THE WESTERN GULF OF ALASKA

A Summary of Available Knowledge

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A SUMMARY OF AVAILABLE KNOWLEDGE

By

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FOREWORD

This report is the result of a joint effort by the staffs of the University of Alaska's Arctic Environmental Information and Data Center (AEIDC) and Institute of Social, Economic and Government Research (ISEGR), under the direction of David Hickok and Victor Fischer, respectively. The overall coordination of the project was conducted by Richard T. Buffler and Eugene H. Buck of AEIDC. The following staff personnel had the primary responsibility for compiling data for the respective sections; Geomorphology-L. Lau, AEIDC; Climate-H. W. Searby, AEIDC: Oceanography-F. F. Wright, and R. L. Seitz, AEIDC; Geology-R. T. Buffler, AEIDC; Hydrology-L. Lau, AEIDC; Biota-E. H. Buck, K. Hulett, L. Lau, AEIDC; Socioeconomic-David Kresge, T. F. Gasbarro, S. Fison, ISEGR; Impact of Environment-Staff, AEIDC and ISEGR. Graphics for the project were supervised by E. Cote and were completed mainly by M. Aho with the assistance of S. Ward and R. Arend, AEIDC. Editing of the report was carried out primarily by L. McNicholas and J. Brogan, AEIDC.

The report attempts to present all available factual data in an unbiased manner. Portions of the text, however, reflect the individual staff member's personal experience and knowledge of the subject. Portions of the report also represent personal communications with numerous other persons.

Research for the report and preparation of a primary draft was carried out during the months of July through October 1973. From November 1973 through January 1974, the draft was reviewed by the Bureau of Land Management, both the Division of Marine Minerals, Washington, D.C. and the Alaska OCS office, Anchorage. Concurrently, the draft was reviewed internally by AEIDC staff plus numerous other pertinent government and industry persons most knowledgeable about various aspects of the report. February and March 1974 were spent incorporating pertinent review comments and preparing the final report.

TABLE OF CONTENTS

THE WESTERN GULF OF ALASKA
A SUMMARY OF AVAILABLE KNOWLEDGE

I. INTRODUCTION

PURPOSE AND SCOPE

The purpose of this report is to provide a comprehensive description of the area known as the Western Gulf of Alaska (defined below). It is an attempt to summarize all currently available knowledge about the area using extensive graphics supplemented with a written text. A comprehensive reference list is included with each section to allow the reader to obtain additional detail. The report is designed to be used (1) as the basis for assessing potential environmental impacts that might result from Outer Continental Shelf (OCS) leasing activities, (2) for planning the development of OCS energy resources, and (3) planning the feasibility of coastal facilities development.

The report consists, first, of a summary of currently available physical, biological and socioeconomic knowledge about the area (sections II through VIII). Included in these sections is a description of the area's resources and any industrial activity involving these resources--past, present, and potential.

Also included in the report is a discussion of present and potential conflicts and interactions between environmental considerations and resource uses, especially with regard to any future exploration for and production of petroleum on the Outer Continental Shelf (OCS). This is not a complete discussion, but it is an attempt to present examples of (1) what effect this environment might have on man's future activities in the area (section IX), and (2) what impact and conflicts might be expected with resource use, especially petroleum exploration and production (Section X). In addition, an attempt is made to define critical environmental data still needed to fully assess the impact of petroleum activities on the area (Section XI).

GENERAL LOCATION AND SETTING

The Western Gulf of Alaska study area comprises the continental shelf of the Gulf of Alaska and Pacific Ocean lying between Cook Inlet and Unimak Island (Figure 1). The area also includes that part of the adjacent coastal zone (including islands) directly influenced by, or having some influence upon, the marine environment.

A map showing the location of all place names mentioned in the report is also included to aid the reader (Figure 2).

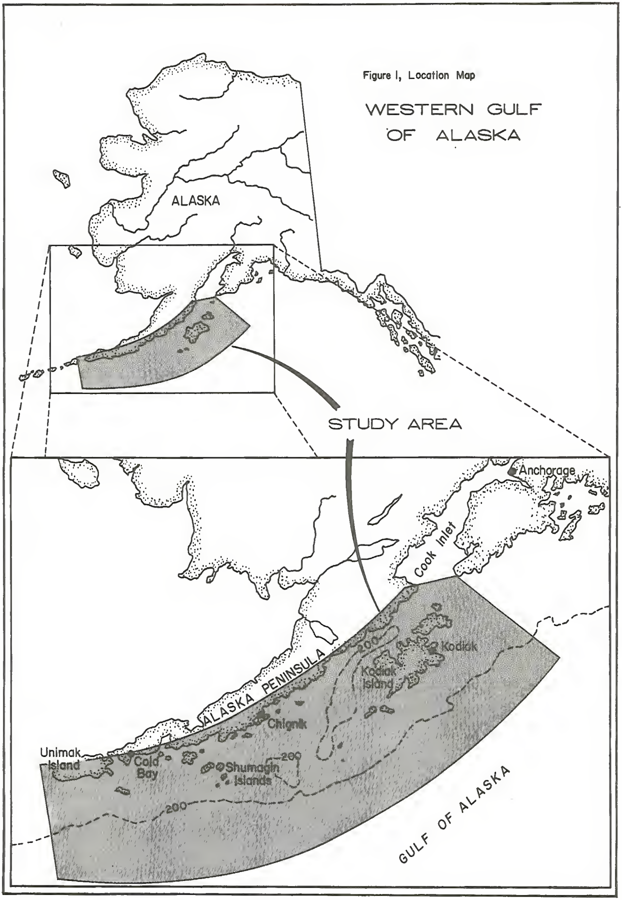


Figure I, Location Map
WESTERN GULF
OF ALASKA
ALASKA
STUDY AREA
Anchorage
Cook Inlet
Kodiak
Kodiak
Island
ALASKA PENINSULA
Chignik
Unimak
Island
Cold
Bay
Shumagin
Islands
200
200
200
200
GULF OF ALASKA

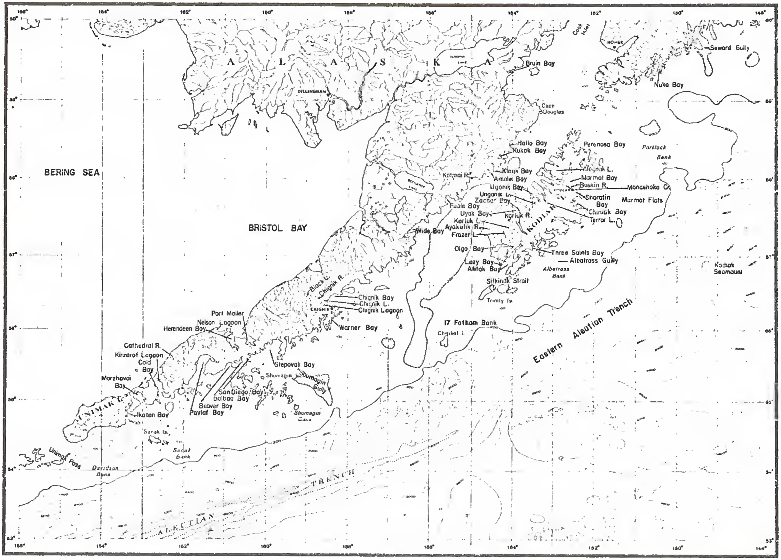


Figure 2a. Place names, Western Gulf of Alaska and vicinity.

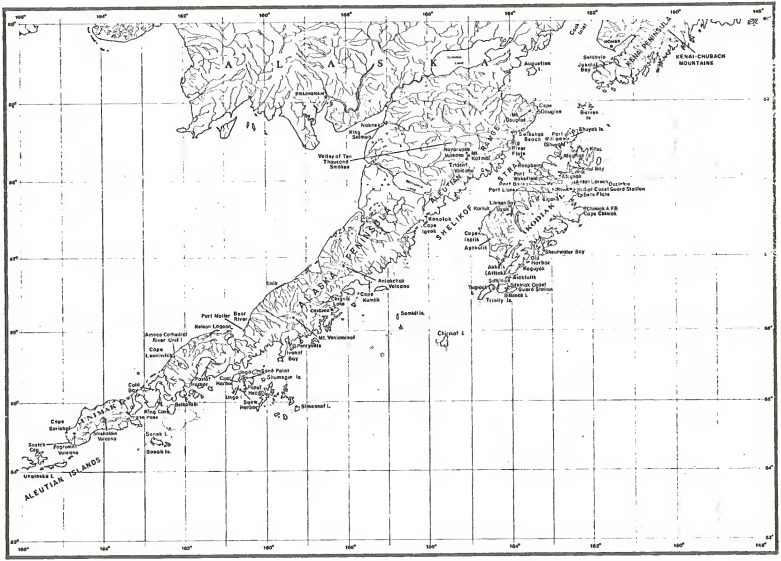


Figure 2b. Place names, Western Gulf of Alaska and vicinity.

II. GEOMORPHOLOGY

INTRODUCTION

The study area is characterized by steep, rugged mountains descending to the sea, a highly irregular coastline, and many islands and island groups (Figure 3). The coastline is indented by bays, inlets, lagoons, fiords, and natural harbors. Steep sea cliffs (10-50 m.), rocks, and an occasional narrow beach mark the shoreline (Wahrhaftig 1965). The continental shelf adjacent to the Alaska Peninsula extends seaward approximately 240 km. at its widest point. This shelf is marked by broad troughs and dotted with islands of varying size. Beyond the shelf, the continental slope descends steeply to the Aleutian Trench and the abyssal plain (Figure 3).

The geomorphology of the study area reflects a combination of active tectonic processes (uplift and active volcanism), constructional (depositional) and destructional (erosional) processes.

Considerable data are available describing the coastal zone. In particular, Wahrhaftig (1965) and Williams (1958) can be consulted for general descriptions. More detailed accounts can be obtained from (1) old expeditionary reports like the Harriman expedition (Merriam 1901), (2) geological surveys (Capps 1937, Atwood 1911); and (3) the Coastal Pilot (Coast and Geodetic Survey 1964). Most of the area is adequately covered by topographic maps of scale 1:250,000 and 1:63,360 (Figure 4).

In general, not much is known about the offshore area. National Ocean Survey (Coast and Geodetic Survey) nautical charts show the general nature of the bottom. The availability of soundings and other data used to compile these charts varies. Some areas such as around Kodiak Island have more data available, as reflected by the more detailed chart coverage (Figure 5). Areas further offshore covered only by the smaller scale charts have relatively few bottom data available.

A detailed bathymetric map covering most of the study area has been provided by von Huene and Shor (1969) (Figure 6), and Scripps Institution of Oceanography has compiled a generalized bathymetric map of the North Pacific (Chase et al. 1970). Detailed bathymetry of the entire Aleutian Arc including the southwest portion of the study area is available from an Environmental Science Services Administration map series (Coast and Geodetic Survey, undated). A generalized bathymetric map of the entire study area compiled from these three sources is presented here (Figure 7). Detailed bathymetric maps of the area produced from available data are also available for a fee from Continental Shelf Data Systems, Denver, Colorado.

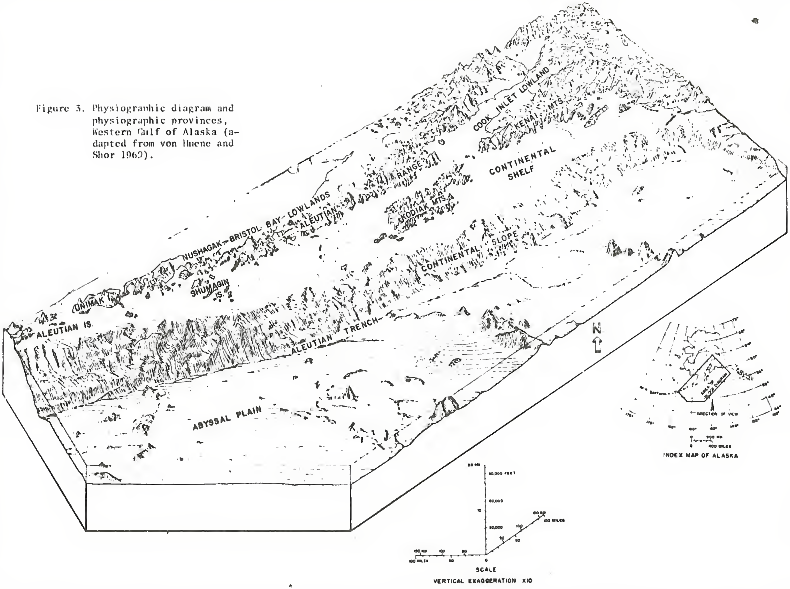
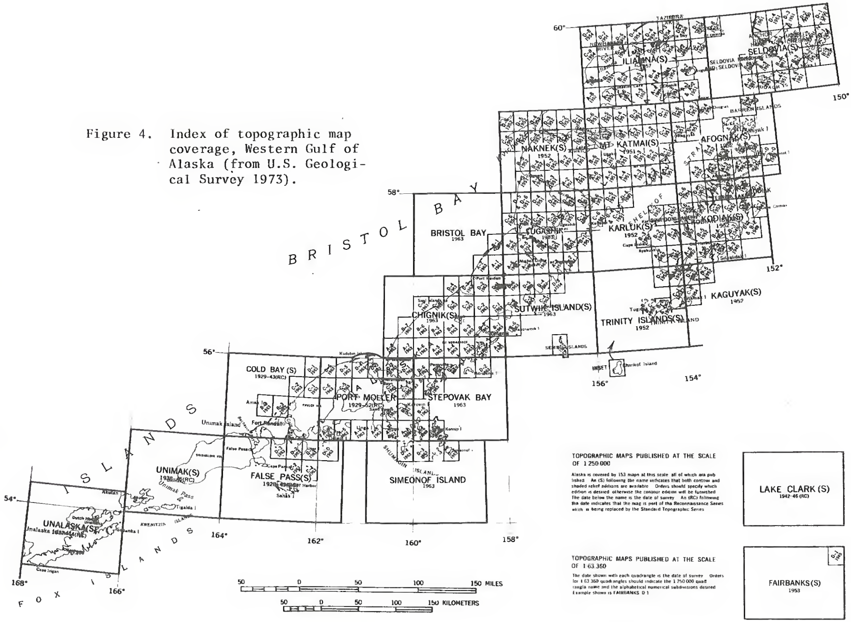


Figure 3. Physiographic diagram and physiographic provinces, Western Gulf of Alaska (adapted from von Huene and Shor 1969).

Figure 4. Index of topographic map coverage, Western Gulf of Alaska (from U.S. Geological Survey 1973).



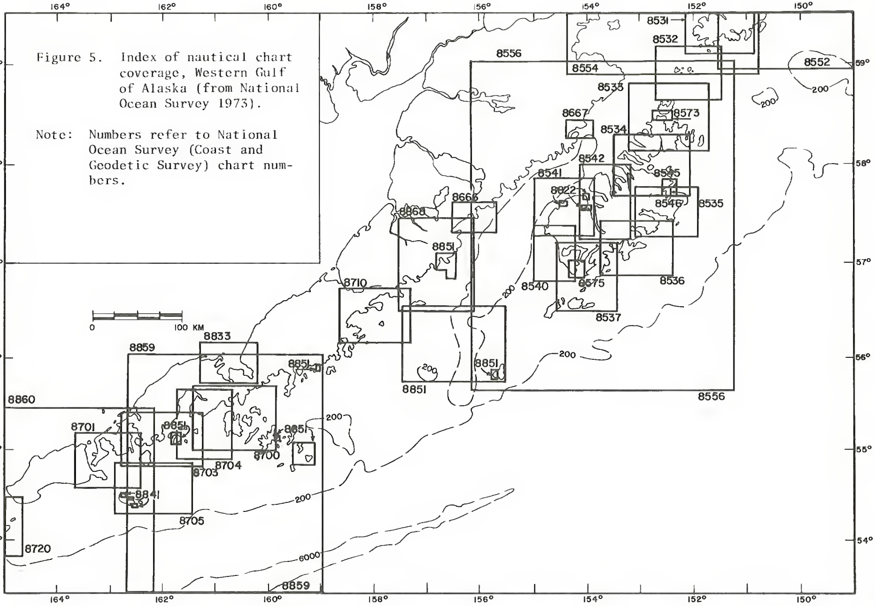


Figure 5. Index of nautical chart coverage, Western Gulf of Alaska (from National Ocean Survey 1973).

Note: Numbers refer to National Ocean Survey (Coast and Geodetic Survey) chart numbers.

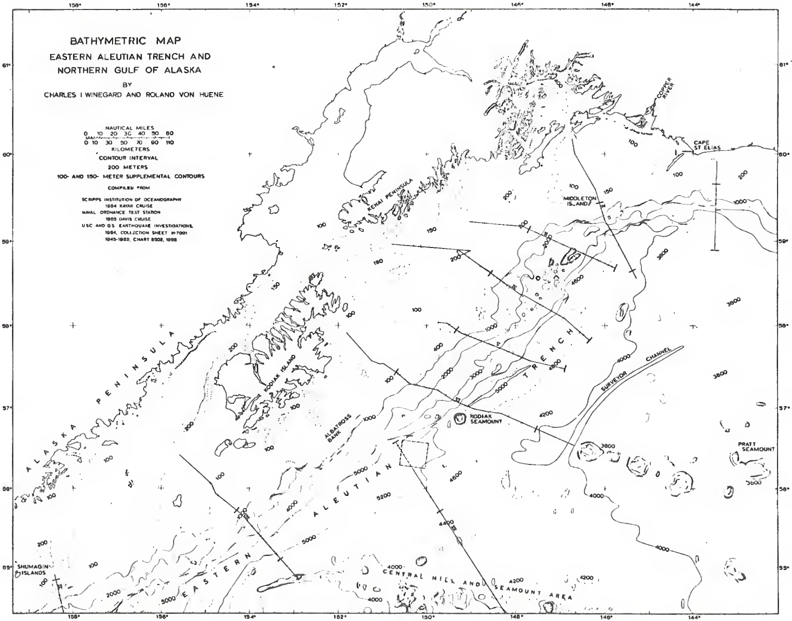


Figure 6. Bathymetric map of a portion of Western Gulf of Alaska (from von Huene and Shor 1969).

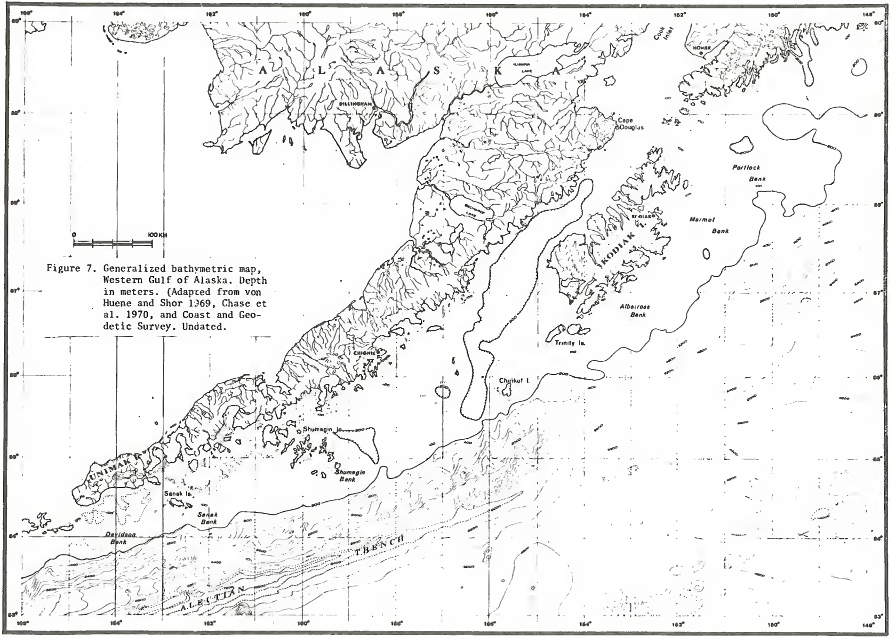


Figure 7. Generalized bathymetric map, Western Gulf of Alaska. Depth in meters. (Adapted from von Huene and Shor 1969, Chase et al. 1970, and Coast and Geodetic Survey. Undated.

Other studies by von Huene (1972) and von Huene et al. (1971, 1972) provide additional descriptive information for the offshore area. Excellent descriptions of the offshore areas also are included in the results of recent Soviet fisheries investigations in the northeast Pacific (Gershanovich 1968, Gershanovich et al. 1964).

In this report, description of the geomorphology is divided into physiographic provinces (Figure 3). Onshore areas described are the Aleutian Range, the Aleutian Islands including Unimak Island and the southern Alaska Peninsula, the Shumagin and other island groups off the southern Alaska Peninsula, and the Kodiak Mountains. Offshore areas considered are the continental shelf, continental slope, Aleutian Trench and abyssal plain.

ALEUTIAN RANGE

The Alaska Peninsula is divided into two provinces, the Nushagak-Bristol Bay Lowland and the Aleutian Range. The Nushagak-Bristol Bay Lowland is a glacial moraine and outwash-mantled lowland flanking the Aleutian Range on the northwest. The Aleutian Range forms the high, mountainous backbone of the Alaska Peninsula. The core of the range consists of folded Mesozoic and Tertiary rocks, upon which many recent and active volcanic centers are superimposed. These volcanoes form the higher peaks, ranging from approximately 1,000 m. to over 2,400 m. (Veniaminof Volcano), and display a spectacular assortment of recent volcanic features (calderas, craters, cones, etc.). Glacial features abound along the entire length of the range (cirques, U-shaped valleys, paternoster lakes, etc.). Fairly large glaciers still remain on a few of the higher volcanoes (Mt. Veniaminof, Mt. Katmai area, Mt. Douglas area), and small cirque glaciers occur on many of the other peaks. The firn line is approximately 1,000 m.

The Pacific coast of the Aleutian Range is characterized by high, rugged cliffs that rise abruptly from the sea as well as many indentations. Many offshore reefs and shoals occur as well. Streams draining the coast are short, steep, and swift, often plunging directly into the sea as waterfalls. The crest of the range is rarely more than a few kilometers from the coast--30 km. at the most.

ALEUTIAN ISLANDS

The Aleutian Islands form a 2,250 km. long arcuate ridge rising 3,600 m. above the sea floor. This ridge is capped by many volcanoes ranging from 600 to over 2,700 m. above sea level. The study area west of Pavlof Bay is considered as part of the Aleutian Islands (Wahrhaftig 1965). The coast of the islands is rugged and irregular, similar to the Aleutian Range, but volcanic features such as lava flows are more dominant, and low wave-cut platforms are characteristic features. The larger volcanic peaks have been intensely glaciated, and a fairly large glacial system still persists on Shishaldin Volcano.

SHUMAGIN AND OTHER OFFSHORE ISLAND GROUPS

The area offshore of the southern Alaska Peninsula is dominated by several island groups, the largest of which is the Shumagin Island Group. This group consists of 15 sizable islands and many smaller islets and rocks. Most of the islands are bold and mountainous. Parts of the islands have a somewhat rolling topography. The highest peak on Unga Island rises over 600 m. above sea level. Total land area of the islands is approximately 6,000 sq. km. The shoreline is rocky, precipitous, and irregular, similar to the Alaska Peninsula described above.

Several other smaller islands and island groups occur off the southern Alaska Peninsula, the more prominent being the Sanak Islands and the Semidi Islands. All of these appear to have characteristics similar to the Shumagin Islands and the Alaska Peninsula coast described above.

KODIAK MOUNTAINS

The Kodiak Mountains are formed by the Kodiak Island Group (Kodiak, Afognak, Shuyak, Raspberry, and associated smaller islands), as well as the Barren and Trinity Island groups, and Chirikof Island. Geologically they constitute a southwest continuation of the Kenai-Chugach Mountains. Exclusive of the Barren Islands and Chirikof Island, the area covered by the Kodiak and Trinity Island Groups equals approximately 17,000 sq. km.

The Kodiak Mountains area has a highly dissected, fiord indented, rugged coast. At one point on Kodiak Island the opposite coasts are separated by only 13 km. of land. Summit altitudes vary between 60 m. (Tugidak Island) and 1,340 m. (Kodiak Island), with Afognak having a maximum elevation of 730 m. (Karlstrom and Ball 1969).

The Kodiak Island Group has a rugged, granitic northeast-trending divide with horns and aretes from which broad, smooth ridges extend northwestward. As on the Peninsula, streams are short and swift, lakes are small, and small ponds are widely scattered. Most of the area has been glaciated, as indicated by the presence of abundant glacial features throughout the area. Only one area on southwest Kodiak Island escaped glaciation during the last glacial period (Karlstrom and Ball 1969). On Kodiak Island the firn line is approximately 1,000 m. along the main divide, which still shelters at least 40 small cirque glaciers all less than 2 miles long (Wahrhaftig 1965).

CONTINENTAL SHELF

The continental shelf in the study area ranges in width from 240 km. north of the Kodiak Island Group to about 50-65 km. off Unimak Island (Figure 7). The total area covered by the shelf is computed to be approximately 155,000 sq. km. Relief on the shelf is due primarily to tectonic processes modified by erosional and depositional processes.

Geological surveys of the Gulf of Alaska have been made by the Soviets in connection with fisheries investigations of the northeast Pacific. Much of the following description of the shelf is summarized from reports of these investigations (Gershanovich et al. 1964, Gershanovich 1970).

The shelf can be differentiated into three main parts--nearshore areas, plateau-like surfaces, and sea valleys (Gershanovich 1964, 1970). Nearshore areas comprise the narrow, shallow parts of the shelf adjacent to the coastline. These areas generally range between 5 to 8 km. in width and down to 30-50 m. in depth. They include many reefs and skerries (stacks) as well as the submerged coastal slopes, and represent sites of active coastal erosion. They are characterized in places by deep inlets or fjords, such as those found in Chignik Bay or northwest Kodiak Island (Figure 6).

The main part of the shelf is characterized by large, broad, plateau-like surfaces with depths ranging from 80 to 120 m. and low bottom grades of 1-5 minutes. Examples of these surfaces are seen southwest and southeast of Kodiak Island.

These plateau-like surfaces are interrupted in places by many isolated banks and shoals that rise, often abruptly, above the general level of the surface. Some of these even rise to above sea level and form islands, reefs, or skerries. All of them are characterized by an irregular and dissected relief, suggesting that they have been subjected to subaerial erosion by streams or glaciers during periods of lower sea level.

Of special interest are the banks and shoals occurring along the shelf edge, which apparently represent tectonically uplifted areas characterized by truncated bedrock and fault scarps on the sea bottom. Albatross Bank off Kodiak Island is an excellent example of one of these shelf edge banks. It extends along the shelf edge for almost 80 km. with a rugged, dissected topography in part that shallows to between 15 and 20 m. in places.

The outer shelf edge break is very distinct, but heavily dissected in profile. It ranges in depth from 120 to 130 m. off Unimak Island to 150-160 m. off Kodiak Island.

The plateau-like areas of the shelf are separated from each other by broad, flat-bottomed depressions or sea valleys that appear to fall into two categories. First are large sea valleys that trend parallel or subparallel to the shelf and probably represent large-scale tectonic depressions or areas of active subsidence. They have broad, flat bottoms and steep sides with 1-3 degree slopes. Shelikof Strait represents this type of sea valley and is approximately 300 km. long, 40.5 km. wide, and almost 300 m. deep along its northern edge (Figure 6). It is separated by a 100 m. sill from another similar depression that extends to the continental margin, but it is cut off from the continental slope by another sill at the shelf edge. These large-scale sea valleys may have been significantly modified by fluvio-glacial processes during periods of lower sea level, as suggested by terraces on the slopes and banks of the sea valleys.

The second type of sea valley is the smaller one, oriented transverse to the shelf and extending offshore from bays and inlets. They also have broad, level bottoms ranging from 10-50 km. wide and steep sides with 2-3 degree slopes. A longitudinal profile along the valleys commonly shows the middle to be deeper than the outer shelf margin forming closed depressions. They may represent valleys eroded by glacial-fluvial processes during lower stands of sea level. Excellent examples of these valleys occur off the southeast coast of Kodiak Island (Figure 6).

Another feature of the shelf not mentioned above, but discovered recently by U.S. Geological Survey investigations, is a prominent fault zone extending parallel with the shelf from Prince William Sound to just opposite Kodiak (von Huene et al. 1971, 1972). Many of the faults have a sharp bathymetric expression with scarps facing both seaward and landward, indicating fairly recent deformation of the sea floor. Some of this deformation probably took place during the 1964 earthquake.

CONTINENTAL SLOPE

Adjacent to the continental shelf is a steep, rugged continental slope that drops more than 5,000 m. to the Aleutian Trench in a distance of 30-80 km. The slope off Kodiak Island has been studied in some detail by the U.S. Geological Survey, providing a much more detailed bathymetric map for a portion of the slope (Figure 8); (von Huene 1972, Piper et al. 1973). In this area, the slope can be separated into three subprovinces--a relatively smooth upper slope, a bench-like middle slope, and a steep, rough lower slope (Figure 9). Slope angles generally vary between 3 and 10 degrees, but angles of 20-30 degrees are common and angles of even 40 degrees are found in places along the lower and middle portions. The most characteristic feature of the slope are the benches. They commonly have raised outer rims comprised

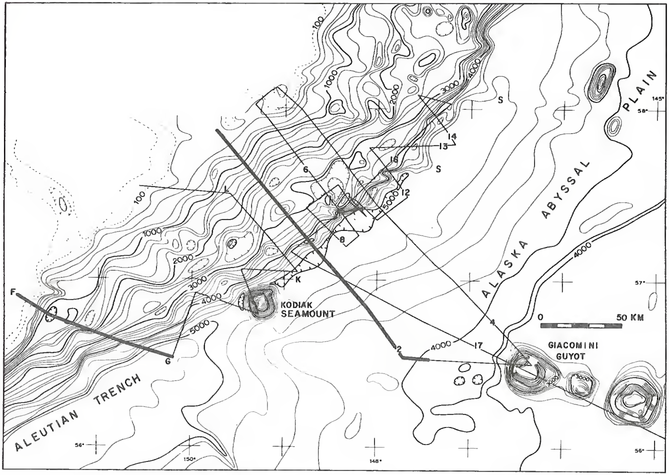


Figure 8. Detailed bathymetric map of portion of continental slope and Aleutian Trench off Kodiak. Contour interval is 200 m. S denotes areas of slump at base of slope (from von Huene 1972).

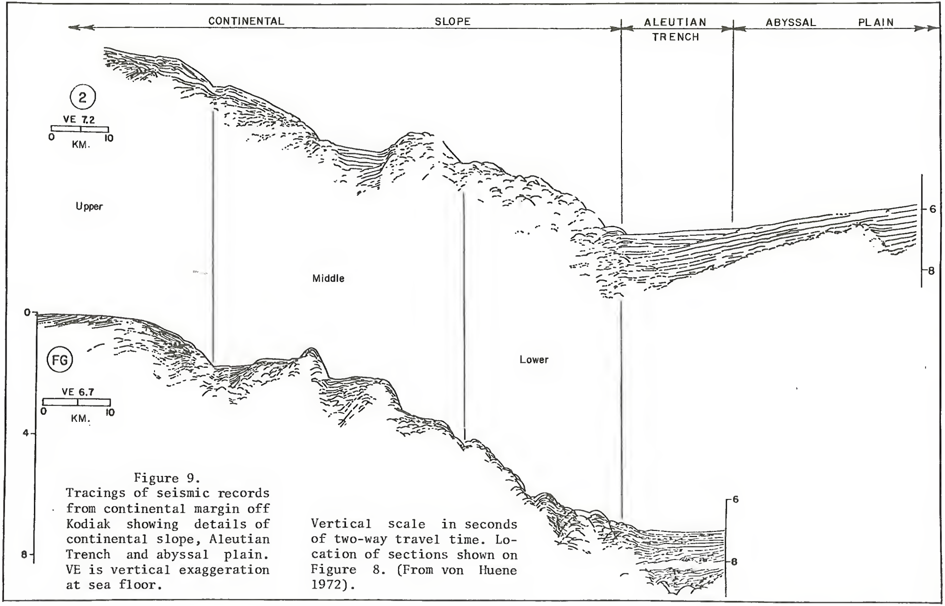


Figure 9.
Tracings of seismic records from continental margin off Kodiak showing details of continental slope, Aleutian Trench and abyssal plain. VE is vertical exaggeration at sea floor.

Vertical scale in seconds of two-way travel time. Location of sections shown on Figure 8. (From von Huene 1972).

of folded sedimentary rocks and inner depressions filled with ponded sediments (Figure 9). These benches apparently were formed by the backward rotation of large landslide blocks, representing large-scale downslope movements along an oversteepened slope. Also characteristic of the slope are small, oblique canyons and ridges as well as closed depressions and hills 1-4 km. across and 70 m. high. The irregular nature of the slope-trench boundary probably represents large-scale slumping of the steep lower slope into the trench (Figure 8 and 9).

Reports of Soviet investigations also contain good general descriptions of the continental slope in the Gulf of Alaska region (Gershanovich et al. 1964, Gershanovich 1970).

ALEUTIAN TRENCH

The portion of the Aleutian Trench between Middleton Island and the Shumagin Islands off Kodiak has been designated the Eastern Aleutian segment (von Huene and Shor 1969). This segment is approximately 1,380 km. long, over 5,000 m. below sea level, and slopes gently along its axis about 1.6 m./km. to the southwest. It basically consists of an asymmetrical, flat-floored, sediment-filled depression about 20-30 km. wide (Figure 9);(von Huene and Shor 1969, von Huene 1972, Piper et al. 1973). This gentle topography is interrupted only by the Kodiak Seamount, the westernmost of a chain of seamounts extending across the Gulf of Alaska (Figure 6).

ABYSSAL PLAIN

The abyssal plain is a relatively smooth, flat-lying depositional surface that slopes generally less than 1.5 m./km. but steepens to 50 m./km. (2-3 degrees) as it merges with the Aleutian Trench (Figure 9). Recent data concerning the abyssal plain in the Gulf of Alaska is presented by Hamilton (1967, 1973).

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III. CLIMATE

INTRODUCTION

The climate of the study area is dominated by a strong marine influence. It is characterized by cloudy skies, moderately heavy precipitation, and cool temperatures. In winter, the waters of the North Pacific provide the moisture for cloudiness and precipitation and the heat that keep temperatures relatively mild. In summer, the water still provides moisture for precipitation and cloud cover, but the water is cooler than the air and temperatures remain moderate. A major west to east storm track lies along the southern portion of the area 10 months of the year. Surface winds are much stronger and more persistent than at inland stations. The mountains of the Western Gulf area exert a strong influence on precipitation, which increases with elevation.

DATA SOURCES

Figure 10 is a map showing the location of all weather stations used in this report. Parameters observed at these stations, data routinely summarized, and current status of each station is shown in Table 1. Detailed summaries of climatic data have been compiled for Kodiak and Cold Bay by the Air Weather Service (AWS), U.S. Air Force. Data for all other locations are taken from Environmental Data Service (NOAA) publications and include only temperature and precipitation. The source of wind data for Cape Sarichef is unknown (probably AWS) and for Sand Point is the U.S. Army Corps of Engineers. The periods of record for all stations are noted on the appropriate tables and figures.

The Gulf of Alaska Operators Committee, a consortium of petroleum companies operating in the Gulf of Alaska, has completed a study of oceanographic and climatologic conditions of the Gulf of Alaska. A summary is available from the Committee, but detailed data is still proprietary information.

REGIONAL WEATHER PATTERNS

Mean surface and upper air patterns for the study area, based on 20 years of record, are shown in Figure 11 (U.S. Weather Bureau 1952). Superimposed on the surface patterns are major and secondary storm tracks (Klein 1957). A strong seasonal change in pressure patterns (between winter and summer) occurs both at the surface and aloft. The frequency of storms in the study area, based on 40 years of weather charts, is shown in Figure 12 (Klein 1957). Regional patterns of temperature and precipitation are shown in Figures 13 and 14. A more detailed discussion of the climatic parameters of the study area follows.

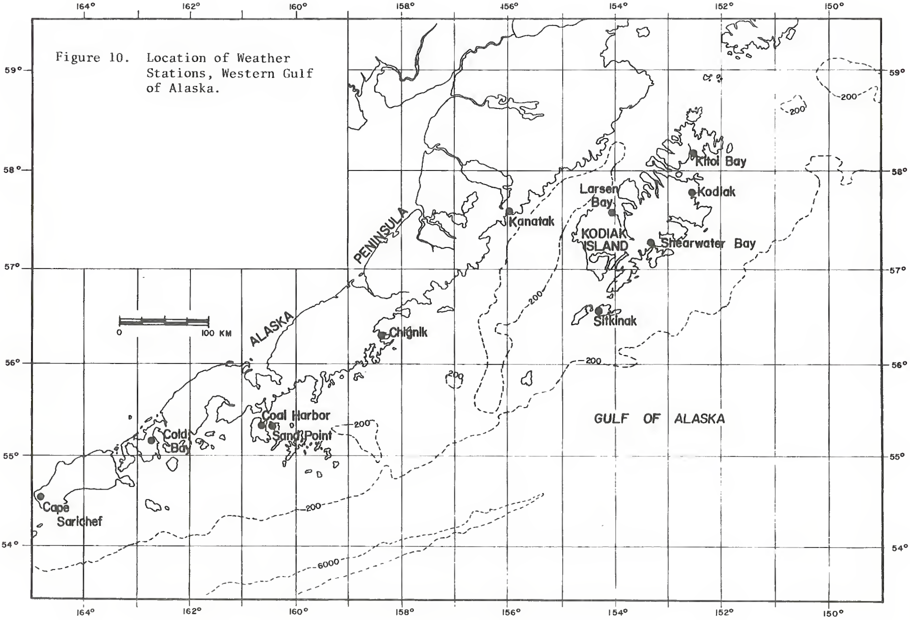


Figure 10. Location of Weather Stations, Western Gulf of Alaska.

	Active Station	Inactive Station	Temp at obsn time	Dewpoint at obsn time	Max/min Temp	24 hour Precipitation	Pressure	Wind	Sky Cover	Cloud Height	Visibility	Weather at obsn time
Kodiak	X		X	X	X	X	X	X	X	X	X	X
Cold Bay	X		X	X	X	X	X	X	X	X	X	X
Kitoi Bay	X				X	X						
Sitkinak	X		X	X	X	X	X	X	X	X	X	X
Chignik	X				X	X						
Cape Sarichef	X		X	X	X	X	X	X	X	X	X	X
Larsen Bay		X			X	X						
Shearwater Bay		X			X	X						
Kanatak		X			X	X						
Sand Point		X			X	X						
Coal Harbor		X			X	X						

Parameters listed to the right of "24 hour precipitation" are observed but not routinely summarized except at Kodiak and Cold Bay. In addition they are not observed on an hourly basis except at Kodiak and Cold Bay, which is a major reason why they are not summarized. Even limited coverage timewise would have some value, and this data could be summarized if a user felt his needs justified the cost.

Table 1. Data Stations and Parameters Observed, Western Gulf of Alaska (from Environmental Data Service [NOAA]).

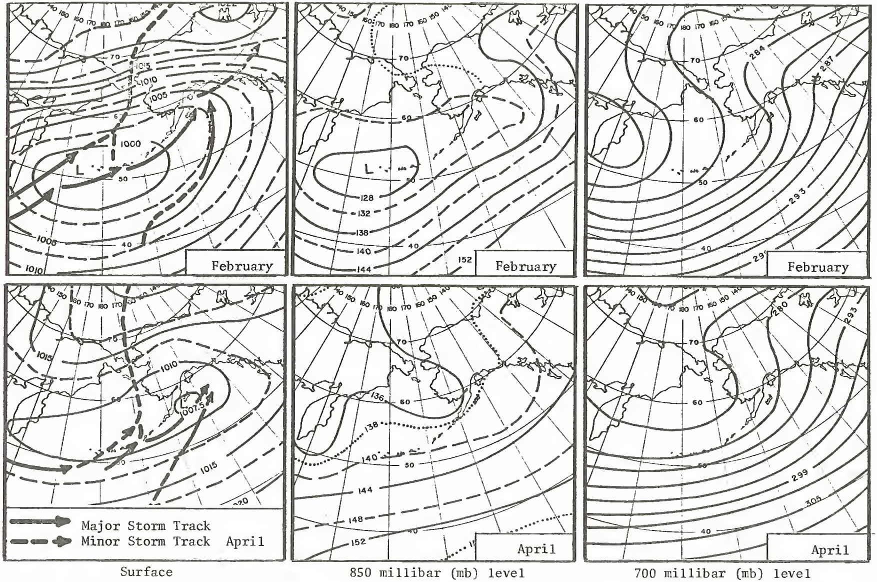
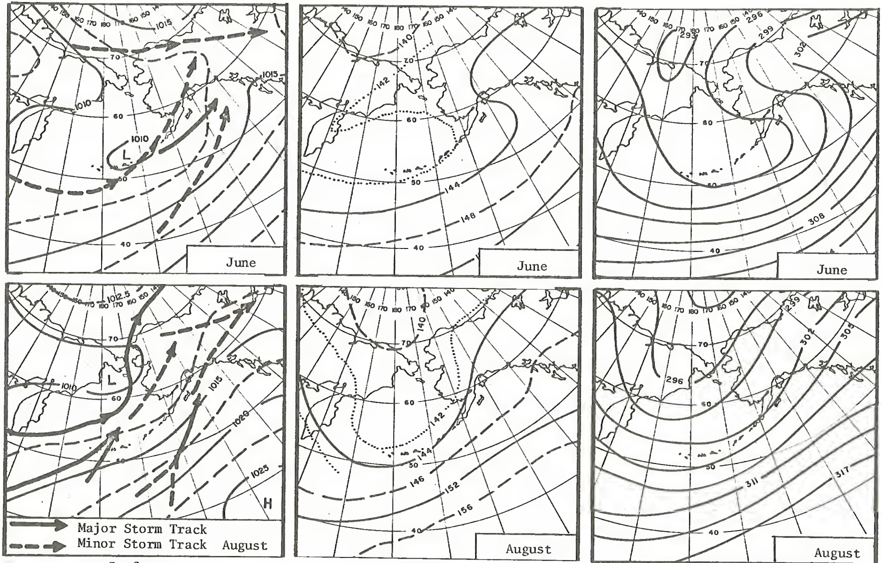


Figure 11. Mean Pressure Patterns, Alaska and North Pacific. Twenty years of record. Isolines on the surface chart are mb's of pressure, the 850 and 700 mb charts are heights in 10's of meters (from U.S. Weather Bureau 1952 and Klein 1957).

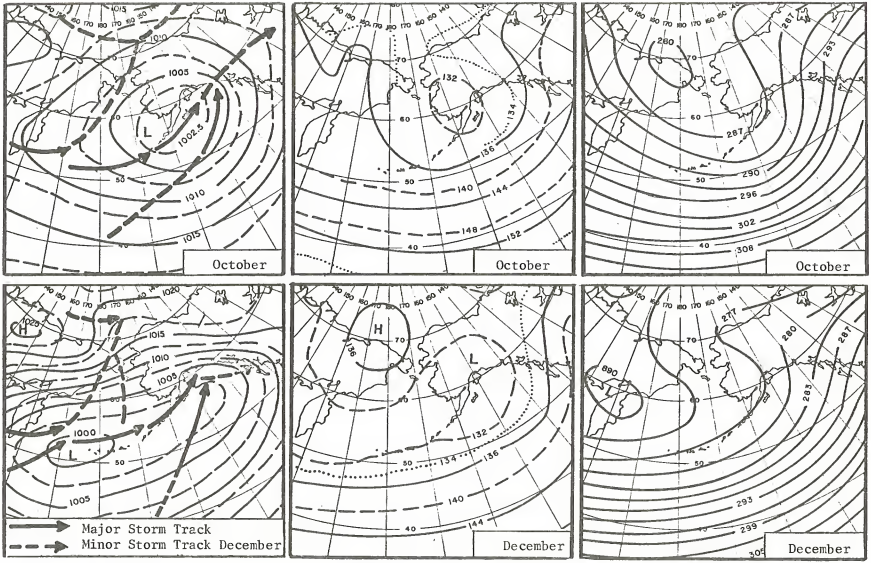


Surface

850 millibar (mb) level

700 millibar (mb) level

Figure 11. Mean Pressure Patterns, Alaska and North Pacific. Twenty years of record. Isolines on the surface (Cont'd.) chart are mb's of pressure, the 850 and 700 mb charts are heights in 10's of meters (from U.S. Weather Bureau 1952 and Klein 1957).



Surface | 850 millibar (mb) level | 700 millibar (mb) level

Figure 11. (Cont'd.) Mean Pressure Patterns, Alaska and North Pacific. Twenty years of record. Isolines on the surface chart are mb's of pressure, the 850 and 700 mb charts are heights in 10's of meters (from U.S. Weather Bureau 1952 and Klein 1957).

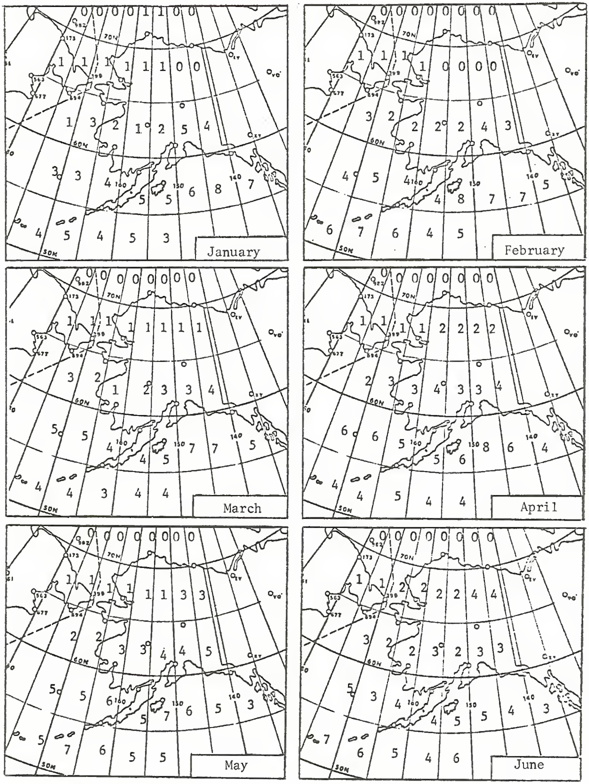


Figure 12. Storm Frequency, North Pacific. Percentage frequency of the number of days with lows or storm centers in five degree squares. Forty years of record (Navy Hydrographic Office 1961).

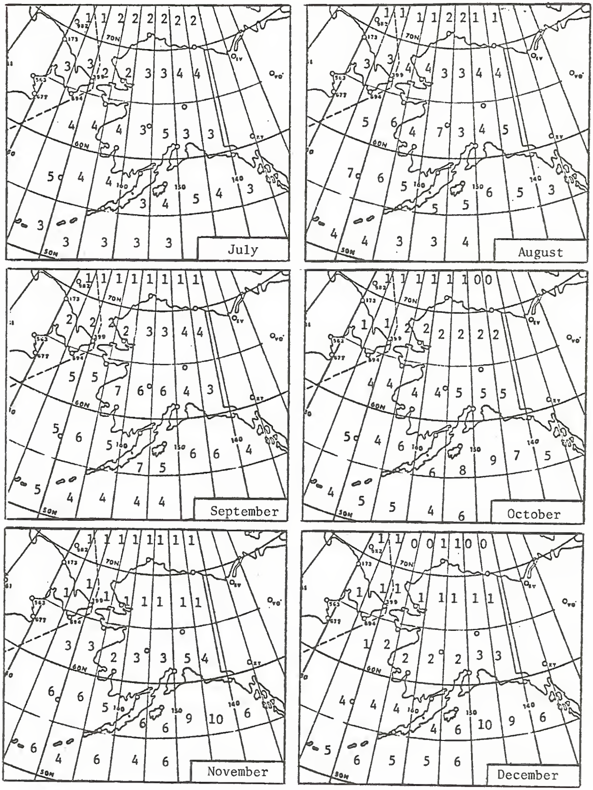


Figure 12, Continued.

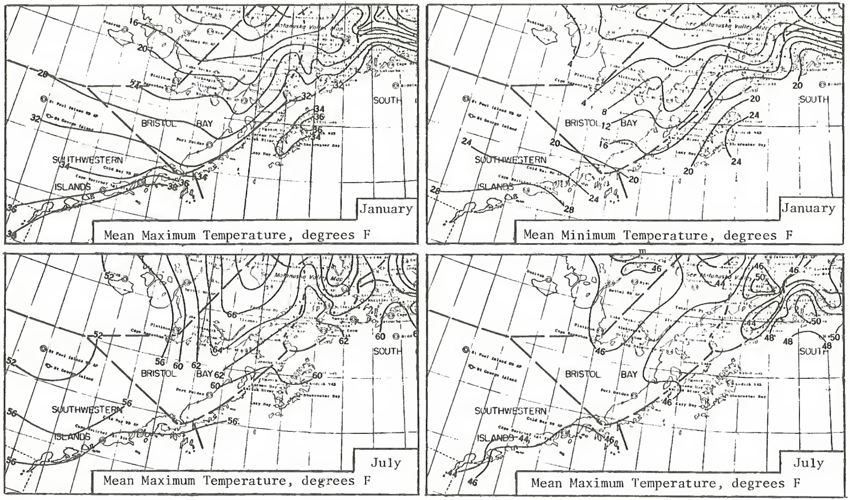
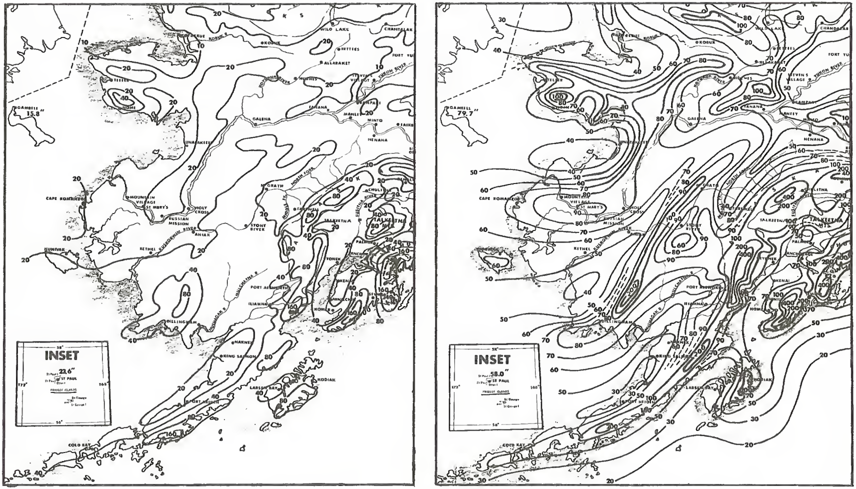


Figure 13. Regional Temperature Distribution, Western Gulf and Southwest Alaska (from Environmental Data Service [NOAA]).



Mean Annual Precipitation (inches)
Includes water equivalent of snow

Mean Annual Snowfall (inches)

Figure 14. Regional Precipitation Distribution, Western Gulf and Southwest Alaska (developed by National Weather Service in cooperation with the U.S. Geological Survey 1973).

TEMPERATURE

Temperature patterns are characterized by relatively cool summers and warm winters, as compared to interior land temperatures at similar or more northerly latitudes. The temperature range between stations in the area is small, the greatest temperature variation being only 6 degrees F (3 degrees C), despite differences in exposure and distances from each other. Individual stations also show small ranges between mean annual maximum and minimum temperatures and extremes. The greatest range between the average annual maximum and minimum is 14.7 degrees F (9.6 degrees C). In comparison, Fairbanks, a typical inland station, has a maximum-minimum range of 22.8 degrees F (12.7 degrees C). The greatest range of extreme temperatures in the study area is 94 degrees F (52 degrees C), compared to Fairbanks which varies 165 F degrees (92 C degrees). Extreme temperatures in the Western Gulf are not persistent for more than a few days at a time.

Average temperature differences between air and water are greatest during fall and winter when the air is as much as 5 degrees F (3 degrees C) colder than the water. This unstable condition results in vertical mixing of the air, maintaining clouds at a higher level than during spring and summer months when the air is more stable and slightly warmer than the water.

Detailed temperature information is provided in Table 2. Percentage frequency of occurrence of the complete range of temperature for Kodiak and Cold Bay is shown in Figure 15. Sea temperatures and sea-air temperature differences are presented in Figure 16.

PRECIPITATION

In nearly any climate, precipitation is probably the most variable parameter measured. Available data shows that annual amounts of precipitation range from 23 inches (584 mm.) at Larsen Bay on the leeward side of Kodiak Island to 121 inches (3073 mm.) at Chignik. Differences are due primarily to variations in terrain and exposure. For instance, Larsen Bay, Cape Sarichef, and Cold Bay are all affected by a terrain obstruction of the general air flow which reduces annual precipitation in those areas.

The air that travels ahead of storms generally flows from a southeasterly direction with a long fetch over water. It is heavily laden with moisture and ready to deposit large volumes of precipitation. Based on precipitation measurements taken near sea level, precipitation on ridges and the windward side of mountain ranges will probably reach as high as 200 inches (5080 mm.) in isolated locations. Precipitation in periods of 24 hours or less is excessively heavy from time to time, resulting in local flooding. Watersheds are small, so floods of this type would be of fairly short duration, similar to flash floods.

Mean annual values of total precipitation (including water equivalent of snow) and snowfall are found in Table 2. Frequency of occur-

STATION: KITOI BAY, ALASKA LATITUDE: 58°11' LONGITUDE: 152°21' ELEVATION: 15'

MONTH	Temperature (°F) Means: Daily Maximum	Daily Minimum	Monthly	Extremes: Record Highest	Year	Record Lowest	Year	Precipitation (in inches): Mean	Greatest Daily	Year	Greatest Monthly	Year	Snow, Ice Pellets: Mean	Greatest Monthly	Year	Greatest Daily	Year	Greatest Depth on Ground	Year	Mean Number of Days: Precipitation .10 Inches or more	Temperature Max: 70° and Above	32° and Below	Min: 32° and Below	0° and Below
(a)	15	15	15	15	-	15	-	15	15	-			8	8	-	8	-			12	15	15	15	15
J	33.6	23.7	28.7	49	1966	-1	1968+	5.69	1.95	1966	9.04	1964	10.8	22.0	1956	6.0	1959	22	1969	11	0	11	25	*
F	35.1	23.9	29.5	51	1962+	-2	1959	4.64	1.48	1958	8.56	1970	13.5	36.7	1968	10.0	1968	38	1969	10	0	7	24	*
M	37.1	23.9	30.5	54	1970+	-3	1959	4.13	1.25	1970	7.72	1970	16.5	45.7	1956	13.0	1956	28	1956	11	0	6	27	*
A	42.7	29.5	36.1	62	1965	9	1960	4.12	1.54	1960	7.06	1969	4.9	13.7	1955	5.8	1955	21	1956	11	0	1	22	0
M	49.9	35.9	42.9	78	1968	19	1965	4.64	1.72	1955	10.45	1955	T	7.0	1968	7.0	1968	7	1968	11	*	0	[illegible]	0
J	54.8	42.2	48.5	79	1961	31	1956+	3.77	2.42	1969	6.63	1965	0.0	0.0		0.0		0		9	1	0	*	0
J	59.8	47.0	53.4	82	1966	35	1966	3.48	1.67	1968	8.69	1958	0.0	0.0		0.0		0		8	3	0	0	0
A	60.4	47.7	54.1	82	1968	34	1955	5.41	2.04	1967	12.41	1957	0.0	0.0		0.0		0		10	3	0	0	0
S	54.2	42.6	48.4	68	1965	27	1956	6.38	2.51	1957	11.16	1957	T	0.5	1956	0.5	1956	0		12	0	0	1	0
O	44.2	32.6	38.4	65	1969	17	1966	6.36	3.35	1957	11.53	1969	1.5	6.0	1955	4.5	1963	5	1963	12	0	1	15	0
N	37.2	27.4	32.3	53	1965	5	1963	5.91	2.00	1959	13.32	1959	5.6	14.4	1956	9.5	1956	8	1958	12	0	5	24	0
D	32.4	22.2	27.3	46	1965	-12	1964	5.64	1.65	1968	10.65	1969	17.9	49.3	1968	14.0	1955	25	1968	12	0	13	27	*
YR	45.1	33.2	39.2	82	1968+	-12	1964	60.17	3.35	1957			70.7	49.3	1968	14.0	1955	38	1969	129	7	44	173	*

STATION: KODIAK, ALASKA LATITUDE: 57°44N' LONGITUDE: 152°31'W ELEVATION: 111 ft.

MONTH	Temperature (°F) Means: Daily Maximum	Daily Minimum	Monthly	Extremes: Record Highest	Year	Record Lowest	Year	Precipitation (in inches): Mean	Greatest Daily	Year	Greatest Monthly	Year	Snow, Ice Pellets: Mean	Greatest Monthly	Year	Greatest Daily	Year	Greatest Depth on Ground	Year	Mean Number of Days: Precipitation .01 Inches or more	Temperature Max: 70° and Above	32° and Below	Min: 32° and Below	0° and Below
(a)	20	20	20	20	-	20	-	20	20	-	20	-	20	20	-	20	-			20	20	20	20	20
J	34.5	26.6	30.8	54	1963	-5	1968	4.93	3.20	1960	10.16	1960	14.9	40.1	1971	10.5	1956	16	1958	16	0	9	22	*
F	34.8	26.1	30.7	56	1957	0	1968	3.91	1.41	1968	9.61	1968	14.5	34.0	1961	10.0	1957	31	1969	15	0	8	21	*
M	36.2	26.9	31.8	57	1968	-1	1966	4.01	1.78	1965	8.12	1965	17.7	74.5	1956	17.8	1956	24	1966	15	0	7	22	*
A	41.2	31.7	36.7	64	1965	11	1949	3.22	1.70	1953	4.98	1953	7.0	21.9	1965	10.5	1966	11	1970	14	0	1	14	0
M	47.7	38.4	43.3	80	1968	20	1949	4.05	1.87	1955	9.53	1955	0.4	4.0	1968	4.0	1968	4	1968	16	0	*	2	0
J	54.2	44.5	49.6	86	1953	30	1968	4.05	2.31	1965	11.78	1965	T	T	1965+	T	1965+	0		15	0	0	*	0
J	59.0	48.9	54.2	82	1967	37	1966	3.60	2.46	1958	8.09	1958	0.0	0.0		0.0		0		14	0	0	0	0
A	59.6	49.8	55.0	83	1968	36	1955	4.67	2.23	1964	9.30	1964	0.0	0.0		0.0		0		15	0	0	0	0
S	54.5	45.1	50.1	71	1965+	26	1968	6.11	2.67	1957	12.60	1957	T	0.2	1956	0.2	1956	T	1958	17	0	0	*	0
O	45.0	35.3	40.4	61	1967	14	1966	5.52	2.47	1952	10.57	1952	2.6	14.9	1961	9.3	1964	9	1964	16	0	1	10	0
N	39.1	31.0	35.3	60	1967	6	1967	5.51	2.34	1959	10.78	1959	5.0	24.3	1965	14.0	1965	11	1963	17	0	4	16	0
D	34.0	25.5	30.0	54	1967	0	1967	4.84	2.03	1962	9.80	1962	[illegible]	28.2	1968	9.0	1957	17	1959+	16	0	10	23	*
YR	45.0	35.8	40.7	86	1953	-5	1968	54.42	3.20	1957	12.60	1957	74.8	74.5	1956	17.8	1956			186	0	40	130	*

(a) Period of Record
* Less than one half
\+ Also on earlier dates, months or years
T Trace, an amount too small to measure

Table 2. Detailed Weather Summaries, Western Gulf of Alaska (from Environmental Data Service [NOAA]). Note: Mean precipitation data includes the water equivalent of snow.

STATION: SITKINAK, ALASKA LATITUDE: 56°33'N LONGITUDE: 154°08'W ELEVATION: 53 ft.

MONTH	TEMPERATURE (°F)							PRECIPITATION (IN INCHES)													MEAN NUMBER OF DAYS				
	Means			Extremes									Snow, Ice Pellets									Temperature			
																						Max		Min	
	Daily Maximum	Daily Minimum	Monthly	Record Highest	Year	Record Lowest	Year	Mean	Greatest Daily	Year	Greatest Monthly	Year	Mean	Greatest Monthly	Year	Greatest Daily	Year	Greatest Depth on Ground	Year	Precipitation .10 Inches or more	70° and Above	32° and Below	32° and Below	0° and Below
(a)	9	9	9	9	-	9	-	8	8	-			4	4	-			4		8	9	9	9	9
J	34.1	26.9	30.5	48	1963	6	1969	3.67	1.92	1967	9.67	1966	6.5	11.2	1967	3.0	1967	9	1967	7	0	8	22	0
F	34.8	27.5	31.2	51	1962	4	1968	3.14	1.75	1964	4.94	1964	3.2	3.2	1963	2.2	1963	10	1967	8	0	10	19	1
M	36.4	27.8	32.1	55	1967	5	1966	3.89	1.05	1962	5.68	1969	1.6	3.0	1967	1.8	1964	18	1961	11	0	9	19	2
A	40.6	31.7	36.2	63	1965	17	1965	3.75	1.77	1963	5.44	1964	1.0	3.6	1964	2.0	1964	8	1961	9	0	3	14	*
M	46.4	36.9	41.7	66	1968	24	1965	3.53	2.02	1965	8.68	1965	1.0	9.2	1965	7.7	1965	8	1965	10	0	1	4	0
J	52.5	43.3	47.9	72	1964	29	1965	3.15	1.78	1969	5.96	1969	0.0	0.0		0.0		0		8	*	*	*	0
J	57.7	48.0	52.9	76	1967	33	1962	3.06	1.44	1962	4.84	1968	0.0	0.0		0.0		0		7	*	0	0	0
A	58.2	48.6	53.4	73	1964+	35	1963	6.68	2.01	1968+	15.31	1963	0.0	0.0		0.0		0		10	*	0	0	1
S	53.6	45.5	49.6	68	1964	30	1964	6.20	2.02	1964	8.30	1966	0.0	0.0		0.0		0		13	0	*	*	0
O	44.4	36.1	40.3	61	1967	22	1966	4.66	1.25	1970	7.33	1964	0.8	2.0	1970	2.0	1970	2	1970	11	0	2	8	1
N	39.7	32.4	36.1	49	1970	3	1963	4.62	1.99	1961	6.80	1962	5.5	10.0	1964	10.0	1964	7	1963	11	0	5	12	*
D	34.4	26.5	30.5	47	1966	7	1964	4.16	1.20	1964	7.16	1963	7.9	14.4	1962	8.7	1962	13	1962	11	0	11	18	*
YR	44.4	35.9	40.2	76	1967	3	1963	50.51	2.02	1965+			27.5	14.4	1962	10.0	1964	18	1961	116	*	49	116	5

STATION: SHEARWATER BAY LATITUDE: 57°21'N LONGITUDE: 152°55'W ELEVATION: 10 ft.

MONTH	TEMPERATURE (°F)							PRECIPITATION (IN INCHES)													MEAN NUMBER OF DAYS				
	Means			Extremes									Snow, Ice Pellets									Temperature			
																						Max		Min	
	Daily Maximum	Daily Minimum	Monthly	Record Highest	Year	Record Lowest	Year	Mean	Greatest Daily	Year	Greatest Monthly	Year	Mean	Greatest Monthly	Year	Greatest Daily	Year	Greatest Depth on Ground	Year	Precipitation .10 Inches or more	70° and Above	32° and Below	32° and Below	0° and Below
(a)	12	12	12	12	-	12	-	12	12	-	12	-								9	12	12	12	12
J	36.6	24.7	30.7	53	1956	0	1963	9.71	4.62	1963	19.05	1961								12	0	8	24	0
F	37.9	25.1	31.5	64	1957	4	1954	6.89	2.72	1958	16.15	1958								10	0	4	22	0
M	38.3	25.3	31.8	54	1954	4	1956	5.35	3.74	1958	12.16	1958								9	0	4	26	0
A	43.9	29.3	36.6	58	1963+	11	1956	6.00	3.12	1962	12.64	1953								9	0	*	20	0
M	49.5	35.6	42.6	68	1960	22	1952	9.10	3.20	1962	13.26	1961								12	0	0	8	0
J	56.8	40.3	48.6	85	1953	27	1962	4.89	3.70	1957	11.30	1958								8	2	0	2	0
J	61.0	45.3	53.2	80	1955	41	1958	4.53	4.37	1952	11.28	1952								8	4	0	0	0
A	62.2	45.8	54.0	77	1955+	31	1955	7.31	7.80	1963	15.31	1953								9	3	0	*	0
S	56.1	41.1	48.6	74	1954	25	1953	9.24	4.60	1959	21.24	1957								13	*	0	4	0
O	47.1	33.1	40.1	64	1963	14	1953	10.96	6.98	1952	19.56	1952								11	*	*	15	0
N	40.8	28.3	34.6	63	1963	10	1963+	13.18	8.37	1959	32.18	1959								12	0	2	20	0
D	36.2	24.1	30.2	57	1955	-1	1957	10.72	5.38	1963	28.25	1963								12	0	7	23	*
YR	47.2	33.2	40.2	86	1953	-1	1957	97.88	8.37	1959	32.18	1959								124	0	34	164	*

(a) Period of Record - Years (through 1970)
* Less than one half
\+ Also on earlier dates, months, or years
T Trace, an amount too small to measure

Table 2, Continued.

STATION: SAND POINT, ALASKA LATITUDE: 55°20' LONGITUDE: 160°30' ELEVATION: 32'

MONTH	TEMPERATURE (°F) Means: Daily Maximum	Daily Minimum	Monthly	Extremes: Record Highest	Year	Record Lowest	Year	PRECIPITATION (IN INCHES): Mean	Greatest Daily	Year	Greatest Monthly	Year	Snow, Ice Pellets: Mean	Greatest Monthly	Year	Greatest Daily	Year	Greatest Depth on Ground	Year	MEAN NUMBER OF DAYS: Precipitation .10 Inches or more	Temperature Max: 70° and Above	32° and Below	Min: 32° and Below	0° and Below
(a)	4	4	4	4	-	4	-	4	4	-			4	4	-	4	-	4	-	4	4	4	4	4
J	35.1	27.2	31.1	45	1942	1	1947	4.70	1.22	1946	6.58	1946	7.6	23.3	1946	6.0	1946	4	1946	20	0	7	20	0
F	35.8	26.8	31.3	48	1947	2	1947	5.82	1.26	1947	9.39	1947	9.4	21.4	1946	11.0	1947	8	1946	20	0	6	21	0
M	34.1	24.2	29.1	48	1942	2	1947	2.76	1.08	1946	3.79	1946	9.7	15.5	1946	6.0	1945	8	1946	16	0	10	26	0
A	40.4	30.6	35.5	53	1945	14	1945	4.33	1.10	1946	5.67	1946	5.3	10.8	1947	9.0	1947	11	1947	17	0	*	18	0
M	45.7	35.8	40.7	64	1942	19	1947	5.75	1.11	1947	7.73	1946	0.2	0.8	1947	0.8	1947	T	1947	18	0	0	6	0
J	51.6	41.3	41.4	62	1945	31	1946	3.64	1.03	1942	5.97	1947	0.0	0.0		0.0		0		17	0	0	*	0
J	56.5	45.9	51.2	70	1946	36	1945	2.05	1.13	1946	2.70	1946	0.0	0.0		0.0		0		12	1	0	0	0
A	55.4	47.7	57.8	64	1945	32	1946	7.61	3.38	1946	8.43	1945	0.0	0.0		0.0		0		13	0	0	1	0
S	53.0	43.7	48.4	61	1946	30	1946	4.28	1.29	1946	4.87	1945	0.0	0.0		0.0		0		17	0	0	1	0
O	47.7	38.8	43.2	58	1941	24	1945	8.37	1.56	1946	11.83	1946	T	T	1946+	T	1946+	T	1945	21	0	0	3	0
N	38.9	30.1	34.5	49	1945	10	1941	4.99	2.62	1946	10.59	1946	6.2	13.3	1945	6.4	1945	6	1945	13	0	3	19	0
D	36.2	27.5	31.8	47	1941	10	1945	6.00	1.72	1945	7.51	1944	2.1	4.3	1946	2.3	1944	2	1945	20	0	8	21	0
YR	44.2	35.0	39.6	70	1946	1	1947	60.30	3.38	1946			40.5	23.3	1946	9.0	1947	11	1947	208	1	34	136	0

STATION: COAL HARBOR LATITUDE: 55° 24' LONGITUDE: 160° 49' ELEVATION:

MONTH	TEMPERATURE (°F) Means: Daily Maximum	Daily Minimum	Monthly	Extremes: Record Highest	Year	Record Lowest	Year	PRECIPITATION (IN INCHES): Mean	Greatest Daily	Year	Greatest Monthly	Year	Snow, Ice Pellets: Mean	Greatest Monthly	Year	Greatest Daily	Year	Greatest Depth on Ground	Year	MEAN NUMBER OF DAYS: Precipitation .10 Inches or more	Temperature Max: 70° and Above	32° and Below	Min: 32° and Below	0° and Below
(a)	8	8	8	16	-	16	-	15	7	-	15	-	15	15	-	7	-			15	8	8	8	8
J	33.2	22.8	28.0	53	1909	-10	1903	3.72	1.53	1907	6.59	1898	9.9	28.0	1903	6.0	1903	Data Not Available		13	0	9	27	1
F	35.3	22.5	28.9	51	1900	-12	1896	4.51	1.65	1905	9.05	1905	12.9	46.0	1896	6.0	1905+			13	0	5	23	2
M	37.0	23.1	30.1	55	1907	-11	1897	3.68	2.00	1906	8.70	1898	8.4	21.5	1896	4.0	1908			12	0	6	26	1
A	39.2	27.2	33.2	59	1902	4	1902	5.56	1.60	1902	18.92	1905	10.1	27.5	1900	10.0	1907			14	0	4	22	*
M	47.5	34.1	40.8	64	1906	12	1894	3.23	1.82	1907	6.79	1908	1.3	6.0	1894	3.0	1908			12	*	0	9	0
J	54.5	40.1	47.3	74	1909	29	1901	2.44	1.53	1905	7.08	1898	T	T	1908+	T	1908+			10	*	0	1	0
J	60.5	44.7	52.6	80	1909	37	1907+	3.10	1.35	1907	6.51	1899	0.0	0	-	0.0	-			11	2	0	0	0
A	58.4	46.4	52.4	71	1894	33	1902	3.78	1.40	1907	6.79	1896	0.0	0	-	0.0	-			14	*	0	0	0
S	54.8	42.3	48.6	75	1908	32	1909+	4.44	1.50	1903	11.51	1896	0.1	1.0	1896	1.0	1896			15	*	0	*	0
O	46.8	35.6	41.2	60	1900	22	1903	4.71	1.40	1906	8.15	1895	1.7	14.2	1900	2.3	1900			15	0	0	9	0
N	41.4	28.7	35.1	59	1896	7	1909	5.25	1.53	1906	12.90	1897	5.2	17.0	1900	4.0	1903			14	0	2	20	0
D	36.5	23.5	30.0	55	1908	-2	1895	4.09	1.75	1905	8.87	1901	7.6	21.2	1896	3.0	1905+			13	0	8	25	0
YR	45.4	32.6	39.0	80	1909	-12	1896	48.51	2.00	1906	18.92	1905	57.2	46.0	1896	10.0	1907			156	2	34	162	4

(a) Period of Record through
* Less than one half
\+ Also on earlier dates, months, or years
T Trace, an amount too small to measure

Coal Harbor observations began in 1892 and ended in 1911. Not all items presented here were continous during that period.

Table 2, Continued.

STATION: LARSEN BAY, ALASKA — LATITUDE: 57° 32'N — LONGITUDE: 154° 00'W — ELEVATION: 15'

MONTH	Temperature (°F) Means: Daily Maximum	Daily Minimum	Monthly	Extremes: Record Highest	Year	Record Lowest	Year	Precipitation (in inches): Mean	Greatest Daily	Year	Greatest Monthly	Year	Snow, Ice Pellets: Mean	Greatest Monthly	Year	Greatest Daily	Year	Greatest Depth on Ground	Year	Mean Number of Days: Precipitation .10 Inches or more	Temperature Max: 70° and Above	32° and Below	Min: 32° and Below	0° and Below
(a)	(8 to 15 years of data)																							
J	36.0	22.5	29.3	55	1963	-5	1963	2.05	0.93	1953	5.24	1967	5.1	22.8	1967	7.3	1967	9	1967	6	0	9	26	*
F	37.2	22.8	30.0	52	1957	-5	1954	1.92	1.05	1959	5.04	1964	4.4	7.5	1964	4.0	1964	8	1967	5	0	6	24	1
M	38.2	24.3	31.3	56	1965	-5	1956	1.38	0.77	1963	3.86	1967	4.1	8.5	1967	4.0	1967	3	1967+	5	0	7	25	*
A	43.9	27.7	35.8	65	1965	2	1952	1.07	0.63	1965	2.50	1965	0.8	4.5	1965	3.0	1965	2	1965	4	0	1	21	0
M	51.6	34.2	42.9	68	1964+	15	1953	0.76	0.52	1964+	2.16	1965	0.3	3.0	1965	2.0	1965	1	1965	2	0	*	10	0
J	59.8	41.8	50.8	83	1953	28	1955	1.19	0.50	1959+	2.56	1955	0.0	0.0	-	0.0	-	0	-	5	3	0	1	0
J	62.0	46.2	54.1	78	1957	34	1964+	1.29	0.65	1961	3.17	1961	0.0	0.0	-	0.0	-	0	-	5	3	0	0	0
A	61.4	47.2	54.3	76	1960	35	1960	2.82	2.10	1954	5.44	1958	0.0	0.0	-	0.0	-	0	-	7	1	0	0	0
S	57.5	43.0	50.2	72	1954	24	1960+	2.90	1.50	1958	3.91	1961	0.0	0.0	-	0.0	-	0	-	7	*	0	1	0
O	45.7	32.1	38.9	61	1954	10	1956	3.03	1.63	1939	4.35	1954	0.8	2.7	1941	2.7	1941	3	1941	9	0	*	15	0
N	39.4	26.5	33.0	51	1962+	-1	1956	2.37	1.44	1961	5.68	1961	1.7	7.0	1939	5.0	1939	7	1939	8	0	3	23	*
D	34.2	21.1	27.7	49	1962+	-3	1964+	2.23	1.55	1958	5.29	1963	4.8	10.0	1965	4.0	1966	5	1966	6	0	10	26	1
YR	47.2	32.5	39.9	83	1953	-5	1963+	23.01	2.10	1954			22.0	22.8	1967	7.3	1967	9	1967	69	7	36	172	2

STATION: CHIGNIK, ALASKA — LATITUDE: 56°18' — LONGITUDE: 158°23' — ELEVATION: 10 ft.

MONTH	Temperature (°F) Means: Daily Maximum	Daily Minimum	Monthly	Extremes: Record Highest	Year	Record Lowest	Year	Precipitation (in inches): Mean	Greatest Daily	Year	Greatest Monthly	Year	Snow, Ice Pellets: Mean	Greatest Monthly	Year	Greatest Daily	Year	Greatest Depth on Ground	Year	Mean Number of Days: Precipitation .01 Inches or more	Temperature Max: 70° and Above	32° and Below	Min: 32° and Below	0° and Below
(a)	8	9	8	10	10	9	9	8	8	8			8	8	8	7	7	9	9	9	9	9	9	9
J	33.7	23.1	28.0	48	1968	-12	1971	11.59	7.15	1930	29.89	1930	8.8	27.2	1931	7.0	1928	23	1972+	19	0	10	25	1
F	31.6	20.0	25.4	47	1971+	-5	1962+	13.14	5.80	1927	22.99	1922	16.8	31.0	1969	12.0	1929	32	1931	15	0	11	23	2
M	32.8	19.6	26.2	49	1970	-6	1971+	5.80	3.49	1928	12.29	1970	8.3	18.0	1969	8.0	1969	47	1972	8	0	12	26	1
A	38.6	25.5	31.8	51	1930	5	1971+	4.54	2.92	1970	7.48	1968	4.9	18.2	1972	8.0	1928	35	1931	7	0	3	24	
M	46.4	33.4	44.4	69	1968	19	1971+	12.53	7.33	1930	35.71	1930	1.2	5.3	1971	5.3	1971	22	1931	14	0	*	11	
J	53.2	39.2	51.8	72	1968	30	1930	14.28	3.60	1969	27.25	1969	0.0	0.0		0.0				14	*	0	1	*
J	58.3	43.1	50.7	76	1971	33	1930	6.07	3.68	1929	11.61	1971	0.0	0.0		0.0				16	*	0		
A	60.4	44.6	51.8	72	1969	33	1928	6.56	7.15	1927	18.09	1927	0.0	0.0		0.0				13	1	0		*
S	54.0	40.7	47.4	75	1930	27	1930	16.34	7.12	1927	34.34	1929	0.0	0.0		0.0				20	*	0	2	*
O	45.5	34.4	39.6	63	1967	14	1970	12.30	6.52	1930	23.29	1969	3.8	12.0	1927	10.0	1927	10	1927	15	0	*	13	
N	50.6	27.4	34.6	57	1970	4	1930	14.61	4.82	1928	27.99	1929	4.9	12.0	1930	4.0	1930	7	1930	16	0	3	22	*
D	35.5	24.6	30.1	55	1970	2	1927	9.39	4.40	1927	18.81	1928	9.8	25.5	1930	9.0	1930	16	1928	15	0	10	24	
YR	44.2	31.3	38.5	76	1971	-12	1971	127.15	7.15				58.5	31.0		12.0		47		172	1	49	171	4

(a) Period of Record
* Less than one half (0.5)
\+ Also on earlier dates, months, or years
T Trace, an amount too small to measure

Table 2, Continued.

STATION: KANATAK, ALASKA LATITUDE: 57°34'N LONGITUDE: 156°02'W ELEVATION: 23 ft.

MONTH	TEMPERATURE (°F) Means: Daily Maximum	Daily Minimum	Monthly	Extremes: Record Highest	Year	Record Lowest	Year	PRECIPITATION (IN INCHES): Mean	Greatest Daily	Year	Greatest Monthly	Year	Snow, Ice Pellets: Mean	Greatest Monthly	Year	Greatest Daily	Year	Greatest Depth on Ground	Year	MEAN NUMBER OF DAYS: Precipitation .10 Inches or more	Temperature Max: 70° and Above	32° and Below	Min: 32° and Below	0° and Below
(a)																								
J	32.8	20.2	24.8	55	1940	-20	1941	1.12			1.75	1925	8.3	12.0	1925	4.0	1940	12	1940	7	0	10	20	3
F	41.4	34.4	37.9	50	1940	20	1941	5.92			8.05	1941	6.9	10.1	1940	5.0	1940	5	1940	20	0	1	9	0
M	36.4	26.1	31.2	51	1940	-13	1940	3.93			4.20	1941	7.6	14.9	1940	5.2	1940	2	1940	14	0	9	15	3
A	46.4	38.1	42.2	57	1940	25	1941	6.81			11.65	1941	0.7	1.5	1941	0.3	1941	1	1941	21	0	0	3	0
M	54.2	44.1	49.4	75	1940	32	1939+	5.15			6.28	1941	0.0	0.0		0.0		0		19	0	0	1	0
J	58.2	47.3	52.9	72	1941	34	1924	2.44			3.00	1941	0.0	0.0		0.0		0		13	*	0	0	0
J	58.5	49.8	54.1	66	1924	40	1924	7.60			10.19	1940	0.0	0.0		0.0		0		5	0	0	0	0
A	61.6	51.2	56.4	65	1940	40	1940	6.02			6.02	1940	0.0	0.0		0.0		0		19	0	0	0	0
S	53.8	44.2	49.1	67	1939	32	1940	8.03			11.12	1941	0.0	0.0		0.0		0		16	0	0	1	0
O	43.2	31.4	37.3	62	1940	0	1939	3.49			4.41	1939	2.1	5.0	1940	5.0	1940	5	1940	15	0	5	15	1
N	39.7	29.0	34.4	53	1924	0	1939	1.16			2.43	1939	3.0	10.0	1939	10.0	1939	10	1939	11	0	9	13	1
D	36.8	26.3	31.5	49	1940	-6	1924	3.51			3.94	1939	18.4	38.7	1939	13.2	1939	15	1940	11	0	7	18	1
YR	46.9	36.8	41.8	75	1940	-20	1941	55.18					47.0	38.7	1939	13.2	1939	15	1940	171	*	41	95	9

STATION: COLD BAY, ALASKA LATITUDE: 55°12'N LONGITUDE: 162°43'W ELEVATION: 95 feet

MONTH	TEMPERATURE (°F) Means: Daily Maximum	Daily Minimum	Monthly	Extremes: Record Highest	Year	Record Lowest	Year	PRECIPITATION (IN INCHES): Mean	Greatest Daily	Year	Greatest Monthly	Year	Snow, Ice Pellets: Mean	Greatest Monthly	Year	Greatest Daily	Year	Greatest Depth on Ground	Year	MEAN NUMBER OF DAYS: Precipitation .01 Inches or more	Temperature Max: 70° and Above	32° and Below	Min: 32° and Below	0° and Below
(a)	(b)	(b)	(b)	28	-	29	-	(b)	27	-	27	-	22	22	-	22	-			27	28	28	28	29
J	32.6	22.9	27.8	49	1966+	-5	1962+	2.32	2.45	1948	8.56	1948	8.8	13.9	1971	9.2	1971	24	1948	17	0	12	25	*
F	32.7	23.3	28.0	50	1957	-9	1947	3.17	2.49	1956	7.87	1944	9.2	23.4	1966	9.7	1949	16	1949	16	0	11	24	*
M	33.5	24.0	28.8	54	1942	-13	1971	1.75	1.34	1955	3.82	1948	8.2	17.6	1949	7.1	1949	9	1962+	16	0	12	27	1
A	38.3	28.3	33.3	60	1942	4	1943	1.46	1.76	1951	3.83	1970	5.0	14.7	1959	6.0	1957	9	1966	14	0	6	22	0
M	44.6	34.3	39.5	65	1964	21	1945	2.29	2.22	1958	6.37	1958	2.1	9.3	1971	3.8	1971	2	1970	16	0	1	3	0
J	50.3	40.3	45.3	69	1953	29	1962	1.95	2.10	1971	6.08	1957	T	0.5	1971	2.6	1971	0		15	0	0	*	0
J	54.3	45.0	49.7	77	1969	36	1971+	1.82	1.74	1963	4.63	1966	0.0	0.0		0.0		0		16	*	0	0	0
A	55.7	46.9	51.3	78	1948	33	1946	4.35	2.17	1951	9.97	1953	0.0	0.0		0.0		0		19	*	0	0	0
S	52.5	42.5	47.5	70	1960	27	1970	4.32	3.42	1965	9.79	1961	T	0.2	1972	0.2	1972	T	1961+	20	*	0	1	0
O	44.7	35.5	40.1	69	1964+	12	1966	4.59	4.95	1968	8.02	1962	2.9	15.6	1968	11.8	1964	13	1962	22	0	*	9	0
N	38.6	30.1	34.4	64	1970+	1	1963	3.79	3.42	1970	7.94	1960	5.7	21.6	1968	8.6	1964	11	1948	21	0	3	19	0
D	33.4	24.1	28.8	51	1970	-9	1950	2.59	1.94	1972	6.40	1972	8.4	19.3	1969	8.4	1969	14	1949	18	0	11	26	*
YR	42.6	33.1	37.9	78	1948	-13	1971	34.30	4.95	1968	9.97	1953	61.0	23.4	1966	11.8	1964			210	1	67	162	[illegible]

(a) Period of Record (b) Climatological standard normals (1931-1960)
* Less than one half
\+ Also on earlier dates, months, or years
T Trace, an amount too small to measure

Table 2, Continued.

STATION: CAPE SARICHEF, ALASKA LATITUDE: 54° 36'N LONGITUDE: 164° 56'W ELEVATION: 175'

Month	Temperature (°F) Means: Daily Maximum	Daily Minimum	Monthly	Temperature (°F) Extremes: Record Highest	Year	Record Lowest	Year	Precipitation (in inches): Mean	Greatest Daily	Year	Greatest Monthly	Year	Snow, Ice Pellets: Mean	Greatest Monthly	Year	Greatest Daily	Year	Greatest Depth on Ground	Year	Mean Number of Days: Precipitation .10 Inches or More	Temperature Max: 70° and Above	32° and Below	Temperature Min: 32° and Below	0° and Below
(a)	16	16	16	16	-	16	-	16	16	-	16	-	13	13	-	13	-	13	-	14	16	16	16	16
J	35.9	27.3	31.6	57	1963	6	1956	1.99	1.50	1964	4.25	1970	5.3	13.7	1960	5.0	1960	10	1961	6	0	8	22	0
F	35.0	25.5	30.3	58	1957	-1	1954	1.69	1.50	1966	4.07	1966	9.7	32.2	1961	6.0	1957	7	1965	6	0	9	23	*
M	36.7	26.5	31.6	58	1967	-5	1956	1.46	1.73	1963	2.80	1955	6.3	21.1	1961	13	1964	16	1964	4	0	7	24	*
A	38.8	29.6	34.2	58	1955	13	1956	1.16	0.75	1957	2.48	1957	2.6	12.9	1960	2.0	1964+	3	1969+	4	0	4	20	0
M	44.1	35.0	39.6	59	1957	14	1953	1.76	1.20	1957	3.46	1958	0.4	2.0	1960	2.0	1957	1	1965+	5	0	*	8	0
J	48.3	39.8	44.1	70	1969	23	1960	1.49	2.10	1970	6.49	1958	T	T	1962+	T	1962+	0	-	3	*	0	1	0
J	52.4	44.3	48.4	74	1969	34	1954	2.98	1.29	1955	6.99	1955	T	T	1953	T	1953	0	-	8	*	0	0	0
A	54.1	45.7	49.9	74	1954	28	1956	2.89	1.60	1958+	5.93	1956	T	T	1953	T	1953	0	-	8	*	0	*	0
S	51.0	42.9	47.0	72	1965	25	1956	3.64	3.20	1965	16.02	1965	0.0	0.0	-	0.0	-	0	-	7	*	0	*	0
O	44.2	36.4	40.3	61	1957+	22	1953	3.25	1.91	1956	5.54	1960	0.5	1.5	1964+	1.5	1963	3	1966	10	0	*	7	0
N	40.2	32.5	36.4	58	1952	23	1963	3.36	1.70	1952	6.62	1960	3.6	9.3	1960	3.0	1965+	6	1968	10	0	1	14	0
D	36.1	27.5	31.8	57	1961	6	1955	1.81	1.43	1970	5.39	1970	8.2	24.6	1960	4.0	1965	9	1958	6	0	6	24	0
YR	43.1	34.4	38.8	74	1969+	-5	1956	27.48	3.20	1965	16.02	1965	32.2	32.2	1961	13.0	1964	16	1964	77	*	35	143	0

(a) Period of Record
* Less than one half
\+ Also on earlier dates, months, or years
T Trace, an amount too small to measure

Table 2, Continued.

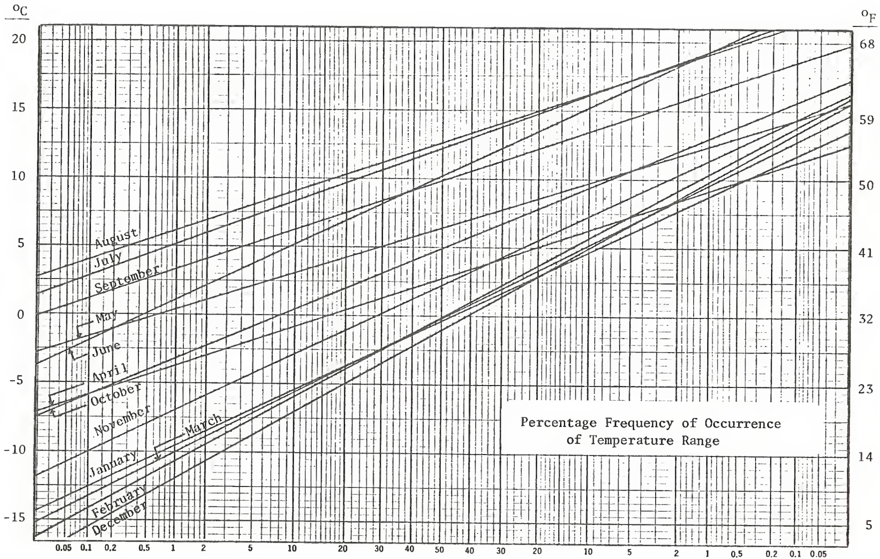


Figure 15. Temperature Distribution, Kodiak. Ten years of data (from Air Weather Service, U.S.A.F.).

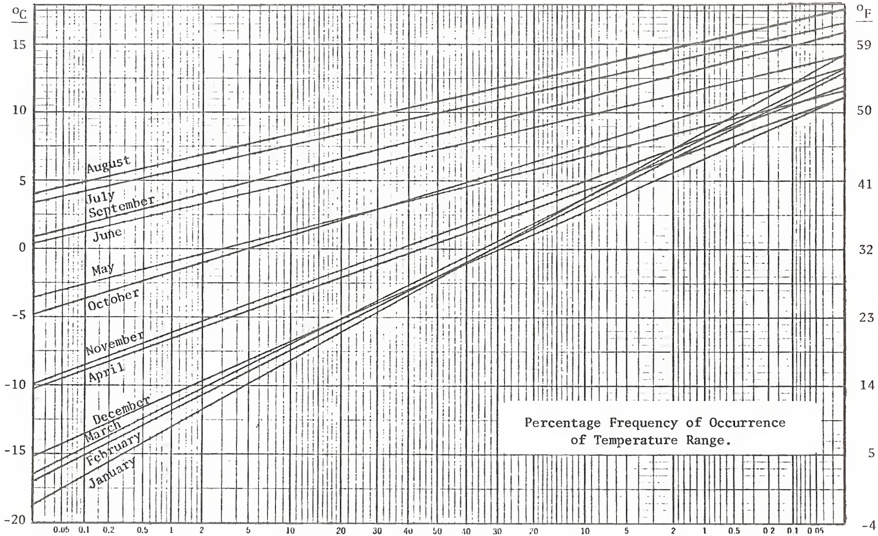


Figure 15, Continued. Temperature Distribution, Cold Bay, Twenty seven years of record (from Air Weather Service, U.S.A.F.).

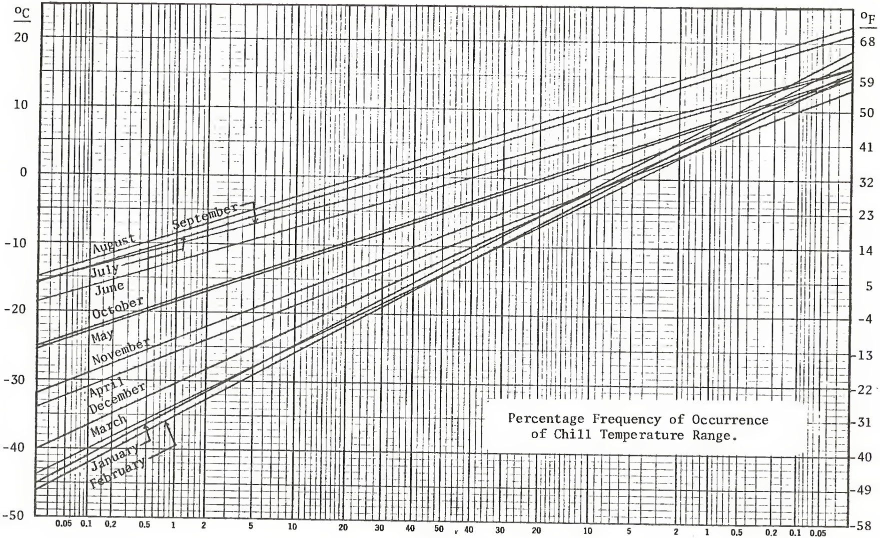


Figure 15, Continued. Temperature Distribution, Cold Bay. Twenty-seven years of record (from Air Weather Service, U.S.A.F.).

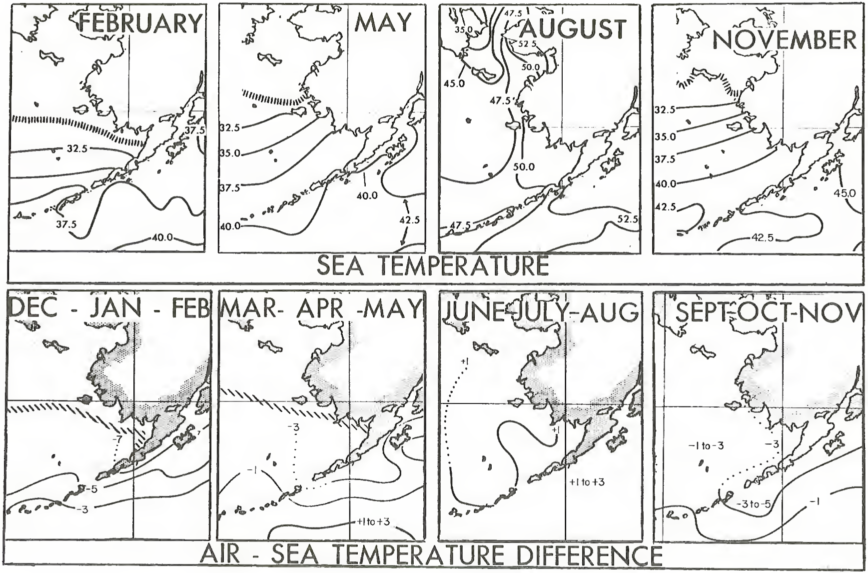


Figure 16. Sea Temperature (degrees F) and Air-Sea Temperature Difference, North Pacific and Bering Sea. Twenty years of record (from Navy Hydrographic Office 1961).

rence of specified monthly amounts of snow, daily amounts of snow, and total precipitation are shown in Tables 3 and 4. The frequency of occurrence of different types of precipitation is shown in Table 5. Data in the last three tables are for Kodiak and Cold Bay only.

SURFACE WINDS

Wind data for four locations (Kodiak, Cold Bay, Cape Sarichef, and Sand Point) are found in Table 6. All four stations show average wind speeds well in excess of those found at interior land stations. Wind speeds at Cold Bay and Cape Sarichef are appreciably higher than those at Kodiak and Sand Point. All four stations reflect terrain influences on wind direction and speed. This limits the usefulness of these wind data for planning at other sites.

Sustained extreme speeds at the reporting stations range from 50 to 75 knots, gusting as high as 100 knots (Table 6). Wind speeds over water are stronger due to less surface friction, and in the event of an unusually intense storm, a sustained wind of approximately 100 knots is possible (Thom 1968). Revisions of original charts presented by Thom (1968) show a recurrence of 100 knot winds once in 25 years and 80 knot winds once in two years along the Alaska Peninsula. These data are based on wind measurement onshore and from ships far offshore in the Pacific. Considering the frequency and intensity of storms just offshore the Alaska Peninsula, an average of one sustained 100 knot wind may occur over open water annually.[1]

Occasionally, winter storms are slow moving or nearly stationary. Such conditions produce a persistent wind direction, creating substantial wave action that could affect coastal or offshore installations.

Average wind directions can be estimated from Figure 11, which shows surface and upper air patterns. The scale of these charts precludes their use in estimating wind speeds. More detailed information on wind direction and speed is available upon request from the National Weather Service.

VISIBILITY

Table 4 presents the frequency of occurrence and cause of visibility values of less than one mile. Table 5 presents the frequency of occurrence of different weather conditions as obstructions to vision. Anything in the air that reduces visibility to six miles (9.6 km.) or less is recorded as an obstruction to vision. Detailed average visibility conditions for Cold Bay and Kodiak are shown in

1 - H.W. Searby, Climatologist, Arctic Environmental Information and Data Center, University of Alaska, Personal communication.

Month	SNOW DEPTH: Monthly values below are percentage frequency of occurrence (based on hourly observations). Categories below are in inches: None	Trace	1	2	3	4-6	7-12	13-24	25-36	37-48	Mean Snow Depth In Inches	Mean No. Days with Snowdepth ≥ 0.1"
J	22	30	9	9	9	10	7	2	*	*	NOT AVAILABLE	15
F	16	32	16	12	11	10	4	*	0	0		15
M	25	33	13	9	6	10	4	*	0	0		13
A	50	31	8	4	2	4	1	0	0	0		6
M	92	7	7	0	0	0	0	0	0	0		*
J	100	0	0	0	0	0	0	0	0	0		0
J	100	0	0	0	0	0	0	0	0	0		0
A	100	0	0	0	0	0	0	0	0	0		0
S	100	*	0	0	0	0	0	0	0	0		0
O	71	16	2	1	1	1	*	0	0	0		1
N	79	25	11	6	3	4	1	0	0	0		7
D	51	27	15	8	5	11	7	2	0	0		15
Yr	63	17	6	4	3	4	2	*	*	*		72

Month	VISIBILITY: Percentage frequency of occurrence. Hourly Obsns/w Vsby < 1 mi., caused by: Fog	Smoke and/or haze	Blwg Snow and/or dust	Precipitation	Total Obsns vsby <1 mi.
J–Yr	NOT AVAILABLE				

Month	SKY COVER: Percentage frequency of occurrence of sky cover (based on hrly observations). Categories below are tenths of total sky cover: 0-3	4-5	6-7	8-9	10	Avg Sky Cover in Tenths
J	13.8	6.5	8.5	15.7	55.5	7.9
F	13.1	5.2	7.3	14.8	59.6	8.1
M	13.0	6.5	0.1	15.4	57.0	8.0
A	8.9	4.7	7.4	16.3	62.7	8.5
M	5.5	3.6	6.5	18.0	66.4	8.9
J	5.4	2.7	5.2	15.3	71.4	9.0
J	3.1	2.2	4.0	12.9	77.8	9.3
A	3.2	2.8	4.3	12.8	76.9	9.3
S	4.2	4.5	7.8	17.3	66.2	8.9
O	8.1	6.7	11.0	20.9	53.3	8.3
N	12.3	6.8	10.1	16.8	54.0	8.0
D	12.9	6.0	9.2	16.1	55.8	8.0
Yr	8.6	4.9	7.5	16.0	63.0	0.5

Month	SNOWFALL: Monthly values below are percentage frequency of occurrence of daily amounts. Categories below are in inches: None	Trace	0.1-0.4	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-6.4	≥ 6.5	Mean Monthly Snowfall (Inches)	Maximum Monthly Snowfall (Inches)	Mean No. Days with Snowfall ≥ 0.1"
J	34	30	10	12	3	1	1	1	*	10.5	19.9	11
F	26	32	21	15	4	1	*	1	0	9.6	23.4	12
M	27	34	19	14	4	1	*	1	*	9.9	17.6	12
A	38	38	12	10	1	*	*	*	0	5.0	14.7	7
M	73	20	5	2	1	0	0	0	0	1.1	9.3	2
J	99	1	*	0	0	0	0	0	0	T	0.5	*
J	100	0	0	0	0	0	0	0	0	0	0.0	0
A	100	*	0	0	0	0	0	0	0	T	0.0	0
S	98	2	*	0	0	0	0	0	0	T	0.2	*
O	63	24	7	5	1	*	0	0	0	2.5	15.6	4
N	43	31	12	11	2	1	*	1	*	6.4	21.6	9
D	28	34	17	13	5	2	1	*	*	10.4	20.3	12
Yr	61	20	9	7	2	1	*	*	*	55.4	23.4	69

Month	PRECIPITATION (INCHES): Monthly values below are percentage frequency of occurrence of daily amts. Categories below are in inches: None	Trace	.01	.02-.05	.06-.10	.11-.25	≥ .26	Mean Monthly Precipitation	Mean No. Days with Pcpn ≥ 0.01"	Maximum Monthly	Minimum Monthly	Maximum in 24 Hrs.
J	17	28	8	17	10	12	8	2.54	17	8.46	0.60	2.49
F	12	31	8	16	10	12	9	2.62	16	7.87	0.08	2.49
M	14	33	8	21	10	9	6	1.82	17	3.89	0.41	1.34
A	16	42	6	15	9	8	3	1.56	13	3.83	0.02	1.76
M	14	36	7	16	9	10	9	2.15	15	6.37	0.62	2.22
J	15	38	8	14	6	14	6	2.19	14	6.98	0.12	2.10
J	13	33	8	16	9	11	9	2.24	16	4.63	0.28	1.74
A	8	29	7	18	10	13	15	3.89	20	9.97	1.40	2.17
S	11	23	7	19	10	17	14	3.81	20	9.79	0.91	3.43
O	7	22	5	19	13	20	13	4.34	22	8.02	1.88	4.90
N	13	20	5	18	12	16	17	4.27	20	8.94	1.46	3.43
D	12	31	8	19	9	14	9	2.88	18	6.49	0.19	1.94
Yr	13	30	7	17	10	13	10	34.31	208	9.97	0.02	4.90

* means less than one half

COLD BAY

Table 3. Detailed Weather Conditions, Cold Bay. Twenty years of record (from Air Weather Service, U.S.A.F.).

	SNOW DEPTH — MONTHLY VALUES BELOW ARE PERCENTAGE FREQUENCY OF OCCURRENCE (BASED ON HOURLY OBSERVATIONS); CATEGORIES BELOW ARE IN INCHES											
Month	None	Trace	1	2	3	4-6	7-12	13-24	25-36	37-48	Mean Snow Depth In Inches	Mean No. Days with Snowdepth ≥ 0.1"
J	29	15	23	8	7	8	6	4	0	0	2.2	17.3
F	34	10	14	14	13	13	9	*	0	0	2.1	15.9
M	31	16	13	12	6	9	7	4	2	0	2.9	16.6
A	77	8	3	3	2	2	0	4	1	0	1.3	4.6
M	0	0	0	0	0	0	0	0	0	0	0	0
J	0	0	0	0	0	0	0	0	0	0	0	0
J	0	0	0	0	0	0	0	0	0	0	0	0
A	0	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0	0	0
O	92	5	1	1	1	0	0	0	0	0	0.1	0.9
N	75	12	5	1	1	5	1	0	0	0	0.5	3.9
D	41	19	12	7	4	9	4	4	0	0	1.8	12.7
Yr	73	7	6	4	2	4	2	2	*	0	-	72.0

	VISIBILITY — PERCENTAGE FREQUENCY OF OCCURRENCE Hourly Obsns/w Vsby <1 mi., caused by:					SKY COVER — PERCENTAGE FREQUENCY OF OCCURRENCE OF SKY COVER (BASED ON HRLY OBSERVATIONS); CATEGORIES BELOW ARE TENTHS OF TOTAL SKY COVER					
Month	Fog	Smoke and/or haze	Blwg Snow and/or dust	Precipitation	Total Obsns vsby <1 mi.	0-3	4-5	6-7	8-9	10	Avg Sky Cover In Tenths
J	1.5	0	.6	1.6	3.7	30.5	6.5	6.4	10.2	46.5	6.5
F	1.6	0	.4	1.5	3.5	30.8	6.0	6.8	12.5	43.9	6.4
M	0.7	0	.8	2.2	3.7	30.0	6.5	8.0	12.2	43.3	6.5
A	1.3	0	.1	.5	1.8	24.3	6.8	9.1	14.5	45.4	6.9
M	0.9	0	0	.1	1.0	17.1	5.1	7.7	15.3	54.8	7.7
J	3.5	0	0	.2	3.6	20.6	6.2	8.9	14.9	49.6	7.3
J	3.5	0	0	.1	3.6	15.7	5.9	8.7	16.4	53.2	7.8
A	2.2	0	0	.1	2.3	16.6	6.8	10.1	17.5	49.0	7.6
S	1.8	0	0	.2	2.1	20.2	7.1	10.4	16.8	45.5	7.2
O	0.5	0	0	.4	0.9	25.6	7.8	9.4	14.1	43.1	6.7
N	0.5	0	.3	.4	1.3	23.3	7.5	7.8	12.4	48.9	7.1
D	0.5	0	.8	1.5	2.8	29.1	7.0	7.5	10.8	45.5	6.6
Yr	1.6	0	.2	.7	2.5	23.7	6.6	8.4	14.0	47.4	7.0

	SNOWFALL — MONTHLY VALUES BELOW ARE PERCENTAGE FREQUENCY OF OCCURRENCE OF DAILY AMOUNTS; CATEGORIES BELOW ARE IN INCHES											
Month	None	Trace	0.1-0.4	0.5-1.4	1.5-2.4	2.5-3.4	3.5-4.4	4.5-6.4	≥ 6.5	Mean Monthly Snowfall	Maximum Monthly Snowfall	Mean No. Days with Snowfall ≥ 0.1"
J	47	26	5	10	6	2	1	1	1	14.9	40.1	8.2
F	44	28	6	11	5	3	1	1	0	14.5	34.0	7.8
M	38	29	7	11	7	2	1	2	3	17.7	74.5	10.3
A	59	21	7	8	3	2	1	*	0	7.0	21.9	6.1
M	95	5	0	0	0	0	0	0	0	.4	4.0	0
J	100	0	0	0	0	0	0	0	0	T	T	0
J	100	0	0	0	0	0	0	0	0	0.0	0.0	0
A	100	0	0	0	0	0	0	0	0	0.0	0.0	0
S	98	2	*	0	0	0	0	0	0	T	0.2	1
O	77	18	1	2	0	*	*	1	*	2.6	14.9	1.6
N	60	30	2	4	2	1	1	*	*	5.0	24.3	3.0
D	37	36	7	9	3	3	2	1	2	12.7	28.2	8.2
Yr	71	16	3	5	2	1	1	*	1	74.8	74.5	45.4

* means less than one half

	TOTAL PRECIPITATION — MONTHLY VALUES BELOW ARE PERCENTAGE FREQUENCY OF OCCURRENCE OF DAILY AMTS.; CATEGORIES BELOW ARE IN INCHES											
Month	None	Trace	.01	.02-.05	.06-.10	.11-.25	≥ .25	Mean Monthly Precipitation	Mean No. Days with Pcpn ≥ 0.01"	Maximum Monthly	Minimum Monthly	Maximum in 24 Hrs.
J	26	18	4	6	8	17	21	4.93	16	10.16	.24	3.20
F	28	20	2	8	7	15	20	3.91	15	9.61	1.41	1.41
M	25	25	2	10	7	16	15	4.01	15	8.12	.89	1.78
A	31	21	4	8	8	12	16	3.22	14	4.98	1.13	1.70
M	27	16	4	8	8	18	19	4.05	16	9.53	1.00	1.87
S	38	19	2	11	6	11	13	4.05	15	11.78	1.42	2.31
S	34	17	4	10	5	13	17	3.60	14	8.09	1.01	2.46
A	34	19	3	8	11	12	13	4.67	15	9.30	1.68	2.23
S	31	19	3	11	7	11	18	6.11	17	12.60	1.80	2.64
O	25	23	1	10	6	14	21	5.52	16	10.57	1.56	2.47
N	21	19	3	7	8	14	28	5.51	17	10.28	0.19	2.34
D	21	17	2	9	5	14	22	4.84	16	9.60	1.78	2.03
Yr	28	20	3	9	7	14	19	54.42	186	12.60	0.19	3.20

KODIAK

Table 4. Detailed Weather Conditions, Kodiak. Ten years of record (from Air Weather Service U.S.A.F.).

PERCENTAGE FREQUENCY OF OCCURRENCE OF WEATHER CONDITIONS AS OBSTRUCTIONS TO VISION																	
	RAIN AND/ OR DRIZZLE		FREEZING RAIN		SNOW AND/ OR SLEET		% OBSERVATIONS WITH PRECIPITATION		FOG		SMOKE AND/OR HAZE		BLOWING SNOW		% OBSERVATIONS w/OBSTRUCTION TO VISION	
MONTH	KODIAK	COLD BAY	KODIAK	COLD BAY	KODIAK	COLD BAY	KODIAK	COLD BAY	KODIAK	COLD BAY	KODIAK	COLD BAY	KODIAK	COLD BAY	KODIAK	COLD BAY
J	19.5	13.3	.1	.4	13.2	21.5	30.6	35.7	8.7	12.5	0	0	2.4	3.7	11.1	21.1
F	16.2	12.9	0	.7	14.0	24.7	28.1	37.1	8.3	11.8	0	0	1.4	7.3	9.7	19.1
M	12.1	10.5	0	.3	16.9	25.7	27.0	35.6	5.4	10.8	0	.1	2.9	6.3	8.3	17.0
A	18.3	15.1	0	.1	10.0	21.3	26.7	35.3	6.1	10.5	0	0	.4	2.2	6.6	12.7
M	32.3	30.7	0	0	.4	5.3	32.3	34.5	12.2	11.5	0	0	0	0	12.2	12.0
J	23.4	33.8	0	0	0	.2	23.4	34.0	16.4	18.0	.1	0	0	0	16.5	18.0
J	24.0	36.0	0	0	0	0	24.0	36.0	17.1	28.3	.4	.1	0	0	17.5	28.3
A	22.0	40.2	0	0	0	0	22.0	40.2	12.8	32.3	0	0	0	0	12.9	32.4
S	22.0	32.8	0	0	.1	.1	22.1	32.9	10.5	18.0	0	0	0	0	10.5	18.0
O	22.1	27.5	0	0	3.4	5.5	24.8	32.6	6.1	9.3	.1	0	0	.2	6.3	9.5
N	25.2	22.3	0	.2	7.2	13.1	31.0	34.0	8.2	10.2	0	.1	1.2	3.0	9.3	13.4
D	17.5	13.9	.1	.8	15.5	22.1	30.9	35.8	6.1	10.3	0	0	2.6	7.4	8.7	17.6
Avg	21.3	24.6	*	.2	6.7	11.3	26.9	35.4	9.8	15.5	.1	*	.9	2.9	10.8	18.4

* less than .05

Table 5. Percentage Frequency of Occurrence of Weather Conditions, Kodiak, 10 years of record, and Cold Bay, 27 years of record (from Air Weather Service, U.S.A.F.).

Avg Wind Speed	Peak Gust	Direction→ Month	0-30	30-60	60-90	90-120	120-150	150-180	180-210	210-240	240-270	270-300	300-330	330-360	Avg Wind Speed	Peak Gust
		WIND DATA PERCENTAGE FREQUENCY OF OCCURRENCE														
11.7	64	Jan	2.31	1.95	5.23	10.59	5.77	10.91	4.78	1.64	5.06	6.86	25.86	18.44	13.4	73
12.9	64	Feb	1.41	2.86	12.53	13.50	10.95	8.12	4.51	4.74	4.68	6.54	24.61	8.91	14.8	74
10.7	51	Mar	1.73	3.66	11.54	14.16	8.44	6.38	3.74	2.95	5.87	8.66	23.58	8.30	12.3	59
11.5	57	Apr	1.61	1.66	7.77	7.38	5.82	1.11	5.01	5.91	7.15	12.26	22.92	7.94	13.2	66
9.0	41	May	2.43	5.06	19.61	13.10	6.87	5.73	2.18	2.39	3.31	5.40	18.83	13.51	10.3	47
8.3	45	Jun	1.75	3.46	18.87	10.71	11.60	8.28	3.29	3.28	4.23	5.05	14.22	12.54	9.5	52
7.1	35	Jul	1.81	1.86	11.19	11.69	5.73	9.75	5.81	5.00	7.60	14.08	13.97	9.57	8.2	40
9.0	49	Aug	1.17	2.42	8.26	7.84	7.69	10.82	2.95	4.14	7.66	17.59	20.27	8.06	10.3	56
9.3	56	Sep	1.98	3.36	12.84	9.80	6.47	4.24	2.43	3.25	5.91	16.93	24.38	7.91	10.8	64
10.7	51	Oct	2.17	2.60	11.21	10.66	5.21	6.07	2.30	2.91	4.70	16.20	26.79	7.64	12.3	59
12.0	59	Nov	2.28	2.81	11.75	13.72	7.45	9.22	5.07	4.64	7.67	13.61	17.69	4.88	13.8	68
12.6	55	Dec	2.06	3.50	16.29	15.68	5.11	7.58	3.45	2.99	4.50	10.15	22.05	9.58	14.5	63
Above Calculated in Knots		YR	1.89	2.93	12.26	11.57	6.39	7.35	3.79	3.65	5.70	9.86	21.26	9.77	Above Calculated in MPH	
							AVERAGE WIND SPEED									
		KNOTS	6.0	7.8	10.5	9.4	9.4	9.4	7.9	7.5	8.9	10.3	11.0	9.1		
		MPH	7.0	9.0	12.1	10.4	10.9	10.9	9.1	8.6	10.2	11.8	12.7	10.5		

Table 6. Wind Speed and Direction, Sand Point. Four years of record (U.S. Army Corps of Engineers, unpublished).

	WIND DIRECTION												WIND SPEED											
	PERCENTAGE FREQUENCY OF OCCURRENCE												MEAN VALUES, SHOWN IN KNOTS											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
N	2.2	1.7	2.6	2.7	2.9	2.6	3.8	2.6	2.1	2.5	2.3	2.0	9.3	9.3	9.7	9.3	8.6	7.1	5.6	6.6	6.3	9.3	9.5	8.4
NNE	2.0	2.2	2.7	2.9	4.5	5.5	4.6	2.8	1.5	2.0	2.7	2.1	14.5	12.1	13.0	12.7	11.5	10.7	7.6	8.1	8.1	14.9	14.2	14.4
NE	3.6	4.2	3.8	4.6	10.3	9.3	8.5	6.7	4.0	3.3	3.7	3.1	15.3	13.3	12.6	12.0	11.1	8.5	6.8	7.2	8.9	12.9	14.0	13.3
ENE	3.0	3.6	2.7	3.8	7.9	7.2	7.3	5.4	4.2	3.4	2.3	2.2	15.3	13.9	12.8	10.3	9.4	6.9	6.4	6.1	7.5	12.3	17.1	14.5
E	4.4	3.5	3.6	6.6	12.5	12.4	12.6	8.7	6.0	3.8	3.4	4.6	14.2	10.7	12.6	8.4	8.4	6.0	5.3	5.6	7.1	10.9	14.9	13.8
ESE	3.2	3.6	3.2	4.1	8.8	6.4	6.9	5.2	4.8	3.5	3.6	3.6	13.1	11.1	11.8	9.6	9.4	6.5	6.2	6.1	9.4	12.4	16.1	13.7
SE	6.2	4.7	4.2	5.9	8.7	7.5	8.3	6.6	6.7	5.3	5.4	3.7	13.2	11.0	10.1	9.3	10.5	7.6	6.9	6.1	8.8	12.0	13.8	12.5
SSE	5.2	3.4	2.9	4.5	4.3	3.7	4.1	3.7	4.6	3.6	5.5	3.0	11.8	8.7	9.9	10.9	8.8	8.2	7.2	7.9	9.5	9.3	11.7	10.5
S	4.1	3.8	3.3	3.8	4.2	2.6	2.9	3.8	5.1	3.5	5.1	2.8	6.5	5.2	6.6	7.1	8.0	5.9	5.8	5.9	7.2	7.3	7.3	7.6
SSW	3.2	4.4	2.7	2.4	3.1	1.9	2.5	3.2	4.1	3.6	4.9	1.7	5.7	6.5	5.9	6.5	7.8	5.9	5.9	6.9	7.8	6.9	6.9	5.6
SW	3.5	4.0	2.7	2.0	2.9	2.3	2.0	3.5	4.3	4.6	4.6	3.6	5.2	5.7	5.0	4.8	6.7	5.6	5.1	5.5	6.0	6.2	5.6	5.4
WSW	2.1	2.7	2.2	1.5	1.4	1.0	1.2	1.6	3.1	3.7	2.5	2.5	5.9	6.7	7.3	7.5	5.6	5.4	3.9	5.3	6.2	6.2	7.4	6.4
W	4.7	8.4	8.6	8.2	5.8	5.7	3.7	7.3	10.2	12.3	7.2	6.8	8.4	8.2	8.9	10.7	6.4	6.5	4.3	6.7	7.6	8.7	7.5	7.2
WNW	13.1	15.8	16.4	12.0	4.5	6.0	4.9	7.5	9.0	12.8	12.4	17.2	14.1	14.2	14.9	11.0	7.6	8.5	6.2	8.2	8.2	11.5	13.2	13.8
NW	24.3	21.7	24.3	22.7	10.9	14.4	13.9	15.9	18.2	22.1	22.0	27.2	12.5	12.5	11.8	10.6	8.6	9.6	7.4	8.7	8.9	10.8	12.6	12.9
NNW	6.1	3.6	7.2	5.6	3.1	3.5	5.1	5.2	4.8	4.7	5.0	5.0	12.7	10.7	11.7	9.2	9.1	8.7	7.2	8.0	7.7	10.6	12.0	9.8
Calm	8.9	8.6	6.9	6.8	4.3	7.9	7.6	10.3	7.5	5.3	7.4	8.2	Monthly Average Speeds											
													10.8	10.0	10.6	9.3	8.6	7.1	5.9	6.3	7.4	9.7	10.7	10.7

Table 6, Continued. Wind Speed and Direction, Kodiak, 10 years of record (from Air Weather Service, U.S.A.F.).

	WIND DIRECTION												WIND SPEED											
	PERCENTAGE FREQUENCY OF OCCURRENCE												MEAN VALUES, SHOWN IN KNOTS											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
N	6.9	10.4	9.4	7.4	5.1	3.5	3.1	2.6	4.5	5.3	7.9	10.3	14.0	15.2	14.7	14.0	11.6	9.7	8.4	9.2	11.3	13.7	14.0	15.8
NNE	5.7	7.1	5.3	4.1	3.0	2.0	1.6	1.7	3.0	3.0	4.8	6.8	17.7	15.9	16.7	13.3	11.5	8.6	6.6	8.7	12.3	14.8	15.2	18.1
NE	1.6	1.7	1.5	1.5	2.0	1.2	1.4	0.8	0.9	1.4	2.5	1.7	12.6	11.9	9.3	8.2	9.1	6.8	5.5	5.9	9.0	10.3	15.2	12.4
ENE	1.5	1.0	0.8	1.3	1.9	1.4	0.8	0.9	1.0	0.7	1.1	1.0	17.6	13.0	9.6	11.1	11.2	13.0	6.9	8.2	14.7	11.9	13.9	13.7
E	2.1	1.8	1.2	1.4	2.7	2.0	1.3	1.1	1.1	1.0	1.6	1.7	19.1	16.2	11.3	13.9	13.5	14.8	10.2	10.1	10.8	12.2	15.5	17.3
ESE	5.2	4.6	3.7	3.5	6.0	6.1	4.4	4.9	3.4	3.0	3.5	3.4	20.4	18.9	21.1	18.4	17.6	18.2	19.2	17.3	16.2	16.5	16.6	18.7
SE	12.7	12.6	10.6	11.4	15.8	16.5	14.1	15.5	10.7	7.8	9.0	7.7	20.4	20.6	19.6	18.7	18.1	18.0	16.7	18.5	15.9	17.5	18.0	17.6
SSE	15.5	15.3	13.5	12.4	15.3	18.4	18.1	15.5	15.3	9.1	11.8	11.7	19.3	20.2	19.5	19.4	18.5	18.0	17.7	18.8	17.5	18.5	18.5	19.3
S	4.7	4.6	3.9	3.5	5.4	2.8	2.8	2.6	3.2	3.2	4.9	4.4	14.3	16.1	15.3	17.1	14.6	13.1	12.7	14.5	13.5	13.5	13.6	13.7
SSW	1.5	1.9	1.4	1.1	1.4	0.4	0.3	0.6	0.9	1.4	1.7	1.6	10.7	15.1	14.2	12.9	12.1	6.7	8.2	10.3	7.0	9.7	10.6	10.6
SW	1.9	2.5	2.5	1.4	1.7	0.9	1.2	1.6	2.4	3.7	3.4	2.9	11.9	15.9	15.7	11.0	12.1	11.8	13.7	11.0	10.8	11.7	11.1	12.7
WSW	5.2	4.8	5.7	4.2	3.7	3.5	5.5	11.3	3.5	12.0	8.3	6.8	16.0	15.6	18.7	16.3	13.4	14.3	15.1	16.2	14.3	16.2	15.6	15.6
W	4.3	4.1	5.1	7.2	6.4	7.6	12.9	14.4	10.6	9.7	6.4	5.7	12.3	13.0	14.6	14.5	13.2	12.7	13.3	13.5	13.4	14.9	14.4	12.6
WNW	6.0	5.9	7.1	11.0	9.4	13.5	14.0	13.4	11.8	10.5	7.8	7.6	11.8	11.6	13.8	14.2	12.4	11.5	11.2	12.3	13.1	14.6	13.3	11.4
NW	8.1	7.5	9.9	12.6	8.6	10.5	8.7	5.8	9.4	11.5	8.9	8.4	14.4	13.6	15.8	14.7	12.3	10.7	10.3	10.7	14.2	15.9	14.7	14.2
NNW	12.3	10.1	14.2	12.2	7.4	6.0	5.1	3.3	8.5	11.9	11.7	13.1	16.3	14.7	15.2	15.1	13.5	10.8	9.7	9.7	13.9	17.6	17.6	15.6
Calm	5.0	4.2	4.1	3.8	4.4	3.8	4.7	3.9	3.7	4.7	4.8	5.1	Monthly Average Speeds											
													15.7	15.8	15.8	15.1	14.1	13.7	13.1	14.2	13.8	14.9	14.9	14.8

Table 6, Continued. Wind Speed and Direction, Cold Bay. Twenty seven years of record (from Air Weather Service, U.S.A.F.).

	WIND DIRECTION												WIND SPEED											
	PERCENTAGE FREQUENCY OF OCCURRENCE												MEAN VALUES, SHOWN IN KNOTS											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
N	4.7	4.6	8.1	7.8	4.0	5.2	3.2	2.0	3.4	4.0	5.4	7.0	16.0	11.3	14.7	11.9	9.5	7.7	6.9	6.0	12.4	13.0	18.9	14.5
NNE	10.6	10.2	7.4	14.8	10.3	14.9	12.4	4.1	9.7	7.0	8.1	12.0	17.5	16.0	12.2	13.3	11.5	8.5	9.1	7.1	13.1	13.5	17.6	17.5
NE	20.7	13.7	5.4	2.4	3.2	4.4	3.3	5.4	4.9	4.2	16.1	14.2	18.2	18.4	13.6	10.2	10.6	8.1	7.4	9.9	13.7	15.8	18.2	14.8
ENE	10.7	9.1	3.0	3.0	2.9	1.6	1.9	2.0	2.1	4.0	7.4	7.3	12.4	14.8	9.7	12.3	12.3	8.0	11.2	11.2	10.0	11.6	14.6	12.0
E	1.0	3.8	4.9	2.4	1.3	0.4	0.6	0.7	1.1	1.0	1.8	3.2	8.4	20.2	15.1	17.7	8.3	6.0	12.0	9.1	10.8	15.0	9.0	8.8
ESE	7.1	6.1	2.6	3.3	3.6	2.3	1.3	1.0	2.4	2.9	4.9	6.0	25.0	16.7	18.4	19.1	18.1	10.5	7.8	17.5	14.6	14.1	13.3	12.9
SE	3.6	5.6	7.6	2.3	4.9	2.2	0.9	2.6	6.0	3.0	5.1	2.8	12.9	17.2	18.7	15.6	17.8	19.3	17.1	12.9	24.4	13.4	13.6	12.0
SSE	11.8	17.4	17.1	13.7	16.3	11.7	19.2	18.0	22.0	8.3	13.0	12.9	14.9	16.6	20.0	17.4	16.1	16.4	17.5	16.6	18.6	16.4	17.1	14.3
S	3.8	2.7	4.8	4.9	4.5	4.9	5.0	6.7	4.0	2.6	3.0	2.2	13.1	15.6	14.8	16.3	19.0	14.0	13.6	8.3	14.1	10.4	13.1	13.9
SSW	4.7	5.6	3.1	5.6	11.2	10.8	18.8	21.5	9.7	4.9	6.8	3.4	15.7	13.3	12.1	12.5	12.5	6.4	9.2	9.9	9.7	13.6	13.9	13.0
SW	3.7	6.0	5.6	7.2	9.5	9.1	7.9	9.3	7.2	4.6	5.5	3.6	17.5	15.7	13.9	17.5	10.9	11.1	8.5	10.8	17.5	18.0	18.5	13.7
WSW	2.4	5.2	5.0	5.9	6.5	10.3	7.9	7.6	5.5	11.7	5.6	3.9	19.5	15.3	16.8	15.0	13.3	11.9	7.8	9.8	10.5	19.6	13.7	14.7
W	2.4	3.7	7.2	4.8	5.9	4.4	2.3	6.0	2.9	5.9	2.7	3.0	10.8	13.2	12.8	9.1	8.8	6.8	4.5	8.0	9.4	13.8	10.5	9.5
WNW	2.7	1.3	7.1	6.7	4.1	5.5	4.1	2.0	6.2	13.3	4.7	5.4	18.0	15.4	15.3	13.0	11.9	7.3	9.2	8.2	11.9	16.7	13.2	16.9
NW	6.8	2.0	5.3	3.6	5.8	3.0	3.0	4.6	5.1	12.6	4.9	6.2	20.2	11.5	15.8	10.1	7.9	6.9	6.3	11.5	11.4	14.3	13.0	19.3
NNW	1.6	2.2	3.9	8.9	4.2	7.2	2.7	5.0	6.4	9.2	4.4	5.6	14.0	15.1	14.4	14.1	11.0	8.5	6.1	8.6	12.4	13.7	10.1	16.7
Calm	1.6	0.8	1.9	2.7	1.8	2.1	5.5	1.5	1.5	0.7	0.6	1.3	Monthly Average Speeds											
													16.5	15.8	15.2	13.9	12.6	9.9	10.1	10.8	14.8	15.1	15.6	14.5

Table 6, Continued. Wind Speed and Direction, Cape Sarichef. Four years of record (from Air Weather Service, U.S.A.F.).

CAPE SARICHEF WIND DATA											
	PERCENTAGE FREQUENCY OF OCCURRENCE							FASTEST MILE		HIGHEST GUST	
	By Speed Groups (Knots)										
Month	Calm	1-3	4-12	13-24	25-31	32-46	> 46	Direction	Speed(kt)	Direction	Speed(kt)
J	1.6	3.3	30.5	47.4	12.0	4.7	0.5	ESE	52		
F	0.8	6.0	30.1	48.8	9.0	4.5	1.8	E	53		
M	1.9	5.8	36.0	42.6	8.3	5.0	0.4	SE	48		
A	2.7	6.7	41.1	39.1	6.8	3.1	0.5	S	52		
M	1.8	7.6	46.4	36.0	6.4	1.6	0.2	SE	64		
J	2.1	14.5	54.7	25.0	2.4	1.1	0.3	ESE	58	NNE	74
J	5.5	14.4	51.8	24.4	3.2	0.7	0				
A	1.5	13.2	53.5	26.5	4.1	0.9	0.3	ESE	55		
S	1.5	7.2	41.8	38.7	5.7	5.1	0				
O	0.7	4.7	36.0	44.5	9.0	4.2	0.2	ESE	50		
N	0.6	6.1	33.8	44.0	10.6	4.5	0.4	ESE	54		
D	1.3	5.4	41.3	38.6	9.0	4.3	0.1	SW	54		
YR	1.8	8.1	41.8	37.6	7.1	3.3	0.3	SE	64		

Note: Data not available where entries are omitted.

WIND DATA																						
	KODIAK											COLD BAY										
	PERCENTAGE FREQUENCY OF OCCURRENCE							FASTEST MILE		HIGHEST GUST		PERCENTAGE FREQUENCY OF OCCURRENCE							FASTEST MILE		HIGHEST GUST	
	By Speed Groups (Knots)											By Speed Groups (Knots)										
Month	Calm	1-3	4-10	11-21	22-27	28-40	≥ 41	Direction	Speed	Direction	Speed	Calm	1-3	4-10	11-21	22-27	28-40	≥ 41	Direction	Speed	Direction	Speed
J	8.9	13.6	31.9	34.3	8.3	2.9	.1	WNW	46	NW	99	5.0	3.6	26.5	37.6	15.5	10.7	1.0	SE	58	SSE	79
F	8.6	15.0	36.2	31.9	5.5	2.8	0	WNW	40	NW	86	4.2	3.5	25.8	41.4	13.9	9.8	1.5	SSE	64	SSW	83
M	6.9	15.2	34.4	33.2	6.9	3.3	*	WNW	48	WSW	73	4.1	2.9	24.7	42.3	16.3	8.9	1.0	ESE	58	SE	79
A	6.8	15.2	41.2	31.8	3.9	1.1	*	WNW	42	NW	84	3.8	2.4	26.2	46.2	13.6	7.1	0.4	SE	52	SSE	69
M	4.3	15.3	49.1	29.2	1.8	0.2	0	SE	34	WSW	53	4.4	3.6	29.8	43.1	12.2	6.0	0.3	SSE	49	SSE	70
J	7.9	21.0	48.8	21.4	0.8	0.1	0	NE	33	NW	61	3.8	3.3	32.3	44.7	10.6	4.9	0.4	ESE	55	NW	82
J	7.6	28.6	49.5	14.0	0.2	0	0	SE	25	E	50	4.7	4.5	34.4	41.3	9.8	5.2	0.1	S	47	ESE	64
A	10.3	25.5	46.3	16.6	1.1	0.3	0	WNW	33	WNW	52	3.9	3.8	30.2	43.4	12.3	6.2	0.2	SE	47	SE	67
S	7.5	20.9	46.9	22.5	2.0	0.2	0	SSE	38	SSE	63	3.7	3.8	31.1	46.0	10.4	4.6	0.4	S	50	SSE	68
O	5.3	15.8	42.0	29.9	4.6	2.3	.1	NW	48	NW	72	4.7	3.6	26.8	42.7	13.8	7.8	0.6	S	48	SE	78
N	7.4	14.1	35.4	32.0	7.5	3.4	.1	WNW	46	WNW	74	4.8	4.2	29.3	38.4	13.2	9.1	0.7	SE	57	W	76
D	8.2	14.0	34.1	33.1	7.6	2.8	.2	NW	59	NW	76	5.1	3.9	29.1	39.1	13.3	8.8	0.7	ESE	56	SSW	76
YR	7.5	17.9	41.3	27.5	4.2	1.6	*	NW	51	NW	99	4.4	3.6	28.9	42.1	12.9	7.4	0.5	SSE	64	SSW	83

* less than .05

Table 6, Continued. Wind Speed for Cape Sarichef, Kodiak and Cold Bay (from Air Weather Service, U.S.A.F.).

Table 7. The table also shows visibility in relation to specific values of ceiling height. In general, visibility is better at Kodiak than at Cold Bay.

Fog is the principal cause of reduced visibility in this area. It is most persistent and obstructive from June through September, when the air contains the most moisture and is warmer than the ocean. Heavy fog, fog that reduces visibility to one-fourth mile (0.4 km.0 or less, occurs at Cold Bay on the average of five days in June (Environmental Data Service).

Other conditions that obstruct visibility are rain, drizzle, freezing rain, snow sleet, smoke, and blowing snow.

Visibility charts for the North Pacific are available (Navy Hydrographic Office 1961) but not presented here since the data are estimates due to a lack of visible reference points.

SKY COVER

Sky cover is significantly more extensive over the western portion of the study area. On the average through the year, 85 percent of the sky over Cold Bay is obscured by clouds, and it is completely overcast more than half the time. At Kodiak, 70 percent of the sky is obscured by clouds, and it is completely overcast less than half the time (Table 4). Ceiling heights--the height of the cloud bases when six tenths or more of the sky is obscured by clouds--at Kodiak and Cold Bay are shown in Table 7. This information is useful to aviation planners because it gives the percentage frequency of occurrence of airfield ceiling and visibility conditions.

SOLAR RADIATION

The source of all heat on earth is radiation from the sun. The amount of radiation reaching the earth depends on major factors such as water vapor, clouds (minute liquid droplets), and latitude. Generally, areas situated at higher latitudes receive correspondingly less radiation from the sun.

A comparison was made between data available from Cold Bay (McRoy 1970) and Palmer (Branton et al. 1972) for a seven-year period, 1964 through 1970. Data from both stations are presented in Langleys (a unit of energy, defined as one gram-calorie per square centimeter). The average annual number of Langleys for the seven-year period for Cold Bay is 58,353; for Palmer, 76,983. Obviously, all conditions other than latitude are not equal at the two locales; the lesser amount of Langleys at Cold Bay is due to extensive cloud cover. Since cloudiness tends to diminish from west to east, the average annual amount of radiation should show a slow trend toward higher values from west to east.

