond the seaward beaches of barrier islands, or beyond the headlands of estuaries, and beyond the tidal level of mean lower low water (MLLW). In the Shumagin region, this area includes the waters and seabed of the sublittoral zone extending across the shelf region, the continental slope and abyssal plain, and the Aleutian Trench. Important habitats included in this category are Unimak Pass, the numerous reefs, banks, and troughs of the continental shelf, and the shelf-edge break and upper slope waters (Figure 3.1). These areas are extremely productive marine systems that support large populations of marine mammals, fish and invertebrates.

Unimak Pass is a critical migration route and foraging area for many species of fish, marine mammals, and seabirds. Gray whales, an endangered species, annually migrate through Unimak Pass on their way to and from the Bering Sea in spring and fall. Other endangered whales such as fin and humpback whales also use this route into the Bering Sea. Northern fur seals use Unimak Pass as the major corridor from their pelagic wintering areas in the Gulf of Alaska to their breeding grounds on the Pribilof Islands.

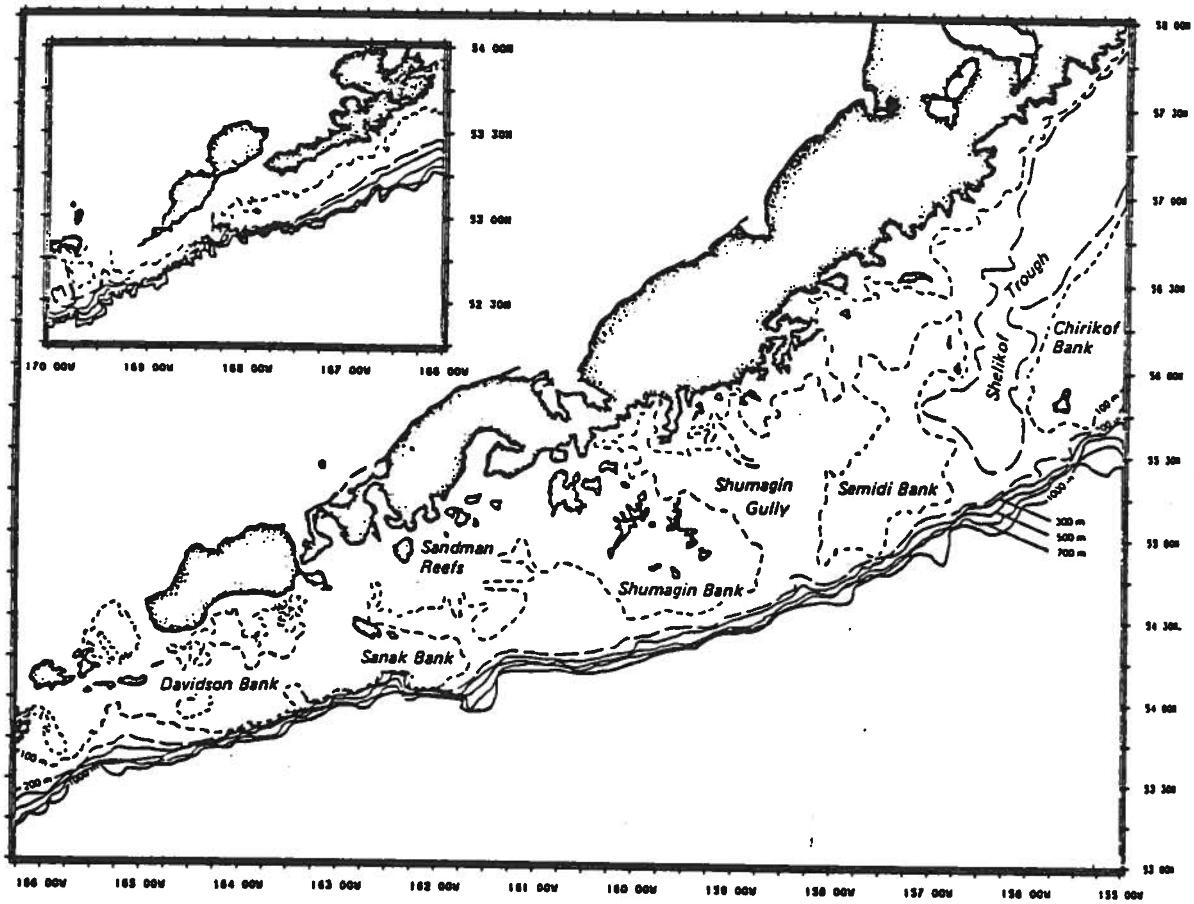

Figure 3.1. Locations of important offshore features of the Shumagin region.

Unimak Pass is also important to certain fish species. Twenty-four percent of the 5 to 12 year old halibut that rear in Bristol Bay return to the Gulf of Alaska through the Pass (Dunlop et al., 1974). It is used by many adult salmon returning to their Bering Sea spawning streams. Unimak Pass also provides a concentration area from May through September for the main population of Pacific ocean perch in the Gulf of Alaska (Major and Shippen, 1970).

The shelf banks (Davidson, Sanak, and Shumagin Banks) and the many reefs provide important habitat for many marine fish species. The banks support a diversity of marine species such as halibut, flounders, cod, pollock, rockfish, shrimp and crab. Sanak Bank supports one of the highest concentrations of Pacific cod in the Gulf of Alaska (Ronholt et al., 1977).

A major migratory phenomenon which characterizes the behavior of many offshore demersal fish species (e.g. Pacific cod, pollock, arrowtooth flounder, rex and flathead soles) is a seasonal movement between shallow shelf waters in spring and summer to slope waters in fall and winter. The shelf edge and upper slope of the Shumagin region is also one of the richest areas for sablefish in the Gulf of Alaska (Low et al., 1976).

3.1.2. Exposed High-Energy Coasts.

Exposed high-energy coasts are defined as open and unprotected coasts that are directly exposed to ocean waves and storm surges. These coasts undergo dynamic shoreline processes of erosion, deposition, and sediment transport. Such shorelines are composed of coarse sand, gravel, and boulder beaches, and well-mixed coastal waters. These areas may also contain exposed rocky headlands and barrier beaches. Generally such areas are slowly eroding wave-cut platforms backed by low sea cliffs, or the headlands of fjords bordered by cliffs up to 600 m in elevation. Coastal waters of these high-energy coasts are typically clear and cold, with surging waves and strong currents.

Most of the exposed southern shore of the Alaska Peninsula contains high-energy coasts, as are the mountainous parts of many of the offshore islands (Figure 3.2). The high-energy rock shorelines provide ideal habitat for abundant marine life. Seaweeds flourish, with rockweed (Fucus) abundant in the intertidal zone and kelps such as Alaria abundant offshore. These rocky coasts also are important habitat for marine mammals, including sea lions, harbor seals, and sea otters. Cape Sarichef on Unimak Island is an important hauling and breeding area for walrus. Sea birds and a diversity of fish and invertebrate species are generally abundant in this habitat.

3.1.3. Rocky Islands and Sea Cliffs.

Rocky islands and sea cliffs include marine islands of volcanic or tectonic origin with rocky shores and steep faces, offshore rocks and capes, and steep, rocky seafronts with a very limited or non-existant intertidal area. They are a dominant coastal habitat of the Shumagin region (Figure 3.3). The islands include many unnamed reefs and rock outcrops as well as the larger

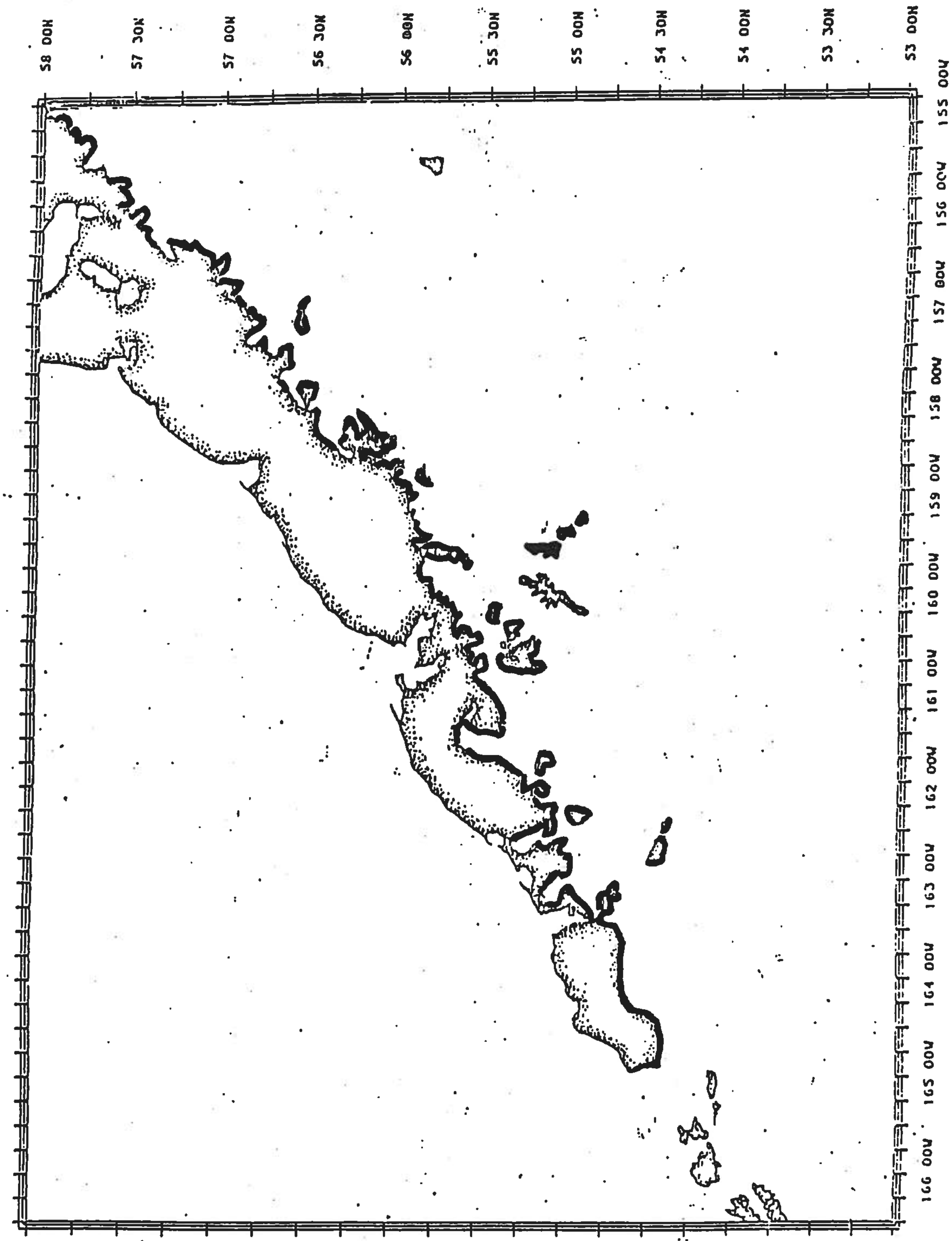

Figure 3.2. Distribution of exposed high-energy coasts in the Shumagin region (after AECRSA, 1984; BBCMP, 1984; RPI, 1986).

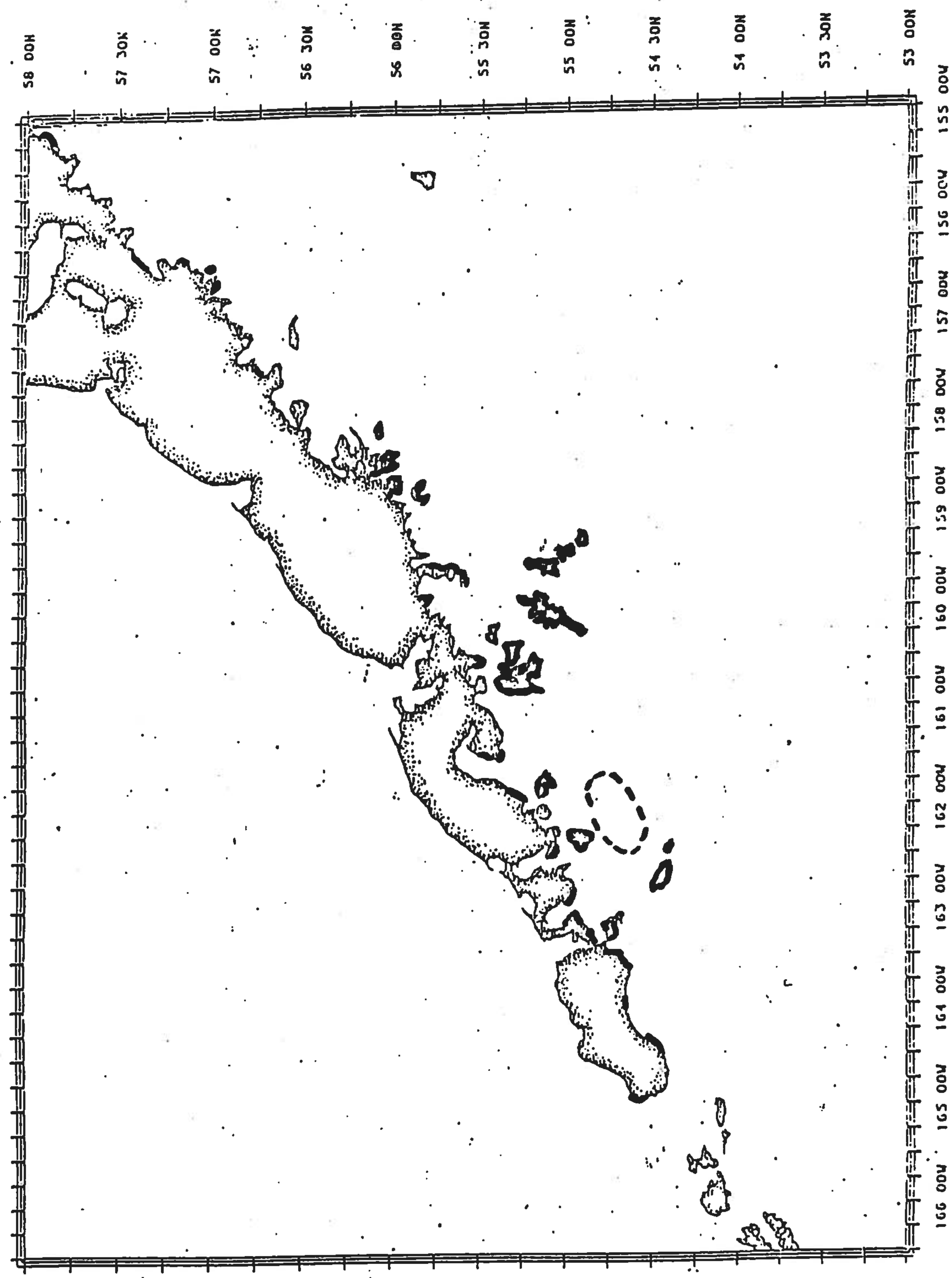

Figure 3.3. Locations of rocky islands and sea cliffs in the Shumagin region (after AECRSA, 1984; BBCMP, 1984; RPI, 1986).

named islands. These islands occur singly and in groups, extending as much as 100 km off the coast. Most prominant of the island groups are the Sanak, Pavlof, and Shumagin Islands. The islands are generally treeless and are either grass, alder or tundra covered (AEIDC, 1976). The Shumagin Islands include 30 named islands covering an area of 72 by 90 km (6,415 square kilometers) (AECRSA, 1984). Tidal currents forcing through the island passes create upwelling of nutrient rich subsurface waters that produce high plankton productivity which supports abundant populations of fish and other marine life.

Rocky reefs and outcrops are best typified by the Sandman Reefs about 50 km south of Cold Bay. This area includes over 100 small islands and rocky outcrops over a 2200 square kilometer area. Most of these islands are less than 30 m in elevation and are capped with upland tundra and bare rock.

Pronounced sea cliffs on the Alaska Peninsula occur at several of the capes, from the Kupreanof Peninsula to the east to Cape Sarichef on Unimak Island. These seacliffs are important nesting areas for sea birds, and are used as sheltered rookeries and haulout areas by seals and sea lions.

Fox (both red and Arctic, the latter mostly introduced by fox farmers) and bald eagles are important predators on many islands, depending on the marine food web for their survival. Sea bird nesting habitats on these islands are frequently controlled by fox predation (AECRSA, 1984). The more important nesting islands such as the Haystacks, Gull, Paul, Jacob and Egg Islands, and Castle Rocks do not have fox populations.

Seabirds on Mitrofania Island avoid fox predation by nesting in rock crevises on cliffs and talus slopes up to the 305 m level. On Big Koniuji, which also has a fox population, seabirds such as crested auklets are able to nest over most of the island. The foxes on this island are believed to be indigenous and an ecological balance between predator and prey apparently has been achieved. In most other areas, fox populations limit sea bird nesting to steep coastal cliffs.

3.1.4. Estuaries.

Estuaries are semi-enclosed bodies of coastal water which are appreciably diluted by freshwater drainage from rivers and streams. They include the brackish waters of lagoon systems and coastal deltas, bays, and inlets extending upstream in drainages to the limit of saltwater intrusion. Most of the rivers of the Alaska Peninsula drain north into the Bering Sea, and extensive estuaries are found there. On the south side of the Peninsula, estuaries are fewer and smaller. Important estuaries opening to the south include the upper waters of Chignik, Bechevin, Morzhovoi, and Cold Bays, as well as Canoe Bay off Pavlof Bay and Zachary Bay on Unga Island (Figure 3.4). Eelgrass beds are found in Wide Bay, Mitrofania Bay, and Chignik Lagoon. Several of the other smaller bays also have estuaries at their headwaters.

Estuaries are vital to the rearing and feeding of fish and shellfish, waterfowl, some sea birds and marine mammals, and for a wide variety of other marine life. These productive areas, at the interface between the aquatic and marine ecosystems, are especially important to the life cycles of salmon and other anadromous fish.

3.1.5. Barrier Islands and Lagoons.

Barrier islands and lagoons are depositional environments formed by offshore sediments or coastal remnants which develop as a barrier of low-lying islands, bars, or spits sheltering a saltwater lagoon that is subjected to periodic or continuous exchange of water with the ocean. Lagoon waters are generally estuarine, and tideflats are commonly present. The barrier features are formed by sand or mud deposits. Intertidal eelgrass beds are found in protected mudflats.

There are three major lagoon systems on the north side of the Alaska Peninsula, only one of which, Bechevin Bay, is connected with the southern Peninsula. The southern coast contains a few small barrier island and lagoon systems scattered along its shore, but these are limited by the steep and rocky coastal topography of much of the region (Figure 3.5). Chignik Lagoon, which is not formed by a barrier island, is the largest lagoon on the southern

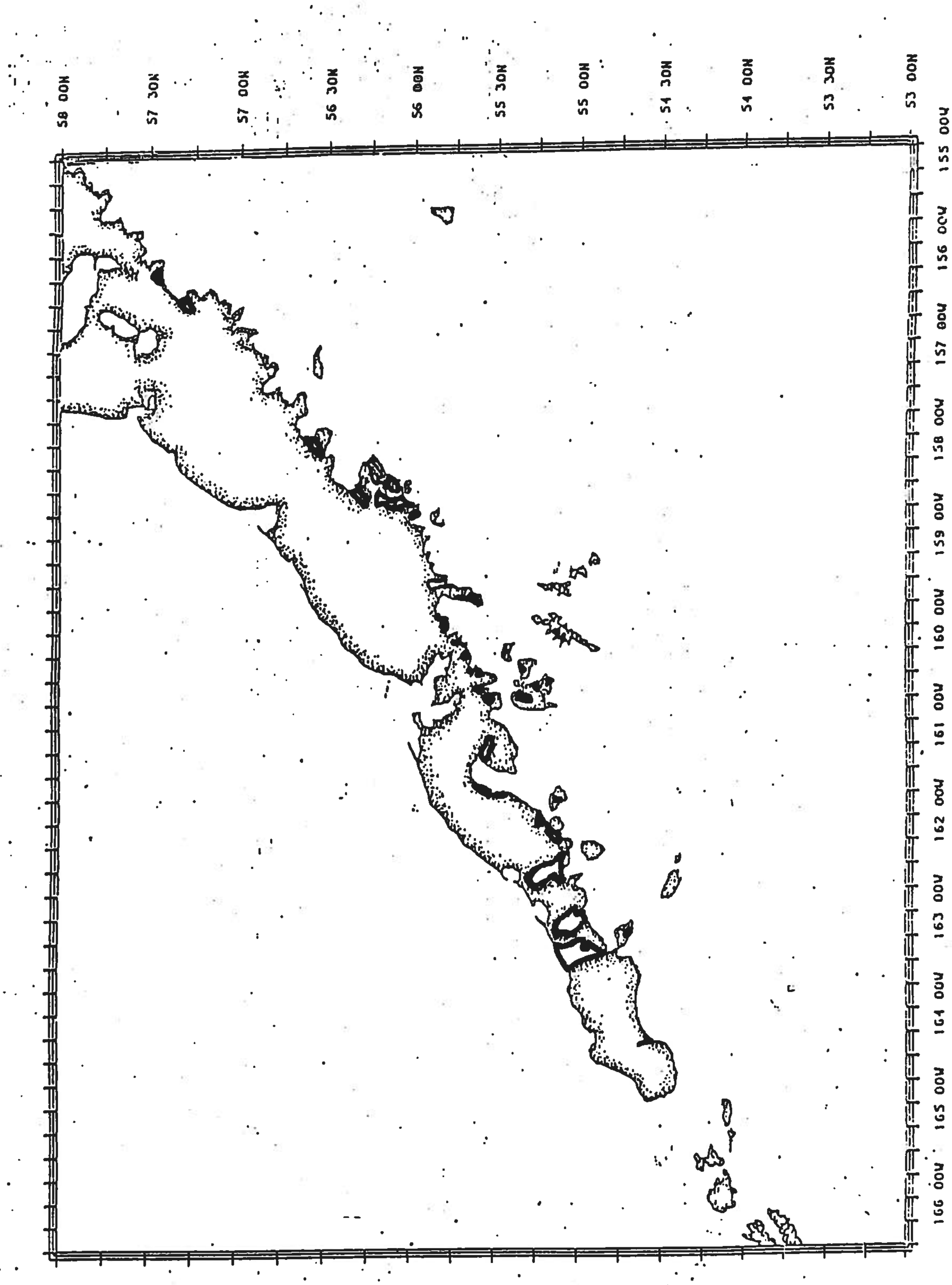

Figure 3.4. Location of estuarine habitats in the Shumagin region (after AECRSA, 1984; BBCMP, 1984; RPI, 1986).

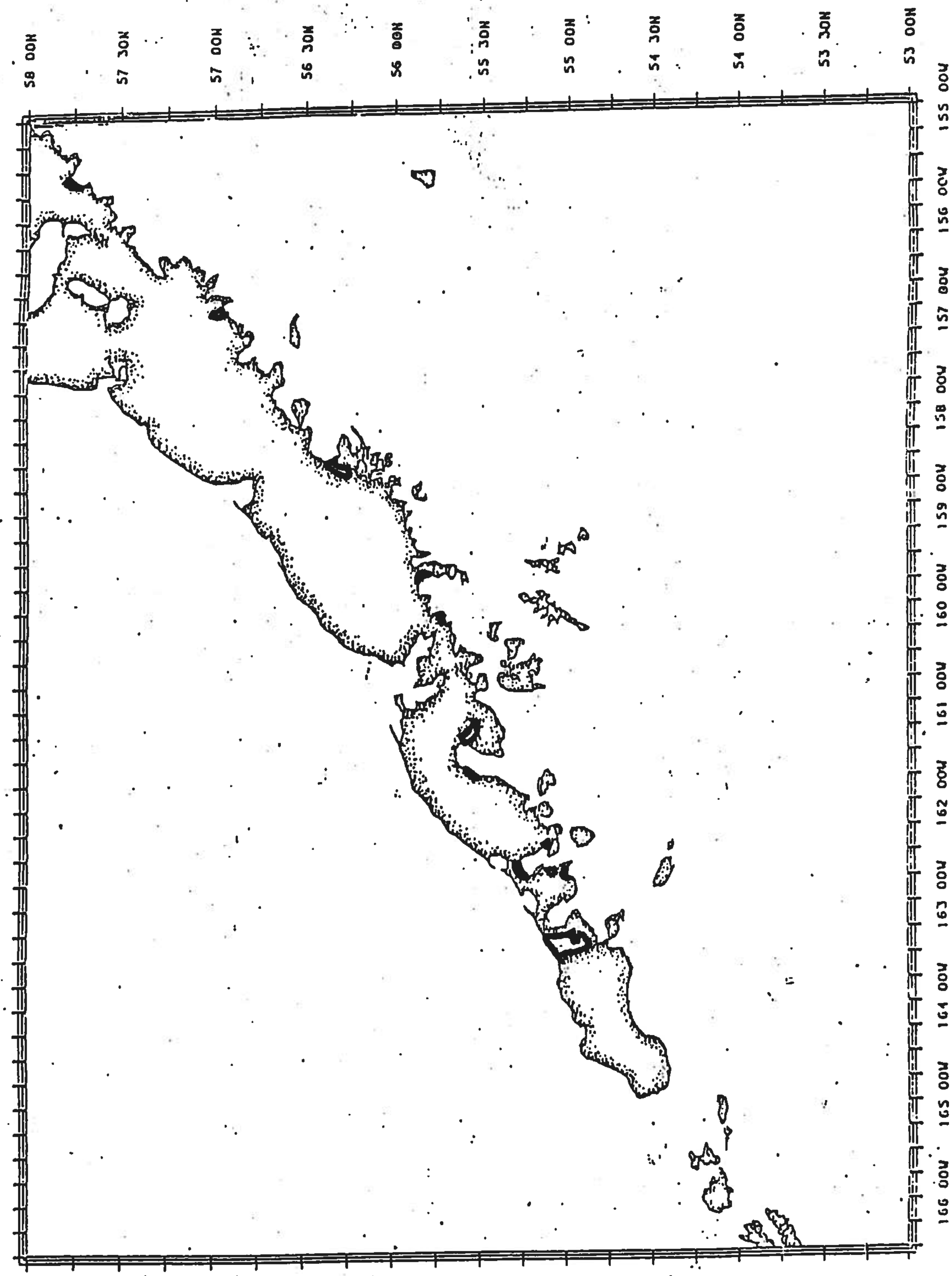

Figure 3.5. Locations of barrier island and lagoon habitats in the Shumagin region (after AECRSA, 1984; BBCMP, 1984; RPI, 1986).

shore. At low tide, about one-half of the lagoon is exposed as an eelgrass mudflat. It is an important rearing area for young sockeye salmon smolts before they enter the marine environment.

3.1.6. Coastal Wetlands and Tideflats.

Coastal wetlands (Figure 3.6) generally are salt marshes, flat coastal areas whose sedimentary substrate is saturated by salt or brackish water, and whose salt- tolerant vegetation is typically adapted for rooting in such saturated soils. Other coastal wetland types are terrestrial freshwater features that also occur in inland areas, such as swamps, freshwater marshes, forested or treeless bogs, wet and moist tundra, and wet riparian corridors. Tideflats (Figure 3.7) are primarily unvegetated expanses that are alternately exposed and covered by tidal cycles.

Saltmarsh marine wetlands on the south side of the Alaska Peninsula are limited by the topography and elevation to the heads of a few bays, such as Bechevin, Morzhovoi, and Cold Bays. Smaller salt marsh areas are formed behind sand dunes and debris lines in several smaller bays. Saltmarshes are extremely important to the biological productivity of their surrounding waters.

Onshore wetlands of the Alaska Peninsula bordering the Shumagin region consist mainly of wet sedge meadows found in poorly-drained peat lowlands, and some wet riparian corridors. The largest expanses of wetland areas are the sedge meadows located at the head of Pavlof Bay and Cold Bay, and the wet tundra at the head of Stepovak Bay and extending into Ivanof Bay. Wet sedge meadows also are found on Sanak and Caton Islands.

Exposed tidal sand flats are developed only off Thin Point at the western aproach to Cold Bay, while extensive protected tidal mud flats occur at the upper reaches or protected arms of sheltered bays such as Cold Bay, Morzhovoi Bay, and Bechevin Bay on the Peninsula.

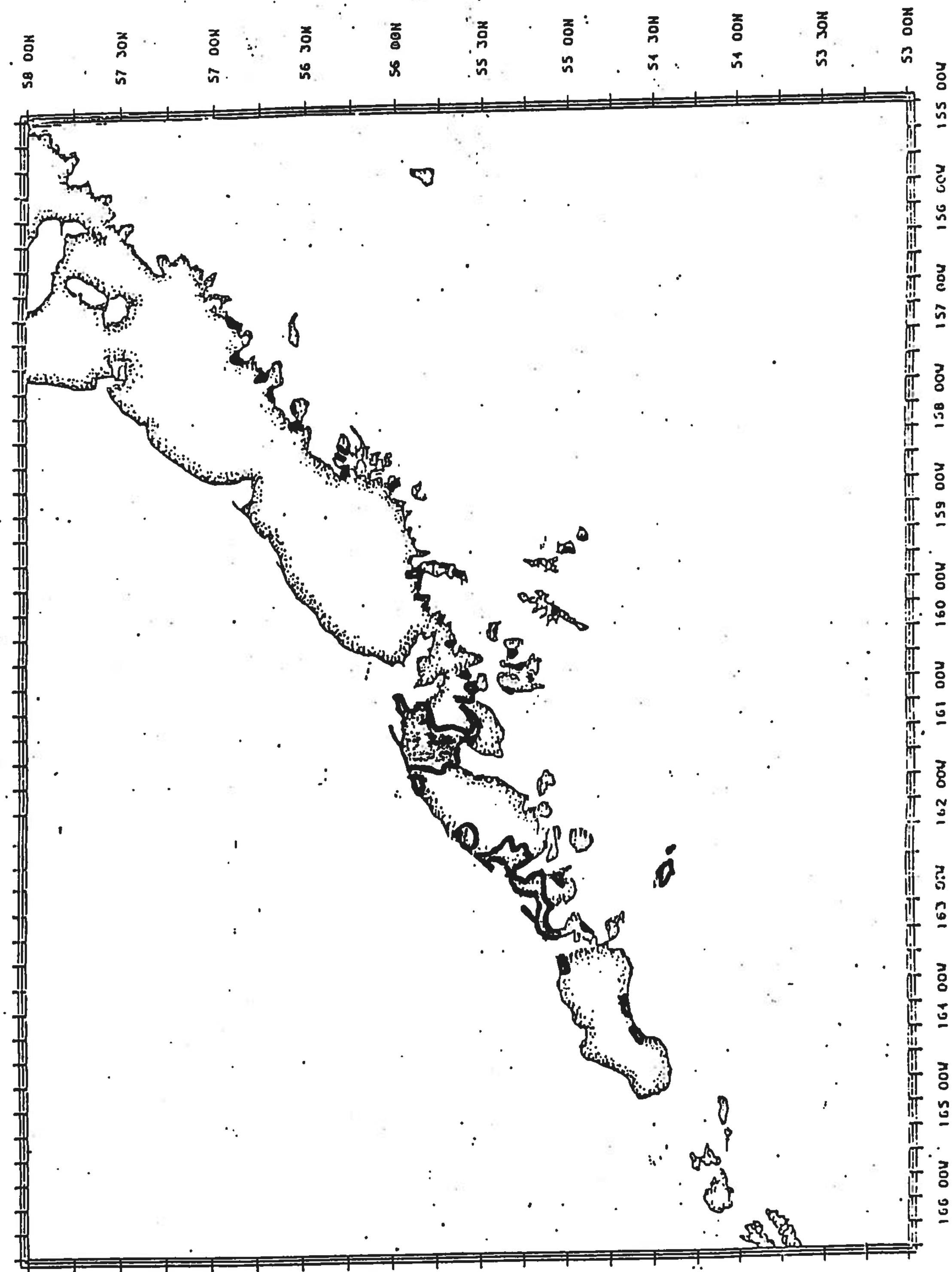

Figure 3.6. Locations of coastal and onshore wetlands in the Shumagin region (after AECRSA, 1984; BBCMP, 1984; RPI, 1986).

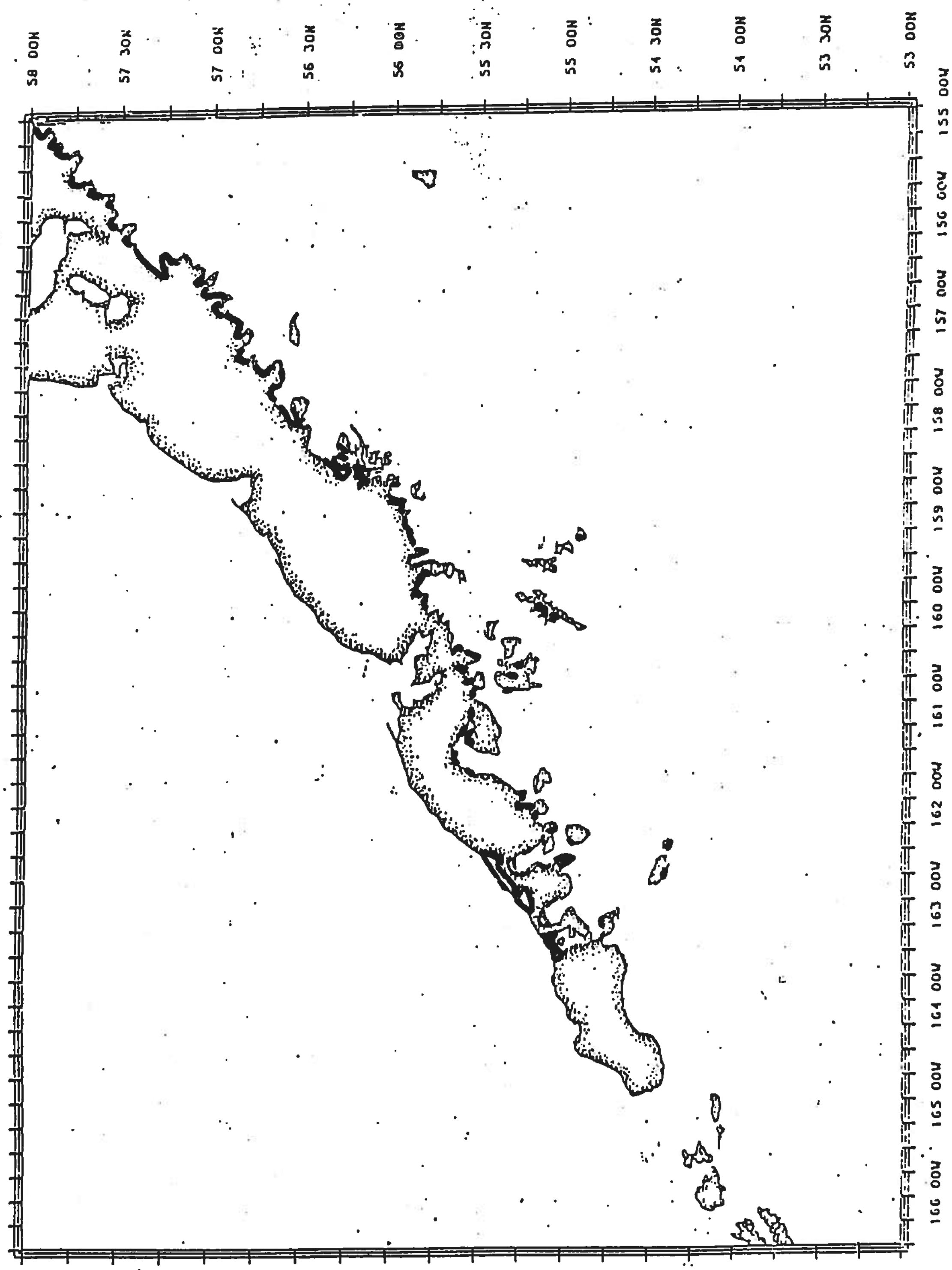

Figure 3.7. Locations of exposed and protected tideflats in the Shumagin region (after AECRSA, 1984; BBCMP, 1984; RPI, 1986).

3.1.7. Rivers, Streams, and Lakes.

This category of aquatic habitats includes freshwater drainages, river systems, floodplains, deltas, lakes, and other smaller bodies of fresh water. These aquatic systems provide important habitat for anadromous fish (Pacific salmon, Dolly Varden char) that may rear in the marine environment, and they also supply nutrients and dilution to coastal systems. Freshwater fish include rainbow trout, pond smelt, sculpins, sticklebacks, and land-locked Dolly Varden char.

Most of the major streams on the Alaska Peninsula drain north into the Bering Sea, and the shorter streams flowing south often drop precipitously as waterfalls along the southern coast. Nevertheless, there are many of these smaller streams that support anadromous fish runs. Many of the larger off-shore islands also have anadromous fish streams. Ponds are present in the Shumagin Islands, but they rarely exceed 40 hectares in size.

3.1.8. Important Upland Habitat.

Important upland habitats begin above the intertidal splash zone of the coast to the crests of all drainage basins. On the Alaska Peninsula and the offshore islands, the plant communities are limited in diversity by climate and terrain to three principal types: moist tundra on lower slopes and rolling terrain; tall shrub in well-drained lower elevations; and alpine tundra at higher slopes and elevations. The steeper slopes and high summit areas are either barren rock or snow and ice fields. In general, terrestrial vegetation is dominated by grasses and mosses, with shrubs such as alder and willow found bordering streams and in lowland areas. Further description of these upland vegetation communities is beyond the scope of this report. For further information, the reader is referred to AEIDC (1976), Bailey (1978) or AECRSA (1984).

Upland habitats along the Alaska Peninsula support terrestrial mammals such as brown bear, caribou, moose, wolf, porcupine, Arctic and red fox, wolverine, lynx, ground squirrel, and snowshoe hare. Common birds include ravens, eagles, hawks, falcons, owls, ptarmigan, and songbirds.

3.2. THE PLANKTON.

3.2.1. Phytoplankton and Productivity.

Regional and seasonal coverage of measurements of primary productivity and nutrient distribution in the Gulf of Alaska and Aleutians, including the Shumagin region, is not uniform. From what is known, nutrient levels are generally high during most of the year, probably due to the vertical mixing of nutrient rich deeper waters by frequent storms. A seasonal halocline generally develops in the summer, resulting in reduced mixing, and phytoplankton are held within the euphotic zone. The summer halocline enhances primary productivity until nutrient levels become limiting. Typical summer nutrient concentrations in surface waters at the 10 m depth (in ug-atoms/liter) reported by NORPAC (1960) are nitrate - 15 to 35; phosphate - 0.5 to 1; and silicate - 2 to 175.

Based on limited data, the rate of primary productivity in the Northeast Gulf of Alaska in the upper 10 m is about 2 $mgC/m^3/hr$ in the spring, and 1.4 in the winter. A review of primary productivity measurements (Anderson and Lam, 1976) indicated that significantly higher rates were found in the Kodiak to Shumagin area than in waters to either the east or west.

The following species are numerically abundant and often dominant in the phytoplankton community:

Diatoms: *Corethron hystrix*, *Coscinodiscus oculis iridis*, *Denticula semina*, *Fragilariopsis* sp., *Rhizosolinia alata*, *Thalassiosira lineata*;

Dinoflagellates: *Ceratium pentagonum*;

Coccolithophorids: *Coccolithus huxleyi*, *C. pelagicus*;

Microflagellates: *Halosphaera viridis*.

3.2.2. Zooplankton.

The zooplankton of the Shumagin Region has received little direct attention. Almost no observations are available for the region of the Shumagin Shelf indicated for petroleum potential. This area is notoriously weather restricted and difficult to navigate. Most available knowledge can be gleaned from studies in adjacent areas such as the Gulf of Alaska and Kodiak shelf regions (e.g. Cooney, 1975; LeBrasseur, 1959a) and from oceanic waters of the subarctic North Pacific (e.g. LeBrasseur, 1959b; McAllister, 1961).

In attempting to describe the zooplankton populations of the proposed Shumagin lease area, it is necessary to recognize that there are strong temporal and spatial variations in the abundance and composition of the zooplankton communities. Diel changes at any depth result from the vertical migration of zooplankton in the water column. Seasonal variations exceeding about half an order of magnitude are associated with the changes in biological productivity. Annual variations result from changes in meteorological patterns influencing large-scale ocean structure and dynamics. On the spatial scale, horizontal and vertical patchiness occur both on small (meters) and large (kilometers) scales. Large scale distribution patterns reflect physical advective processes and water mass distributions.

The zooplankton regimes contained in the Shumagin region probably resemble the four categories that were recognized by Cooney, 1975 for the Gulf of Alaska. Faunal differences are found between adjacent regimes. Although most zooplankton collections reported for the Gulf of Alaska are generally dominated by copepods, euphausiids, and fish larvae, Cooney (1975) noted the following statistical associations of species for a particular regime:

1. The Neritic (nearshore) Regime in the zone of coastal and riverine influence: the copepods *Acartia longiremis* and *Pseudocalanus* spp; euphausiid larvae; and Tanner crab (*Chionoecetes*) larvae.

2. The Shelf Regime, from the neritic zone to the shelf-edge break at about 200 m: the amphipod *Parathemisto pacifica*; the euphausiids *Thysanoessa inermis*, *T. spinifera*. This regime usually contains a mixture of open ocean species and those requiring a more nearshore neritic environment.

3. The Slope Regime over bottom depths of 200 to 2000 m: Parathemisto pacifica; Thysanoessa longipes, T. inermis, T. spinifera.

4. The Open Ocean Regime at bottom depths of over 2000 m: the medusa Aglantha digitale; the chaetognath Eukhronia hamata; copepods Calanus cristatus, C. pacificus, Eucalanus b. bungii; the euphausiid Euphausia pacifica.

Along the Aleutian Island Arc at 175°W, Favorite et al. (1977) report that euphausiids, copepods, and chaetognaths were the important zooplankton components (Figure 3.8). Of the euphausiids, T. longipes and T. inermis were important in the coastal waters, T. longipes dominated in the Alaskan Stream, and E. pacifica was most important in the oceanic region.

3.3. THE BENTHOS.

The benthic organisms of the Shumagin region consist of infauna, sessile plants and animals, and slow-moving epifauna. Abundant benthic assemblages are found throughout the area in the intertidal, sublittoral, and shelf environments of the area. Little is known about the organisms of the continental slope and abyssal plain regions. Best known are the larger, more conspicuous and abundant motile shellfish species of actual or potential commercial importance (see Section 4.2).

3.3.1. Intertidal Biota.

The intertidal environments of the region range from rocky exposed shores to protected inner bays with fine-grained silt and mud sediments. In general, the rocky intertidal environments support the greatest variety and highest densities of biota. A typical intertidal community on rocky shores contains the rockweed (Fucus) and acorn barnacles (Balanus) in the upper zone and blue mussels (Mytilus) in the lower zone. A typical muddy intertidal area would contain polychaete worms and bivalve molluscs as the more dominant members of the community.

Transects conducted at Sand Point (USFWS, 1985) describe the intertidal and subtidal biota that is typical of many parts of the Shumagin region. Inter-

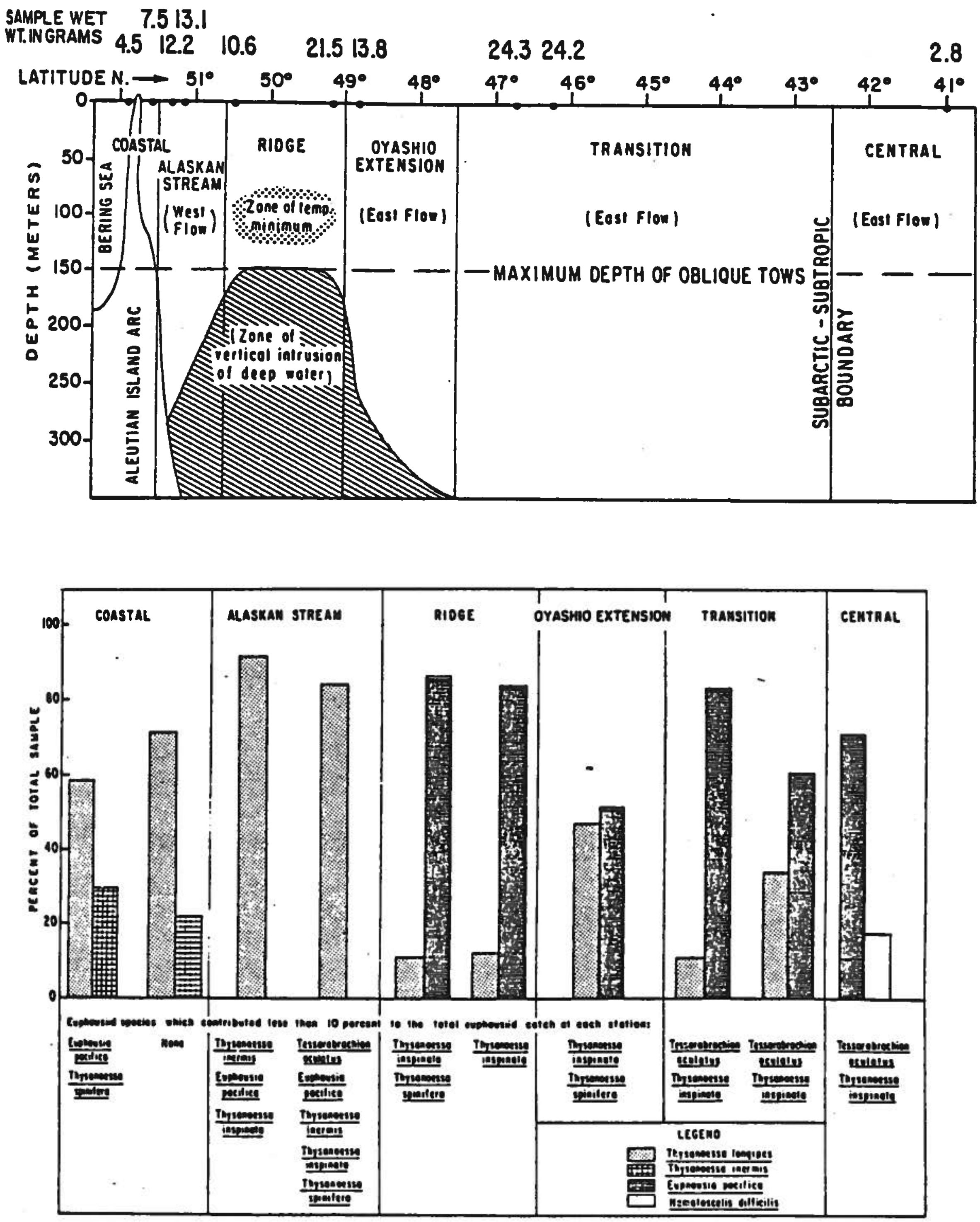

Figure 3.8. Composition of zooplankton samples along 175°25'W during March 1966 in relation to subarctic domains and flow (from Favorite et al., 1977).

