Chapter 4

FORAGE FISH ABUNDANCE AND DISTRIBUTION

by

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SUMMARY

The purpose of this study was to describe the spatial and temporal distribution of forage fishes in the Unimak Pass area and assess this as a basis for explaining the distributions of marine birds and mammals of the region. Distributional analyses of these fish were based on mid-water trawls taken in association with marine bird and mammals surveys and measurements of physical and biotic attributes of the environment. Shipboard sampling was conducted in fall (late September-early October), winter (late February-early March), and spring (late April-early May). The forage fish data were interpreted in light of water mass distributions and characteristics described in Chapter 2 (PHYSICAL PROCESSES AND HYDROGRAPHY) of this volume.

The major findings were as follows:

(1) Young-of-the-year pollock were extremely abundant during fall within the tidally mixed waters around the Krenitzin Islands.

(2) Lanternfish were present in intermediate abundance during all cruises in the deep (> 1000 m) portions of the Gulf of Alaska. It was uncertain if large numbers of this potential prey species were ever within the foraging ranges of most seabirds.

(3) In most portions of the study area and during most seasons, forage fish were relatively uncommon and thus probably did not attract marine birds and mammals to the area.

(4) The paucity of forage fish in fall, winter, and spring seasons was consistent with the general patterns exhibited on the adjacent North Aleutian Shelf, where small fish were numerous only during summer (the season not sampled during the Unimak Pass surveys). But there were typically more forage fish in the Unimak Pass area than on the North Aleutian Shelf, especially during fall.

(5) Bottom fish were not sampled as part of this study, in part because very little sea-floor habitat was within the foraging ranges of birds. The presence of cormorants in coastal habitats indicates that fish were probably available there year-round.

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INTRODUCTION

The waters of the southern Bering Sea and the North Pacific Ocean are among the world's richest fishing grounds. These waters support an abundant and diverse fish fauna—over 300 fish species occur there, about 20 of which are of major commercial importance. Many of the area's birds and mammals are piscivorous, eating largely forage fish, at least in some areas and seasons.

The objective of this study was to assess the distributional abundances of the important forage fish species in the Unimak Pass area. The information collected would be presented such that the potential influence of forage fish abundances in space and time on the distributions and abundances of birds and mammals could be examined.

CURRENT STATE OF KNOWLEDGE

The eastern Bering Sea has long been the focus of fisheries studies and a vast body of information has accumulated. Many of the studies conducted there include some sampling stations near the eastern Aleutian Islands; some conducted in other locations provide pertinent information about species and populations which also occur in the study area. Studies include several comprehensive research programs and publication series: Outer Continental Shelf Environmental Assessment Program (OCSEAP), National Marine Fisheries Service, Northwest and Alaska Fisheries Center (NMFS/NWAFC), Alaska Department of Fish and Game (ADFG), Processes and Resources of the Bering Sea Shelf (PROBES), International North Pacific Fisheries Commission (INPFC), International Pacific Halibut Commission (IPHC), and the Soviet Fisheries Investigations in the Northeastern Pacific (Moiseev 1963). In addition, Bering Sea fish resources are monitored annually by state and federal agencies (ADFG, NMFS/NWAFC).

Not unexpectedly, much of this research and monitoring effort has been directed at commercial species (salmon, halibut, pollock, and sole). Information on forage fish has come primarily from OCSEAP or other ecosystem research programs, or from incidental catches made in studies of commercial species. In this section the available information about the distribution and abundance of forage fish in the Unimak Pass area is summarized, drawing largely upon Craig (1986). Descriptions of fishes commonly designated as groundfish and inshore fishes (partially comprised of forage fishes) are also included because species in these groups not commonly called forage fishes are eaten by birds and mammals and were caught during sampling in this study.

Forage Fishes

The term "forage fish" refers to species that are abundant, small in size, and significant in the diets of non-human consumers. Important forage fish species in the eastern Aleutians include herring, capelin, and sand lance. Available information is largely restricted to herring; little is known about the other two species.

Herring

Pacific herring are distributed nearly continuously around Alaska (Hart 1973). Herring form a significant component of the eastern Bering Sea food web and are the basis of an important commercial fishery.

Spawning populations in the eastern Aleutian Islands comprise a relatively small part of the overall herring biomass in the eastern Bering Sea, but the study area is an important feeding area for herring, including stocks spawned elsewhere in the eastern Bering Sea. Scale-pattern analyses indicate that about 80% of the herring harvested at Unalaska Island are from Bristol Bay (Togiak stock) with 10% from farther north (Nelson Island) and 10% from Port Moller (Walker and Schnepf 1982, Lebida et al. 1984, Rogers and Schnepf 1985). Herring stocks south of the Alaska Peninsula, however, do not appear to mix with Bering Sea stocks (Grant and Utter 1980, Rogers and Schnepf 1985).

The following description of herring in the eastern Aleutians is based largely on recent reports by Malloy (1985) and ADFG (1985). It is supported by more general reviews (Macy et al. 1978, Barton and Wespestad 1980, Barton and Steinhoff 1980, Wespestad and Barton 1981, Warner and Shafford 1981, Wespestad and Fried 1983, Lewbel 1983, Gilmer 1984, LGL 1986, Schwarz 1986, Fried and Wespestad 1985)

Distribution In and Use of the Study Area. Herring spawn in the Aleutians from late April to mid-July (ADFG 1985). Their eggs are deposited both intertidally and subtidally on aquatic vegetation. After the eggs hatch, the larvae remain in nearshore areas until summer and fall, when they move offshore. Patterns of habitat use differ between local and non-local herring stocks. Local stocks are small and are thought to be less prone to migrate long distances than non-local stocks.

Local stocks occur at several places, the principal one being Unalaska Bay. Small stocks are also found in Makushkin and Akutan bays, and possibly in Beaver Inlet. Spawning sites within Unalaska Bay are reported to occur at Nateekin Bay, Captains Harbor and Wide Bay (McCullough 1984). Spawning elsewhere in the study area is likely but undocumented. Local stocks may reside in the eastern Aleutian Islands year-round, but their distribution is not clear due to the large influx of non-local stocks in summer, when herring are distributed throughout much of the study area. Some herring remain in the study area through fall and winter. The winter concentration is small compared to those near the Pribilof Islands, and it is not clear that the Unimak Pass area is used regularly by herring during the winter months. It seems probable that at least the winter concentrations of herring in Unalaska, Akutan and Akun bays are of local stock origin as herring in other areas of Alaska are known to overwinter close to their spawning sites (e.g., Carlson 1980).

The dominant stocks of herring in the eastern Bering Sea are non-local and undertake extensive annual migrations among wintering, spawning and feeding areas. The eastern Aleutian Islands lie along one of these herring migration routes. The largest wintering concentration of these stocks occurs northwest of the Pribilof Islands, more than 700 km from their major spawning area in northern Bristol Bay (Shaboneev 1965, Rumyantsev and Darda 1970, Wespestad and Barton 1981). After spawning, many fish migrate westward along the Alaska Peninsula as far as Unalaska Island, where they feed in summer. These herring are harvested in a food/bait fishery (3200 mt total harvest) which operates over the approximately 90-mi distance between Tigalda Island and Makushkin Bay; most fishing occurs within about a 5-mi radius of shore-based processing facilities in Unalaska and Akutan bays (Malloy 1985).