KODIAK (NAVAL AIR STATION)

JANUARY

Ceiling ↓ vs ↓ Visibility →	≥ 3	≥ 1½	≥ 1	≥ 3/4	≥ 1/2	≥ 1/4	≥ 0
≥ 1800	73.4	73.9	74.0	74.1	74.2	74.2	74.1
≥ 1500	77.5	78.2	78.4	78.5	78.6	78.6	78.7
≥ 1200	81.0	82.0	82.3	82.3	82.5	82.5	82.5
≥ 1000	84.0	85.5	85.9	86.0	86.2	86.3	86.3
≥ 900	85.0	86.6	87.3	87.4	87.6	87.6	87.6
≥ 800	86.3	88.4	89.1	89.2	89.5	89.5	89.5
≥ 700	87.0	89.4	90.1	90.3	90.5	90.6	90.6
≥ 600	87.9	90.8	91.8	92.1	92.4	92.5	92.5
≥ 500	88.9	92.4	93.7	94.0	94.5	94.7	94.7
≥ 400	89.4	93.6	95.0	95.5	96.2	96.4	96.4
≥ 300	89.6	94.2	95.8	96.5	97.3	97.6	97.7
≥ 200	89.7	94.5	96.3	97.1	98.2	98.5	98.8
≥ 100	89.7	94.5	96.3	97.2	98.5	99.1	99.6
≥ 0	89.7	94.5	96.3	97.3	98.5	99.3	100.0

APRIL

Ceiling ↓ vs ↓ Visibility →	≥ 3	≥ 1½	≥ 1	≥ 3/4	≥ 1/2	≥ 1/4	≥ 0
≥ 1800	79.2	79.6	79.8	79.8	79.8	79.8	79.8
≥ 1500	82.9	83.6	83.8	83.8	83.8	83.8	83.8
≥ 1200	85.3	86.1	86.3	86.4	86.4	86.4	86.4
≥ 1000	88.4	89.1	89.8	89.8	89.8	89.8	89.8
≥ 900	89.6	90.9	91.3	91.3	91.4	91.4	91.4
≥ 800	91.2	92.8	93.2	93.3	93.3	93.4	93.4
≥ 700	92.2	93.9	94.3	94.5	94.5	94.5	94.5
≥ 600	93.0	95.0	95.5	95.7	95.7	95.7	95.7
≥ 500	93.6	95.8	96.4	96.6	96.7	96.7	96.7
≥ 400	94.0	96.3	97.1	97.2	97.5	97.5	97.5
≥ 300	94.2	96.7	97.7	97.9	98.2	98.4	98.4
≥ 200	94.2	97.0	98.2	98.6	99.0	99.3	99.3
≥ 100	94.2	97.0	98.2	98.7	99.4	99.7	99.7
≥ 0	94.2	97.0	98.2	98.7	99.4	99.7	100.0

JULY

Ceiling ↓ vs ↓ Visibility →	≥ 3	≥ 1½	≥ 1	≥ 3/4	≥ 1/2	≥ 1/4	≥ 0
≥ 1800	74.9	75.1	75.2	75.3	75.5	75.5	75.5
≥ 1500	77.0	77.4	77.5	77.5	77.7	77.8	77.8
≥ 1200	78.9	79.4	79.5	79.6	79.7	79.8	79.8
≥ 1000	81.0	81.9	82.0	82.1	82.3	82.3	82.3
≥ 900	82.0	82.9	83.1	83.2	83.3	83.4	83.4
≥ 800	83.1	84.3	84.5	84.6	84.7	84.8	84.8
≥ 700	84.0	85.4	85.6	85.7	85.9	85.9	86.0
≥ 600	85.1	86.7	86.9	87.1	87.3	87.3	87.3
≥ 500	86.3	88.2	88.7	88.9	89.1	89.1	89.1
≥ 400	87.5	90.1	90.9	91.1	91.3	91.4	91.4
≥ 300	88.8	92.8	93.9	94.4	94.7	94.8	94.8
≥ 200	89.2	94.1	95.7	96.2	96.7	97.0	97.0
≥ 100	89.3	94.5	96.4	97.3	98.3	98.8	99.0
≥ 0	89.3	94.5	96.4	97.3	98.4	99.1	100.0

OCTOBER

Ceiling ↓ vs ↓ Visibility →	≥ 3	≥ 1½	≥ 1	≥ 3/4	≥ 1/2	≥ 1/4	≥ 0
≥ 1800	85.2	85.3	85.4	85.4	85.4	85.4	85.4
≥ 1500	88.8	89.0	89.0	89.0	89.0	89.0	89.0
≥ 1200	90.9	91.4	91.5	91.5	91.5	91.5	91.5
≥ 1000	93.0	93.6	93.7	93.7	93.8	93.8	93.8
≥ 900	93.4	94.2	94.3	94.3	94.3	94.3	94.3
≥ 800	94.1	95.1	95.1	95.2	95.2	95.2	95.2
≥ 700	94.5	95.6	95.7	95.7	95.8	95.8	95.8
≥ 600	95.0	96.2	96.3	96.4	96.4	96.4	96.4
≥ 500	95.6	97.0	97.1	97.2	97.2	97.2	97.2
≥ 400	96.2	97.7	97.9	98.0	98.1	98.1	98.1
≥ 300	96.5	98.4	98.6	98.7	98.9	99.0	99.0
≥ 200	96.6	98.7	99.1	99.2	99.5	99.5	99.5
≥ 100	96.6	98.7	99.1	99.3	99.7	99.8	99.8
≥ 0	96.6	98.7	99.1	99.3	99.7	99.9	100.0

KODIAK (NAVAL AIR STATION)

COLD BAY

JANUARY

Ceiling ↓ vs ↓ Visibility →	≥ 3	≥ 1½	≥ 1	≥ 3/4	≥ 1/2	≥ 1/4	≥ 0
≥ 1800	64.3	65.7	66.2	66.3	66.7	66.9	66.9
≥ 1500	72.0	74.3	75.2	75.5	76.3	76.5	76.7
≥ 1200	75.3	78.2	79.3	79.6	80.6	80.9	81.1
≥ 1000	80.2	84.1	85.7	86.1	87.4	87.8	88.0
≥ 900	81.2	85.2	87.0	87.5	88.9	89.2	89.4
≥ 800	82.2	86.6	88.7	89.3	90.8	91.2	91.5
≥ 700	82.8	87.4	89.7	90.3	92.0	92.6	92.8
≥ 600	83.4	88.3	90.7	91.4	93.3	93.9	94.2
≥ 500	83.4	88.6	91.4	92.2	94.5	95.5	95.9
≥ 400	83.6	88.8	91.8	92.6	95.1	96.3	96.7
≥ 300	83.6	88.9	91.9	92.9	95.4	96.9	97.3
≥ 200	83.6	88.9	92.1	93.0	95.8	97.5	98.2
≥ 100	83.6	88.9	92.1	93.1	95.8	97.7	98.6
≥ 0	83.6	89.0	92.1	93.1	95.9	97.7	100.0

APRIL

Ceiling ↓ vs ↓ Visibility →	≥ 3	≥ 1½	≥ 1	≥ 3/4	≥ 1/2	≥ 1/4	≥ 0
≥ 1800	61.9	62.8	63.0	63.0	63.1	63.1	63.2
≥ 1500	70.3	71.6	71.8	71.9	72.0	72.0	72.1
≥ 1200	74.9	76.9	77.4	77.6	77.7	77.8	78.0
≥ 1000	79.4	82.0	82.7	83.1	83.4	83.6	83.7
≥ 900	80.8	83.9	84.7	85.1	85.5	85.7	85.9
≥ 800	82.8	86.3	87.4	87.8	88.4	88.6	88.8
≥ 700	84.2	88.0	89.4	89.9	90.6	90.9	91.1
≥ 600	86.1	90.3	91.9	92.6	93.3	93.7	94.0
≥ 500	87.1	91.9	93.7	94.6	95.7	96.3	96.6
≥ 400	87.9	92.9	94.9	95.9	97.0	97.7	98.1
≥ 300	88.1	93.2	95.4	96.4	97.7	98.6	99.0
≥ 200	88.2	93.4	95.7	96.7	98.1	99.1	99.6
≥ 100	88.2	93.5	95.7	96.9	98.3	99.3	99.9
≥ 0	88.2	93.5	95.7	96.9	98.3	99.3	100.0

JULY

Ceiling ↓ vs ↓ Visibility →	≥ 3	≥ 1½	≥ 1	≥ 3/4	≥ 1/2	≥ 1/4	≥ 0
≥ 1800	39.4	39.6	39.8	39.8	39.8	39.8	39.8
≥ 1500	47.8	48.1	48.3	48.3	48.3	48.4	48.4
≥ 1200	55.6	56.3	56.5	56.5	56.6	56.6	56.7
≥ 1000	63.3	64.7	65.0	65.1	65.2	65.2	65.2
≥ 900	66.5	68.2	68.5	68.6	68.7	68.7	68.8
≥ 800	71.6	74.0	74.4	74.5	74.6	74.6	74.7
≥ 700	75.1	77.9	78.5	78.6	78.7	78.7	78.7
≥ 600	79.1	82.8	83.5	83.7	83.9	83.9	83.9
≥ 500	81.8	86.8	88.0	88.3	88.5	88.6	88.6
≥ 400	83.7	89.8	91.3	91.7	92.1	92.2	92.2
≥ 300	84.9	91.9	93.9	94.5	95.1	95.2	95.3
≥ 200	85.4	93.2	95.8	96.7	97.6	97.8	98.0
≥ 100	85.4	93.4	96.2	97.3	98.4	99.0	99.4
≥ 0	85.4	93.4	96.2	97.3	98.4	99.1	100.0

OCTOBER

Ceiling ↓ vs ↓ Visibility →	≥ 3	≥ 1½	≥ 1	≥ 3/4	≥ 1/2	≥ 1/4	≥ 0
≥ 1800	77.5	78.1	78.1	78.1	78.2	78.2	78.2
≥ 1500	85.2	86.3	86.4	86.5	86.5	86.5	86.5
≥ 1200	89.6	90.9	91.2	91.3	91.3	91.3	91.3
≥ 1000	92.5	94.2	94.6	94.6	94.7	94.7	94.7
≥ 900	93.2	95.1	95.5	95.6	95.7	95.7	95.7
≥ 800	94.3	96.5	97.0	97.0	97.1	97.2	97.2
≥ 700	94.8	97.1	97.7	97.7	97.9	97.9	97.9
≥ 600	95.3	97.8	98.4	98.5	98.7	98.7	93.7
≥ 500	95.5	98.2	98.9	98.9	99.2	99.3	99.3
≥ 400	95.6	98.3	99.1	99.2	99.5	99.6	99.6
≥ 300	95.6	98.4	99.3	99.4	99.7	99.8	99.8
≥ 200	95.6	98.4	99.3	99.4	99.8	99.9	99.9
≥ 100	95.6	98.4	99.3	99.5	99.8	100.0	100.0
≥ 0	95.6	98.4	99.3	99.5	99.8	100.0	100.0

COLD BAY

Due to the cumulative nature of this presentation, it is possible to determine the percentage frequency of occurrence for any given limit of ceiling or visibility separately, or in combination of ceiling and visibility. The totals progress to the right and downward. Ceiling may be determined independently by referring to totals in the extreme right hand column. Also, visibility may be determined independently by reference to the horizontal row of totals at the bottom of the page. The percentage frequency for which the station was meeting or exceeding any given set of minima may be determined from the figure at the intersection of the appropriate ceiling column and visibility row.

Table 7. Ceiling and/or Visibility, Kodiak and Cold Bay. Ten and 27 years (from Air Weather Service, U.S.A.F.).

IMMERSION HYPOTHERMIA

Hypothermia is defined as a subnormal body temperature (Navy Hydrographic Office 1961). Immersion hypothermia involves a loss of body heat to the water. Generally, a person will die if his normal rectal temperature (approximately 99.6 degrees F, 37.6 degrees C) drops below 78.6 degrees F (25.9 degrees C).

Approximate human survival time in the sea directly relates to sea surface temperatures. Immersion hypothermia showing approximate survival time is depicted in Figure 17 (Navy Hydrographic Office 1961). These survival times, however, must be viewed as broad estimates, because data records do not incorporate many uncontrollable physiological variables. For example, neither quantitative appraisal nor records have been made of such intangible factors as the physical condition of the immersed individual or of his will to survive. Table 8 relates water temperature to approximate survival time of humans immersed in the sea. Survival time also may be affected by general physique, body position in the water, and amount of subcutaneous fat.

There are two principal schools of thought with regard to survival techniques to use during immersion: (1) Vigorous exercise and (2) passive waiting. Vigorous exercise may dissipate heat reserves more rapidly, although within reasonable time limits, it may keep muscles warm and prevent them from stiffening. During passive waiting, shivering maintains heat production for as long as the rectal temperature remains between 95.0 and 99.6 degrees F (35 and 37.6 degrees C). Passive waiting is currently somewhat favored.

LENGTH OF DAYLIGHT

The total hours of daylight from sunrise to sunset varies with the latitude of a location; the higher the latitude, the greater the range between the longest and shortest days. Table 9 gives figures for two locations within the study area (Cold Bay and Kodiak), and for Homer, which is just north of the eastern end of the study area (Naval Observatory 1959).

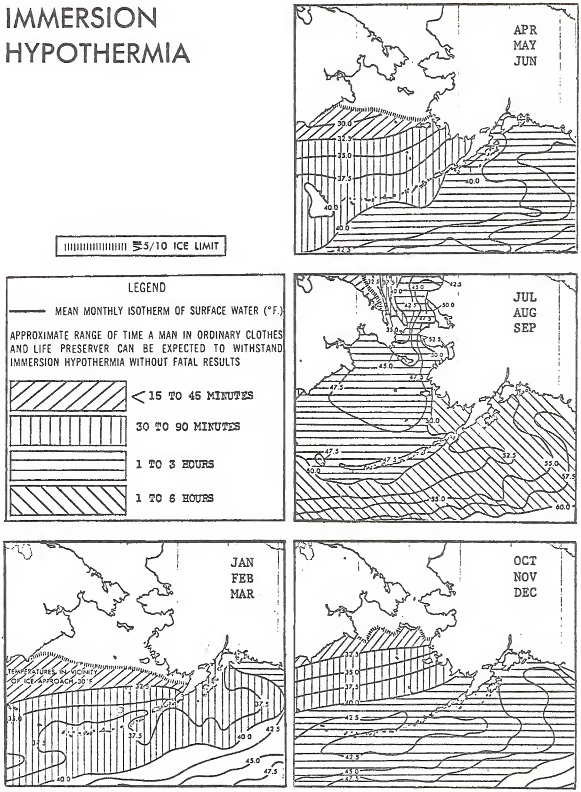


Figure 17. Immersion Hypothermia, North Pacific. Twenty years of record (Navy Hydrographic Office 1961).

Water Temp. (F)	Exhaustion or Unconsciousness	Expected Time of Survival
32.5	15 min.	15-45 min.
32.5-40.0	15-30 min.	30-90 min.
40-50	30-60 min.	1-3 hr.
50-60	1-2 hr.	1-6 hr.
60-70	2-7 hr.	2-40 hr.
70-80	3-12 hr.	3-Indef.
80	Indef.	Indef.

The above table relates water temperature to approximate survival time of humans immersed in the sea.

Table 8. Immersion Hypothermia. Twenty years of record (Navy Hydrographic Office 1961).

Station	Longest Day	Shortest Day
Cold Bay	17h 26m	7h 07m
Kodiak	18h 07m	6h 31m
Homer	18h 44m	5h 59m

The above length of day was computed as the time between sunrise and sunset.

Table 9. Hours of Daylight, Western Gulf of Alaska (from Naval Observatory, 1959).

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IV. OCEANOGRAPHY

INTRODUCTION

The Gulf of Alaska, as well as the entire North Pacific, have been treated as examples of estuarine circulation (Tully and Barber 1960). This may seem farfetched, but by the broadest definition of estuary--a partially enclosed body of water with significant dilution by fresh waters from the land--the surface waters of the North Pacific qualify as a model of estuarine circulation. Many sizable rivers, either directly or indirectly, drain into the area. At the same time, the North Pacific is of normal oceanic depth and in free communication with the remainder of the Pacific and, to a lesser degree, with the Bering Sea and Arctic Ocean. The result is a broad region throughout which the surface waters show definite terrestrial influence, but which, below a well-developed regional pycnocline, show more normal oceanic characteristics (Fleming 1958).

The characteristics of inshore, continental shelf waters around the North Pacific, particularly in the Gulf of Alaska, demonstrate a very marked seasonal variation. During the runoff season, they may be strongly influenced by fresh water inflow, while in winter, oceanic waters may dominate throughout (Royer, In Press). As well, the North Pacific is subject to violent storms which may, particularly in shelf areas, impose notable transitory changes in the waters.

This discussion will concentrate upon the extreme northwestern part of the Gulf of Alaska, essentially the area from Kodiak Island to the end of the Alaska Peninsula at Unimak Pass. Within this restricted area there is considerable local influence from runoff, much of it highly turbid waters from the glaciated terrain of the Kenai and Alaska Ranges. The area is characterized by a relatively broad, smooth continental shelf of variable width, as much as 200 km. east of Kodiak Island, but narrowing to about 80 km. near Unimak Pass. There is one major group of islands--the Kodiak Archipelago--and numerous smaller islands on the shelf. The continental slope is extremely narrow and precipitous in the region, with slopes as great as five to six percent leading to abyssal depths in the Aleutian Trench which parallels the continental margin.

The shelf here is one of the most productive areas of the North Pacific; it supports major fisheries for king, Dungeness, and tanner crab, shrimp, and a variety of bottom fish. Oceanic circulation prevails offshore, while inshore, seasonal terrestrial influences and upwelling produce the fertilization of the waters necessary to support the high local productivity.

Because of the economic importance of the shelf fisheries and the great North Pacific salmon resource, there have been many episodes of oceanographic research in the region. Inaccessibility, severe weather conditions, and political and economic factors have routinely limited the scope of these studies, but by combining material from United States, Soviet, Japanese, and Canadian sources spanning 40 years, a general picture of the oceanography of the Gulf of Alaska can be deduced. This discussion will first review the relatively constant offshore characterisitics and circulation and then proceed to the more complex and more poorly understood situation of the continental shelf waters.

OFFSHORE CIRCULATION

The general geostrophic circulation around the Gulf of Alaska flows counterclockwise (Figure 18). The Subarctic Current, part of the West Wind (North Pacific) Drift, carries water eastward across the Pacific, and then splits to form the Alaska Current and California Current. The broad, slow Alaska Current flows north and then west, passing southwest of Kodiak Island. In the vicinity of Kodiak Island, the current becomes narrower and more intense, forming the Alaska Stream, which flows along the Alaska Peninsula and Aleutian Islands to terminate somewhere in the vicinity of 175°W. Some portion of the stream flows into the Bering Sea, and the remainder doubles back into the Subarctic Current to make the Alaskan Gyral a somewhat closed system (Uda 1963).

Both the Alaskan Stream and Alaska Current are most intense near the edge of the continental slope. Flows as high as 25 cm./sec. have been estimated in the intense region of the Alaska Current off Vancouver Island with estimates of 5-20 cm./sec. elsewhere. Estimated flow of the Alaska Stream in the study area is 25-50 cm./sec., although some ship drift determinations as great as 75 cm./sec. have been made west of Kodiak. Transport estimates for the Alaska Gyral are 1 to $10x10^6$ $m.^3$/sec. (Favorite 1970).

Most estimates of currents in the Gulf of Alaska have been from geostrophic calculations based on hydrographic data (Thompson et al. 1936, McEwen et al. 1930, Favorite 1970). Dynamic current calculations made on data collected since 1928 are fairly consistent; examples of surface and 100 m. depth current in the Northern Gulf of Alaska are shown in Figure 19. The greatest currents, on the order of 50 cm./sec., lie near the shelf break. Also, on the Cape Clear line an eastward countercurrent of over 40 cm./sec. is seen on the shelf.

Because the Gulf of Alaska geostrophic currents are somewhat sluggish, the actual surface currents are influenced greatly by strong winds associated with the frequent storms in the Gulf and by the long-term wind conditions (Boisvert 1969, Searby 1969). In winter, the usual position of the Aleutian low over the Gulf of Alaska generates winds that cause the Alaskan Gyral to increase its transport and dimensions (Figure 20). The greater winter flow and Coriolis intensification cause an increase in mean sea level along the Gulf of Alaska coast nearly 12

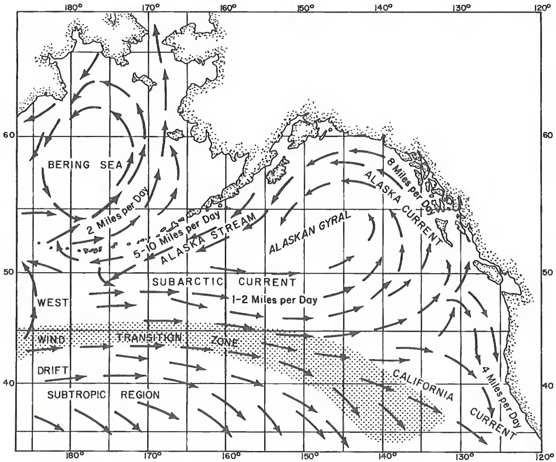


Figure 18. General circulation, North Pacific Ocean--1 mi./day ≅ 2 cm./sec; 50 cm./sec. ≅ 1 knot (adapted from Dodimead, Favorite, Hirano 1962).

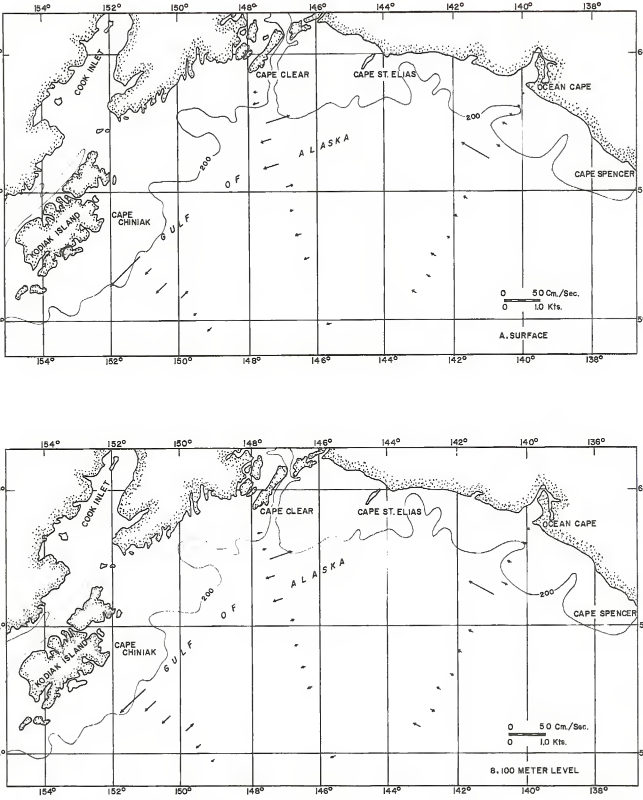


Figure 19. The average calculated current at the surface (A) and 100 M. level (B) shown by vectors. Cape Chiniak, Cape Cleare and Ocean Cape sections, Northern Gulf of Alaska, January (from Thompson et al. 1936).

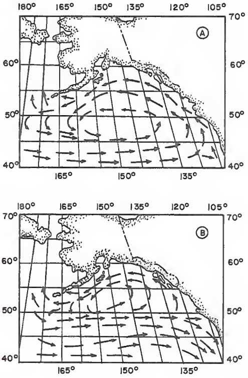


Figure 20.
Permanent currents in the Gulf of Alaska. A - winter; B - summer (from Plathotnik 1964).

cm. above the yearly average (Pattulo 1960). Analysis of Soviet hydrographic data from the Gulf of Alaska has revealed the erratic development of eddies and meanders at the inshore margin of the Alaska Current (Plakhotnik 1964). These eddies are probably at least due in part to local storms (Figure 21).

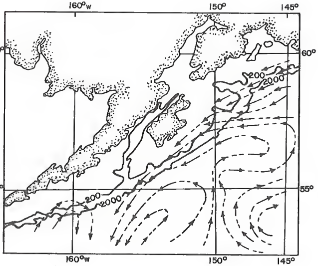
There have been no physical measurements of offshore currents in the Gulf of Alaska, so there is no direct confirmation that the geostrophic calculations are correct. Drift bottle experiments have been performed sporadically since 1930, and have been useful to define the boundaries of the Alaska Gyral, but they cannot clarify exact paths or speeds during transit (Favorite 1964, Fisk 1970).

The driving forces responsible for the offshore circulation in the Gulf of Alaska clearly include both geostrophic and wind-stress components (Roden 1969, Favorite 1970, Royer 1972). From a study of vertical profiles of salinity and temperature, Roden (1969) determined that the winter intensification of flow is very closely tied to the wind field produced by the persistent barometric low centered in the Gulf. This added wind stress alone may produce current velocities in excess of 20 cm./sec. near the edge of the continental shelf. Also, the circulation induces a divergence in the Ekman transport of surface waters, causing upwelling in the central Gulf. Wind stress transport calculations based on monthly mean sea level barometric pressure patterns yield transport calculations that are in fair agreement with geostrophic calculations (Favorite 1970). A plot of such computed transport suggests that mean flow of about $11x10^6$ $m.^3$/sec. to the east occurs in the Alaska Stream near the edge of the continental shelf (Figure 22). Transport computations for the North Pacific are available for the years 1946 through 1968 (Fofonoff 1960, 1961, 1962; Fofonoff and Ross 1962; Fofonoff and Dobson 1963; Wickett 1966, 1967).

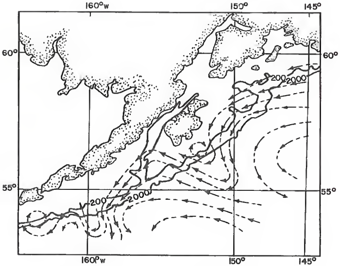
Royer (1972) summarizes the climatologic influence upon circulation in the Gulf and emphasizes the consequences of the normal meteorologic pattern in the area. Throughout the year, but primarily in winter, masses of relatively cold, dry arctic air are drawn over the Gulf where they rapidly absorb both heat and moisture from the warmer sea waters. This heating results in vertical convective movement of air massses and a horizontal divergence of the sea surface, exaggerating the influence of the Gulf low and accelerating the existing geostrophic current.

INSHORE CIRCULATION

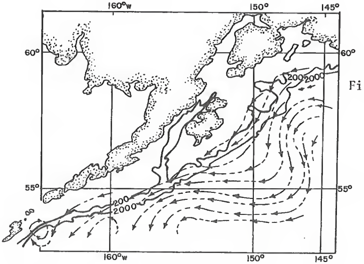
Very little is known of the actual circulation over the Gulf of Alaska continental shelf. The Alaska Stream has considerable influence at the outer margin of the shelf, as discussed above, and presumably induces a general net drift toward the west of all the shelf waters. In summer, when the East Pacific High extends into the Gulf of Alaska, deflection of coastal waters would tend to counter this drift. In



a. April - May 1961



b. October, 1961



c. January, 1962

Figure 21. Surface current charts (from Plakhotnik 1964).

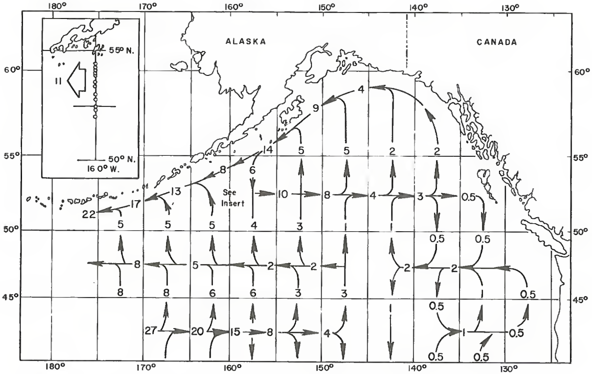


Figure 22. Flow (wind-stress transport [x 10^6 m^3/sec.]) in the eastern North Pacific Ocean determined from records of sea level pressure, February 1970. Insert shows flow computed from oceanographic data obtained at indicated stations (from Favorite 1970).

waters shallower than 200 m., particularly near inshore, local influences make generalization unwise. Along the Gulf of Alaska continental shelf, the most important controls upon circulation (aside from the Alaska Stream) appear to be the tides, seasonally variable fluvial runoff, and topographically controlled local wind effects.

Offshore circulation in the Gulf region, described above, was largely inferred from geostrophic and wind induced transport computations. These cannot be used to infer circulation over the shelf because of the shallow water, irregular boundaries, and the often dominant influence of tidal currents. One series of current determinations has already been presented (Figure 19), but inshore this technique only yields an approximation. Drift bottle or drift card observations can be useful to plot inshore circulation, but their utility depends upon the presence of an active beachcombing fraternity; thus, in Alaska waters they can give only general suggestions of current flow. Among the most useful data here are the direct observations of coastal navigators which are codified in the Coast Pilot (U. S. Coast and Geodetic Survey 1964) and the generalized surface current plots (U. S. Navy Hydrographic Office 1961). Tide tables also may be very useful in some areas. Recently, valuable information on Alaskan coastal currents has been obtained from Earth Resources Technology Satellite (ERTS) imagery which clearly shows the trajectory of turbid river waters on the sea surface (Wright et al. 1973). A very generalized plot of the inshore water surface circulation pattern for the Gulf, based upon all available information, is given in Figure 23.

Tides are an important factor in circulation on the Gulf of Alaska continental shelf. They are of the typical west coast mixed form with a marked diurnal inequality superimposed on the semidiurnal tide. Amplitudes along the Gulf coast are considerable, usually in the range of 2-4 m. (Table 10). Cook Inlet, the major estuary immediately north of the study area, has one of the greatest tidal amplitudes known, in excess of 10 m. at spring tides. Tidal amplitudes and currents have been measured near Middleton Island, which lies at the edge of the continental shelf a few tens of kilometers east of the study area. There the tidal variation over the open shelf is about 3 m.[1] If this value for the tidal range is accepted for the entire shelf, the resulting maximum tidal current velocities (U_{max}) at various depths in the water column (d) can be calculated using the shallow water wave approximation:

$$U_{max} = \frac{H}{2} \quad \frac{g}{d} \quad \text{where} \quad H = \text{tidal amplitude}, \quad g = 9.8 \text{ cm. sec.}^{-2}$$

Calculated current velocities are given in Table 11; and they are in general agreement with tidal currents reported for the area in the Coast Pilot. The flood current in the area usually trends north, while the ebb is to the south. The pattern of currents is extremely variable, however, particularly close inshore where they are most noticeable.

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[1]R. Seitz, Institute of Marine Science, University of Alaska, Personal communication.

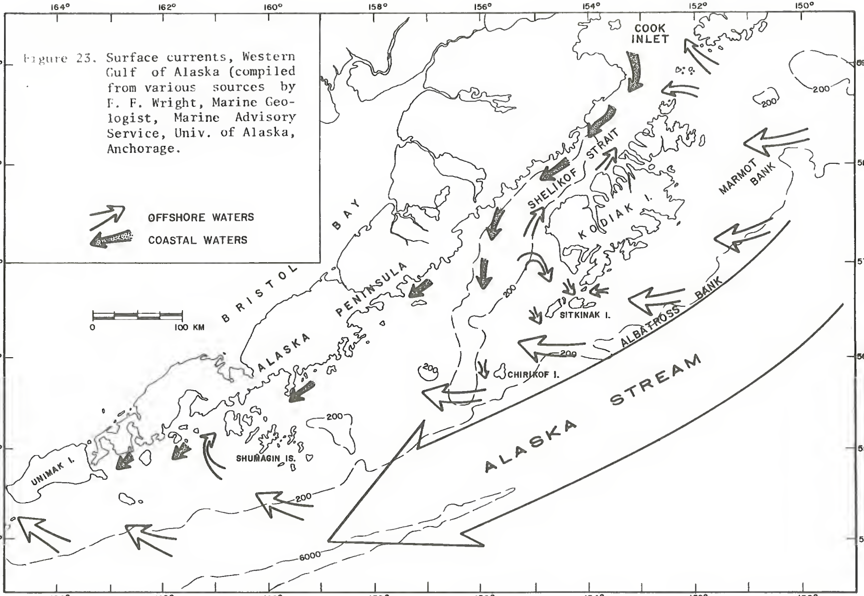

Figure 23. Surface currents, Western Gulf of Alaska (compiled from various sources by F. F. Wright, Marine Geologist, Marine Advisory Service, Univ. of Alaska, Anchorage.

Place	Mean Range* Ft.	Mean Range* M.	Diurnal Range* Ft.	Diurnal Range* M.
Barren Islands	11.4	3.5	13.7	4.2
Ouzinkie, Spruce Island	7.0	2.1	9.1	2.8
Kodiak Harbor	6.6	2.0	8.5	2.6
Port Hobron	6.4	1.9	8.3	2.5
Uyak	11.3	3.4	13.8	4.2
Uganik Passage	11.9	3.6	14.6	4.4
Shuyak Island	11.5	3.5	13.9	4.2
Kukak	11.1	3.4	13.3	4.0
Shumagin Islands	5.6	1.7	7.8	2.4
Beaver Bay	5.2	1.6	7.3	2.2
Pavlof Bay	5.2	1.6	7.2	2.2
Cold Bay	5.2	1.6	7.1	2.2
Sanak Harbor	4.4	1.3	6.6	2.0
Scotch Cap, Unimak Pass	3.3	1.0	5.4	1.6

*Note: Mean range is the difference in height between mean high and mean low water; diurnal range is the difference between mean higher high water and mean lower low water.

Table 10. Representative tidal ranges, Western Gulf of Alaska (from National Ocean Survey 1973)

Depth (m.)	Current (knots)	Velocity (cm./sec.)
10	2.9	149.3
20	2.05	105.6
50	1.3	67.0
100	0.9	46.3
200	0.65	33.5

Table 11. Calculated maximum tidal currents at various depths on an open shelf for a tidal amplitude of 3 m.

Heavy tide rips occur at many points along the Gulf coast. Measured tidal currents at representative sites in the area are given in Table 12. At these stations flood velocities commonly exceed the ebb tides.

The other two factors in coastal circulation are much more erratic. During the runoff season in southern Alaska, the inshore circulation is significantly modified by the large volume of fluvial waters. In an embayment, this runoff factor typically may retard the flood and accelerate the ebb tide. Wind stress, the final factor, is also important as a hazard to navigation and as a potent mechanism of mixing in the surface waters. Its direct influence upon current velocities is apparent only in the open ocean, but inshore along the coast severe storms known as williwaws may develop suddenly and cause much local disturbance. Prevailing winds over the entire shelf in winter tend to assist the ubiquitous westward drift of the Alaska Stream, but they may retard it somewhat in the summer.

The current regime in Shelikof Strait between the mainland and the Kodiak Group is particularly interesting but poorly known. A significant southwest current hugs the mainland shore much of the time. This current is the result of tidal outflow from Cook Inlet and is clearly defined in satellite imagery of the area (Wright et al. 1973). Particularly in winter, this southwest flow is intensified by the pile-up of water from the Alaskan Stream in the Barren Islands sector at the mouth of Cook Inlet (Roden 1969). The Coast Pilot (U. S. Coast and Geodetic Survey 1964) states that the flood tide sets into Shelikof Strait from both ends, contributing to the complexity of the situation. Currents have not been measured in the Strait itself, but vessels report sets commonly in excess of 1 knot (51.5 cm./sec.) in either direction through much of the Strait.

Logan (1970) and the Coast Pilot (U. S. Coast and Geodetic Survey 1964) are the only known sources of information on currents immediately south of Kodiak Island. They report that Sitkinak Strait, separating the Kodiak from Sitkinak and Tugidak Islands, is the site of major tide rips, and under certain conditions whirlpools and very severe seas may develop. When a strong ebb meets an easterly storm from the Gulf or when a strong flood into Shelikof Strait meets a westerly gale, conditions are particularly severe. Average ebb currents are reported to be 2.3 knots (118 cm./sec.) to the east and the flood 1.9 knots (98 cm./sec.) to the west (U. S. Coast and Geodetic Survey 1970). Similar conditions occur on the shoal area between Tugidak and Chirikof Islands known as 17 Fathom Bank. Here Logan (1970) mentions currents as great as 3 knots (154 cm./sec.) and violent seas. Two Liberty Ships cracked their plates and a tug foundered in this area in the winter of 1942.

To the west, on the open shelf between Kodiak Island and Unimak Pass, the regime is strongly influenced by the Alaska Stream. The set is always to the west and has been reliably reported to average about 1.5 knots (77 cm./sec.) west of Chirikof Island (U. S. Coast and Geodetic Survey 1964). Greater currents are believed to occur around the Semidi and Shumagin Islands. This current is particularly sensitive

Place	Flood		Ebb		Difference
	kts.	cm./sec.	kts.	cm./sec.	(Flood-Ebb, cm./sec.)
Chugach Passage	3.1	159.6	1.8	92.7	66.9
Shuyak Strait	3.8	195.7	3.8	195.7	0
Whale Passage, N.W. Entrance	4.6	236.9	2.6	133.9	103.0
Whale Passage, Off Bird Point	4.4	226.6	5.2	267.8	-41.2
Kodiak Harbor	0.9	46.4	0.5	25.8	20.6
Sitkinak Strait	1.9	97.8	2.3	118.4	-20.6
Unga Strait, Shumagin Island	1.2	61.8	0.2	10.3	51.5
Unimak Island, N. of Otter Pt.	0.9	46.4	0.8	41.2	5.2
Unimak Pass, Scotch Cap	3.4	175.1	3.0	154.5	20.6

Table 12. Representative surface tidal currents along the W. Gulf of Alaska (from U. S. Coast and Geodetic Survey 1970)

to the common northeast storms; often it intensifies noticeably toward the southwest as much as a day before the barometer falls.

WATER TYPES OF THE WESTERN GULF OF ALASKA

There are three major domains of distinctive surface waters in the Gulf of Alaska. These are the relatively static region of the central Alaska Gyral, the westflowing Alaska Stream which parallels the continental margin, and the coastal waters (McEwen et al. 1930). There are significant seasonal changes in the circulation of all these areas. The Gyral and its associated Alaska Stream are intensified in winter, when runoff is moderate. During this season, offshore waters may dominate all of the open segments of the shelf. In summer, a weakening of the Alaska Stream and large volume runoff from the hinterland may expand the coastal domain to cover much of the shelf.

In the offshore waters of the Gyral and the Alaska Stream, there is usually a clearly developed pycnocline which appears to be between 100 and 150 m. in depth (Dodimead 1961, Uda 1963, Tully 1964). The thermocline, which is often at a more shallow depth than the major pycnocline, responds dramatically to seasonal influences, but almost invariably shows a temperature maximum, beneath the surface (Figure 24). In winter, a thick, isothermal and isohaline surface layer with a temperature below 3.5 degrees C is produced by wind mixing and heat losss to the atmosphere. This layer is commonly about 100 m. thick. During summer, this same layer is rapidly warmed by insolation, and one or more secondary thermoclines may develop, reflecting episodes of heating punctuated by storm mixing (Uda 1963). Surface waters may exceed 12 degrees C, but normally drop to the winter surface value of 3.5 degrees C or less at depth. The halocline is more stable, but also shows strong seasonal influence (Dodimead 1961). In the winter, surface waters are about 32.8^{o}/oo with the halocline falling at a depth between 100 and 200 m. and the deeper water increasing gradually in salinity to 33.7^{o}/oo (Uda 1963). In summer, the influence of runoff and precipitation significantly lowers the salinity at the surface. Again, reflecting the recent meteorologic history, there may be a number of minor haloclines.

Typical summer offshore water characteristics can be seen in the Temperature-Salinity diagram of conditions south of Kodiak Island and to the west of the Shumagin Islands (Figure 25). Location of stations and profiles are shown in Figure 26. Profiles of temperature, salinity, and dissolved oxygen concentration in the open shelf waters are presented in Figure 27. The thermal regime is somewhat confused, but the salinity profile clearly shows the presence of normal offshore water in the deep which separates Albatross Bank from Kodiak Island. Such ponded masses of normal marine waters are believed to persist throughout the summer in topographic depressions on the Gulf of Alaska shelf. Royer (In Press) believes that the surface water mass behavior on the shelf is highly responsive to atmospheric pressure fields over the Gulf. He emphasizes annual flushing as a result of downwelling in winter and upwelling in

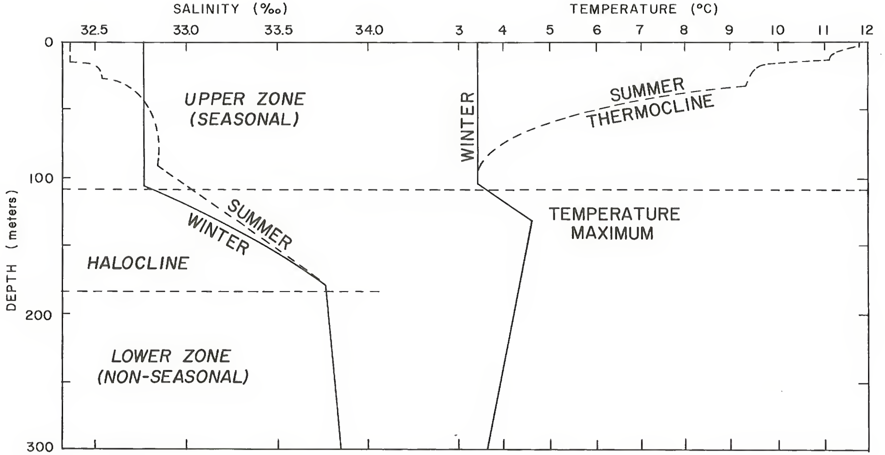

Figure 24. Thermohaline structure offshore Gulf of Alaska (adapted from Dodimead 1961).

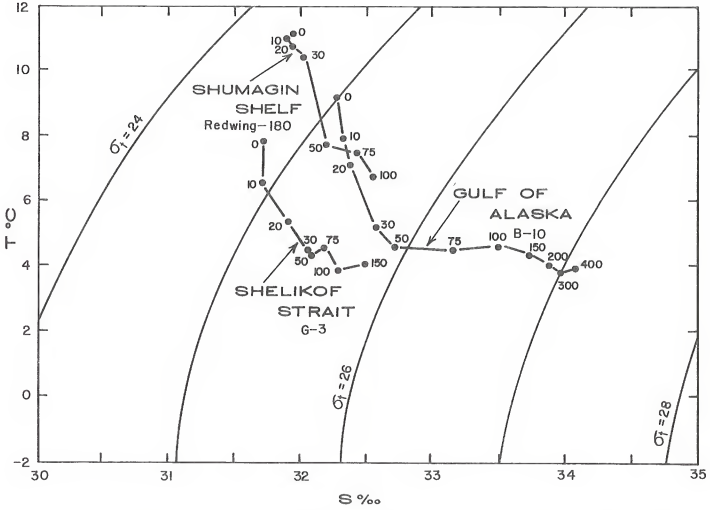

Figure 25. Typical summer water characteristics on the Western Gulf of Alaska continental shelf. Depths in meters. See Figure 26 for station locations (from Wright 1970, and unpublished data from National Oceanographic Data Center).

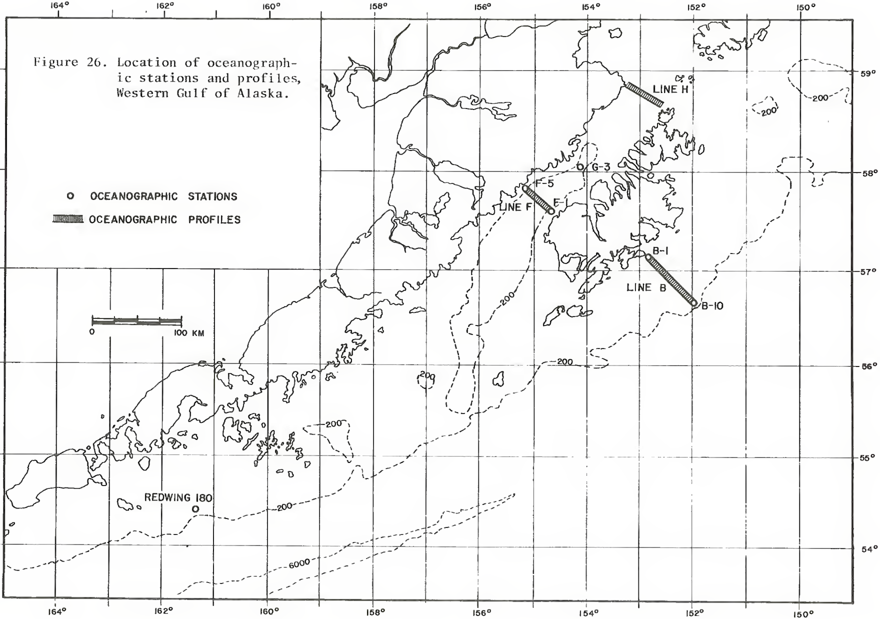

Figure 26. Location of oceanographic stations and profiles, Western Gulf of Alaska.

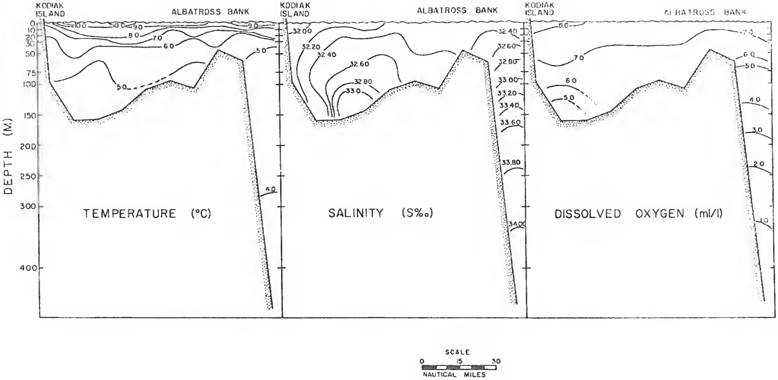

Figure 27. Profiles of oceanographic conditions seaward of Kodiak Island, Line B, June 1967 (from Wright 1970).

summer. Pycnocline depth offshore may coincide with outer continental shelf depths in the Gulf area, but clearly defined structure in the water column over the outer shelf is rarely seen.

Inshore the thermocline structure is more complex and seasonally variable due to the complex terrestrial influence of runoff. Runoff in this region may carry large quantities of silt and clay in suspension (glacial flour) derived from the alpine glaciers common in the coastal ranges. Such turbid waters have sometimes been observed on the sea surface in such areas as Shelikof Strait, probably as a very thin layer of brackish, sediment-laden water which may be no more than centimeters thick (Wright 1971a). Within certain Alaskan fjords, discrete layers of turbid water may spread on density interfaces beneath the surface or settle to the bottom and there move as turbidity flows (Wright 1971b). It is not known if such phenomena occur in the waters of the open shelf, but it is possible; Cook Inlet and Copper River waters have been observed offshore at the surface in satellite imagery (Wright et al. 1973).

The cold meltwater runoff in spring can lead to some curious effects. Upwelling of oceanic waters may take place in which the upwelled waters are warmer than the coastal waters they replace.[1] This is in contrast to the situation on temperate and tropical shelves. Inshore surface water temperatures in summer, because of insolation in bays, may reach values greater than 15 degrees C, but it is more normal to see values of 9-12 degrees C. Typical spring and fall surface water temperatures and a fall bottom water temperature distribution are given in Figure 28 (Shurunov 1964). The plot of surface conditions in the fall definitely suggests the occurrence of eddies developed from the Alaska Stream in the region just east of Kodiak Island.

The distribution of bottom water shows an apparent intrusion of oceanic (colder) waters just west of Kodiak, along the trend of the topographic depression leading into Shelikof Strait. Apparently, normal sea waters may intrude far onto the shelf at times during summer and fall. It has been suggested that the distribution of benthic fish on the shelf may be closely related to these intrusions and to the ponded oceanic waters that may be left behind when the halocline recedes (Plakhotnik 1964).

The temperature-salinity relation in Shelikof Strait, an area strongly influenced by drainage from Cook Inlet, is shown in Figure 25. Profiles of the conservative water characterisitcs in the Strait are given in Figure 29. Water of normal offshore salinity appears toward the mainland side at the south end of the strait.

MIXING PROCESSES AND NUTRIENTS

A variety of mechanisms maintain nutrient values in the Gulf of Alaska. In the central Gulf, as already described, winter upwelling

[1]T.C. Royer, Oceanographer, Institute of Marine Science, University of Alaska, Fairbanks, personal communication.

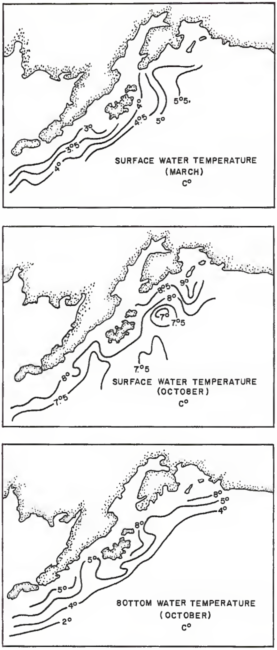

Figure 28. Water temperature on the Gulf of Alaska shelf, 1961 (from Shurunov 1964).

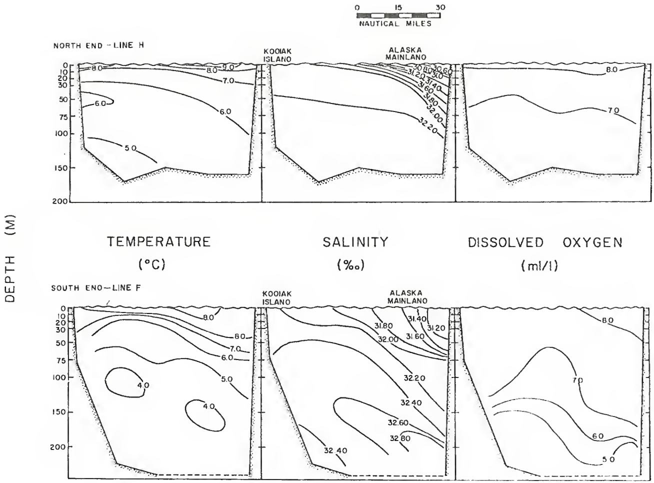

Figure 29. Profiles of oceanographic conditions in Shelikof Strait, June 1967 (from Wright 1970).

appears to be a common phenomenon and these waters are distributed and mixed by both wind action and the geostrophic currents (Roden 1969). Classic coastal upwelling is believed to occur to some degree along this continental margin, usually between April and August, but is apparently quite minor (Royer, In Press). Downwelling, particularly in the winter, may occur on the shelf (Bakun 1973). The principal mechanisms of replenishment of the nonconservative elements in the surface waters of the shelf appear to be storm-wind induced mixing, which may occur at any season; turbulent mixing where the Alaska Stream or tidal currents are perturbed by irregular shelf topography; and the introduction of nutrients from terrestrial runoff. There has been insufficient detailed study of the nutrient budget of the area to assess the relative importance of these factors. There is clearly very significant seasonal variation in these input terms, just as high latitude insolation and water temperature effects vary consumption of the essential nutrients.

The chemical oceanography of the Gulf of Alaska has recently been reviewed by Longerich and Hood (1972). They summarize, in particular, detailed studies of nutrient and other chemical data in the fjords and embayments of the coast plus a variety of generalized studies covering the entire North Pacific. Only a single cruise investigating chemical parameters has been conducted on the continental shelf in the Western Gulf of Alaska. This was conducted in June of 1967 and was restricted to the area immediately around Kodiak Island (Wright 1970). Nutrient concentrations for stations in Shelikof Strait and on the open shelf southeast of Kodiak Island are given in Table 13, and the conservative water characteristics at these stations are given in Figures 27 and 29. The values are rather erratic, reflecting the intense activity of the season. June is the month of greatest insolation and maximum terrestrial runoff. Also, a severe local storm occurred during sampling in Shelikof Strait, interrupting the operation and further serving to mix the waters. In general, all the nutrient profiles show a surface mixed layer from 20 to 50 m. thick in which nutrients, particularly silica, are low. This reflects the seasonal high activity among the phytoplankton. In the deeper waters, nutrient values are relatively high.

Waves

A large proportion of the waves over the open continental shelf of the Gulf of Alaska tend to fall into the category of sea. Many significant waves are generated by large storms in the North Pacific (Extratropical Cyclones) and they are still in the process of development when they enter the study area. As sea, these waves tend to be rather irregular in period and height and to have a trochoidal form, rather than the sinusoidal form typical of swell. Trochoidal waves have relatively broad, flat troughs and sharp, peaked crests, and affect ships out of proportion to their absolute size. These waves are generated by violent storms which tend to travel westward or northeastward parallel to the continental margin. Winds associated with these storms may exceed 50 knots (92.5 k.p.h.) and their duration is often 30 to 40 hours (U.S. Coast and Geodetic Survey 1964). The effective fetch to the southwest

TABLE 13

Nutrient Concentrations in Kodiak Shelf Waters, June 1967 (from Logerich and Hood 1972). See Figure 26 for location of stations.

Station Name	Lat. (N)	Long. (W)	Water Depth (m)	Nutrients µg At/l PO_4	NH_3	NO_2	NO_3	SiO_2
F-1	57°35.0'	154°32.3'	0	0.58	1.60	0.05	0.00	13.0
			10	0.61	1.70	0.07	0.10	12.0
			20	0.58	1.20	0.07	0.20	12.0
			30	0.54	0.90	0.07	0.20	12.0
			50	0.74	1.70	0.11	0.60	14.0
F-5	57°49.0'	155°05.0'	0	0.30	0.80	0.05	0.00	2.0
			10	0.30	1.90	0.05	0.00	1.0
			20	0.35	1.10	0.05	0.00	1.0
			30	0.33	0.70	0.04	0.00	1.0
			50	0.52	1.80	0.06	0.40	3.0
			75	1.04	2.20	1.14	1.90	11.0
			100	1.25	4.20	0.20	3.60	15.0
			150	1.42	3.40	0.39	3.30	22.0
			200	2.14	0.90	0.06	8.40	46.0
B-1	57°08.0'	152°50.5'	0	0.47	1.00	0.06	0.10	5.0
			10	0.55	1.20	0.08	0.20	---
			20	0.84	2.30	0.12	1.10	11.0
			30	0.96	4.50	0.13	1.20	13.0
			50	1.10	4.60	0.14	2.10	16.0
			75	1.20	5.50	0.15	2.60	18.0
B-10	56°36.5'	151°52.0'	0	0.55	1.20	0.03	0.00	2.0
			10	0.52	0.60	0.07	0.40	1.0
			20	0.78	1.00	0.13	1.70	6.0
			30	1.46	2.00	0.19	4.10	24.0
			50	1.73	0.20	0.17	7.60	31.0
			75	1.92	0.10	0.07	7.00	39.0
			100	2.10	0.00	0.03	9.70	47.0
			150	2.48	0.00	0.02	10.7	54.0
			200	2.64	0.00	0.03	10.6	65.0
			300	3.15	0.70	0.01	13.5	88.0
			400	3.26	0.40	0.03	17.2	---

may exceed 1,000 nautical miles (1,850 km.), so theoretically, waves could be generated with a period of about 18 seconds and a significant height of 50 feet (15 m.); (Pierson et al. 1955). There have been unsubstantiated reports of waves of this size in open water in the Gulf, but reliable witnesses with much local experience report that they have never observed waves greater than 30 feet (9 m.) Searby 1969).

Observations of open water waves have been collated in the Climatologic and Oceanographic Atlas for Mariners (Navy Hydrographic Office 1961). These data suggest that during the stormiest season (fall) no more than 10 percent of the waves would have heights greater than 12 feet (3 m.) (Figure 30). An extensive computer model study of the oceanographic climate in the region immediately to the east of the study area has recently been completed by a consortium of petroleum firms.[1] A summary of this study indicates that in fall there is less than 25 percent probability of waves offshore exceeding 14 feet (4 m.).

Such broad-scale studies cannot, of course, consider local problem areas where violent seas over shoals may be produced by winds counter to the currents. Two places within the study area are particularly noted among mariners for difficult wave conditions, the "Heel" (southwest entrance) of Shelikof Strait (Logan 1970) and "Shumagin Gully," west of the Shumagin Islands.[2]

TSUNAMIS

Tsunamis or seismic sea waves are not uncommon in the study area. Tsunamis are ocean waves of extremely long period, typically 10-70 minutes. Their length from crest to crest may be hundreds of kilometers and their height from trough to crest only a few meters. In the open ocean, they cannot be felt aboard ship or seen from the air, but they possess impressive energy.

Tsunamis are believed to originate as vertically displaced columns of ocean water, but the displacing mechanism may vary. Volcanic alterations of the sea floor or submarine avalanches have been proposed as origins of tsunamis, but most tsunamis appear to be associated with seismic activity. Long-period ground waves or large-scale tectonic displacement of the sea floor associated with earthquakes are generally thought to be the causes. Tsunami magnitude appears to be a function of several factors; earthquake magnitude and depth, water depth in region of tsunami generation, extent and velocity of crustal deformation, and the efficiency of energy transfer from the earth's crust to sea water (National Academy of Sciences 1972).

A tsunami "feels the bottom" even in the deepest ocean, and its speed is controlled by the depth of water. In the deep ocean, speeds as

[1] Gulf of Alaska Operators Committee. 1973. Gulf of Alaska Oceanographic Environment. Part 1 of 5. Unpublished report.

[2] S. Yaeger, Mariner, Kodiak, Alaska, personal communication.

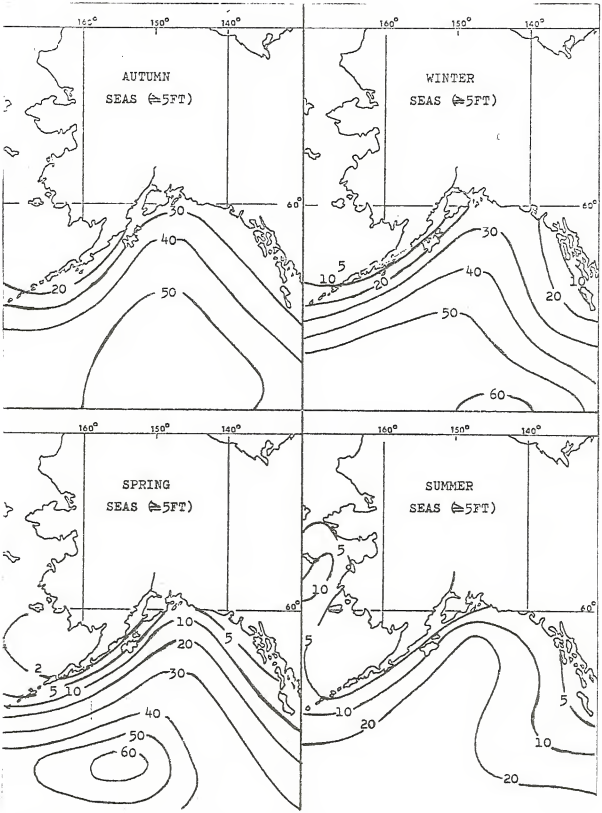

Figure 30. Percentage frequency of seas ≥ 5 ft. (from Searby 1969).

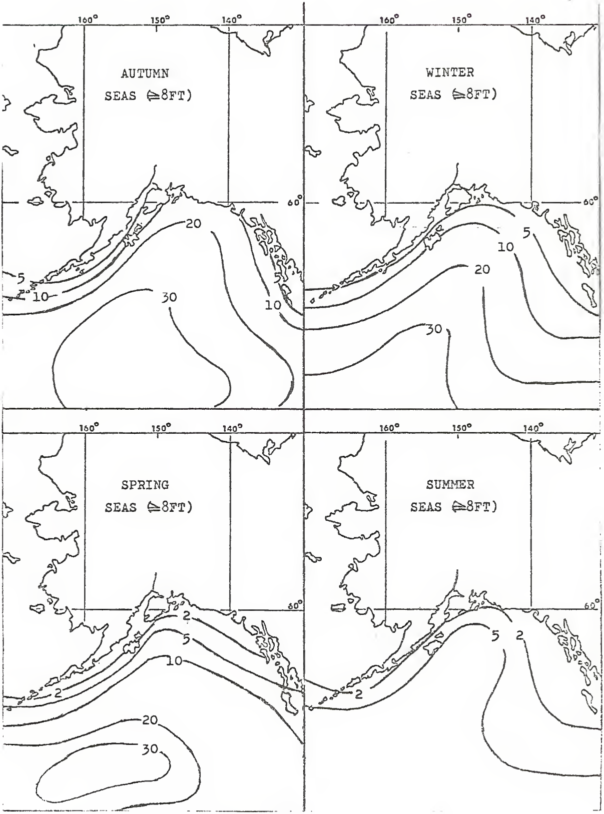

Figure 30, Continued. Percentage frequency of seas ≥ 8 ft. (from Searby 1969).

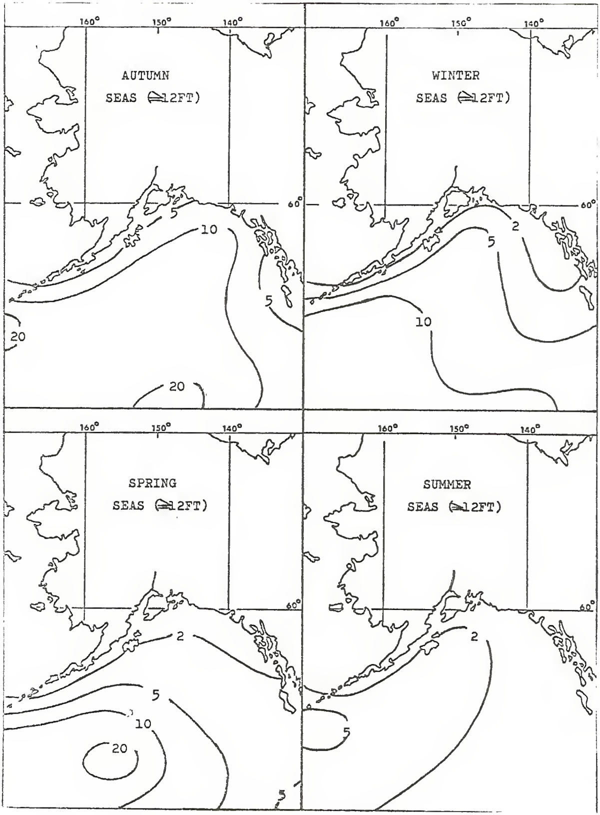

Figure 30, Continued. Percentage frequency of seas ≥ 12 ft. (from Searby 1969).

high as 900 km. per hour may occur. Travel time charts can be prepared to predict approximately when a tsunami generated in a specific area will arrive in another specific area. As a tsunami enters the shoaling water of a coastline, its velocity diminshes, but wave height increases. It is still not possible to accurately predict the wave height of a tsunami as it hits shore; its height may be almost negligible, or it may form crests of considerable height and strike the coast with devastating force. The height of the wave depends on various factors, such as slope of the ocean floor, direction of wave propagation, and speed of the waves. Usually such long period waves are unnoticed over the outer continental shelf.

Tsunamis are most common in the Pacific Ocean; 66 out of 84 (80 percent) of those reported between 1928 and 1963 occurred in this region (U. S. Coast and Geodetic Survey 1965). Because it is a zone of high earthquake activity, the Gulf of Alaska-Aleutian Islands area is a significant generator of tsunamis. Perhaps the most spectacular example of a tsunami generated in the region was during the 1964 Alaska earthquake. A detailed discussion of the cause, effect, and response of this destructive wave is found in a recently published volume (National Academy of Sciences 1972).

Another type of tsunami that can cause damage in restricted harbors and bays also is commonly associated with earthquakes. These waves are generated by earthquake triggered landslides that displace water in the bay and cause waves that can reach elevations more than 60 m. above sea level. This type of wave occurred in Port Valdez during the 1964 earthquake and caused extensive loss of life and property.

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V. GEOLOGY

ONSHORE BEDROCK GEOLOGY

Introduction

The major geologic and tectonic elements of the region are long, linear arcuate belts that parallel and correspond approximately to the major physiographic provinces. The onshore geology of the region is summarized on the generalized geologic map (Figure 31). The subdivisions on the map represent groups of genetically related geologic units. A brief description of each map subdivision is included below. A correlation chart describing in more detail the individual rock units within each subdivision is shown in Figure 32. Additional details of each rock unit can be found in the appropriate references, especially Burk 1965 and Moore 1967, 1969. Also included is an index map showing sources of additional published geologic information (Figure 33). Reference can be made to these maps and reports for more details of the geology of any particular area. Extensive work by petroleum companies has produced much additional information, but most of this is proprietary information.

The bedrock geology of the region can be separated into two basically different units--the Alaskan Peninsula and the Shumagin-Kodiak Shelf--each with its own rock types, structural configuration, and geologic history (Figure 34). The nature of the boundary between these two units is unknown. It may be a fault zone that represents a former major boundary between two crustal plates, or it may simply represent a transition between shallow and deep water sedimentation. The geology of each of these units is discussed in separate sections below.

Alaska Peninsula

The geology of the Alaska Peninsula has been studied by many investigators since the turn of the century. One of the primary investigators has been the U.S. Geological Survey in its continual program of resource evaluation. A detailed investigation and summary of the geology was completed by Burk in 1965, and this work has become the standard reference for the area. The Alaska Peninsula part of the geologic map (Figure 31) has been generalized from Burk's tectonic map, and much of the following summary is extracted from this excellent source (Burk 1965).

The "basement" rocks of the Alaska Peninsula (1)* comprise a suite of "eugeosynclinal" rocks consisting of partly metamorphosed clastic conglomerate, sandstone, shale, carbonate, and volcanic rocks of presumed Paleozoic age overlain by 5,000 to 10,000 meters of limestones, chert, clastics, and miscellaneous volcanic rocks of Permian through Lower Jurassic age. During Early to Middle Jurassic time (176 to 154

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* Numbers refer to subdivisions on geologic map (Figure 31).

Figure 31. Generalized bedrock geologic map, Western Gulf of Alaska. See Figure 32 for more details of rock units (from Moore 1967, 1969; Burk 1965, Barnes 1967, and Von Huene et al. 1971).

LEGEND

Geologic Units

1-Clastic (shale, sandstone, conglomerate), carbonate, and volcanic rocks (metamorphosed in part) of Paleozoic to Early Jurassic age - "basement."

2-Granitic plutonic rocks of mainly Early to Middle Jurassic age (contains some younger plutonic rocks).

3-Clastic rocks of Middle Jurassic to Late Cretaceous age.

4-Clastic and volcanic rocks of Tertiary age.

5-Granitic plutonic rocks of Middle Tertiary age.

6-Clastic rocks (flysch) of Jurrassic (?) to Late Cretaceous age.

7-Clastic and volcanic rocks of Triassic (?) age intruded by ultramafic bodies.

8-Granodiorite plutons of Early Tertiary age.

9-Clastic and volcanic rocks of Tertiary age.

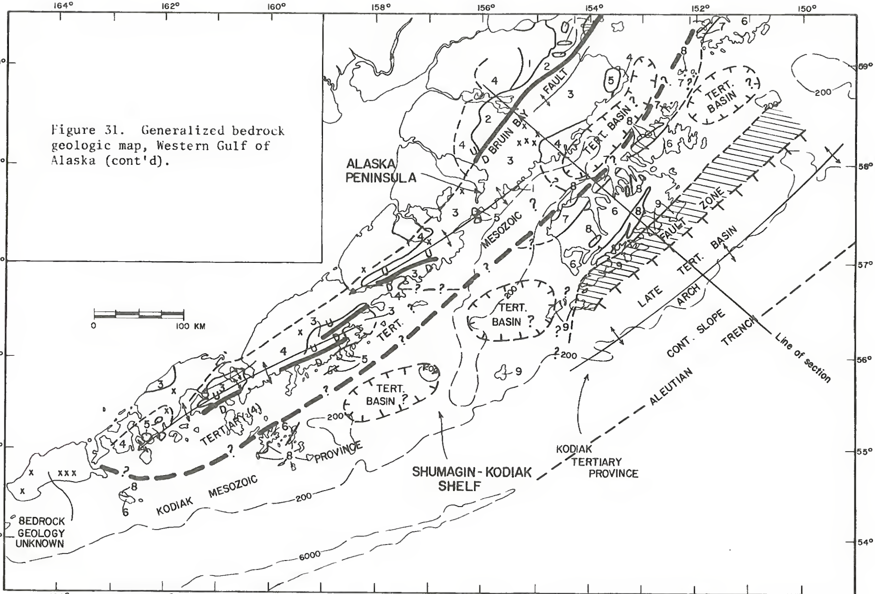
X-Recent and active volcanoes.

Contact between geologic units

Major faults

Major anticlinal axes

Figure 31. Generalized bedrock geologic map, Western Gulf of Alaska (cont'd).



AGE				Southern Alaska Peninsula		Central Alaska Peninsula		N. Alaska Peninsula-Lower Cook Inlet		Kodiak and Vicinity
Mesozoic	Jurassic	M		Not Exposed	Map Unit 1	(See above)	Map Unit 1	(See above)	Map Unit 7	
Mesozoic	Jurassic	Early			Map Unit 1	Largely dark sh., ss., limy concretions in upper 400m. with tuff. and calc. sh., ss. and volc. breccia in lower 300m? (700m.)	Map Unit 1	Porphyritic flows, breccias, tuffs (latite to basalt), some argillite and graywacke (unfossil.) (+2450m. ?max.)	Map Unit 7	
Mesozoic	Triassic	Late			Map Unit 1	Thin lsts. with calc. sh., containing <u>Monotis subcircularus</u>, Cherty beds at base (+425m.?)	Map Unit 1	<u>Kamishak Fm</u>. Calc. sh. lst., chert, <u>Monotis subcircularus</u> and <u>Halobia</u> spp. (+600 m.	Map Unit 7	? — ? — ? Uyak Fm. Black sh., green tuff, pillow basalts, red chert, ultramatic intrusions. Late Tr. Marine fossils. (6000 m.+)
Mesozoic	Triassic	Mid. & Early			Map Unit 1	? — ? Volc. flows, breccias, tuffs, sills on isolated islets, Mid-Permian fossils collected from single lst. (+1225m.?) (Probably Permo-Triassic)	Map Unit 1	? Alted. greenstone, volc. flows, tuffs, breccias of unknown thickness; unfossil. (Presumably Permo-Triassic)	Map Unit 7	
Mesozoic	Permian									? — ? — ? Not Exposed
Paleozoic	Carboniferous					? — ? — ? Not Exposed		? — ? Slate, graywacke, chert, lst., marble, calc. schist, gneiss, qtzite, mica schist. Age unknown, prob. Paleozoic		

Figure 32. Correlation chart of geologic units, Western Gulf of Alaska (from Burke 1965 and Moore 1969).

AGE			Map Unit	Southern Alaska Peninsula	Map Unit	Central Alaska Peninsula	Map Unit	N. Alaska Peninsula - Lower Cook Inlet	Kodiak and Vicinity
Mesozoic	Cret.	Early	3	Staniukovich Fm. Arkosic ss., sltst. (0-600m.)	3	Staniukovich Fm. Arkosic ss., sltst. (0-600m.)	3		Kodiak Fm.? (see above)
Mesozoic	Jurassic	Late	3	Naknek Fm. Arkosic ss, sltst., cgl., clyst. (900-1500m.+)	3	Naknek Fm. Upper dark sltst. and fine-gr. ss. Lower arkosic ss, cgl. sltst. (1500-3000m.+)	3	Naknek Fm. Arkosic ss., some cgl., tuff. Siltst. and arkose in lower part (1700m.+)	Not exposed? (Kodiak Fm. above may be in part Jurassic)
Mesozoic	Jurassic	Late	3	? ?	3	Congl., breccia "Chisik Cgl."	3	Chisik Cgl. Mb. (0-120m.)	
Mesozoic	Jurassic	Late–Middle	3	Not Exposed	3	Shelikof Fm. sh., ss., cgl. (1600-2200m.)	3	Chinitna Fm. Sltst., some ss., calc. concretions (600-900m.)	
Mesozoic	Jurassic	Middle	3		3	?	3	?	
Mesozoic	Jurassic	Middle	3		3	Kialagvik Fm. ss., sh., some cgl. (530 m.)	3	Tuxedni Group. Cgl., ss., sh., sltst., ash beds (2000m.+), includes Bowser, Twist Ck., Cynthia Falls, Fitz Ck., Gaikema Red Glacier Fms. plus L. Bajocian sltst., ss.	
Mesozoic	Jurassic	Middle	3		3	? ?	2	Granite batholiths (176-154 m.y.)	
Mesozoic	Jurassic	E.	3		1	(see below)	2		

Figure 32 (continued)

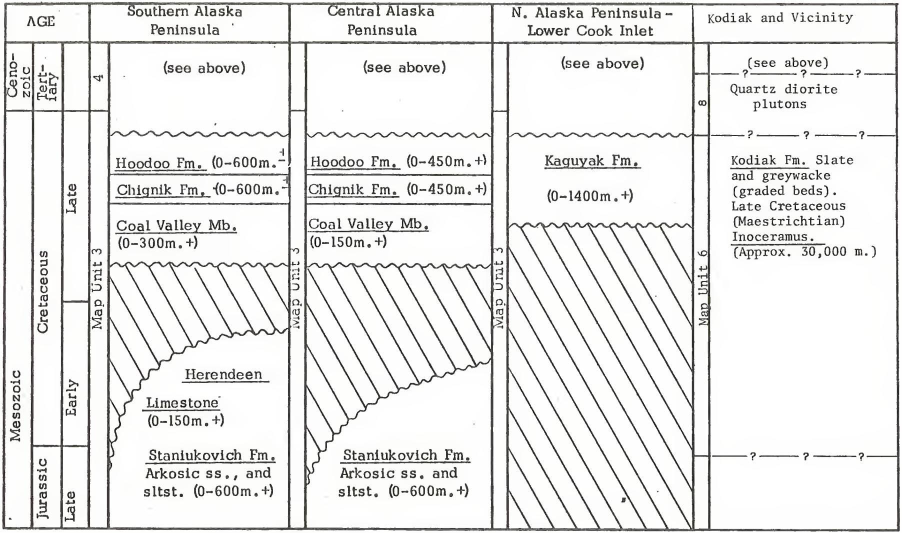


Figure 32 (continued)

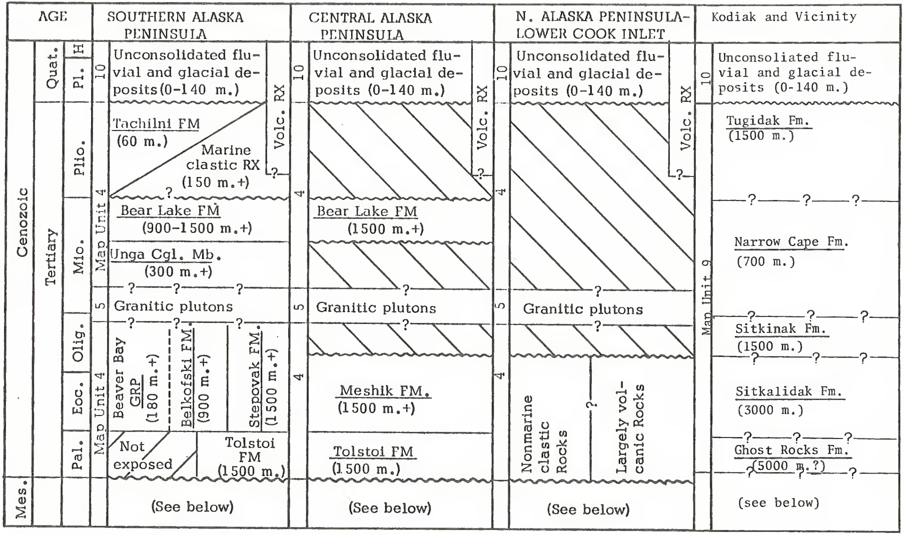


Figure 32 (continued)

Figure 33. Index map of pertinent geologic studies, Western Gulf of Alaska. Numbers refer to areas outlined on map. See literature cited at end of section for more details on references (from Burk 1965 and Moore 1967, 1969).

1. Atwood 1911
2. Burk 1965
3. Capps 1937
4. Grantz 1963
5. Keller and Reiser 1959
6. Kennedy and Waldron 1955
7. Knappen 1929
8. Mather 1925
9. Moore 1967, 1969
10. Smith 1925
11. Smith and Baker 1924
12. Waldron 1961

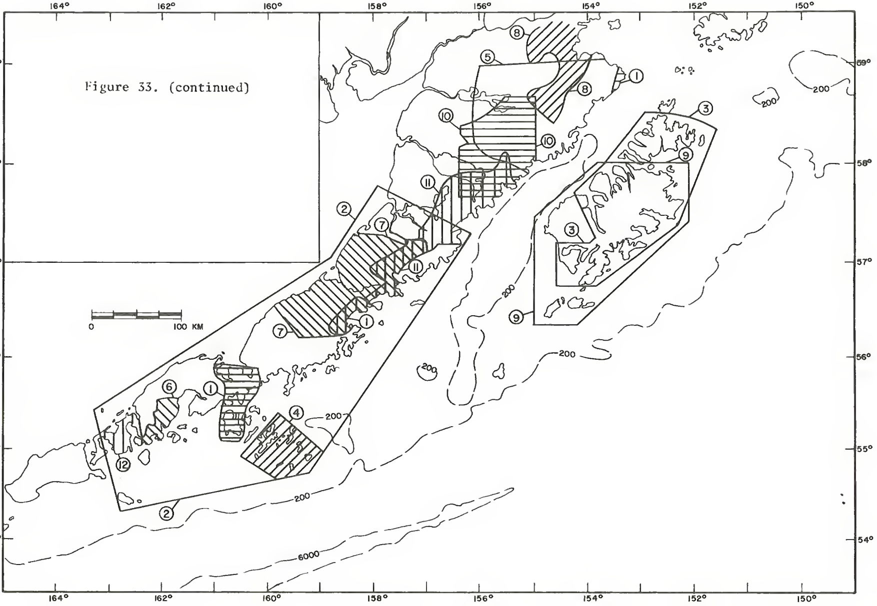


Figure 33. (continued)

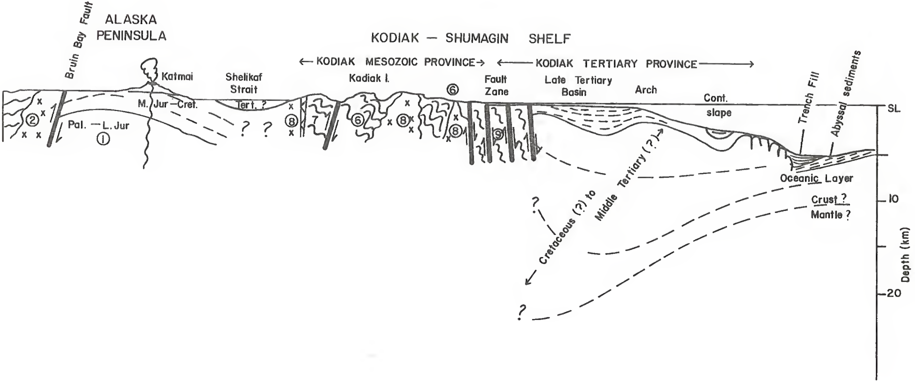


Figure 34. Generalized cross-section, Western Gulf of Alaska (adapted from von Huene et al. 1971 and von Huene 1972).

million years--m.y.--ago), these rocks were intruded by the granitic rocks (2)* that comprise the large Alaska-Aleutian Range batholith. This batholith extends from Becharof Lake on the Alaska Peninsula to the Talkeetna Mountains north of Anchorage. (Reed and Lanphere 1973). Uplift of these "basement" rocks (1 and 2*) provided the source for a thick, continuous sequence of shallow and deep marine clastic sedimentary rocks of Middle Jurassic through Lower Cretaceous age (3)*. Following a period of regional uplift and erosion, another sequence of shallow and deep marine clastic sediments was deposited during Upper Cretaceous time (included with unit 3*). The Tertiary rocks of the area (4)* are characterized by a thick sequence of shallow marine and nonmarine clastics mixed with a variety of volcanic rocks (flows, sills, dikes, tuffs, etc.). During mid-Tertiary time all of these rocks were intruded by another series of granitic plutions (5)*. Extensive volcanic activity has continued to the present as evidenced by the chain of recent and active volcanoes extending along the Peninsula. See Burk (1965) for a more detailed description of the geologic history of the area.

The structural geology of the area is characterized by broad, anticlinal fold complexes paralleled by steeply dipping faults (Figure 31). The northern part of the Peninsula is dominated by the Bruin Bay fault, a steeply dipping reverse fault that separates geologic terranes (1)* and (2)* from terrane (3)*. To the southwest the geological structure is dominated by large en echelon anticlinal complexes containing highly deformed rocks as young as Late Tertiary. The major faults are intimately associated with these anticlinal folds. No major strike-slip faults are known on the Alaska Peninsula. Except for early movements on the Bruin Bay fault, most of the major tectonic features of the Peninsula are thought to have formed during Late Tertiary to Recent time (Burk 1965). Only the major tectonic elements (folds and faults) are shown on the geologic map (Figure 31).

Shumagin-Kodiak Shelf

The geology of the Shumagin-Kodiak Shelf area is much less known due to fewer geologic studies and less exposed land area. Early mineral investigations and a detailed reconnaissance study by Capps (1937) provided the only geologic information of the Kodiak area until more recent studies by the U.S. Geological Survey (Moore 1967 and 1969, Jones and Clark 1973). The reports by Moore (1967, 1969) were used in the compilation of the Kodiak portion of the geologic map (Figure 31) and the correlation chart (Figure 32). A brief report by Grantz (1963) provides a general geologic description of the Shumagin Islands, and Moore (1972, 1973) has made a more recent study of the sedimentary rocks on the Shumagin and Sanak Islands.

The Shumagin-Kodiak shelf separates the Alaska Peninsula from the Aleutian Trench, and its geology is somewhat distinct from the Peninsula (Figure 31). The core of the shelf is a thick sequence of Jurassic (?)

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* Numbers refer to subdivisions on geologic map (Figure 31).

to Cretaceous, deep marine, partly-metamorphosed sandstone and mudstone (flysch deposits) that form a belt of rocks extending from the Sanak Islands through Kodiak to the Kenai Mountains (6)* (Burk 1965, Jones and Clark 1973, Moore 1967, 1969, Moore 1972, 1973). Similar rocks extend further north, forming the core of the Chugach Mountains, and may also extend west in the subsurface along the continental margin of the Bering Sea (Burk 1965, Moore 1973). These rocks apparently are the deepwater (trench or continental rise) equivalents of the Jurassic-Cretaceous sediments on the Alaska Peninsula (3)*. Lying northwest of these rocks, presumably in fault contact on Kodiak Island and in the Kenai Mountains, is a belt of Triassic (?) volcanic rocks, deepwater clastic sediments, and ultramafic bodies (7)*. All of these rocks have been intruded by granitic plutions of early Tertiary age (8)*, which occur on the Sanak Islands, Shumagin Islands, Semidi Islands, as well as forming much of the mountainous terrain of the Kodiak Island group. Uplift of all of these rocks provided the source for a series of deep marine to nonmarine Tertiary clastic sediments and volcanics that are now partly exposed along the southeast flank of the Kodiak Islands (9)*.

The structural geology of the Shumagin-Kodiak shelf is much more complicated than the Alaska Peninsula and is characterized by highly complex and irregular folding and faulting. The strike of the beds and the faulting generally parallels the continental margin and the beds all generally dip to the northwest. An exception is on the Sanak Islands where the beds have a northwest strike. On Kodiak Island unit 6* is separated from unit 9* by one of several steeply dipping faults that represents a zone of differential uplift between Kodiak Island and the adjacent continental shelf.

OFFSHORE BEDROCK GEOLOGY

Introduction

Much less is known about the bedrock geology of the offshore area than the onshore area. The offshore portion of the geologic map essentially represents an extrapolation of onshore geologic belts (Figure 31). This has been supplemented by some marine geological and geophysical studies by the U.S. Geological Survey (Barnes 1967, von Huene et al. 1971, von Huene 1972) and the University of Alaska Geophysical Institute, as well as several holes drilled during Leg 18 of the JOIDES Deep Sea Drilling Program (DSDP) (Kulm et al. 1972). The offshore geology probably is much better known as a result of extensive petroleum company geological and geophysical surveys, but this information is proprietary and is not presently available.

Alaska Peninsula

Basement rocks exposed on the Alaska Peninsula (1)* probably extend offshore in the subsurface and may be, in part, equivalent to the

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* Numbers refer to subdivision on geologic map (Figure 31).

Triassic (?) rocks found along the northwest side of Kodiak Island and on the Kenai Peninsula (7)*. The relationship between these units still is unknown (Figure 34).

The Middle Jurassic to Cretaceous rocks of the Alaska Peninsula (3)* also probably extend offshore at least to the boundary between the Alaska Peninsula and the Shumagin-Kodiak Shelf units. They may represent lateral equivalents of the deepwater flysch sediments on Kodiak Island and adjacent areas (6)*. The distribution of the Mesozoic rocks offshore is only postulated, since they are partly masked by overlying Tertiary basins filled with volcanic and clastic sedimentary rocks (9)*.

The exact distribution of the Tertiary basins is not available knowledge, but their presence is inferred from onshore geology and regional gravity and magnetic data (Barnes 1967 and University of Alaska Geophysical Institute unpublished reports) (Figures 35, 36 & 37). The Tertiary rocks of the Cook Inlet Basin may extend south into Lower Cook Inlet, but if they do they probably are quite thin. They may even connect with another Tertiary basin in Shelikoff Strait, which is inferred from adjacent onshore Tertiary rocks on the Alaska Peninsula and regional geophysical surveys (Figures 35, 36 & 37). The presence of Tertiary rocks on all the islands off the southern Alaska Peninsula suggests that these rocks also cover most of the offshore area between the mainland and the outer Shumagin Islands.

Data on the structural geology of the offshore area are not now available, but presumably the broad onshore en echelon anticlinal folds and faults extend offshore for some unknown distance. Superimposed on these trends is the inferred synclinal Tertiary trough along Shelikoff Strait.

Shumagin-Kodiak Shelf

The Shumagin-Kodiak Shelf essentially consists of two main geologic provinces--the Kenai-Kodiak Mesozoic province and the Kodiak Tertiary province (von Huene et al. 1971).

The presence of similar Mesozoic rocks with similar structural trends on the Sanak Islands, outer Shumagin Islands, Kodiak Islands, and the Kenai Peninsula (units 6, 7, and 8)* suggests that these rocks form a continuous belt that extends the entire length of the shelf. The outcrop areas represent uplifted portions of this belt. The northwest edge of the belt is delineated by the Triassic (?) volcanic, sedimentary, and ultramafic rocks (7)* which extend offshore as a narrow gravity and magnetic high (Figure 35, 36 & 37). This Mesozoic belt is defined on the southeast by a fault zone (see below), although the Mesozoic rocks probably extend further offshore beneath the outer shelf in the deep subsurface as a thick sequence of deformed sedimentary rocks (Figure 34) (von Huene et al. 1971).

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* Numbers refer to subdivisions on geologic map (Figure 31).

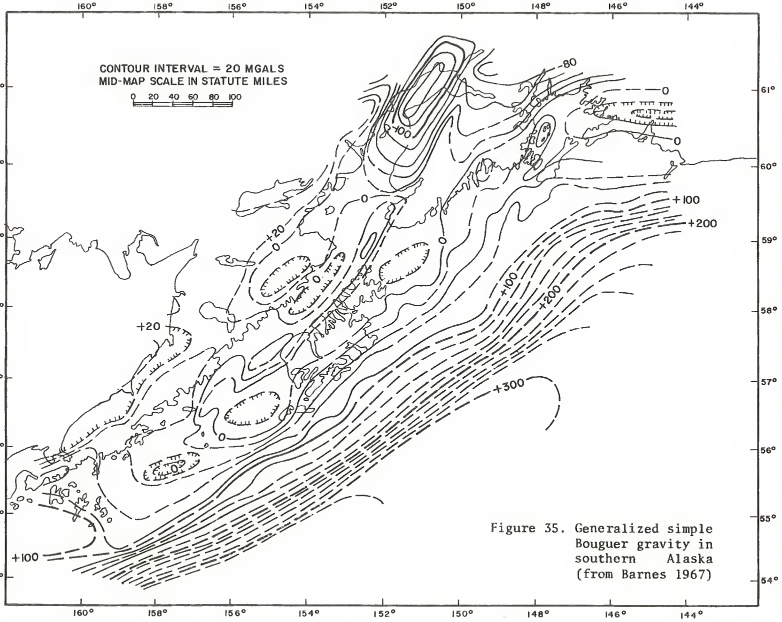


Figure 35. Generalized simple Bouguer gravity in southern Alaska (from Barnes 1967)

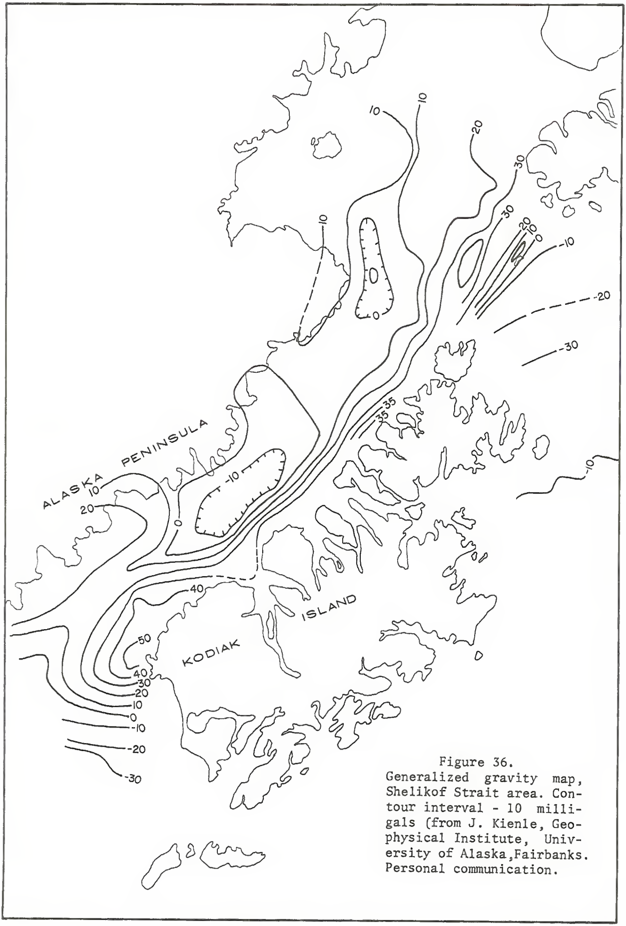


Figure 36.
Generalized gravity map, Shelikof Strait area. Contour interval - 10 milligals (from J. Kienle, Geophysical Institute, University of Alaska, Fairbanks. Personal communication.

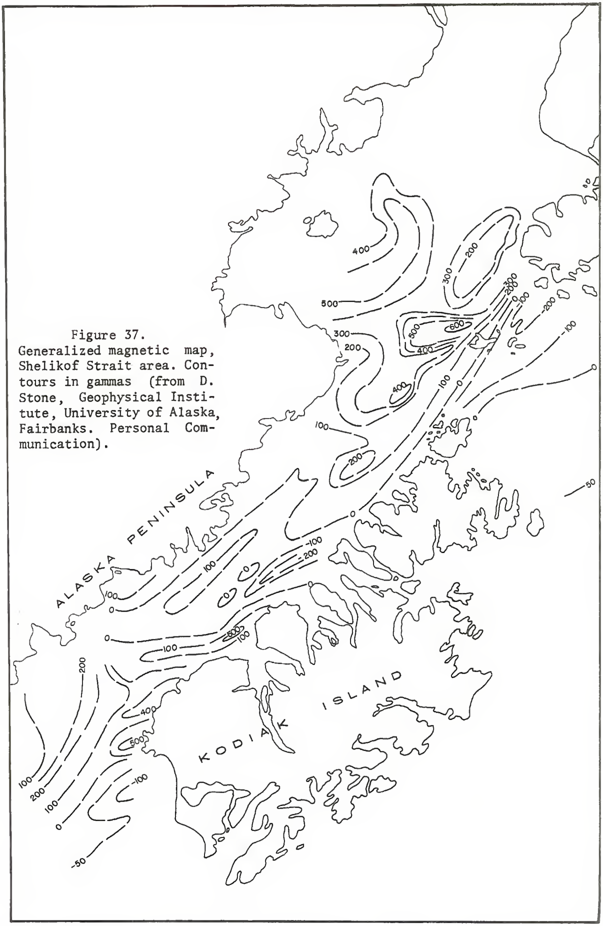


Figure 37.
Generalized magnetic map, Shelikof Strait area. Contours in gammas (from D. Stone, Geophysical Institute, University of Alaska, Fairbanks. Personal Communication).

Superimposed on this Mesozoic belt in the offshore area are several Tertiary basins that probably mask the distribution of the older rocks. These basins, like the one in Shelikoff Strait, are inferred mostly from geophysical data (Figure 35). One seismic line by the U.S. Geological Survey shows a thick (4 km.) section of truncated strata that appears to form the southeast flank of the basin southwest of Kodiak (Figure 38a) (von Huene et al. 1971).

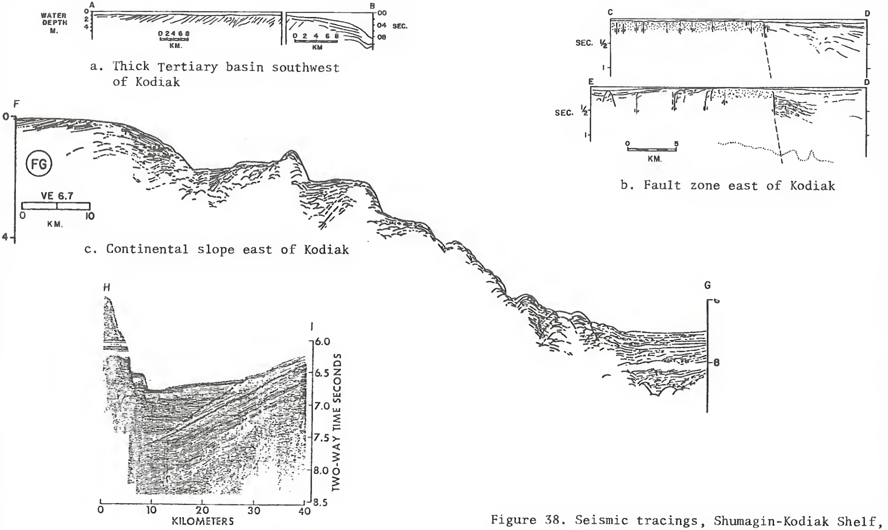
The second main geologic province of the Shumagin-Kodiak Shelf is the Kodiak Tertiary province, which consists of a thick sequence of Early to Late Tertiary, continental to deep marine, clastic sedimentary rocks. Most of the province is covered by the sea, while only a small portion is exposed onshore along the southeast shore of Kodiak Island and the Trinity Islands (9)*. The offshore portion of the province surrounding Kodiak has been only partially delineated by geological and geophysical surveys of the U.S. Geological Survey and holes drilled during Leg 18 of the D.S.D.P. (Shor 1962, von Huene et al. 1967, von Huene and Shor 1969, Shor and von Huene 1972, von Huene et al. 1971, von Huene 1972, von Huene et al. 1972, Hulm et al. 1973). Most of the remaining part of this section is summarized from these studies.

The Kodiak Tertiary province probably extends northeast to connect with the Gulf of Alaska Tertiary province, but its extent to the southeast beyond Chirikof Island along the continental margin is presently unknown. The rocks of this province may even extend west and be equivalent to the rocks forming the Tertiary basin southwest of Kodiak and the Trinity Islands.

For the purpose of discussing the geology, the Kodiak Tertiary province can be divided into five separate subprovinces--a fault zone, a late Tertiary basin, an arch at the edge of the continental shelf, the continental slope, and the Aleutian Trench (Figures 31 and 34).

The province is flanked on the northwest by a zone of folds and faults up to 30 km. wide that parallels the continental margin from Prince William Sound at least as far south as Kodiak Island (Figures 31, 34 and 38b). The zone separates the uplifted Kenai-Kodiak blocks from a subsiding Late Tertiary basin on the continental shelf. A portion of the fault zone occurs subaerially along the southeast coast of Kodiak Island. The faults are characteristically steep and generally shorter than 30 km. in length, although some extend over 50 km. Some faults reach to the sea floor, forming fault scarps with a sharp bathymetric expression, indicating the recency of the faulting. Some movements probably took place during the 1964 Alaska earthquake, as this zone corresponds roughly to the area of most intense aftershock activity and strain release.

A basin filled with up to 3 to 4 km. of Late Tertiary sediments has been formed by the depression of an area seaward of the fault zone off Kodiak. The age of the basin fill is inferred to be Late Tertiary



a. Thick Tertiary basin southwest of Kodiak

b. Fault zone east of Kodiak

c. Continental slope east of Kodiak

d. Aleutian trench east of Kodiak

Figure 38. Seismic tracings, Shumagin-Kodiak Shelf, Western Gulf of Alaska (from von Huene et al. 1971, Piper et al. 1973 and von Huene 1972).

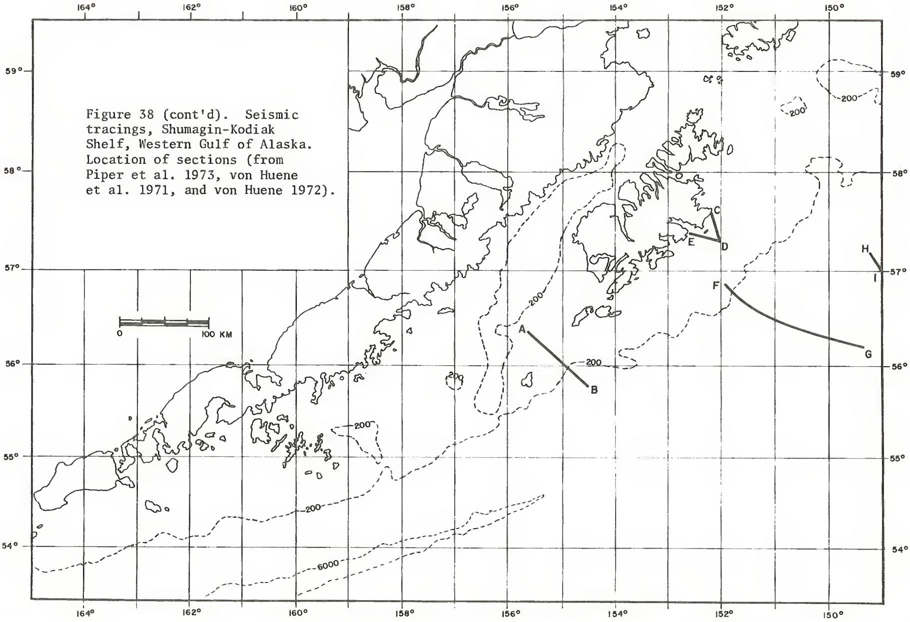


Figure 38 (cont'd). Seismic tracings, Shumagin-Kodiak Shelf, Western Gulf of Alaska. Location of sections (from Piper et al. 1973, von Huene et al. 1971, and von Huene 1972).

because of Miocene and Pliocene strata exposed on the truncated seaward flank of the basin. The basin may extend north to connect up with a similar basin lying north of Middleton Island, or it may represent another isolated basin as inferred elsewhere on the shelf. Underlying this Late Tertiary basin is a thick section of presumably lower Tertiary rocks deposited earlier in an older basin along the continental margin (Figure 34).

The Late Tertiary basin is flanked on the southeast by a broad arch that forms the edge of the continental shelf (Figure 34 and 38c). Although the arch is discontinous at the surface, it probably continues as a deep structure as evidenced by geophysical data along the continental margin. The arch represents a zone of continuous deformation involving tilting, folding, faulting, and truncation during periods of both uplift and subsidence. The arch is characterized by large anticlinal structures (Figure 38c). There apparently has been a net tectonic uplift, as indicated by the overall geometry and by the presence of very deepwater microfossils now found at only 20 fathoms depth. This arch in places has a topographic expression on the sea floor and apparently was above water as one or more islands at various times, as indicated by the local truncation of beds. Middleton Island to the north is a present day example, and Albatross Bank probably was exposed during glacial periods of lowered sea level. Truncated rocks as old as Miocene-Pliocene have been sampled along the arch off Kodiak, while truncated Pliocene-Pleistocene rocks are exposed on Middleton Island.

The continental slope is characterized by a rugged morphology composed of benches, peaks, canyons, and steep slopes (Figure 38c). The benches and peaks probably represent rotated blocks, slumps, or slides resulting from massive downslope movements of the slope. This downslope movement probably is caused by rapid deposition during glacial periods combined with continued tectonic uplift and oversteepening along the shelf break arch and upper slope. Seismic studies suggest that the slope consists of highly deformed Tertiary sedimentary rocks. Cores from holes 181 and 182 of D.S.D.P. Leg 18, however, indicate that the lower part of the continental slope consists of uplifted and tectonically deformed deepwater sediments as young as Pleistocene.

The present Aleutian trench is a very young geological feature that formed in Late Tertiary time and may be even as young as Pleistocene. It is filled by two stratified units (Figure 38d). Overlying an acoustic basement of basalt is a landward dipping sequence of abyssal plain sediments deposited during Miocene to Pleistocene time. Lying on these sediments is a wedge of horizontal Pleistocene turbidity current sediments 20 to 30 km. thick filling the trench.

GEOLOGIC HISTORY

Summary

The Paleozoic geologic history of the region is generally unknown, but apparently consisted of widespread deposition of clastic sediments, volcanics, and limestones at least in late Paleozoic time. Similar deposition continued through lower Jurassic time and culminated with intrusion of the large granitic batholiths that form the backbone of the Aleutian-Alaska Range. During the remainder of the Mesozoic Period, shallow to deepwater clastic sediments were deposited in the Alaska Peninsula region, while deepwater clastic sediments were deposited in an adjacent basin or continental slope-continental rise setting to the southeast. The latter rocks were then intruded by another sequence of granitic batholiths in early Tertiary time, and the whole area was uplifted to form the present continental shelf. Continued subsidence and deposition in this shelf area, plus continual volcanism during Tertiary time, resulted in an enormous thickness of Tertiary marine to continental clastic sediments and volcanics both on the Alaska Peninsula and the shelf. During mid-Tertiary time, these rocks were intruded by a series of quartz diorite plutons along the Peninsula.

Of the five periods of deformation affecting the area, three were associated with plutonic intrusion and involved only broad structural warping, as did the mid-Cretaceous deformation. The major deformation of the area has been fairly recent (post-Miocene) and quite severe, producing essentially all of the structural detail (folds and faults) now exposed. The area apparently still is one of active tectonism as indicated by deformation associated with recent earthquakes, the chain of active volcanoes along the Alaska Peninsula, and the numerous earthquake epicenters that have been recorded in the area. Since this Late Tertiary to Recent period of geologic history had such an influence on the region, it is discussed in more detail below, especially with regard to new theories of plate tectonics.

Late Tertiary Geologic History and Plate Tectonics

The plate tectonic theory is a unifying concept that attempts to combine seafloor spreading, continental drift, crustal structures and deformation, and world patterns of seismic and volcanic activity all together into one coherent picture. It assumes that the entire surface of the earth comprises a series of internally rigid but relatively thin (50-150 km.) lithospheric plates that are continuously in motion with respect to each other (Figure 39a). There are perhaps half a dozen major plates. Virtually all seismicity, volcanism, and tectonic activity is localized around plate margins and is associated with differential motion between adjacent plates. There are basically three types of plate boundaries: (1) Areas such as active oceanic ridges where new oceanic crust is being created and plates are moving away from each other; (2) areas where plates simply move past one another (like the San Andreas fault zone of California), and (3) areas along trenches where one plate slips down under the margin of another and surface area is destroyed.

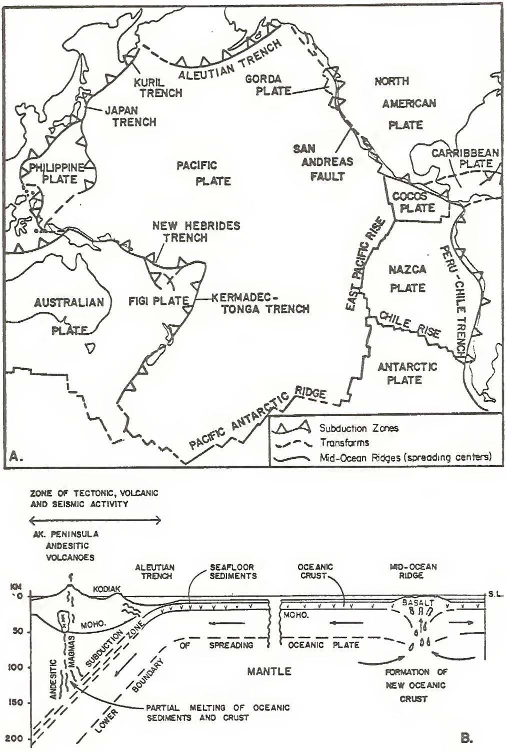


Figure 39. Schematic diagrams showing major elements and mechanisms of plate tectonics theory, Pacific area. A. Map showing major crustal plates as defined by zones of seismicity, volcanism and active tectonism. B. Cross section showing mechanisms as applied to southern Alaska.

According to the plate tectonic theory, the Western Gulf of Alaska with its seismicity, young deformation, and active volcanism landward of a trench is considered a typical example of the third type of plate boundary involving the destruction of an oceanic plate beneath a continental zone along a subduction zone or Benioff Zone (Figure 39b). It has been postulated that the Pacific Plate is being underthrust under the American Plate along the Aleutian Trench at a rate of about 6 cm./yr., a process that has been going on since at least Late Tertiary time and maybe longer (Atwater 1970, Pitman and Hayes 1968). Recent evidence from D.S.D.P. Leg 18 suggests a fairly young age for that portion of the trench off Kodiak (Miocene or possibly as young as Pleistocene) (von Huene 1972).

This model of a fairly recent initiation of underthrusting explains very satisfactorily many of the characteristics typical of the region, such as: (1) The intense Late Tertiary to Recent tectonic deformation, folding and faulting, including deformation resulting from the 1964 earthquake; (2) the uplift of the mountains now surrounding the Gulf of Alaska that began in Miocene time and is continuing today; (3) glaciation that began in Miocene time and became intense 3 to 4 million years ago partially as a result of the uplift of the mountains; (4) the great increase in volcanic activity about 2 to 5 million years ago that probably represents the initial development of the present Alaska Peninsula volcanic chain; (5) the apparent young age of sediments in the Aleutian Trench; (6) the seismic activity; and (7) presence of uplifted and tectonically deformed deepwater Pleistocene sediments on the lower slope.

The Benioff Zone does not manifest itself at the surface as a single shear zone emerging at the trench, but apparently the stresses are redistributed at the surface along the entire continental margin as a diffuse zone of deformation (von Huene 1972, von Huene et al. 1972, Kulm et al. 1973). This is well demonstrated by the distribution of aftershocks following the 1964 earthquake.

ONHORE SURFICIAL GEOLOGY

Introduction

There have been no detailed studies of the onshore surficial geology in the study area. Most geologic studies simply have grouped the surficial deposits as alluvium (Qal), and no attempts have been made to subdivide them into more specific genetic or descriptive units. Information on the distribution of this alluvium can be obtained from the more detailed geologic maps covering the area (Figure 33) and from overlays prepared by the Resource Planning Team of the Joint Federal-State Land Use Planning Commission for Alaska.

An excellent overview of the surficial geology can be obtained, however, from the map "Surficial Geology of Alaska," prepared by the U.S. Geological Survey (Karlstrom et al. 1964). This excellent map presents the generalized distribution of various genetic units for the entire state. A slightly more generalized version of this map covering just the study area is presented here (Figure 40). The distribution of surficial deposits on this map generally reflects the influence of two main agents or processes--glacial-fluvial activity and volcanic activity.

Glacial-Fluvial Activity

Pleistocene time was characterized by repeated glaciations that involved all the mountain ranges in the area as well as the adjacent lowlands. During the last major glacial advance (Naptowne), sea level was lowered and ice probably covered much of the continental shelf, possibly as far as the shelf edge (Coulter et al.1965). Only one small area on Kodiak Island (known as the Kodiak Island Refugium) is known to have escaped glaciation (Karlstrom and Ball 1969).

Most of the mountainous upland area is characterized by erosive features produced by glacier scour--aretes, cirques, U-shaped valleys, etc. Very little glacial debris now remains except in some of the upland valleys. These remaining deposits generally are thin, and a high percentage of bedrock is exposed (Figure 40). Some fairly large glaciers still remain on some of the higher peaks of the Alaska Peninsula--Shishaldin, Veniaminof, Katmai, and Douglas--and many smaller cirque glaciers occur on many of the other peaks on both the Peninsula and Kodiak Island.

Most of the material eroded from the mountains during glacial periods of lower sea level probably was deposited on the continental shelf or beyond on the continental slope. This is supported by the rapid deposition in the Aleutian Trench of a thick section of Pleistocene sediments that had been supplied from the slope (Kulm et al. 1973, Piper et al. 1973).

The present day, rugged and precipitous, fjord indented coastline is a zone dominated by aggressive wave erosion, and deposition is generally limited to narrow beaches, spits, and bars between rocky headlands.

Lowland areas, including stream valleys, actually form a relatively small percentage of the land. These areas are mostly covered by glacial-fluvial deposits consisting of glacial moraines, glacial outwash, modern floodplain and adjacent terrace deposits, and even proglacial lake deposits, such as those found on southwest Kodiak Island (Figure 40). Some eolian deposits, including sand dunes as well as some older coastal deposits, also occur along the coastline.

Figure 40. Generalized surficial geology, Western Gulf of Alaska (Adapted from Karlstrom et al. 1964).

LEGEND

Map Units

1 - Existing glaciers.

2 - Glacial moraines and associated drift, modified to varying degrees.

3 - Glacio-fluvial deposits--outwash and valley-train deposits along glacier fronts and recent moraines grading into fluvial deposits further down-valley.

4 - Fluvial deposits--floodplain, terrace, and alluvial fan deposits.

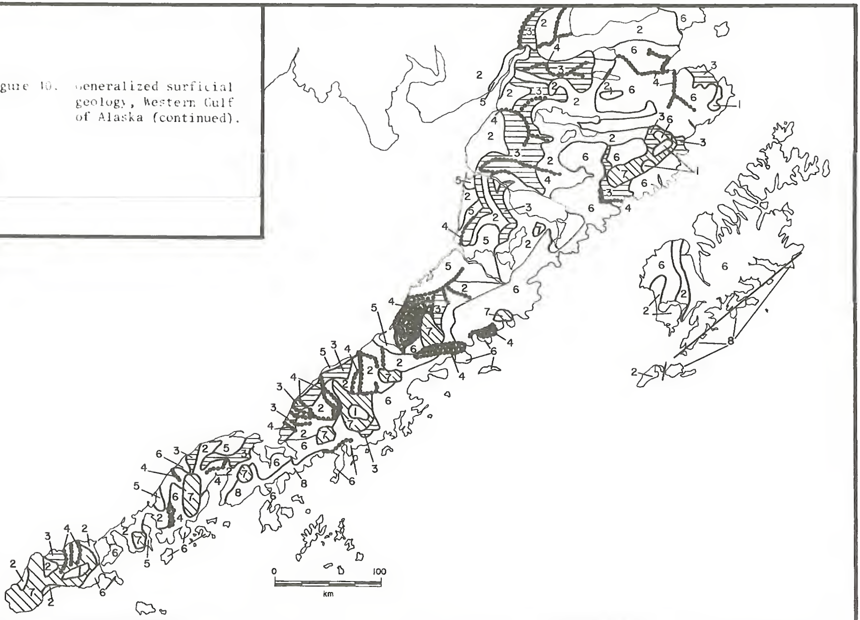
5 - Coastal deposits consisting of beaches, spits, bars, deltas, and interstratified alluvial and marine sediments.

6 - Coarse- to fine-grained undifferentiated deposits associated with moderate to steep-sloped mountains and hills with many bedrock exposures.

7 - Undifferentiated deposits with a high percentage of volcanic rock particles, ash, and pumice flanking volcanic cones and peaks of Quaternary and Tertiary age.

8 - Discontinuous alluvial deposits overlying dissected unconsolidated, semiconsolidated, and locally consolidated silt, sand, and gravel of Tertiary and younger age.

Figure 10. Generalized surficial geology, Western Gulf of Alaska (continued).



Volcanic Activity

Quaternary and Recent volcanic activity also has contributed much surficial material to the area. Large volcanic cones that often rise above the general height of the Aleutian range have been built by volcanic processes. In addition, great quantitities of ash and other ejecta have been supplied to the surrounding area, either by direct fall or indirectly by streams, mud flows, or other mechanisms of downslope movements. The generalized distribution of some of the major deposits flanking some of the major volcanic centers is shown on Figure 40.

The most significant contribution of volcanic material in historic time came from the 1912 eruption of Katmai Volcano, one of the largest eruptions ever recorded. This eruption deposited a blanket of ash over much of the northern Peninsula, and almost a foot fell on parts of Kodiak Island over 100 km. away (Figure 41). Most of the soils of the area and sediments on the sea floor reflect this blanket of ash.

Soils

The general distribution and types of soils in Alaska have been summarized by the U.S. Army Corps of Engineers (1961), and a generalized version of this map for the study area is included here for reference (Figure 42). A reconnaissance soil survey of the state too detailed to present here has recently been completed by the Soil Conservation Service (Rieger 1973). Maps have been finalized but soil descriptions are still in note form. This survey is not expected to be published formally for several years, but the data can be inspected by contacting the Soil Conservation Service, Palmer, Alaska or the Resource Planning Team of the Joint Federal-State Land Use Planning Commission, Anchorage.

Most of the area (more than 60 percent) is covered by coarse-grained, shallow rubble and sandy, gravel soils characteristic of mountain areas with numerous bedrock exposures. Most of the volcanoes are flanked by volcanic soils, while deeper sand and gravel soils occur along most of the major drainages. Mixed soils also occur in places overlying relatively unconsolidated Tertiary rocks, such as the Trinity Islands.

Detailed soil surveys in the study area are available only for one area in northeast Kodiak Island (Reiger and Wunderlich 1960). Soils of this area generally fall into two groups: (1) Those on steep to rolling uplands, and (2) those on nearly level to gently sloping valley bottoms, including alluvial plains and terraces. Common to the upper part of all these soils is the volcanic ash layer deposited from the 1912 Katmai eruption (Figure 41). This layer makes the soils quite acidic.

The soils of steep and rolling uplands make up the majority of soils in the area and include large areas of bedrock. The soil beneath the ash layer is typically a dark reddish-brown, silt loam, which is

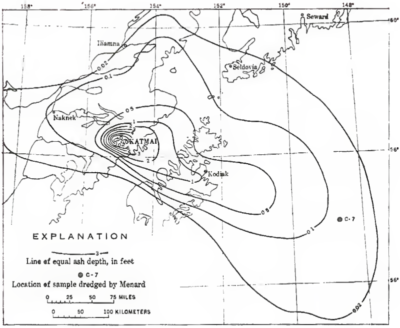


Figure 41. Map showing distribution and thickness of ash erupted from Mt. Katmai, 1912 (from Wilcox 1959).

Figure 42. Generalized soils map, Western Gulf of Alaska (from U.S. Army Corps of Engineers 1961).

LEGEND

Map Units

1-Deep interbedded sand and gravel. Occur principally in alluvial fans, outwash aprons, floodplains, and river terraces bordering morainal complexes and along major drainage lines.

2-Deep silty sandy gravel with boulders. Occur principally in hummocky, end-, lateral-, and ground-moraine complexes in lowlands bordering the rugged mountain ranges. Peat and highly organic silt in depressions.

3-Shallow rubble and sandy gravel. Occur principally in fluvial, glacial, and colluvial deposits associated with rugged, steeply-sloping mountain areas. Numerous bedrock exposures.

4-Deep interbedded silt, sand, and gravel. Occur principally in mixed marine and terrestrial deposits in flat- to gently-sloping coastal plain areas. Peat and highly organic soils in depressions and abandoned stream channels.

5-Shallow to deep interbedded silt, sand, and gravel. Occur principally in discontinuous eolian, fluvial, and glacial deposits mantling upland surfaces and hills underlaid by thick deposits of uncemented to cemented soft bedrock of bedded silt, sand, and gravel.

6-Shallow to deep volcanic silt, sand, and gravel. Occur principally to eolian, alluvial, colluvial, and glacial deposits mantling volcanic peaks, cones and lava fields.

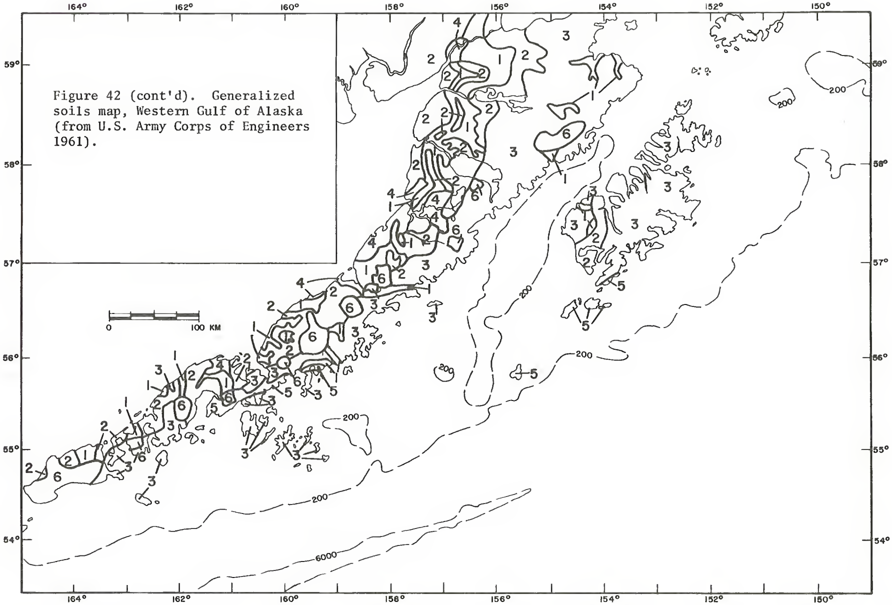


Figure 42 (cont'd). Generalized soils map, Western Gulf of Alaska (from U.S. Army Corps of Engineers 1961).

very rich in organic matter and ranges from 1 m. to a few cm. thick, depending on the steepness and height of the slope. These soil areas generally are well suited for grazing; portions of the lower slopes, if adequately fertilized, are suitable for seeding grass for hay and silage. Erosion potential is high on the moderate to steep slopes, and their use for cropping and transportation are limited.

Soils of the valley bottoms are typically better drained than those of the rolling uplands. Below the ash layer, they consist of a silt loam that overlies glacial-fluvial deposits of coarse sand and gravel. If adequately fertilized, these soils also are suitable for seeding grass for hay and silage. Although these soils could be made suitable for other crops by fertilizing and mixing the ash with underlying materials, the area is generally too cold to adequately mature crops.

Since much of the terrane found throughout the study area is somewhat similar to that in northeast Kodiak, the detailed description of the soils in this area by Rieger and Wunderlich (1960) can generally be applied to the rest of the area. The only noticable difference might be the presence or absence of the ash layer deposited from the 1912 Katmai eruption.

OFFSHORE SURFICIAL GEOLOGY

Introduction

The distribution and composition of bottom sediments in the study area display considerable variation, which is due in part to (1) varying relief on the sea bottom, (2) different hydrodynamic regimes, and (3) different sources supplying different size materials. The sediments mainly consist of terrigenous material, with a high volcanic component in places and local concentrations of organic material (shell debris) (Figure 43).

The only extensive work on bottom sediments of the area has been conducted by the Soviets as part of their continuing investigations of the fisheries of the Northeast Pacific. (Gershanovich et al. 1964, Gershanovich 1968, 1970). These studies were mainly reconnaissance surveys covering large areas, and the data presented are highly generalized. Much of the following discussion is taken from these excellent sources. This information has been supplemented by additional investigations carried out by the Institute of Marine Science, University of Alaska, Fairbanks, and the U.S. Geological Survey. The National Ocean Survey nautical charts for the region also provide general information on the nature and distribution of bottom sediments.

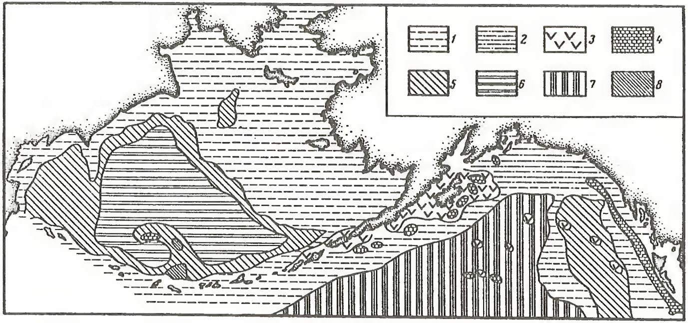


Figure 43. Sketch map of major types of sediments on the bottoms of the Bering Sea and Gulf of Alaska:

1 - terrigenous; 2 - glacial-marine; 3 - vulcanogenic; 4 - slightly carbonate and carbonate (tests, foraminiferal, and others); 5 - slightly siliceous (silceous sponges and diatomaceous); 6 - siliceous (diatomaceous); 7 - deep-sea brown; 8 - mixed (from Gershanovich 1970).

Shelf Sediments

Contemporary sediments on the shelf are generally quite thin and form an irregular veneer no more than tens of meters thick. The sediments consist mostly of terrigenous material eroded from the adjacent mountain areas during glacial periods and deposited by glacial-fluvial processes during lower stands of sea level. Most of the material probably was carried across the shelf and deposited at the shelf edge and on the continental slope.

Determining the actual extent of glaciers and the distribution of glacial material on the Kodiak shelf is still problematic. Earlier workers believed that the topographic highs or banks at the continental margin (e.g., Albatross Bank) were buildups of morainal material and represented the extent of the last glaciation (Capps 1937, Karlstrom 1964). More recent seismic studies, however, suggest that this topographic feature has structural and erosional features and may represent tectonically uplifted areas (von Huene 1966). Sampling of sediments off Kodiak by Wright (1970) indicated no evidence of coarse morainal material at the shelf edge.[1] Not much work has been done yet to positively identify submarine glacial features using high resolution seismic techniques, although this has been done with limited success in a published study off Nuka Bay (von Huene 1966) and an unpublished study by the U.S. Geological survey off Kodiak.[2] This latter study suggests that an ice sheet extended across the shelf to within about 10 km. of the crest of Albatross Bank, while the trough bisecting Albatross Bank probably contained a valley glacier that extended to the continental slope.

The sediments on the shelf also contain varying amounts of volcanic debris supplied by the Katmai eruptions and other volcanic processes. Fine-grained glacial debris brought in from Cook Inlet also may be making a significant contribution. All of these sediments are now being reworked and redistributed by contemporary marine processes.

Along the nearshore parts of the shelf, the sediments are quite variable. Abundant coarse material is being deposited along beaches and adjacent to rocky headlands, reefs, and skerries. Finer sands and muds, however, are being deposited in the deep bays and fjords.

The plateau-like areas generally are covered with a thin veneer of pebbles, gravel, and sand (Figure 44a). Similar sediments also occur on the banks and shoals, but are usually even thinner and often more poorly sorted and coarser-grained. They include pebble-gravels, boulders, and rock fragments that are commonly overgrown with organisms.

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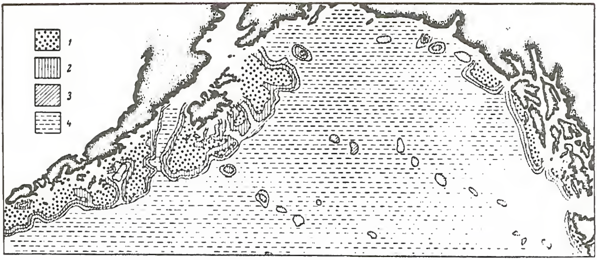
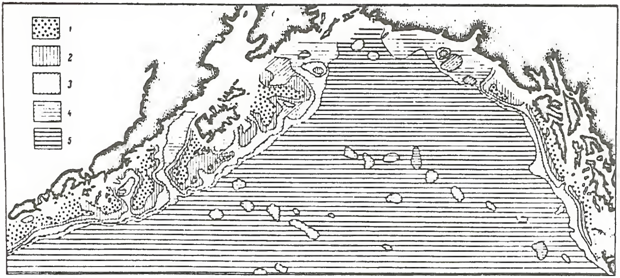
[1] F.F. Wright, Marine Geologist, Marine Advisory Program, University of Alaska, Anchorage, Personal communication.

[2] R. von Huene, Marine Geologist, U.S. Geological Survey, Reston, Va. Personal communication.



A. Sketch map of the distribution of dominant fractions in Recent sediments in the Gulf of Alaska:

1 – sand and coarse sand; 2 – coarse silt; 3 – fine silt; 4 – pelite.



B. Sketch map of the distribution of particles < 0.01 mm (pelite) in Recent sediments in the Gulf of Alaska, %:

1 – < 5; 2 – 5 to 15; 3 – 15 to 40; 4 – 40 to 70; 5 – > 70.

Figure 44. Size distribution of Recent sediments, Gulf of Alaska. A. Distribution of dominant fractions; B. Distribution of pelite (from Gershanovich et al. 1964).

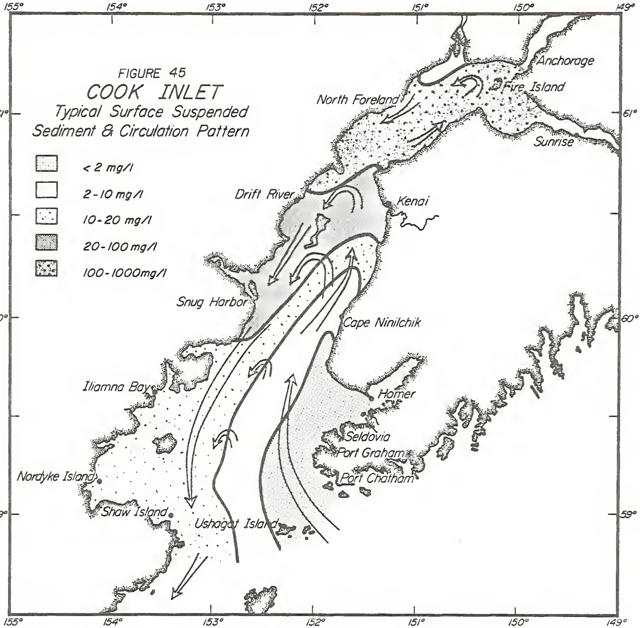
Accumulations of shell debris are commonly found, particularly along the shelf edge banks (e.g., Albatross Bank) (Figure 43). At many places along the banks, sediments are completely absent and bedrock is exposed on the sea floor, reflecting the overall tectonic uplift and erosion of these areas. Bedrock is also commonly found along recent fault scarps. Some muds do occur on the shelf, especially in lower depressions. The overall mud content generally increases to the east, due mainly to greater influx of contemporary, fine-grained, glacio-marine material (Figure 44b).

The distribution of sediments on the shelf appears to follow a normal graded pattern (Figure 44). Coarse sediments generally dominate down to about 70 to 80 m. Between 70 to 80 m. and 120 to 150 m., there is an increase in the content of fine sands and silts plus some clays in lower depressions. Below this depth, especially in the sea valleys like Shelikof Strait, fine-grained sediments persist (sandy mud, mud, clayey mud, plus some organic material). This graded distribution of sediment with depth probably reflects the influence of contemporary marine processes, particularly waves, on the shelf bottom. Above about 100 m., waves, especially those generated by storms, feel the bottom and winnow out finer material, which is then deposited in adjacent deeper water. The concentration of fine-grained muds in the Shelikof Strait sea valley may be, in part, contemporary material being introduced into the area by currents circulating out of Cook Inlet (Figure 45).

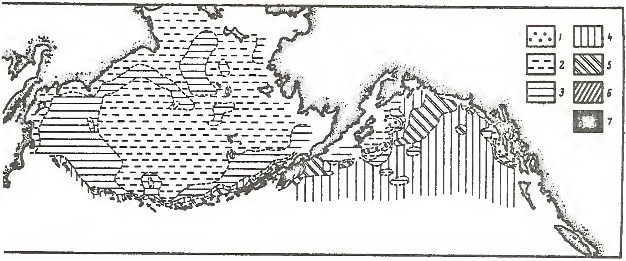
Data on the composition of shelf sediments is somewhat limited with the Soviets providing most available information. The general distribution of various chemical parameters (iron, manganese, authigenic silica, and organic carbon) have been reported for the entire Bering Sea-Gulf of Alaska region (Figure 46), but these maps don't show much detail on the shelf area (Gershanovich 1968, 1970). The high iron content off Unimak Island and vicinity probably reflects a volcanic source for the sediments, while the higher values of organic carbon on the continental slope probably reflect the intersection of an oceanic oxygen-deficient layer with the slope.

A fairly detailed analysis of the mineral compostion of the bottom sediments in the study area was conducted by Bortnikov (1970). He sampled only the coarse silt fraction of the sediments and produced a set of maps showing the distribution of various minerals (quartz, volcanic glass, and several heavy minerals) (Figure 47). These maps reflect well the volcanic and terrigenous origin of much of the sediment. These types of maps also can be useful in determining sediment dispersal patterns and locating possible subsea placer mineral deposits that have been concentrated on the shelf.

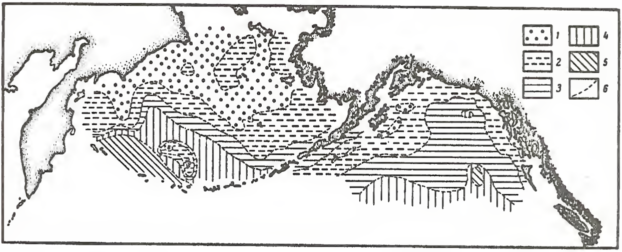
Additional studies of the shelf sediments are being carried out by G. D. Sharma of the Institute of Marine Science, University of Alaska, Fairbanks. Detailed textural data, clay mineralogy, and chemical analyses are presently being determined for 39 stations around Kodiak Island plus 17 stations along the shelf between Unimak Island and north of Kodiak.



(from Wright et al. 1973)

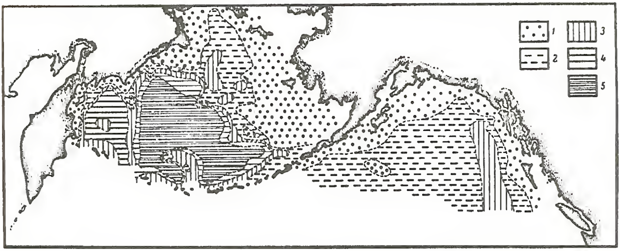


A. Distribution of iron (%) in bottom sediments in the far North Pacific (the Bering Sea and Gulf of Alaska):
1 — < 2; 2 — 2–3; 3 — 3–4; 4 — 4–5; 5 — 5–6; 6 — 6–7; 7 — >7.

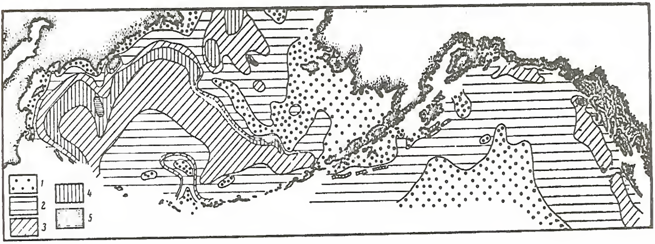


B. Distribution of manganese (in %) in bottom sediments in the far North Pacific (the Bering Sea and Gulf of Alaska):
1 — <0.05; 2 — 0.05—0.10; 3 — 0.10—0.50; 4 — 0.50—1.00; 5 — > 1; 6 — boundaries of areas.

Figure 46. Distribution of chemical parameters (percentage) in bottom sediments, Gulf of Alaska and vicinity. A. Iron; B. Manganese; C. Silica; D. Organic carbon (from Gershanovich 1970).

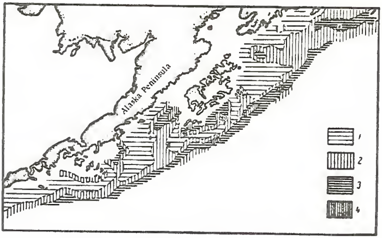


C. Distribution of authigenic silica (in %) in bottom sediments in the far North Pacific Ocean (the Bering Sea and Gulf of Alaska):
1 — < 5; 2 — 5–10; 3 — 10–20; 4 — 20–30; 5 — >30.



