GRAPHIC 2

CIRCULATION AND VULNERABLE HABITAT

III. A. 2. Meteorological Conditions & Oceanography

a. Meterological Conditions: The proposed lease area is strongly influenced by orographic channelling and by drainage winds. Precipitation is variable, but generally moderate in upper Cook Inlet, and heavy in lower Shelikof Strait. Lower Cook Inlet can be considered a transition zone between the Alaskan continental climate and the Pacific maritime climate of Shelikof Strait and the Alaska Peninsula.

Temperature: Mean annual temperature ranges vary considerably between upper Cook Inlet and lower Shelikof Strait. Mean annual and extreme temperatures for reporting stations in Cook Inlet, Shelikof Strait and at Kodiak are given in table III.A.2.a.-1.

Precipitation: The average annual precipitation in upper Cook Inlet (Anchorage) is 37.36 centimeters (14.71 in), and includes 177 centimeters (69.8 in) water equivalent of snow. In lower Cook Inlet (Homer), the average annual precipitation is 70.74 centimeters (27.85 in), and includes the water equivalent of 257.8 centimeters (101.5 in) of snow. At Larsen Bay, adjacent to Shelikof Strait, the average annual precipitation is 54.45 centimeters (23.01 in), including the water equivalent of 55.9 centimeters (22.0 in) of snowfall. Table III.A.2.a.-2 gives average annual precipitation at other reporting stations in lower Cook Inlet and around Kodiak Island. The least precipitation in upper and lower Cook Inlet occurs between April and June. Heavy precipitation in the area begins in September. Precipitation in both upper and lower Cook Inlet can be expected in about 32 percent of the days in each month. Snow occurs in upper and lower Cook Inlet from October to April, and may occur intermittently with rain or sleet.

Skycover (Visibility): Fog is the principal cause of reduced visibility, and is most common from December through February, and from November through March. In the Kodiak area, fog is most common from June through September. Fog forms when the katabatic winds which might have a local wind field effect in lower Cook Inlet. These katabatic winds are usually colder than the surrounding air, and flow under the ambient air overlying the water. Their persistency depends upon the water-air heat flux and upon the stability of the overlying air. The major winter wind feature in lower Cook Inlet is the katabatic wind from the Susitna Valley.

Drainage winds appear off almost every glacier and river valley that enters lower Cook Inlet. Such a wind is observed in the vicinity off Cape Douglas. Kachemak Bay often exhibits katabatic winds because several glaciers terminate at the bay head. These winds flow from the east-northeast at Homer, but seldom persist beyound about 10 nautical miles from the bay mouth.

Climatologically, average surface winds are generally channelled down upper Cook Inlet, but blow southeasterly in lower Cook Inlet. Annual maximum sustained winds for selected return periods for reporting stations along Cook Inlet and at Kodiak are given in table III.A.2.a.-3.

b. Physical Oceanography:

Bathymetry: The northern half of the lease sale ranges from 50 meters (250 ft) near Ninilchik and gradually increases to about 70 meters (230 ft) southwesterly to about St. Augustine Island. Depths continue to increase through the central portion of the area to 100 meters (328 ft) near English Bay, increasing to about 150 meters (492 ft) near Cape Douglas. Southwest of the Barren Islands on the inlet side of Stevenson Entrance are several depressions along the eastern side of Shelikof Strait which exceed 200 meters (656 ft). Near Cape Douglas, depths of 150 meters (492 ft) are typical. They increase to about 270 meters (886 ft) at the southern end of the lease sale area.

Circulation: The net circulation of lower Cook Inlet and the Shelikof Strait shown in graphic 2 is a generalized pattern compiled from Burbank (1977). Dames and Moore (1980), G. Galt (1978), Meunch, et al., (1980), Mungall moisture content of air is high and air temperature is warmer than surface waters.

Winds and Storms: Two large scale climatic regimes exist in the Gulf of Alaska. The winter is characterized by an inland high pressure cell, and frequent storm tracks from the west along the Aleutian Islands. In the summer, lower pressure persists over the continent, and there is reduced storm activity. Fall and spring are transition periods between these two climatic states.

Two dominant climatological processes appear to prevail in Cook Inlet. Wind fields produced by orographic channelling deflect or block synoptic air motions. The new flow depends on the orientation and magnitude of the local pressure gradient and strong accelerations can occur some distance offshore. Drainage or katabatic winds can result from dense air adjacent to the surface flowing downhill and are often focused into jets by orography (Reynolds, 1979).

