The Groundfish Resources of the Eastern Bering Sea and Aleutian Islands Regions

RICHARD BAKKALA, WENDY HIRSCHBERGER, and KATHERINE KING

Introduction

The groundfish resource of the eastern Bering Sea and Aleutian Islands regions is one of the world's largest. At the peak of foreign fishing (1971-74), these regions produced annual catches in the range of 2.0-2.3 million metric tons (t). With enactment of the U.S. Fishery Conservation and Management Act of 1976 (FCMA), the Bering Sea resources within the 200-mile limit came under domestic jurisdiction. Provisions of the FCMA mandate the establishment of management policies to protect and conserve these resources and promote the development of domestic fisheries; at present, groundfish in the Bering Sea are harvested exclusively by foreign fisheries with the exception of U.S. fisheries for Pacific halibut, *Hippoglossus stenolepis*.

The kinds of commercial species taken, the magnitude of foreign catches, and the location of catches of groundfish in the Bering Sea are perhaps not generally known. A number of excellent articles have appeared in *Marine Fisheries Review* and other outlets describing the foreign fisheries in the Bering Sea (Chitwood, 1969; Dickinson, 1973; Miller et al., 1976; Pruter, 1976). These articles have primarily dealt with a description of the methods of operation of the Japanese and Soviet fisheries and the types of fishing and support vessels used in these fisheries.

The intent of this article is to acquaint the reader with the Bering Sea groundfish resources by describing the history of domestic and foreign fishing in the region in terms of species taken, magnitude of catches, and fishing areas, and to discuss the current condition and allowable catches of the various commercial species. Initially, the report will describe the general features of the Bering Sea environment.

The authors are with the Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

Environmental Features of the Region

Unique geographic, climatic, and oceanographic conditions combine to create an environment favorable for supporting the very large populations of groundfish (in addition to some of the world's largest bird and marine mammal populations) found in the Bering Sea. Although the processes responsible for these large populations are not fully understood, they probably originate from the upwelling of nutrient-rich water along the south side of the Aleutian Islands and subsequent mixing of Pacific Ocean and Bering Sea waters, the seasonal extremes in climate in the Bering Sea with a build-up of nutrients during winter months, and the expansive nature of the continental shelf in the eastern Bering Sea (Gershanovich et al., 1974; Sharma, 1974).

The continental shelf and slope are prominent features of the eastern Bering Sea and the location of a majority of their demersal resources (Fig. 1): most of this shelf area lies within the U.S.

ABSTRACT–Commercial fishing for groundfish in the eastern Bering Sea dates back almost 100 years to 1882 when U.S. fishermen began harvesting Pacific cod, Gadus macrocephalus. *The next fishery to develop in the region was the U.S. and Canadian fishery for Pacific halibut,* Hippoglossus stenolepis, *in 1928. Large-scale foreign fisheries began operations in the eastern Bering Sea in 1954, first exploiting flounders off Bristol Bay, but later expanding their fisheries throughout the eastern Bering Sea and Aleutian Islands regions, utilizing a wide variety of demersal species. Beginning in the mid-1960's, walleye pollock,* Theragra chalcogramma, *became the major target species of foreign fisheries and catches rose sharply as exploitation of this large resource intensified. At its peak, the foreign fishery in these regions was one of the world's largest, harvesting more than 2 million metric tons of groundfish annually. Although current U.S. fisheries for groundfish in the eastern Bering Sea and Aleutians are primarily limited to a setline fishery for Pacific halibut, domestic trawl fisheries for other species are expected to develop over the next decade.*

To describe the resources that will be available to the developing U.S. fishery, this article reviews the history of fisheries for groundfish in the eastern Bering Sea and Aleutian Islands regions to illustrate methods and areas of fishing, species taken and the magnitude of catches, and the current condition of the resource.

