MARINE ECOLOGY

Intertidal and Shallow Subtidal Habitats

The intertidal and shallow subtidal environments present in upper Cook Inlet vary significantly from area to area. Figure 5.10 illustrates the diverse habitats present along the northwest shore of Cook Inlet near the proposed project. The intertidal area from the Beluga River south through Trading Bay contains broad expanses of gravel and sand as well as extensive mud flats. From the sandy reaches just south of the Beluga River, the intertidal zone becomes mud to below Three-mile Creek. Gravel exists at the delta of the Chuitna River, however mud flats are present north of Tyonek. The gravel returns south of Tyonek through North Foreland. Mud flats are again present to just north of Granite Point (Beshta Bay), gravel with mixed boulders exist at Granite River, and then the area becomes broad mud tidal flats (Trading Bay) disected by the flow of Nikolai Creek.

The oceanographic conditions vary significantly on each side of the inlet, and to a lesser extent on a site specific basis anywhere along the west side of the inlet. This is a major reason for variations in diversity of intertidal and shallow subtidal habitats.

° Mud Flats

The productivity and species diversity on the broad mud flats of upper Cook Inlet are generally low. In addition, the subtidal species density and diversity in these areas are also low. The limiting factors to productivity in areas dominated by mud flats are the high suspended sediment levels, low light penetration, and climatic variables. In winter months the surface sediments freeze during low tide.

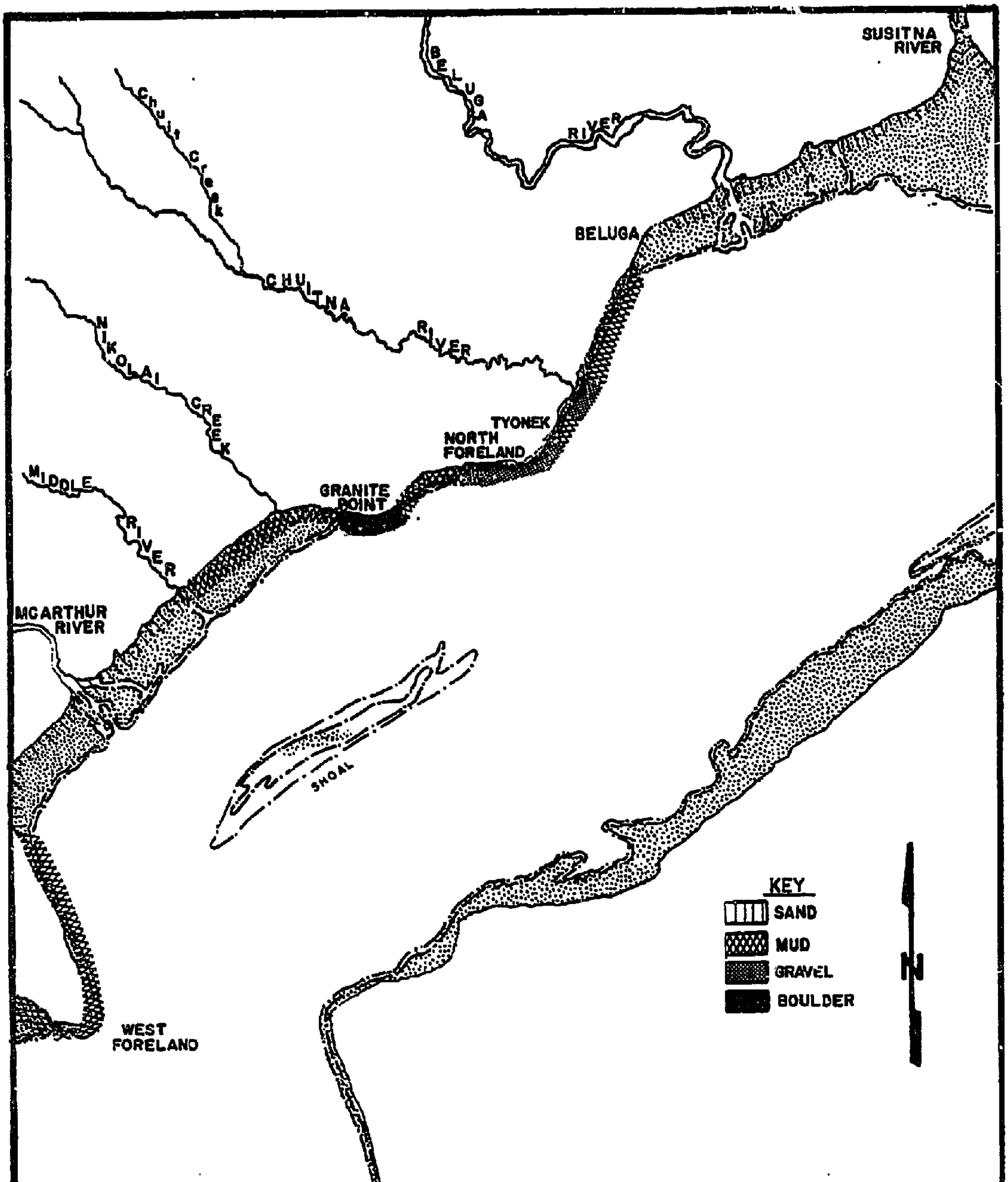


FIGURE 5.10 HABITAT TYPES, COOK INLET SHORELINE

The fauna within the intertidal/shallow subtidal area of mud flats is dominated by pelecypods (clams), primarily Macoma balthica and Mya sp., and polychaete worms (Nephtys, Etcone, Potamilla, Spio) of minor importance, and the clams Clinocardium, the basket cockle, and Pseudopythina, the common clam. There is substantial vertical distribution of the faunal assemblages in the mud flats. Figure 5.11 shows the distribution of the major organisms in the mud flats.

Predation is strong, with diving ducks, gulls and shorebirds being the major predators. A number of transient predators also depend on the infauna. These predators include crab, flatfish, cottids, and some Pacific salmon. Several migratory bird species utilize the mud flats, including the western Sandpiper and Dunlins during spring migration. The Greater Scaup, Old squaw, Surf scoter and Black scoter feed extensively on the mud flats in the winter. A generalized food web for mud flat environments is shown in Figure 5.12.

Gravel and Cobble Substrate

The gravel and cobble intertidal and subtidal areas support moderate densities of gammaride amphipods (Anisogammarus confervicolus) and the isopod Gnorimosphaeroma oregonensis.

In addition, barnacles (Balanus sp.) and mussels (Mytilus edulis) are present during spring, summer and fall. They are preyed upon by nudibranch (Onchidoris balamellata) and snails (nucella emarginata). The barnacles and mussels seldom survive the winter and thus are replaced yearly.

Other important predators include the rock sandpiper, a winter predator; dungeness crab (lancer magister); helmet crab (Telmessus cheiragonus); gray shrimp (Crangon alaskensis ; sand lance (Ammoclytes hexapterus); Pacific staghorn Sculpin (Leptocotuss

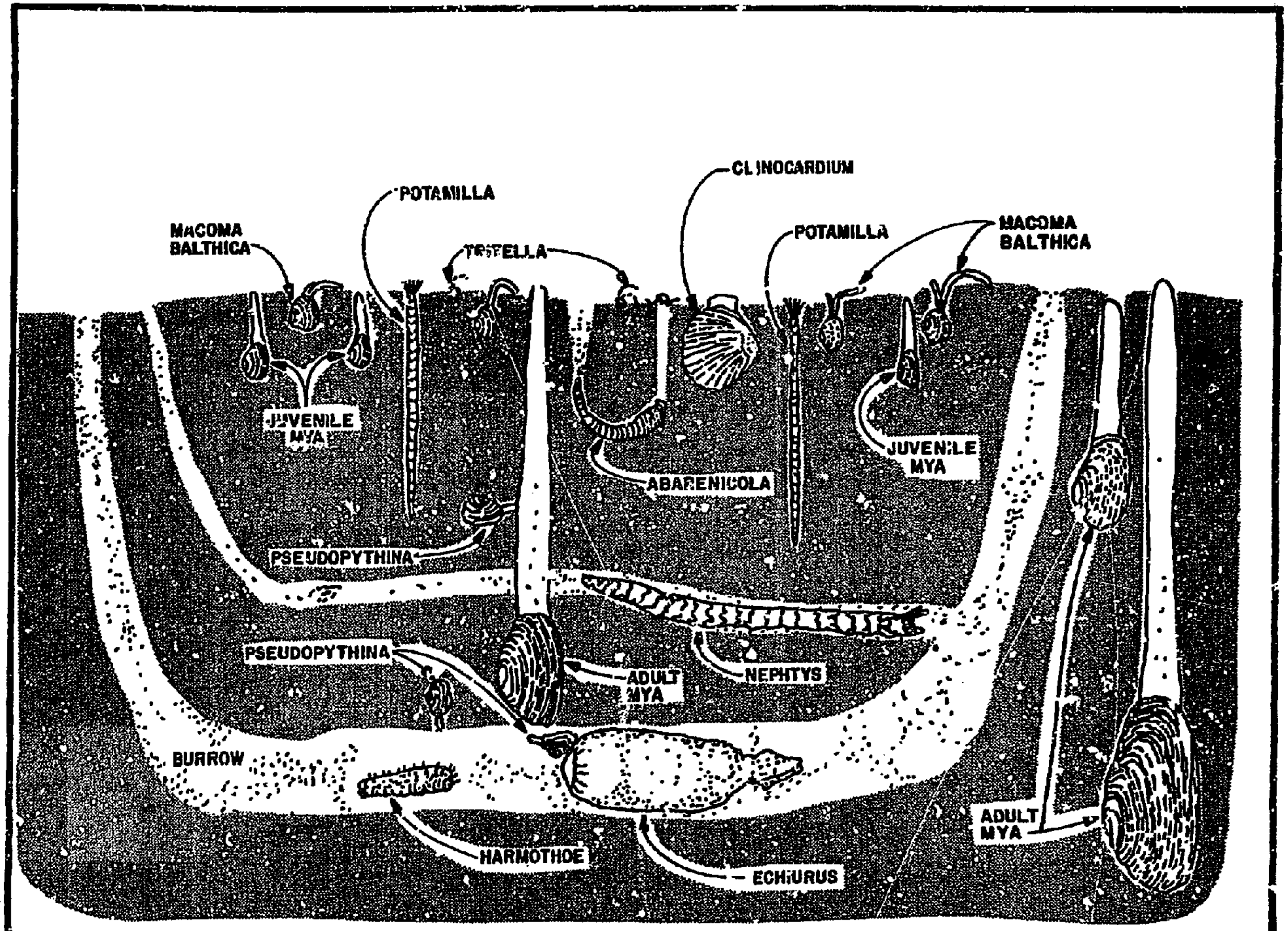


FIGURE 5.11 DISTRIBUTION OF ORGANISMS IN MUD FLATS

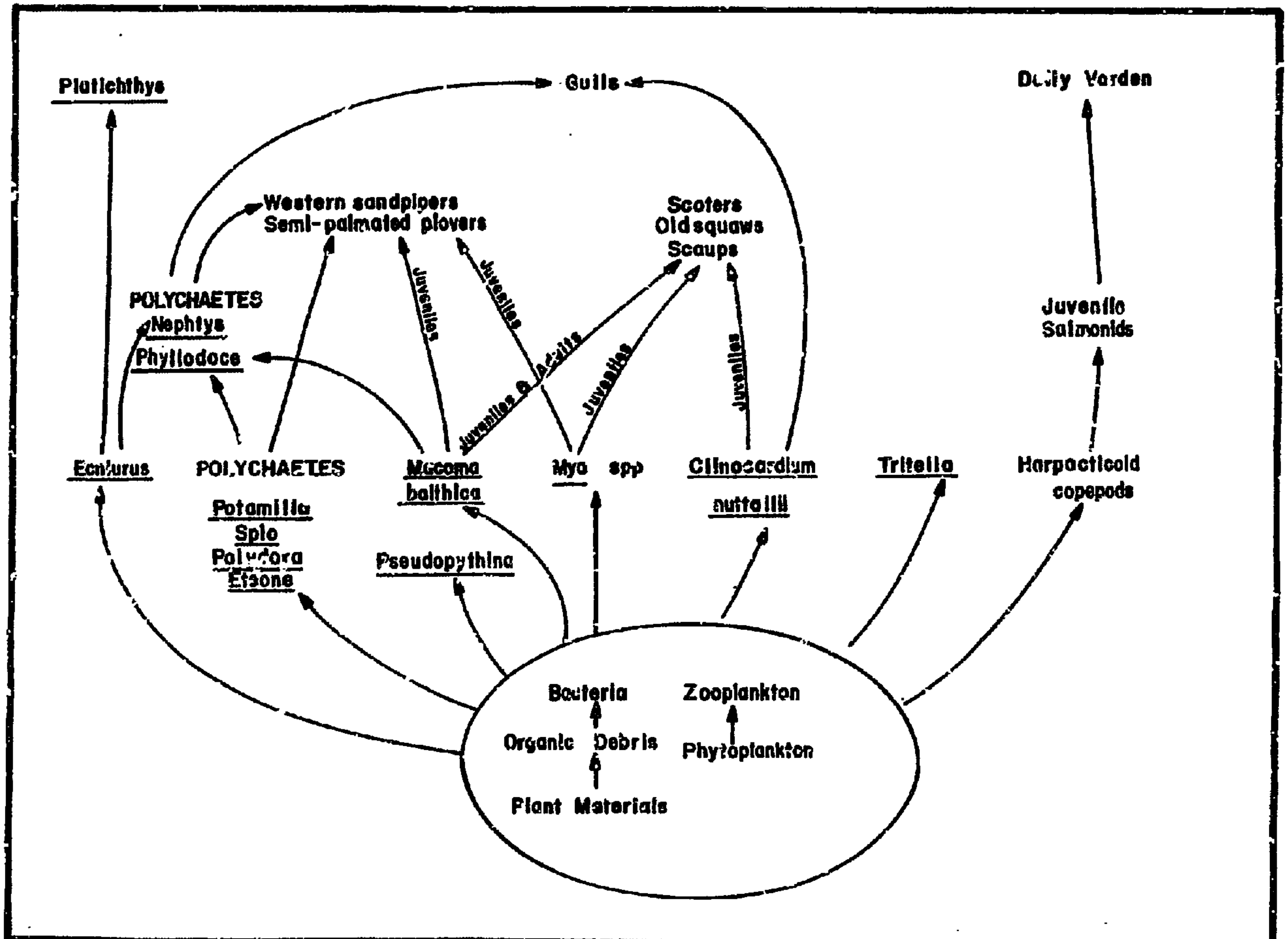


FIGURE 5.12 GENERALIZED FOOD WEB FOR MUD FLAT

armatus); starry flounder (Platichthys stellatus); and flathead sole (Hippoglossoides classodon).

Granite Point Intertidal and Shallow Subtidal Investigation

A July 1981 investigation of the shallow subtidal and intertidal area in the vicinity of Granite Point revealed that the benthic community at all the sampled stations was dominated by the pink clam (Macoma balthica). Three transects with three intertidal stations (high, low and midtide) and one subtidal station were established. The intertidal flats from the airport to Granite Point grades from a fine, muddy clay near the airstrip to gravelly sand toward Granite Point, and grades to coarse sand and gravel at increasing distances from the shoreline. The results of this investigation are summarized in graphic form in Figure 5.13

Marine Species

- Fisheries

  Fish populations in upper Cook Inlet in close proximity to the Trading Bay/Beluga River area include anadromous species (salmon and eulachon), resident species (flounder and sculpin), migratory species (halibut), and shellfish. Of commercial importance in upper Cook Inlet are four of the the five species of Pacific salmon. These salmon are also important sport fish.