The mountains bordering lower Cook Inlet form natural channels for air flow. The major channel axis extends from the Susitna Valley in upper Cook Inlet southward into Shelikof Strait. The channel is bounded by the Talkeetna and Kenai Mountains on the east and the smaller ranges on Kodiak on Afognak Islands, and on the west by the Alaska and Aleutian ranges. There is a break in the channel of air flow at Kennedy and Stephenson Entrances and at Kamishak Gap, an area of low elevation between Lake Iliamna and Kamishak Bay (Science Applications, Inc., 1979).

In March, the winds are persistently from upper Cook Inlet; they align with the channel axis. In April, winds blow in both direction through the Kamishak Gap-Kennedy Entrance channel, and to some extent from upper Cook Inlet and Kachemak Bay. October winds are mostly from the Kamishak Gap. In November, winds can blow from all four of the intersecting channels (Reynolds, 1979).

Adjacent continental land masses, whose interior regions are occupied by dense, cold air during the winter, can cause drainage or (1973), and Schumaker, et al., (1978). Gulf of Alaska seawater enters lower Cook Inlet through Kennedy Entrance and flows north and northwestward. Along the southwestern coastline of the Kenai Peninsula the flow may diverge and produce upwelling. Some of this nutrient-rich water flows along the coastline and mixes within Kachemak Bay.

The main surface flow continues north past Kachemak Bay to Anchor Point where it begins to turn westward due, in part, to the bathymetry in this region.

Some of the water continues north and northwestward. Near Ninilchik, the flow mixes with a strong surface outflow from upper Cook Inlet; then some is diverted to the west.

The westward movement of waters about mid-channel converge with low salinity waters from upper Cook Inlet producing a frontal zone or mid-channel rip which extends the length of the inlet. This convergence produces an accumulation of floating debris and may be a factor of beach debris accumulations (fig. III.A.2.b.-1). A less intense convergence zone (East Rip) occurs on the east side of the inlet. These two frontal zones are strongest during flood tide when the northward moving seawater forces itself between the major outflow of low salinity water from the upper Cook Inlet. A third frontal zone, the West Rip is present outside the lease area just east of Kalgin Island (fig. III.A.2.b.-1).

Circulation near Kamishak Bay is complex, but it is generally slow with some net transport of surface water to the west. After passing Kamishak Bay, it continues into Shelikof Strait where it remains primarily on the western side. Some of the Gulf of Alaska seawater which enters lower Cook Inlet through Stevenson Entrance flows south along the extreme side of Shelikof Strait. A mid-channel rip has been observed within Shelikof Strait, primarily as a result of these two water masses.

Circulation for the fall and winter season is generally similar to the spring and summer seasons. Some differencs occur north of Anchor Point because of more northerly winds and reduced outflow from upper Cook Inlet during the fall.

Nearshore circulation has been studied most intensively in the Kachemak Bay region. Surface circulation in outer Kachemak Bay consists of two counter rotating gyres. Changes in the size of the two gyres and their current velocities are caused by variations in winds, tidal ranges, and fresh water runoff. The circulation can vary daily and the gyres may disappear completely during the fall when intensive storms move in from the south.

The subsurface circulation for inner Kachemak Bay has been described as a positive partially mixed estuary. Fresh water outflow from the Fox River mixes with saline inflow along the bottom of the estuary (Burbank, 1977).

Tides: The circulation in lower Cook Inlet is dominated by the semidiurnal tides (2 high and 2 low in a 24-hour period), and by oceanographic events with a time scale of 3-4 days. About 85 percent of the variance in currents is associated with tidal activity. This indicates that, during a flood tide, the net movement of water is into Cook Inlet and Shelikof Strait while an ebb produces a reversal with water moving out of Cook Inlet and Shelikof Strait. As the tide propagates northward up lower Cook Inlet, the mean range continues to increase with distance from the entrance. Near the entrance to Cook Inlet (at Port Clarence) the mean tidal range is 3.7 meters (12.0 ft). At Cape Ninilchik it is 5.03 meters (16.5 ft), and at Kenai River entrance it is 5.40 meters (17.7 ft). Additional representative tidal data is shown on table III.A.2.b-1. Tidal ranges on the eastern side of the inlet are 0.6 to 1.2 meters (2-4 ft) greater than those on the western side at equivalent latitudes due to the Coriolis effect.