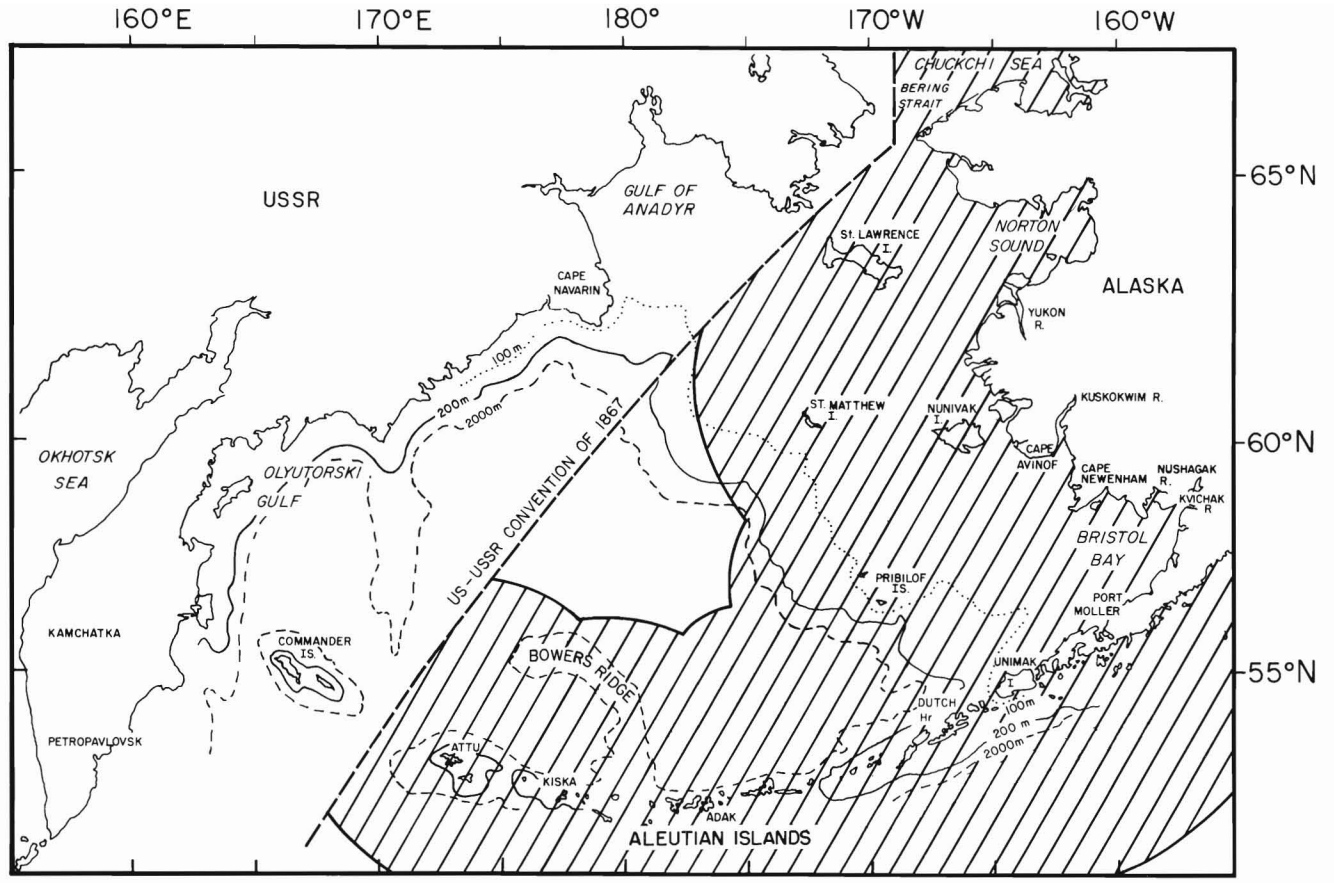


Figure 1.—Geographical locations in the eastern Bering Sea and Aleutian Islands. Crosshatched area is U.S. 200-mile Fishery Conservation Zone.

200-mile fishery conservation zone. The shelf is extremely smooth and has a gentle gradient resulting from sediment deposits originating in coastal areas (Sharma, 1974). The sediments are primarily sand over the inner shelf and silt and clay over the outer shelf and continental slope. The continental slope bordering the eastern Bering Sea shelf is steep and scored with valleys and large submarine canyons.

A second major feature of the region is the Aleutian-Commander Islands arc, a chain of more than 150 islands that forms a partial barrier to the exchange of water between the Pacific Ocean and Bering Sea (Fig. 1). Continental shelf areas throughout most of the chain are narrow and frequently discontinuous between islands but broaden in the eastern Aleutians. The extension of the Aleutian Islands shelf area formed by Bowers Ridge is also of interest to the fisheries. This submerged ridge, forming a northwesterly arc off the west-central Aleutian Islands, is about 500 km long and 75-100 km wide, becoming even wider adjacent to the Aleutian Islands (Gershanovich, 1963). The depth of the ridge summit in the southern portion is 150-200 m and increases to 800-1,000 m in the northern portion.