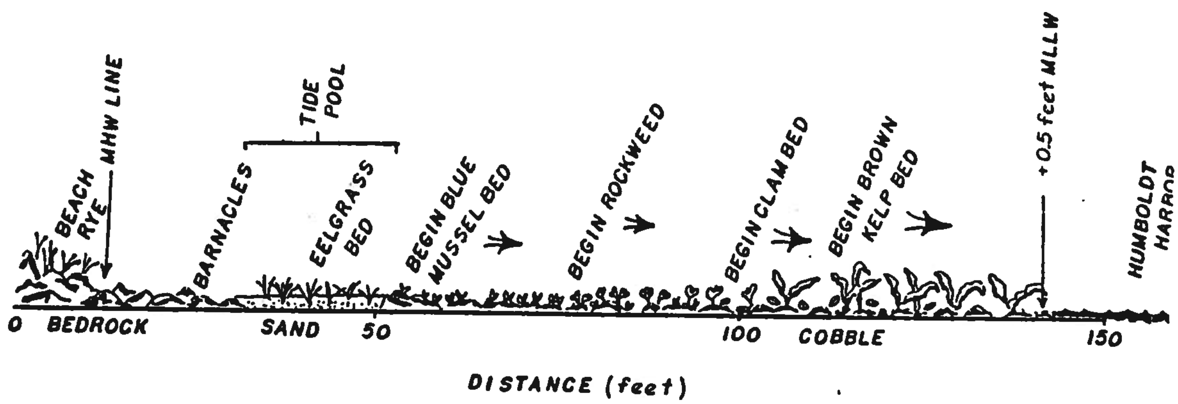

Figure 3.9. Schematic intertidal community profile of Black Point, Sand Point, Alaska (from USFWS, 1985).

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subtidal areas. Sea lettuce (Ulva/Monostroma) is abundant nearshore between the brown algae in the intertidal zone. Shade tolerant red algae of various species form an understory in these kelp beds. Abundant marine gastropods are found attached to the rocky substrate, such as the puppet limpet (Margarites pupillus), frilled dogwinkle (Nucella lamellosa), Sitka periwinkle (Littorina sitkana), and several species of limpets (Acmaea spp.). Other marine invertebrates in this and the following two habitat types include the predaceous sunflower starfish (Pycnopodia helianthoides), various hermit crabs, bryozoans, barnacles, several species of anemones (Metridium senile, Anthopleura artemisia, Tealia crassicornus) and nudibranchs.

3) Gravel/cobble substrate dominated by bivalves. Typical clam species include the blue mussel, soft-shell clam (Mya truncata), butter clam, surf clam (Spisula alaskana), and littleneck clams. Shell debris consists mainly of Saxidomus. Laminarian kelp are often found attached to rock cobble in these deeper areas.

4) Deeper silt/mud bottom (e.g. -10 m MLLW) inhabited by marine worms and clams. Several species of Macoma clams are common in this habitat.

A list of the more common invertebrates found in intertidal and subtidal surveys in the Sand Point Harbor area is given in Table 3.1.

Table 3.1. List of benthic biota collected and observed during biological inventories at Sand Point, Alaska, May 1983 and May 1984 (from USFWS, 1985.)

CLASSIFICATION	COMMON NAME
PLANT KINGDOM	
Division Chlorophyocophyta (Green algae)	
Class Chlorophyceae	
Ulva/Monostroma	sea lettuce
Division Phaeophycophyta (Brown algae)	
Class Phaeophyceae	
Alaria valida	wing kelp
Fucus distichus	rockweed
Fucus furcatus	rockweed
Nereocystis luetkeana	bull kelp
Scytosiphon lomentaria	whip tube
Laminaria saccharina	sugar wrack
Costaria costata	seersucker
Desmarestia spp.	color changer
Cystophyllum spp.	bladder leaf
Agarum cribrosum	sieve kelp
Division Rhodophycophyta (Red algae)	
Class Rhodophyceae	
Halasaccion glandiforme	sea sac
Lithothamnion spp.	red rock crust
Rhodomela larix	black pine
Constantinea simplex	cup and saucer
Rhodymenia palmata	red kale
Division Anthophyta (Flowering plants)	
Zostera marina	eelgrass
ANIMAL KINGDOM	
Phylum Porifera (Sponges)	
Halisarca sp.	encrusting sponge
Phylum Cnidaria	
Class Hydrozoa (Hydroids)	hydroids
Class Anthozoa (Sea anemones)	
Anthopleura artemisia	anemone
Metridium senile	white plumed anemone
Tealia crassicornis	anemone
Phylum Nemertinea (Proboscis worms)	ribbon worms
Phylum Echiura (Burrowing worms)	
Urechis caupo	marine echiurid

(continued)

Table 3.1. (continued).

CLASSIFICATION	COMMON NAME
Phylum Annelida (Segmented worms)	
Class Polychaeta	
Abarenicola sp.	marine polychaete
Cirriformia spirabrancha	marine polychaete
Crucigera irregularis	tube worm
Nephtys sp.	marine polychaete
Nereis sp.	marine polychaete
Owenia sp.	marine polychaete
Spirorbis sp.	tube worm
Phyllodocidae	marine polychaete
Spionidae	marine polychaete
Serpula vermicularis	tube worm
Phylum Mollusca	
Class Amphineura (Chitons)	
Katharina tunicata[1/]	leather chiton
Tonicella lineata	red lined chiton
Class Gastropoda (Univalve mollusks)	
Acmaea pelta	shield limpet
Acmaea strigatella	strigate limpet
Lacuna vincta	common northern chink shell
Littorina sitkana	Sitka periwinkle
Margarites pupillus	puppet margarite
Nucella lima	file dogwinkle
Nucella lamellosa	frilled dogwinkle
Class Pelecypoda (Bivalve mollusks)	
Clinocardium nuttallii	Nuttall's cockle
Hiatella arctica	Arctic saxicave
Macoma balthica	balthica macoma
Macoma nasuta	bent-nose macoma
Mytilus edulis	blue mussel
Nucula sp.	nut shell
Pododesmus macroschisma[1/]	rock oyster
Protothaca staminea	Pacific littleneck
Saxidomus gigantea	butter clam
Mya truncata	soft-shelled clam
Astarte spp.	astarte clam
Yoldia spp.	nut clam
Musculus spp.	clam
Phylum Arthropoda	
Class Crustacea	
Balanus cariosus	acorn barnacle
Balanus glandula	barnacle
Cancer magister	Dungeness crab

(continued)

Table 3.1. (continued)

CLASSIFICATION	COMMON NAME
Cancer oregonensis	hairy cancer crab
Pagurus hirsutiusculus	hermit crab
Telmessus cheiragonus	horse crab
Idothea wosnesenskii	green sea louse
Orchestoidea sp.	amphipod
Gammaridae (2 species)	amphipod
Pandalidae	shrimp
Phylum Echinodermata	
Class Asteroidae (Starfish)	
Henricia leviuscula	blood star
Leptasterias hexactis	six-ray starfish
Pycnopodia helianthoides	sunflower star
Class Ophiuroidea (Basket stars, brittle stars)	
	unidentified brittle star[1/]
Class Echinoidea (Sea urchins, sand dollars)	
Dendraster excentricus[1/]	sand dollar
Strongylocentrotus purpuratus	purple urchin
Phylum Bryozoa	
Membranipora sp.	encrusting bryozoan

[1/] Shell or exoskeleton only

3.3.2. Shelf Benthos.

The benthos of the Shumagin shelf has not been well-studied or characterized. Generally, it is believed to be similar in composition to adjacent shelf areas of the Gulf of Alaska and Kodiak which have been well sampled by NMFS and OCSEAP surveys using both trawls and grab gear. According to Feder and Mueller (1975), crustaceans are the most important taxonomic group from trawl samples (Table 3.2) in the Gulf of Alaska with decapod crustaceans the most common subgroup. Echinoderms, mainly starfish, were the next most common taxa, followed by molluscs, of which the gastropods were predominant. Infaunal organisms sampled by grab (Table 3.3) were dominated by polychaete worms, followed by bivalve molluscs and amphipod crustaceans.

The feeding biology and foodweb relationships of the benthic community are not well understood.

Table 3.2. Major Groups of Benthic Invertebrates Collected by Commercial Trawl in the Gulf of Alaska (after Feder and Mueller, 1975).

Phylum	Subgroup	# of Species	% of Species
ARTHROPODA	Decapoda	24	35.8
	Isopoda	1	1.5
	Subtotal	25	37.3
ECHINODERMATA	Asteroidea	11	16.4
	Echinoidea	4	6.0
	Ophiuroidea	4	6.0
	Holothuroidea	3	4.4
	Crinoidea	1	1.5
	Subtotal	23	34.3
MOLLUSCA	Gastropoda	10	14.9
	Pelecypoda	8	11.9
	Cephalopoda	1	1.5
	Subtotal	19	28.4
TOTAL		67	100.0

Table 3.3. Major Groups of Infaunal Invertebrates in the Gulf of Alaska Taken with a Van Veen Grab (after Feder and Mueller, 1975).

Phylum	Subgroup	# of Species	% of Species
MOLLUSCA	Pelecypoda	30	29.1
	Gastropoda	18	17.5
	Polyplacophora	1	1.0
	Scaphopoda	1	1.0
	Aplacophora	1	1.0
	Subtotal	51	49.5
ARTHROPODA	Amphipoda	17	33.0
	Cumacea	14	13.6
	Harpacticoida	1+	1.0+
	Ostracoda	1+	1.0+
	Thoracica	1	1.0
	Decapoda	2	1.9
	Isopoda	3	2.9
	Subtotal	39	37.9
ECHINODERMATA	Ophiuroidea	8	7.8
	Asteroidea	1	1.0
	Holothuroidea	2	1.9
	Echinoidea	1	1.0
	Crinoidea	1	1.0
	Subtotal	13	12.6
TOTAL		103	100.0

4. FISHERIES OF THE SHUMAGIN REGION

Important commercial fisheries occur in and around the Shumagin region, including domestic, foreign, and joint-venture fisheries. These valuable fisheries occur in the region year-round, varying in the type of fishery and location with the season. The domestic fisheries concentrate mainly on the salmon and king and Tanner crab resources of the region, and are supplemented by halibut, herring, and Dungeness crab fishing. The abundant groundfish resources are harvested primarily by foreign fleets and by joint-ventures, but in recent years there has been an increasing effort by U.S. trawlers in the groundfish fisheries of the Shumagin region.

Seafood processing is also an important component of the economy of the Shumagin region. The 1983 wholesale value of fisheries products in the Chignik area was nearly $22 million, and in the Alaska Peninsula area it was nearly $67 million (ADFG, 1984). Seafood processing plants are located at Chignik, Sand Point, King Cove, and Cold Bay. Both the Sand Point (formerly Aleutian Cold Storage, now Trident Seafoods) and King Cove (Peter Pan Seafoods) operate year-round, processing a variety of fish and shellfish.

Nearly all salmon harvested is either frozen or canned. King Cove and Chignik have the only operating canneries in the region. Both have freezing plants. The Chignik processors (Aleutian Dragon Fisheries and Columbia Wards) can or freeze mainly pink and chum salmon. The King Cove cannery also processes mostly pink and chum salmon, but cans substantial quantities of sockeye and silver salmon as well. While most of the pink salmon catch is canned, most of the other salmon are now frozen. In addition, floating processors generally en route to Bristol Bay enter the area during the early sockeye salmon season, and operate fish buying/processing stations in several of the major bays of the region. In both 1982 and 1983, 22 floating processors operated in the Alaska Peninsula area. Some fish is tendered out of the region to processors in Dutch Harbor or other locations.

Other fish (i.e. halibut, herring) and shellfish (i.e king, Tanner, and Dungeness crab) are freeze-processed, and freighted to Japan or barged to Seattle. The Cold Bay facility (Winky's Peninsula Seafoods) supplies fresh and frozen salmon and crab that are air freighted directly to Japan or the continental U.S.

There is one salmon hatchery in the Shumagin area: the Russell Creek Hatchery near Cold Bay. This hatchery although not fully operational, is designed to rear 39 million fingerling chum salmon and produce 750,000 adult returns a year.

4.1. FISHERY MANAGEMENT AND REGULATION.

The fish and shellfish harvests of the Shumagin region are controlled by various fishery regulations. The State of Alaska, Alaska Department of Fish and Game regulates the salmon, herring, king crab, Dungeness crab, and miscellaneous other shellfish fisheries of the region. The NMFS regulates the domestic and foreign fisheries in the 3-200 mile fishery conservation zone (FCZ) off Alaska, and provides technical support to the North Pacific Fishery Management Council (NPFMC). Seasons, fishing districts, catch limits, gear restrictions are applied to the various fisheries, generally through Fishery Management Plans.

4.1.1. Fishery Management Plans.

The groundfish fisheries of the 200 mile Fishery Conservation Zone off Alaska are managed by fishery management plans (FMP's) prepared by NMFS and NPFMC. This FCZ was established with the passage in 1976 of the Magnuson Fisheries Conservation and Management Act (MFCMA). The law gives first priority to harvesting of fishery resources to U.S. fisherman, and allows foreign fleets to harvest the unused portions of the quotas allocated each year. For both management and resource assessment purposes, each foreign nation is required to report its annual catch and effort for each fishery resource by statistical blocks of 1° longitude by 1/2° latitude, by month, and by vessel class.

The NPFMC has developed FMP's for fishery stocks and fishing areas that detail catch-limits, area/time closures, and gear restrictions for both foreign and domestic vessels, and also allocates catches between foreign nations. There are currently four FMP's in effect for fisheries off Alaska: the FMP for the

Bering Sea and Aleutian Islands Area Groundfish Fishery, the FMP for "Gulf of Alaska Groundfish", the FMP for the "High Seas Salmon Fishery off Alaska", and the FMP for "Tanner Crab Fishery off Alaska". A fifth FMP for the Bering Sea/Aleutian Islands Area King Crab Fishery" has been adopted by the NPFMC, and is currently being implemented while waiting for formal approval.

While the MFCMA gives impetus to domestic fishing, groundfish continue to be harvested at present mainly by foreign fleets that have the large vessels, gear, and experience in these fisheries. However, new NPFMC allocations in Alaska for 1986 have nearly halved the foreign allocation from 1,156,581 mt (metric tons) in 1985 to 682,351 mt in 1986, boosting the level available for domestic processors and maintaining the level for joint-ventures (Tables 4.1 and 4.2). Japan continues to receive the largest share of the foreign fishing allocation, followed by Korea. Poland was dropped from any allocation in 1986 because of joint-venture disputes, and the Peoples Republic of China received its first allocation this year.

4.1.2. Fishery Districts.

The Shumagin region included in MMS's planning area contains much of the NPFMC's Western Regulatory District of the Gulf of Alaska, which extends from 159° to 170° W., and it also contains part of the Chirikof Statistical Area of the Central Regulatory District (Figure 4.1). In these areas, foreign vessels are prohibited from fishing within 12 miles of shore. The Davidson Bank area of the Shumagin region has been closed to foreign fleets since 1983 to encourage the development of domestic fisheries there.

Salmon Districts: The commercial salmon fisheries of the Shumagin region are managed by the State of Alaska. They are divided into two regulatory areas, Alaska Peninsula and Chignik, each with several districts. Most of the Shumagin region is in the Alaska Peninsula area with four districts with the following boundaries:

1. Southeastern - Point Aliaksin to Kupreanof Point, including all of the Shumagin Islands;

Table 4.1. Foreign Fishing Allocations By Nation in the Gulf of Alaska Fisheries Conservation Zone, in metric tons.

Nation	1985 % Allocation	1985 TALFF	1986 TALFF	1986 % Allocation
JAPAN	77.5	35,668	16,110	100.0
KOREA	22.5	10,347	0	0.0
POLAND	0.0	0	0	0.0
USSR	0.0	0	0	0.0
PORTUGAL	0.0	0	0	0.0
CHINA	0.0	0	0	0.0
TOTAL	100.0	46,015	16,110	100.0

2. Southcentral - Arch Point to Point Aliaksin, and including Ulkoinoi and Wosnesenski Islands;

3. Southwestern - Cape Pankof to Arch Point, including Inner and Outer Iliasik, Goloi, Dolgoi, Poperechnoi and Deer Islands;

4. Unimak - Scotch Cap to Cape Pankof, including the Sanak Islands.

The Chignik area has five districts, all of which are within the Shumagin Planning area boundaries:

1. Perryville - Kupreanof Point to Coal Cape;

2. Western - Coal Cape to Jack Point;

3. Central District - Jack Point to Aniakchak Lagoon, excluding the waters of Chignik Bay District;

Table 4.2. 1986 Groundfish Allocations (in metric tons) by Fishery Resource for the Gulf of Alaska.

Species	Domestic (DAP)	Joint-Venture (JVP)	DAP+JVP	Foreign
Pollock	41,841	69,439	111,280	140
Cod	35,000	9,480	44,480	15,520
Flounders	9,384	2,120	11,504	120
POP[1]	3,702	235[2]	3,702	20[2]
Sablefish	15,000	0	15,000	40[2]
Atka Mackerel	440	3,772	4,212	30
Rockfish	5,000	50[2]	5,050	3[2]
Thornyheads	1,500	1,500	3,000	10
Squid	2,000	2,000	4,000	10
Other	5,950	5,950	11,900	280
TOTAL	119,817	94,261	214,128	16,110

1/ Pacific Ocean Perch
2/ Prohibited Species Catch Limits

4. Chignik Bay - all waters of Chignik Bay and Lagoon west of a line between Jack Point to Neketa Creek;

5. Eastern District - Aniakchak Lagoon to Imuya Bay.

Halibut Districts: The halibut fisheries are managed by the International Pacific Halibut Commission (IPHC) under a bilateral treaty between the U.S. and Canada. The Commission sets catch levels and seasons by districts, and regulates gear type to hook and lines. The Shumagin region includes regulatory area 3B (Figure 4.2) and IPHC Statistical Areas 32, 33, and 34. In addition to IPHC regulations, the NPFMC restricts foreign fleets from taking halibut, and have instituted areal closures to bottom trawling to protect halibut stocks and prevent gear-conflicts with long-liners during the halibut seasons.

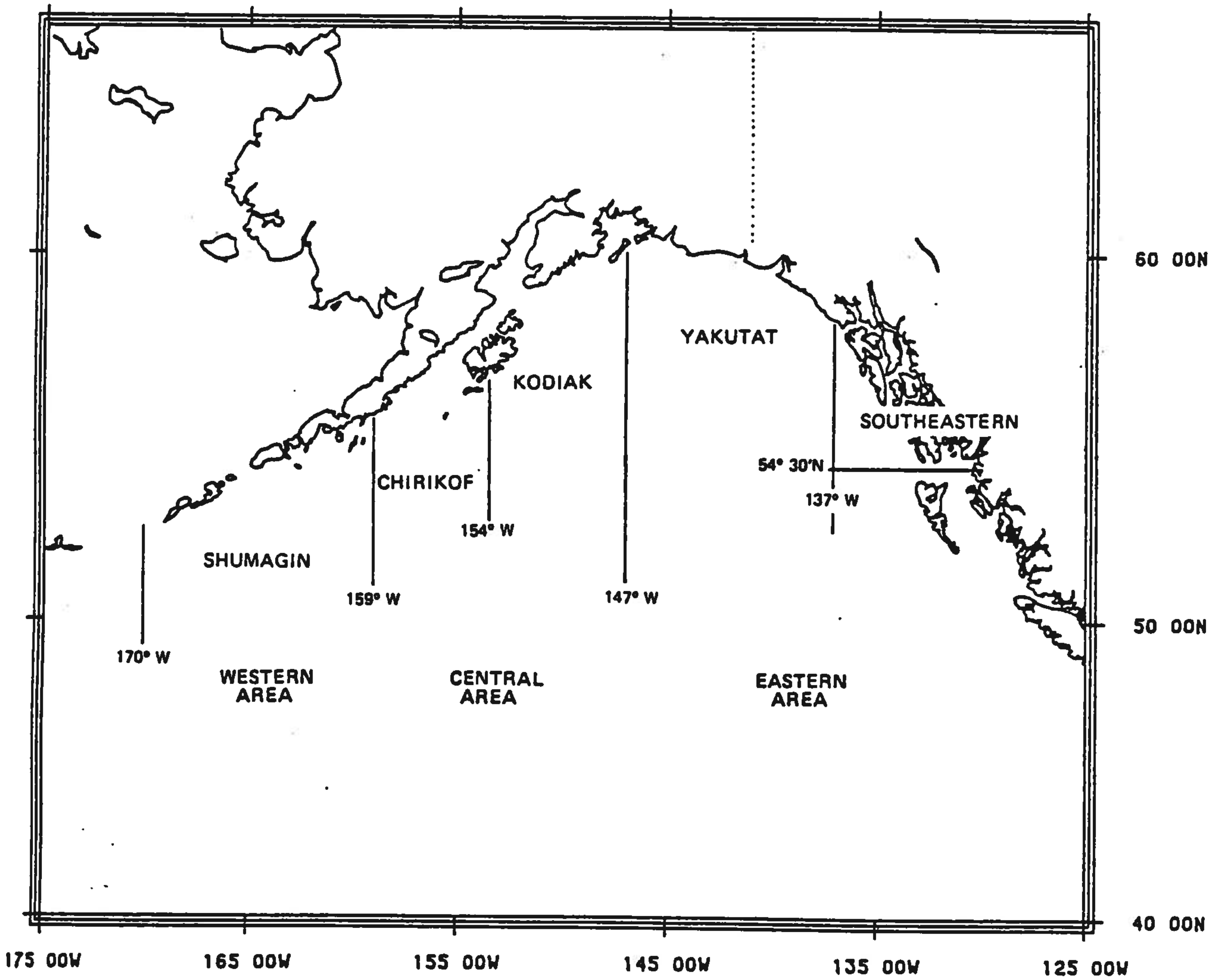

Figure 4.1. International North Pacific Fisheries Commission statistical areas (Shumagin, Chirikof, Kodiak, Yakutat, and Southeastern) and North Pacific Fishery Management Council regulatory areas (western, central, and eastern) for the Gulf of Alaska.

Shellfish Districts: The commercial shellfish fisheries are regulated either by the State of Alaska or by the NPFMC by both resource and statistical area. The Shumagin region contains the following statistical areas:

1. King crab - Statistical Area M (Alaska Peninsula, Figure 4.3) extending from Cape Kumlik (157°27'W) to Scotch Cap and all waters out to 200 fathoms, and the eastern portion of Statistical Area K (Kodiak) from 157°27'W to 156°W.

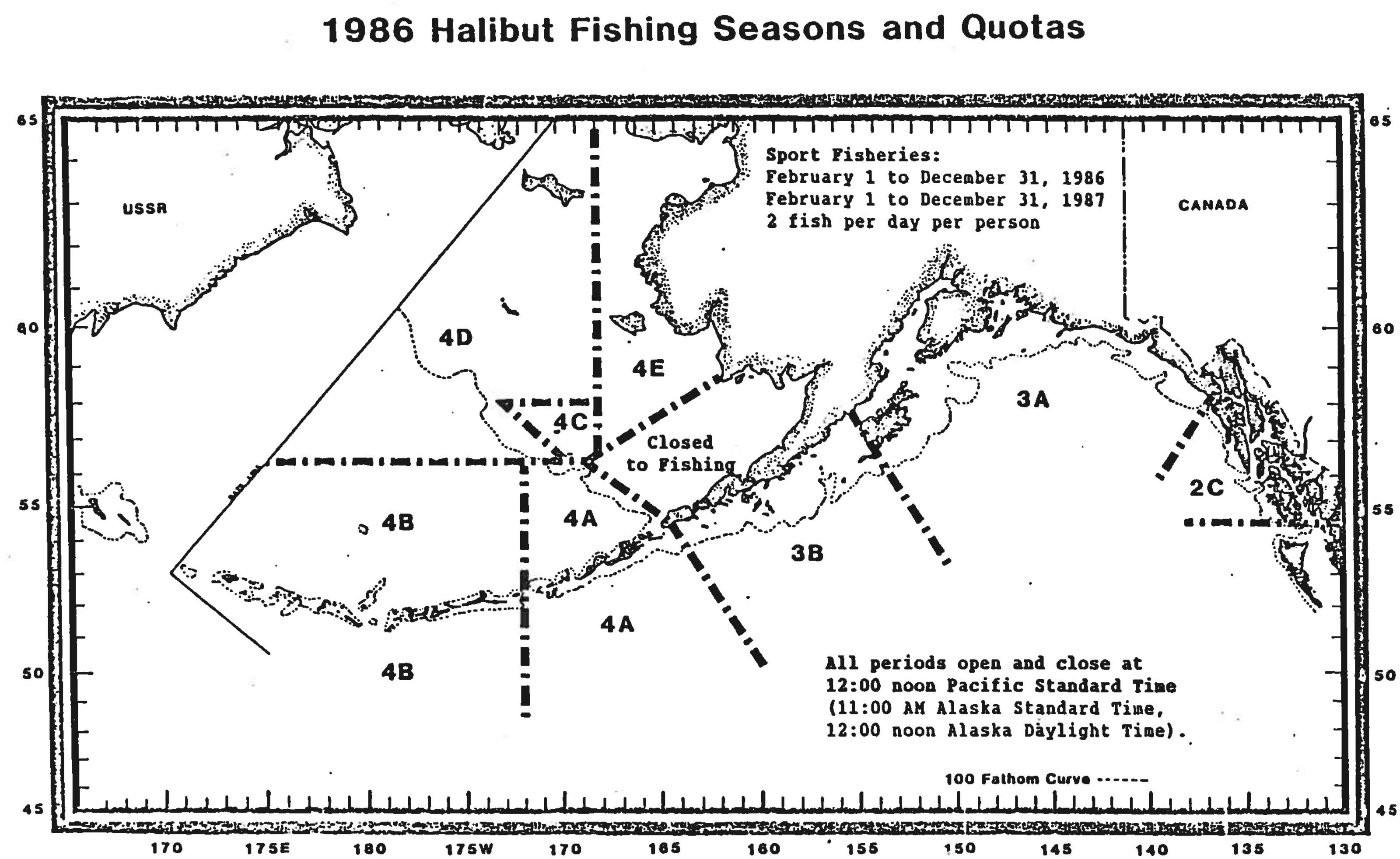

Figure 4.3. Commercial and sport halibut fishing areas for Alaska. The commercial quota for the Shumagin area 4A is 2,000,000 lbs.

2. Tanner crab, Dungeness crab, shrimp, and miscellaneous shellfish - Statistical Area J (Westward Area - Kodiak, Aleutians, and Bering Sea; Figure 4.4). The South Peninsula and Chignik Districts of Area J are in the Shumagin planning area, as is the Semidi Islands Section of the Kodiak District (Figure 4.5). In the Tanner crab fishery this area is also called Registration Area J.

All crab fisheries are restricted to the taking of mature male crabs only as determined by carapace width. Seasons and catch quotas vary for each area, and are established prior to the start of each fishing season. The increased efforts and reduced stocks of king and Tanner crabs has resulted in shortened seasons in all areas.

Limited Entry: Certain fisheries, such as the salmon fisheries, are under a limited entry system whereby a certain number of fishing permits are allocated, and only those persons holding permits for a particular fishery may fish. These permits are set by district, species, and gear type. In the salmon fishery of the Shumagin region, permits are issued for set gillnet, drift gillnet, and purse seine gear for the entire fishing area of the Alaska Peninsula or Chignik Districts.

Prohibited Species: The foreign and joint-venture trawl fisheries often harvest species other than those that are their allocated target. Often this incidental catch of other valuable species can be significant. To protect these stocks and the domestic fisheries for them, the NPFMC has designated certain "prohibited species" that may not be retained by the trawlers and must be returned to the sea immediately upon taking. Quotas are set for the incidental catch of prohibited species, and if exceeded, the directed fishery must cease. In some cases, gear restrictions and time/area closures are imposed by the NPFMC. The prohibited species and their quotas vary by area. In the Shumagin region, these prohibited species include king and Tanner crab, salmon, halibut, and herring.

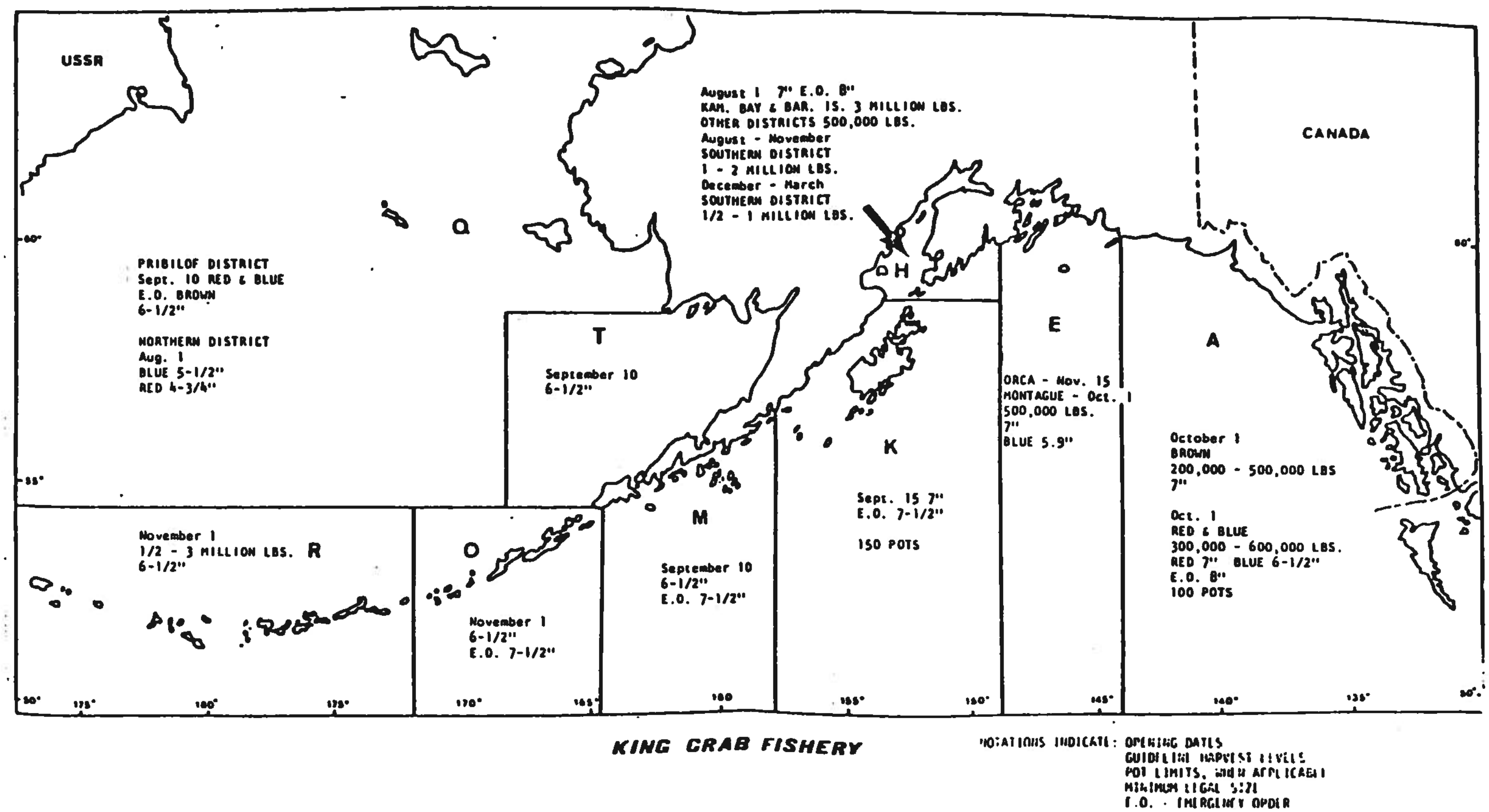

Figure 4.4. King crab fishery statistical areas for Alaska for 1983. The Shumagin Region includes all of Area M and a portion of Area K.

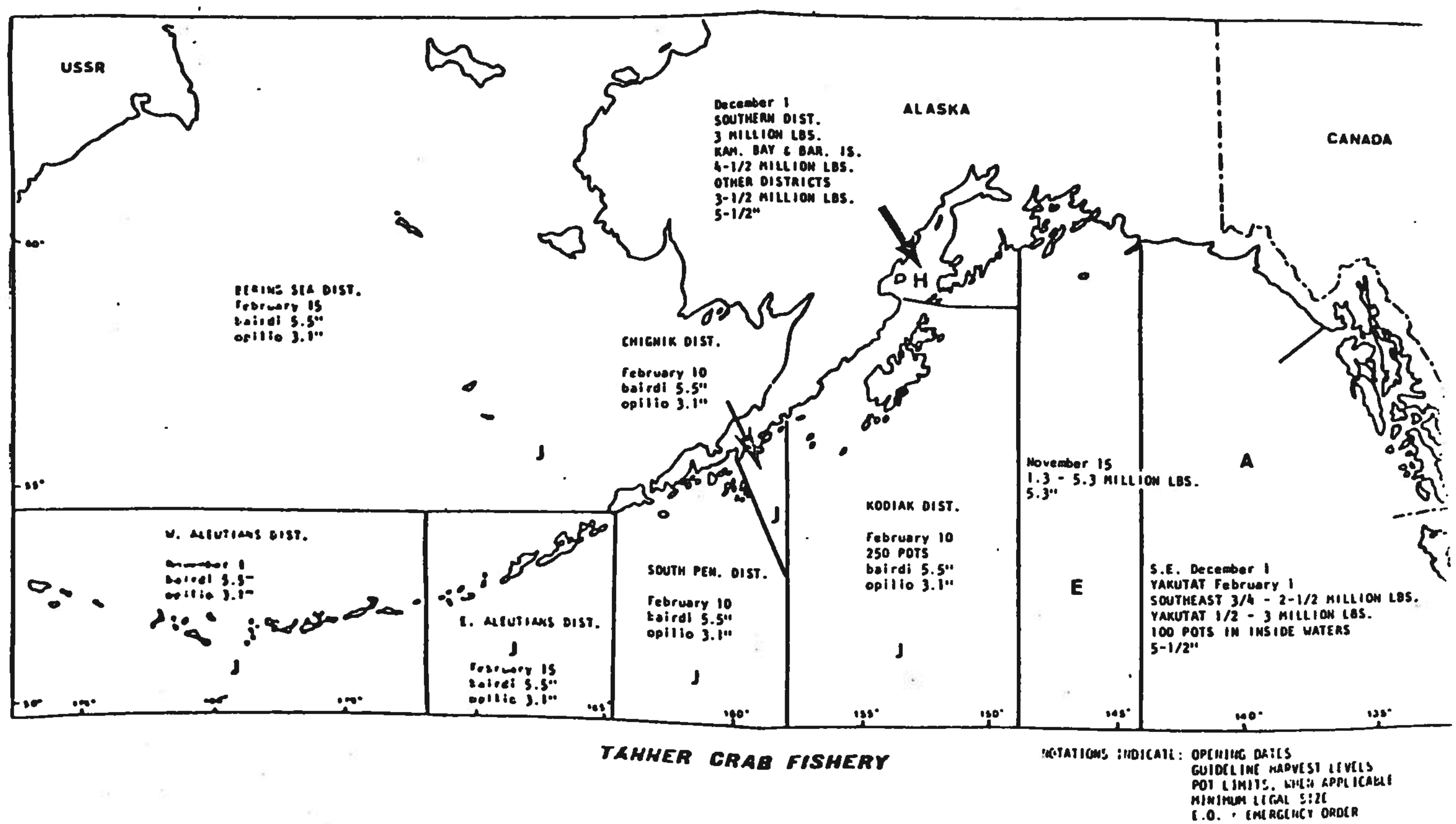

Figure 4.5. Tanner crab fishery statistical areas in Alaska. The Shumagin region is contained in Statistical Area J, and includes all of the South Peninsula and Chignik Districts, as well as a portion of the Kodiak District (from ADFG, 1982b).

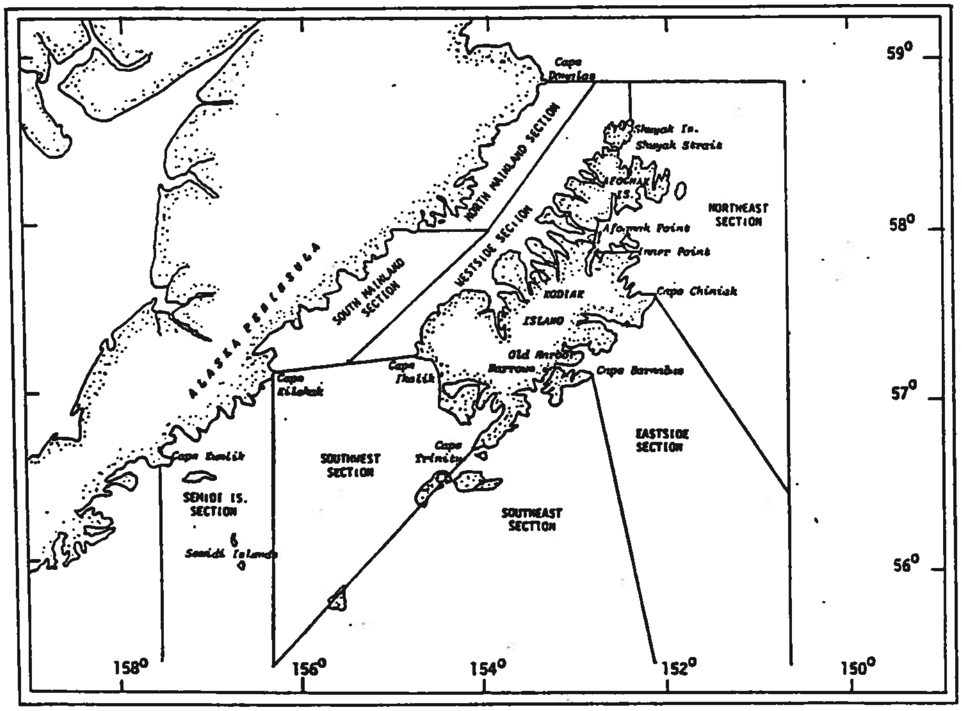

Figure 4.6. Designated Tanner crab fishing sections within the Kodiak District. The Shumagin region contains part of the Semidi Islands Section of this district (from USDOC, 1985b).

4.1.3. Fishery Resource Surveys.

The intensification of the Alaska fisheries has and will continue to complicate the task of conserving and managing the fishery stocks. Part of the effort to manage the multispecies fisheries off Alaska requires continual appraisal of stock sizes and conditions. This effort is accomplished by biennial (Bering Sea) or triennial (Gulf of Alaska) bottom trawl surveys performed by the Northwest and Alaska Fisheries Center.

The year 1984 marked an major advance in stock assessment in the Gulf of Alaska. Between July and October, U.S. and Japan cooperative bottom trawl surveys sampled 823 stations between Cape St. Elias (144°30'W) and the Islands of the Four Mountains in the eastern Aleutians (170°W) (Brown, 1985). The surveys used three fishery vessels (two U.S. and one Japanese) to sample the continental shelf and slope to depths of 1000 m. The survey results were analyzed by 22 subareas overall. The survey data is also examined by International North Pacific Fisheries Commission statistical area and by depth zone within regions. The CPUE values and biomass estimates (kg/km^2) are presented for selected species by 100 m depth intervals to 300 m and by 200 m intervals from 300 to 1,000 m (Brown, 1985). The results are expected to be issued as a NOAA Technical Memorandum in 1986.

Additional analysis of the cooperative trawl survey data specifically for the Shumagin planning area was provided for this report (E.S. Brown, p.c.). In the Shumagin region, there were 242 trawl stations in 18 subareas. The names and locations of these subareas in shown in Figure 4.7. The results of these surveys (as biomass in kg/km^2) in the Shumagin region are contained in later subsections of this report, excluding only the Fox Islands, Chirikof Bank, and Western Gulf of Alaska subareas 1, 7, and 18.

In 1985, the triennial Gulf of Alaska groundfish surveys were conducted in cooperation with U.S.S.R (April-May), Republic of Korea (July-August), and Japan (July-September) (Ronholt, 1985). The results of these surveys were generally not available in time for this report.

4.2. TYPES OF FISHERIES.

Trawl Fisheries: Otter trawl fisheries by Japan, Korea, and the Soviet Union have traditionally harvested large quantities of pollock, cod, Atka mackerel, Pacific ocean perch, and flounders in the offshore waters of the Shumagin region. Although most of the trawl fisheries for groundfish have formerly been by large foreign trawlers, U.S. trawlers greater than 100 feet in length have recently begun domestic and joint-venture efforts at harvesting the groundfish resources of the region. For 1986 in the Gulf of Alaska, domestic fishermen received the largest share of the cod and flounder allocations, and exclusive fishing rights for sablefish and Pacific ocean perch (see Table 4.2). The joint-venture fisheries received the full allocation of Atka mackerel, and the largest share for pollock. Foreign fisherman were also restricted to a minor share of Gulf of Alaska cod.

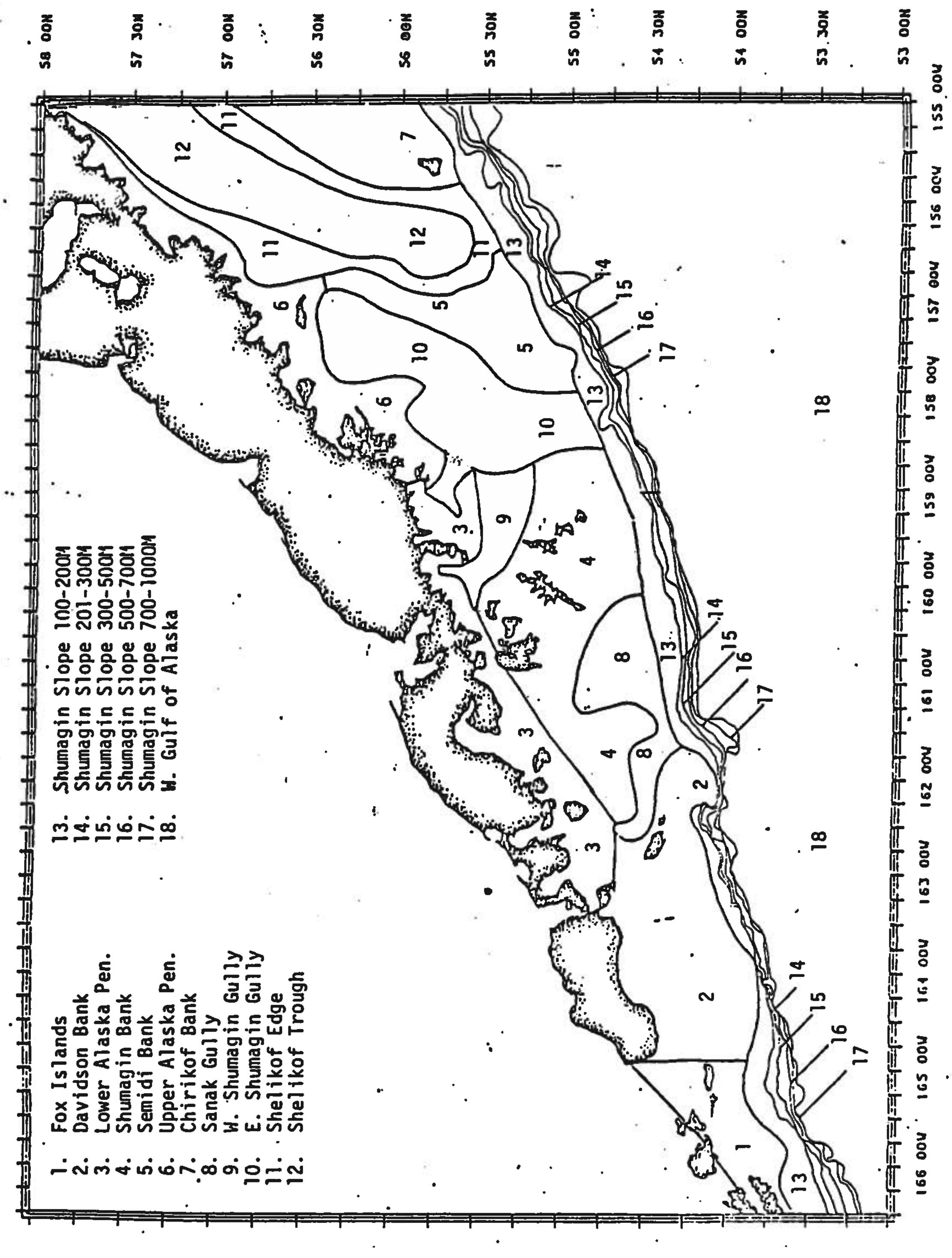

Figure 4.7. Statistical subareas of the Shumagin region used for calculating average biomass of fisheries resources as determined by the 1984 U.S. - Japan cooperative bottom trawl surveys.

Until 1983, foreign fleets harvested most of the groundfish resources in the Gulf of Alaska (Table 4.3). In 1979, joint-venture efforts for pollock began and have increased significantly each year. In 1982, joint-venture efforts accounted for one-third of the pollock landings in the Gulf of Alaska, and have since become the major harvester of this resource. There is also a modest joint-venture effort for Pacific cod, but the domestic effort has remained limited. During 1981 and 1982, a domestic trawl effort for cod landed 665 and 292 mt respectively to supply a salt-cod processing facility at Squaw Harbor on Unga Island, but this operation closed after the 1982 season. Little joint-venture or domestic trawling for other groundfish has occurred in the Shumagin region, and this harvest remains dominated by the foreign fleets.

Longline Fisheries: Longline (or setline) fisheries are conducted for sablefish and halibut by domestic fisherman. Halibut have been fished commercially by Alaska fisherman since the late 1800's. Foreign vessels used to longline for sablefish, rockfish, and cod year-round along the shelf edge and upper continental slope of the Shumagin region.

Purse-Seine Fisheries: Major fisheries are conducted by domestic fishermen for salmon and herring using purse seines. The salmon fisheries are the economic mainstay of the fisheries of the Shumagin region, with annual catches during the past few years ranging from $30 million to $40 million. Approximately 75 per cent of the salmon harvest in the Shumagin region is by purse seine.

Summer is the active season for the salmon fisheries of the Shumagin region. Salmon seiners (also called limit seiners) are restricted by regulation to 58 feet or less in length. Sand Point and King Cove are the main ports for these vessels.

There are two types of purse seine operations employed: hand purse seining and deepwater power seining (AECRSA, 1984). Hand purse seining is used in shallow bays for pink salmon, most commonly using two skiffs to operate the net and the limit seiner to act as the tender. Both hand and power seining are used in deeper waters, but power deepwater seining is restricted to the larger vessels.

Table 4.3. Total Landings of Bottomfish in the Gulf of Alaska by Year (from Galloway, 1985).

Year	Metric tons Foreign	Joint-Venture	Domestic
1977	240,707	-	2,164
1978	164,947	-	4,160
1979	137,205	1,468	4,584
1980	208,036	1,916	3,990
1981	232,542	16,955	4,007
1982	153,297	74,824	8,520
1983	147,438	142,277	8,263
1984	119,216	217,213	5,918

The purse-seine fishery for herring in the Shumagin region is relatively recent, beginning in the summer of 1979 with a 10 ton harvest of sac-roe herring (see Section 4.4.2.1).