Tidal currents reach 2-3 knots at the entrance to lower Cook Inlet. Speeds greater than 8 knots have been reported at narrows, such as the Foreland (Gato, 1976). A strong tidal current exists along the eastern part of lower Cook Inlet north of Anchor Point. The weakest tidal currents are found southwest of Augustine Island (Mungall, 1973 and Meunch, et al., 1978). Energy from the tides is dissipated largely by bottom friction. The presence of sand curves and ridges indicates a strong near bottom current regime in the central lower Cook Inlet (Bouma and Hampton, 1976).

Waves and Swells: Many large wave systems are generated by large storms in the north Pacific and are still in the process of development when they enter the lease sale area. Fishermen have reported waves in excess of 6.1 meters (20 ft) during periods of severe weather in lower Cook Inlet. Return periods for maximum sustained winds and for wave heights are presented in table III.A.2.b.-2, (Bower et al.).

Sea Ice: Sea ice forms in upper Cook Inlet in early December and usually breaks up by late March and occassionally by late April. The ice forms from river water freezing on upper Cook Inlet tidal mud flats. Currents and the winter northwest winds tend to transport the ice southward through the Forelands, past Kalgin Island, and then farther southward along the western coast of lower Cook Inlet (Science Applications, Inc., 1979). By December, scattered sea ice (0.1 to 0.4 coverage) can be found below 60° N, while in upper Cook Inlet broken sea ice (0.5 to 0.7 coverage) can persist through February (Brower, et al., 1977). The maximum extent of scattered ice is as far south as Cape Douglas along the western shore and as far south as Anchor Point on the eastern shore. Although this is the approximate maximum extreme limit for sea ice coverage of oil or greater, scattered fragments of sea ice may be encountered beyond the extreme limit.

In upper Cook Inlet, the ice forms on mud flats and eventually moves into deeper water in lower Cook Inlet. During ice formation on mud flats, fine-grained sediments are incorporated in the ice. These ice floes raft the sediment southward and are a source of the suspended matter observed on the western side of lower Cook Inlet. Often the ice accumulates densely in Kamishak Bay as far offshore as Augustine Island.

Ice also forms in most coves and bays; the amount present varies, often forming and breaking up several times during the season. Rarely does this ice leave the area of origin; however, when it does, it melts rapidly in the warm, turbulent water entering Cook Inlet. Some ice is formed in Kamishak Bay, but the major source is upper Cook Inlet. (Science Applications, Inc., 1979.) Shore ice also forms along the shorelines of both Shelikof Strait and Cook Inlet (Brower, et al. 1977).

Floes in Cook Inlet can be as large as 320 meters (1,049 ft) aside and 1 meter (3.3 ft) thick. It has been reported that ice as thick as 12 meters (39 ft) can form in upper Cook Inlet as a result of successive freezing on tidal flats (Science Applications, Inc., 1979).

There have been no studies on ice hazards to structures or oil transport by ice in lower Cook Inlet. Also, damage to vessels or structures could occur if collisions were made with sea ice of the size reported.

Spray Ice: Ice accumulation on superstructures is a complex process that depends upon sea conditions, atmospheric conditions, and ship size and behavior. Heavy sea spray, freezing rain, or fog can cause icing. Small vessels with low free board, such as fishing boats and small merchant ships, are proned to wave wash in rough seas. Icing can increase a vessels weight and raise the center of gravity, making it top heavy. Also, dangerous stresses can occur to oil-drilling ships and other stationary platforms.

Freezing spray is probably the most common and hazardous form of icing. It usually occurs when the air temperature falls below the freezing temperature of seawater (about -2°C), and when the sea surface temperature is below 5°C. However, if the air temperature is below -18°C, wind-induced spray may freeze before striking a surface and thus not adhere. The stronger the wind and the lower the temperature, the more quickly ice accumulates and deposits thick layers of ice which can cause a vessel to sink.

Structured icing to small vessels in lower Cook Inlet would present little hazard since most vessels can find shelter rather quickly along the eastern coastline of the Kenai Peninsula. However, vessels in Shelikof Strait might find it difficult to avoid icing since many of the bays would contain shoreline ice, and ready access to shelter may not be available.

Noise: Natural background noise in open waters is generally related to the sea state; i.e., the size and frequency of breaking waters. Breaking waves are associated with high winds and open coastlines which combine to produce nearshore underwater noise. Low frequency noises are effectively transmitted through the ground and from the ground to the water. The background noises from biotic sources is addressed in section IV.A.2.d. and e.