Malloy (1985) notes that early accounts of herring in the Unalaska area describe both an early summer run (late June to late July) and a late summer run (late August to early September), but that in current years there seems to be a steady harvest of herring from mid-July through mid-September. Within this summer period the availability of herring is not entirely dependable—weather conditions seem to determine daily movements and behavior patterns. Herring are therefore not always available in "traditional" harvest locations (Malloy 1985).

Trophic Relationships. Herring are an important component of the eastern Bering Sea food web—they are the prey of many seabirds, marine mammals and other fishes (Pace 1984). Of the potentially harvestable population, Lavaestu and Favorite (1978) estimated that 95% is needed by these consumers, leaving only 5% available to the commercial fishery. Herring feeding habits in the study area have not been examined but are presumably similar to those occurring at other locations. ADFG (1985) provides the following summary:

(1) Herring larvae and postlarvae feed on ostracods, small copepods and their nauplii, small fish larvae, and diatoms (Hart 1973). The first foods eaten by larval herring may be limited to relatively small, microscopic plankton that the

larvae must nearly collide with to notice and capture. Early food items may be comprised of more than 50% microscopic eggs (Wespestad and Barton 1981).

(2) Juveniles consume mostly crustaceans such as copepods, amphipods, cladocerans, decapods, barnacle larvae, and euphausiids. Consumption of some small fish, marine worms, and larval clams has also been documented (Hart 1973). In the western Bering Sea–Kamchatka area in November and December, the diet of juveniles has consisted of chaetognaths, mysids, copepods, and tunicates (Kachina and Akinova 1972).

(3) Adults in the eastern Bering Sea in August ate 84% euphausiids, 8% fish fry, 6% calanoid copepods, and 2% gammarid amphipods. Fish fry, in order of importance, were walleye pollock, sand lance, capelin, and smelt. During spring months, food items were mainly *Parathemisto* (Amphipoda) and *Sagitta* (chaetognath). After spawning (eastern Bering Sea), adults preferred euphausiids, copepods (*Calanus* spp.), and arrow worms (*Sagitta* spp.) (Dudnik and Usoltsev 1964). In areas of demersal feeding, stomach contents of herring included polychaete worms, bivalve molluscs, amphipods, copepods, juvenile fish, and detritus (Kachina and Akinova 1972). Barton (1979) found cladocerans, flatworms (Platyhelminthes), copepods, and cirripeds in herring captured during spring months. Rather than exhibiting a preference for certain food items, adult herring feed opportunistically on any large organisms predominating among the plankton in a given area (Kaganovakii 1955).

Important Physical Habitat Factors. Spawning areas provide the best examples of important physical habitat qualities. In the Bering Sea, spawning occurs in the intertidal or subtidal zone on rocky headlands or in shallow lagoons and bays (Barton 1979, Warner and Shafford 1981). Preferred spawning substrates are aquatic vegetation, particularly rockweed (*Fucus*), kelp (*Laminaria*), and eelgrass (*Zostera*). As mentioned above, spawning areas have been located at only three sites in the study area, but others probably exist.

Population Limiting Factors. Herring stocks in the eastern Bering Sea have undergone large fluctuations in abundance over the past 20 years similar to those undergone by clupeid fishes world-wide. Year-class strengths of herring were particularly high in 1957; there were lesser peaks in 1962, 1968, 1974 and 1977. The 1977 year class has in recent years constituted a large portion of the annual commercial harvest of herring in the food/bait fishery at Unalaska Island. The apparent absence of younger fish in this fishery would seem to suggest that harvests may decline in the near future.

Wespestad and Fried (1983) noted that many explanations and hypotheses have been offered concerning the causes of recruitment variability, but most recognize that environmental factors, rather than harvest levels, may be most important in controlling year-class strength unless spawning stocks have fallen below a critical threshold level. It is generally believed that most of the variation in year-class strength is determined during early life history and that water temperature is probably an important factor (Wespestad and Fried 1983)—there is some correlation between the occurrence of warmer waters and increased survival of herring (e.g., Pearcy 1983). Other factors such as predation and availability of suitable spawning habitat could also be contributing factors. Pearcy (1983) concludes that:

> Environmental variables that affect year-class success of herring probably range from single, short-term events such as a storm or freshet that affect the survival of cohorts in an isolated inlet to large-scale events that affect the productivity and circulation of large areas of the northeastern Pacific for a year or more. The synchrony of strong year classes in distant stocks during El Niños supports the idea that large-scale ocean events are important. But we lack information on interannual differences in oceanographic conditions in the northern North Pacific, as well as on specific mechanisms on how varying ocean conditions modify year-class success of herring.

Capelin

Capelin range throughout the Bering Sea (Warner and Shafford 1981) and are presumably abundant in the study area at various times of year. A hundred years ago Turner (1886) remarked "Among the Aleutian Islands these fish abound in incredible numbers." Capelin are generally found in large schools offshore, except during the breeding season when they migrate shoreward to spawn (Macy et al. 1978, Paulke 1985).

Spawning occurs in northern Bristol Bay and along the north side of the Alaska Peninsula, but the eastern Aleutians have not been surveyed for spawning capelin. Along the Alaska Peninsula, schools of spawners are most abundant in mid-May to mid-June; they spawn on pebble-covered beaches and shallow shoals (Barton 1979). Their sticky eggs adhere to the substrate until they hatch, whereupon the larvae move offshore in late summer and fall. The nearshore zone thus serves as both a breeding habitat for adults and a feeding ground for larvae and fry.

Capelin feed primarily on small crustaceans such as copepods, euphausiids, amphipods and decapod larvae, and small fish. Capelin are eaten by salmon, cod, marine mammals and seabirds (Hart 1973, Macy et al. 1978, Vesin et al. 1981). Fiscus et al. (1964) found that the Unimak Pass area was a favored summer feeding ground for fur seals which consumed vast quantities of capelin that had congregated there.

Sand lance

Pacific sand lance is one of the most abundant forage fishes in the eastern Bering Sea, including the eastern Aleutian area. The limited information about this species has been reviewed by Trumble (1973) and Macy et al. (1978). More recent studies have examined sand lance on the north side of the Alaska Peninsula (LGL 1986, Isakson et al. 1986) and near Kodiak (Dick and Warner 1982).