  The five Pacific salmon species found in upper Cook Inlet are:

King (chinook) salmon	Oncorhynchus tshawytscha
Sockeye (red) salmon	O. nerka
Silver (coho) salmon	O. kisutch
Chum (dog) salmon	O. keta
Pink (humpback) salmon	O. gorbuscha

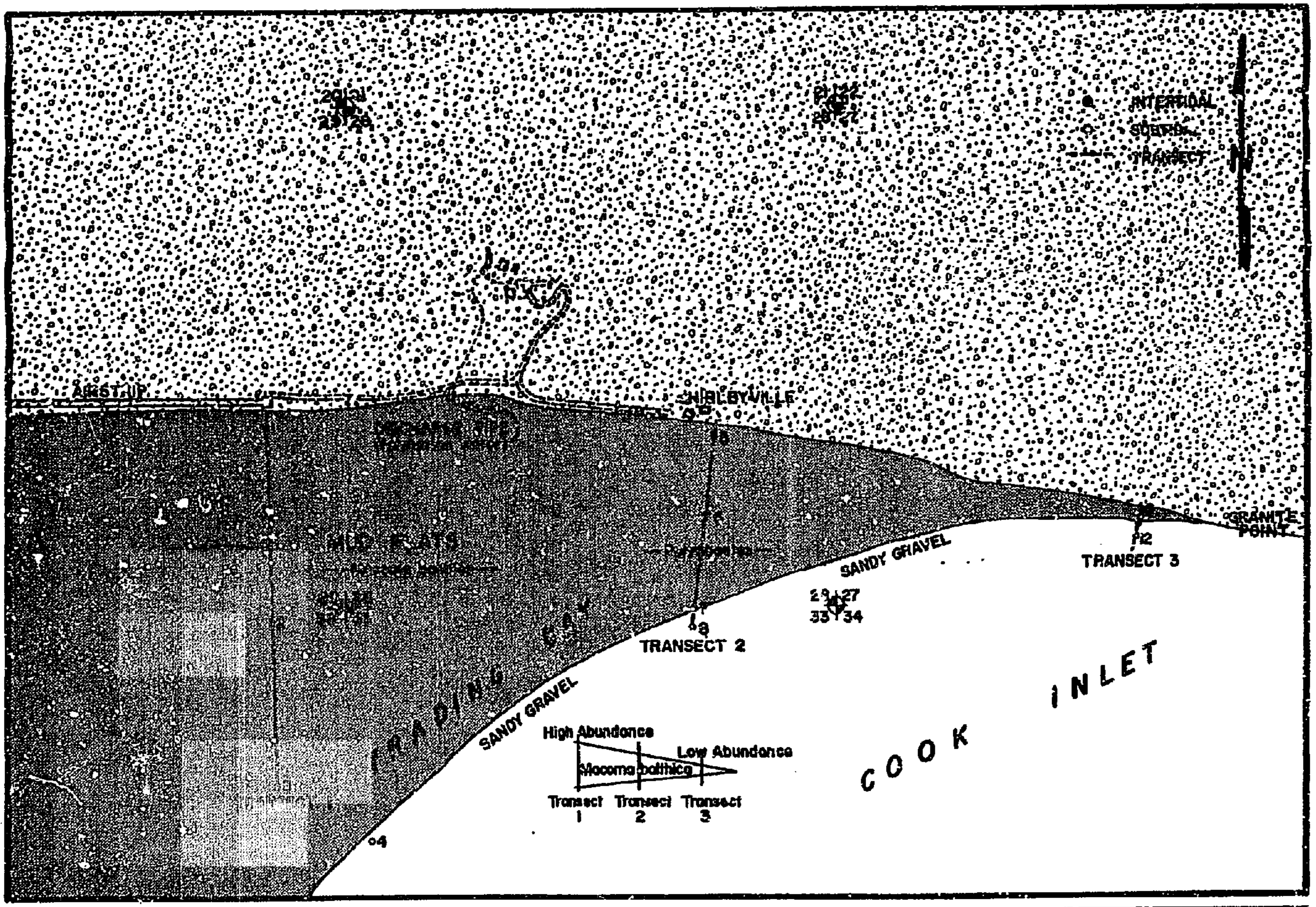


FIGURE 5.13 GRANITE POINT INTERTIDAL AND SHALLOW SUBTIDAL SPECIES ASSEMBLAGES

The general life histories of the five species of Pacific salmon in Cook Inlet is summarized in Table 5.9, as well as under Freshwater Fishes and in Table 5.1. Exceptions to these general features occur frequently. The relationship between salmon and the freshwater streams in the Beluga area is important in that the fish use the freshwater streams only to carry on reproductive and early life stage functions. Adult fish migrate from the marine environment to spawn and then die. Young salmon (fry) inhabit the freshwater streams for a short time, migrate to the sea where they grow rapidly into adults, and return to natal streams to spawn. Early development may also occur there. Some salmon remain in fresh water for 2 to 3 years; Dolly Varden may remain for as long as 4 years.

The different salmon species remain in fresh water varying lengths of time and also return to spawn at different times of the year. The general timing of the life history stages for each of the five species is shown in Table 5.10. The adult fish migrate to fresh water, then the female prepares the nest (redd) and generally spawns with only one male. Several males may be in attendance but usually only the dominant male will spawn with the female. It is estimated that early-run spawners deposit approximately 3,700 eggs each, while late-run spawners deposit approximately 4,100. The eggs are covered with upstream gravel, and the females guard the nest as long as possible but die soon after spawning. Hatching usually occurs in February to March, depending primarily on water temperature. The alevins (yolk sak fry) remain in the gravel for 2 to 3 weeks and then emerge as free-swimming, actively feeding fry. Some fry migrate immediately to the sea, however, most remain in the gravel areas near stream banks. Few lakes in the Beluga area are accessible to salmon. Most remain in fresh water for at least one year before moving out to sea. The life cycle of the king and silver salmon are illustrated in Figures 5.14 and 5.15.

Table 5.9

PACIFIC SALMON IN ALASKA-LIFE FEATURES

Species of Salmon	Time Spent in Fresh Water after Emergence From Gravel	Time at Sea Years	Age at Spawning Years	Average Weight of Adults Pounds	Average Eggs per Female Thousands
Chum (dog)	Less than 1 month	2-4	3-5	8	3.0
Pink (humpback)	Usually less than 1 month	1	2	4	2.0
Silver (coho)	12-36 months	1	3-4	9	3.5
Red (sockeye)	12-36 months	1-4	3-6	6	3.5
King (chinook)	3-12 months	1-6	3-7	20	8.0

Table 5.10

GENERAL SALMON RUN TIMING INFORMATION
FOR NORTHERN COOK INLET STREAMS

Species	Life History Stage*	Activity	Dates
Chinook Salmon	Adults	Enter fresh water	May 15 - July 15
		Spawning	June 20 - Aug. 15
	Juveniles	Outmigration	Apr. 15 - July 15
Sockeye Salmon	Adults	Enter fresh water	May 20 - Aug. 15**
		Spawning	Aug. 1 - Nov. 15
	Juveniles	Outmigration	Apr. 15 - Aug. 1
Coho Salmon	Adults	Enter fresh water	July 10 - Nov. 1***
		Spawning	Aug. 1 - Feb. 1
	Juveniles	Outmigration	Apr. 15 - July 15
Pink Salmon	Adults	Enter fresh water	June 20 - Aug. 15***
		Spawning	July 10 - Sept. 1
	Juveniles	Outmigration	Apr. 15 - June 10
Chum Salmon	Adults	Enter fresh water	July 1 - Sept. 1***
		Spawning	Aug. 1 - Oct. 1
	Juveniles	Outmigration	Apr. 15 - July 10

* Juvenile chinook, sockeye, and coho salmon are present in streams or lakes year round.

** Even numbered years.

*** Odd numbered years.

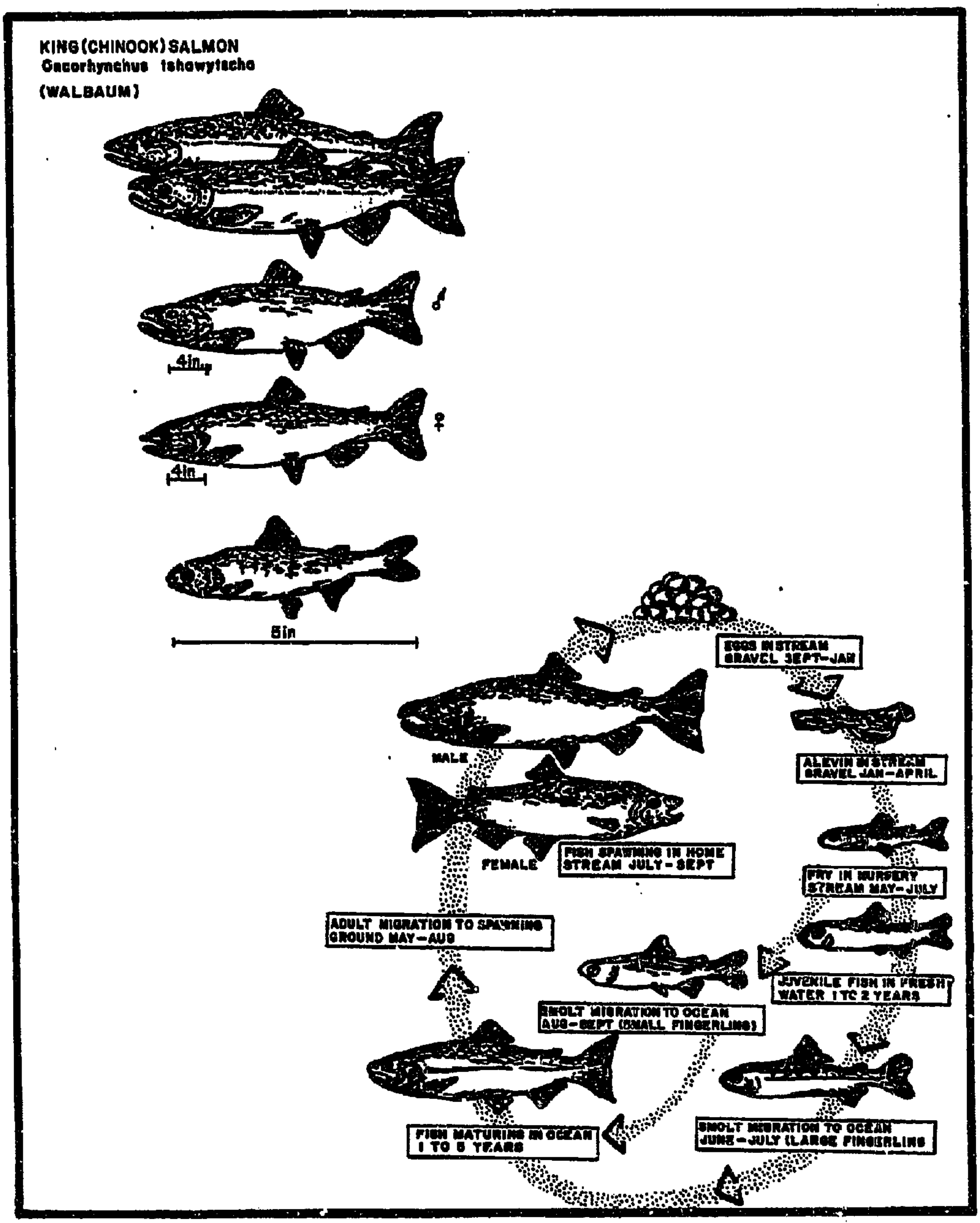


FIGURE 5.14	LIFE CYCLE OF KING SALMON

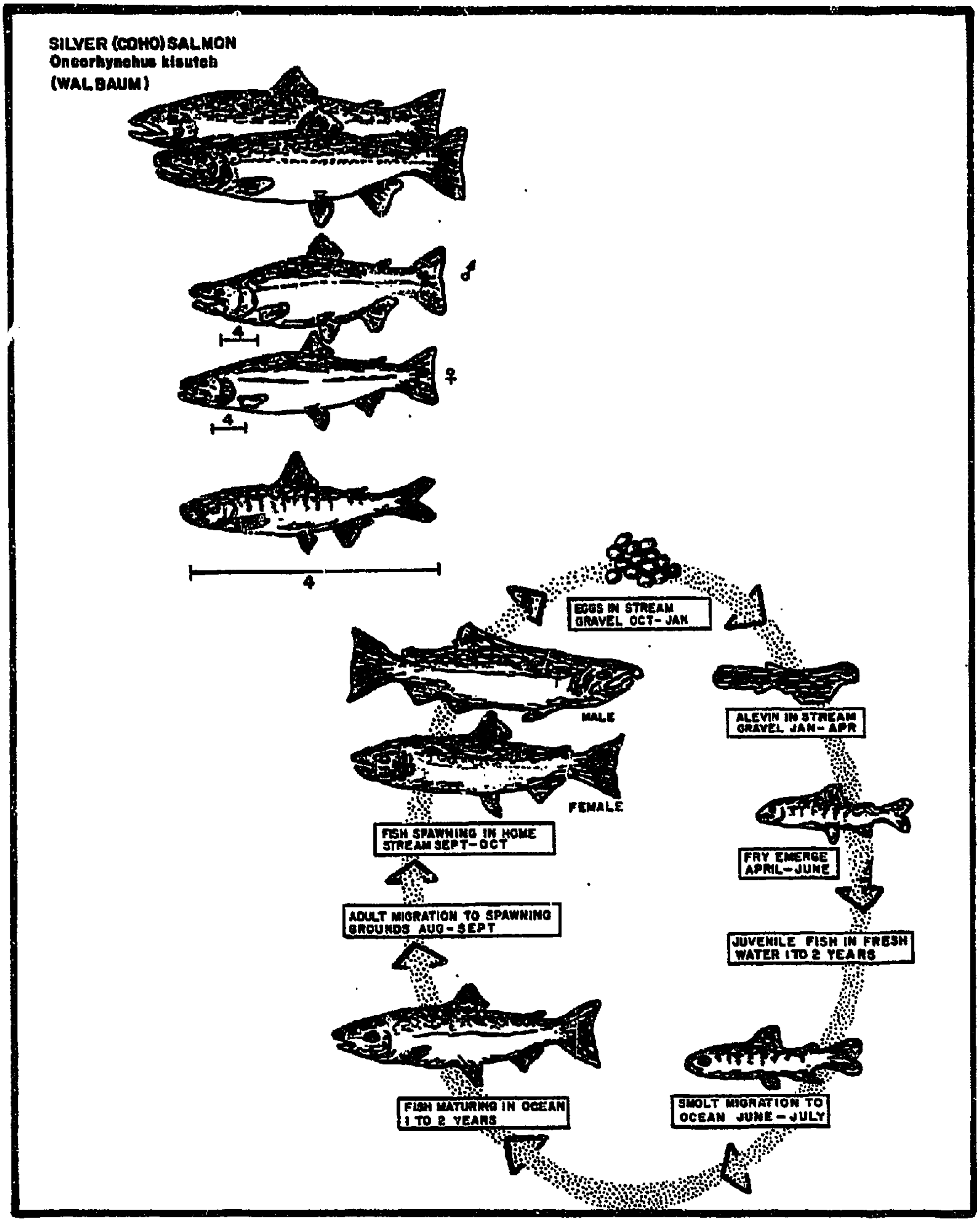


FIGURE 5.15 LIFE CYCLE OF THE SILVER SALMON

The spawning substrate for these salmon varies somewhat by species. Silver (coho), pink (humpback) and chum (dog) prefer a substrate of medium-size gravel, while red (sockeye) prefer fine gravel or sand and king salmon (chinook) prefer coarse gravel.

Young chinooks and cohos feed mainly on insects, including fly and beetle larvae and juveniles (dipterous larvae, trichopteran, and coleopteran juveniles). Other species of salmon fry also serve as an important food source for the coho. Sockeye feed on zooplankton.

Several factors relative to incubation are important to the survival of local salmon populations:

Access to Spawning Sites: Most basic to hatch success is the ability of migrating salmon to reach the spawning sites.

Freedom from Disturbance: Once the redds are established and eggs are deposited, disturbance may increase egg mortality.

Predation by Other Animals - Invertebrate organisms that invade the redds or other fish which feed on dislodged eggs are the major predators.

Diseases: Infection by aquatic fungi increases egg mortality.

Water Quality and Quantity: If the water contains deleterious chemicals and is not adequately oxygenated, is of unsuitable temperature, or does not flow properly around the eggs or larvae, significant mortality results. Proper stream flow, permeability of gravel, and dissolved oxygen concentrations are critical to salmon survival. Foreign substances in the water including siltation of streams has been demonstrated to severely diminish productivity.

Other factors such as adequate rearing habitat, food sources, holding areas, and spawning habitat are also important.

Dolly Varden (char) are widely distributed throughout Cook Inlet. They also migrate from the marine environment to fresh water to spawn. Upstream movement usually begins in late July or August and continues through November. Spawning usually occurs in gravelly streams with a fairly stong current. Unlike the Pacific salmon, Dolly Varden do not die after spawning. Development to hatching requires about 130 days, and the young remain in the gravel for 60 to 70 days. Dolly Varden usually spend three to four years in the creek before going to sea.

Eulachon (hooligan), a small anadromous smelt, is found in abundance in upper Cook Inlet. However, the only known run of eulachon in the Beluga area is at the Beluga River. Eulachon runs begin about May 15 and peak toward the end of May. The eggs hatch in 2 to 3 weeks and the young move downstream immediately.

Resident marine fish found in upper Cook Inlet are primarily flounder, sculpin, and cod. Their distribution is widespread, however their population densities are unknown. They are of little commercial or subsistence importance.

Migratory marine fish include the halibut, which are primarily found in lower Cook Inlet (Kalgin Island and south). Most halibut winter offshore in the Gulf of Alaska. Herring also can be found in fairly large numbers in lower Cook Inlet, and are very rarely found in upper Cook Inlet.

Shellfish, including king crab, dungeness crab, tanner crab, several species of shrimp, clams, oysters, and scallops are all found in commercial quantities in Cook Inlet. Most of these shellfish are found predominantly in lower Cook Inlet, south of the

Forelands. Clams, however, are common in tidal flats in upper Cook Inlet, including Trading Bay.