Surface Trajectories: The previous section (circulation) has intended to give a general description of the near surface water movement within the area. Of primary importance is the surface circulation with respect to oil transport. Studies which have been concerned with surface trajectories have used drift bottle methods (ADF&G, 1978), modeling techniques (Dames and Moore, 1976), coastal sediment dynamics (Hayes, et al., 1976), and the Oil Spill Risk Analysis (USGS, 1980). This section will discuss the results of several drift card studies, and the vulnerability of the coastal habitats. The results of more extensive modeling techniques and the oil spill risk analysis are presented in section IV.A.1.d.

Drift bottle studies provide some indication of the trajectory of a surface pollutant, but no indication of the actual route or rate of movement from the release point. About half of the bottles released in early July from Marathon Diamond site off Anchor Point were found on the north side of Kalgin Island and along the coast south of the East Foreland (fig. III.A.2.b.-1). The rest of the bottles were recovered on the western shore of Cook Inlet between Ursus Cove and Amakdedori Beach.

Bottles released from the ARCO Raven site in July were recovered at Augustine Island and at Amakdedori Beach. These drift bottles also had to cross the Mid-Channel Rip. One other bottle was found on the west side of Kodiak Island.

In August, bottles were released at the ARCO Hawk site. Twenty-seven were found between Ursus Cove and the southern coast of Kamishak Bay. Drift bottles were found north of the release site and two were found on Kalgin Island. Circulation patterns for this region suggest that the net flow is to the south (graphic 2). The bottles recovered a few kilometers north of the release site could have been transported there by a flood tide. It is not clear how the two bottles got to Kalgin Island across the net southward currents.

Burbank (1977) describes and interprets other drift bottle study results. These studies were conducted during August to September (1974) and April to June (1976). Two releases were made in Kachemak Bay in 1974 at release site D and E. The primary recovery sites were along Homer Spit, near Anchor Point, near Amakdedori Beach, and along the west coasts of Shuyak, Afognak, and Kodiak Islands. One bottle was found on the southern end of Kalgin Island.

Only a few bottles were recovered from a release off Anchor Point in 1974, and all but one were found in the vicinity of Anchor Point. The exception was recovered in Spiridon Bay on the west side of Kodiak Island.

A wide distribution of recoveries resulted from a release at station H in 1974. The area from Ursus Cove to Amakdedori Beach and Augustine Island was a principal recovery site. However, the area with the most recoveries (about 65) was the coastline south of the release points. Bottles were found as far as English Bay, on the eastern side of the inlet, and just west of Homer Spit. The net flow, according to the circulation models, is southward from the release site. However, for drift bottles to get south of Cape Starichkof they had to be either advected southward by tidal flow, or transported around the counterclockwise gyre of lower Cook Inlet and advected northwards to the recovery sites at English Bay, Homer Spit, and Anchor Point.

Two releases were made in 1976 in Kennedy Entrance. The major recovery locations were Ursus Cove, Amakdedori Beach, near Cape Douglas, and along both sides of Shelikof Strait. Unexpected recoveries were made on Spruce Island (northeast of Kodiak Island) and on the eastern sides of Shuyak and Afognak Islands, possibly because drift bottles were carried out of Cook Inlet by an ebb tide.

Recoveries were made on the west side of Augustine Island, on Amakdedori Beach, and along the west coast of Shelikof Strait after a release from site N in 1976. One drift bottle was found in Kiliuda Bay on the east side of Kodiak Island. For further details of simulated surface trajectories, and the Oilspill Risk Analysis, refer to section IV.A.1.d.

c. Chemical Oceanography:

Salinity: Salinity ranges from 32 percent at the entrance to Cook Inlet to 10 percent in the extreme northern portion. Seasonal variations with increased runoff produces less saline conditions in the upper inlet from May through September.

Dissolved Oxygen: Oxygen varies from 11 ml/l at the surface east of Cape Douglas to 7 ml/l at just north of the Barren Islands. Waters in Cook Inlet are not oxygen deficient; however, dissolved oxygen may be significantly lower in the upper reaches of bays and harbors where depletion is due to organic decomposition.

Heavy Metals: Water samples, suspended particulates, and sediments were selected for heavy metal analysis along a transect which extended from upper Cook Inlet southeast onto the northeast Kodiak shelf. Samples were also collected along a transect line from lower Shelikof Strait and onto the southeast Kodiak Shelf (figure III.A.2.b.-1). Concentrations of heavy metals in water samples were low when compared to water quality criteria. No special trends were evident, (table III.A.2.c.-1), although cadmium concentrations were somewhat higher in deep water than near the surface (Burrel, 1977).