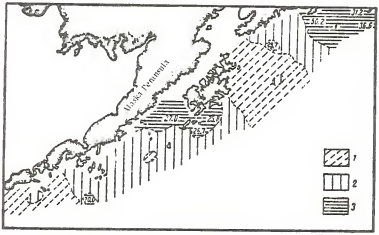
D. Distribution of organic carbon (in %) in bottom sediments in the far North Pacific (the Bering Sea and Gulf of Alaska):
1 — < 0.50; 2 — 0.50–1.00; 3 — 1.00–1.50; 4 — 1.50–2.00; 5 — > 2.00.

Figure 46 (continued)



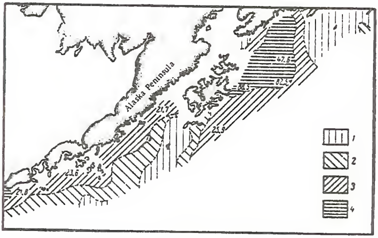
A. Distribution (in %) of silty material (0.01 — 0.1 mm) in surface sediments in the northwestern part of the Gulf of Alaska:

1 — <10; 2 — 10—30; 3 — 30—50; 4 —>50.



B. Distribution of quartz (in %) in the surface sediments in the northwestern part of the Gulf of Alaska:

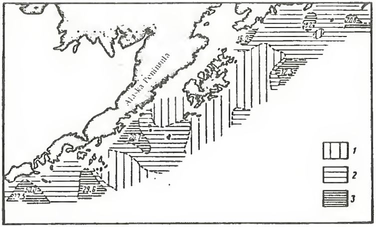
1 — <10; 2 — 10—20; 3 — >20%.



C. Distribution of volcanic glass (in %) in the surface sediments in the northwestern part of the Gulf of Alaska:

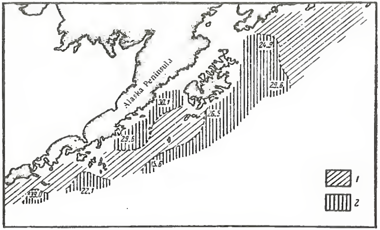
1 — <3; 2 — 3—10; 3 — 10—30; 4 —>30.

Figure 47. Distribution of minerals in silt fraction (percentage) of bottom sediments, Western Gulf of Alaska. A. Silty material; B. Quartz; C. Volcanic glass; D. Heavy minerals; E. Black ore minerals; F. Hornblende; G. Clinopyroxenes. (from Bortnikov 1970).



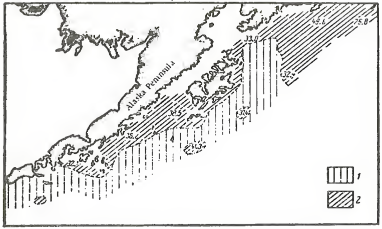
D. Distribution of heavy subfraction minerals (in %) in the surface sediments in the northwestern part of the Gulf of Alaska·

1 — <3; 2 — 3—10; 3 —>10.



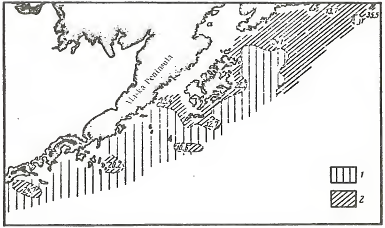
E. Distribution of black ore minerals (in %) in the surface sediments in the northwestern part of the Gulf of Alaska:

1 — <15; 2 — >15.



F. Distribution of hornblende (in %) in the surface sediments in the northwestern part of the Gulf of Alaska:

1 — <20; 2 — >20.



G. Distribution of clinopyroxenes (in %) in the surface sediments in the northwestern part of the Gulf of Alaska:

1 — <10; 2 — >10.

Figure 47. Distribution of minerals in silt fraction (percentage) of bottom sediments, Western Gulf of Alaska. A. Silty material; B. Quartz; C. Volcanic glass; D. Heavy minerals; E. Black ore minerals; F. Hornblende; G. Clinopyroxenes. (from Bortnikov 1970).

Slope Sediments

Sediments now being deposited on the continental slope are composed mostly of fine-grained, terrigenous material plus substantial amounts of volcanic material, especially in the Kodiak area (Figure 43). Small amounts of organic material, mainly forams and diatoms, also occur. As might be expected, sediments get finer-grained with depth. In general, they consist of muddy sand and sandy mud to depths of 500 to 600 m., sandy mud and mud between 600 m. and 2,000 m., and mostly clayey mud greater than 2,000 m. The slope is highly irregular and dissected, and bedrock is exposed at many places.

As noted in the section above, large quantities of sediment probably were supplied to the slope during glacial periods of lower sea level. Much of this material has been or presently is being transported downslope to the trench below as evidenced by (1) seismic records showing rotated blocks that apparently are large slumps or landslides, (2) large slumps at the base of the slope, (3) thickened trench sediments at the mouths of canyons, and (4) thick sands and sandy turbidites found on the lower slope at sites 181 and 182, Leg 18, of the JOIDES Deep Sea Drilling Program (Kulm et al. 1973, Piper et al. 1973). This downslope movement probably is the result of rapid deposition at the continental margin combined with tectonic oversteepening of the slope.

Aleutian Trench Sediments

Sediments filling the Aleutian Trench consist mostly (about 90 percent) of sands, silts, and muds derived from a landward source, and are deposited mainly by turbidity currents flowing down canyons in the lower slope or by sliding, slumping, or creeping off the adjacent slope (Piper et al. 1973). The remaining approximately 10 percent of the sediment is supplied by abyssal plain, turbidite sedimentation and pelagic sedimentation (7 percent and 3 percent, respectively). There is no evidence of reworking of sediments by bottom currents.

MINERALS

Metallic

The metallic mineral potential of the study area is virtually unknown, since there has been very little extensive and detailed exploration. There is enough evidence of mineralization, however, to indicate that parts of the area do have significant potential.

Figure 48 summarizes the distribution of mineral occurrences in the area. The main source of data is the MF map series recently published by the U.S. Geological Survey (Cobb 1972 a-h). Additional detail on the general location of mineral occurrences can be obtained from several recently published reports by the U.S. Geological Survey (Berg and Cobb 1967, Cobb 1972, U.S. Geological Survey 1972, and Cobb 1973). Based on these occurrences, Clark et al. (1972) identified several metal provinces

Figure 48. Provinces and occurrences of metallic minerals, Western Gulf of Alaska.

LEGEND


- Major metal provinces (elements of secondary importance in parentheses (from Clark et al. 1972).


- Areas with high mineral development potential as identified by Resource Planning Team of the Joint Federal-State Land Use Planning Commission.


- Areas with intensive mining claim activity as identified by Resource Planning Team.


- Areas with moderate to low mining claim activity as identified by Resource Planning Team.

Other mineral occurrences are from Cobb (1972a-h).
x - placer deposits ● - lode deposits

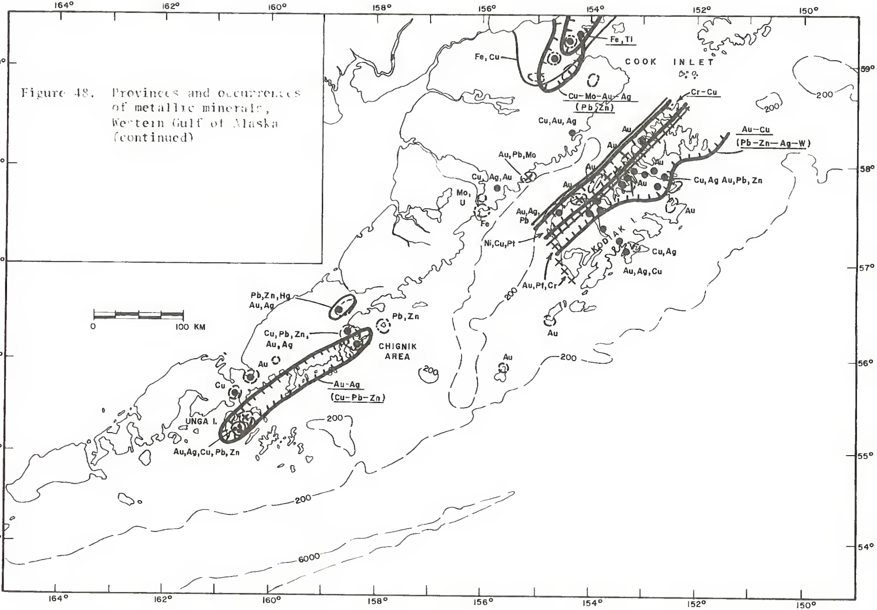


Figure 48. Provinces and occurrences of metallic minerals, Western Gulf of Alaska (continued)

in the region--areas characterized by a distinct association and/or anomalous concentrations of a metal or metals.

The Resource Planning Team of the Joint Federal-State Land Use Planning Commission also has identified several areas of high mineral potential and has outlined areas with mining claim activity; both of these areas are shown on Figure 48. Detailed data on mining claims are stored in the State Division of Geological and Geophysical Survey's computerized Kardex file. This Kardex data has also been plotted on a map of Alaska (Swainbank 1973). The location of all mining claims has recently been plotted by the U.S. Bureau of Mines on quadrangle overlays at a scale of 1:250,000. These maps are available at local Bureau offices.

There are two main areas where mineral occurrences are concentrated and that have known mineral potential, the Unga Island-Chignik area and Kodiak Island. The former area actually consists of two separate areas that were connected into a proposed mineral province or belt (Clark et al. 1972). The southern portion of this area consists of mineralization on Unga Island and vicinity, indicating the presence of both a gold-silver province and a copper-lead-zinc province. There was much activity in this area at the turn of the century. Over two million dollars worth of gold and silver were produced from the now abandoned Apollo Mine on Unga Island between 1891 and 1904. Minor amounts of gold, plus silver, lead, and copper were also produced elsewhere in the area during this period. There has been only a minor amount of activity in recent years.

The Chignik area also contains a gold-silver province and a cooper-lead-zinc province. There is no known production from this region, but there has been considerable activity in recent years. Several local areas are considered high in mineral potential and have had intense mining claim activity (Figure 48). Several Japanese and French companies have recently shown particular interest in a lead-silver-molybdenum prospect at Chignik and a copper prospect at Warner Bay just south of Chignik. A copper prospect near Chignik (possibly the one at Warner Bay) was reported to have been drilled in 1971 (Eakins 1972). There was no known mineral exploration in 1972 (Alaska Division of Geological and Geophysical Surveys 1973).

Descriptions of earlier mineral exploration activities in this region were reported almost annually during the 1920s to 1940s in a series of U.S. Geological Survey Bulletins entitled "Mineral Resources of Alaska." No published material was found describing more recent activities.

The second area where there is a concentration of mineral occurrences is Kodiak Island and vicinity. A recent open file report by the State Division of Geological and Geophysical Surveys presents an excellent summary of the geology and mineral resources of the area (McGee 1972). Gold is the main commodity found on the island. Placer deposits occur along most of the beaches and have been mined from time to time. Maddren (1919) reported that at least 150,000 dollars worth of gold was extracted, but Capps (1937) estimated much more. The gold concentrations appear to be dependent on contemporary storm wave and current activity; it is doubtful that similar deposits exist very far offshore (McGee 1972).

Small gold lode prospects occur throughout the island, mainly in quartz veins associated with granodiorite intrusions, dikes, and sills. These are probably the source for the placer deposits. Minor production is reported from one prospect (Berg and Cobb 1967). There has been a general lack of exploration for gold in inland areas, especially where mineralization might be expected along the flanks of the major granodiorite intrusions forming the core of the islands.

Minor lode occurrences of other commodities have been reported on the island including silver, copper, lead, and tungsten. None of these appear to be commercial deposits, but they have not been explored extensively. In fact, less than 20 percent of Kodiak has been adequately prospected (McGee 1972).

The presence of ultramafic complexes along the northwest coast of Kodiak in the Triassic (?) rocks, plus the occurrence of minor quantities of platinum and chromite in placer deposits, suggest that the area has a potential for platinum, chromite, and nickel (Figure 48). These complexes are part of a long narrow belt of ultramafic bodies that probably extends from Kodiak to beyond the Canadian border (Clark and Greenwood 1972). Extensive mineralization has been found in many of the bodies along this belt. For example, Red Mountain on the Kenai Peninsula near Seldovia contains a significant chromium deposit. Significant ore bodies may occur in the ultramafic bodies on Kodiak.

Another belt of high mineral potential occurs along the west side of Lower Cook Inlet just outside the study area. Included here are large, low-grade titaniferous magnetite deposits as well as copper prospects. There has been considerable activity in this area over the past few years. A copper prospect was drilled west of Mt. Douglas in 1971 and an extensive exploration program for iron was carried out several years ago. There was no activity in 1972.

Most of the study area is presently closed to mineral location (Figure 49). Much of the area is within federal reserves (national monuments or wildlife refuges), while the rest is tied up under the Alaska Native Claims Settlement Act of 1971. Mineral activity in the region will probably not increase until this complex land situation is resolved, which may take several years or longer.

Nonmetallic

There are few known occurrences of nonmetallic minerals in the study area (Figure 50). They include several coal deposits, several pumice deposits, and a sulphur deposit. Construction materials, including sand and gravel, have been identified at several locations by

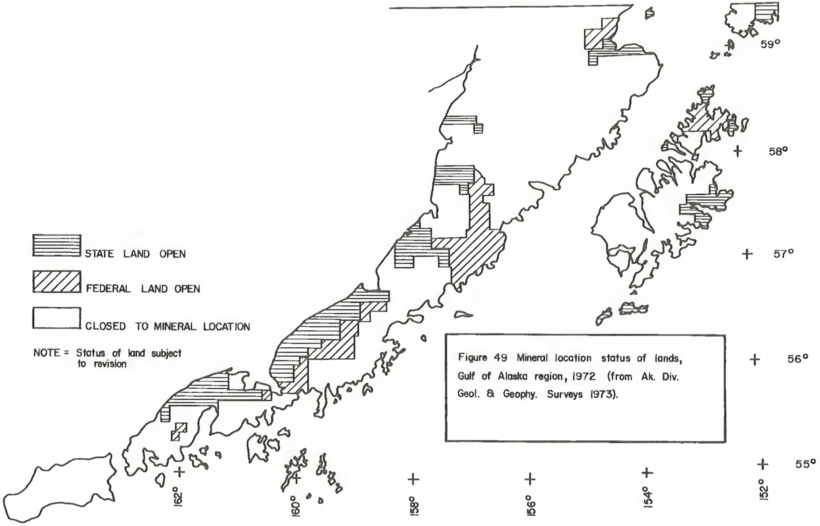


Figure 49 Mineral location status of lands, Gulf of Alaska region, 1972 (from Ak. Div. Geol. & Geophy. Surveys 1973).

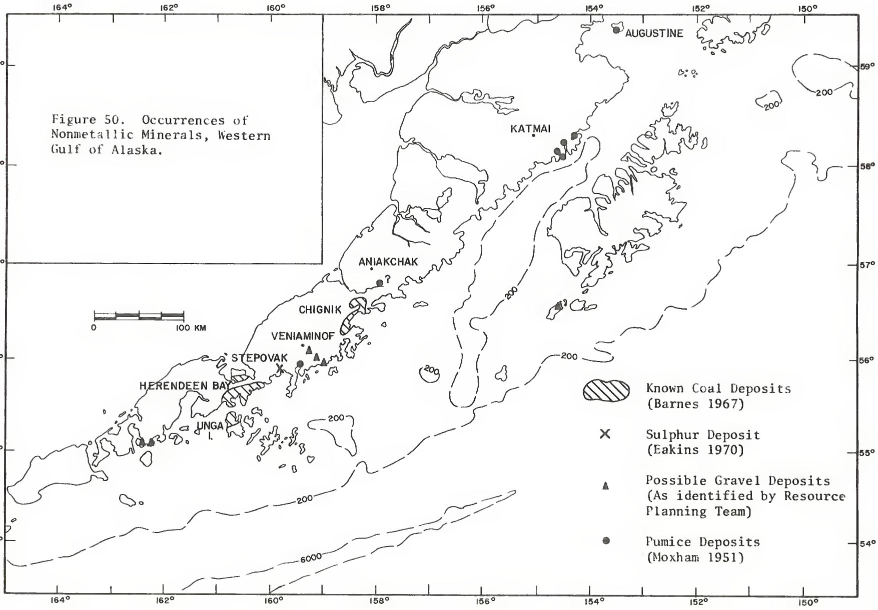


Figure 50. Occurrences of Nonmetallic Minerals, Western Gulf of Alaska.

the Resource Planning Team of the Joint Federal-State Land Use Planning Commission. Many more such deposits undoubtedly occur along stream valleys and elsewhere, and they will be discovered and exploited as the need arises.

Coal is present in significant quantities in three coal fields on the Alaska Peninsula--the Herendeen Bay, Unga Island and Chignik fields. These fields have been summarized by Barnes (1967). Bituminous coal occurs in the Late Cretaceous rocks that underlie at least 15 sq. km. of the Peninsula between Herendeen Bay and Port Moller (Herendeen Bay field). Most of the coal occurs in a large number of closely spaced beds ranging from a few cm. to several meters in thickness. Little is known about the extent or continuity of the beds, and no reliable estimate of reserves can be made. Tertiary lignite-bearing rocks also occur in the area, but they probably do not have much economic value. Some development work occurred between 1880 and 1902, but no commercial production took place. Since Herendeen Bay is blocked by ice much of the time, past development plans included transportation overland 24 km. to Balboa Bay.

Lignite coal beds ranging from a few cm. to several meters in thickness underlie a 15 sq. km. area of northwestern Unga Island (Unga Island coal field). These coals appear to be of poor quality. One mine operated briefly in 1911, but only minor production resulted.

Discontinuous bituminous coal beds up to severel meters thick occur in a belt of Late Cretaceous rocks along the northwest shore of Chignik Bay (Chignik coal field). Not enough data is availabe to estimate reserves.

Sulphur deposits occur in and around the vents of several volcanoes on the Aleutian Islands-Alaska Peninsula. They have been prospected and drilled from time to time, depending on the market for sulpher. Serious preparations were made several years ago to mine one of the larger deposits at Makushin Volcano near Dutch Harbor, just south of the study area. The only significant deposit within the study area occurs near Stepovak Bay. The inaccessibility of this deposit--it occurs on a near-vertical slope covered with ice and snow--prevented close examination of the deposit by the State Division of Geological Survey (Eakins 1970). Float from the area suggests fairly low concentrations, and it is unlikely that this deposit will be of economic interest in the immediate future.

Pumice deposits are the only other nonmetallic mineral in the study area that might have economic importance, mainly as concrete aggregate or admixtures. Potential deposits have been identified near Katmai and in the Veniaminof-Aniakchak area (Moxham 1951). Reworked pumice and ash deposits up to 5 meters thick, mainly from the Katmai eruption, occur along many of the drainages southeast of Katmai, especially along the Katmai River and at the heads of Kukak, Kinak, and Amalik Bays. Minor production occurred at the latter site in 1950. The quantity and quality of these deposits suggest they would be suitable for commercial use. Other deposits are scattered in the drainages surrounding Veniaminof and Aniakchak Volcanoes, but none of these have been investigated or evaluated in any detail. Deposits also occur on Augustine Island in Lower Cook Inlet; they were mined for a brief period between 1946 and 1949.

OIL AND GAS

Introduction

The oil and gas potential of the study area is essentially unknown, but it is believed by industry to be quite high. Exploration has been minimal and only a few test wells have been drilled onshore and none offshore except in Wide Bay. There currently is a high degree of interest and activity in the area by petroleum companies.

Exploration is presently being hampered for several reasons. Onshore, most of the land on the east side of the Alaska Peninsula is not available for leasing. Part of this land lies within Katmai National Monument and the rest is unavailable pending settlement of the Alaska Native Claims Settlement Act of 1971.

Offshore exploration depends entirely on lease sales by the state and federal governments. There presently are no plans by the state for any offshore lease sales in the area, although more state sales in Lower Cook Inlet are likely to be held in the near future. There are no federal Outer Continental Shelf (OCS) sales planned for the area either, but a sale for Lower Cook Inlet is tentatively scheduled for 1976-1977 (Figure 51). This latter sale depends on settlement of litigation between the state and federal governments over ownership of Lower Cook Inlet.

An OCS sale in the Gulf of Alaska is planned, but no date has been scheduled yet. It is unlikely that the sale will take place until the environmental impact of petroleum exploration and development in the area is evaluated. To this end, the Council on Environmental Quality (CEQ) has undertaken a one year comprehensive study to assess this impact. They have been holding hearings throughout the country including a two day session in Anchorage on September 26-27, 1973. A final report is due April 1974. If held, a sale in the Gulf of Alaska probably would cover the eastern part--Hinchinbrook Entrance eastward to Yakutat Bay--since this is the area where most exploration has taken place and nominations already have been submitted by industry.

SALES	1976												1977												1978											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
43 ALASKA (LOWER COOK INLET)		C		ND			T			DES	PH				FES	N	SALE																			
46 ALASKA (BERING SEA SHELF)														C		ND			T			DES	PH				FES	N	SALE							

C= CALL FOR NOMINATION
ND= NOMINATIONS DUE
T= ANNOUNCEMENT OF TRACTS

DES= DRAFT ENVIRONMENTAL STATEMENT
PH= PUBLIC HEARING

FES= FINAL ENVIRONMENTAL STATEMENT
N= NOTICE OF SALE

A decision whether to hold any of the lease sales listed will not be made until completion of all necessary studies of the environmental impact and the holdings of public hearings; as a result of the environmental, technical and economic studies employed in the decision-making process, a decision may, in fact, be made not to hold any sale on this schedule.

If CEQ's study of the environmental impact of oil and gas production on the Atlantic Outer Continental Shelf and in the Gulf of Alaska, determines that development in these areas can proceed in an environmentally satisfactory manner, lease sales in one or both areas will be added to the proposed schedule at the earliest practicable time.

The holding of sale 43 is contingent upon the outcome of pending litigation with Alaska regarding jurisdiction over this area.

Figure 51. Proposed schedule by the Bureau of Land Management for provisional OCS leasing (from Federal Register, V. 38, No. 132, Wed. July 11, 1973).

The oil and gas resources of the study area are best discussed under the heading of three separate provinces: the Alaska Peninsula Mesozoic Province, the Shumagin-Shelikof Tertiary Province, and the Kodiak Tertiary Province (Figure 52). Following discussion of these provinces, there is a summary of present oil company activities and interests in the area. Data for the following sections were taken from discussion with oil company representatives plus various literature sources, especially Miller et al. (1959), Gates et al. (1968), and von Huene et al. (1971).

Alaska Peninsula Mesozoic Province

Mesozoic marine sedimentary rocks of Permian through Cretaceous age outcrop along the entire length of the Alaska Peninsula (Figure 52 and units 1, 3 and 4 of Figure 31). These rocks probably extend offshore to form a belt about 80 to 100 km. wide. This belt may extend west across the southern end of the Peninsula and out under the Bering Sea continental margin. All of these rocks contain oil and gas shows or seeps on the surface and shows of oil and gas in test wells; they all have definite petroleum potential.

Permian through Lower Jurassic rocks probably occur throughout the area in the subsurface, but they only outcrop in one place on the Peninsula south of the Bruin Bay fault at Puale Bay. This section contains abundant limestones and some sandstones that are potential reservoir rocks, and dark shales that could be potential source rocks. Petroliferous beds and tar sands have been reported from these beds (Miller et al. 1959). All of these rocks are essentially untested in the subsurface.

A thick section (over 6,000 m.) of predominately marine clastics of Middle Jurassic through Lower Cretaceous age form the rest of the Mesozoic section exposed on the Alaska Peninsula. This section contains abundant sandstones and conglomerates (potential reservoir rocks) intertongued with marine shales (some known to be potential source rocks). These rocks are also petroliferous as evidenced by numerous oil and gas seeps and petroliferous beds, mainly in the Kanatak area (Figure 52).

These oil and gas seeps were first discovered in the late 1800s. Later investigations reported a flow of about one-half barrel-per-day from the largest seep in the Kanatak area that had covered several acres with a petroleum residue (Capps 1922). This area was visited during the summer of 1973 by geologists of the U.S. Bureau of Mines as part of an overall research project to evaluate oil seeps in Alaska. Water, oil, asphalt, and gas samples were taken at seeps and along streams draining the seep areas. Preliminary results suggest that surface waters contain high amounts of petroleum, but it is not known yet how much is reaching the sea.[1] At one seep, samples of asphalt about 15 to 20 cm. thick

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[1]Don Blasko, Petroleum Engineer, U.S. Bureau of Mines, Anchorage, Personal communication.

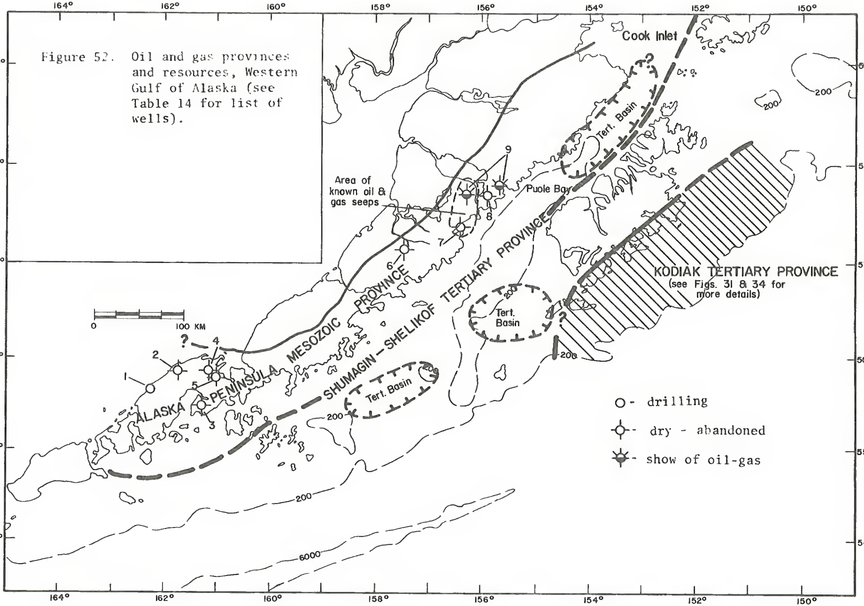

Figure 52. Oil and gas provinces and resources, Western Gulf of Alaska (see Table 14 for list of wells).

covered approximately 5 acres, possibly the same seep reported earlier by Capps (1922). It also was observed that vegetation was greener and appeared to grow better around seeps. These studies by the Bureau hopefully will continue in 1974, when other localities along the Alaska Peninsula will be visited.

At least 12 shallow test wells were drilled on two broad anticlines in the vicinity of the seeps between 1903 and 1940 (Figure 52 and Table 14). Almost all of these contained shows of oil and gas, mainly in the Upper Jurassic rocks. Seven additional deep tests were drilled by major operators between 1959 and 1967, but only minor shows of gas were reported from two of these wells. The lack of commercial production appears to be due to the lack of adequate reservoir rocks, which seems to be common in many Mesozoic rocks. Reservoir qualities might improve to the southwest, where Mesozoic rocks occur in the subsurface.

Mesozoic rocks also extend offshore in the subsurface under Lower Cook Inlet; and they undoubtedly will be an important objective if any lease sales occur here.

There has been no estimate of reserves for this particular province, but the U.S. Geological Survey (1972) has estimated 1.5 billion barrels for the entire Alaska Peninsula. Future success depends on finding favorable structural-stratigraphic situations.

Shumagin-Shelikof Tertiary Province

Several thick Tertiary basins may occur offshore along the shelf between the Shumagin Islands and Shelikof Strait. This is suggested by onshore Tertiary deposits and large offshore gravity lows (Barnes 1967) (Figures 31, 35, 36 and 52). No data on the size or thickness of these basins is available, but they probably contain good reservoir rocks and may contain marine source beds. These source beds, if present, may or may not have been buried deep enough to generate petroleum.

The two basins southwest of Kodiak Island overlie the belt of highly deformed and partly metamorphosed flysch deposits that extends from the Kenai Peninsula to the Shumagin Islands. This lessens the opportunity for the underlying rocks to supply oil to the overlying Tertiary rocks, since any oil generated would have been expelled during the earlier cycle of deformation and uplift.

The oil potential of the basin in Shelikof Strait is enhanced, however, since it overlies the offshore extensions of the Mesozoic province discussed above. Oil found in the continental Tertiary beds in the Cook Inlet Basin possibly originated from similar Mesozoic rocks. The Shelikof Strait basin offers the most attractive prospect of any of these basins.

Table 14. Wildcat wells, Alaska Peninsula Mesozoic Province (see Figure 52 for location of wells).

No.	Name	Completion Date	Total Depth (in meters)	Status
1.	Amoco, Cathedral R. No. 1			Drilling
2.	Pan Amer., David R. No. 1 and 1a	8/18/69	4,197	Dry & Abd.
3.	Pure, Canoe Bay No. 1	10/26/61	2,024	Dry & Abd.
4.	Pan Amer., USA Hoodoo L. No. 1	1/13/70	2,454	Dry & Abd.
5.	Pan Amer., USA Hoodoo L. No. 2	4/28/70	3,810	Dry & Abd.
6.	Cities Service, Painter Ck. No. 1	7/16/67	2,412	Dry & Abd.
7.	Richfield, Wide Bay No. 1	10/17/63	3,830	Dry & Abd.
8.	Humble, Bear Creek No. 1	3/04/59	4,382	Dry & Abd.
9	(Approximately 12 shallow test wells were drilled between 1904 and 1940)			Dry & Abd.

Note: More detailed information about these wells is available from the Alaska Division of Oil and Gas, Anchorage.

All of these basins are virtually unexplored, and apparently very few seismic lines have been run in the area. They certainly offer attractive secondary prospects for future exploration programs.

Another area of Tertiary rocks with some oil potential occurs along the shelf from the Shumagin Islands south. Tertiary rocks occur on most of the islands, but their thickness and extent offshore are unknown. They contain marine rocks and also coal-bearing rocks that might provide sources for oil and gas. They also may overlie Mesozoic rocks that could be a source of oil as mentioned above. The presence of abundant volcanic rocks and volcanic fragments in these sediments, however, makes them more susceptible to alteration, which tends to reduce significantly the reservoir quality of the sands. This makes the area somewhat less attractive.

Kodiak Tertiary Province

A brief description of the Kodiak Tertiary Province has been presented earlier. The petroleum possibilities of this province cannot yet be evaluated. No test wells have been drilled and no indications of petroleum have been reported from the outcrop areas exposed along the southeast coast of Kodiak, although some of these rocks have good reservoir qualities. Occurrences of oil and gas do occur in similar rocks in a comparable province in the eastern Gulf of Alaska region (Plafker 1971).

The Kodiak Tertiary province basically consists of a thick sequence of deformed Early to Middle Tertiary sedimentary rocks, extending from Kodiak Island out to the shelf edge and beyond. Superimposed on these rocks is a relatively undeformed Late Tertiary basin (Figure 34). The rocks adjacent to Kodiak have been highly folded and faulted (fault zone on Figure 34). The relatively undeformed, Late Tertiary sediments filling the basin contain some anticlinal structures and offer favorable objectives. Especially attractive is the shelf edge arch which is characterized by large anticlinal structures and numerous truncations and unconformities that could provide stratigraphic traps. Underlying this entire area is a thick wedge of marine rocks probably containing source rocks that have been buried deep enough to generate petroleum.

The main unanswered question about the province is the orgin of the thick wedge of sediments beneath the shelf edge (Figure 34) and the availability of adequate reservoir rocks in these rocks. A single series of dredged samples from the shelf edge arch area produced deep-water siltstones of Miocene to Pliocene age. The origin of the thick wedge could be due to either folding and repeated thrusting up of fine-grained, deep ocean sediments or uplift of a former trench or continental rise. The latter origin may have provided adequate reservoir sands deposited by turbidity currents.

Portions of the province lie in fairly deep water beyond the shelf edge. This includes a large area where extraction of petroleum is not yet technologically feasible, although it may be in the near future.

This western portion of the Gulf of Alaska has received relatively little exploration effort compared to the eastern portion or the Lower Cook Inlet, but it is considered a highly attractive target for future exploration. Petroleum reserves for the entire Gulf of Alaska have recently been estimated as high as 60 billion barrels.[1]

Oil Company Activities and Interests

Oil company activity and interest in the general Gulf of Alaska area is extremely high. Table 15 gives some idea about past exploration activity in the overall area through 1972. During 1973 several seismic crew months were spent in Lower Cook Inlet, one crew month was spent offshore Unimak Island-Dutch Harbor, and approximately one crew month was spent onshore near Pavlof Bay. In addition, approximately eight crew months were spent by geologic field parties on the Alaska Peninsula, although part of this effort possibly was directed toward the Bristol Bay Tertiary Province on the north side of the Peninsula.

Approximately 12 shallow test wells were drilled near oil seeps between 1903 and 1940, and almost all contained shows of oil and gas. Seven deep exploratory tests were drilled on the Peninsula between 1959 and 1967 to test the Mesozoic rocks, but only minor shows of gas were encountered in several wells. There is presently (April 1974) one exploratory well drilling on the Southern Alaska Peninsula north of Cold Bay (Amoco Cathedral River Unit 1). This well apparently is a deep test of Mesozoic rocks on the Southern Alaska Peninsula.

In addition to the geological and geophysical activity mentioned above, an extensive shallow core hole program was carried out by Exploration Services Company in the Gulf of Alaska and Lower Cook Inlet during 1971 and 1973 in order to obtain stratigraphic information. Over 100 holes were attempted to depths up to 180 m. during eight ship crew months of operation. Equipment difficulties hampered much of the operation, but much useful information was obtained. None of the holes was drilled in the Western Gulf of Alaska. Supplemental to this was a limited soil boring program to obtain strength of materials data needed for pipeline and platform construction.

Three stratigraphic tests are also planned to be drilled offshore the Gulf of Alaska in 1974 by Exploration Services Company. Of the five possible drilling sites, three are in the eastern Gulf of Alaska and two are within the study area off Tugidak Island and in Shelikof Strait. These latter two sites probably would be testing the Tertiary basins off Kodiak mentioned earlier. These tests would be approximately 3,000 m. off-structure stratigraphic tests that would be shut down if any

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[1]Testimony of John Silcox, Standard Oil Co., CEQ Hearings, Anchorage, September 26, 1973.

Table 15. Summaries of exploration activities, Gulf of Alaska - Alaska Peninsula.

A roundup of geophysical work in Alaskan waters

Year	Operator	No. partici-pants	Mileage	Type	Contractor	Gross cost	Remarks
GULF OF ALASKA							
1965		16	14,000	Aeromagnetic	Aero		Eastern sector
1965		9	30,000	Aeromagentic	Aero		Western sector
1965	Texaco	15	228	Reflection	GSI	$ 246,000	Recon.
1966	Texaco	25	753	Reflection	GSI	1,050,000	Eastern sector
1966	Texaco	23	331	Reflection	GSI	1,035,000	Western sector
1966		SC*	1,600	Reflection	GSI		
1967	Conoco	30	4,698	Reflection	Olympic	2,682,150	USGS purchased
1967	Conoco	31	708	Reflection	Olympic	307,316	USGS purchased
1967		SC	5,000	Reflection	GSI		
1968		3	3,900	Aeromagnetic	Aero		Southeast sector
1968	Socal	31	4,300	Aeromagnetic	GSI	2,811,000	USGS purchased
1968	Union	22	7,116	Gravity	GSI	356,000	
1968		SC	1,500	Reflection	Olympic		
1968		SC	2,000	Reflection	Western		
1968		SC	7,000	Gravity	GSI		
1969		SC	5,500	Reflection	GSI		
1969		SC	2,000	Reflection	Olympic		
1969		SC	2,000	Reflection	Western		
1970		SC	2,500	Reflection	GSI		
1970		SC	750	Reflection	Western		
1971		SC	2,000	Reflection	GSI		
1971		SC	2,000	Reflection	Western		
COOK INLET AND SHELIKOF STRAIT							
1962		13	9,200	Aeromagnetic	Aero		Cook Inlet
1964		12	4,000	Aeromagnetic	Aero		Lower Cook Inlet
1964		10	2,000	Aeromagnetic	Aero		Lower Cook Inlet
1965	Texaco	23	1,150	Reflection	GSI	893,000	Lower Cook Inlet

(from Oil and Gas Journal, February 28, 1972)

B. Geophysical and surface mapping activity, crew months (excluding U.S.G.S. and State work).

Year	Alaska Peninsula-Bristol Bay		Gulf of Alaska	
	Surface Geology	Geophysical	Surface Geology	Geophysical
1970	6	4	12	4
1971	3	3	11	7
1972	9	3	8	11

(from A.A.P.G. Bulletins, V.55, p.947; V.56, p.1184; V.57, p.1416) significant oil and gas shows were encountered. Participants will decide on the final three sites. Exploration Services also has applied to the federal government for permits to drill two similar tests in OCS waters in the Gulf of Alaska.

As noted above most of the activity has been centered around the eastern Gulf of Alaska and Lower Cook Inlet. The eastern Gulf of Alaska was nominated by industry for a potential lease sale in 1968, and consequently, most exploration work has concentrated on this area. This sale was cancelled, and a future sale in this area has not been officially scheduled (Figure 51). The possibility of both federal and state lease sales in Lower Cook Inlet also has generated interest, and consequently, the offshore Western Gulf of Alaska has been temporarily deemphasized as an exploration objective in the near future. This explains the relative lack of information compiled by the industry. In fact, the Western Gulf probably would rank fourth in priority behind the Eastern Gulf of Alaska, Lower Cook Inlet, and the Alaska Peninsula. This is not because of its oil potential but because of the lack of projected lease sales and the lack of detailed offshore geological and geophysical data. Further detailed work in this area probably will not be done until such lease sales are proposed.

In addition to geological and geophysical data about the Gulf of Alaska, petroleum companies have been gathering together environmental data. This includes a general description of the physical and biological environment plus studies on the impact of oil operations on the environment. These studies are being coordinated through a consortium of 21 oil companies known as the Gulf of Alaska Operators Committee (Table 16).

This committee presented a lengthy testimony at the Anchorage CEQ hearings Septemeber 26, 1973. They orally summarized their environmental studies and also submitted extensive written testimony and documents that detailed their studies. Although this testimony was primarily directed toward development in the Eastern Gulf of Alaska, much of the data are generally applicable to the entire Gulf area.

The Committee has additional environmental data that are directly applicable to the Western Gulf of Alaska but not presently summarized in any usable form. The committee has expressed willingness to cooperate in making this data available.

OTHER ENERGY RESOURCES

Geothermal

The Alaska Peninsula has a high potential for geothermal resources. All of the recent or active volcanic centers contain potential geothermal systems that could be exploited as an energy source. None of the volcanic

Table 16. Participating compaines in Gulf of Alaska Operators Committee as of July 1973.

Amoco	Conoco	Monsanto	Shell	Union
Arco	Exxon	Murphy	Skelly	
Ashland	Gulf	Pennzoil	SOCAL	
BP	Marathon	Phillips	Sun	
Cities	Mobil	Placid	Texaco	

centers in the study area has yet been officially classified as a "Known Geothermal Resource Area" (KGRA), which requires a competitive lease sale prior to exploration (Godwin et al. 1971). Most of these areas have been designated, however, as areas valuable prospectively by the U.S. Geological Survey (Godwin et al. 1971) or as areas of potential geothermal energy by the Resource Planning Team of the Joint Federal-State Land Use Planning Commission. The areas outlined by the Team are shown on Figure 53.

Thermal or hot springs also generally are the surface manifestation of geothermal systems. At least 13 such springs, all associated with volcanic rocks, have been reported on the Peninsula (Biggar 1972; Miller 1973) (Figure 53). Undoubtedly many more exist. Only a few have any temperature or chemical data available for them.

A research program by the U.S. Geological Survey has been initiated recently to study Alaska geothermal areas including the recent volcanic areas of the Alaska Peninsula.[1] Three and one-half weeks of reconnaissance field work was conducted on the Peninsula in the summer of 1973 to study the geology of and to collect samples of recent and active volcanoes and hot springs. It is thought that the chemistry, age, and volumes of ejected and extruded material can be used to establish where a volcano is in its life cycle. This information can then be used to evaluate its potential as a geothermal energy source. In addition, the chemistry of the thermal springs and adjacent deposits can be used to tell the temperature of waters at depth. These reconnaissance studies hopefully will be used to pick areas for further detailed work including geophysics and possibly even drilling.

No estimate of potential energy available from geothermal systems on the Peninsula is possible at this time, but it is undoubtedly large.

Hydroelectric[2]

There have been no significant hydro developments in the study area. Several very small projects were built to power saw mills and canneries prior to the age of the diesel engine, but most of these are now abandoned.

The physical potential includes numerous sites ranging from very small up to around 30,000 kilowatts in size. Inventory grade analyses indicate the most promising are the Terror Lake, Uganik, Karluk, and Frazier Lake Projects (Figure 54 and Table 17). In comparison with other hydro potentials in Alaska, the four projects are considered relatively small and relatively costly.

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[1]Tom Miller, Geologist, U.S. Geological Survey, Anchorage, Personal communication.

[2]R.J. Cross, Chief of Project Development Division, Alaska Power Administration, Juneau, Alaska, Personal communication.

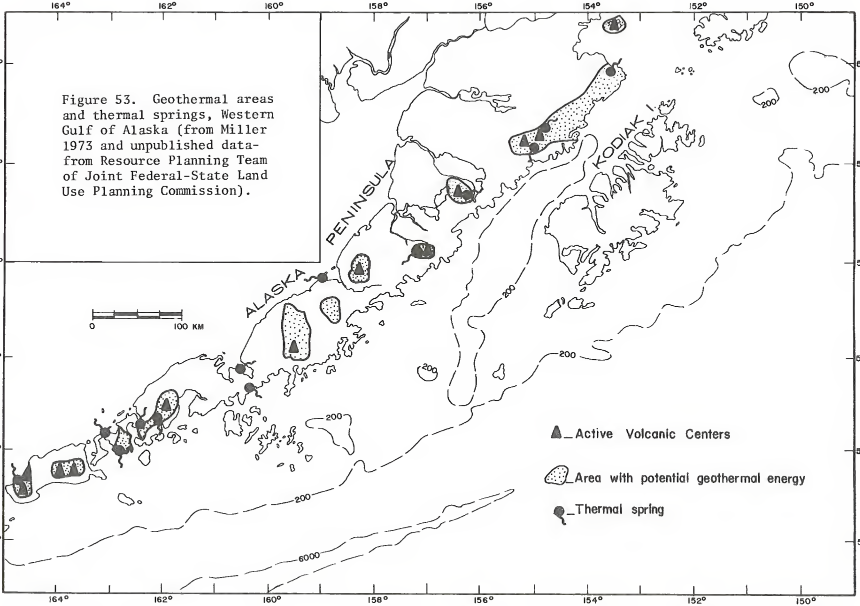

Figure 53. Geothermal areas and thermal springs, Western Gulf of Alaska (from Miller 1973 and unpublished data-from Resource Planning Team of Joint Federal-State Land Use Planning Commission).

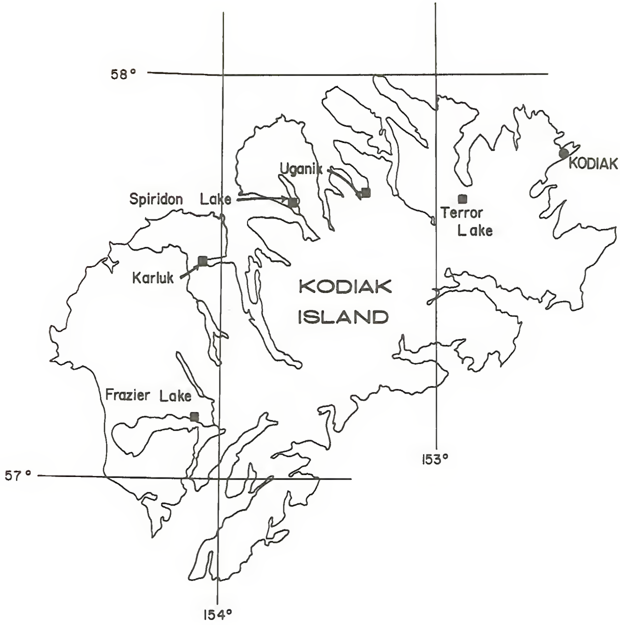

Figure 54. Most favorable hydro potentials, Kodiak Island (from files of Alaska Power Administration, Juneau, Personal communication).

Table 17. Hydro Potential Sites, Kodiak Island (from Alaska Power Administration, Juneau, Alaska, Personal communication).

	Capacity 1000 KW	Annual Energy Million KWH
Terror Lake		
Utility Definite Project Report	30,000 (ultimate)	130
Inventory Plan	15,000	64
Uganik	15,000	68
Karluk	34,000	149
Frazier Lake	7,500	33

The Terror Lake Project has received extensive investigation and is considered the most attractive hydro site on the Island. Detailed project studies by consultants to the Kodiak Electric Association (KEA) were completed in 1967, but the project was not developed because of high costs. KEA has recently reopened its consideration of Terror Lake as one of the few potentially feasible alternatives to diesel-fired generation for the Kodiak area.

Available studies do not indicate any significant hydro potentials on the Alaska Peninsula portion of the study area.

In comparison with diesel engines, investment costs for the identified hydro projects are very large. Cost factors and relatively small power requirements have precluded hydro development in recent years.

Development of the Terror Lake Project is a near future possibility, but it appears unlikely that other potential hydro projects of the study area will be developed in the foreseeable future.

More specific data on Terror Lake is available from the Kodiak Electric Association and for the other projects from the Alaska Power Administration, Juneau, Alaska.

Wind Power[1]

The wind power potential of Alaska is very large and represents a yet untapped energy resource that could be "packaged" and exported or used locally. Power generated from windmills is especially attractive as a low-cost energy source well suited for residences, villages, or other small onshore facilities. Use of such power would be dependent on developing adequate capacity for storing the energy during periods of low wind.

The University of Alaska's Geophysical Institute is currently making an assessment of the wind power potential of Alaska. This assessment includes conducting wind surveys at various locations to characterize the wind regimes (Wentink, In Press). The Western Gulf of Alaska area offers an excellent laboratory for these studies, since the wind blows hard in this region a large percentage of the time. Several sites within the area are being investigated as part of this project, and one location, Cold Bay, is being considered as a prime candidate for further large-scale wind power investigations. Wind data for Cold Bay and also Cape Sarichef on the west end of Unimak Island is presented in Table 18.

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[1]T. Wentink, Geophysical Institute, University of Alaska, Fairbanks, Personal communication.

Table 18. Wind Velocity data from selected stations, Western Gulf of Alaska (from Wentink, In Press).

Location	Mean Annual Velocity (in knots)	Percent of Time at 7-21 Knots	Percent of Time above 21 Knots
Cape Sarichef	13.7 (1952-56?)	57.5	18.5
Cold Bay	15.1 (1956-60)	64.0	24.0

VOLCANISM

Most of Alaska's recent and active volcanoes[1] occur along an arcuate belt extending over 1600 km. from Mt. Spurr opposite Anchorage to the tip of the Aleutian Islands (Figure 55). This belt is part of a larger chain of volcanoes that rim the entire Pacific Ocean Basin, the so-called "Ring of Fire." This "Ring" represents a narrow zone characterized by active tectonism and seismicity as well as volcanic activity landward of a deep-sea trench (Figure 56). The recently developed theory of plate tectonics suggests that all of these factors are related to the underthrusting of one crustal plate beneath another along a subduction zone or "Benioff" zone (Figure 39). Lavas erupted by Pacific Rim volcanoes, therefore, probably are generated by the partial melting of oceanic crust and upper mantle rocks as they are thrust under the adjacent plate.

The arcuate volcanic belt of Alaska contains at least 60 centers that have erupted in recent time (the last 10,000 years). Actvity has been recorded at about 40 of these volcanoes since 1700 A.D., and there has been some type of activity almost every year somewhere along the belt. The latest eruption was on Great Sitkin Volcano in February 1974. Coats (1950) and Powers (1958) presented good overall summaries of Alaska's past volcanic activity.

Sixteen of the active centers occur within the study area, ranging from Pogromni Volcano on Unimak Island to Katmai and associated centers toward the northern end of the Peninsula. The location and a summary of each of these volcanoes is presented in Figure 57 and Table 19 respectively. In addition there are many other centers that undoubtedly have been active in fairly recent times (within the past few thousand years) (Figure 57 and Table 19). Any of these centers could erupt at any time.

The volcanoes form most of the high peaks of the Alaska Peninsula, ranging from a low of about 825 m. at Novarupta Volcano to over 2800 m. at Shishaldin Volcano. In addition to the spectacular scenery offered by these volcanoes, they also represent some of the best examples of recent volcanic features, (cones, craters, calderas, etc.) found anywhere in the world. The area surrounding the Katmai group already has been set aside as a national monument, and several others (Pavlof, Veniaminof, Shishaldin, and Aniakchak) are being considered for some type of recognition in the national system.

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[1] Recent volcanoes are those that probably have erupted during the past 10,000 years but have no historic record of activity. Active volcanoes are those that have had reported activity in historic time (since 1700 A.D.).

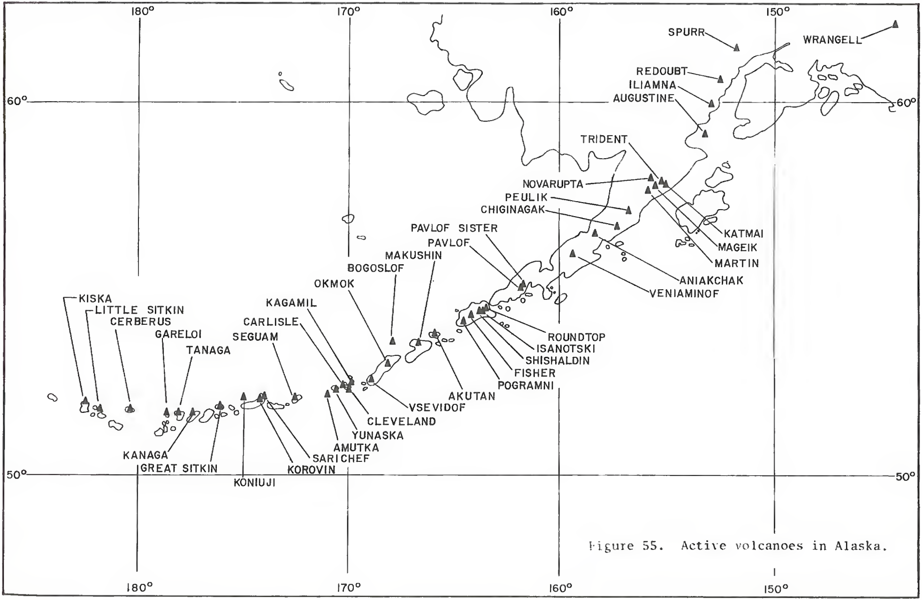

Figure 55. Active volcanoes in Alaska.

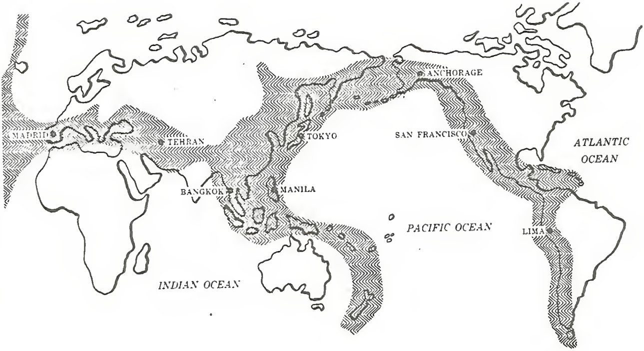

Figure 56. Map showing Pacific Rim belt of active tectonism, and seismicity, and volcanoes, the "Ring of Fire." (from Hansen and Eckel 1971).

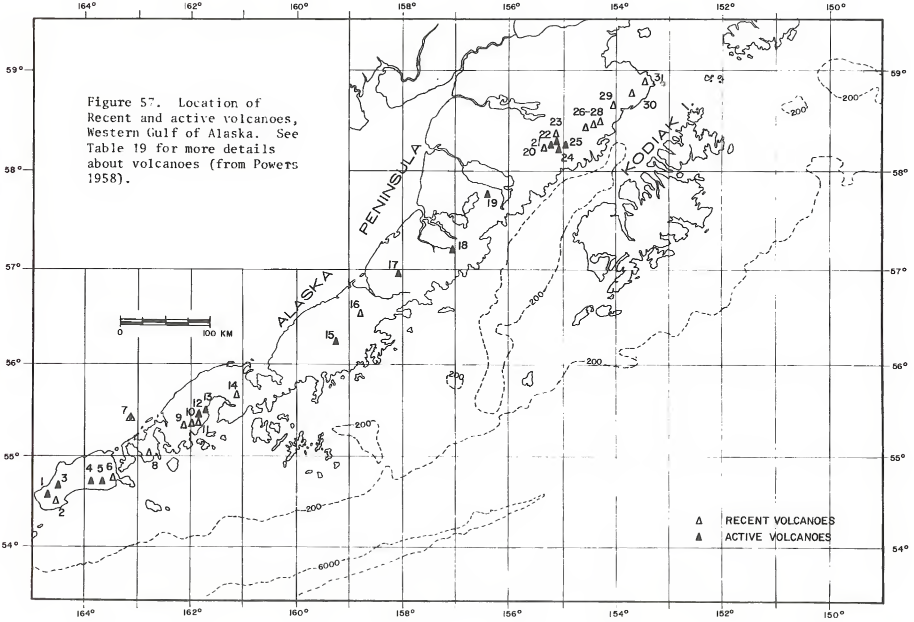

Figure 57. Location of Recent and active volcanoes, Western Gulf of Alaska. See Table 19 for more details about volcanoes (from Powers 1958).

Table 19. Summary of recent and active volcanoes,[1] Alaska Peninsula (Adapted from Powers 1958, MacDonald 1972, Forbes, In Press)

No.[2]	Name	Approx. summit ht. (meters)	No. of eruptions since 1700 A.D.	Date of last eruption	Remarks on Activity
1.	Pogromni	2,002	4	1830	Ash eruptions-1795, 1820, 1827-30; lava flow-1796.
2.	Westdahl	1,560	1	1964	Ash and lava, March 10-April 16, 1964.
3.	Fisher	1,094	1	1826	Possible ash eruption.
4.	Shishaldin	2,857	23	1967	Active-1775-78; smoke-1790, 1865, 1880-81, 1897; ash eruptions-1824-26, 1827-30, 1838, 1842, 1883, 1898, 1922, 1925, 1928-29, 1946-53, 1955, 1963, 1967. Explosive clouds of ash followed by intense steam emission, no lava reported-January 28, 1967.
5.	Isanotski	2,446	4	1845	Ash eruptions-1795, 1830, 1845; possibly some are Roundtop eruptions.

1. Recent volcanoes are defined as those that probably have erupted during the past 10,000 years, but have no historic record of activity. They could erupt at any time. Active volcanoes are defined as those that have had reported activity in historic time (since 1700 A.D.).

2. Location of volcanoes are shown by number on Figure 57.

Table 19, Continued.

6.	Roundtop	1,871	1?	1835?	Ash eruption-1825; possibly some eruptions reported for Isanotski should be credited to Roundtop.
7.	Amak	488			Probably no historic activity.
8.	Frosty	2,012			Probably no historic activity.
9.	Emmons	1,326			Probably no historic activity.
10.	Hague	1,341			Probably no historic activity except intermittent steaming.
11.	Double Crater	1,465			Probably no historic activity.
12.	Pavlof	2,518	25	1973	Active-1970, 1880, 1892; smoke-1838, 1852; ash eruptions-1846, 1866, 1901, 1916, 1922-24, 1929-31, 1926-45, 1948, 1950-53, 1963; ash and lava-1966; eruption of cloud of ash and smoke over 6,000 m. high on November 13, 1973.
13.	Pavlof Sister	2,142	1	1786	Active 1762-1786.
14.	Dana	1,280			Probably no historic activity.
15.	Veniaminof	2,575	8	1944	Smoking-1830-38, 1852, 1874; active-1944; ash eruptions-1838, 1892, 1939; lava eruption-1930.
16.	Purple	954			Probably no historic activity.
17.	Aniakchak	1,355	1	1931	Steaming, ash and lava eruption-1931.
18.	Chiginagak	2,073	2	1929	Smoke and intermittent steaming-1852.

Table 19, Continued.

19.	Peulik	1,474	2	1852	Ash eruption-1814, Smoke-1852.
20.	Martin	1,844	2+	1960	Steaming intermittently since 1912; ash eruption ? -1912.
21.	Mageik	2,210	4	1946	Ash eruptions-1912, 1927, 1936, 1953; Active-1929, 1946.
22.	Novarupta	825	1	1912	Vent breached during 1912 Katmai eruption; pyroclastics erupted first followed by extrusion of plug dome. Vent believed to be one of main sources for ash and pumice flow deposits (glowing avalanche) in Valley of 10,000 Smokes.
23.	Knife Peak	2,316			No historic activity, but has 2 sulfurous fumaroles on summit and flank.
24.	Trident	1,832	3	1968	Steaming-1912; lava eruption-1953; explosive, ash charged vapor columns to great heights-April, 1963 and May, 1964; vent clearing explosions plus ash eruptions-December, 1967 to February, 1968, November, 1968.
25.	Katmai	2,047	7	1931	Explosive eruption with vast pumice and ash deposits accompanied by caldera collapse-1912; steam-1931.
26.	Denison	2,256			Probably no historic activity.

Table 19, Continued.

27.	Steller	2,256	Probably no historic activity.
28.	Kukak	2,012	Probably no historic activity.
29.	Kaguyak	855	Probably no historic activity.
30.	Fourpeaked	2,104	Probably no historic activity.
31.	Douglas	2,134	Probably no historic activity, except for intermittent steaming.

Pacific Rim volcanoes generally are called andesitic, which reflects the chemical composition of the magmas. Andesitic magmas contain more silica and are more viscous than normal oceanic basalts such as those on Hawaii. Eruption of these types of magmas is much more violent and explosive in nature. Material ejected in a fragmental condition (pyroclastic material--ash, lapilli, or bombs) usually builds up large composite cones. Other volcanic phenomena associated with these eruptions include lava flows, ash flows, volcanic landslides and mudflows, ash falls, and gases. Finer material ejected into the air is carried downwind at various distances depending on the frothiness or fineness of the material and the direction and intensity of the wind. Generally, only minor amounts of lava are erupted as flows.

Eruptions can be extremely violent, but moderate eruptions are more representative of these volcanoes (Wilcox 1959). The famous Katmai eruption of 1912 is an excellent example of a violent eruption; it ranks as one of the greatest eruptions in recorded history. More than 25 cu. km. of ash and pumice were blown into the air or flowed into the Valley of Ten Thousand Smokes, and up to a foot of ash fell on Kodiak 160 km. away (Figure 41). An up-to-date summary of this eruption and other volcanic activity in the Katmai region is contained in a book soon to be published by the University of Washington Press (Forbes, In Press).

Augustine Island, located just north of the study area in Lower Cook Inlet, also erupted violently in 1883 and presently is building lava domes in its summit crater that could cause another violent explosion in the near future. This volcano is under intense study by the Geophysical Institute, University of Alaska, Fairbanks.

The eruptions of Trident Volcano in 1952, Mt. Spurr opposite Anchorage in 1953, and Redoubt in 1966-1968 are examples of the less intense type of eruption more characteristic of these volcanoes (Wilcox 1959). They consisted of bursts of gas and ash that rose vertically as a cloud to altitudes up to 20,000 m. These bursts were accompanied by small, viscous, blockylava flows at the vent area. Mudflows composed of ash and meltwater that flowed down the flank of the mountains were mistaken for lava flows.

The past and potential effects of volcanism in the area are discussed in a later section of this report (IX).

SEISMICITY

Alaska is one of the most seismically active areas of the world, both in numbers of earthquakes and in the energy they release. Most of the Alaska earthquakes occur along an arcuate belt extending from the western end of the Aleutian Islands to Prince William Sound (Figure 58). This Alaska belt is part of a narrow, almost continuous earthquake zone that rims the entire Pacific (Figures 56 and 59). This zone, characterized also by active volcanism and tectonic deformation, define the margins of the large Pacific Plate (Figure 39). According to recent

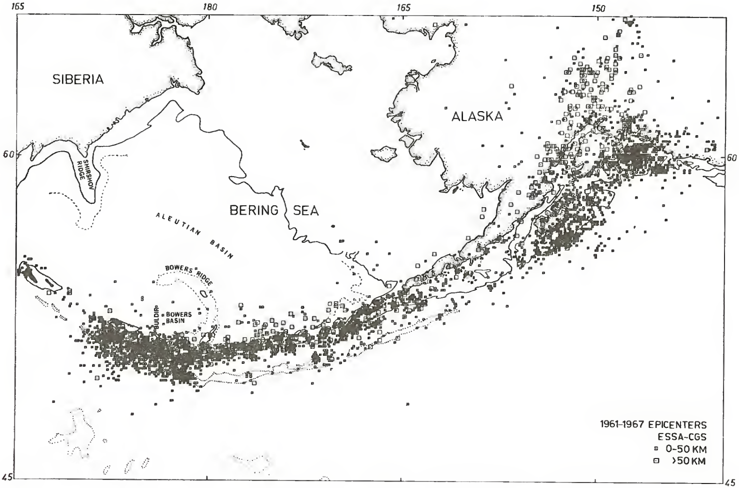

Figure 58. Seismicity of Aleutian Arc-southern Alaska, 1961-1967 (from Kienle 1971).

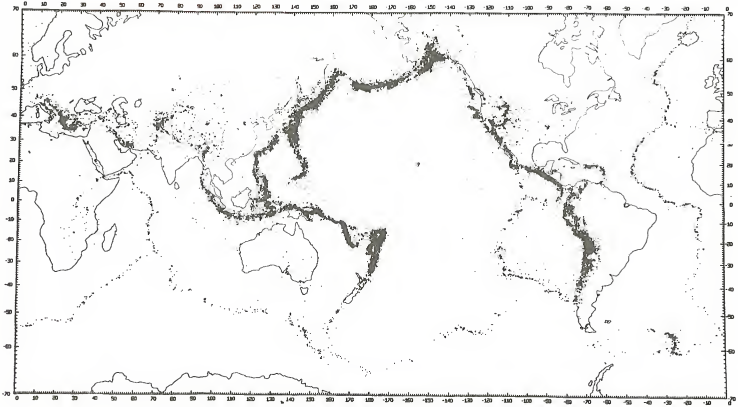

Figure 59. Seismicity of the earth, 1961-1967 (from Sykes 1972).

theories of plate tectonics, the Pacific Plate is being thrust under the North American Plate along the Aleutian Trench, thus providing a generating mechanism for the seismicity (Figure 39).

Most of the earthquakes in the area originate at shallow depths (0-70 km.). The depth of their occurrence corresponds roughly to their distance from the trench, and the distribution of hypocenters approximately defines the configuration of the downgoing plate (Lahr et al. 1974). The lack of many deeper earthquakes may reflect the relatively young age of the underthrusting.

About seven percent of the earthquake energy that is released annually on the earth originates in the Alaska seismic zone (Hansen and Eckel 1971). A large percentage of this energy release occurs during large earthquakes. Between 1899 and May of 1965, nine Alaska earthquakes have equalled or exceeded Richter magnitude 8 and more than 60 have equalled or exceeded magnitude 7. The large earthquakes appear to correspond with the slippage of large blocks, which are defined by the distribution of aftershocks (Sykes 1972). Aftershock zones of all the very large earthquakes in the Alaska-Aleutian area from 1930 to 1970 have been plotted from data of Sykes (1972) (Figure 60). This plot suggests a regular space-time pattern for the earthquakes and also identifies major gaps in activity for large earthquakes. These gaps are regarded as likely sites for future large earthquakes (Sykes 1972). Significantly, the only large earthquake in Alaska during 1972 occurred in one of these seismic gaps (Sitka earthquake, July 1972, magnitude 7.2). The lack of a large destructive tsunami following the Sitka earthquake supports the theory of strike-slip movement along this portion of the plate boundary rather than underthrusting. An underthrusting movement is usually accompanied by large-scale displacements of the sea floor which often cause tsunamis. It also can be seen from the plot that the area of the great 1964 earthquake was without a large earthquake prior to 1964.

Kelleher (1970) also noted that the area involved in the 1938 earthquake near the Shumagin Islands is now very quiet for large earthquakes. This seismic gap (the Kodiak-Shumagin seismic gap) shows especially well on the epicenter distribution map (Figure 58). From an analysis of space-time sequences, Kelleher predicted that a large earthquake will occur in the area sometime between 1974 and 1980. If it were to occur, it most likely would produce a large-scale displacement of the sea floor and possibly generate a tsunami, as did the 1964 earthquake.

This Kodiak-Shumagin seismic gap mentioned above is centered directly in the Western Gulf of Alaska region, and is now the focal point of a joint research effort that hopefully will lead to the prediction of any large earthquake in the region. The project is being conducted by Lamont Observatory with support from the U.S. Geological Survey and the University of Alaska. During 1973, a detailed seismic net of 11 stations was established in the Shumagin Islands, and 5 more

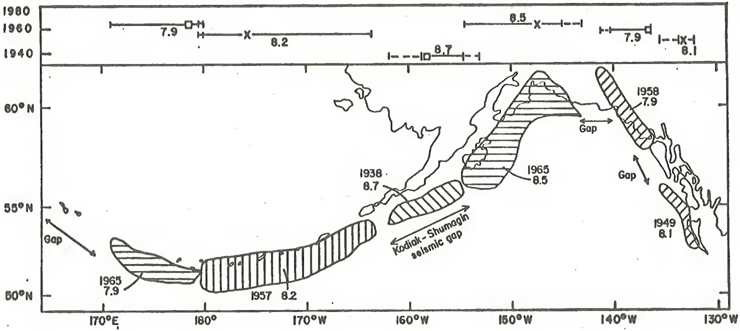

Figure 60. Aftershock areas of great Alaska earthquakes (magnitude greater than 7.9) since 1930. These areas tend to abut without significant overlap and probably represent rupture along major crustal blocks. Gaps in activity are regarded as sites for future very large earthquakes. The apparent space-time relationship of the areas may provide a tool for earthquake predictions (from Sykes 1972).

stations are planned for 1974 (Figure 61). In addition, there are several other stations in the area run by the University of Alaska, NOAA, and the U.S. Geological Survey, which also will be used to monitor seismic activity in the area and to supplement the project (Figure 61).

The objective of this project is to delineate in detail the spatial distribution of low-level seismicity in the seismic gap and to obtain qualitative measure of any change in seismic activity and changes in the physical properties of the rocks that might occur prior to any large event. This type of detailed seismic information may or may not provide a direct means of predicting a large earthquake, but it certainly is a prerequisite for any future seismic prediction program.

The susceptibility of the region to earthquakes and earthquake damage was made particularly evident during the great 1964 Alaska earthquake. With a magnitude of 8.3 to 8.7 this was one of the largest and most violent earthquakes to occur in North America during this century. Subsequently, the 1964 earthquake has received extensive study, and much has been written about it. Perhaps the most comprehensive account is found in a series of eight separate volumes published by the National Academy of Sciences, covering the following topics: Geology, Seismology and Geodesy, Hydrology, Biology, Oceanography and Coastal Engineering, Engineering, Human Ecology, and Summary and Conclusions. A brief discussion of the effects of this earthquake plus earthquakes in general is contained in section IX of this report.

COASTAL PROCESSES AND EROSION

Coastal erosion is generally defined as the wearing away of a shoreline and adjacent uplands by natural marine processes. In erosive action, more material leaves the system than enters it. The extent and degree of erosive action is a direct function of the geologic composition of the shoreline material and the sequence and magnitude of the processes.

The main processes operating against the coastline in the study area are wind-generated waves and currents, which can get quite extreme during large storms. In a few hours, one large storm may move more material than normally would be transferred in many years. Another condition unique to parts of the area is the extreme tidal variations, which permit a higher range of wave action to attack the coast. This forms a higher erosional scarp, which more readily induces bluff failure. Still another significant factor affecting coastal erosion in the study area is tectonic deformation. Tectonic deformation, particularly subsidence, can subject previously unaffected shorelines to accelerated coastal erosion.

As mentioned in earlier sections, most of the coast of the Western Gulf of Alaska is rugged, steep, and rocky with narrow beaches. Here

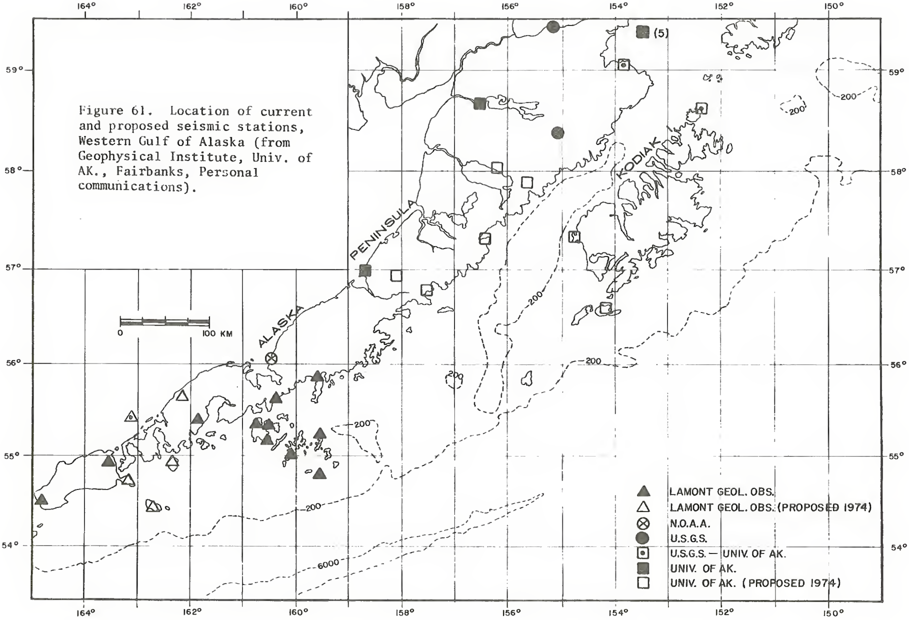

Figure 61. Location of current and proposed seismic stations, Western Gulf of Alaska (from Geophysical Institute, Univ. of AK., Fairbanks, Personal communications).

coastal erosion probably is relatively slow because of the resistant nature of much of the bedrock cliffs, although in some areas of softer Tertiary sediments, erosional rates are undoubtedly higher. Actually very little is really known about the magnitude of natural coastal processes going on in the study area, and for that matter, in Alaska generally. A few qualitative reports of erosion are available from early geological reports and histories of places of habitation, but no quantitative studies have been made. Some idea of processes and volumetric changes could be obtained by comparing old aerial photographs with newer ones and by studying beach ridge patterns where present. This lack of information stems from the fact that most of the coastline is uninhabitated and undeveloped, and erosion has not caused a significant impact or problem. Erosion only becomes a problem where people inhabit or use the coastline.

In 1970-1971, the U.S. Army Corps of Engineers conducted a survey of Alaska's shore erosion problems as part of an overall National Shoreline Study for the entire United States (U.S. Army Corps of Engineers 1971). Within the study area, five villages reported having erosion problems (Figure 62 and Table 20). Apparently the current beach erosion problem at the Kodiak villages was caused by the 1964 earthquake, as the Kodiak area lies directly along the axis of maximum subsidence (Figure 63). This subsidence subjected the shoreline to an acceleration of erosional processes. Details concerning the nature of the specific problem at each village can be obtained from the U.S. Corps of Engineers. To date, only study of the shoreline erosion problems at Port Lions has been authorized and is currently being conducted by the Corps.

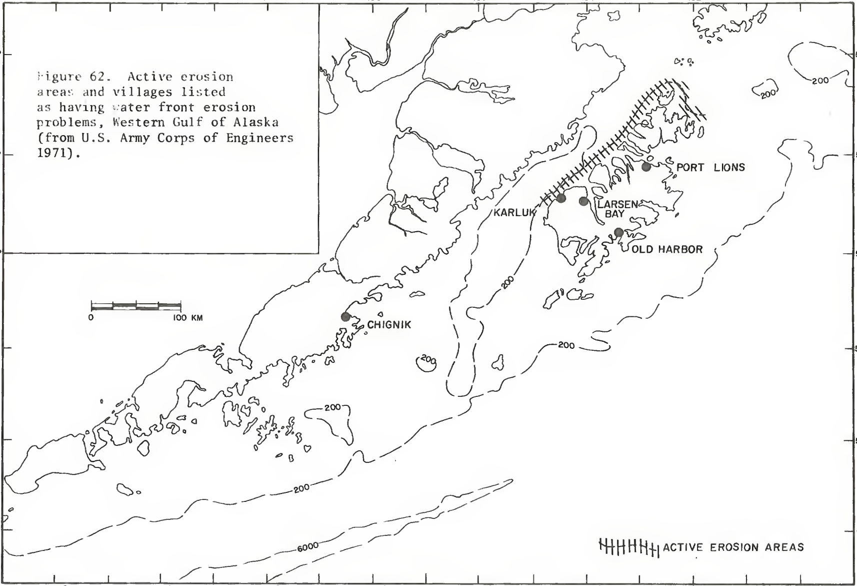

Figure 62. Active erosion areas and villages listed as having water front erosion problems, Western Gulf of Alaska (from U.S. Army Corps of Engineers 1971).

Table 20. List of villages in Western Gulf of Alaska reported to have coastal erosion problems. See Figure 62 for location of villages (from U.S. Army Corps of Engineers 1971).

Village	Erosion	Miles of Coast Affected
Chignik	Maybe	1.0
Karluk	Yes	1.0
Larsen Bay	Yes	1.0
Old Harbor	Yes	1.0
Port Lions	Yes	0.5

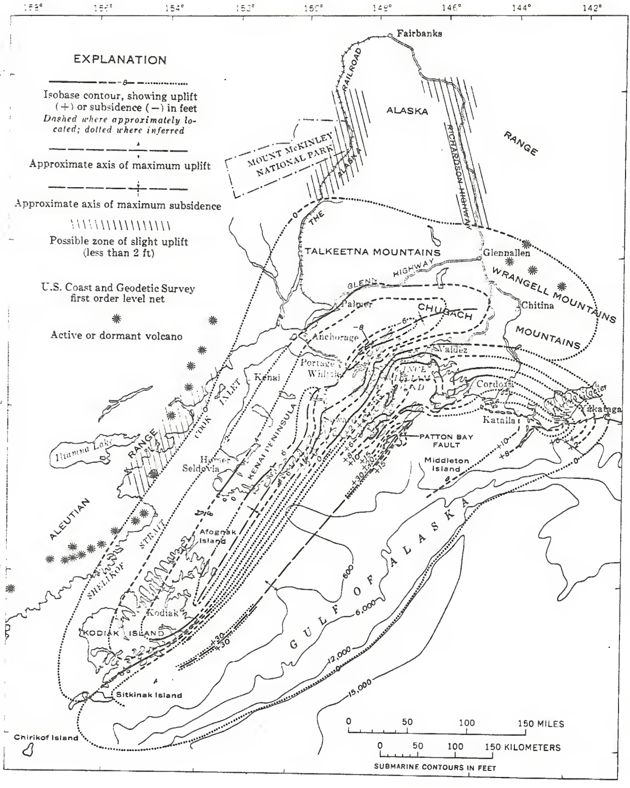

Figure 63. Map showing the distribution of tectonic uplift and subsidence in south-central Alaska (from Plafker 1972).

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_______ 1972b. Metallic Mineral Resources Map of Chignik Quadrangle. MF-374.

_______ 1972c. Cold Bay Quadrangle, MF-441.

_______ 1972d. Karluk Quadrangle, MF-459.

_______ 1972e. Kodiak Quadrangle, MF-460.

_______ 1972f. Mt. Katmai Quadrangle, MF-461.

_______ 1972g. Port Moller Quadrangle, MF-443.

_______ 1972h. Trinity Islands Quadrangle, MF-468.

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VI. HYDROLOGY[1]

INTRODUCTION

The study area is characterized by a steep, rugged, inlet indented coast with scattered lowlands in which glacial and alluvial deposits occur. Most streams are short (none more than 30 to 50 km.) and have narrow floodplains, steep gradients, and small drainage basins. The area is within the maritime climatic zone, which is characterized by high precipitation and mild temperatures. It is essentially free of permafrost except possibly for crestal areas of the Aleutian Range and Kodiak Island. Portions of some of the higher peaks still contain glaciers.

Hydrologic information for the area is scarce and includes only limited data from a few short-term surface water gaging stations on Kodiak Island, data from a few water wells mostly on Kodiak Island, and a few scattered bits of water quality data. Little data are available for the Alaska Peninsula. The U. S. Geological Survey, Anchorage, has conducted limited and sporadic studies for Kodiak and the Kodiak Borough over the past 10 years to help resolve their water supply problems.

SURFACE WATER

Surface water stations in the study area are limited to the Kodiak area. The location, description, and status of these stations are presented in Figure 64 and Table 21. Data from these stations have been published in a series of U. S. Geolgoical Survey publications, the most recent being "Water Resources Data for Alaska, 1971" (U. S. Geological Survey 1972). Pertinent information from this publication for the Kodiak stations is summarized in Tables 22, 23, and 24.

Exposed bedrock and thin soils throughout most of the area, plus the general lack of aquifers, cause runoff rates to be among the highest in the state. For most of the area the mean annual runoff probably averages about 4 cubic feet per second per square mile (c.f.s./mi.^{2}) (44 liters per second per square kilometer-l.s./km.^{2}) (Figure 65). It may reach as high as 8 c.f.s./mi.^{2} (88 l.s./km.^{2}) on the southeast side of Kodiak Island and in higher elevations, and it probably is much less than 4 c.f.s./mi^2 (44 l.s./km.^{2}) in small, low-lying basins. Total discharge for Kodiak and Afognak Islands is reported as 37,600 c.f.s./(1.06 million liters per second).

Mean annual peak runoff for the area (an average of the highest runoff recorded each year) probably averages about 50 c.f.s./mi.^{2} (550 l.s./km.^{2}), but may be as high has 100 c.f.s./mi.^{2} (1100 l.s./km.^{2}) for southeast Kodiak Island and higher elevations (Figure 65). These are some of the highest flood discharge rates in the state. Data on maximum

[1]Much of the narrative for this section is adapted from Feulner 1973a, 1973b and Feulner et al. 1971, 1972.

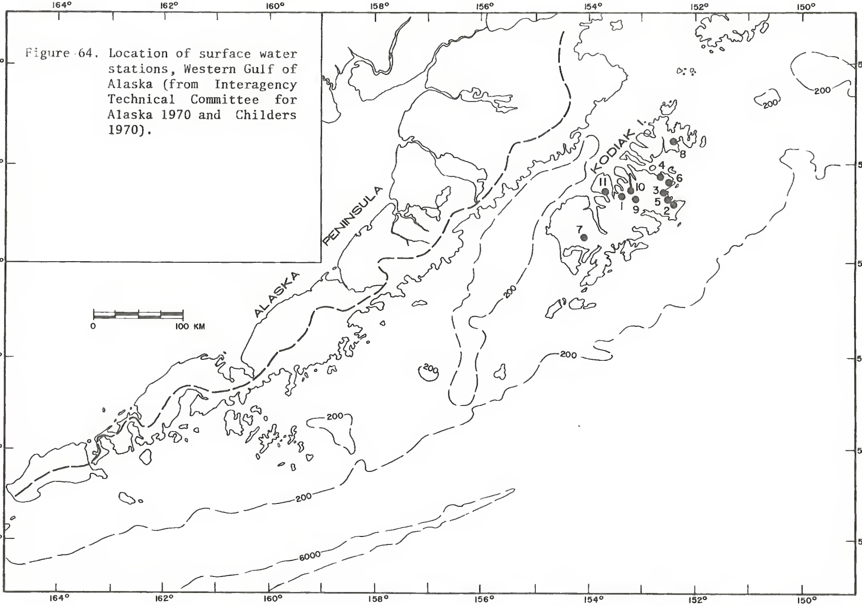

Figure 64. Location of surface water stations, Western Gulf of Alaska (from Interagency Technical Committee for Alaska 1970 and Childers 1970).

Sta. No.	Location - stream	Station Status	Station Type	Type of Data	Purpose	Agency Responsible
1.	Uganik R.	Existing	Continuous Daily	Physical, Chemical	Baseline Hydrologic Data	U.S.G.S.
2.	Myrtle Ck.	Existing	Continuous Daily	Physical, Chemical	Baseline Hydrologic Data	U.S.G.S., Ak. Dept. of Hwys.
3.	Black Canyon Ck.	Existing	Periodic Visit	Physical	Flood Information	U.S.G.S., Ak. Dept. of Hwys.
4.	Red Cloud Ck. Tributary (near Kodiak)	Existing	Periodic Visit	Physical	Flood Information	U.S.G.S., Ak. Dept. of Hwys.
5.	Kalsin Bay Tributary (near Kodiak)	Existing	Periodic Visit	Physical	Flood Information	U.S.G.S., Ak. Dept. of Hwys.
6.	Middle Fork Pillar Ck. (near Kodiak)	Discon-tinued 1970	Continuous	Physical, Chemical	Water Supply	U.S.G.S., Kodiak I. Borough
7.	Dog Salmon Cr. (near Ayakulik)	Proposed (Discon-tinued)	Continuous	Physical, Chemical	Baseline Hydrologic	U.S.G.S.
8.	L. Kitoi Cr. (near	Discon-tinued	Periodic Visit	- -	- -	- -
9.	Terror R. (upstream)	Discon-tinued	Continuous	-	-	-
10.	Terror R. (mouth)	Discon-tinued	Continuous	-	-	-
11.	Spiradon L. (near Larsen Bay)	Discon-tinued	Continuous	-	-	-

Table 21. Surface water programs, Western Gulf of Alaska (from Inter-Agency Technical Committee for Alaska 1970 and U.S. Geological Survey 1972).

Station No.	Drainage Area (sq.mi.)	Period of Record	Discharge - Period of Record				Discharge - Water Year 1971 (cfs)					
			Average (cfs)	Runoff (cfs/mi^2)	Maximum (cfs)	Date of Maximum	Total	Mean	Peak	Maximum Monthly	Minimum Monthly	Runoff (cfs/mi^2)
1.	123	1951-1971	664	5.4	13,700	10/03/52	289,261	792	5,270	4,940	150	6.44
2.	4.74	1963-1971	45.3	9.6	1,110	9/14/69	18,028	49.4	694	443	3.9	10.4
4.	1.51	1963-1971			590	8/29/71						
5.	2.35	1963-1969			250	9/14/69						

Table 22 . Streamflow data, Kodiak area (from U.S. Geological Survey 1972)

Sta No.	Date	Dischg. (cfs)	Silica (mg/1)	Dissolved Iron (ug/1)	Dissolved Calcium (mg/1)	Dissolved Magnesium (mg/1)	Sodium (mg/1)	Potassium (mg/1)	Bicarbonate (mg/1)	Sulfate (mg/1)	Chloride (mg/1)	Dissolved Fluoride (mg/1)	Nitrate (mg/1)	Dissolved Solids (mg/1)	Hardness (Ca, Mg) (mg/1)	Noncarbonate Hardness (mg/1)	Specific Conductance (Micromhos)	PH	Temperature (C degrees)
1	1/6/71	276	4.3	50	6.2	0.9	2.3	0.2	20	4.4	2.0	0.3	1.5	32	19	3	52	7.4	
1	5/26/71	760							20						20	4	53	7.2	5.5
2	10/13/70	22	5.6	0	3.0	0.6	3.3	0.3	11	3.7	3.5	0.3	1.3	27	10	1	41	6.9	7.0
2	11/10/70	186							6						11	6	45	7.2	
2	11/11/70	248							5						12	8	41	7.3	4.5
2	1/5/71	51							8						10	3	41	7.5	1.0
2	3/13/71	38	4.7	40	4.5	1.0	5.2	0.3	9	2.4	1.1	.0	1.4	35	16	9	60	7.1	0.5
2	5/25/71	301							7						8	3	31	6.0	0.5
4	7/21/71	-	3.0				1.8	0.3	8		2.5	0.0			6	0	24	7.0	7.0

Table 23. Water quality data (chemistry) Kodiak area, water year 1971 (from U.S. Geological Survey 1972)

Station No.	Date	Temp. C Degrees	Discharge (cfs)	Suspended Sediment (mg/l)	Suspended Sediment Discharge Tons/day
1	1/6/71	.0	276	2	1.5
1	5/26/71	5.5	760	3	6.2
1	7/21/71	7.0	2460	8	53
2	10/13/70	7.0	22	1	0.06
2	11/10/70	4.5	186	3	1.5
2	11/11/70	4.5	248	9	6.0
2	1/5/71	1.0	51	1	0.14
2	3/18/71	0.5	3.8	1	0.01
2	5/25/71	0.5	301	94	76
2	7/21/71	6.5	221	31	18
2	9/8/71	7.0	54	3	0 .44

Table 24. Water quality data (suspended sediment), Kodiak area, water year 1971 (from U. S. Geological Survey 1972)

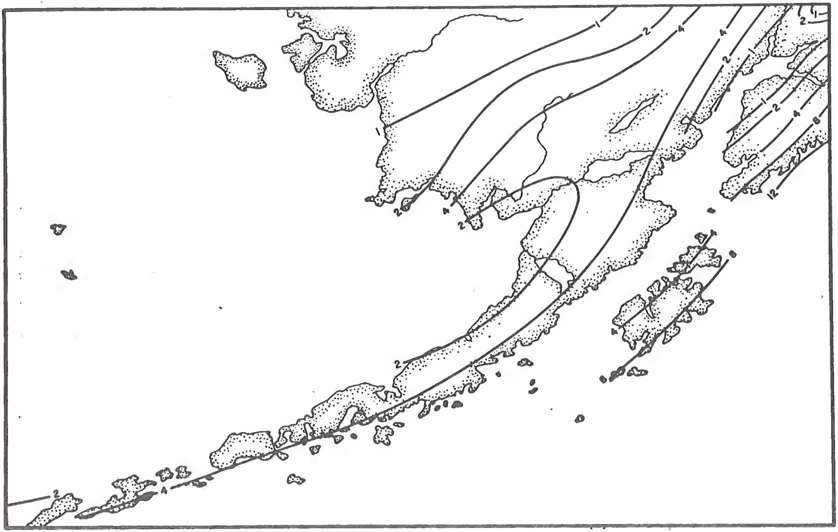

Figure 65a. Mean annual runoff in cu. ft./sec./sq. mile (from Feulner et al. 1971).

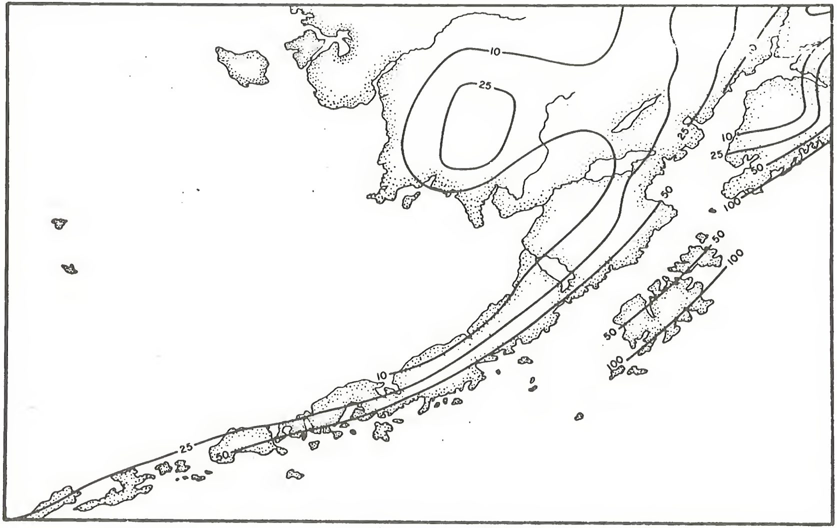

Figure 65b. Mean annual peak runoff in cu. ft./sec./sq. mile (from Feulner et al. 1971).

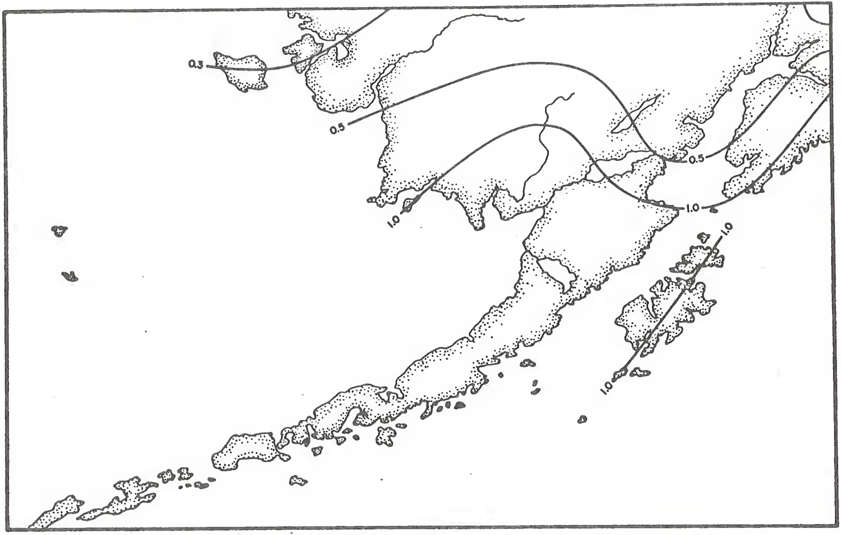

Figure 65c. Mean annual low monthly runoff in cu. ft./sec./sq. mile (from Feulner et al. 1971).

known floods in the Kodiak area are presented in Table 25. In addition to flooding caused by rapid and high peak runoff during storms, floods may also occur during cold winter months when ice jamming causes higher flood stages than normal. In small, low basins or basins with lakes, the peak runoff can be significantly reduced to rates of 10 c.f.s./mi.^{2} (100 l.s./km.^{2}) or lower.

Mean annual low monthly runoff (an average of the lowest runoff recorded each month) probably averages 1 c.f.s./mi.^{2} (11 l.s./km.^{2}) or less (Figure 65). Winter precipitation occurs mostly as snow, but generally enough snow melt or rain occurs to sustain stream flow. During long, cold winters, however, stream flows will drop quite low and cause water shortages for communities depending on them for water.

Winter snowpack and a few glaciers provide most of the water storage. The area contains only two lakes having a surface area over 25 sq. km.--Chignik Lake near Chignik on the Alaska Peninsula and Karluk Lake on southwest Kodiak Island.

Water quality of streams in the area is good. Most streams are low in dissolved solids and appear to range between 17 milligrams per liter (mg./l.) at the outlet to Terror R. (northwest side of Kodiak I.) and 45 mg./l. at Monashka Creek near Kodiak. Most of the surface streams near the coast contain water of a sodium chloride or sodium bicarbonate type. A few lakes may have high iron content waters, that may be corrosive to iron piping if untreated.

Although no stream sediment data has been collected for the Alaska Peninsula area, some generalizations can be made. During summer months, streams draining the larger ice fields on the Peninsula and also areas with recent ash deposits like Katmai may have suspended sediment concentrations as high as 2000 mg./l., while streams draining small mountain glaciers or high mountains probably carry between 5 and 500 mg./l. Streams draining the lowlands carry only small quantities. Winter concentrations probably are less than 10 mg./l., although some streams on the Peninsula may be slightly higher.

Surface water temperatures probably range between 1 degees C and 6 degrees C (33 degrees F-42 degrees F), although shallow lakes could range higher.

GROUNDWATER

Most of the area is considered to have poor potential for large groundwater supplies, generally because of shallow bedrock and a lack of large amounts of surficial water-bearing materials. Limited amounts of groundwater probably are available in low-lying areas covered by alluvial or glacial deposits. Some groundwater is available locally from fractures in bedrock.

Station No.	Drainage Area (sq. miles)	Period of Records (years/dates)	Maximum known floods Date	Discharge Flow Rate (cfs)	Discharge Runoff (cfs/mi^2)
1	123	18(1950-68)	10/3/52	13,700	111
2	4.74	6(1962-68)	8/30/63	1,080	228
4	1.51	5(1962-67)	8/30/63	570	337
7	72.9	2(1959-61)	9/24/61	777	10.6
8	2.63	1(1960-61)	1/20/61	42	16.0
9	15.0	7(1961-68)	8/29/63	4,590	306
10	46.0	5(1963-68)	9/26/66	3,820	83.0
11	23.3	4(1961-65)	3/27/64	189	8.11

Table 25. Maximum known floods, Kodiak area. (See Figure 24 and Table 21 for location and description of stations (from Childers 1970).

Exploration for groundwater has not been extensive, and only a few wells have been drilled, mostly near Kodiak, Cold Bay, and King Cove. The latter two locations have produced useful quantities, but there are little actual data available about the yields of these wells.

Springs are found throughout the area, but have not been cataloged. Several communities and canneries use springs as a water supply, although yields are small.

Groundwater quality of the area is based mainly on data from the few wells in the Kodiak area and varies from 44 to 1,604 mg./l., although a more representative range of values may vary from 150 mg./l. to 250 mg./l. Shallow wells drilled in alluvium near streams generally have acceptable water quality, although some high iron content may be encountered. Bedrock wells or wells near the coast may contain excessive amounts of sodium chloride, while some wells from the eastern Alaska Peninsula may have excessive calcium, sodium, and bicarbonate ions. Groundwater is usually harder than surface water.

Quality of spring water appears to be good. Analysis of those springs on Kodiak Island indicates acceptable quality and low dissolved solid and ion content values.

Limited data indicate groundwater temperature ranges between 2 and 13 degrees C with the higher ranges coming from shallow wells near Kodiak.

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VII. BIOTA OF THE WESTERN GULF OF ALASKA

MARINE BACTERIA

Bacteria in the marine environment, although recognized as important in organic matter decomposition and nutrient recycling, are seldom a priority in oceanographic investigations. Within the study area, only one series of bacterial observations was conducted in the summer of 1960 (Faculty of Fisheries 1961).

Positive tests for hydrogen sulfide production, nitrate reduction and sulfate reduction were recorded at depths of less than 50 m. Negative tests were recorded for all depths exceeding 50 m.

Sparse data precludes any conclusions other than possibly higher bacteria concentration in surface waters.

PLANKTON

Phytoplankton

Data on planktonic primary producers in the Western Gulf of Alaska have been collected largely by the National Marine Fisheries Service (formerly the U.S. Bureau of Commercial Fisheries); the Institute of Marine Science (University of Alaska); the Department of Oceanography (University of Washington), and the Faculty of Fisheries (Hokkaido University). As one moves toward shore, the volume of data available decreases. Cooney (1972) summarized the North Pacific data, and indicates total annual primary production may be two to four times greater near the coast than in the open ocean. Along the coast, nearshore current patterns may produce marked variations between adjacent locations. Japanese data (Faculty of Fisheries 1961) and McRoy et al. (1972) record primary productivity--the rate at which new organic matter in the form of phytoplankton is created--nearest the coast, at the surface, ranging from 0.15 to 1.95 mg. carbon/m.^{3}/hr. south of Unimak Island and from 0.39 to 2.80 mg. carbon/m.^{3}/hr. eastward along the continental slope to the boundary of the study area (Figure 66).

Integrated for the entire water column, productivity ranges from 18 to 408 mg. carbon/m.^{2}/day south of Unimak Island. These values are generally lower than Bering Sea figures and are below the value of 1.0 gm. carbon/m.^{2}/day accepted as indicative of active upwelling (Hood et al. 1971). Maximum values eastward over the continental slope and shelf may approach upwelling levels. These values, recorded during June and July, probably represent the highest productivity achieved by this community. Roden (1967) stated that winter productivity in the Gulf of Alaska is very low.

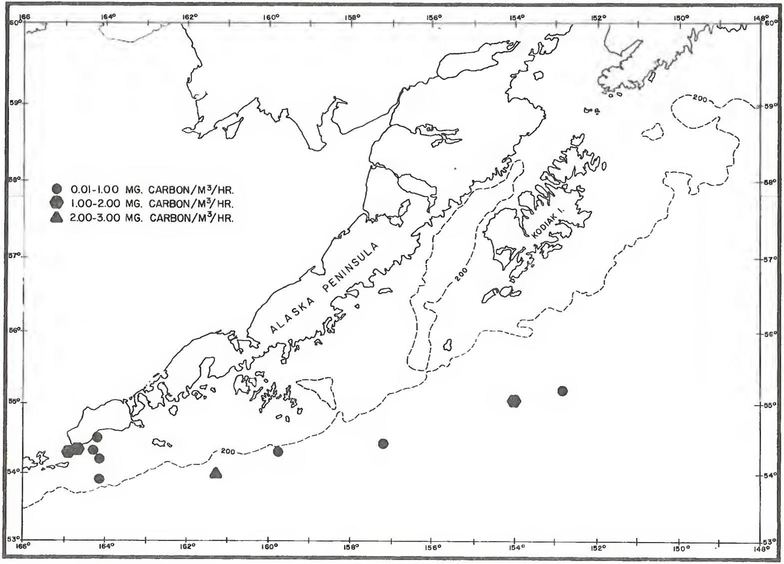

Figure 66. Primary productivity in the Western Gulf of Alaska (from Faculty of Fisheries 1961; McRoy et al. 1972).

The standing crop of phytoplankters--the amount of organic matter in the form of phytoplankton measureable at a point in time--at the surface, measured by the Faculty of Fisheries (1972) in addition to the same two sources previously cited, was found to be highest in the Unimak area (0.2-1.6 mg. chlorophyll a/m.^{3}) and decreases to the east (0.09-0.50 mg. chlorophyll a/m.^{3}).

If these limited measurements were to be accepted as characteristic of this region, the Unimak locale experiences a lesser loss of phytoplankters (possibly to grazing by zooplankton), and thus develops a larger standing crop. Eastward, productivity may be higher, but loss (possibly zooplankton grazing) appears to increase even more, resulting in a lower standing crop of phytoplankters.

Species reported as dominant (Faculty of Fisheries 1957; 1961; 1965) are almost always diatoms with dinoflagellates mentioned once (Table 26). Microplankton were not surveyed for species in these studies, but could contribute significantly to primary productivity.

In a seven-year study of diatoms at Scotch Cap (Unimak Island), Cupp (1937) identified 87 species and 36 genera. Temperate neritic species were most numerous with Asterionella japonica, Thalassiosira nordenskioldii, Chaetoceros debilis and Biddulphia aurita of major importance. November through March was the period of lowest production of diatoms. The spring maximum had its peak in April and May with a smaller autumn maximum in September.

Cupp reported 21 species and 6 genera of dinoflagellates with no large populations in comparison to diatoms.

Following the 1970 Kodiak oil pollution incident, the U.S. Bureau of Commercial Fisheries (now the National Marine Fisheries Service) indicated its intention to: "Undertake research at earliest possible date on...phytoplankton species composition, and primary productivity within the...Kodiak area(s)" (Federal Water Quality Administration 1970). Little information has been collected on these matters to date.

A number of offshore phytoplankton and primary productivity studies were summarized by Cooney (1972), but so little inshore data exists that their application would be highly speculative.

Figure 67 illustrates Northeastern Pacific phytoplankton productivity as summarized by the Food and Agriculture Organization of the United Nations (1972).

TABLE 26

Dominant Phytoplankton Species of the Western Gulf of Alaska (from Cupp 1937; Faculty of Fisheries 1957, 1961, 1965).

Diatoms

1. Achnanthes sp.
2. Actinoptychus undulatus
3. Asterionella japonica
4. A. kariana
5. Asteromphalus heptactis
6. Aulacodiscus argus
7. Bacteriastrum delicatulum
8. Biddulphia aurit
9. B. longicruris
10. B. mobiliensis
11. B. pulchella
12. Cerataulina bergonii
13. Chaetoceros affinis
14. C. compressus
15. C. concavicornis
16. C. constrictus
17. C. convolutus
18. C. curvisctus
19. C. danicus
20. C. debilis
21. C. decipiens
22. C. didymus
23. C. furcellatus
24. C. laciniosus
25. C. lorenzianus
44. Denticula marina
45. Ditylum brightwellii
46. Eucampia zoodiacus
47. Fragilaria islandica
48. F. striatula
49. Grammatophora marina
50. Isthmia nervosa
51. Lauderia borealis
52. Leptocylindrus danicus
53. L. minimus
54. Licmophora lyngbyei
55. Melosira sulcata
56. Navicula sp.
57. Nitzschia closterium
58. N. delicatissima
59. N. pungens
60. N. scriata
61. Pleurosigma sp.
62. Rhabdonema arcuatum
63. Rhizosolenia alata
64. R. delicatula
65. R. obtusa
66. R. semispina
67. R. setigera
68. R. stolterfothii

TABLE 26, Continued.

26. *C. Mitra*
27. *C. peruvianus*
28. *C. pseudocrinitus*
29. *C. radicans*
30. *C. simplex*
31. *C. similis*
32. *C. socialis*
33. *C. subsecundus*
34. *Cocconcis* sp.
35. *Corethron hystrix*
36. *C. valdiviae*
37. *Coscinodiscus angstii*
38. *C. centralis*
39. *C. excentricus*
40. *C. granii*
41. *C. nitidus*
42. *C. radiatus*
43. *Coscinodiscus polychorda*
69. *R. styliformus*
70. *Skeletonema costatum*
71. *Stephanopyxis nipponica*
72. *S. palmeriana*
73. *Streptotheca thamesis*
74. *Striatelia unipunctata*
75. *Thalassionema nitzschioides*
76. *Thalassiosira aestivalis*
77. *T. condensata*
78. *T. decipiens*
79. *T. gravida*
80. *T. nordenskioldii*
81. *T. pacifica*
82. *T. rotula*
83. *T. subtilis*
84. *Thalassiothrix frauenfeldii*
85. *T. longissima*
86. *Trepidoneis* sp.

Dinoflagellates

1. *Ceratium furca*
2. *C. fusus*
3. *C. longipes*
4. *C. pentagonum*
5. *C. tripos*
6. *Dinophysis acuminata*
7. *D. acuta*
8. *D. arctica*
9. *D. caudata*
10. *D. ellipsoides*
11. *D. ovum*
12. *D. rotundata*
13. *Gonyaulax* sp.
14. *Peridinium crassipes*
15. *P. depressum*
16. *P. divergens*
17. *P. ovatum*
18. *P. pentagonum*
19. *P. steinii*
20. *Phalacroma rudgei*
21. *Prorocentrum micans*

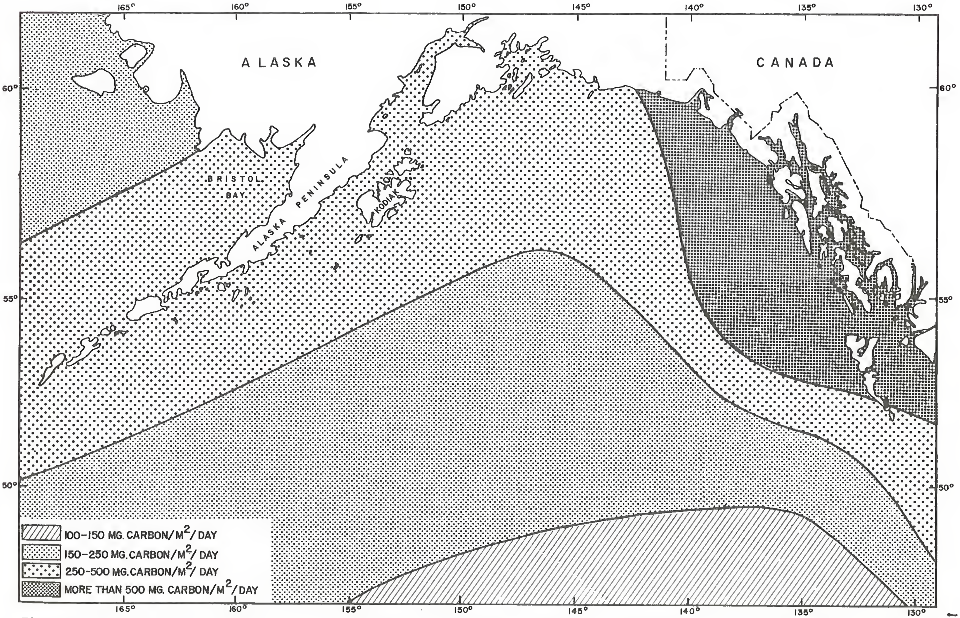

Figure 67. Phytoplankton productivity in the North Pacific Ocean (from Food and Agriculture Organization of the United Nations 1972).

Zooplankton and Micronekton

In addition to the same sources cited for phytoplankton, the zooplankton data from a multinational oceanographic venture (NORPAC) in 1955 have been compiled for the North Pacific.

Cooney (1972), in summarizing available information on the Northeastern Pacific, stated that zooplankton respond more instantaneously to phytoplankton blooms in the open ocean, where deep water forms are readily accessible through vertical migration. In coastal areas, deeper waters are not available to harbor zooplankton; thus, phytoplankton blooms must await current action to provide zooplankton grazers.

The NORPAC Committee atlas (1960) indicates two locales within the study area--northeast of Kodiak and southwest of the Shumagin Islands--of maximum zooplankton density exceeding 400 $cm.^3/1,000$ cu. m. The entire study area exhibits generally higher zooplankton densities than surrounding areas. Densities decrease as one moves east, west, or offshore (Figure 68).

Gulland (1970) noted that zooplankton density is quite variable from year to year. In the coastal North Pacific, copepods compose approximately 75 percent of the zooplankton biomass throughout the year, while chaetognaths, amphipods and euphausiids form most of the remainder, Gulland states. His findings are supported by data on species identified during Japanese cruises (Table 27) within the study area (Faculty of Fisheries 1957; 1961; 1965; 1967; 1972).

Standing crops measured at the surface on Japanese cruises were generally lower in the Unimak area (21 to 411 gm. wet wt./1,000 cu. m.), and higher eastward (107 to 1611 gm. wet wt./1,000 cu. m.) over the outer continental shelf and slope (Figure 69).

It is expected that seasonal abundance of zooplankton would closely follow phytoplankton with maximum abundance from June through August and minimum from December through February. The importance of currents in bringing oceanic species into this region is emphasized by the recognition of *Calanus plumchrus*, *C. cristatus*, and *Eucalanus bungii* in waters over the continental slope south and west of the Shumagin Islands.

LeBrasseur (1965) has mapped the occurrence of individual species at various oceanographic stations occupied between 1956 and 1964 in the northeastern Pacific Ocean. Generally copepods composed more than 70 percent of the biomass except on occasion west of the Shumagin Islands and south of Chirikof Island where euphausiids and amphipods were abundant.

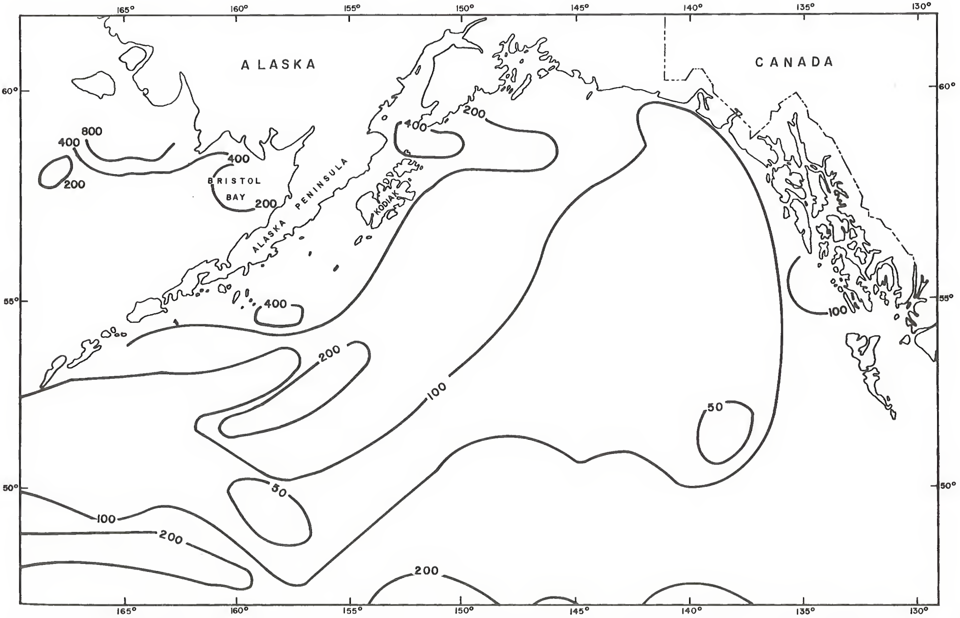

Figure 68. Zooplankton densities in cu. cm./1,000 cu. m. in the North Pacific Ocean (from NORPAC Committee 1960).

TABLE 27

Dominant Zooplankton Species of the Western Gulf of Alaska
(from Faculty of Fisheries 1957, 1961, 1965, 1967, 1972)

Coelenterata

1. Jellyfish

Chaetognatha

1. Sagitta elegans

Annelida

1. Tomopteris sp.

Arthropoda

Crustacea

1. Amphipods
2. Calanus cristatus
3. C. finmarchicus
4. C. plumchru
5. Eucalanus bungii
6. Euphausia pacifica
7. Euthemisto libellula
8. Metridia lucens
9. M. pacifica
10. Thysanoessa longipes
11. Zoea

Mollusca

Gastropoda

1. Pteropods
2. Limacina helicina
3. Clio pyramidata

Chordata

1. Fish larvae

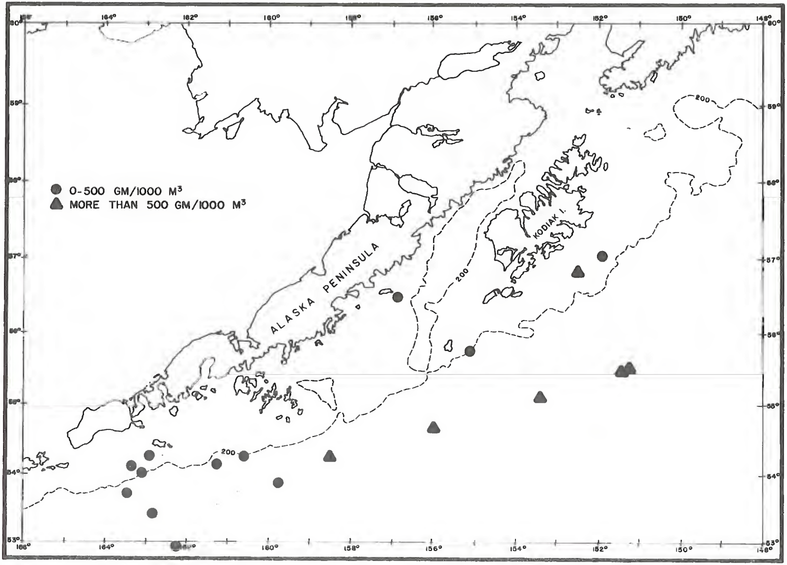

Figure 69. Zooplankton standing crop in the Western Gulf of Alaska (from Faculty of Fisheries 1957, 1961, 1965, 1967, 1972).

Sampling within the study area has been limited, scattered, and monitored primarily in summer months, which severely restricts the understanding of the dynamics within this segment of the marine community. Macroplankton collected by the International Pacific Halibut Commission during the months of December through July from 1926 to 1934 in the Western Gulf still awaits study at the Smithsonian Institution.[1]

Following the 1970 oil pollution incident at Kodiak, the U.S. Bureau of Commercial Fisheries (now National Marine Fisheries Service) proposed that "zooplankton larvae distribution and abundance studies should be immediately undertaken" (Federal Water Quality Administration 1970). Little data has been produced since this statement.

Lisovenko (1964) surveyed the distribution and abundance of Pacific Ocean perch (Sebastes alutus) larvae, and identified centers of larval abundance south and east of Kodiak, extending westward above the continental slope to southwest of the Shumagin Islands. The majority of the larvae were found between the surface and 100 m., and were associated with Calanoid copepods and Euphausiids. These larvae appear from late April to late May or early June in the westernmost regions.

LeBrasseur (1970), in reporting larval fish collected in Canadian zooplankton samples from the northeastern Pacific Ocean, frequently recorded rockfish (Scorpaenidae), sculpin (Cottidae), ronquil (bathymasteridae) and snailfish (Cyclopteridae) larvae offshore in the Western Gulf of Alaska.

MARINE MACROPHYTES

With the exception of extensive studies on eelgrass, Zostera marina, conducted by McRoy of the Institute of Marine Science, University of Alaska, higher producers have been mentioned only briefly in various marine investigations conducted within the study area.

Marine Advisers, Inc. (1971), in a study of the Kodiak harbor, reported that all rocky surfaces in shallow subtidal and lower intertidal areas were rich in Alaria sp. and Laminaria sp. and that Corallina sp., Lithothamnion sp. and Lithophyllum sp. also were present. Within Three Saints Bay, southeastern coast of Kodiak Island, Nybakken (1969) found 20 species inhabiting the intertidal zone (Table 28).

Oil geologists, based on submarine observations, have remarked on the general lack of vegetation in most of the Gulf of Alaska (U.S. Bureau of Land Management 1973). Kelps (Phaeophyta) are common in shallows and around most islands (McRoy 1971). A survey of kelps in Alaska, which was conducted by the United States Department of Agriculture in 1912-1914, yielded a standing stock estimate of almost 2.3 million metric tons for Western Alaska (Rigg 1915). The location

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[1] Richard S. Houbrick, Supervisor for Invertebrates Smithsonian Oceanographic Sorting Center, Smithsonian Institution, Washington, D.C. Personal communication. October 2, 1973.

TABLE 28

Marine Macrophytes of the Western Gulf of Alaska
(from Nybakken 1969; Druehl 1970)

Thallophyta

Chlorophyceae

1. Enteromorpha compressa
2. Enteromorpha intestinalis*
3. Spongomorpha sp.*
4. Spongomorpha coalita
5. Ulva sp.*

Phaeopyceae

(1.) Agarum cribrosum
2. Alaria crispa
3. A. fistulosa
4. A. phylaii*
5. A. praelonga
6. A. taeniata
7. A. tenuifolia
(8.) Chorda filum
9. Chordaria flagelliformes*
10. Colpomenia sinuosa*
(11.) Costaria costata
12. Cymathere triplicata
13. Cytoseira germinata*
14. Dictyosiphon foeniculacens*
15. Ectocarpus sp.*
16. Fucus distichus*
17. Hedophyllum sessile
18. Laminaria dentigera
19. L. groenlandica
20. L. longipes
21. L. personata*
22. L. platymeris*
23. L. saccharina
24. L. setchellii
25. L. yezoensis
(26.) Lessonlopsis littoralis
(27.) Macrocystis integrifoli
28. Thalassiophyllum clathrus
29. Nereocystis leutkeana
30. Scytosiphon lamentana*
31. Soranthera ulvoidae

Rhodophyceae

1. Ahnfeltia plicata
2. Cryptosiphonia woodii*
3. Endocladia muricata
4. Halosaccion glandiforme*
5. Odonthalia floccosa*
6. Porphyra sp.*
7. Porphyra perforata
8. Pterosiphonia bipinnata
9. Rhodomela larix*
10. Rhodymenia palmata*
11. Schizymenia pacifica

Spermatophyta

Angiospermae

1. Zostera marina*

( ) - This species is at the limit of its known range within the study area.

* - These species are listed by Nybakken (1969).

of large beds is shown in Figure 70. McRoy et al. (1969) used the Shumagin Islands for an "example location" of kelp beds within the study area. Nereocystis sp. was reported dominant at King Cove, but was observed only rarely west of this location (Scheffer, 1959). Nereocystis was found washed ashore after a storm in Otter Cove on the southeast coast of Unimak Island.

Druehl (1970) delineated a distinct association of Laminariales occurring from Kodiak westward, which differs from the assemblage of species extending from Yakutat southward. A transition zone exists between Kodiak and Yakutat. The species identified within the study area are included in Table 28.

Feder and Mueller (1972), summarizing studies along the intertidal Gulf of Alaska coast, distinguished between a midlittoral zone dominated by Fucus, and a zone below low tide characterized by Laminaria and Alaria on rocky coasts. When the substrate is soft mud or sand, Zostera marina may occupy the lowest zone, rather than Laminaria and Alaria.

McRoy (1968) listed the location of significant eelgrass Zostera marina, communities within the study area (Figure 71). Z. marina, the only significant vascular plant inhabiting the marine environment in this study area, is distributed widely wherever a soft mud or sand substrate is available, and reaches maximum growth in shallow lagoons such as Kinzarof. In Kinzarof Lagoon, at the head of Cold Bay, McRoy (1970) found the highest standing stock of eelgrass measured in Alaska. His calculations for standing stock were 1840 gm. dry wt./m.^{2} on almost 9 million sq. m. or over 150,000 metric tons of eelgrass in this lagoon alone. In addition, 393 gm. dry wt./m.^{2} associated algae, Chaetomorpha, Fucus, and Ulva were identified.

BENTHIC AND INTERTIDAL INVERTEBRATES

Intertidal fauna

Within the study area, Kodiak Island is best characterized for this group of organisms resulting from three reports on five separate locales (Figure 72). The most extensive study was conducted by Nybakken (1969) in Three Saints Bay. More recently, Marine Advisers (1971) reported organisms of the shallow subtidal zone near Kodiak city, which were observed or collected during a series of dives. The Fisheries Research Institute (1970) surveyed three bays occupied by canneries for both intertidal and subtidal fauna. The species identified by these various investigations are keyed to sampling location in Table 29.

The Fisheries Research Institute study, though based on few samplings, found nematodes characteristic of the mean high tide level, snails and amphipods common at mean tide and barnacles, limpets, and mussels

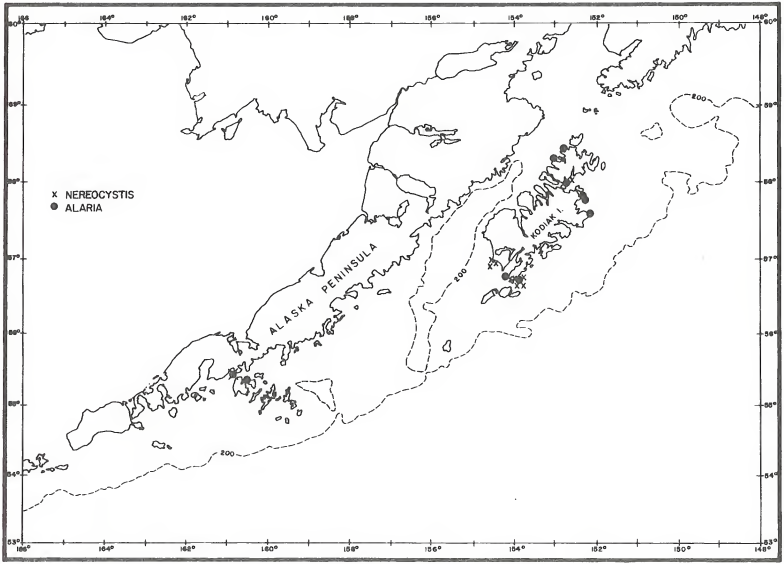

Figure 70. Location of large kelp beds in the Western Gulf of Alaska in 1913 (from Rigg 1915).

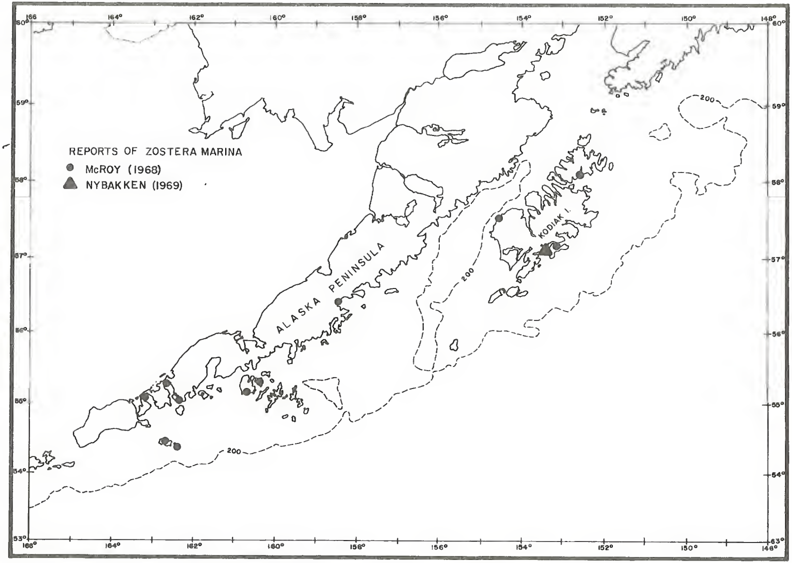

Figure 71. Location of eelgrass communities in the Western Gulf of Alaska (from McRoy 1968; Nybakken 1969).

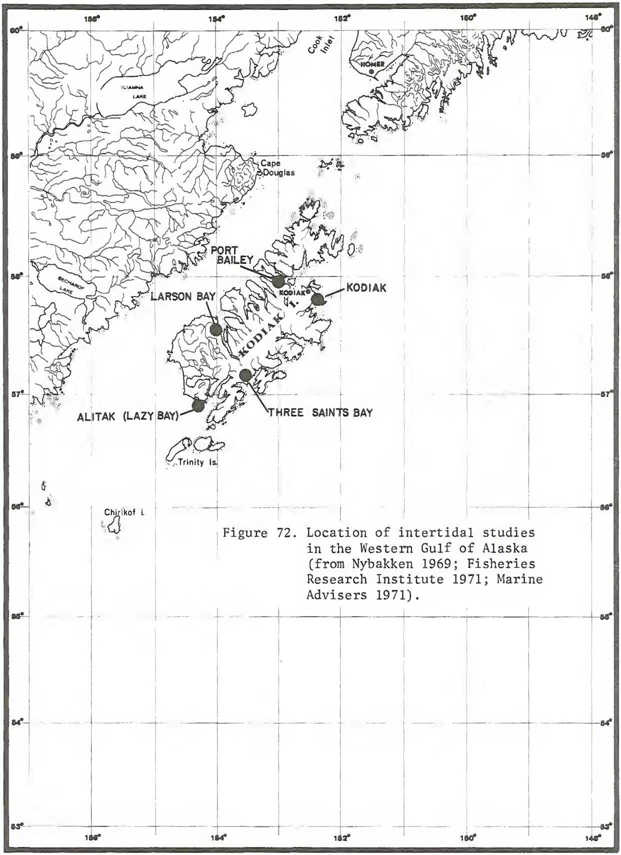

Figure 72. Location of intertidal studies in the Western Gulf of Alaska (from Nybakken 1969; Fisheries Research Institute 1971; Marine Advisers 1971).

TABLE 29

Intertidal and Subtidal Fauna of Kodiak Island (From Marine Advisers 1971; Fisheries Research Institute 1970; Nybakken 1969)

		PROTOZOA
KH	1.	Folliculinidae
		PROIFERA
KH	1.	Three unidentified species
		GOELENTERATA
KH	1.	Abietinarea sp.
KH	2.	Metridium senile
AL, PB, KH	3.	Unidentified anemone
		NEMERTINEA
TS	1.	Cerebratulus, sp.
AL, PB, LB	2.	Emplectonema gracile
		NEMATHELMINTHES
AL, PB, LB	1.	Unidentified species
		ECTOPROCTA
KH	1.	Cellaria sp.
KH	2.	Disporella sp.
KH	3.	Eucratea loricata
KH	4.	Heteropora alaskansis
KH	5.	Smittina retifrons
		BRACHIOPODA
KH	1.	Laques sp.

TABLE 29, Continued.

MOLLUSCA

Al, LB, PB	1.	Acmaea sp.
TS	2.	A. digitalis
KH	3.	A. fenestrata fenestrata
TS	4.	A. mitra
TS	5.	A. pelta
TS	6.	A. scutum
TS	7.	Buccinum baeri
TS	8.	Clinocardium nuttallii
KH	9.	Crepidula nummaria
KH	10.	Cryptochiton stellari
KH	11.	Entodesma saxicola
TS, KH	12.	Fusitriton saxicola
KH	13.	Hiatella arctica
TS	14.	Katharina tunicata
TS	15.	Littorina scutulata
TS	16.	L. sitkana
TS	17.	Macoma balthica
TS	18.	M. nasuta
TS	19.	Margarites pupilla
KH	20.	Modiolus sp.
KH	21.	Mopalia sp.
TS	22.	M. ciliata
TS	23.	Mya arenaria
KH	24.	M. truncata
AL, PB, LB, TS, KH	25.	Mytilus edulis
TS, KH	26.	Nafica clausa
KH	27.	Pododesmus cepio
PB, TS	28.	P. macroschisma
KH	29.	Prototheca staminea
LB	30.	pteropods
KH	31.	Puncturella multistriata
TS	32.	Saxicava sp.
TS	33.	Saxidomus giganteus
TS	34.	Searlesia dira
KH	35.	Solariella peramabilis
TS	36.	Thais lamellosa
LB, AL, PB, TS	37.	T. lima
TS	38.	Tonicella lineata
KH	39.	Trichotropis borealis
KH	40.	T. cancellata
TS	41.	Venerupis staminea
KH	42.	unidentified dorid and eolid nudibranchs

TABLE 29, Continued.

ANNELIDA

AL, LB, PB	1.	Abarenicola pacifica
TS	2.	Arctonoe pulchra
KH	3.	Cheilonereis cyclurus
KA	4.	Chitinopoma groenlandica
TS	5.	Cirratulus cirratus
KH	6.	Crucigera zygophora
TS	7.	Echiurus echiurus
TS	8.	Glycera nana
KH	9.	Idanthyrus ornamentatus
TS	10.	Nephtys caeca
TS	11.	Nereis vexillosa
KH	12.	N. zonata
TS	13.	Nerine foliosa
TS	14.	Pectinarea sp.
TS	15.	Phyllodoce groenlandica
PB	16.	Spirorbis sp.
KH	17.	Spirorbis sp.
KH	18.	S. borealis
KH	19.	S. vitraeus
TS	20.	Thelepus crispus
Al, PB, LB, KH	21.	unidentified polychaete

ARTHROPODA

PB, AL, LB	1.	Ampithec humeralis
TS	2.	Balanus cariosus
PB, AL, TS	3.	B. glandula
TS	4.	Cancer magister
TS	5.	C. oregonensis
LB, PB	6.	C. productus
TS	7.	Chthamalus dalli
TS	8.	Exosphaeroma oregonensis
TS	9.	Idotea wosnesenskii
TS	10.	Mesodotea sp.
PB, TS	11.	Pagettia gracilis
LB, AL, PB	12.	P. productus
PB, LB, KH	13.	Pagurus, sp.
TS	14.	P. hirsutiusculus
KH	15.	Spirontocaris brevirostris
KH	16.	S. kincaide
AL, PB, LB	17.	S. paludicola
TS	18.	Telmessus cheiragonus
KH	19.	unidentified caligoid copepod
KH	20.	unidentified majiid crab

TABLE 29, Continued.

ECHINODERMATA

TS	1.	_Cucumaria curata_
TS	2.	_Dermasterias imbricata_
KH	3.	_Evasterias_ sp.
TS	4.	_E. troschelii_
KH	5.	_Henrecia_ sp.
TS	6.	_H. leviuscula_
TS, KH	7.	_Leptasterias_ sp.
TS	8.	_Ophiopholis aculeata_
KH	9.	_Pisaster_ sp.
TS, KH	10.	_Pycnopodia heilanthoides_
KH	11.	_Solaster endeca_
TS	12.	_Stichopus californicus_
TS, KH	13.	_Stronglyocentrotus drobachiensis_
KH	14.	_S. franciscanus_
LB	15.	unidentified starfish

CHORDATA - UROCHORDATA

KH	1.	Two unidentified species

KEY

KH	=	Kodiak
TS	=	Three Saints Bay
LB	=	Larsen Bay
AL	=	Alitak
PB	=	Port Bailey

characteristic of mean low tide level. No physical characteristics of the beaches surveyed were mentioned to identify the substrate types encountered. Most often the presence of a cannery was indicated by generally higher nematode populations.

Nybakken (1969) found barnacles characteristic of the highest tidal zones in Three Saints Bay. The vertical distribution of all organisms encountered is depicted in Figure 73.

Other documented studies of this habitat are centered around Unimak Island and the tip of the Alaska Peninsula. McRoy et al. (1969) cited Cold Bay as their example for "worm and clam flats" within the study area. Scheffer (1959) noted scattered organisms from this habitat in his report (Table 30). Feder and Mueller (1972) gave a general review of the state of knowledge for each phyla in the Eastern Gulf of Alaska.

TABLE 30

Intertidal and Subtidal Fauna of Unimak Island and the Alaska Peninsula (from Scheffer 1959).

Organism	Habitat	Location
Goose Barnacle, *Lepas* sp.	Attached to *Nereocystis* near Rhizoids	Otter Cove, Unimak Island
Shipworms, *Bankia setacea*	Tubes in Driftwood	Unimak Island
Clam *Liocyma*, sp.	Tideflats	Alaska Peninsula
Rock Oyster, *Pododesmus macrochisma*	Between Tidelines	Alaska Peninsula
20-rayed starfish, *Pycnopodia helianthoides*		King Cove

Within this habitat, snails, limpets, and mussels may be taken for personal use. Sea cumcumbers and sea urchin offer potentials for commercial harvest. Clams are important currently in both recreational and commercial fisheries.

Clams

Six species of clams within the study area are taken for personal use. Razor clams, *Siliqua patula*, are the most important of the six and are the object of the only commercial clam fishery. The approval

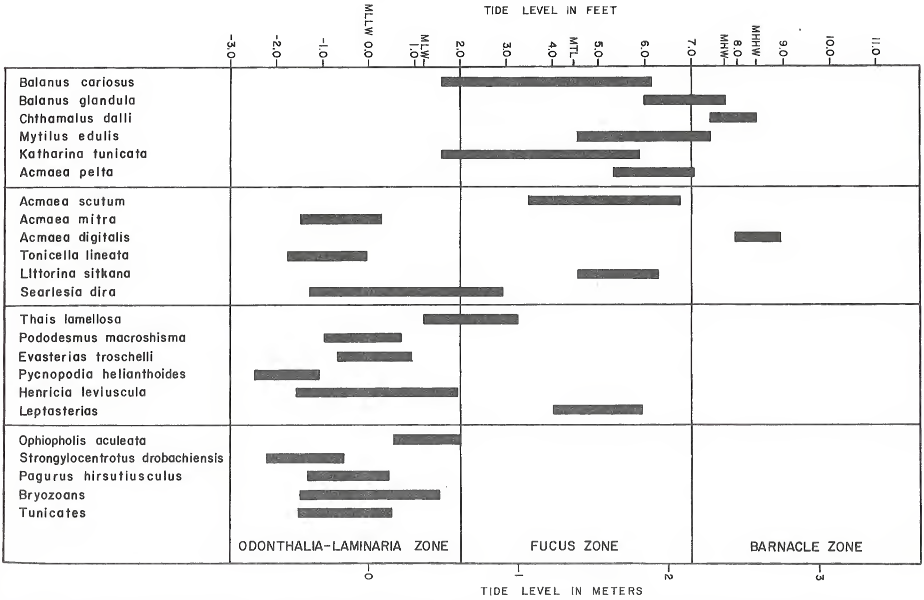

Figure 73. Vertical distribution of intertidal organisms in Three Saints Bay, Kodiak Island (from Nybakken 1969).

of Alaska's Shellfish Sanitation Program by the U.S. Food and Drug Administration, anticipated in early 1974[1], will stimulate this fishery.

Razor clams are most abundant on sandy, surfswept beaches that are low in gravel and clay. They require exposure to the open ocean, and they are not found in water of low salinity or high temperature (Nanaimo Biological Station 1966a). On Unimak Island, Scheffer (1959) always found them below low tideline. The U.S. Bureau of Sport Fisheries and Wildlife (1972) reported razor clams in large numbers in some shallow waters and lagoons on Unimak Island. The Alaska Department of Fish and Game (1973) reported that Swikshak and adjacent beaches on the Alaska Peninsula have been harvested for razor clams since the early 1900s. An "Informational Leaflet" is currently in preparation on the Swikshak razor clam population by the Alaska Department of Fish and Game (Poulin and Gwartney, in press). Small amounts are also harvested from Big River Flats, Hallo Bay, and Tanner Head near Alitak. Davenport reports razor clams in San Diego Bay, north of Sand Point.[2] Figure 74 indicates reported areas where these clams are abundant near Kodiak Island.

Littleneck clams, Protothaca staminea, are found in both tidal and subtidal zones in protected bays and passages in association with butter clams, Saxidomus giganteus. These beaches are generally composed of a mixture of sand and gravel. The clams are found not more than a foot below the surface of the beach in the lower half of the intertidal zone (Nanaimo Biological Station 1966a).