Commercial Fisheries: Commercially important species of fish in Cook Inlet include salmon, halibut, herring, shrimp and crab. The commercial fishing industry (harvesting and processing) is an important source of income and employment. The yearly and mean catches for the period 1973 to 1977 of the various fisheries in Cook Inlet are shown in Table 5.11.

Salmon: The salmon fishery in Cook Inlet is the most important commercial fishery. There are three distinct Cook Inlet salmon fisheries, defined by gear type (purse seine, drift gill net, and set gill net). Upper Cook Inlet areas support primarily gill net fishing. The salmon harvest in recent years has increased substantially due to improved fishery management, enhancement and rehabilitation programs. Annual harvest weight for 1980 was estimated to be 20.4 million pounds (0.224 metric tons), with a real value of $18 million. Harvest projections for the year 2000 are for approximately 28.2 million pounds (12,778 metric tons) with a value of $30.5 million.

The beach area from the northern end of Trading Bay in the vicinity of Shirleyville to the Beluga River is heavily utilized by set net fishermen including many residents of Tyonek. Based on the experience of set net fishermen on the eastern side of Cook Inlet, construction and operation of dock facilities has little impact on set net fishing.

Herring: The Cook Inlet herring fishery is primarily a roe herring fishery. The herring fleet is dominated by purse seiners whose principal employment is in other fisheries. The season is concentrated in a few days between May and mid-June because the roe is of marketable quality for only a very brief period. The average annual catch is approximately 6.4 million

Table 5.11

COOK INLET FISHERIES

1973-1977

Catch in 1,000 Pounds

Year	Salmon	Herring	Halibut	King Crab	Tanner Crab	Dungeness Crab	Shrimp
1973	14,418	3,184	3,972	4,349	8,509	330	4,897
1974	10,341	5,389	1,930	4,602	7,661	721	5,749
1975	18,045	8,298	3,935	2,886	4,952	363	4,752
1976	23,298	9,696	3,418	4,954	5,935	119	6,208
1977	36,012	6,435	3,249	2,027	5,650	76	5,144
Mean	20,443	6,600	3,300	3,764	6,541	322	5,350

pounds (2,919 metric tons) with a real harvest value of approximately $1.3 million.

Halibut: The Cook Inlet halibut fishery is dominated by a small fleet which consists of boats that are often primarily participants in other fisheries, and which fish in protected waters. Many of these boats are less than 35 feet (10.7 meters) in length. The season is between May and August, and is broken into several 2-week periods. Harvest weight and real harvest value of halibut for 1980 are approximately 0.6 million pounds (254 metric tons) and $400,000.

King Crab: The Cook Inlet king crab fishery is dominated by boats smaller than in many other Alaska crab fleets. The typical boat lengths are between 25 and 45 feet (7.6 and 13.7 meters). They generally have a crew of three or four and participate in the fishery from August through March. The harvest for 1980 was approximately 3.7 million pounds (1,667 metric tons) with a real market value of $4.6 million.

Tanner Crab: The tanner crab season is from December through May, and many of the boats participate in both king and tanner crab fishing because of the succession of seasons. The 1980 catch weight was approximately 5.2 million pounds (2,350 metric tons) with a real market value of $1.9 million.

Dungeness Crab: The Cook Inlet dungeness crab fleet consists of boats that typically are 26 to 35 feet (7.9 to 10.7 meters) in length, and have a crew of two. They participate in the dungeness crab fishery from May through December. The annual harvest has fluctuated significantly in recent years, however, more favorable market conditions are expected to stabilize the fishery in the future. Catch statistics and real market value for 1980 are 500,000 pounds (204 metric tons) and $300,000.

Shrimp: There are two shrimp fisheries in Cook Inlet, a trawl fishery and a pot fishery. The trawlers range in length from less than 25 feet to more than 80 feet (7.6 meters to 24.4 meters), and have a crew of three. They participate in the fishery from June through March. Although several times as many boats participate in the pot fishery as in the trawl fishery, the trawl fleet harvests the majority of the annual catch. The pot boats range in length from less than 25 to 45 feet (7.6 meters to 13.7 meters). They generally have a crew of two, and are active throughout the year.

The shrimp fisheries are well developed and have well defined resources. The 1980 harvest of all species amounted to approximately 5.6 million pounds (2,540 metric tons) with a real market value of $1.7 million.

Razor Clams: The Cook Inlet razor clam fishery has been small and sporadic for a number of years. The latest large harvest occurred in 1962 when just less than 200,000 pounds (91 metric tons) were taken. During the five years the fishery was active between 1969 and 1977, the annual harvest averaged less than 24,000 pounds (11 metric tons) and the number of boats in the fishery typically did not exceed three. With the exception of 1972 when a dredge was also used, the hand shovel has been the sole gear type. Although increases in resource abundance, increasingly favorable market conditions, the development of more efficient types of gear, and improved programs for the certification of beaches as a source of clams for human consumption are expected to stimulate renewed activity in this fishery, the razor clam fishery is expected to remain an almost insignificant portion of the Cook Inlet commercial fishing industry.

<u>Sport Fishery</u>: The Cook Inlet area supports a diverse and important sport/recreational fishery. Most sportfishing is for

the five Pacific salmon species. The east side of Cook Inlet (Kenai Peninsula) is the most intense sport fishery, however, the west side of the inlet also supports a lucrative sport fishery. The primary streams utilized for this purpose are in the Susitna drainage.

The major streams in the Beluga area capable of supporting a sport fishery are Nikolai Creek, Chuitna River and the Beluga River. However, there are no catch statistics concerning sport fish harvests from any of the streams or rivers in the Beluga area. Access to these streams would be primarily by float plane or limited wheel plane traffic. Fish harvested for sport/recreation are the five species of Pacific salmon, rainbow trout, Arctic grayling, Dolly Varden, and eulachon.

Sport fish regulations administered through the state Department of Fish and Game restrict the number of fish taken within a 24-hour period. The bag limit for any combination of salmon, trout, grayling and char under 16 inches in length (or 20 inches for king salmon) is 10 per day. Taking king salmon longer than 20 inches is limited to one per day with a maximum of only two in possession. Taking any combination of the other salmon species more than 16 inches in length is limited to three per day.

Subsistence Fishery: Subsistence fishing is of importance to the local residents of the Beluga area (Tyonek). Local Natives use the shoreline of Cook Inlet in the summer and fall to gather a large portion of the food in their diets. The marine resources gathered include clams, cockles, and bottomfish. Of primary importance during the summer months, however, is the harvesting of spawning salmon and smelts.

Methods of harvesting salmon vary. The primary harvest methods utilize drift gill net fishing, beach set nets, and seine net fishing. The drift gill net floats on the water's surface and drifts with the tide, intercepting salmon traveling toward the freshwater streams. Set nets are fished from the beach and are comprised of a small mesh lead net attached to the gill net. Salmon encounter the lead net as they swim along the beach and are led out to the gill net where they become entrapped. Leads are permanently anchored to shore. Seine fishing, although seldom used in upper Cook Inlet, utilizes a length of net to encircle and trap schools of fish.

Subsistence catch records are not generally available and very little specific data concerning subsistence fisheries is available for the Beluga region.

Current marine resource utilization in Cook Inlet is shown in Figure 5.16.

- Birds

Marine birds or seabirds have been defined as birds which, during some part of their life cycle, come in contact with the marine environment. This broad definition includes the migratory waterfowl as well as pelagic species. Primary marine bird habitat within upper Cook Inlet includes offshore waters (more than three nautical miles from land), inshore waters (within three nautical miles of land), steep rock or rubble beaches, sea cliffs, intertidal beaches, and coastal floodplains such as wetlands.

Approximately 180 species of birds are known to inhabit the Cook Inlet region. About 105 to 110 of these species are regarded as being associated with the marine or coastal environment. There is very little qualitative or quantitative information available for pelagic and coastal birds inhabiting Cook Inlet, especially in the Trading Bay to Beluga River region. Non-site-specific information which is available refers to environment types as described above.

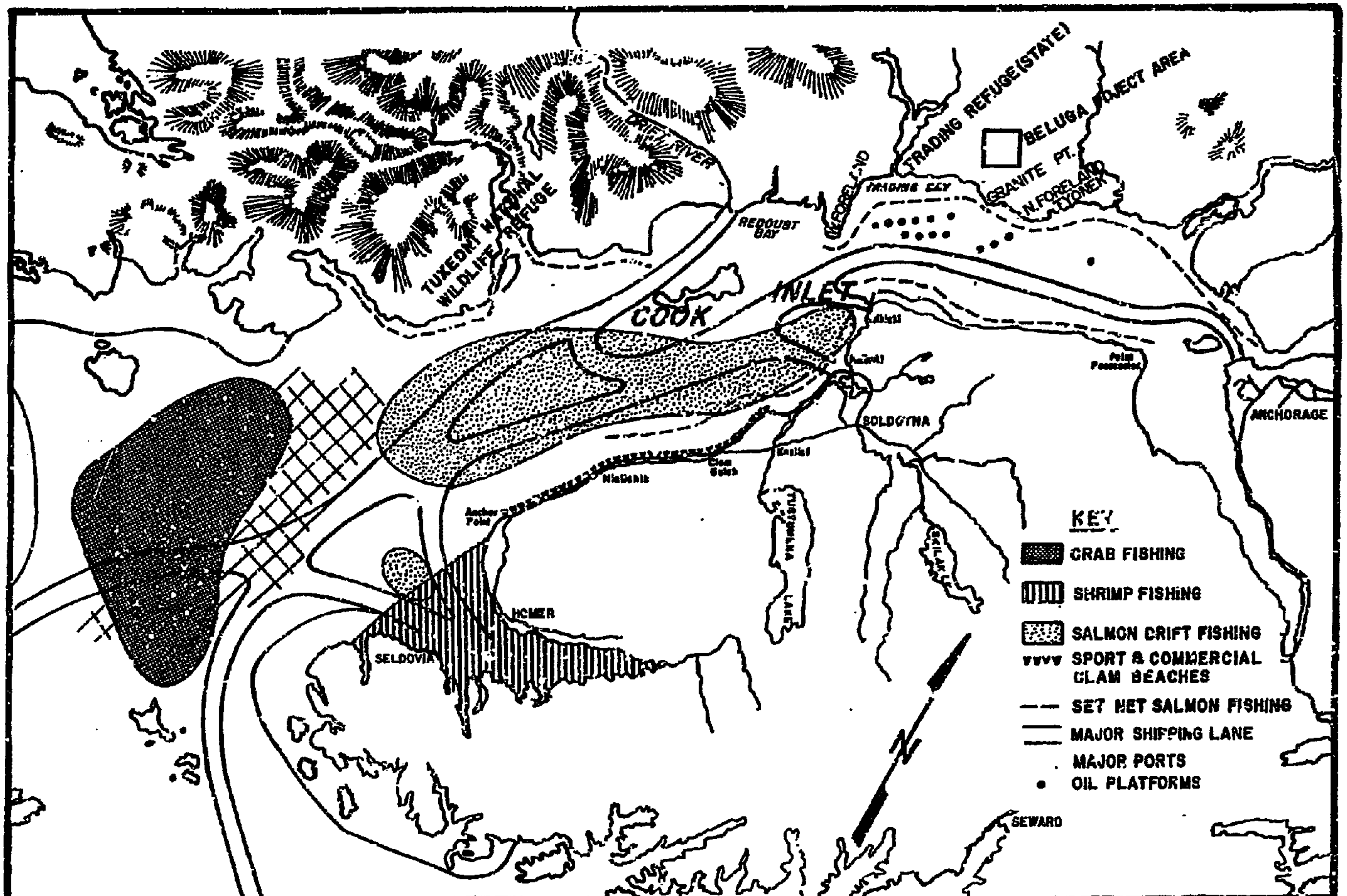


FIGURE 5.16 RESOURCE USE IN THE COOK INLET AREA

Cook Inlet is a geographical funnel for migrating birds moving to and from the Interior, North Slope, and west coast Alaska breeding areas. The highest bird populations occur in Cook Inlet's wetlands during the spring migration period when the area is used by more than 1.25 million ducks and geese (primarily lesser Canada and snow), about 25,000 whistling and trumpeter swans, several thousand cranes, and millions of shorebirds.

Pelagic areas in the upper inlet receive less bird use than areas closer to the mouth of the inlet. During migration and summer periods it appears that selected nearshore areas, estuaries, wetlands, and bays receive significant use by waterfowl and shorebirds.

Coastal wetland areas are important as nesting, resting, and feeding habitat to several species of birds. Trading Bay is a prime wetlands area and supports a diverse waterfowl population. Highest waterfowl populations occur in Cook Inlet's wetlands in spring when they are used by several thousand lesser Canada and snow geese, ducks, and occasional swans and cranes. The fall build-up of waterfowl in the inlet's wetlands begins in early August and peaks in late September. During the fall migration period about 0.75 million ducks and geese utilize wetland areas in Cook Inlet. The fall buildup of waterfowl in the inlet's wetlands begins in early August and peaks in late September.

Sea ducks, shearwaters, murres, gulls, puffins, guillemots, murrelets, and cormorants are the principal seabirds in offshore waters. These birds also inhabit inshore waters, where they nest on sea cliffs or rocky shores. Many of the sea ducks and gulls nest and feed in the sea beach tidal flat and coastal floodplain habitats. Geese and dabbling ducks (puddle ducks), and shorebirds, including black oystercatchers, plovers, snipe, trunstones, sandpipers, yellowlegs, dunlin, dowitchers, surfbirds, and others, also nest and feed in these two wetland habitats.

Pelagic areas in Cook Inlet during the winter months appear to receive comparatively little bird use. During winter months icing conditions in the inlet, in part, regulate the distrubution of wintering birds, i.e., there are fewer birds in areas of moderate to heavy ice cover. Since icing conditions are usually more severe on the west side of the inlet comparatively fewer birds would be present on the west side than on the east side. The most abundant coastal wintering birds were sea ducks, larids, and shorebirds, with very few alcids present.

Seabirds, sea ducks, and shorebirds generally feed on marine animals such as molluscs (gastropods, pelecypods, and cephalopods), crustacea (amphipods, schizopods, and copepods) and several species of fish. Carrion, birds, other marine invertebrates and plants are also utilized by several species of birds.

The largest seabird colony in close proximity to the study area is located in Tuxedni Bay on Chisik and Duck Islands about 120 miles (182 km) south of Anchorage and on the west side of Cook Inlet. Together the bay and islands comprise the Tuxedni National Wildlife Refuge which was established in 1909 by Executive Order. Approximately six seabird colonies are located in Tuxedni Bay, four are located on Chisik Island, one is on Duck Island, and two are on the adjacent mainland. Black-legged kittiwakes and murres are particularly numerous in Tuxedni Bay.

Table 5.12 is a list of migratory waterfowl, shorebirds, and seabirds which can be expected to be found in the Trading Bay/ Beluga region.