Suspended particulate material along the same transect tended to be more concentrated in nearshore and nearbottom waters. These areas also can be expected to have higher concentrations of heavy metals which are partitioned to the suspended particulates (table III.A.2.c.-2).

Sediment samples from lower Cook Inlet and lower Shelikof Strait were not abnormally, high in heavy metal content. No differences were evident between the two transect areas. Greater partitioning of heavy metals to the bottom sediment was within the range of two to three orders of magnitude which is not unusual for coastal marine environments (table III.A.2.c.-3).

Petroleum Hydrocarbons in Water Column: Shaw (1977) analyzed surface water of Cook Inlet for petroleum hydrocarbons. All samples analyzed were found to be less than 1 ppb. Similar results were obtained by Kinney, et al. (1970). These results compare with hydrocarbon levels of other Alaskan marine waters (Bering Sea and Gulf of Alaska) which are representative of pristine waters. Surface tows were made at twenty Cook Inlet stations for the collection of floating tar. Only one station had measureable amounts of tar (0.1 mg). Tar collected in other Alaskan waters average about 2.17 x 10^{-3} mg/m^2 which is low compared to other areas of the world (Shaw, 1977).

Concentrations of low molecular weight (LMW) aromatics in upper Cook Inlet, lower Cook Inlet, and Shelikof Strait are reported in table III.A.2.c.-4. Typical background levels of LMW compound such as benzene in lower Cook Inlet were 10-20 ug/1. The highest concentrations of benzene were found near the West Foreland in Trading Bay at about 60 ug/1. Trading Bay is the location of several offshore gas and oil fields. Sources of these gaseous hydrocarbons may include subsurface seepage from structural faults or leakage from closed wells. Earlier measurements by Kinney, et al. (1970), taken in May and September, 1978, suggest this is a chronic source of petroleum hydrocarbons to the area.

Shelikof Strait waters are similar in LMW aromatic hydrocarbon concentrations to those of Lower Cook Inlet. Although only two stations are reported for the North Pacific, with the exception of the low benzene concentrations, the concentrations of benzenes and toluene are comparable to concentrations in Cook Inlet and Shelikof Strait. Similar values were reported by Sauer, et al. (1978) from the Gulf of Mexico Coast.

Oil in Bottom Sediments: Cook Inlet bottom sediment samples were reportedly below detection limits (0.001ug/g) for hydrocarbons (Kinney, et al., 1970). Similar low levels of hydrocarbons were found in subtidal sediments of lower Cook Inlet (Brenner, et al., 1978). Sediment samples from the intertidal areas of Kamishak Bay were also below detection limits (Shaw, 1977). Hydrocarbons of terrestrial origin were found in Kachemak Bay sediments at concetrations of approximately 1 ug/gm. These were identified in breakdown aromatic products which may have provided some selection or conditioning effect to the biota. The low hydrocarbon concentrations of lower Cook Inlet sediments may be due to tidal flux and storms in the area (Brenner, et al., 1978).

Present levels of hydrocarbons in Cook Inlet waters are attributed primarily to biogenic rather than petrogenic origins, the significance of which, in terms of environmental quality, has not been determined. Higher concentrations of petroleum hydrocarbons typically increase with decreasing sediment grain size. Deposition of fine-grained sediment is expected to occur with reduced current speed. Thus, bottom sediment of silts and clays can be expected to contain more hydrocarbons than sandy sediments. See section III.A.1.b. for a description of the distribution of bottom sediments in the area.

Table III.A.2.a.-1
Mean Annual and Extreme Temperatures

Location	Mean Annual Temperature (°C) Minimum	Maximum	Temperature Extremes (°C) Lowest	Highest
Anchorage	-2.8	6.2	-36.7	29.4
Kenai	-4.3	5.3	-44.4	33.9
Homer	-0.8	5.6	-26.9	27.2
Seldovia	-7.8	14.4	-23.3	25.0
Larsen Bay	0.3	8.4	-20.6	28.3
Sitkinak	2.2	6.9	-16.1	24.4
Kodiak	2.2	7.4	-24.4	30.0

Source: Brower, et al. 1977.

Table III.A.2.a.-2
Average Annual Precipitation

Location	Average Annual Total Precipitation (Inches Rain and Snow)	Average Annual Snowfall (Inches)
Anchorage	14.71	69.8
Kenai	18.94	63.6
Homer	27.85	101.5
Seldovia	8.00	60.0
Larsen Bay	23.01	22.0
Sitkinak	50.51	27.5
Kodiak	56.71	95.0

Source: Brower, et al. 1977.