Along the Alaska Peninsula, sand lance were most abundant during mid- to late summer (July-September) in nearshore waters less than 35 m deep. Their distribution was very patchy—they would form dense schools in shallow water or be partially buried in unconsolidated sediment (Hart 1973, Macy et al. 1978, Dick and Warner 1982). LGL (1986) reported that sand lance in this area consumed a variety of prey in May (euphausiids, copepods, amphipods, mysids, polychaetes and eggs) but mainly copepods in September

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Sand lance in the study area probably spawn in late fall or winter (Macy et al. 1978, Dick and Warner 1982). They may spawn intertidally (Dick and Warner 1982) or at depths of 25-100 m in areas having strong currents (Trumble 1973). These fish require particular substrate compositions for burrowing and presumably spawning. Their adhesive eggs probably hatch in about three months depending on water temperatures. After hatching the larvae become pelagic and widely distributed in the Bering Sea.

Groundfishes

The term "groundfish" refers to a diverse group of fishes that usually inhabit near-bottom offshore waters. It is a term of convenience and encompasses not only flatfishes living directly on the seabottom but also species like pollock which often dwell near the bottom but may be pelagic as well. In addition, many groundfish species have pelagic egg and larval stages.

The Bering Sea is well known for its abundance of groundfish (summarized by Hood and Calder 1981, Lewbel 1983, ADFG 1985, and others). Much of the commercial catch occurs along the continental shelf break adjacent to Unimak Pass and just south of Unimak Pass. The region of highest catches is popularly known as the "Golden Triangle" (between

Unimak Pass, the Pribilof Islands, and Amutka Pass). Because of the commercial value of this resource, a vast amount of information describing groundfish in the Bering Sea and western Gulf of Alaska has accumulated. But the information from the commercial fishery is of relatively little importance with respect to an assessment of forage fish because the large size of the fish targeted and the depths at which they occur precludes their use as prey by most organisms of interest (some marine mammals being important exceptions).

Pollock are emphasized in this report, both because of the numerous reports of marine mammals eating them and because young occur in great abundance in the study area and are heavily preyed upon by some seabirds. Several sources of information are directly pertinent. In 1980 NMFS and Japan conducted a joint survey of groundfish resources in Aleutian Island waters (Ronholt et al. 1982, Wilderbuer et al. 1985, Ronholt et al. 1986). NMFS (1975-81) also surveyed shrimp (and fish) resources in the bays around Unalaska Island. Other information sources include the composition of fishes in commercial fisheries north of Unimak Pass and surveys conducted south of Unimak Pass by NMFS and IPHC.

Distribution In and Use of the Study Area

The broad array of sampling stations indicates that a considerable sampling effort has occurred for groundfish in and around the study area. The list of species caught is long, but two species—walleye pollock and Pacific cod—clearly dominate the groundfish community in the eastern Aleutian Islands. Data show that pollock were abundant in all regions surveyed on the north and south sides of the eastern Aleutians (NMFS 1975-81, Blackburn et al. 1980, IPHC 1980-85, Ronholt et al. 1986) and Pacific cod were abundant in most of these regions. Five additional fishes—rock sole, flathead sole, arrowtooth flounder, Atka mackerel, and Pacific ocean perch—were a dominant species in at least one of the regions surveyed.

Beyond this regional distribution, numerous temporal and spatial differences are exhibited by groundfish species in the study area. Four groundfish surveys, each describing a different portion of the groundfish community in the study area, are briefly summarized below.

Survey 1: **Bays of Unalaska Island (NMFS 1975-81).** Small-mesh trawl surveys were conducted over a several-year period in several bays around Unalaska Island. Pollock, mostly juveniles, were by far the most abundant fish present; the occurrence of other common species differed among bays. Highest catches were recorded in Unalaska and Scan bays, largely due to high catches of pollock. If pollock are excluded, catches in the largest bays (Unalaska, Makushkin, Beaver

Inlet) were about four times greater than in the remaining smaller bays.

Survey 2: **Eastern Aleutian Islands (Ronholt et al. 1986).** A trawl survey was conducted on both the Bering and Pacific sides of the eastern Aleutian Islands, June-November 1980. Trawl depths averaged 230 m (range 31-725 m). Pollock and Pacific cod were abundant on both sides of the islands, but differences among the other species were noted north and south of the Aleutians. Pacific ocean perch and giant grenadier were generally restricted to the Pacific side, with Atka mackerel and Greenland turbot occurring on the Bering side.

Survey 3: **Domestic trawl fishery, north Unimak Pass (Blackburn et al. 1980).** This fishery was conducted in winter (February-March 1980), generally along the 100–fathom contour north of Unimak Pass and Akun Island. Pacific cod accounted for 81% of the catch. The sampling gear used in this survey and in Survey 2 differed, probably accounting for the differences in catch compositions obtained in these surveys.

Survey 4: **Unimak Bight survey (IPHC 1980-85).** Trawl surveys in Unimak Bight located south of Unimak Island are conducted almost annually by IPHC. Trawl depths in this area are typically 27-110 m. Although the Unimak Bight area extends beyond the immediate study area, the data are useful to illustrate annual variability in the catches of groundfish. In these surveys, four species—rock sole, Pacific cod, arrowtooth flounder, and pollock—accounted for 67% of the catch, averaged over the period 1980-85. These results differ considerably from those mentioned above (Survey 2) where Pacific ocean perch accounted for 30% of the sample on the Pacific side of the study area. At least part of this difference is due to the sampling gear used. IPHC trawls are rigged to catch flatfish (i.e., the trawl hugs the sea-floor and has a vertical opening of only 4-5 feet), whereas the NMFS trawls have a much larger opening (20 feet) and thus would catch more "semi-demersal" fish.

Pollock constitute about 80% of the commercial groundfish harvest in the Bering Sea and the eastern Aleutian Islands. The pattern of total groundfish harvests is largely a reflection of the pollock catches.

Pollock catches on the Bering and Pacific sides of the eastern Aleutians differ somewhat (Ronholt et al. 1986). The fish are apparently more abundant on the Pacific side where the population estimate (88,171 tons) and catch per unit effort (56 kg/ha) are higher than on the Bering side (53,725 tons, 42 kg/ha). (Note that these values pertain only to the bottom-dwelling segment of the pollock population; the mid-water segment was not sampled during this survey. In the Bering Sea, only about 8% of the pollock biomass occurs on the bottom [Ronholt et al. 1986].) Pollock on the Bering side tended to be smaller and younger fish: mean length = 41.0 cm and mean age = 3.9 years on the Bering side, and length = 45.9 cm and age = 5.9 years on the Pacific side. Pollock on the Bering side also tended to inhabit shallower waters than those on the Pacific side.

These differences were also reflected in catches of fish within the bays of Unalaska Island where pollock were by far the dominant species. Pollock, mostly juveniles, are 3-20 times more abundant in bays on the northern side of the island than on the southern side. Pollock in Unalaska Bay catches included large fish (approximately 30-55 cm) similar in size to those caught farther offshore on both the Bering and Pacific sides of the Aleutians, but also smaller fish (approximately 15 cm) not caught offshore. This may represent either a habitat preference by juvenile pollock or it may simply result from gear selectivity (trawls used in the bays have smaller meshes). In any case, using these same data, Walters et al. (1985) reported that one-year-old pollock were fairly abundant and widespread in the bays of Unalaska Island in 1980 and less so in 1981.