° Mammals

Numerous marine mammals inhabit or have been reported in Cook Inlet, but only a few species inhabit upper Cook Inlet. Harbor seals (Phoca vitulina) move up and down the west side of the inlet

Table 5.12

WATERFOWL, SHOREBIRDS AND SEABIRDS

Waterfowl and Shorebirds

Common Name	Scientific Name	Occurrence S/S/F/W
Common Loon	*Gavia immer*	C/U/C/U *
Yellow-billed Loon	*Gavia adamsii*	U/R/R/U
Arctic Loon	*Gavia arctica*	C/U/C/C *
Red-throated Loon	*Gavia stellata*	C/C/C/U *
Red-necked Grebe	*Podiceps grisegena*	C/U/C/C *
Horned Grebe	*Podiceps auritus*	C/U/C/C *
Pied-billed Grebe	*Podilymbus podiceps*	+/+/+/+ *
Great Blue Heron	*Ardea herodias*	U/U/U/U *
Whistling Swan	*Olor columbianus*	C/R/C/R
Trumpeter Swan	*Olor buccinator*	C/C/C/U *
Canada Goose	*Branta canadensis*	C/C/C/U *
Brant	*Branta bernicla*	C/R/R/+
Emperor Goose	*Philacte canagica*	R/+/R/U
White-fronted Goose	*Anser albifrons*	C/R/C/+ *
Snow Goose	*Chen caerulescens*	C/-/C/-
Mallard	*Anas platyrhynchos*	C/C/C/C *
Gadwall	*Anas strepera*	C/U/C/U *
Pintail	*Anas acuta*	C/C/C/U *
Green-winged Teal	*Anas crecca*	C/C/C/R *
Blue-winged Teal	*Anas discors*	R/R/R/+ *

S/S/F/W = Summer, Spring, Fall, Winter

C = Common
U = Uncommon
R = Rare
+ = Casual or accidental
- = Not known to occur
* = Known or probable breeder

Table 5.12
Continued
Waterfowl and Shorebirds

Common Name	Scientific Name	Occurrence S/S/F/W	
Northern Shoveler	*Anas clypeata*	C/C/C/U	*
American Wigeon	*Anas americana*	C/C/C/U	*
Redhead	*Aythya americana*	R/R/R/+	*
Ring-necked Duck	*Aythya collaris*	R/R/R/R	
Greater Scaup	*Aythya marila*	C/C/C/C	*
Lesser Scaup	*Aythya affinis*	R/+/R/R	
Common Goldeneye	*Bucephala clangula*	C/U/C/C	*
Barrow's Goldeneye	*Bucephala islandica*	C/C/C/C	*
Bufflehead	*Bucephala albeola*	C/R/C/C	*
Oldsquaw	*Clangula hyemalis*	C/U,'C/C	*
Harlequin Duck	*Histrionicus histrionicus*	C/C/C/C	*
Steller's Eider	*Polysticta stelleri*	C/+/U/C	
Common Eider	*Somateria mollissima*	U/U/U/U	
King Eider	*Somateria spectabilis*	U/-/U/U	
White-winged Scoter	*Melanitta deglandi*	C/C/C/C	*
Surf Scoter	*Melanitta perspicillata*	C/C/C/C	
Black Scoter	*Melanitta nigra*	C/U/C/C	
Common Merganser	*Mergus merganser*	C/C/C/C	*
Red-breasted Merganser	*Mergus serrator*	C/C/C/C	*
Semipalmated Plover	*Charadrius semipalmatus*	C/C/C/-	*
Killdeer	*Charadrius vociferus*	R/R/R/-	*
American Golden Plover	*Pluvialis dominica*	C/+/C/-	
Black-bellied Plover	*Pluvialis squatarola*	C/U/C/-	
Hudsonian Godwit	*Limosa haemastica*	U/U/U/-	*
Bar-tailed Godwit	*Limosa lapponica*	R/-/R/-	
Marbled Godwit	*Limosa fedoa*	R/-/+/-	
Whimbrel	*Numenius phaeopus*	C/U/C/-	
Bristle-thighed Curlew	*Numenius tahitiensis*	+/-/+/-	
Upland Sandpiper	*Bartramia longicauda*	+/-/+/-	

Table 5.12
Continued
Waterfowl and Shorebirds

Waterfowl and Shorebirds

Common Name	Scientific Name	Occurrence S/S/F/W	
Greater Yellowlegs	Tringa melanoleuca	C/C/C/-	*
Lesser Yellowlegs	Tringa flavipes	C/C/C/-	*
Solitary Sandpiper	Tringa solitaria	U/R/U/-	*
Spotted Sandpiper	Actitis macularia	C/C/C/+	*
Wandering Tattler	Heteroscelus incanus	C/U/C/-	*
Ruddy Turnstone	Arenaria interpres	C/R/U/-	
Black Turnstone	Arenaria melanocephala	C/U/C/R	
Northern Phalarope	Phalaropus lobatus	C/C/C/+	*
Red Phalarope	Phalaropus fulicarius	C/R/C/-	
Common Snipe	Gallinago gallinago	C/C/C/R	*
Short-billed Dowitcher	Limnodromus griseus	C/C/C/-	*
Long-billed Dowitcher	Limnodromus scolopaceus	C/-/C/-	
Surfbird	Aphriza virgata	C/U/C/U	*
Red Knot	Calidris canutus	C/-/R/-	
Sanderling	Calidris alba	U/U/U/R	
Semipalmated Sandpiper	Calidris pusilla	U/R/U/-	
Western Sandpiper	Calidris mauri	C/U/C/-	
Least Sandpiper	Calidris minutilla	C/C/C/-	*
White-rumped Sandpiper	Calidris fuscicollis	+/-/+/-	
Baird's Sandpiper	Calidris bairdii	U/-/U/-	
Pectoral Sandpiper	Calidris melanotos	C/-/C/-	
Sharp-tailed Sandpiper	Calidris acuminata	-/-/R/-	
Rock Sandpiper	Calidris ptilocnemis	C/-/C/C	
Dunlin	Calidris alpina	C/R/C/U	*
Pomarine Jaeger	Stercorarius pomarinus	C/R/C/-	
Parasitic Jaeger	Stercorarius parasiticus	U/C/C/-	*
Long-tailed Jaeger	Stercorarius longicaudus	R/R/R/+	
South Polar Skua	Catharacta maccormicki	-/R/R/-	

Table 5.12
Continued
Seabirds

Common Name	Scientific Name	Occurrence S/S/F/W	
Black Oystercatcher	Haematopus bachmani	C/C/C/U	*
Glaucous Gull	Larus hyperboreus	R/R/R/R	
Glaucous-winged Gull	Larus glaucescens	C/C/C/C	*
Herring Gull	Larus argentatus	C/U/C/U	*
Thayer's Gull	Larus thayeri	R/R/R/R	
Ring-billed Gull	Larus delawarensis	R/R/R/R	
Mew Gull	Larus canus	C/C/C/C	*
Bonaparte's Gull	Larus philadelphia	C/C/C/+	*
Black-legged Kittiwake	Rissa tridactyla	C/C/C/U	*
Sabine's Gull	Xema sabini	U/R/U/-	
Arctic Tern	Sterna paradisaea	C/C/C/-	*
Aleutian Tern	Sterna aleutica	U/U/U/-	*
Common Murre	Uria aalge	C/C/C/C	*
Thick-billed Murre	Uria lomvia	R/R/R/R	*
Pigeon Guillemot	Cepphus columba	C/C/C/C	*
Marbled Murrelet	Brachyramphus marmoratus	C/C/C/C	*
Kittlitz's Murrelet	Brachyramphus brevirostris	C/C/C/U	*
Ancient Murrelet	Synthliboramphus antiquus	U/U/U/U	*
Cassin's Auklet	Ptchoramphus aleuticus	R/R/R/-	
Parakeet Auklet	Cyclorrhynchus psittacula	U/U/U/-	*
Rhinoceros Auklet	Cerorhinca monocerata	R/R/R/-	*
Horned Puffin	Fratercula corniculata	U/U/U/R	*
Tufted Puffin	Lunda cirrhata	C/C/C/R	*

as far as and often up the Susitna River. Of the 13 species of whales reported from Cook Inlet, only the beluga (or white) whale (*Delphinapterus leucas*) is found in upper Cook Inlet. While the sea otter (*Enhydra lutris*) populations are reported to be increasing within the inlet, no sea otters have been reported within the specific area of interest though they have been observed in the vicinity of Trading Bay and at Ninilchik on the eastern shore of the inlet.

The following marine mammals have been reported for lower Cook Inlet in addition to those indicated above:

Northern Fur Seal	*Callorhinus ursinus*
Steller Sea Lion	*Eumetopias jubuta*
Dall Porpoise	*Phocoenoides dalli*
Harbor Porpoise	*Phocoena phocoena*
Sperm Whale	*Physeter catodon*
Minke Whale	*Balaenoptera acutorostrata*
Gray Whale	*Eschrichtius robustus*
Humpback Whale	*Megaptera novaeangliae*
Fin Whale	*Babenoptera physalus*
Pacific Right Whale	*Balaena glacialis*
Sea Whale	*Balaenoptera boraelis*
Stejneger's Beaked Whale	*Mescoplodon stejnegeri*
Goose Beaked Whale	*Ziphius cavirostris*
Giant Bottlenose Whale	*Berardius bairdi*
Blue Whale	*Balaenoptera musculus*
Northern Pacific White-sided Dolphin	*Lagenorhynchus acutus*

The beluga whale in upper Cook Inlet feed primarily on salmon, both adults and smolt. The Cook Inlet population of beluga has been estimated to be on the order of 300 to 500 animals and is believed to be a discrete population. These whales generally feed from the bottom to mid-water levels and are known to move into the mouths and often up the mainstem of major rivers (including the Beluga River) to feed on outward migrating salmon. In addition to salmon, belugas are known to eat smelt, flounder, sole, sculpin, lamprey, squid, shrimp, and mussel. In Cook Inlet, belugas have been reported as far north as Ship Creek (Anchorage) and the vicinity of Girdwood, pursuing runs of hooligan.

Reproduction in belugas probably takes place in late May or June with a 12-month gestation period. The calf generally remains with the mother for several years following an eight-month lactation period.

In recent years, both the Minke whale and the beaked whale have been observed in Kenai and Anchorage where, for unknown reasons, individuals have been beached at low tides.

Trading Bay State Game Refuge

The Trading Bay refuge (Figure 5.17) was established in 1976 to protect and perpetuate waterfowl and big game habitat. The refuge is approximately 169,000 acres in size including tidal and submerged lands as well as uplands. The refuge boundaries border on the project area in the vicinity of both the proposed town and plant sites and includes the main stem of Nikolai Creek.

The refuge has been the scene of exploration activities for oil and gas; is crossed by the Cook Inlet Pipe Line; and portions of the refuge have been logged by Tyonek Lumber Company. The latter activity has resulted in bridge crossings of Nikolai Creek and the Chakachatna River and numerous gravel roads that are still utilized by the lumber company. The eastern shore of Chakachatna River is a primary gravel source for commercial development in the area. In addition, one test water well has been drilled as part of the 1981 field program in the vicinity of the Nikolai Creek bridge crossing. The DF&G has recently completed (1981) a waterfowl survey of the Trading Bay area. Nikolai Creek is an important fishery, and the

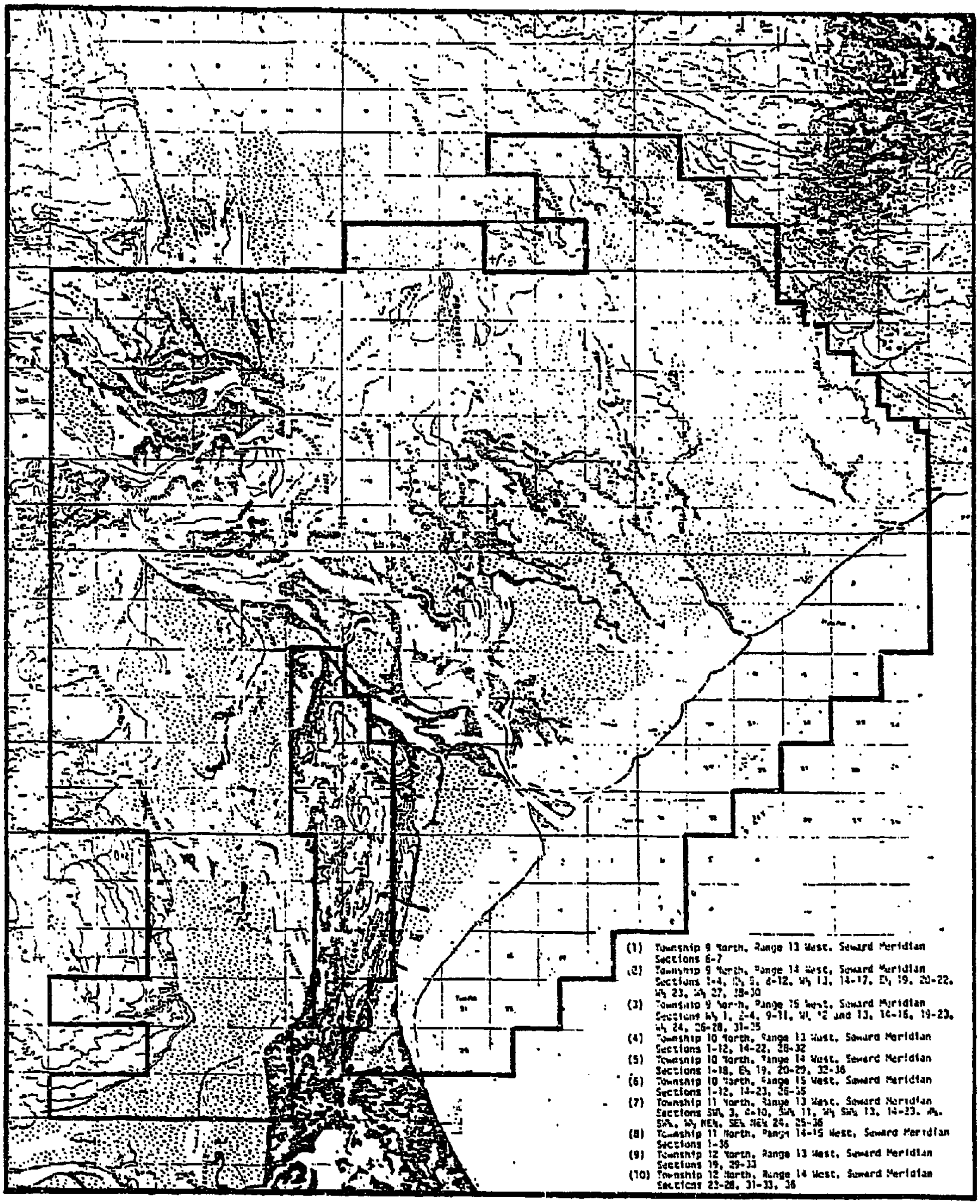


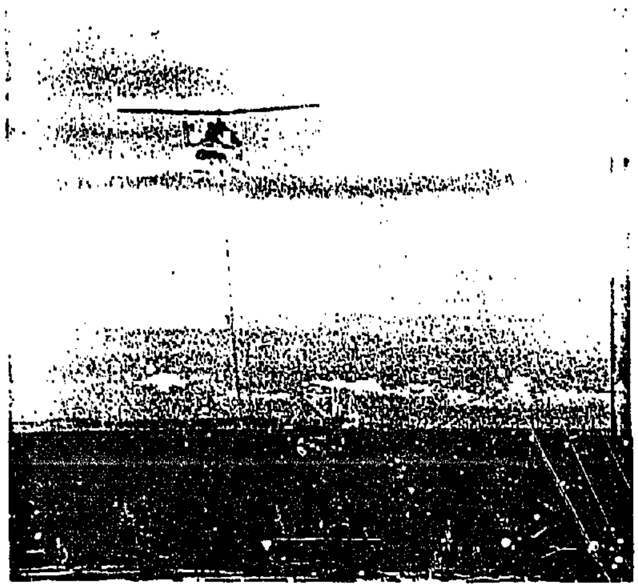
FIGURE 5.17 TRADING BAY STATE GAME REFUGE

area between the Chakachatna River and Nikolai Creek is an important moose wintering area. It would appear from the available browse that the current moose population is far below the carrying capacity of the land. Swans, sandhill cranes, and eagles nest along the general stream course of Nikolai Creek. Road access to the Nikolai drainage makes this area accessible to and important to local residents of the area.

upper Capps

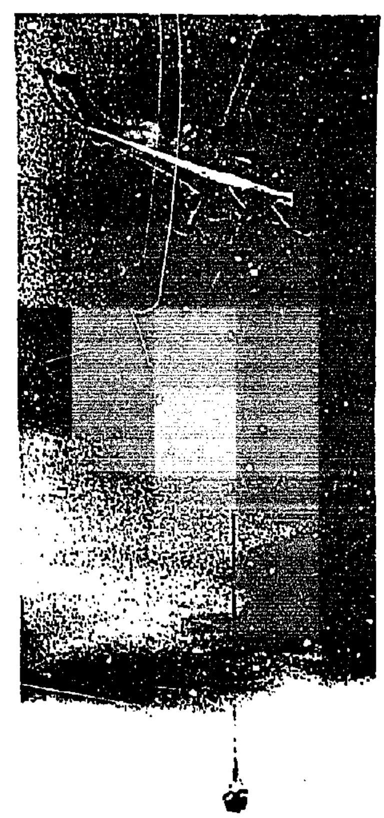
John's Creek

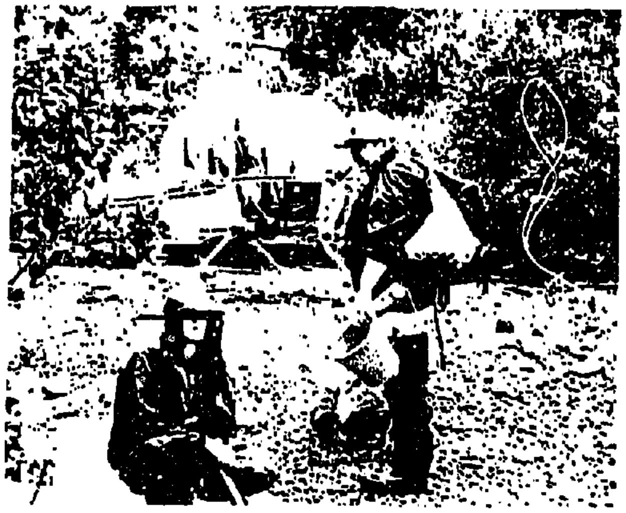
BELUGA FIELD PROGRAM 1981



sub-tidal sampling

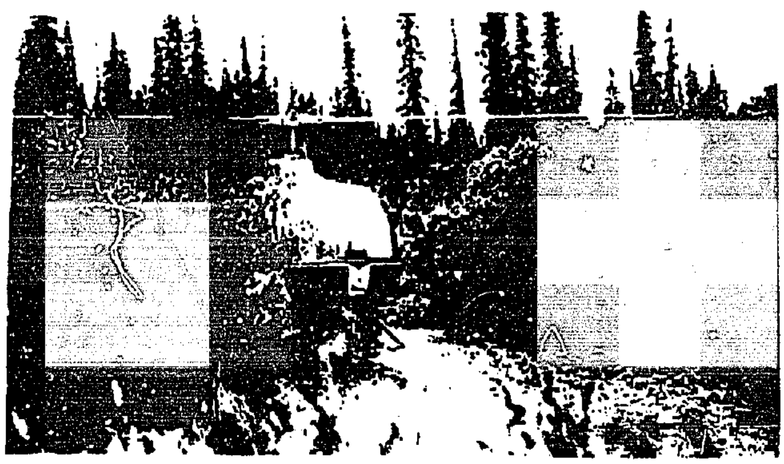
soil's investigation





fish trapping

stream surveys



6.0 CLIMATOLOGY AND AIR QUALITY

CLIMATIC CONDITIONS

The Cook Inlet area in general is in a transitional climate zone between the continental climate of the Interior and the maritime climate more common to the coastal areas farther south. The Aleutian and Alaska mountain ranges to the northeast of the project area are effective in preventing the large, extremely cold air masses that typically settle in the Interior Basin from causing comparably frigid conditions along the inlet during winters. The Kenai and Chugach ranges which run in a northeastern direction to the south of the project area protect the inlet from advection of moist air from the Gulf of Alaska, and from potentially heavy precipitation. The higher elevations experience colder temperatures, more precipitation and stronger winds than the low-lying coastal areas.