Table III.A.2.a.-3
Meteorology/Climatology
Annual Maximum Sustained Winds (MPH)
for Selected Return Periods

Station: Kenai, AK — POR: 1949–75

Return Period - Years	2	5	10	25	50	100	200	1000
Upper Bound	38.70	46.45	53.00	63.76	74.56	89.19	110.25	223.49
Wind Estimate	37.20	43.70	48.61	55.62	61.46	67.86	74.91	94.17
Lower Bound	35.76	41.10	44.58	48.51	50.66	51.64	50.90	39.80

Station: Homer, AK — POR: 1949–75

Return Period - Years	2	5	10	25	50	100	200	1000
Upper Bound	37.41	45.34	52.09	63.28	74.61	90.10	112.63	236.97
Wind Estimate	35.89	42.51	47.56	54.80	60.88	67.58	74.98	95.41
Lower Bound	34.43	39.86	43.42	47.46	49.67	50.68	49.92	38.41

Station: Kodiak, AK — POR: 1949–75

Return Period - Years	2	5	10	25	50	100	200	1000
Upper Bound	45.36	52.10	57.56	66.21	74.54	85.37	100.23	171.13
Wind Estimate	44.03	49.74	53.91	59.70	64.39	69.41	74.80	88.95
Lower Bound	42.73	47.48	50.50	53.83	55.63	56.44	55.82	46.24

Station: Anchorage, AK — POR: 1949–75

Return Period - Years	2	5	10	25	50	100	200	1000
Upper Bound	39.32	48.03	55.52	68.11	81.04	98.99	125.57	279.35
Wind Estimate	37.57	44.76	50.26	58.18	64.85	72.23	80.42	103.13
Lower Bound	35.90	41.71	45.49	49.70	51.90	52.71	51.50	38.07

Source: Brower, et al., 1977.

Table III.A.2.b.-1
Tidal Data for the Lease Sale Area and Surrounding Region

Location	Diurnal Range (ft) [1]	Maximum Diurnal (ft) [2]	Minimum Diurnal (ft) [2]	Maximum Tide (ft) [3]	Miminum Tide (ft) [3]
Anchorage	29.0	38.9	11.2	33.4	- 5.7
Nikiski	20.7	33.5	3.3	25.9	- 7.6
Drift River Terminal	18.1	29.8	2.0	23.2	- 7.3
Iliamna Bay	14.5	22.9	2.6	18.4	- 5.0
Seldovia	17.8	27.9	3.8	22.7	- 5.8
Redfox Bay	13.7	23.8	0.0	18.5	- 5.9
Kodiak	8.5	13.5	1.1	10.7	- 2.8
Larsen Bay	13.7	23.7	0.0	18.5	- 5.8
Katmai Bay	12.8	20.1	2.7	16.3	- 4.2
Kamatok Lagoon	11.8	16.4	4.0	14.0	- 2.4
Sitkinak Lagoon	7.5	13.1	0.7	10.0	- 2.5

[1] Average difference in height between mean higher high tide and mean lower low tide on a single day.

[2] Maximum and minimum differences between the higher high tide and lower low tide that is predicted.

[3] Maximum and minimum tides are that highest and the lowest predicted tides to occur at the location with respect to mean sea level.

Source: Brower, et al., 1977

Table III.A.2.b.-2
Annual Maximum Winds and Waves for Selected Return Periods

Cook Inlet, Shelikof Strait, and Kodiak Area

Return Period years	Maximum sustained wind knots (mph) [1]	Maximum significant wave-meters (ft) [2]	Extreme wave-meters (ft) [3]
5	72 (83)	12.5 (42)	23.0 (75)
10	78 (90.5)	14.0 (47)	26.0 (85)
25	87 (100.9)	17.0 (55)	30.0 (99)
50	94 (109)	19.0 (62)	34.0 (112)
100	102 (118)	21.5 (70)	38.0 (125)

[1] Sustained winds are winds averaged over a period of one minute.

[2] Significant wave height is the average height of the highest one third of all waves (sea and swell) in view.

[3] Extreme wave height is an empirical estimate of 1.8 times the significant wave height.

Source: Brower, et al., 1977.