Pollock use the study area and adjacent waterbodies for spawning (February-June), feeding, migration, and overwintering. In some years spawning occurs in the region north of Unimak Pass and so the pelagic eggs may be initially concentrated adjacent to the study area. Feeding occurs in the bays of Unalaska Island and throughout the study area. In the Bering Sea spawning and feeding migrations tend to be on/off the continental shelf (Maeda 1972, Takahashi and Yamaguchi 1972). Migration between the Bering Sea and the Gulf of Alaska is apparently restricted, as indicated by slight genetic differences between Bering Sea and Gulf of Alaska populations of pollock (Grant and Utter 1980). During winter, the pollock tend to concentrate along the deep outer shelf, extending pelagically into the Aleutian Basin.

Pollock food habits have been summarized by ADFG (1985) as follows. Larvae from the Bering Sea consume mainly copepod nauplii and eggs and adult copepods (especially *Oithona similis*, Clark 1978). Juveniles (less than 35 cm) consume mainly copepods, euphausiids and amphipods. Adults (greater than 35 cm) consume mainly euphausiids, small pollock, and other fish (gadids, cottids, hexagrammids and zoarcids) (Bailey and Dunn 1979). Fish comprise 70% of the diet of adults (Smith et al. 1978).

Factors Affecting Distribution and Abundance

Because of the commercial importance of groundfish, factors affecting their distribution and abundance have received considerable attention (e.g., Alverson et al. 1964; Moiseev 1963; Favorite et al. 1977; Hood and Calder 1981;

Laevastu and Marasco 1982, 1984; Wooster 1983; Favorite 1985; and others). Although a review of these studies and hypotheses regarding population regulation is beyond the scope of this report, discussion of several important features of groundfish populations follow. First, fluctuations in abundance are a comon characteristic of marine fish populations, including groundfish. Fluctuations may be short-term (several years) and long-term (decades), responding to abiotic factors (e.g., water temperature, current patterns) and biotic factors (e.g., food abundance, predation, fishing pressure, changes in migration patterns). These factors, or combinations of factors, occasionally result in the production of a strong year-class of fish for a given species, and this year-class then supports much of the commercial catch of that species for several years. Conversely, a combination of strong biotic factors and poor abiotic conditions could combine to produce a collapse.

Water temperature is a key factor affecting year-class strength. The effect may be direct (e.g., warm temperatures may provide better growing conditions and more food for larval stages) or indirect (e.g., cold temperatures may reduce predator populations—Laevastu and Marasco 1984). Indeed, temperature affects most phases of the life cycle of these fishes. Temperature influences overwintering, migration to spawning grounds, timing of spawning, and all aspects of fish energy budgets (the amount of food ingested, the digestion rate, and general metabolic rate).

Other factors affecting groundfish distributions in the study area include seabed topography and substrate characteristics. Many species are closely associated with the shelf break which is located immediately north and south of the eastern Aleutians. This association might be a preference for a particular water depth, temperature, or substrate; it may be due to increased productivity along the shelf break resulting from upwelling of nutrient-rich water; or it may reflect an "edge effect" where species diversity and abundance is greater at the juncture of different habitats.

Inshore Fishes

The relatively narrow band of water adjacent to the shoreline supports one of the most diverse biological communities in the Unimak Pass environment. In this zone may be found a variety of fishes that demonstrate a great amount of variation in utilization of inshore waters. Included are species that only spawn there, those that only feed there, and those entirely limited to inshore waters. Unlike salmon, herring, and groundfish, this fish community receives little use by man. However, this group merits consideration because of direct trophic links to several commercially-harvested species. Further, as discussed in previous sections, salmon, herring, and some groundfishes may themselves spend considerable periods of time in inshore waters.

Knowledge of inshore fishes in the eastern Aleutians is very limited. Some species are mentioned in early records (Turner 1886, Scheffer 1959, FWS 1974). The most complete listing is provided by Wilimovsky (1964), who collected 103 species in the intertidal zone of the eastern Aleutian Islands. Twenty-seven families of fish were represented, including flounders (8 species), salmonids (6), greenlings (5), rockfishes (4), and cods (4), but sculpins (28) were the dominant group, and Wilimovsky notes, "No other faunae in the world contain such a high proportion of cottoid (sculpin) forms". Hubbard (1964) provides additional information about 33 species from the intertidal waters of Umnak Island.

Simenstad et al. (1977) provide a description of the inshore fishes at Amchitka Island west of the Unimak Pass area; these fish populations probably resemble those in our present study area. These authors describe two inshore communities characterized in the following paragraphs.

Inshore Rock-Algae Community

This community is characterized by a diverse assemblage of fishes intimately associated with the extensive algal growth dominating the rocky nearshore coast. Abundant submarine algal growths cover subtidal rock terraces. Most conspicuous are the dense kelp beds of *Alaria fistulosa* which sometimes extend to the 20-m depth contour; these beds increase the structural complexity of the habitat available to fish. The spatial heterogeneity and diversity of the algal growth and associated food resources are responsible for the abundance and diversity of fishes. Representative fishes in this community are the rock greenling, red Irish lord, northern ronquil, silverspotted sculpin, great sculpin, dusky rockfish, and Pacific cod. For the most part, this assemblage consists of sedentary bottom fishes; however, a few occupy the kelp canopy (dusky rockfish, silverspotted sculpin, and some less abundant snailfish species). Although the latter fishes move freely about the kelp blades either singly (silverspotted sculpin, snailfish) or in schools (dusky rockfish), the bottom-associated fishes appeared restricted to a particular site.

During winter when the kelp forest is greatly thinned, the pelagic fishes descend into the subtidal zone and its lush *Laminaria* growth. Other species also move into deeper water in winter, perhaps to avoid wave action or to follow food resources.

Intertidal Community

These fish inhabit the surge channels and tide pools of the rocky intertidal zone. Although this assemblage can be considered an extension of the inshore rock-algae community, it has some distinctive species. Common fishes in tide pools include the crescent gunnel, high cockscomb, ribbon prickleback, juvenile great sculpin, sharpnose sculpin, and spotted snailfish.

Fish densities in the tide pools averaged 98 fish per 3-6 m^3 tide pool (range 20-250 fish). During high tide when the intertidal zone is flooded, adult rock greenling, anadromous Dolly Varden, and coho salmon are present. This habitat also provides a nursery ground for juvenile fishes. Simenstad et al. (1977) found that the prey of these fishes (amphipods, mysids) play an important role in the transfer of energy from algae-based detritus to the inshore fish community.

Additional information about inshore fishes is available for another region closer to the study area—the northern coastline of the Alaska Peninsula (LGL 1986, Isakson et al. 1986). However, since the habitats there are not similar to those in the Unimak Pass area, it follows that the fish communities and habitat usage are not the same and so these data are not included here. The northern coastline of the Alaska Peninsula consists primarily of exposed sand-gravel beaches in contrast with the generally rocky coastline (interspersed by small sections of beach) of the eastern Aleutian Islands.