The four seasons are not well defined in the region. Winter generally begins mid-October and lasts until mid-April. Monthly average temperatures vary between 10° and 30°F during this season. However, temperatures fall well below freezing, with the possibility of some inland locations reaching -50°F. The total annual snowfall ranges between 70 and 100 inches with December, the coldest month, receiving the greatest snowfall. The difference in expected snowfall between the inlet shore and the higher elevations of the Capps Field is probably reflected by the above stated range in total snowfall. Springtime occurs from mid-April to June when the average daily temperatures rise from 30°F in April to near 50°F in June. Precipitation is lowest in the spring with monthly averages around 1 inch. During the summer precipitation increases rapidly. About 40% of the total annual precipitation falls between mid-July and the end of summer. July is also the warmest month of the year with the average daily temperature near 55°F. Autumn is brief, accompanied by a decrease in precipitation. Most precipitation occurs as rain early in the season and snow later, although snow may predominate throughout the season at the higher elevations. Temperatures also fall rapidly during this short season; monthly average temperatures for September and October differ by 15°F.

The bar charts on Figure 6.1 summarize monthly variations in average daily temperatures, average daily temperature ranges, and precipitation for the part of the Cook Inlet Basin in which the proposed project is located. The average values shown should be considered as generally occurring for the entire area from the plant site to the coal fields.

These charts are based on isopleth maps prepared by the U.S. Environmental Data Service from data taken at weather stations associated with the National Oceanic and Atmospheric Administration. Figure 6.2 shows the locations and activities of these stations. Stations represented by double circles monitor wind speed and direction, sky cover and cloud ceiling heights in addition to measuring temperatures and precipitation. Knowing these parameters would make it possible to calculate how much dilution of air pollution concentrations occurs as a function of the meteorology or atmospheric conditions. Wind profiles for the Kenai and Anchorage stations indicate that a general wind pattern exists for the entire inlet region. However, local variations in wind profiles and turbulent diffusion are expected in the project area due to the effects of terrain roughness. The rough surface should increase mechanical turbulence allowing for the atmosphere to be well mixed during periods of high winds. During the winter, winds from the north/northeast are dominant and as summer approaches the prevailing winds are from the south/southwest. The annual average wind speed at both Kenai and Anchorage is approximately 7 mph. Monthly average wind speeds range from 4 to 9 mph at Anchorage. Figure 6.3 illustrates wind roses for Kenai, Anchorage, and the Phillips Petroleum's Platform "A" located approximately 5 miles due east of Tyonek.

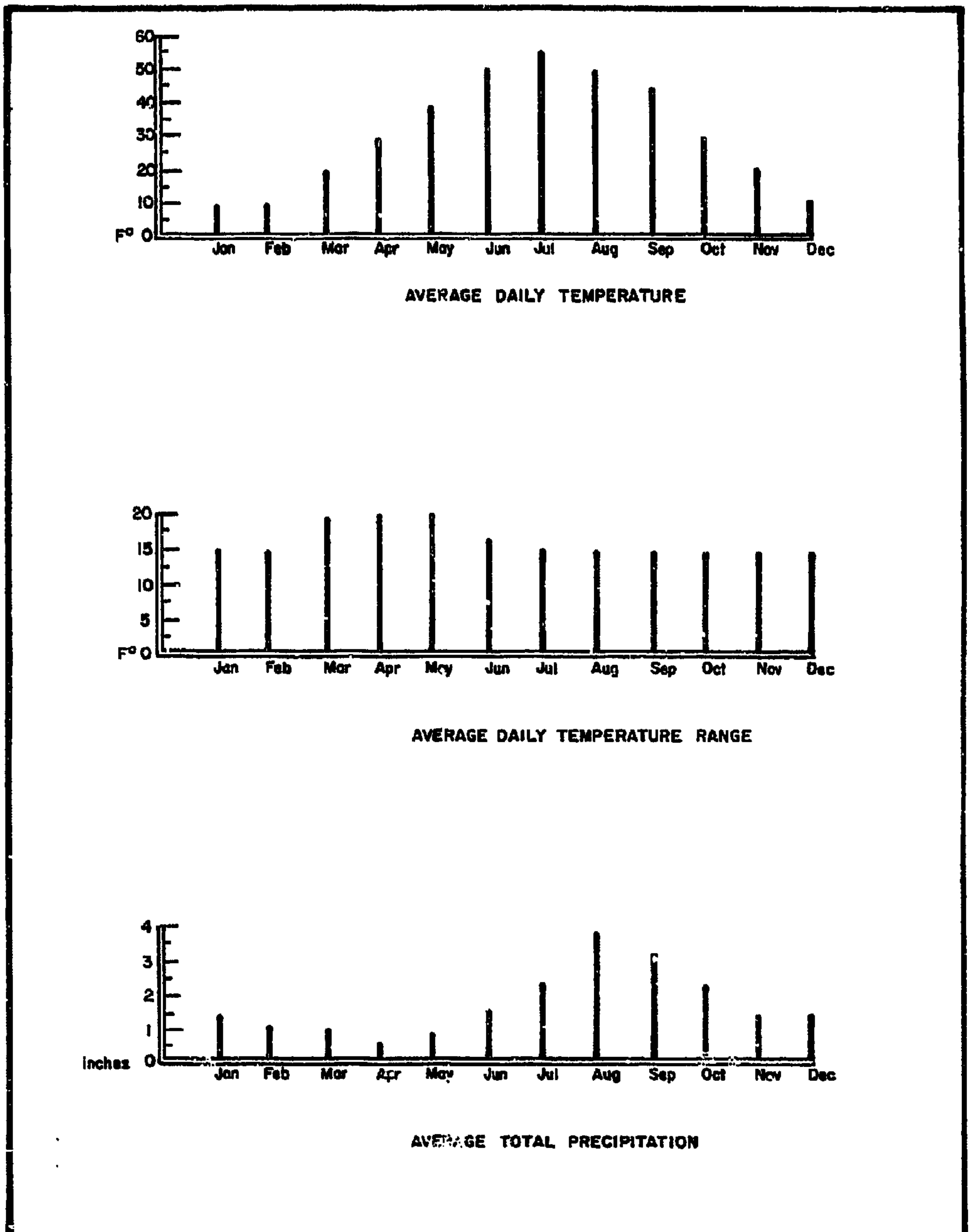


FIGURE 3.1 REPRESENTATIVE CLIMATIC CONDITIONS FOR PROJECT AREA

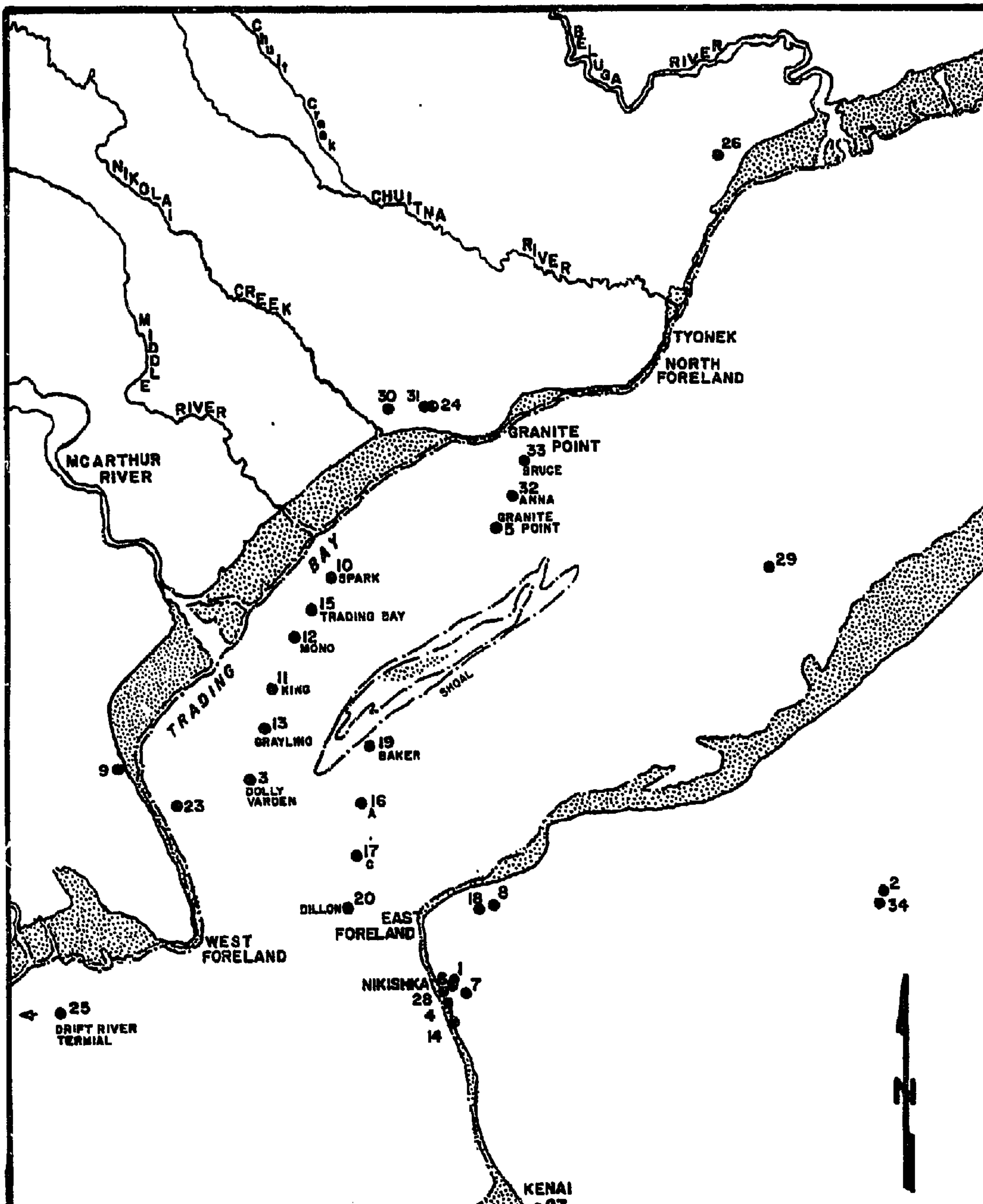
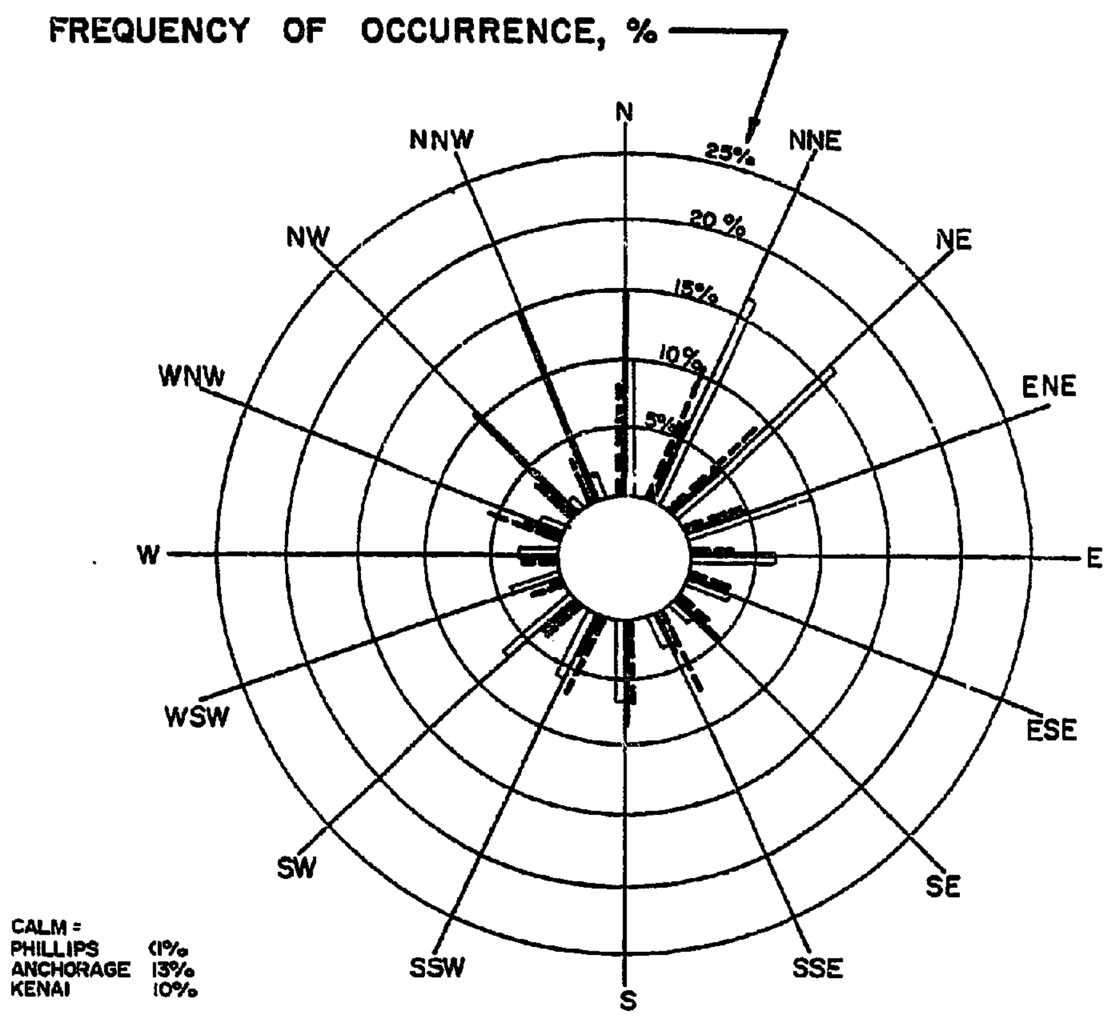


FIGURE 6.2	LOCATIONS OF WEATHER MONITORING STATIONS



LOCATION	SYMBOL	SEASON	DATA PERIOD	NUMBER OF OBSERVATION DAYS
PHILLIPS PLATFORM	———	ANNUAL	74 - 79	2
ANCHORAGE	- - - -	ANNUAL	51 - 60	24
KENAI	▭	ANNUAL	64 - 70	8

NOTE: KENAI ROSE HAS CALMS DISTRIBUTION BETWEEN THE 1-3 & 4-6 KNOT GROUPINGS.

FIGURE 6.3 WIND ROSE

Observations from the Kenai and Anchorage stations are used to describe the turbulent structure of the atmosphere. Wind speed, time of day, cloud cover and cloud ceiling height data are combined with estimates of the intensity of solar radiation to classify the atmosphere into one of six atmospheric stability categories designated by the letters A through F. Stability Class A represents the most turbulent conditions and is associated with strong solar radiation input and dominating convective currents. Stability Class F describes very stable air absent of convection currents. For Kenai, the annual frequencies of occurrence of the various stability classes are: Class A - 0%, Class B - 1%, Class C - 10%, Class D - 62%, Class E - 9%, Class F - 18%. This distribution reflects the rather common occurrence of cloudy skies (Class D). It also suggests that the dispersion of contaminants released into the atmosphere will be controlled most of the year by wind speed and roughness of the ground surface. This is discussed in more detail in Section 15.0 AIR QUALITY.