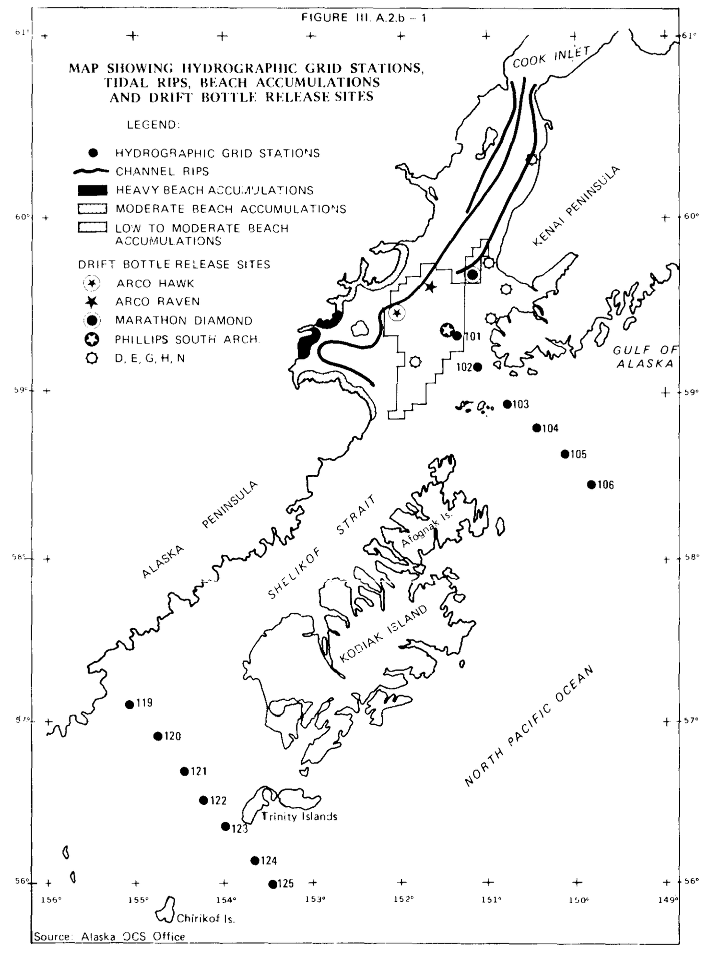

Table III.A.2.c.-1
Trace Metal Concentrations (ug/1) Measured in the Water of the Northwest Gulf of Alaska, Shelikof Strait, and Lower Cook Inlet

Station Number 1/	Depth (m)	Cd	Pb	Cu	Zn	V	Se	Cr
101	0	-	-	-	0.70	1.2	-	-
	80	-	-	-	0.30	1.4	-	-
102	0	-	-	-	n.d.	-	-	-
	100	-	-	-	0.25	-	-	-
104	0	0.03	0.04	0.20	0.28	1.6	-	-
	95	0.05	0.05	0.24	n.d.	1.4	-	-
106	81	0.025	0.035	0.16	-	-	-	-
119	0	0.02	0.025	0.26	n.d.	-	n.d.	0.23
	240	0.03	0.035	0.16	n.d.	1.5	n.d.	n.d.
120	0	0.04	0.13	0.42	0.50	-	-	-
	280	0.06	0.06	0.26	n.d.	-	-	-
121	0	0.04	0	0.26	0.42	1.3	-	-
	220	0.04	0.05	0.33	n.d.	1.7	-	-
122	0	0.025	0.08	0.28	0.24	-	-	-
	40	0.03	0.07	0.23	0.20	-	-	-
124	·	0.025	0.15	0.28	0.40	1.6	n.d.	n.d.
	105	0.05	0.10	0.24	n.d.	1.7	n.d.	0.06
Water Quality Criteria 2/ (ppb)		5	50	45	1	71,000	25	100
Difference with Criterion 3/		10^{-1}	10^{-2}	10^{-2}	close	10^{-3}	10^{-3}	10^{-2}

1/ Refer to Figure III.A.2.b.-1 for location of station numbers along the Lower Cook Inlet and Shelikof Strait transects.
2/ Water Quality Criteria are from EPA 1976. The criteria for Cd, Pb, and Cr are expressed as numerical limitations by EPA. However, criteria for Cu, Zn, and Se are expressed as 0.01 of the lowest 96 hour LD 50 test results cited in EPA literature. EPA has no criterion for vanadium; a commonly accepted criterion has been derived from literature review of bioassay results discussed in State of California Water Quality Criteria Document (McKee and Wolf, 1963).
3/ "Difference with Criterion" expresses the highest reported concentration of the respective trace metal in order(s) of magnitude less than the applicable water quality criterion.

n.d.: trace mental not detectable by instrumentation.