METHODS

The forage fish community of the Unimak Pass study area was sampled during three seasonal cruises. These cruises, all using the NOAA ship R/V *Miller Freeman* were as follows:

MF-86-10	18 September 1986-7 October 1986	fall
MF-87-02	14 February 1987-9 March 1987	winter
MF-87-05	21 April 1987-14 May 1987	spring

The sampling design for the overall study consisted of a series of survey lines organized to provide bird and marine mammal transect coverage parallel and perpendicular to isobaths within the study area. Sampling to describe the biotic and physical environment, including forage fish, occurred at stations distributed along the bird and mammal transects, usually where perpendicular and parallel tracks intersected. These stations were occupied the night following completion of the bird and mammal censuses. In most cases fishing occurred in the morning or evening, either just prior to or following the censuses. The locations of sampling stations are shown in Figures 1 - 3.

Sampling for forage fish was done using a Marinovich midwater trawl. The net was 50' long and 33' in diameter. The mesh was graduated (3, 2.5, 2, 1.25") with a 0.5" liner to help retain the small forage fish. This was the same net as was used in the North Aleutian Shelf Ecological Process study (Craig 1987). Captured fish were identified, measured, and weighed.

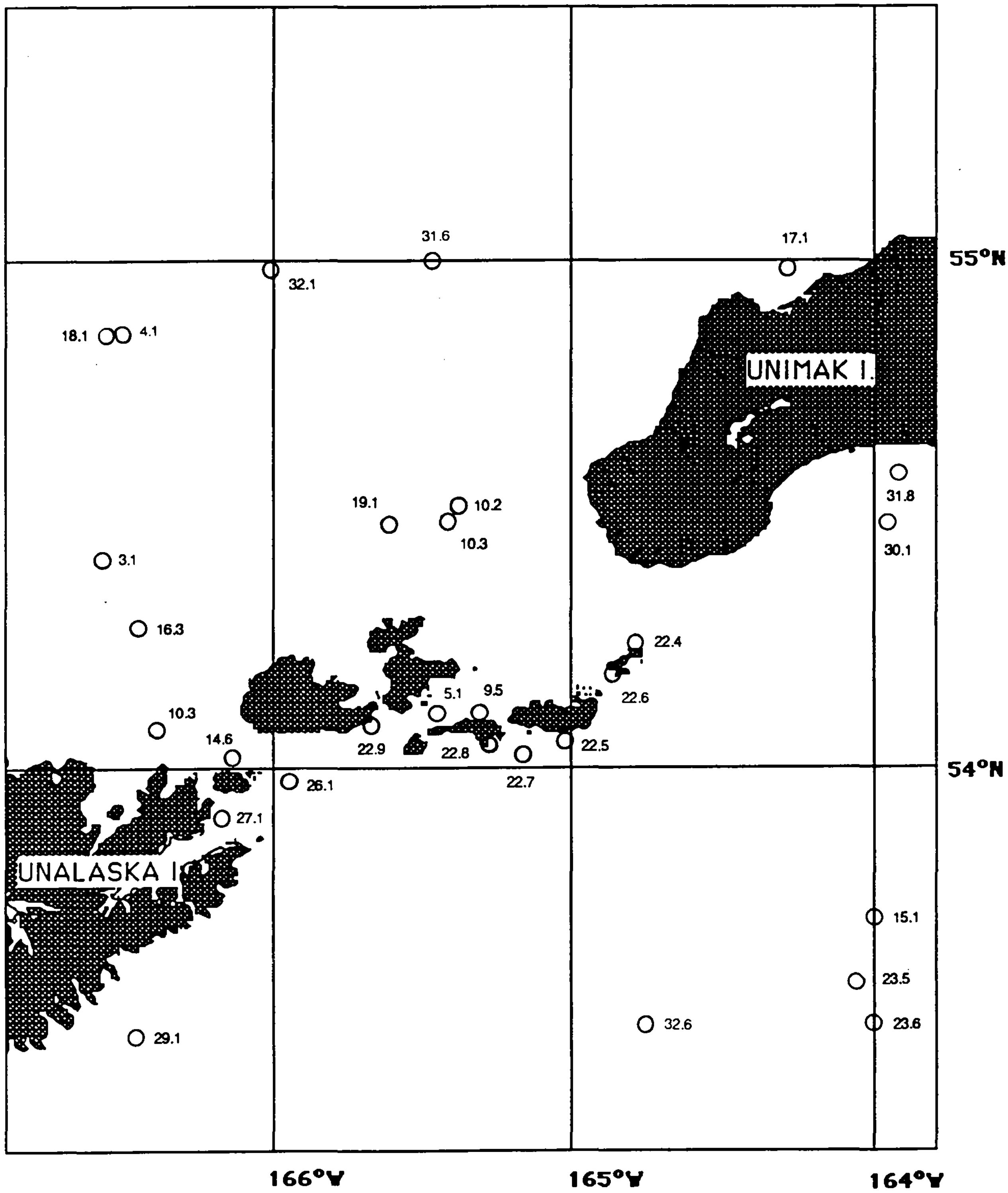

Figure 1. Locations of midwater trawl stations sampled during the fall, 1986, cruise, Unimak Pass area, Alaska. Sampling station numbers are shown.