Other aspects of the climatology that should be noted are:

° Possible sunshine	Less than 50%, annual average
° Sky (cloud) cover (sunrise to sunset)	70% annual average occurrence, 40% annual average full coverage
° Mean daily solar radiation	225 Langleys, annual average
° Precipitation greater than 0.01 inches	Less than 120 days, annual
° Shortest day	5½ hours
° Longest day	19½ hours
° Heating degree days (base 65°F)	10,864, annual average total (Anchorage)

EXISTING AMBIENT AIR QUALITY

National and Alaska Ambient Air Quality Standards set maximum levels of several pollutants: Ozone, carbon monoxide, surfur dioxide, total suspended particulates, hydrocarbons, nitrogen dioxide and lead. The Clean Air Act as Amended August 7, 1977 (PL 95-95) defines three classifications for areas which meet these standards: Class 1 areas are considered to have pristine air quality with the allowance for minimal introduction of additional air pollutants; Class II areas, in which pollution will be allowed to increase to accommodate moderate industrial growth; and Class III areas which are the most heavily industrialized. Some areas are specifically defined in the regulations as mandatory Class I Areas (40 CFR 81 Subpart D). The Cook Inlet Air Quality Control Region is designated a Class II Attainment Area for all criteria pollutants. The Tuxedni National Wildlife Refuge, about 80 miles southwest of the project area, is a mandatory Class I Area (40 CFR 81.402). Anchorage, approximately 75 miles east/northeast of the proposed plant site, is one of two areas of Alaska in nonattainment with the ambient air quality standards for carbon monoxide. The Prevention of Significant Deterioration (PSD) permit program administered by EPA limits the amount of controlled pollutants which can be emitted by a new source in order to ensure that the ambient air quality standards are not violated in any area which could be affected by the new source.

ATMOSPHERIC EMISSION SOURCES

The actual air quality on the western shore of Cook Inlet near Tyonek is not known. Several sources of emissions of particulate matter, sulfur oxides, carbon monoxide, nitrogen oxides and hydrocarbons are scattered throughout the onshore area, with a number of offshore oil and gas platforms concentrated in the Nikishka/Kenai area. Nitrogen dioxide emissions are greatest, with products of combustion representing the majority from both offshore and onshore pollutant emission sources. The impact of these existing sources on ambient air quality tends to be very localized with the highest regional concentrations occurring where source congestion is greatest. The most congested areas include Trading Bay and Salamatof, and even in these areas separation between individual sources is good

(Dames and Moore, 1978). For these reasons, air quality within the area is expected to be well within the National and Alaska Ambient Air Quality Standards. These existing sources will have to be considered in evaluating the impact that new sources would have on ambient air quality, especially if the new sources are expected to have their maximum impact to the immediate south of the site.

Visibility is occasionally a problem throughout the inlet area. At Anchorage, the visibility is one-half mile or less 5% of the time during December and January, primarily due to fog. The Alaska Department of Environmental Conservation may, in its discretion, require any person proposing to build or operate an industrial process, fuel burning equipment, or incinerator in areas of potential ice fog to obtain a permit to operate and to reduce water emissions (18 AAC 50.090). In addition, snowfalls frequently decrease visibility to less than 3 miles.

7.0 OCEANOGRAPHY

PHYSICAL OCEANOGRAPHY OF COOK INLET

Cook Inlet is a large tidal estuary in Southcentral Alaska which flows into the Gulf of Alaska. The estuary lies between latitudes 50° and 61° 30' north and longitudes 149° and 154° west. The inlet is more than 150 nautical miles long and 50 nautical miles wide at the mouth. At its northern tip Cook Inlet divides into Turnagain Arm (43 nautical miles long) and Knik Arm (45 nautical miles long).

The inlet is bordered by more than 100 square miles of tidal marsh, found primarily in the Susitna flats at the northwest end and in Trading and Redoubt bays on the northwest side of upper Cook Inlet.

For discussion purposes, the inlet is divided into lower, central, and upper regions (Figure 7.1). The lower division extends from the mouth to an east-west line from Chinitna Bay to Anchor Point. The upper region lies north of an east-west line from East Forelands to West Forelands. Granite Point, the site for the proposed methanol plant, lies just north of Trading Bay in upper Cook Inlet; the Drift River Terminal is in Redoubt Bay on the west side of centr., Cook Inlet.

The Cook Inlet environment is diverse, and water quality varies greatly from the mouth of the inlet to the head. The tidal range in Cook Inlet is one of the largest in the world. The upper portion of the inlet is a shallow silt-laden basin. At the Forelands the maximum depth is approximately 75 fathoms (450 feet). Below the Forelands, the bottom slopes to a depth of more than 100 fathoms (600 feet) at the mouth.

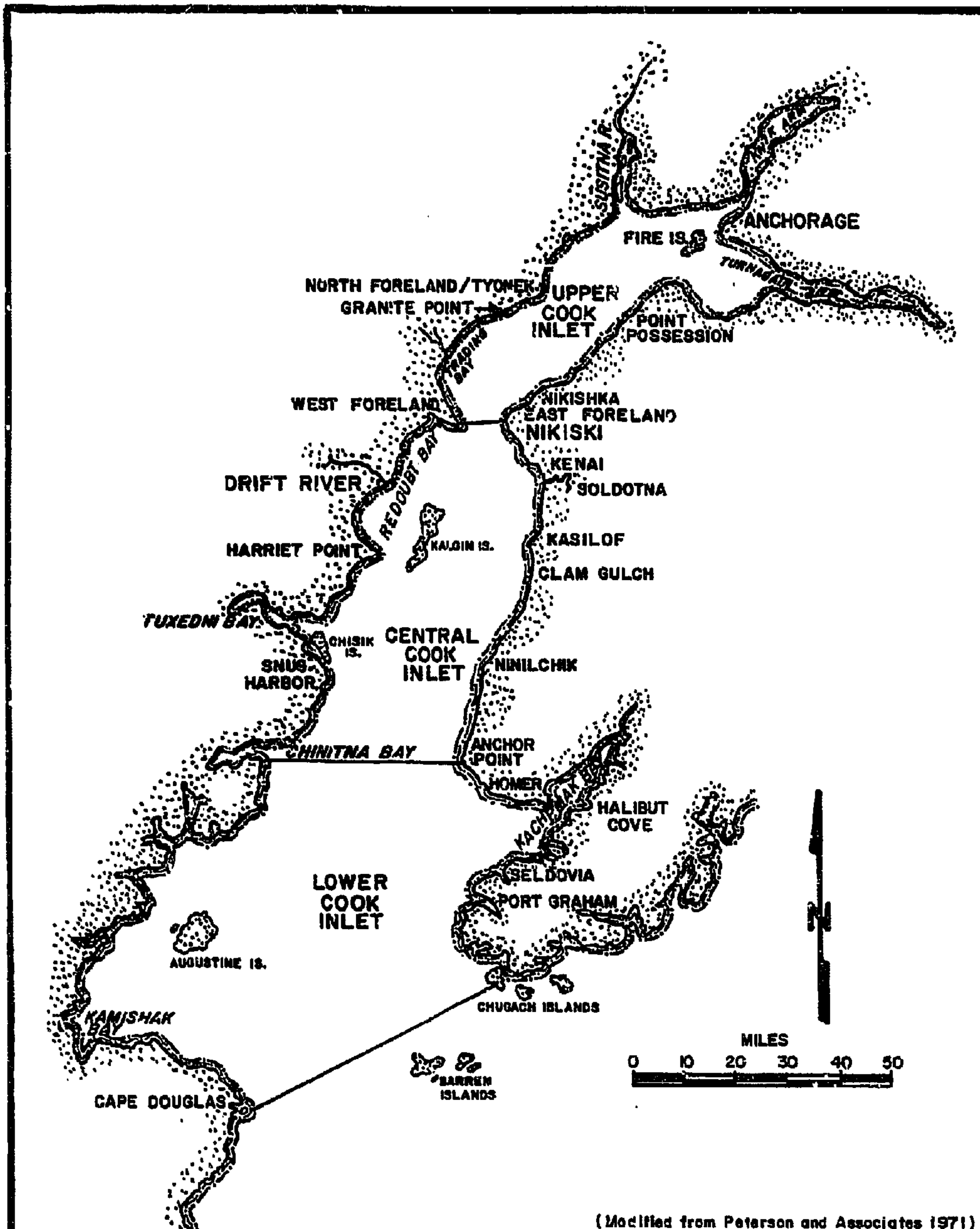


FIGURE 7.1	DIVISIONS OF COOK INLET

Tides and Currents

The tides in Cook Inlet are semidiurnal with a marked inequality between successive low waters. At the mouth of the inlet the mean diurnal tidal range is 13.7 feet. The range increases to 19.8 feet at Kenai and 29 feet at Anchorage. At the ends of both Knik and Turnagain arms, the tidal range exceeds 35 feet. These mean ranges can be exceeded during the spring and fall equinox periods by more than 5 feet. The time lag between high water at the mouth and at Anchorage is about 4.5 hours. It has been estimated that the time lag at Drift River is approximately 2 hours at low tide and 1.7 hours at high tide.

The following tidal ranges are applicable for the central and upper portions of the inlet. These ranges vary slightly for the Tyonek/Beluga area.

Table 7.1

COOK INLET TIDAL RANGES

	KENAI (ft.)	ANCHORAGE (ft.)	BELUGA (ft.)
Estimated Highest Tide	27.0	36.0	--
Mean Higher High Water	20.7	30.0	21.00
Mean High Water	20.0	29.0	20.40
Mean Tide Level	11.1	15.5	11.25
Mean Low Water	2.1	2.2	2.10
Mean Lower Low Water	0.0	0.0	0.0
Estimated Lowest Tide	-6.0	-4.9	--

The extreme tides in the inlet create strong currents. The average maximum tidal currents range from 1 to 2 knots in lower Cook Inlet, 4 to 6 knots between the Forelands, and 2 to 3 knots near Anchorage. Current direction is determined by bathymetry. Higher velocities for currents vary within the inlet; however, the high velocities are associated with flood tides. In the Tyonek area, current velocities have an estimated range from 3 to 6 knots.

CIRCULATION

The circulation of waters within Cook Inlet has been extensively studied. Generally waters from the Gulf of Alaska flow into Cook Inlet through the Kennedy Entrance between the Chugach Islands and Cape Douglas. The waters must pass a steep entrance ramp into the inlet, causing upwelling. The nutrients and plankton from the Gulf of Alaska are carried into the inlet creating an area of high productivity in the lower inlet/Kachemak Bay region.

The waters from the gulf move northward along the east side of the inlet and across the inlet at Anchor Point. Waters also flow into Kachemak Bay, and eddies are created at the mouth of the bay. Minor quantities of water move northward past the forelands and into the upper inlet. Turbid water from the upper inlet mixes with the clear water from the gulf north of Anchor Point. Because of the vast difference in the density between waters of the upper inlet and those from the Gulf of Alaska, lateral mixing is slow. However, the rapid currents and tidal action keep the waters of the inlet well mixed vertically. Lateral mixing produces convergence zones in which denser saline waters flow under less saline waters and produce rip tides. These rip tides produce considerable horizontal shear. Circulation patterns and main rip tide locations are illustrated in Figure 7.2.

Upper Cook Inlet

The waters of upper Cook Inlet mix with each tidal cycle. This is due to the large tidal fluctuations and the shallow sea bottom. In

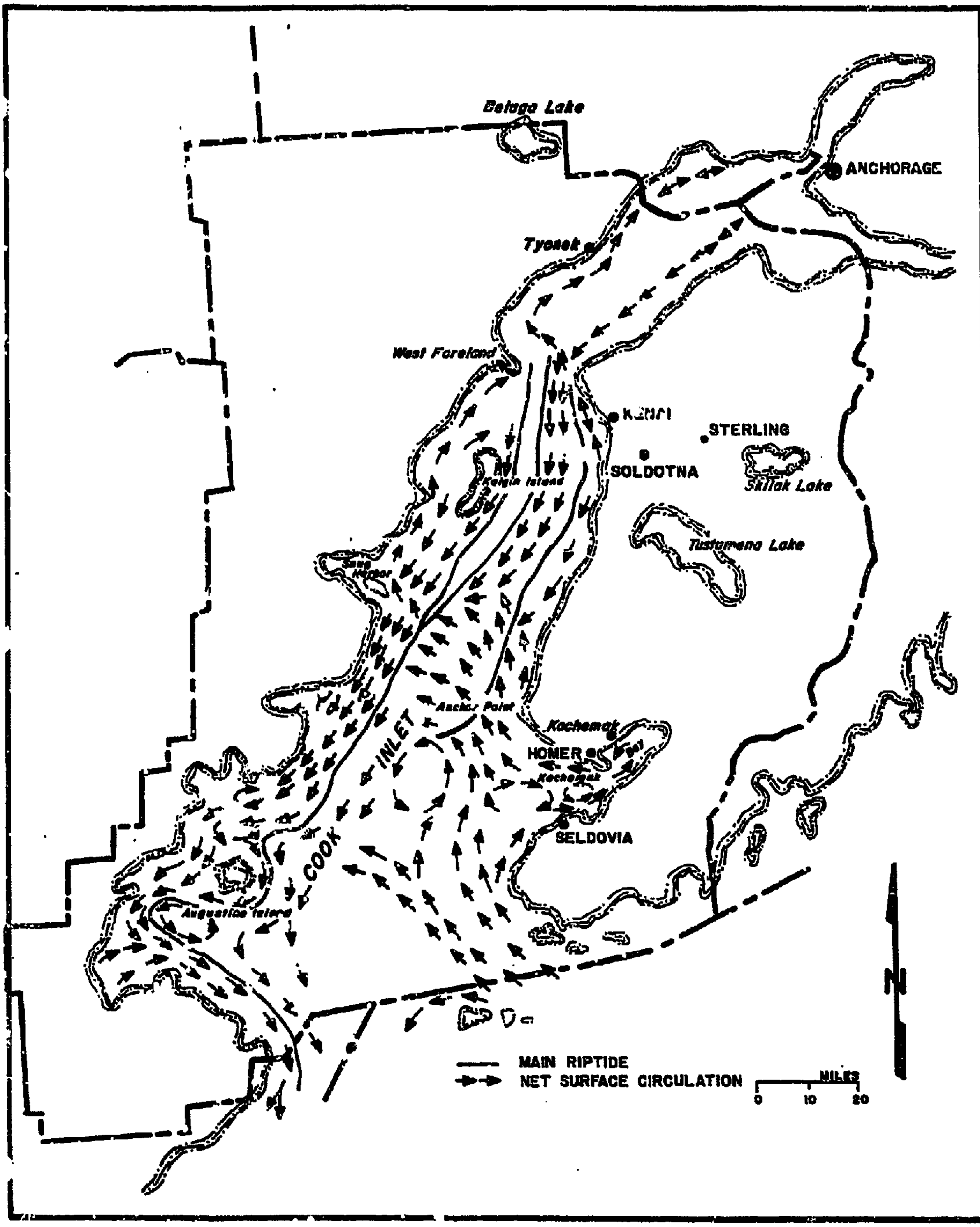


FIGURE 7.2 NET SURFACE CIRCULATION

the spring and summer a large amount of fresh water flows into the upper inlet from major tributaries including the Beluga, Susitna, Little Susitna, Matanuska, Knik, Eagle, Twenty-mile, Placer, Resurrection, and Swanson rivers. The increase in fresh water volumes causes a net outward movement of upper inlet waters of as much as a mile each tidal cycle. In the winter, however, when runoff is greatly reduced, there is practically no net outflow from the upper inlet.

Middle Cook Inlet

The middle inlet is characterized by saline oceanic water moving northward along the eastern shore, and the outward movement of fresh runoff water from the upper inlet along the western shore. Lateral separation of these waters is maintained.

Lower Cook Inlet

In the lower inlet a vertical stratification of the water masses occurs. The denser, colder, more saline oceanic waters underlie the warmer, less saline waters of the inlet. As the inlet becomes shallower to the north the dense oceanic waters are forced upward and mix with the inlet waters.

WATER CHEMISTRY

The waters of Cook Inlet change chemical make-up seasonally, due primarily to variations in the volume of freshwater inflow. During summer, large quantities of nitrate, nitrite, silicate, and suspended sediments are carried into the inlet from rivers, streams and other runoff sources. During the winter, with decreased freshwater inflow, there is an increased intrusion of oceanic water, and salinity, phosphate and ammonia concentrations increase.

Salinity

The salinity of Cook Inlet varies with the season due to increased freshwater runoff in summer. During May through September the increased discharge from rivers and streams and other runoff sources decreases the salinity of the upper inlet. At Anchorage salinity varies from 6 to 15 parts per million (ppm) during the summer. In the winter, freshwater inflow is reduced and the intrusion of more saline oceanic waters is evidenced by an increase in salinity. The salinity of waters near Anchorage in the winter usually is approximately 20 ppm. At the mouth of the inlet, however, the salinity values remain relatively constant at 32 ppm. The salinity in the Beluga/Tyonek area varies between 10 and 20 ppm in the summer months.