Gill-Net Fisheries: A second major fishery for salmon uses gill-nets. Both drift gill-nets and set gill-nets are used. Although not as popular as purse seining, gill nets account for about one-quarter of the salmon harvest of the Shumagin region, with drift gillnets the more common gear.

Pot Fisheries: Pot fisheries by U.S. fishermen are for king crab, Tanner crab, Dungeness crab, and pandalid shrimp. Local crab fisheries began in the 1960's as a supplement to the seasonal salmon and halibut fisheries. Crab fishing and processing has allowed fishing and processing to become year-round activities in the region. Though annual harvest of all species of crab have fluctuated drastically, the annual values of the harvests have shown less severe changes. In 1982, the commercial catch of crabs from the South Peninsula fishing district in the Shumagin region was:

King crab - 1.6 million pounds worth $5.4 million,

Tanner crab - 4.6 million pounds worth $4.8 million,

Dungeness crab - 0.5 million pounds worth $402,000.

The king crab fishery is in the fall (generally opening in September), and the Tanner crab fishery is in the late winter (generally February and March). Dungeness crab are harvested from August through December. Large crabber/trawlers from the Pacific Northwest participate in the fishery, which they share with the domestic fleet of salmon seiners out of Sand Point and King Cove which re-rig for the crab fishery.

Dredge Fishing: A dredge fishery for scallops is pursued by U.S. fisherman on the continental shelf.

4.3. SHELLFISH RESOURCES.

The best known invertebrates in the Shumagin region are the commercially important shellfish. Within this area there are 14 species representing six families of harvested invertebrates (Table 4.4). Of these species, Dungeness crab, Tanner crab, king crab, shrimp, and scallops are taken by regulated fisheries. Information on these resources and their fisheries is contained in the following subsections.

4.3.1. Red and Golden King Crabs.

Red king crab (Paralithodes camtschatica) support the most important shellfish fishery in Alaskan waters. Major fishing grounds occur on the Kodiak shelf, in the southeastern Bering Sea, and in the Shumagin shelf region along the southern side of the Alaska Peninsula in both the South Peninsula (Area M) and Unalaska (Area O) crab fishery areas (see Figure 4.3). King crab are distributed in bays and passages throughout the Shumagin region, as well as across

Table 4.4. A List of Commercially Important Invertebrates of the Shumagin Area (from AECRSA, 1984).

COMMON NAME	SCIENTIFIC NAME
Bivalve Molluscs	
Weathervane Scallop	Patinopecten caurinus
Razor Clam	Siliqua patula
Crustaceans	
Dungeness Crab	Cancer magister
Tanner Crab	Chionoecetes bairdi
Golden King Crab	Lithodes aequispina
Red King Crab	Paralithodes camtschatica
Pink Shrimp	Pandalus borealis
Dock Shrimp	Pandalus danae
Humpy Shrimp	Pandalus goniuris
Coonstripe Shrimp	Pandalus hypsinotus
Ocean Pink Shrimp	Pandalus jordani
Spot Shrimp	Pandalus platyceros
	Pandalus montaquitridens
Sidestripe Shrimp	Pandalopsis dispar

the entire shelf and upper continental slope. Seven stocks have been identified in the South Peninsula Fishing District (AECRSA, 1984); the most productive in recent years has been the Pavlof Bay stock.

The Shumagin region's red king crab population has been declining since 1979, and has not shown any recent signs of recovery. Causes of this decline have been attributed to low reproduction, increased predation (particularly by cod and halibut), and to disease. Year class recruitment has been weak and, in addition, a 1983 survey found that 28 per cent of the breeding females in Belkofski Bay were barren (AECRSA, 1984). This indication of an insufficient number of male crabs for mating had already been observed in Bristol Bay and Kodiak, but for the first time in the South Peninsula district.

The 1984 U.S.-Japan bottom trawl surveys found only low numbers of king crab along the lower Alaska Peninsula, the Shelikof Trough Edge, east Shumagin Gully, and on Sanak Bank. Estimated biomass for the region is 204 mt, with highest abundance (Figure 4.7) along the lower Alaska Peninsula with 23 kg/km^2 (E.S. Brown, p.c.).

Red king crab begin spawning migrations in December and January when they begin moving from their deepwater feeding areas on the outer shelf to shallower nearshore breeding areas in March and April. The sexes migrate separately, with the females beginning earliest, the young males following, and the older males last. Preferred breeding grounds are areas of mud or sand bottom where water temperatures are below 10°C. On the breeding grounds, the females form dense aggregations and emit chemical pheromones that attract the males. In the Shumagin region, nearshore breeding areas are identified in Pavlof, Ikatan, Morzhovoi, Beaver, Balboa and Belkofski Bays.

The peak breeding season extends through April and May. After breeding, adult males return to their deepwater feeding areas, and females and smaller males move offshore to intermediate depths. Juvenile king crab remain in the shallow nearshore areas to rear until about age four or five.

Females carry their fertilized eggs for about a year, or from the time of breeding until the eggs hatch the following spring. The hatched larvae are planktonic, and drift in shelf waters for about 10 to 12 weeks. Some larvae from the Pacific side of the Alaska Peninsula are probably carried into the Bering Sea to augment the Bristol Bay stock. Following the larval stage, the young metamorphose into small juvenile crabs, settle to the bottom, and spend their first year of life feeding in shallow rocky inshore, and often intertidal areas. The exact locations of nursery areas and podding locations in the Shumagin region are not known. As they grow in subsequent years, the juveniles slowly range to greater depths.

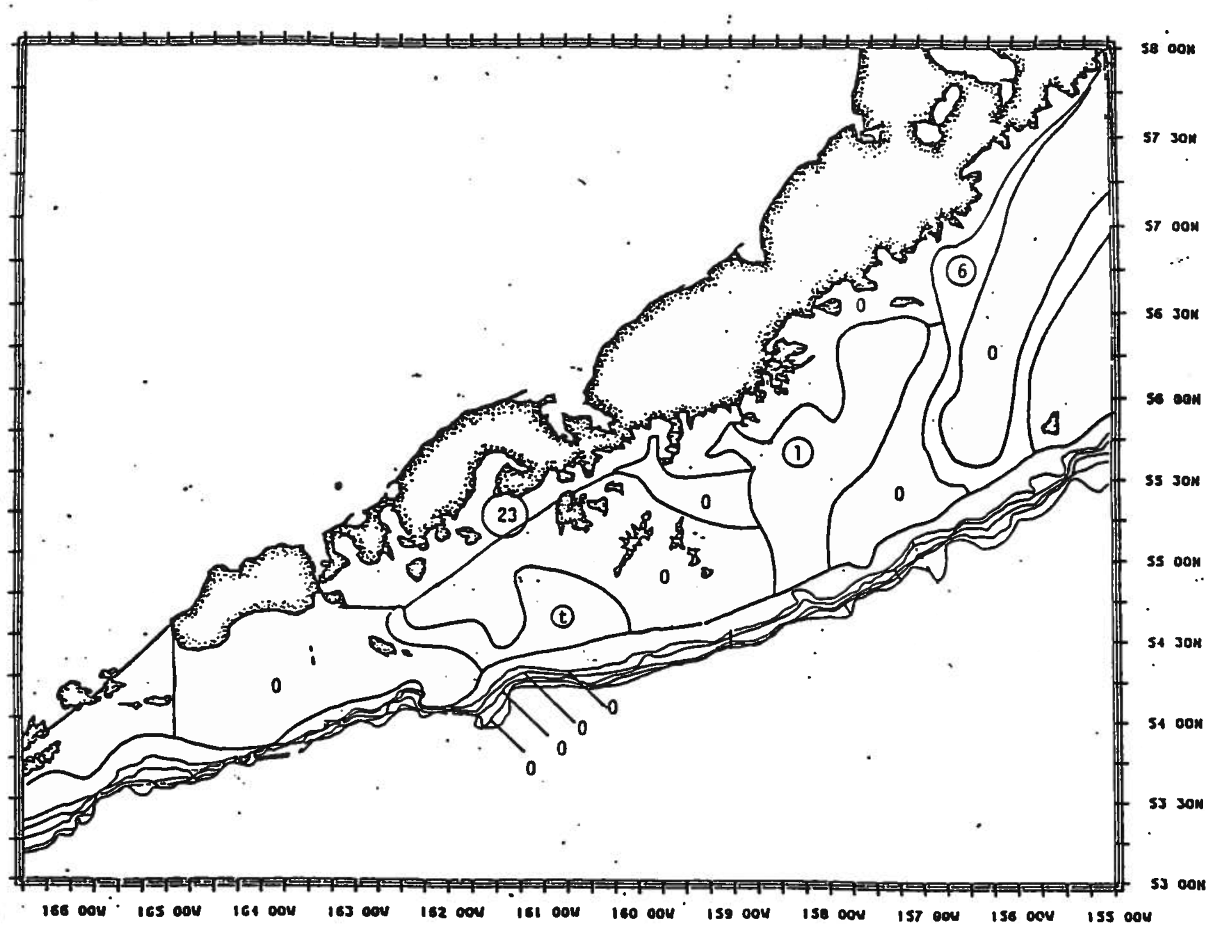

Figure 4.7. Biomass distribution (kg/km²) of king crabs (Lithodidae) in subareas of the Shumagin regions based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

Red king crabs are omnivorous both as juveniles and adults. Common foods include molluscs, polychaete worms, algae, other crustacea, and jellyfish. Adults are fairly free of predation except during their molting periods in the early spring. Juveniles are eaten by cod, sculpins, herring, various flatfish, and by seals.

Golden (or brown) king crabs (<u>Lithodes aequispina</u>) is a little studied species that occupy the deeper waters (to 1000 m) of the shelf edge and continental slope of the Gulf of Alaska and Bering Sea. Major concentrations are found along the Aleutian Islands in deepwater areas of strong tidal currents.

4.3.1.1. The King Crab Fishery.

The domestic pot and ring net fisheries for king crab are the sole target fisheries for this resource in State and FCZ waters. The king crab harvest in the Shumagin region occurs in Area M (Chignik and South Peninsula Districts) and the westward portion of Area K (Kodiak). The season normally runs from September to January, but because of increased effort and reduced stocks the season has been severely shortened in recent years. For example, in 1982 the season lasted only 10 days. The red king crab fishery has been closed since 1983 because of low stocks of harvestable males in the Kodiak, Chignik, South Peninsula, Aleutians, and Bristol Bay areas.

Although modest in comparison to either the Bristol Bay or Kodiak fisheries, in the past the Shumagin region has provided sizeable catches of red king crab. The Chignik/South Peninsula harvests accounted for 5 per cent of the 1982-83 harvest of the Westward Region, or 1.6 million pounds worth about $5.4 million. The decline in red king crab stocks is believed to be due to weak year class strengths and low recruitment during recent years, an unusual increase in predator abundance, and other variables in the natural environment (NMFS, 1983). It is anticipated that many of the red king crab stocks will need at least three or four years to recover to the point where they can again support a significant target fishery.

Overfishing and handling mortality have undoubtedly also contributed to the greatly reduced king crab stocks of the Shumagin region. The peak catch of 1966 yielded 22.6 million pounds, over half of which came from the Davidson Bank and Unimak Bight area. This area declined in catch and by 1970 the fishery has shifted to certain discrete schools of crabs in inshore bays. In 1982, Pavlof Bay accounted for 70 per cent of the Area M harvest, with Morzhovoi and Belkofski Bays yielding 23 per cent. Minor harvests are also taken in Balboa Bay and the Chignik area. All areas have declined in the productivity of the red king crab schools, with a resulting severe decline in harvests, and fishery closures in recent years.

Up to the closure of the red king crab fishery in 1983, the ex-vessel value of the fishery continued to increase despite decreased harvests. At the same time as harvests declined, the fishing effort as measured by the number of boats participating, continued to increase. The 1980-82 effort ranged from 51 to 63 boats. In 1983, Area M was made a "super exclusive" registration area in an attempt to limit the fishing effort of the area. Any vessel fishing in Area M would not be allowed to fish in any other area.

King crab are either processed locally at King Cove and Sand Point, on floating processors, or tendered to other ports such as Kodiak, Dutch Harbor, and Akutan. Nearly all the crab is cooked and frozen and then exported as leg sections to both domestic and foreign markets.

The deepwater golden king crab also occurs in the Shumagin region in limited commercial quantities. An unregulated fishery for golden king crab, has been allowed in the Shumagin region in recent years, but no substantial stocks have been located and landings have remained small (AECRSA, 1984). Coupled with strong tides, the deep waters where they are fished make the use of conventional king crab gear difficult, and new and modified fishing methods are being sought. Some investigators believe the resource may be able to provide yearly catches of 20 million pounds or about 9,100 mt (NMFS, 1983). As much as 59,000 pounds a year have been taken as incidental catches to the red king crab fishery during the 1970's.

With the collapse of the red king crabs in 1981, some boats began a directed fishery on golden king crabs (Blackburn, 1983). During 1981-82, 1.2 million pounds of golden king crab were taken from the Adak area, and 100,000 pounds near Dutch Harbor. In 1983 a 50-boat fleet landed an estimated 8 million pounds in the Adak fishery, and 16 boats in the Dutch Harbor area landed 1.2 million pounds.

4.3.2. Tanner Crab.

There are four species of Tanner crab inhabiting Alaska waters, Chionoecetes bairdi and C. opilio which predominate, and C. tanneri, and C. angulatus which are less abundant. Of the two commercially important species, C. opilio is confined to central and northern waters of the Bering Sea, while bairdi Tanner crab range more southerly, from the southern Bering Sea to throughout the Gulf of Alaska. In the Shumagin region, C. bairdi inhabits the seabed from the littoral zone out to the upper slope region to depths of 1000 m. Fisheries concentrate on the species at depths of about 50 to 125 m.

The Tanner or snow crab is a relatively recent fishery in Alaska waters, first developing in 1967, and increasing through the early 1970's. Tanner crab are a widespread and abundant resource, outnumbering king crab in abundance in most areas. The resource has, however, shown a decline in abundance similar to that observed for king crab. While many reasons have been put forth to explain the declines, the most plausible explanations center on unusual increases in predator abundance and other variations in the natural environment.

Bairdi Tanner crab populations in the Shumagin region crashed during 1976-77 to about 10 per cent of their previous abundance. Since 1980, the abundance of sub-adult crabs began to increase, and the population of the region now appears to be restabilizing. The estimated biomass of bairdi Tanner crab in the Shumagin region, based on the 1984 U.S.-Japan cooperative bottom trawl surveys was 862 mt (E.S. Brown, p.c.). The species was widespread, being found in all areas except the upper slope (100-300 m) in low abundance (Figure 4.8), with greatest densities (53 kg/km^2) found on the outer slope at depths of 700 - 1000 m.

Less is known about Tanner crab biology than for red king crabs. Mature crabs segregate into male and female schools and remain fairly sedentary (AECRSA, 1984), performing limited migrations from deeper to shallower waters to breed and molt. Breeding occurs between January and June. The eggs are carried by the females for about eleven months. The larvae are released the following spring and are planktonic in the upper 60 m of the water column for up to several months.

Juveniles appear to rear in shallow areas, forming patchlike aggregations of similarly sized individuals. After several years they enter the deeper waters as adults. Specific spawning or rearing locations in the Shumagin region are not known.

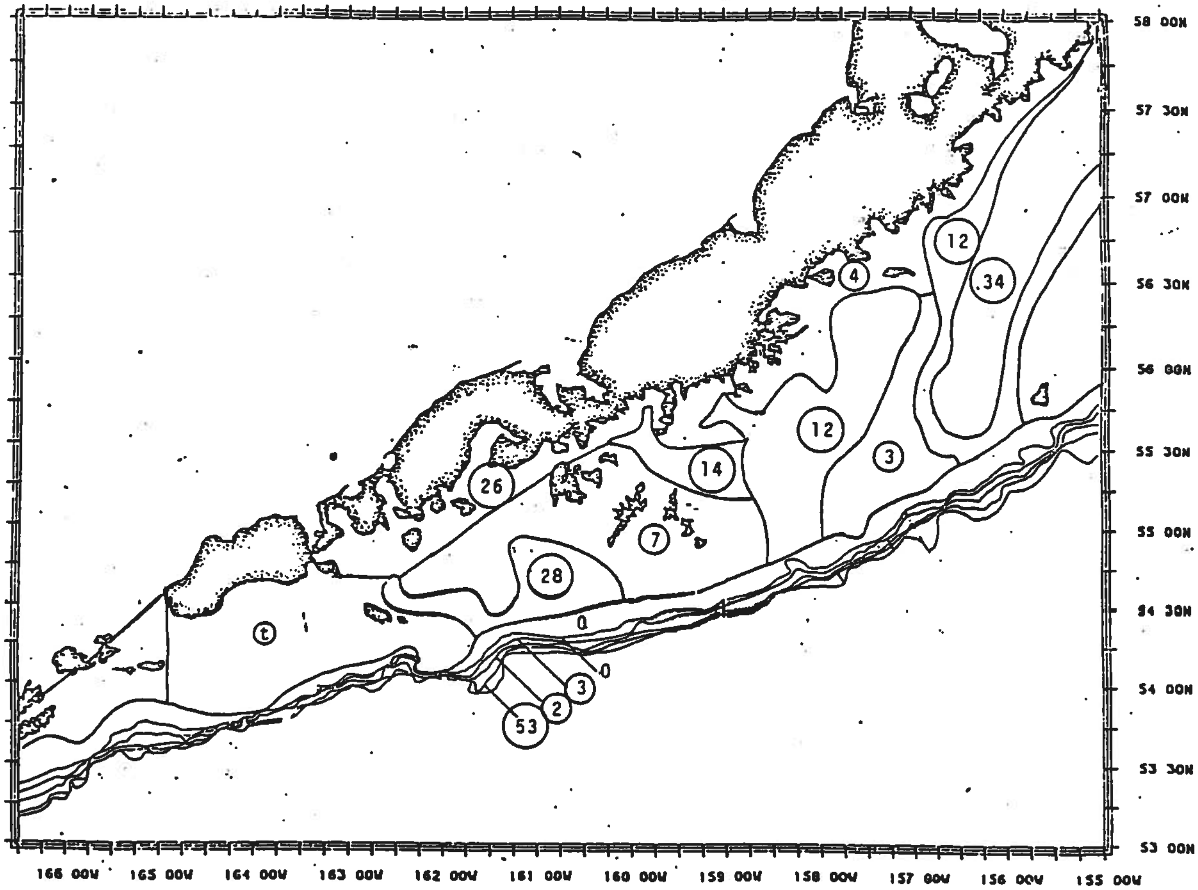

Figure 4.8. Biomass distribution (kg/km²) of Tanner crabs in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

Juvenile Tanner crab feed on small benthic organisms and detritus, the adults are benthic omnivores. Predators are not well known, but undoubtedly include a variety of fish species.

4.3.2.1. The Tanner Crab Fishery.

The Shumagin region is contained in ADF&G's Statistical Area J for the regulation of the Tanner crab fishery. This includes both the South Peninsula and Chignik Districts. Formerly a year-round fishery, the seasons are now limited to a February opening, and last about one month before harvest levels are reached.

The Tanner crab fishery began in the South Peninsula District in 1967 and in the Chignik District in 1971 as a supplement to the declining king crab fishery. Catches in the South Peninsula peaked in 1975-76 at 11 million pounds and have slowly declined since, reflecting a reduced population. As with the red king crab harvest, ex-vessel values continued to increase with the reduced landings, and reached a record value of $4.8 million in 1981-82. Stocks appear to have stabilized in recent years, allowing an annual harvest of 3 to 4.5 million pounds. The 1983 harvest was 2.85 million pounds, taken in February and March (ADFG, 1984). The 1984 harvest declined to 1.78 million pounds (ADFG, 1986). The Chignik District catch also peaked in 1976 at 6.9 million pounds but remained fairly level at about 3 million pounds through 1983 (3.5 million pounds in 1983). However, in 1984 the harvest declined dramatically to 0.78 million lbs (ADFG, 1984). The combined Chignik/South Peninsula harvest of bairdi Tanner crab accounted for 25 per cent of the harvest of the Westward Region in 1983, valued at about $23 million.

The most productive Tanner crab fishing areas are Pavlof Bay, Chignik Bay, Belkofski Bay, Cold Bay, and around the Sanak Islands. Other areas where Tanner crab are harvested in the Shumagin region include Unimak Bight, Ikatan Bay, Morzhovoi Bay, Balboa Bay, Stepovak Bay, and around the Shumagin Islands. In 1982 and 1983, 72 and 82 vessels respectively participated in the harvest. These include vessels from Sand Point and King Cove as well as non-resident vessels. After the 1983 season, the State of Alaska made the fisheries a "super exclusive" registration area, as was done for the red king crab fishery. However, the NPFMC did not adopt this restriction for federal waters, so its effect is limited.

Tanner crab are processed at both King Cove and Sand Point, and shipped frozen to both domestic and foreign markets. A new method of processing, known as "snap and pull", which scores the shell along the leg joints, has increased the popularity of this crab in the restaurant trade and for home consumption.

4.3.3. Dungeness Crab.

The Dungeness crab (Cancer magister) supports one of Alaska's most important and stable fisheries. There is a modest Dungeness crab fishery in the Chignik and South Peninsula districts of the Shumagin region. Harvestable populations appear to be widespread in the region, but few highly productive areas are known.

Dungeness crab range from the Aleutians to California. Relatively little is known about the abundance or biology of Dungeness crab in the Shumagin region (AECRSA, 1984). In general they inhabit bays, estuaries, and along ocean beaches from the intertidal zone to shelf depths of about 50 m, preferring a more shallow distribution than king or Tanner crabs. Although found on almost any bottom substrate, they favor sand and silt-mud areas. Limited seasonal movements are known to occur. During summer these crab are found in soft sediments in shallow areas off the mouths of rivers, in the fall they move offshore into deeper coastal waters.

Dungeness crabs are carnivores, feeding mainly on other crustaceans, clams, mussels, and polychaete worms. Chief predators include octopus and bottom fish such as halibut and dogfish shark.

4.3.3.1. The Dungeness Crab Fishery.

The Dungeness crab fishery is regulated by ADF&G under Statistical Area J, Chignik and South Peninsula Districts. The fishery began in 1968 with a record harvest of 1.2 million pounds. Since then it has been sporadic, fluctuating between nearly zero and 200,000 pounds annually. Interest in Dungeness crab fishing in the Shumagin region has increased in the past few years, as an alternative to reduced stocks of king and Tanner crabs. Recent harvests jumped to 526,000 pounds in the South Peninsula District in 1983, and 667,000 pounds in the Chignik District (ADFG, 1984), with catches in all of the major bays and in Unimak Bight. These harvests declined to 264,000 lb and 381,000 lbs respectively in 1984 (ADFG, 1986). The actual size of the resource and its overall commercial potential are unknown.

Most Dungeness fishermen are from outside the region. In 1983 only two of ten vessels were local. Although the season runs from May to February, most of the activity is from July through November (ADFG,1984).

frozen export. Earlier, the crabs had to be carried live to Kodiak for processing which added costs and resulted in large dead losses to the fisherman.

4.3.4. Shrimp.

There are two genera and 14 species of pandalid shrimp in Alaska waters that are of commercial value. Seven of these species are regularly fished commercially (see Table 4.3). Of these, the pink shrimp (Pandalus borealis) and the sidestripe shrimp (Pandalopsis dispar) are commercially the most important. The Shumagin region has historically been the most productive region in Alaska for the harvest of both species of shrimp.

Shrimp are found in bays and inlets, as well as on the continental shelf throughout the Shumagin region. Many bays and inlets of the region provide vital rearing and reproduction areas. Most pandalid shrimp prefer sand or mud bottoms, in water depths of 80 to 200 m. Pink shrimp, the dominant species, are found in commercial abundance in the outer shelf area at depths of 70 to 120 m (Favorite et al., 1977). Humpy shrimp (P. goniuris) prefer mid-shelf areas with constant low temperatures and muddy bottoms. The greatest concentrations of spot shrimp (P. platyceros) are somewhat deeper than pink shrimp, generally from 110 to 218 m. Only spot shrimp prefer rocky areas.

Pandalid shrimp perform daily vertical feeding migrations, leaving the bottom at dusk to feed in the water column. Annual movements are less well documented, but the shrimp appear to school in the early spring to spawn and disperse again about May. Their larvae are planktonic for about 60 to 90 days, and may be dispersed throughout the water column. The juveniles settle to the bottom in shallow areas, moving deeper as they grow.

Pandalid shrimp populations in the Shumagin region used to be large but are currently depressed. Their populations may be on the recovery, at least in some areas. Increased numbers of juveniles were found during 1983 surveys in Pavlof Bay (AECRSA, 1984). Shrimp are carnivorous bottom feeders on marine worms and small crustaceans, but will also consume algae and other plant materials.

4.3.4.1. The Shrimp Fishery.

The shrimp fishery in the Shumagin region began in 1968, and increased steadily to a record harvest of 45 million pounds in 1977-78. Stocks then plummeted in subsequent years, resulting in closure of the entire area in 1980. Except for 1981-82 when the offshore waters were opened to allow for exploratory fishing, for which no harvests were reported, the area has remained closed to shrimp fishing. The South Peninsula shrimp stocks appear to remain severely depressed with little indication of recovery. Harvests in the Chignik district plunged from almost 13 million pounds in 1980 to only 71,000 pounds in 1981, and to nothing in 1982 or since (AFDF, 1983).

Historically important shrimping grounds in the Shumagin region were Balboa Bay and Unga Strait, Pavlof Bay, Morzhovoi Bay, the shelf waters surrounding the Shumagin Islands, Stepovak Bay, and around Mitrofania Island in the Shumagin District, and Mitrofania and Kuiukta Bays, Chignik Bay, Kujulik Bay, Aniakchak Bay, and Nakalilok Bay in the Chignik District.

Pink shrimp dominate the shrimp populations of the Shumagin region. They have accounted for the majority of the shrimp landings, with Pavlof Bay being the most productive fishing area, where over 25 million pounds were harvested in 1977-78. Most of the fishing effort has been by Kodiak trawlers using beam and otter trawls. A few Chignik area fisherman also trawled for shrimp. Processing was done at both Sand Point and King Cove, as well as at a now closed shrimp plant at Squaw Harbor.

4.3.5. Clams and Other Molluscs.

Weathervane Scallop: Weathervane scallops (Patinopecten caurinus) are common in water depths from 50 to 150 m. They range from Unimak Pass to southeast Alaska. Scallops are not as commercially abundant in the Shumagin region as they are off Kodiak and to the east. Most of the dredge fishery for scallops occurs in the Chignik District. Much of the South Peninsula District, i.e. Unimak Bight and all bays, is closed to scallop fishing to prevent further damage to crab stocks or for gear conflicts. Open areas appear to have a limited abundance of scallop resources. Exploratory surveys of closed areas in 1982 did not locate any large populations of scallops for future harvest.

The South Peninsula harvest of scallops began off Shumagin Bank in 1975, with a landing of 2508 pounds of meat. Subsequent harvests have been small and sporadic, but in 1982, 33,358 pounds were landed. All vessels that participate in the fishery are non-resident, and there is no local processing in the region.

Razor Clams: Razor clams (Siliqua patula) are most abundant on sandy exposed beaches in the intertidal and subtidal zones. Fine sand with some glacial silt is typical of razor clam beds (Nosho, 1972). They are not found in enclosed water bodies. A large razor clam area in the Shumagin region is in San Diego Bay, but it does not appear to be commercially significant.

Hardshell Clams: Hardshell clams such as little necks, butter, surf and horse clams are located in both the intertidal and subtidal zones, especially near freshwater outflows. Alaska surf clams are primarily subtidal marine. Modest beds of surf clams are reported in the Chignik area, including Chiginagak Bay (2 miles of beds), Yantarni Bay (10 miles), Aniakchak Bay (5 miles), and Hook Bays (1 mile) (BBCMP, 1984). Other undiscovered or lesser beds undoubtedly occur throughout the region.

Squid: Squid are a pelagic resource that has not been fully exploited in the Shumagin region. The resource appears to be abundant and in good stock condition, although the abundance and potential yields have not been determined. The majority of squids found in Alaska are oceanic species of the family Gonatidae (Wilson and Gorham, 1982a). Little is known about the distribution, biology and feeding habits of these species, but they appear to be most abundant in continental slope and upwelling areas.

Catches by commercial and fisheries research vessels in the Gulf of Alaska consist primarily of Berryteuthis magister, B. anonychus, and Gonatus spp. (Wilderbuer, 1985). The maximum sustainable yield for the Gulf of Alaska is believed to be greater than 5,000 mt; actual harvests have been far less (Table 4.4). The estimated biomass of squid in the Shumagin region is 560 mt (E.S. Brown, p.c.). Nearly all the squid are found along the slope, with small amounts on Davidson and Semidi Banks. Highest mean densities (200 kg/km^2) were along the slope at the 300 - 500 m depths (Figure 4.9).

Table 4.4. Optimum Yield (OY) and Catch (mt) of Squid in the Gulf of Alaska from 1977 to 1985 (from Major, 1985).

Year	OY	Foreign	Joint-Venture	Domestic	Total
1977	--	--[a]	0	0	0
1978	2,000	322	0	0	322
1979	5,000	425	0	0	425
1980	5,000	841	0	0	841
1981	5,000	1,135	0	0	1,135
1982	5,000	278	16	0	294
1983	5,000	267	4	0	271
1984	5,000	120	5	0	125
1985	5,000				

a/Catch was not recorded as OY not established prior to 1979.

Squid are harvested primarily by foreign trawlers, mostly in the central and western Gulf of Alaska. There has been a small harvest by joint-ventures in recent years. Most of the harvest is taken incidental to directed fisheries on other groundfish species, and has consequently declined in amount as the foreign fishing effort has decreased.

Squid are also an important prey of 26 marine mammal species in the eastern North Pacific and Bering Sea (Fiscus, 1982). Those squid of the Family Gonatidae are the most important, particularly in offshore areas.

4.3.6. Sea Urchins.

Sea urchins are a potential commercial fishery resource that is presently underutilized (Wilson and Gorham, 1982b). Commercial markets for urchin roe exist in the Orient as well as Greece, Spain, Italy, and France. Three

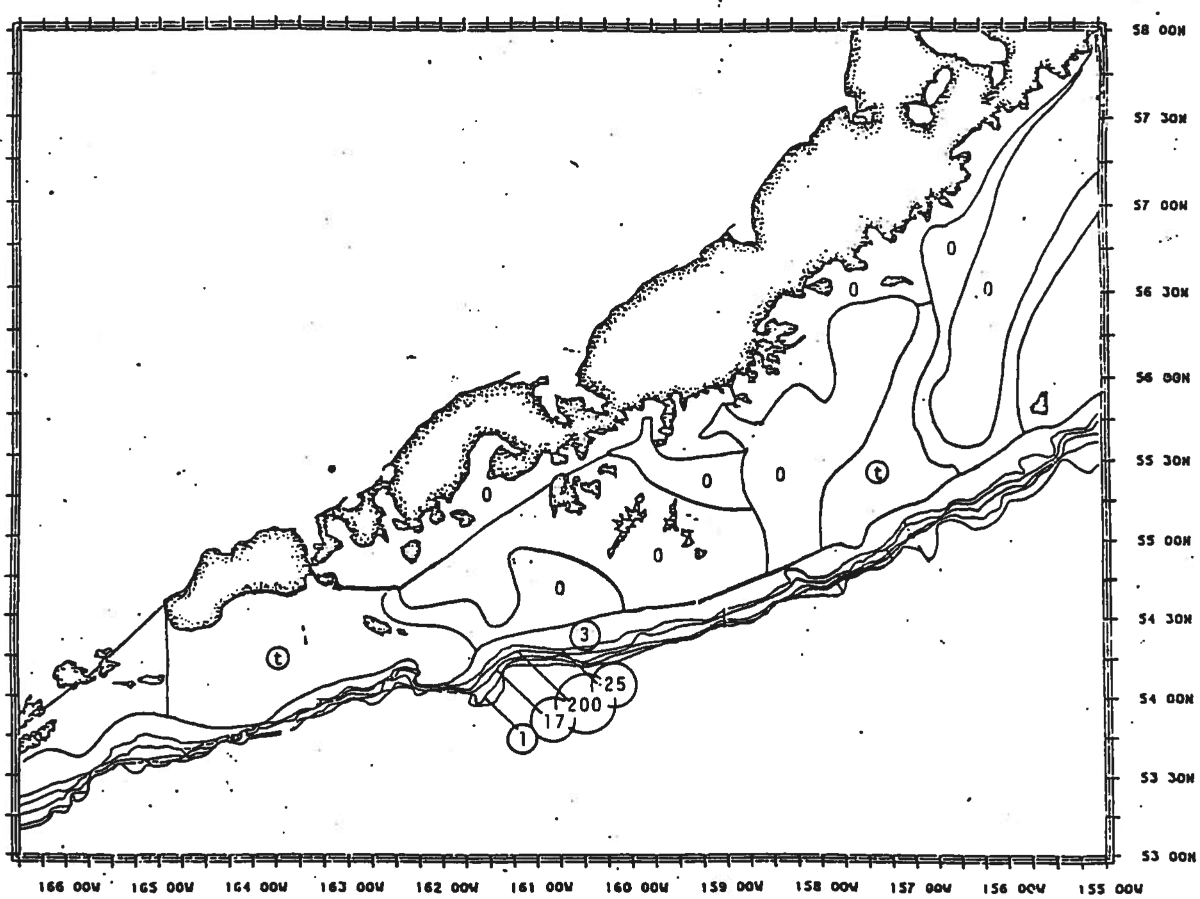

Figure 4.8. Biomass distribution (kg/km²) of squid in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

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species exist in Alaska that are of economic potential. All three occur in the Shumagin region. They are Stongylocentrotus franciscanus (red urchin), S. droebachiensis (green urchin), and S. purpuratus (purple urchin). All live at depths ranging from the intertidal or shallow subtidal to depths of 100 m.

4.4. FINFISH RESOURCES.

The finfish resources of the Shumagin area consist of a variety of both pelagic and demersal species. The occurrence and approximate abundance of some species are relatively well known while data on other species are sometimes non-existent. The following information on pelagic and demersal species will be more regional and less detailed for some species than others.

The pelagic species that are of commercial importance include five species of Pacific salmon, herring, and four species of smelt. The demersal fishes are defined here as those species with a high degree of orientation to bottom features. There are approximately 50 demersal fish species which are of sizes suitable for commercial exploitation. However, only a few species occur in sufficient abundance to support large-scale commercial fisheries in the Shumagin region (e.g., sablefish, Pacific ocean perch, cod, pollock, and six species of flatfish - halibut, yellowfin sole, flathead sole, arrowtooth flounder, rock sole, and starry flounder). With the exception of sablefish and rockfish stocks, the groundfish resources of the Shumagin region are healthy and in stable conditions.

4.4.1. Pacific Salmon.

All five species of Pacific salmon either spawn in freshwater tributaries to the Shumagin region or use the marine waters of the region for rearing, feeding, and migration during the ocean phase of their life cycle. The locations of spawning streams are adequately known for the region, but the movements of adult salmon and ocean migrants through offshore or coastal waters are not well defined. Likewise, the identities of the stocks passing through the region are poorly known. It is believed that many of the Bristol Bay sockeyes return through the passes in the eastern Aleutians and Shumagin area. Salmon research has indicated that the sharply defined salinity and temperature boundary along the seaward edge of the Alaskan Current functions as a guidance cue to these migrating salmon.

Pink Salmon: The pink (humpback) salmon, *Oncorhynchus gorbuscha*, are the smallest and most abundant species of salmon in the Gulf of Alaska, including in the Shumagin region. The average weight of returning adults is 1.6 kg.

Pink salmon have a two-year life cycle. The adults return to their spawning streams and rivers in the summer, generally between July 10 to August 30 in the Shumagin region (AECRSA, 1984). Pinks often spawn in the intertidal zone at the mouth of a river or stream. The fry emerge the following spring (mid-March to mid-May) and move or are carried directly to sea where they form large schools in nearshore and littoral areas. They spend their first summer in these estuarine coastal areas before moving offshore in the fall. Pinks then spend only one year in their ocean migration before beginning their spawning returns at age two. As such, pink salmon spend about one-quarter of their life in the shallow nearshore zone, and a significant portion of their food as juveniles are insects taken by surface feeding. These habits imply that pink salmon may be especially vulnerable to a nearshore oil spill.

There are many short streams along the south side of the Alaska Peninsula and on several of the larger islands that support pink salmon runs, but Mino Creek, Settlement Point, and Southern Creek on Deer Island have occasionally produced nearly half of the pink salmon runs in the region. Apollo Creek and Middle Creek are two other important streams with a potential to produce 800,000 fish (AECRSA, 1984). Both "odd" and "even" year runs yield large returns in most locations, except for some streams where "even-year" runs predominate.

Sockeye Salmon: Sockeye or red salmon (*Oncorhynchus nerka*) are the most important salmon species in the Shumagin region. The major sockeye runs occur in the Chignik River. Other spawning streams along the Peninsula are numerous but the runs are small. Unga, Wosnesenski, and Nagai Islands also have sockeye streams.

Sockeyes are the earliest salmon species to return to freshwater in the Shumagin region, generally beginning their runs by mid-June and ending by late August. Spawning occurs in streams with lake systems between mid-July and late September. The eggs are deposited in gravel-bottomed streams and lake shores. The fry emerge late the following spring (April to June), and spend from one to three, sometimes up to five years in the lakes before outmigrating during the late spring and summer to enter the sea. In the Chignik River system, the smolts outmigrate in mid- to late May. These smolts tend to remain nearshore for up to one year, feeding and growing, before they move offshore to begin their ocean migrations. At first their distribution is localized near the natal streams, but by late summer a more or less continuous band of juvenile salmon of many different river origins forms in the shelf waters across the Gulf of Alaska (Figure 4.9). This distribution probably reflects the counterclockwise movement of the salmon with the prevailing coastal currents (Favorite et al., 1977).

Immature sockeyes range throughout the North Pacific and central to western Bering Sea for one to four years, making two or more circuits of their ocean migration routes, depending on how many winters they spent while maturing, before moving towards their natal streams. Limited information suggests that during the first winter the fish are found south of 50°N and move north of this latitude in late spring to feed between 160°W and 170°E. As winter approaches, the maturing fish remain north of 50°N while the younger salmon return farther south. In their final year they move toward the coastal waters of their river origins. The typical age of returning fish is 3 to 7 years, weighing an average of 2.6 kg.

Chum Salmon: Chum or dog salmon (*Oncorhynchus keta*) are another important salmon of the Shumagin region. Chum salmon spawn in streams and rivers of the Shumagin region, and often spawn in the coastal zone at the mouths of these tributaries. They begin returning to their natal streams in early July, and may continue through early September. Spawning takes place from late July to the end of September. The fry emerge in late winter to early spring and find their way to sea within one month. The smolts school in estuarine and nearshore waters where they feed and grow for the summer, before moving offshore. Their ocean migrations range throughout the North Pacific and central-western Bering Sea, and may last from one to six years, but the typical age of returning spawners is three to five years. Returning adults average 3.3 kg in weight, but may reach 15 kg.

In the Shumagin region, Canoe Bay is the major producer of chum salmon, but smaller runs occur in tributaries of every major bay along the Alaska Peninsula, as well as on Korovin, Unga, and Wosnesenski Islands. Many chum salmon heading for the Yukon and Kuskokwim River systems pass through False Pass and Unimak Pass.

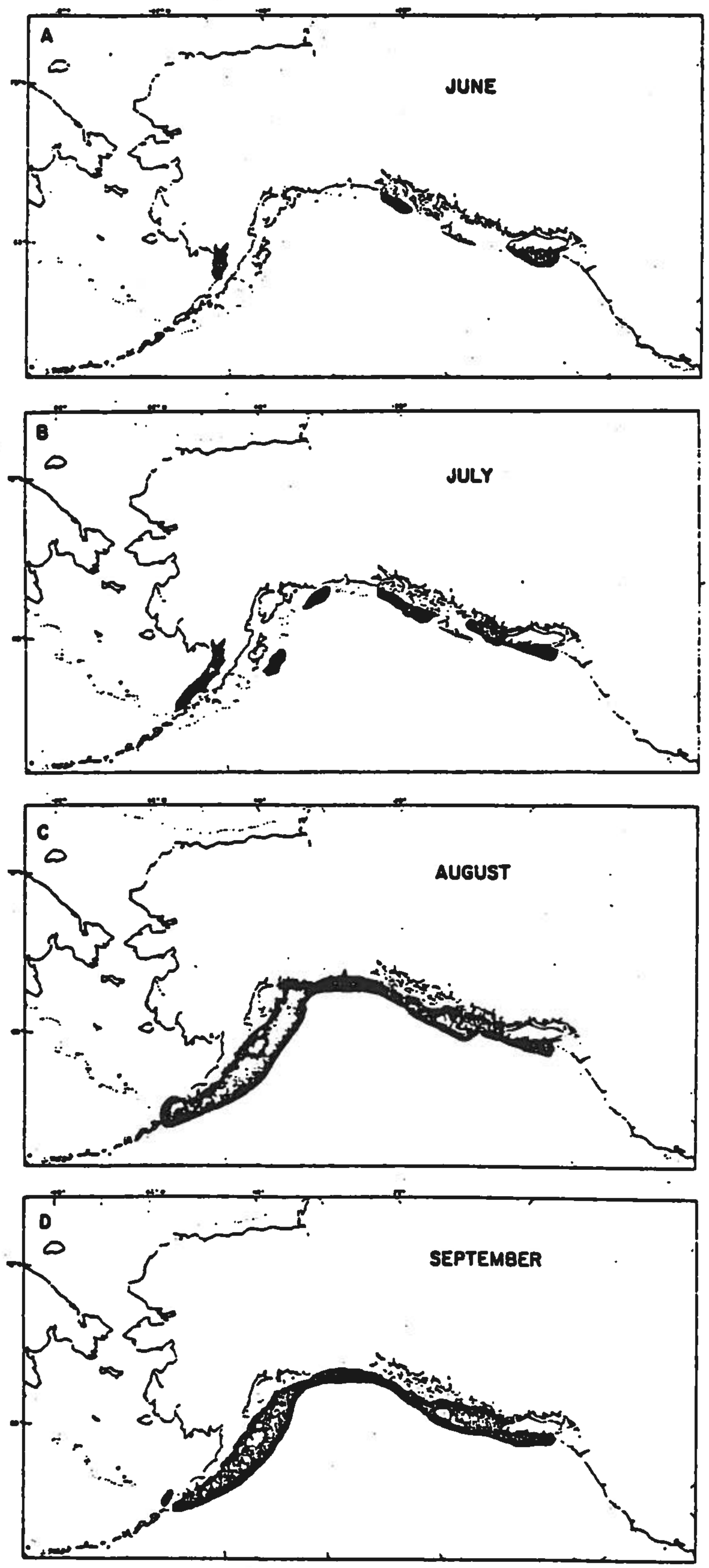


Figure 4.9. General distribution of juvenile salmon in the Gulf of Alaska and eastern Bering Sea during their first months at sea (from Favorite et al., 1977).

Coho Salmon: Coho or silver salmon (Oncorhynchus kisutch) occur in limited abundance in the Shumagin region. Small runs are known for small tributary streams to bays along the Alaska Peninsula from the Kupreanof Peninsula to Unimak Island (AECRSA, 1977). Runs are also known for Thinpoint Cove, Grub Gulch, and in the Stepovak, Ivanof, and Chignik Rivers (BBCMP, 1984). Very few of the islands are known to have coho runs. Humboldt Creek near Sand Point supports a small run of coho and pink salmon, as well as Dolly Varden char (Salvelinus malma). The annual coho run is estimated at 50 to 250 fish (USFWS, 1983).

Coho salmon are relatively late spawners, not returning to their natal streams and lakes until late August through October, and not spawning until October through mid-January. Coho spend considerably more of their life in freshwater than the other salmon species, from one to five years, and most spend only one year at sea. During their ocean life they range throughout the North Pacific and the central and western Bering Sea. Typical spawners are age 3 to 5, and weigh 3.4 kg.

King Salmon: King or chinook salmon (Oncorhynchus tshawytscha) are not as common in the Shumagin region as the other species of salmon. The Chignik River contains the only substantial run of kings in this area. The preference of king salmon for large rivers virtually eliminates them from most other southern Alaska Peninsula streams, although occasional strays do appear in smaller tributaries. The offshore region is used by ocean migrants who spend from one to six years at sea, and the nearshore may support some of the smolt populations. Alaska Peninsula kings average 8.9 kg in weight.

4.4.1.1. The Salmon Fisheries.

Salmon harvests in the Shumagin region differ between the South Peninsula and Chignik Districts. In the South Peninsula, harvests have ranged between 7 and 13 million fish over the past five years. In the Southeastern, Southcentral, and Southwestern Districts of the Alaska Peninsula area, pink salmon dominate the harvests in even numbered years. In odd-numbered years, the western portion of the Southwestern District has relatively few pinks. In 1982, pinks contributed 36 per cent and sockeyes 31 per cent of the regions harvest (ADFG, 1984a). In 1983, an "off" year for pink salmon, sockeyes made up the majority of the catch (47%), followed by pinks (29%), chum (21%), coho (2%), and chinook (0.6%) (ADFG, 1984b).

In value, sockeye salmon contributed the most to the $67 million wholesale value of the salmon fishery in 1983, with pinks and chums of secondary importance. This is a limited entry fishery; in 1983, there were 127 seine permits for the Alaska Peninsula and 100 for the Chignik area. In addition, there are 166 drift gillnet and 116 set gillnet permits in the Alaska Peninsula area (ADFG,1984).

Relatively good catches of sockeyes and chums are realized in the June fisheries in the Unimak District, and in July in the Southwestern District. In June, the salmon fishery in the South Peninsula District targets on sockeye returns in the South Unimak and Shumagin Island areas. Since this fishery is takes primarily Bristol Bay fish, the harvest levels are set according to return estimates and harvest forecasts for the Bristol Bay fishery. The Unimak District fishery is allocated 6.8 per cent of the forecasted run and the Shumagin Islands receive 1.5 per cent. Most of the fishing effort is in the Unimak District, using purse seines and drift gill nets. Many chums, plus some pinks and king salmon are also incidentally caught. In the Shumagin Islands, nearly all the effort is with purse-seine gear.

Fishing in the other South Peninsula districts peaks in late-July and August with the pink salmon runs. The Southwestern District is fished mainly by local seiners, with Volcano Bay, Belkofski Bay, Deer Island waters, and Ikatan Bay being the major fishing areas (AECRSA, 1984). Chum salmon catches are also good in Volcano Bay, Belkofski Bay, and Cold Bay. The Southcentral District is fished for pinks and chums by the areas' fishermen. East Pavlof Bay, Canoe Bay, and Coal Bay are the major fishing areas. Drift gillnetting is prohibited in this district. The Southeastern District fishery for pinks and chums begins in mid-July and peaks in early August.

Purse-seining for pink salmon by the Sand Point fleet is the major fishery, beginning offshore in the deeper waters around the Shumagin Islands and progressing inshore to the Peninsula bays and capes. Popof Head is one of the many important fishing areas of the District. Set gillnets sites are scattered throughout the bays, with Stepovak and Balboa Bays being most heavily fished. Chum salmon and incidental catches of sockeyes and cohos are also taken throughout the district.