Source: Burrell, RU #162,/163/288/293/310, Annual Report, 1976, 1977, 1978.

Table III.A.2.c.-2
Selected Heavy Metals (ug/1) in Suspended Sediments from the Northwest Gulf of Alaska, Shelikof Strait and Lower Cook Inlet

Station Number	Depth (m)	Cr	Mn	V	Al
102	1				10.0
	98				9.6
103	1		0.13±0.04	0.020	3.79±0.43
	125		0.26±0.02	0.021±0.012	7.40±0.19
104	1		0.061±0.010	0.0056	2.46±0.08
	96		0.67±0.03	0.059±0.014	27.38±0.13
106	81		0.54±0.12	0.057	26.3±1.0
119	1		0.68±0.09	0.070±0.051	32.4±1.0
	204	n.d.	6.48±0.08	0.094±0.045	35.3±0.8
120	1		0.38±0.07	0.036	16.5±0.6
	281		7.10±0.09	0.224±0.063	103±1
121	1		0.26±0.04	0.025	15.0±0.6
	220		2.64±0.08	0.148±0.051	69.9±0.8
122	1		0.24±0.04	0.036	15.1±1.0
	35		0.35±0.04	0.053±0.024	28.3±0.5
124	1	Tr	0.28±0.03	0.028±0.020	14.6±0.4
	105		0.30±0.04	0.030±0.029	25.5±0.6

n.d. - not detectable above background

Tr - 0.04-0.10 ug/1 above background

Table III.A.2.c.-3
Total Heavy Metal Content of Bottom Sediments
From the Northwest Gulf of Alaska, Shelikof Strait, and Lower Cook Inlet

Station Number	Depth Interval (cm)	Mn [1]	V [2]	As [2]	Ba [2]	Co [2]	Cr [2]	Fe(%)	Sb [2]
102	4-6			2.9	670	16	97	3.9	4.9
	8-10			2.6	1100	17	102	4.2	9.7
	12-14			5.2	790	16	100	4.0	9.6
	14-18			2.6	610	15	89	3.6	8.1
104	0-2	846±39	72±19						
	4-6	546±48	108±24						
	8-10	570±42	94±22						
105	0-2			4.7	460±80	5	192	1.32	0.26±0.06
	4-6			1.8	560±120	16	82	3.72	0.70±0.08
119	0-2	991±48	130±29						
	4-6	802±45	137±27						
	8-10	724±47	119±28						
120	0-2	1066±51	164±31						
	4-6	958±47	123±28	2.9	670±60	16	97	3.85	0.99±0.10
	8-10	997±57	167±32	2.6	1100±60	17	102	4.18	0.97±0.12
	12-14	1074±52	150±30	5.2	790±80	16	100	3.96	0.96±0.11
	16-18	931±49	144±28	2.6	610±60	15	89	3.63	0.81±0.09
121	0-2	782±53	118±26	5.4	760±80	15	117	4.10	0.82±0.12
	4-6	690±50	121±29	3.8	710±80	15	106	3.93	0.73±0.12
	8-10	744±44	114±16	5.6	670±70	13	96	3.39	0.82±0.09
122	0-2	312±31	27±15	2.9	260±30	3	15	0.83	0.17±0.06
124	0-2	489±47	83±25	2.8	630±60	8	67	2.75	0.52±0.10
	4-6	541±45	88±23	3.3	570±70	9	61	2.73	0.93±0.09
	8-10	464±45	70±22	3.7	460±60	9	59	2.96	0.33±0.09

1/ mg/kg dry weight
2/ ug/kg

Source: Burrell, 1977.

Table III.A.2.c.-4
Summary of the Average Concentrations of LMW Aromatics in Surface Waters from the North Pacific, Shelikof Strait, Lower Cook Inlet, and Upper Cook Inlet

The C_2-benzenes Include Ethylbenzene, and Xylenes in ng/liter (ppt)

Location	No. Samples	Benzene	Toluene	C_2-Benzenes
Upper Cook Inlet	17	30 ± 17	78 ± 67	32 ± 19
Lower Cook Inlet	2	18	26	12
Shelikof Strait	17	16 ± 4	38 ± 14	11 ± 4
North Pacific	2	3	21	48

Source: Cline, et al., 1980.

For a complete description of salmon, herring, & bottomfish, see back of graphics 5 – 8

III. DESCRIPTION OF THE AFFECTED ENVIRONMENT