Cockles, Clinocardium nuttalii, horse clams, Schizothaerus nuttallii, and Alaskan surf clams, Spisula alaskana, are minor species which occur in habitats similar to those of butter clams, although surf clams are most often found in subtidal areas (Nosho 1972). Soft-shell clams, Mya sp., occur in quantity at Cold Bay (Kirkwood in Haynes and McCrary 1967) and throughout the region.

Most clams feed on plankton and detritus which they filter from surrounding waters. Little is known about their feeding selection and preference.

Life histories of clams have not been studied in detail in the Western Gulf of Alaska. Elsewhere in Alaska and British Columbia, clams reproduce by shedding eggs and sperm into the water, where fertilization occurs. Developing larvae are motile for 3 to 16 weeks, living in and on the sand near where they were spawned. Spawning takes place during the summer, when rising water temperatures reach 13 degrees C for razor clams or about 20 degrees C for butter clams. Larvae settle when still quite small to spend the remainder of their life cycle in bottom sediments (Nosho 1972). Figure 75 depicts the early life history and life cycle for the razor clam. Data do not exist that would allow for a more statistical approach to clam life history in this region.

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[1] Kenneth L. Torgerson, Seafood Sanitation Coordinator, Alaska Dept. of Health and Social Services, Juneau. Personal communication. Dec. 18, 1973.

[2] Glenn Davenport, Area Management Biologist, Alaska Department of Fish and Game, Cold Bay. Personal communication.

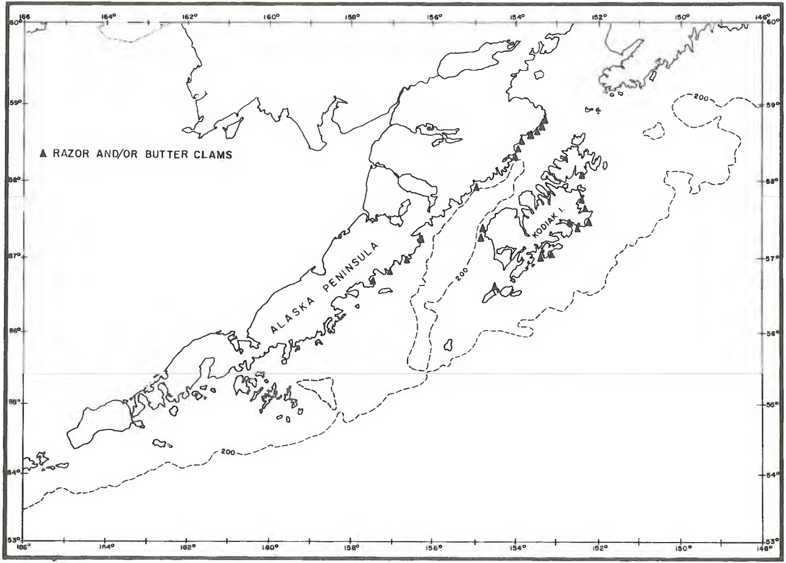

Figure 74. Location of significant razor and butter clam beaches in the Kodiak-Shelikof Area (from Fay 1972).

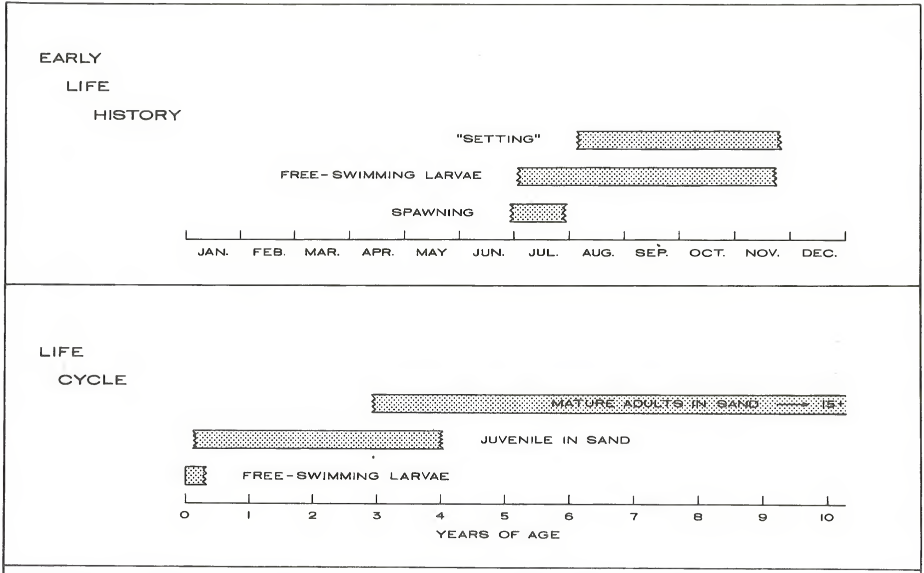

Figure 75. Early life history and life cycle of the razor clam, <u>Siliqua patula</u> (from Nanaimo Biological Station 1966a, Nosho 1972).

Razor clams spawn for the first time at the end of their third year, when they are about 8.5 cm. in length. Butter clams spawn at four years, when they are about 5 cm. Littleneck clams spawn first at two or three years when slightly more than 2.5 cm. long. Clams may live for a maximum of 15 to 20 years (Nanaimo Biological Station 1966a).

Nosho (1972) has summarized the knowledge for cockles, razor, and butter clams along the Eastern Gulf of Alaska coast.

Benthic fauna

Soviet investigations of benthic fauna in the Gulf of Alaska have been more extensive than investigations conducted by the United States. Semenov (1965) calculated an average benthic invertebrate biomass for the continental shelf in the Western Gulf of Alaska at 180 gm. wet wt./m.^{2} from bottom grab samples which were preserved in formalin and weighed in the laboratory at the completion of the cruises. The continental slope averaged 19 gm. wet wt./m.^{2}. High concentrations of benthic organism were found in Unimak Pass, south of Sanak Island, in the vicinity of Trinity Island, on Albatross and Portlock Banks, and west of Kodiak Island (Figure 76).

Benthic invertebrates were divided for analysis into four trophic groups representing different feeding types (Table 31). Figure 77 illustrates the distribution of the dominant trophic groups.

Sessile (nonmobile) filter feeders were dominant at moderate depths (44-92 m.) and attained higher biomass than any other group (81-988 gm./m.^{2}). These organisms were most abundant along the shelf margin, between submarine canyons, and on banks, such as southwest of Chirikof and Sanak Islands. This was attributed to stronger currents in these areas which prohibited sediments from accumulating. Rocky or gravel substrates provided many excellent points for attachment while currents yielded a continuous supply of food.

Between 52 and 158 m., both mobile filter feeders and browsers were common, though separated according to sediment composition. On coarser sediments, mobile filter feeders reached a biomass of 15-209 gm./mm.^{2}. On finer sediments, browsers predominated with a biomass of 439 gm./mm.^{2}. These two groups were encountered most regularly in the Trinity-Chirikof Island vicinity.

Lowest on the shelf, from 100 to 244 m., were the nonselective consumers with a biomass of 15-112 gm./m.^{2}. This group was characteristic of the entrance to Shelikof Strait, west of Kodiak Island.

Varied bottom topography and sediment character resulted in an irregular distribution of trophic groups. For example, Albatross Bank had a fairly regular relief, and sessile filter feeders predominated. On Portlock Bank, depressions retaining sediment were common, and mobile filter feeders attained a higher biomass than sessile forms.

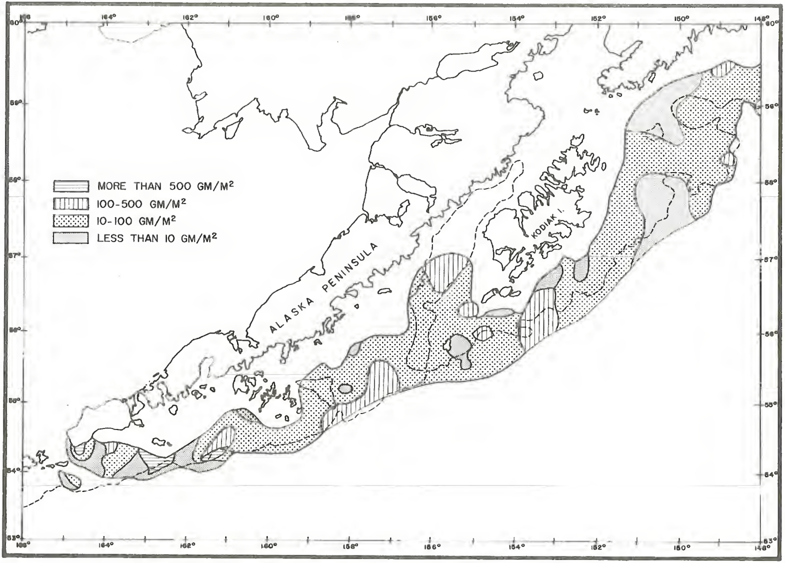

Figure 76. Benthic fauna biomass in the Western Gulf of Alaska (from Shevtsov 1964, Semenov 1965).

TABLE 31

List of Major Species of Benthic Fauna in The Gulf of Alaska Shallows (from Semenov 1965; Shevtsov 1964)

KEY TO SYMBOLS USED IN LIST:

Affliation to trophic group: S-nonmobile filter feeders; M-mobile filter feeders; B-browsing detritus eaters; N-nonselective detritus eaters

OCTOCORALLIA	
Family Pennatulidae	
Leioptilum gurneyi	S
LAMELLIBRANCHIATA	
Family Nuculidae	
Nucula tenius	B
N. charlottensis	B
N. mirabilis	B
Acila castrensis	B
Family Ledidae	
Leda fossa	B
L. pernula	B
L. conceptionis	B
L. minuta	B
Yoldia myalis	B
Y. scissurata	B
Y. sanesia	B
Y. tracieformis	B
Portlandia japonica	B
Family Arcidae	
Limopsis aquitanica	M
Family Mytilidae	
Dacrydium vitreum	
Modiolus modiolus	S

TABLE 31, Continued.

Musculua discors	S
M. seminudus	S
Crenella columbiana	M
Family Pectinidae	
Chlamys beringlianus	M
Pecten alaskense	M
Family Anomiidae	
Pododesmus macrochisma	S
Family Limidae	
Lima attenuata	M
Family Astartidae	
Astarte multicostata	M
A. alascensis	M
A. foani	M
A. bennettii	M
A. montaqui var. *warhami*	M
Rictocyma esquimalti	M
R. zenkevitchi	M
Family Carditidae	
Venericardia ventricosa	M
V. crebricostata	M
V. stearnsii	M
Family Cardiidae	
Serripes groenlandicus	M
Cardium funcanum	M
C. ciliatum	M
Family Veneridae	
Liocyma fluctuosa	M
Family Mactridae	
Spisula alascana	M
Family Tellinidae	
Tellinula salmonea	B
Macoma calcarea	B
M. incongrua	B

TABLE 31, Continued.

Family Saxicavidae	
Saxicava arctica	S
Family Myacidae	
Mya intermedia	
Family Pandoridae	
Pandora bilirata	M
Family Cuspidariidae	
Cuspidaria beringensis	
POLYCHAETA	
Family Phyllodocidae	
Phyllodoce groenlandica	
Family Glyceridae	
Glycera capitata	
G. tesselata	
Goniada annulata	
Glycinde armigera	
Family Nephthydidae	
Nephthys ciliata	
Family Eunicidae	
Buince kobiensis	
Onuphia conchylega	
O. iridescens	B
O. parva	
Lumbriconereis bifurcata	
Family Spioidae	
Laonice cirrata	B
Family Magelonidae	
Magelona pacifica	B
Family Cirratulidae	
Cirratulus cirratulus	
Chaetozone setosa	
Family Scalibregmidae	
Scalibregma inflatum	N

TABLE 31, Continued.

Family Maldanidae	
Praxilella gracilis	N
Axiothella catenata	N
Asychis disparidentata	N
A. similis	N
Maldane sarsi	N
Family Sabellariidae	
Idanthyrsus armatus	B
Family Sternaspididae	
Sternaspis scutata	N
Family Ampharetidae	
Melinna cristata	B
M. elisabethae	B
M. ochotica	B
Lisippe labiata	B
Amphicteis scafobranchiata	B
Family Trichobranchidae	
Terebellides stroemi	B
Family Terebellidae	
Artacama proboscidea	N
Pista cristata	B
P. vinogradovi	B
Family Sabellidae	
Chone cincta	S
Myxicola infundibulum	S
Family Serpullidae	
Crucigera irregularis	S
Serpula zygophora	S
Spirorbis sp.	S
SIPUNCULIDA	
Family Sipunculidae	
Golfingia eremits	N
G. margaritacea	N
G. schuttei	N
G. vulgaris	N
Phascolion strombi	N

TABLE 31, Continued.

BRACHIOPODA	
Family Terebratellidae	
Terebratulina californicus	S
T. unguicola	S
Family Rhynochonellidae	
Frieleia halli	S
CRUSTACEA	
Order Amphipoda	
Family Lysianassidae	
Anonyx nugax	
Family Ampeliscidae	
Ampelisca plumosa	S
A. eoa	M
A. macrocephala	M
Byblis gaimardi	M
Family Phoxocephalidae	
Pontarpinia longirostris	
Family Gammaridae	
Maera prionochira	
Melita dentata	
Family Taronidae	
Surthoe crenulata	
Order Cirripedia	
Family Balanidae	
Balanus balanus	S
B. crenatus	S
B. hesperias	S
B. rostratus	S
Order Decapoda	
Family Axiidae	
Calastacus investigatoris	

TABLE 31, Continued.

ASTEROIDEA	
Family Porcellanasteridae	
Ctenodiscus crispatus	N
Family Echinasteridae	
Henricia spiculifera	
OPHIUROIDEA	
Family Ophiacanthidae	
Ophiophthalmus cataleimnoides	B
O. normani	B
Family Ophiactidae	
Ophiopholis aculeata	B
O. pilosa	B
O. mirabilis	B
Family Amphiuridae	
Amphioplus macraspis	B
A. craterodmeta	B
A. perirecta	B
A. sundevalli	B
A. carchara	B
A. psilopora	B
A. pugetana	B
Family Ophiolepididae	
Amphiophiura ponderosa	B
Ophiura criptolepis	B
O. sarsi	B
O. leptoctenia	B
O. maculata	B
O. tetracantha	B
O. quadrispina	B
ECHINOIDEA	
Family Schtellidae	
Echinarchnius parma	M
Family Schisasteridae	
Brisaster latifrons	N
B. Townsendi	N

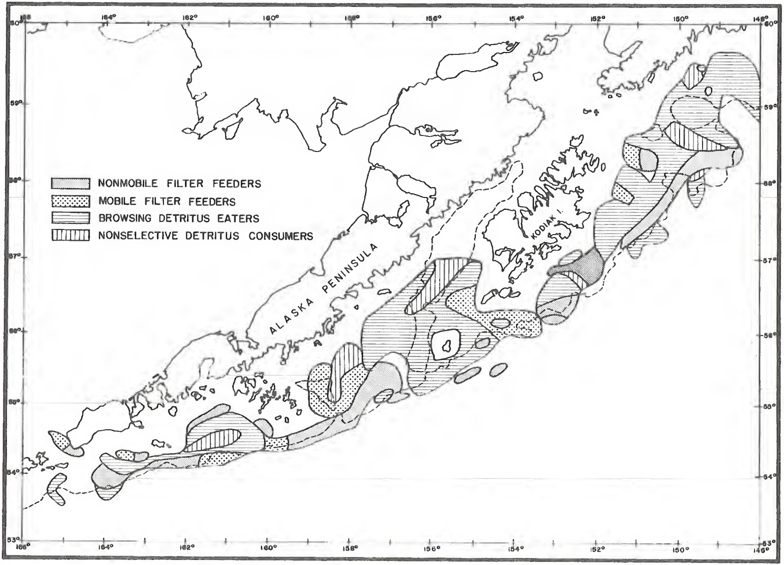

Figure 77. Dominance of various feeding types in benthic fauna in the Western Gulf of Alaska (from Shevtsov 1964, Semenov 1964).

Benthic invertebrate biomass was greater in the study area than for the Eastern Gulf of Alaska, possibly due to stronger currents and less glacial siltation in the Western Gulf (Semenov 1965). A high percentage of this biomass was estimated to be available for fish food in the Gulf of Alaska compared to other parts of the North Pacific (Moiseev 1964).

The most extensive American investigation which recorded benthic fauna has been the exploratory fishing drag program of the National Marine Fisheries (undated). Caution must be exercised in interpreting data from such trawl studies. Different trawl surveys used different gear, altering the susceptibility of various groups to capture. The National Marine Fisheries Service surveys did not trawl in a regular sampling pattern, thus effort is not equal throughout the study area (Figure 78).

Surveys in the Western Gulf were limited to summer only--979 of 1,296 trawls were taken between June 1 and August 31 and no trawls were recorded from late October through early April. Fifty-four percent of these stations were surveyed with shrimp trawls and 35 percent with scallop dredges. The remainder used various other gear. Thus, much of the catch may have been incidental to the target species sought.

Data indicate locations where concentrations of certain organisms have been noted during the warmer months of the year. Absence of data should not be interpreted as indicative of the absence of the organisms and may result from bias in the sampling program--either in gear, season, or sampling effort. Certainly other areas of concentration exist which have not been recorded in the limited sampling conducted in this area.

Within the study area 20 major benthic invertebrate types were reported (Table 32). Of these 10 were more commonly encountered or yielded high catches per hour trawled. Large catches per hour trawled for these 10 groups were recorded at locations shown in Figure 79. Large quantities of mussels, basketstars, and sea pens were most often encountered west of Chirikof Island. Large catches of sea cucumbers and sea urchins were frequently recorded on Portlock Bank and in the vicinity of the Barren Islands. Abundant sea anemones and starfish were reported from scattered locations.

Hitz and Rathjen (1965) recorded benthic invertebrates east of Kodiak and reported that half the invertebrate biomass obtained in the survey drags was composed of heart urchins and that 20 percent was starfish. The remaining invertebrates were commercial species and will be discussed individually in following sections.

Barysheva (1965) reported 14 species of Cumacean crustaceans occurring in the Gulf of Alaska, but did not identify sampling locations. The Faculty of Fisheries, Hokkaido Univ. (1968) has made only one series of trawls near Seward Gully, which yielded little invertebrate information. Marine Advisers (1971), diving at depths of between 25 and 45 m. near Kodiak, reported many common intertidal species (Table 29) plus benthic species, *Pecten caurinus*, and *Neptunea lyrata*.

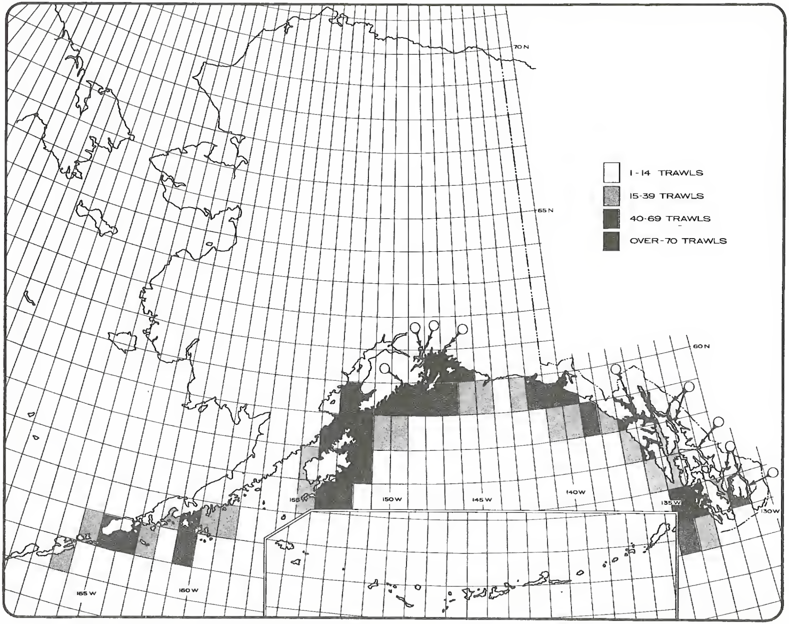

Figure 7: Distribution of National Marine Fisheries Service trawl effort in the Western Gulf of Alaska (from Buck 1973).

TABLE 32

Major Benthic Invertebrate Groups reported from 1,296 National Marine Fisheries Service Exploratory Fishing Drags in the Western Gulf of Alaska (from National Marine Fisheries Service, undated)

Group	Occurrence in Drags	Maximum Catch (kg./hr.)
Sea Cucumbers	common	1,360
Starfish	common	815
Sea Urchins	common	755
Sea Anemone	common	180
Basketstars	common	180
Sea Pens	common	90
Mussels	occas.	725
Brittlestars	occas.	300
Crabs	occas.	25
Hermit Crabs	occas.	30
Barnacles	occas.	35
Sponge	seldom	225
Whelks	seldom	15
Sand Dollars	seldom	225
Clams	rare	90
Horse Crab	rare	Trace
Sea Fan	rare	Trace
Octopus	rare	Trace
Box Crab	rare	Trace
Worms	rare	Trace

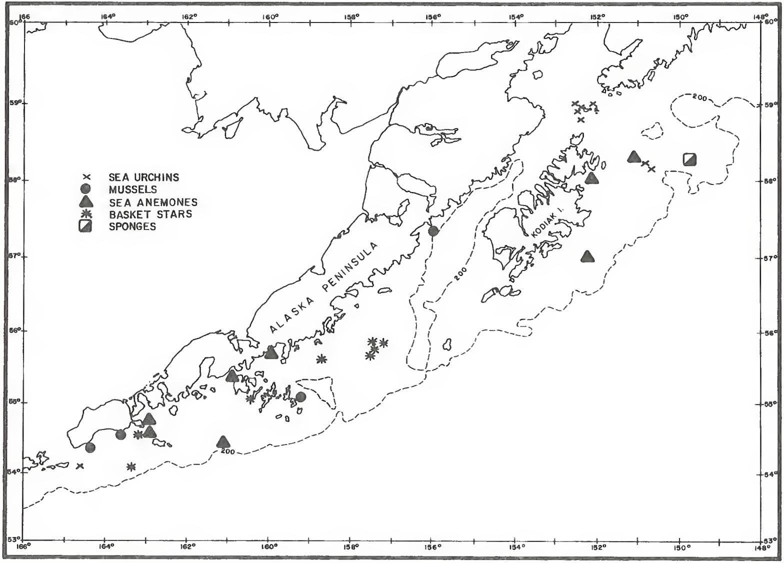

Figure 79a. Location of large trawl catches of benthic fauna reported by the National Marine Fisheries Service in the Western Gulf of Alaska; unweighted composite of data collected over a period of 23 years (from National Marine Fisheries Service, undated).

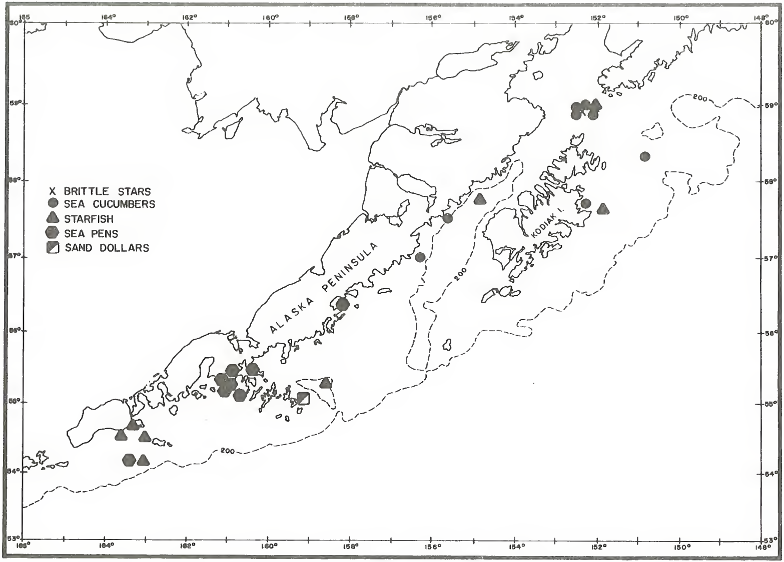

Figure 79b. Location of large trawl catches of benthic fauna reported by the National Marine Fisheries Service in the Western Gulf of Alaska; unweighted composite of data collected over a period of 23 years (from National Marine Fisheries Service, undated).

Scheffer (1959) conducted little benthic work, but does report Mytilus californicus in 60 m. of water near Sanak Island. Eyerdam's (1960) list of mollusk and brachiopod species of Afognak and Sitkalidak Islands is comprehensive (Table 33).

King Crab

King crab rank with salmon as one of the most valuable commercial species harvested from the Western Gulf waters, with peak harvests exceeding 50,000 metric tons in 1966. Vigorous commercial fisheries have existed in the study area for more than 20 years (Buck 1973). These fisheries concentrate on the continental shelf south and east of Kodiak Island and west of the Shumagin Islands.

Two species contribute to the commercial catch. Paralithodes camtschatica provides almost the entire harvest; small quantities of P. platypus have been recorded at Kodiak (Gray et al. 1965).

Exploratory fishing drags of the National Marine Fisheries Service (undated) provide limited information on king crab distribution within the Western Gulf. In late summer large quantities of these crabs were found south of Unimak Island, from Balboa to Pavlof Bays north and west of Unga Island, and widely scattered to the south and east of Kodiak (Figure 80). Crabs were caught in quantity from 36 to 200 m., although crabs have been reported from depths to 350 m. (Eldridge 1972a) and in the immediate sub-tidal zone for spawning (Gray and Powell 1966). Most crabs appeared concentrated between 50 and 170 m. in late summer. The maximum catch recorded was 695 kg./hr. Trawls in the Eastern Gulf indicate a much lower abundance of this species there (Hitz and Rathjen 1965). Caution, similar to that expressed previously for benthic fauna, should be observed in the interpretation of incidental trawl catches.

The International Pacific Halibut Commission (1964) reported catches of king crabs incidental to a halibut survey conducted during 1961 to 1963 on a regular sampling pattern (Figure 81). Catches of king crabs in excess of 200 individuals per hour trawled are indicated in Figure 82. King crabs were taken in quantity throughout the region and with greatest frequency northeast and southwest of Kodiak Island. Caution, similar to that expressed previously for benthic fauna, should be observed in the interpretation of incidental trawl catches. The National Marine Fisheries Service, Northwest Fisheries Center, Seattle, is currently completing a series of maps based upon trawl catches taken during this survey. These maps will be available in early summer of 1974.

Adult king crabs move to shallows of less than 75 m. to breed in the spring and return to deeper waters in the summer and early autumn (Powell and Reynolds 1965). Hayes and Montgomery (1963) found that more than 90 percent of the crab tagged for study were recaptured within 56 km. of their release. This indicates no major movement by individual crabs. Immature crabs remain in inshore shallows separate from adults. Adult crabs may school by size, sex, or condition of carapace, except during the mating season (Eldridge 1972a).

TABLE 33

Mollusca collected from Afognak and Sitkalidak Islands (from Eyerdam 1960).

PELECYPODA

Astarte alaskensis
A. arctica
A. esquimalti
A. rollandi
Bankia setacea
Campsomyax kennerlyi
Clinocardium californiense
C. ciliatum
C. fucanum
C. nuttallii
Cuspidaria beringensis
Entodesma saxicola
Kellia laperousei
K. suborbicularis
Leda minuta
Limatula subauriculata
Lyocyma viridis
Lyonsia pugetensis
L. striata
Macoma alaskana
M. balthica
M. brota
M. incongrua
M. inflatula
M. inquinata
M. middendorffii
M. nasuta
M. sitkana
M. yoldiformis
Modiolaria laevigata
M. nigra
M. substriata
M. vernicosa
Modiolus modiolus
Mya intermedia
M. japonica
M. truncata
M. truncata var. uddevallensis
Mytilus californianus
M. edulis
Nucula (Acila) castrensis
N. tenuis
N. tenuis expansa
Pandora (Kennerlia) bilirata
P. (K.) filosa
Pecten alaskensis
P. caurinus
P. (Chlamys) hindsii navarchus
P. islandicus beringianus
Phacoides annulata
P. tenuisculpta
Pododesmus (Monia) macrochisma
Protocardia centifilosa
Protothaca staminea
P. staminea orbella
Rochefortia aleutica
R. planata
R. tumida
Saxicava arctica
S. pholadis
Saxidomus gigantea
Schizothaerus capax
Serripes groenlandicum
S. laperousii
Siliqua patula
S. patula alta
Spisula alaskana
Tellina lutea
T. lutea venulosa
T. salmonea
Thyasira flexuosa
Venericardia alaskana
V. ventricosa
Yoldia ensifera
Y. limatula
Y. scissurata

TABLE 33, Continued.

SCAPHOPODA

Dentalium dalli

OPISTHOBRANCHIA

Acteocina eximia
Cylichnella alba
C. attonsa
C. nucleola
C. occulta
Haminoea olgae
H. vesicula

NUDIBRANCHIA

Anisodoris nobilis
Melibe leonina

PTEROPODA

Spiratella pacifica

PULMONATA

Arctonchis borealis
Siphonaria (Liriola) thersites

PROSOBRANCHIA

Admete couthouyi
A. couthouyi gracilior
Aforia circinata
Bela alaskensis
B. chiachiana
B. excurvata
B. fidicula
B. inequita
B. nobilis
B. pleurotomaria
B. rosea
B. scalaris
B. sculpturata
B. solida
B. turricula
Beringius crebricostatus
B. eyerdami
B. kennicotti
Chrysodomus lirata
C. pribiloffensis
C. satura
Colus (Latisipho) jordani
Olivella boetica
Searlesia dira
Sprioglyphis lituellus

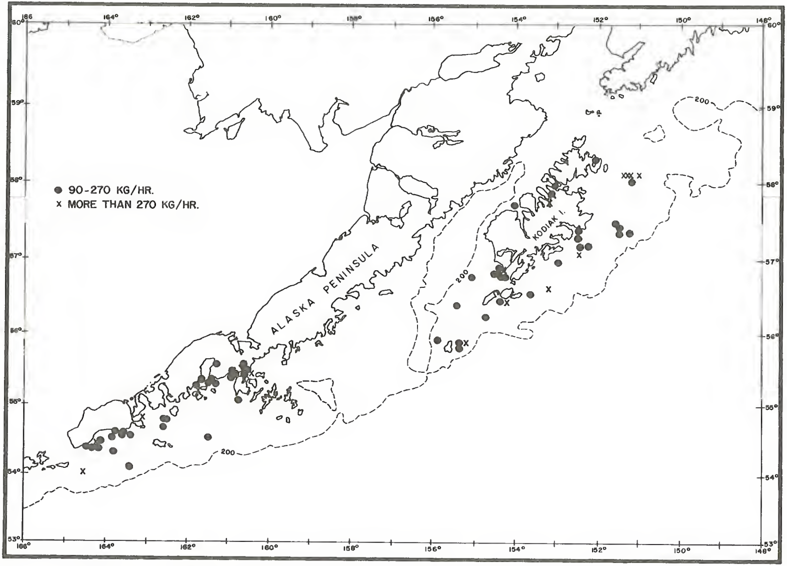

Figure 80. Location of large trawl catches of king crab reported by the National Marine Fisheries Service in the Western Gulf of Alaska; unweighted composite of data collected over a period of 23 years (from National Marine Fisheries Service, undated).

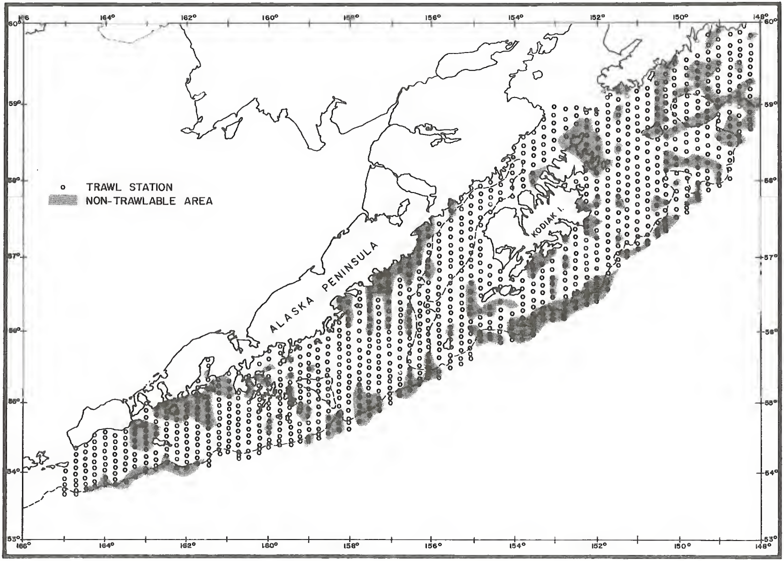

Figure 81. Distribution of trawl stations repetitively sampled by the International Pacific Halibut Commission during 1961 to 1963 (from International Pacific Halibut Commission 1964).

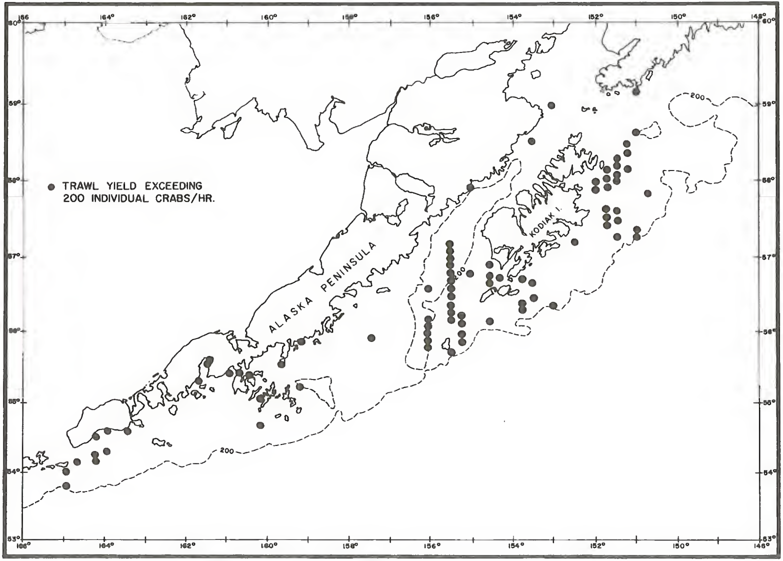

Figure 82. Location of large trawl catches of king crab reported by the International Pacific Halibut Commission in the Western Gulf of Alaska (from International Pacific Halibut Commission 1964).

In the Kodiak area, Powell and Reynolds (1965) identified six distinct stocks which appear to maintain their separation (Figure 83).

Gray and Powell (1966) reported that king crabs mature sexually at five to seven years when carapace length is approximately 100 mm. Young females and older males reach the spawning grounds first and begin breeding as early as mid-March. Older females and young males may continue the breeding into late May. The Kodiak vicinity alone is reported to have 19,120 sq. km. of potential breeding area, of which 13,028 sp. km. of area are more than 48 km. offshore (McMullen 1967a).

Male king crabs are polygamous and, even when newly matured, appear to breed successfully with five to seven females. The king crab fishery harvests males only at a minimum carapace width of 17.8 cm. This allows males one or two breeding seasons after maturity and before exposure to commercial harvest. In probably an extreme example, Kingsbury and James (1971) reported 93 percent of the adult males on the breeding grounds at Alitak in 1970 were of sublegal size.

The ratio of males to females on breeding grounds is an important factor in reproductive success and may be influenced by fishing intensity. McMullen (1967c) reported a sex ratio of 11 females per male on the Marmot Flats breeding ground in 1967. Yoshihara in Haynes and Lehman (1969) reported nine males with 700 females on the Kaguyak spawning area in 1968. Powell and Gray (1964) reported that the commercial catch in some years apparently exceeded the recruitment of newly matured males into the breeding population. Thus the sex ratio of mature females to mature males increased and a greater proportion of the catch became "recruits" or crabs exposed to their first year of commercial harvest. Some areas have seen harvests composed of 80 percent recruits (Alaska Dept. of Fish and Game 1973b). West of Kodiak, along the Alaska Peninsula, harvests have taken greater than 50 percent recruits (McMullen and Yoshihara 1970).

King crabs seem to prefer kelp covered reefs or rocky areas for spawning (Powell and Nickerson 1965). Within two hours after the female molts, ovulation and fertilization is accomplished. Mated females leave the spawning area, while males may remain for more than one month to continue breeding (Powell in Haynes and Lehman 1969). Haynes (Haynes and Lehman 1969) indicated increased fecundity with increased size; the largest females produce up to 400,000 eggs (Figure 84).

After being carried externally for about 11 months by the female, eggs hatch into zoea larvae. The zoea larvae are planktonic and feed upon diatoms. After approximately 60 days the larvae molt to glaucothoe and become benthic in habit for the remainder of their life cycle. From investigations in the Bering Sea, king crab feed on a wide variety of benthos (McLaughlin and Hebard 1959).

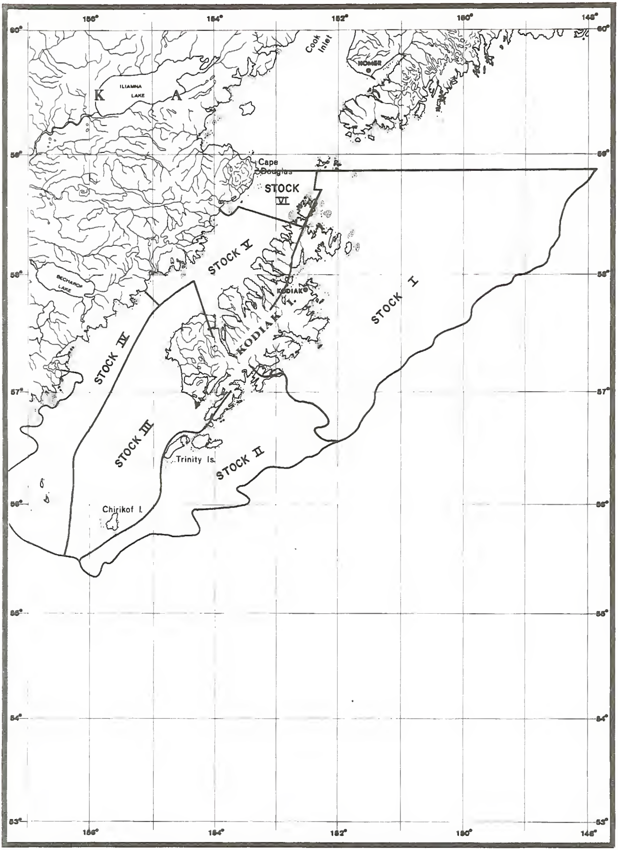

Figure 83. Preliminary boundaries of king crab stocks in the Kodiak Island vicinity which appear to maintain partial separation (from Jackson and Manthey 1969).

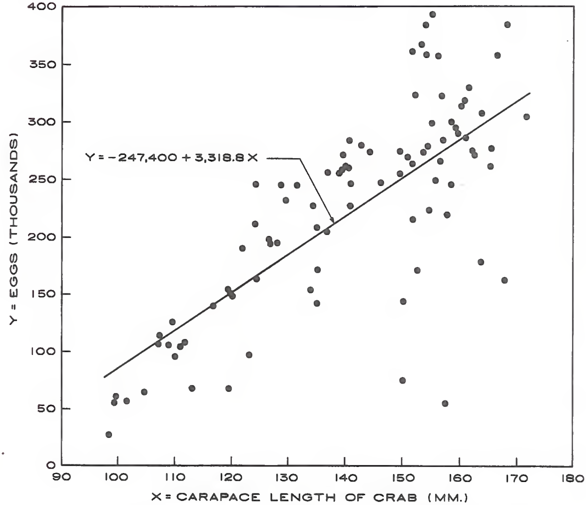

Figure 84. Relation of number of eggs to carapace length of female king crabs (from Haynes and Lehman 1969).

The variable survival rate among juvenile crabs results in great variability in the numbers of crabs of different year classes which mature and are recruited into the commercial fishery. Upon reaching maturity, females molt once a year prior to breeding. With each molt, approximately six mm. in carapace length is gained. Males molt once a year in their sixth, seventh, and eighth years, but in later years molt biennially or (rarely) triennially (Jackson and Manthey 1969). Powell (Haynes and Lehman 1969) believed males who skip molting two consecutive years may die after their next mating. Males may add up to 20 mm. in length to their carapace with each molt.

Males grow significantly larger than females (Powell and Nickerson 1965) and may reach maximum ages exceeding 15 years although exact aging is impossible (Eldridge 1972a). Due to the heavy commercial fishery, older age classes now are rarely encountered. Figure 85 depicts the early life history and life cycle of the king crab.

The 1964 earthquake and accompanying tidal wave did not greatly disrupt the crab population in the Kodiak vicinity (Powell and Nickerson 1965).

Tanner Crab

Tanner crabs are the basis for one of Alaska's newest fisheries. The Western Gulf has produced the bulk of this species, with more than 4,000 metric tons landed in 1969 (Buck 1973). Areas fished for this species are similar to those harvested for king crabs.

Although 3 species of Chionoecetes are found in this area, only C. bairdi is presently harvested in the Western Gulf (Brown and Powell 1972). C. angulatus is common on the Gulf abyssal plain down to 2,050 m. (Brown 1971). C. opilo is most abundant north and west of the study area. Further discussion will be confined to C. bairdi.

Exploratory fishing drags of the National Marine Fisheries Service (undated) provide a general picture of tanner crab distribution and abundance throughout the study area during summer and early autumn. Tanner crabs were taken in quantity near the eastern end of Unimak Island, between Unga Island and Pavlof Bay; Alitak Bay; Marmot-Chiniak Bays, and in the Cape Douglas vicinity (Figure 86). Abundance and distribution may vary considerably with the season due to vertical movements which are inadequately understood.

Crabs were caught in quantity by the National Marine Fisheries Service between 38 and 244 m., though they were reported as deep as 520 m. (Brown 1971) and enter much shallower waters for spawning (Brown and Powell 1972). Crabs appeared most concentrated between 50 and 130 m. during late summer and early autumn. The maximum trawl yielded 1,512 kg./ hr. Caution, similar to that expressed previously for benthic fauna, should be observed in the interpretation of incidental trawl catches.

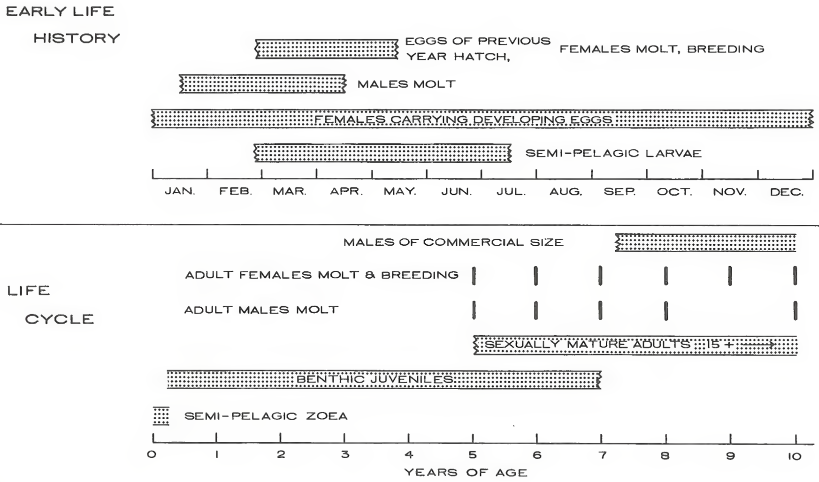

Figure 85. Early life history and life cycle of king crab, Paralithodes camtschatica (from Powell and Nickerson 1965, Powell and Reynolds 1965, Gray and Powell 1966, Haynes and Lehman 1969, Jackson and Manthey 1969).

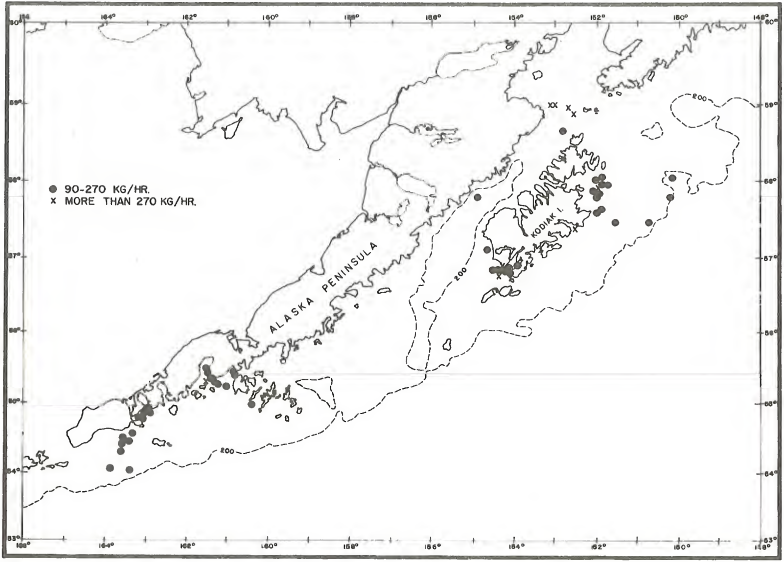

Figure 86. Location of large trawl catches of tanner crab reported by the National Marine Fisheries Service in the Western Gulf of Alaska; unweighted composite of data collected over a period of 23 years (from National Marine Fisheries Service, undated).

The International Pacific Halibut Commission (1964) reported catches of tanner crabs in excess of 200 individuals per hour trawled at the station locations indicated in Figure 87. Tanner crabs were distributed widely throughout the entire continental shelf of the Western Gulf of Alaska. Caution similar to that expressed previously for benthic fauna, should be obwerved in the interpretation of incidental trawl catches.

Apparently, tanner crabs compose a high proportion of the benthic invertebrates east of Kodiak Island. Hitz and Rathjen (1965) found that 22 percent of their invertebrate catch was tanner crab in the Eastern Gulf of Alaska. Heart urchins were the only invertebrate encountered more often.

Female tanner crabs mature sexually when they reach a carapace width of 70 to 100 mm. and males when they reach a width of 90 to 140 mm. Breeding commences in shallow areas in early January and may continue into mid-May (Brown and Powell 1972). Lehman (Haynes and Lehman 1969) found unmolted females with new egg clutches. Molting in females ceases upon maturity and is not essential to successful breeding.

Little is known of the life history of C. bairdi within the Western Gulf of Alaska. Developing eggs are carried by female tanner crabs for about 11 months. Females carry from 5,000 to 140,000 eggs; 30,000 to 80,000 eggs are considered average. Upon hatching, tanner crab larvae spend time in a planktonic existence before settling to the bottom for the remainder of their life cycle (Eldridge 1972b). The early life history and life cycle for C. bairdi must be considered tentative, as determinative studies are lacking (Figure 88).

Maximum size of tanner crabs differs between sexes. Males continue to molt throughout their life and may exceed 200 mm. carapace width. Females cease molting soon after they molt to maturity and may reach a carapace width of no more than 125 mm. (Eldridge 1972b).

Catches of tanner crabs are continuing to increase each year and no pattern to this fishery has been established. Currently, no commercial size limit is imposed by the Alaska Department of Fish and Game in a "males only" fishery, although processors may restrict landings to some minimum size, now about 125 mm. This practice may allow males at least one breeding season before exposure to the fishery.

Eldridge (1972b) reviewed the tanner crab. Parts of his information, derived from studies of C. opilio, must be used with reservation when applied to C. bairdi.

Dungeness Crab

The Dungeness crab, Cancer magister, supports a major inshore commercial fishery in the Kodiak area with catches exceeding 3,000 metric tons in the late 1960s.

In the remainder of the study area, this fishery has been irregular with much smaller harvests (Alaska Department of Fish and Game 1972).

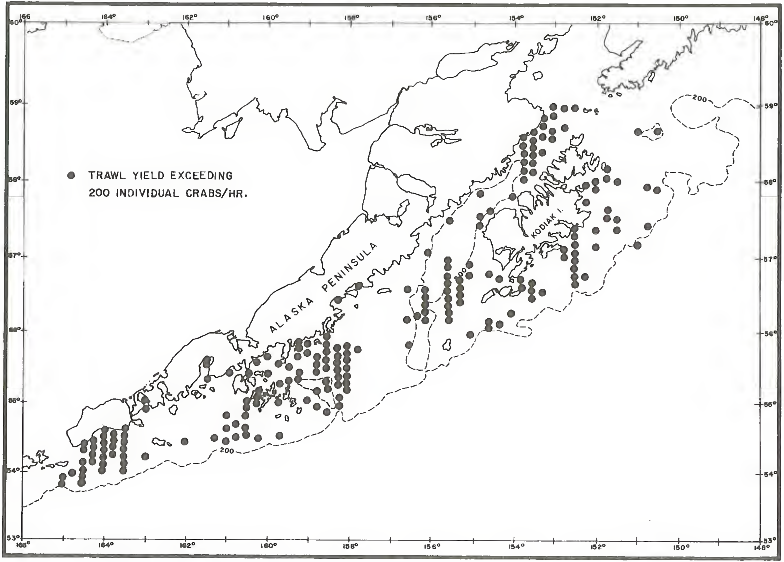

Figure 87. Location of large trawl catches of tanner crab reported by the International Pacific Halibut Commission in the Western Gulf of Alaska (from International Pacific Halibut Commission 1964).

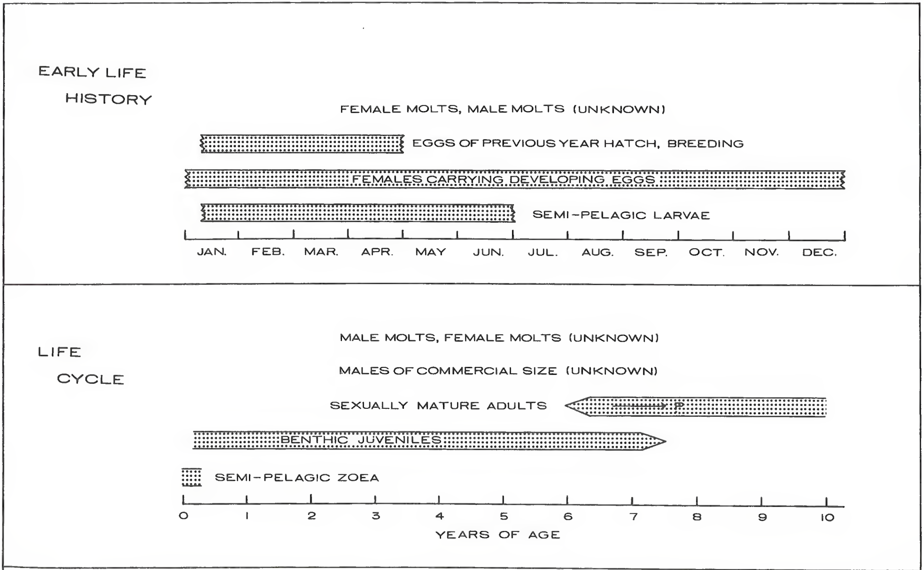

Figure 88. Early life history and life cycle of tanner crab, *Chionoecetes* sp. (from Haynes and Lehman 1969, Brown and Powell 1972, Eldridge 1972b).

Exploratory fishing drags (undated) of the National Marine Fisheries Service indicated a scattered distribution of this species in the Western Gulf. Few large catches were recorded during the summer and were located south of the Trinity Islands, in Beaver Bay, and along the southern coast of Unimak Island (Figure 89). Crabs were caught in quantity between 46 and 96 m., though they may be concentrated between tideline and 50 m. during spawning earlier in the spring, or as deep as 200 m. during the remainder of the year (Nanaimo Biological Station, undated). Large catches of crabs were encountered most often between 62 and 88 m. The maximum trawl produced 94 kg./hr. Caution, similar to that expressed previously for benthic fauna, should be observed in the interpretation of incidental trawl catches.

The International Pacific Halibut Commission (1964) reported catches of Dungeness crabs in excess of 200 individuals per hour trawled at station locations indicated in Figure 90. Dungeness crabs were found in quantity in the same general locations as were reported in the National Marine Fisheries Service surveys. Caution, similar to that expressed previously for benthic fauna, should be observed in the interpretation of incidental trawl catches.

These crabs move offshore during the winter and return to shallow waters in early spring and summer (Mayer 1972). Generally, these crabs prefer a firm, sandy bottom (Nanaimo Biological Station, undated).

Dungeness crabs appear regularly in trawls east of Kodiak Island. Hitz and Rathjen (1965) reported that Dungeness composed 3.5 percent of the benthic invertebrate catch. This was the second highest catch of commercially important invertebrates, exceeding only tanner crab.

Male Dungeness crabs with a carapace width greater than 140 mm. are mature, while females mature upon reaching 100 mm. Time of mating in Gulf waters has not been determined, though summer is reported as the breeding season in British Columbia. Eggs are not spawned until late fall or early winter (Nanaimo Biological Station, undated).

As many as 1.5 million eggs are carried on the abdomen of the female and hatch in the spring. Larvae then spend as long as 3 months in a planktonic form before settling to the bottom for the remainder of their life cycle (Nanaimo Biological Station, undated).

Both sexes of Dungeness crab mature in three years. The male attains a larger maximum size than the female and both may live from eight to ten years. Molting may occur annually in mature adults. Large males may exceed 200 mm. carapace width, while females seldom exceed 150 mm. (Mayer 1972). A commercial size limit of 17.8 cm. width, in the Kodiak and Chignik Districts would appear to allow males a minimum of two breeding seasons prior to exposure to the fishery. Early life history and life cycle are presented in Figure 91, but must be considered tentative, since much of the present knowledge of Dungeness crabs has been collected farther south. Current investigations by the Alaska Department of Fish and Game at Sharatin Bay on Kodiak Island are expected to greatly increase the understanding of Dungeness crab in Gulf of Alaska waters (Alaska Dept. of Fish and Game 1973b).

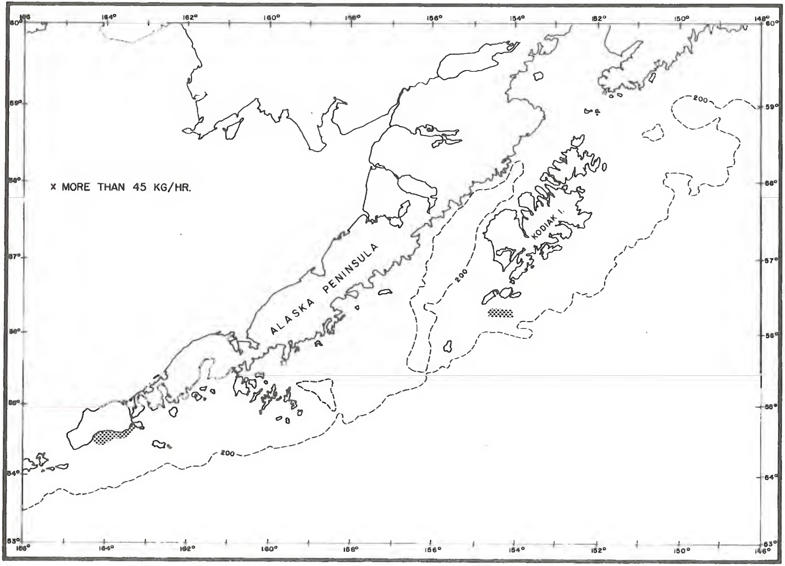

Figure 89. Location of large trawl catches of Dungeness crab reported by the National Marine Fisheries Service in the Western Gulf of Alaska; unweighted composite of data collected over a period of 23 years (from National Marine Fisheries Service, undated).

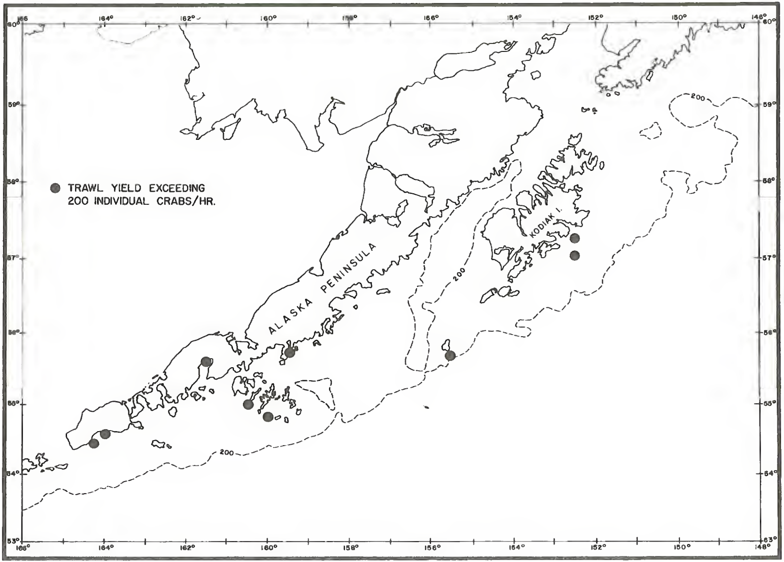

Figure 90. Location of large trawl catches of Dungeness crab reported by the International Pacific Halibut Commission in the Western Gulf of Alaska (from International Pacific Halibut Commission 1964).

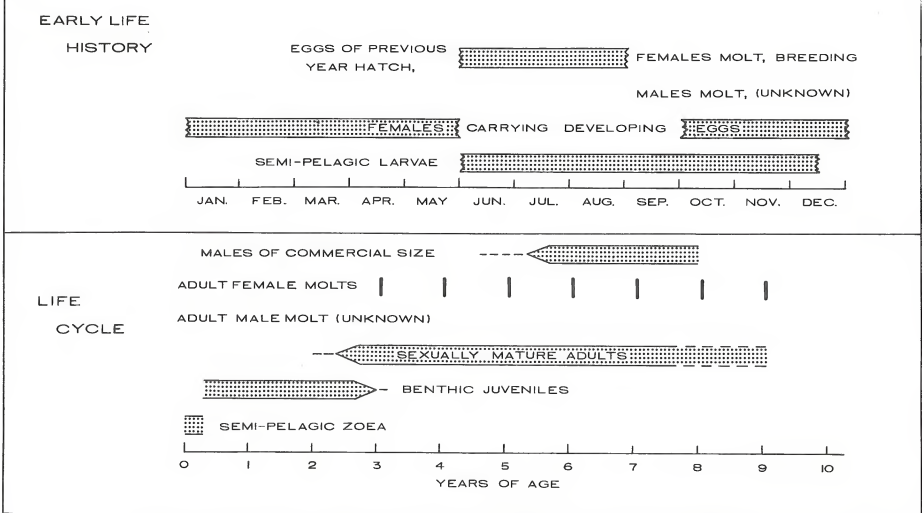

Figure 91. Early life history and life cycle of Dungeness crab, Cancer magister (from MacKay 1942, Mayer 1972).

Dungeness crab feed on benthic fauna; stomach analyses show a preponderance of clams and various crustaceans (Mayer 1972).

Shrimp

A large volume of the shrimp harvest on the continental shelf of the Western Gulf of Alaska has been developed by Japan, the USSR and the United States within the past decade--with more than 40,000 metric tons harvested in recent years. Four species occur in commercial quantity: *Pandalus borealis* (pink); *P. hypsinotus* (coonstripe); *P. goniurus* (humpy); and *P. dispar* (sidestrip). Of these four, *P. borealis* comprises 97 percent of the catch landed in Kodiak (Olsen in Haynes and Lehman 1969). Major fishing areas are east and south of Kodiak Island and east of the Shumagin Islands. Kodiak clearly dominates the West Coast shrimp harvest today (Alaska Department of Fish and Game 1973b).

Shrimp species move off the ocean bottom at night, each species differs in the proportion of individuals which migrate upward and the distance upward traveled. Different species can be found all the way from the surface to at least 466 m. (U.S. Bureau of Commercial Fisheries 1965). In the Western Gulf, large concentrations are found over sand, silt, or mud subtrates; exploration conducted in more rocky and more difficult trawling areas has been too limited to truly assess the potential of those areas.

Exploratory fishing drags of the National Marine Fisheries Service (undated) have identified areas of shrimp concentration in the Western Gulf for the four commercial species as well as reporting small quantities of *Danae*, *Hippolytid*, *Spriontocaris*, and *Cragon* shrimp.

P. goniurus and *P. hypsinotus* are encountered at depths between 40 and 200 m. with most concentrations from 60 to 130 m. Large hauls were encountered more regularly in late summer at these depths.

Large quantities of *P. goniurus* and *P. hypsinotus* were found in Alitak and Uganik Bays, with scattered showings throughout the rest of the region (Figures 92 and 93). Largest hauls were 2,000 kg./hr. for *P. goniurus* and 350 kg./hr. for *P. hypsinotus*.

Pandalopsis dispar was broadly distributed from 88 to 258 m. but was concentrated between 110 and 210 m. Large hauls were encounted throughout the summer for this species. Marmot Bay, waters southeast of Cape Douglas, and the Shumagin Islands vicinity held large quantities, with many scattered large trawls thoughout the area (Figure 94). The maximum trawl for this species yielded over 2,050 kg./hr.

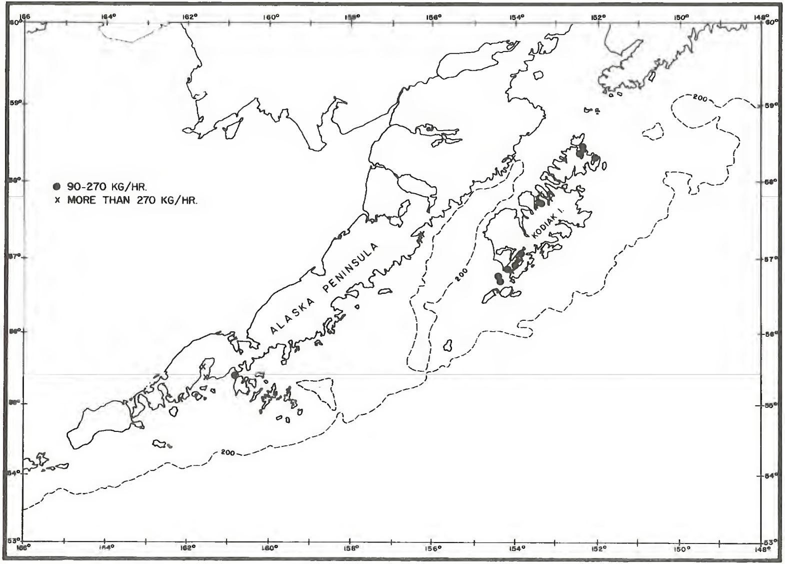

Figure 92. Location of large trawl catches of humpy shrimp reported by the National Marine Fisheries Service in the Western Gulf of Alaska; unweighted composite of data collected over a period of 23 years (from National Marine Fisheries Service, undated).

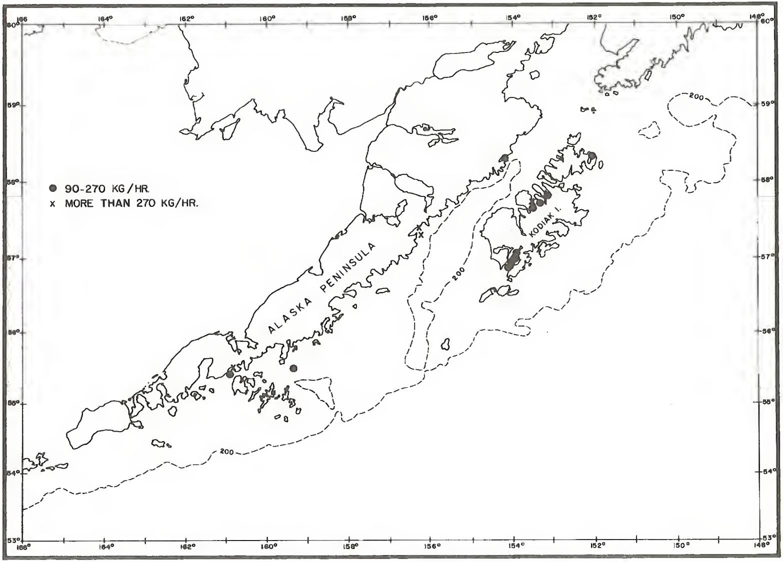

Figure 93. Location of large trawl catches of coonstripe shrimp reported by the National Marine Fisheries Service in the Western Gulf of Alaska; unweighted composite of data collected over a period of 23 years (from National Marine Fisheries Service, undated).

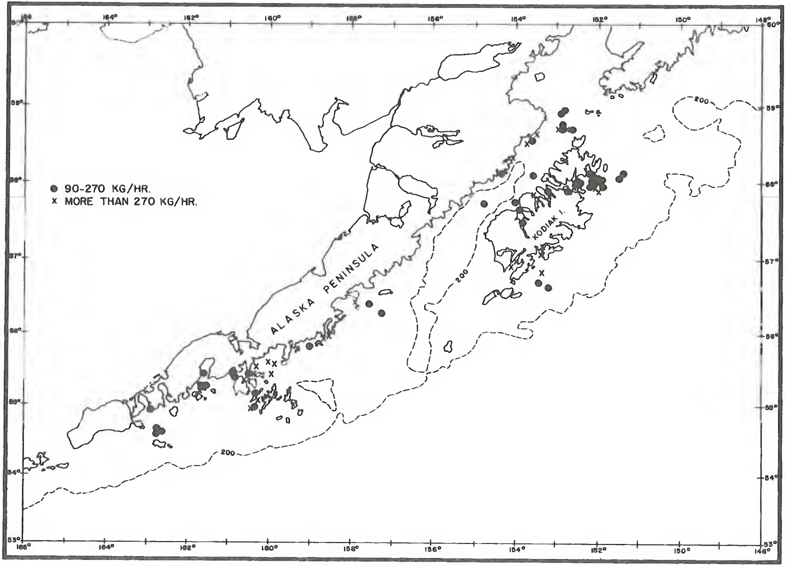

Figure 94. Location of large trawl catches of sidestripe shrimp reported by the National Marine Fisheries Service in the Western Gulf of Alaska; unweighted composite of data collected over a period of 23 years (from National Marine Fisheries Service, undated).

P. borealis is the most abundant shrimp species in the Western Gulf. Inhabiting moderate depths from 40 to 232 m., this species appeared most concentrated between 110 and 170 m. Large hauls were encountered with increasing frequency throughout the summer into early autumn. Almost any large bay along the north and southeast coasts of Kodiak and Afognak, along with Stepovak, Balboa, and Pavlof Bays were spectacular producers. Widely scattered, large hauls were made throughout the area (Figure 95). The largest trawl produced over 5,500 kg./hr.

In addition to U.S. exploration, the USSR has identified (Ivanov 1969) producing areas which lie farther offshore (Figure 96). These yield P. borealis primarily. Japanese exploration has been documented best by Butler (1967).

Barr and McBride (1967) found that P. borealis made a diurnal movement off the bottom at dusk and returned to the bottom in early morning (Figure 97). Barr found that peak feeding occurred from 2100 to 2400 hours (Haynes and Lehman 1969). Vertical separation may be maintained between species; Ronholt reported that bottom trawls caught 67 percent P. borealis when fishing on the bottom, but yielded 81 percent P. goniurus when fishing off the bottom (Haynes and Lehman 1969).

Seasonal movements also may be important. Pederson reported that fishermen in the Kodiak area land a much higher proportion of Pandalopsis dispar from February through May than the remainder of the year (Haynes and Lehman 1969). McCrary concluded from catch analysis that gravid females and older shrimp move to deeper waters (Haynes and Lehman 1969). Ivanov (1964) found shrimp tended to concentrate where warmer waters of the Alaska current overran the continental shelf, causing sharp temperature gradients. In particular, shrimp avoided waters warmer than 8 degrees C and tended to accumulate at 3.5 to 4.2 degrees C. Such conditions regularly occur east of the Shumagin Islands where Soviet shrimpers have made large harvests (Figure 98).

All four species of shrimp have quite similar life histories and will be discussed together. Spawning normally occurs in August and September, with Pandalopsis dispar preceding P. borealis (Jackson in Haynes and Lehman 1969). From 900 to 3,000 developing eggs are carried by the female on her abdomen. Larger, older females normally carry the greater number of eggs (McBride in Haynes and Lehman 1969). P. borealis larvae hatch from February through April or early May, and Pandalopsis dispar hatch slightly later, from April into mid-July (Jackson in Haynes and Lehman 1969).

Ivanov (1969) observed that the use of bays and island regions by spawning shrimp afford the benefits of unique circulation patterns, which prevent larvae from drifting into unfavorable areas. Larvea are free-swimming for approximately two and one-half months when they settle to the bottom to assume adult behavior. These juveniles are most abundant in waters deeper than 40 m. However, at the onset of winter, they appear to migrate to shallower waters of less than 40 m. (McCrary in Haynes and Lehman 1969).

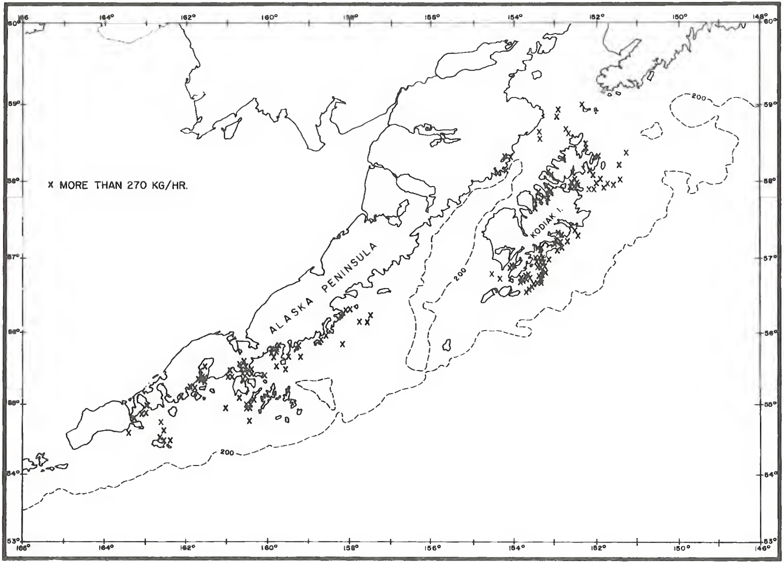

Figure 95. Location of large trawl catches of pink shrimp reported by the National Marine Fisheries Service in the Western Gulf of Alaska; unweighted composite of data collected over a period of 23 years (from National Marine Fisheries Service, undated).

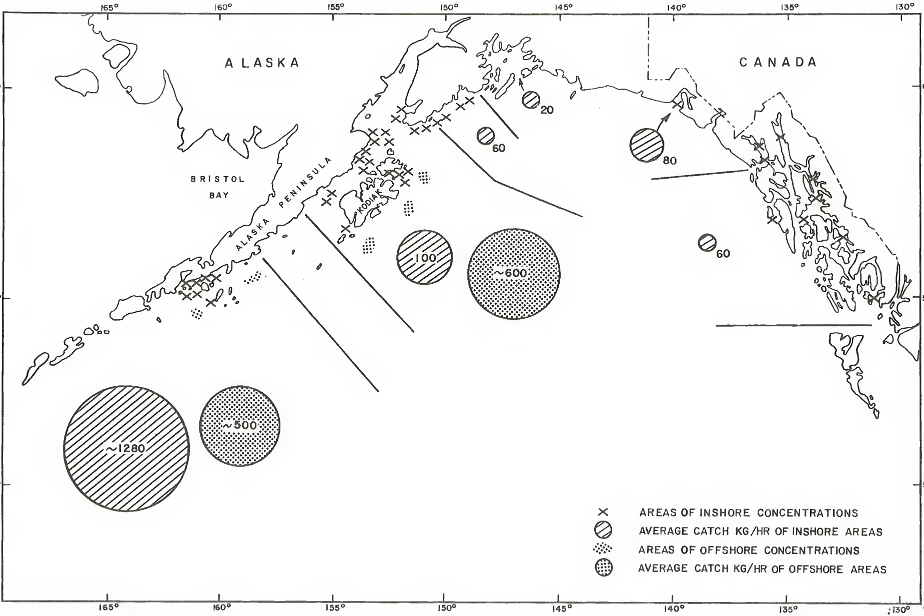

Figure 96. Location of Soviet offshore shrimp grounds, Alaskan inshore shrimp grounds and comparative catches in Gulf of Alaska (from Ivanov 1969).

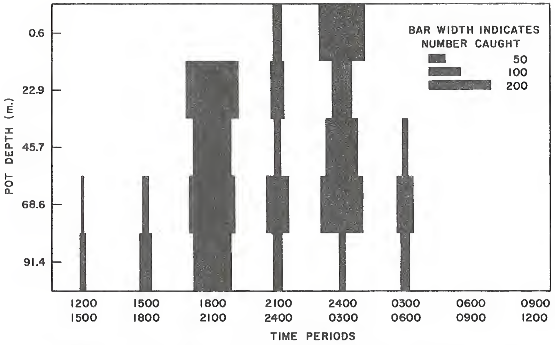

Figure 97. Catches of pink shrimp for 3-hour fishing periods throughout a 24-hour period in pots of a surface-to-bottom set (from Barr and McBride 1967).

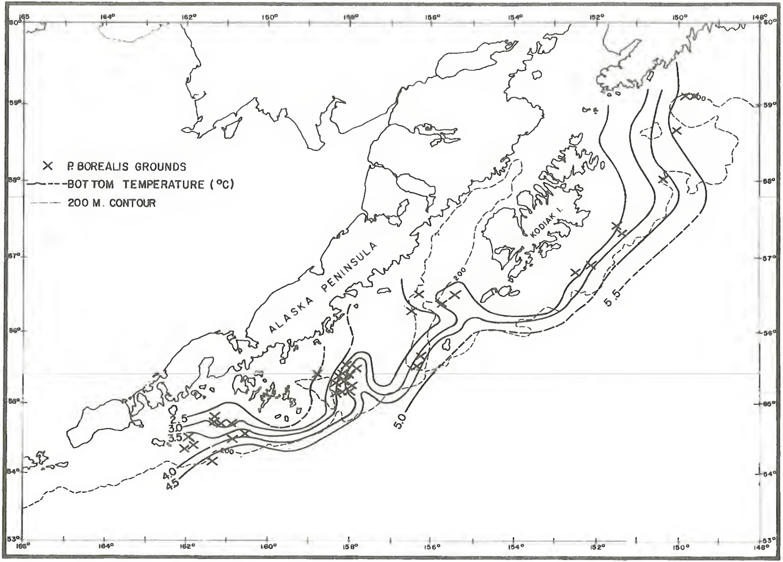

Figure 98. Bottom temperature isotherms in the Western Gulf of Alaska (from Ivanov 1964).

Shrimp have a unique life history in which individuals transform their sex. Almost all shrimp initially develop as males, though initial development as females has been reported in P. goniurus and P. hypsinotus (McCrary in Haynes and Lehman 1969). Shrimp reach maturity as males in two years. At two and one-half years, most breed as males, though at three and one-half years a few have already transformed into females (Ivanov 1969). McCrary found six months to be the average time required for an individual to change sex (Haynes and Lehman 1969). By four and one-half years of age, all shrimp change to breeding females. Few females apparently live beyond six years (Ivanov 1969). Figure 99 presents the early life history and life cycle for P. borealis.

Shrimp feed principally upon zooplankton (Barr in Haynes and Lehman 1969). The most common item identified in food studies on shrimp was brachyuran crab larvae.

The average size of shrimp in the Kodiak area is larger than that of shrimp caught in the Shumagin area. Shrimp near Sanak Island were the smallest measured (Ivanov 1964). Ivanov (1969) attributed this to the warmer currents in the Kodiak area, which cool as they run westward.

Shrimp are measured for carapace length from the posterior of the eye socket to the posterior lateral edge of the carapace. In the Shumagins, Ivanov (1969) found P. borealis males to average 19 mm. at first breeding (two and onehalf years), and females to average 25 mm. at first spawning (four and onehalf years).

Molting pattern is not well known. Females molt into a special shell prior to breeding which has hairs for egg attachment. Upon hatching the eggs, females molt back into nonbreeding shells (Ivanov 1964).

Fox (1973) has prepared a general summary of shrimp and shrimp fishing in the Eastern Gulf of Alaska.

Scallops

An Alaskan scallop fishery has been developed in the Gulf of Alaska within the past five years and has produced a peak harvest of slightly more than 600 metric tons from the Kodiak area in 1970. The weathervane scallop, Patinopecten caurinus, is the only one of eight scallop species in the Gulf of Alaska that is large enough or sufficiently abundant to support commercial development (Hennick 1973). Major commercial fishing areas are shown on Figure 100.

Exploratory fishing drags by the National Marine Fisheries Service assisted in locating important scallop beds (National Marine Fisheries Service, undated; U.S. Bureau of Commerical Fisheries 1968). In addition to the exploratory trawl reports, moderate fishing effort identified one new bed running from Cape Ikolik towards Afognak Island on the east side of Shelikof Strait (Hennick 1973). Scallop beds generally appeared compact and restricted in area. Drags adjacent to a rich scallop bed produced little, yet drags in the main bed yielded high poundage.

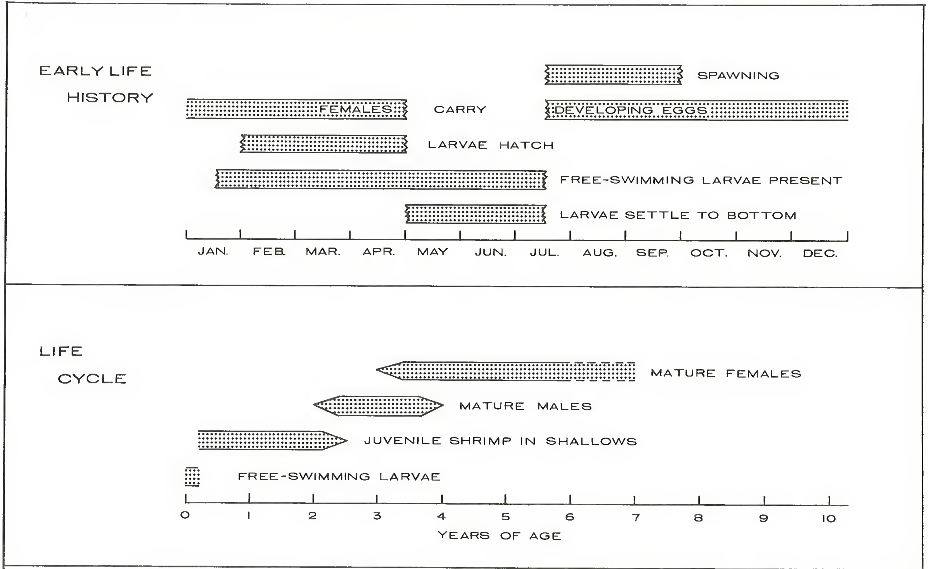

Figure 99. Early life history and life cycle of pink shrimp, Pandalus borealis (from Haynes and Lehman 1969, Ivanov 1969).

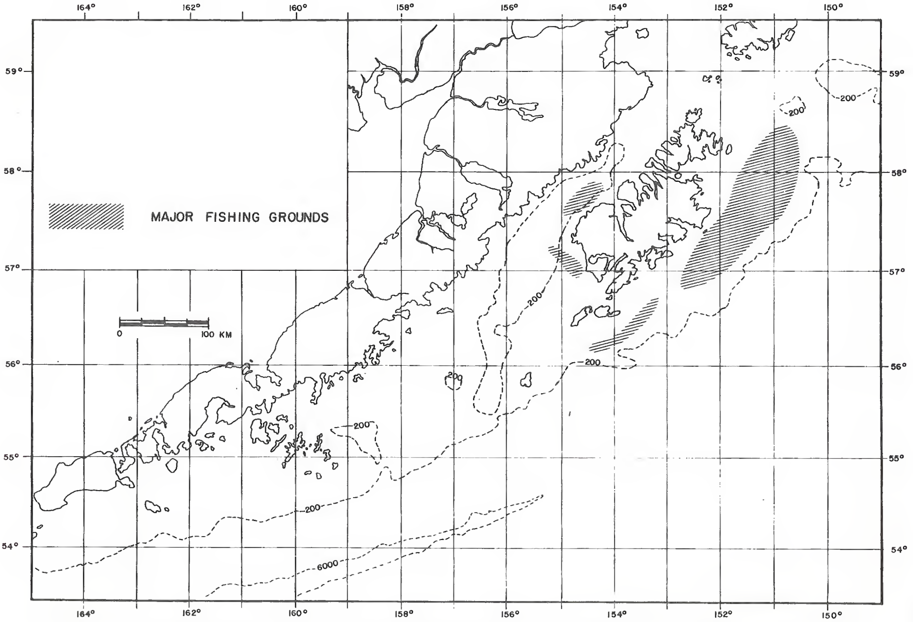

Figure 100. Location of major scallop beds fished commercially in the Western Gulf of Alaska (from Fay 1972).

Large trawl catches were made on the western end of Portlock Bank, the western end of Marmot Flats, along the 100 m. contour of Albatross Bank, Beaver and Pavlof Bays (Figure 101). The latter location does not sustain a commercial fishery. Caution, similar to that expressed for benthic fauna, should be observed in the interpretation of trawl catches.

National Marine Fisheries Service drags found concentrations of scallops between 42 and 138 m. with the majority located from 60 to 100 m. (National Marine Fisheries Service, undated; U.S. Bureau of Commercial Fisheries 1968). The most productive dredge yielded 703 kg./hr.

Hitz and Rathjen (1965) reported that scallops composed 1 percent of the invertebrate biomass in the Eastern Gulf. The Yakutat and Kodiak areas produce the entire commercial harvest for the Gulf of Alaska.

Life history information on the scallop in the Western Gulf of Alaska is limited. Scallops mature sexually in their third year when they may be 80-125 mm. from umbo to outer shell margin. Spawning in the Kodiak area begins in early June and may continue into early July (Hennick 1970). Scallops do not move to special areas for breeding. Fecundity has not been studied in this species. At spawning, males and females release sperm and eggs into the water where fertilization occurs. Fertilized eggs settle to the bottom and adhere to the substrate. After two or three days, these eggs hatch and larvae begin a two and one-half week planktonic phase. At the end of this time, the individual settles to the bottom as a juvenile (Hennick 1973).

Hennick (1970) believes a single ring is added to the dorsal valve of the shell for each year of growth. Scallops may live more than 15 years; one exceptional specimen has been reported with 28 annual rings (Hennick 1973). Most scallops caught commercially at Kodiak are seven to eleven years of age. Maximum size of specimens has exceeded 225 mm. valve height. A dredge ring (minimum size of 102 mm. diameter) restricts the harvest to large individuals, but may allow only one breeding season prior to exposure of scallops to the fishery. The early life history and life cycle of this species are presented in Figure 102.

Areas commerically harvested generally have mud, clay, sand, or gravel substrates. Little is known of the abundance of scallops in more rocky areas, because trawling is difficult in such areas.

Juvenile tanner crab are commonly encountered in scallop hauls and appear to occupy a similar habitat. King crab and Dungeness crab are encountered less often. Scallop dredging is restricted during seasons of high potential conflict, such as the king crab breeding season (Hennick 1973).

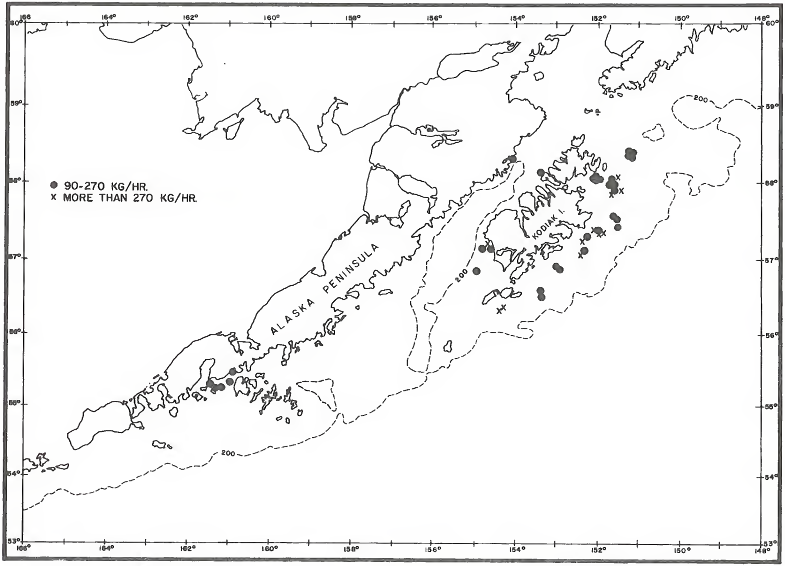

Figure 101. Location of large trawl catches of scallops reported by the National Marine Fisheries Service in the Western Gulf of Alaska; unweighted composite of data collected over a period of 23 years (from National Marine Fisheries Service, undated).

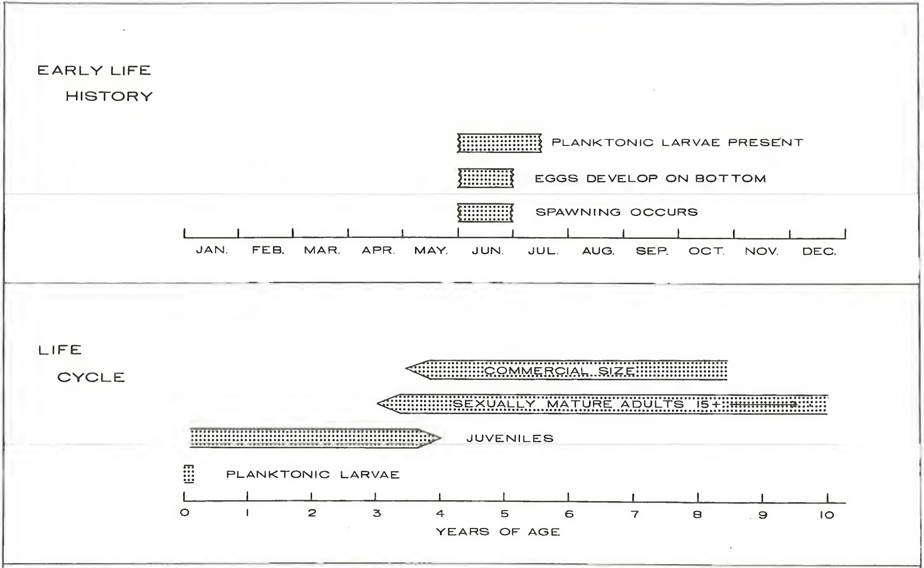

Figure 102. Early life history and life cycle of the weathervane scallop, Patinopecten caurinus (from Hennick 1970, 1973).

PELAGIC FAUNA

Pelagic Invertebrates

Squid are the only pelagic invertebrates mentioned in the literature as significant in the Western Gulf. Exploratory fishing drags of the National Marine Fisheries Service (undated) contained squid in small quantities at only two stations east and north of Sitkalidak Island. The U.S. Bureau of Land Management (1973) reported that squid use the intertidal and nearshore subtidal area of the Gulf of Alaska for spawning. Scheffer (1959) collected a squid, Rossia pacifica, stranded on a beach at Unimak Island after a storm.

Fish

Noncommerical species as well as undeveloped commercial stocks have been identified in the Western Gulf of Alaska by various authors. Exploratory fishing drags of the National Marine Fisheries Service (undated) yielded 18 groups which might be categorized here (Table 34). All drags yielding over 90 kg./hr. were plotted in Figure 103. Table 35 lists taxa which have been reported from all sources in the Western Gulf. Similar caution, as mentioned previously for benthic fauna, should be observed in the interpretation of these trawl data.

A regular pattern of stations throughout the continental shelf of the Western Gulf of Alaska was repetitively sampled during summer, fall, and winter seasons by the International Pacific Halibut Commission (1964) during 1961-1962 (Figure 81). Incidental catches of elasmobranches, sculpins, grenadiers (rattails), ronquils, and rockfish (other than Pacific Ocean perch) exceeding 90 kg./hr. are plotted in Figure 104. Similar caution, as mentioned previously for benthic fauna, should be observed in the interpretation of incidental trawl catches. Rockfish and grenadiers were found in quantity only at the continental shelf edge and slope. Elasmobranches were recorded in large quantity only in Shelikof Strait and north of Afognak Island. Sculpins and ronquils were abundant throughout the entire continental shelf area.

Hitz and French (1965) pointed to the possibility of a commercial fishery for pomfret, Brama japonica, which were particularly abundant offshore southwest of Kodiak.

A study of epipelagic fishes caught incidentally during salmon high seas sampling, reported Atka mackeral, Pleurogrammus monoterygius; jack mackerel, Trachurus symmetricus, and pomfret, Brama japonica, as frequently encountered in the Northern Gulf (Larkins 1964).

Sebastes aleutianus and Sebastolobus sp. were two groups of rockfish which Alverson et al. (1964) reported were increasingly abundant with depth in the Alaska Peninsula region. Maximum catches were reported between 365 and 550 m.

TABLE 34

Noncommercial Fishes Reported from 1,296 Exploratory Fishing Drags of the National Marine Fisheries Service in the Western Gulf of Alaska (from National Marine Fisheries, undated)

	Group	Occurrence	Maximum Catch (kg./hr.)
1.	Sculpin	abundant	315
2.	Capelin	common	660
3.	Smelt	common	115
4.	Rockfish (ex. _S. alutus_)	moderate	890
5.	Ronquil	moderate	100
6.	Eelpout	moderate	70
7.	Hake	occasional	155
8.	Sandfish	occas.	85
9.	Pricklebacks	occas.	85
10.	Skate	occas.	70
11.	Blennies	occas.	40
12.	Atka Mackerel	occas.	20
13.	Lumpsucker	Rare	65
14.	Giant Wrymouth Eel	Rare	20
15.	Tomcod	Rare	10
16.	Greenlings	Rare	Trace
17.	Sand Lance	Rare	Trace
18.	Poachers	Rare	Trace

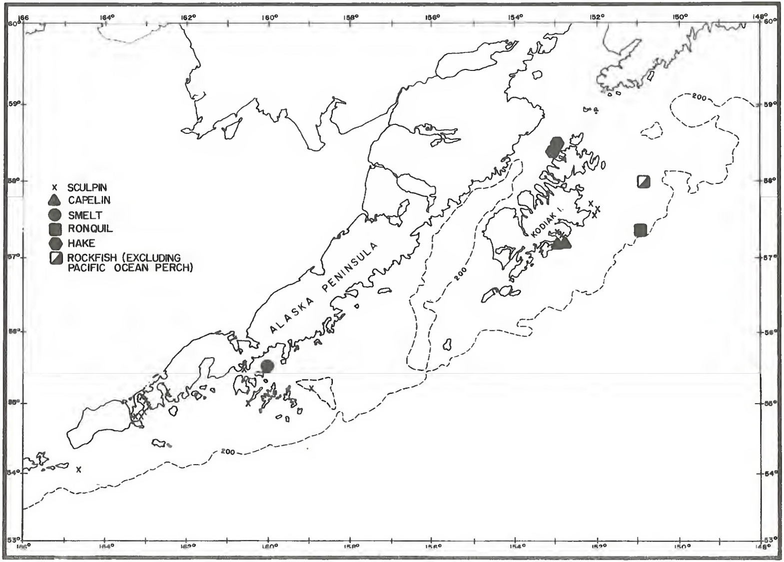

Figure 103. Location of large trawl catches of noncommercial fish reported by the National Marine Fisheries Service in the Western Gulf of Alaska; unweighted composite of data collected over a period of 23 years (from National Marine Fisheries Service, undated).

TABLE 35

Noncommercial Fishes of The Western Gulf of Alaska
(from Quast and Hall 1972; Larkins 1964; Marine Advisers 1971)

Family Agonidae (poachers)
- *Anoplagonus inermis*
- *Aspidophoroides bartoni*
- *Asterotheca alascana*
- *A. infraspinata*
- *Bathyagonus nigripinnus*
- *Bothragonus swani*
- *Pallasina barbata*
- *Podothecus acipenserinus*
- *Sarritor frenatus*
- *S. leptorhynchus*

Family Ammodytidae (sandlances)
- *Ammodytes hexapterus*

Family Bathylagidae (deepsea smelts)
- *Bathylagus stilbius*

Family Bathymasteridae (ronquils)
- *Bathymaster caeruleofasciatus*
- *B. signatus*
- *Ronquilus jordani*

Family Bramidae (pomfrets)
- *Brama japonica*

Family Carangidae (jacks and scads)
- *Trachurus symmetricus*

Family Cottidae (sculpins)
- *Artediellus pacificus*
- *Blepsias bilobus*
- *Cottus aleuticus*
- *Dasycottus setiger*
- *Enophrys diceraus*
- *Eurymen gyrinus*
- *Gymnocanthus galeatus*
- *G. pistilliger*
- *G. tricuspis* (?)
- *Hemilepidotus* sp.
- *H. jordani*
- *Hemitripterus villosus*
- *Icelinus borealis*
- *Icelus spatula*
- *I. spiniger*
- *I. uncinalis*
- *Leptocottus armatus*
- *Malacocottus kincaidi*
- *Myoxocephalus* sp.
- *M. jaok*
- *M. polyacanthocephalus*
- *Nautichthys pribilovius*
- *Oxycottus acuticeps*
- *Radulinus asprellus*
- *Triglops forficata*
- *T. macellus*
- *T. metopias*
- *T. pingeli*
- *T. scepticus*
- *Ulca bolini*

TABLE 35, Continued.

Family Cyclopteridae (lump fishes and snailfishes)

Aptocyclus ventricosus
Careproctus abbreviatus
C. colletti
C. gilberti
C. ostentum
C. spectrum
Cyclopteropis phrynoides
Eumicrotremus orbis
Liparis cyclostigma
L. dennyi
L. mucosus
L. ochotensis

Family Hexagrammidae (greenlings)

Hexagrammos decagrammus
H. stelleri
Pleurogrammus momopterygius
Ophiodon elongatus

Family Gadidae (cods)

Antimora rostrata
Eleginus gracilis
Microgadus proximus

Family Lamnidae (mackerel sharks)

Lamna ditropis

Family Lumpenidae (Eel-blennies)

Lumpenus sagitta

Family Macrouridae (rattails)

Coryphaenoides sp.

Family Merluccidae (Hake)

Merluccius productus

Family Osmeridae (smelt)

Hypomesus pretiosus
Mallotus villosus
Osmerus eperlanus
Spirinchus thaleichthys
Thaleichthys pacificus

Family Petromyzontidae (lampreys)

Lampetra japonica

Family Pholididae (gunnels)

Apodichthys flavidus

Family Psychrolutidae

Psychrolutes paradoxus

Family Rajidae (skates)

Raja kincaidi

Family Scombridae (tunas)

Thunnus thynnus

Family Scorpaenidae (rockfishes)

Sebastes aleutianus
S. polyspinis

TABLE 35, Continued.

S. ciliatus
S. diploproa
S. melanops
S. mystinus (?)
S. variegatus
S. zacentrus
Sebastolobus sp.
S. alascanus

Family Squalidae (dogfishes)
Squalus acanthias

Family Stichaeidae (pricklebacks)
Anisarchus medius
Chirolophis polyactocephalus
Delopepis gigantea
Leptoclinus maculatus
Lumpenella longirostris
Lumpenus sagitta
Lyconectes aleutensis
Xiphister atropurpureus

Family Trichodontidae (sandfishes)
Trichodon trichodon

Family Zoarcidae (eelpouts)
Embryx crotalina
Lycodes brevipes
L. diapterus

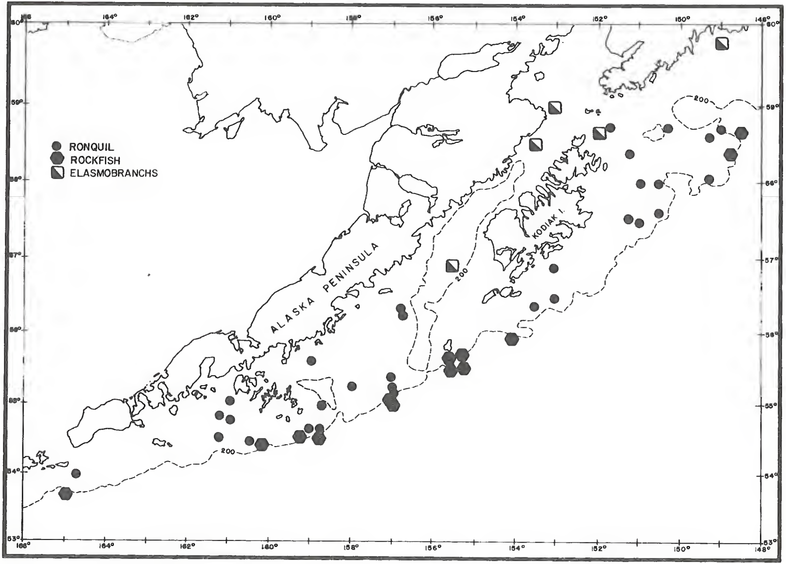

Figure 104a. Location of large trawl catches of noncommercial fish reported by the International Pacific Halibut Commission in the Western Gulf of Alaska (from International Pacific Halibut Commission 1964).

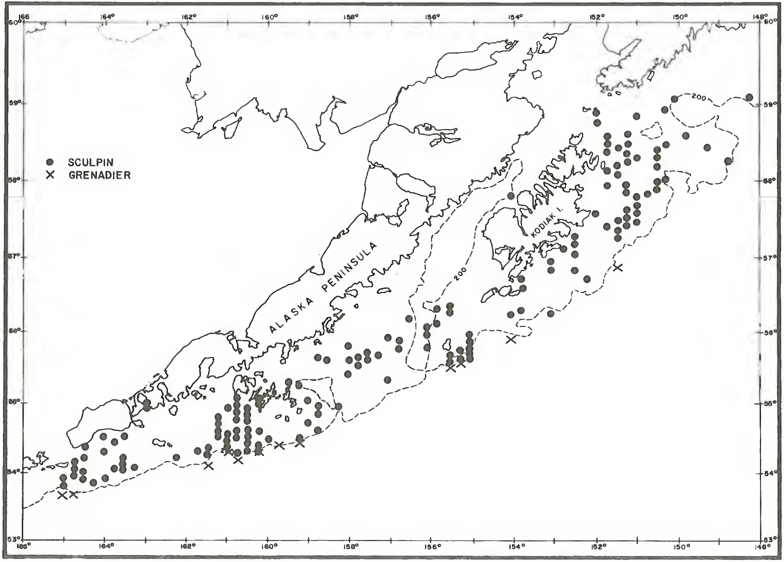

Figure 104b. Location of large trawl catches of noncommercial fish reported by the International Pacific Halibut Commission in the Western Gulf of Alaska (from International Pacific Halibut Commission 1964).

Elasmobranches, both Rajidae and Squalus acanthias, were encountered in small numbers at all depths with skates (Rajidae) found in slightly greater abundance (Alverson et al. 1964).

Sculpins and rattails comprised the highest proportion of miscellaneous fish encountered by Alverson et al. (1964). Sculpins were most frequent from the surface to 185 m., while rattails were the dominant roundfish below 365 m. off the Alaska Peninsula.

The Faculty of Fisheries (1957, 1961, 1966, 1968, 1969) reported species identified from larvae obtained in plankton tows and adults caught in bottom trawls. Scheffer (1959) and Marine Advisers (1971) recorded several additional inshore species. Quast and Hall (1972) have systematically reviewed Alaskan fishes. All species recorded in the study area are included in Table 35.

Pollock

Pollock, Theragra chalcogrammus, in the North Pacific (primarily in the Bering Sea) have yielded the largest annual harvest of food fish in the world since the decline of the South American anchoveta fishery. Catches in the Western Gulf have grown dramatically in the past decade with combined harvests by Japan and the USSR now totaling over 10,000 metric tons annually. The United States has never harvested this species in quantity (Buck 1973). Pollock are regularly harvested from the area shown in Figure 105 in the Western Gulf.

Exploratory fishing drags of the National Marine Fisheries Service (undated) indicated a major concentration of pollock southeast of Kodiak Island along the edges of Albatross Bank (Figure 106). Many large catches were made in late spring between 110 and 155 m., although good quantities were evident from 75 to 265 m. Catches to nearly 12,000 kg./hr. were reported. Caution, similar to that mentioned previously for benthic fauna, should be observed in the interpretation of incidental trawl catches.

A more recent National Marine Fisheries Service survey conducted in 1972 in the Kodiak area and reported by Alton and Nicholl (1973) found pollock concentrated in the same areas between 110 and 240 m. Catches averaging 710 to 890 kg./hr. were calculated, indicating a substantial resource (Figure 107).

The International Pacific Halibut Commission (1964) reported catches of pollock in excess of 90 kg./hr. at the station locations indicated in Figure 108. Pollock were taken in quantity along the continental shelf edge and along gullies and canyons within the shelf. Caution, similar to that mentioned previously for benthic fauna, should be observed in the interpretation of incidental trawl catches.

An early estimate by the U.S. Bureau of Commercial Fisheries (1965) placed the potential annual harvest of pollock for the Alaska Peninsula between 4.2 and 5.6 thousand metric tons. These fish ranged

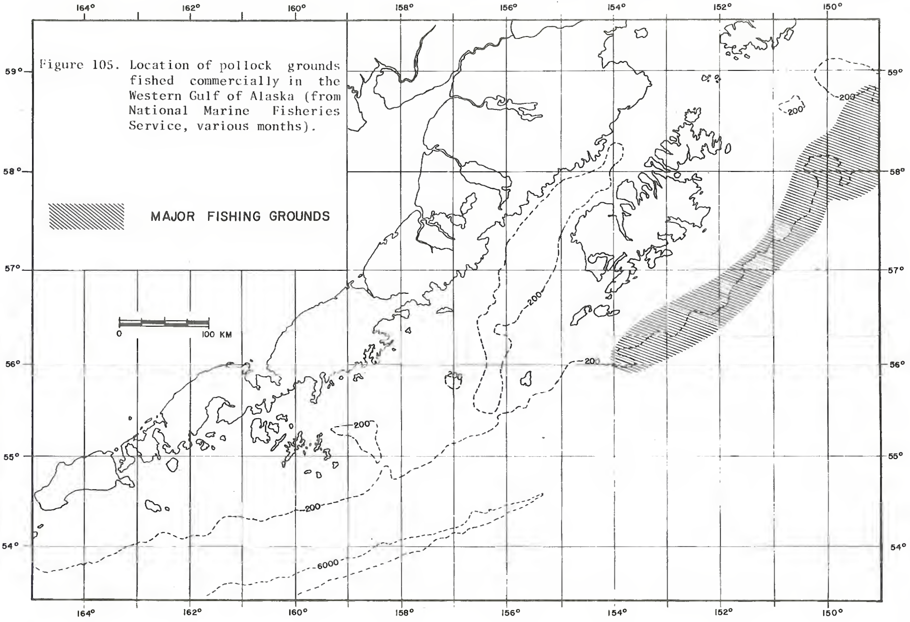

Figure 105. Location of pollock grounds fished commercially in the Western Gulf of Alaska (from National Marine Fisheries Service, various months).

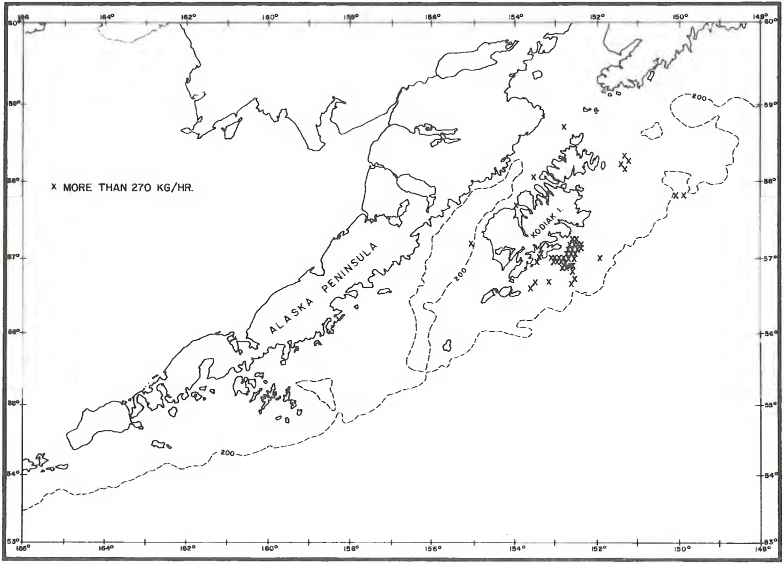

Figure 106. Location of large trawl catches of pollock reported by the National Marine Fisheries Service in the Western Gulf of Alaska; unweighted composite of data collected over a period of 23 years (from National Marine Fisheries Service, undated).

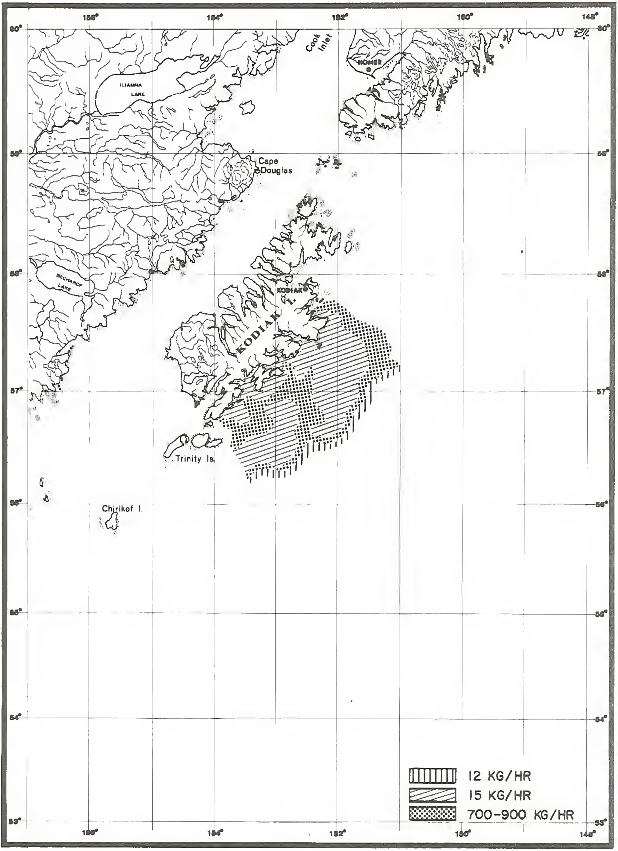

Figure 107. Pollock distribution and potential in the Kodiak vicinity (from Alton and Nicholl 1973).

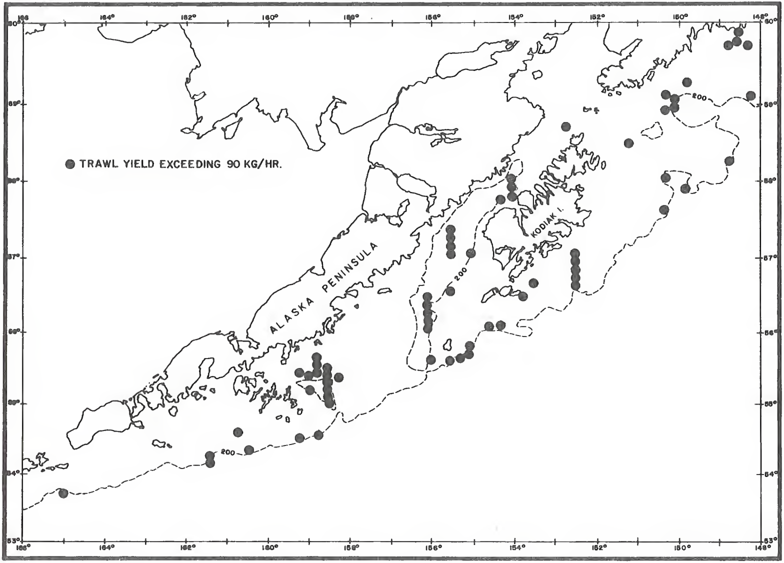

Figure 108. Location of large trawl catches of pollock reported by the International Pacific Halibut Commission in the Western Gulf of Alaska (from International Pacific Halibut Commission 1964).

in length from 22 to 62 cm. and averaged 33 cm. The 1972 survey found 38 to 46 cm. fish to be the most frequently encountered size class of adults off Kodiak (Alton and Nicholl 1973). The Food and Agriculture Organization of the United Nations (1972) estimated the maximum annual yield of the entire Northern Gulf of Alaska to be 25,000 metric tons.

On the Alaska Peninsula, pollock may occur at greater depths than off Kodiak. Alverson et al. (1964) found the maximum average catch on the Alaska Peninsula between 275 and 365 m., decreasing progressively at shallower depths. In Shelikof Strait, they calculated maximum average catches from 180 to 275 m.

Life history of the pollock has not been studied in the Western Gulf. In other North Pacific areas, pollock form dense schools in their spawning migrations during late winter through early summer to inshore shallows where they spawn from 200,000 to 1.5 million eggs. These eggs are planktonic, and hatch in the upper water in 12 days at 6 to 7 degrees C as they float with the currents (Kasahara 1961). As juveniles develop, they progressively become more bottom-dwelling in habit. Pollock mature at three to four years when they are 30 to 40 cm. in length. Pollock may live as long as twelve to fifteen years (Alton and Nicholl 1973). Early life history and life cycle are depicted in Figure 109.

Pollock prefer planktonic crustaceans and small fish as food. Alton and Nicholl (1973) reported daily vertical movements of both juveniles and adults which are probably related to feeding habits. Kasahara (1961) reported temperature to be important in determining area and vertical distribution.

Pacific Cod

The earliest commercial fishery in the study area was based on Pacific cod, Gadus macrocephalus. This fishery was developed by the United States shortly before the purchase of Alaska, but U.S. participation has declined. Less than 1,500 metric tons per year are now harvested by Japan all along the Gulf Coast incidental to blackcod and Pacific Ocean perch fisheries (Buck 1973).

Exploratory fishing drags of the National Marine Fisheries Service (undated) located scattered concentrations of Pacific cod south and east of Kodiak as well as west of the Shumagin Islands (Figure 110). Large quantities were found at depths between 80 and 215 m. with no optimum depth discerned. This species was moderately abundant throughout the trawling period from late spring to early autumn. Caution, similar to that mentioned previously for benthic fauna, should be observed in the interpretation of incidental trawl catches.

The International Pacific Halibut Commission (1964) reported catches of Pacific cod in excess of 90 kg./hr. at station locations indicated in Figure 111. Pacific cod were taken in quantity along the outer continental shelf and along gullies and canyons within the shelf. Caution, similar to that expressed previously for benthic fauna, should be observed in the interpretation of incidental trawl catches.

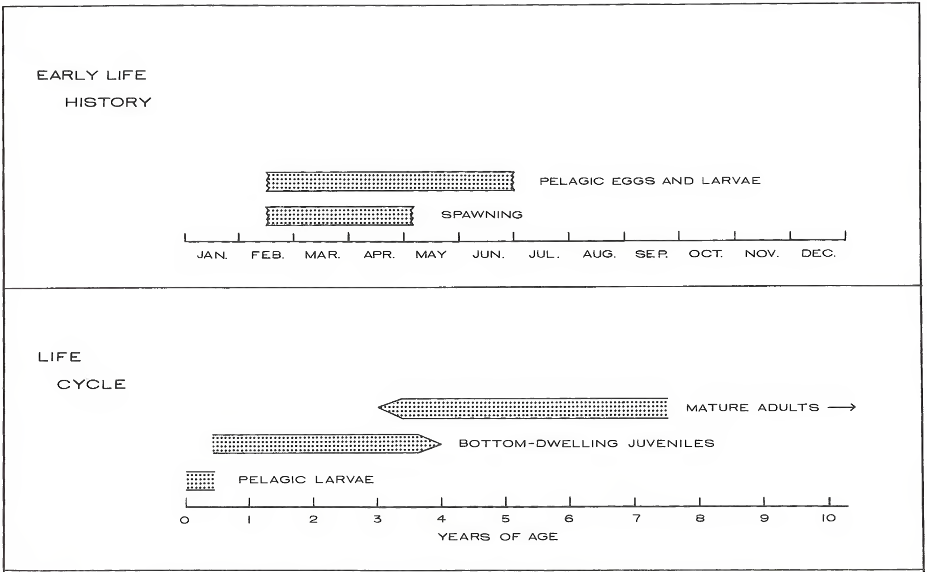

Figure 109. Early life history and life cycle of pollock, Theragra chalcogrammus (from Kasahara 1961, Alton and Nicholl 1975).

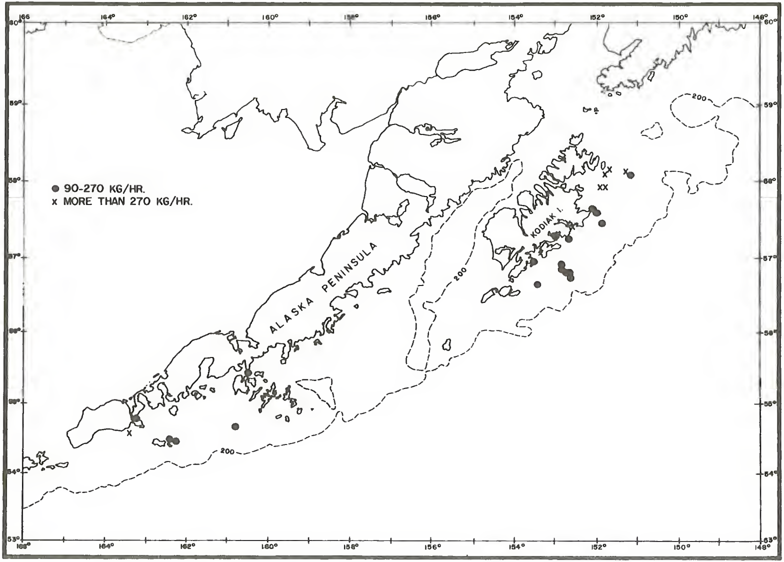

Figure 110. Location of large trawl catches of Pacific cod reported by the National Marine Fisheries Service in the Western Gulf of Alaska; unweighted composite of data collected over a period of 23 years (from National Marine Fisheries Service, undated).

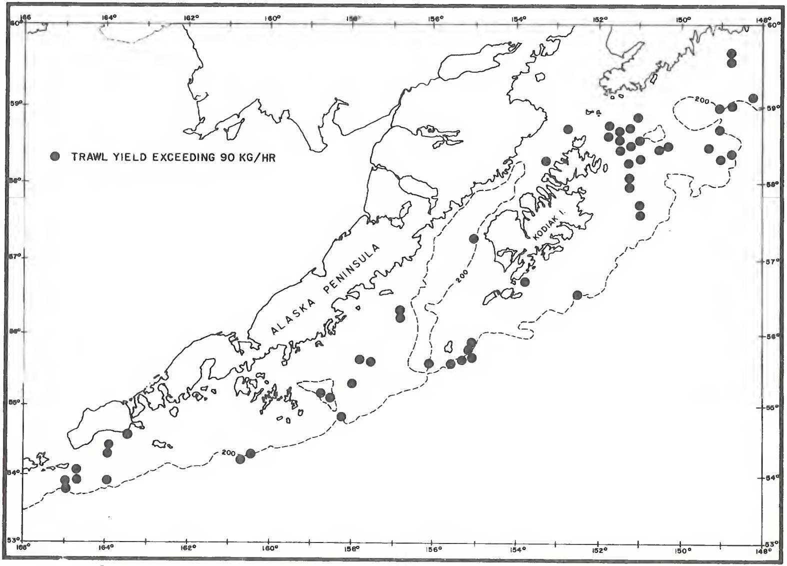

Figure 111. Location of large trawl catches of Pacific cod reported by the International Pacific Halibut Commission in the Western Gulf of Alaska (from International Pacific Halibut Commission 1964).

The U.S. Bureau of Commercial Fisheries (1965) found Pacific cod most abundant at depths less than 90 m. in Gulf of Alaska and Alaska Peninsula waters. For the Alaska Peninsula, the potential annual yield was estimated at between 4.1 and 5.4 thousand metric tons. The Food and Agriculture Organization of the United Nations (1972) estimated the maximum sustainable annual yield of the entire Northern Gulf of Alaska to be 30,000 metric tons. Alverson et al. (1964) found this species to be the dominant roundfish in waters of less than 180 m. deep over the continental shelf in the study area. Greatest average catches were found between 90 and 180 m. with fish from 22 to 72 cm. in length (average length was 42 cm.).

Pacific cod have well-defined seasonal movements which appear to be controlled by temperature. They migrate to deeper offshore waters for the winter.

The life history of the Pacific cod has not beeen studied in the Western Gulf. In other North Pacific areas, spawning generally takes place during late winter and spring with 1.4 to 6.4 million eggs per female sinking to the bottom where they hatch in 20 days at 4 degrees C (Kasahara 1961). Maturity is reached in two to three years in British Columbia, and individuals may live eight to ten years (Nanaimo Biological Station 1966b). Kasahara (1961) reported Soviet studies in colder waters where these fish do not mature until five to nine years of age. Early life history and life cycle are shown on Figure 112.

This species feeds upon other bottom fish and crustaceans. In coastal areas, herring may become important as food. Growth is rapid; individuals may reach a length of 60 cm. in three to five years.

Blackcod

Blackcod, also called sablefish, have supported a Japanese fishery harvesting less than 5,000 metric tons annually in the study area this past decade with only token United States harvest (Buck 1973). South Korea has recently begun fishing for blackcod off Kodiak. Blackcod are regularly harvested from the area shown in Figure 113 in the Western Gulf.

Blackcod, *Anoplopoma fimbria*, were uncommon in exploratory fishing drags of the National Marine Fisheries Service (undated) because these fish occur at depths which were not trawled sufficiently (Figure 114). Substantial quantities were encountered from 115 to 465 m. Blackcod are believed to migrate to even deeper waters during the winter, and this might be associated with spawning activity (Reeves 1972). Caution, similar to that expressed previously for benthic fauna, should be observed in the interpretation of incidental trawl catches.

The International Pacific Halibut Commission (1964) reported catches of blackcod in excess of 90 kg./hr. at station locations indicated in Figure 115. Blackcod were taken throughout the Western Gulf along the continental shelf edge and margin. Caution, similar to that mentioned previously for benthic fauna, should be observed in the interpretation of incidental trawl catches.

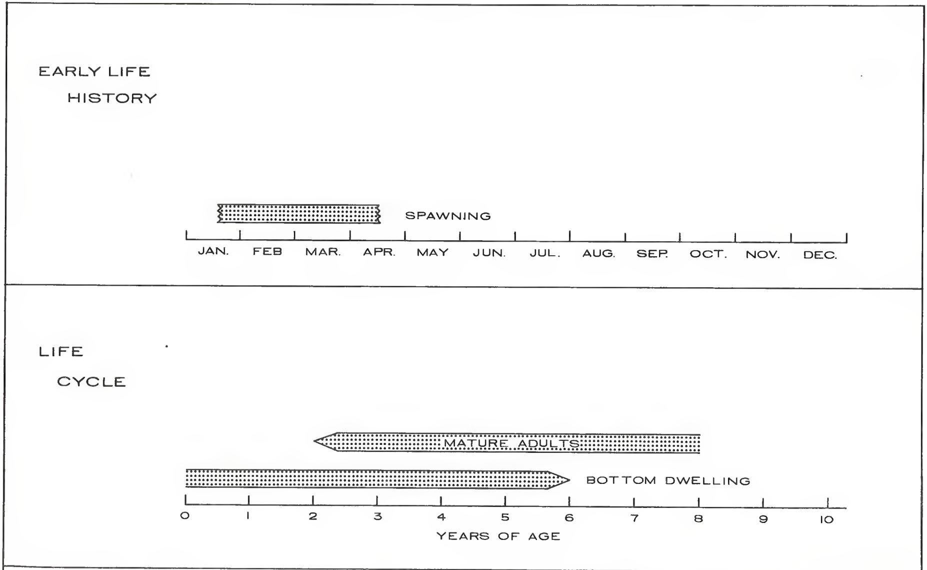

Figure 112. Early life history and life cycle of Pacific cod, *Gadus macrocephalus* (from Kasahara 1961, Nanaimo Biological Station 1966b).

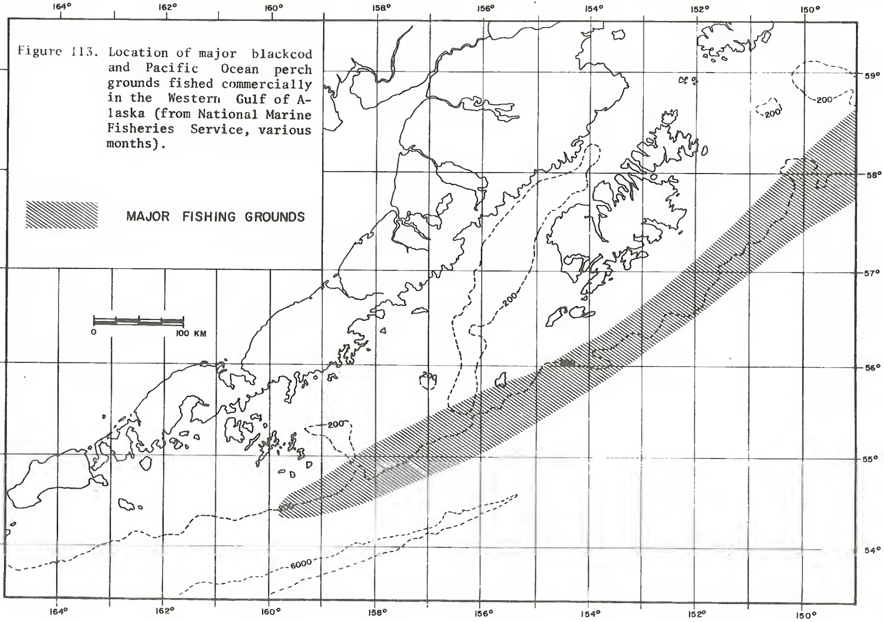

Figure 113. Location of major blackcod and Pacific Ocean perch grounds fished commercially in the Western Gulf of Alaska (from National Marine Fisheries Service, various months).

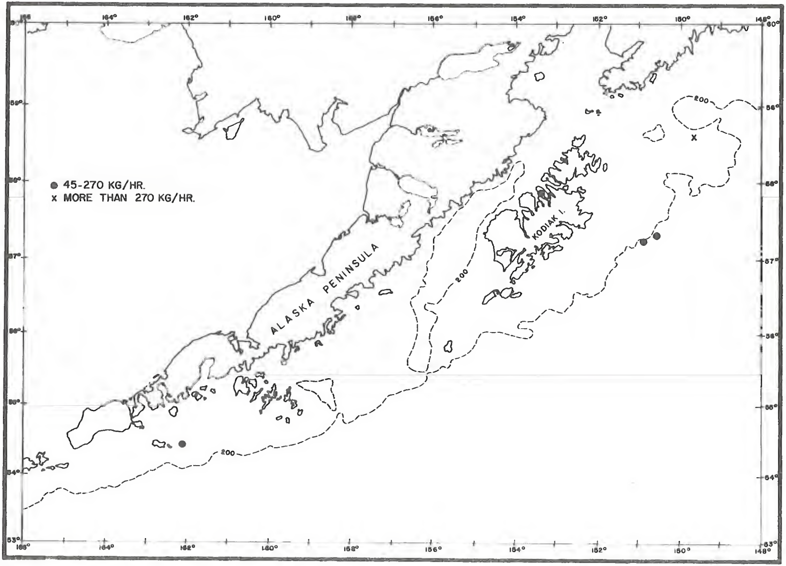

Figure 114. Location of large trawl catches of blackcod reported by the National Marine Fisheries Service in the Western Gulf of Alaska; unweighted composite of data collected over a period of 23 years (from National Marine Fisheries Service, undated).

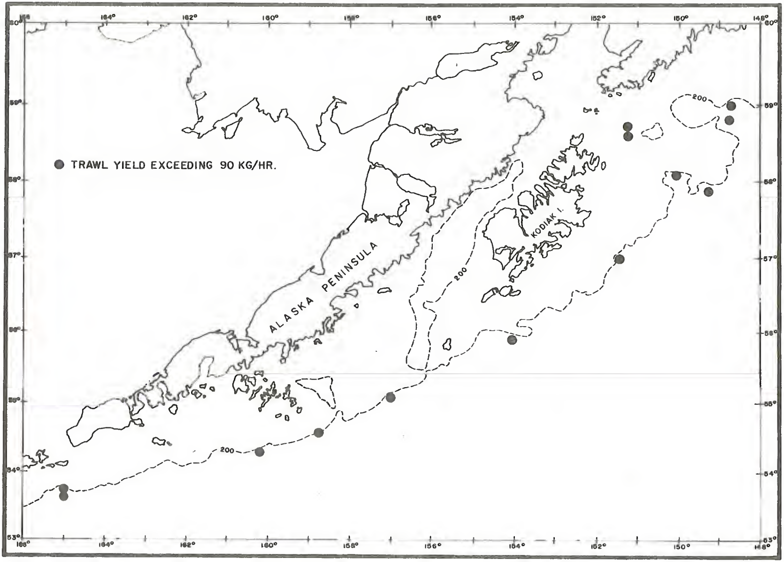

Figure 115. Location of large trawl catches of blackcod reported by the International Pacific Halibut Commission in the Western Gulf of Alaska (from International Pacific Halibut Commission 1964).

The U.S. Bureau of Commercial Fisheries (1965) found blackcod to be the dominant deepwater fish in the Alaska Peninsula region, being most abundant at depths of between 365 and 550 m. on the continental slope. The potential annual yield from the Alaska Peninsula was calculated between 6.3 and 9.1 thousand metric tons of fish averging 51 cm. in length. The Food and Agriculture Organization of the United Nations (1972) estimated the maximum sustainable yield of the entire Northern Gulf of Alaska to be 18,000 metric tons annually.

Life history of the blackcod has not been studied in the Western Gulf. In other North Pacific areas, spawning takes place in the late winter after which developing eggs and larvae float in the surface water. Immature fish, less than 30 cm. in length, may school in surface coastal waters and at shallow depths. Early life history and life cycle are depicted in Figure 116.

Blackcod mature in six to eight years, although they may reach commercial size in only five years. Food consists of small fish and crustaceans (Nanaimo Biological Station, undated). Individuals may live nine years or more (Reeves 1972) and exceed 4 kg. in weight and 75 cm. in length (Shubnikov 1963).

Herring

A substantial herring fishery has existed in the Kodiak district throughout the second quarter of this century, reaching a peak of more than 45,000 metric tons in 1947. Large numbers of herring, *Clupea harengus pallasii*, were found in almost all Kodiak Island bays (Figure 117). After the market for reduction herring collapsed in the late 1950s, a limited Japanese market for herring roe kept the fishery going (U.S. Army, Corps of Engineers 1973). In recent years, the fishery has concentrated in Uyak, Uganik, and Chiniak Bays and in the Old Harbor area (Alaska Department of Fish and Game 1973b).

Few large catches of herring were caught in the exploratory fishing drag program of the National Marine fisheries Service (undated), since these fish are not regularly concentrated near the bottom in deeper waters. Catches which exceeded 90 kg./hr. were taken during September in bays on both sides of Shelikof Strait.

Limited data on herring life history have been collected within the Western Gulf of Alaska. Gulf of Alaska herring remain inshore during most of their life cycle. Spawning takes place along the shore from late April to early June in the Kodiak area. Females discharge eggs which are fertilized by milt (spermatozoa) released by the males. Fertilized eggs adhere to kelp, eelgrass or any convenient substrate. Individual females deposit an average of 20,000 eggs each year (Nanaimo Biological Station 1966c).

Eggs develop for about 16 days before hatching into planktonic larvae. Mortality in the egg and larval stages can be quite variable. It may be excessive in some years, resulting in the dominance of individual year classes in herring populations. Herring gradually develop from larvae into juveniles during a two-month planktonic existence. Juvenile herring form schools and frequent kelp beds for protection during the summer.

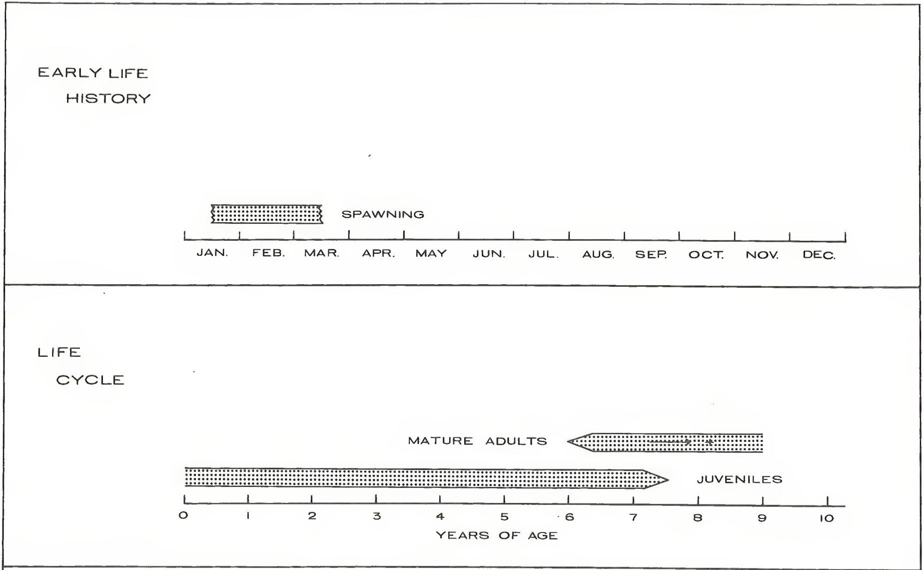

Figure 116. Early life history and life cycle of blackcod, *Anoplopoma fimbria* (from Nanaimo Biological Station, undated).

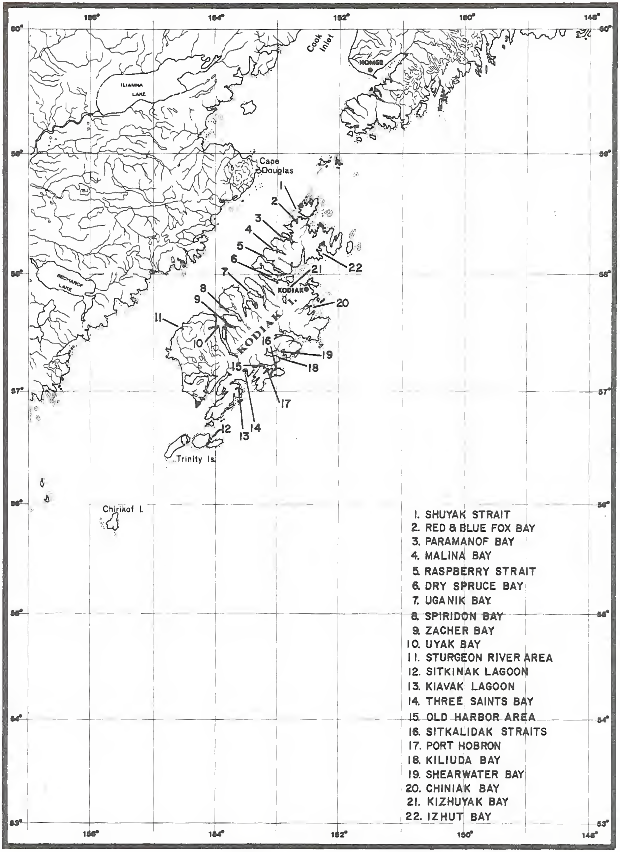

Figure 117. Location of major herring grounds fished commercially in the Kodiak vicinity (from U.S. Army, Corps of Engineers 1973).

Juveniles move slightly offshore in early autumn. Few details are known about juvenile life history prior to three or four years of age, when individuals first return to spawn (Nanaimo Biological Station 1966c). Tagging programs may be able to delineate separate migratory populations, but no studies of this scope have been undertaken within the Western Gulf. Early life history and life cycle are shown in Figure 118.

Herring feed upon zooplankton and migrate vertically in pursuit of this diet. Growth has not been adequately studied in the Gulf region, although fish older than six or seven years are only rarely encountered (Reeves 1972).

Pacific Ocean Perch

Soviet and Japanese trawlers have fished extensively for Pacific Ocean perch, Sebastes alutus, within the study area throughout the past decade with harvests approaching 50,000 metric tons in the mid-1960s (Buck 1973). Soviet literature has contributed substantially to our understanding of this species and its life history. Pacific Ocean perch are regularly harvested from the areas shown in Figure 113 in the Western Gulf.

Exploratory fishing drags by the National Marine Fisheries Service (undated) recorded large quantities of this species east of Kodiak Island over the outer continental shelf and slope (Figure 119). Scattered concentrations were also recorded in the Shelikof Strait. Fish appear concentrated between 160 and 250 m. Caution, similar to that expressed previously for benthic fauna, should be observed in the interpretation of incidental trawl catches.

The International Pacific Halibut Commission (1964) reported catches of Pacific Ocean perch in excess of 90 kg./hr. at the station location indicated in Figure 120. Pacific Ocean perch were taken in quantity along the continental shelf edge and along gullies and canyons within the shelf. Caution, similar to that expressed previously for benthic fauna, should be observed in the interpretation of incidental trawl catches.