The Chignik District harvests all five species of salmon. Red salmon, followed by pinks and chums dominate the harvest. The Chignik River supports the largest salmon runs in the District. Most of the harvest is by purse-seine gear from vessels up to 56 ft in length. Between 1960 and 1982, annual salmon harvests averaged 2.2 million fish per year, and since 1977 have averaged over 3 million fish. The record harvest of 1982 saw 102 vessels earn $16.1 million in salmon landings, an average of just under $159,000 per vessel. Most of the Chignik District harvest is processed in Chignik and at the Columbia Wards fish camp across from Chignik Lagoon. Ten floating processors operated in Chignik Bay in 1983 (BBCMP, 1984). Some of the harvest is delivered to Kodiak processors.

4.4.2. Pacific Herring.

The Pacific herring (Clupea harengus pallasi) occurs in most coastal waters of the Gulf of Alaska with the greatest concentrations around Kodiak Island, Prince William Sound, and southeast Alaska. The Joint U.S.- Japan cooperative bottom trawl surveys conducted in 1984 for groundfish in the central and western Gulf of Alaska provided a biomass estimate of 49,000 mt for herring, of which only 173 tons are estimated for the Shumagin region (E.S.Brown, p.c.). Most of these herring were found in the nearshore region of the Alaska Peninsula (Figure 4.10) with a mean biomass of 22.8 kg/km^2. The low biomass estimates from the 1984 trawl surveys are undoubtedly influenced by the dispersal of the herring schools off the bottom, as well as by gear type and seasons of coverage.

Herring stocks in the Shumagin region may be of mixed origin (AECRSA, 1984). Little is known of the stock sizes and their stability, or of the locations of their overwintering areas. Populations east of Canoe Bay have the faster growth and smaller size features characteristic of Gulf of Alaska stocks, while Canoe Bay populations resemble the larger size fish of the Bering Sea.

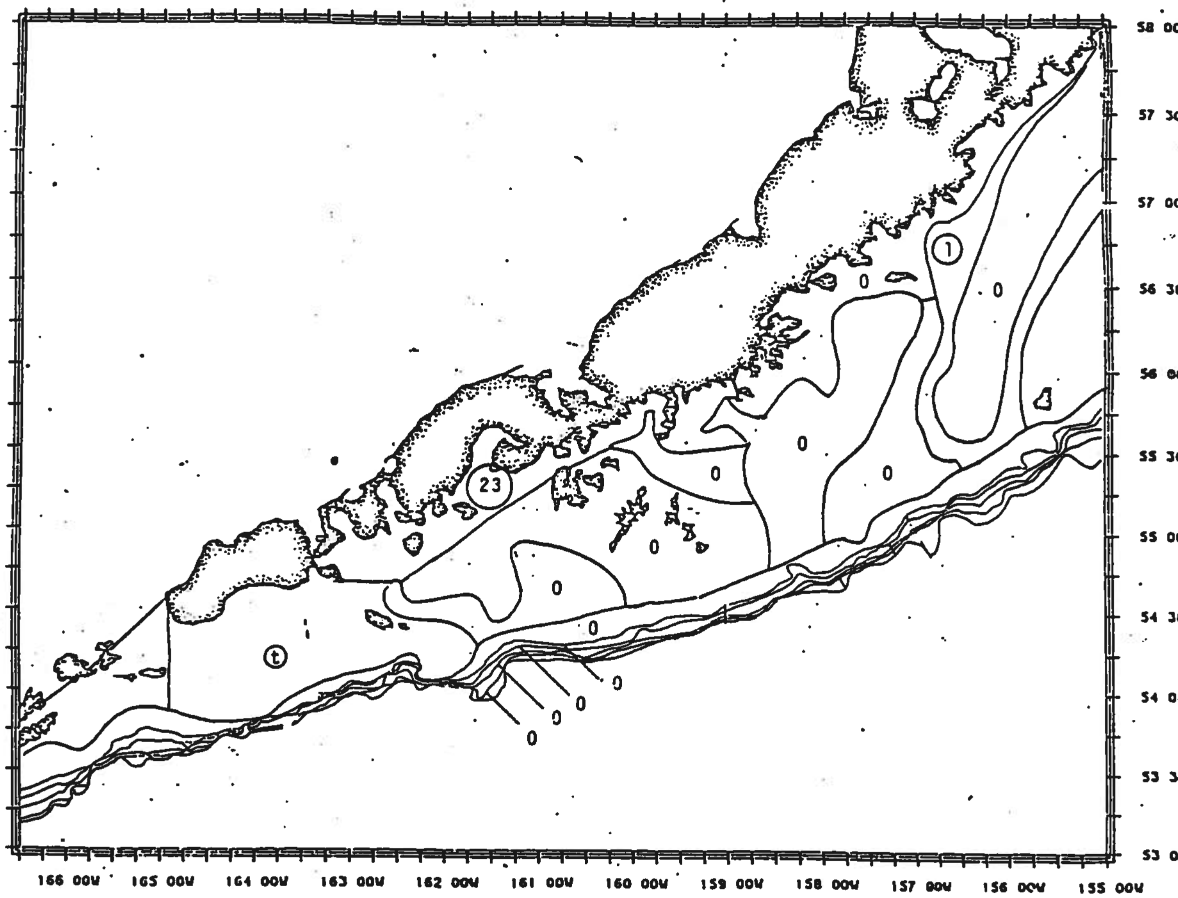


Figure 4.10. Biomass distribution (kg/km²) of Pacific herring in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

Herring are a semi-demersal species that spend much of their ocean life in large schools near or above the sea bed, but they also inhabit near-surface waters during their spawning migrations. In late winter, large schools of herring leave their overwintering areas for their spawning grounds. Here they tend to congregate in the deeper waters and near the bottom. As spawning approaches, they form massive schools in shallow (0 to 20 m depth) nearshore waters. Distinct spawning periods occur regionally between April and May, lasting from a few days to several weeks.

In the Shumagin region, spawning has been observed in shallow nearshore waters in and adjacent to Cold Bay, King Cove, Belkofski Bay, Bear Bay, the Pavlof

Islands, Pavlof Bay, Canoe Bay, Balboa Bay, American Bay and Stepovak Bay (AECRSA, 1984), as well as Castle Bay, Aniakchak Bay, Amber Bay, Wide Bay, Kukak Bay, and along Cape Kekurnoi (BBCMP, 1984). It is believed that these same general spawning areas are returned to annually, although the timing may vary in response to annual differences in water temperatures. In warm years herring appear to spawn earlier than in cold years. The locations of the wintering areas of the spawning stocks is unknown.

The shed eggs of herring are adhesive and are deposited on solid substrates rather than being loosely broadcast in the water. The preferred spawning substrate is marine plants such as eelgrass and rockweed, but barren rock substrate is extensively used in the Shumagin region (BBCMP, 1984). The eggs are laid in vast quantities because mortality is high. Eggs deposited in the intertidal zone are exposed to desiccation and dehydration, and in storms the kelp to which eggs are attached may be torn loose and cast ashore or to drift.

The hatched larvae live briefly in the plankton for 6 to 10 weeks before metamorphosing to juveniles. The most critical time for herring survival occurs during their early months. These metamorphosed young form small schools in the vicinity of their spawning grounds and gradually move toward low-salinity areas in the mouths of bays and inlets in which they are hatched. The movements of these schools of juveniles in the Shumagin region is not known (AECRSA,1984).

By early fall, the rapidly growing juveniles may reach four inches in length and form schools of over one million fish. By late fall these schools disperse and the herring move offshore into deeper coastal waters where they stay for about 2-1/2 years while maturing. At age three to four (length 15 to 20 cm) the fish are sexually ripe and and join the older adults to return to the shallows to spawn. Longevity of herring may reach 15 years, but fish older than age 10 are uncommon.

After spawning, the herring shoals break up into smaller feeding schools and disperse over wide areas during the summer and fall, generally at depths of 20 to 40 m (Favorite et al., 1977). Herring are largely zooplankton feeders. They are an important prey of many species of fish, marine mammals, and sea birds.

4.4.2.1. The Herring Fishery.

Overall, the herring resource in Alaska appears to be in good condition and surveys of inshore spawning stocks have indicated an increase in abundance since the late 1970's (NMFS, 1983). There have been no foreign allocations of herring since 1980, and herring is now considered a prohibited species in foreign groundfish operations.

Most of the domestic harvest of herring is taken in subsistence and commercial inshore fisheries. The herring fishery in the Shumagin region first began in 1979, with one vessel taking a summer harvest of 10 tons of sac-roe herring. The fishery substantially increased in subsequent years to 787 tons worth $747,000 taken by 40 purse seine vessels in the South Peninsula District in 1981 (AECRSA, 1984), while the Chignik District averaged 518 mt in 1980 and 1981 (BBCMP, 1984). In 1982, the sac-roe fishery in the South Peninsula District declined to 176 tons harvested, but a winter food/bait fishery for spawned out herring and fish with a low roe content was initiated that harvested 565 tons. AFDF (1983) estimates that an additional 3,600 mt erroneously reported for the Shumagin area in 1982 were actually harvested in a late summer seine fishery for food and bait herring in the eastern Aleutians. The value of roe-herring in 1982 was $550/ton, while the food and bait herring was valued at $160 and $240/ton respectively. The total value of the harvest was $203,000. In 1983, the fishery was closed to the harvest of roe-herring, and the winter fishery failed to locate any schools of herring.

Canoe Bay has been the major fishing area for roe-herring in the South Peninsula District. Smaller harvests have also been taken from a number of the other bays from Stepovak Bay to Cold Bay. Stepovak Bay has been the sole location of the winter food/bait fishery. In the Chignik District, over 90 per cent of the harvest is taken in Amber, Aniakchak, and Castle Bays.

Except for 1979, the seine vessels participating in the harvests are from outside the Shumagin region, with some local boats serving as tenders. The Sand Point processing facility (Aleutian Cold Storage) froze the entire catch for 1982.

4.4.3. Atka Mackerel.

Atka mackerel (Pleurogrammus monopterygius) are a commercially important species of the continental shelf and shelf edge. These fish are distributed throughout the Gulf of Alaska, but are most abundant west of 148°W in the Kodiak, Chirikof, and Shumagin areas at depths of 50-350 m (Ronholt, 1985). They are a pelagic species but become demersal when they move inshore to spawn. Spawning takes place during the summer in straits and island passes over hard bottom or kelps, upon which the fish lay their adhesive eggs.

The estimated biomass of Atka mackerel in the western Gulf of Alaska is 36,000 mt (Brown, 1985), 98 per cent of which is located in the 0-100 m depth zone in the Shumagin statistical area. Mean densities of 242 kg/km^2 were found on the Shumagin Shelf, with maximum abundance on Davidson Bank (Figure 4.11), with an average biomass of 1596 kg/km^2.

Atka mackerel mature at age 4+, at a length of about 30 cm. The fish encountered in the Shumagin area in 1984 averaged 39.6 cm in length and had a mean weight of 0.9 kg (Brown, 1985). Although the stocks are currently depressed with no apparent recruitment in the eastern and central Gulf of Alaska, they have been under-exploited in the Shumagin region and appear to be in excellent stock condition.

4.4.3.1. Atka Mackerel Fisheries.

Foreign nations have historically been the principal harvesters of Atka mackerel (Table 4.4). The Soviet fisheries dominated the harvest during the period 1970-1980, and the Koreans from 1981-1983 (Ronholt, 1985). In 1984, the Japanese took most of the small foreign catch, but this fishery was slightly exceeded by joint-venture fisheries. These joint-venture operations began in 1983, with the major effort in the Shumagin area delivering to Korean vessels. The first reported domestic harvest of Atka mackerel, also from the Shumagin area, was reported in 1984.

Catches of Atka mackerel in the Gulf of Alaska have declined steadily over the past ten years and the distribution of effort has shifted westward (Ronholt, 1985). The Kodiak area was the major producer of the catch during the peak

Table 4.4. Optimum Yield (OY) and Catch (mt) of Atka Mackerel in the Gulf of Alaska from 1977 to 1985 (from Major, 1985).

Year	OY	Foreign	J.-Venture	Domestic	Total
1977	22,000	19,455	0	0	19,455
1978	24,800	19,588	0	0	19,588
1979	26,800	10,948	1	0	10.949
1980	28,700	13,163	3	0	13,166
1981	28,700	18,727	0	0	18,727
1982	28,700	6,760	0	0	6,760
1983	28,700	11,470	790	0	12,260
1984	28,700	537	585	31	1,153
1985	4,678				

years of the fishery, which reached a high of 28,000 mt in 1975. This fishery has drastically diminished to only a trace in 1984. In 1978, and again from 1981 - 1983, the Chirikof region was most productive. In 1984, 94 per cent of the small annual catch of 1,152 mt came from the Shumagin area. Shumagin harvests had averaged about 3,000 mt from 1981 to 1983.

The total biomass of Atka mackerel in the Gulf of Alaska is uncertain. Ronholt (1985) gives estimates of from 69,210 to 89,167 mt, and a maximum sustainable yield of 7,800 mt. Given the apparent collapse of the stock based on declining catches, the westward shift in distribution, low abundance as indicated by resource surveys, and weak recruitment, the NPFMC established greatly reduced harvest levels in 1985 for all but the Shumagin area. This area received an optimum yield of 4,678 mt, while Chirikof and Kodiak areas were set at 500 and 100 mt respectively.

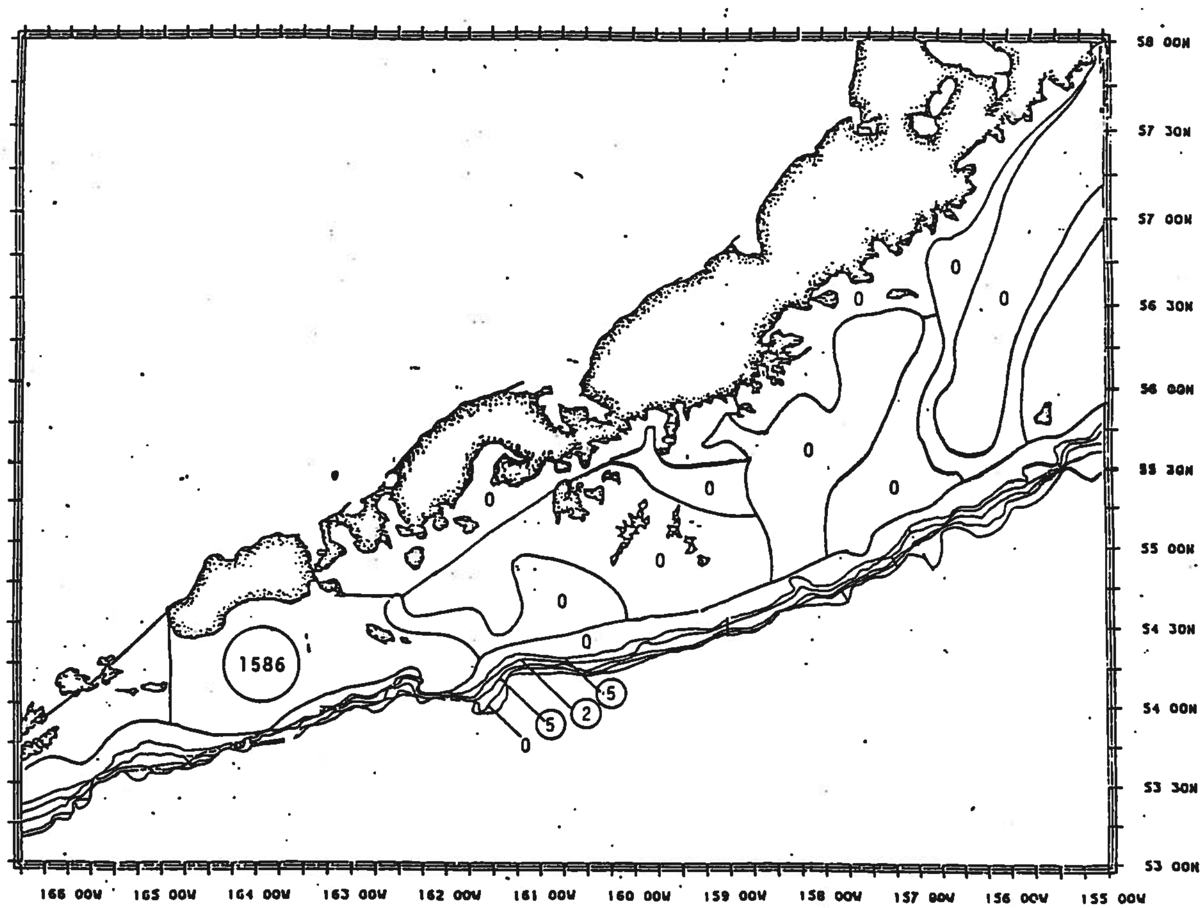


Figure 4.11. Biomass distribution (kg/km²) of Atka mackerel in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

4.4.4. Alaska Pollock.

Alaska or walleye pollock (Theragra chalcogramma) is a widely distributed semi-demersal species endemic to the North Pacific from central California to Japan. Although generally classified as a bottomfish, it more appropriately should be considered semi-demersal, as it typically inhabits the bottom waters closely overlying the seafloor. Pollock are the most abundant groundfish in the Gulf of Alaska, with an estimated biomass of 1.2 million mt (Brown, 1985). The major fishing grounds are in the Bering Sea and Gulf of Alaska. The pollock that inhabit the Gulf of Alaska between 147° and 170°W (i.e. Kenai Peninsula to the Fox Islands) are considered a separate stock from those of the Bering Sea, Aleutian Islands, or eastern Gulf (Alton and Megrey, 1985).

Pollock are also the most abundant groundfish in the Shumagin region, with an estimated biomass of 488,557 mt or 4,954 kg/km². The greatest mean concentration found in the 1984 cooperative surveys was 24,868 kg/km² in the East Shumagin Gully (Figure 4.12). Other concentration areas are the Shumagin slope, Sanak Bank, the west Shumagin Gully, near Unimak Pass, and along the edge of the Shelikof Trough.

Pollock schools range in depth from the surface to over 700 m, but are especially abundant along the shelf edge at depths of 100 to 300 m. The highest densities of pollock in the 1984 trawl surveys in the western Gulf of Alaska were found in the Shumagin area at depths of 200-300 m (Brown, 1985), where the mean catch per unit effort (CPUE) was 21.3 mt/km² (Table 4.5). CPUE was second highest (13.3 mt/km²) in the Chirikof statistical area at depths of 100 - 200m. However, the Shumagin area ranked third behind the Kodiak and Chirikof areas in total pollock biomass (Brown, 1985) because of its smaller shelf area.

Temperatures play a major role in the areal and vertical distribution of pollock throughout their range, the fish preferring 2° to 5 C° waters. In the Bering Sea, pollock generally winter in the deeper warmer waters off the shelf edge, gradually moving to shallower waters as the seasons progress. Similar movements in the Shumagin region have not been confirmed.

Pollock are spring spawners in Alaska waters, where they form dense schools in certain shelf areas. The Shelikof Strait appears to be the main spawning area. However, their eggs and larvae are found over a wide area, suggesting that other spawning locations exist as well (Janusz, 1983). Less extensive spawning probably also occurs on the Shumagin shelf. In the joint- venture fisheries in Shelikof Strait, pollock are caught in pelagic trawls targeting on spawning schools that ascend off the bottom.

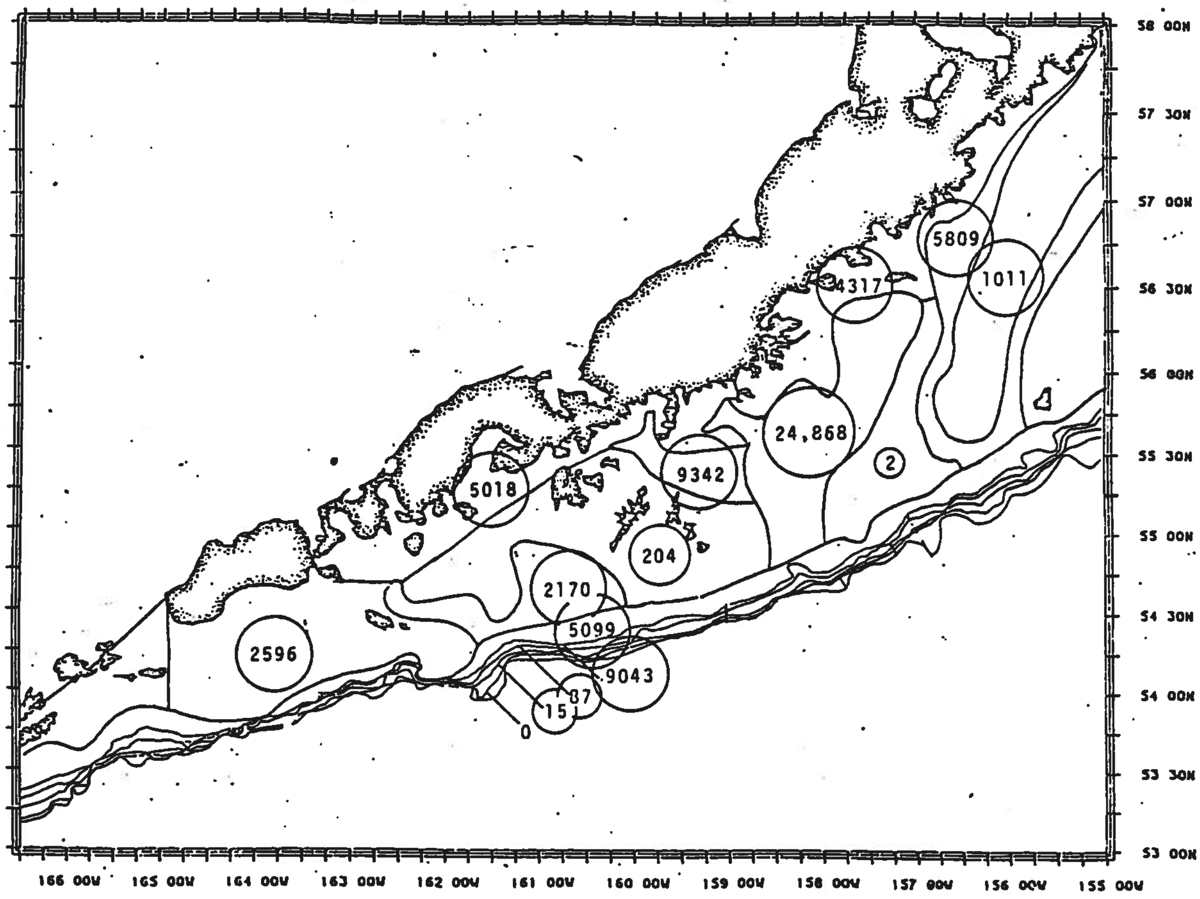


Figure 4.12. Biomass distribution (kg/km²) of Alaska pollock in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

The released eggs are pelagic and float near the sea surface. The larvae and young juveniles primarily occupy the upper 40 m of the water column (Bakkala et al., 1983), settling toward the bottom during the fall. Juvenile pollock are widely distributed from shallow to deep shelf areas, but are usually most abundant inside the 100 m isobath (Alton and Megrey, 1985). High densities of age 1 pollock have been found in Pavlof Bay, Unga Strait, and Stepovak Bay within the Shumagin region. By the second year, most subadults inhabit deeper shelf waters.

Table 4.5. Estimated Biomass (mt), Catch per Unit Effort (CPUE), and Mean Size of Alaska Pollock Based on the 1984 U.S. - Japan Cooperative Bottom Trawl Survey of the Central and Western Gulf of Alaska (from Brown, 1985).

	Area/ depth (m)	CPUE (kg/km^2)	Biomass (t)	Mean Length (cm)	Mean Weight (kg)
Shumagin (170°W-159°W)					
	0-100	2,794	124,009	45.0	0.8
	100-200	11,240	163,392	48.0	0.9
	200-300	21,318	58,350	49.1	1.0
	300-500	29	75	--	1.1
	500-700	2	6	--	0.9
	700-1000	∅	∅	--	--
	Subtotal		345,826	46.8	
Chirikof (159°W-154°W)					
	0-100	1,663	44,383	40.1	0.6
	100-200	13,294	315,700	43.6	0.7
	200-300	810	9,324	43.8	0.6
	300-500	132	215	--	0.9
	500-700	1	2	--	--
	700-1000	∅	∅	--	--
	Subtotal		369,624	43.1	
Kodiak (154°W-147°W)					
	0-100	1,768	69,264	31.2	0.5
	100-200	8,842	381,805	45.1	0.8
	200-300	2,264	25,073	46.4	0.9
	300-500	86	257	--	1.0
	500-700	25	38	--	0.8
	700-1000				
	Subtotal		476,437	42.4	
Yakutat (147°W-144°W)					
	0-100	396	4,856	--	0.5
	100-200	568	4,573	--	0.7
	200-300	167	58	--	0.3
	Subtotal		9,487		
Total (170°W-144°W)		4,646	1,201,374	43.8	0.8

Sexual maturity is reached by age three or four at body lengths of 32 (males) to 40 cm (females). Female pollock age 3 to 10 range in length from 39 to 54 cm and in weight from 0.5 to 1.1 kg and may produce from 180,000 to over 500,000 eggs per individual (Table 4.6). Pollock in the Shumagin area are somewhat larger and presumably older than in other parts of the Gulf of Alaska (Brown, 1985). Results of the 1984 trawl surveys found that age 3 and older fish account for most of the stock biomass (Alton and Megrey, 1985). In the Shumagin statistical area, the abundance of age 6 fish (1978 year class) far exceed any other age group (Figure 4.12), while younger fish were of greater relative abundance in the Chirikof and Kodiak areas.

Pollock stocks currently appear to be increasing or stable in the Shumagin area, but declining in the Chirikof area (Shelikof Strait). More fish in the 40 to 60 cm range occurred in the Shumagin region, and age 5 to 8 fish composed 80 per cent of the population. Pollock may live to age 14 - 15, and average about 48 cm in length at age 7. However, harvesting pressure begins at age three, and few large fish are taken in heavily fished areas.

Table 4.6. Average Weight, Length and Fecundity of Female Pollock in the Gulf of Alaska (from Megrey, 1985).

Age	Weight (kg)	Length (cm)	Fecundity (eggs/female)
3	0.491	39.10	178,957
4	0.671	43.67	255,766
5	0.729	45.42	290,383
6	0.788	46.79	319,644
7	0.876	48.57	360,622
8	0.993	50.56	410,575
9	1.032	51.78	443,452
10	1.137	53.86	503,623

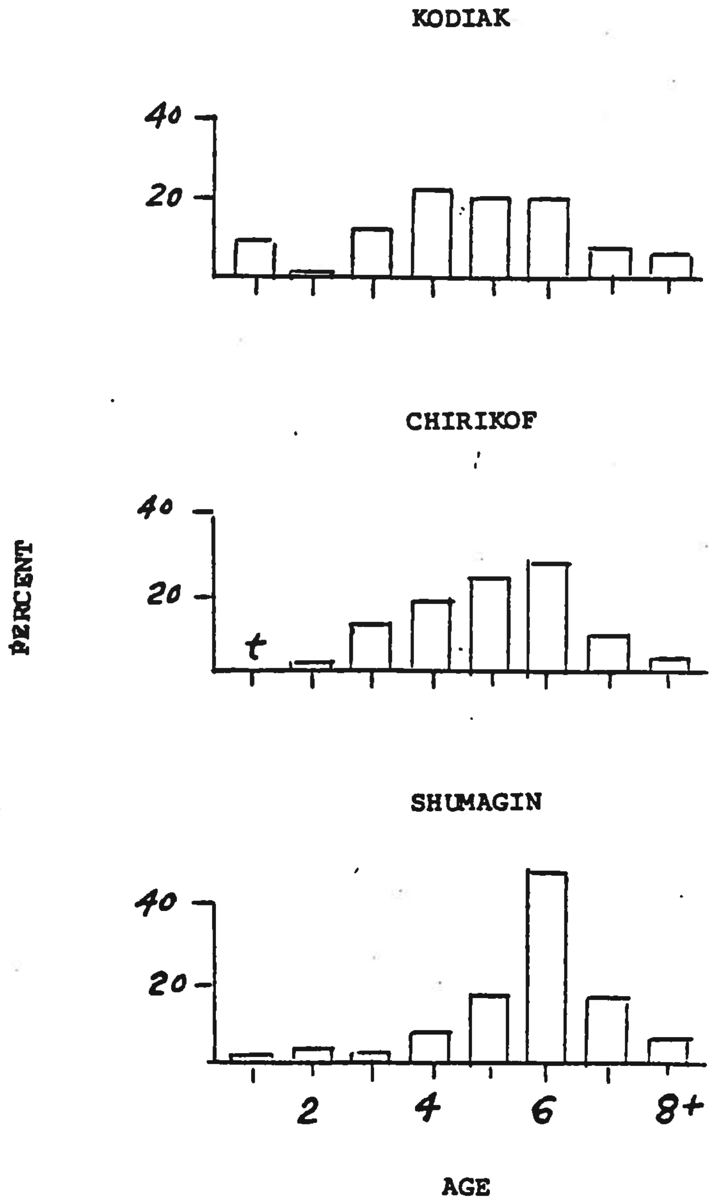


Figure 4.12. Age composition of Gulf of Alaska pollock from results of U.S. - Japan cooperative survey of 1984 (from Alton and Megrey, 1985).

Young pollock feed mainly on small crustaceans such as euphausiids, amphipods, and large copepods. Adults also consume larger benthic invertebrates and fish, including a significant portion of their own young. They are an important prey of fur seals, sea birds, and other fish.

4.4.4.1. The Pollock Fisheries.

Gulf of Alaska pollock was an undeveloped resource until about ten years ago. It has been an important species in the foreign trawl fisheries of the Bering Sea, and as demand increased, fleets began extending their fisheries to other parts of Alaska. Pollock comprise the largest proportion of the groundfish catch taken from the Shumagin region.

The early pollock harvests of the 1960's were a by-catch of Soviet and Japanese trawlers targeting on rockfish. As rockfish harvests declined from overfishing, there was a shift and an expansion in effort in the early 1970's to the pollock resource, and the harvest of pollock in the Gulf of Alaska exceeded 100,000 mt by 1977 (Alton, 1985). With additional resource surveys and improved biomass estimates since 1977, the optimum yield of the pollock resource in the Gulf has been increased from 150,000 mt in 1977 to 416,600 mt in 1984.

Important changes have occurred in the pollock fisheries since 1977 under MFCMA. In 1977, the Koreans entered the Gulf of Alaska trawl fisheries. Since 1981, the Soviets have not been allowed to fish in the Gulf of Alaska. Regulatory actions in the 1980's have essentially redirected the foreign fisheries in the Gulf of Alaska away from a multi-species bottom-trawling operation to a surimi-oriented fishery for Alaska pollock (Major, 1985b). The Japanese have converted much of their fleet from large freezer trawlers to surimi (a minced fish product) factory trawlers.

Joint-venture agreements between U.S. catcher vessels and foreign processing vessels targeting on pollock began with small harvests in 1978, and this effort grew rapidly in the 1980's, so that by 1983 the joint-venture fisheries became the largest harvester of pollock in the Gulf of Alaska. This new otter trawl fishery was initiated by the discovery of large and dense spawning aggregations of pollock in the Shelikof Strait in 1980. During this time however, the domestic harvest has remained small, averaging less than 1,000 mt annually since 1977.

The pollock harvest in the Gulf of Alaska since 1977 is given in Table 4.7. In 1984 the total catch was 306,600 mt, up 42 per cent from 1983 and 260 per

Table 4.7. Optimum Yield (OY) and Catch (mt) of Alaska Pollock in the Gulf of Alaska from 1977 to 1985 (from Major, 1985).

Year	OY	Foreign	J.-Venture	Domestic	Total
1977	150,000	117,834	0	238	118,064
1978	168,800	96,392	34	1,044	97,470
1979	168,800	103,187	566	2,031	105,784
1980	168,800	112,997	1,136	904	115,037
1981	168,800	130,324	16,857	563	147,744
1982	168,800	92,612	73,917	2,217	168,746
1983	256,600	81,358	134,131	120	215,649
1984	416,600	99,260	207,104	329	306,693
1985[a]	321,600	(14,500)	(222,000)	(1,700)	(238,200)

a/ preliminary data for January to September

cent since 1977 (Alton, 1985). Joint venture fisheries accounted for 68 per cent of the harvest. Japan, Korea, and Poland participated in the foreign effort. Domestic fisheries took only 329 mt. The joint venture fisheries spend almost all their effort between January and April for pre-spawning and spawning pollock on their spawning grounds in Shelikof Strait. Most of the pollock are harvested therefore, in the Chirikof statistical district of the Central Regulatory Area.

The foreign fisheries took most of their 1984 catch in three areas - south of the Fox Islands in the eastern Aleutians, near the Shumagin Islands, and south and southwest of Kodiak (Figure 4.14). Both of the former, but not the latter, areas were also important in 1983. The Shumagin Islands area is especially important to the foreign fleets during the fall and winter seasons, where, since 1981, it has accounted for the major portion of the annual catch of the surimi trawlers and other foreign trawlers (Figure 4.15).

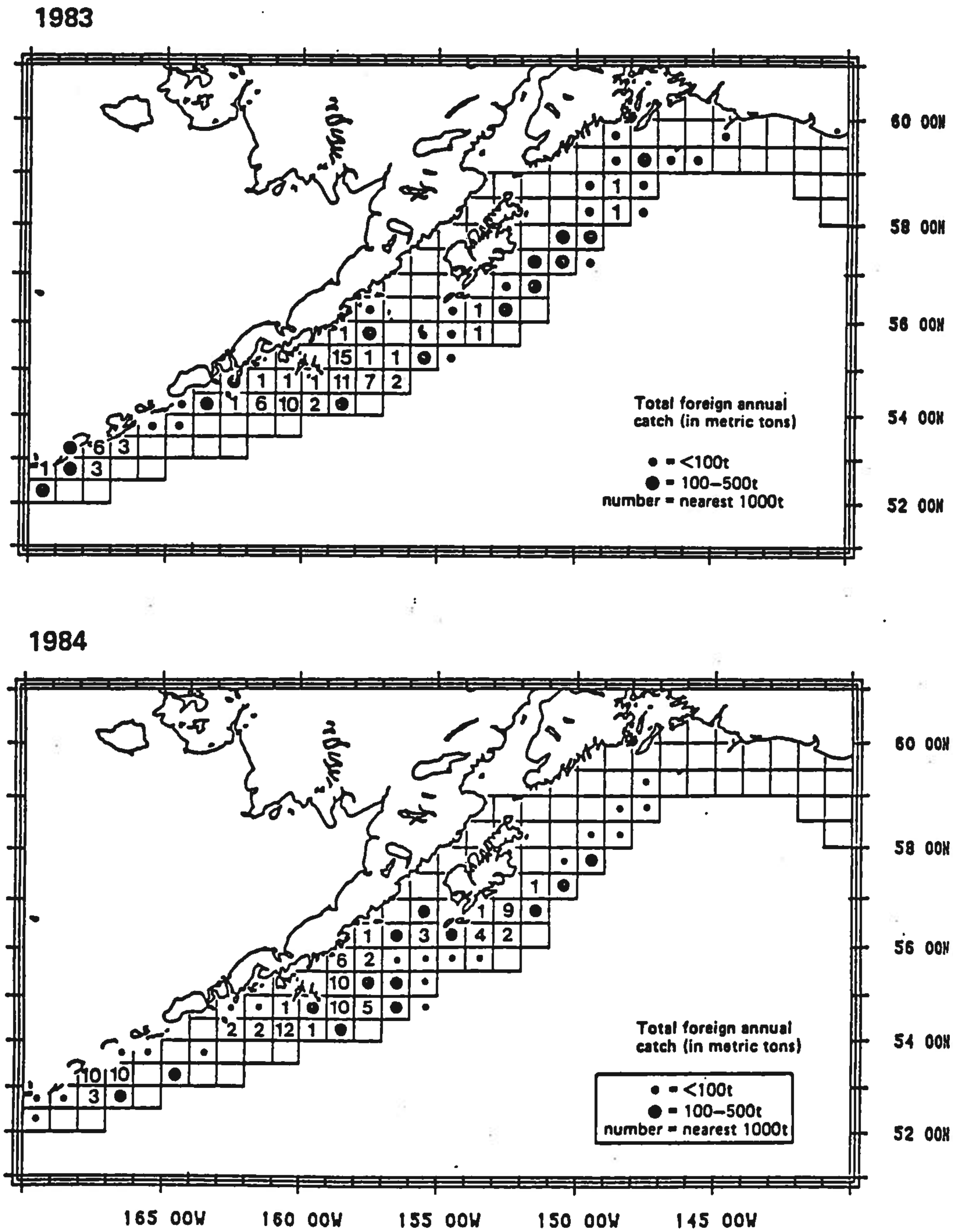


Figure 4.14. Distribution of pollock catch by all foreign nations in the Gulf of Alaska in 1983 and 1984 (from Alton, 1985).

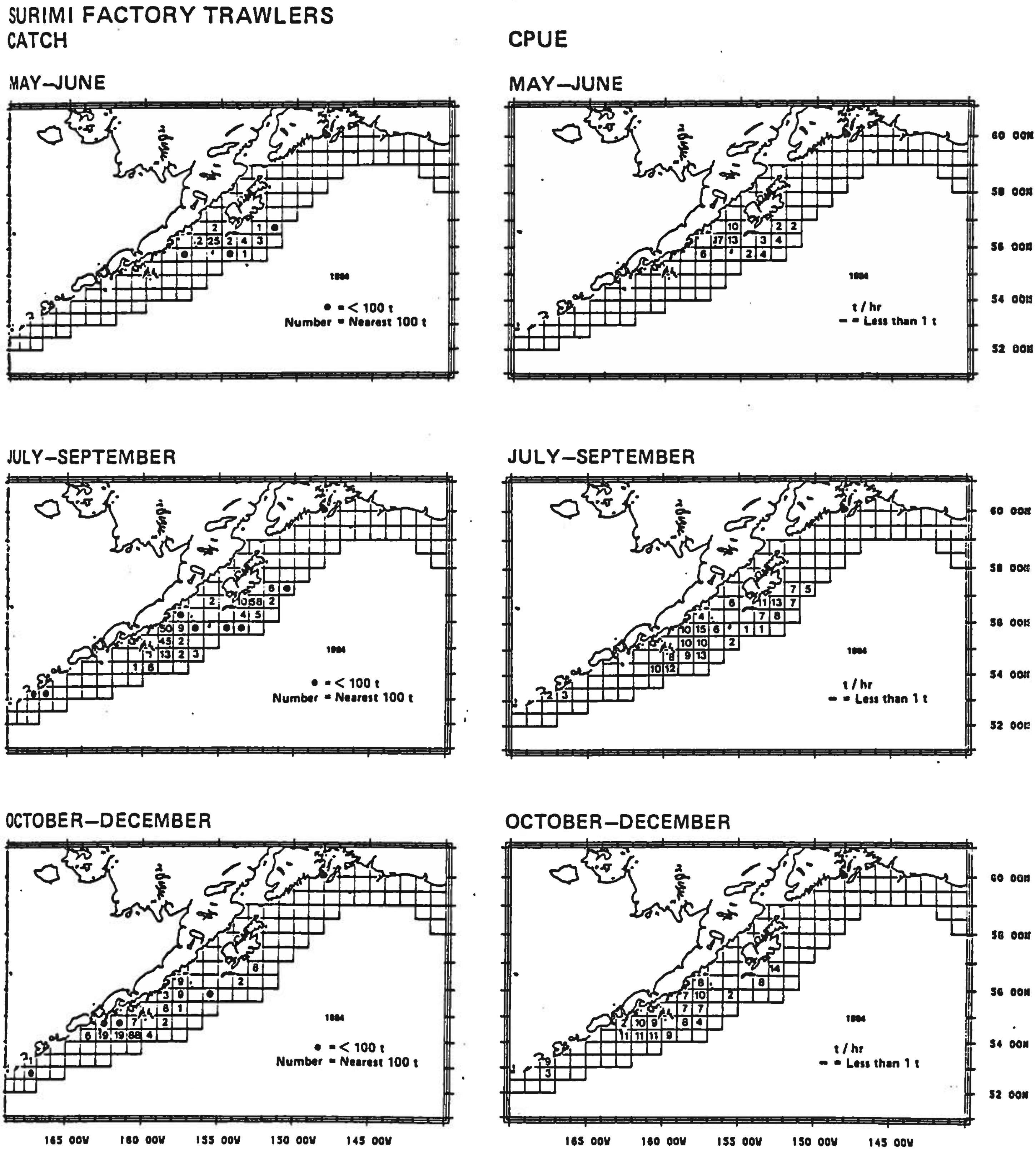


Figure 4.15. Distribution of catch and CPUE of pollock by Japanese surimi trawlers in the Gulf of Alaska in 1984 (from Alton, 1985).

4.4.5. Pacific Cod.

Pacific cod (Gadus macrocephalus) range from southern California, through Alaska westward to Korea and China. Cod are the third most abundant groundfish in the west and central Gulf of Alaska, with an estimated biomass in the Shumagin region 163,534 mt (1,804 kg/km²). They are abundant on the Shumagin shelf areas, especially the West Shumagin Gully (Figure 4.16) where a mean biomass of 13,479 kg/km² was found in the 1984 trawl surveys (E. S. Brown, p.c.).

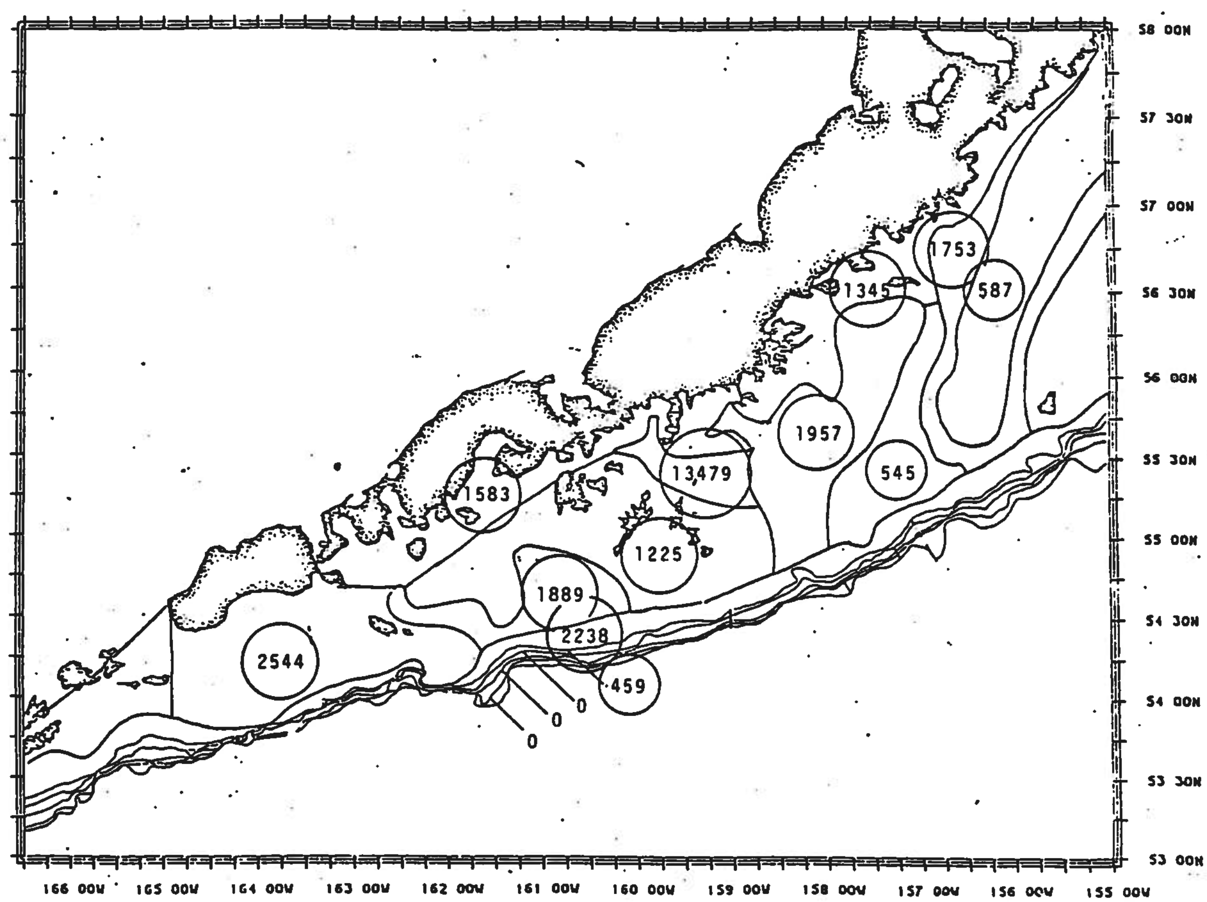


Figure 4.16. Biomass distribution (kg/km²) of Pacific cod in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

Pacific cod stocks appear to be increasing throughout the Gulf of Alaska, especially in the Shumagin region, despite increasing catches. Groundfish trawl surveys conducted in 1984 (Zenger and Blackburn, 1985) estimate cod biomass in the Gulf of Alaska at 535,837 mt, of which 170,025 mt was contained in the Shumagin statistical area, 132,218 mt in the Chirikof area and 208,665 mt in the Kodiak statistical area (Table 4.8). The highest CPUE (4,341 kg/km^2 in the Gulf of Alaska 1984 surveys was in the 100-200 m depth range in the Shumagin area (Brown, 1985). Here the Shumagin area ranked second to Kodiak in total cod biomass. Age 2+ cod dominated in the Shumagin area during the 1984 trawl surveys.

Cod are primarily a benthic species inhabiting shelf and slope waters to over 500 m. They are generally a shallower water species than pollock, being most abundant in water depths of 100-200 m (see Table 4.8). In the southeastern Bering Sea, cod migrate to the deeper waters of their range in autumn and return to shallower areas in spring and summer. These movements are probably true, at least to a limited extent, in the Shumagin region also.

Pacific cod mature early, at age 2 to 3 and have a longevity of up to 9 years. They spawn in later winter and early spring in shelf waters in schools rising off the bottom. The eggs are demersal and slightly adhesive. The pelagic larvae hatch after 10 to 20 days. Juveniles seem to prefer coastal areas with rocky bottoms. In the Shumagin region, Smith (1982) found 4 to 7 month old cod in inner Pavlof Bay, Wide Bay, and Paule Bay at depths of from 18 to 60 m.

Pacific cod are a relatively fast-growing species, attaining a length of 60 cm by age 3 and 100 cm by age 8. Most Pacific cod taken in trawls are immatures, averaging about 46 cm in length.

Cod are opportunistic feeders, preying on a wide variety of benthic invertebrates and fish, including worms, crabs, molluscs, shrimp, sand lance, pollock, herring, and flatfish. In turn they are preyed upon by seals, small cetaceans, and large halibut.