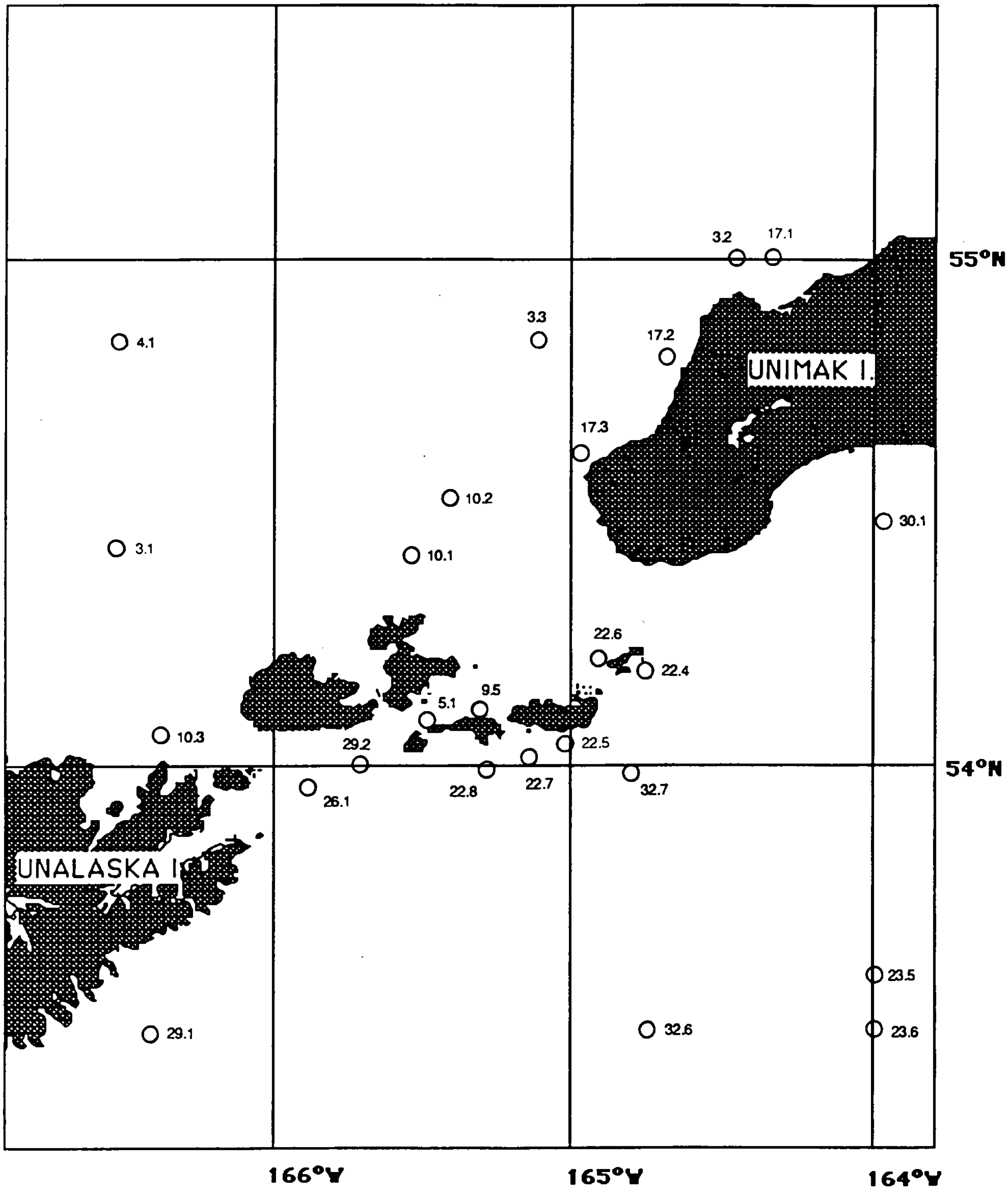

Figure 2. Locations of midwater trawl stations sampled during the winter, 1987, cruise, Unimak Pass area, Alaska. Sampling station numbers are shown.

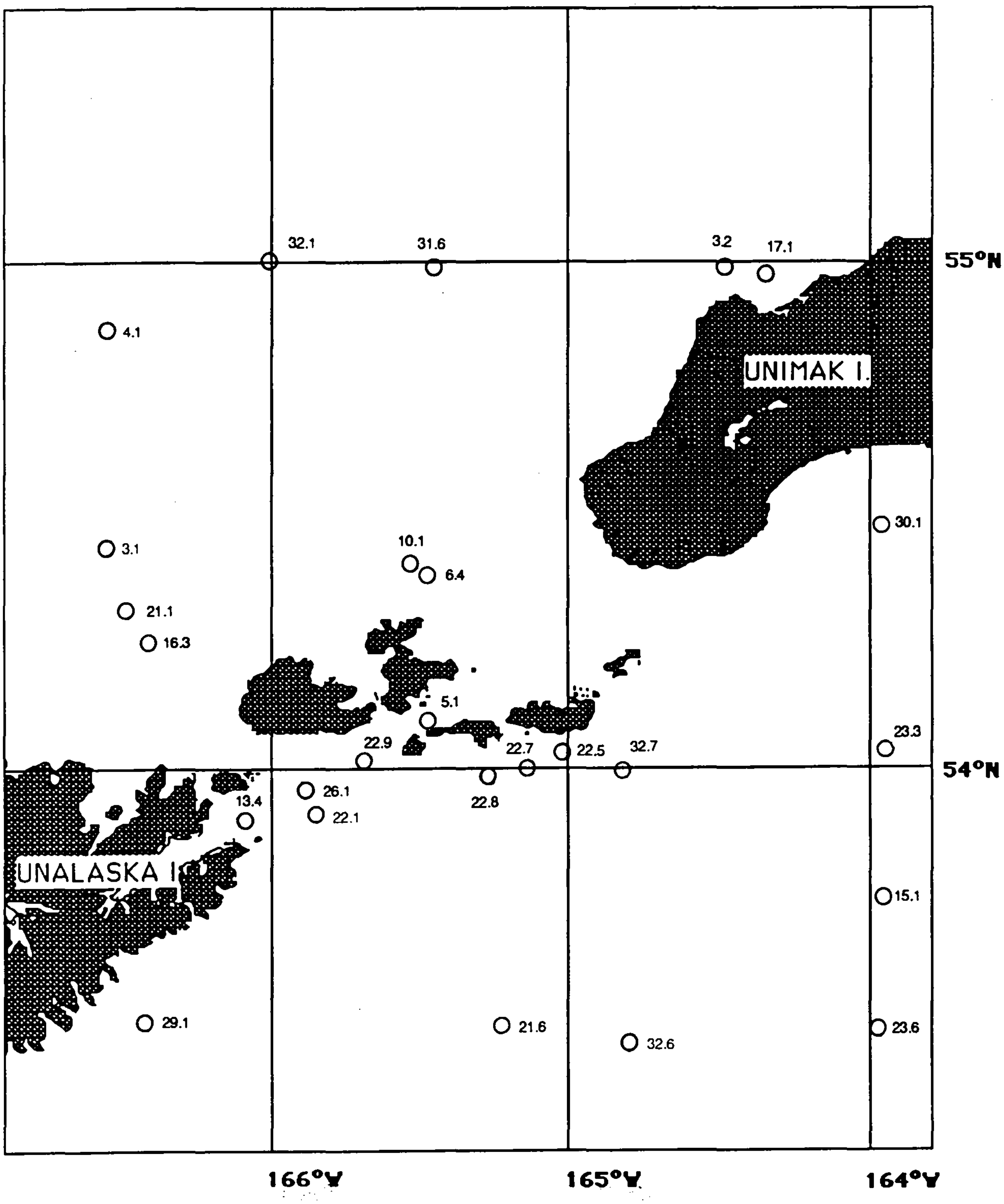

Figure 3. Locations of midwater trawl stations sampled during the spring, 1987, cruise, Unimak Pass area, Alaska. Sampling station numbers are shown.

RESULTS

Fish catches in the Unimak Pass study area varied markedly among seasons and watermasses (see Chapter 2: PHYSICAL PROCESSES AND HYDROGRAPHY, this volume, for distributions and descriptions of watermasses). Only a few species were ever abundant in catches (Table 1). These were pollock, lanternfishes (multiple species, primarily northern lampfish *Stenobrachius leucopsarus* and bigeye lanternfish *Protomyctophum thompsoni*), and on one occasion the bathylagid northern smoothtongue (*Leuroglossus stilbius*).

Fish catches were at their highest during the fall cruise. Pollock (young-of-year) were the most numerous forage fish available to bird and mammal predators. This prey was most concentrated in the Tidally Mixed Waters (TMW) around the Krenitzin Islands (Fig. 4). Lanternfishes were also caught in abundance, in both the north and south portions of the Gulf of Alaska Water (GAWn and GAWs). These catches were made in the deep-water portions of the study area. The GAWn also yielded good numbers of northern smoothtongues during this cruise.