The Bering Sea climate is mainly subarctic, except in the southernmost part which lies in the temperate zone (Sharma, 1974). These climatic conditions produce sub-zero water temperatures and pack ice cover over extensive areas of the continental shelf in the northern and eastern Bering Sea in winter and spring. These conditions cause extensive offshore movements of groundfish to deeper, warmer waters of the outer shelf and slope in winter. Pack ice begins to from in the Bering Sea in November, usually reaches maximum coverage in late March, and begins to retreat northward in April or May (Fig. 2). The Bering Sea is usually ice-free by early summer. The region of the outer shelf lying between the Pribilof Islands and Unimak Island, and deeper waters of the Bering Sea, are generally ice-free throughout the year due to the influence of warmer Pacific Ocean waters.

The dominant water movement over the eastern Bering Sea continental shelf originates from Pacific Ocean water entering the Bering Sea in the vicinity of Unimak Island (Fig. 3). Surface currents are generally northerly over the

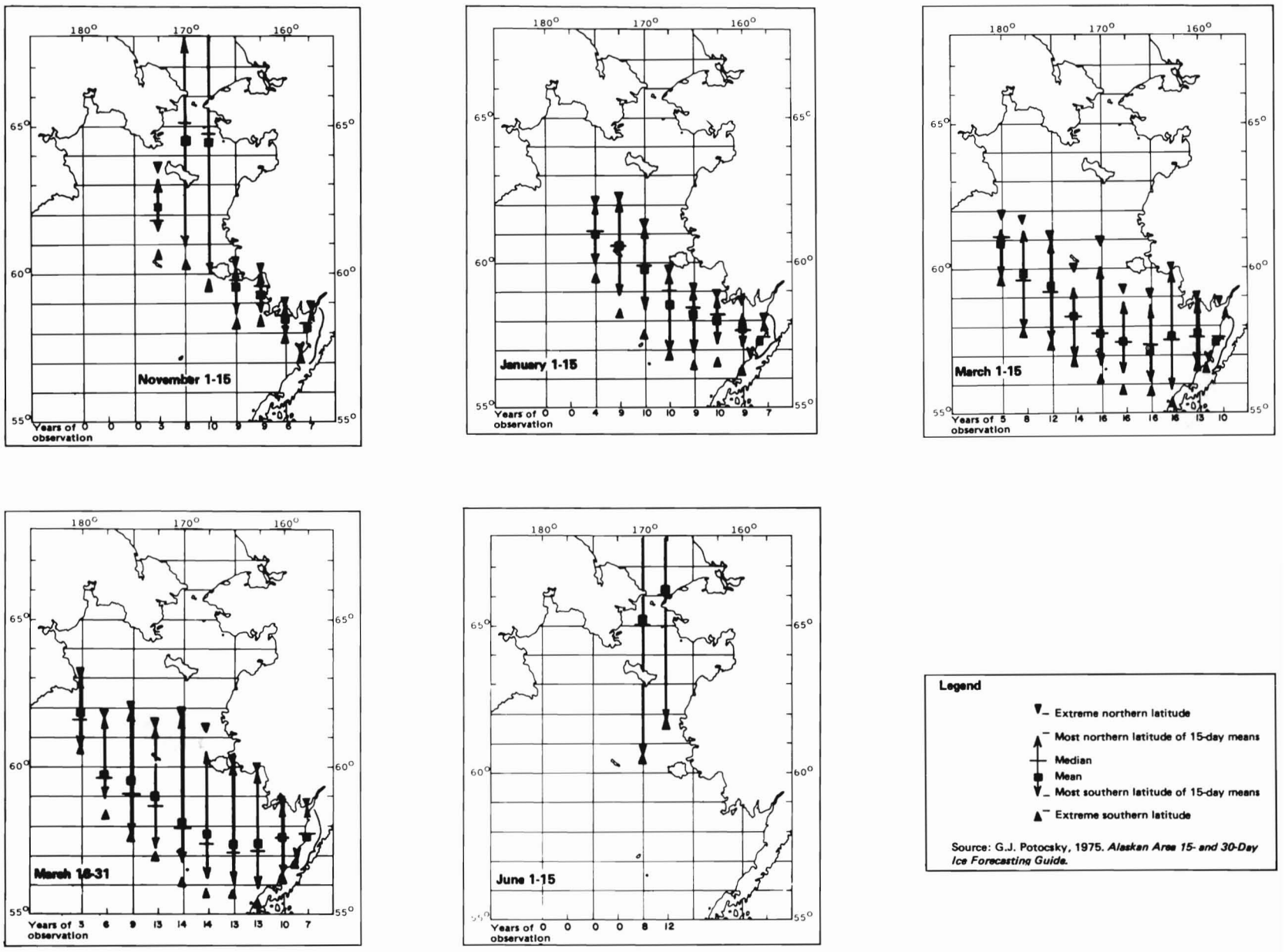
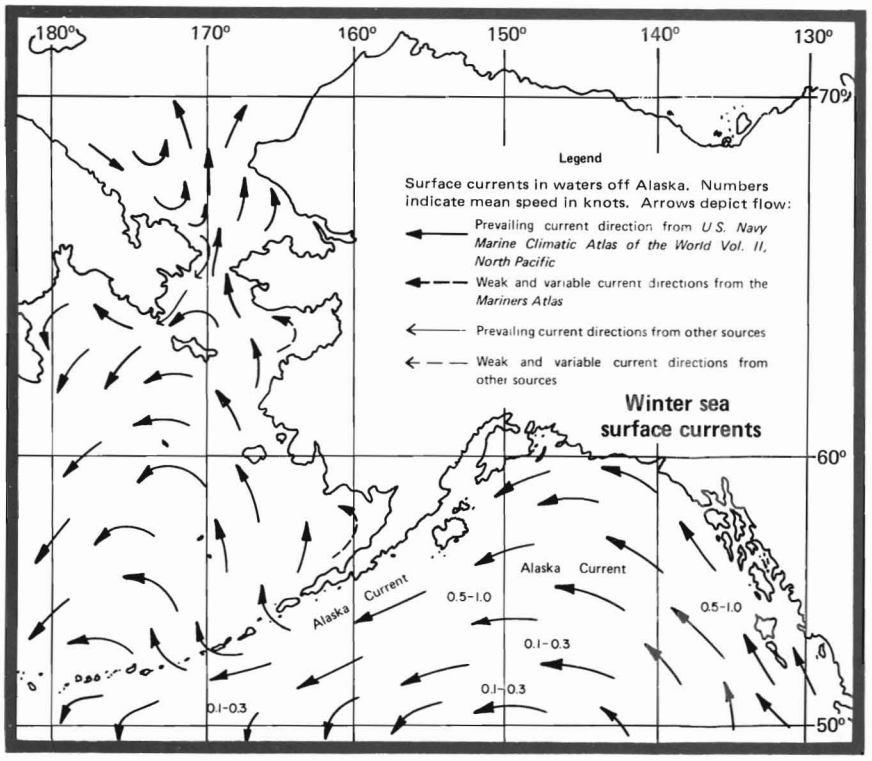