Table 4.8. Estimated Biomass (mt), CPUE (kg/km²), and Mean Size (cm and kg) of Pacific Cod Based on the 1984 U.S. - Japan Cooperative Bottom Trawl Surveys of the Central and Western Gulf of Alaska (from Brown, 1985).

Area/ depth (m)	CPUE (kg/km^2)	Biomass (t)	Mean Length (cm)	Mean Weight (kg)
Shumagin (170°W–159°W)				
0–100	2,641	109,165	46.2	1.3
100–200	4,341	58,756	55.4	3.5
200–300	823	2,098	58.9	2.4
300–500	2	6	--	1.6
500–700	0	0	--	--
700–1000	0	0	--	--
Subtotal		170,025	48.9	
Chirikof (159°W–154°W)				
0–100	1,839	45,690	43.4	1.1
100–200	3,474	76,818	55.7	2.1
200–300	896	9,594	58.8	2.5
300–500	77	116	58.5	2.1
500–700	0	0	--	--
700–1000	0	0	--	--
Subtotal		132,218	49.7	
Kodiak (154°W–147°W)				
0–100	1,099	40,054	37.4	1.2
100–200	3,930	157,996	52.9	1.9
200–300	1,017	10,497	60.5	2.1
300–500	41	114	--	2.6
500–700	2	4	--	1.8
700–1000	0	0	--	--
Subtotal		208,665	49.2	
Yakutat (147°W–144°W)				
0–100	784	8,957	--	1.7
100–200	2,079	15,564	58.8	5.5
200–300	1,251	408	--	2.4
Subtotal		24,929	--	
Total 170°W–144°W)	2,225	535,837	49.3	1.7

4.4.5.1. The Cod Fishery.

Pacific cod were first fished by longline in the Shumagin region at the turn of the century. After years of over-exploitation, they have made significant increases in abundance in recent years, and have allowed catches in the 1980's to regain historic levels. Since 1977, the importance of Pacific cod in the groundfish fisheries of the Gulf of Alaska has grown significantly, increasing from 2,256 mt to 36,401 mt in 1983 (Table 4.9). The 1984 decrease in harvest was largely due to a reduction in the Japanese catch which was limited to the Shumagin and Chirikof statistical areas to reduce the incidental catch of sablefish (Zenger and Blackburn, 1985). The domestic catch in 1983 was the largest since the salt cod fisheries closed over 30 years ago. The 1984 joint-venture harvest nearly doubled that of 1983. Allocations in 1985 reflect an increased domestic effort and a gradual phasing out of foreign participation in this fishery. The domestic harvest in the Shumagin region from 1984 to 1985 increased from 750 to 5,748 mt, while the foreign allocation was reduced from 12,498 to 7,500 mt. Most of the foreign catch comes from the Shumagin and Chirikof statistical areas; most of the domestic and joint-venture catches from the Kodiak statistical area.

Table 4.9. Optimum Yield (OY) and Catch (mt) of Pacific Cod in the Gulf of Alaska from 1977 to 1985 (from Major, 1985).

Year	OY	Foreign	J.-Venture	Domestic	Total
1977	6,300	1,988	0	270	2,258
1978	40,600	11,371	7	785	12,163
1979	34,800	13,174	713	985	14,872
1980	60,000	34,245	466	611	35,322
1981	60,000	34,969	58	1,060	36,087
1982	60,000	26,936	193	2,250	29,379
1983	60,000	29,777	2,426	4,198	36,401
1984	60,000	15,897	4,649	2,637	23,219
1985	60,000				

The estimated optimum yield (OY) of Pacific cod in the Gulf of Alaska is estimated at 60,000 mt, well above the expected harvest levels for the existing fishery. Only in the Shumagin and Chirikof areas, may harvest approach OY because of the lack of sablefish protective regulations in these areas. The combined Shumagin-Chirikof harvest has accounted for 68 to 85 percent of the total Gulf harvest of cod since 1978.

Current fisheries use both longline and trawl to catch cod. Most of the foreign effort is by longline, with some incidental trawl harvest. By contrast, the current domestic and joint-venture fisheries are primarily by trawl (Zenger and Blackburn, 1985).

4.4.6. Sablefish.

Sablefish or blackcod (*Anoplopoma fimbria*) range throughout the continental margin of the North Pacific from California to Japan, with their center of abundance in the Gulf of Alaska. They are the dominant species of the deepwater fish community. Sablefish ranked fourth in abundance of groundfish species in the 1984 trawl surveys (Brown, 1985), with an estimated biomass of 395,000 mt, of which about 92,428 mt is in the Shumagin region. The 200-300 m depth range in the Shumagin area yielded the highest biomass densities of sablefish (7,633 kg/km²; Figure 4.17) in these surveys (E.S. Brown, p.c.). The total abundance of sablefish in the Shumagin region, however, appears to be less than to the east (Kodiak and Yakutat areas).

Sablefish stocks were depressed throughout the Gulf of Alaska in the late 1970's, but there are recent signs of improvement in most areas as a result of a strong 1977 year class (Fujioka, 1985). The populations in the Shumagin and Chirikof areas in particular have significantly improved since 1981 (Table 4.10). The larger fish are deepwater inhabitants, generally fished at depths of 300 to 800 m along the continental slope.

Sablefish reach sexual maturity between ages 5 to 8. Spawning migrations occur during winter to deep waters (250 to 750 m) off the slope. The important spawning areas are not known. The eggs are buoyant, and the fry are pelagic and abundant offshore, moving progressively shoreward as they grow.

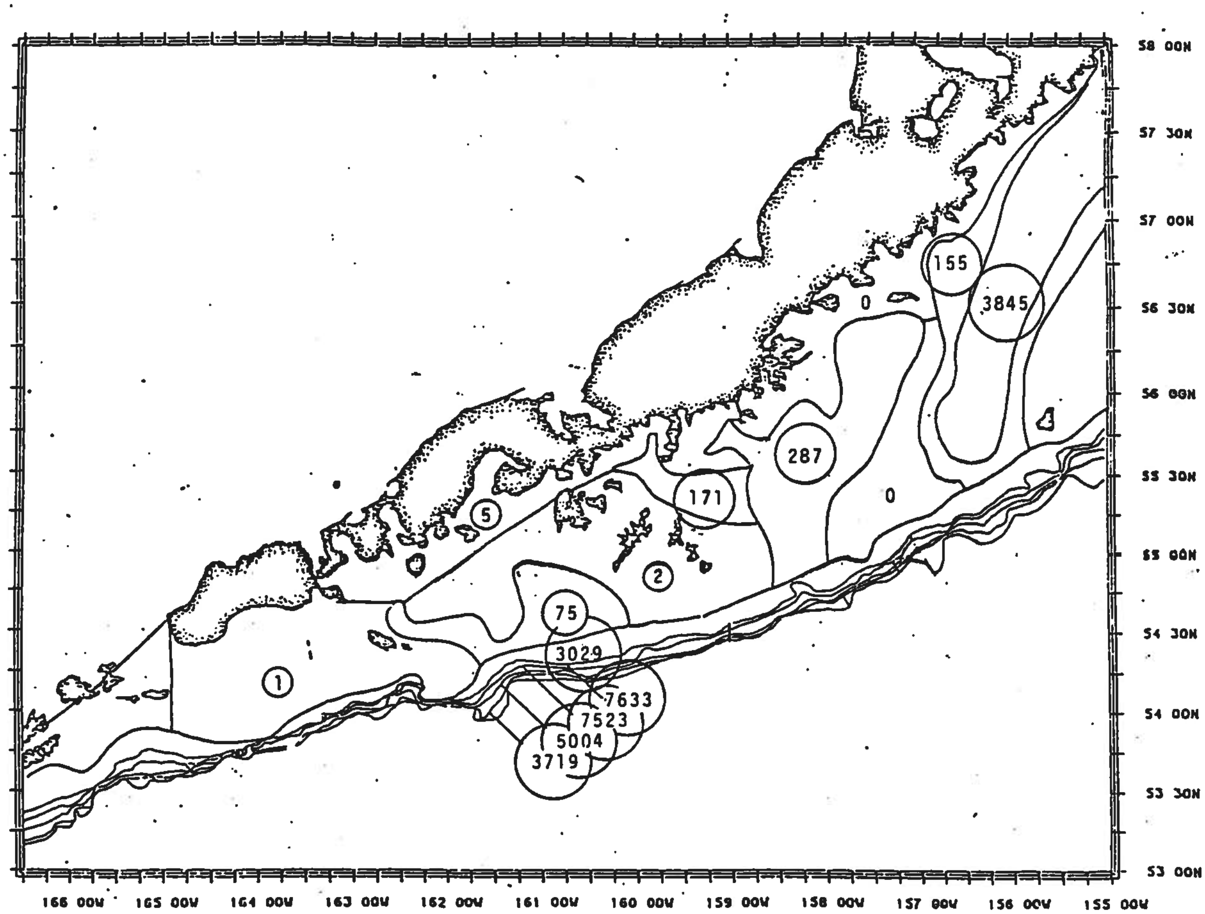


Figure 4.17. Biomass distribution (kg/km²) of sablefish in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

Small immature fish are known to inhabit shallow bays and inlets during the late spring - early summer, often in the surface waters. Juveniles inhabit shallower waters than the adults. One-year olds have been found in relatively high abundance in the eastern Shumagin nearshore regions. They become increasingly demersal with age. The mean weight of fish caught in the Shumagin surveys ranged from 0.7 kg in the 0-100 m depths range to 2.9 kg in the 700 - 1,000 m depths (Brown, 1985).

It has been learned that in southeast Alaska waters, sablefish in their 3rd and 4th year migrate to the open ocean and move westward until reaching

Table 4.10. Relative Population Weight (RPW) as an Index of Sablefish Biomass for the Gulf of Alaska, by Statistical Area, 1979-84 (after Fujioka, 1985).

Year	Shumagin	Chirikof	Kodiak	Yakutat	South-eastern	Total
1979	11,580	61,237	55,413	35,148	25,324	188,702
1980	17,819	57,951	57,945	52,437	27,982	214,134
1981	27,851	52,437	41,640	66,712	51,123	249,763
1982	41,309	87,115	79,715	67,076	44,752	319,967
1983	52,409	73,761	83,812	51,175	39,329	297,486
1984	43,782	102,625	115,957	44,213	38,334	344,911

maturity (Fujioka, 1985). With maturity, these fish appear to migrate eastward towards the eastern Gulf of Alaska to spawn. There is still debate over whether sablefish stocks are geographically distinct between regions or represent one continuous intermingling population. There is some evidence for a major genetic separation of stocks in the Kodiak region, about 140°W. If this is true, then the sablefish in the Shumagin region may be from a different stock than those in the Gulf of Alaska.

Sablefish live to about age 20 or more and may exceed 100 cm in length. The average length of commercial size fish is 53 cm (21 inches), general age is between 3 and 8 years.

Sablefish are omnivorous, known to feed on squid and lantern fish, herring, sand lance, and crustaceans.

4.4.6.1. The Sablefish Fishery.

Sablefish have been harvested by U.S. and Canadian fishermen in the Gulf of Alaska since early in this century. The fishery remained small and local

Table 4.11. Estimated biomass (mt), CPUE (kg/km²) and mean size (cm and kg) of sablefish based on the 1984 U.S. - Japan cooperative bottom trawl survey of the central and western Gulf of Alaska (from Brown, 1985).

Area/ depth (m)	CPUE (kg/km^2)	Biomass (t)	Mean Length (cm)	Mean Weight (kg)
Shumagin (170°W-159°W)				
0-100	3	116	43.0	0.7
100-200	1,281	18,629	53.6	1.7
200-300	6,261	17,119	59.2	2.4
300-500	10,741	24,947	60.5	2.6
500-700	5,299	10,649	61.6	2.5
700-1000	784	1,468	61.7	2.9
Subtotal		72,928	57.1	
Chirikof (159°W-154°W)				
0-100	15	387	40.9	0.7
100-200	419	9,950	54.4	1.7
200-300	4,333	49,779	58.3	2.3
300-500	5,607	8,411	58.8	2.2
500-700	7,445	14,118	59.8	2.5
700-1000	5,421	16,358	64.6	1.4
Subtotal		99,003	59.0	
Kodiak (154°W-147°W)				
0-100	62	2,435	38.2	0.8
100-200	2,895	125,063	53.4	1.7
200-300	4,055	44,883	58.4	2.3
300-500	3,704	10,074	63.1	2.8
500-700	4,939	7,655	58.5	2.2
700-1000	8,062	27,758	60.9	2.6
Subtotal		217,868	54.6	
Yakutat (147°W-144°W)				
0-100	39	478	--	0.4
100-200	477	3,838	50.9	1.7
200-300	2,079	727	64.1	2.9
Subtotal		5,043		
Total (170°W-144°W)		394,842	55.9	1.9

until the Japanese longline fleets expanded into the Gulf of Alaska in 1963. Sablefish catches reached a record high of 67,000 mt in 1972, and averaged around 50,000 mt for several years after. The subsequent decline in stock abundance led to substantial restrictions in sablefish harvests beginning in 1978. Since that year, harvests have been held to an average of 9,206 mt per year.

The domestic harvest has steadily increased its percentage of the take (Tables 4.11 and 4.12), and in recent years the foreign effort has been steadily phased out. In 1985, the domestic effort totally replaced directed foreign fishing for sablefish in the Gulf of Alaska (Fujioka, 1985), and harvested nearly 10,000 mt. Today sablefish is second to halibut among Gulf of Alaska groundfish in economic value and total landings by domestic fishermen.

Although primarily a longline fishery, both 1984 and 1985 saw an increased catch using pot gear and bottom gillnets. In the Shumagin statistical area (Western Regulatory Area) in 1985, 1,295 mt of sablefish were taken by longline, 702 mt by pots, and 27 mt by trawl. This area accounted for 18 percent of the total Gulf harvest, not including the harvest from the Chirikof area of the Central regulatory area.

4.4.7. Pacific Halibut.

The Pacific halibut (Hippoglossus stenolepis) ranges from California to the northern Bering Sea, in water depths from 50 to over 400 m. The International Pacific Halibut Commission (IPHC) believes that the halibut resource in 1986 has rebuilt itself throughout much of its range, particularly in the Gulf of Alaska, partially due to the decreased by-catches of halibut by the trawl-fisheries (see below).

The estimated biomass of halibut in the western and central Gulf of Alaska in 1984 was 320,000 mt (Brown, 1985), ranking it fifth in groundfish abundance in the Gulf of Alaska. Estimated biomass in the Shumagin region is 76,794 mt: Highest mean biomass in the Shumagin region was found along the Shelikof Trough Edge (Figure 4.18) at 1,557 kg/km^2. Other major halibut grounds in the

Table 4.12. Catch (mt) of Sablefish in the Gulf of Alaska, by Nation, 1980 - 1985 (after Fujioka, 1985).

Year	U.S.	Japan	ROK	Other[a]	Total
1980	2,384	4,831	891	20	8,542
1981	1,941	6,910	1,062	4	9,917
1982	2,910	4,921	724	1	8,556
1983	3,761	4,334	632	275	9,002
1984	8,594	844	256	536	10,230
1985[b]	9,886	9	0	18	9,913

a - mainly joint-venture fisheries
b - preliminary data

Table 4.13. Harvests (mt) of Sablefish in the Western Regulatory Area of the Gulf of Alaska, 1983-1985 (after Fujioka, 1985).

Fishery	Year		
	1983	1984	1985
Domestic	2	349	2020
Joint-venture	134	283	0.4
Foreign	1363	754	8
Total	1499	1386	2028

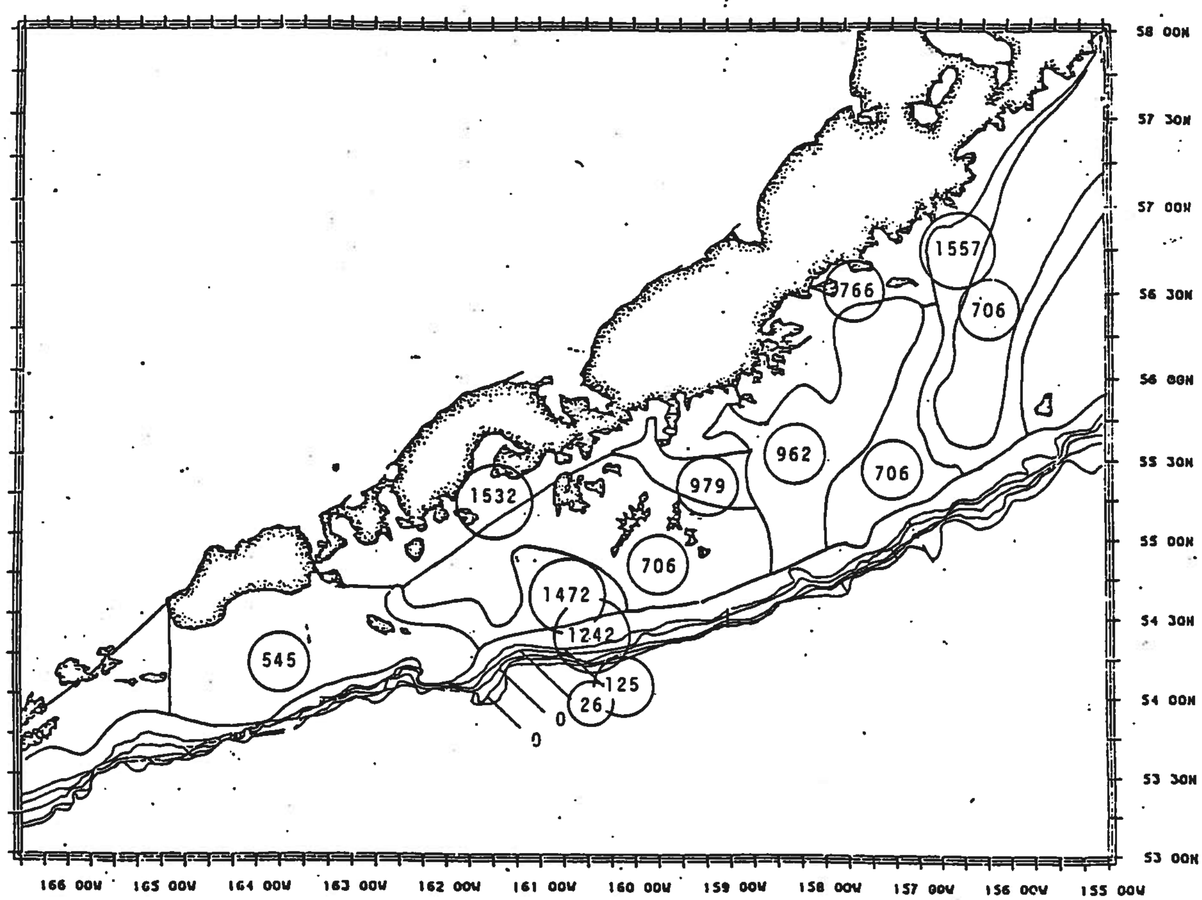


Figure 4.18. Biomass distribution (kg/km²) of Pacific halibut in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

Shumagin region are located at Chirikof Spit and Chirikof Gully, Shumagin Gully (St. Pierre, 1984), and around the Shumagin Islands, the Shumagin, Sanak and Davidson Banks, and Unimak Bight at depths of 100 to 200 m (AECRSA, 1984). A large percentage of halibut in the Shumagin region appear to be immatures (St. Pierre, 1984).

Female halibut mature at about age 12, males at age 8. Pacific halibut spawn during the winter (November to March) at clearly defined locations along the continental slope and shelf edge at depths of 200 m or greater. The Chirikof Bank, Shelikof Trough, and Shumagin Gully (Figure 4.19) have been identified as major spawning areas in the Shumagin region (St. Pierre, 1984).

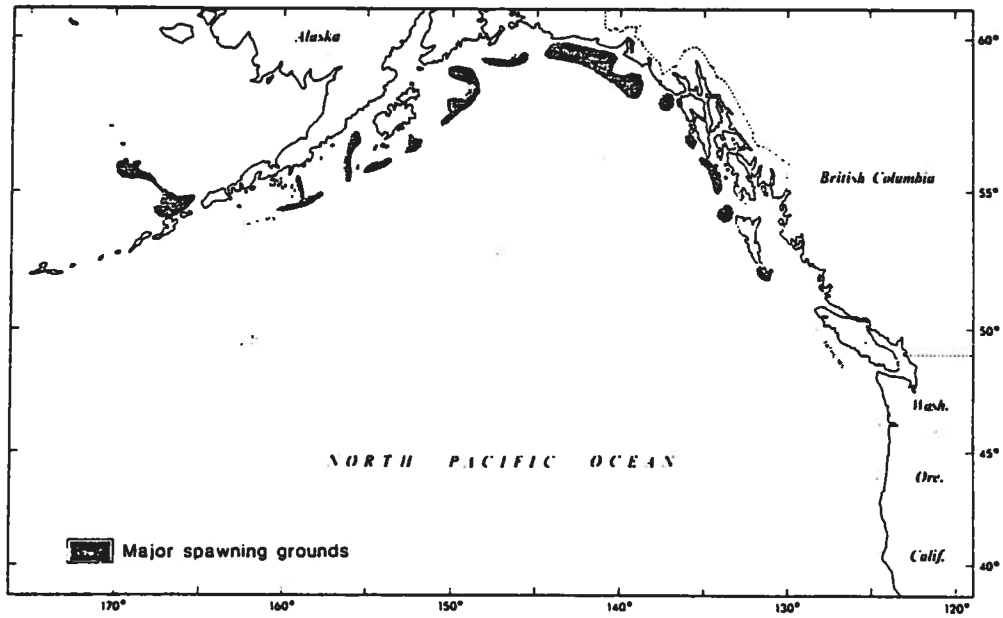


Figure 4.19. Locations of major spawning grounds of Pacific halibut in the Gulf of Alaska and southern Bering Sea (from St. Pierre, 1984).

Halibut eggs are nearly neutrally-buoyant, and free-float at midwater depths of 100 to 700 m for 12 to 20 days before hatching into planktonic larvae. As the larvae develop their specific gravity decreases and they slowly rise toward the surface layer about two months after spawning. During this period of larval growth and development, which may last for more than six months, the larvae are transported great distances and are widely distributed by the currents.

During late development, the postlarvae are found near the sea surface where they are transported by prevailing winds toward the continental shelf waters. Many larvae from the Kodiak, Chirikof, and Shumagin regions are probably transported into the Bering Sea. With metamorphosis in May and June, the juvenile halibut settle on the shelf bottom, preferring banks and mouths of bays where they feed and grow. Important halibut nursery areas in the Shumagin region include Unimak Pass, Unimak Bight and Sanak Bank, and the waters off the Shumagin Islands.

By age 2 to 4, immature halibut are widely dispersed over the continental shelf and exhibit an eastwardly migration counter to the prevailing currents.

The immature halibut of the Shumagin region migrate eastward to fall and winter spawning grounds in the central and eastern Gulf of Alaska, counter-balancing the reverse drift of the developing eggs and larvae in the Alaskan Stream (St. Pierre, 1984). By adult age of 5 years and older, they concentrate on clearly defined grounds but continue to make widespread horizontal movements along the shelf. A significant portion of Bering Sea reared halibut, approximately 24 per cent of ages 5 to 12, migrate through Unimak Pass to Gulf of Alaska waters to mature and spawn.

Adult halibut also appear to make seasonal migrations from deepwater spawning and wintering areas to shallow water feeding areas in the summer. Halibut are omnivorous and opportunistic predators, feeding on both planktonic, nektonic and benthic organisms. Crabs, fish such as sand lance and herring, pollock and other flatfish are common components of their diet.

4.4.7.1. The Halibut Fishery.

The halibut setline fishery is one of the oldest fisheries in the Shumagin region, beginning in the 1920's with American and Canadian fleets. Since 1981, the halibut fishery in Alaskan waters has been restricted to U.S. fishermen only.

The halibut fishery in the Shumagin Region is in Regulatory Area 3B (see Figure 4.2), which runs from Cape Trinity to Unimak Island. Halibut fishing grounds in the Shumagin region are located around the Shumagin Islands, off Sanak Island, on Davidson Bank, and in Shelikof Strait. Halibut landings from these areas have been consistent but small when compared to the more productive fisheries in other parts of the Gulf of Alaska. Ex-vessel values in the South Peninsula have ranged from $69,000 to $500,000 in the past five years (AECRSA, 1984). In 1984, total landings for the region were 313 mt, down from 680 mt in 1983, with Sand Point landing 269 mt, King Cove landing 36.5 mt, and Chignik landing 7.2 mt (ADFG, 1986). In the past King Cove and Chignik over 100 mt in most years.

Most of the harvest has been by non-local vessels. Local participation is limited to 35 small boats (less than 40 feet in length) from Sand Point and King Cove. Both the King Cove and Sand Point processors freeze halibut, and are reportedly planning to increase their handling capacity.

The halibut fishery in the Chignik vicinity (Cape Douglas to Kupreanof Point) harvested an average of 546 mt per year between 1978 and 1982, worth an average value of $1.5 million (BBCMP, 1984).

Although there is local interest in expanding the fishery, halibut openings in the region are generally short, lasting only 10 days in 1983, and have occurred during the summer when most local boats are participating in the salmon fisheries. The 1986 catch limit for Area 3B has been set at 10.3 million pounds, and the fishery will be allowed open on the following dates: April 30- May 2; May 29-31, Aug 25-27; and Sept. 23 to closure when the catch limit in the adjacent Area 3A is reached.

4.4.8. Other Flatfish.

Although there are a number of common flatfish species in the Gulf of Alaska, only about seven are available in commercially significant quantities. Because they have not been heavily fished in the Gulf of Alaska, most stocks of these species are in excellent condition. The triennial Gulf of Alaska bottom trawl surveys, repeated in 1984, produced a biomass estimate for flatfish other than halibut in the central and western regions of 1,638,712 mt (Rose, 1985). Biomass estimates by species and area are given in Table 4.13. The increased representation of shallower-water species, particularly yellowfin sole, over earlier biomass estimates is due, at least in part, to a better coverage of the banks and nearshore waters in the 1984 survey than in previous surveys. This more thorough coverage has increased the biomass estimates for the Shumagin area by 26 per cent, and for the Kodiak-Chirikof areas by 329 per cent.

Arrowtooth Flounder: The arrowtooth flounder (or turbot - Atheresthes stomias) ranges from central California to the eastern Bering Sea to depths of 1000 m. They were found at all depth strata sampled by the 1984 trawl surveys, being most abundant between 100 and 200 m (Figure 4.20; Rose, 1985). They are second only to pollock in abundance for groundfish in the western and central Gulf of Alaska, with an estimated biomass of 1.1 million mt (Brown, 1985). It is the dominant flounder in the west and central Gulf of Alaska (62 percent of the biomass).

Table 4.13. Flatfish Biomass Estimates (mt) for Other than Halibut in the International North Pacific Fisheries Commission Statistical Areas of the Gulf of Alaska, Based on the 1984 Triennial Bottom Trawl Surveys, with 95% Confidence Intervals (from Rose, 1985).

	Area				
Species	Shumagin	Chirikof	Kodiak	Total	95% CI
Arrowtooth Flounder	99,336	340,662	580,585	1,020,583	15
Flathead Sole	60,458	75,524	130,733	266,715	30
Rock Sole	52,242	20,526	45,893	118,661	18
Yellowfin Sole	51,133	2,097	19,743	72,973	51
Rex Sole	10,439	22,812	30,007	63,258	21
Dover Sole	4,673	15,960	39,153	59,786	20
Butter Sole	1,172	9,389	6,892	17,453	67
Starry Flounder	1,535	2,411	10,583	14,529	75
Alaska Plaice	448	1,351	526	2,325	57
Sand Sole	0	909	445	1,354	15
English Sole	36	264	412	712	162
Greenland Turbot	113	159	45	317	60
Deepsea Sole[a]	0	0	46	46	133
Total	281,585	492,064	865,063	1,638,712	

a/ *Embassichthyes bathybius*

Arrowtooth flounder are also the dominant flatfish (240,195 mt biomass) in the Shumagin region. The greatest mean biomass of 8,620 kg/km² (Figure 4.21) occurs along the Shumagin Slope between 100 - 200 m water depth (E.S. Brown, p.c.). The species averages about 40 cm (15 inches) in size, but has the largest size range of individuals, with the largest individuals (over 50 cm) occupying depths below 200 m.

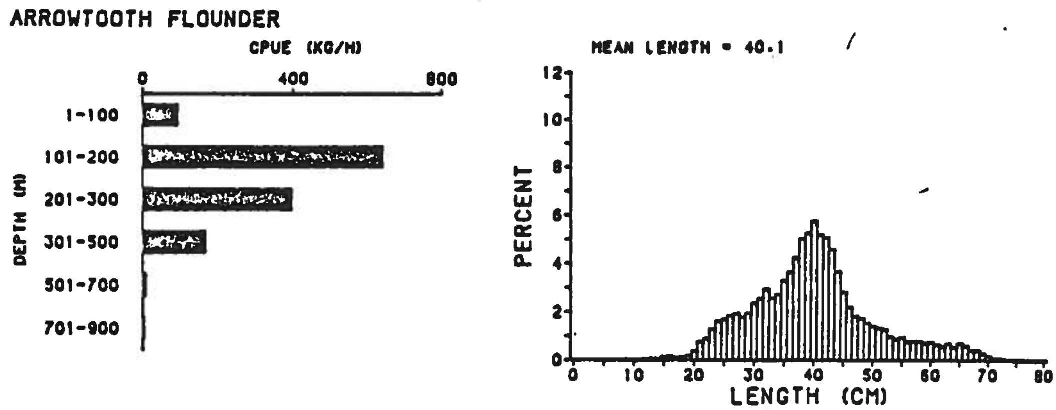


Figure 4.20. Length composition and depth distribution of arrowtooth flounder in the western and central Gulf of Alaska as determined by the 1984 triennial survey (from Rose, 1985).

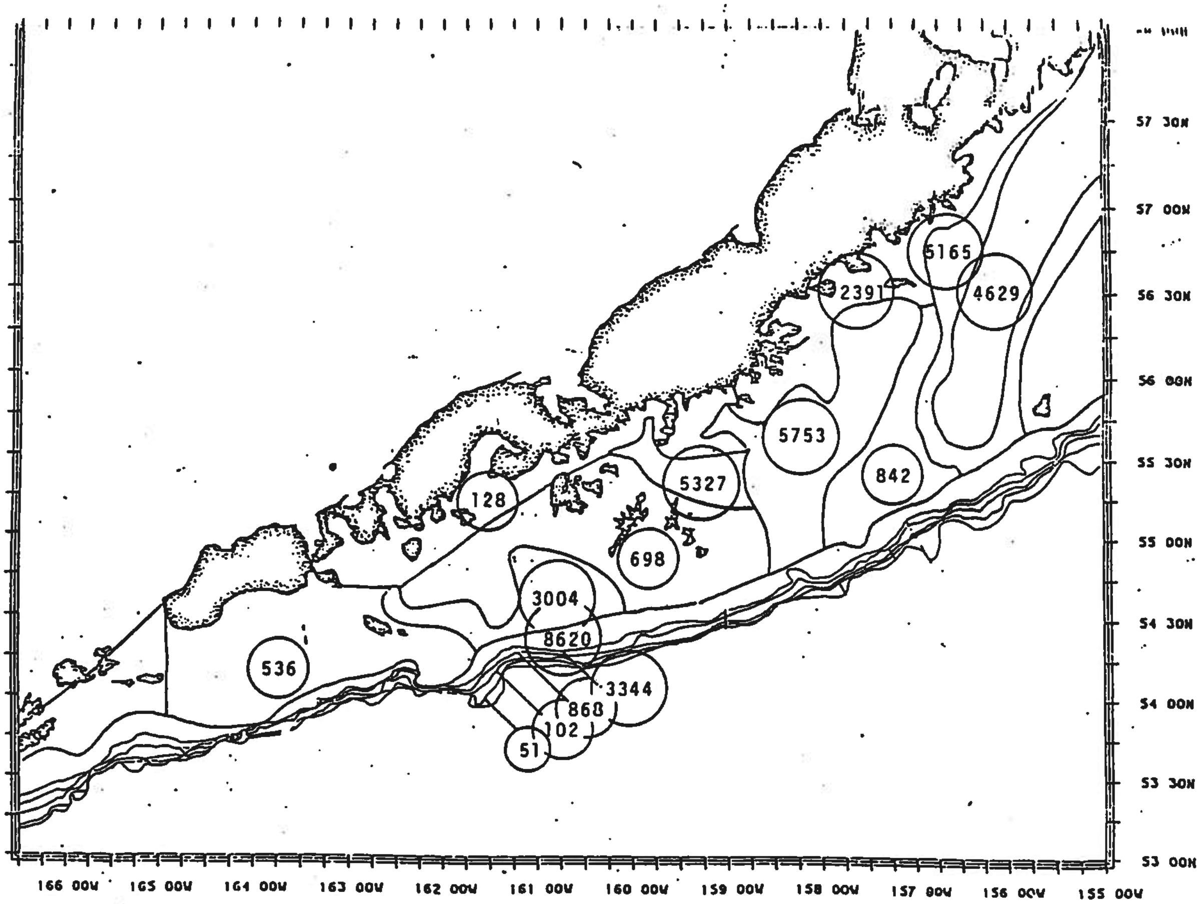


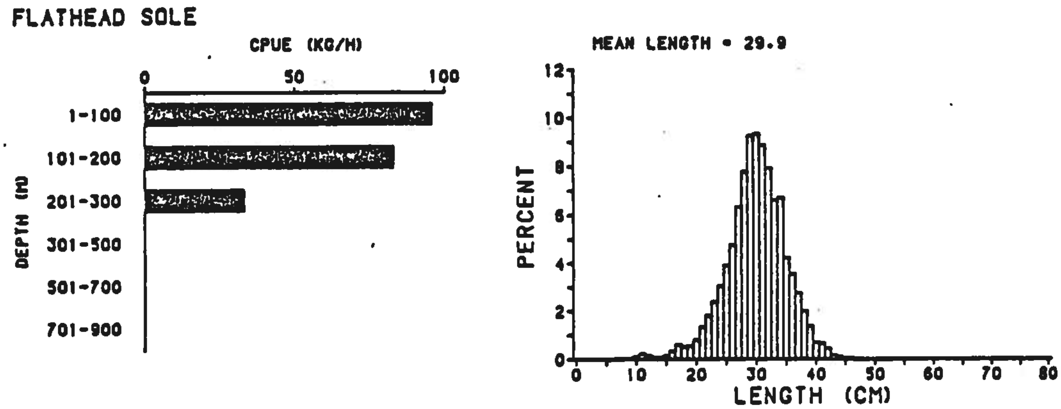
Figure 4.21. Biomass distribution (kg/km²) of arrowtooth flounder in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

Flathead Sole: Flathead sole (Hippoglossoides elassodon) are a relatively small flounder that ranges from California throughout the Bering Sea, and to Asia. It is found over most of the continental shelf in depths less than 300 m (Rose, 1985), with greatest abundance at depths of less than 200 m. The estimated biomass in the Gulf of Alaska is 277,000 mt (Brown, 1985). It contributes 16 per cent of the flatfish biomass in the west and central Gulf of Alaska. It is the second most abundant flounder in the Shumagin region (estimated biomass of 110,576 mt), where it is found in greatest abundance along the upper Alaska Peninsula (5,565 kg/km²) and the West Shumagin Gully (3,582 kg/km²) (Figure 4.22). The species has a relatively narrow size range, averaging 30 cm.

Yellowfin Sole: Yellowfin sole (Limanda aspera) is considered by many fishery experts to be the most abundant flounder worldwide. Large concentrations exist in the eastern Bering Sea, off the Kamchatka Peninsula, and in the Sea of Okhotsk. In the Gulf of Alaska it is most abundant in embayments and shallow nearshore areas at depths less than 100 m (Rose, 1985). Estimated biomass of yellowfin sole in the western and central Gulf of Alaska is 76,000 mt (Brown, 1985). They contribute 4 per cent of flatfish biomass, being also abundant on the Kodiak shelf and in lower Cook Inlet. The Shumagin region supports a resource estimated at 53,380 mt (third most abundant flatfish), with greatest mean abundance along the lower Alaska Peninsula at 6,808 kg/km² (Figure 4.23; E.S. Brown, p.c.). It is a small flounder, averaging 29 cm.

Rock Sole: Rock sole (Lepidopsetta bilineata) are also known to be abundant in both the eastern and western North Pacific. It is the most shallow-water flatfish listed here, being most common at depths less than 100 m. Rock sole inhabit not only embayments or nearshore areas, but also the offshore banks. Its estimated biomass in the Gulf of Alaska is 124,000 mt (Brown, 1985), with 49,595 mt in the Shumagin region. It contributes 7 per cent of the flatfish biomass in the west and central Gulf. In the Shumagin region it ranks fourth to arrowtooth flounder in abundance. Areas of greatest abundance in the Shumagin region are Davidson Bank, along the coast of the Alaska Peninsula, and on Shumagin Bank with mean biomass estimates ranging from 1,285 to 839 kg/km² (Figure 4.24). Their size ranges from 22 to 36 cm and averages 29 cm.

A.



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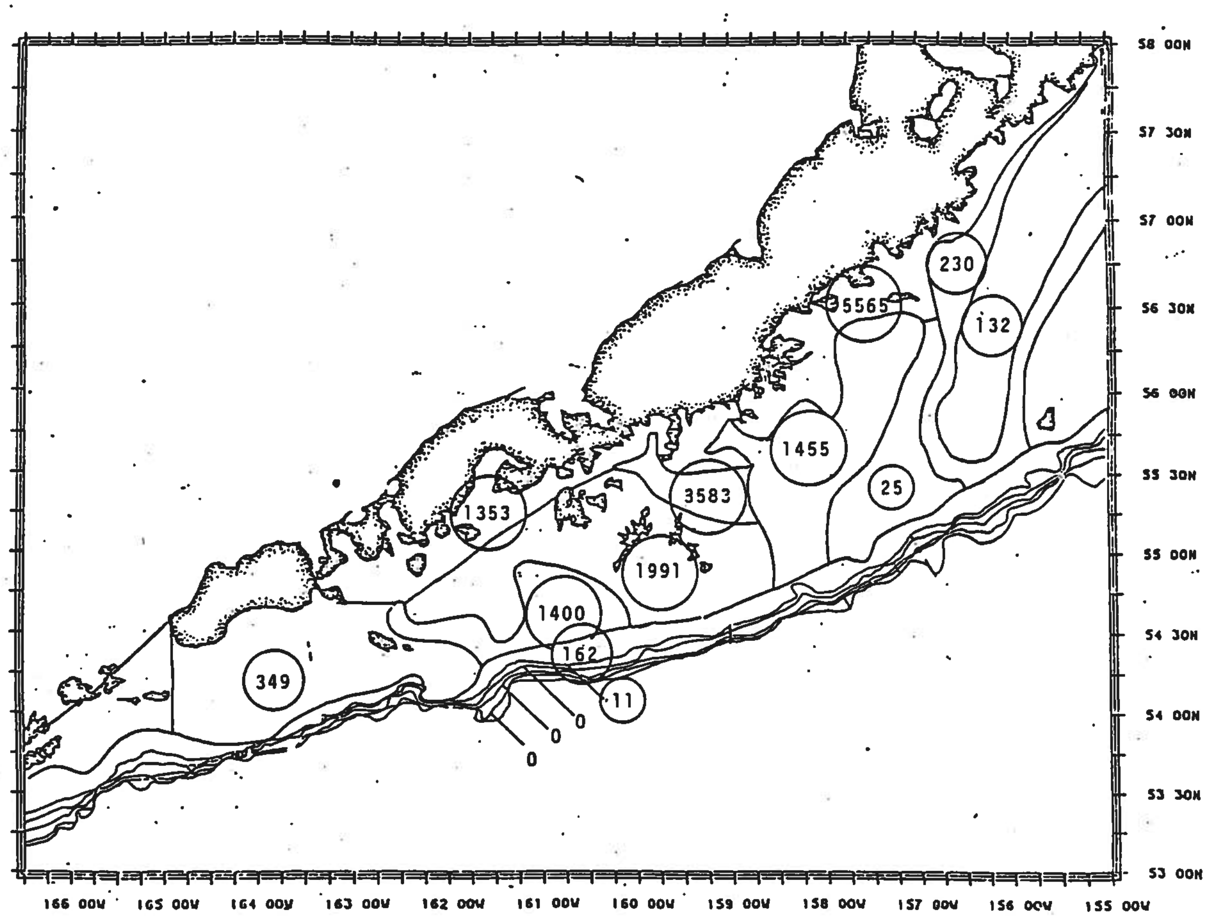
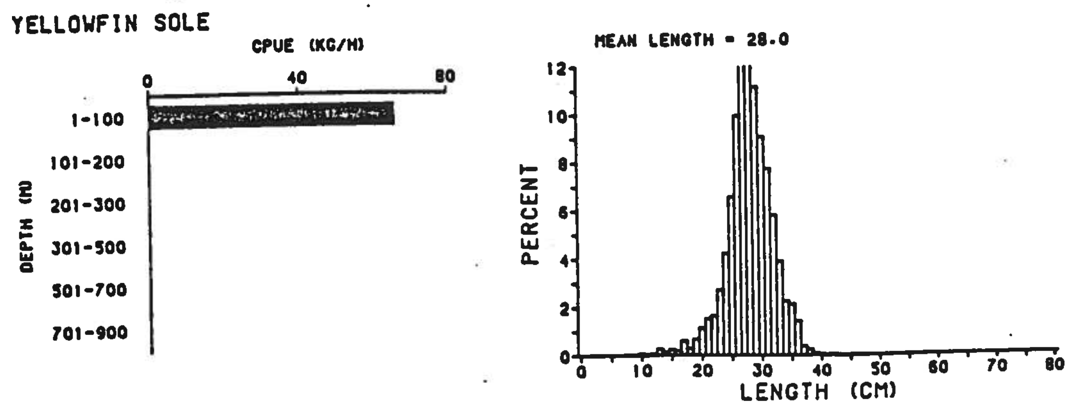


Figure 4.22. A) Length composition and depth distribution of flathead sole in the western and central Gulf of Alaska as determined by the 1984 triennial survey (from Rose, 1985); B) Biomass distribution (kg/km²) of flathead sole in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

A.



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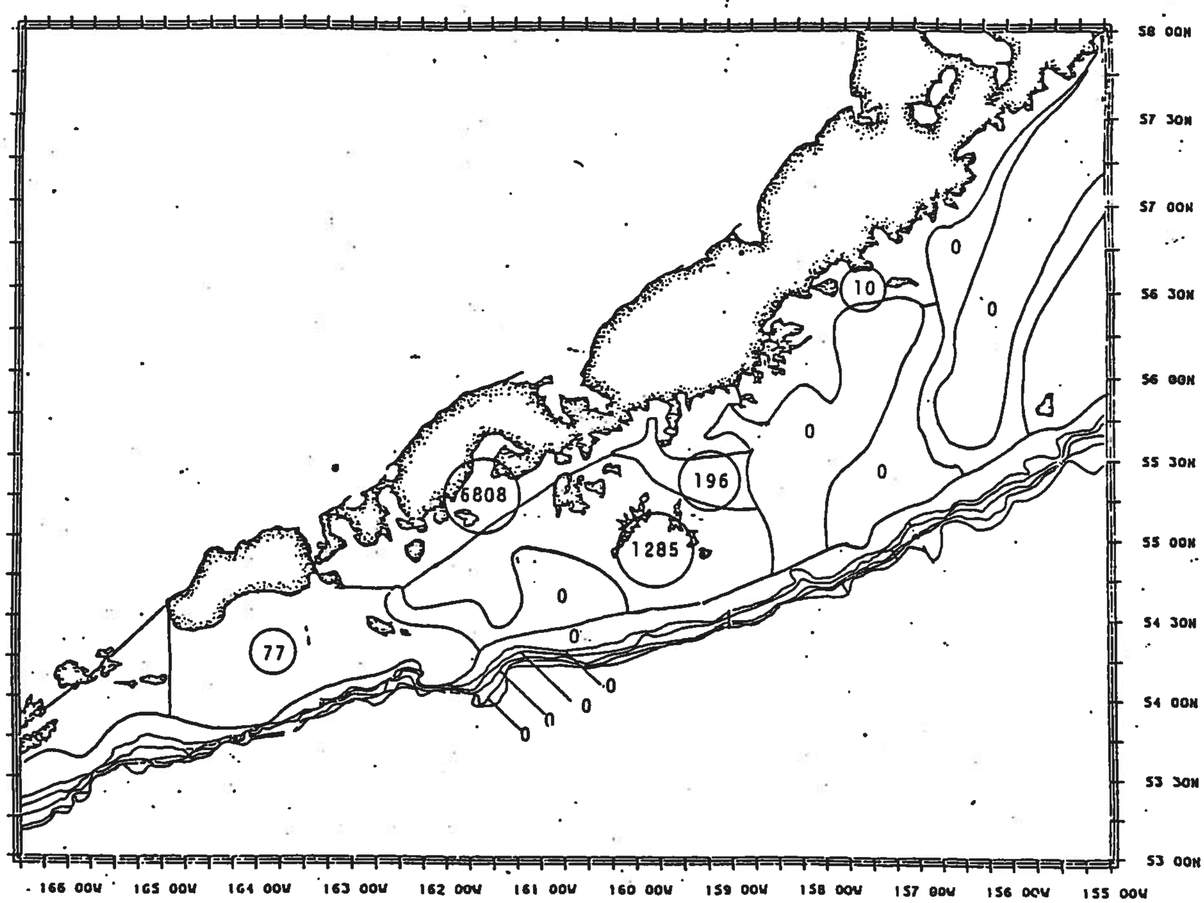


Figure 4.23. A) Length composition and depth distribution of yellowfin sole in the western and central Gulf of Alaska as determined by the 1984 triennial survey (from Rose, 1985); B) Biomass distribution (kg/km²) of yellowfin sole in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

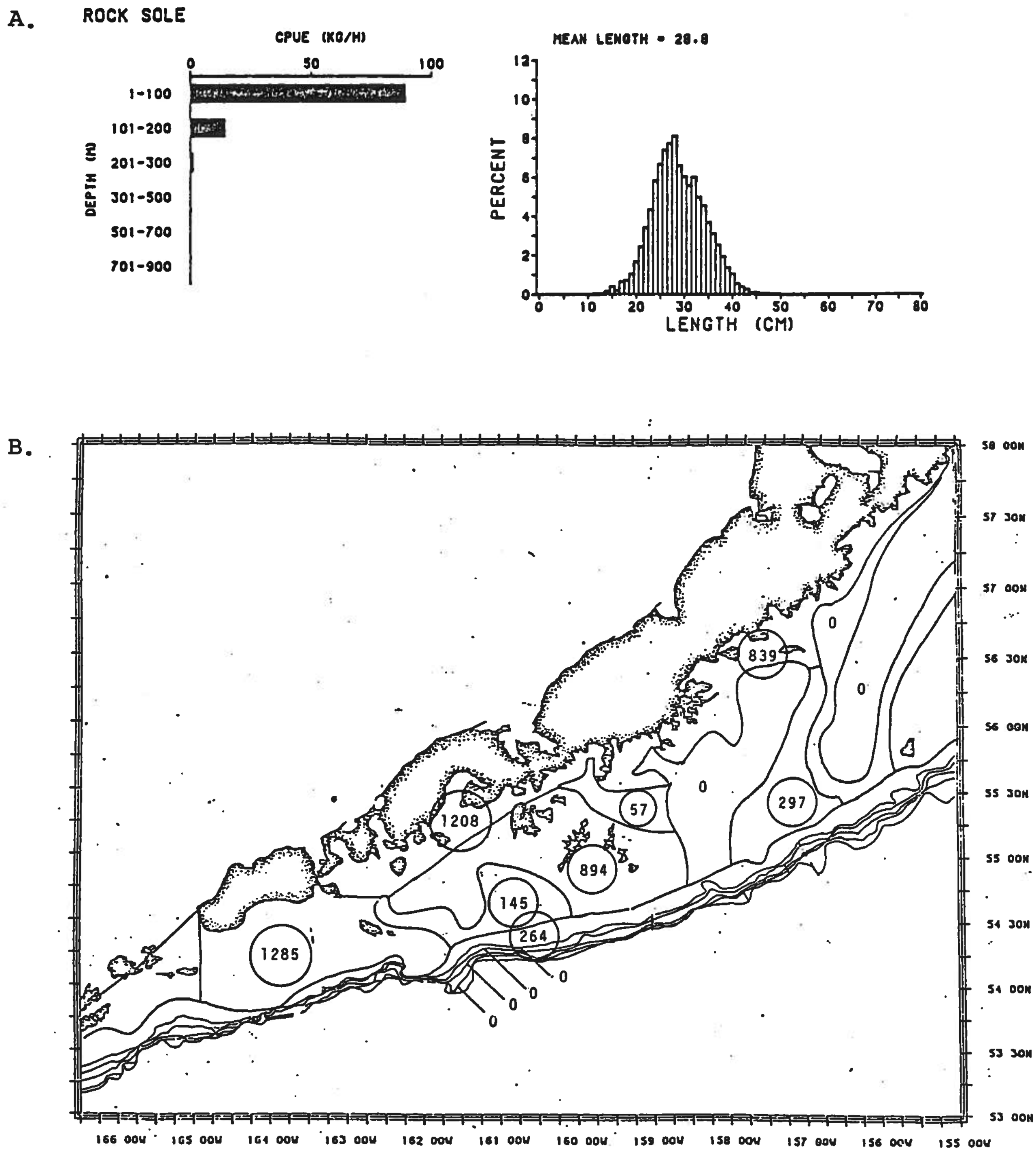


Figure 4.24. A) Length composition and depth distribution of rock sole in the western and central Gulf of Alaska as determined by the 1984 triennial survey (from Rose, 1985); B) Biomass distribution (kg/km²) of rock sole in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

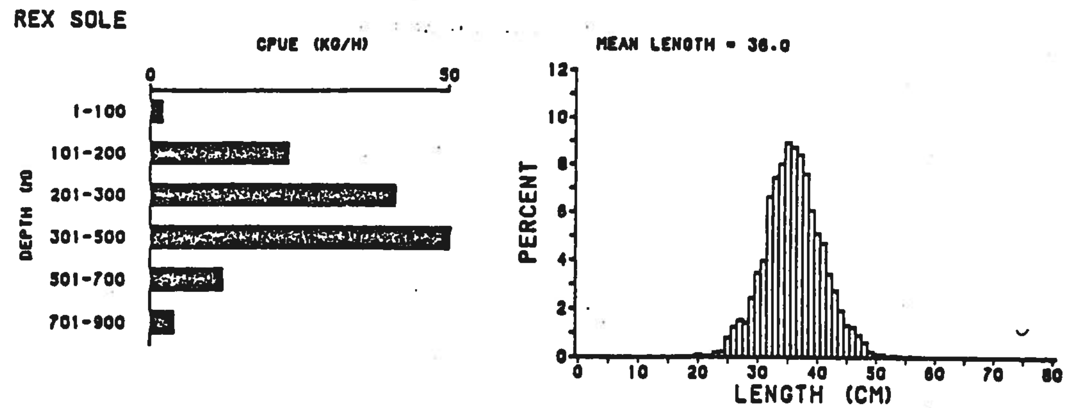
Rex Sole: Rex sole (Glyptocephalus zachirus) are found in a wide range of depths, but generally deeper than 100 m. Biomass in the central to western Gulf of Alaska is estimated at 68,000 mt (Brown, 1985). They are most common in gullies and on the outer slope at depths of 300 to 500 m (Figure 4.25). They decrease in abundance west of Kodiak, where they contribute 4 per cent of the flatfish biomass. In the Shumagin region they are the fifth most abundant flatfish with an estimated biomass of 15,650 mt. Maximum mean biomass was 989 kg/km^2 in the Shelikof Trough, and 931 kg/km^2 in the 200 - 300 m depths of the Shumagin slope. Their general size is in the 35-39 cm range.