As a result of the increased freshwater inflow, the Alaska current and the Coriolis effect, the water on the eastern side of Cook Inlet tends to be more saline than on the western side.

Temperature

The temperature of waters varies with season from below 32° to 60°F (0° to 15°C) in the upper inlet. The lower inlet is affected by the intrusion of warmer waters from the Gulf of Alaska and thus the waters range in temperature from 48° to 50°F (9° to 10°C). During the winter, the upper inlet loses enough heat to form ice on the water's surface and also loses heat throughout the vertical column. However, during spring, freshwater inflow and warm air temperatures melt the ice and the water temperature rises.

Suspended Sediments

Discharges of fresh water from the major rivers which flow into Cook Inlet carry large amounts of suspended sediment. The Susitna River and other rivers flowing into Knik Arm represent 70 to 80% of the total sediment flow into the inlet. As with temperature and salinity, suspended sediment loads vary seasonally. This is due to the large amount of glacially derived sediments which combine with sediments in the summer and fall runoff waters.

In the upper inlet the small-size particles, clays and silt-size particles are kept in suspension by strong tidal action. The heavier particles are deposited at the mouths of the streams and rivers. The distribution of sediments within the inlet is shown on Figure 7.3.

Concentration of suspended sediments varies within the inlet from negligible at the mouth to 3,000 micrograms per liter (μg/ℓ) in Knik Arm. In the Beluga/Tyonek area the concentration varies from 250 to 1,000 μg/ℓ.

Nutrients

Nutrients are introduced into the estuarine environment of Cook Inlet through both natural and man-made sources. Total concentration of nutrients is found to gradually increase with distance toward the mouth of the inlet. Nutrients of importance include ammonia, nitrite, nitrate, phosphate and silicate. The increase of these nutrients in the southern portion of the inlet causes an increase in productivity. Marine biological resources increase dramatically. Low levels of nutrients associated with high turbidity in the upper inlet are responsible for the near absence of plankton.

Ammonia concentration decreases northward toward Knik and Turnagain Arms, however, ammonia concentrations do not fluctuate seasonally. Sources of ammonia input to Cook Inlet include oceanic entrainment, freshwater inflow, precipitation and man-made sources. Of these, oceanic entrainment provides more than 80% of the ammonia in the inlet. Ammonia is used by phytoplankton and is one of the first elements decomposed by bacteria. Concentration of ammonia in the upper inlet ranges from 0.5 to 2.0 μg/ℓ.

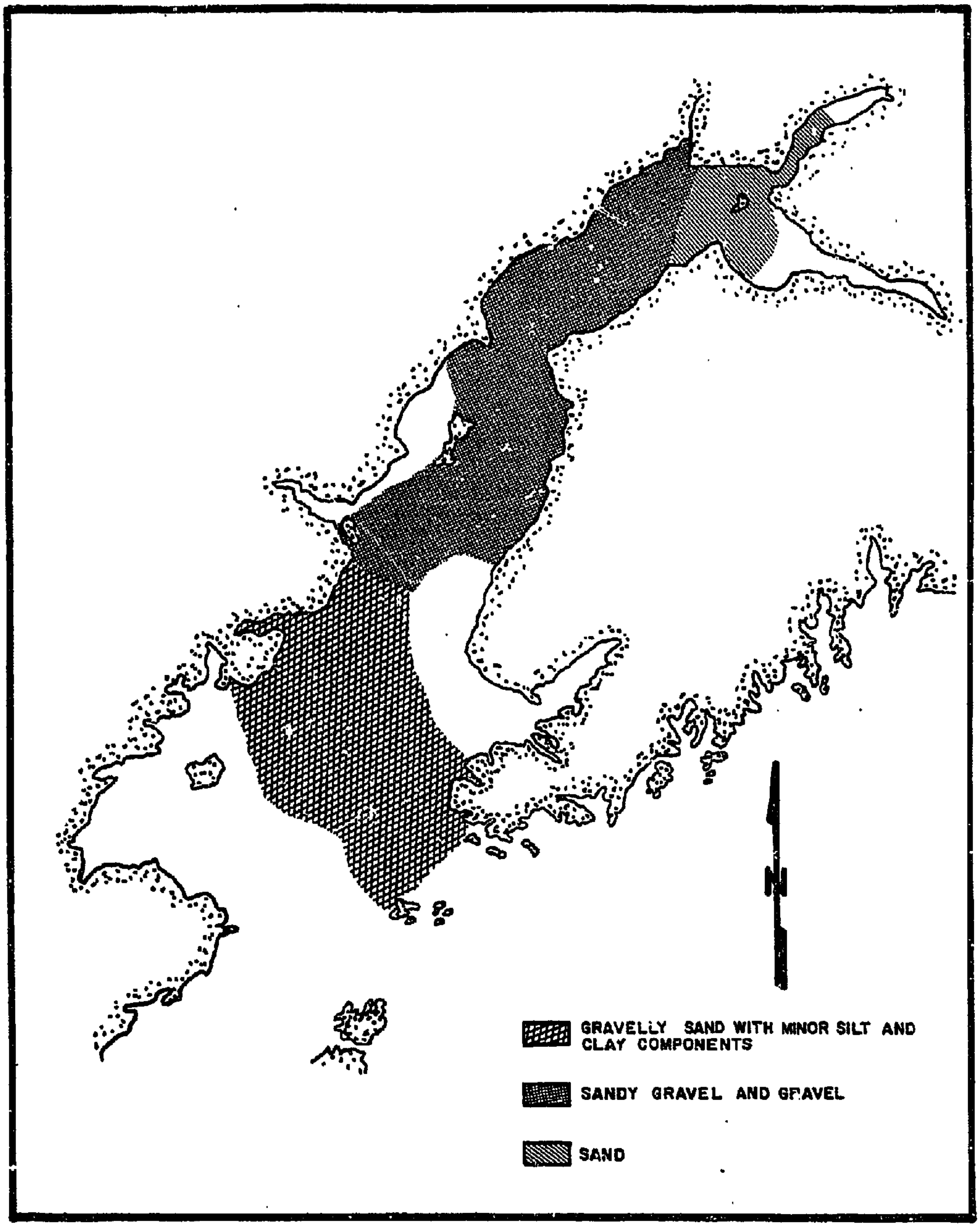


FIGURE 7.3 BOTTOM SEDIMENTS IN COOK INLET

Nitrite concentration in the inlet varies from 0.02 to 0.52 µg/ℓ. There is a gradual increase in concentration seaward.

Nitrate concentration increases from below detectable limits at the mouth to 23.5 µg/ℓ near the head of the inlet. The increase in concentration can be attributed to higher freshwater inflow, lower biological activity, and higher municipal waste inputs.

Phosphate-phosphorus concentration ranges from 1 µg/ℓ at the ocean entrance to approximately 2.3 µg/ℓ between Anchor Point and Kalgin Island, then decreases to about 0.7 µg/ℓ in Knik Arm. The high amounts of freshwater inflow at the head of the inlet reduce the phosphate concentration.

Silicate concentration is directly related to the concentration of suspended sediments and thus decreases in concentration toward the mouth of Cook Inlet. Concentration ranges from 82 µg/ℓ near Knik Arm to 9 µg/ℓ at the ocean entrance.

Dissolved oxygen saturation levels for Cook Inlet range from 6.5 to 9.5 µg/ℓ. These levels may decrease slightly during winter months in upper Cook Inlet when there is an ice cover. Dissolved oxygen is necessary for aerobic marine life. Dissolved oxygen saturation value increases with decreasing temperature and salinity and decreases with suspended sediment concentration. The high suspended sediment concentration in the upper inlet also may cause a slight decrease in the dissolved oxygen saturation level. The high level of turbulence and strong currents throughout the inlet, however, help maintain the dissolved oxygen level at or near saturation.

pH values in Cook Inlet vary seasonally and with location. The pH can vary from 7.7 near the head of the inlet to 8.4 at the mouth.

SEA ICE

Heavy ice normally accumulates in upper Cook Inlet around mid-December, exists in greatest quantities during the colder months of December and January, and remnants may be present through mid to late April. Sea ice in Cook Inlet is found primarily north of the Forelands and generally moves with the currents southward toward warmer waters. The extent of the ice coverage depends on the severity of the winter and the prevailing winds.

Temperature and snow cover control ice growth in the inlet. When air temperatures are extremely low and snow cover marginal for extended periods of time, the ice cover will be thicker and more extensive than usual.

Ice in the inlet takes many forms. Usually the ice is floe ice, which in periods of extremely low ambient temperature and little or no snow cover can increase in thickness by as much as 1 inch per day, forming cakes or pans of ice. The pans have a normal thickness of 2 to 4 feet but may attain thicknesses of 6 to 8 feet under uncommonly severe conditions. Tidal action moves the pans of ice back and forth in the upper inlet causing small pieces to break off and form individual pieces of stranded ice, called "Stamukhi". Shorefast ice forms in shallow intertidal areas such as tidal flats. Tidal action deposits large blocks of ice on the beach or along the shoreline. The blocks of ice then freeze to the underlying mud. These blocks of ice are exposed to air and submerged with water during the tidal cycle and build mats of ice, 6 to 10 feet in thickness. Piles of ice may break off and go adrift during periods of extreme high tide and enter other ice floes in the inlet. Ice piles such as these can be dangerous to the smaller ships, tugs, and barges which operate within northern Cook Inlet.

Sea ice tends to accumulate along the western shoreline of Cook Inlet due to prevailing winds and currents. Ice formed in upper Cook

Inlet has a lower salinity due to freshwater discharges into the inlet, and would tend to be harder than ice found in lower Cook Inlet and the Gulf of Alaska. These freshwater discharges also carry large amounts of suspended sediments of which a large part is glacial flour. The ice which contains these sediments would tend to break more easily than ice which doesn't. This would in part mitigate the ice hardness due to the lower salinity of upper Cook Inlet.

Ice occasionally causes difficulties with shipping within Cook Inlet. With the decrease in demand for freight to be shipped during the winter and the possibility of sustaining damage to the vessel as a result of impacts with ice flows, most tug and barge operations generally terminate in upper Cook Inlet from mid-November to late March. The average tug length in Cook Inlet is approximately 120 feet, and none of the tugs or barges is strengthened for ice conditions.

Though ice must be acknowledged as a factor important to navigation and berthing of ships in Cook Inlet, it has not caused significant difficulties to the large vessel trade. Anchorage, at the head of Cook Inlet where ice accumulation is greatest, is the port of call for an average of two to three Totem Ocean Trailer Express and Sea-Land Service Company ships weekly throughout the year, with 15 to 20 Chevron USA ships using the port facilities yearly. These ships have extra plating to prevent damage due to the ice, with the exception of the two ships operated by Totem. Totem's marine manager feels their fine-line ships have a greater tendency to cut through the sea ice than do the wider ships. Totem's vessels have not sustained damage due to ice floes which has required repair ahead of the regular maintenance schedule.

Servicing of the many oil platforms within Cook Inlet also continues throughout the winter months without significant difficulties due to the sea ice. The Alaska Husky, a 182-foot ship operated by Amoco Production Company, transports fuel, water, and miscellaneous supplies to and from two of the three oil platforms nearest Granite Point, the Bruce and the Anna, twice weekly with little difficulty and without an accelerated maintenance schedule. None of the above companies has ever had a ship cancelled due to the ice in Cook Inlet. An occasional short delay has been experienced, waiting for the tidal action to wash the ice from the berthing area for a more facile entry. Past experience indicates tankers transporting methanol from Drift River should have no significant trouble with ice in Cook Inlet.

PORTS

There are 6 ports or terminal facilities within the inlet. These include Seldovia, Homer, Kenai/Nikiski, Ninilchik, Drift River, and Anchorage. Anchorage, at the head of Cook Inlet, is the most ice-affected location within the inlet. Anchorage is also the largest of the ports and is a modern, year-round facility that handles more than one million short tons of cargo per year. The Nikiski port handles primarily out-bound petroleum products including crude, residuum, finished products and liquified natural gas (LNG). Another major product is urea, which is shipped primarily to Japan.

The ports of Kenai, Homer, Seldovia and Ninilchik are primarily small boat harbors and support the fishing industry in lower Cook Inlet. The Drift River Terminal is a single-berth fixed-platform offshore loading facility which transfers crude oil from the offshore platforms aboard tankers for transport to refineries.

8.0 ARCHAEOLOGIC & HISTORIC SITES

A paucity of archaeological investigations in the area requires that an understanding of the history and prehistory be gleaned from regional sources of information.

ETHNOHISTORY AND SETTLEMENT PATTERNS

Settlement Patterns

The area is currently inhabited by the Tanaina Athapaskan Indians, speakers of the Upper Inlet dialect of the Dena'ina language of the Na-Dene speech family. Archaeological evidence indicates that the ancestral Na-Dene moved across the Bering Strait into the present State of Alaska by the tenth millenium B.C., near the end of the final great glacial period. They continued to spread east and south during the period of deglaciation, and diversification of the Pacific Athapaskan subfamily is considered to have been completed by about 1000 A.D. It is further considered that the earlier inhabitants of the Cook Inlet area were Pacific Eskimo or their direct ancestors, and they were occupying the area at least seasonally beginning before and lasting until after 1000 A.D., with the Tanaina moving into Knik Arm, specifically, between 1650 and 1780 A.D.

A complex relationship between the people and the land can be described for the inhabitants of Cook Inlet. Location along the food-rich sea coast enabled the fairly settled way of life known as Central-Based Wandering: A community that spends part of each year wandering in the performance of subsistence activities, and the remainder of the year at a settlement, or central-base. The settlement patterns of the Northern Athapaskans, as well as of the Pacific Eskimos, also can be characterized by a sedentary seasonal settlements-complex. This is one in which the year is divided into a winter season during which little resource exploitation occurs and the people gather at their winter settlements, and a hunting and fishing season from the spring to the fall when people are scattered in small hunting, sealing or fishing camps. In the case of the Tanaina on Cook Inlet, it is probable that people gathered at the seashore or riverbanks in concentrated settlements during the fishing seasons or sea mammal hunting seasons, and in the intermittent seasons task groups moved about to hunt wild game, trap, etc.

The socio-territorial relationships of historic and prehistoric inhabitants of Cook Inlet can be broken down into three segments. The local band was a community body resident in one locale, and structured around family ties. The regional band was oriented toward an extensive exploitive territory with regard to its biotic resources. The sites of these resources and routes of access to the sites determine the stations and movements of various groupings. The task groups were short-term groupings of people specifically created for exploitive activities. Task groups formed in the Cook Inlet area could have been a male trapping pair or trio, a trapping party of a few families, a moose hunting party or camp, a fish camp, a berry gathering party, or a trading party. It is apparent that the settlement patterns were determined by and changed according to the ecological potentiality of the locale, combined with the exploitive ability of the human occupants.

Dwellings

Aboriginal Tanaina dwellings were characteristic of those of the Pacific Eskimo, and were also built on Kodiak Island, the Aleutian Islands, and Prince William Sound. The winter house, known as a "barabara" in Russian and "nichil" in Dena'ina was rectangular, and semi-subterranean, excavated to a depth of two to four feet. It fits in the category of the Third Period of Kachemak Bay. The dwelling which extended "five trees long" was constructed with split vertical logs, and had four or five fireplaces and a smoke hole at the top. To the main part of the barabara, or winter house, one or more secondary rooms were added, for sleeping rooms (depending on the number of families sharing the dwelling), a sweat house, and possibly a menstrual lodge. These were excavated to the depth of the main lodge. Floors of the sweat house and sleeping rooms were rough hewn planks and the remaining floors were spread with grass. A narrow, semi-subterranean shed served as an entrance way. The summer houses, used also for fish smoking, were simplified versions of the winter houses. Excavation was to two feet, length was a maximum of 20 feet, and three corner posts sufficed.

Petroff (1880) and Porter (1890) report that by 1880 house construction had changed and a log dwelling erected entirely above ground replaced the barabara. The dwelling was divided into an outer room for cooking and rough labor, and an inner room for sleeping.

Secondary dwellings, constructed for short-term use such as on hunting expeditions, were of various types. The semi-spherical "beaver house" made of bent alders covered with birch bark or skins was common. Another type was the lean-to, or one-sided lodge. This was also constructed from covered alder poles.

Caches

The Tanaina in the Tyonek Upper Inlet area constructed two types of storage caches. One was an underground cache constructed similarly to the winter house, however the roof was lower and the whole house was sunken and covered with earth. The caches were generally situated some distance from the village and the main advantage of this type was that they could not easily be detected and therefore were protected from Eskimo raids. At the Kijik site on the west shore of Lake Clark west of Cook Inlet, 29 small, deep depressions thought to have been caches were noted. Storage pit depressions were also found on the northwestern Kenai Peninsula. The more common log building, situated on a platform and raised on poles, was also utilized in the Tyonek area.