The U.S. Bureau of Commercial Fisheries (1965) identified large concentrations between 200 and 300 m. in Seward and Albatross Gullies, south of Unimak Pass, and in the canyon entering Shelikof Strait. Generally, fish were encountered 20 to 60 m. above rocky bottoms and in submarine canyons and gullies. Fish ranged from 17 to 43 cm. in length and averaged 35 cm. The potential annual yield for the Alaska Peninsula region was calculated to be between 4.5 and 13.6 thousand metric tons. The Food and Agriculture Organization of the United Nations (1972) estimated the maximum sustainable yield of the entire Northern Gulf of Alaska to be 95,000 metric tons annually.

Soviet investigations (Lyubimova 1965) found Pacific Ocean perch inhabiting depths of 100 to 450 m. or more. Concentrations were associated with the Alaska Current in temperature regimes of 4 to 6.5 degrees C. Maximum concentration occurs during summer and autumn east and southeast of Kodiak Island, southwest of the Shumagin Islands, and south of Unimak Island (Figure 121).

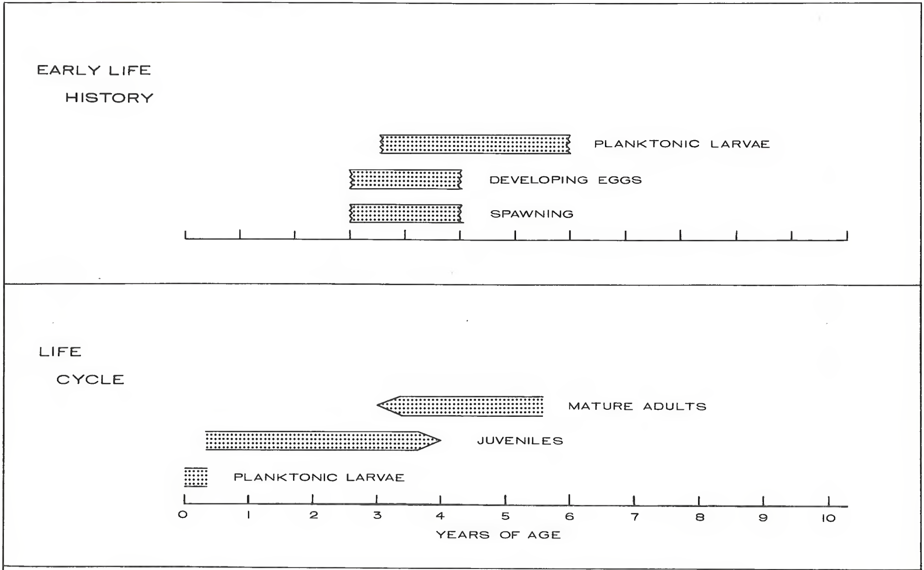

Figure 118. Early life history and life cycle of herring, Clupea harengus pallasii (from Nanaimo Biological Station 1966c).

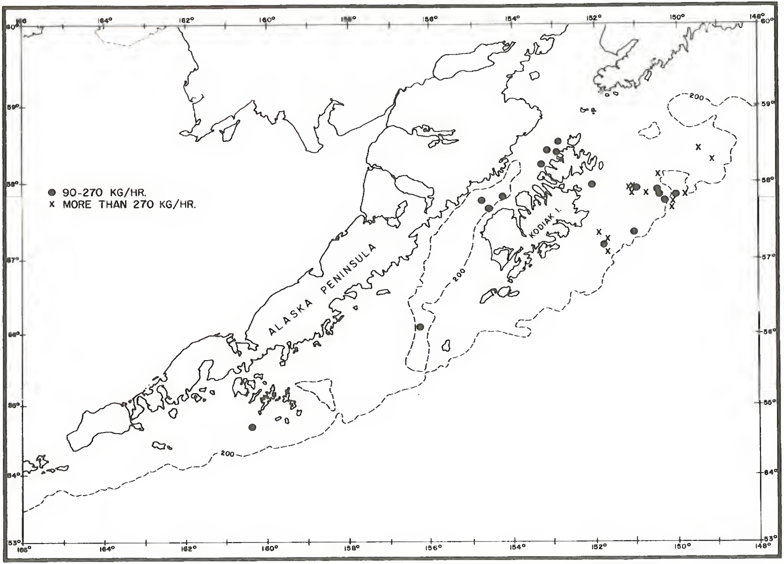

Figure 119. Location of large trawl catches of Pacific Ocean perch reported by the National Marine Fisheries Service in the Western Gulf of Alaska; unweighted composite of data collected over a period of 23 years (from National Marine Fisheries Service, undated).

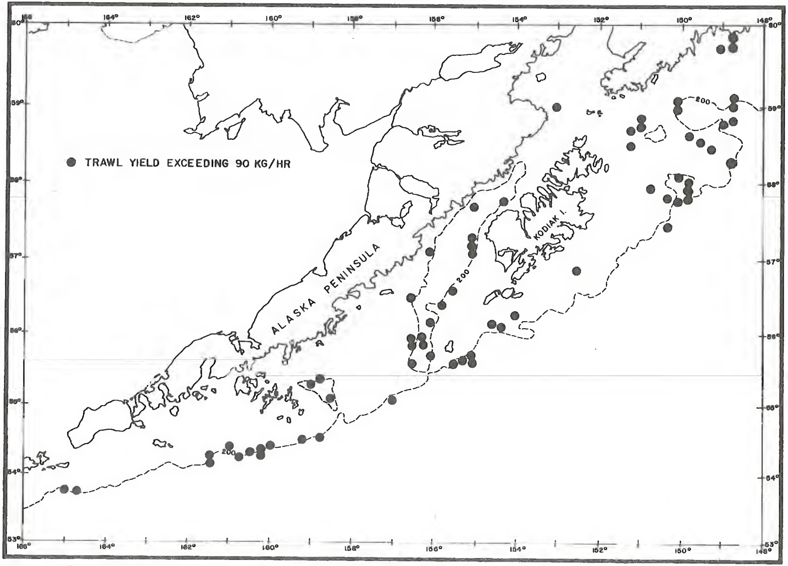

Figure 120. Location of large trawl catches of Pacific Ocean perch reported by the International Pacific Halibut Commission in the Western Gulf of Alaska (from International Pacific Halibut Commission 1964).

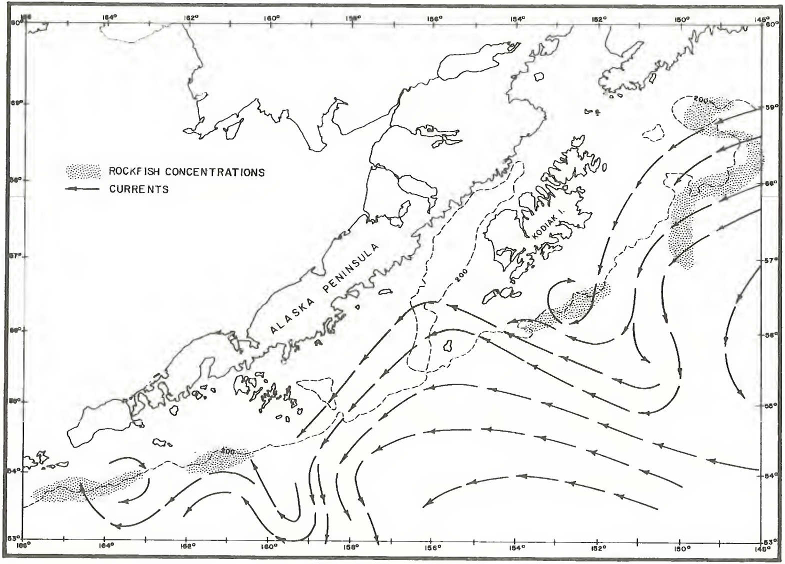

Figure 121. Concentrations of Pacific Ocean perch reported in Soviet investigations (from Lyubimova 1965).

Pacific Ocean perch stocks of the Western Gulf of Alaska are highly mobile and undertake substantial seasonal migrations (Lyubimova 1965). These movements appear linked to reproduction and wintering activities of the species. Following copulation, which occurs within the previously mentioned concentration areas in late September through November, females depart for the northern part of the Gulf, traveling eastward from Portlock Bank. Arriving in January, the females have avoided the cooler winter water temperatures of the Western Gulf. Males congregate for overwintering in the Chirikof-Kodiak Island area or further north. Their migration to wintering areas occurs in late December and January.

As waters warm in spring and zooplankton populations increase, Pacific Ocean perch gradually return to the Western Gulf. Concentrations may reappear in March or April off Kodiak Island, and as late as July or August in the Unimak area.

Limited data on Pacific Ocean perch life history have been collected by Soviet investigators within the Western Gulf. Pacific Ocean perch mature initially at five to seven years when they are 24 to 27 cm. in length. Fertilization in late September and October is internal and precedes the wintering migration of females. Depending on the size of the female, from 10,000 to 300,000 eggs develop internally until larvae are expelled in late April to early June (Lyubimova 1964). Larvae may be released at depths of 200 to 250 m., slightly above the bottom. Highest larval abundance has been observed in the Yakutat area, decreasing to its lowest point off Unimak Island (Lisovenko 1964).

Juvenile rockfish are generally found in cooler, shallower water of the Western Gulf. They gradually become more demersal in habit during their third year of life. Early life history and life cycle are depicted in Figure 122.

Individual Pacific Ocean perch reach a maximum length of 50 cm. and a maximum age of 30 to 35 years (Reeves 1972). Active feeding and weight gain occur primarily in the feeding concentrations along the outer shelf and slope from May to September. Although their diet is composed primarily of planktonic crustaceans, some feeding occurs upon benthic species of mollusks and small fish. Diurnal, vertical movements of Pacific Ocean perch are believed to be associated with feeding behavior (Lyubimova 1965). Individuals may reduce their food intake in autumn and winter; adults usually do so to a greater extent than young fish.

Flatfish (excluding halibut)

The commercial harvest of flatfish in the Western Gulf peaked at slightly less than 6,000 metric tons annually in the late 1960s. The current areas fished for these species are shown in Figure 123 (Buck 1973). Flatfish accounted for more than 50 percent of all fish caught during exploratory trawling on the inner continental shelf (Alverson et al. 1964). Thirteen species of flatfish, excluding halibut, were recorded from exploratory fishing drags of the National Marine Fisheries Service (undated) in the Western Gulf of Alaska (Table 36).

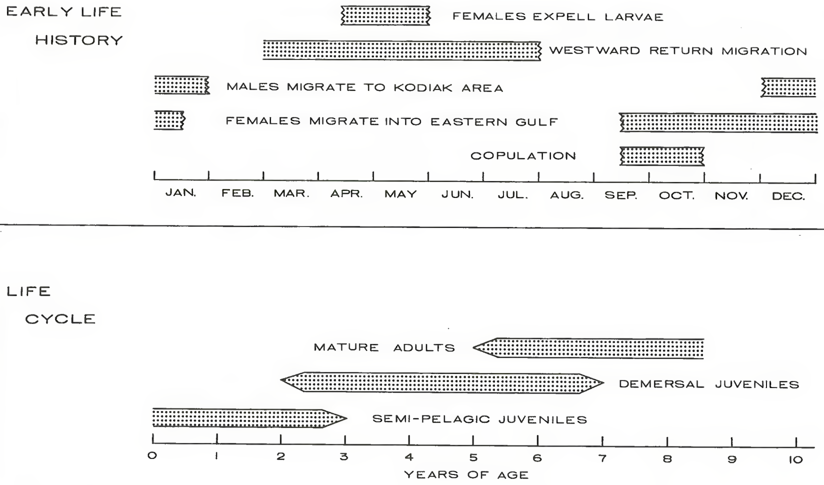

Figure 122. Early life history and life cycle of Pacific Ocean perch, Sebastes alutus (from Sisovenko 1964, Lyubimova 1964).

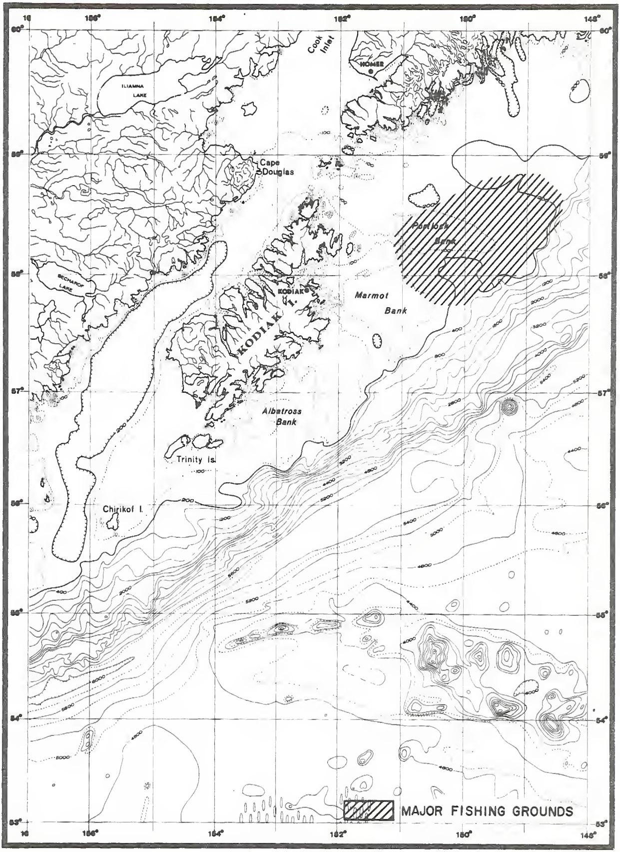

Figure 123. Location of flatfish grounds fished commercially in the Western Gulf of Alaska (from National Marine Fisheries Service, various months).

TABLE 36

Flatfish (excluding halibut) species of the Western Gulf of Alaska (from Alverson et al. 1964; National Marine Fisheries Service, undated)

	Scientific Name	Common Name
1.	Atheresthes stomias	Turbot
2.	Citharichthys sordidus	Mottled sand dab
3.	Glyptocephalus zachirus	Rex sole
4.	Hippoglossoides elassodon	Flathead sole
5.	Isopsetta isolepis	Butter sole
6.	Lepidopsetta bilineata	Rock sole
7.	Limanda aspera	Yellowfin sole
8.	Lyopsetta exilis	Slender sole
9.	Microstomus pacificus	Dover sole
10.	Parophrys vetulus	English sole
11.	Platichthys stellatus	Starry flounder
12.	Pleuronectes quadrituberculatus	Alaska Plaice
13.	Psettichthys melanostictus	Sand Sole

Only seven species were caught at a rate of 90 kg./hr. or greater. The locations of large catches for these species are indicated in Figure 124. Many large catches were taken on the continental shelf and slope east of Kodiak Island. Turbot and flathead sole yielded the greatest number of large catches and are the most abundant species of flatfish with potential commercial value in the Western Gulf. Caution, similar to that expressed previously for benthic fauna, should be observed in the interpretation of incidental trawl catches.

The International Pacific Halibut Commission (1964) reported flatfish catches in excess of 90 kg./hr. at the station locations indicated in Figure 125. Rex and dover soles were found in quantity along the continental shelf edge and slope. Yellowfin sole in inshore shallows and butter sole along bank edges were seldom found in abundance. Rock sole were abundant throughout the study area on offshore banks. Turbot and flathead sole were regularly encountered in large quantity in canyons and gullies on the continental shelf. Caution, similar to that expressed previously for benthic fauna, should be observed in the interpretation of incidental trawl catches.

Distribution of species is related to depth (Alverson et al. 1964). Eight species can be considered shelf inhabitants with their maximum catches recorded at depths less than 90 m. (Table 37). The flathead sole inhabits intermediate depths. The remaining species were most abundant at depths in excess of 275 m.

Turbot has the most commercial potential of the flatfish species in the Western Gulf (U.S. Bureau of Commercial Fisheries 1965). It is the most abundant flatfish species as well as having the largest average size of 37 cm. Potential annual yield for the Alaska Peninsula region alone is estimated at between 20.4 and 27.2 thousand metric tons. The Food and Agriculture Organization of the United Nations (1972) estimated the maximum sustainable yield of the entire Northern Gulf of Alaska to be 60,000 metric tons annually.

Shuntov (1965) found that adult turbot preferred water temperatures of 3 to 4 degrees C. Juveniles are found in shallow water. Shuntov believes that adult migrations to the shallows for spawning, rather than planktonic egg and larval drift or juvenile migration, are primarily responsible for this characteristic.

Flathead and rock sole are also abundant in the Alaska Peninsula region. Their respective potential annual yields have been estimated at 5.4 to 6.8 thousand and 10.4 to 13.6 thousand metric tons (U.S. Bureau of Commercial Fisheries 1965). The Food and Agriculture Organization of the United Nations (1972) estimated the maximum sustainable yields for the entire Northern Gulf of Alaska for these species to be 20,000 and 15,000 metric tons respectively.

Flatfish reproduction and life cycles are not well known. Spawning is believed to occur in late winter through early summer in coastal shallows. Eggs of such species as yellowfin sole are believed to be pelagic, while others such as rock sole are considered demersal. Large flatfish may spawn in excess of two million eggs in a season. Size at maturity and life span are not known (Nanaimo Biological Station, undated).

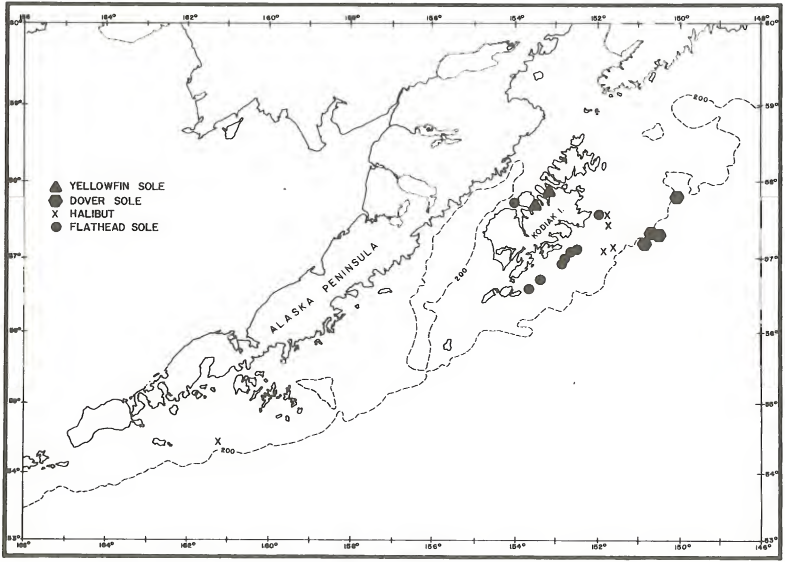

Figure 124a. Location of large trawl catches of flatfish reported by the National Marine Fisheries Service in the Western Gulf of Alaska; unweighted composite of data collected over a period of 23 years (from National Marine Fisheries Service, undated).

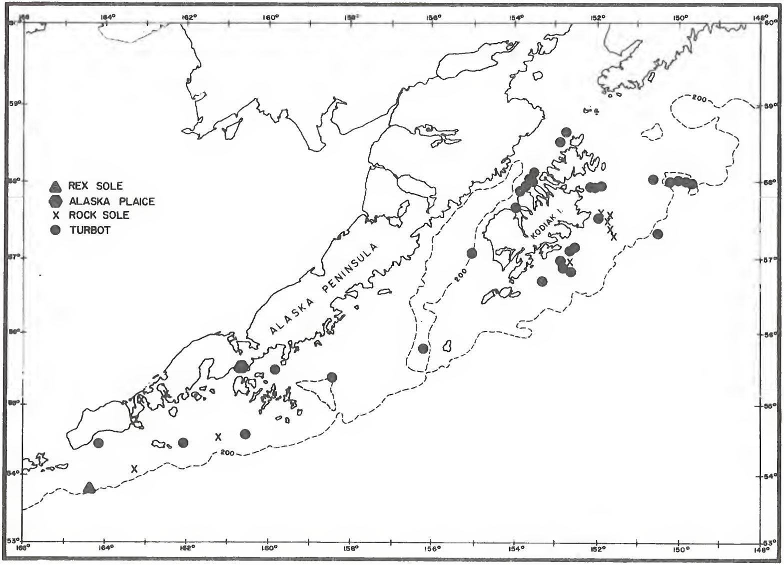

Figure 124b. Location of large trawl catches of flatfish reported by the National Marine Fisheries Service in the Western Gulf of Alaska; unweighted composite of data collected over a period of 23 years (from National Marine Fisheries Service, undated).

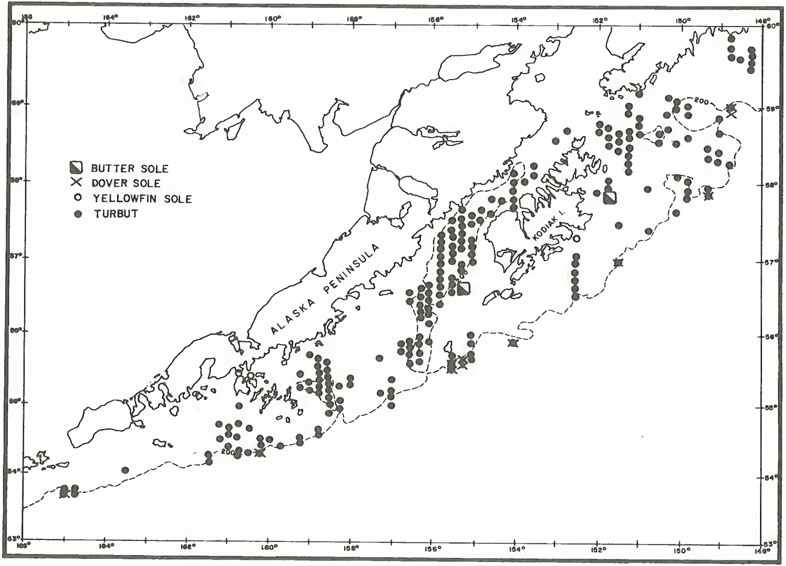

Figure 125a. Location of large trawl catches of flatfish reported by the International Pacific Halibut Commission in the Western Gulf of Alaska (from International Pacific Halibut Commission 1964).

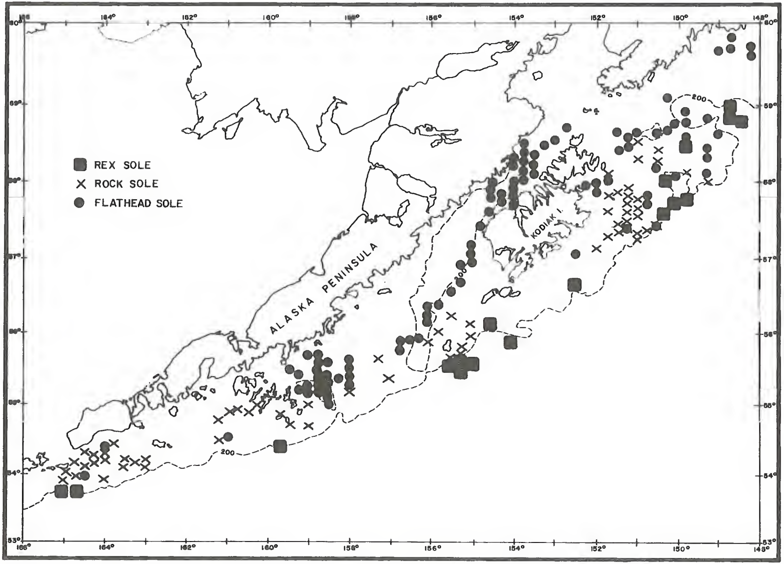

Figure 125b. Location of large trawl catches of flatfish reported by the International Pacific Halibut Commission in the Western Gulf of Alaska (from International Pacific Halibut Commission 1964).

TABLE 37

Pounds of Flatfish caught per hour of Exploratory trawling by Depth Intervals in the Alaska Peninsula Region (from Alverson et al. 1964)

Species	Depth in Meters				
	1-90	90-181	182-272	273-364	365-547
Atherestes	26	137	541	992	698
Citharichthys	T	1	T	0	0
Glyptocephales	1	4	34	26	120
Hippoglossoides	21	80	145	31	2
Isopsetta	6	1	T	T	0
Lepidopsetta	159	46	3	0	0
Limanda	13	8	0	0	0
Microstomus	T	1	6	29	87
Parophrys	T	T	0	0	0
Platichthys	4	T	0	0	0
Pleuronectes	1	T	T	0	0
Psettichthys	1	T	0	0	0

(T = Trace)

Food generally consists of benthic invertebrates and small fish, but varies widely between species (Kasahara 1961).

Halibut

Halibut, Hippoglossus stenolepis, have long supported a commercial fishery in the Gulf of Alaska with harvests in the Western Gulf approaching 15,000 metric tons in the mid 1960s (Buck 1973). Major fishing grounds for halibut in the Western Gulf are shown in Figure 126. Thompson and Van Cleve (1936) reported that along the Gulf coast, west of Cape Spencer, halibut are freely migratory and should be considered as a biological unit stock for management purposes.

Halibut catches averaged highest in weight per hour trawled during exploratory fishing in waters less than 90 m. deep off the Alaska Peninsula. No other region in the Northeastern Pacific produced higher average catches. Over 95 percent of the halibut taken between Chirikof Island and the Shumagin Islands were less than 65 cm. in length (Alverson et al. 1964).

International Pacific Halibut Commission (1964) trawl investigations found halibut most abundant between 65 and 140 m. in the vicinity of Chirikof Island and northest of Kodiak Island (Figure 127). Exploratory fishing drags of the National Marine Fisheries Service (undated) recorded several large catches; most were located east of Kodiak Island in waters 50 to 130 m. deep (Figure 124). Caution, similar to that expressed previously for benthic fauna, should be observed in interpretation of incidental trawl catches of halibut recorded by the National Marine Fisheries Service. Halibut have been recorded at depths to 1,100 m. (Nanaimo Biological Station 1966d).

The Food and Agriculture Organization of the United Nations (1972) estimated the maximum sustainable yield of the halibut for the entire Northern Gulf of Alaska to be 21,000 metric tons annually.

Female halibut usually do not mature until ten to twelve years of age. Males may mature at seven to eight years (Bell and St. Pierre 1970). Spawning takes place from November to January at depths between 275 and 400 m. Large females may produce in excess of 2.5 million eggs during a spawning season.

The specific gravity of the eggs and larvae enables them to remain suspended at midwater depths as they drift with ocean currents. Hatching occurs in about 20 days at 5 degrees C (Forrester and Alderdice 1973). As development proceeds, larvae rise closer to the surface. Inshore surface currents carry many larvae into coastal shallows favorable for growth. At an age of six to seven months, juvenile halibut settle to shallow bottoms. As they grow, they move into progressively deeper waters.

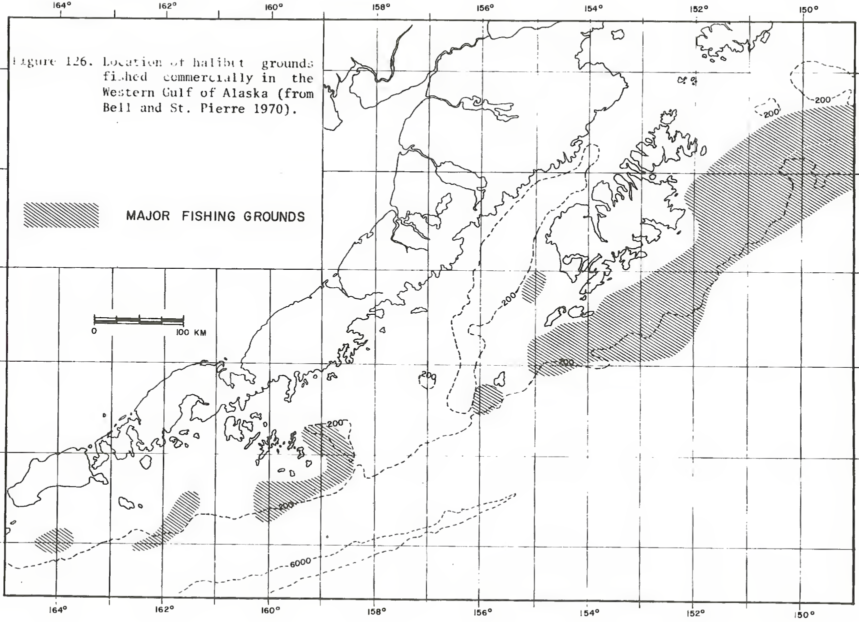

Figure 126. Location of halibut grounds fished commercially in the Western Gulf of Alaska (from Bell and St. Pierre 1970).

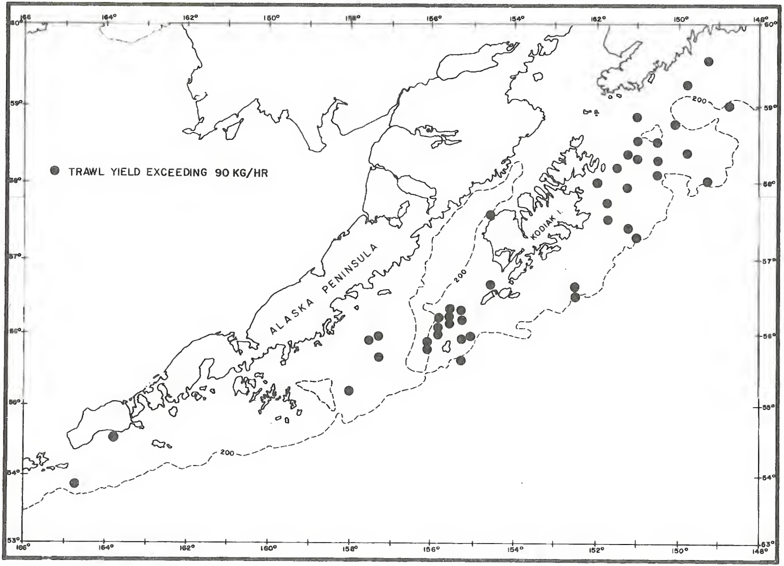

Figure 127. Location of large trawl catches of halibut reported by the International Pacific Halibut Commission in the Western Gulf of Alaska (from International Pacific Halibut Commission 1964).

While juvenile halibut may move only short distances, mature fish participate in extensive spawning migrations (more than 3,500 km. in one exceptional tagging return) (Bell and St. Pierre 1970). Halibut tagged off Cape Chiniak, Kodiak Island, have been recovered in significant numbers in British Columbia waters (International Pacific Halibut Commission 1973). Mature fish migrate eastward out of the Western Gulf of Alaska to spawn at the edge of the continental slope between Kodiak Island and Yakutat. Westerly currents return eggs and larvae to the Western Gulf where development of juveniles is completed in shallow bays along the Alaska Peninsula (Thompson and Van Cleve 1936). Important spawning grounds in the Western Gulf are located in Seward Gully and in the vicinity of the Trinity and Chirikof Islands (Bell 1972).

Female halibut grow to a larger size than males. Males may attain ages of more than 25 years, weights up to 55 kg., and lengths to 140 cm. Females may attain ages exceeding 40 years, weights of 210 kg., and lengths of 240 cm. (Nanaimo Biological Station 1966d; Bell and St. Pierre 1970). Early life history and life cycle are depicted in Figure 128.

Halibut feed primarily upon benthic fauna, including a large variety of fish as well as larger invertebrates. Juvenile halibut feed primarily on small crustaceans (Bell and St. Pierre 1970). Normally, temperatures between 3 and 9 degrees C are optimum for this species (Thompson and Van Cleve 1936).

Salmon

The five salmon species will each be discussed in detail in separate subsections. Figure 129 presents general information on Western Gulf of Alaska salmon populations. Summer high seas tagging locations of mature salmon returned from inshore areas in the Western Gulf of Alaska during 1964 and 1965 are shown (Hartt et al. 1965; Hartt et al. 1966). Caution must be used in interpreting salmon distribution from these data since they represent only a few months during two years on primarily mature fish.

Juvenile salmon are found in coastal areas in the months immediately following their outmigration from fresh water prior to their emigration to oceanic feeding and rearing areas. Straty (in press) found most juvenile sockeye salmon to be concentrated in the upper few meters of surface waters within 40 km. of the coast in southern Bristol Bay. Hartt et al. (1966) found immature sockeye, pink, chum, and coho salmon in a belt within 32 km. of the coast along Southeastern Alaska. They stated that in areas with a wider continental shelf, distribution of fingerlings may extend further offshore. Salmon fingerlings were found moving southwestward through the Shelikof Strait in the Kodiak area.

Chinook Salmon

Chinook salmon, Oncorhynchus tshawytscha, are relatively scarce within the study area. Commercial catches are largest in the South

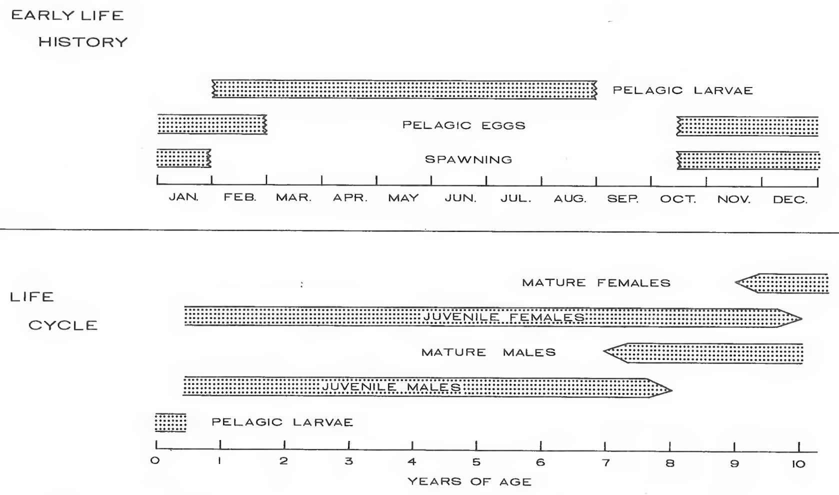

Figure 128. Early life history and life cycle of halibut, Hippoglossus stenolepis (from Thompson and Van Cleve 1936, Bell and St. Pierre 1970, Forrester and Alderdice 1973).

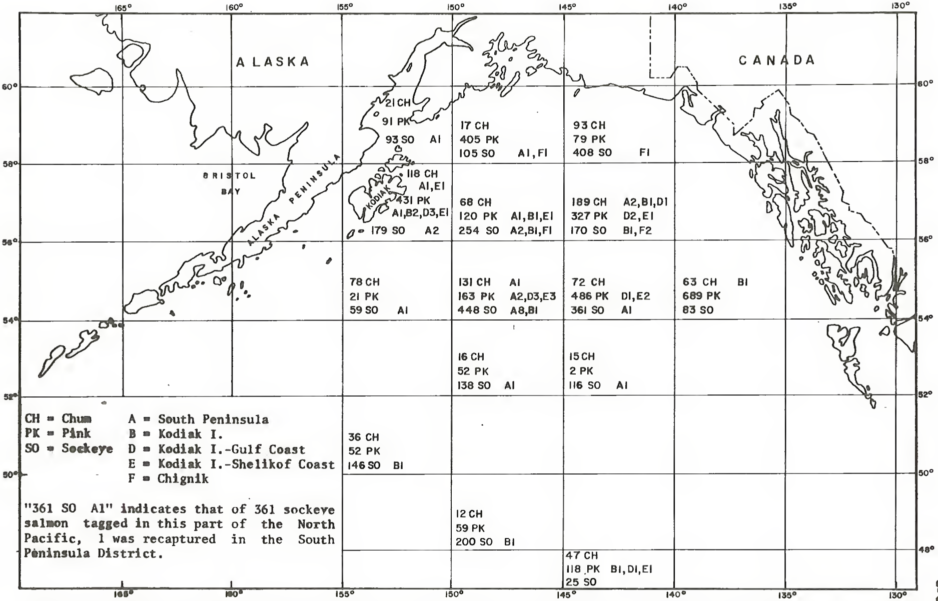

Figure 129. Tagged high seas salmon which spawned in the Western Gulf of Alaska, 1964-1965 (from Hartt et al. 1965, 1966).

Peninsula district where migratory stocks pass through the Shumagin Islands (Buck 1973). Few chinook were caught off the South Peninsula (Figure 130) in experimental fishing with gill net (Powell and Peterson 1957). Significant numbers of chinook appear off the South Peninsula between mid-June and late July with the peak run occuring in mid-July (Figure 131).

In the Chignik district, the Chignik River is a significant spawning area for chinook (Figure 132). Most large commercial catches in this district are taken in Upper Chignik Lagoon and are probably Chignik River stock (International North Pacific Fisheries Commission 1961-1970). Chinook arrive in numbers in the Chignik district during the entire month of July; the run peaks at midmonth (Figure 131).

Three rivers of southwestern Kodiak Island have spawning populations of chinook: The Karluk River, the Ayakulik River (Red Lake), and the Frazer Lake drainage (Figure 132). The Frazer Lake population was established in 1966 following a four-year artificial stocking program. Adults returned for the first time in 1968, and more have returned each year since. Most of the significant commercial catches are recorded in the vicinity of the Karluk-Ayakulik River systems, although many are also taken all along Shelikof Strait (Alaska Department of Fish and Game 1973b). These Shelikof Strait fish are probably migrants bound for the Karluk-Ayakulik systems or Cook Inlet. Chinook arrive in numbers in early June, and are available to the salt water fishery through late July (Figure 131). Peak catches are normally taken between mid-June and mid-July. Large numbers of spawners have been counted in Karluk River by mid-August (Van Hulle and Murray 1973).

Chinook females spawn an average of 5,000 eggs during August and September. Eggs incubate in stream gravel, overwintering to hatch the following spring. Young may migrate immediately to the ocean or spend as much as two years in fresh water. Normally they spend two to four years in the ocean before returning to spawn. In extreme cases, individuals may not return to spawn until eight years of age (Burner 1963). While they are in the ocean, chinooks feed upon herring and sand lance utilizing other small fish, crustaceans, and squid when available (Nanaimo Biological Station, undated).

Coho Salmon

According to commercial catch data coho salmon, *Oncorhynchus kisutch*, rank fourth in abundance among the five salmon species in the study area (Buck 1973). In the South Peninsula district, largest catches are made in the Shumagin Islands. These fish could be bound for Stepovak Bay spawning streams (Figure 133), but little is known of coho stock within this district. Cohos are present in large number from mid-July into September, with the peak run during the latter half of July (Figure 134). Figure 135 illustrates the offshore occurrence of coho salmon in the study area (Powell and Peterson 1957).

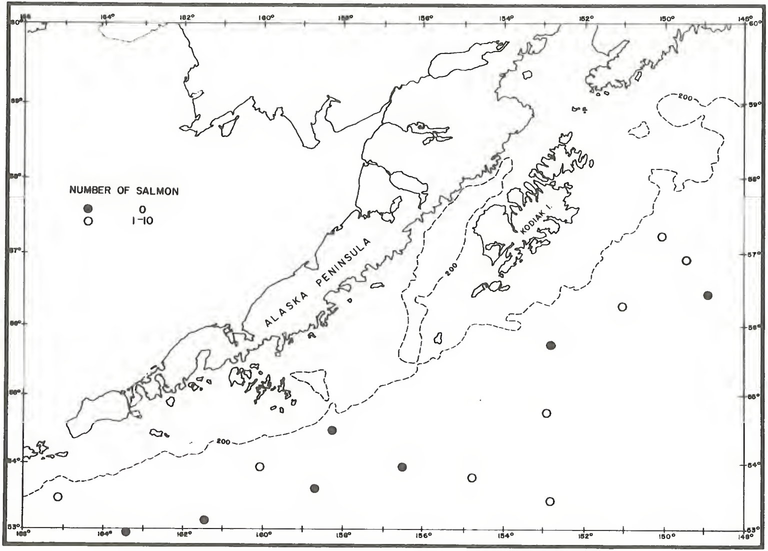

Figure 130. Distribution of chinook salmon in the offshore areas of the Western Gulf of Alaska during 1955 (from Powell and Peterson 1957).

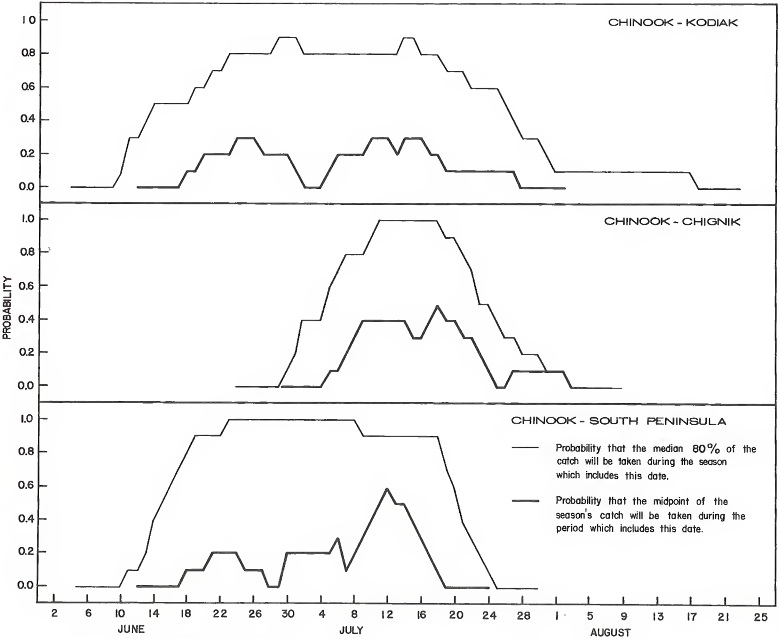

Figure 131. Timing of chinook salmon commercial harvest in the Western Gulf of Alaska (from International North Pacific Fisheries Commission [illegible])

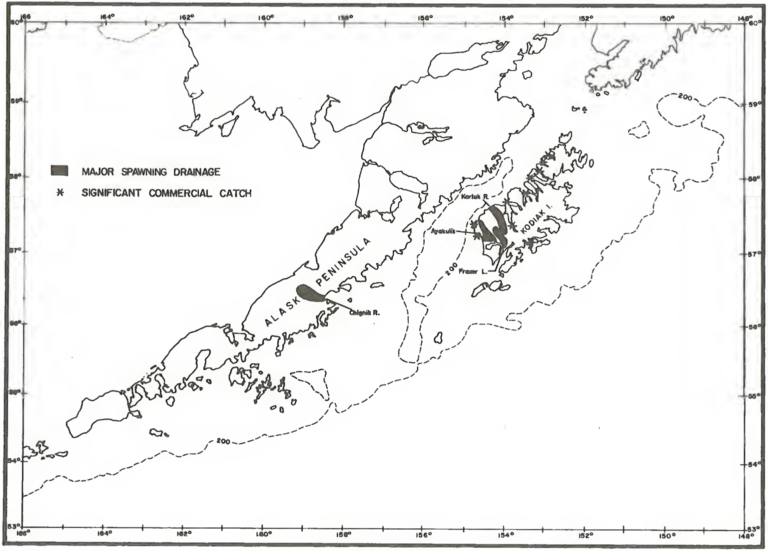

Figure 132. Significant chinook salmon spawning drainages and harvest locales in the Western Gulf of Alaska (from International North Pacific Fisheries Commission 1961-1970, Alaska Department of Fish and Game 1973b).

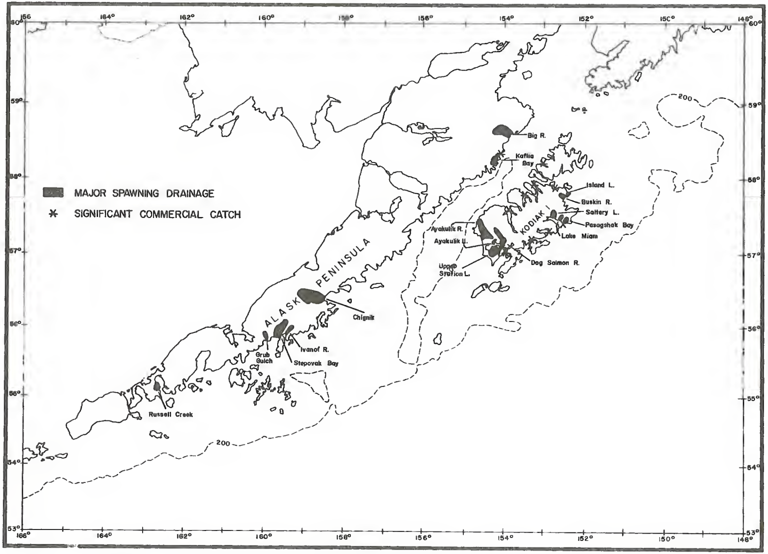

Figure 133. Significant coho salmon spawning drainages and harvest locales in the Western Gulf of Alaska (from International North Pacific Fisheries Commission 1961-1970, Alaska Department of Fish and Game 1973b).

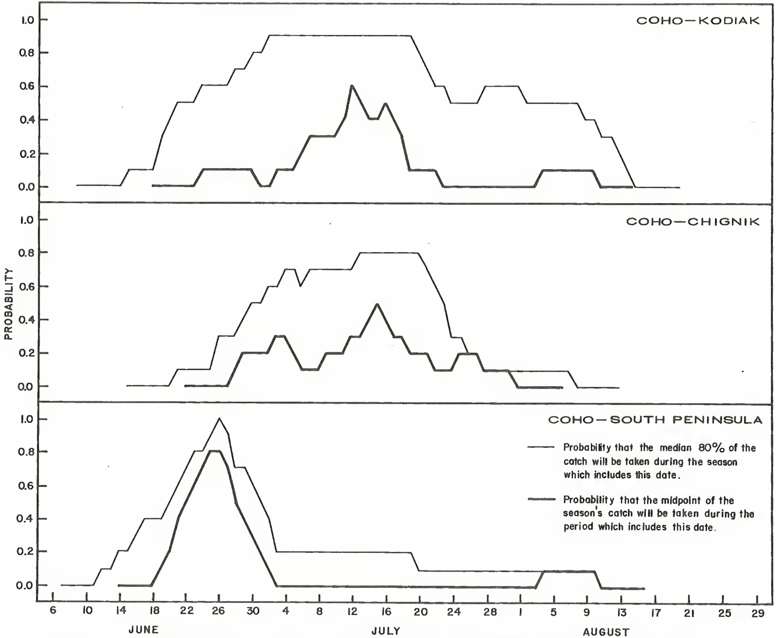

Figure 134. Timing of coho salmon commercial harvest in the Western Gulf of Alaska (from International North Pacific Fisheries Commission 1961-1970).

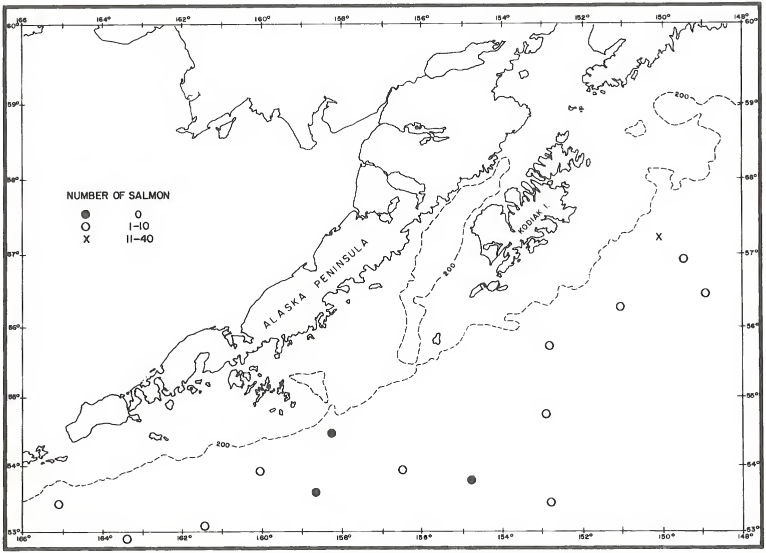

Figure 135. Distribution of coho salmon in the offshore areas of the Western Gulf of Alaska during 1955 (from Powell and Peterson 1957).

Commercial catch data indicates that Chignik district cohos are most abundant in Upper Chignik Lagoon (International North Pacific Fisheries Commission 1961-1970). These fish are probably spawners of the Chignik River system. Cohos arrive in late July and are commercially harvested into September. Peak abundance occurs during the first half of August (Figure 134).

In the Kodiak District, cohos spawn in streams which are concentrated in the northeast and southwest corners of Kodiak Island. A few significant spawning drainages are located on the west side of Shelikof Strait (Figure 132). Large commercial catches have been taken regularly in the vicinity of spawning drainages as well as around Afognak Island (International North Pacific Fisheries Commission 1961-1970). Cohos are taken from mid-June into mid-September with peak runs arriving in mid-August (Figure 134). Roelofs (1964) reported that cohos enter the Afognak Lake system in early August. Cohos were observed spawning in the Buskin and Karluk Rivers during October (Van Hulle and Murray 1972, 1973). Van Hulle and Murray (1972) recorded the main smolt outmigration from one Kodiak drainage between mid-June and mid-July (Figure 136).

During autumn, cohos spawn an average of 3,500 eggs per female in freshwater streams. Eggs develop in the gravel, overwintering to hatch the following spring. Juvenile cohos spend one to two years in fresh water before outmigration to salt water. After an additional year or two in salt water, cohos return to spawn and die (Burner 1963). In the marine environment, cohos feed upon herring and sand lance, as well as other small fish, squid, and crustaceans (Nanaimo Biological Station, undated).

Chum Salmon

Chum Salmon, Onocorhynchus keta, spawn throughout the study area. According to commercial harvest data, chums are most abundant in the South Peninsula district (Buck 1973). Powell and Peterson (1957) show chums to be abundant offshore throughout the study area (Figure 137). Most chums in the South Peninsula district are caught along the south shore of Unimak Island or in bays northwest of the Shumagin Islands (International North Pacific Fisheries Commission 1961-1970). Major spawning systems are scattered throughout this district (Figure 138). Significant numbers of chums are present from mid-June to early August (Figure 139).

Compared to the Kodiak and South Peninsula districts, the Chignik district produces small numbers of chums. Most are caught along the coast and bays northeast of Chignik, along the west side of Shelikof Strait. Several significant spawning systems are located here (Figure 138). Fish are present from early July through mid-August, with peak runs in late July (Figure 139).

In the Kodiak district, chums spawn abundantly in drainages along the southeast coast of Kodiak Island. Smaller numbers spawn throughout the area and large commercial catches are widespread (Figure 138). This species is most abundant, according to commercial harvest data,

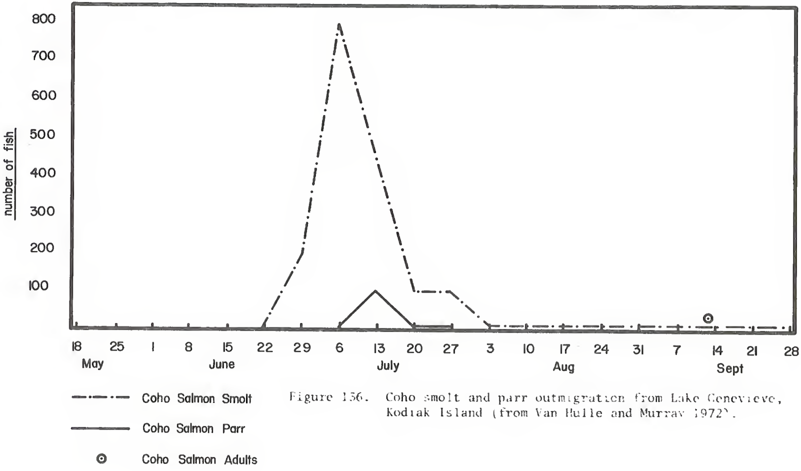

Figure 136. Coho smolt and parr outmigration from Lake Genevieve, Kodiak Island (from Van Hulle and Murray 1972).

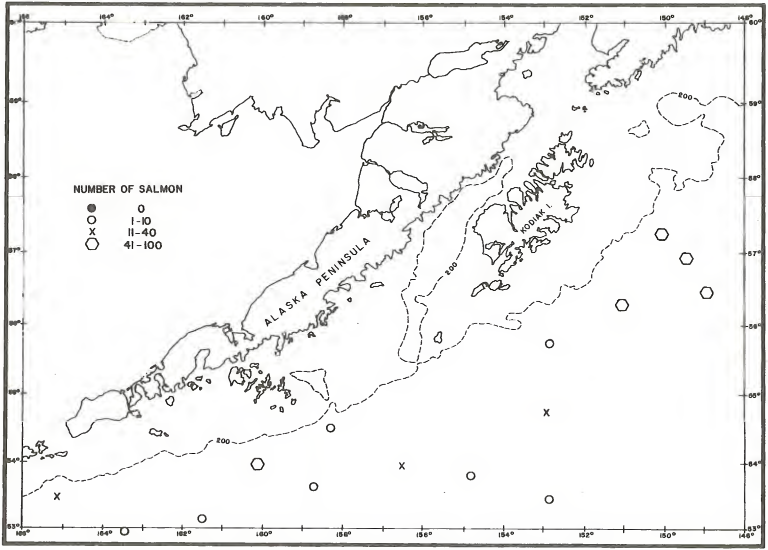

Figure 137. Distribution of chum salmon in the offshore areas of the Western Gulf of Alaska during 1955 (from Powell and Peterson 1957).

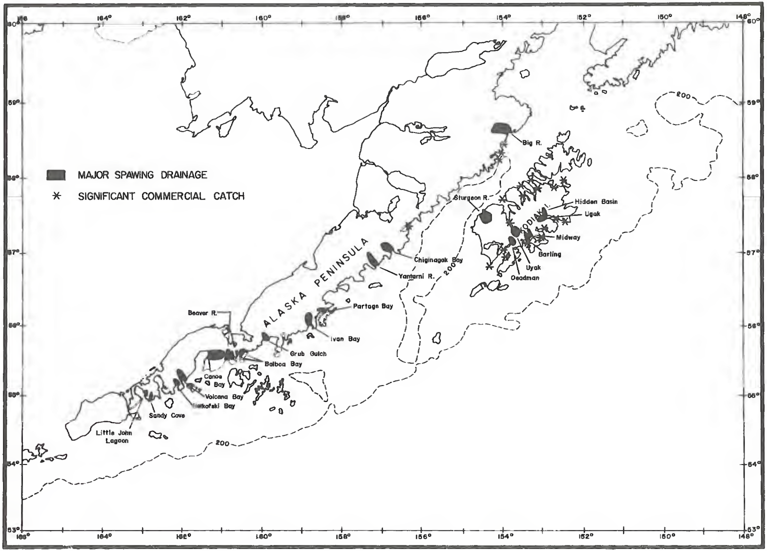

Figure 138. Significant chum salmon spawning drainages and harvest locales in the Western Gulf of Alaska (from International North Pacific Fisheries Commission 1961-1970, Alaska Department of Fish and Game 1973b).

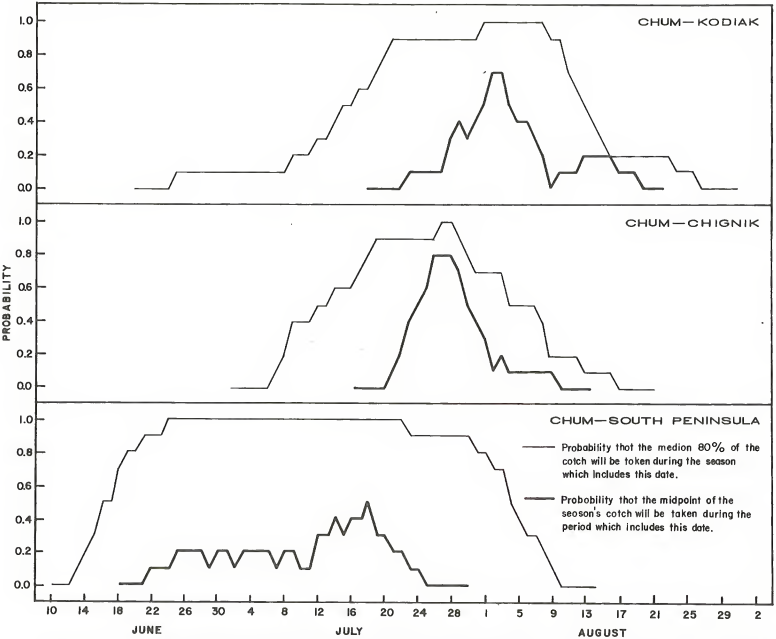

Figure 139. Timing of chum salmon commercial harvest in the Western Gulf of Alaska (from International North Pacific Fisheries Commission 1961-1970).

along the southeast coast of Kodiak Island and the west side of Shelikof Strait. Chums appear in early July and remain abundant into late August. Peak runs normally arrive during the last week in July and the first week in August (Figure 139).

During autumn, chum salmon spawn in freshwater gravel averaging 3,000 eggs per female. Eggs develop in the gravel through the winter to hatch the following spring. Young chums move directly to salt water where they spend four years or less growing and maturing. At the end of this period, adults return to the coastal environment to spawn (Burner 1963). Chums feed primarily on small crustaceans (Nanaimo Biological Station 1967).

Pink Salmon

Pink salmon, Oncorhynchus gorbuscha, are abundant in the study area and may be caught in almost every bay or inlet along the coast during the spawning season. Powell and Peterson (1957) recorded pink salmon offshore throughout the study area (Figure 140).

Pink salmon are harvested in quantity throughout the Shumagin Islands and in bays along the coast northwest of these islands (International North Pacific Fisheries Commission 1961-1970). Spawning occurs in many small systems throughout this district (Figure 141). Pinks arrive in late June through early August with peak abundance in late July in the South Peninsula district (Figure 142).

In the Chignik districk, pinks are most abundant along the coast and in the bays northeast of Chignik. In this area, many small spawning systems exist (Figure 141). Here they arrive in late July and are numerous through mid-August. Peak abundance occurs in late July (Figure 142).

Kodiak district pinks spawn throughout the region and catches are widely distributed (Figure 141). Largest catches are regularly recorded from the southeast coast of Kodiak and in the Alitak Bay area. In recent even numbered years, Uganik Bay has produced large catches. Pinks arrive in number by mid-July and are abundant through mid-August. Peak catches are generally recorded the last week in July and the first week in August (Figure 142). Roelofs (1964), from observations at Afognak Lake, believed that most pink fry emigrated before early May, although small numbers were still observed in mid-May.

Pink salmon spawn an average of 2,000 eggs per female during late summer in freshwater streams. Eggs develop in the gravel through the winter and move immediately into salt water where they spend the next one and one-half years. Pink salmon mature by two years of age and return to spawn. Pink salmon feed primarily upon planktonic crustaceans while in salt water (Burner 1963).

Sockeye Salmon

Sockeye salmon, Oncorhynchus nerka, rank with pink salmon as the most abundant of the salmon species in the study area. Powell

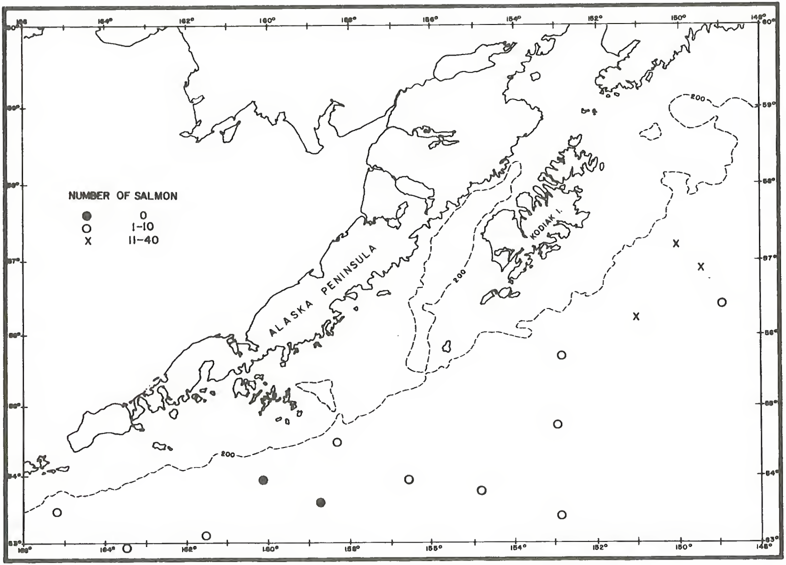

Figure 140. Distribution of pink salmon in the offshore areas of the Western Gulf of Alaska during 1955 (from Powell and Peterson 1957).

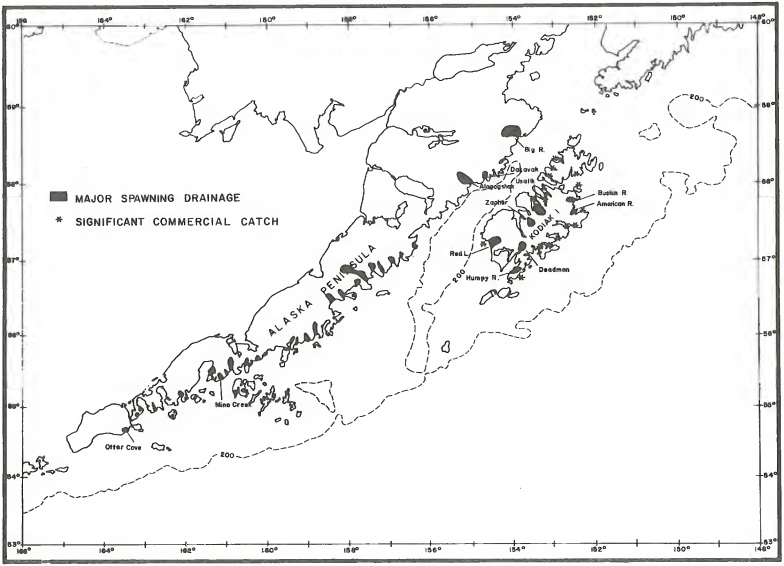

Figure 141. Significant pink salmon spawning drainages and harvest locales in the Western Gulf of Alaska (from International North Pacific Fisheries Commission 1961-1970, Alaska Department of Fish and Game 1973b).

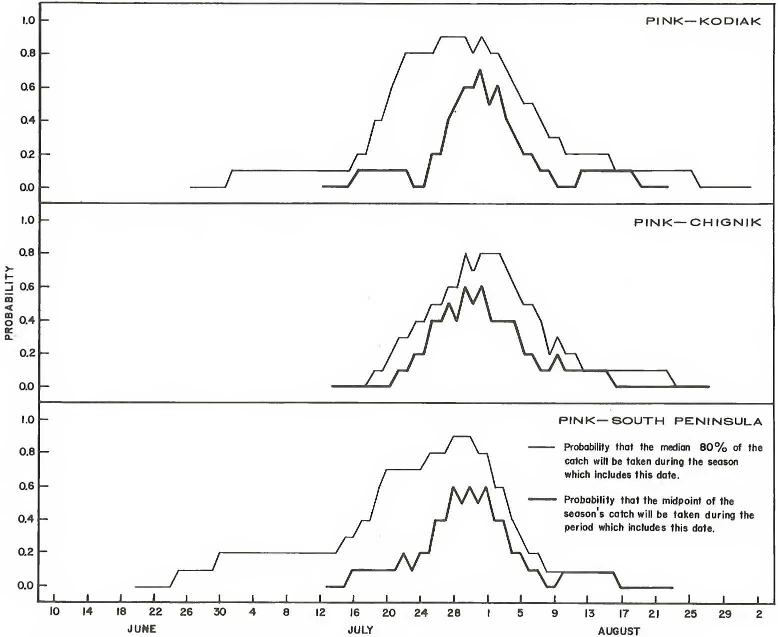

Figure 142. Timing of pink salmon commercial harvest in the Western Gulf of Alaska (from International North Pacific Fisheries Commission 1961-1970).

and Peterson (1957) found sockeye at all offshore stations sampled in the study area (Figure 143).

In the South Peninsula district, sockeye are most abundant along the south coast of Unimak Island (International North Pacific Fisheries Commission 1961-1970). The fish arrive in mid-June and are abundant into early July; the run peaks in late June (Figure 144). Few drainage systems support sockeye in this district (Figure 145). Most of these fish are probably migrants bound for other districts.

The Chignik River supports a large run of sockeyes. Normally, large commercial catches are taken in Upper Chignik Lagoon on these stocks as they congregate before ascending the river to spawn. Fish appear in mid-June and remain abundant into early August (Figure 144). Two separate runs occur within this system. An early run in June is primarily bound for Black Lake, while a later run in July and August spawns in the Chignik Lake drainage (Burgner et al. 1969).

In the Kodiak district, sockeyes spawn abundantly in several systems on the southwest coast of Kodiak Island and on the west side of Shelikof Strait (Figure 145). Usually the largest commercial catches are taken in the vicinity of the southwestern Kodiak spawning drainages. Spawning escapement may extend over a two to four month period in the Karluk River system (Burgner et al. 1969). Sockeyes normally become abundant in mid-June and are numerous through late August. No regular peak is evident in catches within this district (Figure 144).

Sockeyes spawn between 2,000 and 4,000 eggs per female, depending upon size, in freshwater streams and lakes during late summer or early autumn (Hartman and Conkle 1961). Eggs develop in the gravel substrate through the winter to hatch the following spring. Young sockeyes migrate to lakes within the river system soon after hatching. The timing of this migration to Karluk Lake may vary from April to July depending upon when the initial spawning occurred (Hartman et al. 1967). Juveniles may spend up to three years in fresh water before they migrate to salt water. This normally occurred from late June through mid-July in one system on Kodiak Island (Figure 146). In Afognak Lake, peak emigration took place between May 27 and June 10 in 1963 (Roelofs 1964). Mature adults return to spawn after one to four years in salt water to complete the cycle. Sockeyes feed primarily upon planktonic crustaceans during their marine life (Burner 1963).

Trout and char

Two species of this group utilize the coastal marine environment of the Western Gulf of Alaska for a portion of their life cycle. Dolly Varden, Savelinus malma, abound in almost all freshwater systems within the study area with portions of many populations being anadromous. Steelhead trout, Salmo gairdneri, are not as widely distributed as the Dolly Varden char, but are more sought after by sport fishermen.

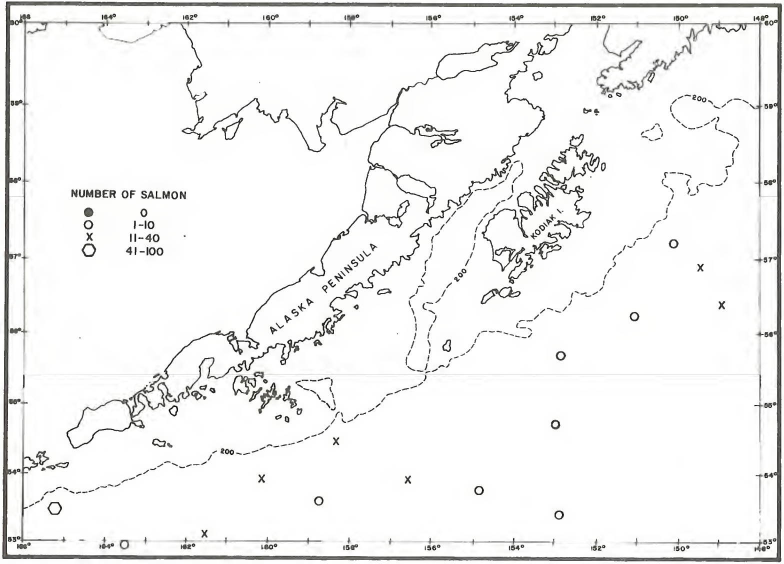

Figure 143. Distribution of sockeye salmon in the offshore areas of the Western Gulf of Alaska during 1955 (from Powell and Peterson 1957).

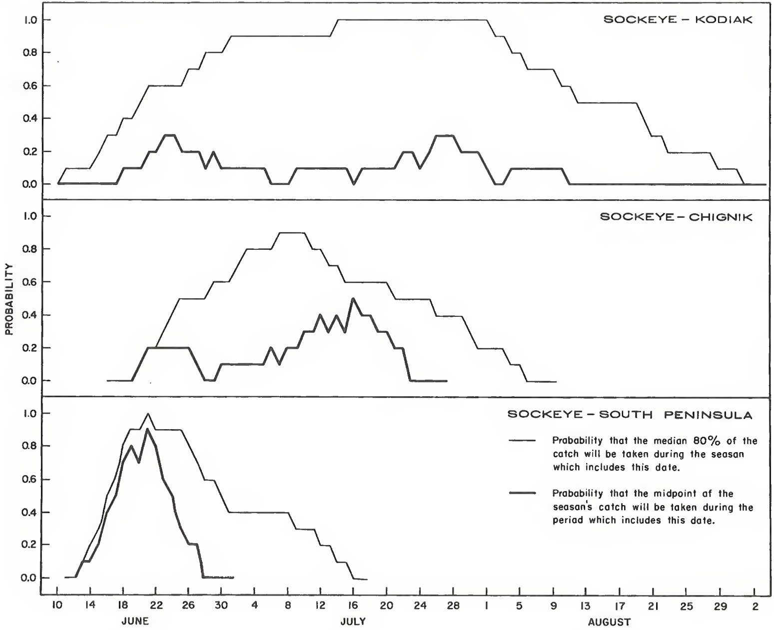

Figure 144. Timing of sockeye salmon commercial harvest in the Western Gulf of Alaska (from International North Pacific Fisheries Commission 1961-1970).

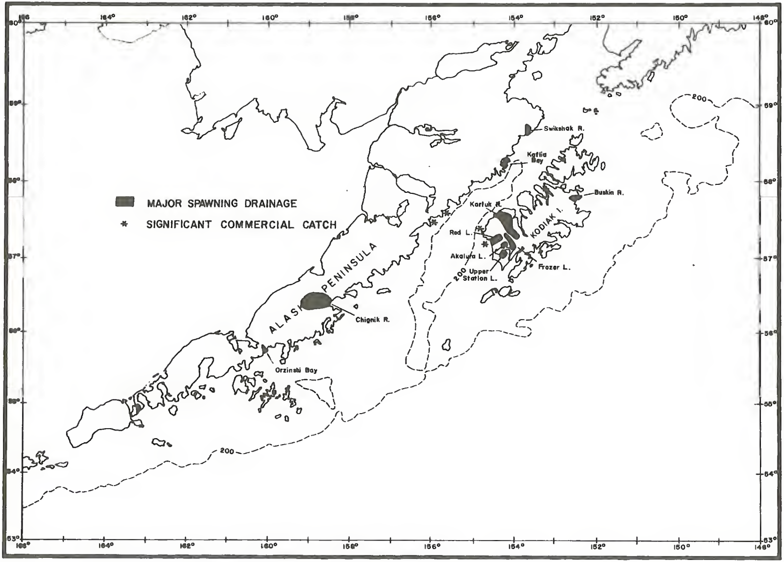

Figure 145. Significant sockeye salmon spawning drainages and harvest locales in the Western Gulf of Alaska (from International North Pacific Fisheries Commission 1961-1970, Alaska Department of Fish and Game 1973b).

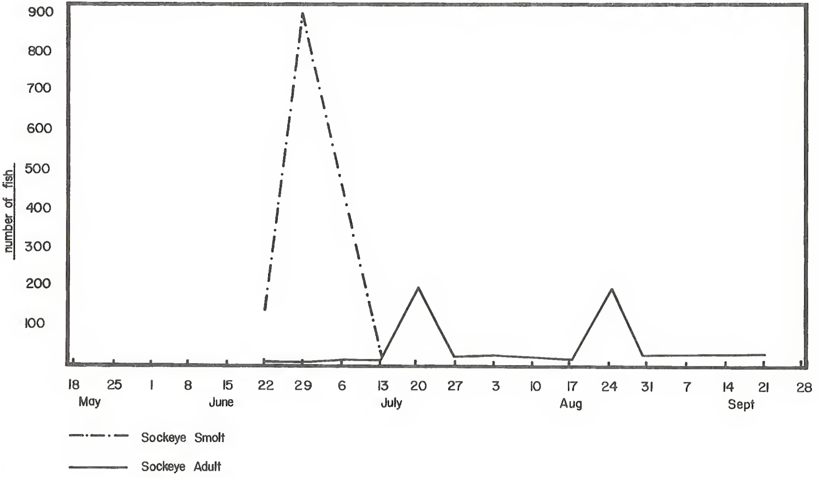

Figure 146. Sockeye salmon smolt outmigration and adult spawning inmigratio[illegible] - Lake Genevieve, Kodiak Island (from [illegible] and [illegible] 19[illegible]).

Mature, migrant Dolly Varden return to freshwater streams to spawn in late summer and early autumn. Van Hulle and Murray (1972) reported that char began arriving in mid-July and continued at least through mid-September (Figure 147). Roelofs (1964) first observed char entering the Afognak Lake system in late June during 1963. This migration reached its peak in mid-July. Spawning occurs in October and November when females, dependent on size, deposit 600 to 6,000 eggs in freshwater stream gravels. Eggs develop through the winter and young char emerge from the gravel in spring. Juvenile Dolly Varden remain in fresh water until their third or fourth year (Armstrong 1969). Juveniles outmigrate to the ocean in late spring and early summer. Van Hulle and Murray (1972, 1973) found that the main outmigration in the northern part of Kodiak Island occurred from mid-May to late June. Roelofs (1964) found that most Dolly Varden had emigrated from Afognak Lake prior to early May in 1963.

Since Dolly Varden overwinter in freshwater lakes, a return migration each year in late summer and early autumn brings marine juveniles and ripening adult spawners back into freshwater. Maturity is usually reached in five to six years. After spawning in stream gravels, adults join migrating juveniles in lakes to spend the winter. When spring arrives, surviving fish outmigrate once more to the ocean. This pattern is repeated each year (Armstrong 1969).

Armstrong (1969) doubted if more than half the Dolly Varden spawners survive to spawn a second time. The maximum age may be eight years for this species.

Steelhead spawn in the Karluk and Ayakulik Rivers on Kodiak Island and in the Chignik River on the Alaskan Peninsula (Figure 148). Undoubtedly, other migrant populations of steelhead exist within the study area, but are probably of minor importance. Powell and Peterson (1957) found steelhead widely distributed offshore in the study area.

In the Western Gulf, mature steelhead return from the ocean and enter freshwater streams to spawn in late summer and early autumn. Depending upon the size of the female, 200 to 8,000 eggs are deposited in the stream gravels in late winter or early spring (Paddock 1971). Steelhead overwinter in large freshwater lakes.

Although steelhead may spawn in successive years, repeat spawners are comparatively few. Van Hulle and Murray (1972) reported only 23 percent of the Karluk River steelhead were repeat spawners in the spring of 1972.

Depending upon water temperature, young steelhead emerge from gravels in mid to late summer. Juvenile steelhead may remain in fresh water two to three years before migrating to the ocean. Peak outmigration normally occurs in late spring and early summer, although individual fish may enter the ocean at almost any season. Most Alaskan steelhead spend one to two years in the ocean before returning to spawn for the first time. Occasionally, individuals may spend three or (rarely) four years at sea prior to spawning. One steelhead exceeding eight years of age was reportedly taken offshore of the Shumagin Islands, but this was an extremely old individual (Sheppard 1972)

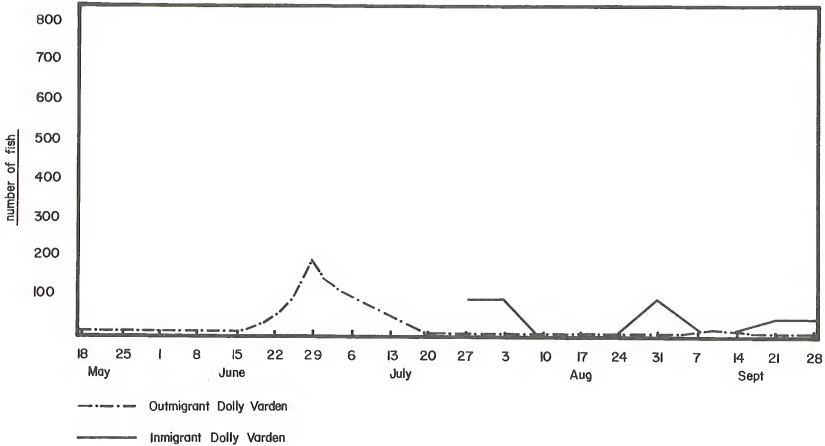

Figure 147. Dolly Varden char migration - Lake Genevieve, Kodiak Island (from Van Hulle and Murray 1972).

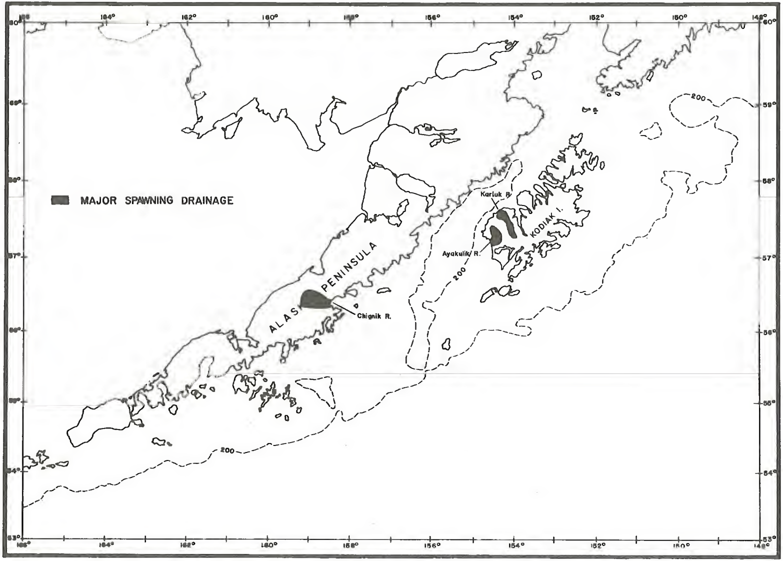

Figure 148. Significant steelhead spawning drainages in the Western Gulf of Alaska (from Alaska Department of Fish and Game 1973b; Van Hulle and Murray 1972, 1973).

Waterbirds

The international bird resource is well represented in the Western Gulf of Alaska. Many migrate from country to country, crossing invisible boundaries through the Arctic. Others, adapted to high latitude summers, migrate each year between the northern and southern hemispheres (Shuntov 1964). Millions of ducks and geese breed in or pass through the Western Gulf of Alaska on their way to wintering grounds along the Pacific flyway. The ability of this area to supply the needs of these vast numbers of waterfowl directly affects the recreation and sport potential of the entire Pacific coastal area (U.S. Department of the Interior 1964).

Diversity is limited to less than 150 species, the majority of which migrate south for the winter (Table 38). Birds of a single species often number more than a million. Passerines are not well represented, possibly due to the cold and the general lack of trees. Water-loving birds abound, especially the seabird and shorebird species.

Some species of ducks and geese occur in the area in the hundreds of thousands, notably black brant, *Branta nigricans* and emperor geese *B. leucopareia*. Although both breed further north, they concentrate along the north coast of the Peninsula in the fall, then migrate west and south.

The world population of emperor geese winter in the Aleutians and the southwest Gulf of Alaska, where they frequent coastal lagoons and bays. Here they feed along the beaches, predominantly on algae, kelp, and green shoots of *Elymus* and *Equisetum* (Murie 1959), as well as ripe eelgrass seeds. Although there is a small, resident population in Siberia, almost the entire world population of about 100,000 inhabit Alaska at some time (Bartonek et al. 1971).

The black brant population of the Pacific flyway is often characterized as staging entirely in Izembek Lagoon and then leaving en mass. Actually, although brant concentrate in the lagoon, they may be found in many places along the coast of the Peninsula feeding on eelgrass seeds, a highly nutritious and critical food source. A cold wind from the north in late October or November usually signals the fall departure of black brant (Jones 1972). Most of the geese then leave for the Pacific states, but small groups overwinter in the Shumagin and Simeonof Islands.

Thousands of ducks also migrate through the area; the pintail, *Anas acuta*, is the most common (U.S. Department of the Interior 1973). Mallards, *Anas platyrhynchos*, and green-winged teal, *Anas crecca carolinensis*, are the most widely distributed resident dabbling ducks. Both species nest inland, but winter in lagoons and bays along the coast, feeding on mollusks and small crustaceans.

Table 38. Bird Check List for Kodiak Island and Izembek National Wildlife Range (from Bartonek and Sowl 1972; U.S. Department of the Interior 1965, 1973).

SPECIES	KODIAK	IZEMBEK N.W.R.
Common Loon	PR-c	PR-c
Yellow Billed Loon		
Arctic Loon	WV-c	WR-u
Red-Throated Loon	TV-c	PR-u
Red Necked Grebe	PR-c	PR-u
Horned Grebe	SR-c	WR-u
Short Tailed Albatross		
Black-Foot Albatross	AV-r	
Laysan Albatross		AV-r
Fulmar	SR-o	AV-r
Sooty Shearwater	SR-c	
Slender-Bld Shearwater	SR-a	AV-r
Fork-Tailed Petrel	TV-r	AV-r
Leach's Petrel		AV-r
Double-Crstd Cormorant		PR-u
Pelagic Cormorant	PR-a	PR-u
Red-Faced Cormorant	SR-c	PR-u
Great Blue Heron		
Whistling Swan	SR-u	TV-u, PR-u
Trumpeter Swan		
White-Fronted Goose	TV-o	TV-r
Emperor Goose	WR-o	TV-c, WR-c

Table 38. (continued)

SPECIES	KODIAK	IZEMBEK N.W.R.
Lesser Goose	WR-o	TV-c, WR-c
Cackling Canada Goose	TV-o	TV-r
Dusky Canada Goose	TV-o	
Black Brant	TV-u	TV-c
Mallard	PR-c	SR-c, WR-u
Pintail	PR-c	TV-c, PR-u
Gadwall	PR-c	SR-u
Green-Winged Teal	PR-u	SR-c, WR-u
American Widgeon	PR-c	TV-r
Short-Bld Dowitcher		TV-r
Long-Billed Dowitcher		TV-r
Western Sandpiper	SR-c	TV-c, WR-u
Hudsonian Godwit		
Bar-Tailed Godwit		TV-r
Sanderling		WR-u
Red Phalarope		TV-c
Northern Phalarope	TV-c	TV-c, SR-c
Pomarine Jaeger		AV-r
Parasitic Jaeger	SR-u	SR-r
Long-Tailed Jaeger		AV-r
Glaucous Gull		TV-r, WR-r
Glaucous-Winged Gull	PR-a	PR-c
Herring Gull	PR-u	
Mew Gull	SR-c	SR-u, WR-r

Table 38. (continued)

SPECIES	KODIAK	IZEMBEK N.W.R.
Bonaparte's Gull	SR-c	AV-r
Black-Legged Kittiwake	SR-a	TV-c, SR-c
Sabine's Gull		TV-r
Arctic Tern	SR-c	SR-c
Aleutian Tern		SR-c
Common Murre	PR-c	PR-u
Thick-Billed Murre		AV-r
Pigeon Gullemot	PR-u	PR-u
Marbled Murrelet	PR-u	PR-u
Kittlitz's Murrelet		AV-r, SR-r
Ancient Murrelet	WR-u	PR-u
Cassin's Auklet	WR-u	AV-r
Parakeet Auklet		SR-r
Crested Auklet	PR-a	PR-r
Horned Puffin	SR-c	PR-u
Tufted Puffin	SR-c	PR-u

STATUS

PR- Permanent Resident
SR- Summer Resident
WV- Winter Visitor
SV- Summer Visitor
TV- Transient Visitor
AV- Accidental Visitor
WR- Winter Resident

ABUNDANCE

a- abundant
c- common
u- uncommon
o- occasional
r- rare

Many diving and sea ducks also reside in the area. These ducks feed primarily on aquatic fauna (Table 39). Consequently, they have a stronger flavor than "grazing" ducks and are little utilized for food. Some northern countries have created small industries based on the down which eider duck use to line their nests.

Gaviidae-Loons

Of the four Alaskan loon species, three occur regularly in the study area: The Arctic loon, *Gavia arctica*; the common loon, *G. immer*, and the red-throated loon, *G. stellata*. The yellow-billed loon, *G. adamsii*, sometimes occurs as a straggler (U.S. Department of the Interior 1973). The common loon is a permanent resident of the Gulf. Loons nest on inland lakes, but winter along the coast. Using their feet to propel themselves, they can dive to depths of 60 meters in pursuit of their principal food--small fish (Table 40). Because their feet are so welladapted for diving, loons are extremely awkward on land (Peterson 1961).

Podicipedidae-Grebes

Both the red-necked grebe, *Podiceps grisegena*, and the horned grebe, *P. auritus*, are found in the study area in summer, but only the red-necked grebe is a permanent resident. Like the loon, grebes nest inland on ponds or lakes. They build nests of rotting vegetation which decays and releases heat and may aid egg incubation (Murie 1959). Except when nesting, grebes inhabit the inshore zone. They are capable of partially submerging, and frequently resemble small periscopes (Gabrielson and Lincoln 1959).

Diomedeidae-Albatross

Never abundant, three species of albatross are found in this part of the North Pacific during the summer: The black-footed albatross, *Diomedea nigripes*; the Laysan albatross, *D. immutabilis*, and the short-tailed albatross, *D. albatrus*. The latter was believed to be headed for extinction after Japanese feather hunters had slaughtered some five million birds on their main breeding grounds by 1903. In 1939 the volcano on the breeding island erupted, further decimating the population to less than 100. Recent sightings confirm the bird's continued existence and the population appears to be increasing (Sanger 1972b).

Albatross have become notorious ship-followers (McHugh, 1955), scavenging anything on the ocean surface. Albatross found in the Western Gulf breed in winter, and normally range as far north as Alaska

Table 39. Food Habits of Diving Ducks

	Percentage of Total Diet						
Name	Pondweeds	Misc. plant	Molluscs	Insects	Crustaceans	Fishes	Misc. animal
Scaup	19	25	39	7	7		
Goldeneye	9	17	10	28	32	3	1
Bufflehead	7	14	16	41	17	4	1
Oldsquaw	2	10	16	11	48	10	3
Harlequin		1.5	25	10	57	2.5	4
Steller eider	3	10	19	13	45	2	8
Common eider		4	82	2	7		5
King eider		5	46	5	19		25
Spectacled eider	7	16	42	32	3		
White wing scoter		6	75	2	13	2	2
Common scoter	5	5	65	3	17	3	3
Surf scoter	3	9	61	10	10	3	4

Source: Cottam and Knappen 1939, Cottam 1939.

Table 40. Feeding Methods and Foods of Sea Birds

GROUP	Habitat	Piracy	Dipping	Pattering	Surface seizing	Surface filtering	Scavenging	Plunging	Pursuit plunging	Pursuit diving	Bottom feeding	Night feeding	Fish	Cephalopods	Crustaceans	Other invertebrates	Carrion/Birds etc.
Diomedea	OP				0		o			.		o?	o	0	o	.	o
Pterodroma	P			.+	o+		o					0+	.	0	o	.	o
Puffinus	OP			.	o		.	.+	0	o+		o	0	0	0	.	o
Oceanodroma	OP			o	o	?				.		o	o	.+	0	.+	
Phalaropus	LOP				0								.		0	o	
Stercorariu	LOP	0*	o				.	o					0	.	.+	.	.
Larus	LCO	o	o	.	o		o	o					o	.	o	o	o
Larus "Rissa"	COP	.	0		o+		.	o+		.			0	.	o	.	.+
Larus "Xema"	LOP		0	?	o			o					0	?	0	?	.
Sterna	LCOp	.	o					0					0	.	o+	.	.
Alca and Uria	Op									0			C	.	o	.	
Cepphus	Co									o	0		0	.	0	o	
Brachyramphus	C				o?					0			o+		0	o	
Synthliboramphus	COP				?					0	.?		o		o+	o	
Cyclorrhynchus	0									0			.*	.	0	o	
Aethia	CO									0					0	.+	
Cerorhinca	cO									0		o	0		0		
Fratercula and Lunda	COP									0			0		o	o	

Habitat; L, land; some or all species feed in terrestrial or freshwater environments for at least part of the year; the feeding methods used and food obtained by these species (or at these times) are not considered in the table. C, coastal; 0, offshore; P, pelagic. Lower case indicates that a habitat is used relatively little.
Feeding methods. Plunging is surface plunging except where specified. Pursuit diving is primarily wing-propelled except where specified.
Symbols. 0, feeding method or food group of major importance; o, of minor importance; +, indicates that importance may be underestimated, or is certainly greater in some species.
Source: N. P. Ashmole. 1971. Sea Bird Ecology and the Marine Environment.

only in summer. Kuroda (1960a) theorized that squid, the albatross' main food, are too large in the northern latitudes to be eaten by the end of summer (Table 40). Nakamura (1963) could find no evidence of the correlation between water temperatures and numbers of albatross, which Kuroda (1955, 1960b) found previously. Albatross wings are aerodynamically ideal for floating on seabreezes, and although albatross are sometimes found feeding in tide rips, they usually feed far from shore (Sanger 1972b).

Procellaridae-Shearwaters, Fulmars, and Petrels

Those species of Procellaridae which occur in the study area include the sooty shearwater, *Puffinus griseus*; the short-tailed shearwater, *P. teniurostris*; the scaled petrel, *Pterodroma inexpectata*; the Pacific fulmar, *Fulmarus glacialis*; and possibly the pale-footed shearwater, *Puffinus carneipes*.

The fulmar is the only member of this family which breeds in the Western Gulf. There is at least one colony of almost 400,000 in the Semidi Islands (Figure 149 and Table 41), and strong circumstantial evidence indicates a colony somewhere off of Afognak Island, since many birds are observed in Shelikof and Marmot Straits.[1] The other species breed in the southern hemisphere where their colonies are of some economic importance. Coastal-dwelling Australians and New Zealanders supplement their diets with young shearwaters, colloquially called muttonbirds (Falla et al. 1966). Serventy (1967) presented a discussion of the ecology of the short-tailed shearwater in the South Pacific.

Procellaridae often feed together. Arnold (1948) estimated 38,000 fulmars and 160,000 shearwaters feeding in a tide rip in Isanotski Straits. They were feeding on a reddish-orange marine organism. The organic contents of 10 shearwater stomachs obtained in Alaska included: amphipods, 13 percent; schizopods, 15 percent; undetermined crustaceans, 20.8 percent; squid, *Loligo* sp., 16.1 percent; undetermined marine invertebrate flesh (possibly squid), 29.4 percent; and fish, 5.7 percent (Cottam and Knappen 1939). Sanger (1972a) reported squid, fish, and plankton to be the most frequently cited food items (Table 40). These are taken at or near the surface, although Sanger personally observed *P. teniurostris* and *P. griseus* caught in salmon nets at depths of one to two meters.

Fisher (1952), in his book *The Fulmar*, gave a detailed description of the biology of these birds. In the early days of whaling fulmars developed the scavenging habit. Fisher theorized that fulmars are expanding their range by following ships south. The fulmar's yearly cycle seems to be almost identical throughout its range. Egg-laying begins in early May, and the last eggs hatch in July. By September

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[1]Leroy Sowl, Supervisory Fish and Wildlife Biologist, U.S. Bureau of Sport Fisheries and Wildlife, Anchorage. Field notes compiled during special studies.

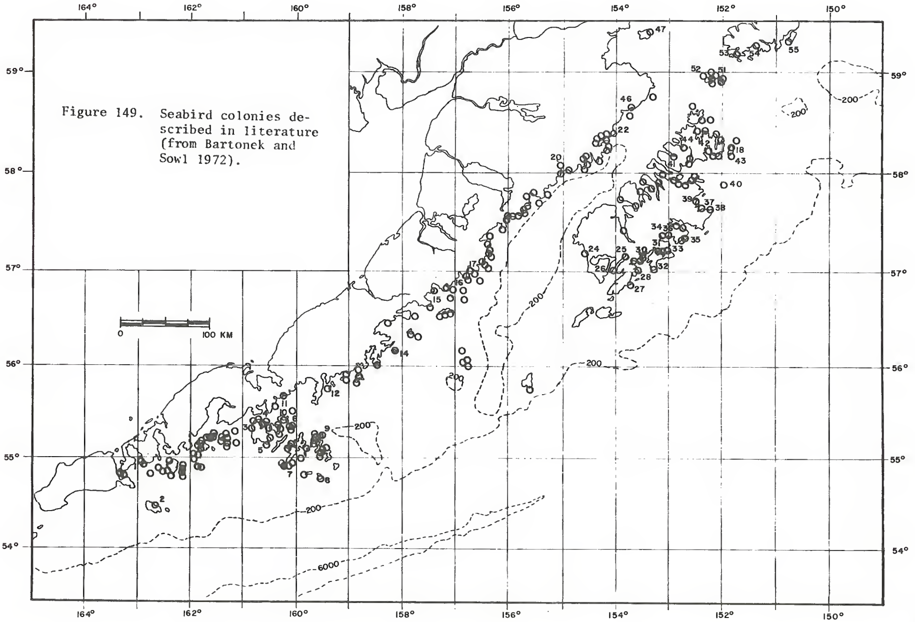

Figure 149. Seabird colonies described in literature (from Bartonek and Sowl 1972).

all the young are fledged. Young chicks feed on an oily secretion of the parent bird. This smelly substance can be accurately ejected by both parents and young to a distance of one to two meters. In other parts of the north where fulmar eggs and young are regularly harvested and sold, this oily secretion is a nuisance. Natives harvest eggs in the Alaskan Pribilofs.

Hydrobatidae-Storm Petrels

The two species found in the Western Gulf are the fork-tailed petrel, Oceanodroma furcata, and Leach's petrel, O. leucorhoa. These nocturnal birds are known in literature as Mother Carey's Chickens. Their habit of following ships' lights has created a number of superstitions about them. One is that they presage storms, but actually they are attracted to the calm wake of a ship in heavy seas (Alexander 1954).

Since storm petrels are burrowers and nocturnal, their colonies are difficult to observe. Murie (1959) speculated that the birds burrow in the Shumagin Islands. Both species nest in the Gulf, and egg-laying commences in May. By the end of August, most young are fledged and take to the ocean. The Leach's petrel migrates south for the winter, but the fork-tailed petrel is a year-round resident.

When feeding, these birds fly very low over the water and patter with their feet to help maintain height (Alexander 1954) (Figure 150). This may create suction (Ashmole 1972). They feed on crustaceans, fish, and mollusks (Sanger 1972a) and are also attracted to oily substances on the water (Alexander 1954).

Phalacrocoracidae-Cormorants

The pelagic, Phalacrocorax pelagicus; red-faced, P. urile; and double-crested, P. auritus, cormorants all nest in cliffs in the Western Gulf area (Table 41). The double-crested cormorant, however, is very adaptable and also nests on flat islands (Murie 1959). The pelagic is common throughout the area, but the double-crested cormorant is rare (U.S. Department of the Interior 1973 and 1965). The red-faced cormorant nests from the Shumagin Islands west along the Aleutian Chain (American Ornithologists' Union 1957).

Cormorants nest in small colonies and lay two to six bluish eggs on a carelessly assembled mass of vegetation, usually seaweed mixed with guano (Alexander 1954). In the southern hemisphere this guano is economically important.

Cormorants are expert divers, propelling themselves with their feet in pursuit of their principal prey, fish (Figure 150). There is some evidence that their hearing is acute enough to guide them in murky water (Alexander 1954). Cormorant plumage is much less dense than other sea birds, and its wetability may aid in diving. The feathers become so waterlogged that cormorants are often observed on posts or trees spreading their wings to dry. Cormorants are permanent residents in the Western Gulf.

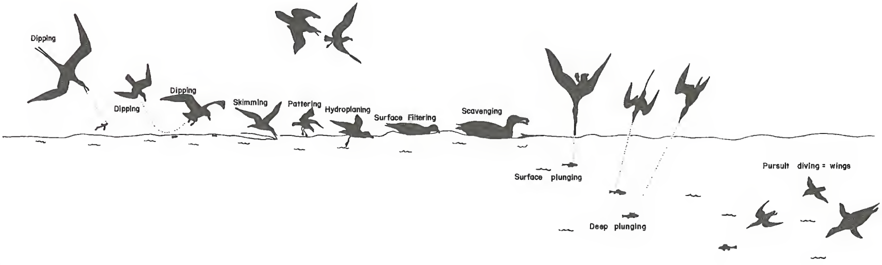

Figure 150. Feeding methods of seabirds (from Ashmole 1971).

Table 41. Seabird colonies in The Western Gulf of Alaska identified in the literature (from U.S. Department of the Interior 1972).

Map reference	Nameplace	Species	Numbers
1	Amagat I.	Horned puffin	15,000
2	Sanak Is.	F-t. petrel	
		Tufted puffin	
		Leach's petrel	
3	Bay Pt.	Murres	
4	Round I.	B-l. kittiwakes	Medium
		T-b. murres	
	Zachary Bay (islets)	Tufted puffin	
		Horned puffin	
		Pib. gullemot	
5	Delarof Harbor	B-l. kittiwakes	Very large
		Tufted puffin	
		Horned puffin	
		Pig. guillemot	
6	The Haystacks	B-l. kittiwakes	
		Murre	
7	Bird I.	B-l. kittiwakes	
		Murre	
8	Big Kiniuji I.	Tufted puffin	
		Horned puffin	
9	Castle Rock	B-l. kittiwake	
10		Murres	
10	Karpa I.	Murres	Very large
11	Stepovak Bay	B-l. kittiwakes	
		Tufted puffin	Some
12	Mitrofania I.	Tufted puffin	Some
13	Semidi Is.		
	Aghiyuk I.	Murres	Millions
		Fulmars	Great numbers
		B-l. kittiwake	
		Tufted puffin	
		Horned puffin	
		Pig. guillemot	
	Chowlet I.	Fulmar	Great numbers
		Murre	
		Tufted puffin	
		Horned puffin	
		Pib. guillemot	
	Aliksemit I.	Fulmar	
	Semidi Islands		
	Suklik I.	Fulmar	
	Kuliktagik I.	Fulmar	
	Anowik I.	Fulmar	
	Kateekuk I.	Fulmar	
	Aghik I.	B-l. kittiwake	

Table 41. (continued)

Map reference	Nameplace	Species	Numbers
14	Atkulik I.	B-1. kittiwake	
		Murre	
15	Cape Kuyuyukak	B-1. kittiwake	
		Murre	
		B-1. kittiwake	
16	Amalik Bay	Tufted puffin	
		Cormorants	
17	Puale Bay	Tufted puffin	
		Cormorants	
18	Sea Lion Rocks	Fulmars	
	Sea Otter I.	Fulmars	
19	Uganik Bay	Puffins	
		G-2. gull	
		Cormorant	Few
20	Kashvik Bay	Pig. gullemot	
21	Uganik Passage	Puffins	
		G-2. gull	
22	Kukak Bay	Horned puffin	100
	Kukak Point	D-c. cormorant	8 pr.
		Pelag. cormorant	80 pr.
		R-f. cormorant	10 pr.
		G-w. gull	
	Yugnak Rocks	Horned puffin	
		Tufted puffin	
23	Spiridon Bay	Puffins	
		G-w. gull	
	Chief Pt.	B-1. kittiwake	
	Ditto Is.	B-1. kittiwake	
24	Ayakulik	G-w. gulls	
		Cormorants	
25	Uyak Bay	B-1. kittiwake	10,000*
26	Deadman Bay	Puffins	
		Cormorants	
27	Fiat Island	Tufted puffin	
28	Cape Kiavak	Cormorants	
	Sitkalidak Strait	B-1. kittiwakes	
		G-w. gulls	
29	Avnulu Creek	Tufted Puffin	
30	John I.	B-1. kittiwake	
		Tufted puffin	
		Cormorants	
31	Cathederal I.	B-1. kittiwake	
		Tufted puffin	
		G-w. gull	
		Cormorants	

Table 41. (continued)

Map reference	Nameplace	Species	Numbers
32	Midway Bay	G-w. gull	
		Mew gull	
		Arctic tern	
33	Ghost Rocks	Cormorants	
34	Ladder I.	Tufted puffin	
		G-w. gull	
35	Boulder Bay	B-1. kittiwake	100,000*
36	Gull Point	B-1. kittiwake	
37	Svitiak I.	G-w. gull	
		Tufted puffin	
	Utesisto I.	B-1. kittiwake	
	Middle Bay	Tufted puffin	
	Vicsoki I.	G-w. gull	
		Tufted puffin	
		B-1. kittiwake	
	T. S. Inter	G-w. gull	
		Tufted puffin	
		B-1. kittiwake	
	Zamka I.	Cormorants	
		Tufted puffin	
		G-w. gull	
	Cliff I.	Cormorants	
		Tufted puffin	
		G-w. gull	
	Puffin I.	Cormorants	
		Tufted puffin	
38	Chiniak I.	B-1. kittiwakes	100,000
		Tufted puffin	
39	Parrot I.	Pig. guillemot	
		Tufted puffin	
		Cormorant	
		G-w. gull	
40	Taliudek I.	C. murre	
		B-1. kittiwake	
41	Foul Bay	Pig. guillemot	
		Cormorants	
		Puffins	
42	Peril Cape	Cormorants	
	Izhut Bay	B-1. kittiwake	
43	Edge Mountain	Cormorants	
44	Big Waterfowl Bay	Puffin	
		Pig. guillemot	
45	Whale I.	B-1. kittiwake	100,000
	Anton Larsen Bay	B-1. kittiwake	
		G-w. gull	
		Puffins	

Table 41. (continued)

Map reference	Nameplace	Species	Numbers
	Sharatin Bay	B-l. kittiwake	
		G-w. gull	
		Puffins	
	Kekur Point	B-l. kittiwake	
		G-w. gull	
		Puffins	
	Bare I.	B-l. kittiwake	
		G-w. gull	
46	Shakun Rocks	Tufted puffins	
		Horned puffins	
47	Augustine I.		
	Chisik I.	B-l. kittiwakes	Abundant (25,000)
		D-c. cormorant	Common
		Pelag. cormorant	Fairly common
		G-w. gull	Common
		Pig. guillemot	Common
		Common murre	Abundant
		Horned puffin	Common
		Tufted puffin	Fairly common
	Duck I.	B-l. kittiwakes	Large colony
		Common murre	Abundant
		Horned puffin	Common
		Tufted puffin	Fairly common
	Tuxedni Bay	B-l. kittiwake	Large colony
49	Gull Island	B-l. kittiwake	Many
		Murres	Many
		Pig. guillemot	
		Horned puffin	
		Tufted puffin	Many
		Cormorants	
50	Glacier Spit	Cormorants	
		G-w. gull	
51	East Amatul: (Barren Is.)	B-l. kittiwake	100,000
		Murres	
		Puffins	
52	Nord I. (Barren Is.)	B-l. kittiwake	100,000
		Murres	
		Puffins	
53	Elizabeth I.	Cormorants	
		B-l. kittiwake	(5,000)

Haematopodidae-Oystercatchers

The black oystercatcher, Haematopus bachmani, is a permanent resident in the Western Gulf, inhabiting the rocks along the shore. Its primitive nest is merely beach rocks or perhaps a depression in a rock, where two to three eggs are laid in late spring (Peterson 1961). The family unit probably lasts at least into fall. Although their bills are adapted for opening mollusk shells, the technique must be taught to the young.[1]

Oystercatchers forage for bivalves, oysters, crabs, and marine worms below the high tide mark (Peterson 1961). They blend into their habitat so well that they are seldom seen, but they are common on the southern side of the Peninsula and on Kodiak Island (U.S. Department of the Interior 1965 and 1973).

Charadriidae and Scolopacidae-other shorebirds

These birds have been grouped together since little work has been done on them in this area. Generally, they feed on insects, crustaceans, mollusks, worms, and invertebrates in tidal flats and marshes. Many of these birds breed in the study area or migrate through from the north, but occur only rarely in winter (Jacques 1930).

Phalaropidae-Phalaropes

Two species of phalarope nest in the Western Gulf, the red phalarope, Phala fulicarius, and the northern phalarope, Lobipes lobatus. Although Phalaropes are classed as a shorebird, they are usually found on the oceans, spinning and bobbing for plankton and marine invertebrates (Peterson 1961) (Figure 150).

This bird is unique because the female is larger and gaudier than the male and does the courting, while the male builds the nest and incubates the eggs (Alexander 1954).

Stercoraridae-Jaegers

The pomarine, Stercorarius pomarinus, parasitic, S. parasiticus, and long-tailed, S. longicaudus, jaegers all occur in the Western Gulf. Jaegers are both predatory and parasitic, forcing other birds, especially the Larids, to disgorge recently eaten fish (Sanger 1972a) (Figure 150). When this food source is not available they feed on small mammals, insects, and eggs and young of other birds. Carrion or refuse on the water surface is also eaten (Alexander 1954).

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[1]Nikko Tinbergen, Consultant. Special television program on oystercatchers, "The Specialist." Time-Life Films , Inc. New York, N.Y.

Jaegers are not colonial nesters, but often seem so since they are attracted to the true colonial birds (Belopolskii 1957) (Figure 149). Jaegers nest in a hollow in the ground, where the female lays two to three eggs in June (Alexander 1954). When not breeding, they feed farther offshore than the Larids. Jaegers spend the winter along the Pacific coast south of the study area.

Laridae-Gulls and terns

These colonial nesters are common to abundant throughout the Western Gulf of Alaska (Table 40). The commonest species are the glaucous-winged gull, Larus glaucescens, and the black-legged kittiwake, Rissa tridactyla, both permanent residents of the study area. The glaucous-winged gull shares the predatory and parasitic instincts of the jaeger, but spends more time on land. Belopolskii (1957) in his comprehensive book on sea bird colonies in the Barents Sea, examined 25 glaucous gull, L. hyperboreus, stomachs which contained 36 percent adult murres, 32 percent nestlings and eggs, 8 percent kittiwake young and eggs, 12 percent eider young and eggs, and 20 percent lemmings. Belopolskii thought that gulls normally preferred fish, switching to other food sources when fish are scarce (Table 40). The glaucous gulls he observed preferred to force kittiwakes to disgorge rather than fish themselves. In Alaska, gulls commonly harass brown bear for salmon.

Pearson (1968) observed the diet of the lesser black-backed gull, Larus fuscus, in the Farne Islands, to be 75 percent fish, while kittiwake and tern diets were nearly 100 percent fish. Belopolskii (1957) noted that when fish are scarce, birds specifically adapted for fishing such as murres, take all the available fish. Kittiwakes then turn to crustaceans and other less concentrated food, which results in a smaller clutch size.

Two terns are summer residents of the area, the Arctic tern, Sterna paradisea, and the Aleutian tern, S. aleutica. Both birds are common colonial nesters in the area. Although the Aleutian tern formerly nested on Kodiak Island, it is now believed to breed only on the Alaska Peninsula and associated islands (American Ornithologists' Union 1957). Belopolskii (1957) noted that in the Barents Sea, eiders, which are not a colonial nester, frequently appear to nest in colonies on the rim of tern colonies. He theorized that the masses of terns served as protection for the eider broods.

In winter, these birds both migrate out of the study area. The Aleutian tern migrates to the southwest and is frequently found on Japanese islands (American Ornithologists' Union 1957). The Arctic tern makes one of the most arduous migrations known, flying south as far as the edge of the Antarctic ice pack, a distance of almost 20,000 kilometers (Orr 1970).

Alcidae-Auks, Murres, Puffins

There are a number of references on this unique bird family but except where noted, the following discussion will be based largely on Kozlova's observations in Russia (Kozlova 1957).

Two murre species reside in the Western Gulf, the common, Uria aalge, and the thick-billed, U. lomvia. They are difficult to distinguish without examination, and are often found in the same flock (Murie 1959). Murres are specialized for fishing and pursue their prey underwater. In Russia their spring diet consists largely of capelins and cod with 10 percent crustaceans. In summer the diet is virtually all fish, predominantly herring. Belopolskii (1957) felt that these seasonal differences are due to availability rather than seasonal preferences.

Murres are exclusively colonial nesters (Table 41). Sowl[1] estimated that the colony at Cape Unalishagvak contained 275,000 birds. These colonies are located on cliff plateaus and ledges which can be approached from the sea. Murres are unable to take off from level ground.

Murres are so adapted to colonial nesting that they have lost their nest-building instinct. Their eggs are laid on bare rock, and often collect in crevices. If a murre parent returns and its eggs are gone, it gets an egg from the nearest crevice. According to Belopolskii (1957), the least dominant murres are pushed to the outer edge of the colonies where predation from gulls and jaegers occurs most frequently. The dominant birds in the flock are most likely to reproduce, protected by sheer numbers of birds.

Belopolskii felt that the eggs themselves are well-adapted to colonies. They are extremely tough and can withstand rolling and falling which other eggs cannot. The pointed end of the egg helps maintain position on the ledge, and at the end of incubation, the center of gravity shifts to the pointed end. This is adaptively critical, as murres probably would not have time to start over if the eggs were destroyed near the end of incubation. Murre eggs are large and nutritious and are often harvested in other areas of the world.

Murres are most at home on the open ocean where they winter and also find refuge during severe storms. Occasionally, a massive die-off occurs following winter storms (Bailey and Davenport 1972).

The pigeon guillemot, Cepphus columba, is a permanent resident in the Western Gulf. On the Pribilofs, their diet was found to consist of 56.8 percent amphipods, 20.8 percent crabs, 17.2 percent isopods and 4 percent fish. These birds feed just below the surface of the water, frequently dipping their heads into the water or even swimming with the head completely submerged. They nest in pairs at the top of cliffs, just above the tide or in caves along the coast, but never

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[1]Leroy Sowl, Supervisory Fish and Wildlife Biologist, U.S. Bureau of Sport Fisheries and Wildlife, Anchorage. Field notes compiled during special studies.

without shade (Drent 1965). The guillemots are not as specialized as other alcids, and can nest inland because of their flight maneuverability and their ability to take off from land.

Three murrelets, the marbled, Brachyramphus marmorata; Kittlitz's murrelet, B. brevirostra; and the ancient murrelet, Synthliboramphus antiquum, all nest in the study area. The marbled and ancient murrelets are permanent residents.

The ancient murrelet is nocturnal and feeds on marine invertebrates in the upper water layers. It dives infrequently. This murrelet frequents shallow marine waters in summer, but in winter does not enter semi-closed areas such as bays or inlets. They nest in abandoned puffin burrows or dig their own about one-half meter long and lined with grass. Both parents brood steadily and can be seized on the nest. The young leave the nest at night, long before they can fly.

The marbled and Kittlitz's murrelets are believed to nest far from land in tundra and rock slides. A Kittlitz's nest was recently discovered and photographed by Edgar Bailey at Cold Bay (Jones 1972). Both birds feed on small fish, mollusks, and crustaceans.

The only auklet permanently residing in the study area is the abundant crested auklet, Aethia cristatella. Cassin's auklet, Ptychoramphus aleutica, is a rare winter resident. Both the parakeet, Cyclorrhyncus psittacula, and the least auklet, Aethia pusilla, are summer residents.

Crested auklets gather in large flocks to feed on small crustaceans and polychaetes just below the water surface (Figure 150). They are very active birds and spend much time in flight or running along the rocks, especially at sunset when they leave the nesting area. They nest in cliffs and rocks, in crevices, or between stones. The young are fed on small crustaceans which are carried in a neck pouch that Aethis develop in the breeding season. The crested auklet nests east to the Shumagin Islands, wintering in the same area (American Ornithologists' Union 1954). It is not well adapted to migrating and is very susceptible to severe winters. The crested auklet is nocturnal only during the breeding season (Alexander 1954).

The least auklet resembles the crested and often feeds with it (Bedard 1968). In some areas of the world these auklets are relished for food and trapped with nets by the natives.

Two puffins are common summer residents in the study area, the horned puffin, Fratercula corniculata, and the tufted puffin, Lunda cirrhata. Part of both populations overwinters here. The tufted puffin, endemic to this region, has a distribution which strikingly parallels that of the northern sea lion, Eumetopias jubata (Uduardy 1963). These puffins frequently nest together in burrows which they dig with their powerful hind feet. The horned puffin generally digs two entrances to his burrow. Puffins feed largely on fish, supplemented by crustaceans, mollusks, and other invertebrates. Their wings are specialized for swimming underwater (Figure 150), but consequently they lack flight maneuverability.

The size of puffin colonies is difficult to estimate, but Sowl[1] observed colonies of several hundred thousand. In some parts of the world, the tufted puffin is gathered by natives holding nets which the puffins can't avoid since they lack maneuverability. The meat and fat are used for food, and the skins made into parkas.

Marine Mammals

Marine mammals were almost solely responsible for the early development of Alaska. George Wilhelm Steller of the Bering expedition first described the fur seal, Callorhinus ursinus, and the sea otter, Enhydra lutris, after being shipwrecked in 1741 on the Commander Islands (Kenyon 1969). The Russians established many colonies in the Western Gulf and the Aleutians to serve as stations for the hunters. Scammon (1874) described the days of the great Nantucket whalers, enticed to Alaska by the right whale, Balaena glacialis. As late as 1970, the fur seal, harbor seal, Phoca vitulina, and Steller sea lion, Eumetopias jubata, harvests in Alaska were estimated at a combined value of more than three million dollars (Kenyon 1971).

Except for subsistence use by certain Alaskan Natives, the Marine Mammal Protection Act of 1972 prohibits all harvest of marine mammals. An exception is made for the fur seal, which is regulated by international treaty.

Enhydra lutris-the sea otter.

Unless otherwise noted, a comprehensive summary by Karl Kenyon (1969) is used in the following discussion.

The sea otter treaty was signed by Woodrow Wilson. Actually, fewer than 2,000 sea otters remained (Alaska Department of Fish and Game 1973a). Since the fur harvest was not regulated, no accurate records exist of the number of otter skins harvested prior to 1911. Lensink (1960) estimated that there were more than 900,000 animals harvested. Although sea otters can only be harvested by Natives at present, their pelts may be worth 280 dollars apiece. This figure is high because of the scarcity of pelts as well as their superior quality. If sea otters were harvested annually at the sustainable rate of 2 to 2.5 percent of their population, the pelts could become less valuable.

Sea otters may be found in several favorable areas in the North Pacific, but they are especially abundant in the Western Gulf and along the Aleutian Islands (Figure 151). Kenyon conducted aerial

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[1]Ibid.

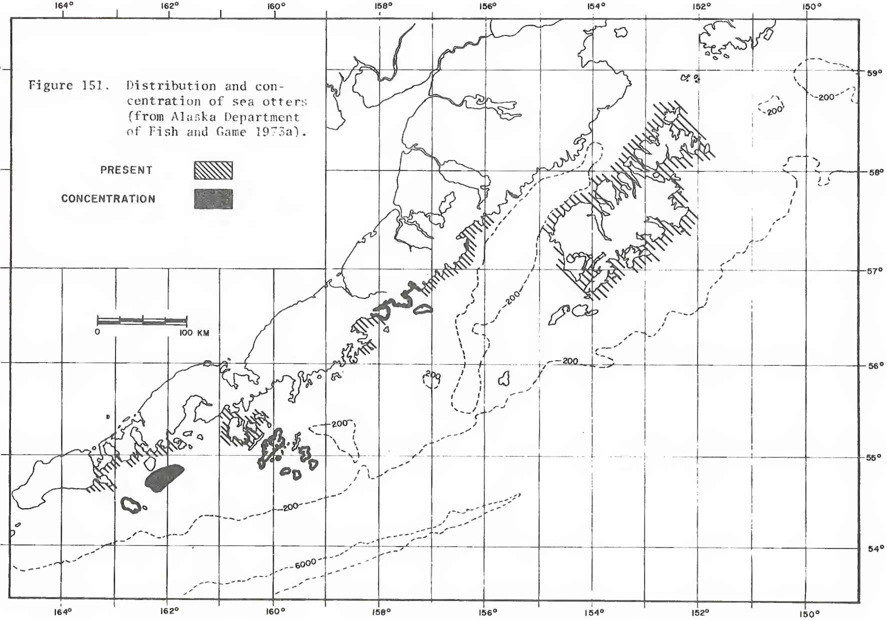

Figure 151. Distribution and concentration of sea otters (from Alaska Department of Fish and Game 1973a).

surveys of the principal otter colonies in Alaska from 1957 to 1965. Five of these colonies are located in the study area, including the Sanak Islands, Sandman Reefs, the Shumagin Islands, the central Alaska Peninsula, and Kodiak Island. The total population of the area was estimated at more than 20,000 otters. Schneider (1973) believed that aerial survey estimates were consistently lower than actual populations, and estimated the population in the same area to be between 27,000 and 35,000.

Sea otters do not undergo seasonal migrations. When ice invades their habitat, as in the winter of 1971-1972, mortality is very high (Jones 1972). Although otters can maneuver on land, food is always consumed in the water. Their diet is largely composed of echinoderms and mollusks. Sea urchins, Echinoidea, are the most prevalent single item (Murie 1959).

Sea otters are generally confined to coastal areas where the water is less than 75 meters in depth (Alaska Department of Fish and Game 1973a). Although kelp beds are frequently cited as a limiting factor, several colonies are located far from any kelp beds. Male otters prefer the exposed points along shore, while females congregate along the coast between these points.

Otters give birth to a single pup only once every two years, but infant mortality is low. They are capable of rapid population expansion. Sea otters breed year-round, but the peak pupping season comes in spring (Alaska Department of Fish and Game 1973a). According to Kenyon, gestation takes about 13 months, due to delayed implantation (Figure 152). In severe winters when food is difficult to obtain, pups born in the fall often survive because they are small enough to nurse through the winter. Larger pups are often abandoned by females who cannot provide enough food for herself and her young.

Sea otters depend on their dense fur to trap air for insulation. Fur is kept scrupulously clean, and any physical contamination of their water is not only dangerous, but in the case of oil, almost invariably fatal.

Eumetopias jubata-the Steller sea lion

Mathisen and Lopp (1963) stated that the Western Gulf area is the center of the world population of Steller sea lions. Of a total population between 240,000 and 300,000 (Kenyon and Rice 1961), as many as 60,000 are found in the study area (Mathisen and Lopp 1963). A map of rookeries and their estimated populations can be found in Table 42 and Figure 153. Generally, sea lions prefer rocky outcrops for their rookeries and resting places (Alaska Department of Fish and Game 1973a).

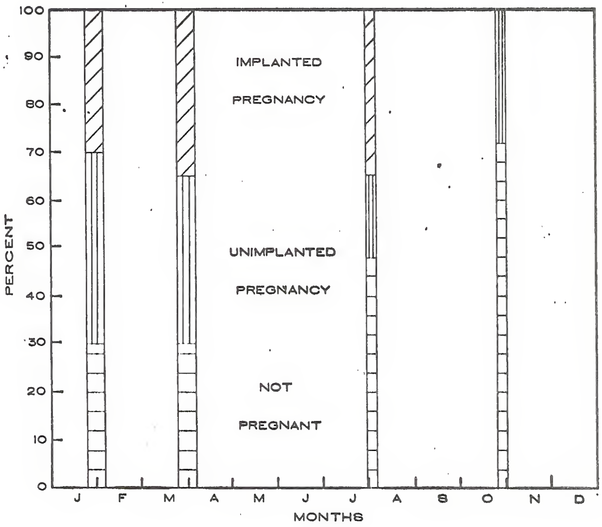

Figure 152. Phases in the reproductive cycle of the female sea otter (from Kenyon 1969).

Table 42. Steller Sea Lion Rookeries and Hauling Grounds (from Alaska Department of Fish and Game 1973a).

Ref. No.	Location	Population
178	Bird Island	260
179	Sanak Island (South Rock)	3200
180	Cherni Island	380
181	Clubbing Rocks	5600
182	Pinnacle Rock	980
190	Nagai Island	15
191	Twins	10
192	Chernabura Island	2000
192	Simeonof Island	150
200	Amak Island	2000
201	Sea Lion Rocks	350
205	Wosnesenski Island	300
206	Jude Island	3000 (Pups)
207	Shumagin Islands (Sea Lion Rocks)	400
208	Unga Island (Unga Cape)	30
209	The Whaleback	600
210	The Haystacks	100
215	Atkins Island	3100
216	Castle Rocks	400
217	Kupreanof Peninsula (Kupreanof Point)	35
218	Spitz Island	700
219	Mitrofania Island	216
220	Seal Cape	10
235	Atkulik Island	100
236	Atkulik Island	10
237	Sutwik Island (West end)	738
238	Sutwik Island (Foggy Cape)	Unknown
239	Cape Kumlik	10
240	Ugaiushak Island	600
241	Chowiet Island	5000
245	Chirikof Island	500
246	Sundstrom Island	100
250	Sitkinak Island (Cape Sitkinak)	470
251	Twoheaded Island	3600
252	Cape Hepburn	
253	Bert Point	
255	Cape Barnabas	1000
256	Ugak Island	440
257	Chiniak Island	600
258	Long Island (Vera Bay Rocks)	
259	Cape Ugat	50
265	Puale Bay (Rocks at entrance)	2800
266	Outer Seal Rocks	50
267	Tombstone Rocks	50
268	Middle Cape	25

Table 42. (continued)

Ref. No.	Location	Population
315	Cape Gull	100
316	Cape Ugyak	100
317	Takli Island (Rocks west of Island	Unknown
320	Marmot Island	10000
321	Afognak Island (Tonki Cape)	100
322	Afognak Island (Cape Paramonof)	50
323	Latax Rocks	3300
324	Cape Nukshak	500
325	Sugarloaf Island	10000
326	West Amatuli (Southeast end)	1600
327	Sealion Rocks	500
328	Ushagat Island	100
329	West Amatuli (Rocks on west end)	100
410	Augustine Rocks	500

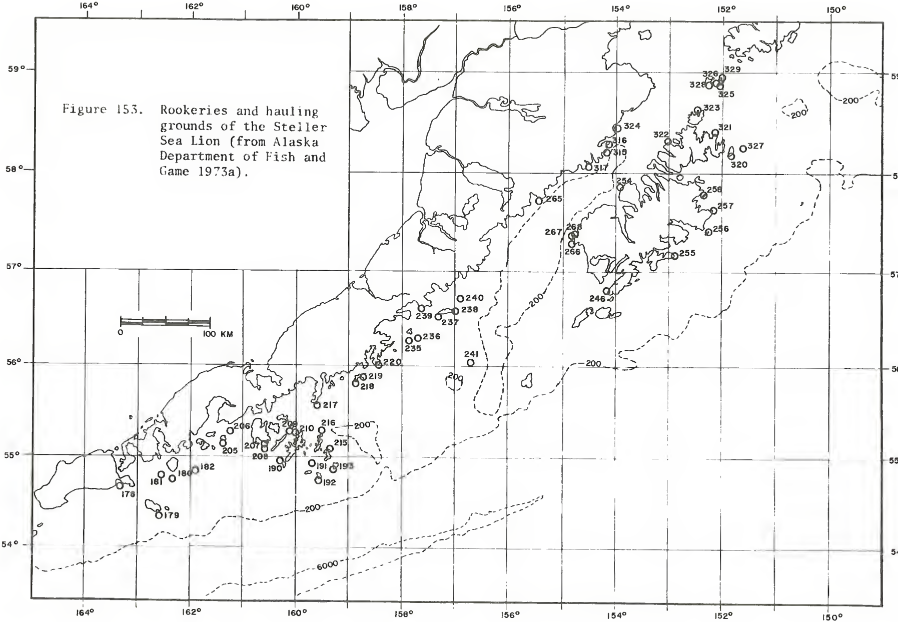

Figure 153. Rookeries and hauling grounds of the Steller Sea Lion (from Alaska Department of Fish and Game 1973a).

The Steller sea lion does not make seasonal migrations. Some move north in late summer and early fall (Kenyon and Rice 1961). These bulls retreat when ice advances, but ice is not a restricting element. A small, permanent population remains on the Pribilof Islands, surrounded in winter by ice-infested seas (Kenyon 1962). These islands have supported as many as 15,000 sea lions, but intensive hunting almost exterminated them. With protection, the population has risen to about 6,000 animals (Kenyon 1962).

Steller sea lions are territorial during summer (Alaska Department of Fish and Game 1973a). Their rookeries are generally large, averaging 1,000 animals in the Aleutians (Kenyon and Rice 1961). Most are born in June. Although they can swim at birth, they are very awkward. The bond between mother and pup may last more than a year, an unusually long time for any animal (Sandegrer 1970). Territories are abandoned at the end of summer. Males and females separate and disperse into scattered bays and estuaries along the coast (Alaska Department of Fish and Game 1973a).

These sea lions are notorious because of their fondness for commercially important fish, especially salmon, halibut, and herring. There is a definite economic loss to fishermen because of gear damage and actual loss or damage of fish (Thorsteinson et al. 1961). Tikhomirov (1964) said that sea lions are often hauled up in crab tangle nets, which indicates that crab is part of their diet. These nets are no longer legal in the United States. The diet of sea lions includes rockfish, sculpin, greenling, sand lance smelt, salmon, halibut, flounder, octopus, shrimp, crab, and herring (Alaska Department of Fish and Game 1973a and Tikhomirov 1964).

Phoca vitulina richardi (richardsi)-harbor seal

The land-breeding harbor seal is abundant throughout the southern part of Alaska (Figure 154). John Vania (U.S. Senate 1972) estimated that there are approximately 200,000 in Alaska. He also estimated that 30,000 animals could be harvested without affecting the population. Harbor seals are worth about 7.5 dollars apiece (Kenyon 1971), which represents a potential economic value of 225,000 dollars.

Harbor seals are difficult to count since they do not usually congregate in hugh colonies like fur seals and sea lions. Small groups of 100 or less are found all along the Western Gulf coast on sand bars, beaches, and low rocks (Alaska Department of Fish and Game 1973a). The Phocidae are less adapted to land movement than either the sea lion or fur seal, and require a ready access to water (Scheffer 1972).

Harbor seals are considered a nuisance because they raid salmon gillnets (Pike and MacAskie 1969). Bishop (1967) collected four harbor seal stomachs off Kodiak which contained octopus and squid.

In a discussion on the pagophilic pinnipeds, Burns (1970) remarked that two subspecies of harbor seals occur in Alaska, richardi and largha. There are no skeletal differences, but largha is an ice-loving species. The largha species pups in May, before richardi. The earlier pups are born with a lanugo, a white fur covering.

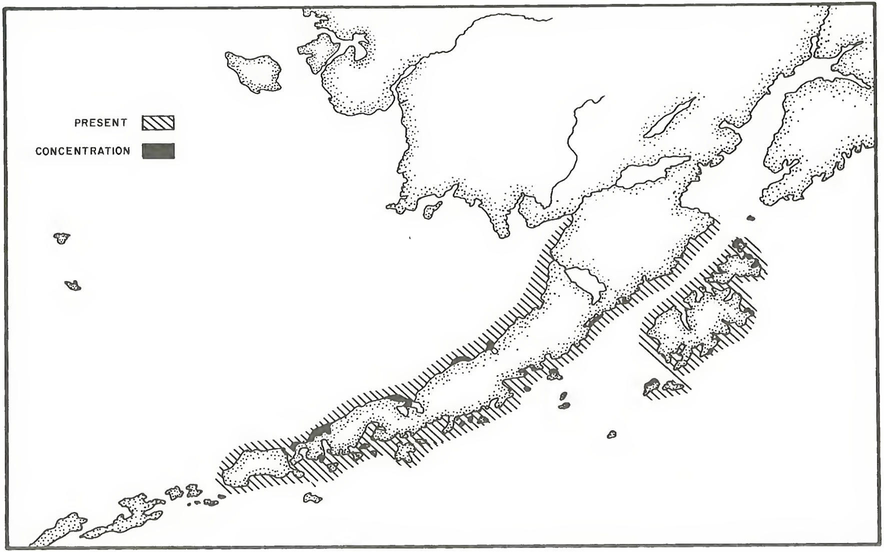

Figure 154. Distribution and concentration of harbor seals (from Alaska Department of Fish and Game 1973a).

Land-breeding seals give birth in June, and most pups have lost the lanugo by then. If pups are born earlier they retain the lanugo, but are deserted by their parents. Bishop (1967) presented a detailed discussion of reproduction, age determination, and behavior of the harbor seal.

Callohinus ursinus-Northern fur seal

Baker et al. (1970) presented a complete discussion of the fur seal which is used for the following discussion except where noted.

The northern fur seal is found in the Western Gulf in the fall, winter, and spring. A herd of approximately 1.4 million migrates to and from the main breeding ground on the Pribilof Islands (Figure 155). They travel in small groups between 16 and 145 kilometers offshore. Portlock Bank and the Sanak Islands are noted as areas of concentration.

The males winter in the Gulf of Alaska, then in June proceed north along the coast and through the Aleutian passes, False Pass, and Isanotski Strait (Murie 1959). The females winter from Bristish Columbia southward along the Pacific coast (Pike and MacAskie 1969). They arrive on the breeding grounds later than the males. After breeding, the main exodus occurs in November.

Historically, fur seals always have been very important to Alaska. In 1970, 276 Americans depended on the fur seal as their only livelihood, while another 173 were seasonally employed. In this same year, the gross income from fur seals was 3,249,325 dollars. Between 40,000 and 50,000 fur seals have been taken annually (Kenyon 1971).

Odontoceti-the toothed whales

A number of the toothed whales are found in the Western Gulf (Figure 155). The harbor porpoise, (Phocoena phocoean; Dall's porpoise, Phocoenoides dalli; killer whale, Orcinus orca; and sperm whale, Physeter catoden, are the most common (Table 43).

Pike and MacAskie (1969) stated that Dall porpoises are numerous in the Gulf of Alaska from February through September. They are probably migratory (Scheffer 1972). Harbor porpoises are more common inshore, while Dall's porpoises are more common in open waters (Scheffer 1949). Neither of these porpoises is commercially important in the United States, but the Danes and Russians use them for food (Scheffer 1972). Although Dall's porpoises are often caught in salmon nets (Mizue and Yoshida 1965), their principal food was found to be squid (Mizue et al. 1966).

Killer whales are an important predator in Alaska and have a potential value as aquarium specimens (Scheffer 1972). They are hunted for food in Norway (Matthew 1968). The diet of killer whales may vary substantially.

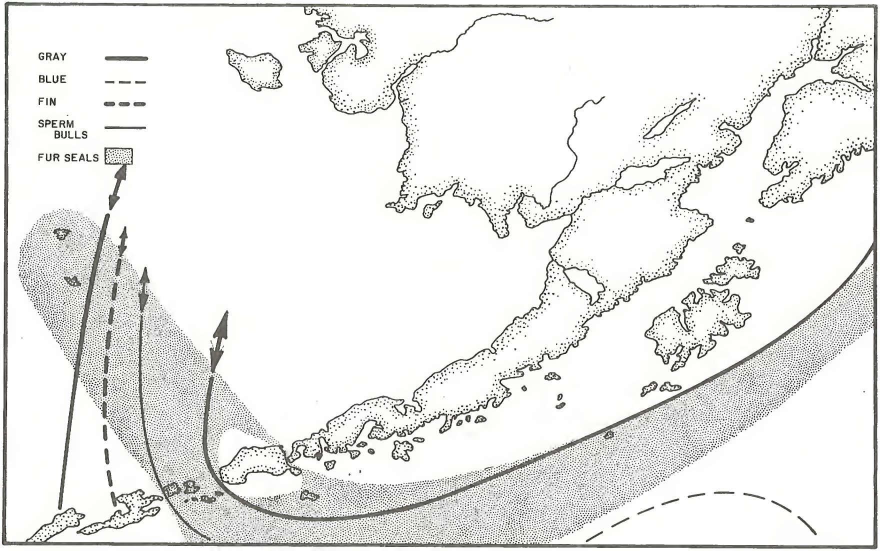

Figure 155. Migration routes of whales and fur seals (from Matthews 1968, Baker et al. 1970).

Table 43. Distribution and Abundance of Whales from Kodiak to Unimak Pass

rare (+), moderately common (++), common (+++)

Species	Abundance
Toothed Whales	
North Pacific white-sided dolphin (*Lagenorhynchus obliguidens*)	+
Short-finned pilot whale (*Gopicephala macrorhyncha*)	1 record
Killer whale (*Orcinus orca*)	++
Harbor porpoise (*Phocoena phocoena*)	+++
Dall's porpoise (*Phocoenoides dalli*)	+++
Sperm whale (*Physeter catoden*)	++
Bering sea beaked whale (*Mesoplodon stejnegeri*)	+
Goose-beaked whale (*Ziphius cavirostis*)	+
Giant bottlenose whale (*Berardius bairdi*)	+
Baleen Whales	
Blue whale (*Balaenoptera musculus*)	+
Fin whale (*B. physalus*)	++
Sei whale (*B. borealis*)	++
Minke whale (*B. acutorostrata*)	+++
Humpback whale (*Megaptera novaeanglieae*)	+
Gray whale (*Eschrichtius robustus*)	++
Right whale (*Balaena glacialis*)	+

Nishwak and Handa (1958) recorded the diet to be fish, squid, octopus, dolphins, whales, and seals in that order. Rice (1968) dissected 10 stomachs and found the remains of seven sea lions, seven elephant seals, two harbor porpoises, one minke whale, two opah halibut, one halibut, two sharks, and a squid.