Dover Sole: Dover sole (Microstomus pacificus) inhabit a wide depth range also, but are generally a deepwater species with maximum abundance below 500 m (Figure 4.26). These sole contribute about 4 per cent to the flatfish biomass of the west and central Gulf. They rank sixth in abundance of flatfish in the Shumagin region, having an estimated biomass of 9,589 mt (E.S. Brown, p.c.). Dover sole are most abundant (1,220 kg/km^2) along the slope at depths of 500 to 700 m. Their size is similar to that of rex sole, averaging in the upper 30's cm.

Starry Flounder: Starry flounder (Platichthyes stellatus) are abundant throughout the eastern and western North Pacific, These relatively large flatfish are generally found in shallow waters less than 40 m depth in near-shore regions and embayments with freshwater discharges. Because of their more restricted distribution, they contribute only 1 per cent to the biomass of flatfish in the west and central Gulf. They are seventh ranked in flatfish biomass in the Shumagin region (2,387 mt), being most abundant (207 kg/km^2) between 0 - 100 m along the lower Alaska Peninsula (Figure 4.27).

Butter Sole: Butter sole (Isopsetta isolepis) rank eighth in flatfish biomass in the Shumagin region (1,245 mt). The contribute about 1 per cent to total flatfish biomass. They are shallow-water flounders mostly restricted to depths less than 100 m. They occur both nearshore and on the offshore banks (Figure 4.28), being found in highest abundance (69 kg/km^2) nearshore along the lower Alaska Peninsula (E.S. Brown, p.c.). Butter sole average 28 cm in size.

A.



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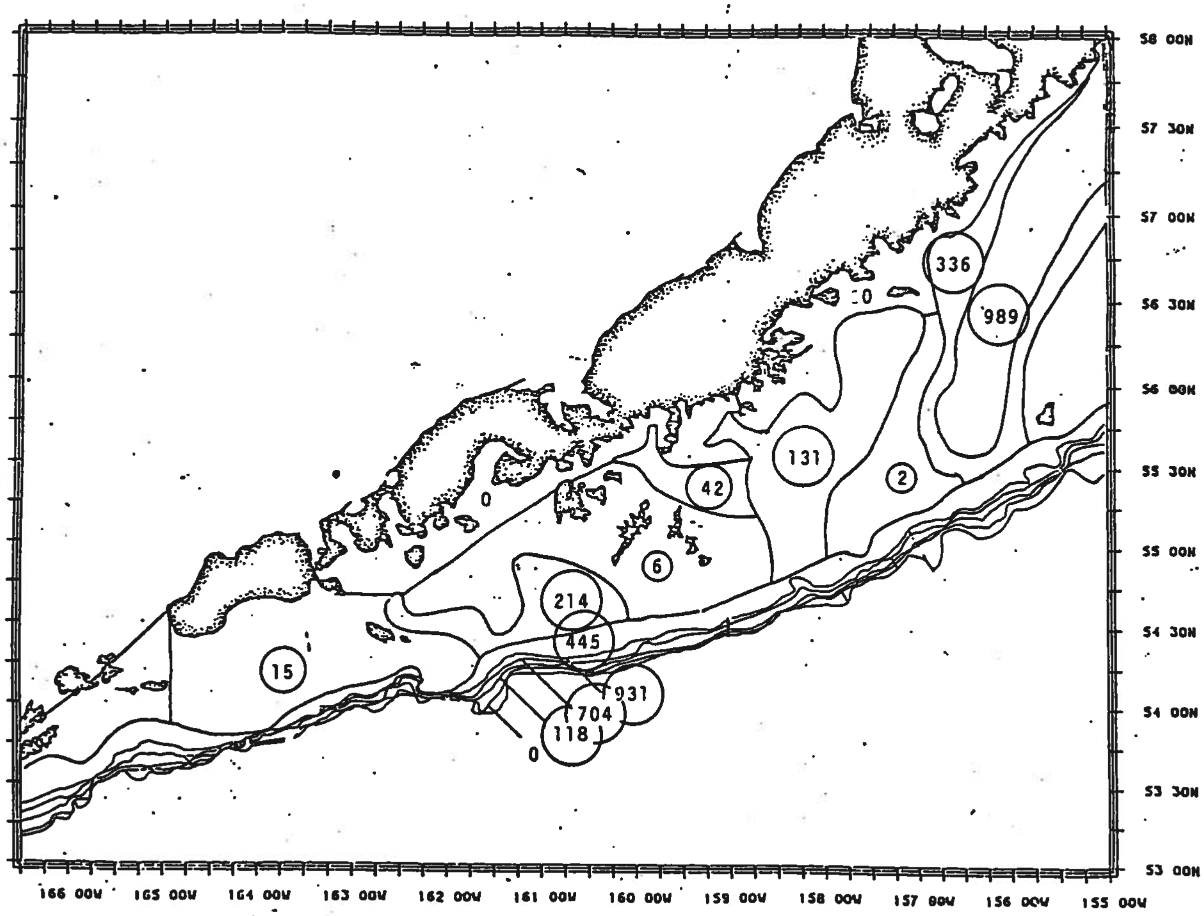
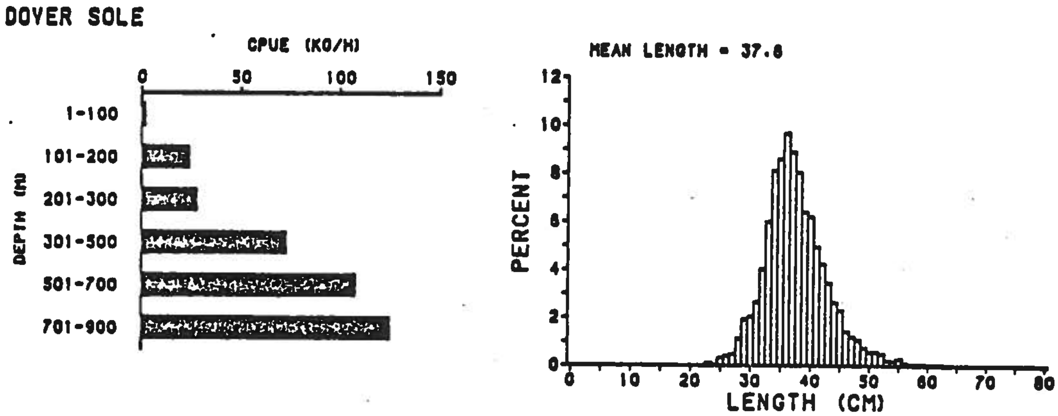


Figure 4.25. A) Length composition and depth distribution of rex sole in the western and central Gulf of Alaska as determined by the 1984 triennial survey (from Rose, 1985); B) Biomass distribution (kg/km²) of rex sole in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

A.



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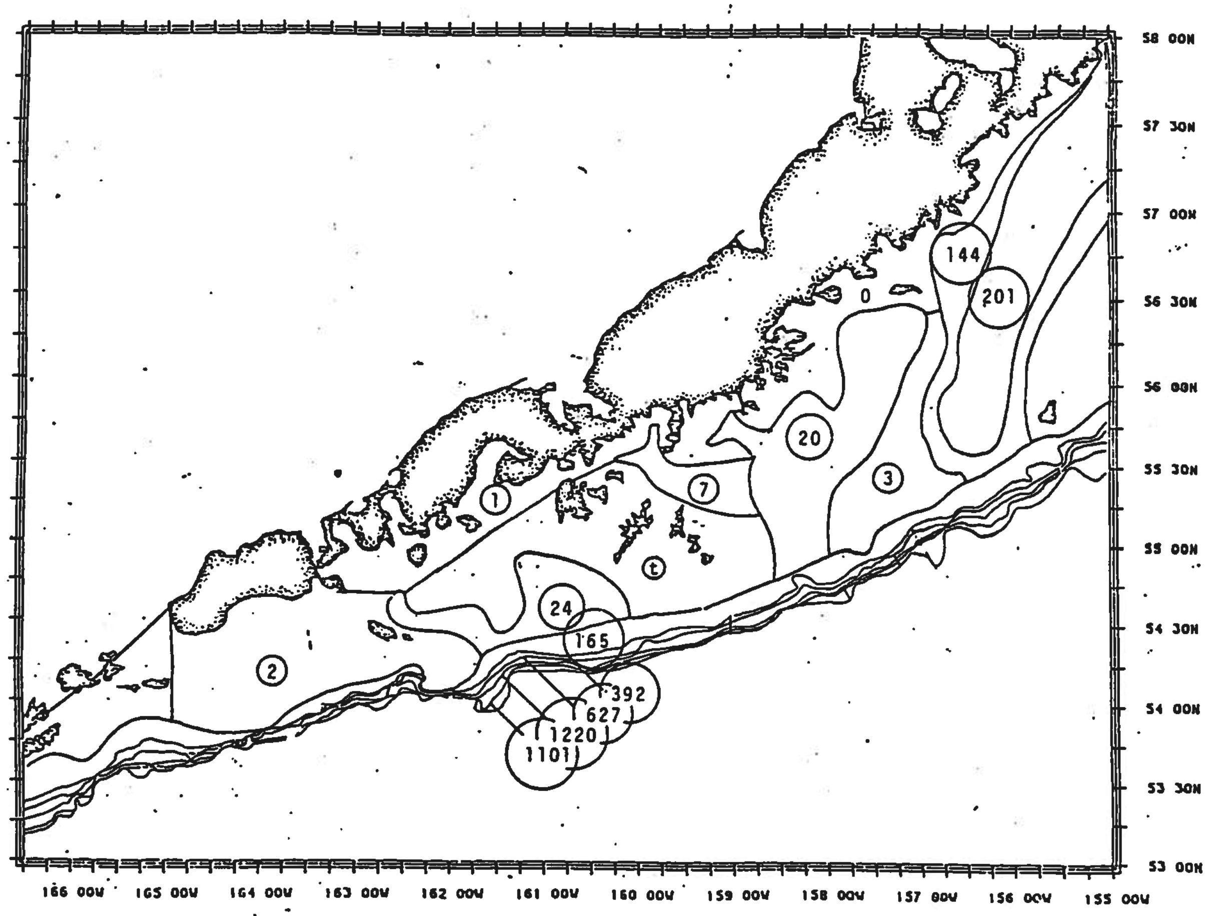

Figure 4.26. A) Length composition and depth distribution of Dover sole in the western and central Gulf of Alaska as determined by the 1984 triennial survey (from Rose, 1985); B) Biomass distribution (kg/km²) of Dover sole in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

A.

B.

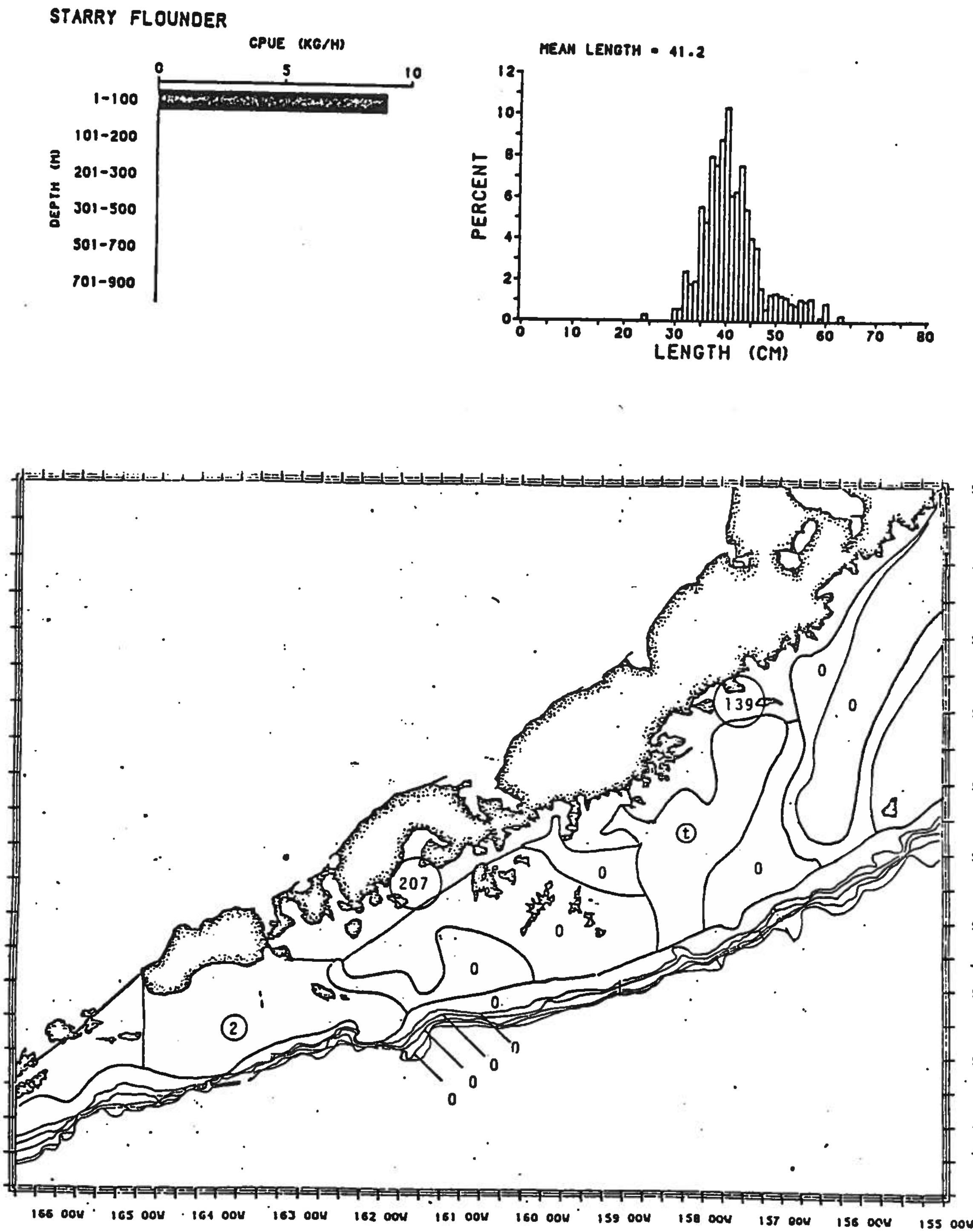

Figure 4.27. A) Length composition and depth distribution of starry flounder in the western and central Gulf of Alaska as determined by the 1984 triennial survey (from Rose, 1985); B) Biomass distribution (kg/km²) of starry flounder in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

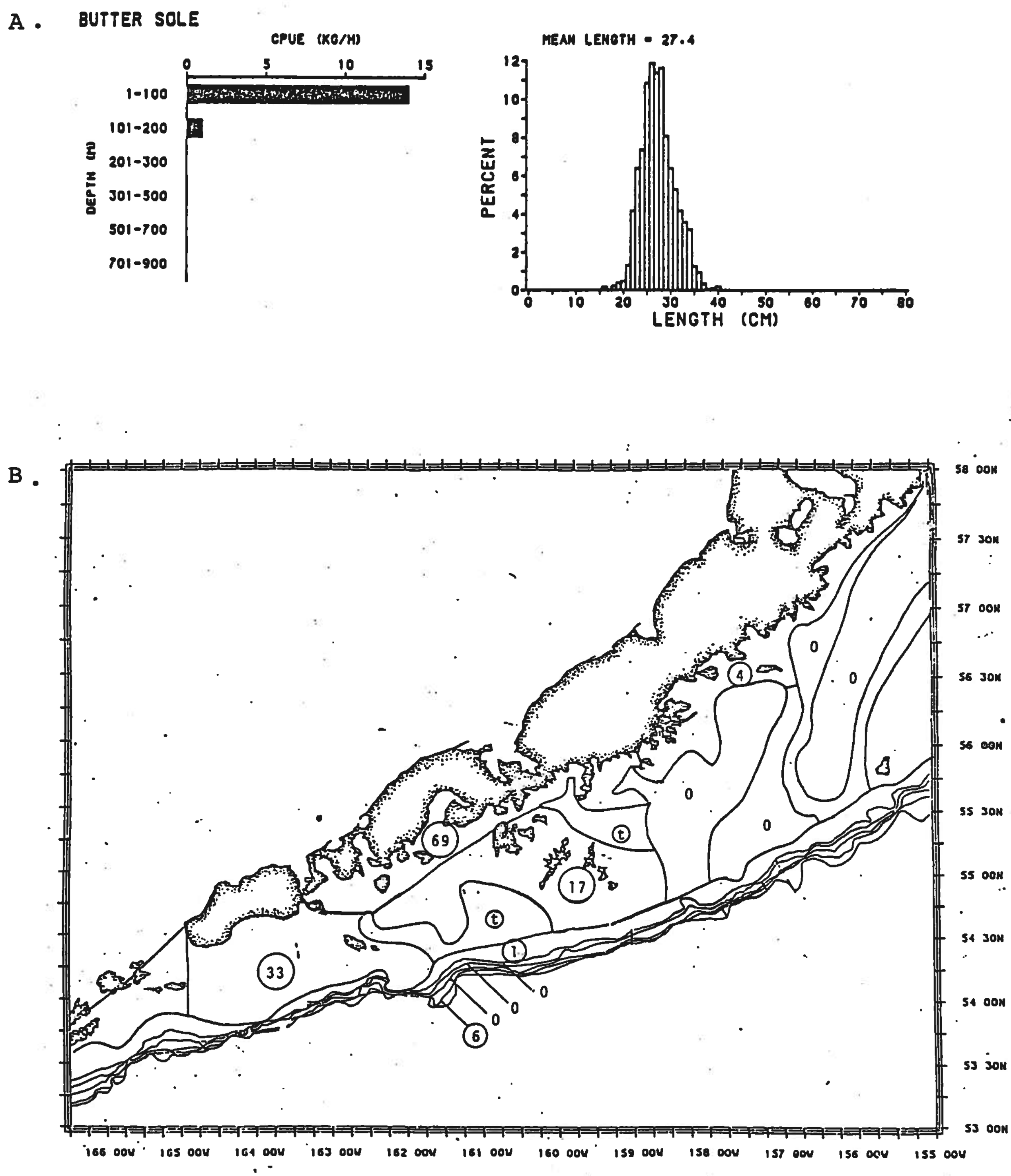

Figure 4.28. A) Length composition and depth distribution of butter sole in the western and central Gulf of Alaska as determined by the 1984 triennial survey (from Rose, 1985); B) Biomass distribution (kg/km²) of butter sole in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

4.4.8.1. The Flatfish Fisheries.

Five species of flatfish other than halibut, account for 99 per cent of the catch in the Gulf of Alaska. They are the arrowtooth flounder, flathead sole, rock sole, rex sole, and Dover sole (Rose, 1985). For management purposes in the Gulf of Alaska, these and the minor species are presently treated as a single resource category.

Flatfish are generally not the principal target or component of the catch of trawl-fisheries. They do however, often make up a considerable component of the catch, up to one-third or more (Rose, 1985). About 98 per cent of the small domestic harvest of flatfish is taken by trawlers, where flatfish composed 12 per cent of their catch.

Arrowtooth flounder is the dominant flatfish in the Gulf-wide trawl fisheries. For example, in 1984 arrowtooth flounder composed 86 per cent of the foreign catch of flatfish, and 76 per cent of the joint-venture catch (Rose, 1985). However, most joint-ventures and some foreign trawlers operating in the Shumagin area took lower percentages of arrowtooth flounder (44-68%) and higher percentages of rex sole, rock sole, and yellowfin sole.

The flatfish fisheries are relatively unexploited and could support appreciably higher harvests without harm to the stocks. However, by-catch of halibut, pollock, cod, sablefish, and Pacific Ocean perch is a problem of their fishery. Restrictions on the fishery to protect halibut are in place. In 1984 the halibut by-catch equalled 12 per cent of the flatfish catch in existing commercial fisheries. It may not be possible to fully utilize the flatfish stocks in the Gulf of Alaska without significant impacts on other fishery stocks, particularly halibut (Rose, 1985).

The principal harvest of flatfish in the Gulf has been by the foreign fisheries, primarily the Japanese who took about 90 per cent of the catch in the late 1970's, and 70 per cent in the early 1980's (Table 4.14). In the Shumagin and Chirikof areas, the Republic of Korea participated heavily in the fishery also. In 1983 and continuing in 1984, the catch by the joint-venture fisheries increased dramatically, taking 2,697 and 3,123 mt respectively

Table 4.14. Optimum Yield (OY) and Catch (mt) of Flatfish in the Gulf of Alaska from 1977 to 1985 (from Major, 1985).

Year	OY	Foreign	Joint-Venture	Domestic	Total
1977	23,500	16,038	0	684	16,723
1978	33,500	14,314	5	852	15,171
1979	33,500	13,474	70	384	13,930
1980	33,500	15,497	209	140	15,846
1981	33,500	14,443	18	403	14,864
1982	33,500	8,986	18	274	9,278
1983	33,500	9,531	2,692	439	12,661
1984	33,500	3,033	3,449	397	6,879
1985	33,500				

(Galloway, 1985), mainly in the Kodiak area but also in the Shumagin and Chirikof areas. In the Shumagin and Kodiak areas in 1984, the joint-venture fleets were the major harvester of flatfish, taking over half the catch. This shift in catch distribution, as evidenced by the decreasing overall catch, was partly due, however, to a decreased foreign fishery allocation and subsequently lower effort.

4.4.9. Pacific Ocean Perch.

The Pacific ocean perch (POP) complex contains five species of red rockfish that are managed together as one entity (Carlson et al., 1985). The five species are:

Pacific ocean perch - Sebastes alutus
rougheye rockfish - S. aleutianus
shortraker rockfish - S. borealis
northern rockfish - S. polyspinis
sharpchin rockfish - S. zacentrus.

These species occupy similar habitats throughout all or part of the Gulf of Alaska. The Pacific ocean perch, S. alutus is by far the most abundant member of this group overall, and ranges throughout the Gulf of Alaska. Only S. zacentrus is not resident to the Shumagin region, being found only from Kodiak eastward.

These rockfish were heavily exploited in the 1960's and early 1970's by foreign trawlers and their stocks are currently depleted. Resource surveys conducted since the late 1970's indicate that their populations are remaining at low levels despite the restrictions imposed on foreign and domestic fishing that are designed to allow rebuilding of the stocks. The estimated biomass of Pacific ocean perch in the Gulf of Alaska and in the Shumagin region (in parentheses) in 1984 was 174,000 (43,884) mt; for northern rockfish - 76,000 (44,630) mt, for rougheye rockfish - 65,000 (11,217) mt, and for shortraker rockfish - 21,000 (670) mt (Brown, 1985 and p.c.). It is noteworthy that over half the total biomass of northern rockfish was found in the Shumagin statistical area.

Pacific ocean perch stocks are estimated at only 20 per cent (range 11.2 to 30.8 per cent) of their former abundance despite the current conservation measures (Carlson et al., 1985). Length frequency, age structure, and catch levels have not improved greatly in the past several years, and with the possible exception of an appearence of the 1976 year class in the 1984 catches, no influx of recruits has been noted. Rebuilding programs to increase the stocks through fishing restrictions are expected to take 20 to 50 years to achieve the desired improvements.

The center of abundance for Pacific ocean perch is from Kodiak to the eastern Aleutians. This demersal species ranges from southern California to the Kurile Islands in the western North Pacific. They commonly inhabit shelf edge and upper slope waters at depths from 150 to 500 m, and are most abundant around 200 to 300 m. Particularly important habitats of the species are over rocky bottoms and in submarine canyons, gullies and other depressions of the upper continental slope; all areas where trawling is difficult. Their habit of spending considerable time above the sea floor also makes them difficult to catch with trawls. The 1984 Gulf of Alaska trawl surveys (Brown, 1985) reported highest densities of POP (16,863 kg/km²) between the 200 - 300 m depths along the Shumagin slope (Figure 4.29; Table 4.15).

Northern rockfish averaged 493 kg/km² in the Shumagin region. They were found in highest abundance (3,136 kg/km²) between depths of 100 - 200 m (E.S. Brown, p.c.), and were also abundant on Davidson Bank (Figure 4.30). Rougheye rockfish in the Shumagin region averaged 124 kg/km² and were most abundant along the slope at 300 - 500 m, with a highest mean biomass of 3,531 kg/km² (Figure 4.31). Shortraker rockfish were found in the Shumagin region almost exclusively in the 300 - 500 m depths along the slope (Figure 4.32). Their highest mean biomass was 290 kg/km².

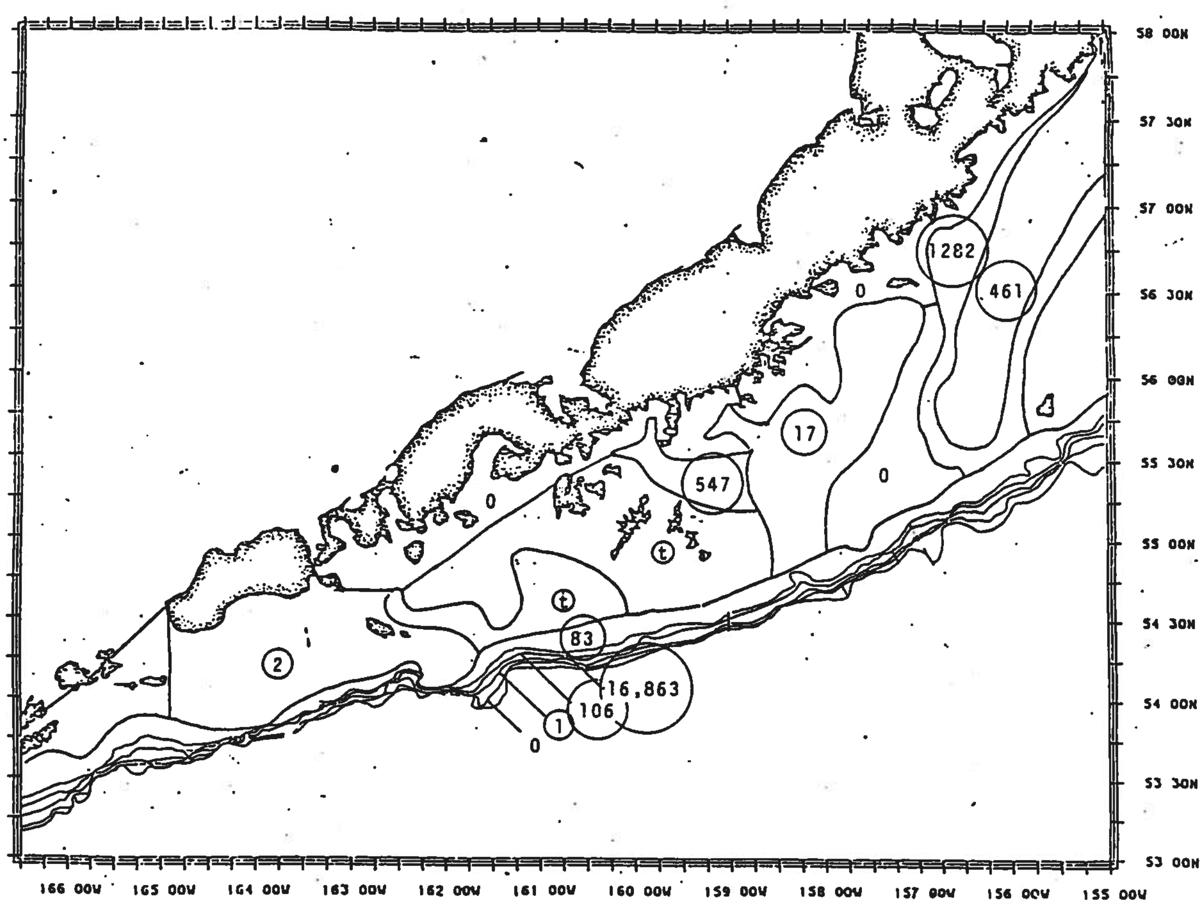

Figure 4.29. Biomass distribution (kg/km²) of Pacific ocean perch in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

Table 4.15. Estimated Biomass (mt), CPUE (kg/km²), and Mean Size (cm and kg) of Pacific Ocean Perch, Northern Rockfish, and Rougheye Rockfish in the Shumagin Region of the Gulf of Alaska (from Brown, 1985).

Area/ depth (m)	CPUE (kg/km^2)	Biomass (t)	Mean Length (cm)	Mean Weight (kg)
		Pacific Ocean Perch		
0-100	3	138	21.8	0.3
100-200	851	11,505	33.7	0.5
200-300	19,006	48,432	32.7	0.6
300-500	90	212	35.8	0.6
500-700	5	12	--	0.4
700-1000	0	0	--	--
Subtotal		60,299	32.8	
		Northern Rockfish		
0-100	425	17,725	--	0.6
100-200	1,731	23,427	31.8	0.7
200-300	455	1,153	31.7	0.5
300-500	2	7	--	--
500-700	1	2	--	--
700-1000	0	0	--	--
Subtotal		42,314		
		Rougheye Rockfish		
0-100	0	0	--	--
100-200	8	109	35.9	0.5
200-300	42	109	39.3	0.6
300-500	5,775	13,593	44.8	1.5
500-700	0	0	--	--
700-1000	0	0	--	--
Subtotal		13,811		

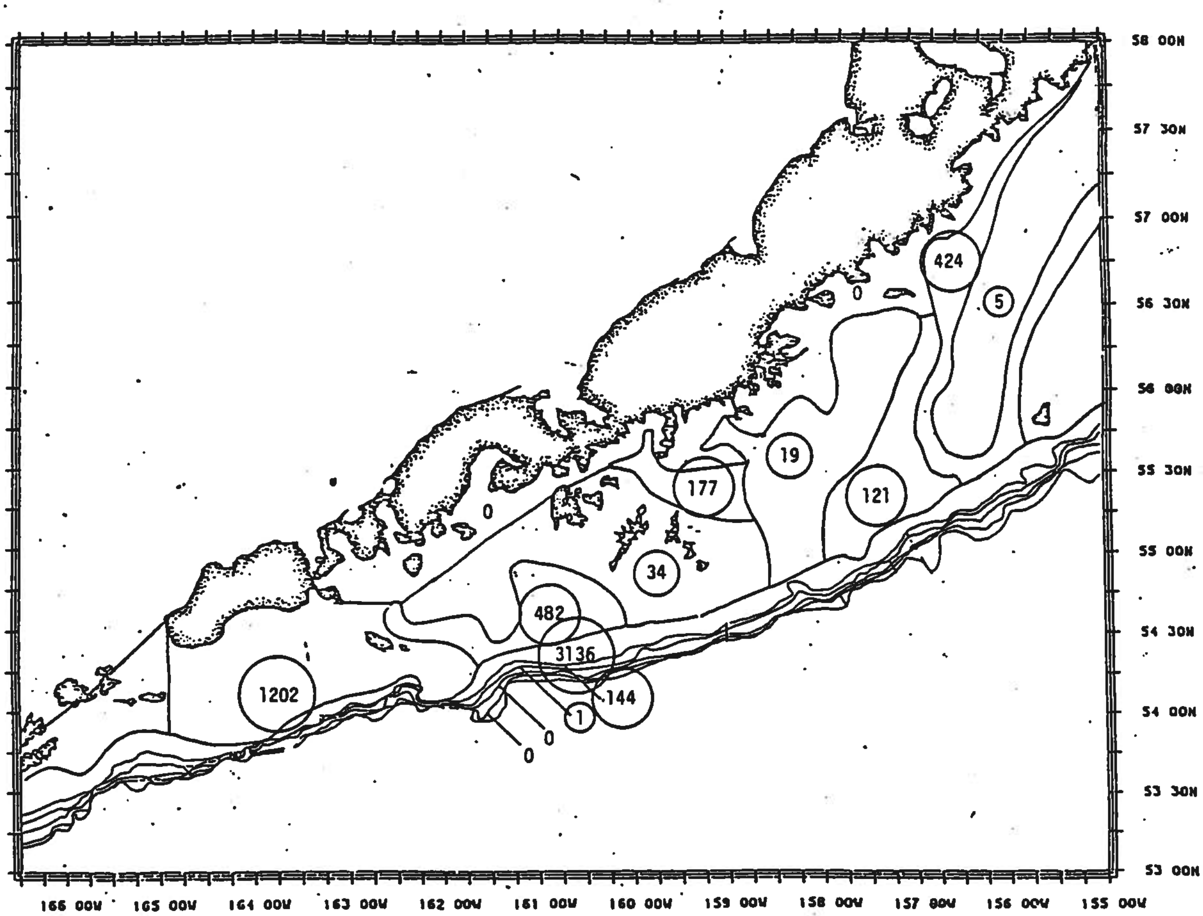

Figure 4.30. Biomass distribution (kg/km²) of northern rockfish in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

Pacific ocean perch are slow-growing and long-lived. Adults range in size from 17 to 43 cm; it takes about 8 to 12 years for POP to reach lengths of 33 cm, the average size of the commercial catch. Subsequent growth is even slower, with fish over 30 years of age measuring less than 40 cm. Individuals exceeding 50 cm in length are uncommon. Until recently, biologists thought they lived no more than 30 - 35 years. New aging techniques have indicated even much greater longevity, perhaps over 90 years for Pacific ocean perch and to 140 years for rougheye rockfish (Chilton and Beamish, 1982; Carlson et al., 1985).

The reproductive rate and fecundity of Pacific ocean perch is also slow. POP don't reach maturity until the males are at least 6 to 7 years old, and the females 9 to 11 years.

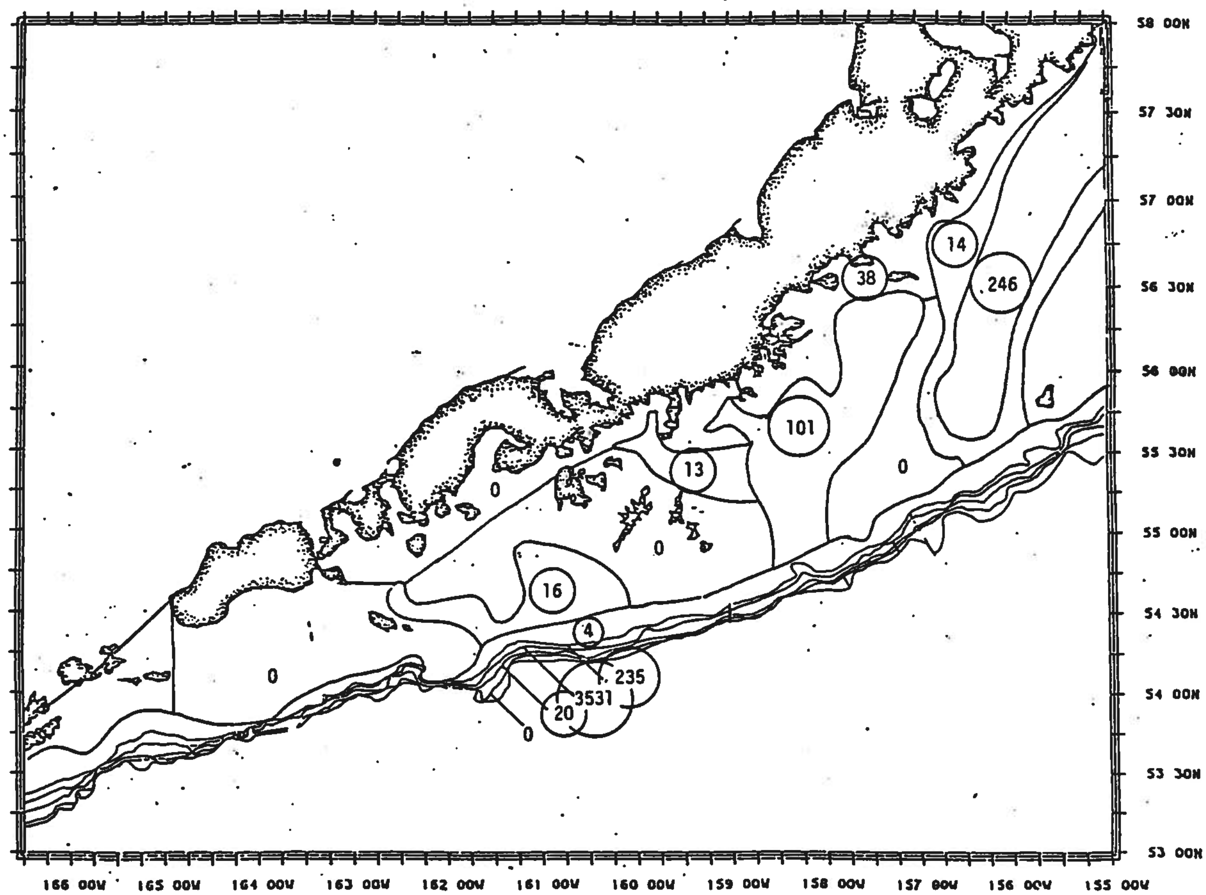

Figure 4.31. Biomass distribution (kg/km²) of rougheye rockfish in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

The distribution and abundance of Pacific ocean perch appears to be influenced by age, and by seasonal spawning and foraging movements. Foraging movements of adults from deep to shallow waters appears to occur seasonally. In the Shumagin region, foraging occurs from May to September, chiefly in the Unimak Pass area at depths of 150 to 200 m. Feeding ceases during mating, when the fish move offshore to deeper waters, after which the schools segregate by sex.

Females are ovoviviparous and spawn once a year, generally in the late winter and early spring (Favorite et al., 1977). Spawning takes place 25 to 30 m off the bottom in depths of about 400 m and the newborn larvae ascend to mid-water depths of about 250 m. The planktonic stage lasts for about one year,

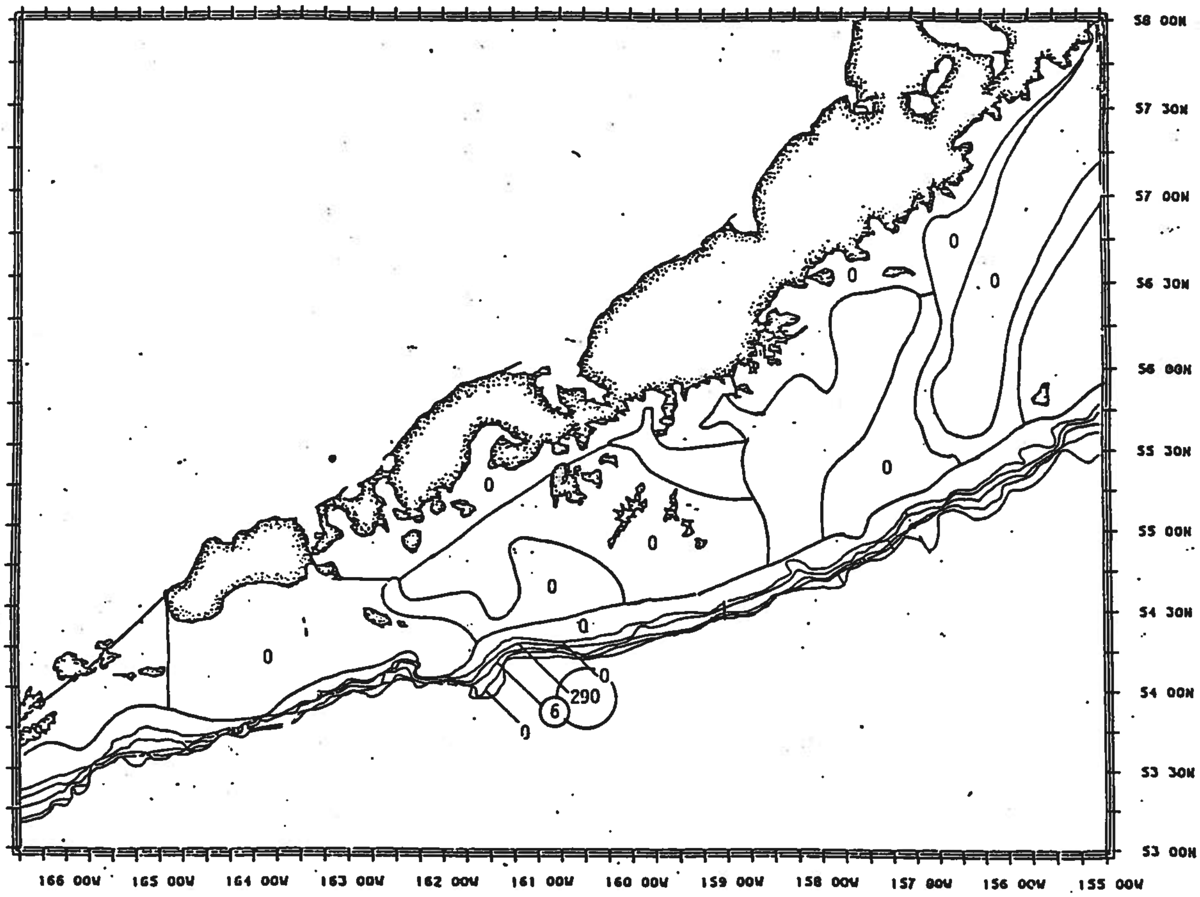

Figure 4.32. Biomass distribution (kg/km²) of shortraker rockfish in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

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and the juveniles settle near the bottom at 125 to 150 m depths, where they remain until they mature and move progressively deeper as they increase in size and age.

Pacific ocean perch prey on small crustaceans (copepods, euphausiids, and shrimp), and also on squid and small fish.

4.4.9.1. The Pacific Ocean Perch Fishery.

Prior to the intensive Soviet and Japanese trawl fisheries in the 1960's, Pacific ocean perch was the dominant demersal fish at the 200-300 m depths in the northeastern Pacific. POP comprised over 90% of the rockfish catch in these areas. In 1960, foreign fleets removed approximately 6,100 mt of this rockfish from the eastern Bering Sea. By 1962 the fishery had expanded into the Aleutian Islands and Gulf of Alaska waters. Subsequent growth of the fishery was rapid. Massive efforts by the foreign fleets produced peak catches for all regions of 474,100 mt in 1965. Soon after however, total catches declined almost as rapidly as they had increased.

By 1977, annual harvests of Pacific ocean perch had declined to 21,451 mt and continue to decline. In 1982, total catch amounted to only 1.6 per cent of the 1965 peak harvest. During this time the biomass in the Aleutian Island stock may have declined 76.7 to 98.2 per cent from 1964 to 1979, and in the Gulf of Alaska this decline may have been reduced 69.1 to 99.5 per cent.