Figure 2.—Distribution of pack ice in the Bering Sea during selected periods of the year (Potocsky, 1975).



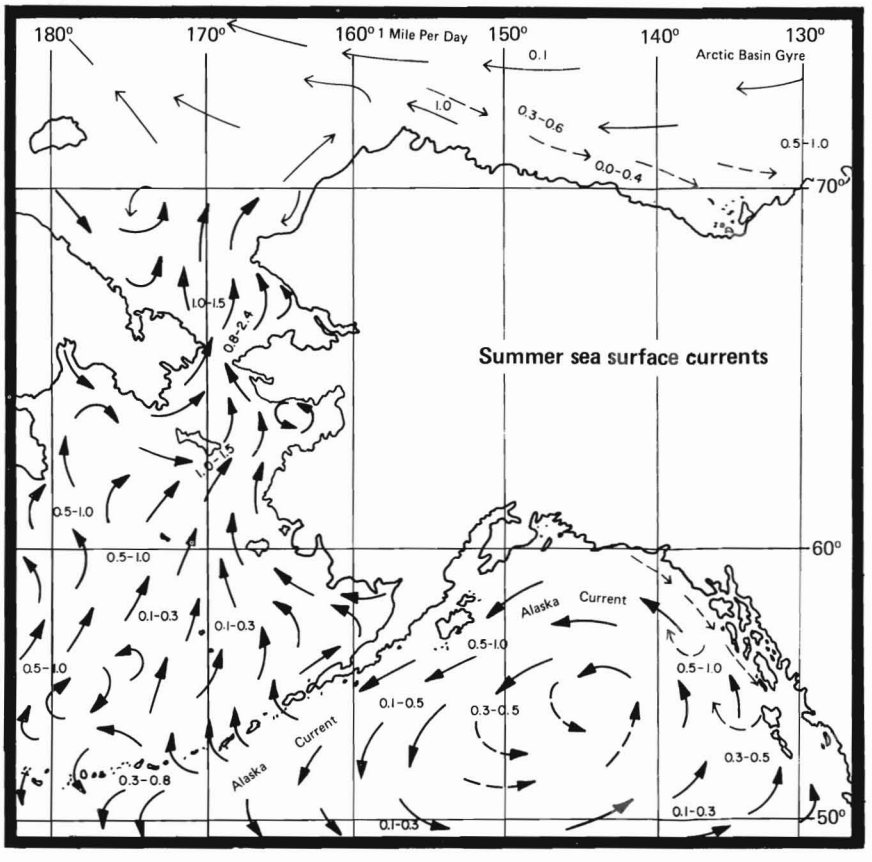


Figure 3.—Sea surface currents in the eastern Bering Sea (Brower et al., 1977).

shelf but shift to a westerly or southwesterly direction over deeper water in winter.

Commercially Utilized Species of Groundfish

The Bering Sea supports about 300 species of fish, the majority of which live on or near the bottom (Wilimovsky, 1974). About 31 species from the demersal or semidemersal group are presently used as food fish. Only seven species, because of their abundance or high market value, are consistently targeted upon by foreign and domestic fisheries while an additional five species are occasionally targeted on (Table 1). Abundance of the 19 remaining species is relatively low and they form only an incidental part of catches. Many other species are taken during fishing operations and some of these, such as sculpins (family Cottidae), may be utilized for reduction to fish meal

Table 1.—Demersal species in the eastern Bering Sea and Aleutian Islands regions utilized for food fish by foreign and domestic fisheries.

Common and Scientific names
Species consistently targeted upon
Pollock, *Theragra chalcogramma*
Pacific ocean perch, *Sebastes alutus*
Atka mackerel, *Pleurogrammus monopterygius*
Sablefish, *Anoplopoma fimbria*
Yellowfin sole, *Limanda aspera*
Greenland turbot, *Reinhardtius hippoglossoides*
Pacific halibut, *Hippoglossus stenolepis*
Species occasionally targeted upon
Pacific cod, *Gadus macrocephalus*
Rock sole, *Lepidopsetta bilineata*
Flathead sole, *Hippoglossoides elassodon*
Arrowtooth flounder, *Atheresthes stomias*
Rattails, *Coryphaenoides* spp.
Species incidentally caught [1,2]
Harlequin rockfish, *Sebastes variegatus*
Rougheye rockfish, *Sebastes aleutianus*
Dusky rockfish, *Sebastes ciliatus*
Northern rockfish, *Sebastes polyspinis*
Shortspine thornyhead, *Sebastolobus alascanus*
Shortraker rockfish, *Sebastes borealis*
Darkblotched rockfish, *Sebastes crameri*
Yelloweye rockfish, *Sebastes ruberrimus*
Blue rockfish, *Sebastes mystinus*
Sharpchin rockfish, *Sebastes zacentrus*
Splitnose rockfish, *Sebastes diploproa*
Yellowmouth rockfish, *Sebastes reedi*
Alaska plaice, *Pleuronectes quadrituberculatus*
Rex sole, *Gluptocephalus zachirus*
Butter sole, *Isopsetta isolepis*
Longhead dab, *Limanda proboscidea*
Dover sole, *Microstomus pacificus*
Starry flounder, *Platichthys stellatus*
Skates, *Raja* spp.

[1]Includes species that may be marketable as food fish but are not targeted upon because of their low abundance.
[2]Because of problems in identification of rockfish, the species listed may be incomplete or contain species not actually occurring in the Bering Sea-Aleutian Islands regions.

along with wastes from filleting operations and food fish that are too small for filleting.