Sperm whales winter in warmer latitudes, but males are often found as far north as the Gulf in summer (Rice 1971). Kodlov (1970) reported that they range north to the Bering Straits in search of their principal food, squid. Population estimates are uncertain. Omura and Ohsume (1971) estimated 167,000 male sperm whales in the North Pacific and stated that the population is not being harvested at maximum sustainable yield. Doi (1971) stated there are only 65,000 male sperm whales in the North Pacific and the population is definitely being depleted. Scheffer (1972) estimated the value of a sperm whale at 2,331 dollars.

Mysticeti-Baleen whales.

Baleen whales are so named because of the baleen plates they use to strain their principal foods; plankton, euphausids, pteropods and Calanus sp. (Matthews 1968). These whales are generally larger than the toothed whales and include the blue whale, Ballaenoptera musculus, which can measure 32 meters and weigh up to 108 metric tons (Storer and Usinger 1965). This whale is rare in the study area.

The minke whale, Balaenoptere acutorostra, is the most common baleen whale in the Western Gulf. This small whale has not been commercially important in the Eastern Pacific, but both Norway and Japan utilize it (Rice 1971). With continued depletion of the larger whales by Soviet and Japanese whalers, hunting the smaller whales has become economically feasible (McHugh 1969).

The fin whales, B. physalus, only recently hunted, have decreased from a recruitment population of 20,000 to 9,000 (Rice 1971). Not only is this below the maximum sustainable yield, it also indicates the susceptibility of these animals to hunting pressure. A similar trend was noted for sei whales, B. borealis, which were not formerly economically important. This stock is yet at or below maximum sustainable yield according to Rice (1971), who also noted a strange, contagious disease which causes the loss of the baleen plates. The eventual spread and effect of this disease is unknown.

The gray whale, Eschrichtius robustus, is one of the few whales which has been definitively studied. After calving in the warmer California waters, gray whales begin to migrate up the coast, staying close to the shoreline (Scheffer 1972). Passing through the study area, they move into the Bering Sea and concentrate near Bering Straits before dispersing south to their breeding grounds again. The discovery of its calving grounds in the lagoons of Baja California in the early 1800s almost resulted in the species' extinction. By 1946-47, there were only about 250 gray whales known to exist in the Pacific (Matthews 1968), but with protection, stocks have increased to around 11,000 (Rice 1971).

TERRESTRIAL BIOTA

Coastal Vegetation

The Western Gulf coastline is characterized by rocky cliffs and steep slopes. Vegetation appears to be impoverished although a great variety of plant species occur in the study area (Table 44). Most of these plants can be arbitrarily sorted into groups or associations.

The association nearest the coast can probably best be characterized by grass, Elymus arenarius, sometimes called wild rye grass. The habitat of this association is sand, either along beaches or occasionally on inland dunes. Common associates are Senecio pseudoarnica, an attractive yellow flower resembling a daisy; Lathyrus maritimus, a beach pea; Honckenya peploides, seabeach sandwort; and Mertensia maritima, the common oysterleaf. These species are encountered throughout the region on all sandy beaches, but species dominance varies as sand decreases and gravel and rocks increase.

The dominant plant in rockier portions of the coast is Potentilla villosa, cinquefoil, which grows in pockets of soil formed in crevices of rocks. The other species found with Potentilla are highly variable due to the constantly shifting conditions on the wind-swept rocks. No static associations have time to form in these rockier areas (Hulten 1973).

Further inland, the grasses are dominated by bluejoint or Calamagrostis group. At times the distinction between this group and the beachgrass association is quite clear, as Murie (1959) reported: "Elymus, exposed to the sands of the sea, clung to the open face of this slope to the crest. At the exact point where the ground leveled off toward the interior, the other, more inland, grass formation began with a dense growth." Although the Calamagrostis group is dominant, two other grasses share the inshore habitat, the Poa, blue grass, and the Bromus, brome grass. An abundance of grasses is common along the coastline of many of the small islands, where the most notable vegtation is often grass cover. This obvious resource has led to great interest in these islands as possible agricultural areas with high potential for grazing (Gasser 1952).

Burrowing animals often utilize these grassy areas. The dense mat of roots forms the roof of burrows for such rodents as voles and for burrowing alcides, such as pigeon guillemots and puffins. In winter, the grasses supply a readily available food source for these rodents when awakened by a drop in body temperature.

Table 44. Plant Species Described From Study Area (Hulten 1968)

1. COASTAL

Agrostis exarata
A. scabra
Poa emines
P. macrocalyx
Puccinellia nutkaenis
P. pumila
Agropyron pauciflorum
Elymus arenarius
Carex macrocephala
C. Gmelini
Juncus arcticus
Polygonum Fowleri
Atriplex Gmelini
A. alaskensis
Stellaria humifusa
Sagina crassicaulis
Honckenya peploides
Cochleania officinalis
Spergularia canadensis
Draba hyperborea
Draba hyperborea
Fragaria chiloensis
Potentilla fruticosa
P. villosa
P. Egedii
Astragalus polaris
Lathyrus maritimus
Ligusticum scoticum
Glehnia littoralis
Armeria maritima
Mertensia maritima
Plantago maritima
Galium aparine
Senecio pseudo-Arnica
S. nuda

2. SEAWATER/MARSHES

Zostera marina
Ruppia speralis
Puccinellia Langeana
Carex Lyngbyaei
Rumex transitorius
Hippuris tetraphylla
Castilleja hyetophila

3. SANDY SOIL

Poa glauca
Hordeum jubatum
Luzula acuata
Salix glauca
Rumex graminifolius

3. Continued

Sagina intermedia
Minuartia macrocarpa
Silene acaulis
Melandrium affine
Papaver alaskanum
Aphragmus Eschscholtzianus
Oxytropis campestris
Androsace alaskana
Chrysanthemus bipinnatum
Artemisia Tilesii
A. borealis

4. ROCKS/STONY SLOPES

Cryptogramma crispa
Thelypferis limbosperma
Cystopteris fragilis
Polypodium vulgare
Calamagrostis purpurascens
Poa paucispicula
P. brachyanthera
Carex circinnata
Bromus ciliatus
C. nigricans
Luzula spicta
Tofieldia coccinea
Lloydai serotina
Salix rotundifolia
Polygonum caurianum
Claytonia Scammoniana
C. sarmentosa
Stellaria monantha
S. laeta
Cerastium Beeringianum
Minuartia arctica
M. rubella
M. rossii
Anemone parviflora
Cardamine bellidifolia
Drba fladnizensis
D. hirta
D. maxima
Arabis lyrata
A. hirsuta
Sedum rosea
Saxifraga oppositifolia
S. serpyllifolia
S. flagellaris
S. bronchialis
S. mertensiana
S. bracteata

Plant Species Cont.

4. Cont.

Saxifraga unalaschensis
S. foliolosa
S. caespitosa
Heuchera glabra
Tellima grandiflora
Chrysosplenium Wrightii
Geum Tossii
Supinus nootkatensis
Astragalus unbellatus
Oxytropis Maydelliana
O. nigrescens
Diapensia lapponica
Androsace chamajasme
A. septentrionalis
Polemonium pulcherrimum
Eritrichium Chamissonis
Lagotis glauca
Pedicularis capitata
P. Kanei
Galium boreale
Campanula uniflora
Aster sibiricus
Chrysanthemum arcticum
Artemisia globularia
Arnica frigida
Senecio resedifolius
S. hyperborealis
Hieracium triste

5. GRASSY SLOPES

Botrychium lunaria
B. boreale
B. lanceolatum
B. lanceolatum
Carex anthoxanthea
Luzula multiflora
Cerastium aleuticum
C. arvense
Sagina saginoides
Melandrium apetalum
Drabe stenoloba
D. borealis
Saxifraga nivalis
Astragalus alpinus
Gentiana platuperfla
Plantago lanceolata
Campanula rotundiflora

6. WET SOIL

Equisetum plaustre
Trigolchin palustris
Alopecurus alpinus
A. aequalis

6. Cont.

Agrostis borealis
A. alaskana
Calmagrostis inexpansa
Deschampsia caispitose
D. beringensis
Vahlodea atropurpurea
Cathbrosa aquatica
Poa palustris
P. nemoralis
P. leptocoma
Puccinellia kamtschatica
P. glabra
Festuca rubra
Eriophorum Scheuchzeri
E. russoleum
Scirpus microcarpus
Eleocharis palustris
Carex dioica
C. Mackensies
C. glareosa
C. disperma
C. tenuiflora
C. laevilulmis
C. Kelloggii
C. bicolor
C. media
C. stylosa
C. Enanderi
C. Mertensii
C. macrochaeta
C. spectabilis
C. nesophila
C. livida
C. rostrata
C. rhynchophysa
C. saxatilis
Lysichton americanum
Juncus Drummondii
J. Mertensianus
J. falcatus
J. alpinus
J. triglumis
J. biglumis
J. bufonius
Luzula wahlenbergii
L. parviflora
Tofieldia pusilla
Sisyrinchium litorale
Corallorrhiza trifida
Populus balsamifera
Salix fuscescens
S. niphoclada
S. myttillifolia
S. Barclayi

6. Cont.

Salix alaxensis
S. sitchensis
S. arbusculoides
Myrica gale
Alnus incana
Urtica gracilis
U. Lyalli
Koenigia islandica
Rumex arcticus
R. fenestratus
Oxytia digyna
Polygonum pennsylvanicum
Claytonia sibirica
C. Chamissoi
Stellaria crispa
S. crassifolia
S. calycantha
S. sitchana
S. ruscifolia
Cerastium Fischerianum
Sagina occidentalis
Caltha palustris
Trollius Kiederianus
Delphinium glaucum
Ranunculus hyperborea
R. raptans
R. gelidus
R. Bongardi
R. occidentalis
R. occidentalis
Barbara orthoceras
Rorippa islandica
Cardamine pratensis
C. umbellata
Parrya nudicaulis
Leptarrhena pyrolifolia
Saxifraga Lyallii
S. hieracifolia
S. ferruginea
Chrysosplenium tetrandum
Luetkea pectinata
Potentilla norvegica
Sanguisorba Menziesii
Acer glabrum
Epilobium latifolium
E. luteum
E. palustre
E. anagallidifolium
E. leptocarpum
E. behringianum
E. Hornemannii
E. sertulatum
Angelica genuflexa
Romanzoffia unalaschensis
Plagiobothris orientalis
Mimulus guttatus
Veronica americana
Pinguicula vulgaris
Plantago macrocarpa
Galium triflorum

6. Cont.

Galium kantschaticum
G. trifidum
Valeriana capitata
Aster junciformes
Petasites frigidus
P. hyperboreus
Arnica amplexicaulis
A. Chamissonis
Senecio congestus
S. triangularis
Prenanthes alata

7. WATER

Isoetes muricata
Equisetum fluviatile
Sparganium angustifolium
S. hyperboreum
Potamogeton epihydrus
P. alpinus
P. gramineus
P. praelongus
P. perfoliatus
P. Berchtoldi
P. filiformis
P. vaginatus
Calamagrostis deschampoides
Carex aquatilis
Montia fontana
Nuphar polysepalum
Caltha leptosepala
C. natans
Ranunculas trichophyllus
R. confervoides
Subularia aquatica
Callitriche verna
C. anceps
Epilobium glandulosum
Hippuris vulgaris
H. montana
Utricularia vulgaris
U. minor

8. MEADOW & BOG

Botrychium miltifidum
Triglochin Maritimum
Hierochloe alpina
Phleum commatatum
Arctagrostis latifolia
Trisetum spicatum
Poa arctica
P. lanata
P. malacantha
P. hispidus
P. Stenantha
Arctophila fulva
Festuca brachyphylla
Bromus Pumpellianus

8. Cont.

Bromus sitchensis
Hordeum brachyantherum
Eleocharis nitida
Carex scirpoidea
C. pyrenaica
C. macloviana
C. Lachenalii
C. brunnescens
C. Podocarpa
Luzula tundricola
Veratrum viride
Veratrum viride
Allium schoenoprasum
Fritillaria camschatcensis
Iris setosa
Cypripedium guttata
Dactylorhiza aristata
Coeloglossum viride
Plannanthera convallariaefolia
P. dilatata
Salix reticulata
S. phlebophylla
S. arctica
S. cyclophylla
S. stolonifera
S. commutata
Betula kenaica
Alnus crispa
Polygonum viviparum
Aconitum delphinifolium
A. maximum
Anemone Richardsonii
Ranuculus Eschscholtzii
R. Maconuii
Oxygraphis galcialis
Thalictrum alpinum
T. sparsiflorum
Corydalis pauciflora
Draba nivalis
D. lactea
Saxifraga punctata
Parnassis palustris
P. Kotzebuei
Rubus arcticus
Potentilla palustris
P. hyparctica
Sibbaldia procumbens
Geum macrophyllum
G. calthifolium
Lathyrus palustris
Vicia biflora
V. langsdorffi
V. adunca
V. epipsila
Epilobium angustifolium
Cicuta Douglasii
C. mackenzieana
Conioselinum chinense

8. Cont.

Angelica lucida
Rhodendron camtschaticum
Loiseleuria procumbens
Andromeda polifolia
Chamaedaphne calyculata
Oxycoccus microcarpus
Primula tschuktschorum
P. cuneifolia
P. egaliksensis
Dodecatheon pulchellum
Lysimachia thyrsiflora
Gentiana algida
G. glauca
G. prostrata
G. amarella
G. aleutica
Swertia perennia
Menyanthes trifoliata
Polemonium acutiflorum
P. boreale
Romanzoffia sitchensis
Myosotis alpestris
Veronica Wormskuolkii
V. Stelleri
Euphasia mollis
Castilleja unalascheensis
Rhinanthus minor
Pedicularis Chamissonis
P. verticillata
P. parviflora
P. Langsdorfii
P. sudetica
P. Oedera
Pinguicula villosa
Solidago multiradiata
L. lepida
A. subspicatus
Erigeron peregrinus
Antennaria monocephala
A. Friestiana
A. rosea
Achillea borealis
Artemisia arctica
Arnica hessingii
A. latifolia
Senecio lugens
Taraxacum ceratophorum
T. triglonobum
T. kamtaschaticum
Hieracium gracile

9. TUNDRA & HEATH

Lycopodium selago appressum
Eriophorum angustifolium
Trichophorum caespitosum

Carex leptalea
C. pauciflora
C. canescens
C. Buxbaumii
C. pluriflora
C. limosa
Juncus filiformis
J. Oreganus
Spiranthes Romanzoffiana
Malaxis monophylla
Betula nana
Anemone narcissiflora
Drosera anglica
D. rotundifolia
Saxifraga hirculus
Rubus chamaemorus
Dryas octopetala
D. integrifolia
Sanguisorba stipulata
Empetrum nigrum
Ledum palustre
Phyllodoce aleutica
Phyllodoce aleutica
Cassiope Stelleriana
C. lycopodioides
Arctostaphylos alpina
Vaccinium vitis-idaea
V. uliginosum
Pedicularis labradorica
Campanula lasiocarpa
Saussurea angustifolia

10. WOODS/ACID SOILS

Lycopodium selage
L. annotinum
Lycopodium clavatum
L. alpinum
Selaginella selaginoides
Equisetum silvaticum
E. pratense
Botrychium virginianum
Adiantum pedatum
Thelypteris phegopteris
Athyrium felix-femina
Polystichum Braunii
Dryopteris dilatata
Gymnocarpium dryopteris
Blechnum spicant
Picea sitchensis
Hierochloe odorata
Cinna latifolia
Streptopus amplexifolius
Plananthera obtusata
Listera cordata
Salix depressa
S. pulchra
S. Scouleriana
Moehringia lateriflora
Coptis trifolia
Actae rubra
Mitella pentandra
Ribes lacustre
R. hudsonianum
Spiraea Beauverdiana
Aruncus sylvester
Sorbus scopulina
S. sitchensis
Amelanchier florida
Rubus pedatus
R. idaeus
R. spectabilis
Rosa nutkana
Geranium erianthum
Viola glabella
Shepherdia canadensis
Circaea alpina
Echinopanax horridum
Osmorhiza purpurea
O. chilensis
Heracleum lanatum
Cornis suecica
C. canadensis
Pyrola asarifolia
P. minor
P. secunda
Moneses uniflora
Cladothamnus
Vacinium ovalifolium
Trientalis europaea
Gentiana propinqua
Sambus racemosa
Viburnum edule
Linnaea borealis
Erigeron acris

11. INTRODUCED

Phleum pratense
Agrostis gigantea
Avena sativa
Poa trivialis
P. pratensis
Bromus tectorum
B. hordaceous
Agropyron repens
Triticum aestivum
Rumex acetosella
R. acetosa
R. obusifolia
R. cripus
Polygonum aviculare
Chenopodium album
C. Berlandieri
Stellaria media

11. Cont.

Cerastium fontanum
Spergula arvensis
Ranunculas repens
R. acris
Thlaspi arvense
Sisymbrium altissimum
Brassica juncea
B. rapa
Capsella bursa-pastoris
C. rubella
Erysimum cheiranthoides
Potentilla gracilis
Trifolium hybridum
T. repens
Gilia achilleaefolia
Galeopsis bifida
Veronica serpyllifolia
Plantago major
Anaphalis margaritacea
Anthemis cotula
Matricaria matricariodes
Senecio vulgaris
Taraxacum officinale
Sonchus arvensis

12. PARASITIC

Crobanche fasciculata
Boshniakia rossica

Even further inland, Hulten (1960) described a "mosaic" of alpine heath and meadow in which Carex, sedge, dominates. Sedge is widespread, being cited by Hanson (1951) as the dominant species of several coastal communities on Kodiak Island.

The tall vegetation of most of the Alaska Peninsula and Kodiak Island is composed of birch, Betula nana; willow, Salix sp; and alder, Alnus crispa. The association of Sitka spruce, Picea stichensis, and birch, Betula kenaica, extends about halfway down Kodiak Island and reaches the general vicinity of Becharof Lake on the mainland (Murie 1959). Observers disagree, but the forest may be slowly advancing southwestward along the Peninsula on Kodiak Island. Griggs (1934) believed that the forest had not yet reached its climatic limit. Capps (1934) reported the forest edge advancing about one mile per century.

Coastal Fauna

The most likely land birds to come in contact with the coastal waters are falcons and eagles, which nest in cliffs and trees along the coastline. These large, conspicuous birds usually prey on the marine life of an area. Murie (1959) noted in particular that the northern bald eagle, Haliaeetus leucocephalus, preys on murres, fulmars, and cormorants. Eagles also prey on a variety of other marine life, including herring, salmon (usually after they have spawned), Dolly Varden, sea urchins, clams, and crabs (Bent 1938). Kenyon (1969) reported that bald eagles often scavenge dead sea otters.

The eagle's marine diet may have some adverse consequences. Remains of murres, fulmars, and cormorants have been found in eagle nests, where young eaglets may be particularly susceptible to many types of contamination from these birds of prey. Furthermore, eagle eggs with abnormally thin shells, typical of birds feeding on organisms with a high pesticide content, have been reported from Kodiak Island (U.S. Departments of Agriculture and the Interior 1972).

The peregrine falcon, Falco peregrinus pealei, has been seen in the study area, but its population is uncertain. Murie (1959) noted the endangered bird feeding on least and crested auklets. Sowl thought he saw a peregrine on Chakliut Island, but was unable to make positive identification.[1] Cade (1960) said, "On the Alaska Peninsula and throughout the Aleutians, sea cliffs of volcanic origin provide abundant nesting habitat for peregrines...there can be little doubt that in this region these birds (cliff-nesting seabirds) provide the bulk of the food of peregrines." On a nest map, Cade noted that he had seen several peregrine nests in the Western Gulf and a gyrfalcon, Falco rusticola, nest on Kodiak Island. Gyrfalcons breed in the Aleutians and throughout Alaska (Peterson 1961). Gyrfalcons feed on various birds including marine and shore birds (White and Springer 1965).

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[1] Ibid.

The smaller rodents are numerous along the Western Gulf shoreline, nesting among the Elymus and Calamagrostis associations. There is some evidence that their numbers are cyclic, much like the snowshoe hare. After the peak of one apparent cycle, the tundra vole, Microtus oeconomus, was reportedly decimated on the Alaska Peninsula in the winter of 1953-1954 (Schiller and Raush 1956). Having observed a number of beetles, ticks, and mites infesting a heavy population of Microtus oceanomus on Amak Island, Murie (1959) speculated that "...an aggregation of more or less parasitic invertebrates in a dense mouse population could be an important element in the cyclic behavior of these rodents." In support of his theory, Murie observed that both lemmings and meadow mice (tundra voles) were scarce on the Alaska Peninsula during that same summer, and that "...none of the beetles mentioned above were noticed that summer, either on the Alaska Peninsula or on Unimak Island."

Shrews, Sorex sp., are also abundant in the study area. Schiller and Rausch trapped 12 Sorex vagrans around an abandoned cannery at Kukak Bay. Sorex cinereus were reported by Osgood (1904) as numerous in the coastal region. Shrews are insectivores, and most predators do not like their taste.

Lepus othus, the tundra hare, is found on the Alaska Peninsula south of the forest (Schiller and Rausch 1956). This hare does not frequent coastal areas, except in peak population years. The varying hare, Lepus americanus, was introduced to Kodiak in 1934, and is now found on the south end of the island in willow and alder associations.[1]

Ground squirrels, Citellus parrgi, are common on the Peninsula and Kodiak, as well as near shore islands. They can apparently swim some distance (Marie 1959).

Martes americana, the marten, occurs in the forests of the Alaska Peninsula, but is rarely found in the coastal study area. It has been introduced on Kodiak.

Mustela erminea, the ermine, occurs in habitats throughout the study area, and is frequently found along the coast. The ermine feeds on small mammals and birds, and prefers to kill its own food rather than scavenge. Schiller and Rausch (1956) noted an ermine feeding on a glaucous-winged gull.

The red fox, Vulpes fulva, is indigenous to Kodiak Island and the entire Western Gulf area. This fox is particularly abundant along the coast, where it feeds on rodents in the grasses and forages along the beaches for a variety of marine and intertidal life. Murie reported that Wetmore et al. (1945) observed these foxes feeding on flounders stranded on the beach at Thin Point. Murie (1959) himself observed that red foxes "...spend much time on the beaches of these islands, where they dug for clams they located by scent. They also picked up crabs at low tide and ate codfish or other carrion thrown up on the beach." Murie cited Beals and Longworth as finding fox droppings

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[1]W. Troyer, Former refuge Manager, Kodiak National Wildlife Refuge. Personal communication.

composed almost entirely of locally abundant beachfleas. At Dolgoi Island, Murie (1959) examined 57 red fox scats. One dropping contained 100 percent sea urchins, and three were composed entirely of beachfleas. These findings are summarized in Table 45.

The blue fox, Alopex lagopus, is not common in the study area, but it does occur. Where it has been introduced for fox-farming on offshore islands, the blue fox has become very abundant, at times decimating and eliminating the bird life of an island. Sowl observed that where old cabins existed, (presumably indicating past fox-farming) there were apt to be few if any birds.[1] Further west, in the Aleutian Chain, foxes present a very real threat to some endangered bird species (Murie 1959).

Racoons, Procyon lotor, were introduced to Long Island off Kodiak. Murie (1959) reported that there were still some left in 1936, although they were not flourishing. None survive today.

Mink, Mustela vison, have been sighted throughout the Alaska Peninsula. Mink were introduced to Kodiak and Afognak Islands via Long Island. Schiller and Rausch (1956) captured one, but after thriving on a diet of voles, it died when fed a small fish. Bones of the fish pierced the abdomen of the mink. It seems unlikely that mink feed on fish in the wild, though fish meal is one of their principal foods in captivity.

Gulo luscus, the wolverine, though never found in great numbers, does occur on the Alaska Peninsula and on Unimak Island. Voracious by nature, wolverines frequently forage along the beaches and will eat anything feasible. Beals and Longworth (Murie 1959) reported tracks on Unimak Island "...on practically all the beaches from Swanson Lagoon to Banjo Bay." The Alaska Department of Fish and Game (1973a) reported that wolverines are particularly fond of marine mammals which have died at sea and been washed ashore.

The land or river otter, Lutra canadensis, resembles its marine cousins so closely that the two often share the same habitat. Wetmore reported that land otters were frequently seen "...swimming boldly out to the islands, lying off the coast." River otters eat small fish, as well as freshwater and marine aquatic invertebrates (Burt and Grossenheider 1964).

The lynx, Lynx canadensis is found throughout the Alaska Peninsula, but is most common in the forested zone where it feeds on the abundant snowshoe hare. Generally not a scavenger, the lynx is unlikely to frequent the beaches of the area. Although the snowshoe hare was artifically introduced on Kodiak, no one has yet imported these large cats to that island.

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[1]Leroy Sowl, Supervisory Fish and Wildlife Biologist, U.S. Bureau of Sport Fisheries and Wildlife, Anchorage. Personal communication.

Table 45. Composition of 27 red fox scats

Item	Occurrence	Percent
Microtus	38	52
Bird	16	21.9
Beach fleas	6	8.2
Sea urchin (*Strongylocentrotus*)	4	5.4
Mussel (*Mytilus*)	2	2.7
Heavy cloth	2	2.7
Brown paper	2	2.7
Hair seal (*Phoca* sp.)	1	1.3
Small fish	1	1.3
Large bone	1	1.3

The wolf, Canis lupus, occurs throughout the study area. Turner (1886) stated that wolves crossed over the ice to Unimak Island. This may occur in severe winters throughout this region, but most of the islands are not large enough to support a population of wolves. Wolves are hunters and prefer to kill their own food; they will continue to feed on a kill for many weeks (Mech 1970). During severe winters, however, they will scavenge along the beaches, feeding on marine mammal carcasses when available. Murie (1959) reported that in the winter of 1918 the fur of two wolves was greasy, "...showing that they had been living off a whale carcass."

The brown bear, Ursus arctos, is one of the study area's most lucrative attractions (Figure 156). Hunters and photographers come from all over the world to stalk these monsters. In 1959, a total of 232,106 dollars was spent in Alaska to hunt the Kodiak bear; the greater portion of this money is spent by people from outside the state.[1] Despite its reputation for ferocity, these bears will generally retreat from people when possible.[2] Garbage dumps are constant attractions for bears which often creates a hazard (Clark 1957).

Bears have well-defined movement patterns (Figrue 157). In spring, they leave their dens and move to the coast where they graze on emerging vegetation and forage for carrion left over from winter. When the salmon run begins, bears congregate along the streams and lakes. As soon as berries begin to ripen, the bears abandon salmon areas and feed almost exclusively on berries until denning. During the winter, if awakened, they are likely to scavenge the beaches again in search of carrion. Being omnivorous, however, they also feed on seaweed at these times. Sowl observed a bear swimming to an island off the Alaska Peninsula and theorized that it might be feeding on bird eggs.[3]

Many ungulates have been introduced to the Western Gulf area including bison, Bison bison; Sitka black-tailed deer, Odocoileus hemionus sitkensis; Roosevelt elk, Cervus canadensis roosevelti; Dall sheep, Ovis dalli; mountain goat, Oreamnos americanus; and reindeer, Rangifer tarandus tarandus. In particular, Kodiak Island has been a noted experimental area for introducing exotic species, such as Sitka black-tailed deer (1934); elk (1927); beaver (1929-31); varying hare (1935-36); and muskrat (1929). Unsuccessful introductions to this island include mink, marten, Dall sheep, moose, and spruce grouse (U.S. Department of the Interior 1972). Ungulates are likely to frequent the beaches and coastal areas only in times of heavy snow when beaches may be the easiest places for travel. When very hungry, they will eat seaweed.

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[1]Willard Troyer and Richard Hensel. "The Brown Bear of Kodiak Island." Unpublished manuscript. U.S. Bureau of Sport Fisheries and Wildlife, Anchorage.

[2]Ibid.

[3]Leroy Sowl, Supervisory Fish and Wildlife Biologist, U.S. Bureau of Sport Fisheries and Wildlife, Anchorage. Personal communication.

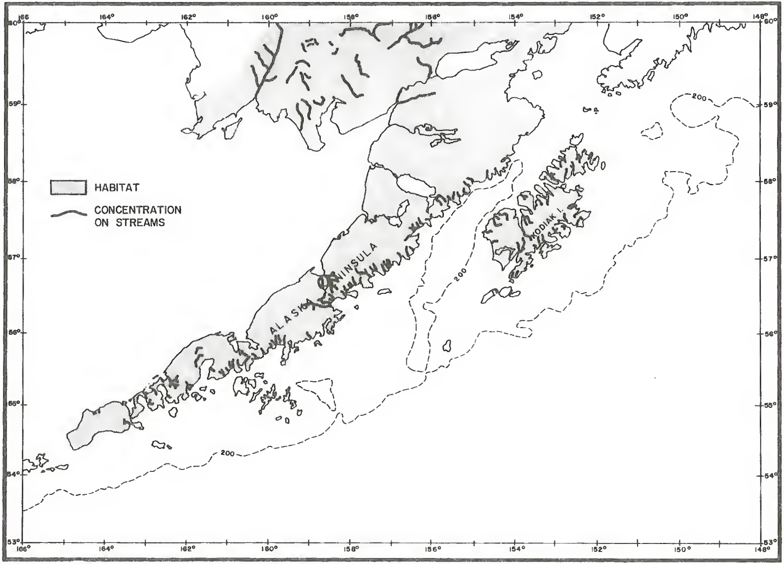

Figure 156. Distribution and concentration of brown bear (from Alaska Department of Fish and Game 1973a).

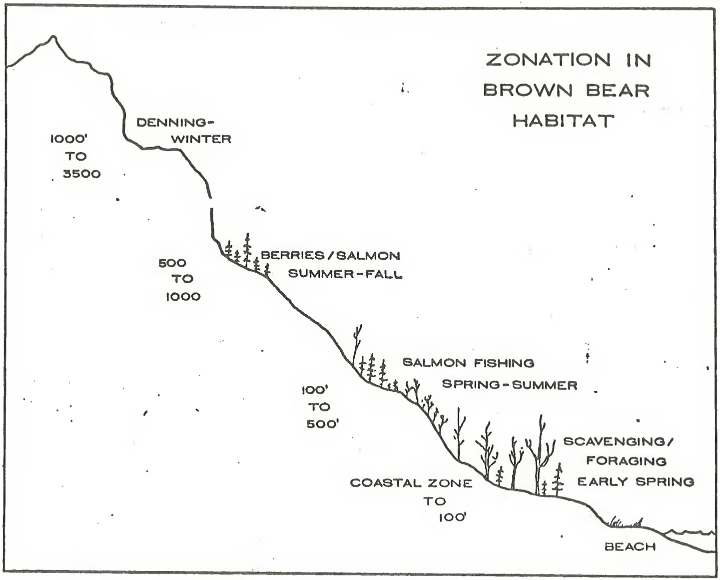

Figure 157. Zonation in brown bear habitat (from Clark 1957).

Caribou, Rangifer tarandus granti, and moose, Alces alces, are indigenous to the study area and range throughout the Alaska Peninsula (Figures 158 and 159). The caribou herd on the mainland contains approximately 14,000 animals, which migrate in a traditional, though relatively leisurely, fashion. Generally, the herd stays on the north side of the Alaska Peninsula. During winter, a few small bands congregate on the west side of Pavlof Bay. Caribou are reported to migrate to Unimak Island occasionally by swimming across Isanotski Strait. There is a resident herd of at least 1,500 individuals on Unimak island. This herd usually congregates along the northside lowlands, has no specific calving grounds, and does not migrate (Hemming 1971).

ECOLOGICAL SYSTEMS AND MECHANISMS

Ecologists often disagree on terminology and subdivisions of the environment. Classification in the Western Gulf area is particularly difficult, because almost no ecological research has been done--either in terrestrial regions, the intertidal zone, offshore waters, or on the outer continental shelf. For example, energy flow, predation, competition, critical limiting factors and other aspects of food chain dynamics are not well known. Most terrestrial information derives from reconnaissance and is descriptive in nature.

According to Rickets et al. (1968), three important interlocking factors--degree of wave shock, the bottom type, and tidal exposure--determine the distribution of marine fauna, particularly invertebrates, within a specific habitat.

Wave shock is determined by the size of the unbroken water body, water depth, and wind velocity, and direction. The presence of eelgrass and other factors which modify wave force determine the species composition of animal communities. The greatest modification of wave force is evident in closed bays, sounds, and estuaries, where fauna are different from those which inhabit the open coast. Some species occur in both closed and open areas, but those found in closed locations frequently differ in habit and habitat from those found in exposed areas.

The bottom type (clay, sand, gravel, silt, etc.) is important, because the various species of benthos have different requirements that can be satisfied only by specific bottom types. For instance, some animals with holdfasts require a rocky substrate while others, such as some clams, require sandy bottoms.

Tidal exposure--the length of time that intertidal fauna are exposed to air--varies from zones above the level of high spring tides, where animals are splashed by waves or spray only a few times each month, to the level of low spring tides, where species are uncovered only a few hours each month.

Many protected estuaries and intertidal waters exist within the broad category of "ice affected coast" (Figure 160). These waters

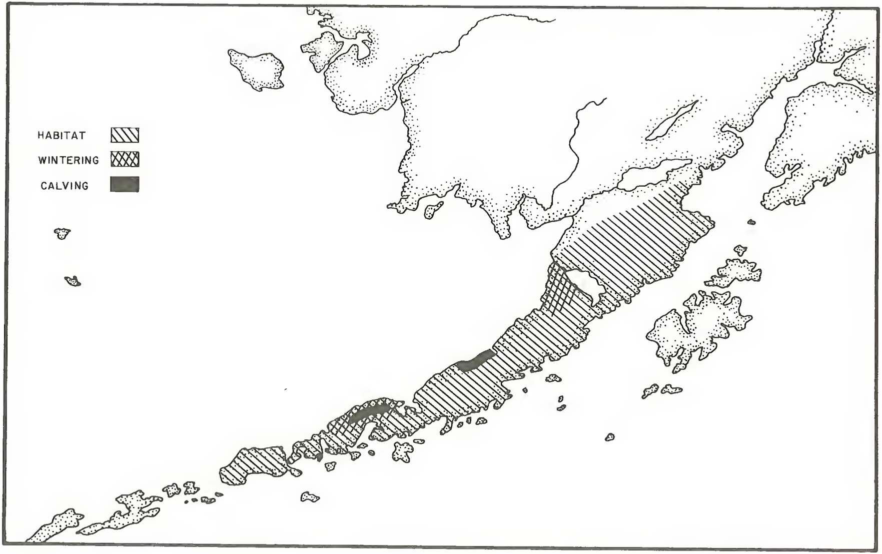

Figure 158. Distribution of caribou (from Alaska Department of Fish and Game 1973a).

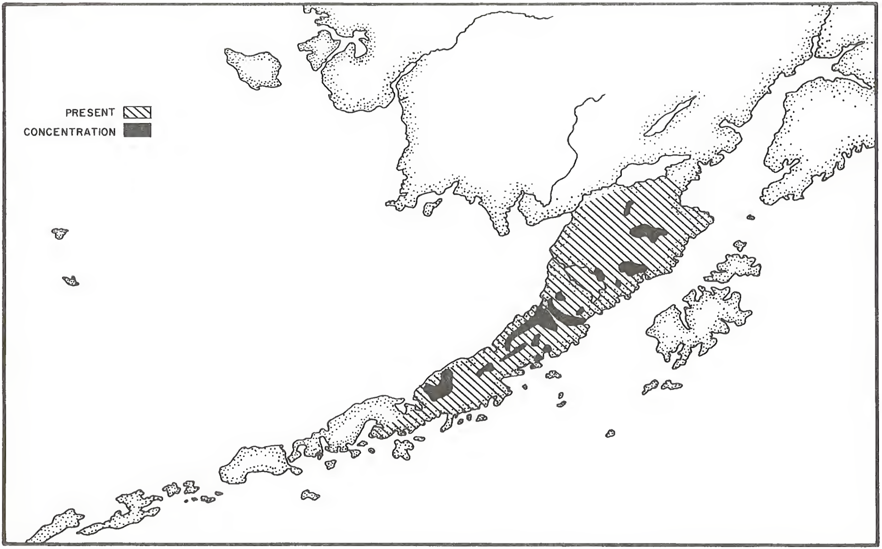

Figure 159. Distribution and concentration of moose (from Alaska Department of Fish and Game 1973a).

FIGURE 160

Marine Ecosystem of the Western Gulf of Alaska
(With Coastal Zone Information Included)

Boundary of Continental Shelf

The continental shelf boundary consists of the offshore waters to a depth of 200 m. Estimated shelf area is 60,000 square miles. Plant growth is dependent upon light received and the presence of nutrients. Mixing by wave and current action brings nutrients into the lighted zone. Shelf depths are shallow enough to support abundant marine life. Drifting singlecelled plants occur throughout the zone. More complex plants occur along particular coastal areas. Plant productivity is considered moderate (220 kg./hectare). Animals present are microscopic drifters; bottom processors (worms, etc.); clams, sponges, crabs, sea urchins, starfish, bottom fish (halibut, flounders, etc.); free-swimming fish (salmon, pollock, herring, trout, etc.); jellyfish, seals, sea lions; sea otters; several species of toothed and baleen whales, and narwhales (rare). Many species of shorebirds and oceanic birds are found near coasts. The worldwide shelf area supports approximately 90 percent of the ocean fisheries, and provides sufficiently shallow depths for mineral exploration and oil drilling. Its waters are also used extensively by man for transportation and recreation.

Wave Beaten Coast

Wave beaten coast includes all seaward coasts in the Gulf of Alaska; waves are the primary mixing agent. Estuaries are generally wide, short indentations in land, with depths of less than 100 m; they support larval and immature stages of most marine animals. Plant productivity is highest in these areas; kelp and intertidal seaweeds occur. Most types of marine fauna are found here, with a high incidence of clinging and intertidal species (mussels, barnacles, snails, and small crabs). The habitat favored by bald eagles is abundant. Many estuaries are highly prooductive. The wind generally is brisk; the climate is maritime; fishing is good. The coast provides many anchorages for ships.

Fjord Estuaries

Coasts here were eroded by past glaciers and are protected from the direct pounding of sea waves. The water is stratified, limiting high plant production to a period in early spring; such production is low during the summer. Kelp and intertidal seaweeds are found here. Phytoplankton productivity is variable. Micro and macro marine fauna are essentially the same as those found along the wave beanten coast. The estuaries may exchange water as infrequently as once per year; none are known to be stagnant. Occasional high winds blow through the valleys. The climate is maritime. There are many shelters, anchorages, and harbors in this region.

Oceanic

The ocean depth in these areas is greater than 200 m. Plant productivity is low due to a limited photosynthetic zone. Most animal life is found above mid-depth. Baleen and toothed whales and seals are present, as are most Alaskan shore and oceanic birds. Shipping and fishing are the main major commercial activities in this region.

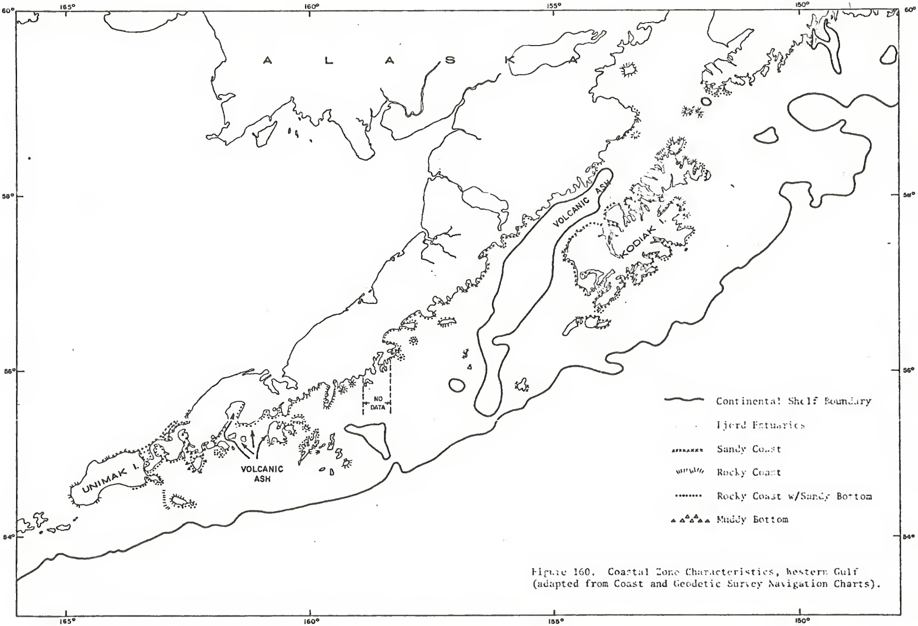

Figure 160. Coastal Zone Characteristics, Western Gulf (adapted from Coast and Geodetic Survey Navigation Charts).

are among the most productive in the world. Mechanisms and conditions interplay here to maintain energy transport at rates often considerably greater than those in offshore waters. Tidal action promotes rapid circulation of nutrients and food, and aids in the rapid removal of waste products. Diverse plant species and life forms--phytoplankton, benthic microflora, seaweeds, and sea grasses--provide a relatively continuous photosynthetic production during the growing season throughout the water mass. The close contact between producers and consumers enhances biomass productivity. Large eelgrass beds provide some protection for communities by partially dissipating wave and tidal forces (Odum 1963).

Ecological relationships in the marine environment are influenced greatly by the prevailing westerly current pattern; the rugged, irregular bottom relief of this area, and the migratory life style of many faunal species. These three factors combine to yield a complex and ever changing pattern of environmental conditions. Due to the lack of substantial ecological investigation within this marine system, it is possible to provide only a general overview of these conditions.

The Alaska Current continually carries suspended and planktonic matter in and out of the Western Gulf. The current flows into the study area from the east and flows out in a westerly direction, either south of the Aleutian Chain, or north into the Bering Sea. A portion of this organic matter becomes concentrated in eddies and gyrals adjacent to the main current flow, as Lisovenko (1964) found in his study of Pacific Ocean perch larvae and eggs. In this manner, the rate of passage or loss of organic production from the study area may be somewhat retarded.

In comparison to other coastal environments, this study area receives little organic or inorganic matter from the adjoining terrestrial environment, due to its short, steep drainage gradients and extensive volcanic topography. Thus, materials contributed from adjacent marine systems to the Western Gulf currently can be expected to have a far greater influence on its marine environment than does the input of materials from adjacent terrestrial systems.

The rate at which organic production within an environment is utilized, and thus the rate at which energy is transferred between stages of the food chain, is indicative of community metabolism. The ratio of phytoplankton standing crop to primary productivity provides one measure of this parameter (Table 46). In the vicinity of Unimak Island, a phytoplankton standing crop can accumulate with a low primary productivity; while eastward over the continental shelf and slope, primary productivity is rapidly consumed with little accumulation of a standing crop. Larger zooplankton populations eastward of Unimak Island serve to substantiate the higher community metabolism and rate of energy transfer in this portion of the study area. Insufficient data exist to extend this analysis into the Kodiak area, but that area might be expected to exhibit a similar high rate of energy transfer.

Table 46. Community Metabolism of Primary Producers in the Surface Waters of the Western Gulf of Alaska (station locations are indicated in Figure 66).

Station No.	Reference	Position	Primary Productivity mg C/m^3 /hr	Standing Crop mg chl a/m^3	Ratio (Standing crop/productivity)
2	McRoy et al. (1972)	54°15'N, 164°34'W	1.35	-	-
44	Faculty of Fisheries (1961)	54°20'N, 164°53'W	1.95	1.37	0.703
1	McRoy et al. (1972)	54°17'N, 164°19'W	0.85	1.6	1.882
41	McRoy et al. (1972)	54°27'N, 164°11'W	0.15	0.2	1.333
43	McRoy et al. (1972)	54°10'N, 164°14'W	0.40	0.6	1.500
44	McRoy et al. (1972)	53°53'N, 164°17'W	0.55	0.5	0.909
45	Faculty of Fisheries (1961)	54°04'N, 161°12'N	2.824	0.5	0.177
46	Faculty of Fisheries (1961)	54°18'N, 159°50'W	0.805	0.2	0.248
47	Faculty of Fisheries (1961)	54°22'N, 157°19'W	0.387	0.09	0.233
48	Faculty of Fisheries (1961)	55°01'N, 153°58'W	1.174	0.28	0.239
49	Faculty of Fisheries (1961)	55°11'N, 152°51'W	0.974	0.28	0.287

The abyssal depths south of the study area are a "semidesert," with relatively little biomass per unit area. Compared to the total depth of the water column, the photosynthetic zone in this region is extremely small, and productivity may often be limited by an insufficient nutrient supply.

The complexity of the submarine topography and sediments serves to provide numerous, varied habitats and support a rich, diverse fauna. The many canyons and gullies in this region provide convenient habitat for species which must migrate between different depths to fulfill specific life stage requirements. The irregular topography disrupts normal current patterns to create eddies and other unique circulation features which further dissect the environment into numerous subhabitats, each with its own unique physical conditions, capable of supporting a unique assemblage of flora and fauna.

Four major migratory patterns characterize faunal movements in this region: Offshore-onshore movements; anadromous species; migrants along the coastal region, and migrants between depths.

Flatfish exhibit an offshore-onshore migratory pattern, thus aiding the transport of organic production into and out of the coastal bays by making use of the coastal environment when it is most productive and avoiding it when physical conditions may highly stress the organism, such as during the winter season. These species tend to utilize the continental shelf extensively when not inhabiting coastal bays.

Anadromous species, such as salmon, exploit the productivity of the freshwater environment during reproductive and initial life stages. Maturing individuals pass through the coastal zone on their way to and from offshore waters where they spend most of their saltwater existence.

Species such as halibut and Pacific Ocean perch leave the study area periodically to spawn and overwinter in the more hospitable habitats of adjacent marine regions. Favorable currents return their eggs and larvae to the Western Gulf, while adults return under their own power.

The king crab is an example of a species which migrates vertically within the study area, moving between shallow spawning grounds and deeper feeding areas. Species which migrate vertically benefit from the unique character of different habitats within the study area at various stages of their life history; thus, they utilize the diversity of this region to their advantage.

Together, these movements of fauna circulate the organic production which they have assimilated in any one location within the study area throughout the entire region, thus typing all systems into a unit-ecosystem whose major characteristic might best be described as constant dynamic change.

Specific in-depth, freshwater ecological studies have not been conducted within the study area.

In the oceans, life is dominated by physical factors--waves, tides, currents, salinities, temperatures, pressures, and light intensities--which largely determine the structure of a biological community. Conversely, in the terrestrial environment, physical and biological factors interacting together determine the fate, distribution, and abundance of plant and animal species, with biological factors--succession, competition, and predation--directing this process in certain situations (Odum 1963).

Plant communities have been defined by grouping species. The predominance of an individual species within a plant community may vary greatly from place to place. Together, the plants and animals in an area comprise the biotic community, and in conjunction with their accompanying physical setting, form an ecosystem. The ecosystems depicted in Figure 161 characterize the Western Gulf area. (Joint Federal-State Land Use Planning Commission 1973, Viereck and Little 1972).

The maritime climate of the Western Gulf moderates the temperature but creates a heavy cloud cover with a resultant decrease in solar energy. Consequently, most of the land is covered with low, slowly growing vegetation. Primary consumers are herbivores and are widely distributed in both terrestrial and marine ecosystems. Secondary consumers, predators, also utilize both land and marine life. The intertidal zone is relatively bountiful in winter when food may be scarce elsewhere.

Many species living on land forage far out at sea and enrich the land with nutrients from the sea. In addition, oceangoing species such as salmon, spawn and die in fresh water. Their carcasses contribute significant nutrients to the land. In return, the nutrients from the land leach to the ocean.

In ages past, the environment was quite different. For about 500 million years, the world climate has alternated between warm periods of extensive tropical flora and ice ages. An ice sheet, centered on the U.S.-Canadian border and believed to have been as much as 4.3 km. thick, once covered all of the study area. Between 4,500 and 7,500 years ago, temperatures were about 2 C degrees warmer than now; the Arctic Ocean, for example, was ice-free. Presently, the worldwide temperature appears to be decreasing. Current glacier recession will halt if the temperature continues to decrease.[1]

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[1]M. Mitchell, Jr., Project Scientist for Climatic Change, Environmental Data Service. Silver Springs, Maryland. Personal communication.

FIGURE 161

Terrestrial Ecosystems of the Western Gulf of Alaska

Moist Tundra

Moist tundra consists of meadows of tall grass interspersed with dense, low, heath shrubs; found between sea level and 457 m. elevation, occupying poorly drained, shallow, loam soils of upper mountain slopes, and wet, silty soils on lower slopes and drainages. Mammals in such areas are the brown-grizzly bear, wolf, wolverine, caribou, Arctic hare, red fox, Arctic fox, lemming, and mice. The birds are ptarmigan, ravens, songbirds, dabbling and diving ducks, geese, brant, swans, grebes, loons, sandhill cranes, shorebirds, hawks, bald eagles, jaegars, snowy, and other open country owls. Man derives much of his livelihood from the sea and rivers of the region, gathering important edible herbs and roots, fuel, insulation, craft and building materials and obtaining meat, hides, and furs. The climate is cool. Coastal areas are subject to severe storms and great sea waves.

Wet Tundra

Wet tundra is usually found in areas with little topographic relief; standing water is almost always present in summer, and numerous shallow lakes are common. Dominant vegetation is sedge and cottongrass, usually forming a mat; a few woody and herbaceous plants occur on drier sites, and rooted aquatic plants occur along shorelines and in shallower lakes. Associated plants are lichens, mosses, low-growing willows, dwarf birch, Labrador tea, cinquefoil, beach rye, lowbush cranberry, bog cranberry, and occasionally rooted aquatic plants (bur reed, pond weed, pendent grass, and mare's tail). Soils are composed of poorly drained peat layers overlying silty and sandy sediments. Decomposition of vegetative growth by soil organisms is inhibited by cool temperatures. Less vegetation decomposes than is produced annually, resulting in sphagnum and sedge peat accumulation. Mammals are brown-grizzly bear, wolf, wolverine, caribou, moose, Arctic hare, mink, weasel, muskrat. Birds are ptarmigan, ravens, songbirds, dabbling and diving ducks, other geese, brant, swans, shorebirds, jaegars, marsh hawks, and open country owls. This system produces significant amounts of forage for reindeer and caribou, and provides abundant rich waterfowl habitat. The climate is cool and windy. Coastal areas are subject to wave erosion and damage by great sea waves.

Alpine Tundra

Alpine tundra is found in mountainous and exposed areas and consists of barren rocks and rubble interspersed with low herbaceous and shrubby plant mats, most prominently low heath shrubs, such as cassiopes and mountain-heaths. Other important species include bog blueberry, crowberry, mountain cranberry, alpine azalea, and several dwarf willows. This system occurs above 305 m., occupying lower mountain, hill, and ridge areas. Mammals are brown-grizzly bear, wolf, wolverine, elk (Afognak Island), mountain goat (Kodiak Island), fox, marmot, ground squirrel, lemming, and pika. Birds are ptarmigan, ravens, songbirds, some shorebirds, golden eagles, marsh hawks, gyrfalcons, snowy, and other open country owls. Man's activities in this system are usually of short duration, and limited to hunting and recreation. This system is usually moisture deficient in summer. Plant regeneration is often extremely slow.

High Brush

High brush consists of dense to open deciduous brush, basically of two types: (1) Coastal alder thickets, extensive Sitka alder thickets often having a well developed grass and fern understory. Associated species are bluejoint, devilsclub, willow, Sitka mountain ash, currant, thimbleberry, salmonberry, blueberry, and huckleberry. (2) Floodplain thickets are dominated by willows and alders. Associated shrubs include dogwood, prickly rose, raspberry, buffaloberry, highbush cranberry. This system develops rapidly on newly formed alluvial deposits that are periodically flooded. The high brush ecosystem is found on a variety of soils, including those poorly drained with permafrost in low river valleys, and wet to well-drained shallow upland soils on moraines, outwashes and mountain slopes with intermittent permafrost. Mammals are brown-grizzly bear, moose, wolf, wolverine, snowshoe hare, mountain goat (Kodiak Island), red fox, lynx. Birds are ptarmigan, ravens, hawks, owls, and songbirds.

Sitka Spruce Forest

A dense, evergreen forest ecosystem, Sitka spruce is the sole conifer on Afognak and Kodiak Islands. The understory includes crowberry, bearberry, rose, devilsclub, elderberry, salmonberry, highbush cranberry, red-osier dogwood, and ferns. This system is found on steep mountain slopes and valleys bordering the coast, descending from above 150 m. near Cook Inlet and on Afognak Island to sea level at its western limit on Kodiak Island. The substrate is composed of a complex of permafrost-free land surfaces and soils common to steep rocky slopes, glacial masses, extensive outwashes and morainal areas. Soils are shallow, coarse, loamy and well-drained near timber line. On lower slopes and high moraines soils are stony, gravelly, well-drained, and productive. Poorly drained, mucky peat soils occupy slopes and depressions in some areas. Soils on Afognak and northern Kodiak Island include surface ash layers. Mammals are brown-grizzly bear, wolf, wolverine, red fox, lynx, marten, squirrels, Roosevelt elk (on Afognak Island). Birds are blue grouse, ravens, crows, diving ducks, Canada geese, grebes, loons, bald eagles, hawks, songbirds, and woodland owls. The climate is maritime and wet.

Ice and Persistent Snow

Precipitation is heavy; average runoff is high year-round, peaking in midsummer, with distinct diurnal differences in runoff volume. Outburst floods occur occasionally; the ice and snow have a great effect on the streams. The alpine tundra ecosystem is closely associated. Algae occur on glaciers, and coarse rock debris is common on newly exposed areas. Meltwater carries rock material downstream to form terraces and outwash deposits. Exposed materials are soon invaded by lichens and mosses, followed by annual grasses, shrubs, and alder. Further succession may take place. Mammals are sheep, goats, caribou (which utilize such areas primarily for insect relief and as cool rest areas). Birds are numerous, and include ravens, eagles, and falcons. Airflow is generally downhill, and cool.

Lakes

Circulation is usually restricted in deep lakes, and stratification is evident. Production is higher in shallow lakes due to greater circulation. Shallow lakes usually contain the following aquatic plants: (1) Rooted submerged aquatics, such as bur reed and pond weed; (2) rooted emergent species, such as pendent grass, mare's tail, and marsh fivefinger. Lake bottom materials vary from bedrock to clays, including stones, gravels, and silts. Small shallow lakes in low bog areas fill rapidly, and usually reach the high brush stage. Submerged mucks consisting of mineral and organic deposits are the best producers of underwater vegetation for aquatic life. Mammals are moose, beaver, mink, weasel, muskrat, and land otter. Birds are songbirds, dabbling and diving ducks, geese, swans, grebes, loons, shorebirds, bald eagles, owls, hawks (including ospreys and peregrine falcons). Fish are trout, grayling, char, salmon, and others. Certain lakes are critical as spawning and nursery areas for salmon, and as breeding, nesting, and resting areas for migratory waterfowl. Shorelines and shallow lakes are heavily used by moose. Many lakes are used for recreation.

Riverine

Generally, streams are either glacial or non-glacial. Streambeds vary from sandy to gravelly and stony, with fine sands, silts, and silty clays in areas of slow-moving water. As streambeds change course, plant invasion occurs. Glacier-fed streams carry large amounts of sand and silt. Mammals are brown-grizzly bear, wolf, wolverine, moose, beaver, red fox, lynx, mink, weasel, muskrat, and land otter. Birds are songbirds, ravens, owls, dabbling and diving ducks, geese, grebes, loons, bald and golden eagles, hawks (including ospreys and peregrine falcons), and shorebirds. Fish are grayling, trout, char, salmon, and others. River channels are constantly changing. Heavy use of this system is made by man for recreation.

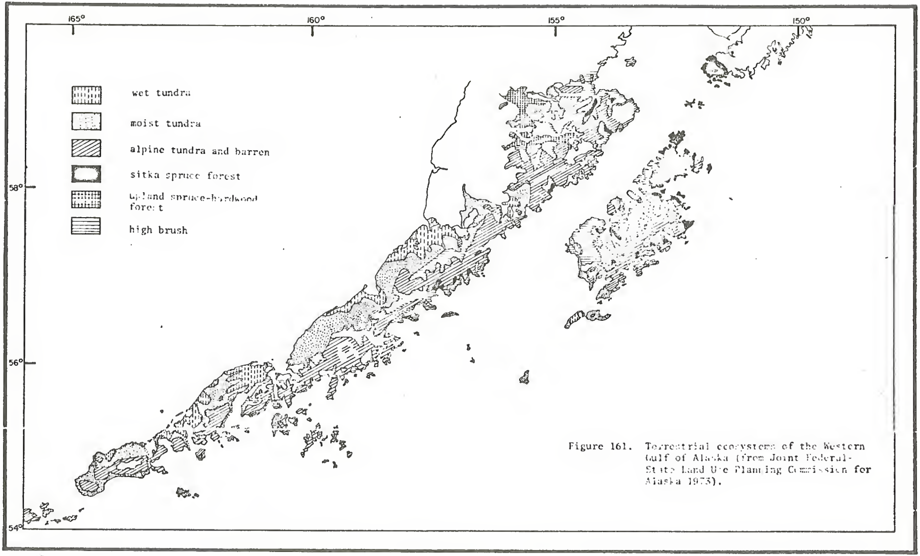

Figure 161. Terrestrial ecosystems of the Western Gulf of Alaska (from Joint Federal-State Land Use Planning Commission for Alaska 1973).

Flora in the study area have changed considerably in response to these climatic changes. Fossilized trees as large as 3 m. in diameter are found along the northwest coast of Unga Island, the largest island of the Shumagin Group. These fossils have been identified as belonging to the genera Sequoia or Metasequoia, which were widespread over the northern hemisphere from about 35 degrees north latitude to beyond the Arctic Circle during warmer times. Mastodons and mammoths also flourished in what are now Arctic and sub-Arctic regions. Metasequoia sp. flourished more than 20 million years ago. Its growth was apparently restricted to valleys and areas of low to moderate elevation, possibly flood plains, where humidity was high. Temperatures were moderate, rarely dropping to the freezing point. The trees on Unga Island were covered with sedimentary material between 11 and 25 million years ago (Eakins 1970).

Many reports clearly indicate the advance of Sitka spruce from Afognak Island, across Kodiak Island and toward the Alaska Peninsula (Griggs 1934; Lutz 1963; Murie 1959). Sitka spruce were planted on Unalaska Island in the Aleutians in 1805, and have produced cones and seedlings. There is great disagreement, however, as to whether such forests have existed in the Aleutians in the past. The forest edge on the Peninsula is advancing at a rate of approximately a mile per century. If current conditions prevail, these trees might, in time, cover the entire Alaska Peninsula.

The biotic environment of the Western Gulf is presently, and has always been, in a state of constant change.

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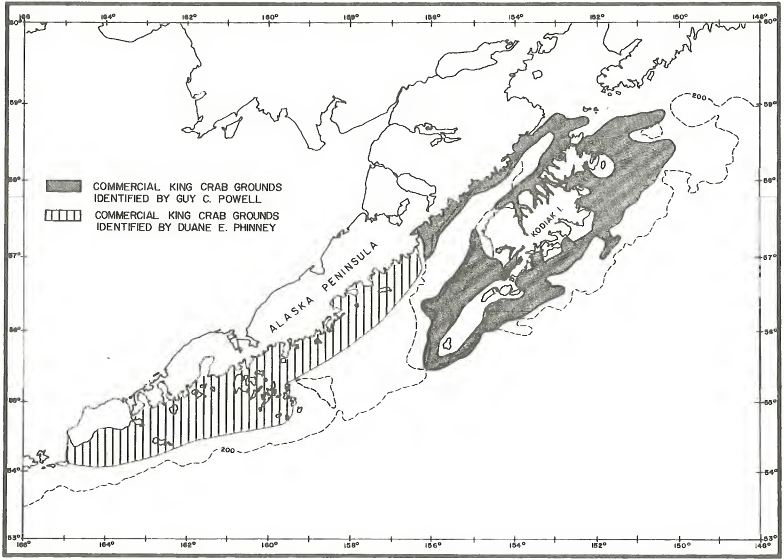

Figure A-1. Commercial king crab grounds identified by research and management staff, Division of Commercial Fisheries, Alaska Department of Fish and Game, Kodiak, Alaska (personal communication: Guy C. Powell, Fishery Biologist, June 21, 1974 and August 7, 1974; Duane E. Phinney, Regional Shellfish Coordinator, June 12, 1974).

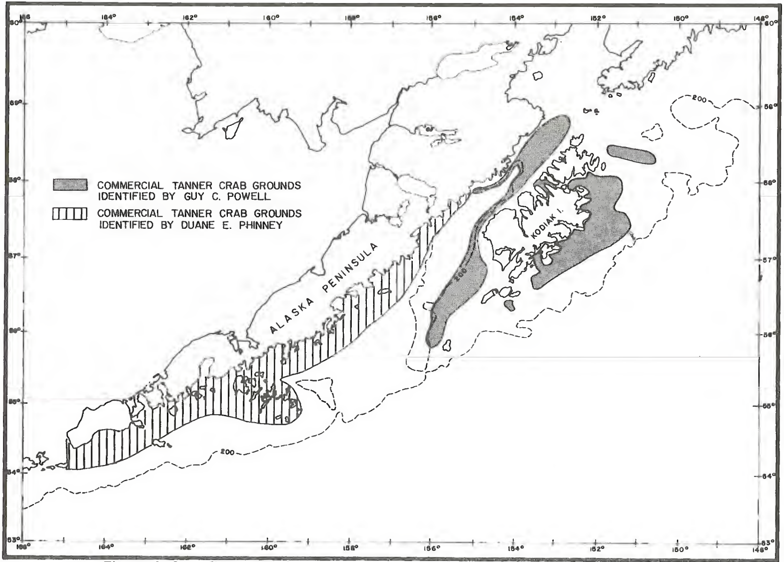

Figure A-2. Commercial tanner crab grounds identified by research and management staff, Division of Commercial Fisheries, Alaska Department of Fish and Game, Kodiak, Alaska (personal communication: Guy C. Powell, Fishery Biologist, June 21, 1974 and August 7, 1974; Duane E. Phinney, Regional Shellfish Coordinator, June 12, 1974).

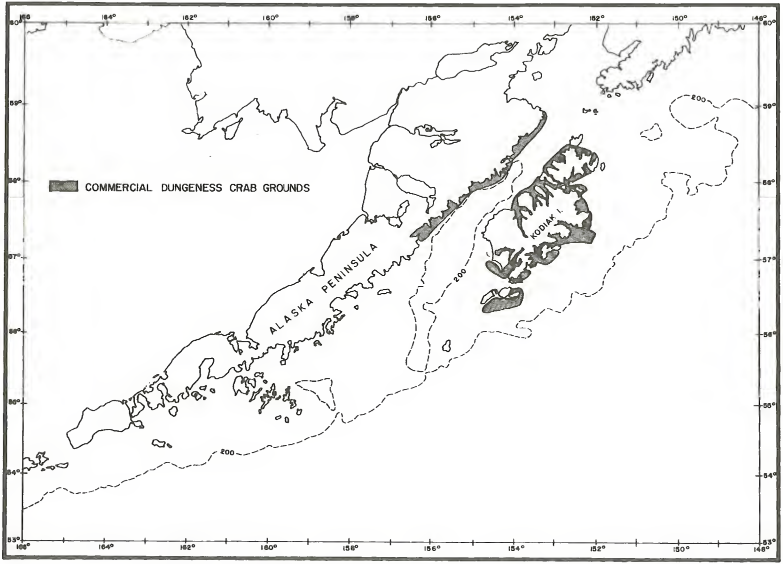

Figure A-3. Commercial Dungeness crab grounds identified by research and management staff, Division of Commercial Fisheries, Alaska Department of Fish and Game, Kodiak, Alaska (personal communication: Guy C. Powell, Fishery Biologist, June 21, 1974 and August 7, 1974).

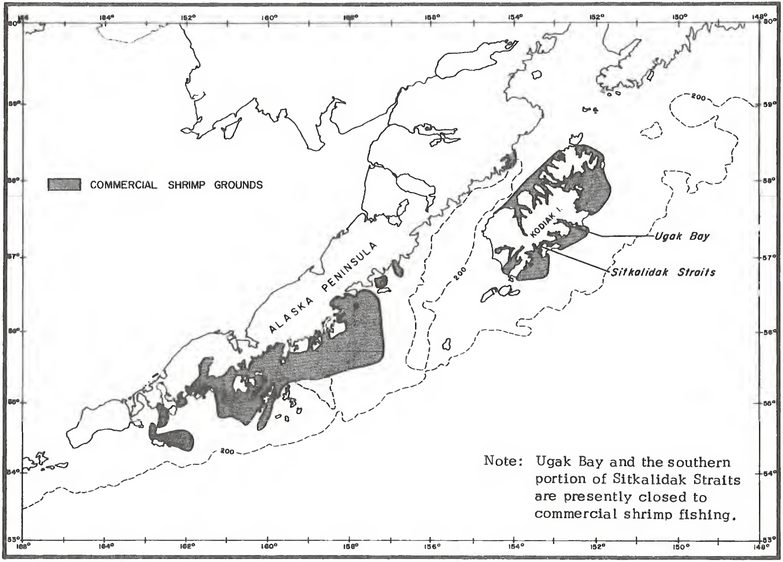

Figure A-4. Commercial shrimp grounds identified by research and management staff, Division of Commercial Fisheries, Alaska Department of Fish and Game, Kodiak, Alaska (personal communication; Peter B. Jackson, Fishery Biologist, July 30, 1974).

VIII. SOCIOECONOMICS

GENERAL DESCRIPTION OF THE STUDY REGION

Overview

At the time of the 1970 census, the combined population of the Kodiak and Aleutian Islands Census Divisions was about 17,500 persons. Of this total, about 11,000 persons lived in the Western Gulf region as defined in this study. Most of the population of the region fall into two principal racial groups: whites and Aleuts. The white population is largely concentrated in the military bases and in the city of Kodiak. The population of most other communities in the region is predominantly Aleut.

Except for military bases, the only major population center in the Western Gulf of Alaska is Kodiak with a population of 3,800. No other community in the region has a population of more than a few hundred. There are, however, several large military and Coast Guard bases located at Kodiak, Adak, and Shemya. As shown in Table 47, there are over 5,000 military personnel in the region. Compared to a civilian labor force of only 4,000, defense activities clearly have a powerful impact on the economy and society of the region. The effects are particularly pronounced in the Aleutian Islands where military personnel amounts to nearly half the total population and is three times as large as the civilian labor force.

The economy of the region is highly dependent upon the government sector, by far the largest employer. The figures in Table 47 show that government employment, civilian and military combined, accounts for 75 percent of total employment in the region. This proportion ranges from nearly 60 percent for the Kodiak Census Division to over 90 percent for the Aleutian Islands Division. Within the Aleutian Islands, government civilian employment alone exceeds total private employment. Throughout the Western Gulf region, the major private industries are commercial fishing and fish processing. The primary commercial fisheries are shellfish (particularly king crab), salmon, and halibut. On the average, fishing and processing accounts for about half of private employment, and during the peak summer months, the proportion is substantially higher. The importance of the fishing industry, with its inherent seasonality, is one factor producing the relatively high unemployment rate in the region.

Median family income in the area is significantly lower than the statewide figure of 12,443 dollars in 1970. Income is only moderately lower than average in Kodiak, but in the Aleutians, family income is only about two-thirds the state level. This gap widens if the cost of living is taken into account. For example, the cost of food in Kodiak is approximately 15 percent higher than in Anchorage. Although reliable

Table 47

SUMMARY STATISTICS, 1970

KODIAK AND ALEUTIAN ISLANDS CENSUS DIVISIONS

	Kodiak Census Division	Aleutian Is. Census Division	Total
Population	9,409	8,057	17,466
White	7,215	5,564	12,779
Aleut	1,582	1,972	3,554
Other	612	521	1,133
Military Personnel	1,491	3,689	5,180
Civilian Labor Force	2,935	1,088	4,023
Employment	2,653	925	3,578
Private	1,754	437	2,191
Government	899	488	1,387
Unemployment	282	163	445
Rate (percent)	9.6	15.0	11.1
Median Family Income	$11,166	$8,553	$10,253

Sources: U.S. Bureau of the Census 1970b, Babb 1972.

data are not available for the Aleutians, it is not unusual for living costs in comparable remote areas to be 30 to 50 percent higher than in Anchorage. On the other hand, there is a substantial amount of subsistence fishing and hunting in the region which is not reflected either in the income or cost of living figures.

In all, the socioeconomic environment of the Western Gulf of Alaska is difficult to analyze comprehensively due to the social, economic, and geographical diversity of the region itself. The aggregate statistics are, of course, dominated by the military-related activities. Because of this, the aggregate statistics in many instances provide poor measures of important aspects of social and economic development. Where possible, special 1970 Census computer runs were used to obtain data on socioeconomic characteristics by race. For Kodiak these runs sometimes make it possible to divide the Census data into two components: the Kodiak Island Borough and the Kodiak Naval Station (now the Kodiak Coast Guard Base). In the following discussion, every effort will be made to present sufficiently detailed data to accurately reflect the area's diversity.

Definition of the Study Region

Principally, the region consists of Kodiak Island and vicinity and the southern coast of the Alaska Peninsula as far west as Unimak Island. As shown in Figure 162 this geographic area includes all or part of three census divisions: all of the Kodiak Division, part of the Aleutian Island Division, and part of the Bristol Bay Division. The Census Divisions are of considerable importance because they are the areas for which much of the socioeconomic data are reported. Since the economic activity and the population of the Bristol Bay Division is centered well north of the Western Gulf, Bristol Bay is not included in this study. Wherever possible, the data for the Alaska Peninsula and the Aleutian Islands will refer only to those communities within the geographic study area. However, Nelson Lagoon will be treated as part of the study area even though it is on the north side of the peninsula. In terms of social and economic relationships, Nelson Lagoon is clearly a part of the region being studied. Also, in some cases the available data will be for the Aleutian Island Census Division as a whole.

The communities within the Western Gulf region are shown on Figure 162 and are listed in Table 48. The list includes all communities reported separately in the 1970 census. A summary description of each of these communities is given in the following section.

Major Communities in the Western Gulf Region

Kodiak and Vicinity

Kodiak, the oldest permanent settlement in Alaska, was founded by the Russians in 1792(?). The city flourished as a sea otter trading

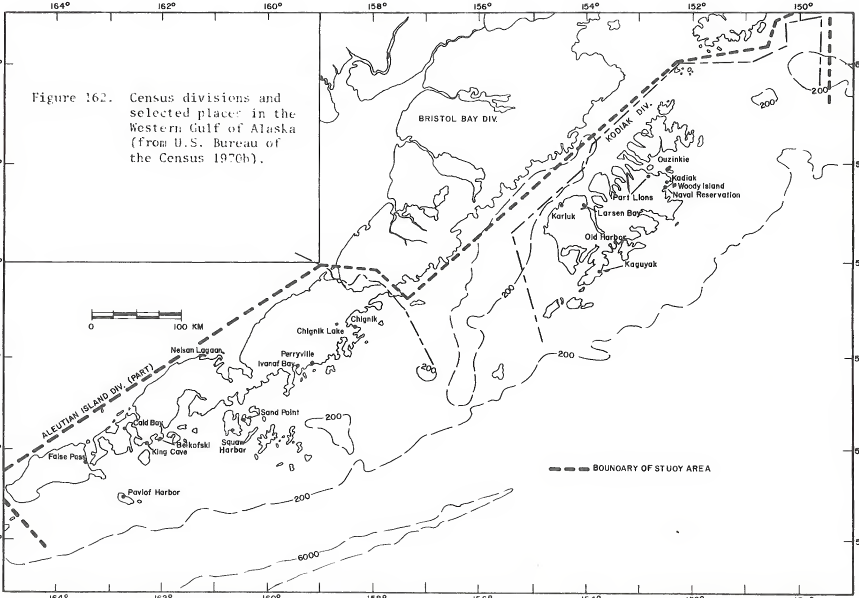

Figure 162. Census divisions and selected places in the Western Gulf of Alaska (from U.S. Bureau of the Census 1970b).

Table 48

COMMUNITY SIZE

WESTERN GULF OF ALASKA 1970

	Population
3000 or more population	
Kodiak	3,798
Kodiak Station	3,052
300-400 population	
Sand Point	360
200-299 population	
Cold Bay	256
King Cove	283
Old Harbor	290
Port Lions	227
100-199 population	
Akhiok	115
Chignik Lake	117
Larsen Bay	109
Ouzinkie	160
25-99 population	
Belkofski	59
Chignik	83
False Pass	62
Ivanof Bay	48
Kaguyak	59
Karluk	98
Nelson Lagoon	43
Pavlof Harbor	39
Perryville	94
Squaw Harbor	65
Woody Island	41

Source: U.S. Bureau of the Census 1970b.

center and by 1860 the community's population of Natives and Europeans numbered 1,500. Beginning in the 1840s the Russians had limited the killing of sea otters to insure a sustained yield.

When the United States purchased Alaska in 1867, regulation of the sea otter harvest ceased. As a result, intensive hunting drove the sea otter to near extinction. Kodiak's population and economy declined correspondingly. Between 1890 and 1929 the city's population averaged about 400. Beginning in the 1920s salmon fishing became the dominant force in the economy. Several canneries were built in the Kodiak area and by 1939 the population of the city rose to 864.

As early as 1892 the Japanese processed king crab. By 1902 Japanese and Russian floating canneries were operating in Alaskan waters. Since the Americans already had a prosperous salmon fishery, they showed little interest in harvesting king crab. In addition, they could not compete with cheap Japanese labor, lacked crab canning and harvesting technology, and knew little about the biology of the species. Americans were starting to investigate king crab production when World War II intervened.

Prior to the war the Navy began to worry that Japan might attack the continental United States via the Aleutian Islands. To avert such a threat, they began a military buildup in Alaska. Kodiak was chosen as a site for one of the first bases. In August 1939, 2,500 civilian construction workers, an Army garrison of 7,600, and more than 700 Navy personnel poured into Kodiak to begin construction of Kodiak Naval Station. The military activities strengthened Kodiak's economy and by the end of the war, the population in the city had increased to 4,000.

After the war the salmon industry in the area was on the decline. In 1948 a Kodiak resident built a small floating cannery and became the first American to process king crab commercially. In 1950 the Koidak area catch was only 29.5 metric tons, but its potential was soon recognized and the industry expanded tremendously. By 1960 the catch was 41,250 metric tons.

In March of 1964 in the midst of its king crab prosperity, Kodiak was hit by an earthquake and devastating seismic waves. The waterfront seafood processing plants were severely damaged and much of the fishing fleet was lost. More than 40 percent of the downtown business areas was destroyed. The losses in the city of Kodiak alone totaled more than 22 million dollars, but with the assistance of federal loans and grants, the rebuilding of Kodiak was under way within two months. The construction activity helped offset the temporary loss of employment in other industries. The modernization of the community in the post-earthquake period and the diversification in the fishing industry helped stablize Kodiak's economy over the longer run.

Between 1960 and 1970, despite a reduction in military activity, Kodiak's population increased to 3,800 (U.S. Bureau of the Census 1970b). Today Kodiak is by far the largest city in the Western Gulf of Alaska. It is the trade, service, government, and transportation center for Kodiak Island. King crab production has declined in recent years, but the harvest of a variety of other seafood has continued Kodiak's prosperity.

Woody Island, located one mile from the city, is considered part of the Kodiak urban area. The population of Woody Island has declined markedly from 111 in 1950 to 41 in 1970. A few homes, a Baptist mission, a Federal Aviation Agency communications stations, and a small school are now the only facilities on the island. Transportation to Kodiak is provided by a converted fishing boat when weather permits, and during bad weather, the island is effectively isolated (Tryck, Nyman and Hayes 1968).

The Kodiak Coast Guard Base is located at Kodiak Station about four miles southwest of the city of Kodiak. Prior to its transfer on July 1, 1972, this facility was the Kodiak Naval Station. The base provides logistic support to Coast Guard units in the area which includes three ships, an air station, a communications station, and a LORAN (long-range aid to navigation) station. The base lends support to other vessels on patrol in Alaska and ships of the National Atmospheric and Oceanographic Administration. Assistance in military and civilian search and rescue missions is also available.[1]

The 1970 Census reported 3,052 military personnel and their dependents living on the naval base. In October 1973 the Coast Guard information officer said that the population on the base had been reduced to 2,300 persons. Housing is provided for military personnel and dependents. Recreational, commissary, and medical services are provided by the Coast Guard. The Coast Guard has a five-year plan for modernization and construction on the base. They anticipate that the number of personnel stationed at the base will gradually increase.[2]

Chiniak Air Force Station, located southeast of Kodiak, is connected with the Kodiak urban area by a 45 mile road. Of the 120 personnel stationed at the Chiniak facilities, approximately one-third live in Kodiak or outlying areas with their families (Tryck, Nyman and Hayes 1968).

Kodiak Island Villages

Six villages, inhabited primarily by Natives, are also part of the Kodiak Island Borough: Port Lions, Ouzinkie, Old Harbor, Akhiok, Larsen Bay, and Karluk. Between 1960 and 1970 all these communities

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[1]H.A. Parker, Public Information Officer, Kodiak Coast Guard Base, October 1973. Personal communication.

[2]Ibid.

increased in size with the exception of Ouzinkie which experienced a 25 percent decline. The combined growth rate for these villages during the 1960s was 15 percent. Of 1,056 persons living in the Kodiak villages, only 130 (12 percent) are white (Evans and Rybeck 1973). Nearly all of the Natives are of Aleut ancestry according to the 1970 Census.

The economy of all of these villages is heavily dependent upon the fishing industry which offers nearly all of the opportunities for employment and cash income. Processing plants are located in or near all of the villages. These plants handle a variety of seafood resources found in abundance near the villages, including salmon, shrimp, scallops, and several varieties of crab. In addition to commercial fishing, subsistence fishing and hunting are important pursuits in these villages.

There is a small sawmill at Ouzinkie and plans to build another at Port Lions to harvest local timber stands. However, the total employment in lumber is expected to be minor compared to fishing. There is a limited amount of tourism employment--primarily guided hunting and fishing trips--but recreational potential near these outlying villages remains largely undeveloped.

The communities closest to Kodiak (Port Lions, Ouzinkie, and Old Harbor) have relatively modern housing and offer a wider range of facilities and services than are found in most Alaskan villages. Village modernization in these areas was primarily the result of post-earthquake construction. The new village absorbed the populations of Afognak and Port Wakefield which were heavily damaged and deemed unsafe for continued habitation. The villages of Akhiok, Kauluk and Larsen Bay, which are more remote from Kodiak, suffered relatively minor earthquake damage. Thus, there was little need for major rebuilding. In general, these villages have poor housing, a low level of basic services and facilities, and living conditions are much more primitive than those found elsewhere on the island (Tryck, Nyman, and Hayes 1968).

None of the borough villages has a road connection with Kodiak, although there are plans to build roads to the city from Port Lions and Ouzinkie. All villages are linked to Kodiak via regularly scheduled air service. In addition, fishing boats are commonly used to transport passengers and goods. Port Lions is also served by the Alaska State Ferry Tustumena which provides connections with Kodiak and Homer.

Seafood canneries and processing plants are located at Port Williams, Port Bailey, Uganik Bay, Zachar Bay, Uyak Bay, and Lazy Bay. During the fishing season as many as 50 to 100 persons live and work at these plants. At the end of the season the facilities close and nearly everyone leaves, except a few maintenance personnel (Tryck, Nyman and Hayes 1968).

Unspecified Places on Kodiak Island

In 1970, 9,409 persons were accounted for in the populations of the city of Kodiak, Woody Island, Kodiak Station, and the outlying villages. This leaves 1,460 persons who were not given a particular location (Table 49). The Census ennumeration maps do not show the boundaries of the districts which hold these persons, but most of the general areas were near the city of Kodiak. Additionally, since more than 80 percent of this residual population is white, it is likely that many of these persons live in the vicinity of the city of Kodiak (Table 49).

Sand Point

Sand Point, with a population of 360, is the largest village in the Alaska Peninsula portion of the Western Gulf (U.S. Bureau of the Census 1970b). From 1880 until 1950 the population of Sand Point grew very slowly. Then the area's fishery expanded and the population of Sand Point grew rapidly. Between 1950 and 1960 the population increased by 137 percent (U.S. Bureau of the Census 1960). Much of this growth is attributable to migration from other Western Gulf communitites with fewer economic opportunities.

Except for a brief period of placer gold mining during the early part of this century, Sand Point's economy has been dominated by the fishing industry (Alaska Consultants, Inc. 1970). The first canneries were built there in the late 1880s to process cod. Later, when the cod were fished out, salmon became the primary fishery resource. Since World War II, king crab, tanner crab, and halibut have been harvested and processed at Sand Point. Today Sand Point's economy is entirely dependent on two fish processors. One freezes crab, halibut and salmon. The other is a cannery for king crab. Salmon fishing is also important to Sand Point's economy, but most of the local harvest is collected by cannery tenders and taken to King Cove for processing. Since 1966 king crab catches in the Sand Point area have declined drastically. This segment of the fishery has changed from a year-round opearation to a seasonal one. Increased seasonality in the harvesting of king crab has been offset to some extent by a shift to other species such as tanner crab.

Sand Point is a major halibut port. Halibut vessels fishing in the Bering Sea or in the Aleutian Islands must have their licenses validated and catches recorded at Sand Point before sale. In addition, the regulations require halibut vessels to lay over for eight days following a fishing run. After this time their licenses can be validated for the next trip (International Pacific Halibut Commission 1972). The halibut fleet layovers during the fishing season (which extends from April to October) provide a significant inflow of money into the local economy.

Although the villages of Cold Bay, King Cove, Port Moller, Squaw Harbor, Perryville, and Belkofski are all located within a 160 km. radius of Sand Point, the community is relatively isolated from Alaska's

Table 49

POPULATION BY RACE AND SEX--BY COMMUNITY

WESTERN GULF OF ALASKA 1970

PLACE	ALL RACES			WHITE			NEGRO		
	Male	Female	Total	M	F	Tot	M	F	Tot
Alaska Peninsula									
Belkofski	31	28	59	2	3	5	1	0	1
Chingnik	44	39	83	7	9	16	0	0	0
Chignik Lake	62	55	117	1	1	2	0	0	0
Cold Bay	193	63	256	166	48	214	9	0	9
False Pass	36	26	62	4	0	4	0	0	0
Ivanoff Bay	29	19	48	1	1	2	0	0	0
King Cove	145	138	283	14	17	31	0	0	0
Nelson Lagoon	25	18	43	2	2	4	0	0	0
Pavlof Harbor	22	17	39	1	0	1	0	0	0
Perryville	51	43	94	2	2	4	0	0	0
Sand Point	187	173	360	48	44	92	0	0	0
Squaw Harbor	46	19	65	9	4	13	0	0	0
Unspecified Places	52	25	77	36	5	41	2	0	2
Subtotal	923	663	1586	293	136	429	12	0	12
Kodiak Island									
Akhiok	61	54	115	1	1	2	0	0	0
Kaguyak	39	20	59	19	7	26	0	0	0
Karluk	58	40	98	2	1	3	0	0	0
Kodiak	2055	1743	3798	1668	1426	3094	27	17	44
Larsen Bay	48	61	109	9	9	18	0	0	0
Old Harbor	157	133	290	10	11	21	0	0	0
Quzinkie	99	61	160	11	6	17	0	0	0
Port Lions	128	99	227	26	17	43	0	0	0
Woody Island	19	22	41	12	15	27	3	3	6
Kodiak Station	1897	1155	3052	1736	1034	2770	65	40	105
Unspecified Places	804	656	1460	668	526	1194	2	0	2
Subtotal	5365	4044	9409	4162	3053	7215	97	60	157
WESTERN GULF-TOTAL	6288	4707	10995	4455	3189	7644	109	60	169

Source: U.S. Bureau of the Census, 1970 Census, special computer runs.

Table 49 (continued)

POPULATION BY RACE AND SEX--BY COMMUNITY

WESTERN GULF OF ALASKA 1970

PLACE	INDIAN			ALEUT			ESKIMO			OTHER		
	M	F	Tot	M	F	Tot	M	F	Total	M	F	Total
Alaska Peninsula												
Belkofski	0	0	0	28	25	53	0	0	0	0	0	0
Chingnik	0	0	0	37	29	66	0	1	1	0	0	0
Chignik Lake	1	0	1	60	51	111	0	3	3	0	0	0
Cold Bay	3	2	5	9	7	16	2	3	5	4	3	7
False Pass	0	1	1	30	25	55	2	0	2	0	0	0
Ivanoff Bay	0	0	0	28	18	46	0	0	0	0	0	0
King Cove	2	1	3	128	120	248	1	0	1	0	0	0
Nelson Lagoon	0	0	0	23	16	39	0	0	0	0	0	0
Pavlof Harbor	6	5	11	14	12	26	1	0	1	0	0	0
Perryville	3	3	6	46	38	84	0	0	0	0	0	0
Sand Point	4	4	8	128	121	249	2	1	3	5	3	8
Squaw Harbor	0	0	0	15	14	29	0	0	0	22	1	23
Unspecified Places	0	0	0	17	17	34	0	0	0	0	0	0
Subtotal	19	16	35	563	493	1056	8	8	16	31	7	38
Kodiak Island												
Akhiok	0	0	0	60	53	113	0	0	0	0	0	0
Kaguyak	0	0	0	17	13	30	0	0	0	3	0	3
Karluk	0	0	0	56	39	95	0	0	0	0	0	0
Kodiak	32	21	53	244	235	479	14	17	31	70	27	97
Larsen Bay	0	0	0	39	52	91	0	0	0	0	0	0
Old Harbor	1	0	1	142	119	261	4	3	7	0	0	0
Quzinkie	5	1	6	83	54	137	0	0	0	0	0	0
Port Lions	1	0	1	98	78	176	0	0	0	3	4	7
Woody Island	0	0	0	0	0	0	0	0	0	4	4	8
Kodiak Station	4	7	11	6	1	7	1	1	2	85	72	157
Unspecified Places	14	20	34	95	98	193	10	6	16	15	6	21
Subtotal	57	49	106	840	742	1582	29	27	56	180	113	293
WESTERN GULF TOTAL	76	65	141	1403	1235	2638	37	35	72	211	120	331

Source: U.S. Bureau of the Census, 1970 Census, special computer runs.

major population centers. Air transportation provides the only scheduled passenger service from Sand Point to other Alaska communities. To supplement the limited scheduled service, there is a good deal of non-scheduled air traffic between Sand Point and communities on the Peninsula and Kodiak. Marine transportation is also important to the community. Much of the local transportation is provided by fishing vessels. In addition, Seattle-based steamships transport goods to Sand Point and return to the States with processed seafoods.

King Cove

The village of King Cove was established in 1911 following the construction of a large salmon cannery at the site (Alaska State Housing Authority 1968). Native families soon settled near the new plant and began taking part in the commercial fishing industry. The first U. S. Census enumeration of the village in 1939 recorded a population of 135. King Cove grew steadily until 1960 (U.S. Bureau of the Census 1960) and then held nearly constant between 1960 and 1970.

Today the King Cove seafood processing plant is a large and well-developed installation processing salmon and crab. It is the only processing plant in the village, but has offered stable employment to local residents since it began operations in 1912. The average monthly employment for 1968 was 220. Additional workers must be imported from other parts of Alaska during peak periods. Employment has seasonal variations due to the nature of the fishing industry, but the plant's ability to process both salmon and crab keeps it in operation nearly year-round.

King Cove is a major trading and supply center on the Alaska Peninsula. When the fishing vessels in the area need repair, the marina at the processing plant services them. In addition, the company's oil dock supplies fishing boats from communities within a 160 km. radium of King Cove. Commercial development in the village is primarily family-owned mercantile businesses, but these stores carry a wide variety of merchandise considering the remoteness of the community from sources of supply. Air freight shipments from Anchorage are generally routed through the large airport at Cold Bay and are then brought to King Cove, usually by amphibious aircraft. Air passenger flights via Cold Bay are available from King Cove to Anchorage three times each week. Steamships from Seattle serve the ice-free port of King Cove year-round.

Cold Bay

Cold Bay is the only predominantly white community in the Alaska Peninsula portion of the Western Gulf. The community was established as a military base and airport during World War II. Today the airport is jointly maintained by the Federal Aviation Agency and the State of

Alaska. The airport is used primarily as a refueling stop for international freight shipping and much of the traffic is military cargo flights. Flying Tiger freight lines and Reeve Aleutian Airways maintain small base camps and a few employees in Cold Bay.

The economy of Cold Bay consists almost entirely of state and federal government employment. The U. S. Fish and Wildlife Service headquarters for the management of the Izembeck and Aleutian National Wildlife Refuges are located in Cold Bay. The Alaska Department of Fish and Game also maintains a headquarters there. The U. S. Weather Bureau has a station at the airport. There is a remote duty Air Force site 16 km. from town which is manned by 40 military personnel.

State and federal housing is available so that government employees can move their families to Cold Bay. However, there are few accommodations for dependents of airline employees or military personnel. The Native population generally consists of just a few families and fluctuates from year to year. There is no cannery in Cold Bay, but the Natives do have some opportunities for employment with government agencies and airlines.

Despite its remoteness, Cold Bay is served by non-stop passenger service from Anchorage six times per week. Depending on the type of aircraft, the flight takes between one hour and 45 minutes and two hours and 40 minutes. Cold Bay's large, modern airport serves as the transportation hub for the Alaska Peninsula area of the Western Gulf.

<u>Other Villages in the Western Gulf Region</u>

According to the 1970 Census, there are 12 other small villages in the Western Gulf region: Belkofski, Cape Sarichef Air Force Station, Chignik, Chignik Lake, Chignik Lagoon, False Pass, Ivanof Bay, Nelson Lagoon, Pavlof Harbor, Perryville, Port Moller, and Squaw Harbor. Nelson Lagoon is on the north coast of the Alaska Peninsula, False Pass is on Unimak Island, and the remaining villages are on the south side of the Alaska Peninsula. In 1970, the total population in these villages was 687. The population is made up almost entirely of Natives, with Aleuts comprising nearly 80 percent of the total. Only 92 whites reside in these villages and most are school teachers and their families, except for 26 military personnel at Cape Sarichef.[1]

Commercial fishing and fish processing offer the only significant sources of wage employment in any of the nine villages. In fact, several of the villages are essentially "company towns" associated with the local cannery. In the extreme case of Squaw Harbor, the cannery owns almost all the level land as well as the houses in the villages (Jones 1973).

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[1] Dorothy Jones, Sociologist, Institute of Social, Economic and Government Research, University of Alaska, Fairbanks. October 1973. Personal communication.

During the past several decades, there have been substantial, and sometimes quite rapid, changes in the population of these villages as families have migrated from one village to another or to larger cities. Some of these shifts have been only temporary, perhaps in response to seasonal demands of the fishing industry. Individuals may spend part of the year away from their homes working in canneries, in other local communities, or on Kodiak Island.[1] Other shifts are more permanent. For example, some of the young people who leave the area to go to high school do not return.[2] In addition, families choose to leave those villages that lack adequate employment opportunities in order to relocate in nearby villages with better job opportunities and superior community services (Jones 1973).

As a result of this continuing process of migration, the population figures for these small villages have to be interpreted very cautiously. Existing villages may decline or even disappear while other villages grow and new villages are created. For example, the last remaining family recently moved from Pavlof (or Pauloff) Harbor, a village with a reported population of 39 in the 1970 Census (Jones 1973). Conversely, the village of Ivanof Bay came into existence between the 1960 and 1970 Census. Beginning in 1965, some of the residents of Perryville moved to nearby Ivanof Bay, which they felt was a better site for a village (U. S. Public Health Service 1969). Clearly, in examining the socioeconomic structure of the region, it is important to recognize the dynamic interactions among the small villages and between the villages and the larger communities.

POPULATION AND EDUCATION

Patterns of Population Change

Figure 163 illutrates that over time there have been two massive shifts in population levels in the study region. Both shifts were due to outside forces imposed on the region. The first Russian contacts and occupation came around 1760 and from that time to the first U. S. census in 1880, the Native population dropped from 7,500 to 2,500 (Rogers 1972). After this tragic decline, the population remained virtually constant up to 1939. Then, during World War II, the large amount of military construction and the inflow of troops to the region caused the population to exceed 7,000 by 1950.

In the postwar period, population continued to grow steadily; there was an increase of 15 percent between 1950 and 1960 and over 30 percent between 1960 and 1970 (Table 50). The gain in the most recent period occurred despite a decline in military personnel in the area. Although there has been strong growth overall, it has not been distributed evenly

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[1]Marion Soule, Kodiak Manpower Center, October 1973. Personal communication.

[2]Ibid.

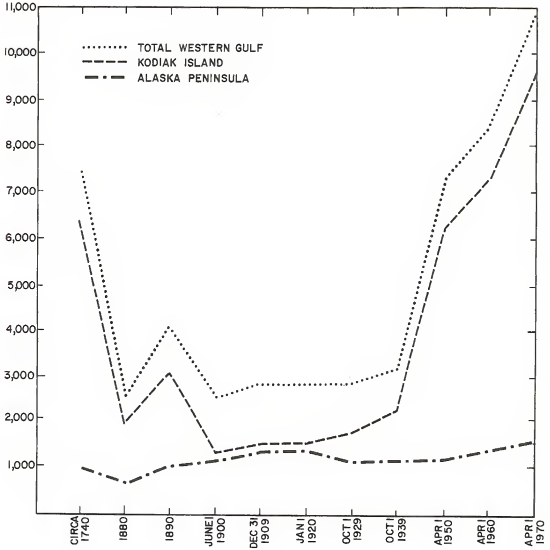

Figure 163. Regional population of the Western Gulf of Alaska, 1740-1970 (from Rogers 1972).

Table 50

POPULATIONS OF CITIES AND VILLAGES

WESTERN GULF OF ALASKA 1929-1970

	April 1 1970	April 1 1960	April 1 1950	Oct. 1 1939	Oct. 1 1929	% Change 1950-60	% Change 1960-70
WESTERN GULF REGION	10,995	8,653	7,510	3,235	2,844	+15.2	+27.5
KODIAK ISLAND	9,409	7,174	6,264	2,094	1,729	+14.5	+31.2
Akhiok	115	84	72	-	-	+16.7	+36.9
Kaguyak	59	36	-	-	-	-	+63.9
Karluk	98	129	144	189	192	-10.4	-24.0
Kodiak (City)	3,798	2,628	1,710	864	442	+53.7	+44.5
Kodiak Station	3,052	2,743	3,000	-	-	- 8.6	+11.3
Larsen Bay	109	72	53	38	-	+35.8	+51.4
Old Harbor	290	193	121	109	84	+59.5	+50.3
Ouzinkie (formerly Uzinkie)	160	214	177	253	168	+20.9	+25.2
Port Lions (formerly Afognak)	227	190	158	197	298	+20.3	+19.5
Woody Island	41	78	111	54	116	-29.7	-47.4
Unspecified Places	1,460	807	718	390	429	-	-
ALEUTIAN COMMUNITIES IN WESTERN GULF	1,586	1,479	1,246	1,141	1,115	+18.7	+ 9.9
Belkofski	59	57	119	140	123	-52.1	+ 3.5
Cape Sarichef A.F.S.	26	-	-	-	-	-	-
Chignik	83	99	253	224	-	+24.1	-28.2
Chignik Lagoon	45	108	-	-	-	-	-
Chignik Lake	117	107	-	-	-	-	-
Cold Bay	256	86*	-	-	-	-	*
False Pass	62	41	42	-	-	-2.4	+51.2
Ikatan	-	-	29	-	-	-	-
Ivanof Bay	48	-	-	-	-	-	-
King Cove	283	290	162	135	-	+79.0	- 2.4
Nelson Lagoon	43	-	-	-	-	-	-
Pavlof Harbor	39	77	68	61	52	+13.2	-49.4
Perryville	94	111	-	-	-	-	-15.3
Port Moller	6	-	33	45	-	-	-
Sand Point	360	254	107	99	69	-	+41.7
Squaw Harbor	65	-	45	-	-	-	-
Unga	-	-	107	152	150	-	-
Unspecified Places	-	249	281	285	721	-	-

* In 1960 the pppulation of the Air Force station at Cold Bay was not included in the population total.

Sources: U.S. Bureau of the Census 1950, 1960, 1970b; Rogers 1972.

throughout the region. As shown in Table 50, some communities remained stagnant or declined during the 1960s while others grew very rapidly. The city of Kodiak also grew much more rapidly than the region as a whole.

The wide range in regional growth rates resulted from the social and demographic diversity of the region's population. For example, Aleut birthrates are much higher than those for whites. Thus, the expected rate of natural increase for Native villages is higher than for a predominantly white community. The growth pattern is not only influenced by movements of families from one community to another, but also by the substantial migration into and out of the region as a whole. Finally, the movements of military personnel and the relative importance of defense related activities can be key factors in determining a community's growth or decline.

Population on Kodiak Island

The population of Kodiak Island can be divided into two distinct components: (1) the Kodiak urban area, consisting of the city of Kodiak, Woody Island, the Naval Base at Kodiak Station and the outlying areas around the city; (2) the villages located along the coast of Kodiak Island. The two components do, of course, have close social and economic ties but their demographic characteristics are very dissimilar. Most noticeably, the population of the Kodiak urban area is predominantly white, while 85 percent of the village population is Aleut (Table 49).

The population of the Naval Base (Kodiak station, which became Kodiak Coast Guard Base in 1972) includes both military personnel and their dependents and is a little more than 90 percent white. Although there is no regional data on the racial composition of military personnel, the proportion of whites to other racial groups in the Armed Forces is also 90 percent for the state of Alaska. Thus, Kodiak Station offers a typical example of how the inclusion of a military base can significantly alter the reported racial composition of a city or region.

Except for people living on the Naval Base, three-fourths of Kodiak Island's population live in the city of Kodiak. Although the population of Kodiak is 80 percent white, more than one-third of the Natives on Kodiak Island live in Kodiak. In fact, more than 20 percent of the Natives in the entire Western Gulf region live in Kodiak. As the commercial and industrial center of the region, the city of Kodiak has historically offered economic opportunities that attract migration. As a result, Kodiak's rate of growth and the composition of its population is determined much more by migration than by natural increase.

During the decade from 1960 to 1970, the Kodiak Census Division grew by 31 percent (Table 51). The civilian population grew by 2,500 or 48 percent while the number of military personnel was cut from 1,800 to 1,500. The white population grew by the relatively small amount of 24 percent; undoubtedly a reflection of the high proportion of whites in

Table 51

POPULATION GROWTH, 1960-1970

KODIAK CENSUS DIVISION

	1960 CENSUS			1970 CENSUS			% Change Of Total 1960-1970
	Male	Female	Total	Male	Female	Total	
Total Population	4,378	2,796	7,174	5,365	4,044	9,409	+31.2
Civilian	2,571	2,796	5,367	3,899	4,019	7,918	+47.5
Military Personnel	1,807	--	1,807	1,466	25	1,491	-17.5
White	3,611	2,211	5,822	4,162	3,053	7,215	+23.9
Non-white	767	585	1,352	1,203	991	2,194	+62.3
Negro	72	46	118	97	60	157	+33.1
Indian	12	7	19	57	49	106	+66.1 (Indian, Aleut, Eskimo, Other combined)
Aleut	*	*	*	840	742	1,582	
Eskimo	*	*	*	29	27	56	
Other	683	532	1,215	180	113	293	

*In 1960 Census Aleut and Eskimo are included in the "other" category.

Sources: U.S. Bureau of the Census 1960, 1970b; Babb 1972.

the military. Since 1970 the military cutback has continued; the number of personnel was reduced to 1,300 in 1971 and to 660 in 1972 (Alaska Department of Labor 1972). In July 1972 the base was transferred to the Coast Guard which now has 600 personnel stationed there.[1] Direct measures are not yet available but it is certain that the direct and indirect effects of this drastic military cutback will have a significant impact upon Kodiak's population.

The nonwhite population in the Kodiak Census Division grew by more than 60 percent between 1960 and 1970, an average annual increase of 5 percent. That growth is clearly in excess of the rate of natural increase due to significant migration into the Kodiak area. The figures in Table 52, although only approximations, provide estimates of natural increase and migration as the sources of population growth. The estimated net increase in civilian nonwhite population is 874 persons. Of that total, 250 persons or 28 percent, are attributable to net in-migration. The remaining population growth of 625 persons is natural increase (births minus deaths) of the resident nonwhite population.

Despite the reduction in military personnel, there is an estimated in-migration of 332 white persons. Since some military personnel are accompanied by their dependents, a reduction in the military personnel generate a reduction in the civilian population as well. Thus, if one could adjust for all military related population movements, the net in-migration of non-military families would be even larger than the estimates in Table 52. Even without making this adjustment, migration accounts for 20 to 30 percent of the population growth among whites as well as nonwhites.

Table 53 shows how the population growth was distributed among the city of Kodiak, Kodiak Station, and Kodiak Island villages and outlying areas. Although only 40 percent of the white population lived in the city of Kodiak, over 60 percent of the growth in the white population was in the city. It is interesting that the population of Kodiak Station increased even though the number of military personnel was reduced. This was due to the substantial increase in the housing provided on the military base for families of military personnel.

The Native population throughout the Kodiak area grew quite rapidly. In both the city and the villages and outlying areas the growth was in excess of the rate of natural increase. Thus, there seems to have been a general pattern of migration of Natives from other areas to Kodiak Island.

Table 52 also contains estimates of the rates of natural increase for 1960, 1970, and average rates over the decade. For all population groups shown, there is an extremely sharp drop in the rate of natural increase between 1960 and 1970. This is due to the reduction in the birthrate during that period (Rogers 1971). This phenomenon occurred throughout the country and is generally attributed to several factors.

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[1]H.Z. Parker, Public Information Officer, Kodiak Coast Guard Base, October 1973. Personal communication.

Table 52

COMPONENTS OF POPULATION CHANGE 1960-1970

KODIAK CENSUS DIVISION

	All Races			White			Non-white		
	1960	1970	Change 1960-70	1960	1970	Change 1960-70	1960	1970	Change 1960-70
Population	7174	9409	2235	5822	7215	1393	1352	2194	842
Military personnel[1]	1807	1491	-316	1626	1342	-284	181	149	-32
Civilian population	5367	7918	2551	4196	5873	1677	1171	2045	874
Births	248	259	2457	172	175	1646	76	84	811
Deaths	39	56	487	24	34	301	15	22	186
Natural increase	209	203	1970	148	141	1345	61	62	625
Rate of natural increase (total pop.)	2.91%	2.16	2.37[2]	2.54	1.95	2.06[2]	4.51	2.82	3.53[2]
Rate of natural increase (civ. pop.)	3.89%	2.56	2.97[3]	3.53	2.40	2.67[3]	5.21	3.03	3.89[3]
Migration			265			48			217
Civilian Migration			581			332			249

[1]Calculated assuming that 90 percent of military personnel are white. That is the average proportion for the state during the 1960-1970 period.

[2]Calculated using the average of the 1960 and 1970 population figures.

[3]Calculated using the average of the 1960 and 1970 civilian population figures.

Sources: U.S. Bureau of the Census 1960, 1970b.

Table 53

POPULATION CHANGE 1960-1970
Kodiak, Kodiak Station and Kodiak Island Village and Outlying Areas

(Number of Persons)

	TOTAL			WHITE			NONWHITE		
	1960	1970	Change 1960-70	1960	1970	Change 1960-70	1960	1970	Change 1960-70
City of Kodiak	2,628	3,798	+1,170	2,222	3,094	+872	406	704	+298
Kodiak Station	2,743	3,052	+309	2,469	2,770	+301	274*	282	+8
Kodiak Island Villages and Outlying Areas	1,803	2,559	+756	1,131	1,351	+220	672	1,208	+536

*Estimated by assuming that 10 percent of population is nonwhite.

Sources: U.S. Bureau of the Census 1960, 1970b; Rogers 1972.

There were improvements in birth control methods and programs to provide information on family planning. In the Kodiak region, the change in the Native birthrate was remarkable. The rate of natural increase fell from 5 percent in 1960 to 3 percent in 1970. The rate of natural increase among whites also declined and it remained lower than the rate for nonwhites, but the gap between the two groups was narrowed. In 1970 the rate of natural increase for nonwhites was about 25 percent higher than the rate for whites.

Further evidence confirming the drop in birthrates is provided by the fertility ratios in Table 54. A fertility ratio is the number of children under five years old per 1,000 women of childbearing age, which is taken to be all women between 15 and 49 years old (Rogers and Cooley 1963). By including data for Alaska and for the U.S., Table 54 shows that the decline in the birthrate was widespread. The fertility ratio for nonwhites in Kodiak is only 13 percent higher than the fertility ratio for whites. That difference is even smaller than the one measured by the rates of natural increase in Table 52. However, the fertility ratios for Kodiak are very high when compared either to the Alaska or U.S. average. Despite the absolute reduction in the birthrate, the natural growth rate for Kodiak remains high when compared to other regions.

Population in Alaska Peninsula Communities

A precise description of population change in the Alaska Peninsula communities is difficult to obtain because of the form in which census data are reported. The more detailed census information, particularly in 1960, is reported on the basis of census divisions. Data for the Aleutian Island Census Division are reported in Table 55 because the communities in the Western Gulf study region are included within this division. As shown in that table, total population in the Aleutian Islands Census Division grew by 34 percent from 1960 to 1970, a pace very similar to that observed in the Kodiak region. But in the Aleutian Islands, over half of the growth is due to the expansion in military personnel from 2,400 to almost 3,700. As a result, the white population grew very rapidly, more than 50 percent. In sharp contrast, the size of the Native population remained essentially constant over the decade.

The composition of the population in Alaska Peninsula communities differs markedly from the Aleutian Islands Census Division taken as a whole (Table 56). More than two-thirds of the population on the Alaska Peninsula is Aleut while the population of the Aleutian Islands is predominantly white. The Alaska Peninsula has more than half of the Aleut population in the census division and only eight percent of the white population because the major military installations are located in the western part of the region. The number of military personnel on the Alaska Peninsula is negligible. Clearly the aggregate statistics for the census division cannot accurately describe the situation in the Alaska Peninsula communities.

Table 54

FERTILITY RATIOS* BY RACE

KODIAK CENSUS DIVISION 1960 and 1970

	ALASKA	ALASKA WHITE	ALASKA NON-WHITE	KODIAK TOTAL	KODIAK WHITE	KODIAK NON-WHITE	TOTAL U. S. (in thousands)
1960							
Children under 5	34,193	24,602	9,591	963	736	227	20,321
Women 15-49	49,407	38,660	10,747	1,406	1,142	264	41,601
Fertility ratio	692	636	892	685	644	860	488
1970							
Children under 5	32,075	23,825	8,250	1,073	819	254	17,119
Women 15-49	72,512	58,503	14,009	2,144	1,683	461	48,624
Fertility ratio	442	407	589	500	487	551	352

*Children under 5 years per 1,000 women 15-49 years old

Sources: Rogers and Cooley 1963; U.S. Bureau of the Census 1960, 1970b.

Table 55

POPULATION GROWTH, 1960-1970

ALEUTIAN ISLANDS CENSUS DIVISION

	1960 CENSUS			1970 CENSUS			% Change Of Total
	Male	Female	Total	Male	Female	Total	1960-1970
Total Population	4,254	1,757	6,011	5,772	2,285	8,057	+34.0
Civilian	1,842	1,757	3,599	2,108	2,260	4,368	+21.4
Military Personnel	2,412	--	2,412	3,664	25	3,689	+52.9
White	2,905	785	3,690	4,309	1,255	5,564	+50.8
Non-white	1,349	972	2,321	1,463	1,030	2,493	+ 7.4
Negro	77	8	85	216	21	237	+178.8
Indian	13	8	21	36	25	61	
Aleut	*	*	*	1,054	918	1,972	+ 0.9
Eskimo	*	*	*	16	14	30	
Other	1,259	956	2,215	141	52	193	

*In 1960 Census Aleut and Eskimo are included in the "other" category.

Sources: U.S. Bureau of the Census 1960, 1970b; Babb 1972.

Table 56

ALEUTIAN ISLANDS AND ALASKA PENINSULA

POPULATION, 1970

	Aleutian Islands Census Division		Alaska Peninsula Communities	
	Population	Distribution of population (percent)	Population	Distribution of population (percent)
Total population	8,057	100.0	1,509	100.0
White	5,564	69.1	388	25.7
Nonwhite	2,493	30.9	1,121	74.3
Aleut	1,972	24.5	1,022	67.7
Other	521	6.5	99	6.6

Sources: Babb 1972, U.S. Bureau of the Census, 1970 Census, special computer runs.

The data in Table 50 indicate that the total population of the Alaska Peninsula increased by 107 persons (9.9 percent) from 1960 to 1970. Sand Point was the only established community which exhibited significant increases, while most other villages lost a substantial portion of their population. Although direct information is not available to divide growth into natural increase and migration components, some approximate allocations can be made. If it is assumed that the birth and death rates are roughly the same as for the nonwhite population in Kodiak, the rate of natural increase would be 3.89 percent in the Aleutians (Table 57).[1] This would imply a natural increase over the decade of about 600 persons and, thus, a net out-migration of nearly 500 persons from the Alaska Peninsula villages.

The fertility ratios shown in Table 58 indicate that the use of the Kodiak rate of natural increase may substantially underestimate the natural growth in the Alaska Peninsula villages. Fertility ratios for nonwhites in the Aleutian Islands Census Division, and particularly in the Alaska Peninsula villages, are much higher than those in Kodiak. In fact, the 1970 Alaska Peninsula fertility ratio for nonwhites is nearly 50 percent higher than the comparable ratio for Kodiak. If, in light of this, the estimated rate of natural increase in the Alaska Peninsula villages were increased, the estimate of net out-migration would also increase.

Summary

During the period 1960 to 1970, total civilian population in the Western Gulf region has shown strong growth despite the reduction in military personnel stationed there. The civilian population movements due to migration, among both whites and nonwhites, have increased the importance of the city of Kodiak as the social and economic focal point for the Western Gulf reigon.

School Facilities and Enrollments

Elementary and High Schools

Between 1960-61 and 1970-71 total school enrollment on Kodiak Island rose from 1,356 to 2,493 students, an increase of 84 percent for the decade (Table 59 and Figure 164). Between 1970-71 and fall 1973 total enrollment dropped by 12 percent to 2,187 students.

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[1] The vital statistics for the Aleutian Islands Census Division are not used here because of questions concerning their reliability. They are, for example, grossly inconsistent with the fertility ratios reported in Table 56. It may be that lack of medical facilities in the region has caused underreporting in birth statistics.

Table 57

POPULATION CHANGE 1960-1970

	ALEUTIAN ISLANDS Nonwhites			ALASKA PENINSULA All Races		
	1960	1970	Change 1960-70	1960	1970	Change 1960-70
Civilians	1,961	2,056	+95	1,479	1,586	+107
Natural Increase			781			596
Rate on Natural Increase			3.89			3.89
Migration			-686			-489

Sources: U.S. Bureau of the Census 1960, 1970b; U.S. Bureau of the Census, 1970 Census, special computer runs.

Table 58

FERTILITY RATIOS* BY RACE

ALEUTIAN ISLANDS REGION 1960 and 1970

	ALASKA			ALEUTIAN ISLAND CENSUS DIVISION			TOTAL U.S. (in thousands)
	TOTAL	WHITE	NONWHITE	TOTAL	WHITE	NONWHITE	
1960							
Children under 5	34,193	24,602	9,591	608	242	366	20,321
Women 15-49	49,407	38,660	10,747	853	432	421	41,601
Fertility ratio	692	636	892	608	560	869	488
1970							
Children under 5	32,075	23,825	8,250	738	430	308	17,119
Women 15-49	72,512	58,503	14,009	1,150	694	456	48,624
Fertility ratio	442	407	589	642	620	675	352
1970 Alaska Peninsula Communities							
Children under 5	213	29	184				
Women 15-49	299	74	225				
Fertility Ratio	712	392	818				

*Children under 5 years per 1,000 women 15-49 years old.

Sources: Rogers and Cooley 1963; U.S. Bureau of the Census 1960, 1970b; U.S. Bureau of the Census, 1970 Census, special computer runs.

Table 59

TOTAL SCHOOL ENROLLMENT

KODIAK ISLAND 1958-59 to 1972-73

	ELEMENTARY*				HIGH SCHOOL**				
YEAR	WHITE	NATIVE	OTHER	SUBTOTAL	WHITE	NATIVE	OTHER	SUBTOTAL	TOTAL
1958-59	960	328	23	1311	189	31	3	223	1534
1959-60	817	282	16	1115	180	32	0	212	1327
1960-61	814	309	10	1133	182	41	0	223	1356
1961-62	NA	NA	NA	NA	NA	NA	NA	NA	NA
1962-63	905	362	39	1306	240	43	2	285	1591
1963-64	850	342	23	1226	249	46	4	299	1525
1964-65	1016	342	28	1386	313	41	9	363	1749
1965-66	1088	343	37	1468	345	11	5	361	1829
1966-67	1279	387	46	1712	358	34	6	398	2110
1967-68	1349	406	60	1815	384	82	9	475	2290
1968-69	1207	509	72	1788	403	82	9	494	2282
1969-70	1189	568	76	1832	383	135	9	527	2360
1970-71	1228	570	63	1861	412	215	5	632	2493
1971-72	1168	553	53	1774	361	209	12	582	2356
1972-73				1797				442	2239
Fall 1973				1686				501	2187

*Grades K through 8
**Grades 9 through 12

Sources: Sullivan and Rose 1970, Alaska Department of Education 1973.

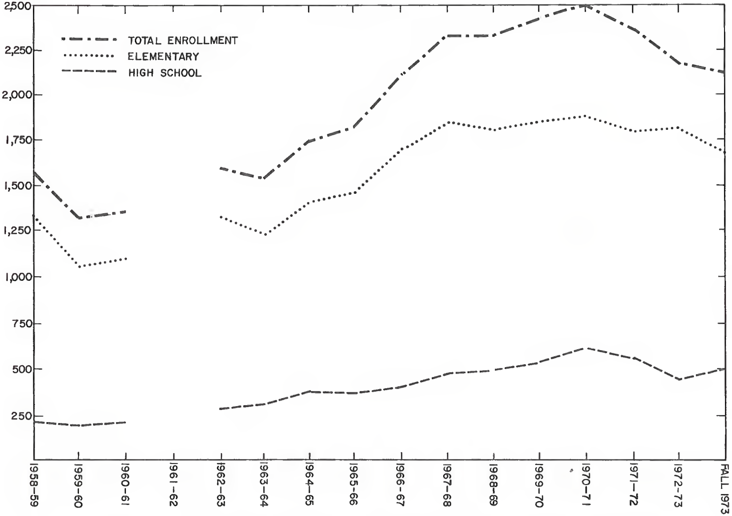

Figure 164. Kodiak Island school enrollment, 1958-59 to 1972-73 (from Sullivan and Rose 1970, Alaska Department of Education 1973).

In fall 1973 Kodiak's elementary school enrollment was 1,686 compared to 1,861 in the 1970-71 school year, a drop of 9 percent (Table 59). However, most of the decrease is accounted for by a drop in the enrollment at the Base elementary school following the cutback in military personnel (Alaska Department of Education 1970, 1973). The remainder of the decrease is attributable to a significant decline in the birthrate. High school enrollment has been somewhat erratic in recent years, but in general has declined since 1970 (Table 59).

All of the schools on Kodiak Island, except St. Mary's School, are administered by the Kodiak Island Borough School District. The operating budget for 1972-73 was more than 4,270,000 dollars; 333,000 dollars of it came from local sources (Main, Lafrentz and Co. 1973). In the Kodiak urban area, the Borough operates three elementary schools (East, Main, and the Coast Guard Base), a junior high school, and the Kodiak-Aleutian Regional High School. In addition to these schools, about 13 percent of the borough students attend small schools in rural areas. Total enrollment for these predominantly Native schools in the fall of 1973 was 285 (Table 60). The elementary schools at Akhiok, Chiniak, Karluk, and Larsen Bay have two classrooms each, and Port Lions has three. A new 300,000 dollar elementary school was completed at Ouzinkie in 1973 (Kodiak Island Borough 1973).

In the past, low school enrollments in the villages have not justified the establishment of high school programs. As a result, village students attend the regional high school in Kodiak. Beginning in 1972 the school at Old Harbor extended its program to offer a secondary curriculum. Ninth graders are now required to attend high school in Old Harbor, but students in the higher grades have the option of attending high school in Kodiak. The fall 1973 secondary school enrollment at Old Harbor was 15 students.

School Facilities and Enrollments

All of the villages on the Western Gulf portion of the Alaska Peninsula, except Squaw Harbor, have small elementary schools. All of the schools are run by the State Operated School System except for King Cove, which is an independent school district (Alaska State Housing Authority 1968). In fall 1973, the total enrollment for these schools was 396. This is an increase of more than 50 percent from the 1965-66 average of 259 students. During this interval the proportion of white enrollment dropped 20 percent. In fall 1973, the largest school was Sand Point with 133 students and 9 teachers. Ivanof Bay was the smallest with 12 students 1 teacher.

Until very recently, there were no high schools on the Alaska Peninsula due to low population and scattered distribution of settlements. Students attended U. S. Bureau of Indian Affairs high schools in Alaska or other states; most went to high school in Anchorage or Kodiak and lived with local families under the State Boarding Home Program. In the past few years, a secondary curriculum has been added to the schools at King Cove and Sand Point. The school program in these two communities now continues through the twelfth grade.

Table 60

SCHOOL ENROLLMENTS

WESTERN GULF OF ALASKA

ALASKA PENINSULA

Fall 1973

	Students	Teachers
Belkofski	15	1
Chignik Bay	19	1
Chignik Lagoon	8	1
Chignik Lake	32	2
Cold Bay	26	2
False Pass	8	1
Ivanof Bay	12	1
King Cove	113	9
Nelson Lagoon	11	1
Perryville	19	1
Sand Point	133	9
Squaw Harbor	-	-
TOTAL	396	29

KODIAK ISLAND

Fall 1973

Kodiak Villages	Students	Teachers
Akhiok	32	2
Kaguyak	-	-
Karluk	16	1
Larsen Bay	20	1
Old Harbor	93	6
Ouzinkie	39	2
Port Lions	55	3
Chiniak School	30	2
SUBTOTAL	285	17
Kodiak Urban Area		
Kodiak Aleutian Regional High Sch.	501	44
Kodiak Jr. High	312	20
Main Elementary	440	22
Kodiak Base Elementary	371	19
East Elementary	278	19
SUBTOTAL	1,902	124
KODIAK TOTAL	2,187	141

Source: Alaska Department of Education 1973.

To serve rural students from Kodiak, the Alaska Peninsula, and the Aleutian Islands, the Kodiak-Aleutian Regional High School was built by the State of Alaska in 1967. State operation of the facility ended after the 1972-73 school year and the Borough has since taken over the 22 classroom building for use as the borough high school. A four million dollar borough addition to this high school of 10 classrooms, swimming pool, gymnasium, and library-media center was scheduled to open in November 1973.[1]

Along with the regional high school, the State operated a dormitory to house rural students. The dormitory also closed after the 1972-73 school year and future use of the building has not been determined. Since fall 1973 students from Kodiak Borough villages, who formerly lived in the dormitory, are being housed in a cottage-style living arrangement. The cottages were converted from living quarters formerly used by the faculty and staff of the state regional high school. Each cottage has a central apartment for the houseparents and adjoining apartments for girls on one side and boys on the other. About 12 students live in each cottage. The living arrangement is designed to offer greater personal care than was provided in the dormitory. In its first two months of operation, the program has been highly successful according to school administrators, students, and cottage houseparents. Formerly about one-third of the dormitory students dropped out during the first few weeks of school. Be comparison, only three students out of 55 who started in fall 1973 have gone back to villages.[2]

About 30 students from Alaska Peninsula and Aleutian Island communities are attending Kodiak High School and living with local families under the State Boarding Home Program. High school personnel indicated this program is not as successful as the cottage style living arrangement, but at present, students residing outside the borough are not eligible to live in the cottages.[3]

Most Kodiak students follow an educational program of basic subjects such as English, math, science and social students through their freshman and sophomore years. During the last two years of high school, they can continue these courses at a more advanced level or obtaining vocational training. About one-third of the high school students choose the vocational programs is substantially higher. The head of the program estimated that about 75 percent of the Native males and 50 percent of the Native females choose the vocational curriculum.[4]

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[1]Gordon Kent, Curriculum Director, Kodiak High School, October 1973. Personal communication.

[2]Jim Johnson, Cottage Supervisor, Kodiak Island Borough, October 1973. Personal communication.

[3]Nelda Osgood, Home School Coordinator, Kodiak High School, October 1973. Personal communication.

[4]Gordon Kent, Curriculum Director, Kodiak High School, October 1973. Personal communication.

All vocationl classes are open to males and females, but the business education and home economics courses attract most of the female students. Business education courses include office procedures, office machines, bookkeeping, typing, and shorthand. Most of the students enrolled in the technical and industrial courses are males. This portion of the vocational program has course offerings which include carpentry and boat building, small and outboard engines, fisheries, electronics, diesel mechanics, automotive mechanics, metal shop, welding, metal fabrication, machine shop trades, drafting, and surveying. The most frequent specialization among Native students is the fisheries program. Beginning in the 1973-74 school year, much of the program is being taught on board a new 12.6 m. Delta Marine seiner. The floating classroom is used in conjunction with such courses as fisheries, galley cooking, marine diesel, oceanography, electronics, and small engines.

According to the director, the skill level attained by individuals varies, but all the vocational programs are geared to equip students with job-entry level skills. In addition to course work, many vocational students receive credit for on-the-job training in their specific interests through cooperative agreements with the school and local businesses. In the fall of 1973, about 60 students were receiving some co-op experience. The director said the programs attempt to train students in vocations which will give them the potential for long-term employment in the Kodiak Island area.

Kodiak Community College

A community college program began in Kodiak in 1968 as a joint venture of the University of Alaska and the local borough school district. In the past five years, the program has grown from its initial enrollment of 95 students to 600 students in the fall of 1973 (Kodiak Island Borough 1973). The credit division of the Kodiak Community College offers a two year program leading to an Associate of Arts Degree with majors in behavioral sciences, liberal arts, office administration, police administration, science, vocational arts, and fisheries technology. In fall 1973, there were 345 students enrolled in nine daytime and 33 evening credit courses. About 30 students were carrying a full-time academic load.[1]

The non-credit division of the Community College is sponsored locally. The fall 1973 program included 18 non-credit courses with an enrollment of 167 students in a wide range of courses including fur sewing, conversational Aleut, clerical skills, cake decorating, and welding. In addition, about 80 students are enrolled in an adult basic education program which is designed to prepare students to take the GED test series to attain a State of Alaska high school equivalency diploma. This program is offered in the city of Kodiak and in five of the island's outlying villages.

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[1]Carolyn Floyd, Director, Kodiak Community College, October 1973. Personal communication.

The first building of the Kodiak Community College was completed in October 1972 under the University of Alaska construction program. The new facility includes seven classrooms, library, office, and student lounge; however, space and equipment are still inadequate to handle all of the College's programs. In October 1973 ground was broken for a vocational building which will house two classrooms, an arts and crafts room, fisheries and marine diesel shops, maintenance shop, and additional office space. It is scheduled for completion in 1974.

Educational Attainment

A standard measure of a population's general education level is the median school years completed by persons more than 25 years old. As a whole, Alaska has historically had a relatively high educational level (Rogers and Cooley 1963). This remained true in 1970 as the median school years completed by both males and females were higher in Alaska than in the total United States (Table 61). In the Kodiak Island Borough and Aleutian Islands Census Divisions, the median school years for men were lower than the state average but still exceeded the U. S. average. The same was true for women in Kodiak, but in the Aleutian Islands, the median school years for women were substantially lower than either the state or U. S. average.

Another measure of educational attainment is the percentage of high school graduates in the more than 25 years of age population. Kodiak's figures of 57.2 percent for males and 56.5 percent for females are below state averages, but considerably higher than the national percentages of 51.9 for males and 52.8 for females. In the Aleutians, 65.5 percent of the men completed high school, a proportion nearly up to the statewide average. However, only 48 percent of the women in the Aleutian Islands completed high school, which is a lower fraction than the national or state average.

As shown in Table 61 these high levels of educational attainment are only characteristic of the white population. In the Kodiak Island Borough only 18.9 percent of the more than 25 year of age nonwhite population were high school graduates compared to 71.5 percent for whites. Similarly, in the Aleutian Islands only 20.5 percent of the nonwhites were high school graduates compared to 79.2 percent for whites.

At the other end of the scale, Alaska also tends to have a relatively large proportion of persons more than 25 years of age who have no education at all. However, in Kodiak and the Aleutians less than two percent of this group has had no education, a figure on a par with the U. S. average. A breakdown of these statistics by race reveals that less than one percent of whites had no education, while more than five percent of nonwhites had no education. These figures, although high, are lower than statwide where 12 percent of the more than 25 years of age nonwhites had no education.

Table 61
EDUCATIONAL ATTAINMENT
KODIAK, ALEUTIAN ISLANDS, ALASKA, AND U.S. 1970

Years Of School Completed	KODIAK ISLAND BOROUGH Total Number	Percent	White Number	Percent	Nonwhite Number	Percent	KODIAK STATION Total Number	Percent	ALEUTIAN ISLANDS Total Number	Percent	White Number	Percent	Nonwhite Number	Percent	ALASKA Total Number	Percent	White Number	Percent	Nonwhite Number	Percent	U.S. Total Percent
MALES, 25 years old and over	1,721		1,251		470		600		2,211		1,616		595								
No school years completed	37	2.1	6	0.5	31	6.6	10	1.7	42	1.9	0	0.0	42	7.1		2.4		0.4		11.8	1.6
Elementary: 1-4 years	68	4.0	7	0.6	61	13.0	0	0.0	100	4.5	7	0.4	93	15.6		3.5		0.7		17.0	4.4
5-6 years	54	3.1	10	0.8	44	9.4	0	0.0	156	7.1	26	1.6	130	21.8		2.9		1.1		11.9	5.9
7 years	97	5.6	40	3.2	57	12.1	5	0.8	57	2.6	6	0.4	51	8.6		2.5		1.7		6.7	4.6
8 years	190	11.0	96	7.7	94	20.0	44	7.3	125	5.7	75	4.6	50	8.4		7.6		7.2		10.0	12.9
High School: 1-3 years	291	16.9	199	15.9	92	19.6	135	22.5	282	12.8	215	11.3	67	11.3		14.7		14.9		13.6	18.6
4 years	607	35.3	540	43.2	67	14.3	245	40.8	836	37.8	742	45.9	94	15.8		36.1		39.6		19.0	27.7
College: 1-3 years	195	11.3	176	14.1	19	4.0	78	13.0	301	13.6	262	16.2	39	6.6		14.6		16.3		6.5	10.7
4 years	96	5.6	91	7.3	5	1.1	51	8.5	180	8.1	167	10.3	13	2.2		7.6		8.8		2.0	6.8
5 years or more	86	5.0	86	6.9	8	0.0	32	5.3	132	6.0	116	7.2	16	2.7		7.9		9.3		1.4	6.7
High School Graduates		57.2		71.5		19.4		67.6		65.5		79.6		27.3		66.2		74.0		28.9	51.9
Median School Years Completed	12.3*		NA		NA				12.4		NA		NA		12.5		NA		NA		12.1
FEMALES, 25 years old and over	1,230		862		348		501		908		500		408								
No school years completed	13	1.1	0	0.0	13	3.7	0	0.0	13	1.4	0	0.0	13	3.2		2.6		0.4		12.3	1.6
Elementary: 1-4 years	41	3.3	13	1.5	28	8.0	7	1.4	64	7.0	0	0.0	64	15.6		3.3		0.4		16.1	3.4
5-6 years	53	4.3	8	0.9	45	12.9	0	0.0	110	12.1	0	0.0	110	27.0		3.2		0.9		13.2	5.4
7 years	59	4.8	11	1.2	48	13.8	13	2.6	56	6.2	5	1.0	51	12.5		2.0		1.0		6.8	4.2
8 years	202	16.4	106	12.0	96	27.6	14	2.8	73	8.0	6	1.2	67	16.4		6.5		5.2		12.5	12.6
High School: 1-3 years	167	11.6	113	12.8	54	15.5	96	19.2	159	17.5	99	19.8	60	14.7		15.2		15.4		14.4	20.1
4 years	418	34.0	356	40.4	62	17.8	216	43.1	276	30.4	250	50.0	26	6.4		39.6		44.8		16.4	34.1
College: 1-3 years	133	10.8	133	15.1	0	0.0	116	23.2	79	8.7	69	13.8	10	2.5		15.1		17.3		5.5	10.6
4 years	83	6.7	83	9.4	0	0.0	39	7.8	54	5.9	54	10.8	0	0.0		8.0		9.3		2.2	5.4
5 years or more	61	5.0	59	6.7	2	0.6	0	0.0	24	2.6	17	3.4	7	1.7		4.5		5.3		0.7	2.7
High School Graduates		56.5		71.6		18.4		74.1		47.6		78.0		10.6		67.2		76.7		24.8	52.8
Median School Years Completed	12.3*		NA		NA		NA		11.6		NA		NA		12.4		NA		NA		12.1
TOTAL, 25 years old and over	2,951		2,113		818		1,101		3,119		2,116		1,003								
No school years completed	50	1.7	6	0.3	44	5.4	10	0.9	55	1.8	0	0.0	55	5.5		2.3		0.4		12.0	1.6
Elementary: 1-4 years	109	3.7	20	0.9	89	10.9	7	0.6	164	5.3	7	0.3	157	15.7		3.4		0.6		16.6	3.9
5-6 years	107	3.6	18	0.8	89	10.9	0	0.0	266	8.5	26	1.2	240	23.9		3.1		1.0		12.5	5.7
7 years	156	5.3	51	2.4	105	12.8	18	1.6	111	3.6	11	0.5	102	10.2		2.3		1.4		6.7	4.4
8 years	392	13.3	202	9.5	190	23.2	58	5.3	198	6.3	81	3.8	117	11.7		7.1		6.3		11.1	12.6
High School: 1-3 years	458	15.5	312	14.6	146	17.8	231	21.0	441	14.1	314	14.8	127	12.7		14.9		15.1		14.0	19.4
4 years	1,025	34.7	896	42.0	129	15.8	461	41.9	1,112	35.7	992	46.9	120	12.0		37.7		42.0		17.8	31.1
College: 1-3 years	328	11.1	309	14.5	19	2.3	194	17.6	380	12.2	331	15.6	49	4.9		14.9		16.8		6.0	10.6
4 years	179	6.1	174	8.2	5	0.6	90	8.2	234	7.5	221	10.4	13	1.3		7.8		9.0		2.1	6.1
5 years or more	147	5.0	145	6.8	2	0.2	32	2.9	156	5.0	133	6.3	23	2.3		6.4		7.5		1.0	4.6
High School Graduates		56.9		71.5		18.9		70.6		60.4		79.2		20.5		66.8		75.3		26.9	52.4

* Total for Kodiak Census Division

Source: Bureau of the Census, 1970 Census, special computer runs

LABOR FORCE AND EMPLOYMENT

Labor Force

The size of the labor force in any region is determined jointly by the characteristics of the local population and by the availability of employment opportunities. Obviously, in the long-run there has to be a close relationship between the size of the population base and the size of the labor force. However, this relationship is not necessarily constant over time, nor is it the same for all regions. In particular, there can be large differences in the observed participation rates, for example, in the proportions of the populations that choose to seek employment. One of the key factors determining the participation rate is the availability of employment opportunities. When jobs are easy to find, more people decide to seek employment, thus causing an increase in the participation rate and in the labor force.

In the Western Gulf region, both the size of the local population and the employment opportunities are subject to large fluctuations due to outside forces. First, the movement of military personnel and dependents can cause sharp changes in the regional population. In addition, the major private industry is fishing and fish processing which exhibits wide variation seasonally and from one year to another due to weather conditions and cycles in the fish populations.

Consequently, while the workforce in the Western Gulf is trending upward, it displays considerable variation around the long-run growth trend (Table 62). In Kodiak, the average civilian work force in 1971-72 is 50 percent larger than the average work force in 1961-62. For that same period, the civilian work force increased by 58 percent in the Aleutian Islands Census Division, but the Western Gulf region includes only part of the Aleutian Islands Census Division. In terms of population, the Western Gulf includes about one-third of the census division. Thus, the statistics reported for the Aleutian Islands Census Division can only be regarded as rough indicators of the characteristics of the communities on the Alaska Peninsula which are included in the Western Gulf region.