The total harvest of Pacific ocean perch in 1984 was 4,452 mt. Most of the harvest was by trawlers, both small and large, but a small allocation was given to the sablefish longlining fleets. Japan took 56 per cent of this catch and domestic and joint-ventures took 42 per cent. Most of the Japanese harvest came from the Kodiak and Chirikof statistical areas, while most of the joint-venture catch was from the Shumagin area. The 1980 - 1985 catch statistics for Shumagin and Chirikof are given in Table 4.16.

4.4.10. Thornyheads and Other Rockfish.

Thirty one species of Sebastes and two species of Sebastolobus inhabit waters of the Gulf of Alaska (Bracken and Ito, 1985), and regularly occur in the commercial fishery landings, both foreign and domestic. They include both nearshore species and those inhabiting the shelf and slope throughout the Gulf, both pelagic and demersal. The species of Sebastes can be categorized as either shelf-pelagic or shelf-demersal in depths less than 200 m, or slope (deepwater) species at depths over 250 m (Table 4.17). The two Sebastolobus species (called thornyhead rockfish or thornyheads) inhabit deep waters of the shelf edge and slope, with a range of depths from 100 to 1,600 m (Shippen, 1985).

Table 4.16. Optimum Yield (OY) and Catch (mt) of Pacific Ocean Perch in the Gulf of Alaska from 1977 to 1985 (from Major, 1985).

Year	OY	Foreign	Joint-Venture	Domestic	Total
1977	30,000	23,439[a]	0	12	23,451
1978	25,000	8,174	0	5	8,179
1979	25,000	9,750	68	105	9,923
1980	25,000	12,447	20	4	12,471
1981	25,000	12,176	1	7	12,184
1982	11,475	7,988	3	2	7,993
1983	11,475	5,416	1,975	15	7,406
1984	11,475	2,599	1,734	119	4,452
1985	6,083				

a/ This amount includes all rockfish harvested by Japan in 1977, as they were not reported separately.

Resource surveys in 1984 found that one species of "other rockfish" dominates this group in the Kodiak and Shumagin areas (Bracken and Ito, 1985). This was the dusky rockfish (S. ciliatus) with an estimated Gulf of Alaska biomass of 25,700 mt. This species mainly inhabits the nearshore shelf zone, inside the normal area where the Pacific ocean perch fisheries have operated. The Shumagin region contains an estimated 7,621 mt of dusky rockfish (E.S. Brown, p.c.). It was most abundant in the West Shumagin Gully between 100 - 200 m (Figure 4.33), with a mean biomass of 412 kg/km².

Of the thornyhead rockfish, the shortspine thornyhead (Sebastolobus alascanus) are the more abundant. This species inhabits depths ranging from 92 to 1,460 m, and are generally abundant at all depths below 200 m. They have an estimated biomass of 78,000 mt in the Gulf of Alaska, with about 21,163 mt being located in the Shumagin region (E.S. Brown, p.c.). Greatest abundance in the

Table 4.17. List of the Rockfish Identified by U. S. Observers in the Foreign and Joint-Venture Fisheries of the Gulf of Alaska, with Identification of Their Association in Shelf Pelagic, Shelf Demersal, or Slope (Deep Water) Rockfish Assemblages (after Bracken and Ito, 1985).

Common Name	Scientific Name	Assemblage
Pacific Ocean Perch Complex		
Pacific ocean perch	Sebastes alutus	slope
northern rockfish	Sebastes polyspinus	slope
rougheye rockfish	Sebastes aleutianus	slope
sharpchin rockfish	Sebastes zacentrus	slope
shortraker rockfish	Sebastes borealis	slope
Thornyhead Rockfish		
longspine thornyhead	Sebastolobus altivelis	slope
shortspine thornyhead	Sebastolobus alascanus	slope
Other Rockfish		
aurora rockfish	Sebastes aurora	slope
black rockfish	Sebastes melanops	shelf pelagic
blackgill rockfish	Sebastes melanostomus	slope
blue rockfish	Sebastes mystinus	shelf pelagic
bocaccio	Sebastes paucispinus	shelf demersal
canary rockfish	Sebastes pinniger	shelf demersal
China rockfish	Sebastes nebulosus	shelf demersal
copper rockfish	Sebastes caurinus	shelf demersal
darkblotched rockfish	Sebastes crameri	slope
dusky rockfish	Sebastes ciliatus	shelf pelagic
greenstriped rockfish	Sebastes elongatus	shelf pelagic
harlequin rockfish	Sebastes variegatus	slope
pygmy rockfish	Sebastes wilsoni	slope
quillback rockfish	Sebastes maliger	shelf demersal
redbanded rockfish	Sebastes babcocki	slope[b]
redstripe rockfish	Sebastes proriger	shelf demersal
rosethorn rockfish	Sebastes helvomaculatus	shelf demersal
silvergray rockfish	Sebastes brevispinus	shelf demersal[a]
splitnose rockfish	Sebastes diploproa	slope
tiger rockfish	Sebastes nigrocinctus	shelf demersal
widow rockfish	Sebastes entomelas	shelf pelagic
yelloweye rockfish	Sebastes ruberrimus	shelf demersal
yellowmouth rockfish	Sebastes reedi	slope
yellowtail rockfish	Sebastes flavidus	shelf pelagic

a/ Small silvergray rockfish are pelagic, large fish are demersal.
b/ occurs in both slope and deep shelf catches.

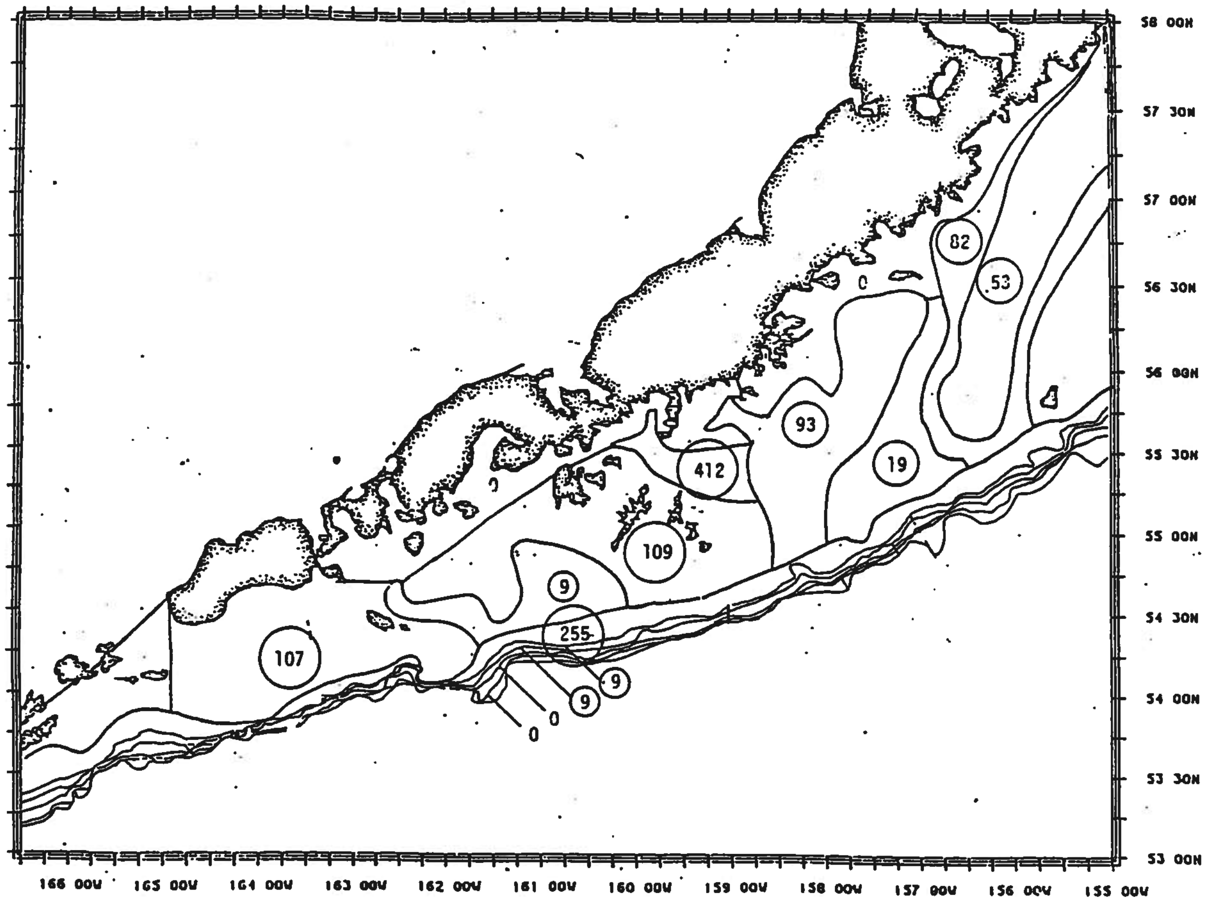

Figure 4.33. Biomass distribution (kg/km²) of dusky rockfish in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

Shumagin region (4,705 kg/km²) is found along the slope at depths of 200 - 300 m (Figure 4.34). The smaller and deeper-water longspine thornyhead (S. altivelis) is rarely taken in trawl surveys in the Gulf of Alaska. It inhabits a depth range of 370 to 1600 m.

Shortspine thornyheads attain lengths up to 75 cm. Longspine thornyheads grow in size to 38 cm (Shippen, 1985). Like Pacific ocean perch, these other species also appear to be long-lived, and the new 'break-and-burn' aging technique (Chilton and Beamish, 1982) has significantly increased the age estimates for most species. For example, surface aging technique for otoliths gave a mean age estimate for yelloweye rockfish of 20 years, with a range of 7 to 63 years; the break-and-burn technique found a mean age of 44 years with a range of 15 to 105 years (Bracken and Ito, 1985).

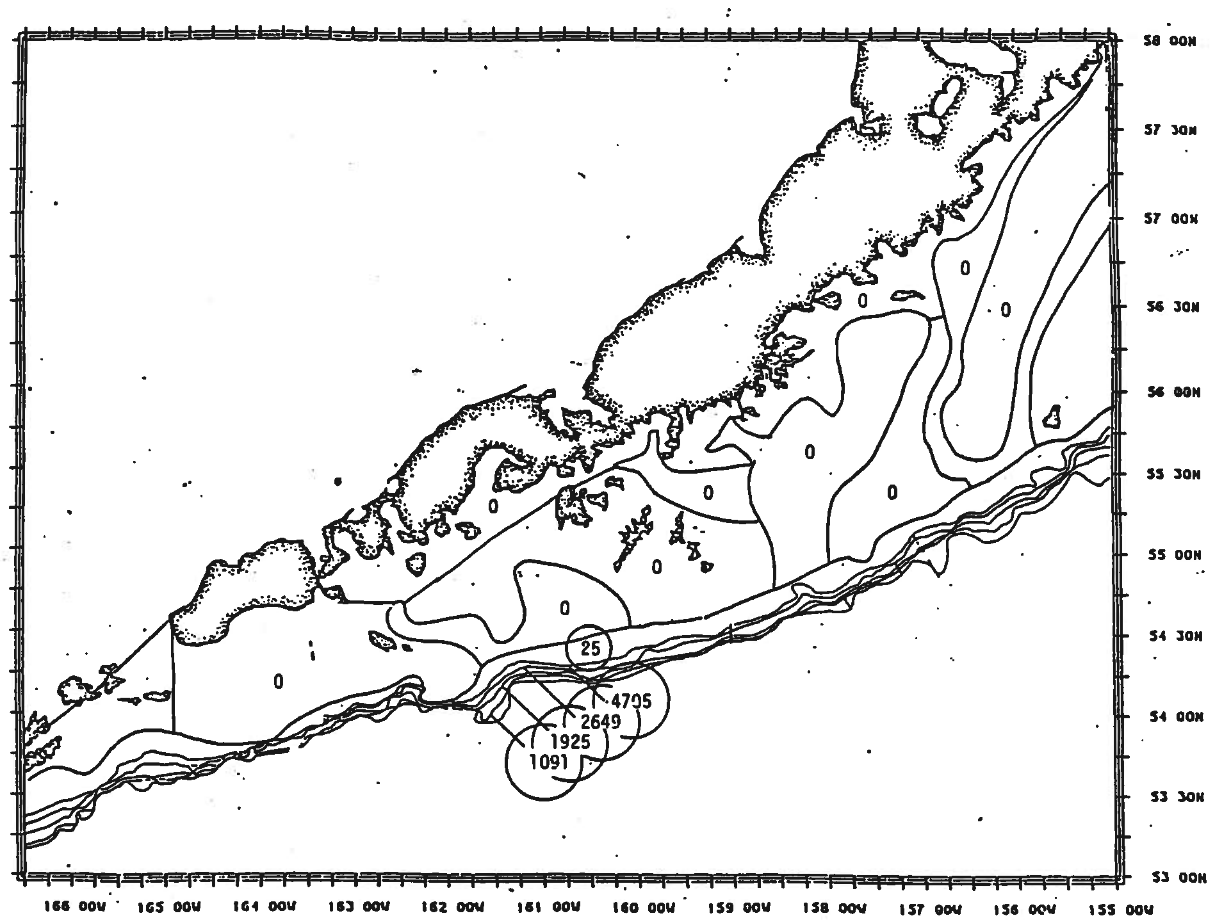

Figure 4.34. Biomass distribution (kg/km²) of shortspine thornyhead rockfish in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

4.4.10.1. Other Rockfish Fisheries.

Foreign nations historically grouped their catch statistics into two major categories, Pacific ocean perch and "other rockfish". Since 1979 however, five species of rockfish with similar color and physical characteristics to S. alutus were combined in the Pacific ocean perch complex (see Section 4.4.9) and were required to be reported as such. Also, prior to 1980, catches of shortspine and longspine thronyhead rockfish were also reported as "other rockfish", but have since been required to be reported separately. Beginning in 1979, "other rockfish" as currently defined in the FMP for "Groundfish in the Gulf of Alaska", include all those species of the genus Sebastes that are not included in the POP complex discussed above (see Table 4.17). In 1984, thornyheads became a separate catch entity for reporting by the domestic fisheries as well (Shippen, 1985)

Thornyheads and "other rockfish" have been harvested in the foreign fisheries for Pacific ocean perch along the shelf edge and slope since those fisheries began in the early 1960's. The pre-1980 reporting requirements preclude any breakdown of the historic catch record into species composition from the foreign catch data. Since 1977 however, U.S. observers on foreign vessels have been able to estimate the annual harvest of individual species. Also using observer data, it is possible to estimate the catches for the three rockfish groups by foreign and joint-venture fisheries since 1978. Between 1978 and 1984, the average and peak catches of "other rockfish" was 2,100 and 4,341 mt (in 1981) in the central and western Gulf, and the peak catch of thornyheads was 1,351 mt in 1980. The substantial declines in landings for 1983 and 1984 are at least in part due to the reduced POP and other target species allocations and area restrictions imposed on the foreign fisheries.

Thornyheads are not usually a target species of the commercial fisheries, although recently the Japanese longline fishery has targeted on the short-spined thornyhead (Sebastolobus alascanus) (AECRSA, 1984). They are usually taken in trawl and longline fisheries for other species such as Pacific ocean perch, sablefish, other rockfish, and deepwater flatfish (Shippen, 1985). The catches of thornyheads have been declining since 1980 (Table 4.19), reflecting recent U.S. management actions mentioned above. Most of the recent harvests have been from the western (Shumagin) and central (Chirikof and Kodiak) regions.

Little is known about the stock abundance of these fish, in part because of the incidental nature of their catch, and also because resource surveys have not sampled the deepwater areas where they are in greatest abundance. What information is available suggests that thornyheads are in greatest abundance in the central and western regions of the Gulf, with a standing stock estimated at 80,637 mt.

Table 4.18. Optimum Yield (OY) and Catch (mt) of Thornyhead Rockfish in the Gulf of Alaska from 1977 to 1985 (from Major, 1985).

Year	OY	Foreign	J.-Venture	Domestic	Total
1977	--	0[a]	0[a]	0[b]	0
1978	--	0[a]	0[a]	0[b]	0
1979	--	0[a]	0[a]	0[b]	0
1980	3,750	1,351	0	0[b]	1,351
1981	3,750	1,340	0	0[b]	1,340
1982	3,750	788	0	0[b]	788
1983	3,750	718	12	0[b]	730
1984	3,750	164	19	24	207
1985	3,750				

a/Probably unreported small catches not reported because OY not established.
b/Thornyheads were included in "Other Rockfish" category prior to 1984.

Rockfish have also been taken incidentally in domestic fisheries for sablefish and halibut, but were of little commercial interest until recently. Directed fisheries using automatic jigging machines began in 1978 in southeast Alaska waters. By the early 1980's, the fishery had converted to hook and setline gear for the demersal species and expanded considerably. In 1984, a record catch of over 800 mt was landed by Alaskan fishermen. This fishery in the southeast (e.g. Sitka area) targets on yelloweye and quillback rockfish, but over 15 other species are also landed (Bracken and Ito, 1985). With noticeable declines in catch already occurring on existing fishing grounds, this fishery may expand to other areas, such as Kodiak and the Shumagins in the near future.

4.4.11. Other Fish.

The fishes or groups of fish contained in this category are currently of little or no commercial value to the fisheries of the Shumagin area. They may be, however, of ecological importance in the food web, may have significance to sport fisheries, or be of subsistence value. Alternatively, they may be a common component in the by-catch of the present commercial fisheries, and may have some future economic potential in the fisheries. Fish in the latter category have generally had no special studies directed at addressing the status of their stocks; what we know of them comes from the commercial fisheries data (Major, 1985b). Unfortunately, in this respect, because of the change of the foreign fisheries from a multi-species bottom-trawling operation to a pollock-oriented fishery, less by-catch of these other species is now taken, and less information on their stocks is being acquired.

Forage Fish: Forage fish are important components of the marine food webs of the Shumagin shelf. Major forage species include capelin (Mallotus villosus), Pacific sand lance (Ammodytes hexapterus), sculpins (Scorpaenidae spp.), surf smelt (Hypomesus pretiosus), rainbow smelt (Osmerus mordax), and eulachon (Thaliechthys pacificus), as well as Pacific herring discussed earlier.

Capelin, a member of the smelt family, may be more abundant than herring in the Shumagin region, with greatest abundance toward the tip of the Peninsula. Like herring, capelin spawn in May and early June, usually in the surf zone of fine gravel beaches. Peak spawning is at night or on overcast days during periods of high tides and active surf. Spawning locations are believed to be widespread, and may potentially include any beach of suitable substrate (BBCMP, 1984). Smelts, primarily eulachon, composed 16 per cent of the commercial by-catch of "other species" in the trawl fisheries of the west and central Gulf of Alaska (Major, 1985b)

Sculpins: Sculpins compose about 50 per cent of the by-catch in the "other species" category from the commercial fisheries in Shumagin, Chirikof, and Kodiak statistical areas of the Western and Central Regions of the Gulf of Alaska (Major, 1985b). The two most commonly caught sculpins and their biomass estimates in the Shumagin region are: Myoxocephalus spp. - 3,240 mt;

and yellow irish lord (Hemilepidotus jordani) - 5,216 mt (E.S. Brown, p.c.). Both species were most abundant in the coastal waters of the lower Alaska Peninsula at 237 and 187 kg/km² respectively (Figures 4.35 and 4.36). Other less abundant but commonly caught sculpins in the Shumagin region are bigmouth sculpin (Hemitripteris bolini), blackfin sculpin (Malacocottus kincaidi), and spinyhead sculpin (Dasycottus setiger).

Skates: Skates (Family Rajidae) are also relatively common in the by-catch of the 1984 trawl fisheries in the Western and Central regions of the Gulf of Alaska, where they composed 20 per cent of the fish in the "other species" category (Major, 1985b). The estimated biomass of skates in the Shumagin region is 16,816 mt (E.S. Brown, p.c.), with highest densities (694 kg/km²) on the Shumagin Bank (Figure 4.37).

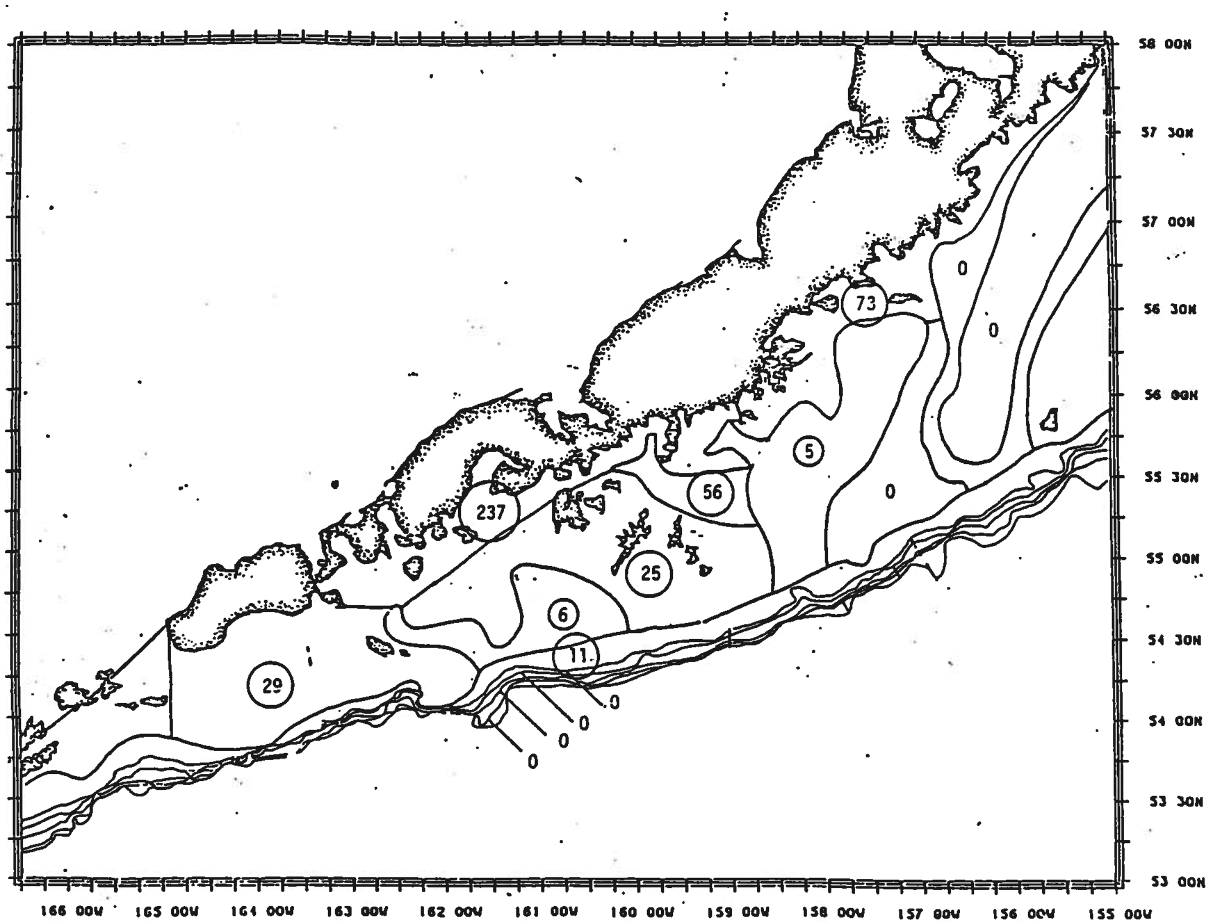

Figure 4.35. Biomass distribution (kg/km²) of Myoxocephalus spp. in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

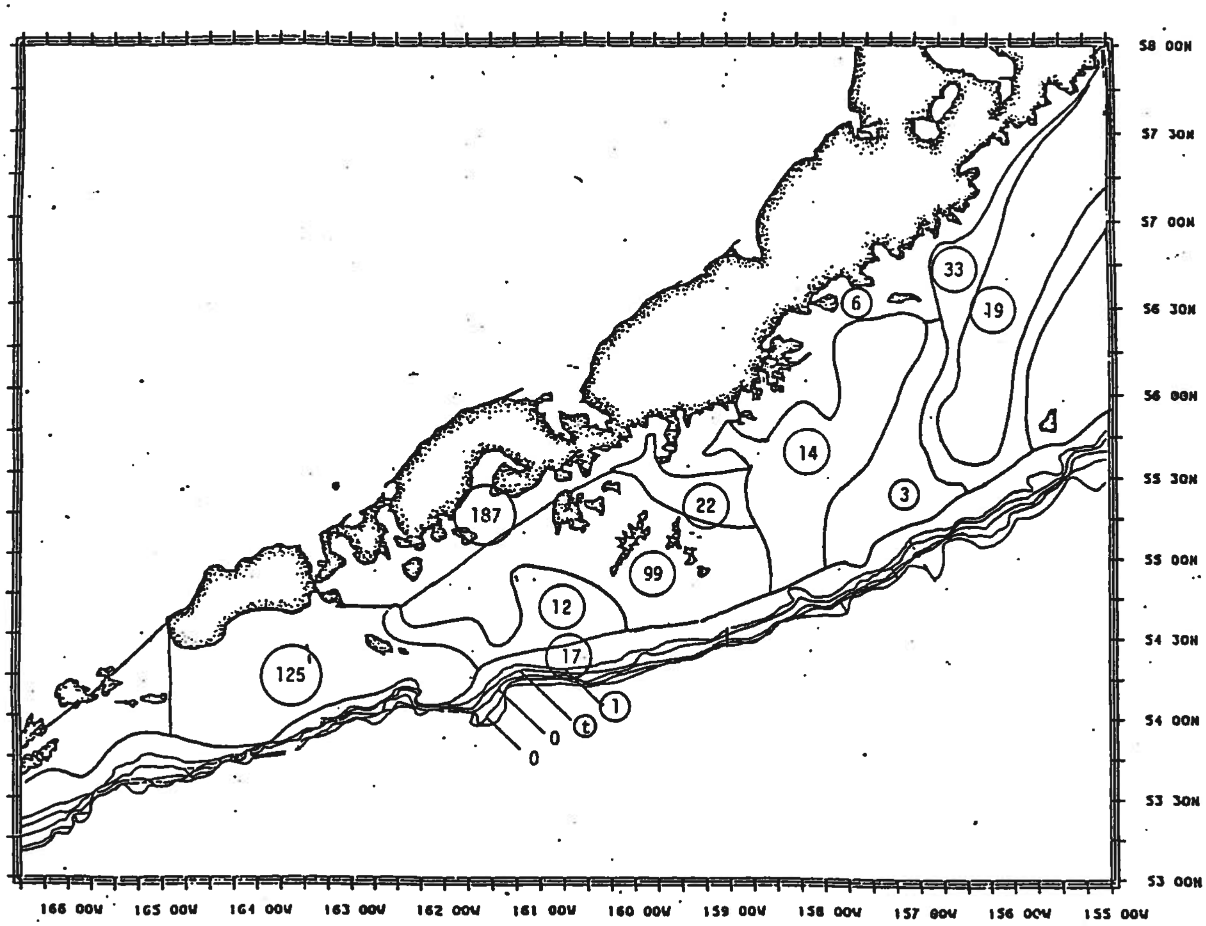

Figure 4.36. Biomass distribution (kg/km²) of yellow irish lords in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

Sharks: Sharks composed 11 per cent of the 1984 trawl by-catch in the "other fish" category from the western and central Gulf of Alaska. (Major, 1985b). Three species are common; spiny dogfish (Squalus acanthias) with an estimated biomass of 1,085 mt; salmon shark (Lamna ditropis) - 4,841 mt; and Pacific sleeper shark (Somniosus pacificus) - 165 mt.

Rattails or Grenadiers: Giant grenadiers (Coryphaenoides pectoralis) are the eighth most abundant groundfish in the west and central Gulf of Alaska with an estimated biomass of 251,000 mt (Brown, 1985). About half this biomass 108,951 mt) is contained in the Shumagin region along the continental slope at depths of 300 - 1000 m. The maximum mean biomass of 22,017 kg/km² was found

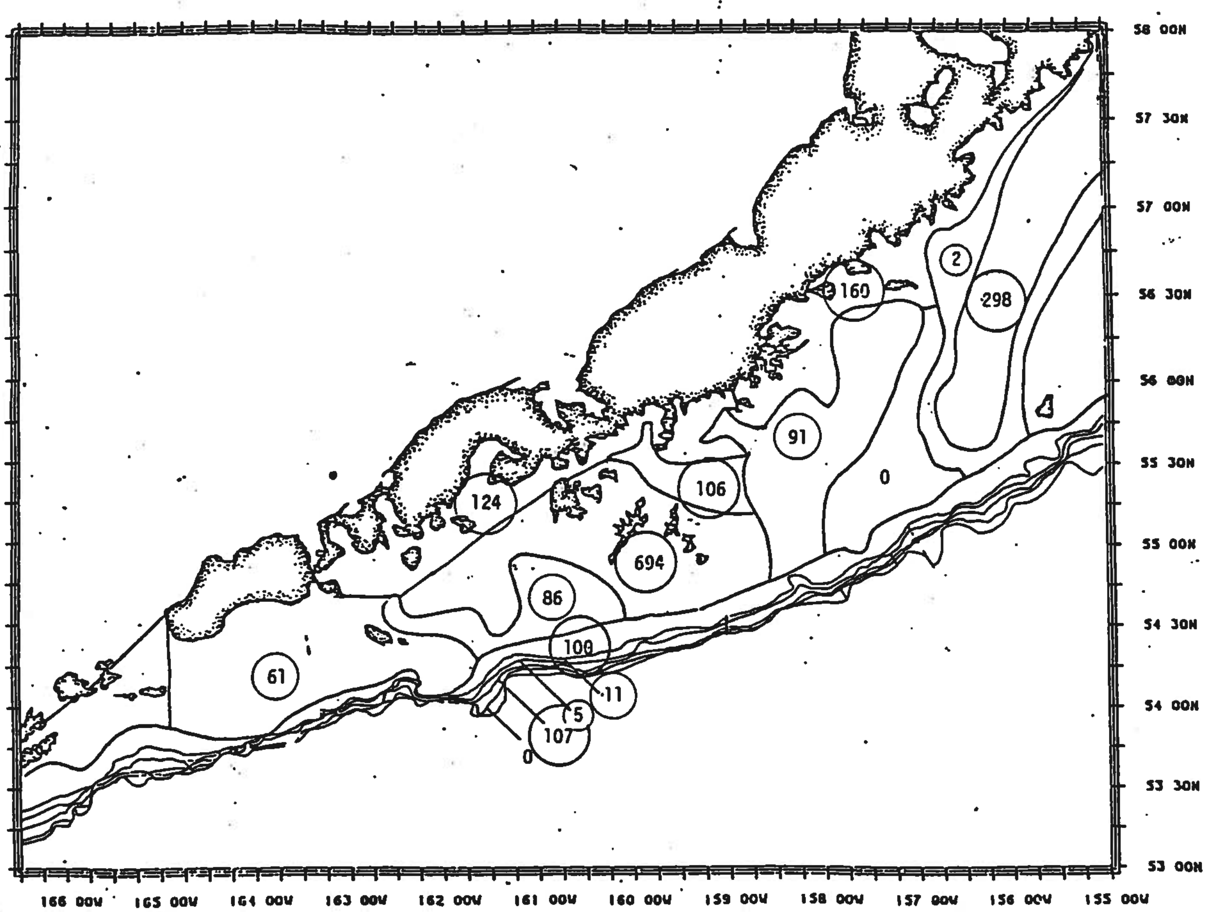

Figure 4.37. Biomass distribution (kg/km²) of skates (Rajidae) in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

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in the 500 to 700 m depth range (Figure 4.38). Another species, C. cinereus, has an estimated biomass of 10,898 mt in the western and central Gulf, with about 2,317 mt in the Shumagin region (E.S. Brown, p.c.). This species is most abundant along the slope at depths of 700 - 1000 m (1,010 kg/km²; Figure 4.39) and is probably also abundant at greater depths.

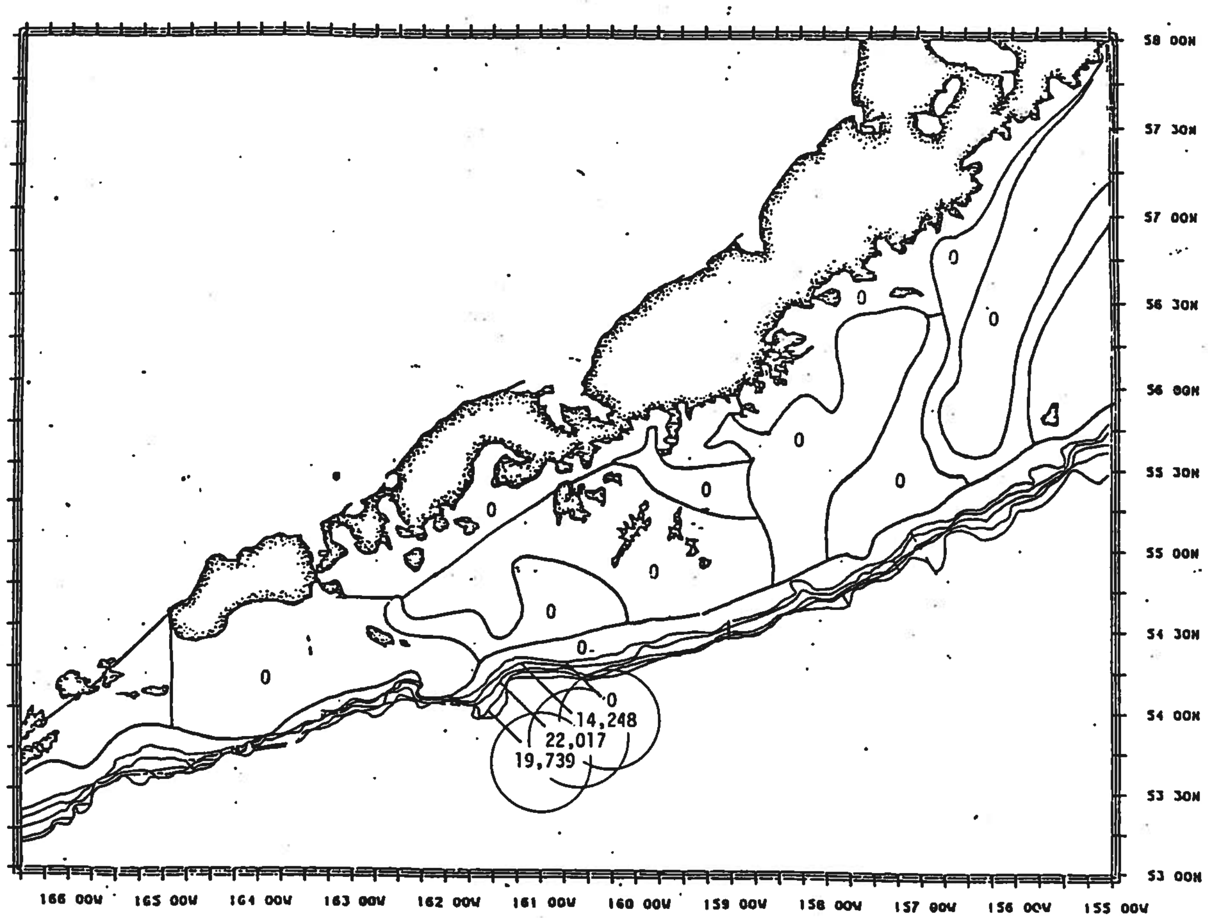

Figure 4.38. Biomass distribution (kg/km²) of giant grenadiers (Coryphaenoides pectoralis) in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

Steelhead Trout: Steelhead trout (Salmo gairdneri) are the anadromous form of rainbow trout. There is a run of steelhead trout in the Chignik River. Ocean-phase trout from as far away as Oregon and Washington origin have been captured in the offshore waters of the Shumagin region (Shepard, 1972), and may be using the Alaskan Gyre for their movements in the same manner as salmon. All information indicates that these fish occupy the upper 15 m of the water column during their ocean migrations.

Arctic Char: Arctic char (Salvelinus alpinus) occur throughout the Shumagin region, in nearly every watershed from freshwater streams and lakes, to

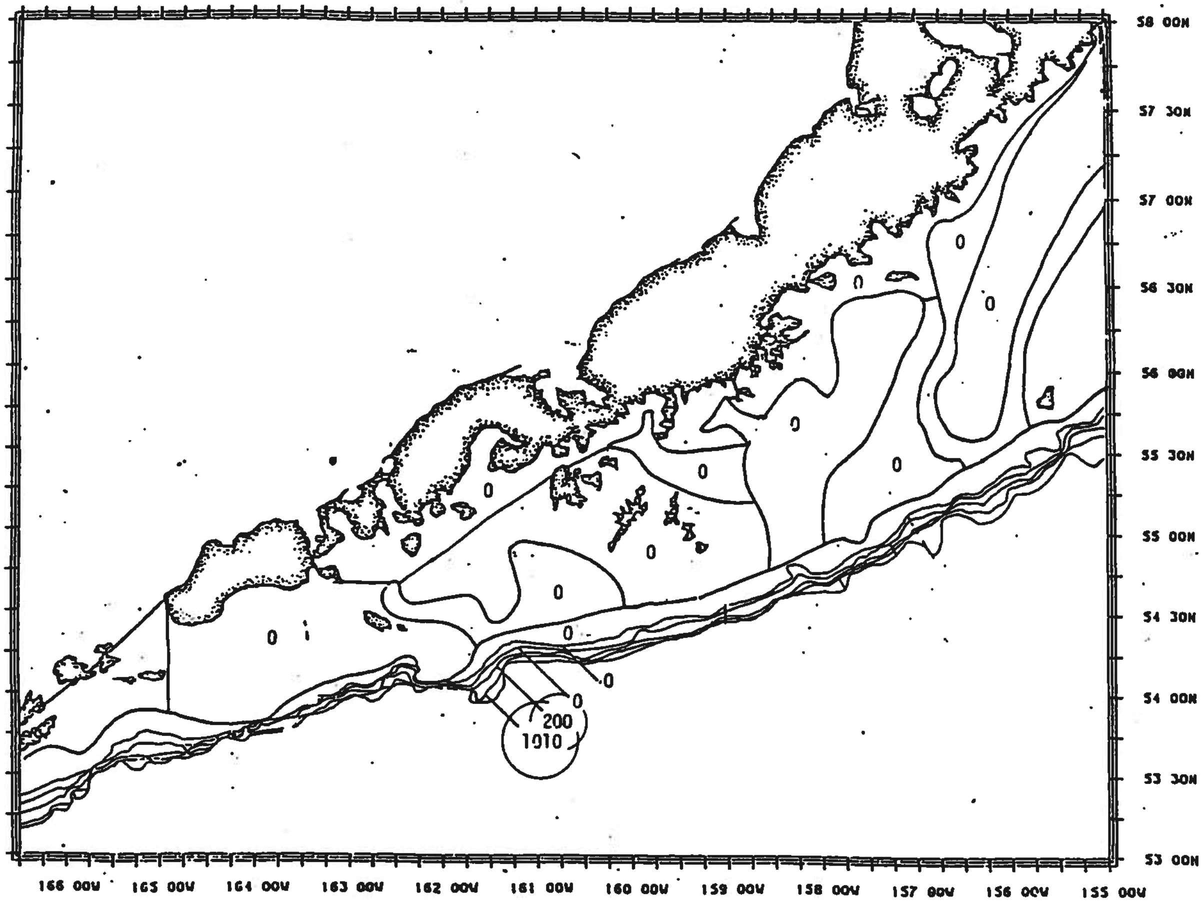

Figure 4.39. Biomass distribution (kg/km²) of Coryphaenoides cinereus in subareas of the Shumagin region based on the results of the 1984 U.S. - Japan Cooperative bottom trawl surveys (E. S. Brown, p.c.).

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brackish lagoons and nearshore marine waters. Young char live in freshwater systems for two to five years before beginning annual spring feeding migrations to coastal marine waters, and returning in the fall to freshwater spawning and overwintering areas. In the Chignik River system, the seaward migration occurs from April through June, returning to Chignik Lake and Black Lake from late July through September (BBCMP, 1984). The major portion of their annual diet is the small fish and invertebrate prey consumed in nearshore marine waters. Unlike salmon, char are repeat spawners, but it is estimated that mortality at first spawning may be 50 per cent or greater due to limited overwintering habitat.

4.5. Regional and Subregional Differences in Fish Biomass.

Certain regional and subregional differences in fish distribution and abundance are apparent from the information contained in the previous sections. These differences are related to the habitat preferences and environmental forces affecting fish distribution and life histories. The Shumagin shelf and slope is narrower and on the average shallower than the adjacent Chirikof and Kodiak regions, and this is reflected at least partially in the relative abundance and estimated biomasses of the demersal species sampled by the cooperative trawl surveys. These differences are presented in Table 4.19.

Alaska pollock is the dominant fish in both the Shumagin and Chirikof regions, but it is second in abundance to arrowtooth flounder in the Kodiak region (Table 4.19). Pacific cod are important in all three regions. Pacific ocean perch, yellowfin sole, and especially Atka mackerel are of relatively greatest importance in the Shumagin region, while Pacific halibut and Dover sole are less important compared to the Chirikof or Kodiak regions.

Within the Shumagin region, subregional differences also readily apparent (Table 4.20). Among the shallower shelf areas, Davidson Bank was dominated by pollock and cod, and was the area of greatest abundance of Atka mackerel and rock sole. Shumagin Bank was dominated by flathead and yellowfin sole and by cod, and had the highest biomass of skates. Semidi Bank was the least productive area in the region, and had very few pollock. The nearshore waters of the Lower Peninsula contained highest biomasses of yellowfin sole, and was also the area of highest average biomass of Myoxocephalus sculpins, starry flounder, and yellow Irish lords. The Upper Peninsula yielded highest abundance of flathead sole.

Along the deeper portions of the Shumagin Shelf, the Shelikof Edge was dominated by pollock, and had the highest mean biomass of Pacific halibut in the Shumagin region. Sanak Gully was dominated by catches of arrowtooth flounder and pollock, but was not the area of highest abundance of any of the species listed. The West Shumagin Gully contained the greatest abundances of Pacific cod, the dominant species in this area, and dusky rockfish. The East Shumagin Gully yielded the highest biomass of Alaska pollock.

Table 4.19. Ranked Order of Abundance of Groundfish in the Shumagin Region by Estimated Biomass (1000 mt) with Comparison to the Chirikof and Kodiak Regions (after Brown, 1985).

	Shumagin		Chirikof		Kodiak	
Resource	Rank	Biomass	Rank	Biomass	Rank	Biomass
Alaska pollock	1.	346	1.	370	2.	476
Pacific cod	2.	170	3.	132	4.	208
Arrowtooth flounder	3.	99	2.	341	1.	581
Giant grenadiers	4.	91	5.	84	7.	75
Sablefish	5.	73	4.	99	3.	218
Flathead sole	6.	60	7.	76	6.	131
Pacific ocean perch	7.	60	12.	20	8.	52
Rock sole	8.	54	11.	21	9.	48
Yellowfin sole	9.	53	17.	2	15.	21
Pacific halibut	10.	49	6.	83	5.	171
Northern rockfish	11.	42	16.	8	14.	25
Atka mackerel	12.	36	19.	0	19.	0.5
Shortspine thornyhead	13.	20	9.	25	13.	30
Rougheye rockfish	14.	14	14.	12	11.	38
Rex sole	15.	10	10.	23	12.	30
Shortraker rockfish	16.	8	18.	2	16.	11
Dusky rockfish	17.	6	15.	9	17.	10
Dover sole	18.	5	13.	16	10.	39
Pacific herring	19.	0.2	8.	33	18.	1
Totals		1196.2		1356		2165.5

Table 4.20. Abundance (in kg/km²) of the ten most abundant fishery resources in the subareas of the Shumagin Shelf and Slope based on the 1984 U.S. - Japan Cooperative Trawl Surveys (Data from E.S. Brown, p.c.).

Rank	Resource	kg/km²	Resource	kg/km²	Resource	kg/km²
	Davidson Bank		Shumagin Bank		Semidi Bank	
1.	Alaska Pollock	2,596	Flathead Sole	1,991	Arrowtooth Flndr	842
2.	Pacific Cod	2,544	Yellowfin Sole	1,285	Pacific Halibut	706
3.	*Atka Mackerel	1,586	Pacific Cod	1,225	Pacific Cod	545
4.	*Rock Sole	1,285	Rock Sole	894	Rock Sole	297
5.	Northern Rockf.	1,202	Pacific Halibut	706	Northern Rockf.	121
6.	Pacific Halibut	545	Arrowtooth Flndr	698	Flathead Sole	25
7.	Arrowtooth Flnd	536	*Skates	694	Dusky Rockfish	19
8.	Flathead Sole	349	Alaska Pollock	204	Dover Sole	3
9.	Y. Irish Lord	125	Dusky Rockfish	109	Tanner Crab	3
10.	Dusky Rockfish	107	Y. Irish Lord	99	Y. Irish Lord	3
	Lower Peninsula		Upper Peninsula		Shelikof Edge	
1.	*Yellowfin Sole	6,808	*Flathead Sole	5,565	Alaska Pollock	5,809
2.	Alaska Pollock	5,018	Alaska Pollock	4,317	Arrowtooth Flndr	5,165
3.	Pacific Cod	1,583	Arrowtooth Flndr	2,391	Pacific Cod	1,753
4.	Pacific Halibut	1,532	Pacific Cod	1,345	*Pacific Halibut	1,557
5.	Flathead Sole	1,353	Rock Sole	839	Pac. Ocean Perch	1,282
6.	Rock Sole	1,208	Pacific Halibut	766	Northern Rockf.	424
7.	*Myoxocephalus	237	Skates	160	Rex Sole	336
8.	*Starry Flounder	207	Starry Flounder	139	Flathead Sole	230
9.	*Y. Irish Lord	187	Myoxocephalus	73	Sablefish	155
10.	Arrowtooth Flndr	128	Rougheye Rockf.	38	Dover Sole	144
	Sanak Gully		West Shumagin Gully		East Shumagin Gully	
1.	Arrowtooth Flndr	3,004	*Pacific Cod	13,479	*Alaska Pollock	24,868
2.	Alaska Pollock	2,170	Alaska Pollock	9,342	Arrowtooth Flndr	5,753
3.	Pacific Cod	1,889	Arrowtooth Flndr	5,327	Pacific Cod	1,957
4.	Pacific Halibut	1,472	Flathead Sole	3,583	Flathead Sole	1,455
5.	Flathead Sole	1,400	Pacific Halibut	979	Pacific Halibut	962
6.	Northern Rockf.	482	Pac. Ocean Perch	547	Sablefish	287
7.	Rex Sole	214	*Dusky Rockfish	412	Rex Sole	131
8.	Rock Sole	145	Yellowfin Sole	196	Rougheye Rockf.	101
9.	Skates	86	Northern Rockf.	177	Dusky Rockfish	93
10.	Sablefish	75	Sablefish	171	Skates	91

(continued)

Table 4.20. (continued).