Fish were more scarce in winter than in fall (Table 1). The only fish species common in any catches in winter were lanternfishes and these were abundant only in the extreme south of the study area in the deep portions of the GAWs. Most of the Bering Sea (Shelf Break Water [SBW] and GAWn) and the waters around the Krenitzin Islands (TMW) were virtually devoid of forage fish (Fig. 5). Fish, primarily pollock, were present in the Alaska Coastal Water (ACWn and ACWs) but most of these fish were too large to be prey to most birds (the average mass of 49 pollock caught was 869 gm). There were, however, small numbers of capelin captured in the ACWs; winter was the only cruise during which this species was captured.

In spring even fewer fish were caught than in winter (Table 1). Only lanternfishes were captured in any abundance and these were restricted to the deep southerly portions of the GAWs (Fig. 6).

DISCUSSION

Patterns of abundance of forage fish were very simple. Lanternfishes were found in moderate abundance at all times only in the deep waters of the Gulf of Alaska and in the deep parts of the Bering Sea during the fall cruise. Small pollock were very abundant during the fall, especially in the mixed waters around the Krenitzin Islands. With these few exceptions, most of the study area appeared to have relatively low abundances of pelagic forage fishes. There were, no doubt, additional fish present on or near the sea floor that were missed by midwater trawls. Indeed the occasional rock dredge or trynet sample taken during the winter cruise produced fish, most commonly flatfish

Table 1. Numbers of fish caught per 30 min haul by trawl, averaged by watermass and season. (SBW=Shelf Break Water, TMW= Tidally Mixed Water, GAW=Gulf of Alaska Water, ACW=Alaska Coastal Water, n=north [Bering Sea], s=south [Gulf of Alaska].).

Fall	N	Squid	Pollock	Myctophid	Bathylagid	Capelin	Other	Total
SBW	6	0.2	26.8	0.0	0.0	0.0	0.5	27.5
TMW	12	0.0	539.8	0.3	0.0	0.0	1.6	541.6
GAWn	3	7.3	0.0	72.0	64.7	0.0	0.0	144.0
GAWs	6	0.5	62.8	28.7	0.0	0.0	0.5	92.5
ACWn	1	0.0	10.0	0.0	0.0	0.0	3.0	13.0
ACWs	1	0.0	10.0	0.0	0.0	0.0	5.0	15.0
Winter								
SBW	1	2.0	0.0	0.0	0.0	0.0	0.0	2.0
TMW	10	0.0	0.1	0.0	0.0	0.0	1.7	1.8
GAWn	3	0.0	0.3	3.0	0.0	0.0	0.3	3.7
GAWs	4	4.0	0.0	50.8	0.0	0.0	0.8	55.5
ACWn	5	0.0	21.6	0.0	0.0	0.0	1.2	22.8
ACWs	2	0.0	36.0	0.0	0.0	6.0	2.0	44.0
Spring								
SBW	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TMW	6	0.0	0.2	0.0	0.0	0.0	5.3	0.3
GAWn	7	0.0	0.7	0.0	0.0	0.0	0.0	0.7
GAWs	8	0.6	0.4	58.6	0.1	0.0	2.4	59.8
ACWn	2	0.0	2.0	0.0	0.0	0.0	6.5	2.5
ACWs	4	0.0	1.0	0.3	0.0	0.0	1.5	1.3

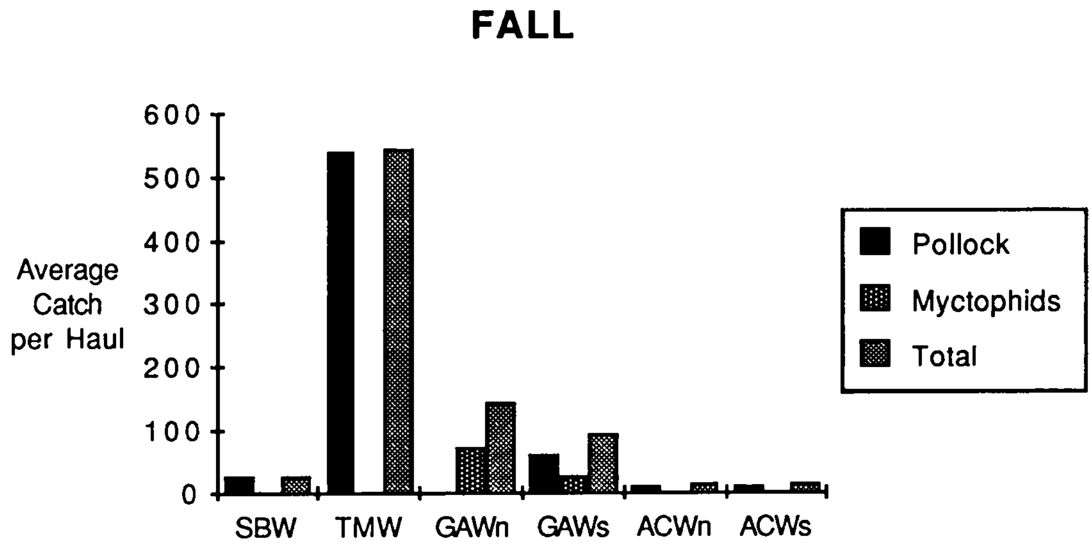

Fig. 4. Catch distribution by water mass of forage fish near Unimak Pass during the fall cruise (SBW=Shelf Break Water, TMW= Tidally Mixed Water, GAW=Gulf of Alaska Water, ACW=Alaska Coastal Water, n=north (Bering Sea), s=south (Gulf of Alaska).

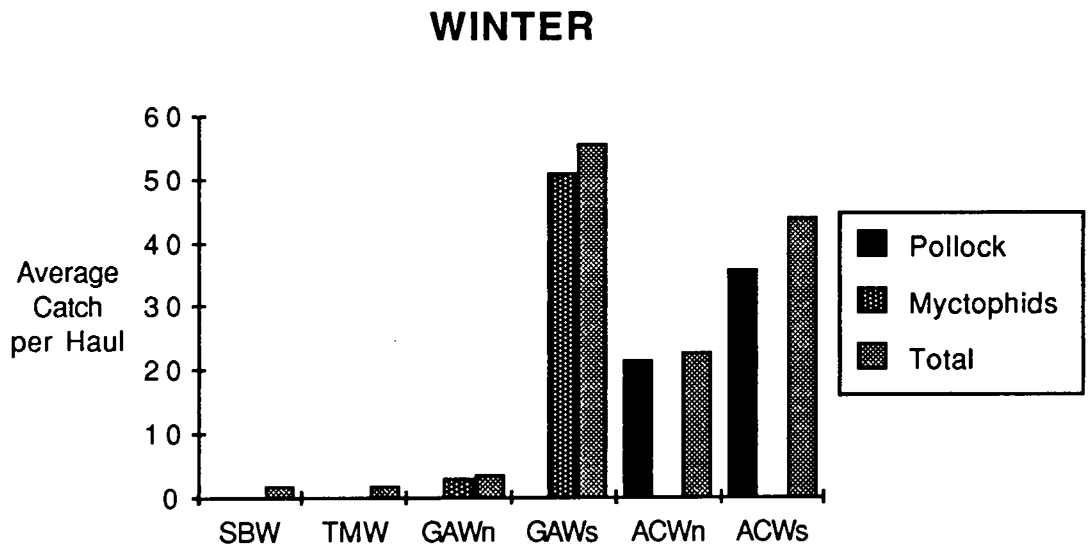

Fig. 5. Catch distribution by water mass of forage fish near Unimak Pass during the winter cruise (SBW=Shelf Break Water, TMW= Tidally Mixed Water, GAW=Gulf of Alaska Water, ACW=Alaska Coastal Water, n=north (Bering Sea), s=south (Gulf of Alaska).