Burial

According to Osgood (1937), the dead, along with their essential possessions, were disposed of by cremation in the Tyonek area. The ashes were then wrapped in birch bark and hung in a tree. A method known to have been used by the Eskimo in Alaska south of the Bering Strait was box burial. In Tyonek, the dead were also known to have been cremated and placed, with possessions, in a box on posts. By 1805 only the rich were cremated, and by the late 1800s, due to Russian influence, cremation was no longer practiced. Grave offerings continued, however, and burials were frequently in structures resembling miniature houses.

Hieromonk Nikita visited in 1881 a grave of a former local chief at Tyonek. A small house in the shape of a chapel, equipped with a door and a window, had been constructed over the grave. Inside the structure was a table, food, clothes, a gun, a razor and other items, many of European descent, that a wealthy Tanaina would value. Petroff (1880) also witnessed a burial house at Tyonek filled with Russian samovars, rifles, blankets and other costly items.

Material Culture

Osgood (1937) states that it is probable that metal working, to the extent of pounding crude copper into useful shapes, was a custom of the Upper Inlet Tanaina. Dumond and Mace (1968) concurred that at least in late prehistoric times copper was used by the Natives in Southcentral Alaska. Copper objects were attributed to the late prehistoric sequence at Kachemak Bay, and Captain James Cook reported that the Cook Inlet Natives had spears and knives with copper blades. Prince William Sound and the Copper River were the nearest sources of native copper. The Athapaskans of Cook Inlet used to travel the Matanuska River and cross the 12-day portage to the Tazlina River where they traded with the Copper River Indians.

It is a point of conflict whether the Tanaina were producers of pottery. Osgood (1937) reports that the pottery sherds discovered by Jacobsen at an abandoned village called Soonroodna, on the south shore of Kachemak Bay, are evidence that the Tanaina had pottery, and he concludes that they made it themselves. He states, however, that his informants have no memory of the Tanaina ever having made pottery. It is considered that pottery users in the Naknek drainage and on the Pacific were Eskimos. In addition, two gravel-tempered sherds excavated by DeLaguna at Kachemak Bay are thought to represent the last of the Pacific Eskimos residing there before the arrival of the Tanaina. In addition, pottery sherds recovered in 1966 at Fish Creek on Knik Arm, which were associated with Pacific Eskimo occupation were of relatively thick, gravel tempered ware, globular form, with a rim identical to those from the Naknek drainage from a time between 1000 and 1500 A.D. Therefore, it can be expected that there is at least a sporadic occurrence of later pebble tempered pottery along the shores of Cook Inlet (Dumond 1969), and it can be concluded that there is stronger evidence in favor of pottery representing the Eskimo culture, than its replacement Tanaina culture.

The uncovering of a coal labret (lip ornament) at the same Fish Creek site substantiates the evidence of Eskimo occupation of the area. Captain James Cook stated that the Tanaina of Tyonek in 1778 used fewer lip ornaments and more nose ornaments than the Eskimo of Prince William Sound. Nose and ear ornaments were made of beads and carved bone.

A simple pointed harpoon with blades attached, nine feet one inch long, was collected at Tyonek. This was utilized for sea otters, seals and porpoises. A spear-thrower with a hook on the end is thought to have been used in the area. The bow had a guard and no sinew backing. Roughly hewn pieces of wood, slightly curved at the striking end, were used as clubs to kill seals and for dispatching sea otters after they were drawn alongside the kaiaks with harpoons.

The aboriginal man's knife was generally made of stone, two inches wide, eight inches long, and pointed. The handle was narrowed for grasping. The woman's knife was fashioned after the Eskimo ulu, a semi-ovaloid blade of stone set lengthwise in a handle. Adzes were made from hard stone, and scrapers from beaver teeth, mussel shells, and stone. No saw-like implements are known.

The foregoing list describes some of those tools used by the Tanaina Athapaskans of the Tyonek area. Frederica DeLaguna's exhaustive archaeological investigation in Cook Inlet, particularly in Kachemak Bay, can offer clues as to what cultural remains might be found in the study area. Her collection contains a large proportion of stone objects due to their resistence to decay. Bone and wood objects are highly susceptible to destruction by salt water. The stone industry of the early Kachemak Bay culture is characterized by the importance of chipping. This emphasis subsides as polished slate takes its place. Notched stones appear in the second period, as do grooved stones. Stone types commonly found in the later stages are the slate awl, slate mirror and decorated stone lamp.

In the bone industry, the Thule Type I harpoon head is most important in the First Period. In later periods the barbed dart head replaces it in importance, and incised decorations on bone objects become more common. The labret is found even from the earliest periods, and the double pointed bird bone awl, bone scrapers, red shale beads and rectangular bone and shell beads appear in the later stages.

Pottery and copper are uncommon, and are restricted to the last stage of the Third Period.

European Contact and Trade

The first documented contact between Pacific Drainage Athapaskans and Europeans occurred in 1778 when, searching for the northwest passage, Captain James Cook sailed into the inlet that now bears his name. Toward the close of that century other English navigators visited and traded with the coastal Tanaina.

In 1786 the Russians settled at St. George on the Kenai Peninsula and 13 years of struggle between various trading companies ensued. Finally, in 1799 the Russian American Company was formed and maintained a monoploy. Trade with the Russians was merely an elaborated form of trade patterns that had been occurring between the Indians and Eskimos before contact with the Russians. From the Russians the Tanaina received iron, beads, clothing and furnishings in exchange for furs.

At the time of the sale of Alaska to the United States, the assets of the Russian American Company were purchased and the Alaska Commercial Company was founded. A trading station was established at Tyonek at that time. The Western Fur and Trading Company also opened a post north of Tyonek at Ladd near the mouth of the Chuitna River. Tyonek is considered the earliest permanent settlement on upper Cook Inlet. Petroff reported 117 inhabitants in the town in his 1880 census report. A post office was opened in 1897.

Gold fever drew hundreds of prospectors to upper Cook Inlet, and in May 1898, 300 prospectors were reported camping on the beach at Tyonek. Large boats would go up the inlet in the summer, and touch at Tyonek. There, people would change to small boats and dories to reach Turnagain Arm. The Indians were used as guides and for manual labor.

In 1899, Captain Edward F. Glenn of the Twenty-fifth Infantry commanded the Cook Inlet Exploring Expedition which was based in Tyonek. The goal was to explore, survey, establish, and mark the trail from Tyonek to various locations. The routes were to be eventually made available to the public, and information was gathered regarding topographical features, feasible routes for railroad construction, sites for military reservations, the location and condition of natives encountered, etc. Expeditions were dispatched in the directions of the mouth of the Tanana River, Sushitna station, Circle City, and Eagle City.

According to the register of accounts for the Alaska Commercial Company, 16 types of skins were traded in 1884. The trading station's clerks kept a daily diary of events in the town and reported that there was much travel between towns by the inhabitants, and game was particularly scarce.

Historic and Prehistoric Sites

DeLaguna (1934) notes four archaeological sites near the study area (Figure 8.1). The modern village of Ladd is situated on the ancient site, Ts'ui´tna, from which the name of the river Chuit is probably derived. The town has been called Ladd since 1895, when it was a trading post and fishing station. Near the current site of Tyonek is the old village site, Qa´qesle. In the woods at the top of the hill behind the village site are the houses where the Tanaina lived for fear of raids by the Kodiak Eskimo. Old Tyonek is called Ta'naq and the site of Tsila´xna is at a small stream south of Granite Point. In addition, the site of Tobona, meaning "people of the beach," is located two miles south of Tyonek. Californsky's Fish Camp is along the beach 5½ miles southwest of Tyonek. Located about two miles southeast along the beach from the Kodiak Lumber Mills camp at North Foreland is a native cemetary, and on the bluff in front of McCord's cabin is evidence of prehistoric habitation. One-and-a-quarter miles inland on a road near the mouth of Tyonek Creek is Lake Batunglyashi. The lake, according to oral tradition, is the site of the last Indian war. Located within the modern town of Tyonek are many historic sites.

Proposed construction would avoid the land located within the boundaries formerly designated as the Moquawkie Reservation. The only

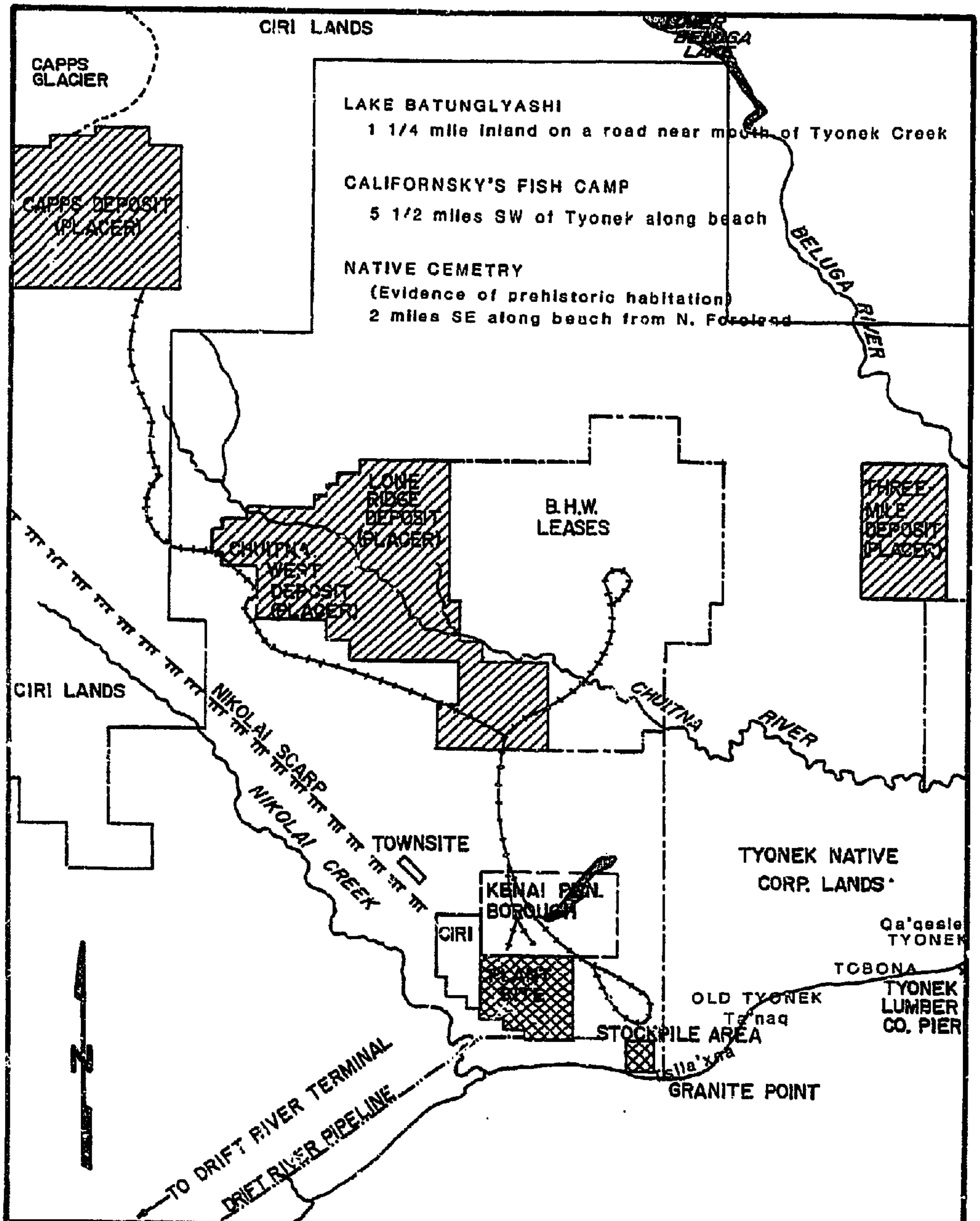


FIGURE 8.1 ARCHAEOLOGIC & HISTORIC SITES

site that lies outside these boundaries and within the study area is the Village of Ladd.

ARCHAEOLOGIC SITES

The area of study has been inhabited by two distinct cultures, the Pacific Eskimo, and more recently, the Tanaina Athapaskan Indian. Any major excavation in the proposed town or plant sites should be preceeded by an archaeological reconnaissance to determine the presence or absence of historic or prehistoric sites.

Dr. James Kari, of the Alaska Native Language Center at the University of Alaska, Fairbanks, has accumulated a vast knowledge of placenames for the Tanaina territory, many of them located away from the coastline. It would appear that the Tanaina may have been more than just coastal dwellers. More than 75 placenames have been identified in the Tyonek area, thus indicating that there exists a whole range of sites that are significant either mythologically or historically to the Tyonek people that cannot be evidenced archaeologically.

Two factors have placed a limit on the possibility of survival of prehistoric and historic sites in the study area. It has been ascertained archaeologically that the Tanaina Athapaskans were predominantly coastal dwelling people. It is also evident that the violent tidal action of the inlet has been constantly eroding the shoreline. It is possible, therefore, that artifacts, or even entire prehistoric settlements situated on the extreme coastline, may have been washed away by now. This phenomenon has been encountered on the northwestern Kenai Peninsula It has been estimated that between 1953 and 1974 the bluff in areas between the North Foreland and Tyonek and between Ladd and Three Mile Creek had retreated two feet per year. In addition, the bluff around Granite Point is characteristic of a zone highly susceptible to erosion. Also, the study area has been crossed with numerous lumber roads and seismic investigation trails, thus increasing the probability that sites may have been destroyed and historic trails may have been obscured.

9.0 OTHER FRAGILE LANDS

The Surface Mining Control and Reclamation Act (SMCRA) of 1977 directed the Secretary of the Interior to establish a permanent regulatory procedure for surface coal mining and reclamation operations. The regulatory program is intended to control adverse environmental impacts stemming from activity in and around surface coal mines. Although neither the federal program nor state program has been instituted in the State of Alaska at this time, a surface mining regulatory program is imminent and it is assumed it would resemble the present federal regulatory program. An integral part of the present federal program is the establishment of criteria for the evaluation of permit applications to determine if a proposed mine area should be declared suitable or unsuitable for surface coal mining operations. None of the criteria deals with the determination as to whether reclamation is technologically and economically feasible under the Act. This is discussed further in the volume of this report dealing with mining plans. The other criteria deal with compatibility of the proposed mining operation with the following outlined environmental elements. The remainder of this section discusses each of these elements with reference to key land management criteria presented in the federal program.

FRAGILE OR HISTORIC LANDS

Fragile lands, according to SMCRA, are geographic areas containing natural, ecologic, scientific or aesthetic resources that could be damaged or destroyed by surface coal mining operations:

> Examples of fragile lands include valuable habitat for fish or wildlife, critical habitats for endangered or threatened species of animals or plants, uncommon geologic formations, National Natural Landmark sites, areas where mining may cause flooding, environmental corridors containing a concentration of ecologic and aesthetic features, areas of recreational value due to high environmental quality, and buffer zones adjacent to the boundaries of areas where

> surface coal mining operations are prohibited under Section 522(e) of the Act and 30 CFR 761.

Within these proposed mining areas there are no critical wildlife habitat areas or endangered or threatened plant species. There would, however, be a general loss of noncritical vegetation and wildlife habitat. There are valuable fish habitats in the areas adjoining the proposed mining locations, however, with proper precautions and controlled mining activities effects on these streams could be minimized. Due primarily to its inaccessibility, this land currently receives essentially no recreational use. The local Native population constitutes the only significant hunting and fishing activities. It is expected that the proposed mining activities could be conducted acceptably as envisioned by the federal regulatory program.

NATURAL HAZARD LANDS

Natural hazard lands according to SMCRA means:

> geographic areas in which natural conditions exist which pose or, as a result of surface coal mining operations, may pose a threat to the health, safety or welfare to people, property or the environment, including areas subject to landslides, cave-ins, large or encroaching sanddunes, severe wind or soil erosion, frequent flooding, avalanches in areas of unstable geology.

No lands of this type exist within the proposed mine area which would render a mining operation incompatible with this criteria. The nearest lands representing this definition would be the unstable bluffs of the Chuitna River Gorge. Due to natural erosion there are bluff areas that are subject to periodic slides but the area is sufficiently removed from the mine areas as to not be impacted by mining activities.

RENEWABLE RESOURCE LANDS

These are lands in which "the mining operations could inflict a substantial loss or reduction of long-range productivity of water supply or of food or fiber products." This area is not known as or utilized for a watershed or a water source. It also would fall outside of the timber harvest area, as it is at or above tree-line in nearly all locations. A mine site would not be incompatible with this criteria.

LAND PLANNING

The contemplated mining activity is compatible with existing land use plans or programs. The proposed mine sites are located in the second most extensive untapped coal reserve in Alaska. The area has largely been controlled by the State of Alaska under a leasing policy encouraging energy development. A portion of the area now is owned by CIRI Native corporation, which encourages energy development through resource oriented policies. Mining operations in the Chuitna and Capps coal field areas are considered consistent with the intended land use and industrial development in this area.