	Shelikof Trough		Slope 100 - 200m		Slope 201 - 300m	
1.	Arrowtooth Flndr	4,629	*Arrowtooth Flndr	8,620	*P. Ocean Perch	16,863
2.	Sablefish	3,845	Alaska Pollock	5,099	Alaska Pollock	9,043
3.	Alaska Pollock	1,011	*Northern Rockf.	3,136	*Sablefish	7,633
4.	*Rex Sole	989	Sablefish	3,029	*Shrtsp. Thrnyhd.	4,705
5.	Pacific Halibut	706	Pacific Cod	2,238	Arrowtooth Flndr	3,344
6.	Pacific Cod	587	Pacific Halibut	1,242	Rex Sole	931
7.	Pac. Ocean Perch	461	Rex Sole	445	Pacific Cod	459
8.	Skates	298	Rock Sole	265	Dover Sole	392
9.	Rougheye Rockfish	246	Dusky Rockfish	255	Rougheye Rockfish	235
10.	Dover Sole	201	Dover Sole	165	Northern Rockfish	144

	Slope 301 - 500m		Slope 501 - 700m		Slope 701 - 1000m	
1.	Giant Grenadier	14,248	*Giant Grenadier	22,017	Giant Grenadier	19,739
2.	Sablefish	7,523	Sablefish	5,004	Sablefish	3,719
3.	*Rougheye Rockf.	3,531	Shrtsp. Thrnyhd	1,925	Dover Sole	1,101
4.	Shrtsp. Thrnyhd	2,649	*Dover Sole	1,220	Shrtsp. Thrnyhd	1,091
5.	Arrowtooth Flndr	868	Coryph. cinereus	200	*Coryph. cinereus	1,010
6.	Rex Sole	704	Rex Sole	118	*Tanner Crab	53
7	Dover Sole	627	Skates	107	Arrowtooth Flndr	51
8.	*Shortraker Rockf.	290	Arrowtooth Flndr	102	Butter Sole	6
9.	*Squid	200	Rougheye Rockfish	20	Squid	1
10.	Pac. Ocean Perch	106	Squid	17	--	

*/ = The subarea of maximum abundance for the resource in the Shumagin region.

In the deeper waters of the Shelikof Trough and continental slope, pollock and cod become less abundant and are replaced by members of the deepwater fish assemblages. In Shelikof Trough, arrowtooth flounder and sablefish dominate, and rex sole are found in their highest average biomass. The outer shelf - slope between 100 and 200 m is the area of greatest abundance of arrowtooth flounder, the dominant species, as well as northern rockfish. Pacific ocean perch are in highest abundance at slope depths of 201 - 300 m; this is the only area where they dominate the fish community. Sablefish and shortspine thornyheads were also most abundant between these depths. At depths of 301 - 500 m along the slope, giant grenadiers become predominant, and rougheye rockfish, shortraker rockfish, and squid are found in their highest biomasses.

Between 501 - 700 m, giant grenadiers are again dominant and reach their highest abundances (22 mt/km^2), rivaling the peak biomass achieved by Alaska pollock (24.9 mt/km^2) in the East Shumagin Gully. Dover sole was also found in highest abundance at these depths. In the deepest slope waters between 701 - 1000 m, giant grenadiers continue to dominate the deepwater fish assemblage, while Coryphaenoides cinereus and Tanner crabs were also sampled in their highest biomass levels.

Among all species of fish examined, only arrowtooth flounder were ubiquitous in all areas and depth ranges from the Lower Peninsula to the 700+ m depths of the outer slope.

5. MARINE MAMMALS OF THE SHUMAGIN REGION

Marine mammals are an important component of the marine ecosystem of the Shumagin region. Of the 116 species of marine mammals in the world oceans, there are 21 species that can be considered to be regular inhabitants or migrants in the Shumagin region, and 5 species that are vagrants to the region (Table 5.1). The northern sea lion, northern fur seal, harbor seal, sea otters, harbor porpoises, Dall's propoises, killer whales and goosebeak whales occur in the Shumagin region year-round, the others are migrants and seasonal visitors. These marine mammals of the Shumagin region can be loosely classified into coastal species with some association with land, i.e. seals, sea lions, and sea otters; and pelagic species that include the whales and porpoises.

The following sections highlight pertinent basic information for the various species, and attempt to portray more detailed information concerning each species' natural history within the Shumagin region. For fuller discussions of the life history and biology of these species, the reader is referred to other pertinent publications. A more complete discussion of nearly all these species is contained in Morris et al. (1983).

5.1. CETACEANS.

The Shumagin region is important seasonally for a number of whale species. Some species summer and feed in the region, while others migrate through the area to and from more distant feeding or calving grounds. Included in this list are seven species of endangered whales: gray, right, fin, sei, blue, humpback and sperm whales. Detailed discussions of the biology of each of these endangered whales has recently been published in "The Status of Endangered Whales", Marine Fisheries Review Vol 46(4), 1984.

5.1.1. Gray Whales.

Gray whales (Eschrichtius robustus) of the California stock migrate through coastal waters of the Shumagin region in the spring (April through June), passing through Unimak Pass on their way to their summer feeding areas in the

Table 5.1. List of Marine Mammals and Their Seasons of Occurrence in the Shumagin Region. C = Common, A = Greatest Abundance, F = Few, R = Rare Visitor, - = Not Known or Expected to Occur, ? = No Recent Data Available.

Common Name	Species Name	Season Winter Jan-Mar	 Spring Apr-Jun	 Summer Jul-Sep	 Autumn Oct-Dec
Cetacea					
Right whale	Balaena glacialis	-	R	F-R	R
Fin whale	Balaenoptera physalus	R	C	A	R
Sei whale	Balaenoptera borealis	R	A	C	R
Blue whale	Balaenoptera musculus	-	R	F	R
Minke whale	Balaenoptera acutorostrata	?	A	A	?
Humpback whale	Megaptera novaeangliae	R	C	C	C
Gray whale	Eschrichtius robustus	A	C	F	C
Sperm whale	Physeter macrocephalus	-	F	C	C
Killer whale	Orcinus orca	C	C	C	C
Short-finned pilot whale	Globicephala macrorhynchus	-	-	R	-
Dall's porpoise	Phocoenoides dalli	C	C	C	C
Harbor porpoise	Phocoena phocoena	C	C	C	C
Pacific white-sided dolphin	Lagenorhynchus obliquidens	R	C	A	R
Risso's dolphin	Grampus griseus	R	R	R	-
Northern right whale dolphin	Lissodelphis borealis	-	-	R	-
Giant bottlenose whale	Berardius bairdii	?	R	R	?
Goosebeak whale	Ziphius cavirostris	C	C	C	C
Bering Sea beaked whale	Mesoplodon stejnegeri	?	?	?	?
White whale	Delphinapterus leucas	R	R	R	R
Carnivores					
Northern sea lion	Eumetopias jubatus	C	C	C	C
Northern fur seals	Callorhinus ursinus	C	A	C	A
California sea lion	Zalophus californianus	-	-	R	-
Harbor seal	Phoca vitulina	C	C	C	C
Northern elephant seal	Mirounga angustirostris	-	R	R	-
Walrus	Odobenus rosmarus	R	R	R	R
Sea otter	Enhydra lutris	C	C	C	C

Bering and Chukchi Seas, and return again in the late fall - early winter (October through December) on their southward migration to breeding areas off California and Mexico (Rice et al., 1984). Most of these movements are within a few miles of shore. Near land, they typically remain within 2 km of the coast; most of the animals are seen within 1 km of shore. At least 3/4 of their population (estimated at between 13,450 to 19,210 - Rice et al., 1984) passes through the Shumagin region twice annually. Unimak Pass, particularly along the western shore of Unimak Island, is vitally important for their migrations.

Little sighting information has been published for gray whales in the Shumagin region. Data from Kodiak and Unimak Pass for spring and fall are much better, and from this information it is apparent that the migration route should take them directly through the Shumagin lease area (H. Braham, p.c.). It is unknown where most whales cross the gap between Kodiak Island and the Alaska Peninsula, but, as about 75 per cent of the gray whale population appears to migrate along the south side of Kodiak Island, their path may include an offshore divergence in their migration route. In the spring migration, it is uncertain how many whales swim directly from the southwest tip of Kodiak Island to Unimak Island, or whether they intercept the south side of the Alaska Peninsula somewhere between Cape Providence and Chignik Bay. Leatherwood et al. (1983) report that two gray whales seen off the Trinity Islands were headed north toward the Peninsula. The path of their spring migration, if it follows the irregular southern coast of the Alaska Peninsula, is also uncertain. A few recent sightings of gray whales have been reported in nearshore areas along the south side of the Peninsula between 156° and 160°W (Leatherwood et al., 1983). It is unknown whether these whales follow bottom contours or topographic features on land, or whether they enter bays or pass from headland to headland.

Gray whales feed on benthic invertebrates, primarily amphipods and other small crustaceans. It is also not known if feeding occurs to any extent.

Presumably, the same paths in the opposite direction are taken in the fall, but this is undetermined. Recent aerial surveys conducted in November and December of 1985 found gray whales along most of the coast of the Alaska

Peninsula, usually very near shore (G. Wheeler, p.c.). They appear to follow headlands and to cross the mouths of major bays. Several gray whales were sighted offshore also, to as far as 100 nm from land. Some whales were observed near the Semidi Islands, indicating that at least in the fall, many whales cross Shelikof Strait in the vicinity of Castle Cape.

The best information suggests that gray whales will first be abundant in the Shumagin region in early May. They begin to appear as early as March and are still seen into July (H. Braham, p.c.). A few whales may even inhabit the area in the summer as they have been reported near Kodiak Island and in Shelikof Strait (Leatherwood et al., 1983). In autumn, they begin reappearing in the Shumagin region as early as October and are abundant in late November and December.

It will be important for this lease sale to determine the migration paths more accurately. Most whales should migrate in or near the islands or between the islands and the coast. Aerial surveys out of Sand Point or Cold Bay would help further determine the specific routes taken by the whales, and delineate the breadth or narrowness of the migration corridor. Local pilots may be able to provide much of this information.

5.1.2. Right Whales.

The Pacific right whale (Balaena glacialis) is a summer migrant to Alaska waters. This species is the world's most endangered large cetacean. The population is severely depleted by commercial whaling in the 19th and early 20th centuries, and may now number no more than 100 individuals in the North Pacific. Historic summer feeding areas used by this whale were in shelf and coastal waters ranging from the Gulf of Alaska to the Bering Sea. The western Gulf of Alaska was historically the most productive area for the whaling effort for right whales. Most of the sightings of right whales in the North Pacific in recent decades have been made in the area immediately south of Kodiak Island (Rice and Wolman, 1982) and in waters within approximately 100 km radius of the Aleutian Islands and Alaska Peninsula west of 158°W from May to August (Leatherwood et al., 1983). There have been no recent sightings of right whales in the Shumagin region, and further surveys should be conducted in the summer to determine their possible presence in the proposed lease area.

Right whales have elongate and finely fringed baleen plates, and feed primarily in surface waters on small zooplankton such as copepods (Lowry et al., 1982).

5.1.3. Fin Whales.

Fin whales (Balaenoptera physalus) are relatively common pelagic whales of the outer shelf and continental slope. The estimated size of the North Pacific population is 14,620 to 18,630 (Mizroch et al., 1984a). There are generally considered to be two stocks of fin whales in the North Pacific, one on each side of the ocean (Lowry et al., 1982). The North American stock migrates from Mexico to Alaska waters, to as far north as the Chukchi Sea, in the spring and summer to feed. The Shumagin shelf has been a traditional whaling area for fin whales, and continues to provide records of numerous fin whale sightings during the warm months.

Although fin whales usually are found singly or in small groups, loose feeding aggregations estimated at a hundred or more fin whales have been observed on the Shumagin shelf (D. Stewart, p.c.). Large concentrations of fin whales were also recently reported for lower Shelikof Strait in late spring and summer (Leatherwood et al., 1983). Aerial surveys in July and August, 1985 found fin whales in groups of up to 25 individuals along the Shumagin Shelf, particularly in the waters between the Semidis and Mitrofania Island (G. Wheeler, p.c.).

Fin whales, like minke and humpback whales, have relatively thick and coarse baleen fringes, and feed on both large zooplankton (euphausiids and large copepods), squids, and small schooling fish such as capelin, pollock, and herring (Lowry et al., 1982; Mizroch et al., 1984a; Kajimura and Loughlin, in press).

5.1.4. Sei Whales.

Sei whales (Balaenoptera borealis) range across the North Pacific Ocean from Alaska to Japan. The northernmost part of their summer feeding range reaches the shelf and continental slope of the Shumagin region, and although they are believed to be common, their specific distribution in the region is poorly known. The size of the North Pacific population is estimated at 22,000 to 37,000 whales. There may be three separate stocks of sei whales in the North Pacific (Mizroch et al., 1984b), of which the central stock, that ranges between 175° and 155°W, would migrate to the Shumagin Shelf during June through August or September.

Based on information for sei whales in other oceans, it is the pregnant females that travel to the highest latitudes, and would thus be expected in Alaska waters (Mizroch et al., 1984c). They also are nomadic whales, being found in small groups or as solitary individuals. Aerial surveys conducted in 1985 found no sei whales in the Shumagin region (G. Wheeler, p.c.).

Sei whales have have relatively fine baleen fringes and feed mainly on large copepods, but also consume larger zooplankton (i.e. euphausiids), squids, and small schooling fish (Lowry et al., 1982).

5.1.5. Blue Whales.

Blue whales (Balaenoptera musculus) of the North Pacific stock occur as far north as the Shumagin region from May through September. The offshore waters of the region is part of the Aleutian summer feeding area of blue whales. Whalers took about 50 blue whales a year in the waters south of the Aleutians up to 1930 (Mizroch et al., 1984c). The Davidson Bank area was a center for these whaling activities, and it may still be an important summer feeding area for blue whales. The 1985 aerial surveys of the Shumagin region did not locate any blue whales, however (G. Wheeler, p.c.). The current estimate of their population size in the North Pacific is 1,600 (range 1,400 to 1,900), but this remains to be verified by censusing.

These largest of the whales, feed on plankton and concentrate in productive upwelling areas. Like most balaenopterids, they are nomadic, and have no well defined social or schooling structure. They generally occur as solitary individuals or small groups (Mizroch et al., 1984c). Blue whales have relatively finely fringed baleen plates suited for feeding on euphausiids (krill) which they do almost exclusively.

5.1.6. Humpback Whales.

Humpback whales (Megaptera novaeangliae) range throughout the Gulf of Alaska and Aleutians in the summer. High densities have been reported from south of the Aleutians and from Unimak Pass eastward (Leatherwood et al., 1983). They can be expected in the Shumagin region from May through October, most commonly in nearshore areas with abundant forage fish populations. The 1985 aerial surveys found humpback whales at several locations across the Shumagin Shelf from nearshore coastal waters to as far offshore as 120 nm from August through November (G. Wheeler, p.c.).

It is not known from which wintering area(s) these humpbacks originate. Tagging has shown that some, at least, winter in the Ryuku and Bonin Islands area of the western North Pacific (Johnson and Wolman, 1984).

Historically, large numbers of humpback whales used this area but were removed by Russian whaling fleets in the early 1960's. The pre-exploitation population in the North Pacific was probably around 15,000 and is now about 1,200 or 8 per cent of its former size (Johnson and Wolman, 1984). The Asian wintering component of this population is probably less than 100 individuals. If the population recovers, increased numbers of humpback whales could be expected to use the Aleutian Islands - Alaska Peninsula area again (H. Braham, p.c.).

Humpbacks feed on large zooplankton (krill, copepods, and other crustaceans) and small schooling fish such as herring, sand lance, capelin, juvenile salmonids, and young pollock (Johnson and Wolman, 1984).

5.1.7. Sperm Whales.

The sperm whale (Physeter macrocephalus) ranges northward to the Shumagin region in the spring and summer. Formerly they appear to have been widespread throughout the Gulf of Alaska, but their present center of abundance appears to be west of the Shumagin region in the Aleutian Chain. They are mainly a deepwater whale and feed primarily in open ocean and continental slope waters. They probably appear regularly in the Shumagin area in waters beyond the shelf edge. The 1985 aerial surveys found sperm whales along the continental slope of the Shumagin region in July and August (G. Wheeler, p.c.).

The eastern North Pacific stock of sperm whales, exclusive of calves and juveniles has recently been estimated at 274,000 of which there are an estimated 111,400 mature males age 13 and older, and 162,000 mature females (Gosho et al., 1985). Most of the sperm whales that migrate as far as the Aleutians and into the Bering Sea are the large, often solitary bachelor males. The highly social females and juveniles remain farther south (to about 50°N) in warmer waters.

Sperm whales are long-lived animals, reaching up to 60 years or more in age. Males reach a length of 17 m; females rarely exceed 12 m (Kajimura and Loughlin, in press). Gestation lasts about 15 months, and lactation about 2 years. As such, females produce calves only every 4 or 5 years.

Sperm whales feed primarily on medium to large-sized mesopelagic squids, but also, usually in higher latitudes, take demersal fishes such as deepwater sharks, sablefish, skates, rockfish (Gosho et al., 1984; Kajimura and Loughlin, in press). Their principal food in the Gulf of Alaska appears to be fish. Squid content of sperm whale stomachs from the Gulf of Alaska averaged 32 per cent, while in the Bering Sea - Aleutians area it was from 71 to 94 per cent.

5.1.8. Non-endangered Cetaceans.

Minke Whales: Minke whales (Balaenoptera acutorostrata) are the most common small whale in the Shumagin region and elsewhere in the Gulf of Alaska. Population estimates however, are not available for the North Pacific. Minkes are generally migratory, appearing in coastal waters of the Gulf of Alaska in the spring and migrating south in the fall. They are most abundant in the Aleutians and along the Alaska coast in May to July (Lowry et al., 1982).

They often inhabit shallow waters close to coasts, but are also common offshore (Morris et al., 1983). Often they concentrate in areas of abundant food, feeding chiefly on forage fishes such as capelin and herring, but also consuming macrozooplankton (i.e. euphausiids) when abundant (Lowry et al., 1982).

Pacific White-Sided Dolphin: This oceanic cetacean (Lagenorhynchus obliquidens) ranges from Alaska to Baja California, and may occasionally be found in the Shumagin region. Incomplete population estimates for the eastern North Pacific range from 30,000 to 50,000 animals (DOC, 1984). In the Gulf of Alaska, it is common in continental shelf and slope waters in spring and summer (Morris et al. 1983). Their range is believed to extend westward through the Shumagin and Aleutian areas. The species is highly gregarious and usually travels in schools of hundreds to thousands of individuals.

Their diet in the Gulf of Alaska is not known (Kajimura and Loughlin, in press) but is probably similar to that off Washington and Oregon where they consume small schooling fishes and squids from the surface to mid-water depths. Since they occur both in open ocean and continental shelf waters, their diet undoubtedly varies with location and season.

Killer Whale: Killer whales (Orcinus orca) range throughout the Gulf of Alaska and Bering Sea year-round. They are common in continental shelf waters, and may appear in bays, harbors and coastal waters of the Shumagin region year-round. They also frequent offshore waters along the shelf edge and continental slope. A minimum population estimate for killer whales in the Gulf of Alaska is 286, with 96 whales in southeast Alaska, 173 in Prince William Sound, and 17 in Shelikof Strait (Leatherwood et al, 1984). Additional whales probably also occurred in coastal areas not surveyed and offshore. Estimates for the Shumagin region, Aleutians, and Bering Sea are not available. Peak abundance in the Shumagin region appears to be from March through October.

The presence of killer whales in an area is usually related to availability of their prey: fish and other marine mammals. They feed in both coastal and shelf waters, and are opportunistic feeders. Their diverse diet in the eastern North Pacific includes sharks, fishes (salmon, flounder, cod), squids, sea birds and marine mammals including both cetaceans and pinnipeds (Lowry et al., 1982; Kajimura and Loughlin, in press).

Harbor Porpoise: The harbor porpoise (Phocoena phocoena), is the smallest cetacean in Alaska. It is a coastal species of ice-free subarctic waters in both the North Pacific and North Atlantic. In the North Pacific it ranges from California into the Bering Sea, and across to the U.S.S.R. and Japan. It is a year-round resident in the Shumagin region, being common in bays, inlets and other shallow areas along the coast. Populations densities are relatively low, with most sightings being of individuals or pairs. They may occasionally be found up to 40 km or more from shore. Population estimates for the North Pacific are not available.

Harbor porpoise feed in coastal waters on a variety of small, nonspiny schooling species of fish, primarily clupeids such as herring, small cod and pollock, and on squids (Kajimura and Loughlin, in press).

Dall's Porpoise: The Dall's porpoise (Phoecoenoides dalli) is the most common cetacean in Alaska waters, ranging throughout the North Pacific and Bering Sea south of the winter pack-ice edge. The estimated size of the North Pacific population (excluding Washington, Oregon and California) is 837,460 to 1,342,518 animals. Between 136,671 and 253,865 animals inhabit the Gulf of Alaska (Bouchet, 1981). In the Shumagin region, they occur nearshore, but are considered most abundant in offshore waters near and beyond the shelf break (Leatherwood et al., 1983). They are present at all times of the year but appear to be most numerous during summer. They usually are seen in groups of two to five individuals but sometimes these groups may contain as many as several hundred. They are rarely solitary.

Dall's porpoise are subject to considerable mortality from entanglement in gill nets used by the Japanese high seas salmon fisheries. Prior to 1978, the reported incidental take in this drift gillnet fishery reached as high as 20,000 per year. Since 1978, the highest takes found by NMFS was 6,000 in 1982, and the lowest was 3,000 in 1983. During 1985, the estimated incidental take of the species by this salmon fishery was 2,700 animals inside the U.S. Fishery Conservation Zone (MMC, 1986).

Feeding data for Dall's porpoise is available from those animals incidentally caught in the Japanese fishery (Lowry et al., 1982; Kajimura and Loughlin, in press). They feed in both shelf and oceanic waters. In shelf waters of the Gulf of Alaska, they are known to eat capelin, pollock, and sand lance. In the central North Pacific they have been found to feed almost exclusively on gonatid squid (90 per cent of total stomach contents examined) and myctophid fish.

Beluga Whales: The beluga or white whale (Delphinapterus leucus) inhabits both the Bering Sea and Arctic ocean and there is a small isolated population in Cook Inlet. Few, if any Bering Sea whales would be expected in the Shumagin region, although they have been sighted in False Pass (AECRSA, 1984). The Cook Inlet population of 300 - 500 whales winters in lower Cook Inlet and Shelikof Strait and may reach the extreme northeastern edge of the Shumagin planning area. Leatherwood et al. (1983) report one sighting near the southwest entrance to Shelikof Strait.

Beluga whales feed in coastal waters on a variety of fish and shellfish, depending on location and season. In the Gulf of Alaska they are believed to consume herring, other schooling fish such as smelt and juvenile salmon, and also squid, crustaceans, and other suitable prey (Lowry et al., 1982; Kajimura and Loughlin, in press).

Goosebeak Whale: The goosebeak whale (Ziphius cavirostris), also known as Cuvier's beaked whale, is widely distributed in all major oceans except for polar areas. In the North Pacific it is distributed from the Bering Sea to the tropics. It may be the most abundant beaked whale in the Gulf of Alaska (Kajimura and Loughlin, in press). It is primarily an oceanic species. Stomach contents appear to vary according to geographic area, but are believed to be almost exclusively squid and some deep-sea fish.

Other Cetaceans: Other whales and porpoises that may irregularly be found in the Shumagin region are the short-finned pilot whale, Risso's dolphin, northern right whale dolphin, North Pacific giant bottlenose whale, and Bering Sea beaked whale.

5.2. PINNIPEDS.

5.2.1. Northern Sea Lion.

The northern or Steller's sea lion (Eumetopias jubatus) ranges across the North Pacific and Bering Sea from the Kuril Islands to California (Schusterman, 1981). Its center of abundance is in the Gulf of Alaska and Aleutian Islands. Recent estimates of the world population range between 245,000 to 290,000, with about 200,000 in Alaska waters (Loughlin et al., 1984). It is one of the most important marine mammals of the Shumagin region, occurring there throughout the year. Although more common in coastal waters within 25 km of shore, sea lions may also frequent offshore fishing banks. Large groups may be seen far from land in association with commercial fishing activities. However, they can not be considered truly pelagic as are northern fur seals.

Northern sea lions are the largest of the eared seals. Adult males weigh about one metric ton and average 2.8 meters in length. Females are considerably smaller, averaging 270 kg and 2.4 m (Kajimura and Loughlin, in press). Age of sexual maturity is 4 to 5 years for females and 5 to 7 years for males. Males do not successfully defend breeding territories, however, until they are about age 9.

Sea lions are gregarious and polygynous, and utilize traditional breeding and pupping rookeries and haul-out locations which are usually located on remote islands or rocky, inaccessible coasts (Kajimura and Loughlin, in press). Loughlin et al. (1984) identified 51 existing rookeries from the Kuril Islands to California. The rookery and haulout areas in the Shumagin region are found on a variety of habitat substrates ranging from sand to boulder-strewn beaches, to bedrock ledges. Most often these locations are chosen on exposed points or isolated small islands.

Populations of sea lions in the Gulf of Alaska to central Aleutians have declined 52 per cent from approximately 140,000 animals in 1960 to 68,000 animals in 1985 (H. Braham, p.c.). Since 1975, the decline has exceeded 5 per cent annually. Their present numbers are currently less than one half of 1960's levels. Recent surveys (1985) of sea lion numbers in the area from Cape Sitkinak to Unimak Pass indicate a population of under 14,000, and less than 100,000 for the entire Gulf of Alaska. The causes of this decline are uncertain, but could be due to factors such as entanglement in fishing gear, both active and lost or discarded, and to depletion or changes in availability of important food species due to commercial fisheries (MMC, 1986). Recent studies indicate that juvenile mortality is the greatest contributor to their decline (H. Braham, p.c.).

Northern sea lions disperse widely throughout their range during fall and winter, and are frequently seen near coasts and out to the continental shelf edge. Adults begin to gather on their breeding rookeries in mid- to late May. The dominant bulls establish territories and gather harems of 14 to 17 sexually mature and pregnant females. Pupping generally occurs in these defended territories between mid-May to mid-July, peaking in mid-June. Females breed again within 7 to 10 days of giving birth. As the breeding season wanes in early July, the adults begin to desert their territories and return to sea. An estimated 40 per cent of the population is at sea at any given time during the summer (BBCMP, 1983). Although rookeries are occupied year-round, the numbers of sea lions present decreases in the winter when many sea lions leave the rookeries in favor of more protected waters located in favorable feeding areas.

Not all sea lions occupy rookeries during the breeding season. Immature and nonbreeding adults occupy hauling grounds, generally located adjacent to the rookeries. Males and females without pups may establish breeding territories in these haulout areas, but few pups are born in haulout areas. Other locations that may be used irregularly for coming ashore are called stop-over sites.

The locations of identified rookery, haulout, and stop-over sites in the Shumagin region are given in Figure 5.1. Chowiet Island, the larger southern

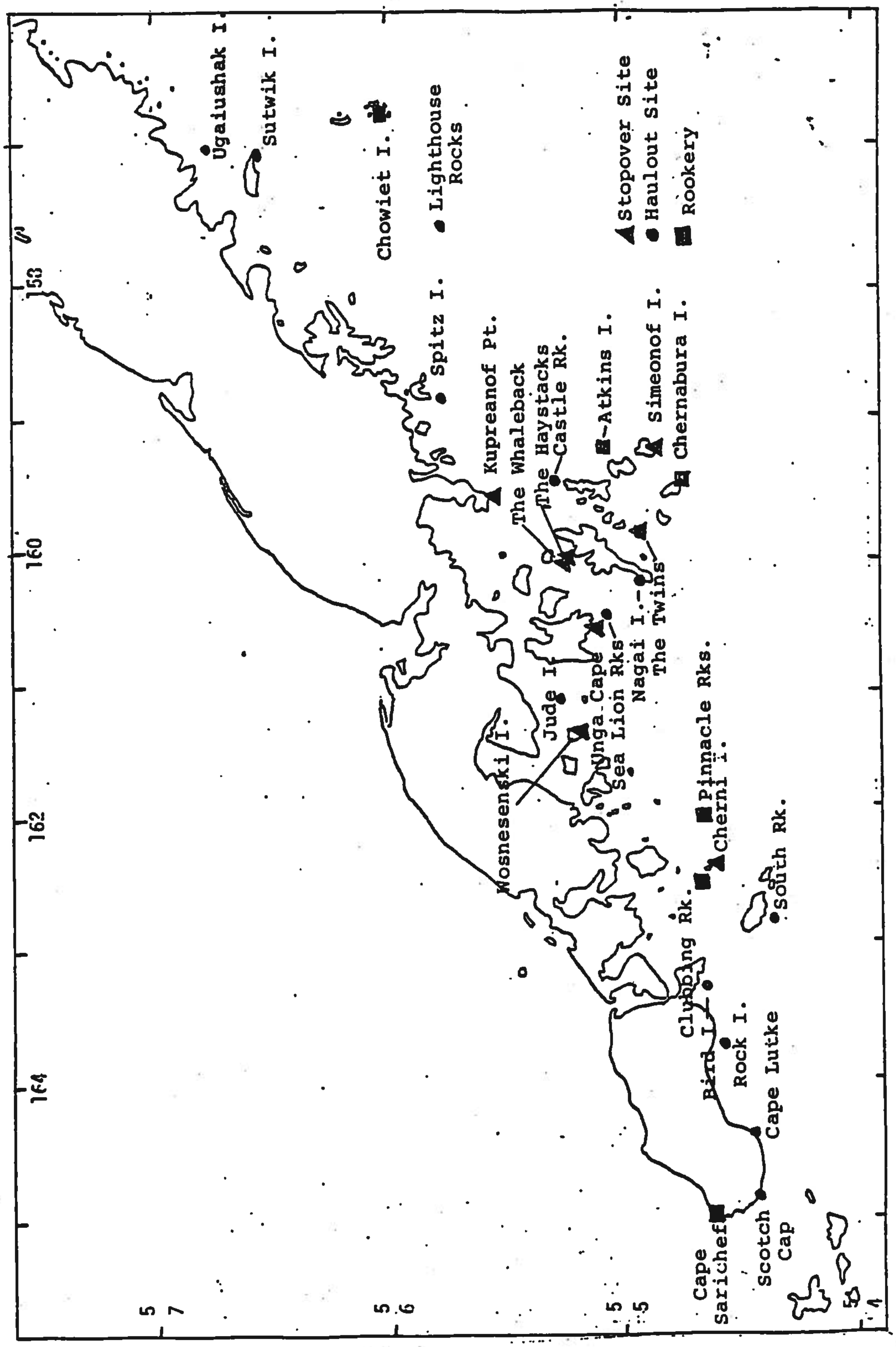

Figure 5.1. Locations of northern sea lion rookeries, haulout sites, and stop-over sites in the Shumagin region.

island of the Semidi Islands, is the major rookery and haulout location for sea lions in the Shumagin region. Other important rookeries are on Atkins Island, Chernabura Island, and Pinnacle and Clubbing Rocks in the Sandman Reefs. These are five of the ten most important sea lion rookeries in the entire Gulf of Alaska (AECRSA, 1984). NMFS resurveyed all these rookery and haulout sites in June of 1985. The counts obtained for each location during that survey are presented in Table 5.2, along with counts from previous years when available. These counts demonstrate a continuing decline in the sea lion population (H. Braham, p.c.).

As high as 25 percent of the adult females fail to breed each year. Sea lion pups can swim within hours of birth but generally remain ashore and nurse for about one month before entering the sea. More than half of these new pups die during their first year, due to drowning, malnutrition, disease, abandonment, or to predators.

Feeding locations of this species have not been identified, but probably coincide with areas of high fish distribution and abundance. Their principal feeding areas are on the continental shelf and coastal waters. Sea lions feed primarily at night on a wide variety of fish, octopus, squid and crustaceans. Squid and pollock are most important in the Gulf of Alaska (Table 5.3). Other fish, including cod, capelin, rockfish, greenling, herring, are also common components of their diet (Kajimura and Loughlin, in press). In the Alaska Peninsula area, salmon account for approximately 6.3 per cent of their diet.

5.2.2. Northern Fur Seal.

Northern fur seals (Callorhinus ursinus) are probably found in the offshore waters of the Shumagin region in small numbers during most of the year. These seals winter in the North Pacific, as far south as Mexico, and summer in the Bering Sea. Most of the adult breeding males remain in the Bering Sea and Gulf of Alaska each winter, while females and juveniles migrate further south. Most seals spend about half the year at sea (November through May or June), and the remainder of the year (July through October) on or near their breeding grounds. They are most frequently found within 70 to 130 km of land along the continental shelf and slope, usually as solitary animals but occasionally in groups up to 100.

Table 5.2. Population Counts from Northern Sea Lion Rookeries, Haulout Areas, and Stop-over Sites in the Shumagin Region from 1978 to 1985 (from H. Braham, p.c.)

Location	1978	1979	1985
Chowiet Island (R)	4419	4441	2059
Chirikof Island (R)	3699	5199	2346
South Rock	1320	--	892
Clubbing Rocks (R)	2661	1162	1251
Pinnacle Rock (R)	3692	2731	1588
Nagai Island	--	--	183
Chernabura Island (R)	2758	1504	487
Jude Island	--	--	315
Sea Lion Rocks	--	--	377
Atkins Island (R)	3943	5000	1562
Castle Rock	541	--	12
Spitz Island	--	--	645
Sutwik Island	--	--	224
Ugaiushak Island	--	--	166
Total	23,033	20,037	12,107

Small numbers of non-breeding or immature animals may remain in the North Pacific during the summer while the majority of the population is on the breeding grounds on the Pribilof Islands. Highest numbers are present across the Shumagin shelf in late fall (November-December) and in the spring (April to June) during their migrations between the Pribilof Islands and California. Unimak Pass is the major migratory route for the species.

The northern fur seal population is presently declining at a rate of about 8 per cent a year. In the 1940's and 1950's, over 400,000 were born annually on the Pribilof Islands. The population of the Pribilof Islands now numbers about 750,000, or about half the population level of the mid-1970's, and nearly down to one-third of the two million animals in the early 1950's. This is below the optimum sustainable population level, and if the decline continues, the population will decline to less than half its present size in seven to ten years (MMC, 1986).

Table 5.3. List of Rookeries, Haulout Sites, and Stopover Locations Used by Northern Sea Lions in the Shumagin Region of the Gulf of Alaska (after AECRSA, 1984).

Location	Number of Sea Lions[1/]
Rookeries:	
Chowiet Island	-
Atkins Island	1211 - 9500+
Chernabura Island	1437 - 3303
Pinnacle Rock	141 - 5479
Clubbing Rocks	0 - 5600
Cape Sarichef	-
Haulouts:	
Spitz Island	25 - 700
Lighthouse Rocks	1078 - 1315
Castle Rock	189 - 541
Nagai Island	15 - 405
Sea Lion Rocks	187 - 400
Jude Island	0 - 3000
South Rock	972 - 3200
Bird Island	0 - 260
Rock Island	25 - 54
Cape Lutke	22
Scotch Cap	-
Stop-overs:	
Kupreanof Point	-
The Whaleback	-
The Haystacks	-
Unga Cape	-
Simeonof Island	-
The Twins	-
Wosnesenski Island	-
Cherni Island	-

1/ Includes high and low numbers reported during all seasons of observation (source Calkins and Pitcher, 1982).

Table 5.3. Rankings for Preferred Prey of Three Abundant Pinniped Species in the Gulf of Alaska (after Kajimura and Loughlin, 1985).[a/]

Rank	Northern Sea Lion	Northern Fur Seal	Harbor Seal
1.	Alaska pollock	Pacific sand lance	Alaska pollock
2.	Squids (general)	Capelin	Octopuses
3.	Pacific herring	Pacific herring	Capelin
4.	Capelin	Squids (Gonatidae)	Eulachon
5.	Pacific cod	Squids (Gonatidae)	Pacific herring
6.	Pacific salmon	Alaska pollock	Pacific cod
7.	Octopuses	Pacific salmon	Flounders
8.	Sculpins	Rockfishes	Shrimps
9.	Flounders	Atka mackerel	Pacific salmon
10.	Rockfishes	Pacific cod	Squids (general)

[a/] Rankings are by combination rank index for sea lions, modified volume index for fur seals, and index of relative importance for harbor seals.

Possible causes for the alarming decline are believed to include increased mortality due to entanglement in discarded or lost fishing gear and other debris, disease, and to decreasing food supply due to fishing or natural cycles. Juvenile mortality appears to be a major factor as it is with northern sea lions.

Fur seals feed primarily at night. Since they are widely distributed from continental slope to coastal waters, their diet reflects the large differences in food availability between these areas. A total of 53 species of fish and 10 species of squid are known in their diet (Kajimura and Loughlin, in press). Principal forage fishes (see Table 5.3) on continental shelf and coastal waters include herring, capelin, rockfish, pollock, sand lance, Atka mackerel, salmon. Squid are a principal food in waters beyond the continental shelf.

Capelin is the most important food item in the Unimak Pass area in all months (Lowry et al., 1982). Other components of their diet in this region includes squid, pollock, Atka mackerel and sand lance (Lowry et al., 1982; Trumble, 1973).

5.2.3. Harbor Seals.

The Pacific harbor seal (<u>Phoca vitulina richardsi</u>) ranges from Baja California to the western Aleutians, and into the Bering Sea. Population estimates vary, but are probably at least 295,000 (DOC, 1984), which is probably near historical levels (Bigg, 1981). However, the Marine Mammal Commission (MMC, 1986) reports recent declines of harbor seals in certain areas of Alaska similar to the decline in northern sea lion and northern fur seal populations. Nevertheless, the species remains the most abundant pinniped of coastal Alaska south of the Bering Sea.

Harbor seals are nonmigratory year-round residents in the Shumagin region. They usually live close to the coast, seldom being found more than a few kilometers from shore. They often enter rivers and lakes far from marine waters. Harbor seals are considered common along the south coast of the Alaska Peninsula, and around the Shumagin and Sanak Islands. There is no good data on the distribution and abundance of harbor seals, or thier rookeries/haulout grounds in the Shumagin region. Most of the pertinent information on harbor seals results from research conducted by the Alaska Department of Fish and Game as part of the OCSEAP Environmental Studies (Pitcher and Calkins, 1979), whose surveys of haulouts and rookeries never extended west of the Trinity Islands.

Harbor seals are usually solitary when in the water but form sizeable groups of mixed sex and age when hauled out (Bigg, 1981). Haulout areas used by harbor seals include rocks, sandbars, and beaches of remote islands. These areas are scattered throughout the region. Many of these haulout areas are traditional, and may be used either for resting or pupping. The world's largest harbor seal rookery is located on Tugidak Island, southwest of Kodiak and near the northeast corner of the proposed Shumagin lease area. Other important haulouts in the Shumagin region are known at Cape Igvak, Hartmann Island and Wide Bay, Sutwik Island, and Cape Kumlium (BBCMP,1984).

Reproductive maturity is reached by females at 3 to 5 years of age, and by males at 5 or 6. In the Gulf of Alaska, pupping occurs from late May to mid-July, with the peak in June. Each female bears a single pup. Unlike the closely related spotted seal (Phoca largha) of the Bering and Arctic Seas, harbor seal pups molt their lanugo hair before birth, are born with the spotted type of adult hair, and can swim at birth (Bigg, 1981). Pups are weaned after 3 to 4 weeks, after which the females breed again. Breeding lasts from late May to early August. Pups are born annually. Pups weigh about 28 pounds at birth and about 50 pounds at weaning.

Average adult females weigh 59 kg and are 1.5 m long; adult males weigh 73 kg and average 1.6 m long (Kajimura and Loughlin, in press). Longevity may exceed 30 years. Harbor seals rely on blubber for their insulation from cold water temperatures, and the hair is of little insulative value (Bigg, 1981). Usually their skin temperature is close to ambient while internal temperature is maintained at 35° to 40°C. Thus, these seals would be less sensitive to thermoregulatory disorders resulting from oiling of their pelt than are sea otters and fur seals.

Harbor seals feed on a variety of nearshore prey, which varies by location and season. Newly weaned pups feed primarily of benthic crustaceans such as shrimp. Most common prey of adults in the Gulf of Alaska include octopus, squids, and fish such as herring, cod, pollock, capelin, sand lance, and salmon (Kajimura and Loughlin, in press). Pollock and octopus are most important (see Table 5.3). Specific feeding locations have not been identified, but are probably broadly distributed. These seals are believed to feed in the late afternoon and twilight hours, although tidal changes and diel photoperiods influence their feeding times.

Chignik Lagoon and Chignik Bay natives take some harbor seals for subsistence purposes (BBCMP, 1984).

5.2.4. Walrus.

The Pacific walrus (Odobenus rosmarus) has its primary range from the Bering Sea to the Arctic Ocean in association with sea ice (Figure 5.2). Extra-

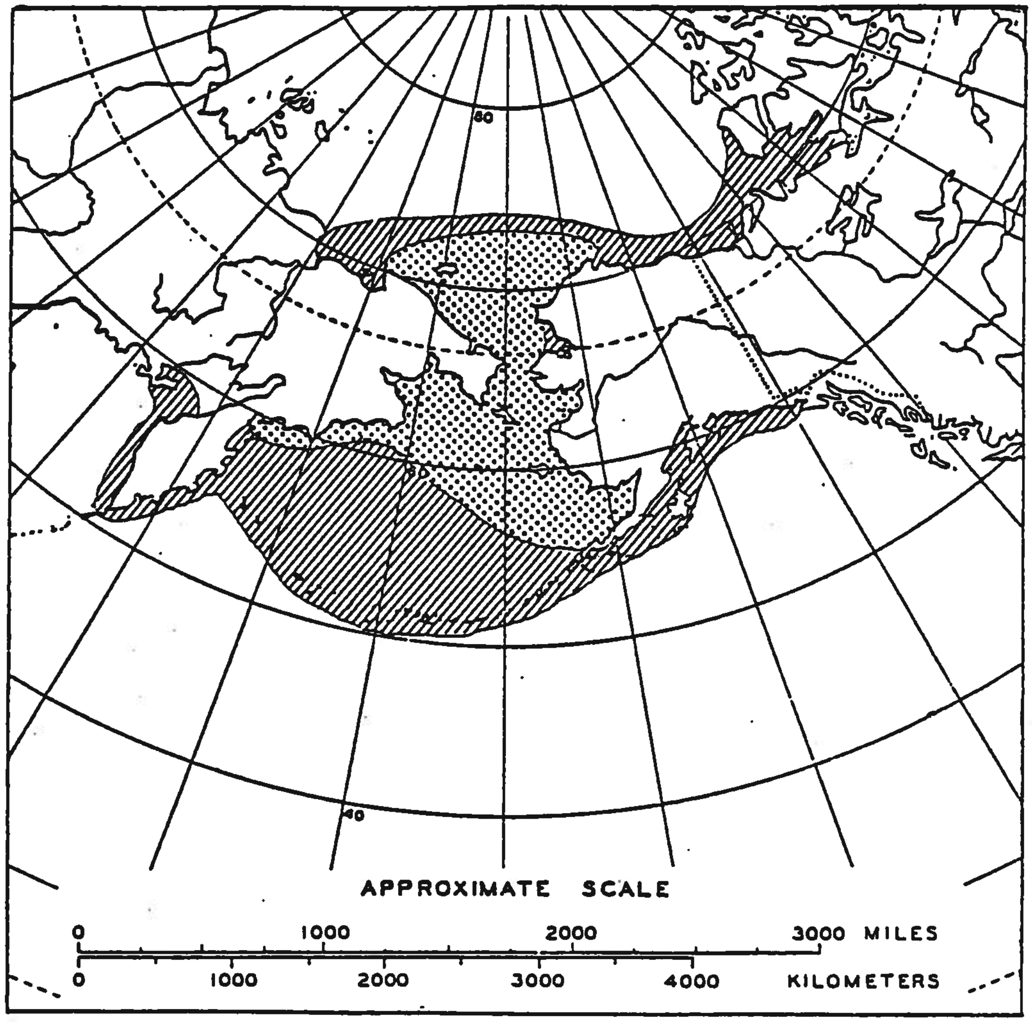

Figure 5.2. General distribution of Pacific walruses. Stippled area is primary range; cross-hatched area indicates limits of recent sightings (from Fay, 1981).

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limital records of walrus in the Gulf of Alaska, including Kodiak Island and Cook Inlet (Fay, 1981) indicate that lost or wandering individuals may occasionally be found in the Shumagin region.

5.2.5. Other Pinnipeds.

Northern elephant seals (Mirounga angustirostris) are uncommonly seen in low numbers in the area during spring and summer. There are three records of the species from the eastern Aleutians and Unimak Pass (Leatherwood et al., 1983; Kajimura and Loughlin, in press). Their population off California is currently increasing rapidly with some range expansion. An occasional California sea lion (Zalophus californianus) may also be seen during the summer.

5.3. SEA OTTERS.

Sea otters (Enhydra lutris) range throughout the Gulf of Alaska, Aleutian Islands, and into the Bering Sea. Prime sea otter habitat is in coastal kelp beds in the vicinity of reefs and rocky shoals, but they also occupy shallow offshore areas in water depths less than 30 to perhaps 60 m. Much of the coastal marine area of the Shumagin region is high to medium value habitat for sea otters, particularly in the offshore islands. In addition to the Sanaks and Sandman Reefs, primary otter habitats are the Shumagin Islands, Morzhovoi and Ikatan Bays, and the southeastern coast of Unimak Island. Other otter concentrations are scattered throughout the remaining islands and coastal areas. In 1983, 100 sea otters were reported in Chignik Bay (BBCMP, 1984).

The Sanak Islands and Sandman Reefs served as a refugia for the sea otter population of the 18th and 19th centuries, when fur-hunting virtually eliminated it from most of its range in Alaska. Since 1911, they have repopulated much of their former range, but in some areas they continue to remain absent or few. Of an estimated Alaska-wide population of 101,000 to 121,000 (Lowry et al., 1982), or perhaps 150,000 to 200,000 (H. Palmisano, p.c.), an estimated 20,000+ sea otters can be found in the Shumagin region. They occupy the region year round, and are mostly seen as single animals or in small groups. Large groups of up to 1000 have been reported however.

Pupping and breeding occur throughout the year, but breeding is most active in September and October, and pupping reaches a peak in May. Sea otter productivity in the Aleutians is known to be low, with a female producing one pup every two years. This may be due to high otter densities and food limitations, since in Prince William Sound and off California sea otters are found to breed annually (Lowry et al., 1982). Pups generally remain with their mothers for about one year. In the Aleutians, sea otters segregate by sex. Territorality during breeding has been observed under some conditions.

The diet of sea otters consists of benthic invertebrates and fish, predominantly crabs, clams, sea urchins, and octopus. Sea urchins are the primary prey in newly exploited areas in the Aleutian chain, while fish were the primary prey of long-established populations (Lowry et al., 1982). In the Sand Point area, where sea otters are common, numerous "otter digs" are observed in the benthos (USFWS, 1985). It appears that otter predation has significantly affected the integrity of the benthic community. Clam shells litter the substrate, primarily Saxidomus, Protothaca, and Clinocardium. Large sea urchins (Strongylocentrotus spp.), an important prey of the sea otter, are conspicuously lacking. Smaller urchins were observed only in the intertidal zone and between or under rocks in the subtidal zone.

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