The data in Table 63 show how the participation and unemployment rates in the Western Gulf region compared to the state averages. Participation rates in the Aleutian Islands were extremely low for both men and women. The male participation rate in the Aleutians was 68 percent, compared to 79 percent for the state and for Kodiak Island Borough; the female participation rate was only 30 percent, compared to 46 percent for the state and 55 percent for Kodiak. There are major differences in the participation rates of whites and Natives. In both the Aleutian Islands and Kodiak the participation rate for white males was roughly 87 percent compared to less than 60 percent for Native males. However, the participation rates for Native males in this region were higher than the statewide rate of 51 percent for Native males.

Table 62

WORKFORCE ESTIMATES

	Kodiak Census Division	Aleutian Islands Census Division
1961	2364	1551
1962	2315	1469
1963	2439	1624
1964	2483	1854
1965	2986	1837
1966	3447	1817
1967	3666	2024
1968	3418	2137
1969	3090	2015
1970	3155	1987
1971	3332	2489
1972	3689	2284

Source: Alaska Department of Labor, various dates.

Table 63

LABOR FORCE AND EMPLOYMENT 1970

Kodiak, Aleutian Islands, Alaska and U.S.

	Kodiak Island Borough			Aleutian Islands			Alaska			U.S.
	Total	White	Nonwhite	Total	White	Nonwhite	Total	White	Nonwhite	
TOTAL CIVILIAN POPULATION, 16 years old and over	3,813	2,722	1,091	2,317	1,079	1,238	159,702	128,367	31,335	139,089,535
Civilian labor force	2,585	2,013	572	1,088	571	517	98,296	84,960	13,336	80,051,046
Percent of total (participation rate)	67.8	74.0	52.4	47.0	52.9	41.8	61.5	66.2	42.6	57.6
Employed	2,342	1,863	479	925	547	378	89,236	78,231	11,005	76,553,599
Unemployed	243	150	93	163	24	139	9,060	6,729	2,331	3,497,447
Percent of civilian labor force	9.4	7.5	16.3	15.0	4.2	26.9	9.2	7.9	17.5	4.4
MALE, 16 years old and over	2,062	1,457	605	1,042	392	650	76,547	61,363	15,184	65,282,635
Civilian labor force	1,624	1,263	361	709	344	365	60,293	52,490	7,803	49,549,239
Percent of total (participation rate)	78.8	86.7	59.7	68.0	87.8	56.2	78.8	85.5	51.4	75.9
Employed	1,480	1,191	289	609	334	275	54,114	47,931	6,183	47,623,754
Unemployed	144	72	72	100	10	90	6,179	4,559	1,620	1,925,485
Percent of civilian labor force	8.9	5.7	19.9	14.1	2.9	24.7	10.2	8.7	20.8	3.9
FEMALE, 16 years old and over	1,751	1,265	486	1,275	687	588	83,155	67,004	16,151	73,806,900
Civilian labor force	961	750	211	379	227	152	38,003	32,470	5,533	30,501,807
Percent of total (participation rate)	54.9	59.3	43.4	29.7	33.0	25.9	45.7	48.5	34.3	41.3
Employed	862	672	190	316	213	103	35,122	30,300	4,822	28,929,845
Unemployed	99	78	21	63	14	49	2,881	2,170	711	1,571,962
Percent of civilian labor force	10.3	10.4	10.0	16.6	6.2	32.2	7.6	6.7	12.9	5.2

Sources: U.S. Bureau of the Census, 1970 Census, Alaska special computer runs; U.S. Bureau of the Census 1970b.

Along with the low participation rates, the unemployment rate for Natives was 16 percent in Kodiak and 27 percent in the Aleutians. By comparison, the white unemployment rate was 7.5 percent in Kodiak and 4.2 percent in the Aleutians. The high nonwhite rate accompanied by a low participation rate is precisely what would be expected. The lack of employment opportunities has caused Natives to drop out of the labor force. Furthermore, this picture is consistent with the migration patterns discussed previously. The lack of employment opportunities contributes to the observed out-migration from the Aleutian Island region. Although Kodiak's Native unemployment is high compared to the white rate, Kodiak's rate is lower than the average statewide unemployment rate for nonwhites.

Due to seasonal factors, the unemployment rates are probably overestimated and the participation rates are underestimated by the data in Table 63. The 1970 census was taken on April first, and that is close to the seasonal low point for employment in the Western Gulf region. The comparison of the different rates at that point in time would, however, still produce relevant results.

Occupations of the Employed

The government sector has traditionally been one of the most important in Alaska's economy, and in 1970 the government hired a third of the male work force and 41 percent of the female work force (Table 64). In the Aleutian Islands the share of government employment, 41 percent for males and 60 percent for females, represented an even larger portion of the workers than the state average. By Alaska standards the Kodiak Island Borough had a low proportion of government employment (30 percent), and of that, more than half was local government employment. In contrast, government employment in the Aleutians consists almost entirely of state and federal employees. Since Kodiak functions as the commercial and industrial center of the Western Gulf region, the private sector accounts for a relatively large proportion of Kodiak's total employment. The addendum to Table 64 again emphasizes the importance of the military on both the Kodiak area and the Aleutian Islands.

The distribution of occupations in the Western Gulf region is shown in Table 65. Perhaps the major deviation from the state pattern is the relatively large number of individuals (particularly females) employed as operatives and laborers. This reflects the large amount of employment generated by the fish processing industry in the Kodiak area. Among the female workers in Kodiak, a large number have apparently found employment as cannery workers rather than as clerks and secretaries.

Seasonal Variation in Employment

In tracing the movements over time, the pattern of employment in the Western Gulf of Alaska is dominated by the pronounced seasonal fluctuations in the fishing industry. Figures 165 and 166 show the

Table 64

Class of Worker

Kodiak 1970

CLASS OF WORKER (Civilians)	KODIAK ISLAND BOROUGH TOTAL Number	TOTAL Percent	WHITE Number	WHITE Percent	NONWHITE Number	NONWHITE Percent	KODIAK STATION TOTAL Number	KODIAK STATION TOTAL Percent
MALES, Employed, 16 years old and over	1,480		1,191		289		84	
Employee of Private Company	960	64.9	740	62.1	220	76.1	18	21.4
Employee of Own Corporation	30	2.0	30	2.5	0	0.0	0	0.0
Federal Government Worker	116	7.8	105	8.8	11	3.8	66	78.6
State Government Worker	76	5.1	52	4.4	24	8.3	0	0.0
Local Government Worker	189	12.8	161	13.5	28	9.7	0	0.0
Self-Employed Worker	109	7.4	103	8.6	6	2.1	0	0.0
Unpaid Family Worker	0	0.0	0	0.0	0	0.0	0	0.0
FEMALES, Employed, 16 years old and over	862		672		190		227	
Employee of Priv. Co.	505	58.6	379	56.4	126	66.3	108	47.6
Empl. of own Corp.	0	0.0	0	0.0	0	0.0	0	0.0
Fed. Gov. Empl.	65	7.5	41	6.1	24	12.6	92	40.5
State Gov. Empl.	81	9.4	63	9.4	18	9.5	6	2.6
Loc. Gov. Empl.	187	21.7	165	24.6	22	11.6	21	9.3
Self-Employed Worker	24	2.8	24	3.6	0	0.0	0	0.0
Unpaid Family Worker	0	0.0	0	0.0	0	0.0	0	0.0
TOTAL, Employed, 16 years old and over	2,342		1,863		479		311	
Employee of Priv. Co.	1,465	62.6	1,119	60.1	346	72.2	126	40.5
Empl. of own Corp.	30	1.3	30	1.6	0	0.0	0	0.0
Fed. Gov. Empl.	181	7.7	146	7.8	35	7.3	158	50.8
State Gov. Empl.	157	6.7	115	6.2	42	8.8	6	1.9
Loc. Gov. Empl.	376	16.1	326	17.5	50	10.4	21	6.8
Self-Employed Worker	133	5.7	127	6.8	6	1.3	0	0.0
Unpaid Family Worker	0	0.0	0	0.0	0	0.0	0	0.0
ADDENDUM: Military Personnel	247						1,244	

Source: Bureau of the Census, 1970 Census, Alaska, special computer runs.

Table 64 (continued)

Class of Worker

Aleutians, Alaska and O. S. 1970

CLASS OF WORKER (Civilians)	ALEUTIAN ISLANDS TOTAL Number	Percent	WHITE Number	Percent	NONWHITE Number	Percent	ALASKA TOTAL Number	Percent
MALES, Employed, 16 years old and over	609		334		275		54,114	
Employee of Private Company	354	58.1	217	65.0	137	49.8	30,080	55.6
Employee of Own Corporation	0	0.0	0	0.0	0	0.0	1,186	2.2
Federal Government Worker	184	30.2	81	24.3	103	37.5	9,261	17.1
State Government Worker	53	8.7	29	8.7	24	8.7	5,066	9.4
Local Government Worker	11	1.8	7	2.1	4	1.5	3,872	7.2
Self-Employed Worker	7	1.1	0	0.0	7	2.5	4,560	8.4
Unpaid Family Worker	0	0.0	0	0.0	0	0.0	89	0.2
FEMALES, Employed, 16 years old and over	316		213		103		35,122	
Employee of Priv. Co.	127	40.2	85	39.9	42	40.8	18,686	53.2
Empl. of own Corp.	0	0.0	0	0.0	0	0.0	232	0.7
Fed. Gov. Empl.	146	46.2	112	52.6	34	33.0	5,959	17.0
State Gov. Empl.	43	13.6	16	7.5	27	26.2	4,030	11.5
Loc. Gov. Empl.	0	0.0	0	0.0	0	0.0	4,384	12.5
Self-Employed Worker	0	0.0	0	0.0	0	0.0	1,510	4.3
Unpaid Family Worker	0	0.0	0	0.0	0	0.0	321	0.9
TOTAL, Employed, 16 years old and over	925		547		378		89,236	
Employee of Priv. Co.	481	52.0	302	55.2	179	47.4	48,766	54.6
Empl. of own Corp.	0	0.0	0	0.0	0	0.0	1,418	1.6
Fed. Gov. Empl.	330	35.7	193	35.3	137	36.2	15,220	17.1
State Gov. Empl.	96	10.4	45	8.2	51	13.5	9,096	10.2
Loc. Gov. Empl.	11	1.2	7	1.3	4	1.1	8,256	9.3
Self-Employed Worker	7	0.8	0	0.0	7	1.9	6,070	6.8
Unpaid Family Worker	0	0.0	0	0.0	0	0.0	410	0.5

ADDENDUM: Military Personnel 3,689

Source: Bureau of the Census, 1970 Census, Alaska, special computer runs.

Table 65

OCCUPATIONS OF THE EMPLOYED

OCCUPATION	ALEUTIAN ISLANDS Number	ALEUTIAN ISLANDS Percent	KODIAK Number	KODIAK Percent	ALASKA Number	ALASKA Percent
MALE employed, 16 years old and over	609	100.0	1,564	100.0	54,114	99.9
Professional, technical and kindred workers	97	15.9	204	13.0	10,385	19.2
Managers and administrators, except farm	56	9.2	204	13.0	8,238	15.2
Sales Workers	8	1.3	25	1.6	2,331	4.3
Clerical and kindred workers	39	6.4	62	4.0	3,239	6.0
Craftsmen, foremen and kindred workers	183	30.0	336	21.5	13,012	24.0
Operatives, except transport	71	11.7	226	14.5	4,021	7.4
Transport equipment operatives	25	4.1	65	4.2	2,497	4.6
Laborers, except farm	36	5.9	229	14.6	4,650	8.6
Farmers and Farm managers	--	--	--	--	95	0.2
Farm laborers and farm foremen	4	0.7	5	0.3	144	0.3
Service workers, except private household	90	14.8	208	13.3	5,477	10.1
Private household workers	--		--		25	--
FEMALE employed, 16 years and over	316	99.8	1,089	100.2	35,122	100.1
Professional, technical and kindred workers	39	12.3	206	18.9	6,988	19.9
Managers and administrators, except farm	19	6.0	58	5.3	2,053	5.8
Sales Workers	41	13.0	55	5.1	2,595	7.4
Clerical and kindred workers	106	33.5	257	23.6	13,478	38.4
Craftsmen, foremen and kindred workers	--	--	23	2.1	425	1.2
Operatives, except transport	39	12.3	214	19.7	1,477	4.2
Transport equipment operatives	--	--	5	0.5	244	0.7
Laborers, except farm	15	4.7	28	2.6	382	1.2
Farmers and Farm managers	--	--	--	--	39	0.1
Farm laborers and farm foremen	--	--	--	--	57	0.2
Service workers, except private household	48	15.2	213	19.6	6,385	18.2
Private household workers	9	2.8	30	2.8	999	2.8

Source: U.S. Bureau of the Census 1970b.

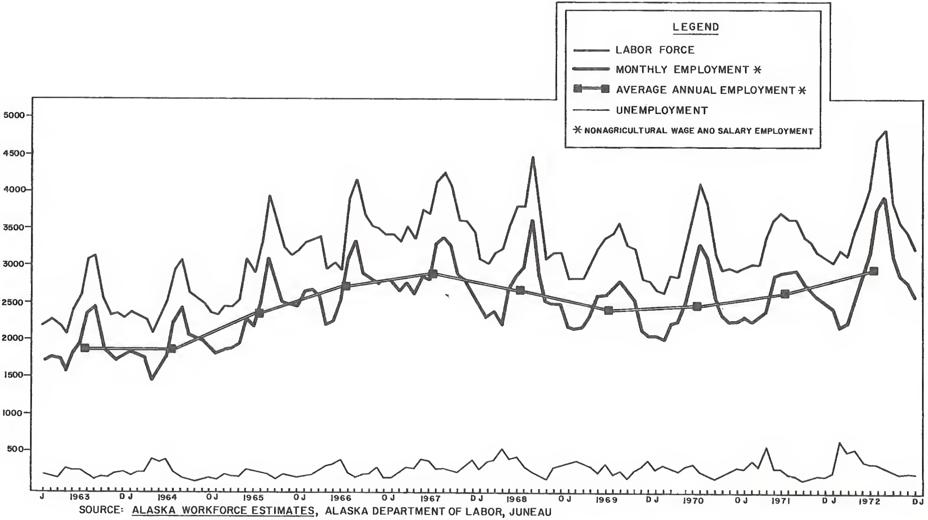
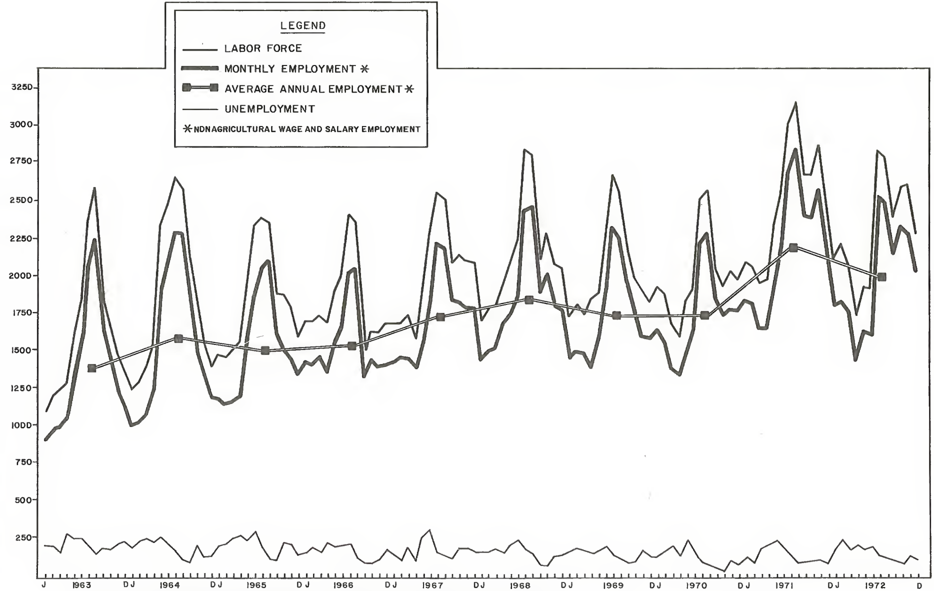


Figure 165. Kodiak Island labor force and employment, 1963-1972 (from Alaska Department of Labor, various dates).



SOURCE: ALASKA WORKFORCE ESTIMATES, ALASKA DEPARTMENT OF LABOR, JUNEAU

Figure 166. Aleutian Islands labor [illegible] and employment, 196[illegible] (from Alaska Department of Labor, [illegible] date).

movement in the average annual employment and the monthly variations around the average. The graphs also illustrate how closely the seasonal movements in the labor force, due to changes in participation rates, match the movements in employment.

The fact that the fishing industry is the source of the seasonal variation is confirmed by Figures 167 and 168. In Kodiak, manufacturing, which is actually fish processing, is the only industry with any significant seasonal variation. Fish processing is also the primary cause of seasonal fluctuation in the Aleutian Islands Census Division, but there the pattern is reinforced by a similar fluctuation in the construction industry.

Employment by Industry

Employment in each of the major industries in the Kodiak area is shown in Table 66 for the period 1961 to 1972. The discussion below outlines the factors which have produced the observed development of each sector.

Contract Construction

In the early 1960s contract construction accounted for only one percent of the total employment in the Kodiak labor market area. However, the Good Friday earthquake and tidal waves of 1964, which destroyed a major portion of the downtown area, created a boom in the construction industry. Rebuilding homes, buildings, businesses, roads, and harbor facilities was underway within two months after the disaster. Average employment in contract construction in the second half of 1964 was 294 persons. By comparison the average for the same months in 1962 was only 44. The post-earthquake construction peaked in 1965, with an average of 312 persons (13.5 percent of the total employment) working in the industry. Construction employment declined after 1965 but the impact of earthquake related rebuilding was evident through 1968.

In 1970 construction employment declined to 1.9 percent of the total employment, a proportion which approached that of the early 1960s. In 1971 the trend reversed and construction employment rose with the beginning of a number of major projects in Kodiak area including a new high school, community college building, bio-dry plant to process cannery wastes, and extensive road work. In 1972 construction employment averaged 125 persons--4.3 percent of the total employment. According to the Kodiak Manpower Center, construction employment in 1973 was high, with most positions being filled by local residents.

It is likely that a five year plan for modernization and expansion of the Kodiak Coast Guard base will continue to keep construction employment at high levels. According to the base public works officer, 6.5 million dollars in construction projects has been authorized for fiscal year 1974. An additional 7.5 million dollars has been requested

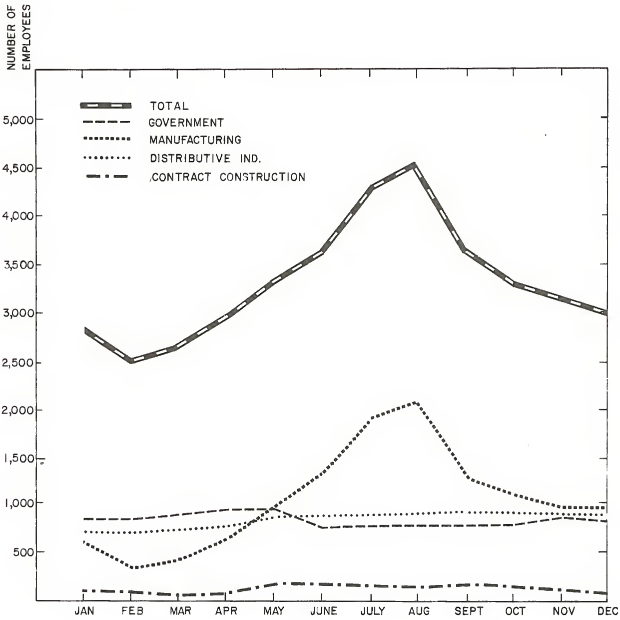


Figure 167. Kodiak Island total employed workforce by industry and month, 1972 (from Alaska Department of Labor, various dates).

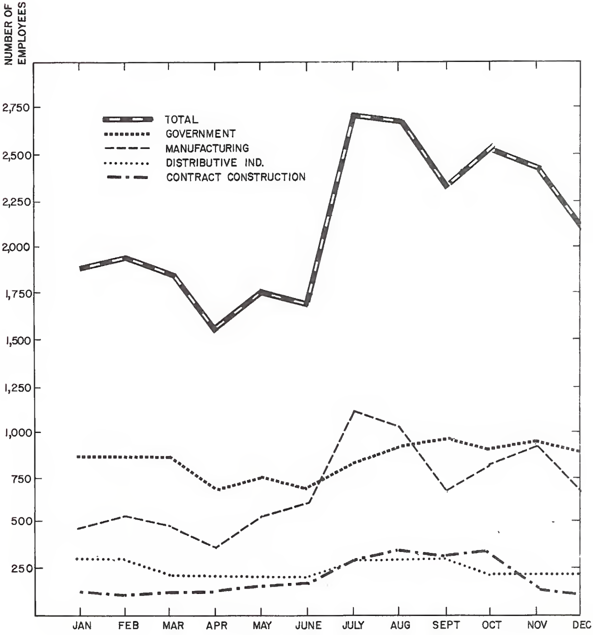


Figure 168. Aleutian Islands total employed workforce by industry and month, 1972 (from Alaska Department of Labor, various dates).

Table 66

NONAGRICULTURAL WAGE AND SALARY EMPLOYMENT BY INDUSTRY

KODIAK LABOR AREA

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
TOTAL EMPLOYMENT	1824	1780	1876	1890	2310	2700	2875	2650	2395	2468	2619	2878
Contract Construction	24	28	**	176	312	291	191	166	84	46	61	125
Manufacturing	606	643	643	492	630	832	1014	811	664	743	768	866
Transportation, Communication, and Public Utilities	79	96	119	124	142	160	226	227	236	216	266	228
Trade	164	167	160	157	211	324	331	319	326	346	343	355
Service	83*	96*	116*	**	196	215	193	165	168	190	241	232
Government	831	719	765	773	783	823	862	893	836	838	851	821
Other	27	31	73	168	36	55	58	69	81	89	89	251

INDUSTRIAL DISTRIBUTION OF EMPLOYMENT
(PERCENT)

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Contract Construction	1.3	1.6	**	9.3	13.5	10.8	6.6	6.3	3.5	1.9	2.3	4.3
Manufacturing	33.2	36.1	34.3	26.0	27.3	30.8	35.3	30.6	27.7	30.1	29.3	30.1
Transportation, Communication, and Public Utilities	4.3	5.4	6.3	6.6	6.1	5.9	7.9	8.6	9.9	8.8	10.2	7.9
Trade	9.0	9.4	8.5	8.3	9.1	12.0	11.5	12.0	13.6	14.0	13.1	12.3
Service	5.1	5.4	6.2	**	8.5	8.0	6.7	6.2	7.0	7.7	9.2	8.1
Government	45.6	40.4	40.8	40.9	33.9	30.5	30.0	33.7	34.9	34.0	32.5	28.5
Other	1.5	1.7	3.9	8.9	1.6	2.0	2.0	2.6	3.4	3.6	3.4	8.7

*Includes Miscellaneous

**Withheld to comply with disclosure regulations.

Source: Alaska Department of Labor, various dates.

for fiscal year 1975, but is subject to congresssional approval. Estimates of construction beyond 1975 are not available. In addition it is anticipated that the base will award 1 million dollars annually for small construction contracts such as road repairs, re-roofing of buildings, and painting.

Manufacturing

In the Western Gulf of Alaska manufacturing is virtually synonymous with sea food processing. The industry has consistently accounted for 25 to 35 percent of the total employment. The lowest employment levels for manufacturing were recorded following the 1964 Alaskan earthquake. More than half of the island's canneries were concentrated in the city of Kodiak which was one of the areas hardest hit by the disaster. All plants suffered some structural and equipment damage and several were destroyed. The following year average employment in manufacturing remained low, but by 1966, the work force averages approached former levels, and in 1967 employment reached a peak of 1,014. The following two years registered a decline, but beginning in 1970 the total average monthly employment gradually increased to the 1972 total of 866.

The impact of the fishing industry has always been understated in Alaska's employment statistics because there have been no reliable estimates of the direct employment in commercial fishing. Available statistics included only those employees covered by unemployment insurance. Beginning in 1972 many commercial fishermen were able to sign up for the unemployment insurance program and have subsequently been added to the work force estimates in the miscellaneous category. According to the Alaska Department of Labor, more than 90 percent of the persons in the miscellaneous category for Kodiak in 1972 are commercial fishermen. This would add nearly 200 persons to the employment in manufacturing shown in Table 66 for 1972. Although the miscellaneous category does not as yet include all of the commercial fishing employment, lumping this category with manufacturing makes it clear that known employment in the fishing industry is more than a third of the total annual employment.

Trade and Service

Trade and service employment over the past five years has averaged about 20 percent of the total employment. The month to month variation in this sector is minimal and does not follow a consistent pattern from year to year. Trade and service employment increased gradually between 1968 and 1971 and then leveled off in 1972. Average 1972 employment in these industries was 232 persons in service and 355 in trade.

Transportation, Communications, and Public Utilities

In recent years employment in transportation, communications, and public utilities ranged from eight to 10 percent of total employment.

Average monthly employment in these industries remained fairly constant. In 1967 there were 226 persons employed per month and in 1972, 228. Some decline in employment occurs during the winter months but the seasonal variation is not very large.

Government

In 1961 government employment in the Kodiak area accounted for nearly half of the civilian work force. From 1965 to 1970 the share varied between 30 and 35 percent. On July 1, 1972 the Naval base was closed and the facility was taken over by the Coast Guard. According to the Cosst Guard's public information officer, all civilian employees who were working for the Naval base at the time of closure were offered positions with the Coast Guard. Nonetheless, current civilian employment on the base is 90, only about one-third of the previous employment of the naval base. As a result, the government share of total employment dropped below 30 percent in 1972.

Although total government employment declined as the naval base was phasing out, much of the slack was taken up by an increase in state and local government employment. Between 1969 and 1972 state and local government employment increased 42 percent. Kodiak is the regional center for state government in the Western Gulf and Aleutian areas. Agency offices here include the State Departments of Fish and Game, Health, Highways, Labor, Public Safety, and Public Works.

Most of the local government employment is also concentrated in Kodiak which is the headquarters for the Kodiak Island Borough. Teachers and school employees in Kodiak and the smaller villages are sill borough employees and they constitute a major portion of the local government employment. In addition to the borough government, the city of Kodiak maintains a local government which employees police, fire, public works, harbor, sanitation, and administrative personnel.

INCOME AND COST OF LIVING

Distribution of Income

In 1969, median family income in the Kodiak Census Division was 11,200 dollars (Table 67), about 10 percent below the median family income for the state as a whole. As shown in Table 67, the distribution of income in the Kodiak Island Borough is quite similar to the statewide pattern with 62 percent of the families having incomes in excess of 10,000 dollars. About 67 percent of the white families in the Kodiak Island Borough have incomes of 10,000 dollars and above, a figure equivalent to the statewide average for whites (Table 67). Among nonwhite families 43 percent have incomes over 10,000 dollars, much lower than the white average, but considerably higher than the statewide average of

Table 67

Income of Families 1969
KODIAK

	KODIAK ISLAND BOROUGH									KODIAK STATION		
	TOTAL			WHITE			NONWHITE			TOTAL		
	Number	Percent		Number	Percent		Number	Percent		Number	Percent	
ALL FAMILIES	1,449			1,136			313			562		
Less than $1,000	13	0.9		8	0.7		5	1.6		11	2.0	
$1,000-1,999	29	2.0		16	1.4		13	4.2		13	2.3	
2,000-2,999	63	4.3	16.8	32	2.8	14.1	31	9.9	26.9	0	0.0	10.3
3,000-3,999	47	3.2		42	3.7		5	1.6		9	1.6	
4,000-4,999	93	6.4		63	5.5		30	9.6		25	4.4	
5,000-5,999	64	4.4		39	3.4		25	8.0		79	14.1	
6,000-6,999	37	2.6		32	2.8		5	1.6		64	11.4	
7,000-7,999	69	4.8	21.6	41	3.6	18.8	28	8.9	30.6	60	10.7	47.2
8,000-8,999	66	4.6		40	3.5		26	8.3		31	5.5	
9,000-9,999	75	5.2		63	5.5		12	3.8		31	5.5	
10,000-11,999	143	9.9		130	11.4		13	4.2		74	13.2	
12,000-14,999	294	20.3		232	20.4		62	19.8		78	13.9	
15,000-24,999	352	24.3	61.7	314	27.6	66.8	38	12.1	42.5	84	14.9	
25,000-49,999	104	7.2		84	7.4		20	6.4		3	0.5	
50,000 or more	0	0.0		0	0.0		0	0.0		0	0.0	

Median Family Income $11,166*

*Kodiak Census Division

Source: U.S. Bureau of the Census, 1970 Census, Alaska, special computer runs; U.S. Bureau of the Census 1970b.

Table 67 (continued)

Income of Families 1969
Aleutian Islands, and Alaska

	ALEUTIAN ISLANDS									ALASKA					
	TOTAL			WHITE			NONWHITE			TOTAL		WHITE		NONWHITE	
	Number	Percent		Number	Percent		Number	Percent		Percent		Percent		Percent	
ALL FAMILIES	1,080			664			416								
Less than $1,000	8	0.7		0	0.0		8	1.9		2.2		1.6		5.6	
$1,000-1,999	26	2.4		6	0.9		20	4.8		2.3		1.4		7.5	
2,000-2,999	24	2.2	18.5	7	1.1	14.1	17	4.1		2.7	14.1	1.7	9.9	8.3	37.7
3,000-3,999	71	6.6		33	5.0		38	9.1		3.2		2.2		8.6	
4,000-4,999	71	6.6		47	7.1		24	5.8		3.7		7.0		3.7	
5,000-5,999	83	7.7		58	8.7		25	6.0		5.0		4.3		8.8	
6,000-6,999	102	9.4		69	10.4		33	7.9		4.9		4.6		6.8	
7,000-7,999	98	9.1	41.4	66	9.9	46.3	32	7.7	33.6	4.6	23.5	4.5	22.4	5.2	30.1
8,000-8,999	103	9.5		76	11.4		27	6.5		4.7		4.7		4.9	
9,000-9,999	62	5.7		39	5.9		23	5.5		4.3		4.3		4.4	
10,000-11,999	144	13.3		93	14.0		51	12.3		10.2					
12,000-14,999	147	13.6		107	16.1		40	9.6		14.3					
15,000-24,999	117	10.8	39.9	45	6.8	39.6	72	17.3	40.6	28.2	62.2		67.7		32.1
25,000-49,999	24	2.2		18	2.7		6	1.4		8.7					
50,000 or more	0	0.0		0	0.0		0	0.0		0.8					
Median Family Income	$8,553									$12,443		$13,464			

Source: U.S. Bureau of the Census, 1970 Census, Alaska, special computer runs;
U.S. Bureau of the Census 1970b.

only 32 percent for nonwhites. At the lower income levels, less than 5 percent of Kodiak's white families have incomes below 3,000 dollars, compared to 16 percent for Native families. However, for the state as a whole more than 21 percent of the nonwhite families have incomes less than 3,000 dollars.

The median income in the Aleutian Islands Census Division is 8,500 dollars, nearly a third lower than the state average (Table 67). The difference in income level is so large that it is difficult to make comparisons between the distributions of income. Obviously, a large proportion of the families in the Aleutian Islands region have low incomes and a small proportion have high incomes. Only 13 percent of the families in the Aleutians have incomes above 15,000 dollars compared to 38 percent for the state.

In the Aleutian Islands there appears to be less disparity between the incomes of white and nonwhite families with both having roughly 40 percent in the above 10,000 dollars income range (Table 67). The widest differences are in the low income ranges where only 14 percent of the whites earn less than 5,000 dollars compared to 26 percent for nonwhites. Since a majority of the white families in the Aleutians military dependents, it is not surprising that the white income distribution most closely resembles Kodiak Station. If military benefits were taken into account, the difference between white and nonwhite incomes would be greater. Still, as in Kodiak, incomes of nonwhite families in the Aleutian Islands are substantially higher than statewide averages for nonwhites.

Public Assistance Income

State public assistance, U. S. Bureau of Indian Affairs general assistance, and Food Stamps are the three major forms of public assistance available to local residents. The state public assistance programs include payments for old age assistance, aid to the blind, aid to the disabled, and aid to dependent children. Table 68 shows the number of cases and the dollar payments in each category for October of 1970, 1971, and 1972. For October 1972 the total amount of state public assistance in the Western Gulf region was 36,315 dollars. Comparable statistics are not avilable for years prior to 1970, because regulations for receiving assistance under these programs were changed in that year. Between 1970 and 1972 the number of Kodiak residents receiving funds from all of these progams increased from 120 to 191. At the same time, the number of recipients in the Alaska Peninsula region declined from 30 to 22. The 1970 census reported that less than three percent of the families in Kodiak were receiving public assistance (U.S. Bureau of the Census 1970b). In the Aleutians, despite the very low income levels prevailing there, less than 1.5 percent of the families were receiving any form of public assistance.

Table 68

MONTHLY PUBLIC ASSISTANCE*

WESTERN GULF** OF ALASKA OCTOBER 1970, 1971, 1972

	Number of Cases					Dollar Payments				
	OAA	AB	AD	AFDC	TOTAL	OAA	AB	AD	AFDC	TOTAL
KODIAK										
1970	29	2	24	65	120	$3,038	$435	$3,573	$13,108	$20,154
1971	35	3	19	66	123	3,471	488	3,077	14,881	21,917
1972	46	3	31	111	191	4,344	497	5,791	21,468	32,100
ALEUTIANS (Communities in Western Gulf)										
1970	12	1	3	14	30	1,868	169	425	4,014	6,476
1971	16	1	3	10	30	2,987	203	459	3,372	6,321
1972	12	2	2	6	22	1,525	273	257	2,160	4,215
WESTERN GULF										
1970	41	3	27	79	150	4,906	604	3,998	17,122	26,630
1971	51	4	22	76	153	6,458	691	3,536	18,253	28,238
1972	58	5	33	117	231	5,869	770	6,048	23,628	36,315

*OAA=old age assistance, AB-aid to the blind, AD=aid to the disabled, AD=aid to dependent children.

**Combination of statistics for Kodiak District and Aleutian Communities (Anchorage District) in Western Gulf.

Source: Alaska Department of Health and Social Services, various dates.

U.S. Bureau of Indian Affairs general assistance is available only to Natives. In 1968 these payments in the Western Gulf totaled 110,585 dollars (Table 69). In 1969 and 1970 the amount of assistance was cut to half of the 1968 level. Since 1970, payments have increased to the 1972 total of 172,018 dollars which represents assistance to 166 cases.

The Food Stamp Bonus Coupon program receives funding from the U.S. Department of Agriculture, but is administered by the State. Administration of this program for Alaska Peninsula recipients is handled through the Anchorage office of the Division of Family and Children's Services. The Kodiak office of the Division of Family and Children's Services distributed nearly 200,000 dollars in food stamps in the Kodiak area during 1971 (U.S. Office of Economic Opportunity 1971).

Earnings and Wage Rates

The earnings data in Table 70 show that the observed differences in regional incomes are not due solely to differences in the relative importance of various occupations. There is a consistent earnings differential in virtually all occupational categories. In Kodiak, males typically earn about 10 percent less than the statewide averages. There is considerable variation in the size of this gap with operatives making 30 percent less and laborers actually earning slightly more than the state average. Female earnings in Kodiak average 25 percent less than the state levels. However, in this case a substantial part of the gap is due to the difference in occupational mix. A relatively large share of the female employees in Kodiak are workers in canneries where the annual pay is low, in part because of the seasonal nature of the industry. The work force in the Aleutians consistently earn less in the various occupational categories, and the gap is much wider than in Kodiak. On the average, males earn 25 percent less than the state average and females earn nearly 50 percent less.

Table 71 gives Kodiak area average monthly wage rates by industry for the 1960-1972 period. In general, wage rates have increased throughout this period at an average annual rate of 5.7 percent. The average monthly wage in 1972 was 845 dollars compared to 436 dollars in 1960, an increase of 95 percent. The following discussion of wage rates lists the industries in descending order from highest average monthly wage in 1971 to lowest.

Contract construction has consistently averaged the highest wage rates of any industry in the Kodiak area. Beginning in 1965, the average monthly wage rates for construction were more than 1,000 dollars during every year except 1967. No other industry in Kodiak has averaged more than 1,000 dollars in any year. Construction wage rates rose from an average 341 dollars in 1960 to 1,556 dollars in 1972.

State and local government has shown a relatively rapid increase in wages between 1964 and 1972. In this interval, state and local government wages rose from a monthly average of 549 dollars to 910 dollars, an average annual increase of 6.5 percent.

Table 69

BUREAU OF INDIAN AFFAIRS GENERAL ASSISTANCE

WESTERN GULF OF ALASKA COMMUNITIES
FISCAL YEARS 1968-1972

	F. Y. 1968		F. Y. 1969		F. Y. 1970		F. Y. 1971		F. Y. 1972	
Community	Amount	Cases	Amount	Cases	Amount	Cases	Amount	Cases	Amount	Cases
Aleutian Islands										
(Communities in Western Gulf)										
Belkofski	$ 1,900	2	$ 110	1	$ -	-	$ 1,159	1	$ 621	1
Chignik	5,202	6	-	-	-	-	369	1	1,563	5
Chignik Lake	10,818	8	6,383	9	8,050	6	3,659	3	8,930	10
Chignik Lagoon	958	3			505	1	592	1	1,442	1
Cold Bay	-	-	-	-	-	-	700	1	620	1
Ivanof Bay	8,027	6	725	1	663	1	-	-	-	-
King Cove	2,291	3	200	1	-	-	-	-	1,250	2
Pavlof Harbor	1,100	1	-	-	-	-	-	-	-	-
Perryville	13,093	15	-	-	4,290	6	-	-	695	3
Port Moller	-	-	-	-	-	-	1,808	1	904	1
Sand Point	2,239	2	357	2	628	3	852	1	3,876	3
Subtotal - Aleutian	$ 45,628	46	$ 7,775	14	$ 14,136	17	$ 9,175	9	$ 19,901	28
Kodiak Island										
Afognak	-	-	-	-	-	-	-	-	-	-
Akhiok	13,351	13	6,711	7	6,756	8	11,925	8	23,787	14
Karluk	4,450	8	3,150	3	348	2	7,046	12	23,807	24
Kagayuk	-	-	-	-	-	-	-	-	-	-
Kodiak	10,109	20	4,885	12	11,748	24	42,575	48	50,067	55
Larsen Bay	5,564	5	3,334	3	4,007	5	800	1	7,759	6
Old Harbor	25,082	32	20,004	20	18,127	21	26,360	21	33,247	26
Ouzinki	1,920	2	2,054	3	1,063	5	8,550	7	13,273	12
Port Lions	4,481	7	231	1	224	1	-	-	240	1
Subtotal - Kodiak	$ 64,957	87	40,369	49	42,273	66	97,256	97	152,180	138
TOTAL	$ 110,585	133	$ 48,144	63	$ 56,409	83	$ 106,431	106	$ 172,081	166

Source: U. S. Bureau of Indian Affairs, Anchorage District Office files.

Table 70

EARNINGS BY OCCUPATIONAL GROUPS 1970

	Kodiak Census Division	Aleutian Islands Census Division	Alaska
Median earnings for selected occupation groups			
MALE, 16 years old and over with earnings	10,214	8,519	11,242
Professional and managerial	12,929	11,283	13,796
Craftsmen and foremen	11,111	9,346	12,098
Operatives	6,591	4,333	9,566
Laborers	6,885	6,333	6,747
FEMALE, 16 years old and over with earnings	3,576	2,477	4,818
Clerical and kindred workers	4,406	2,600	5,296
Operatives	2,287	1,650	2,274

Source: U.S. Bureau of the Census 1970b.

Table 71

Kodiak Area Nonagricultural Average Monthly Wage

1960 - 1972

Industrial Classification	1960	1961	1962	1963	1964[2]	1965	1966	1967	1968	1969	1970	1971	1972
Total Nonagricultural Industries	$436	$476	$527	$504	$579	$607	$620	$559	$636	$657	$665	$714	$845
Mining	*	*	*	*	*	*	*	*	*	*	*	*	*
Contract Construction	341	638	848	680	913	1066	1167	965	1153	1133	1100[3]	1229	1556
Manufacturing	474	502	548	521	607	553	531	441	525	576	601	641	630
Transportation, Commuications and Utilities	399	450	491	532	607	628	668	544	631	615	671	709	1047
Wholesale and Retail Trade	373	427	477	527	529	580	572	577	594	588	574	596	660
Finance, Insurance and Real Estate	439	507	513	482	495	517	488	500	575	564	580[4]	649	*
Services and Miscellaneous	247	291	356	365	433	463	483	470	449	435	460	491	569
Federal Government	NA	NA	NA	NA	469	469	525	570	638	689	673	691	898
State and Local Government	NA	NA	281	NA	549	621	647	687	703	785	811	922	910

*Not shown to avoid disclosure of information for individual firms.
[1]For three quarters only.
[2]The 1st Quarter 1964 Statistical Quarterly contained employment and earnings data, by industry and by area, for all nonagricultural workers in wage and salary employment, including those not covered by unemployment insurance. Previous issues contained data only for covered workers. These new data appear in all subsequent issues of the Statistical Quarterly.
[3]1st Quarter 1960 not shown to avoid disclosure.
[4]1st Quarter 1960 only included to avoid disclosure.
(Source: Alaska Department of Labor, Statistical Quarterly, 1960-72.)

Transportation, communications, and public utilities wages increased steadily between 1960 and 1966, declined during 1967-69, and have increased since that time. Average wages in the industry rose 78 percent between 1960 and 1971 and then jumped by 48 percent in 1972 alone. The average wage in 1972 was 1,047 dollars, second only to contract construction.

Federal government wages, which had remained virtually constant between 1968 and 1971, increased by 30 percent in 1972. This nearly eliminated the disparity between the average wages paid to federal government workers and wages paid in state and local government positions. In 1972 the state and local government average wage was 910 dollars and the federal government wage was 898 dollars.

Finance, insurance, and real estate industries have had erratic variations from year to year; however, the overall trend has been a moderate increase from an average 439 dollars in 1960 to 649 dollars in 1971.

Wholesale and retail trade wages increased from 373 dollars in 1960 to 580 dollars in 1965. From then to 1971 they increased very little, but rose by 11 percent in 1972 to reach a level of 660 dollars.

Manufacturing (fish processing) ranks first in percentage of persons employed, but next to lowest in average monthly wages. Wages in manufacturing have been the most unstable of Kodiak industries, a reflection of the cyclic nature of seafood processing. In 1960 the average monthly manufacturing wage was 474 dollars and it increased to 607 dollars in 1964; however, in 1967 the average wage declined to 441 dollars. Since 1967 manufacturing wages have risen to 630 dollars in 1972.

Services and miscellaneous industries ranked last in average monthly wages despite the fact that between 1960 and 1972 average montly wages more than doubled, going from 247 dollars to 569 dollars. That is still a third lower than the average wage in the Kodiak area.

Cost of Living

The Quarterly Report on Alaska Food Prices is the only data series which provides direct information on the cost of living in Kodiak relative to other areas (Marsh 1973). The report is based on a "market basket" of 45 food items which are surveyed nationwide by the U. S. Department of Agriculture (Table 72). The cost of this market basket is used to calculate food price ratios between Seattle and selected Alaska communities. These ratios for Kodiak Anchorage, Fairbanks, and Juneau from 1957-1973 are shown in Table 73. Prior to 1960, food prices in Alaska were based almost exclusively on a city's proximity to the port of Seattle. Thus, in the late 1950s Kodiak had lower food prices than either Anchorage or Fairbanks, while Southeastern Alaska communities such as Juneau had the lowest food prices in the state. As the state grew during the 1960s, prices rose much less rapidly in Anchorage and

Table 72

AVERAGE RETAIL PRICES OF 45 FOOD ITEMS IN SELECTED ALASKA CITIES

JUNE 1973

Food Item	Unit	Juneau	Kodiak	Anchrg.	Fair-banks	Bethel	Nome
Flour.	10 lb.	1.77	2.34	1.76	1.93	2.44	2.58
Rice	28 oz.	1.24	1.22	1.22	1.12	1.49	1.53
Corn Flakes.	18 oz.	.58	.62	.48	.64	.75	.75
Bread, white	1½ lb.	.56	.59	.58	.62	.79	.86
Round steak.	1 lb.	1.90	1.88	1.54	1.98	2.85	2.58
Chuck Roast.	1 lb.	1.20	1.33	1.09	1.28	2.45	1.77
Hamburger.	1 lb.	.99	1.18	.94	1.06	1.67	1.23
Pork chops	1 lb.	1.60	1.64	1.71	1.70	1.95	1.72
Bacon.	1 lb.	1.37	1.54	1.42	1.36	1.91	1.75
Wieners.	1 lb.	1.20	1.30	1.03	1.04	1.63	1.39
Frying chicken	1 lb.	.99	.96	.79	.93	1.24	1.21
Tuna fish.	6½ oz.	.58	.64	.57	.62	.69	.84
Milk, fresh.	½ gal.	.98	1.11	.98	1.08	1.57	1.75
Ice cream.	½ gal.	1.27	1.37	1.16	1.38	2.12	1.97
Butter	1 lb.	.96	1.10	.94	.98	1.61	1.35
Milk, evap..	14½ oz.	.26	.32	.26	.28	.35	.34
Milk, powdered	12 qt.	2.66	2.23	2.48	2.05	2.83	3.40
Eggs, fresh.	1 doz.	.84	.83	.73	.82	1.12	1.12
Orange juice, frozen . .	12 oz.	.58	.80	.80	.76	.80	1.14
Apples	1 lb.	.45	.54	.49	.54	.72	.72
Bananas.	1 lb.	.34	.49	.29	.36	.52	.62
Oranges.	1 lb.	.31	.42	.33	.42	.51	.59
Potatoes	1 lb.	.18	.14	.22	.22	.31	.34
Onions	1 lb.	.31	.39	.36	.58	.50	.56
Carrots.	1 lb.	.37	.39	.36	.38	.52	.58
Lettuce.	1 lb.	.62	.64	.64	.66	.79	.73
Cabbage.	1 lb.	.36	.37	.30	.40	.46	.49
Tomatoes, fresh.	1 lb.	.72	.79	.62	.84	1.13	.95
Grapefruit juice	46 oz.	.84	.89	.80	.82	1.06	1.11
Tomato juice	46 oz.	.61	.62	.60	.66	.97	.99
Pears	No. 2½ can	.64	.72	.74	.78	.74	.82
Peaches.	No. 2½ can	.63	.74	.57	.63	.80	.77
Fruit cocktail	303 can	.41	.48	.41	.45	.55	.54
Corn	303 can	.32	.36	.29	.40	.43	.47
Tomatoes, canned . . .	303 can	.37	.40	.36	.42	.47	.52
Baby foods	4½-5 oz.	.15	.18	.15	.22	.23	.22
Coffee	3 lb.	3.26	3.51	3.76	3.49	4.38	3.91
Salad or cooking oil .	48 oz.	1.54	1.80	1.42	1.54	2.17	2.31
Margarine.	1 lb.	.39	.42	.30	.53	.49	.45
Mayonnaise	1 qt.	.94	1.14	.88	.96	1.43	1.38
Cola drink	6-pack	1.06	1.30	1.18	1.26	1.84	1.78
Beans, dried	2 lb.	.61	.80	.76	.61	.62	.82
Sugar.	10 lb.	1.92	2.30	1.72	1.79	2.78	2.67
Tomato soup.	10½ oz.	.19	.22	.20	.20	.26	.31
Cr. of Mushroom soup .	10½ oz.	.24	.26	.23	.25	.35	.35
TOTAL*		39.31	43.31	38.46	41.04	55.29	54.28
TOTAL**		27.91	30.91	27.12	29.83	40.90	38.89
% of Seattle**, ***		121	134	118	129	177	169
Total, March, 1973**		26.80	29.75	26.90	28.79	41.02	37.64
Total, June, 1972**		24.73	27.73	25.05	27.07	38.59	37.00

* New revised food list
** Old food list
*** Based on May, 1973 U.S. Department of Labor, BLS "Retail Food Prices by Cities"

Source: Marsh 1973.

Table 73

FOOD PRICES IN SELECTED ALASKA CITIES

AS PERCENT OF SEATTLE

1957-1963

	KODIAK	ANCHORAGE	FAIRBANKS	JUNEAU
1957	131	136	154	123
1958	128	136	149	121
1959	129	133	148	123
1960	134	130	149	121
1961	133	129	143	118
1962	130	128	140	119
1963	130	128	143	119
1964	129	128	141	120
1965	136	132	148	131
1966	133	133	146	128
1967	134	132	144	127
1968	134	127	141	126
1969	132	125	140	127
1970	136	120	138	119
1971	137	124	136	121
1972	135	121	129	121
1973*	135	120	130	122

*Based on first and second quarters only.

Source: Marsh 1973.

Fairbanks than in Kodiak and Seattle. As the size of the market expanded in Alaska's urban centers, it led to increased competition among retail grocers, larger volume buying and more efficient merchandising (Marsh 1973). Compared to Anchorage and Fairbanks, Kodiak's growth has been moderate. One large grocery store supplies most of the food for the city of Kodiak and for a number of the villages on Kodiak Island. There are no competitive national grocery chains in the area. In June of 1973 food prices in Kodiak were 14 percent higher than in Anchorage and 4 percent higher than in Fairbanks.

In addition to the data on food prices, there is one other recent piece of information concerning the cost of living in the Western Gulf region. In 1972 the Alaska Division of Personnel conducted a suvery in various parts of Alaska to determine the costs of housing and food for state personnel (Alaska Department of Administration 1972). The survey measured food and beverage purchases (exclusive of alcoholic beverages, tobacco, and non-food products) and made adjustments for special diets, hunting, fishing, gardening, or maintenance of livestock. Housing expenditures included rent, mortgage payments, utilities, taxes, and insurance. The survey concluded that state employee food expenditures in Kodiak averaged 1,163 dollars per person, about 20 percent higher than the Anchorage figure and statewide average (Table 74). Average annual housing expenditures of 1,132 dollars per person in Kodiak were seven percent higher than the state average, but five percent less than Anchorage. But the houses in Kodiak tended to be smaller than average so housing costs per square foot were found to be nine percent higher than statewide and 21 percent higher than Anchorage. Furthermore, the condition of housing in Kodiak was found to be lower than in Anchorage or 21 percent is actually an underestimate of the true differential in the cost of housing. Based on the study's findings, the Division of Personnel recommended that Kodiak employees should receive three to four salary steps above Anchorage, that would amount to about a 15 percent cost of living adjustment for state employees in Kodiak (Alaska Department of Administration 1971).

HOUSING AND PUBLIC SERVICES

Housing

Kodiak Urban Area

In terms of the facilities offered, the quality of housing in Kodiak area appears adequate. The 1970 Census of Housing estimated that 93 to 95 percent of the 2,500 housing units in the Kodiak Census Division had hot and cold running water, flush toliets, bathtubs or showers, and complete kitchens (Table 75). In the city of Kodiak the 1970 census estimated that 99 percent of the homes had these facilities. These statistics for such facilities are comparable to the national averages and are considerably higher than the statewide average of 85 percent. On the other hand, the census data indicate that the number of persons per room in Kodiak is higher than average. Furthermore, a 1972 study by

Table 74

COSTS OF FOOD AND HOUSING FOR STATE EMPLOYEES 1972

	KODIAK						STATEWIDE		ANCHORAGE	
			KODIAK/STATE RATIO		KODIAK/ANCHORAGE RATIO					
	HOUSEHOLD	PERSON	HOUSEHOLD	PERSON	HOUSEHOLD	PERSON	HOUSEHOLD	PERSON	HOUSEHOLD	PERSON
Average Annual Food Expenditures	$3,862	$1,163	121	119	130	120	$3,185	$ 978	$2,960	$ 971
Average Annual Housing Expenditures	3,756	1,132	109	107	103	95	3,438	1,055	3,644	1,196
Average Housing cost per square foot	$3.86	--	109	--	121	--	$3.54	--	$3.19	--

Source: Alaska Department of Administration 1972.

Table 75

HOUSING CHARACTERISTICS

KODIAK CENSUS DIVISION 1970

	KODIAK				ALASKA		
	TOTAL		RURAL		TOTAL	RURAL	U.S.
	Number	Percent	Number	Percent	Percent	Percent	Percent
Total Population	9,409		2,498				
All year round housing units	2,536	100.0	742	100.0	100.0	100.0	100.0
POPULATION							
pop. in housing units 1970	8,364		2,392		276,918	143,656	
per occupied unit	3.5		3.5		3.5	3.8	
owner	3.7		3.8		3.8	4.0	
renter	3.4		2.9		3.2	3.3	
Piped Water in Structure							
Hot and cold	2,372	93.5	584	78.7	85.8	72.7	95.2
Cold only	90	3.5	84	11.3	2.6	4.7	2.3
None	74	2.9	74	10.0	11.6	22.5	2.4
Flush Toilet							
For exclusive use of household	2,415	95.2	630	84.9	85.3	72.7	95.0
Also used by another household	9	0.4	-	-	1.1	0.9	1.0
None	112	4.4	112	15.1	13.6	26.4	4.0
Bathtub or Shower							
For exclusive use of household	2,388	94.2	602	81.1	84.9	72.2	94.2
Also used by another household	4	0.2	-	-	1.1	1.3	1.0
None	144	5.7	140	18.9	14.0	26.9	4.8
Complete Kitchen Facilities							
For exclusive use of household	2,357	92.9	575	77.5	85.4	72.9	95.4
Also used by another household	3	0.1	-	-	0.3	0.3	0.2
No complete kitchen facilities	176	6.9	167	22.5	14.4	26.8	4.4
Rooms							
1 room	98	3.9	45	6.1	9.2	13.5	1.9
2 rooms	261	10.3	99	13.3	10.6	11.7	3.3
3 rooms	343	13.5	133	17.9	14.8	13.4	11.2
4 rooms	766	30.2	229	30.8	22.4	20.9	20.9
5 rooms	576	22.7	101	13.6	20.9	19.7	24.9
6 rooms	352	13.9	103	13.8	11.6	10.8	19.9
7 rooms	94	3.7	23	3.1	5.6	5.5	9.4
8 rooms or more	46	1.8	9	1.2	4.9	4.7	8.1

(Continued)

Table 75 (Continued)
HOUSING CHARACTERISTICS - Kodiak Census Division 1970

	KODIAK				ALASKA		U.S.
	TOTAL		RURAL		TOTAL	RURAL	
	Number	Percent	Number	Percent	Percent	Percent	Percent
Persons							
All occupied units	2,384	100.0	677	100.0	100.0	100.0	100.0
1 person	264	11.1	113	16.7	13.7	12.9	17.6
2 persons	642	26.9	192	28.4	24.7	22.2	29.6
3 persons	401	16.8	66	9.7	17.3	16.0	17.2
4 persons	436	18.3	104	15.4	17.1	16.5	15.4
5 persons	304	12.8	78	11.5	12.1	13.0	9.8
6 persons	173	7.3	60	8.9	7.1	8.3	5.3
7 persons	90	3.8	36	5.3	4.5	5.9	2.7
8 persons or more	74	3.1	28	4.1	3.6	5.4	2.4
Persons Per Room							
All occupied units	2,384	100.0	677	100.0	100.0	100.0	100.0
1.00 or less	1,934	81.1	502	74.2	81.0	73.9	91.8
1.01 - 1.50	300	12.6	91	13.4	10.0	11.3	6.0
1.51 or more	150	6.3	84	12.4	9.0	14.9	2.2
Bedrooms							
All year-round units	2,625	100.0	763	100.0	100.0	100.0	100.0
None	99	3.8	61	8.0	9.9	13.6	2.4
1	572	21.8	235	30.8	22.9	21.4	15.8
2	1,096	41.8	266	34.9	30.0	28.3	33.9
3	790	30.1	181	23.7	27.6	27.0	35.4
4 or more	68	2.6	20	2.6	9.6	9.7	12.6
House Heating Fuel							
All occupied units	2,535	100.0	719	100.0	100.0	100.0	100.0
Fuel oil, kerosene, etc.	2,416	95.3	719	100.0	56.6	70.8	26.0
Electricity	21	0.8	-	-	4.8	5.4	7.7
Other fuel	98	3.9	-	-	3.2	1.2	0.4
Water Heating Fuel							
Utility gas	23	0.9	-	-	22.1	10.0	55.1
Fuel oil, kerosene, etc.	1,390	54.8	461	64.1	23.9	25.9	9.8
Electricity	556	21.9	84	11.9	32.5	32.8	25.4
Bottled, tank, or LP gas	392	15.5	63	8.8	5.2	6.7	5.0
Other fuel	63	2.5	-	-	1.9	0.3	0.2
None	111	4.4	111	15.4	11.3	22.7	3.9

(Continued)

Table 75 (Continued)
HOUSING CHARACTERISTICS - Kodiak Census Division 1970

	KODIAK				ALASKA		
	TOTAL		RURAL		TOTAL	RURAL	U.S.
	Number	Percent	Number	Percent	Percent	Percent	Percent
Cooking fuel							
Utility gas	18	0.7	-	-	12.1	9.6	49.2
Electricity	1,386	54.7	193	26.8	58.9	42.5	40.6
Bottled, Tank or LP Gas	753	29.7	248	34.5	18.2	28.2	8.4
Fuel oil, kerosene, etc	378	14.9	278	38.7	7.1	12.9	0.5
Clothes Washing Machine							
Wringer or spinner	246	9.7	177	24.6	8.5	14.7	11.2
Automatic or semi-automatic	1,984	78.2	400	55.6	58.5	57.1	59.9
None	305	12.0	142	19.7	33.0	28.2	28.9
Clothes Dryer							
Gas heated	123	4.9	65	9.0	4.2	4.8	12.4
Electrically heated	1,569	61.9	243	33.8	48.3	46.0	29.4
None	843	33.2	411	57.2	47.5	49.2	58.3
Dishwasher							
Yes	326	12.9	36	5.0	21.9	17.2	18.8
No	2,209	87.1	683	95.0	78.1	82.8	81.1
Home Food Freezer							
Yes	1,305	51.5	388	54.0	41.3	47.8	28.2
No	1,230	48.5	331	46.0	58.7	52.2	71.8
Television (number of sets)							
1	1,654	65.2	282	39.2	59.6	51.7	66.8
2 or more	391	15.4	55	7.6	19.3	12.9	28.7
None	490	19.3	382	53.1	21.1	35.4	4.5
Battery-Operated Radio							
Yes	2,121	83.6	554	77.1	85.4	84.5	72.7
No	414	16.3	165	22.9	14.6	15.5	27.3

Source: U.S. Bureau of the Census 1970c, 1970d.

the Alaska Department of Administration, Division of Personnel, concluded that the homes of state employees in Kodiak were smaller and more crowded than the homes of state employees elsewhere (Alaska Department of Administration 1972).

Although the quality of housing in Kodiak is quite high, the amount is barely sufficient for the growing community. The Community Economic Development Committee, for example, notes that there is now a major housing shortage in the Kodiak urban area (Kodiak Island Borough 1973). In October 1973 ads in the local newspaper indicated that there were no homes or apartments for sale or rent in Kodiak.[1]

Many of the homes in the city of Kodiak were built by the government in the early 1940s to house Naval personnel. Later, when housing was built on the base, the city homes were rented to Kodiak residents. In 1970 the houses were sold to a Kodiak developer, and after renovation, the homes were sold at prices ranging from 13,000 to 19,000 dollars.[2] In 1973 a 1.7 million dollar apartment complex was completed on Alaska State Housing Authority land in the Kodiak urban renewal area. The complex contains 66 one, two, and three bedroom apartments with rents ranging from 260 dollars to 320 dollars per month. The Apartments have had full occupancy since they opened.[3]

The Kodiak Coast Guard base has 575 housing units which serve as quarters for military and civilian personnel. The housing was built in the 1940s, but most units have been remodeled and supplied with modern appliances and furnishings.[4] In 1973 the Coast Guard contemplated moving 50 civilian employees and their families to the city of Kodiak to allow more room for additional military families. Due to the housing shortage in Kodiak they were not able to make the move.[5]

Other Western Gulf Communities

In the villages on Kodiak Island, both the quality and the availability of housing varies widely. The Alaska State Housing Authority described the housing at Old Harbor as in "acutely short supply" with more than

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[1]Larry Grober, Kodiak Island Properties, October 1973. Personal communication.

[2]Ibid.

[3]Wayne Cherrier, Cherrier, King, Cherrier, October 1973. Personal communication.

[4]H.Z. Parker, public information officer of Kodiak Coast Guard Station. October 1973. Personal communication.

[5]Larry Broaber, Kodiak Island Properties, October 1973. Personal communication.

one family living in many of the units (Tryck, Nyman and Hayes 1968). Although the homes are overcrowded, Old Harbor's housing is in good condition. All of the homes were built by the U. S. Bureau of Indian Affairs after the original town was destroyed in the 1964 earthquake. However, Old Harbor's new housing has been criticized on the following grounds:

> The redevelopment at Old Harbor has been cited by the American Institute of Architects as an example of very poor esthetic planning. Although Old Harbor is located in a beautiful setting which provides an opportunity to develop an imaginative street pattern and architectural treatment of houses to fit the scenery. A gridiron street pattern was established and the houses are of identical box-like design. (Tryck, Nyman and Hayes 1968).

All the housing in Port Lions and a large part of the housing in Quzinkie was also built after the earthquake. A number of Ouzinkie homes are still in poor condition and it is anticipated that 10 new homes financed under the government's Turnkey III program will be built in the community within the next year.[1]

The community of Kaguyak was destroyed in the 1964 earthquake and its residents were relocated in new homes built for them by the U.S. Bureau of Indian Affairs in the nearby village of Akhiok. Apart from these homes, the housing in Akhiok is generally substandard. A majority of the housing at Larsen Bay and Karluk is also in poor condition. The Alaska State Housing Authority described several homes in Karluk as "extremely deteriorated and unsafe for occupancy" (Tryck, Nyman and Hayes 1968).

In spite of the poor housing conditions and the shortage of housing in most of the Kodiak villages, representatives of the Native corporation see little possibility that the situation will be remedied within the next two to three years. They have attempted to fund housing through a variety of state and federal programs, but have been largely unsuccessful.[2]

Housing in most of the small Native villages on the Alaska Peninsula portion of the Western Gulf is likewise in poor condition, overcrowded, and in short supply. However, in Cold Bay the housing which is provided for government workers and airline personnel is generally good.[3] The houses at King Cove are in good condition, but smaller than the average size of homes in urban Alaska (Alaska State Housing Authority 1968).

The Alaska State Housing Authority described the housing at Sand Point as an "unusually high quality" by Alaskan standards and further noted:

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[1]Allen Panamarofn, Koniag, Inc., October 1973. Personal communication.

[2]Ibid.

[3]Dorothy Jones, Sociologist, Institute of Social, Economic, and Government Research, University of Alaska, October 1973. Personal communication.

> Most homes are well constructed and well maintained, making this an extremely attractive looking community. With the difficulties involved in ordering building supplies out of Seattle and with no local building contractor, the condition of Sand Point's housing is even more impressive. The housing in the town's new subdivision is superior to most Anchorage subdivisions (Alaska Consultants 1970).

This description does not apply to all homes in Sand Point as there are still a number of residents living in Quonset huts and other substandard housing. In 1969 the U. S. Public Health Service conducted a survey of homes in Sand Point and did find that most had a full range of facilities and adequate space (Alaska Consultants 1970).

Public Services

Medical Care

The only hospital in the Western Gulf of Alaska is located in the city of Kodiak. It is owned by the borough but administered by the Grey Nuns of the Sacred Heart. The hospital is a modern facility, built in 1969, which has 26 beds plus a nursery. The average patient load in 1972 was 50 percent of capacity and the hospital administrator estimated that the 1973 patient load would average 55 percent of capacity.[1] In a recent study the Alaska State Housing Authority concluded that the new hospital would adequately meet Kodiak's needs for the next 15 to 20 years (Tryck, Nyman and Hayes 1968). All four doctors in Kodiak in 1973 were general practitioners, but one is also trained as a surgeon. In addition to these resident doctors, the hospital has the services of a third or fourth year medical student from the University of Washington on a rotation basis every six weeks. In October of 1973 the total hospital staff was 48 persons.[2]

The State runs a public health center in Kodiak with a program which includes immunizations, TB chest clinics, communicable and veneral disease clinics, mother and child good health clinics, and a school health program. One public health nurse serves the Kodiak urban area and another works in the outlying Kodiak villages on an intinerant basis (Kodiak Chamber of Commerce 1973). Alaska Natives receive care at the Kodiak hospital under a contract agreement with the U.S. Public Health Service.[3]

Private medical services in Kodiak are available through a small doctor's clinic which has a staff of four doctors, two dentists and one optometrist.[4] The Coast Guard station maintains a 17 bed dispensary for

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[1]Sister Claire Reedy, Administrator, Griffin Memorial Hospital, Kodiak October 1973. Personal communication.

[2]Ibid.

[3]Ibid.

[4]Ibid.

military personnel and their dependents. The medical staff includes four physicians, three dentists and four nurses. Illness or injuries which require treatment beyond the capabilities of the dispensary are treated at the Elmendorf Air Force Base hospital in Anchorage or the Kodiak city hospital (U.S. Coast Guard 1973).

Each of Kodiak's six outlying villages has a village health aide who has been trained by the Indian Health Service under a program run by the Alaska Native Federation. Since no medical facilities have been built in the villages, the health aides operate out of their homes or the school. The health aides call the Kodiak hospital each night via a side ban radio communication system to report medical problems in the village and receive instructions. For cases requiring hospitalization or a doctor's care, patients generally are flown to Kodiak via commercial aircraft. In emergencies villagers can be evacuated by Coast Guard aircraft.[1]

Medical facilities and services in the Alaska Peninsula region are very limited as there is no hospital or physician in the area. Improved medical service is a major need in the area, especially in light of the high rate of serious accidents which occur on fishing boats and in the processing plants. At present, the best medical facility on the Alaska Peninsula is a health clinic in Sand Point run by the Baptist General Conference. It is staffed by a registered nurse and is primarily an out-patient facility. The clinic includes a delivery room, space for emergency surgery, and two beds for patients awaiting evacuation to Anchorage or to Kodiak. The clinic serves Sand Point, neighboring villages and the transient fishing fleet (Alaska Consultants 1970). Another clinic staffed by a resident nurse is located in King Cove. It is funded jointly by the city and the local seafood processing plant (Alaska State Housing Authority 1968).

The U. S. Public Health Service and the State provide health care to the region on an itinerant basis. A state public health nurse visits most communities two or three times a year. U. S. Public Health Service doctors and dentists also hold clinics in the villages two or three times per year. For serious medical problems Alaska Peninsula residents generally are flown to Anchorage via scheduled air flights. In emergency the Coast Guard can evacuate persons to the Kodiak hospital (Alaska Consultants 1970).

Utilities

The City of Kodiak provides water for the urban area. The system had been improved but until very recently it had not been able to supply the huge quantities of water required by the fish processing industry.

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[1]Sister Claire Reedy, Administrator, Griffin Memorial Hospital, Kodiak October 1973. Personal communication.

During periods when the local reservior was low, some of the processing plants had to shut down operations for several weeks at a time. As a result the reservior was expanded in the summer of 1973 and negotiations are currently underway to attract two more processing plants to Kodiak.[1]

The City of Kodiak also supplies the urban area with a sewer system; however, most homes in the outlying areas are served by septic tanks. A five million dollar plan is currently under way to expand the urban sewer services and build a sewage treatment facility. Port Lions, Ouzinkie, Old Harbor, and Akhiok have water and sewer systems which were built by the Public Health Service. Larsen Bay and Karluk do not have public utility systems for water or for sewer (Kodiak Island Borough 1973).

The Kodiak urban area and Port Lions receive power from the Kodiak Electric Association; Ouzinkie has a city electric plant and Old Harbor is supplied power through the Alaska Village Electrical Cooperative Association. The U. S. Coast Guard Station and Chiniak Air Force Base have their own self-contained power systems (Kodiak Island Borough 1973).

Electricity and water are supplied to the residents of Sand Point by one of the local processing plants. Sand Point has no community sewer system. Some of the homes are attached to a sewer line which discharges untreated sewage into a local slough. Others have lines which dispose untreated sewage into the sea. The community has regulations regarding the dumping of garbage but has no city operated garbage disposal system. Much of the city's refuse is simply dumped off the end of the dock. Cannery wastes are ground up before they are dumped into the sea (Alaska Consultants 1970).

The City of King Cove operates a generating plant which supplies electricity to the residents of the community. Homes receive water from a line which serves the cannery; however, during the winter the line is sometimes frozen. King Cove has no sewage system. Homes with plumbing commonly have individual septic tanks. Those without plumbing rely on outhouses or "honey buckets." There is no refuse collection system in the community. Garbage is burned on the beaches where the remains will supposedly be taken out by the tide. However, much of the debris is carried through the community by strong winds. The canneries dump their processing wastes into the bay (Alaska State Housing Authority 1968).

For the most part, residents of the eight small villages on the Alaska Peninsula do not have public utilities. Water is supplied by private wells or by local springs and streams. Sewage and garbage

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[1]Jack Ioadore, Kodiak City Manager, October 1973. Personal communication.

desposal is generally primitive. Chignik is the only village with a community power supply. In other villages individual homes are sometimes connected to small private generators, but mainly residents of these communities are without electric power (Federal Field Committee for Development Planning in Alaska 1971).

Communications

On Kodiak Island direct distance dialing telephone service is available in the Kodiak urban area, Port Lions, Chiniak Air Force Station and the Kodiak Coast Guard Base. All other communities rely on radios for communication, though RCA plans to extend "bush" radio telephone service to all the Kodiak villages within the next few years (Kodiak Island Borough 1973).

The Armed Forces Radio Service has maintained a radio station in Kodiak for 31 years. Today it broadcasts 24 hours per day. There is no commercial radio station in the area but there are two cable color television channels in Kodiak. A radio transceiver is based in the Kodiak Island Borough Hospital. The unit is used to extend medical assitance to the villages (Kodiak Island Borough 1973).

In the Western Gulf of Alaska radio telephone is an important means of communication. Many boats in the fishing fleet have radio contact with their home canneries which creates a comprehensive radio network. In most of the smaller communities on the Alaska Peninsula the only communications facilities consist of two-way radios. On the Alaska Peninsula the only communities with telephone service are Sand Point and Cold Bay (Alaska Consultants 1970).

INDUSTRIAL ACTIVITY

Commercial Fishing and Fish Processing

Fisheries, the mainstay of the Western Gulf economy, are partly based outside its defined geographic boundary. The salmon, shellfish, and part of the halibut caught on the north side of the Alaska Peninsula and in the Aleutian Islands region are processed in the Western Gulf of Alaska. Therefore, the fisheries data included in the following discussion will encompass both the south and north side of the Alaska Peninsula, as well as the Aleutians and the Kodiak Island group. This area coincides with Alaska Department of Fish and Game management areas 9 through 13 (Figure 169) which include Kodiak, Chignik, South Peninsula, North Peninsula, and the Aleutians.

The U. S. commercial fisheries of the region are comprised of salmon, shellfish, and halibut, plus small amounts of other fish. Salmon constituted the most important fishery up until the 1960s, but since that time the value of shellfish has exceeded the salmon value in most years. Halibut make up the third most important fishery. Rogers

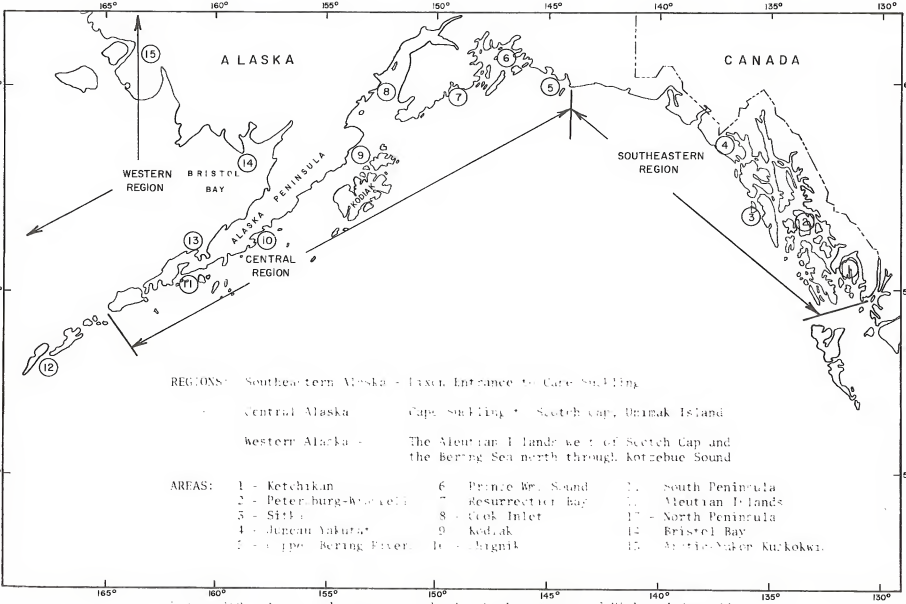

Figure [illegible]69. Areas and regions of the Alaska Department of Fish and Game (from Alaska Department of Fish and Game, various years).

(1972) reports that in 1972 the value of the halibut landings from the international high-seas fleets equaled 29.3 percent of the total salmon value harvested in the region. Other fish harvested in the Western Gulf such as pollock, Pacific cod, Pacific ocean perch, and blackcod, while important to the fishing industries of the USSR and Japan, are not yet economically important to the economy of study region.

Salmon Fishing[1]

As is typical in Alaska, the salmon harvest of the Western Gulf of Alaska is highly cyclic. The 1960-1971 harvest data indicate alternating high and low catches for most years (Table 76). For this discussion, Kodiak and Chignik will be treated separately and the South and North Peninsula and the Aleutians will be discussed as a group (Aleutian-Peninsula).

The Kodiak management area consists of nine districts where all five species of eastern Pacific salmon are harvested (Figure 170). The salmon fishery began in the area in 1882 and for 30 years red salmon was the principal species harvested. Since 1924, however, pink salmon have dominated the catch, and chum salmon have become the second most important species. Red salmon, which have declined drastically since the early years of the fishery, is now the third ranking species in the region.

In the early years of the fishery, beach seines were the most common gear. Traps were introduced after 1920, and their use probably accounts for the increased catch. In later years, red salmon catches began to decline because of the intensive beach seining near the mouths of the major salmon-producing streams and poor fishing regulation. Regulations in the early years were fixed prior to the beginnng of the seasons and were not adjusted in accordance with the size of the runs. Under these regulations along some coastal areas, the salmon were subjected to continuous harvesting as they migrated. In recent years the fishery has been managed by district or groups of districts through the fixing of seasonal and weekly fishing periods for the various stocks of salmon. Trap gear was outlawed by state law in 1959, and the purse seine is now the most common type of gear in the region, followed by set gill nets which are used only in certain locations.

When they run in sufficient numbers, red salmon are the first species harvested in the Kodiak area. This fishery usually begins in June and continues throughout the summer as red salmon are taken incidentally during the pink salmon fishery. Pink salmon become available in early June. At first these fish are generally caught near the capes; then, as the season progresses, the fish migrate into the bays. In recent times, most of the pinks have been caught on the even years.

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[1]Much of the information concerning salmon fisheries was derived from the Governor's Study Group on Limited Entry, 1973.

Table 76

COMMERCIAL SALMON CATCH BY AREA

WESTERN GULF OF ALASKA 1960-1971

YEAR	Total Western Gulf Region thousands of fish	Kodiak Area thousands	Kodiak Area % sub-region	Chignik Area thousands	Chignik Area % sub-region	Aleutian Peninsula* Area thousands	Aleutian Peninsula* Area % sub-region
1960	14,283.6	8,456.3	59.2	1,069.0	7.5	4,758.3	33.3
1961	9,453.3	4,882.0	51.6	955.1	10.0	3,616.2	38.3
1962	23,588.8	15,750.1	66.8	2,249.4	9.5	5,589.3	23.7
1963	11,926.2	6,249.6	52.4	2,195.3	18.4	3,481.3	29.2
1964	20,768.7	13,713.8	66.0	2,578.3	12.4	4,476.6	21.6
1965	10,196.9	3,692.1	36.2	1,880.2	18.4	4,624.6	45.4
1966	15,095.7	12,217.9	80.9	1,160.2	7.7	1,717.6	11.4
1967	2,343.0	735.2	31.4	662.7	28.3	945.1	40.3
1968	16,353.3	10,337.5	63.2	2,395.9	14.7	3,619.9	22.1
1969	19,037.7	13,678.5	71.9	2,179.0	11.4	3,180.2	16.7
1970	22,556.8	13,939.2	61.8	3,094.7	13.7	5,522.9	24.5
1971	12,398.5	6,378.1	51.4	1,999.0	16.1	4,021.4	32.5

*Includes South Peninsula, North Peninsula and Aleutian Islands.

Source: Rogers 1972.

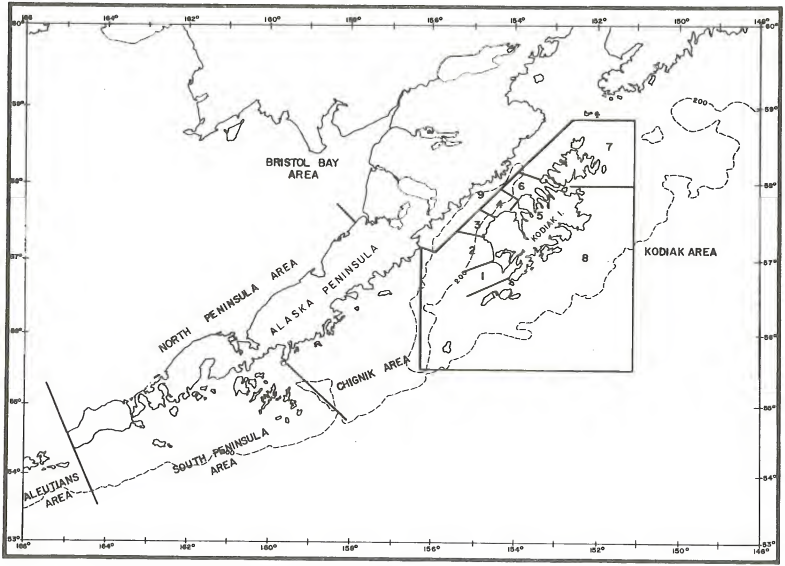

Figure 170. Alaska Department of Fish and Game areas and subareas in the Western Gulf of Alaska.

During the odd years regulations are more strict since there are fewer streams producing fish. The fishery is regulated by fixing of weekly fishing periods. When this proves inadequate and not enough fish return to the streams, districts are closed by emergency orders until it is certain that enough spawners will eventually return. The pink salmon usually peak during the last week of July through the first week of August; however, some variations do occur. More than 10 percent of the pink salmon run can be harvested during a single day's fishing due to the recent increases in the amount of gear in the fishery. Chum and silver salmon are usually harvested after the pink fishery by purse seines. The few king salmon taken are harvested incidentally during the pink fishery. The Kodiak area accounts for most of the salmon caught in the Western Gulf (Table 76). With two exceptions (1965 and 1967) the Kodiak subregion accounted for more than half of the catch from 1960 through 1971.

The Chignik management area (Figure 170) is located on the south side of the Alaska Peninsula and extends 160 km. east and west of Chignik Bay. Salmon harvesting on the Chignik area began in 1888 and for many years was confined to a very small area within a few kilmeters of the Chignik River. The principal species, red salmon, was generally part of the catch. Traps operated in the area until 1954. Salmon are now harvested exclusively by purse seines or hand purse seines.

Two red salmon runs enter the Chignik River system. The early run enters Chignik Lagoon in early June and peaks toward the end of June. The late run enters the lagoon late in June and peaks about the middle of July. Most Chignik red salmon are caught in the Chignik Lagoon. A significant portion of the catch is now harvested east of Chignik Bay near Cape Kumlik and in the vicinity of Cape Igvak. The red salmon fishery is regulated with the aid of daily weir counts and catch statistics. Weekly fishing periods are adjusted according to the strength of returning runs. Only short hand seines are used to take salmon in the Chignik Bay district and these are mainly in the shallow Chignik Lagoon. Coho salmon are taken within Chignik Lagoon in late summer after the red salmon run. King salmon are also taken in small numbers during the red salmon harvest.

Pink and chum salmon are the predominant species taken in the other districts within the Chignik area. Most harvesting of these species takes place after the red salmon run in the Chignik Bay district has tapered off. Unlike the fishing at Chignik Bay, longer seines are used in these districts for harvesting pink and chum salmon. The fish are harvested by an annual average of 75 seine boats. The largest pink and chum harvests in the area have occurred within the past decade. This growth of the harvests is attributed to fishing regulations which have set fixed fishery periods and have closed areas when necessary to permit adequate escapements. The Chignik area accounted for an annual average of 15 percent of the Western Gulf's salmon catch from 1960 to 1971.

The Aleutian-Peninsula area consists of the south and north sides of the Alaska Peninsula and the Aleutian Islands. The south peninsula area (Figure 170) lies between Unimak Pass and Samalga Pass. Salmon fishing in this area began near Cold Bay and Stepovak Bay in 1908. Gradually, harvesting activities spread to the False Pass area and then to the Shumagin Islands. In 1918 red salmon was the major species taken in all areas except the Shumigan Islands where pink salmon predominated. Beach seines were the most common gear in the early years, with traps becoming numerous after 1917.

Fishing begins in June in the Ikatan-Morzhovoi Bay vicinity and on the south side of Unimak Island. The fish harvested are red salmon bound for Bristol Bay and chums bound for nearby districts and western Alaska. Near Popof Head in the Shumagin Islands, red salmon bound for Bristol Bay and chums bound for the Alaska Peninsula streams are harvested in June. The south Unimak fishery employs drift gill nets and purse seines; the Shumagin fishery utilizes seines and gill nets. When the red chum runs decline, the Unimak fishery seiners begin havresting pink salmon in the Shumagin Islands, Pavlof Bay, and Cold Bay.

Fishing began in the north peninsula area in 1906 at Nelson Lagoon where red salmon were taken by gill nets. In 1912 the harvest of red salmon began at Port Moller, utilizing purse seines. Red salmon catches on the north peninsula peaked in 1921 and recent catches have approached only 20 to 25 percent of the peak catch. Chum salmon has been and is the second most important species in the area. Fishing gear utilized in the north Alaska Peninsula area includes set gill nets, drift gill nets, and some purse seines. Harvesting begins in the area between Nelson Lagoon and Ilnik in June after the south Unimak fishery has begun and continues in the Bear River and Nelson Lagoon areas until late August and early September respectively.

The salmon fishery in the Aleutian Islands area (Figure 170) occurs almost entirely in the bays of Unalaska Island. Most of the catch is taken after the completion of the June fishing in the south Unimak area. The harvesting is done with purse seines. Pink salmon is the principal species harvested. Fisheries management in the area is often hampered by adverse weather and long distances.

Catch statistics for the Aleutian-Peninsula area can been seen in Table 76. This area accounted for an annual average of 30 percent of the total salmon catch of the Western Gulf of Alaska from 1960 through 1971. Most of the salmon harvested in the Western Gulf of Alaska is canned, although small amounts are sold fresh, frozen, or cured. Since the early 1960s a market for salmon roe has been increasing. The total salmon roe production increased from approximately 34.7 metric tons in 1962 to 1,315 metric tons in 1971 (Governor's Study Group on Limited Entry 1973). In the Western Gulf of Alaska area, 20 plants processed salmon in 1972. Table 77 indicates the types of salmon products processed in each plant. The majority of these plants produced either canned or frozen salmon or salmon eggs; however, one plant produced smoked fish, and four of the plants produced salted fish.

Table 77

ALASKA SALMON PROCESSORS - 1972

WESTERN GULF OF ALASKA

Operator	Location	Canned	Frozen	Smoked	Salted	Eggs
		SALMON PRODUCTS				
Alaska Ice and Storage, Inc.	Kodiak		x			
Alaska Packers Association	Larsen Bay	x				x
	Chignik	x				x
B and B Fisheries	Kodiak	x	x			x
C and C Fisheries	Pleasant Harbor			x	x	
Columbia Wards Fisheries	Port Bailey	x				
	Alitak	x	x			x
King Crab, Inc.	Kodiak	x	x			x
Borge Larsen	False Pass				x	x
Marubeni America Corp.	Kodiak					x
Middle Bay Fisheries	Kodiak		x			x
New England Fish Co.	Uganik Bay	x	x			x
Peter Pan Seafoods	False Pass	x			x	x
	King Cove	x			x	x
Queen Fisheries	Kodiak		x			x
Western Alaska Enterprises, Inc.	False Pass					x
	Kodiak					x
	Larsen Bay					x
Whitney-Fidalgo Seafoods, Inc.	Uyak	x				x
	Kodiak	x				x

Source: Alaska Department of Fish and Game 1973a.

Shellfish

King Crab: Presently the most productive king crab areas in the Western Gulf of Alaska are in the Kodiak Island, Aleutian and Bering Sea areas (Table 78). During the mid-1960s the Kodiak area was the largest producer, but from 1966 to 1971, king crab production in Kodiak declined from 41,000 metric tons to 5,300 metric tons.

Since 1967 the Aleutian Islands-Bering Sea area has been the most productive, with nearly three-fourths of the entire catch of the Western Gulf.

Eldridge (1972) describes the patterns and trends of the king crab fishery as follows:

> Before one can adequately understand the changes which have taken place in the level of landings during the development of the king crab resource, one must be aware of the technological and economic factors which influenced that development.
>
> One of the most important factors is the nature of the produce itself and how it was marketed. In short, until the early and mid-1960s, the demand and the technological capability of the fishing fleet, not the abundance of the king crabs, regulated the catches of king crab. In other words, the peak catches of king crab occurred in the mid-1960s because it was not possible until that time to (1) catch and process large quantitites of king crab, and, more importantly, (2) to sell the king crab once it has been processed. At the present time, landings more nearly reflect the relative abundance of king crab because the demand is sufficient to absorb any amount of king crab that can be caught.
>
> Another important trend in the development of the fishery was the change in size and efficiency of vessels. Initially, the fishery was dominated by small, relatively inefficient vessels. Although many of these vessels are still in the fishery, they have been replaced in large part by more efficient larger vessels.
>
> The entry of large vessels led to a drastic change in the location and time of fishing for king crabs. For instance, in 1960 in the northeast fishing district of Kodiak, approximately 90 percent of the catch occurred in the inshore grounds; whereas since 1965 only about 20 percent of the catch has been taken there. In addition, the fishery has changed from primarily a winter to a summer and fall one.

Table 78

KING CRAB CATCH - WESTERN GULF OF ALASKA 1965-1971

(Thousands of Pounds)

Year	Kodiak	Chignik	So. Peninsula	Aleutians-Bering Sea
1971	11,820.0	13.3	4,211.8	49,785.2
1970	12,069.5	22.8	3,512.2	31,896.1
1969	12,724.1	310.1	4,335.3	35,559.8
1968	22,117.6	341.7	10,940.0	42,120.0
1967	62,864.4	247.7	17,180.0	44,810.0
1966	90,726.2	561.3	22,519.9	41,473.2
1965	76,837.9	769.9	14,407.0	36,296.0

Source: Alaska Department of Fish and Game, various years.

The fishing strategy also changed with the development of the fishery. Formerly, fishermen preferred to fish for the larger crabs in the more accessible fishing grounds. An example of this is the early fishery for king crabs in Chiniak Bay which is quite close to the town of Kodiak. At the present time, they fish all available grounds and keep all legal crabs. Furthermore, the total catch is regulated primarily by quotas imposed by the Alaska Department of Fish and Game rather than the level of demand for king crab meat.

Current prices paid to king crab fishermen are high. In the Kodiak area the 1973 price went as high as 1.57 dollars per kg., as compared to the 1972 rate of 86 cents per kg.[1] During the 1973 season eight processor ships operated in the Kodiak area, and it is estimated that these ships accounted for 40 to 50 percent of the total amount of crab processed.[2]

Dungeness Crab:[3] The amount of Dungeness crab caught in the various areas of the Western Gulf is shown in Table 79. Kodiak is by far the most productive area for this species. Much of this crab is found in the bays on the southwest corner of Kodiak Island. Dungeness crabs comprise an inshore fishery with most found between two and 20 fathoms. They range much closer to shore than the king crab, which is usually caught at depths up to 150 fathoms. Because the Dungeness crab is an inshore species, smaller vessels, cheaper gear, and small pots can be used.

Dungeness landings in Alaska fell from 6,000 metric tons in 1968 to 1,700 metric tons in 1971 (Alaska Department of Economic Development 1972). Supplies were so low that wholesale price quotations were rarely given. The price to fishermen was reported to be 40 cents per kg. in January 1972 and by the end of the year had nearly doubled to 75 cents per kg. (Alaska Department of Economic Development 1973).

Tanner Crab: Tanner crab harvests have been steadily increasing since 1967 when catch statistics were first recorded (Table 80). Most tanner crab are caught in the Kodiak area where the 1971 catch amounted to 3,400 metric tons. In that same year the South Peninsula area recorded a catch of 950 metric tons. Although figures are not yet available, it is expected that tanner crab landings at Kodiak in 1972 exceeded 4,500 metric tons (Alaska Department of Economic Development 1973b). Kodiak fishermen received 26 cents per kg. for this species during 1973 (Alaska Department of Economic Development 1973c).

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[1]Kodiak Mirror, September 10, 1973.

[2]Ibid.

[3]Much of the information in this section is derived from Wolf Management Service 1965.

Table 79

DUNGENESS CRAB CATCH - WESTERN GULF OF ALASKA - 1965-1971

(Thousands of Pounds)

Year	Kodiak	Chignik	So. Peninsula	Aleutians - Bering Sea
1971	1,445.9	5.9	5.9	16.2
1970	5,741.4	-	5.4	711.9
1969	5,813.7	305.6	750.7	629.1
1968	6,829.1	-	953.4	-
1967	6,663.7	-	-	-
1966	1,416.3	-	-	26.4
1965	3,331.6	-	16.8	-

Source: Alaska Department of Fish and Game, various years.

Table 80

TANNER CRAB CATCH - WESTERN GULF OF ALASKA

1967-1971
(Thousands of Pounds)

Year	Kodiak	Chignik	So. Peninsula	Aleutians
1971	7,410.8	152.3	2,140.8	-
1970	7,708.1	2.8	2,093.6	-
1969	6,822.7	38.1	606.3	21.0
1968	2,560.7	21.6	110.6	12.8
1967	111.0	1.6	3.1	-

Source: Alaska Department of Fish and Game, various years.

Shrimp: Most shrimp caught in Alaska are harvested in the Western Gulf. The region's shrimp fishing grounds are shown on Figure 96. Most of the catch is taken in the Kodiak area, where in 1971 approximately 37,200 of the region's 40,100 metric tons of shrimp were harvested (Table 81).

The 1972 shrimp catch in the Kodiak area was estimated to be 26,800 metric tons, a reduction of 10,400 metric tons from the 1971 harvest. The reduction partially resulted from the Alaska Department of Fish and Game's efforts to reduce the harvest by eliminating the carryover concept in quarterly shrimp quotas. Prior to May 22, 1972 any portion of the quota not harvested during one quarter was carried over to the following quarter (Alaska Department of Fish and Game 1973b).

The harvest was also reduced by a water shortage which drastically curtailed shrimp processing operations in Kodiak from late January through April 1972. In addition, the Shrimp Trawlers Association went out on strike from March through May. The strikers sought a price increase for delivered shrimp and settled for 12.1 cents per kg., 2.75 cents more than the pre-strike price (Alaska Department of Fish and Game 1973b). For 1972 as a whole, the average ex-vessel price for raw, whole shrimp in Kodiak was 11.6 cents per kg. (Alaska Department of Fish and Game 1973c). However, because of deductions made by processors for trash fish and debris contained in gross deliveries, this is somewhat higher than the fishermen actually received.

Other Shellfish: Razor clams and scallops are also taken in the Western Gulf of Alaska. Virtually all scallops are taken at Kodiak which averaged a harvest of approximately 450 metric tons annually betweeen 168 and 1971 (Alaska Department of Fish and Game, various years). Most of the clams dug in the Western Gulf of Alaska are also harvested in the Kodiak area. The clam harvest increased from one metric ton in 1967 to 86 metric tons in 1971 (Alaska Department of Fish and Game, various years).

Shellfish Processors: There were 24 shellfish processors listed in the Western Gulf of Alaska for 1972. These produce: fresh, frozen, and canned crab meat and shrimp, fresh and frozen scallops; and frozen, canned and fresh (bait) razor clams. Twelve of these plants are located in the city of Kodiak--six on other parts of Kodiak Island, and the remaining six on the south side of the Alaska Peninsula (Alaska Department of Fish and Game 1973a).

Halibut[1]

Halibut harvests in Alaska coastal waters are closely regulated by the International Pacific Halibut Commission. From 1960 to 1970 landings

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[1]Much of the information in this section was dervied from International Pacific Halibut Commission 1973.

Table 81

SHRIMP CATCH - WESTERN GULF OF ALASKA

1965-1971

(Thousands of Pounds)

Year	Kodiak	Chignik	So. Peninsula
1971	82,153.7	1,091.7	5,228.2
1970	62,181.2	890.7	4,399.0
1969	41,243.5	419.9	2,657.0
1968	34,361.6	1,153.7	4,373.9
1967	38,267.9	-	-
1966	24,097.7	-	-
1965	13,810.2	-	-

Source: Alaska Department of Fish and Game, various years.

of halibut remained fairly stable at 22,700 to 27,200 metric tons annually. After the 1971 season, research results became available which indicated that the stock of halibut was being seriously depleted and quotas would have to be reduced. As a result of lower quotas, the price of halibut doubled from 66 cents per kg. in 1971 to approximately 1.32 dollars per kg. in 1972. The rise in price, combined with recent salmon runs, induced more vessels to enter the halibut fishery.

The port of Kodiak is the major landing point in Alaska for the halibut catch. In 1972 nearly 4,100 metric tons of halibut were landed in Kodiak out of a total Alaska catch of 10,700 metric tons. The landings in Kodiak have generally increased in recent years despite the reduction in the halibut quotas. More vessels are electing to land their catches in Kodiak rather than Prince Rupert, Seattle, or other southern ports because the prices being paid at Kodiak have increased relative to the prices at the other ports.

Sand Point is the other major halibut port in the Western Gulf region. Until 1972 landings at Sand Point had been declining since they peaked at 1,700 metric tons in 1966. In 1971 only 320 metric tons of halibut were landed at Sand Point. These landings, however, rose to 470 metric tons in 1972.

Herring Fishery

Most herring caught in the Western Gulf of Alaska are taken from the Kodiak area. The 1971 and 1972 Kodiak catches were 568,000 and 195 metric tons, respectively (Alaska Department of Fish and Game 1973b). During the summer of 1972 an additional 48 metric tons of herring were harvested for sale to the halibut boats for bait.

Subsistence Fisheries

Although quite widespread, subsistence fishing is not as important in the Western Gulf of Alaska as it is in some other areas of the state. The regional supervisor for commercial fisheries in the Kodiak area reports the following subsistence figures for the past 10 years (1963-1972):[1]

Area	Subsistence Fish per year
Kodiak	14,000-20,000
Chignik	5,500
AK Peninsula-Aleutians	5,000

[1]Jack Lechmer, Regional Supervision, Alaska Department of Fish and Game, Commercial Fisheries Division, Kodiak, October 1973. Personal communication.

Value of Catch

In 1970 the value of the salmon catch to fishermen amounted to approximately 15.7 million dollars (Table 82). In that same year, fishermen earned a total of 18.1 million dollars for the shellfish catch and 3.5 million dollars for the catch of other species (halibut, herring, and bottom fish). The total value to fishermen of all fish products from the Western Gulf in 1970 amounted to approximately 37.3 million dollars.

In 1970 the wholesale value to processors totaled 41.5 million dollars for salmon, 38.5 million dollars for shellfish, and 4.5 million dollars for other fish (Table 83). The comparison of the raw fish value to wholesale values indicates the value added by processing. The proportion of value added in processing for all salmon products amounted to 62 percent of total wholesale value in 1970. For shellfish and other fish the value added in processing was 53 percent and 23 percent respectively in 1970.

The data in Table 84 show how the proportion of value added in processing has changed over time relative to the value added by fishermen. In the years for which data are available, the share of value added attributable to processing has remained remarkabley constant in the salmon industry. On the average, about two-thirds of the wholesale value of salmon is due to processing and one-third is value added by fishermen. In sharp constrast to this, the share of value added by fishermen has reached nearly 60 percent of total value in the king crab industry. As the catch of king crab has declined and the price has more than doubled, the fishermen's share of value added has increased markedly. Both the price and the share of value added have moved quite erratically in the shrimp industry. If anything, the processors seem to have gained a somewhat larger share of value added as the price of shrimp has risen in recent years.

External Factors Affecting Fisheries

Oil Pollution:[1] During February and March 1970, oil was found in the coastal waters and on the shores of Kodiak Island. It was estimated that at least 1,600 km. of coastline along the eastern side of Kodiak Island group, Alaska Peninsula, Kenai Peninsula, and Montague Island in Prince William Sound were affected by oil. Old Afognak was the only area where oil was found in large quantities; oil on kelp was estiamted at 18 kg. per 30 m. for 2.4 km. surveyed. In other areas, small concentrations of oil were found on birds, sea mammals, beaches, and debris. A joint investigation by the Federal Water Quality Administration and the State of Alaska concluded that the most likely source of the oil was tankships which dumped ballast waters and "slop" oils at sea as they entered Cook Inlet to pick up crude oil.

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[1]Much of the information for this section was derived from Federal Water Quality Administration 1970.

Table 82

COMMERCIAL CATCH AND VALUE TO FISHERMEN

WESTERN GULF OF ALASKA - 1960-1971

Year	SALMON Pounds	SALMON Value	OTHER FISH[a] Pounds	OTHER FISH[a] Value	SHELLFISH Pounds	SHELLFISH Value	SHELLFISH VALUE as percent of SALMON VALUE
1960	68,413,676	$ 6,981,304	57,600	n.a.	27,818,268	$ 2,012,525	28.8%
1961	43,333,428	5,107,366	-	-	46,032,354	3,551,884	69.5
1962	84,842,568	11,583,229	-	-	58,655,575	5,038,748	43.5
1963	46,751,004	5,763,453	-	-	81,696,787	6,049,795	105.0
1964	83,887,121	8,862,267	619,550	n.a.	87,566,140	6,598,043	74.5
1965	44,085,000	5,497,988	1,482,095	n.a.	145,469,400	13,365,875	243.1
1966	68,366,127	9,095,851	6,266,580	n.a.	180,834,700	18,774,022	206.4
1967	14,760,994[b]	2,310,522[b]	5,157,395	n.a.	169,007,100	16,813,824	727.7
1968	68,836,779	9,888,957	3,983,708	n.a.	126,631,900	19,933,433	201.6
1969	87,089,240	12,101,053	2,273,945	$ 61,173	114,382,598	18,873,679	156.0
1970	102,219,503	15,742,936	11,218,948[a]	3,473,179[a]	134,249,063	18,141,886	115.2
1971	64,616,970	10,387,206	10,599,117[a]	3,106,349[a]	166,684,050	23,372,309	225.0

[a] Halibut included in 1970 and 1971, not reported for earlier years.

[b] Kodiak 1967 catch only one-tenth 1948-1970 annual average

n.a. - Data not available

<u>Source</u>: Rogers 1972.

Table 83

FISH PRODUCTS AND WHOLESALE VALUE BY SPECIES AND TYPE OF PRODUCT

WESTERN GULF OF ALASKA - 1970

	Pounds Prepared for Market	Wholesale Value to Processor	Wholesale Value per Pound
SALMON			
Fresh	397,908	$ 100,225	$ .25
Frozen	2,851,424	1,177,851	.41
Cured[a]	55,950	39,190	.70
Canned	53,116,944	35,988,884	.68
Roe	3,442,120	4,215,114	1.22
TOTAL SALMON	59,864,346	$41,521,264	$ .69
OTHER FISH			
Halibut	8,712,988	4,356,491	.50
Herring	152,235	147,773	.97
Herring eggs or kelp	-	-	-
Bottom Fish	53,149	3,298	.06
Other	26,727	2,695	.10
TOTAL OTHER FISH	8,945,144	$ 4,510,257	$ .50
SHELLFISH			
King Crab	11,476,763	20,281,672	1.77
Dungeness	4,386,530	2,048,392	.47
Tanner Crab	2,240,417	2,443,957	1.09
Shrimp	10,306,294	12,830,446	1.24
Clams	217,355	60,811	.28
Scallops	748,284	863,676	1.15
TOTAL SHELLFISH	29,375,643	$38,528,954	$1.31
TOTAL ALL PRODUCTS	98,185,133	$84,560,478	$ .86

[a] Cured salmon other than roe

Source: Rogers 1972.

Table 84

SHARES OF VALUE ADDED IN SELECTED FISHERIES PRODUCTS
1965-1971

Year	Pounds Processed (Millions of pounds)	Wholesale Value per Processed Pound	Value to Fishermen per Processed Pound	Percent of Value Added by Processing	Percent of Value Added by Fishermen
			SALMON PRODUCTS[a]		
1965	31.5	66.2	17.5	74	26
1966	47.2	59.6	19.3	68	32
1967	n.a.	n.a.	n.a.	n.a.	n.a.
1968	45.1	66.8	22.0	67	33
1969	n.a.	n.a.	n.a.	n.a.	n.a.
1970	59.9	69.4	26.3	62	38
1971	46.8	75.3	22.2	71	29
			KING CRAB[b]		
1965	34.0	93.1	37.4	60	40
1966	46.1	96.3	34.0	65	35
1967	29.9	123.6	50.1	59	41
1968	19.3	219.8	113.1	49	51
1969	12.8	207.3	115.5	44	56
1970	14.8	167.3	88.9	47	53
1971	17.1	188.7	111.3	41	59
			SHRIMP[b]		
1965	2.6	70.7	28.4	60	40
1966	3.3	99.6	38.4	61	39
1967	8.8	88.3	19.3	78	22
1968	5.7	124.7	40.6	67	33
1969	8.1	98.5	20.2	79	21
1970	11.4	124.1	26.0	79	21
1971	14.9	106.0	26.3	75	25

[a]Data pertains to the Western Gulf of Alaska region and was taken from Governor's Study Group on Limited Entry 1973 and Rogers 1972.

[b]Data is not available specifically for the Western Gulf of Alaska; therefore, data pertaining to the entire state was utilized (Alaska Department of Economic Development 1972). Since most of the king crab and shrimp taken in the state are harvested in the Western Gulf it was felt that relevant value-added statistics could be obtained using statewide information.

The damage caused to the fisheries by this particular spill was minimal, probably because of low oil concentrations. However, the potential exists for extensive damage. In another incident several months prior to the February-March 1970 episode, one fisherman reported that he had to discard an entire catch of 4.5 metric tons of shrimp because oil fouled his catch. Oil could also damage large amount of fishing gear and crab floats and lines. This happened to a limited extent during the February-March 1972 oil incident.

Fisheries Waste Processing[1]

Processing plants in Kodiak have traditionally dumped their seafood wastes back into the bay and relied on the winds and tides to disperse and recycle the debris. The amount of waste varies with the method of processing and the species involved. Processing waste for king crab, when frozen in the shell, is only bout 18 percent of harvested weight. By comparison, waste for shelled crab is over 60 percent. The highest levels of waste, 80 to 84 percent, occur in canned shrimp processing. Thus, the Kodiak area's 1971 harvest of 37,200 metric tons of shrimp, resulted in an estimated 29,500 metric tons of waste being dumped into the surrounding waters.

The concentration of 14 processing plants in the city of Kodiak has created a pollution problem which has come under attack by the U. S. Environmental Protection Agency. The agency announced that after April 1, 1973 the city's plants could no longer dispose of their processing wastes by dumping them into the bay. The EPA regulation provided the opportunity for a private firm, Bio-Dry, Inc., to build a one million dollar plant in Kodiak to process the seafood wastes. The facility, the first of its kind in the United States, produces a high-quality protein meal which is used as a supplement to animal food.

In order for Bio-Dry to process their wastes, the seafood plants must build large hoppers which can hold at least eight hours of strained processing wastes. The material from the hoppers is dumped into trucks and transported to the Bio-Dry plant for processing. The net cost or net payment for processing wastes is dependent upon the market price of crude protein. Contracts between Bio-Dry and the seafood processors stipulate that Bio-Dry will pay for the wastes if the price of protein is above a certain level; if the price falls below that threshold, however, the processing plants have agreed to pay Bio-Dry for the service.

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[1]Don Egelus, Manager, Kodiak Bio-Dry Plant, October 1973. Personal communication.

By October 1973 only six of Kodiak's processing plants were using the Bio-Dry facility. EPA has extended the deadline for compliance with the regulation to allow the other plants to install the necessary equipment. Until these plants provide the Bio-Dry plant with their wastes, it will continue to operate far below capacity. The manager of Bio-Dry indicated that his firm planned to install equipment to handle fish processing wastes, but would not do so until enough seafood plants are tied in to justify the additional expenditure.

Foreign Fisheries

Table 85 shows the extent to which other nations harvest fish resources of the Western Gulf region. Except for shrimp and halibut, little foreign competition exists for those fish species currently of economic value to Western Gulf fishermen. The Soviet Union and Japan harvested 33 percent and seven percent, respectively, of the region's shrimp catch between 1916 and 1969. Approximately 30 percent of the halibut taken in the region between 1905 and 1969 were taken by Canadian fishermen, but much of the Canadian catch is generally landed at either Kodiak or Sand Point for processing.

The demersal or ocean bottom fishery (excluding halibut) of the Western Gulf has been utilized almost solely by foreign fishermen. Japanese fishermen harvest virtually all of the pollock, Pacific cod, blackcod, and flatfish. Soviet and Japanese fishermen each take about half of the Pacific Ocean perch. As the stocks of fish currently being harvested by U.S. fishermen decline, the demersal fishery will become increasingly important to U.S. fishermen, and foreign competition will become a more important factor in the fisheries economy of the Western Gulf.

Agriculture

Agriculture is a small segment of the economy of the Western Gulf of Alaska. There are no commercial vegetables or feed crops produced. Native grasses are harvested on only 61 hectares (Alaska Crop and Livestock Reporting Service 1973). The mainstay of the agricultural sector is beef cattle production. In 1971 there were approximately 4,500 beef cattle, 105 sheep and a few horses in the region (Table 86). These animals utilized nearly 158,000 hectares of grazing land under lease from the federal and state governments. Figure 171 shows the principal grazing areas of the Western Gulf.

The beef industry is still underdeveloped. It operates under several handicaps which account for its slow growth rate. Stephens (1973) has summarized these handicaps as follows:

> ...The Alaskan beef producer, unlike his counterpart in other states, must raise his cattle from calves to full-grown steers, slaughter and market them by himself. There are limited-service

Table 85

FOREIGN FISHERIES INVOLVEMENT IN THE WESTERN GULF OF ALASKA

Species	Year of First Recorded Catch	Total Historic Catch* (millions of pounds)	National Distribution of Catch (Approx. Percentage)
Shrimp	1916	307.9	U.S.A. - 60 U.S.S.R. - 33 Japan - 7
Tanner Crab	1964	10.3	U.S.A. - 100
King Crab	1930	588.5	U.S.A. - 99 U.S.S.R. - 1
Herring	1907	1154.0	U.S.A. - 100
Salmon			
Pink	1905	1841.6	U.S.A. - 100
Coho	1905	85.7	U.S.A. - 100
King	1905	11.2	U.S.A. - 100
Chum	1905	732.6	U.S.A. - 100
Red	1905	1830.9	U.S.A. - 100
Pollock	1933	81.1[a]	Japan - 100
Pacific Cod	1905	14.6[b,c]	Japan - 100
Pacific Ocean Perch	1956	703.4[a]	Japan - 56 U.S.S.R. - 44
Blackcod	1913	38.1[a]	Japan - 99 U.S.A. - 1
Halibut	1905	1538.3[b]	U.S.A. - 70 Canada - 30
Flatfish (excluding halibut)	1933	52.4	Japan - 100

[a]Also includes Cook Inlet and a portion of Prince Willian Sound

[b]Also includes Cook Inlet, Prince William Sound and Yakutat

[c]1956-69 only

*From first record to 1969 in Western Gulf of Alaska

Source: Buck 1973.

Table 86

FEDERAL AND STATE GRAZING LEASES

WESTERN GULF OF ALASKA - 1971

Area	Acreage	Annual Rental	Issued	Expiration	Authorized Stocking Rate (A.U.'s)[1]	Livestock on Lease: Cattle	Sheep	Horses
Chirikof Island	31,067	$600.00	1/1/56	12/31/76	1,000	598		5
Kodiak-Middle Bay	21,650	$120.00	12/11/71	12/31/97	200	174	-	10
Kodiak (Antone-Larsen Bay)	24,400	$115.70	1/1/57	12/31/76	208	107	-	21
Harventer and Bear Islands	430	$ 25.00	1/1/64	12/31/83	30	14	-	-
Kodiak-Narrow Cape	21,005	$390.00	5/1/70	4/30/95	650	560	-	6
Kodiak - Ugak Bay	9,540	$ 36.00	11/1/71	12/31/95	60	66	-	-
Kodiak - Saltery Cove	35,557	$165.00	1/1/71	12/31/2001	275	155	-	-
Sitkinak Island	84,200	$900.00	1/1/60	12/31/79	1500	(Lessee's Estimate) 915	-	-
Spruce Island	3,600	$ 50.00	1/1/59	12/31/78	75	11	-	-
Kodiak-Uganik Bay	6,000	Free Use	1/1/55	12/31/74	40	Goats 17 Sheep 5		
Sitkelidak Island	74,700	$580.00	1/1/60	12/31/79	850	781	55	28
Sitkink Island	17,000	$240.00	1/1/60	12/31/74	400	80	50	2
Kodiak-Passagshak Bay	25,040	$264.00	8/1/70	7/31/95	440	386	-	4
Sanak Island	10,100	$150.00	1/1/63	12/31/82	250	161	-	-
Woenesenski Island	7,500	$ 45.00	1/1/60	12/31/79	75	69	-	-
Simeonof Island	10,850	$165.00	1/1/61	12/31/80	275	273	-	-
Chernabvea Island	7,248	$120.00	1/1/64	12/31/83	200	100	-	-
TOTALS	389,887				6,528	4,472	105	80

(1) An animal unit (A.U.) is considered to be the equivalent of one cow, five sheep or one horse over six months of age.

Source: U.S. Department of the Interior, Bureau of Land Management, land status computer printouts of the Aleut, Bristol Bay and Koniag Regional Native Corporations, July 1973.

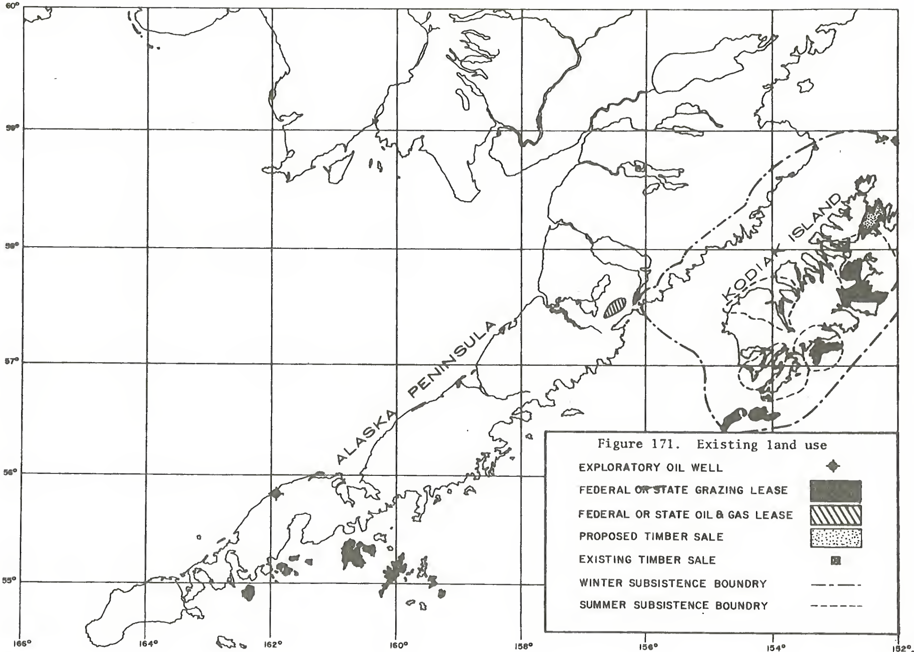

Figure 171. Existing land use

industries such as feed and equipment dealers and no feedlot operators. He does not have an organized market in which to sell his product. He does not have a banking system that is familiar with his industry. Much of the land on which he grazes his stock is leased from the state or federal government. This has tended to discourage the ranchers' willingness to make capital improvements on such lands. Currently some of this land is under consideration for selection by Native villages as part of the Native Land Claims Act. This has limited development on those lands until the land selections are made.

The characteristics of beef raising per se, create other problems. Beef cattle require large areas of land for grazing. The only areas in the state suit able for grazing throughout the year are in southern coastal districts. The most suitable areas in terms of climate and vegetation, Kodiak Island and adjacent islands on Aleutian Chain, are remote. This causes significant increases in transportation costs of the various production inputs, especially grain. Heifers cannot be bred until they are two years old and have a nine-month gestation period. Beef cattle in Alaska are usually not slaughtered until they are two-and-a-half years old. The capital required to begin and maintain production must therefore be inveted for an extended period of time. This tends to increase working capital requirements and venture risk.

Alaskan beef cannot at this time be produced at a competitive price and equal quality as the beef being shipped into the state. The vast majority of fabricated beef sold in the retail trade in Alaska is USDA Choice Grade. The significant aspect of Choice Grade for this discussion is the degree of marbling in the meat (flecks of fat) required. Choice grade is achieved by taking the animal off grass and intensively feeding it grain before slaughter. This is usually done in other states by "feedlot operators" who specialize in "finishing off" or bringing the animal "up to grade." In Alaska the transportation cost of grain to beef production areas, (either imported or locally grown), is too expensive to permit this final fattening process before slaughter. Consequently, Alaskan beef is primarily grass-fed and at best could be graded as USDA Good, one grade below Choice.

Brown bear predation is another problem faced by beef cattle producers, particularly on Kodiak Island. According to the U.S. Bureau of Sport Fisheries and Wildlife (1972, Kodiak ranchers have reported that, on the average, 47 head of cattle are lost to brown bear predation annually.

Beef and veal production in the Western Gulf area averaged 132 metric tons yearly from 1965 through 1972 with an average yearly value of 140 thousand dollars (Alaska Crop and Livestock Reporting Service 1973). During 1970 production amounted to 151 metric tons and was valued at 161 thousand dollars in 1971, 91 metric tons valued at 107 thousand dollars were produced and in 1972 production amounted to 121 metric tons and was valued at 150 thousand dollars (Alaska Crop and Livestock Reporting Service 1973). Most of the beef produced on Kodiak Island is processed at a cooperative slaughterhouse near the town of Kodiak. Three hundred head were processed at the slaughterhouse in 1972.[1] The beef is primarily sold as locker beef with a small portion being sold as manufactured beef.

The cattle on the islands south of the Alaska Peninsula receive very little management. Many herds have run wild for years and have a high proportion of bulls. Until recently only a few of these animals have been slaughtered, and these were for local consumption only. During the summer of 1973, 100 head of cattle were barged from Sanak Island to Kodiak for slaughtering.[2] Additional cattle from the south peninsula area will probably be processed at the Kodiak slaughter facility.

Reindeer were once grazed on Kodiak Island and the Alaska Peninsula. In July 1933, a permit was issued to the Alitak Native Reindeer Company by the U.S. General Land Office for grazing 20,000 reindeer on 259,000 hectares, but this lease expired in 1953 (U.S. Bureau of Sport Fisheries and Wildlife 1972). In 1968 it was reported that there were still 600 reindeer on Kodiak Island, but very few animals were being harvested (Federal Field Committee for Development Planning in Alaska 1968). These animals are not herded but roam at will in the southwest portion of Kodiak Island, mostly north of Olga Bay. It is estimated that approximately 50 animals are killed yearly for local consumption.[3]

Forestry

Little timber harvesting takes place in the Western Gulf of Alaska, although the U. S. Forest Service (1973) estimates that Kodiak, Afognak, and the Shuyak Island group could supply between 40 to 50 million board feet per year on a sustained-yield basis. Currently the only active operation is on the southern end of Afognak Island (Figure 171). The annual cut is small, approximately one million board feet. The operation employs about five men, and all of the logs are taken to a sawmill at Jakolof Bay on the Kenai Peninsula.[4] There is no significant lumber or pulp manufacturing capabilty in the region.

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[1] Mr. and Mrs. Bill Burton, owners, Burton Ranch Kodiak, October 1973. Personal communication.

[2] Ibid.

[3] Ibid.

[4] Karl Armstrong, Land Specialist, Koniag, Inc. Kodiak, October 1973. Personal communication.

A contract to cut approximately 525 million board feet on Chugach National Forest land from the Perenosa Bay area at the north end of Afognak Island (Figure 171) was sold by the U. S. Forest Service to Columbia Lumber Company of Alaska 1968. No action was taken on the sale due to a drop in the export market. Since that time the original purchaser has entered into a third-party agreement with Afognak Timber Company to operate under the contract. Because of environmental considerations, the timber sale was modified to reduce the total volume to be harvested to approximately 330 million board feet. The harvesting is to be carried out over a period of 10 years. The Afognak Timber Company is preparing to start logging operations and is presently looking for a site on which to construct a sawmill. The sawmill may not be located within the Western Gulf of Alaska. According to the environmental impact statement submitted by the U. S. Forest Service, the logging operation and the associated mill would employ 50 to 120 people and could result in an annual flow of wages paid to employees directly associated with the timber operation of about two million dollars (U.S. Forest Service 1973). Currently the final environmental impact statement is being prepared for submission to the President's Council on Envrionmental Quality.

Minerals and Petroleum

No major mineral or petroleum activity exists in the Western Gulf of Alaska although considerable mineral and oil exploration has occurred in the past. There are many mining claims in the region, but only a few are active; production is negligible. Gravel is the principal resource extracted from the Kodiak area, and sales of this material amount to approximately 200,000 dollars per year. Exploratory activities continue in the region on a limited basis with most of it being directed to oil and not to hard minerals. During 1972 geologic field crews of three major oil companies were active at Port Moller. Currently an exploratory oil well is being drilled on the north side of the Alaska Peninsula near the Cathedral River at Cape Leonivitch (Figure 171). As of mid-August 1973 the well had been drilled to 4,500 m.[1]

Tourism and Recreation

Tourism is not a major activity in the Western Gulf region. Although the available data are quite sketchy, it appears that significant numbers of tourists come to only a few points within the region. Kodiak Island is the most popular tourist area, in part because it is the most accessible. There is excellent stream and lake fishing, as well as gun or camera hunting for the world famous Kodiak bear. Nearly half the guides registered in Alaska are licensed to guide on Kodiak Island. There are 12 registered guides who are residents on Kodiak Island, and more than half of these are listed as offering guide service

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[1]Mr. Marshall, Petroleum Geologist, Alaska Department of Natural Resources, Division of Oil and Gas, August 1973. Personal communication.

to hunt the Kodiak brown bear (U.S. Department of Commerce 1973). The U. S. Bureau of Sport Fisheries and Wildlife reports that guides who serve bear hunters alone gross well over 200,000 dollars annually and that the average expenditure of a nonresident hunter amounts to more than 3,000 dollars (U. S. Bureau of Sport Fisheries and Wildlife 1972).

The city of Kodiak reported that a total of 6,000 visitors used the facilities under its jurisdiction in 1972 (Alaska Department of Natural Resources 1972). Seventy-five percent of these are nonresidents. Some of the attractions within the Kodiak area are the Old Russian Church, the Historical Society Museum, the fishing fleet, canneries, and the historical drama, "Cry of the Wild Ram," usually held at the Monashka Bay Amphitheatre.

Statistics available for the Kodiak National Wildlife Refuge show that there were 7,681 visits for recreational purposes made to the refuge in 1971 (U.S. Bureau of Sport Fisheries and Wildlife 1972). Approximately half of these visits were made for hunting and fishing. Other recreational uses made of the refuge include trapping, picnicking, boating, and fruit and vegetable collecting. Visits made to the Aleutian Islands and Izembeck National Wildlife Refuges in fiscal year 1972 totaled 2,560 (Alaska Department of Natural Resources 1972).

A portion of Katmai National Monument is in the Western Gulf area but virtually all visitors to that area enter via King Salmon or Naknek and remain in that part of the monument which is in the Bristol Bay region. The U.S. Forest Service maintains eight recreational cabins on Afognak Island. These cabins received 800 visitor days of use during the first nine months of 1973.[1]

TRANSPORTATION FACILITIES AND COSTS

Overview

The principal means of transportation in the Western Gulf of Alaska are by air and sea. There are no links to the rest of the state by highway or rail and there are only a few local highway links with the region. The region's harbors are, however, accessible to deep-draft, seagoing vessels and its sea routes are usually ice free during the entire year. Kodiak and Port Lions are linked to the state's marine highway system. Air transportation within the region is well developed and there is daily jet service to the city of Kodiak from Seattle and Anchorage. Air and sea transport, particularly in the Alaska Peninsula and the Aleutians, is often hampered by severe weather conditions. With the exception of the city of Kodiak, transportation costs within the Western Gulf of Alaska are high.

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[1]Gordon P. Edgars, Acting Resource Management Assistant, U.S. Forest Service, Kodiak, Alaska, October 1973. Personal communication.

Transportation Facilities

Airports

There are airports or float plane landing sites for nearly every village in the Western Gulf region. Protected bays and coves provide seaplane landing sites most of the year. The region's lakes and rivers make the area accessible to float planes in summer, and to ski-equipped planes in winter. There are seven trunk airports which have runways 1,050 m. or longer and are capable of handling large aircraft. All are equipped with lights and can handle nighttime traffic. The airports at Cold Bay and Kodiak can handle large jet aircraft and, along with the airport at the Sitkinak Coast Guard Station, are the only airports in the region with paved runways. Cold Bay and Kodiak have facilities for plane handling, maintenance, and traffic control. Except for the trunk airports, the airports and landing sites in the region are suitable only for small aircraft. They have runways shorter than 1,050 m. and are unlighted. Statistics on the region's airports are shown in Table 87.

Roads

Most roads in the Western Gulf region are located in the northeast portion of Kodiak Island. Cold Bay is the only other area in the region where there is any extensive road network. A few other village have local service roads which represent very little areas. There are approximately 184 km. of state roads and 22 km. of city roads on Kodiak Island (Kodiak Chamber of Commerce 1973). Of this, about 10 percent is paved, 80 percent graded and drained gravel or dirt, and the remaining 10 percent is unimproved.[1] Most roads connect the city of Kodiak with the various military installations on the island and most of the cattle ranches. Afognak Island, north of Kodiak Island, has one unimproved road which is approximately 8 km. long and extends from Afognak Bay to Afognak Lake where there is a military reservation camp (U.S. Forest Service 1970). The Cold Bay road network extends approximately 80 km. and primarily provides access to various military sites and to the harbor (U.S. Geological Survey 1943).

Within the next five year period, road construction and upgrading will take place on a small scale within the region, according to current State Highway Department plans. All of this work will take place on Kodiak Island. The estimated cost of this activity for the period 1973 through 1977 is approximately seven million dollars (Table 88). The work will primarily consist of reconstruction, paving, and bridge building.

Harbors

The harbors of the Western Gulf of Alaska accommodate deepdraft ocean vessels and most have facilities for off-loading freight. The majority of these facilities are owned and operated by fish processing

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[1]Estimated from Alaska Department of Highways, General Highway Maps, 1965-1967.

Table 87

PRINCIPAL AIRPORTS

WESTERN GULF OF ALASKA - 1973

Airport Location	Runway Size	Runway Surface	Largest Aircraft	Population Served	Other Information
Akhiok	Unusable	Dirt			
Cape Sarichef AFS	3500x120	Gravel			Lighted
Chignik	1340x50	Dirt	206	83	
Chignik Lagoon	2250x35	Gravel	Goose	54	
Chignik Lake		Gravel			Under construction
Cold Bay	5126x150 10,128x150	Asphalt Asphalt	DC-8	185	Lighted Lighted
Karluk	Lake Beach		Goose	98	
King Cove	4000x100	Gravel	DC-3	283	Lighted
Kodiak	7500x150 5000x150 5000x150	Asphalt Asphalt Asphalt	720	3798	Lighted Lighted Lighted
Old Harbor	2000x100	Gravel	402	290	
Port Lions	2600x150	Gravel	402	227	
Sand Point	3800x150	Gravel			
Sitinak CGS	4500x150	Asphalt			Lighted

Sources: Alaska Legislative Council 1972, Alaska, Dept. of Public Works, Division of Aviation -"Landing Area Inventory - 1973" - prepared for the Joint Federal State Land Use Planning Commission.

Table 88

PROPOSED HIGHWAY AND SERVICE ROAD CONSTRUCTION ACTIVITIES*

FOR WESTERN GULF OF ALASKA 1973 - 1977

Project Location	Project Description	Estimated Total Cost Dollars	Yearly Subtotal	Total
	Construction and Improvement of Major Roads			
	1973			
Kodiak Highway	Mill Bay Road, pave 2.6 mi.	$ 250,000		
Rezanoff Drive (Kodiak)	Pave 1.9 miles of existing street	311,000		
Cape Chiniak (Kodiak)	Kodiak Naval Air Station, mile 0 to mile 2.2. Reconstruction on new alignment and pave including construction of two bridges	1,949,000	$2,510,000	
	1974 None			
	1975			
Cape Chiniak (Kodiak)	Mile 2.2 to mile 7.2. Reconstruction on existing alignment and pave 5.1 miles including construction of six bridges	$2,300,000	$2,300,000	
	1976 None			$4,810,000
	Construction and Improvement of Local Service Roads and Trails			
	1973			
Kodiak	Marine Way, pave from Rezanoff Drive to 6th Avenue	$ 20,000		
Kodiak Is. Borough	Reconstruct Melnitsa Lane	66,000	$ 86,000	
	1974			
Kodiak Is. Borough	Reconstruct Lakeview Drive	$ 15,000	$ 15,000	
	1975			
Kodiak	Mission Road, pave from 10th Avenue to city limits	$ 15,500		
Kodiak Is. Borough	Otmeloi Way, construct from Miller Point Road to Mill Bay Road	70,000	$ 85,000	$ 186,500
		GRAND TOTAL		$ 7,056,000

*Specific cost information not available

Source: Alaska Department of Highways 1972.

plants. Some of the harbors offer facilities to haul boats out of the water and make minor repairs. A few can provide supplies such as food, fresh water, and marine hardware. Information concerning the facilities and supplies available at each harbor in the region is provided in Table 89.

The city of Kodiak has by far the most developed harbor facilities in the Western Gulf. These include two cargo docks, a ferry dock, two transient floats, and a small boat harbor. The two cargo docks handle most of the freight coming into Kodiak. One of these includes a recently completed container dock with a "Super Sam" crane capable of unloading containerized freight weighing up to 20 metric tons. This dock is principally used by Sea Land, Inc. which has a preferential use agreement with the city. The other cargo dock (108 m. long) serves only for off-loading non-containerized freight and has no crane. There is only one small warehouse serving both docks. The ferry dock also serves as a fuel off-loading facility and is used by fishermen.

The small boat harbor has 226 permanent berths which is inadequate to meet current needs.[1] There is a waiting list of some 300 vessels for berths. It is estimated that during the summer months 650 vessels use the small boat harbor. About 95 percent of these are fishing vessels. The harbor has two unloading docks (51 and 45 meters long) and two grid irons for boat repairs. There are two transient floats in Kodiak Harbor; one is located within the small boat harbor and can accommodate 30 vessels and the other is located in the Near Island Channel and can handle between 50 and 60 vessels.

Transportation Services

Passenger Service

Most passenger traffic in and out of the Western Gulf of Alaska is by air. Two certificated route carriers, Western Airlines and Wien Air Alaska, Inc., serve the region, along with several air taxi operations, two of which operate out of Kodiak. Nearly all of the Western Gulf villages listed in the U.S. Census are serviced by scheduled commercial air flights (Figure 172) and the majority of these receive scheduled service two or more times a week (Tables 90 and 91). As shown in Table 92, Kodiak and Cold Bay have the region's busiest airports. During fiscal year 1971, nearly 40,000 passengers enplaned at Kodiak, representing 73 percent of the region's total passenger traffic. Cold Bay accounted for 6,800 passengers, or 12 percent of the total commercial passenger traffic within the region.

Kodiak Island is also on the Southwest Marine Highway System. During the summer, the ferry M/V Tustumena stops at Kodiak and Port Lions three times a week, providing service to Seward, Seldovia, Homer, and Anchorage. During the winter, ferry service is reduced to twice a

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[1]Harbormaster, City of Kodiak. October 1973. Personal communication.

Table 89

HARBOR FACILITIES - WESTERN GULF OF ALASKA

Harbor	DESCRIPTION OF DOCK, WHARFS OR PIERS Face (ft).	Depth Along Side (ft).	Other
KODIAK ISLAND			
Kodiak	360	30	Supplies Available: marine hardware, fresh water, gasoline, diesel oil, kerosene and lubricating oils. General repairs can be made by local machine shops. Large container crane.
	170	19	
	150	30	
	68	70	
(new container dock)	n.a.*	n.a.	
Women's Bay	1200	27	
	500	28	Naval Defensive Sea Area
Ouzinkie	104	28	
Shearwater Bay	100	17	Timber skidway which can handle 38-ton craft
Old Harbor	25	face of wharf becomes dry 4' above low water	
Moser Bay	n.a*	20	
Lazy Bay	140	28	Slipway capable of hauling out vessels up to 130 tons
Olga Bay	n.a.	11	
Port William	184	21	Supplies available: fresh water, diesel fuel, gasoline
Larsen Bay	n.a.	n.a.	Marine railway can handle boats up to 100 gross tons
Iron Creek	100	18	
Port Vita (Vista)	180	15	
Port Wakefield	75	19	
Sheep Island	110	30	Supplies available: fresh water, machine shop scow ways
Port O'Brien	105	20	
	30	20	
Zachar Bay	100	18	
Port Baily	150	n.a.*	Supplies available: fresh water, fuel oil, diesel oil, gasoline, marine hardware. Machine shop at cannery.

(continued)

Table 89 (continued)

HARBOR FACILITIES -WESTERN GULF OF ALASKA

Harbor	DESCRIPTION OF DOCK, WHARFS OR PIERS Face (ft).	Depth Along Side (ft).	Other
ALASKA PENINSULA - ALEUTIANS			
Chignik	62	18	
Chignik Lagoon	n.a.*	dry in low water	
Ivanoff Bay	n.a.*	22	
Sand Point	180 60	24 15	Machine shop. Supplies available: gasoline, kerosene, lubricating oil, diesel oil, fresh water, marine hardware
Baralof Bay	190	27	Supplies available: fresh water, machine shop, fuel oil, gasoline
King Cove	Wharf has two faces can handle vessels up to 4,800		Supplies available: fresh water, coal and gasoline. Has slipway for vessels up to 100 feet in length.
Cold Bay	500	30	
False Pass	225	26	Supplies available: gasoline, fuel oil, fresh water
Port Moller	145	25	

*Information not available

Source: U.S. Department of Commerce, Coast and Geodetic Survey, United States Coast Pilot 9 - Pacific and Arctic Coasts, ALASKA Seventh (1964) Edition including 1966 and 1971 supplements.

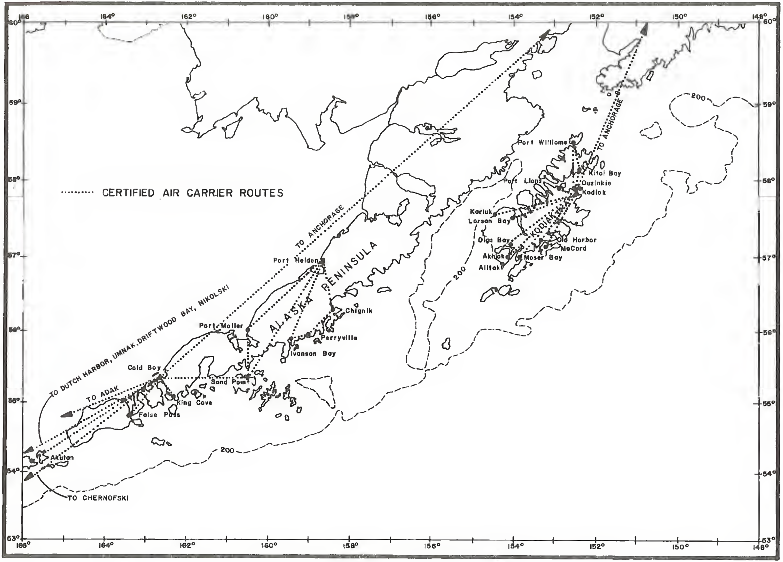

Figure 172. Certified air carrier routes in the Western Gulf of Alaska (from Reuben H. Donnelley Corp. 1973).