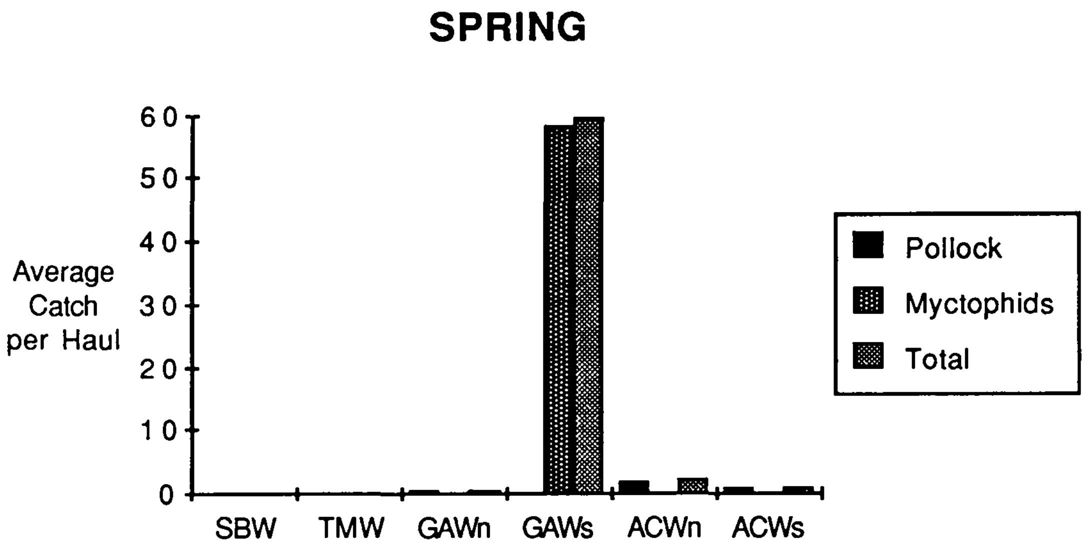

Fig. 6. Catch distribution by water mass of forage fish near Unimak Pass during the spring cruise (SBW=Shelf Break Water, TMW= Tidally Mixed Water, GAW=Gulf of Alaska Water, ACW=Alaska Coastal Water, n=north (Bering Sea), s=south (Gulf of Alaska).

and sand lance. The bottom fish were probably regular prey for birds, such as cormorants, that foraged in shallow water.

This assessment of the availability of forage fish contrasts markedly with the review of existing data provided in the introduction and with the results of similar surveys in the adjacent North Aleutian Shelf (NAS). Some key forage fish that were expected to occur were largely absent from our samples (herring, sand lance, and capelin). The scarcity of these fish in samples was probably caused partly by the lack of sampling in summer, during which time spawning for herring and capelin occurs in the eastern Aleutians. In the NAS herring and capelin were captured in large numbers only in late May through early June (Craig 1987); sand lance occurred in the water column over a longer period but still only during summer. Forage fish were abundant in the Unimak Pass area during the fall, and in the very deep waters (>1000 m) of the Gulf of Alaska throughout the year; at these times forage fish were scarce on the NAS.

Because forage fish were scarce in deep water in much of the study area, there were few instances in which to expect many piscivorous birds or mammals to be present. The young-of-year pollock in the Krenitzin Islands were readily available to seabirds and their location and timing was such that they were present adjacent to the large colonies of Tufted Puffins during the chick-rearing period. Puffins were frequently seen feeding in these areas and monitoring of chick meals at puffin colonies in this area documented that pollock were the predominant prey (S. Hatch, USFWS, pers. comm.). Lanternfish occur regularly in the diets of some seabirds (e.g. Red-legged Kittiwakes) and must come up from depth near or to the surface at times (night), although very few were caught in surface sampling or bongos. Lanternfish vertical migrations are extensive and well documented and their presence in surface waters may have been more prevalent than we documented (Case et al. 1977, Scott and Scott 1988) . There was little indication of an association between seabird distribution and that of lanternfishes. The birds most restricted to the deep waters where lanternfishes occur—albatrosses, Mottled Petrel, Leach's Storm-Petrel—were quite uncommon. Dall's porpoises, which are known to prey extensively on lanternfishes, did have a distribution that reflected the distribution of forage fish; i.e., in winter and spring it corresponded to lanternfish distribution.

RECOMMENDED FURTHER RESEARCH

The data collected during the present investigations indicated that, through most of the study area and during most of the cruises, there were relatively few forage fish available for marine birds and mammals. The diet information collected (see Chapter 5: MARINE BIRD ABUNDANCE AND HABITAT USE, this volume) also indicated that the seabirds present were preying much more heavily on zooplankton than on fish. Therefore, further effort documenting the distribution and abundance of forage fish becomes a rather low priority in terms of research needs in this area. The major exception to this conclusion is that, if a summer sampling period could be arranged, sampling for forage fish would be of value. In the adjacent NAS summer sampling documented a greatly increased availability of forage fish and a corresponding increase in bird use of this resource. Also, capelin abundance in Unimak Pass is reportedly high during the summer and is thought to attract fur seals to this area at that time.

ACKNOWLEDGEMENTS

We are indebted to the the entire crew of the Miller Freeman for their cooperation and assistance in making this study such a success.

We thank CDR Taguchi, who found ways to accommodate our innumerable trips through (and residence in) all passable passes in the Krenitzin Islands. LT Brian Hayden (FOO) made arrangements for all our requests and last-minute changes in plans, allowing us to obtain all our samples where and when we wanted them. We also appreciate his assistance in keying out unusual fish. The persistence of the ship's fishermen is greatly appreciated. They found humor in making repeated attempts to document the absence of small fish even when we could see and ignore the presence of large numbers of larger fish.

The review of fisheries of the Unimak Pass area draws extensively, frequently with little or no modification, from a review by Peter Craig. The portions presented here are for completeness and for the convenience of the reader. We appreciate his thoroughness and organization. Extensive editing of drafts of this chapter were provided by Robert Dillinger and Joe C. Truett.

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