Table 90

NON-STOP AIRLINE FLIGHTS

KODIAK ISLAND SEPTEMBER 1973

TO:	FROM:	Flights per Week	Flight time	One-way fare	Type of Aircraft*
Akhiok	Kodial	3	1 hr. 5 min.	$36.	LEC
Akhiok	McCord	varies	25 min.		GGS
Alitak	Akhiok	3	20 min.		GGS
Alitak	Moser Bay	3	40 min.		GGS
Anchorage	Kodiak	8	45 min.	40.	737
Karluk	Larsen Bay	3	20 min.		GGS
Kitoi	Kodiak	3	15 min.	16.	GGS
Kodiak	Alitak	4	1 hr. 5 min.	33.	GGS
Kodiak	Anchorage	8	50 min.	40.	737
Kodiak	Karluk	3	35 min.	33.	GGS
Kodiak	Larsen Bay	3	1 hr. 5 min.	28.	GGS
Kodiak	Old Harbor	6	30 min.	23.	CES
Kodiak	Olga Bay	2	40 min.	33.	GGS
Kodiak	Port Lions	12	15 min.	14.	GGS
Kodiak	Port Williams	3	35 min.	23.	GGS
Larsen Bay	Kodiak	1	1 hr. 10 min.	28.	GGS
McCord	Kodiak	varies	30 min.	25.	GGS
Moser Bay	Kodiak	3	45 min.	33.	GGS
Old Harbor	Kodiak	12	30 min.	23.	CES
Olga Bay	Alitak	2	15 min.		GGS
Ouzinkie	Kodiak	6	10 min.	10.	GGS
Port Lions	Kodiak	6	15 min.	14.	GGS
Port Lions	Ouzinkie	3	35 min.		GGS
Port Williams	Kitoi	3	20 min.	16.	GGS

*LEC=Lockheed Electra Turbo-Prop; GGS=Gruman G21A Goose; 737=Boeing 737 (all series).

Source: Reuben H. Donnelley Corp. 1973.

Table 91

NON-STOP AIRLINE FLIGHTS

ALEUTIAN ISLANDS AND ALASKA PENINSULA SEPTEMBER 1973

TO:	FROM:	Flights per Week	Flight time	One-way fare	Type of Aircraft*
Adak	Anchorage	3	2 hrs. 45 min.	$173	LEC
Adak	Attu	1	1 hr. 20 min.	93	LEC
Adak	Cold Bay	3	2 hrs.	128	LEC
Adak	Shemya Island	2	1 hr. 20 min.	84	LEC
Akutan	Cold Bay	1	1 hr. 15 min.	33	GGS
Amchitka	Adak	2	45 min.	54	LEC
Anchorage	Adak	3	4 hrs. 15 min.		LEC
Anchorage	Cold Bay	8	3 hrs. 20 min	117	Y11/LEC
Attu	Shemya	1	15 min.	11	LEC
Cape Sarichef	Cold Bay	2	35 min.	19	Y11
Chignik	Port Heiden	2	30 min.	27	PRP
Chignik Lagoon	Chignik	2	10 min.	11	PRP
Cold Bay	Adak	3	1 hr. 45 min.	128	LEC
Cold Bay	Akutan	1	3 hrs. 25 min.	33	GGS
Cold Bay	Anchorage	6	1 hr. 30 min.	117	DC6/Y11/LEC
Cold Bay	Chernofski	varies	1 hr. 50 min.	49	GGS
Cold Bay	Dutch Harbor	2	45 min.	33	Y11
Cold Bay	False Pass	3	1 hr. 20 min.	22	PRP
Cold Bay	King Cove	3	15 min.	17	PRP
Cold Bay	Sand Point	3	25 min.	27	Y11
Driftwood Bay	Dutch Harbor	2	10 min.	21	Y11
Dutch Harbor	Cape Sarichef	2	30 min.	15	Y11
Dutch Harbor	Cold Bay	2	40 min.	33	Y11
Dutch Harbor	Driftwood Bay	2	10 min.	21	Y11
Dutch Harbor	Umnak	2	30 min.	23	Y11
False Pass	Cold Bay	3	45 min.	22	PRP
Ivanoff Bay	Perryville	2	10 min.	11	PRP
King Cove	Cold Bay	3	15 min.	17	PRP
Nikolski	Umnak	2	20 min.	11	Y11
Perryville	Chignik Lagoon	2	50 min.	17	PRP
Port Heiden	Ivanoff Bay	2	1 hr. 50 min.	35	PRP
Port Heiden	Sand Point	2	1 hr. 40 min.	44	PRP
Port Moller	Port Heiden	2		22	Y11
Sand Point	Cold Bay	2	30 min.	27	Y11
Sand Point	Port Heiden	1		44	Y11
Sand Point	Port Moller	2	10 min.	22	Y11
Shemya	Adak	1	1 hr. 35 min.	84	LEC
Shemya	Amchitka	2	50 min.	47	LEC
Umnak	Dutch Harbor	2	20 min.	23	Y11
Umnak	Nikolski	2	20 min.	11	YLL

*PRP=Prop Aircraft, type varies; LEC=Lockheed Electra Turbo-Prop; Y11=Namco YS-11; GGS= Gruman G21A Goose; DC-6=Douglas DC6.

Source: Reuben H. Donnelley Corp. 1973.

week and there is no service to Anchorage or to Port Lions. In the two year period 1970-72, annual travel to Kodiak by ferry averaged 3,370 passengers and 73 cars (Alaska Department of Public Works 1972).

The Kodiak urban area is currently serviced by a licenses franchised bus company which provides school bus service, airport passenger service and charter service. The city is also served by a taxi company which offers 24 hour service.

Freight Service

Air freight and U. S. mail are carried by both the certificated route air carriers and the authorized air taxis serving the region. Most of this freight passes through Kodiak and Cold Bay (Table 92). Kodiak handled 815 metric tons of freight and mail in fiscal year 1971 or 52 percent of the freight carried by commercial carriers in the region. Cold Bay handled 648 metric tons or 42 percent of the total carried.

Mail accounts for much of the air cargo carried by certificated air carriers in the region, particularly to the smaller communities. Over half of the communities listed in Table 92 receive more tonnage of U.S. mail than they do regular air freight. This is due to postal service regulations for transport of intra-Alaska mail which permit a wide range of goods to be shipped by parcel post. The parcel post rate is lower than the air freight rate because of a subsidy paid to the airlines by the U. S. Postal Service. Naturally this encourages shippers to use the U. S. Postal Service as a major freight mover in rural Alaska. Much of the freight previously moved by barge or ship is now shifting to parcel post as stores find that they can operate with lower inventory investment by paying just a little more for mail delivery of their goods (Alaska Legislative Council 1972).

The city of Kodiak is the principal harbor of the Western Gulf of Alaska and the major transhipment point for freight destined for the Aleutians, Alaska Peninsula, and Bristol Bay. None of the other harbors handles enough freight to be considered individually in the annual statistics of the U.S. Army, Corps of Engineers (1960-1971). The amount of freight received, shipped, or transferred in Kodiak harbor from 1960 through 1971 is shown in Table 93. Most freight is fuel oil, gasoline, and outbound fish products. There is regular sea freight service to the city of Kodiak from Anchorage and Seattle. Scheduled service is provided by Sea Land Service, Inc. two to three times per month. Western Pioneer Lines, Foss Launch and Tug, Puget Sound Tug and Barge, and Northland Marine Lines provide unscheduled service to the city. There are two petroleum products distributors that also provide regular service to Kodiak.

Freight service to the outlying villages of Kodiak Island is unscheduled. Western Pioneer Lines serves many of the locations which have fish processing plants and transports fish products to Seattle. Some freight is handled by private fishing boats and cannery tenders.

Table 92

AIRPORT ACTIVITY STATISTICS OF CERTIFICATED ROUTE AIR CARRIERS -FY 1971

AIRPORT ACTIVITY - WESTERN GULF OF ALASKA

Airport	Enplaned Passengers	Freight (tons)	Mail (tons)	Total Cargo and Mail (tons)
		KODIAK ISLAND		
Akhiok	700	0.77	1.81	2.58
Karluk	869	1.79	2.37	4.16
Kitoi Bay	105	1.78	0.09	1.87
Kodiak	39,894	552.26	345.97	898.23
Larsen Bay	75	0.46	0.41	0.87
Moser Bay	334	0.49	0.21	0.70
Old Harbor	2,094	3.33	4.36	7.69
Ouzinkie	2,059	1.42	2.82	4.24
Port Williams	183	0.44	0.19	0.63
		SOUTH ALASKA PENINSULA - ALEUTIANS		
Cold Bay	6,742	354.28	360.06	714.34
False Pass	220	1.28	4.01	5.29
King Cove	430	4.32	11.28	15.60
Pauloff Harbor	23	0.25	1.38	1.63
Perryville	4	0.19	-	0.19
Sand Point	809	7.87	20.99	28.86
TOTAL	54,746	954.24	760.95	1,715.19

Source: U.S. Department of Transportation 1972.

Table 93

FREIGHT TRAFFIC MOVING THROUGH KODIAK HARBOR 1960-1971

Year	Tons of Freight Received, Shipped or Transferred
1960	38,289
1961	39,623
1962	80,267
1963	73,775
1964	62,285
1965	127,584
1966	212,675
1967	133,247
1968	109,645
1969	115,863
1970	124,479
1971	148,444

Source: U.S. Army, Corps of Engineers 1960-1971.

Sand Point receives scheduled freight service once a month from Sea Land Service, Inc. Western Pioneer Lines, Inc., Foss Launch and Tug, Puget Sound Tug and Barge, and Northland Marine Lines provide unscheduled service to most of the Alaska Peninsula and Aleutian ports, particularly to those areaa which export fish products to Seattle.

Transportation Costs

One way commercial airline passenger fares for some of the direct flights between communities of the Western Gulf of Alaska and Anchorage and of flights within the region are shown in Tables 90 and 91. In general, the passenger cost per kilometer tends to be higher in Alaska than for comparable distances in the contiguous United States due to the lower traffic volume and higher operation and maintenance costs in Alaska (Table 94).

Air freight rates for general and specific commodities between Western Gulf communities and Seattle are shown in Table 95. The general commodity rate is usually higher than the rates given to those specific commodities handled frequently and in large volume. Air freight is flown directly to Kodiak from Seattle, whereas freight going to the Alaska Peninsula and the Aleutians has to be transshipped at Anchorage. There are no specific commodity rates between Anchorage and communities in the Western Gulf of Alaska; all goods are charged the general commodity rate.

If an unweighted average is calculated for the rates shown in Table 95, the average cost of shipping goods by air to Kodiak is about 15 percent higher than the cost of shipping to Anchorage, even though these cities are approximately equal distants from Seattle. Goods are freighted from Seattle to Alaska Peninsula or Aleutian communities via Anchorage are charged an additional $30/cwt. for the transport from Anchorage. Again using an unweighted average, the rates from Seattle to Cold Bay are nearly 150 percent higher than those from Seattle to Anchorage. The average air freight rates for southbound seafood, when compared with those from Anchorage, are 37 percent higher from Kodiak and well over 100 percent higher from Chignik, Sand Point or Cold Bay.

Sea freight rates between Seattle and Kodiak average considerably less than rates to other areas in the Western Gulf (Table 96). According to the tariffs of Sea Land, Inc., typical rates to outlying communities of Kodiak are 20 percent more than those to Kodiak. Rates to Chignik are 300 percent higher and those to Sand Point, False Pass and KingCove are 66 percent higher. Southbound shipments of canned seafood cost only one percent more to ship from outlying Kodiak are 20 percent more than those to Kodiak. Rates to Chignik are 33 percent higher and those to Kodiak. Rates to Chignik are 33 percent higher and those to Sand Point, False Pass, and King Cove are 66 percent higher. Southbound shipments of canned seafood cost only one percent more to ship from outlying Kodiak communities than from Kodiak. Southbound rates from Chignik are eight percent higher, while those from Sand Point, False Pass, and King Cove are 36 percent higher.

Table 94

COMPARISON OF COMMERCIAL AIRLINE FARES

WITHIN THE WESTERN GULF OF ALASKA

AND BETWEEN THE WESTERN GULF AND ANCHORAGE
(With Fares for Comparable Distances in the Contiguous United States)

Pair	Tourist One-Way Fare (tax included)	Distance	Passenger Cost per Mile*
Anchorage - Cold Bay	$ 117.00	625 miles	$ .19
Anchorage - Kodiak	40.00	250 miles	.16
Cold Bay - Port Moller	27.00	103 miles	.26

*Cost per mile computed from Direct Distance Between Points and Tourist Fare as of Sept. 1, 1973

Source: Reuben H. Donnelley Corp. 1973.

Table 95

COMPARATIVE GENERAL AND SPECIFIC COMMODITY AIR FREIGHT RATES

BETWEEN SEATTLE AND COMMUNITIES OF THE WESTERN GULF OF ALASKA[1]
(dollars per 100 lbs.)

FROM SEATTLE	TO ANCHORAGE	TO KODIAK	To CHIGNIK[2] SAND POINT COLD BAY
General Commodities	$ 22.10	$ 29.50	$ 52.10
Meat	19.20	24.50	49.20
Milk	16.90	19.20	46.90
Eggs	22.10	21.45	52.10
Produce	19.20	21.45	49.20
Household Goods	22.10	24.50	52.10
Personal Effects	22.10	24.50	52.10
TO SEATTLE	**FROM ANCHORAGE**	**FROM KODIAK**	**From CHIGNIK SAND POINT COLD BAY**
Seafood	10.00	13.65	22.00
Canned seafood	10.00	-	20.20

[1] Airfreight to Anchorage and Kodiak is direct from Seattle. To Chignik, Sand Point and Cold Bay air freight travels via Anchorage.

[2] Rates between Anchorage and Chignik, Sand Point and Cold Bay are based on a general commodity rate of $30/cwt. except for fish which is $10/cwt.

Sources: Official Air Freight Local Rates Tariff No. LR-1- Reeve Aleutian Airways Inc., Wien Alaska Inc., Western Air Lines.

Table 96

COMPARATIVE SEA FREIGHT COSTS OF VARIOUS COMMODITIES

TO SEVERAL COMMUNITIES OF THE WESTERN GULF OF ALASKA FROM SEATTLE[1]
(dollars per 100 lbs.)

From Seattle	To Kodiak	To Kodiak Is. Outlying Communities	Additional Cost[2] (percentage)	To Chignik	Additional Cost[2] (percentage)	To Sand Point False Pass King Cove	Additional Cost[2] (percentage)
Cement, sand, gravel	1.70	2.35	38	2.59	52	3.24	91
Building woodwork	8.34	9.68	16	10.66	28	13.32	60
Metal collapsed cans in pkg.	2.20	2.55	16	2.80	27	3.51	60
Dairy Prod., fresh, refrig.	5.02	7.04	40	7.74	54	9.67	93
Fruits, Veg., frozen	7.92	9.21	16	10.14	28	12.68	60
Motor Vehicles	8.51	9.17	8	10.14	19	12.68	49
Iron and steel articles	3.01	3.53	17	3.88	30	5.14	71
Lumber, rough or surfaced	2.62	2.86	9	3.19	22	3.99	52
Eggs (in wooden cases)	4.66	5.25	13	5.79	24	7.23	55
Meat, fresh (not frozen)	8.21	12.52	52	13.70	67	17.13	109
Compressed gases	3.17	3.55	12	3.88	22	4.86	53
Salt	2.32	2.45	7	2.70	16	3.37	45
Average additional cost northbound (percent)			20		32		66
Fish canned (southbound)	2.32	2.35	1	2.51	8	3.15	36

[1]These costs are 7% higher than those stated in the published tariffs because published tariffs do not reflect the most recent price increases

[2]As compared to shipping cost to Kodiak.

Source: Sea Land Freight Tariffs 139 and 197

In general, the rates from Seattle to Kodiak are significantly higher than the rates to Anchorage. This is due solely to the much larger volumes that are involved in the Anchorage shipments. It is interesting to note that for smaller shipment sizes the rates to Anchorage are actually higher than those to Kodiak.

LAND USE AND LAND STATUS[1]

Background Information

In discussing the land use and land status of the Western Gulf of Alaska, the land area on the north side of the Alaska Peninsula from approximately Ilnik to Unimak Pass will also be included as this area is socially and economically related to the Western Gulf. The eastern boundary on the Alaska Peninsula was chosen to coincide with the Aleut regional Native corporation boundaries. Land use and land status on both sides of the Alaska Peninsula from this eastern limit westward will be significantly influenced by the Aleut corporation and its member villages.

The Western Gulf of Alaska is currently undergoing a redistribution of land under the provisions of both the Alaska Statehood Act (U.S. 72 Stat. 339) and the Alaska Native Claims Settlement Act (ANCSA) (P.L. 92-203). Until final implementation of both these Acts, land ownership patterns and the uses permitted on the land will be changing constantly. These Acts will eventually produce three major land owners in the region: the federal government, the state and its municipalities, and the Alaska Natives. The Alaska Statehood Act (1959) provided a grant of federal lands to the state amounting to 43.2 million hectares (104.6 million acres). These lands are to be selected by the state from any open, available public domain lands owned by the United States. The state has selection rights until January 1984. State land selections in the Western Gulf are shown on Figure 173.

ANCSA, passed in 1971, provides for selection and conveyance of 16.2 million hectares (40 million acres) of land to Alaska Natives and provides for the redistribution of most of the state's lands. The provisions of the Act have priority over the land selection provisions in the Alaska Statehood Act. Because of this priority, state selection rights have been nullified on some lands and delayed on others. Under provisions of ANCSA, the Secretary of the Interior has withdrawn from the jurisdiction of the public land laws most of the public domain lands of Alaska. For the state as a whole, these withdrawals include:

> Approximately 42.9 million hectares (106 million acres) from which the Natives of Alaska can select their 16.2 million hectares (40 million acre) entitlement.

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[1]Information contained in this chapter is based upon the lands situation as of September 1, 1973.

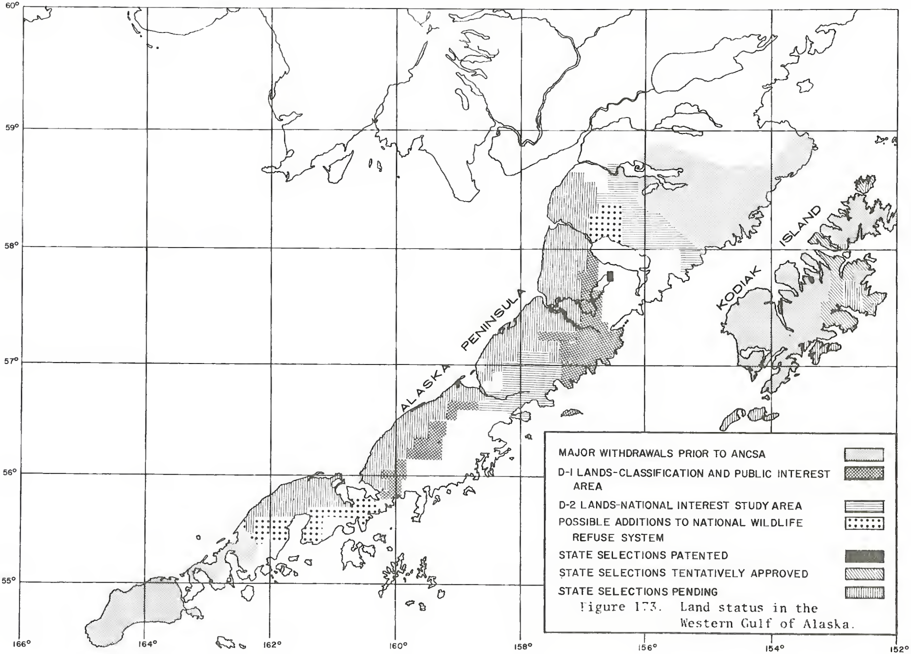

Figure 173. Land status in the Western Gulf of Alaska.

3.0 million hectares (7.5 million acres) for utility corridors.

770,000 hectares (1.9 million acres) for possible additions to the National Wildlife Refuge System.

32.4 million hectares (80 million acres) of lands of significant national importance to merit classification as a National Forest, Park, Wild or Scenic River, or Wildlife Rufuge (D2 Lands).

30.8 million hectares (76 million acres) of lands of significant public interest to warrant future classifiaction by the Secretary of the Interior (D-1 Lands).[1]

With the exception of utility corridor withdrawals, all these categories of land are represented in the Western Gulf of Alaska region and are shown on Figures 173 and 174.

Current Land Use

The economy of the Western Gulf of Alaska is primarily marine based. Intensive land use occurs only where land is used for a community site or a military site. However, the land area of the Western Gulf is used extensively for subsistence, livestock grazing, and recreational activities. Primarily, subsistence activities on the land consist of hunting and trapping. The areas used by the Natives of Kodiak Island for subsistence activities on the island and along the west shore of Shelikof Strait are shown on Map 4. Little information is available concerning the specific subsistence areas used by Alaskan Natives in other areas of the Western Gulf. No records are available which show the number of animals harvested for subsistence purposes in the Western Gulf. In the Kodiak area and that portion of the Alaska Peninsula across Shelikof Strait from Kodiak Island, the principal species harvested are the Sitka black-tailed deer, beaver, land otter, and red fox. Harbor seals are harvested in the adjacent waters. Elsewhere on the Alaska Peninsula that is in the Western Gulf and on the eastern Aleutian Islands, beaver, muskrat, mink, land otter, weasel, and fox are the principal species harvested. Moose and caribou are hunted on the Alaska Peninsula and Unimak Island and throughout the area large numbers of waterfowl are harvested (Federal Field Committee for Development Planning in Alaska 1968).

Livestock (cattle and sheep) grazing utilizes 158,000 hectares of land in the Western Gulf of Alaska. This range currently supports about 4,600 head and has an estimated total carrying capacity of 6,500 head (Table 86). Recreational use takes place over much of the area. Trophy hunting for brown bear is popular on Kodiak Island and on the Alaska Peninsula where trophy moose are also found.

Archeological sites represent another type of land use in a historical sense. Many sites have been found in the Western Gulf of

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[1]Public Law 92-203 (Sec. 11), Public Land Orders: 5150, 5169, 5178, 5810, 5181, 5182, 5190, 5192, 5193 and League of Women Voters 1973.

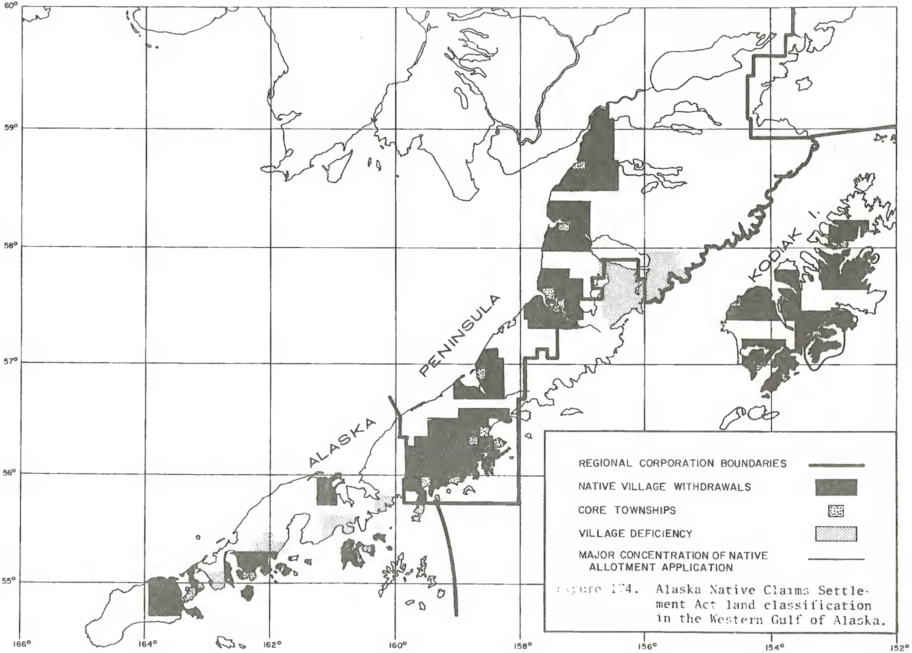

Figure 174. Alaska Native Claims Settlement Act land classification in the Western Gulf of Alaska.

Alaska, especially on Kodiak Island (Figure 175). Records kept by the State Division of Parks indicate that there are 292 known sites on Kodiak Island and 72 sites on the remaining portion of the Western Gulf area.[1] Probably only half of the sites in the area have been discovered, especially on the coastal areas which historically supported greater human populations because of the more constant food supply provided by the sea.[2]

Land Status

The Western Gulf of Alaska as defined on Figure 171 contains approximately 4,398,000 hectares.[3] The area currently contains 17 categories of lands. Some categories represent a permanent determination of land status while other are only temporary classifications. The total area in the different categories exceeds that of the region by about 800,000 hectares (two million acres) (Table 97) because the withdrawals created by ANCSA overlap previously withdrawn federal lands and lands selected by the state in accordance with the Statehood Act. In addition, some of the Native village withdrawals overlap each other. A discussion of each land category including the present status and the constraints to use follows. The land use constraints on each category can be seen in Tables 98, 99, and 100.

Lands With a Permanent Status Classification

Because of the nature of some lands in the Western Gulf of Alaska their withdrawal has permanent status. These include Katmai National Monument, Chugach National Forest lands, military reservations, National wildlife refuges, power sites or project withdrawals, outer continental shelf lands, and state patented and private patented lands. These lands, with the exception of power sites or project withdrawals, continental shelf and private lands, are shown on Figure 173. All categories except continental shelf lands are in Table 97.

Katmai National Monument

Approximately 353,245 hectares of Katmai National Monument are in the Western Gulf of Alaska. Land use in this area is quite restricted because the area was originally withdrawn to protect unique geologic features and later expanded to protect wildlife habitat (Table 99). This area is withdrawn from appropriation under the public land laws, location and entry under the mining laws, and leasing under the Minerals

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[1]Dr. Karen Workman, Archeologist, Alaska Department of Natural Resources, Anchorage. July 1973. Personal communication.

[2]Ibid.

[3]This figure was calculated by extracting figures from the Bureau of Land Management's computer print-outs for the Native Regional Corporations within the Western Gulf. The lands were as follows:

Aleut - 1,675,800 hectares
Bristol Bay - 832,750 hectares
Koniag - 1,889,700 hectares

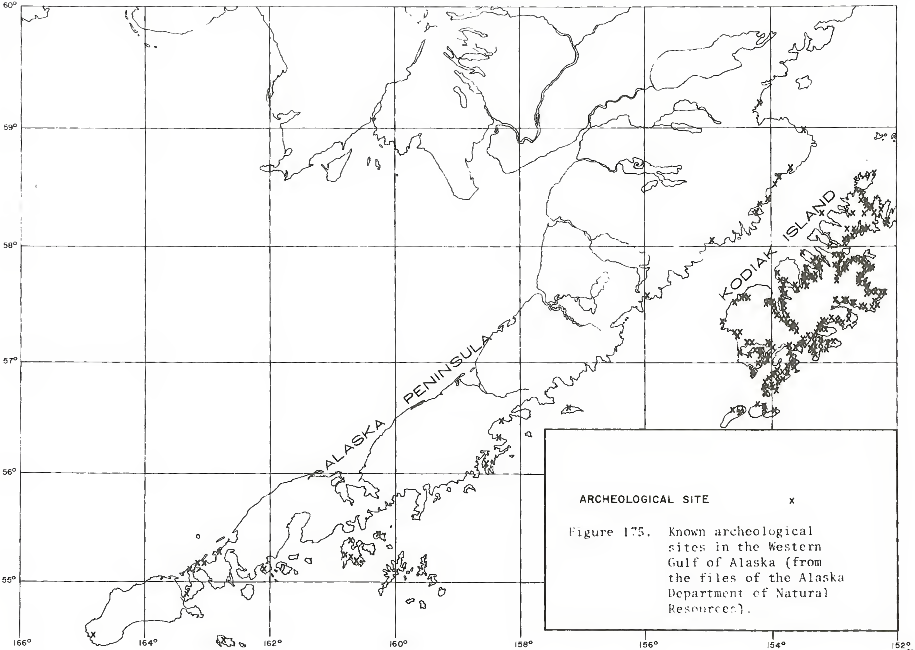

Figure 175. Known archeological sites in the Western Gulf of Alaska (from the files of the Alaska Department of Natural Resources).

Table No. 97

LAND STATUS

WESTERN GULF OF ALASKA - 1973

STATUS CATEGORY	ACRES*
Patented Lands	
Private	10,015
State	3,900
State Selections	
Tentatively Approved	641,347
Pending	1,601,853
Native Allotment Applications	35,085
Indian Reserves	25,409
Military Reservations	47,262
National Forest	464,292
National Monument	872,858
National Wildlife Refuge	2,912,636
Power Site or Project and Other Withdrawals	20,675
Lands Withdrawn Under ANCSA	
Classification and D-1 Lands	874,697
D-2 Lands	627,786
Wildlife Refuge Replacement	452,643
Village Withdrawal	3,356,407
Village Deficiency	934,117
Regional Deficiency	820
Total Land Acres Withdrawn	12,881,802
Total Land Acres in Region	10,868,000

*Land acres only

Source: U.S. Department of the Interior, Bureau of Land Management, land status computer printouts of the Aleut, Bristol Bay and Koniag Regional Native Corporations, July 1973.

Table 98

CONSTRAINTS TO USE ON LANDS WITHDRAWN UNDER ANCSA AND REVOKED INDIAN RESERVE LANDS

Expiration Date	Revoked Indian Reserves 12/18/73	D-2 Lands 12/18/78	Village Withdrawals 12/18/78	Village Deficiency Withdrawals 12/18/78	Regional Deficiency Withdrawals 12/18/78	D-1 and Classification Lands Indefinite	Wildlife Refuge Replacement Lands Indefinite
Appropriation Under Public Land Laws	No	No	No	No	No	No	No
Location and Entry Under Mining Laws	No	No	No	No	No	For metaliferous minerals only	No
Leasing under Minerals Leasing Act of 1920	No	No	No	No	No	No	No
Hunting, fishing and other forms of recreational use	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Grazing	Yes[a]	Yes[a]	Yes[a]	Yes[a]	Yes[a]	Yes[a]	Yes[a]
Timber Harvesting	Yes[a]	Yes[a]	Yes[a]	Yes[a]	Yes[a]	Yes[a]	Yes[a]

[a]Provisions for interim administration in Section 17 of ANCSA authroize the Secretary of the INterior to make contracts and to grant leases, permits or easements on these lands. Under present Bureau of Land Management policy this authority is rarely exercised and very few uses are permitted on the land.

Sources: Public Law 92-302 (ANCSA); Public Land Orders 5169 through 5188.

Table 99

CONSTRAINTS TO USE ON LANDS WITHDRAWN PRIOR TO ANCSA AND PENDING STATE SELECTIONS

	Katmai National Monument	Chugach National Forest	Military Reservations	National Wildlife Refuges	Power Sites or Projects	Outer Continental Shelf	Pending State Selections
Appropriation Under Public Land Laws	No	Under Mining Laws	No	No	No	No	No
Location and Entry Under Mining Laws	No	Yes	No	Yes Except Kodiak	Yes	No	No
Leasing Under minerals leasing Act of 1920	No	Yes	No	Yes	Yes	Yes	No
Hunting, fishing and other forms of recreational use	Yes (No hunting)	Yes	Yes	No hunting or fishing on some	Yes	N/A	Yes
Grasing	No	Yes	Yes	Yes	Yes	N/A	Yes[a]
Timber harvesting	No	Yes	Yes	N/A	Yes	N/A	Yes[a]

[a]The Secretary of the Interior has interim administrative authority on these lands giving him the right to make contracts and to grant leases or easements on these lands.

Sources: U.S. Public Law 92-203 (ANCSA); U.S. Public Land Orders 5169 through 5188.

Table 100

LAND USE CONSTRAINTS GOVERNING LAND UNDER THE JURISDICTION OF THE STATE OF ALASKA

Classification	Disposal	Mineral Deposits Acquired	Disposal of Timber and/or Materials	Grazing	Recreation
Unclassified lands	no	claim staking	no	no	yes
Agricultural lands	lease or sale	leasing	yes	short term lease	yes
Commercial lands	lease or sale	leasing	yes	short term lease	
Grazin g lands	lease only	claim staking	yes	yes	yes
Industrial lands	lease or sale	leasing	yes	short term lease	yes
Material lands	no	claim staking	yes	yes	yes
Mineral lands	no*	claim staking	yes	yes	yes
Public recreation lands	no	leasing	yes	no	yes
Private recreation lands	lease or sale	leasing	yes	short term lease	yes
Residential lands	lease or sale	leasing	yes	short term lease	yes
Reserved use lands	no	leasing	yes	no	yes
Timber lands	no	claim staking	yes	yes	yes
Utility lands	lease or sale	claim staking	yes	short term lease	yes
Watershed lands	no		yes	yes	yes
Open-to-entry	lease or sale	leasing	yes	no	yes
Tide and submerged lands	lease or sale	leasing	yes	n.a.	yes

* except those acquired by escheat or foreclosure

Source: Alaska Statutes, Title 38; Alaska Administrative Code, Title II.

Leasing Act. No hunting is allowed, but subsistence fishing is permitted along with sport fishing, berry picking, and other recreational uses. The state does not have selection rights on lands in Katmai National Monument.

National Forest Lands: The Western Gulf of Alaska contains 187,900 hectares of Chugach National Forest lands. This land is closed to appropriation under all the public land laws except the public mining laws which permit location, entry, and patent. Mineral leasing is permitted under the Mineral Leasing Act. The various renewable surface resources of the national forests are managed under the principles of the Multiple Use Act of 1960.

The Alaska Native Claims Settlement Act names three Native villages which can exercise land selection rights in the Chugach National Forest; Port Lions, Ouzinkie, and Afognak. Under the provisions of the act no village can select more than 27,973 hectares (69,120 acres) of National Forest land. If each village exercised its selection privileges to the maximum, all or part of approximately 10 townships could be converted to Alaska Native ownership. Koniag, Inc. is currently trying to obtain eligibility for three more villages within the Chugach National Forest on Afognak Island. The proposed villages are Port Williams, Kitoi, and Litnik. If the villages become eligible to select land under ANCSA, an additional 83,918 hectares (207,360 acres) could be selected from the National Forest area.

National Forest lands covered by village withdrawals are closed to all forms of appropriation under the public land laws and from location and entry under the mining laws. Interim administration of the lands covered by village withdrawals prior to conveyance will be the responsibility of the Secretary of Agriculture who has the authority to make contracts and issue leases, permits, rights-of-way, or easements. Before any of the preceding activities take place the Secretary shall obtain the views of the concerned regional corporation or villages having interest in those lands.[1] The State of Alaska does not have selection rights for Chugach National Forest lands on Afognak Island.

National Wildlife Refuges: The Western Gulf of Alaska includes several National Wildlife Refuges containing 1,178,744 hectares (Table 97). Kodiak National Wildlife Refuge is the largest with 695,802 hectares. Other refuges include those in the eastern Aleutian Islands, namely Izembeck, Semidi, Simeonof, and Aleutian Islands National Wildlife Refuges. Under ANCSA several villages have selection rights on these wildlife refuges. The U.S. Bureau of Sport Fisheries and Wildlife estimates that Native entitlements for the villages of Kaguyak, Alitak, Old Harbor, and Larsen Bay will remove approximately 111,890 hectares

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[1]Federal Register, Title 43, Vol. 38, Subpart 2650, Section 2650-1, May 30, 1973.

from the Kodiak National Wildlife Refuge (U.S. Bureau of Sport Fisheries and Wildlife 1972). Village selections of False Pass, King Cove, and Belkofsky could take as much as six townships from the Izembeck refuge. The villages of Uganik and Ayakulik which border the refuge are also being considered for eligibility under ANCSA. If these villages obtain selection rights under ANCSA an additional 55,945 hectares could be withdrawn from the refuge.

All refuge lands are closed to appropriation under the public land laws. Most uses are allowed on a permit basis or in specified areas. However, hunting and fishing are not allowed on the Simeonof and Semidi Refuges which were established to protect sea otters, sea birds, and sea lion rookeries respectively. Mining pf hardrock minerals is not permitted on the Kodiak Refuge.

Regulations issued under the Alaska Native Claims Settlement Act contain provisions whereby lands selected from the refuge will remain subject to the laws and regulations governing the use and development of the refuge.[1] Also, the Native corporations are not entitled to subsurface rights on any land selected in the National Wildlife Refuges.[2] The United States government also reserves the right of first refusal if any refuge land is ever sold by any village corporation. The state does not have selection rights on national wildlife refuges.

Military Reservations: There are approximately 19,000 hectares of military reservations in the region. Most is contained within the Kodiak Naval Station which was transferred to the United States Coast Guard in July 1972. Under provisions of Public Land Order 5187, all military reservations are closed to appropriation, mining, and mineral leasing (Table 99) in order to protect the public interest in the lands when they are no longer needed for military or defense purposes. Some uses are permitted at the discretion of the agency administering lands. While any of the area remains a military reservation, the state has no selection rights.

Power Sites: There are approximately 8,367 hectares withdrawn for power sites or projects and other miscellaneous withdrawals. Power sites or power project areas are closed to appropriation under the public land laws but other uses may be permitted (Table 99).

State and Private Patented Lands: State patented lands total approximately 1,580 hectares in the Western Gulf. These include state selections to which the state has received patent, mineral estate patents, airport conveyances, and quitclaim deeds. The figure shown in Table 97 does

[1]Federal Register Section 2650, 4-6.

[2]P.L. 92-203 Section 14.

not include tidelands, submerged lands, and shorelands granted to the state in the Statehood Act.[1] State patented lands now represent a very small portion of the region, but if all the lands which are tentatively approved or pending approval are eventually patented, the state will have title to approximately 930,000 hectares or two percent of the region, exclusive of tide or submerged lands or lands under non-tidal navigable water.

State patented lands, as well as those tentatively approved by the U.S. government for patent under the Statehood Act, are under state management. These lands are unclassified but subject to eventual classification. The various classifications determine the use permitted. Land use constraints governing each classification are summarized in Table 100. All various land categories can be utilized for purposes "other than for which classified, provided such use is consistent with the public interest," according to the Alaska Administration Code.

There are approximately 4,000 hectares of private patented lands in the Western Gulf of Alaska. The owner determines the use of the surface resources of the land and of its subsurface resources if he has subsurface rights. If the subsurface rights are reserved to the government, prospecting and oil and gas exploration can be conducted on the land by the owner or by someone other than the owner who would have to obtain a permit from the government. Because of their small size and scattered nature, private lands are not shown on the maps.

Outer Continental Shelf Lands: These lands include the seabed and subsoil beyond the territorial limits (4.8 km.). Federal jurisdiction prevails in this zone to the 200 meter isobath, and the United States could claim beyond if it is capable of exploiting the subsoil and seabed resources (Hickok and Warnicke 1970).

The laws and regulations which pertain to other public lands of the United States are not applicable to continental shelf lands. The lands cannot be appropriated and are not open to entry under the mining laws.

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[1]Title II of the Alaska Administrative Code defines these lands as follows:

Submerged lands: "...covered by tidal waters between the lines of mean low water and seaward to a distance of 3 geographical miles or further as may hereafter be properly claimed by the state."

Tidelands: "...periodically covered by tidal waters between elevation of mean high tide and mean low tides."

Shorelands: "...covered by non-tidal waters that are navigable under the laws of the United States up to ordinary highwater mark as modified by accretion, erosion or reliction."

Geological and geophysical explorations can take place and oil and gas can be extracted through lease. The United States reserves the right to helium from all gas produced in the area and to fissionable materials such as thorium and uranium.[1]

Lands with a Temporary Status Classification

State Selected Lands: The state has selected and not yet received patent for a total of 907,800 hectares under provision of the Alaska Statehood Act (Table 97). Approximately 259,000 hectares have been tentatively approved for patent. About 647,000 hectares are pending approval. The location of the tentatively approved and pending acreage can be seen on Figure 173. Under the provisions of ANCSA, each Native village corporation can select up to 27,973 hectares (69,120 acres) or three townships from state selected or tentatively approved land which was selected before January 17, 1969.[2] There is no upper limit on the land the Native village corporations can select from state selections made after this date. There are approxiamtely 23 villages which could select lands from state selections and the amount each village corporation will select will not be known until after December 31, 1974, the deadline for village selections. State lands selected by village corporations will be made up from other land areas but not necessarily from within the Western Gulf region.

Tentatively approved lands are under the management of the state and are subject to classification and the land use constraints discussed under patented state lands. State selected lands which are pending approval are administered by the Secretary of the Interior, who has the authority to make contracts, issue leases, permits, rights-of-way, or easements. Prior to this the Secretary of the Interior would obtain the view of the state. Land uses permitted on these lands can be seen in Table 100.

Native Allotment Applications: Native allotment applications do not constitute a land withdrawal. Under Sec. 14(h) of ANCSA, a portion of 800,000 hectares (2 million acres) will be conveyed to Alaska Natives throughout the state to cover applications that were applied for under the Native Allotment Acts of 1887, 1906, and 1910 which were repealed by ANCSA. This land will also cover additional applications authorized by Section 12 (b) of ANCSA which conveys up to 65 hectares (160 acres) of land to a Native who applied for it within two year after the enactment of ANCSA as a primary place of residence on August 31, 1971. There are 14,200 hectares of allotment applications made prior to and after ANCSA in the Western Gulf area. The major portion of these are on Kodiak Island (Figure 174).

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[1]United States Code Title 43, Section 1331.

[2]Federal Register Section 2651-4.

Lands Withdrawan Under Section D-2 of ANCSA: Under Section D-2, of ANCSA, lands were withdrawn for study and for possible recommendations to Congress as additions to or creation as units of one of the "four systems"; National Park, Forest, Wildlife Refuge, and Wild and Scenic River Systems. This withdrawal expires on December 18, 1978. The amount of D-2 lands withdrawn in the region totals 254,065 hectares. Land use constraints for these lands are indicated in Table 99.

These lands are currently being reviewed by the Secretary of the Interior, who before December 18, 1973, must submit to Congress legislative proposals for their includsion in one of the "four systems." Lands originally withdrawn under the D-2 classification and not recommended for the "four systems" will be available for selection by the state, regional corporations, and for appropriation under the public land laws after they have been classified. Congress has until December 18, 1978 to act upon the Secretary's recommendations. After this date, lands not acted upon will be open to state selections and appropriation under the public land laws. Prior to December 18, 1978, the Native Claims Settlement Act permits the state and the Native regional corporations to identify D-2 lands desired for selection, but these can only be conveyed if they are not incorporated into the "four systems."

The Secretary of the Interior can make contracts, grant leases, permits, rights-of-way, or easements. Mineral lease applications will be rejected until the public land order classifying D-2 lands is modified or the lands are reclassified to permit mineral leasing.

Native Selections Under ANCSA: Lands withdrawn under ANCSA for Native selections also have a temporary status. The following statement explains for the state as a whole the Native land selection process and the role and time limits attached to each withdrawal category:

> The village land selection of 22,000,000 acres (8,900,000 hectares) for the whole State must be selected from lands designated as: a) village withdrawal area or b) village deficiency land if the regular withdrawal is insufficient. This land is selected by the village corporation. First to be selected are all available lands in the townships in which the village is located. Then additional land is selected based on village enrollment. The minimum entitlement for an incorporated village with an enrollment of at least 25 is three townships. This selection must be completed by December 18, 1974 and will result in surface lands going to residents, businesses, subsistence sites, non-profit organizations, municipal corporations, or other selected users. The subsurface rights go to the regional corporation.
>
> If the entitlement of all the villages in the State does not total 22 million acres, the remaining acreage

is divided amongst the regions on a population basis. The regional corporations then allocate these acres to their village corporations, based upon need, population and historic uses. The villages then select where the acres are to be used within their village withdrawal or deficiency areas in order to complement their original entitlement selections. As in other village selections, the subsurface rights accrue to the regional corporations.

The regional land selection of 16,000,000 acres (6.4 million hectares) for the whole state must be selected from lands designated as: a) village withdrawal lands remaining of b) regional deficiency land if in sufficient village withdrawal remains. This land is selected by the regional corporation. Each region's entitlement is based on the size of the region's area with deductions for previous village selection. Land is selected on the basis of the regional corporation's management decisions for the future of the region. This selection must be completed by December 18, 1975 and will result in the land being used according to the regional corporation's plan for the future of the region. Selection from unreserved and unappropriated public lands outside the withdrawal areas of 1,500,000 (600,000 hectares) for the whole state must be selected for the preservation of historical places and cemetery sites and residence land for small non-village groups and individuals. Selection of the place of residence for non-village individuals must be completed by December 18, 1973. This will result in the preservation of sites of importance to the region as well as residence land outside the established villages.

Selection of any remaining lands to fulfill the 40 million acre (16.2 million hectares) entitlement of the Act must be selected from remaining withdrawal or deficiency lands. The regional corporation selects these lands based on regional enrollment. Through this section the entire 40 million acre entitlement is insured in accordance with the Act (Arctic Environmental Information and Data Center 1972).

The land from which Native village corporations and regional corporations can select their entitlement totals 1,736,707 hectares. Approximately 1,358,338 hectares of this are classified as village withdrawals, 378,037 are classified as village deficiency withdrawals, and 332 as regional deficiency withdrawals. Under Sections 11, 12, and 14 of ANCSA the following villages are eligible to select land:

VILLAGE		MAXIMUM LAND ALLOWED (hectares)
Kodiak Island:		
Afognak	-	27,972
Akhiok	-	27,297
Kaguyak	-	27,972
Karluk	-	27,972
Kodiak	-	9,324
Larsen Bay	-	37,297
Old Harbor	-	46,621
Ouzinkie	-	37,297
Port Lions	-	46,621
Uyak	-	27,972
Aleutian Islands:		
Belkovski	-	27,972
Chignik	-	27,972
Chignik Lagoon	-	27,972
Chignik Lake	-	37,297
False Pass	-	27,972
Ivanof Bay	-	27,972
King Cove	-	46,621
Nelson Lagoon	-	27,972
Pavlof Harbor	-	27,972
Perryville	-	27,972
Sand Point	-	46,621
Squaw Harbor	-	27,972
Unga	-	27,972

Currently Koniag, Inc. is trying to obtain eligibility for the following additional villages on Kodiak Island:[1]

Aiaktalik
Anton Larsen
Ayakulik
Bell's Flats
Kitoi
Litnik
Port Williams (Shuyak)
Uganik
Woody Island

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[1]Karl Armstrong, Lands Specialist, Koniag, Inc. Kodiak, October 1973. Personal communication.

Land use constraints on land withdrawn for Native selections can be seen in Table 98. After December 18, 1975 most lands not selected by the native corporations will be classified by the Secretary of the Interior to protect the public interest. The state will have selection rights on most of these lands.

Miscellaneous Land Withdrawals: Other land having temporary status includes the 10,280 hectare Karuluk Indian Reserve located on Western Kodiak Island. It is the only Indian reserve in the Western Gulf of Alaska region and was revoked under Sec. 19 of ANCSA. However, its lands are being held intact until December 18, 1973, when the village corporation of Karluk is to exercise the option provided under Sec. 19 of ANCSA. The corporation may then choose either to retain both surface and subsurface rights to the entire reservation and give up any other land selection opportunities and monies as provided in the Act, or to select its entitlement (27,972 hectares) to surface rights only, and be eligible for all the other benefits of the Act.

Land use constraints in effect until December 18, 1973 can be seen in Table 98. If the Karluk village corporation decides to retain ownership of both surface and subsurface rights, the land uses will be immediately determined by the village corporation. If the corporation elects to retain surface rights, land use constraints will be similar to those on other lands withdrawn for Native selections.

Land designated under Section 17(d)(1) of ANSCA and Public Land Order 5180 and 5186 were withdrawn to determine their proper classification in order to protect the public interest. There are 353,990 hectares of these public interest areas. Some of these lands are subject to immediate selection by the State of Alaska.[1] Village and regional corporations may select any of these lands that are encompassed by village withdrawal areas or village and regional deficiency withdrawals.[2] The State of Alaska may select D-2 lands only after December 18, 1974. These selections may be made only from areas now covered by the 25 township Native withdrawals.[3]

Wildlife refuge replacement lands were withdrawn to serve as possible replacements for existing refuge lands that are selected by the Native village corporations. There are 183,185 hectares in this classification. All are located adjacent to the Izembeck National Wildlife Refuge. The Secretary of the Interior is under no time constraints to rescind or reclassify either Section 17(d)(1) or wildlife replacement lands. Land use constraints imposed on these lands are given in Table 98.

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[1]U.S. Public Land Order 5186.

[2]U.S. Pl. 92-203, Sec. 17 (d)(1).

[3]Esther C. Wunnicke, co-counsel, Joint Federal-State Land Use Planning Commission, November 1973. Personal communication.

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IX. EFFECTS OF THE ENVIRONMENT ON RESOURCE USE

GEOMORPHOLOGY

The rugged, mountainous terrain and the generally poor weather conditions (see below) make flying extremely hazardous in the study area. Most places level enough for landing strips are surrounded by mountains. This dangerous situation is emphasized by the recent crash of a U.S. Air Force cargo plane near Cold Bay in September 1973.

Parts of the offshore area are extremely hazardous for navigation; navigation is especially difficult around islands where there are many reefs and skerries. Most of the nearshore areas are fairly well charted, but much of the area further offshore is only lightly charted (Figure 5). Particularly dangerous in this offshore area are the banks and shoals along the outer shelf edge. These areas are not well charted and many are quite shallow, some even approach sea level in a few places. This area was a zone of intense uplift during the 1964 earthquake (Figure 63) and any bathymetry prior to that time could have been significantly changed by the uplift.

Many bays and fiords in the area offer natural harbors for refuge from storms. The coastline is best described in the Coastal Pilot (Coast and Geodetic Survey 1964), plus an interesting personal description of the coast by Logan (1970?).

CLIMATE-OCEANOGRAPHY

The severe weather and wave conditions found throughout the region make human activities difficult at times. Sustained winds, especially those associated with the severe winter storms traveling northeastward along the storm track, will frequently range from 50 to 75 knots and occassionally will reach over 100 knots above open water. Aircraft operations, especially landings and takeoffs, can be extremely hazardous during these storms. In addition, these wind velocities are strong enough to damage offshore structures if they are not properly designed. Strong winds in the vicinity of mountains can also cause severe turbulence that is hazardous to aircraft and buildings. Williwaws, short but violent local storms, can develop and adversely affect both land and ocean based installations. Generally, wind speeds over land are not as strong as over water, but may still damage structures.

Storms often move slowly or remain stationary for several days; this creates substantial wave activity. Theoretically, waves up to 18 m. high could be generated, but generally, waves greater than 9 m. have not been observed. The steep shape of the forming waves is more of an impediment to ship operations than is the actual wave height.

Tidal currents in the area are appreciable but generally not extreme like they are in Cook Inlet to the north. Locally, in restricted passes or passages, currents can reach significant velocities. Tidal ranges are fairly great in the northern part of the study area.

Temperatures in the area are not extreme and do not hamper outdoor activities to any extent, although occasionally the cold northerly winds cause temperatures to drop the chill factor to -30 degrees F (-34 degrees C). Sea temperature varies about 16 degrees F (9 degrees C) through the year, and may drop to the mid-30's during the coldest months. In winter a person could perish with as little as 30 minutes exposure in the water (Figure 16, Table 8). During periods of critically low temperatures, condensation and spray can form ice on the superstructure of ships, oil platforms, and onshore structures. Icing of aircraft also becomes a problem.

Ceiling and visibility in the area are extremely low much of the time (Table 7) and can severely restrict the use of aircraft. Areas can be "socked in" for extended periods. The scarcity of alternative landing facilities in the area makes this an especially critical problem. Dense fog, especially during the summer months, also poses a serious hazard and can hamper both onshore and offshore surface operations.

Enroute aircraft are affected by cloud cover, heights of cloud bases and tops, visibility, turbulence, icing and flight level winds. All will vary with the season in amount or intensity. No climatological data for these parameters exist for enroute conditions. It is advisable to request a weather briefing from an FAA Flight Service Station or a National Weather Service Office.

HYDROLOGY

Providing an adequate water supply for onshore facilities may be another problem. Kodiak experienced a severe water shortage last year, and several canneries had to shut down operations. This was caused by an unusually low runoff which was unable to keep the present reservoir filled. The city is now building a larger reservoir. Since the groundwater potential of the region is fairly poor, furnishing a water supply system for any sizable, onshore facility probably would involve building a local dam and reservoir. This might, in turn, damage such things as salmon spawning areas unless corrective measures were taken (such as a fish ladder).

GEOLOGY

Seismicity

The study area lies within an active seismic belt and is extremely susceptible to earthquake damage. The area is included in seismic risk zone 3, areas susceptible to earthquakes between magnitudes 6.0 and 8.8 and areas where major structural damage from those earthquakes could occur. As seen in Figure 176 many earthquakes with magnitudes greater than 6.0 have occurred in the study area this century.

The area between Kodiak and Unimak Island is characterized by a "seismic gap," an area that has not experienced a large earthquake (7.0) in the past several years (since 1938). Time-space studies of large earthquakes along the Aleutian trench and vicinity suggest that this seismic gap or block may experience a large earthquake in the near future, perhaps sometime between 1974 and 1980 (Kelleher 1970).

Damage due to earthquakes can be severe and can be caused by a variety of factors. The primary effects are due to direct seismic vibration of the ground, which causes ground breakage, mud or sand emission from cracks, ground lurching and shaking, and local subsidence of unconsolidated sediments. Structural damage is the main result of this ground motion.

Secondary effects caused by earthquakes include fires, seismic sea waves, and both subaerial and submarine landslides. Large scale tectonic changes, such as uplift and subsidence, can also have widespread effects. In addition, earthquakes can cause local and regional effects on the biology, hydrology, atmosphere, and magnetic field.

The great 1964 Alaska earthquake illustrates the potential impact on the area. Late in the afternoon of March 27, 1964, one of the greatest geotectonic events of our time occurred in Southern Alaska. Half of Alaska was rocked and jarred by the most violent earthquake to occur in North America this century. Few earthquakes in history have been this large. Its magnitude has been computed by various observers to range from 8.3 to 8.75 on the Richter Scale. The epicenter of the earthquake was located at the head of Prince William Sound on the south flank of the Chugach Mountains about 130 km. east-southeast of Anchorage. The hypocenter, or point of origin, was at a depth of 20-50 km. The duration of the earthquake was only estimated because of the lack of instrumentation; observers calculated the duration of the shock to be between three and four minutes.

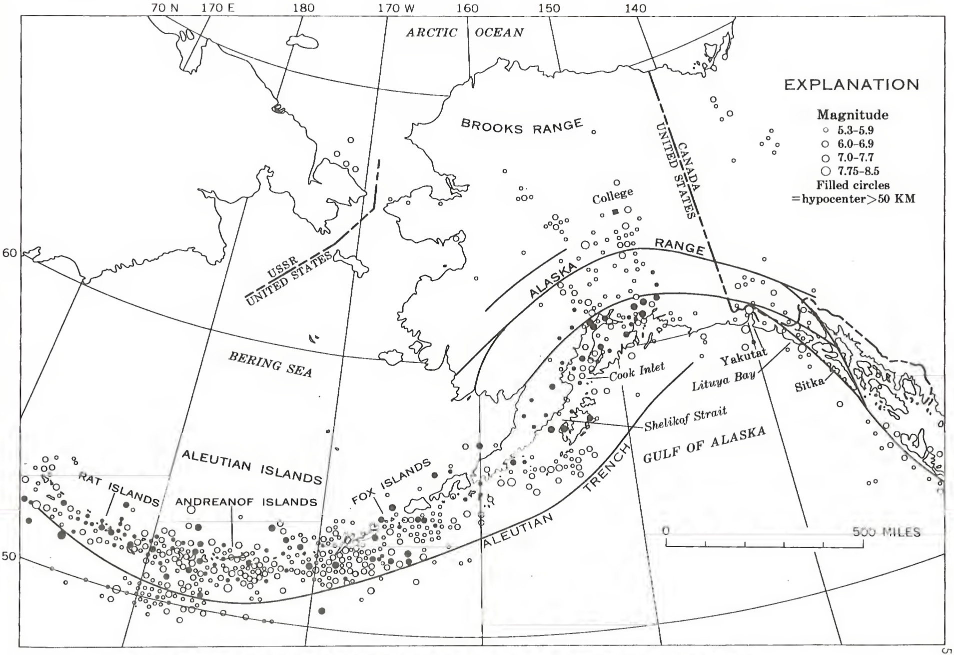

Figure 176. Epicenters of Major Alaskan Earthquakes, 1898-1961 (from Hansen 1971).

This earthquake has become renowned for its long duration and great destructiveness. Thousands of people lost their homes, 114 people were killed, and the economy of the entire state was disrupted. Seismic seawaves swept the Pacific Ocean from the Gulf of Alaska to Antarctica. All these effects discussed above occurred during this earthquake.

The earthquake also provided a great natural laboratory for studying the cause and effects of large earthquakes. Numerous investigations were made following the earthquake, and numerous publications followed reporting the results. Perhaps the most significant publication was a series of 8 volumes by the National Academy of Sciences. These volumes cover each of the following topics: Geology, Seismology and Geodesy, Hydrology, Biology, Oceanography and Coastal Engineering, Human Ecology, and Summary and Conclusions.

The northern part of the study area around Kodiak Island was directly affected by the 1964 earthquake. Local subsidence of alluvial material plus numerous landslides and rockslides accompanied the shaking; large-scale tectonic movements also occurred. The axis of maximum subsidence trended northeast along central Kodiak Island, the line separating uplift from subsidence trended along southeast Kodiak, and the axis of maximum uplift trended offshore southeast of Kodiak (Figure 63). Widespread flooding occurred in areas of both tectonic and compaction subsidence. Changes in the local hydrology were observed. The most devastating effect of the earthquake resulted from seismic sea waves that caused loss of life and wiped out several villages as well as downtown Kodiak. Two reports by Plafker and Kachadoorian (1966) and Kachadoorian and Plafker (1967) discuss in detail the effects of the earthquake in the Kodiak region.

Tectonic movements of the sea floor would probably have the most significant effect on any oil operations in the study area. Areas of uplift could expose to near sea level portions of the sea floor, which then would become navigation hazards. Vertical movements along faults potentially could cause damage to pipelines laid across them; an especially vulnerable area would be the fault zone opposite the southeast coast of Kodiak Island. This zone contains many recent fault scarps, and any pipeline from the shelf edge to Kodiak would cross it. Pipelines and structures would have to compensate for vertical displacements of at least 3 m., the maximum movement observed during the 1964 earthquake. In addition, any wells drilled through near-surface faults, especially the ones flanking anticlinal structures on the shelf edge, would be vulnerable to damage.

Large scale displacements of the sea floor would probably cause seismic sea waves or tsunamis similar to the 1964 earthquake. Low-lying coastal areas, especially those that experience both tectonic and compaction subsidence, would be extremely susceptible to inundation by sea waves. Any new coastal facilities should be built on high ground. In addition, most ground damage and foundation failure during the 1964 earthquake occurred in areas of saturated, unconsolidated Quaternary deposits or artificial fill, due to partial liquefaction and differential settlement. These factors also should be considered in the placement of any onshore petroleum facilities.

Earthquake prediction is on the verge of becoming a practical reality (Scholz et al. 1973). This is largely due to the recent study of effects premonitory to earthquakes, such as coastal movements and anomalous changes in tilt, fluid pressure, electrical and magnetic fields, radon emmission, the frequency and occurrence of small local earthquakes, and the ratio of the number of small to large shocks. Most significant is the possible premonitory change in the ratio of the number of the seismic shear velocity (Scholz et al. 1973). It soon may be possible to predict large earthquakes in the study region more accurately. To this end, a detailed seismic net is being established in the Shumagin Island area (Figure 61).

In addition, the U.S. Geological Survey is conducting field studies in the area as part of an overall study of earthquake hazards in southern Alaska. The project is under the direction of George Plafker and field work in the Kodiak region was carried out during the 1973 season by Warren Coonrad. The objective of the overall project is to study and evaluate seismic risk in Alaska from tectonic displacement, seismic shaking, and secondary geologic effects. A more general goal is to gain insight into tectonic processes within the seismically active zones of Alaska, especially southcentral Alaska. Field work in the Kodiak Island area concentrated upon active faults and displaced shorelines.

Volcanism

As mentioned in an earlier section, the study area includes a chain of active and potentially active volcanoes extending along the coast of the Alaska Peninsula. All of these volcanoes are potentially hazardous to nearby activites, because of both the processes and secondary effects.

These volcanoes tend to erupt andesitic lavas and ejecta which are more viscous than normal oceanic lavas. Eruptions associated with these andesitic volcanoes tend to be more violent and explosive and, therefore, more hazardous. Primary eruptive phenomena include:

1. Krakatoan eruptions - large violent explosions involving a voluminous outpouring of ejecta and destruction of large portions of the volcano summit, mainly because of collapse.

2. Nuee ardente (ash flow, "glowing cloud") - clouds of incandescent gases and ejecta that flow swiftly downslope from the volcano summit. They can flow away from the volcano for many miles and potentially are extremely hazardous and destructive of anything in their paths.

3. Pyroclastic eruptions - pyroclastic ejecta can range in size from blocks and bombs to fine-grained ash, and is the main type of material forming andesitic volcano cones. Deposition of significant thicknesses of ash can oocur 160 km. away from the volcano depending on the direction and magnitude of the wind.

4. Turbulent ash clouds and columns - bursts of gas, steam and ash that rise vertically to heights of 15,000 to 30,000 meters, can be especially hazardous to aircraft in the area.

5. Lava flows - are generally of minor importance in the formation of andesitic volcanic centers. Due to the viscous nature of the lava, the flows generally don't extend far from the eruptive center before congealing.

In addition to the primary eruptive phenomena, there are various secondary phenomena associated with eruptions that could be hazardous:

1. Volcanic mudflows and landslides - mixtures of ejecta and meltwater that flow off the flank of volcanoes after eruption

2. Flash floods - caused by the sudden melt of snow and ice following an eruption, or possibly due to the breakup of ice-dammed lakes

3. Lightning discharges - often associated with volcanic eruptions

4. Corrosive rains - caused by acidic volcanic gases that mix with precipitation

5. Earthquakes - caused by volcanic processes within the plumbing system of the volcano

6. Seawaves - caused by submarine eruptions or by large mudflows or nuee ardentes flowing into the ocean

Examples of almost all of these eruptive phenomena have occurred in the study area or in nearby areas during historic times. The 1912 Katmai eruption is an excellent example of a large violent explosion; it ranks as one of the greatest eruptions in recorded history. More than 24 cu. km. of material was ejected and produced a thick blanket of ash east of Katmai. The ash blanket was 0.3 m.

(one foot) on Kodiak Island, over 100 miles away. This eruption also produced a massive nuee ardente that filled a valley northwest of Katmai and formed the Valley of Ten Thousand Smokes. Large earthquakes felt locally also were associated with this eruption. A detailed summary of the volcanic activity of the Katmai region is contained in a book soon to be published by the University of Washington Press (Forbes, In Press).

The eruption of Augustine Volcano in 1883 is another example of a violent eruption that created a large summit crater. Associated with this eruption was a massive mud slide down the north flank of the mountain. The slide apparently reached the sea and caused a large seawave, which struck English Bay with a maximum amplitude of 30 ft. Fortunately the tide was low and there was no loss of life. This volcano is presently building another lava dome within the crater and could erupt with another violent explosion at any time. Although it is located just north of the study area, its marine location and its proximity to transportation routes still make it hazardous to any activities in the area.

There are many other examples of how volcanic activity can disrupt man's activity in the region. The Katmai ashfall caused numerous problems on Kodiak and caused "acid rains" in Seward and Cordova. In 1953, Mt. Spurr showered ash on Anchorage, which damaged aircraft and necessitated an expensive cleanup. The eruption produced a mushroom cloud that rose to a height of approximately 20,000 m. in 40 minutes, a good example of a violent, turbulent ash cloud eruption. The 1966 eruption of Mt. Redoubt caused a massive mudflow plus a flash flood that threatened the pipeline terminal at Drift River. A seismic party in the Drift River Valley had to be evacuated. Pavlof Volcano is currently erupting (November 1973) with a cloud up to 6,000 m., and lava flowing down the northeast side. This volcano could be potentially disruptive of activities at Cold Bay, only 50 km. away.

Like earthquakes, volcanic prediction is on the verge of becoming a practical reality. Premonitory effects include increases in microseismic activity, tilting of the inflating volcano, increased fumarolic activity, changes in the local magnetic and telluric field, and even changes in the ionosphere-reflecting layer. Perhaps the most promising predictive tool available today is the monitoring of microearthquakes. Microearthquakes apparently increase in frequency prior to eruptions, a response to the buildup of cumulative seismic strain associated with resurgent growth of a lava dome. This tool is being used extensive by Japanese scientists, but it is only just beginning to be used in this country.

Augustine Island is one of the few places where microearthquakes are now being studied. The University of Alaska Geophysical Institute has been carrying out a detailed geophysical study of the volcano since 1970. This project is currently under the direction of Dr. Jurgen Kienle. So far the research has demonstrated a high level of recurrent microearthquake swarm activity. A buildup of activity was recorded in October, 1971, just prior to a minor eruption. Five seismic stations are now continuously monitoring the microearthquake activity. Additional geophysical monitoring of the volcano, such as tilt studies and magnetic studies, will be carried out as more funds become available for the project.

Augustine is presently the only Alaska volcano under continuous surveillance. Scientists believe that there is a real need to expand research of Alaska volcanoes, and it is hoped that seismic stations can eventually be placed on all volcanoes in the vicinity of man's activity. In addition to geophysical studies, satellite surveillance and monitoring capabilities should be initiated. An integrated volcano monitoring and warning system for the entire Cook Inlet-Alaska Peninsula area would be the desired end result.

BIOLOGY

Man's activities can be affected by the biological environment in many ways. Foremost is the presence of mosquitoes and flies. Because of adverse effects on natural ecosystems, the State Department of Environmental Conservation has regulations governing use of insecticides. Permits for their use are required on a project by project basis.[1]

Less common, but more serious is the behavior of cliff nesting birds in response to aircraft. When an aircraft approaches, the birds commonly dive from their nests into the ocean often in dense swarms. Aircraft flying close to a cliff below nest level can be in considerable danger of hitting these relatively large birds. Helicopter rotor blades are particularly vulnerable.

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1. Kyle Cherry, Alaska Department of Environmental Conservation, Anchorage, Alaska. Personal communication.

Both black and brown bears are a valuable resource, but can be a nuisance around a camp. Carelessly handled food and garbage can attract bears and lead to their eventual destruction. Brown bears, with low populations and relatively low reproductive potential, are particularly vulnerable and can be easily eliminated from an area. Bears are dangerous when they become accustomed to humans.

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X. IMPACT AND CONFLICTS OF RESOURCE USE

POLLUTION

Past and Present Sources

Waste disposal is a problem in the city of Kodiak, where 16 processing plants, plus the city, have been dumping untreated wastes into waters adjacent to the community. The U.S. Army Corps of Engineers (1973) reports that these accumulated wastes are responsible for depressed oxygen levels in the harbor water and for the production of hydrogen sulfide gas. The Environmental Protection Agency (1971) believes that these gas emissions and their tendency to cause algal mats to rise to the surface are detrimental to the ecological balance of the area.

Kodiak is proceeding with a plan proposed by Tryck, Nyman, and Hayes (1971) to solve the city's problems at the forecasted 1990 population level. Industrial wastes from the processing plants will be screened and the residues processed into protein concentrate for animal food. Screens are scheduled to be installed by mid-February 1974.[1] Domestic wastes will be collected by a separate system, treated, and discharged into Woody Island Channel. Kodiak has received a grant from the Environmental Protection Agency and construction is scheduled to begin soon.[2]

The U.S. Coast Guard station at Kodiak will be served by a system that will separate storm and sanitary sewers. This system is presently in the design stage and should be completed within several years.[3]

Sewage has been traditionally dumped into the nearest convenient water body in most communities in the study area. The Environmental Protection Agency, U.S. Public Health Service, and the Alaska Department of Environmental Conservation are developing plans to control the problem.

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1. Bill Lamoreaux, Alaska Operations Office, Environmental Protection Agency, Anchorage. Personal communication.

2. Stanley Brust, Alaska Operations Office, Environmental Protection Agency, Anchorage.

3. W.G. Colman, Chief, Engineering Branch, U.S. Coast Guard, Kodiak, personal communication.

The frequency of oil pollution incidents during development of the Cook Inlet oil and gas fields was estimated using 47 randomly selected aerial surveillance flights conducted during the height of development operations--June 1966 to April 1968 (Evans 1969). These flights were not made in response to any reported spills, but were merely routine patrols. Nine significant spills were discovered containing dark ropy masses of oil at least 0.3 sq. km. in area or 0.8 km. in length. Seven of the nine spills were considerably larger. These observations suggest that during development of offshore oil fields, significant amounts of oil can be found on the water approximately 20 percent of the time. Small patches of irridescent sheen were found on most flights (Evans 1969).

No in-depth studies of possible damage to the ecosystem were conducted during development of the Cook Inlet fields. The most serious known damage involved oil from an unknown source, which killed an estimated 1,800 to 2,000 sea ducks (Evans 1969).

Subsequent to development of the Cook Inlet oil and gas fields, the National Environmental Policy Act of 1969 has been enacted. The effectiveness of this legislation on future offshore operations in Alaskan waters has yet to be demonstrated.

Shipping operations can result in chronic spills in ports. The U.S. Army Corps of Engineers (1973) discusses the study conducted by Speyer and Tolkoff (1971) in Woman's Bay near Kodiak, an area where Navy and Coast Guard ships had been moored and fueled for about 30 years. This study concluded that the oil and fuel accumulated from years of seepage, tank cleaning, deballasting, and from normal shipping operations had made the soft muddy bottom in the vicinity of the Coast Guard pier relatively barren of marine flora and fauna, as compared to other areas within Woman's Bay.

Future Sources

Experience in Cook Inlet indicates that normal shipping can be an important source of accidental spills, either from ship collisions or human error in loading operations (U.S. Department of Interior 1970b). All of the larger spills resulted from these causes. Thus, even without development of petroleum resources in the Gulf of Alaska, there probably will be an increase of oil pollution incidents, if the current steady growth of ship traffic in the study area is maintained. A high percentage of this traffic handles petroleum products.

Production of oil from the Gulf of Alaska outer continental shelf also would increase the activity. Some information about the effects of oil production in the Gulf can be gained from experience in Cook Inlet, The Environmental Protection Agency is instituting a discharge permit system (Environmental Protection Agency 1973) that requires implementation of sewage treatment standards by July 1, 1977. Application of these regulations to small settlements may be difficult because of high costs, but wastes from canneries and industrial operations probably will receive adequate treatment by that date.[1]

Two major oil pollution incidents are known to have occurred recently in the study area. The Kodiak oil spill of 1970, presumably from a tanker discharging crude oil ballast, caused considerable damage to biotic resources as documented by the Federal Water Pollution Control Administration (U.S. Dept. of Interior 1970b). Effects from this incident were observed for nearly two months. Observers estimated that at least 1,600 kilometers of beachline were affected during the Kodiak incident. It also was estimated that an average of 16 dead birds was found per kilometer of beach inspected. At least 10,000 sea birds, mainly murres, auklets, guillemots, gulls, goldeneyes, and old squaws, were killed and washed up on beaches. No estimate was made of birds that might have been killed, but did not wash up on beaches. Numerous seals and sea lions were also reported to be covered by oil. No in-depth studies were conducted to appraise damage to lower life forms. Background studies recommended as a result of the investigation have not been carried out.

In March 1972, a tanker grounding at Cold Bay in the Alaska Peninsula released portions of its cargo of diesel fuel and gasoline into Cold Bay, an important habitat for fish and wildlife including brant and emperor geese (U.S. Coast Guard 1973). The total amount of fuel lost was about 4,600 barrels. An in-depth appraisal of possible damage to marine organisms was not made. No significant damage was documented and winds kept the oil from areas where birds concentrated.

During development of the Cook Inlet oil and gas fields, intermittent surveillance was conducted by several state and federal agencies (U.S. Dept. of the Interior 1970a). During the period between May 1966 and 1968, 122 oil pollution incidents were logged by various agencies conducting surveillance or responding to reports of spills. Only incidents were reported that involved "significant" amounts of oil with "significant" believed to be at least one barrel or more. Five spills were estimated to be more than 1,000 barrels, and several more were large spills of unestimated size. These spills resulted from pipeline breaks, tanker accidents, overfilling of tanks, leaks aboard platforms, and leaks and spills from various appurtenances aboard platforms and docks. Concentrations of mud sacks, pallet boards, and garbage also were observed frequently, but were not included in the list. The frequency of spills was greatest during the development phase of the Cook Inlet fields. By 1969, when most of the fields had been developed, the frequency of incidents dropped off significantly (U.S. Department of Interior 1970a).

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1. Steven Provant, Chemist, U.S. Environmental Protection Agency, Alaska Operations Office. Personal communication.

although there are differences between the two projects. For example:

1. Operations in the Gulf would be in deeper water, but would not be subjected to such tidal currents as are found in the Inlet;

2. OCS operations would be regulated entirely by the federal government, while Cook Inlet development is regulated by both federal and state agencies;

3. Surveillance and enforcement of regulations would be more difficult in the Gulf. Flying weather is adverse and major operating bases are distant. These difficulties are magnified significantly by the unreliability of forecasts; and

4. It is impossible to predict what special problems would be created by pipelines, loading facilities, or undersea completions due to uncertainties as to how oil would be produced and transported. It is not known whether platforms would be permanent or whether undersea completions would be utilized. Tankers could be loaded from offshore platforms or onshore facilities that would require feeder pipelines.

Oil spills in a developing and producing oil field can result from a number of causes including blowouts, minor emissions from wells and drilling platforms, pipeline breaks, spills during loading and offloading of tankers, cleaning of ballast tanks and deballasting of tankers, ruptures of tankers and ruptures of storage tanks ashore. It is difficult to estimate the amount of oil which could be spilled from such operations.

Kinney et al. (1970) estimate that 0.3 percent of the oil produced and handled in Cook Inlet ended up in the Inlet as effluents or spills. This is probably a conservative figure because it is based on estimated volumes of reported spills. Neither the amount of oil lost in unreported spills nor the results of offshore tanker operations is included in this estimate.

Hoult (1971) estimates that 0.1 of one percent of all oil transported or produced offshore is spilled on the sea. The U.S. Department of Interior (1972) includes a much lower estimate based on operations that would be comparable to the proposed trans-Alaska pipeline. Their estimates range from 0.007 percent forecasted for trans-Alaska pipeline oriented operations to 0.231 percent for worldwide operations, assuming non-use of "load on top" procedures on tankers.[1]

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1. "Load on top" is a procedure for management of "slops" (residual oil remaining aboard a tanker after its cargo has been unloaded). The purpose is to reduce the amount of oil wasted overboard during deballasting operations.

The Federal Water Pollution Control Administration, in their assessment of the 1970 Kodiak pollution incident (U.S. Dept. of Interior 1970b), made an appraisal of the handling of slop oil and tank cleaning residues from tankers serving Cook Inlet. They estimate the volume of slop oil to be 3,000 barrels for a 250,000 barrel tanker. At that time, at least, the practice was to dump slop oil at sea. This would represent a spillage of slightly more than one percent of the oil handled. If industry estimates of 100 barrels of slop oil per tanker are accepted, the loss would be .033 percent of the oil handled, assuming the average capacity of a tanker to be 300,000 barrels. Little use was apparently made on on-shore deballasting facilities at that time.

The U.S. Department of Interior (1970b) discusses in detail the problems of washing cargo tanks and disposing of the oily residues either at sea or into shore-based ballast treatment facilities. Although it is impossible to determine the exact amount of oil spilled into the ocean as a result of these operations, it is clear that it can amount to several hundred barrels per tanker per trip. Even under optimum conditions when all residual oil from tank cleaning and ballasting in cargo tanks is pumped ashore into ballast treatment facilities, a large amount of oil will still reach the sea. The best available treatment of cleaning water or ballast at Valdez will result in 10 parts per million of oil remaining in the effluent from the facilities (U.S. Department of Interior 1972). This will amount to about 12 barrels of oil per day when the trans-Alaska pipeline is operating at full capacity. The exact composition of the oil remaining in the effluent is unknown, but it seems likely that the soluble fractions would remain to be discharged into the sea. Kinney et al. (1970) estimate that crude oil under Cook Inlet conditions biodegrades at a relatively rapid rate. It is impossible to predict the biodegradation rate at Valdez, however, and also to predict the effect of this oil prior to biodegradation.

The potential for oil spills is somewhat greater if the possibilities of well blowouts are considered. Kash et al. (1973) state that OCS operations during the period 1953 to 1971 resulted in one blowout per 500 holes drilled. They also cite a U.S. Geological Survey study (U.S. Department of Interior 1971) for the same period that listed 19 blowout accidents resulting in personal injury or damage to property and the environment.

The U.S. Coast Guard[1] states that a policy established by presidential executive order will permit no further discharge of ballast at sea by U.S. registered tankers after 1980. If this policy becomes fully effective. it will do much to alleviate a large segment of the problem, but only where a large portion of the vessels are of U.S. registry.

Regardless of which estimates of quantities of oil spilled are more accurate, it is clear that a considerable amount enters the sea. Appraisal of the impact from oil pollution requires knowledge of how much oil will

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1. Lt. (jg.) David Binns, U.S. Coast Guard, Anchorage, Alaska. Personal communication.

be spilled, what kind of oil it is, where it will go, what resources will be affected, and how vulnerable these resources are to damage from the type of oil involved. Few data are available on which to base such appraisals.

Fluids used when drilling for petroleum may be toxic. Falk and Lawrence (1973a) investigated drilling and sump fluids. Drilling fluids were found to be acutely toxic to fish, while sump fluids were highly variable and generally lower in toxicity. It seems doubtful that waste drilling fluids would reach toxic limits on the outer continental shelf of the Gulf of Alaska. Falk and Lawrence (1973a) recommended, however, that toxic materials used during a drilling operation should not be released into water bodies without meeting a prescribed toxicity limit.

Flaring of gas from producing wells and burning off of sump pits has polluted the air in some areas (Evans et al. 1972). The Alaska Department of Environmental Conservation has established that operations on lands and waters under state jurisdiction must meet state air quality standards. These standards require that there be no significant degradation of air quality.[1] Jurisdiction of the outer continental shelf by the Environmental Protection Agency under the Clean Air Act of 1970 is in doubt.[2] This is presently being researched and a legal opinion is being sought.

Natural Sources

Many natural oil seeps are located along the Alaska Peninsula. Up to one-half barrel per day has been reported at one seep. The most active seeps are in the Kanatak area (Figure 52), where they are being studied and sampled by the U.S. Bureau of Mines. Preliminary results suggest significant oil is being introduced into surface waters, but it is not yet known how much is reaching the sea.[3] Hopefully, these Bureau of Mines studies along the Alaska Peninsula will continue and a quantitative evaluation of the effect and amount of the oil reaching the marine environment through natural processes may be possible.

Impact of Spilled Oil on Marine Biota

Dean (1968) pointed out that medium molecular weight, aromatic hydrocarbons have greater solubility and are more soluble than the heavier elements in crude oil. These toxic soluble elements would evaporate slowly

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1. Kyle Cherry, Alaska Department of Environmental Conservation, Anchorage. Personal communication.

2. Steven Provant, Chemist, Environmental Protection Agency, Anchorage. Personal communication.

3. Don Blasko, Mining Engineer, U.S. Bureau of Mines, Anchorage. Personal communication.

in the cold waters of the Western Gulf and their impact probably would last longer than in warm waters. The heavier tars and asphalts, while less soluble and less toxic, would not evaporate readily and would have more of a mechanical impact on such items as the feathers on birds.

The Offshore Oil Task Group of Massachusetts Institute of Technology (1973) summarized the impacts of petroleum derivatives on various groups of marine organisms. They emphasized the significant toxicity of the soluble aromatic derivatives, and stressed the high variability of results from studies, depending on type of oil, circumstances, and method of study. They have classified impacts of hydrocarbons on organisms into five categories as follows:

1. Lethal toxicity,
2. Sub-lethal disruption of physiological or behavioral activities,
3. Effect of direct coating by oil,
4. Incorporation of hydrocarbons in organisms which cause tainting and/or accumulation of hydrocarbons in food chains, and
5. Changes in biological habitats.

The first two categories refer to interference with cellular and sub-cellular processes. Effects of direct coating are the purely mechanical results that would occur from coating by any compound with physical characteristics similar to crude oil. Incorporation of hydrocarbons in organisms is important because of the potential for accumulation of carcinogens and tainting of human food supplies. These five categories are useful for analysis of the effects of crude oil on biota.

The Massachusetts Institute of Technology (1973) studies also provide a table interpreted from information of various other studies, which outlines the estimated toxicity ranges of certain general biotic groups. These estimated ranges of critical concentrations of crude oil in parts per million are as follows:

Flora	$10^4 - 10^5$
Finfish	$10^4 - 10^5$
Larvae	$10^2 - 10^3$
Pelagic crustaceans	$10^3 - 10^4$
Gastropods	$10^4 - 10^5$
Bivalves	$10^4 - 10^5$
Benthic crustaceans	$10^3 - 10^4$
Other benthic invertebrates	$10^3 - 10^4$

These data from the Massachusetts Institute of Technology studies plus other available data have been used to compile a table attempting to show the susceptibility of various biotic groups to injury from crude oil (Table 101). This table lists the biotic groups found in the Western Gulf of Alaska area (column one), characterizes their habitat (column two), and gives their areas and seasons of peak abundance where known (columns three and four). Column five is an attempt to show the vulnerability of each

TABLE 101 —— SUSCEPTIBILITY OF MARINE ORGANISMS TO INJURY FROM CRUDE OIL

BIOTIC GROUP	HABITAT	AREAS OF PEAK ABUNDANCE	SEASON OF PEAK ABUNDANCE	VULNERABILITY TO DAMAGE BY CRUDE OIL (by month) J F M A M J J A S O N D	REMARKS
Marine Bacteria	Pelagic - near surface	Near surface - near productive bays	?		Speculative & not highly probable
Phytoplankton - Diatoms predominant	Pelagic - near coast, near surface	Unimak area - peak populations eastward suppressed by zooplankton grazing	April - October		
Zooplankton and Micronekton	Pelagic - follow phytoplankton and may graze off population peaks	NE of Kodiak, SW of Shumagins	June - August		Speculative
Marine Macrophytes	Intertidal to 20 m. - eelgrass below low tide	Shallow lagoons - Cold Bay	Growing season		Mortality low unless contamination severe
Intertidal fauna - including clams	Intertidal or subtidal - clams on sandy beaches	Kodiak, Unimak	Yearlong		Vulnerability moderate
Clam Adults	Intertidal or subtidal - firm, wave-swept sand	Westward	Yearlong		Vulnerability low
Clam Larvae	Shallows	Westward	July - November		
Benthic Invertebrates	Depth variable (40-250 m.) bottom, type variable	Throughout	Yearlong		Low probability of impact owing to habits
King Crab - Adults	Inside bays & passages spawn in shallows & on continental shelf, Cook Inlet to Unimak Pass	Summer concentration S. of Unimak, S. and E. of Kodiak	Summer concentrations		Low probability of impact owing to habits
King Crab - Spawning	Shallows - subtidal to 100 m.	Same	March - May		
King Crab - Immature	Shallows	Same			
King Crab - Larvae	Semi-pelagic to benthic	Same	Semi-pelagic, March - July		
Tanner Crab - Adults	Abyssal plain to 2050 m. concentrate 50-130 m. late summer	E. Unimak, Unga Island - Pavlof, Alitak Bay, Marmot-Chignik Bays, Cape Douglas			Low probability of impact in deep water
Tanner Crab - Spawning	Shallows	Same	January - mid May		
Tanner Crab - Larvae	Semi-pelagic to benthic	Same	semi-pelagic, January - July		
Dungeness Crab - Adults	Shallows in summer, offshore in winter, firm sand, bays & ocean beaches, 46-96 m. or to 200 m.	S[illegible]mer concentration S. of Trinity Islan[illegible], [illegible]vor Bay, S. coast of Unimak	summer - shallow winter - deep		Low probability of impact in deep water
Dungeness Crab - Spawning	[illegible]ideline to 50 m.	Same	Late fall		
Dungeness Crab - Larvae	S[illegible]mi-pelagic to benthic	Same	Semi-pelagic, June - Dec		
Shrimp (4 species) - Adults	Pelagic, concentrate 60-210 m bays, surface at night	Alitak, Uganik, Marmot Bay, [illegible]pe Douglas, SE Kodiak, & Afognak, Stepovak, Pavlof & Balboa Bays	Yearlong		Low probability of impact in deep water
Shrimp - Spawning	Bays and islands	Same	August - September		
Shrimp - Larvae	Semi-pelagic and benthic	Same	Free swimming, February - July		
Scallops - Adults	Throughout Gulf, 60-180 m. mud, clay, gravel, sand	Portlock Bank, Marmot Flats, Albatross Bank, Beaver to Pavlof Bays	Yearlong		Too deep for tainting
Scallops - Larvae	Planktonic		June and July		
Pelagic Invertebrates - Squid	Intertidal and near shore subtidal	E and N Sitkalidak, small quantities	Yearlong		
Fish - non-commercial (23 families)	Varied habitats, surface to depth	Varied	Yearlong		Variable exposure depending on habits
Pollock - Adults	Daily vertical movement, benthic 75-265 m. near Kodiak, deeper on peninsula	SE of Kodiak on Albatross Bank	Yearlong		deep water - no exposure
Pollock - Spawning	Inshore shallows, eggs float near surface		March - May		
Pacific Cod	80-215 m, deep offshore waters in winter, pelagic eggs	S and E of Kodiak, Shumagin Islands	Eggs March - July		
Black Cod	115-550 m. eggs and immatures at surface	Dominant deep waters fish of peninsula	Spawn February - March		
Herring - Adults	Bays, inshore most of life cycle, Spawn along shore	Kodiak Bays and Shelikof Strait	Spawn April - May		damage to kelp would reduce spawning habitat
Herring - Larvae	Planktonic	Same	April - August		
Pacific Ocean Perch	Concentrate 160-250 m. down to 450 m., 20-60 m. above rocky bottoms & canyons	Seasonal migrations E. of Kodiak, S. of Unimak Canyon at Shelikof Strait	March - August		Deep water
Pacific Ocean Perch - Larvae	Demersal	Mainly in eastern gulf	April - June		Deep water
Flatfish (excluding halibut)	From less than 90 to more than 275 m. Spawning & juvenile life unknown	Shelf and slope E. of Kodiak and Western Peninsula			Deep water
Halibut - Adults	Most less than 90 m. to as deep as 1100 m.	Chirikof Island and NE of Kodiak, migratory			Deep water
Halibut - Eggs and Larvae	Midwater, drift to coastal shallows	Seward Gully, Trinity and Chirikof Islands	November - September		

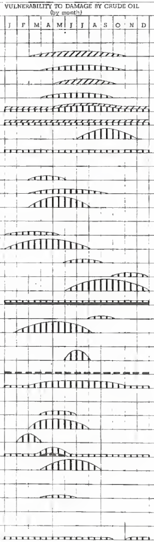
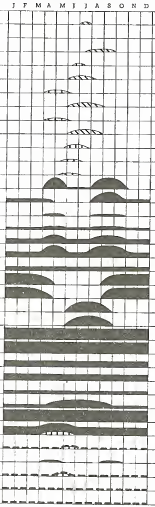


TABLE 101 (CONT.)

BIOTIC GROUP	HABITAT	AREAS OF PEAK ABUNDANCE	SEASON OF PEAK ABUNDANCE	VULNERABILITY TO DAMAGE BY CRUDE OIL (by month) J F M A M J J A S O N D	REMARKS
Chinook Salmon - Adults	Shallow waters	Chignik River and SW Kodiak	July		Possible interference with migration
Chinook Salmon - Immatures	2-4 years, feed on small fish, crustaceans and squid	Unknown	Unknown		Exposure uncertain
Coho Salmon - Adults	Shallow waters	Chignik	Mid July - September		Migration
Coho Salmon - Immatures	1-2 years, feed on small fish, crustaceans and squid	Unknown	Unknown		Exposure uncertain
Chum Salmon - Adults	Abundant throughout, shallow waters	Southeast Kodiak, Unimak, NW of Shumagins	June - early August		Migration
Chum Salmon - Immatures	As much as 4 years, feed on small crustaceans	Unknown	Unknown		Outmigrant fry
Pink Salmon - Adults	Shallow waters	Throughout	June - August		Migration
Pink Salmon - Immatures	1.5 years, feed on planktonic crustaceans	Unknown	Unknown		Outmigrant fry
Sockeye Salmon - Adults	Shallow waters	Abundant throughout	June - August		Migration
Sockeye Salmon - Immatures	1-4 years in salt water. Feed on planktonic crustaceans	Unknown	Unknown		Smolts migrate at surface
Trout and Char	Unknown - general distribution in shallow water	General	Spawn mid-July to mid-September		Exposure uncertain
Steelhead	Widely distributed offshore	Karluk, Ayakulik and Chignik Rivers	Late summer to early autumn		Exposure uncertain
Black Brant	Bays with eelgrass and other vegetation, maritime feeders	Western peninsula	Autumn, Spring		No data to adequately assess possible habitat damage
Emperor Geese	Bays with eelgrass and other vegetation, maritime feeders	Western peninsula	Autumn, Winter		No data to adequately assess possible habitat damage
Canada Geese	Occasionally along coastal beaches	Not common	Autumn, Spring		No data to adequately assess possible habitat damage
Puddle Ducks (mallard, teal, pintails, baldpates)	Bays, marshes, river mouths; sometimes feed on salmon carcasses	Throughout, some yearlong	Autumn - Spring		No data to adequately assess possible habitat damage
Diving Ducks (Scaup)	Bays, shallows, protected waters; marine feeders	Throughout, some yearlong	Autumn - Spring		No data to adequately assess possible habitat damage
Sea Ducks (eiders, scoters, old squaws, harlequins)	Bays, estuaries, sometimes unprotected waters; marine feeders	Throughout, some yearlong	Autumn - Spring		No data to adequately assess possible habitat damage
Mergansers	Bays, estuaries, marine feeders	Throughout, some yearlong	Yearlong		No data to adequately assess possible habitat damage
Loons	Bays, estuaries, marine feeders	Throughout, some yearlong	Fall and Winter		No data to adequately assess possible habitat damage
Grebes	Bays, estuaries, marine feeders	Throughout, some yearlong	Fall and Winter		No data to adequately assess possible habitat damage
Albatross	Surface of open ocean and occasionally tiderips	Peninsula	Summer		No data to adequately assess possible habitat damage
Tubenoses (Shearwaters, fulmars, petrels)	Channels, passes, marine feeders	Shelikof and Marmot Straits, Unimak	Summer		No data to adequately assess possible habitat damage
Storm petrels	Channels, passes, marine feeders	Unknown	Yearlong		No data to adequately assess possible habitat damage
Cormorants	Coastal waters, dive for food	Kodiak, Katmai	Yearlong		No data to adequately assess possible habitat damage
Oystercatchers	Intertidal	Alaska Peninsula and Kodiak	Yearlong		No data to adequately assess possible habitat damage
Shorebirds	Intertidal or marine - mud flats	Alaska Peninsula and Kodiak	Yearlong		No data to adequately assess possible habitat damage
Jaegers	Partly marine feeders on open waters	Alaska Peninsula and Kodiak	Yearlong		No data to adequately assess possible habitat damage
Gulls and Terns	Colonial nesters, partly marine feeders	Alaska Peninsula and Kodiak	Glaucous-winged yearlong, other summer		No data to adequately assess possible habitat damage
Auks, murres, puffins	Colonial nesters, totally marine feeders, open waters	Alaska Peninsula and Kodiak	Yearlong		No data to adequately assess possible habitat damage
Sea Otters	Offshore reefs and kelp beds to 75 mm. depth	Throughout	Peak pupping, April - June		Significant matting of fur eliminates insulation
Steller Sea Lion	Shallow waters - feed on fish	Throughout	Pupping in June		susceptibility appears slight
Northern Fur Seal	Migrate about 150 miles offshore	Not abundant	Spring, Autumn		
Harbor Seal	Water to 55 m. - along bars, beaches low rocks	Throughout	Pupping late May, early June		
Toothed Whales	Mostly offshore	Unknown	Unknown		
Baleen Whales	Mostly offshore	Unknown	Mostly summer		



KEY TO EFFECTS

- Lethal toxicity
- Sub-lethal disruption of physiological or behavioral activities
- Effects of direct coating by oil
- Incorporation of hydrocarbons in organisms which cause tainting and/or accumulation of hydrocarbons in food chain.
- Changes in biological habitats

group on a monthly basis in conformity with what is known of their life history. The category of impact is shown by the various bar patterns and the thickness of the bar indicates the estimated severity of the impact. A thin bar indicates a relatively low impact.

A brief discussion of the susceptibility of various biotic groups follows:

Marine Bacteria. Crude oil can be a food for certain marine bacteria (Kinney et al. 1969, Friede et al. 1972). Friede et al. (1972) suggest the possibility that some carcinogenic petroleum hydrocarbons could be concentrated by bacteria and passed up the food chain.

Phytoplankton. Although the Massachusetts Institute of Technology (1973) study reports that most zooplankton are filter-feeding crustaceans commonly found on the surface layers of coastal waters. They would, therefore, be subject to concentrations of oil-water emulsion. Friede et al. (1972) also point out that zooplanktonic filter feeders may also concentrate carcinogenic compounds and pass them up the food chain or deposit them on the bottom as fecal pellets.

Marine Macrophytes. Little is known about the effects of oil on marine macrophytes. Templeton (1972) stated that plants covered with oil produce new shoots unless the plant bases and surrounding soil have become contaminated. Individual seedlings and annuals rarely recover. Overall effects appear moderate.

Intertidal fauna. The Massachusetts Institute of Technology (1973) report discussed findings from a number of studies that showed highly variable effects in this group. Susceptibility appears low in bivalve molluscs and periwinkles. Some groups, such as limpets, have a high susceptibility even at low concentrations of oil.

Clams. Blumer et al. (1970) reported prolonged tainting of commercial clams resulting from a spill of fuel oil. Massachusetts Institute of Technology (1973) treated larvae as a single group with relatively low resistance to the toxic effects of oil.

Benthic Invertebrates. This group contains many species and forms living in various habitats. Most are in deep water and are assumed to be relatively invulnerable to oil. Egg and larval stages of many species, however, float on the surface or with the current and would be vulnerable (Wilber 1959).

Crabs. Most adult crabs are deep water dwellers most of the year and are assumed to be relatively immune to damage. An exception is the Dungeness crab, which moves into shallow water during the summer. Also during spawning, crabs move into shallows and their exposure would increase at that time.

Some heavier fractions of oil may sink to the bottom (Friede et al. 1972), where they remain for some time and could taint shellfish. Instances have been cited where shellfish were tainted and their marketability reduced by exposure to even slight amounts of oil (Blumer et al. 1970, Wilber 1969). No such instance has been reported in Cook Inlet, where active crab fisheries have undoubtedly been exposed (Kinney et al. 1969, Evans et al. 1972).

Larvae are assumed to be vulnerable during the period when they are pelagic. Immatures also probably would be vulnerable in shallow water. The National Marine Fisheries Service is conducting studies of the toxic effects of crude oil on tanner crab.

Shrimp. All important species in the Western Gulf of Alaska prefer depths of 60 meters or deeper, except for a vertical migration toward the surface at night. At this time they would be more exposed and more vulnerable. Shrimp are most vulnerable in the larval stage. A catch of shrimp at Kodiak was reported to be coated with oil during the 1970 Kodiak oil spill incident (U.S. Department of Interior 1970b). The effect of sinking oils on the marketability of shrimp in the Gulf of Alaska is not predictable, although shrimp could be tainted, particularly during their nocturnal migrations toward the surface.

Scallops. Blumer et al. (1970) cite serious and long-lasting tainting of scallops as a result of a spill of fuel oil near West Falmouth, Mass. Since Gulf of Alaska scallops prefer depths greater than 60 meters, it seems unlikely that many of them would be affected. The planktonic larvae would be the most vulnerable stage for scallops.

Pelagic invertebrates (squid). The Massachusetts Institute of Technology (1973) report indicates pelagic crustaceans are moderately vulnerable to toxic effects of oil. Although the direct effects on squid are unknown, the oil presumably would affect their food supply.

Fish, Noncommercial. Numerous species in the 23 families of noncommercial fish use various habitats ranging from the surface to considerable depths. Most of the deep water species probably would be relatively immune to the effects of oil. A species living in shallow water, either permanently or during a shallow water stage of its life cycle, could be susceptible. Wilber (1969) quotes Gutsell (1921) as follows: "The eggs of sea fishes which do not seek fresh, brackish, or shore waters in which to spawn, differ from the eggs of all these and of fresh water species in that they are typically floating. In many cases, at least, the larvae for a time are also floating." Most of these species would thus be susceptible to damage from oil at some stage in their life cycle.

Pollock, Pacific Cod, Blackcod, Pacific Ocean Perch, and Flatfish. These are all benthic forms living in deep water. They would be vulnerable only for short periods during spawning and in the larval stages.

Herring. This shallow water species spends most of its life cycle near shore. Planktonic larvae and spawning adults are particularly susceptible to toxic effects (Kunhold 1970). Their spawning activities would also be affected if the kelp upon which they deposit their eggs were damaged.

Salmon. Salmon adults are usually found in shallow habitats and could be affected by toxic elements in the water. Rice (1973) indicates that crude oil could upset salmon migration patterns by upsetting olfactory senses. If this were to unduly delay spawning migration, it might cause heavy losses to an entire year class. Smolt and fry migrate in shallow water and would be highly vulnerable. On the other hand, Rice (1973) also demonstrated that pink salmon fry avoid crude oil and might escape its effects if an alternative migration route were available.

Trout, Char, and Steelhead. Not enough is known of the habits of these species to appraise their vulnerability. Presumably, they would be similar to salmon.

Birds (general). Erickson (1963) and Aldrich (1970) describe the effects of oil on birds. Oil mats their feathers, reducing their buoyancy and insulation ability. Not only is the affected bird chilled and hindered in its mobility, but it may, while preening, injest some oil and be subject to its toxic qualities. Birds cannot recognize oil spills and avoid the danger. Birds whose habits bring them into closest contact with oil would be most susceptible.

Black Brant and Emperor Geese. These are entirely marine feeders and would be highly vulnerable to losses from the mechanical effects of oil.

Canada Geese and Puddle Ducks. To the extent that these species are less oriented to marine habitats, they would be less susceptible than emperor geese and brant.

Diving Ducks. These species use the Western Gulf all year, but nest in fresh water. They would be most vulnerable in fall, winter, and early spring when they are on salt water.

Sea Ducks. Except for nesting of scoters and the harlequin duck, sea ducks are entirely maritime in habit and would be vulnerable most of the year. The greatest numbers of these birds would be in the study area during spring and fall migration.

Mergansers, Loons, and Grebes. These species nest on fresh water and winter on salt water. Their vulnerability would be similar to that of the diving ducks.

Albatrosses. These birds are found in the Western Gulf in summer and could become trapped in any oil spilled in their feeding areas, particularly in tide rips, where both spilled oil and birds tend to concentrate.

Tubenoses and Storm Petrels. These birds are totally marine feeders and would be highly susceptible to mortality from oil.

Cormorants. Although the double-crested cormorants sometimes nests in fresh water, the two other cormorant species found in Alaska nest adjacent to marine habitats. In winter, all feed on exposed open water and could be caught in spilled oil during that period.

Oystercatchers and Shorebirds. Birds of this group feed in the intertidal zone and could be affected by oil washing ashore.

Jaegers. All the jaegers are associated with salt water, the parasitic and pomarine jaeger more so than the long-tailed which nests inland. These birds do not feed on the water but could come in contact with food contaminated by oil. Their risk of exposure to oil is not as high as marine feeders.

Gulls and terns. Birds of these groups that nest in colonies adjacent to salt water or that winter on salt water would be highly vulnerable to oil pollution.

Auks, Murres, and Puffins. These birds spend all their time in or on salt water, except for periods they are engaged in nesting activities. This group is probably the most susceptible of all birds to losses from oil.

Sea Otters. A sea otter depends on the cleanliness of its fur for warmth; consequently, anything that would mat its coat could be fatal. These animals spend their entire lives in salt water and could suffer high mortality from spilled oil.

Other Marine Mammals. Straughan (1973)[1] reports no detectable damage to sea lions or elephant seals as a result of oiling during the Santa Barbara oil spill. Marine mammals of the Western Gulf of Alaska, with exception of sea otters, are assumed to be relatively resistant. Nursing young, however, might ingest toxic quantities and suffer damage. Any loss of food supplies would be injurious to their populations.

Special Circumstances. Species at the end of their range, already stressed by environmental conditions to which they are not well adapted, and species already harvested at or beyond their limit, could be particularly vulnerable to any additional stress. Also, the use of chemical dispersants, a possible side effect of spilled oil, could be injurious to marine biota.

Impact of Spilled Oil on Upland Biota

A combination of storm and high tides could drive oil onto coastal marshes and beaches and could cause losses in such groups as puddle ducks and shorebirds. A large number of terrestrial mammals such as mink,

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[1] Testimony by Dr. Dale Straughan before the Council of Environmental Quality, Anchorage, Alaska, September 26, 1973.

weasel, river otter, fix, muskrat, beaver, deer, bear, and otter could be exposed to oil, either directly or through their food supply. Impacts from such contact probably would not be severe, but damage to their habitat could be significant. Repeated severe contamination could eliminate important habitats. Chronic low level pollution could also alter habitats to a presently unknown degree.

Other predominantly terrestrial species which occasionally contact salt water while feeding, such as eagles, falcons, and some hawks, also could be affected.

OTHER IMPACTS OF INDUSTRY ACTIVITIES

Impact on Fisheries

Presently, the only major industry in the study area is fishing, and conflicts with other industries are at a minimum. If another large industry, such as the petroleum industry, were to move into the area, certain impacts and conflicts with the fisheries might arise.

Ships and boats needed to support petroleum activities would considerably increase traffic in the area, causing additional navigational hazards to the fishing fleet. This increased traffic also would increase competition for the already overcrowded port facilities, requiring construction of additional facilities. Kodiak harbor is the major port in the area and is already overcrowded, although a new small-boat harbor is planned for the near future.

Petroleum development activities would take up space in the marine environment now being used for fishing activities; this problem is discussed by the U.S. Department of the Interior (1973). Allowing for a navigation safety zone, it is estimated that each platform would occupy 8,000 to 20,000 sq. meters (two to five acres). Other obstructions, such as unburied pipelines, seafloor completions, wellhead stubs and debris, could be a hazard to trawling operations.

Petroleum developments in various bays of the study area, such as along the southeast coast of Kodiak Island, Chignik Lagoon, and Pavlof, Canoe, Beaver or Balboa Bays, also could interfere with fishing activity. A case in point is a proposal by industry to run pipeline from the north side of the Alaska Peninsula to a tanker-loading facility in Canoe Bay.[1] Such potential conflicts should be studied before any development begins.

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1. Glen Davenport, Area Management Biologist, Commercial Fish Div., Alaska Department of Fish and Game, Cold Bay, Alaska. Personal Communication.

Activities on all navigable waters would be by permit from the U.S. Army Corps of Engineers. Applications for Corps permits are circulated to all interested parties for comments and recommendations. Such recommendations may be included in the permit as stipulations to protect affected resources. In some cases permits may be denied.

Gravel extraction from streams could affect fish spawning habitats. Where anadromous fish streams are involved, such activities would require a permit from the Alaska Department of Fish and Game, which would include stipulations for protection of fish resources. Similar activities on other streams and on tidelands require a permit from the Alaska Department of Natural Resources. The proposal would then be reviewed by the Alaska Department of Fish and Game, which would recommend stipulations.[1]

Spilled oil can have direct impact on fishing activities. During the development phase of the Cook Inlet oil field, fishermen frequently complained that even a thin film of oil on their nets rendered them stiff and difficult to handle and accelerated deterioration. The 1970 Kodiak incident also resulted in oiled gear. In the autumn of 1970, a shrimp fisherman reported his trawl had picked up a tar-like substance that contaminated his shrimp catch (U.S. Department of the Interior 1970).

The major conflicts presented by marine geophysical surveys result from the use of high velocity explosives and the direct disturbance of fishing activities. Surveys using high velocity explosives, such as dynamite, Nitromon, or Geogel, have resulted in mortality to fish under varying circumstances. Falk and Lawrence (1973b) discuss both refraction and reflection surveys conducted with a variety of devices including vibroseis, dinoseis, flex-o-gun, pan air gun, seismogen air gun, aquapulse, and sparker. They experimented with various charges and determined that air guns are relatively harmless to fish. This is substantiated by experiments conducted by Wienhold and Weaver (1972) on coho salmon in Alaska. Surveys are now being conducted successfully without explosives, and there is little indication that explosives will be used in the Gulf of Alaska (Alaska Oil and Gas Association 1973).

Conflicts between seismic operations and fishermen can be minimized by planning surveys outside the neighborhood of fishing activities. Such coordination and planning probably could have avoided the recent (September 1973) incident in Kachemak Bay, where seismic boats became entangled in and destroyed crab pot floats. A review of proposed programs by the Alaska Department of Fish and Game or the National Marine Fisheries Service should minimize such problems.

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[1]Jay Bergstrand, Assistant Chief, Habitat Section, Alaska Dept. of Fish and Game, Anchorage, Alaska. Personal communication.

Perenosa Timber Sale, Afognak Island

Although the Afognak timber sale is not directly related to petroleum activities in the area, it is discussed here in some detail because it does reflect the problems to be encountered when new developments by a major industry occur.

Afognak Island covers 458,800 acres and is one of the larger islands in the Kodiak Group. It possesses the general geomorphic characteristics of the Kodiak Mountains described earlier, but it is more moderate in relief than Kodiak Island, with slopes of about 30 degrees or less. Most precipitation is rain, which averages 150 cm. (60 inches) on the eastern coast. Less rainfall occurs in the western part of the island, while higher elevations receive more. Snow occurs in variable amounts between November and April. Drainage is generally deranged due to past glacial activity. Soil development has been minimal since the last glaciation, and soil depths vary between 46 and 92 cm. Organic soils are present in muskeg areas (U.S. Forest Service 1973).

Afognak is one of the few forested islands in the Western Gulf area. The northern third of the island is completely forested, while the southern two-thirds are less densely covered. Interior portions of the island and other nonforested areas (western parts of the island) are covered with grasses and forbs with patches of alders and willow; 278,500 acres (1,100 sq. km.) are forested while 180,300 acres (730 sq. km.) are unforested. Most commercial timber is between sea level and 150 m. in elevation and within 2.5 km. of tidewater. The forest is essentially pure Sitka spruce--a very unique condition for this northwestern location.

Briefly, fish and wildlife resources of the island include crab, shrimp, and halibut in offshore waters as well as trout and salmon (pink, coho, chum, and some sockeye and chinook) in the streams. Also present are Roosevelt elk (the only elk herd in Alaska, which consists of approximately 450 animals although the population is now declining), Sitka black-tailed deer (perhaps 1,100 animals), brown bear (population unknown) and such mammals as land otter, marten, beaver, red fox, muskrat, voles, shrews, squirrels, and hares. Birds inhabiting Afognak include willow ptarmigan, waterfowl, shore birds, and the rare and endangered bald eagle, peregrine falcon, and osprey. All of the above fauna are found within the sale area. Elk, salmon, and some eagle surveys have been made on the island, as well as very general habitat location and description surveys for these and certain other species.

The proposal to sell timber on Afognak Island resulted from a study by a task force appointed by Alaska Governor Walter J. Hickel in the mid 1960s. The reported goal of the study group was to recommend likely ways of further utilizing Alaskan timber resources, broadening

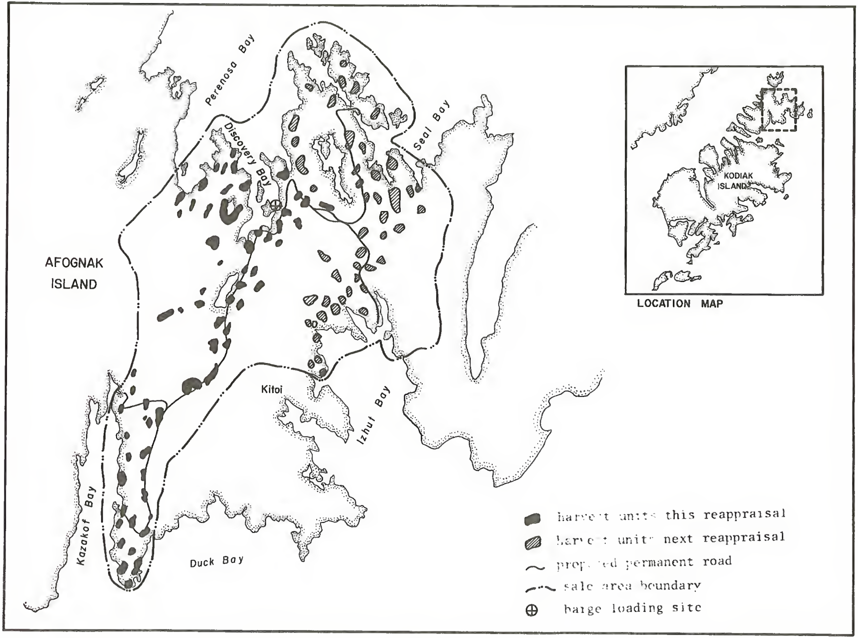

Figure 17?. Proposed Perenosa Timber Sale, Afognak Island (from U.S. Forest Service 197?).

and diversifying the economic base, and providing employment for Alaskans. It was decided in 1967 that a timber industry centered around the Kodiak Island group should be initiated. The U.S. Forest Service then began to plan for the development of the Afognak timber resource (U.S. Forest Service 1973). The task force felt that timber sales on other islands within state and local jurisdiction (Shuyak and Kodiak Islands) also could be planned at an appropriate time.

The Perenosa Timber Sale, involving 525,000 MBF[1] of Afognak Island forest, was offered at oral auction by the U.S. Forest Service on June 4, 1968. The sale was awarded at a high bid of $27.05/MBF. The appraisal value was $4.35/MBF. During the remainder of 1968 and into 1969, the export market for log cants dropped and the original purchaser did not develop the sale. On July 15, 1969, the sale was assumed by another timber company. Export markets have since improved, and the present sale operator now wishes to proceed with the resource harvest.

The Forest Service has revised the original scope of the sale and reduced the total sale volume, reportedly to preserve elk habitat, to protect crab rearing areas along the shore, and to reduce clearcut acreage. The scope of the present sale is summarized on Figure 177 and Table 102.

A clearcut silvicultural system, using high-lead logging techniques, will be used almost exclusively. Some tractor logging may be done experimentally or where local soil or freezing conditions permit. Of the 200 km. of proposed logging road, approximately 75 km. will become high grade roads suitable for tourist and recreational use. Logs will not be stored in offshore waters, but will be decked on land and barged to a sawmill, presumably somewhere other than Afognak Island (U.S. Forest Service 1973).

TABLE 102

Perenosa Timber Sale information, revised proposal (from U.S. Forest Service 1973).

Total sale volume, MBF[1]	332,329
Total clearcut acres logged	12,074
Total number of clearcut units	121
Average clearcut unit size (acres)	100
Maximum unit size	228
Smallest unit size	34
Logging road mileage	140.3
Logging period, years	10
Volume logged per year, MBF	32,200
Acres logged per year	1,200

Note: The recomputed stumpage price for the sale is near $19.00/MBF.

1 MBF = thousand board feet of lumber, where a board foot is arbitrarily one 12 in. x 12 in. x 1 in. piece of wood.

There is considerable controversy over the Perenosa timber sale. Objections to the harvest of this timber resource can be divided into environmental, fish and wildlife, and socioeconomic concerns and are discussed below.

Soil erosion is the greatest environmental concern pertaining to the Perenosa sale. Volcanic ash soils underlie the organic soil layer. Once this duff layer is removed, the ash soils are subject to erosion by wind and water runoff. This may be especially critical where logging or road building is planned on steeper slopes or near streams.

U.S. Forest Service and other silviculturalists are also concerned with the potential of Sitka spruce to regenerate following logging operations. Comparatively poor restocking and regeneration occurred following logging around Kazakof Bay during World War II (Harris 1972) and following an insect kill in the Discoverer Bay area in the 1930s (U.S. Forest Service 1968). This is believed to be due to the intense competition seedlings received from grasses and forbs. The Afognak situation may be similar and is further complicated by the island's nutrient-deficient soils (particularly in growth-important nitrogen). Replanting spruce seedlings may be necessary to achieve desirable stocking after logging. To aid restocking, the mechanical removal or chemical destruction of competing plants could be used, but this action could cause further erosion problems and chemical poisoning of the soil, fish, and wildlife in the area. Reproduction since 1955 on sale areas in the Raspberry StraitAfognak Strait area has been quite satisfactory, however, and mechanical or chemical planting or treatment is not anticipated at this time.[1]

Logging slash disposal methods are another concern that have been questioned with allegations that insect infectations may threaten developing seedlings and surrounding healthy trees. Still another concern involves possible air and water pollution from sawmills.

Logging also will disturb and displace some fish and wildlife. With good harvesting practices, wide leave strips along streams, and careful road layout, damage to fish and wildlife habitats could be minimal. The fear of damage to Afognak's commercial fishery due to poor harvesting practices has caused many people in the Kodiak area to oppose the sale. Poor logging practices could block salmon migrations and destroy the water quality of the spawning streams by siltation or increased water temperature.

The effect of timber harvest on the elk population is unknown. Elk require some forest cover on their habitat range, but U.S. Forest Service personnel believe that the sale will benefit the elk population by providing more browse production and edge effect. Other observers fear that the removal of the forest cover will cause further reduction

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[1]Richard Woodrow, former Acting Forest Supervisor, Chugach National Forest, U.S. Forest Service, Anchorage, Alaska. Personal communication.

of an already declining population. The brown bear population on the island is unknown. Some fear that logging activity will increase bear-man conflicts. The incompatability of these animals with man, combined with a likely increase in hunting pressure, may cause a decline in the bear population. The effect of the timber harvest on the deer population, as well as small mammals in the food chain, is also unknown; experience elsewhere indicates that the effects should be minimal or perhaps enhancing.

The U.S. Forest Service is attempting to protect the habitat of rare and endangered peregrine falcons which migrate through the sale area, but some feel these efforts may be insufficient.

In summary, it can be stated that some adverse effect on fish and wildlife and an associated population decrease of some species will occur with the timber harvest and increased human use of the area.

Much of the conflict between Afognak resource users centers around the socioeconomic aspects and implications of the sale. Economically, many people (not only Kodiak area residents) question foreign money interests, such as Japanese, harvesting Alaska resources and selling them abroad, particularly when national and local wood demand and prices are quite high. The U.S. Forest Service claims that this is an opportunity to reduce the United States balance of payments deficit. Many Kodiak area residents feel that the taxes received from sale receipts will not pay the costs of increased services and school facilities that will be needed to accommodate the estimated 50-120 new jobs created. Local residents state that they do not want to pay this added burden. The sawmill will increase demand for power, and there is some concern over potential business and residential energy shortages if the sawmill is located in Kodiak. Concern also has been voiced over cost/benefit and economic profile computations in view of the rotation age (110 years) and the use of Chugach Working Circle statistics rather than local data alone.

With logging, the island will lose its wilderness and primitive character. The U.S. Forest Service maintains that several nearby areas (Kodiak National Wildlife Refuge, Katmai National Monument, Nellie Juan Wilderness Study Area) provide adequate wilderness. Some who disagree maintain that their personal recreational areas will be lost with greater use of the island. Clearcut patches are also opposed on aesthetic grounds, even though the U.S. Forest Service considers it necessary from a biological and economic standpoint.

Another objection to the sale arises from Koniag, Inc. and village corporations selecting land pursuant to the Alaska Native Claims Settlement Act of 1971 (PL 92-203). Villages presently qualified to select land on Afognak Island within the sale area could choose as much as one-third of the sale area. Other villages are alleged to exist by the Native corporations and, if certified, most of Afognak Island might be selected under the terms of the Act. The U.S. Forest Service is protesting the qualification of some of these additional villages.[1] Koniag, Inc. and villages of Afognak Island oppose the sale primarily on fishery, environmental, aesthetic, and ethnic-historical grounds. Even though these corporations would receive the financial return (after costs) of the sale, they question the dollar value in relation to other values which might be lost. In essence, local residents and Native groups question how such a sale and resultant development might affect their quality of life. All 12 individuals who testified at the August 1973 public hearing in Kodiak on the Draft Environmental Statement for the Perenosa Sale, opposed the sale.[2]

Data Gaps

Some feel that several things pertinent to the understanding of the sale area and the impact of the logging operation are poorly known and need to be better understood. A detailed soil survey has not been made, and the consequences of removing the duff layer and exposing the erodable soil have not been determined on Afognak. The U.S. Forest Service maintains that harvesting in the Afognak Straits area has not created any erosion problem and likewise shouldn't on Afognak. More detailed fishery and wildlife surveys might be necessary for factual impact analysis, yet, the U.S. Forest Service feels that the data are adequate.

Finally, the relationships between socioeconomic costs and benefits have not been satisfactorily related to the local people.

Impact on Quality of Life and Aesthetics

The study area is largely rural and much of it is undisturbed wilderness, showing little evidence of man's activities. More than 16,000 sq. km. (4 million acres) are in permanent status as National Forest, National Monument or National Wildlife Refuge. These areas are managed by agencies with responsibility for considering at least a portion of these lands for primitive and wilderness status under the Wilderness Act of 1964 (Public Law 88-577). Additional lands are withdrawn under the Alaska Native Claims Settlement Act of 1971 (Public Law 92-203) for possible inclusion into one of these management systems. The rugged coastlines and numerous bays and islands are a spectacular landscape.

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[1] John Raynor, Timber Management Assistant, Chugach National Forest, Anchorage, Alaska, and Gordon Edgars, former Acting Timber Management Assistant, Kodiak Work Center, Chugach National Forest, Kodiak, Alaska.

[2] Gordon Edgars, Ibid.

Outside of the City of Kodiak (80 percent non-Native) and Cold Bay (mostly non-Native), most of the residents of the study area are Native--Unalaska Aleuts to the west and Kaniagmiut Eskimos to the east. These village people are predominately maritime (Hickok 1968). Hickok (1968) emphasizes that the Aleuts depend on their knowledge of the sea for a livelihood.

To a large extent this is also true of the Kaniagmiut, although they are converting more rapidly than the Aleuts from a subsistence economy to dependence on the commercial fishery. To these people, the sea is a way of life that has undergone only gradual change for generations.

Arnold (1968) described village Alaska with all its economic, educational, health, and service problems. He summarized as follows: "Village Alaska will persist because of circumstances and choice. What this means is suggested in the remarks (relating to American Indians generally) of an Indian Association spokesman." Arnold then goes on to quote Munschenheim[1] as follows:

> "I am never surprised, but always dismayed, when well-meaning but poorly informed people ask why do not the Indians integrate themselves more effectively into the general society...to reply simply that probably they'd rather not, or, contrariwise, that they do not have the opportunity to integrate, would not, either way, properly answer the question. Nor would it be very informative to reply that for the most part they do not have the op portunity and that, in any case, they have strong attachment to their own cultural heritage and are understandably ambivalent in their reactions to the alien society which has engulfed them. This is, it seems to me, a reasonable statement of the case, but it is quite meaningless to anyone who is unfamiliar with the values on the one side of the equation, namely the character and quality of the cultural heritage to which Indians are attached."

The primitive maritime lifestyle of Native residents in the study area seems well established. The adherence of the approximately fifty non-Natives in the villages and the non-Native residents of Kodiak and Cold Bay to such a lifestyle is more difficult to appraise. Most of the military are transient and any impact on them would be temporary. Many other non-Natives are, however, permanent or semi-permanent residents of the area. Perhaps they feel this same quality of life compensates for generally low incomes, inconveniences, and high priced manufactured goods.

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[1]Carl Munschenheim, "The National Significance of Indian Health," speech delivered before the Fourth National Conference on Indian Health, Nov. 30, 1966.

Steinhoff (1969) in a study of the value of wildlife and related recreation on the Kenai National Moose Range, analyzed how Alaska residents rated the values of accessibility, facilities, wilderness, wildlife, and scenery. He determined that 76 percent of the Alaska resident respondents to his questionnairee listed the Moose Range as one of the factors that induced them to stay in Alaska. Knight and Hornocker (1970) found that a large preponderance of Idaho residents listed similar amenities of environment, open space, hunting and fishing, and outdoor recreation as their major reasons for remaining in Idaho.

Pearse (1971) in discussing the proposal for an international Arctic Wildlife Range, emphasized the non-industrial values that, though difficult to measure, must be recognized and equated with industrial values. Large expanses of wilderness with its wildlife and the existing way of life of the Native people are among these values. He emphasized that once destroyed, neither can be reconstructed.

Weeden (1969) suggested that petroleum development could be carefully controlled and could provide economic benefits to the state with minimum disruption of these values. He stressed that this would require a rigid acceptance of a middle course of restrained development which has not yet been achieved in Alaska. Petroleum development in the Cook Inlet area has had considerable impact on these non-industrial values (Evans 1969). Even an oil rig in Shelikof Strait, for example, would have significant impact on the many miles of shoreline of the Katmai National Monument and would destroy the wilderness character of the area. The haste to explore the Arctic Slope oil fields has also led to the visual and erosional impact described by Brooks et al. (1971). The "Hickel Highway," pushed through the Brooks Range without advance notice, consideration of impact on other resources, or consultation with affected peoples, is a case in point. The Natives of the Arctic Slope, and Anaktuvuk Pass in particular, are most concerned about the effect this type of access will have on their way of life (Upicksoun 1973). Norgaard (1972) believes that the major costs to Alaskans of petroleum development will be in terms of wilderness, hunting and fishing, and outdoor recreation--the amenities that have great value to many of the state's citizens.

Even if not a drop of oil is spilled, there still will be roads, increased traffic, construction of shore-based facilities, removal of construction materials, and new population centers. All these will have tremendous impact on the aesthetic and wilderness character of the study area. These activities plus the lure of jobs (however transitory), the probable increased cost of living, and the unplanned access to the land, all will cause changes in the lifestyle of village Alaskans within the study area. Whether or not these changes are desirable in the long run, they will, as Pearse (1970) has pointed out, be irreversible. Arnold (1968) indicated that they may be undesirable, particularly if they occur too rapidly.

While impacts of petroleum development on quality of life and aesthetics can be predicted fairly reliably, little information is available to determine the quality of life that Alaskans desire or how to evaluate it. Neither do we know how to evaluate the aesthetic and wilderness values of a landscape. Because they are so seriously affected by industrial development, these values should be studies as carefully as the natural biotic systems that will be affected.

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XI. DATA GAPS

INTRODUCTION

Except for local areas, little environmental information about the study area is available. The amount of detail available varies with the topic, location, and time of year of observations. There are enough data to provide an overall understanding of the study area, but detail is insufficient to provide an adequate baseline for evaluating change which might result from a few of the more significant data gaps discussed below.

GEOMORPHOLOGY

Perhaps the most significant lack of data under this category is the absence of detailed bathymetry over most of the shelf. Areas around Kodiak and other islands and along the Alaska Peninsula coast are only moderately well charted, while the outer shelf areas, especially over the shallower banks, are inadequately charted. Especially critical are the areas charted before the 1964 earthquake, some of which underwent significant changes in elevation during the earthquake. Any offshore development would require bathymetric studies.

OCEANOGRAPHY

Oceanographic investigations in the Gulf of Alaska area have been conducted sporadically during the past 45 years. These studies have primarily been oriented towards evaluating the fisheries of the region. Only recent studies have gathered baseline data that lead to a basic understanding of the entire air-sea system. Most of the data have been collected in the open ocean, few data exist for the shelf areas. Such observations as have been made on the shelf are scattered in location and time. Most observations have been made during summer months.

Because of unfavorable weather conditions at other times of year, there has been, and is presently, only one systematic study to gather a set of continuous observations of physical data in the Gulf of Alaska shelf waters. The Institute of Marine Science has a project under the direction of Dr. Tom Royer that has been making hydrographic observations along a transect perpendicular to the Seward coastline to just beyond the continental slope approximately bimonthly since December 1970. During the summer of 1967, an extensive survey program around

Kodiak Island was begun, but the project died due to lack of funding after only one cruise. All other observations have been made at various times on miscellaneous foreign and domestic cruises in the area.

Most of the physical oceanographic information collected yield little insight into the short-term variations of conditions over the continental shelf. Apparently, the air-sea interaction over the shelf modifies oceanographic conditions to a large extent which requires local data before local dynamics can be completely understood (Royer 1972).

Very limited chemical data are available for the shelf area (Longerich and Hood 1972). Chemical properties change daily and seasonally and are closely related to the physical transport and dispersion of water masses. Most of the present data consist of short-term observations of specific chemical parameters. No information exists on the seasonal effects or dynamic processes which control these concentrations.

CLIMATE

Available climatic information is of limited value. Development at a specific location will require detailed local data. Gathering of data will be difficult and costly because of the remoteness of the area and the lack of local personnel to run stations. Even then, data for a specific site may not become useful until that site has been occupied for some time.

Knowledge of offshore weather could be increased by weather buoys. Such a buoy is currently operating southeast of Kodiak just outside the study area, but is still being tested and is encountering operational difficulties. There are no plans for use of any buoys within the study area. Some offshore data could be gathered on platforms if they are constructed in the area.

GEOLOGY

Only a basic geologic framework can be established from existing reconnaissance work. Most detailed information about the area has been obtained by petroleum and mining companies, and is not generally available due to its proprietary nature.

Knowledge of sand and gravel resources will be critical for development of onshore facilities. The Resource Planning Team of the Joint Federal-State Land Use Planning Commission tentatively identified streams that could have sand and gravel resources.

The oil and gas potential of the study area is completely unknown. The actual outlines of potential basins have not been adequately defined, even by the oil companies. Estimates of up to 40 billion barrels have been made for the outer Kodiak shelf. The potential will remain purely speculative until wells are drilled and the area is tested. Apparently, no large scale effort will be made by petroleum companies to obtain additional geologic data in the study area until there is some assurrance of lease sale, although some companies may continue reconnaissance studies. Exploration interest could change drastically, especially along the Alaska Peninsula, if a significant discovery were made at the Cathedral River well, which is presently being drilled.

Little is known about oil reaching the environment through natural processes. The U.S. Bureau of Mines has begun investigation of natural oil seeps, and some data should be available soon.

Other resources of the area have not been evaluated. Mineral potential is probably high in certain areas but further exploration will not be carried out until the land status is decided. The geothermal and wind power potential is also high, and may be further evaluated in the near future. The University of Alaska Geophysical Institute is investigating the feasibility of an experimental windmill farm at Cold Bay, and also has a proposal in to CRREL to drill a test well on Augustine Island to study its geothermal potential.

The predictability of earthquakes and volcanic eruptions is another data gap. The establishment of a seismic net in the Shumagin Islands in the summer of 1973 is just the first step toward earthquake prediction in the Kodiak-Shumagin seismic gap. With the recent breakthrough in prediction capabilities, there is a good chance that some major losses at present and future facilities in the area could be avoided. Volcanic eruptions probably could be predicted also, if a seismic net was expanded to other active volcanoes besides Augustine Volcano.

HYDROLOGY

No detailed hydrologic data are available except in the Kodiak area where water quality and sediment samples are occasionally collected at a few stream-gauging stations. Although runoff is high, it is irregular and seasonal in the Kodiak area. Groundwater is limited and restricted to alluvial valleys. Kodiak has serious water shortage, due to limited reservoir capacity and low winter runoff.

Development of onshore facilities would require a careful evaluation of water availability at the site. Observations of streamflow over several years would be necessary to evaluate stream water availability, and test wells would have to be drilled to evaluate groundwater.

Due to the irregular high peak runoffs characteristic of the area, there is a high potential for flash floods along the lower reaches of streams. Careful evaluation of potential flood hazards for onshore facility sites also would be an important aspect of any development plans.

BIOLOGY

Life history information is deficient for many species occupying the Gulf of Alaska, particularly where the timing of various life stages is altered as compared with more southern populations of similar species. Information on seasonal abundance is fragmentary at best. For most species, qualitative and quantitative data are totally lacking.

Migration patterns of many species are totally unknown. Detailed information is lacking even for such commercially important species as salmon. Only fragmentary information is available on inshore and offshore seasonal movements of the most commercially important species. For instance, the movements and requirements of salmon during their early life cycle at sea is almost unknown. There are also few data on environmental conditions that limit species at the extremes of their range. The factors in the marine environment that might cause sockeye salmon populations to fluctuate widely are unknown. For most commercially important species, data on which to establish optimum harvest rates are lacking. The impact of habitat changes on these optimum rates which might occur with outer continental shelf development cannot be appraised.

The interrelationships among marine species and their habitats are unclear. For instance, the likely extent and duration of damage to zooplankton or to marine macrophytes with development, and its impact on higher trophic levels, are unknown. The effect of cumulative stresses are not known for any species.

The effect or significance of environmental change cannot be measured because baseline data in this ecosystem are totally lacking. For instance, Black (1973) points out that knowledge of the normal growth rates of a mollusks could be used as a rough measure of the impact on it resulting from an alteration of its habitat. No such growth information is available for species in the study area. The National Marine Fisheries Service initiated studies in Prince William Sound to establish present hydrocarbon levels in invertebrates. Similar studies should be conducted in the Gulf of Alaska.

In general, the basic effects of oil on organisms and their food chain are poorly understood although the MIT (1973) offshore oil task group lists the impact of oil on many species, little work has been done in cold water areas that could be applied to the study area. Few comprehensive studies have been conducted of oil spills. The work of Blumer et al. (1970) on the West Falmouth Massachusetts oil spill is probably the most comprehensive. Even that, however, lacked baseline data to compare with changes that might have resulted from the spill. The mechanisms of toxicity have not been worked out, particularly with regard to the ability of organisms to concentrate potentially carcinogenic compounds which may be passed upward through the food chain.

Some studies have opened up entirely new questions. Rice's (1973) study of avoidance of oil by pink salmon fry raises the possibility of interference with olfactory mechanisms that guide migration of both fry and adults. On the other hand, these fish might have the capacity to avoid oil whenever they have the opportunity.

Some work has been done on predicting the course and dispersion of an oil spill. Warner et al. (1972) applied the factors of Coriolis force and vertical kinematic eddy viscosity to wind and current data to derive a model that would have predicted the course of the Chedabucto Bay spill. With data available from local sources such as fishermen and weather forecasters, the course of a spill in the Western Gulf could within reasonable limits, be predicted about two days in advance.[1] Long-term predictions would, however, require better data on winds and currents than are available at present for most of the study area. More climatological stations could provide such data.[2]

Some work has been done on rates of biodegradation of oil (Kinney et al. 1969, Friede et al. 1972). It is known that the rate varies inversely with temperature, but much has yet to be learned about the rate at which oils will change form and toxicity under various conditions.

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1. F. F. Wright, Oceanographer, Marine Advisory Program, University of Alaska, Anchorage, Alaska. Personal communication.

2. H. W. Searby, Climatologist, Arctic Environmental Information and Data Center, Anchorage. Personal communication.

SOCIOECONOMICS

A review of the socioeconomic data for the study area reveals several particular data gaps.

1. Ethnology of Rural Populations. Although current and past life styles have been described, it is not known how rural inhabitants feel about the desirability, extent, and direction of future change. Natives may develop this information as they proceed with land selection under the Alaska Native Claims Settlement Act (PL-92-203).

2. Land Tenure. Perhaps the most significant data gap involves future land tenure. The land situation is currently in a state of flux pending settlement of the Alaska Native Claims Settlement Act (PL-92-203). It is probable that a large portion of the coastal zone probably will be under either private ownership or controlled by individuals, Native villages, and regional corporations. This could include most of Kodiak Island plus much of the coastline south of Katmai National Monument, a total coastal zone greater than that of the state of Texas. How this private control of a large portion of the coastal zone will affect development in the area remains to be seen.

3. Tourism. Data on the potential for tourism in the Western Gulf area is not adequate. Some studies have been made in adjacent areas being considered for parks and monuments.

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