History of Commercial Fishing

North American Fisheries

Pacific Cod Fisheries

Although the utilization of Bering Sea bottomfish resources by U.S. and Candian fishermen has been relatively minor each year, fishing activities date back more than 100 years. Pacific cod was the first species taken, initially by an exploratory effort involving a single schooner in 1864, and then on a regular annual basis starting in 1882. Vessels operated from ports in Washington and California and from shore stations in the eastern Aleutian Islands (Cobb, 1927). Canadian vessels also participated in the fishery to a limited extent. Throughout its history, the Bering Sea cod fishery was conducted largely by sailing schooners. Fishing was by handlines from one-man dories. Fishing areas were along the north side of Unimak Island and the Alaska Peninsula to Bristol Bay from depths of about 25 to 100 m (Cobb, 1927).

The North American cod fishery reached its peak during World War I when estimated annual catches ranged from 12,000 to 14,000 t (Pereyra et al., 1976[1]). In comparison, the current large foreign fishery has annually taken about 58,000 t of Pacific cod from the eastern Bering Sea in recent years. Following 1920, numbers of North American vessels and their catches gradually declined until the fishery was terminated in 1950.

Pacific Halibut Fisheries

Although cod fishermen reported the presence of Pacific halibut in the Bering Sea as early as the 1800's, they were not harvested commercially until 1928 (Thompson and Freeman, 1930). Commercial fishing for Pacific halibut in the eastern Bering Sea was sporadic in the 1930's and 1940's. The fishery started on a regular annual basis in 1952 but catches remained low through 1957, ranging from only 24 to 158 t per year (Myhre et al., 1977). Effort by the U.S. and Canadian fisheries increased substantially in subsequent years. Catches reached 4,400 t in 1962 and 4,900 t in 1963, but then declined steadily to 173 t in 1973. Since 1973, landings have been relatively low, ranging from 260 to 450 t per year. Reduced catches resulted from a decline in abundance of Pacific halibut and restrictions placed on the fishery because of this decline. Factors that may have contributed to the decline in abundance (Hoag, 1976) included: 1) Overfishing by the North American and Japanese setline fisheries in the early 1960's, 2) high incidental catches of juveniles in foreign trawl fisheries, and 3) adverse environmental conditions.

There has also been a minor commercial halibut fishery by U.S. and Canadian vessels in the Aleutian Islands since 1960. Catches from the Aleutian region have ranged from 0 to 180 t annually.

Halibut vessels use setline gear (International Pacific Halibut Commission, 1978) consisting of a longline on which branch lines or gangions, each with a hook, are attached at regular intervals along the longline (usually from about 6 to 9 m). A unit of setline gear (about 500 m long) is called a "skate"; from 4 to 12 skates are tied together into a string for fishing. Fishing depths are normally from 90 to 275 m, but range from less than 30 to more than 500 m. Traditional halibut fishing areas in the eastern Bering Sea are shown in Figure 4. The fishing season is currently 21 days in April and 19 days in August or September.

Foreign Fisheries

Five foreign countries (besides Canada) have participated in the groundfish fisheries of the eastern Bering Sea and Aleutian Islands. Japan has had the longest history of fishing in the region and has mounted the greatest effort over the years. The first documented fishery for demersal species by the Japanese in the eastern Bering Sea (in 1958) and the nation having the second largest removals of groundfish in the region has been the U.S.S.R. The Japanese and Soviet fleets were followed by those of the Republic of Korea (ROK) in 1967. The number of vessels and magnitude of the ROK catches has remained much smaller than that of Japan and the U.S.S.R., however. The Taiwanese have also had a fishery in the eastern Bering Sea since late 1974 but involving only one or two trawlers. Polish vessels fished briefly in the eastern Bering Sea in 1973 (Law Enforcement Division, 1975[2]). Since then, Poland has agreed to abstain from further fishing in the eastern Bering Sea but has been allowed to fish in certain waters of the Aleutian Islands. They have not pursued this fishery, however.

Japanese Fishery

Following the initial exploratory effort by two trawlers in 1930, the Japanese returned to the eastern Bering Sea with a mothership-catcher boat type operation in 1933 (Forrester et al., 1978). This fishery targeted on walleye pollock and flounders off Bristol Bay, which were processed into fish meal aboard the mothership and then carried back to Japan via transport vessels. However, in 1937 the price of fish meal dropped and the fishery was terminated. Annual catches of pollock and other species during this 5-year period ranged from 3,300 to 43,400 t.

In 1940-41, the Japanese returned to the eastern Bering Sea with another mothership-type operation, this time targeting on yellowfin sole. The catches of about 10,000 t each year were frozen for human consumption.

Although the Japanese fishing fleet was destroyed during World War II, it was soon again to become the major

[1]Pereyra, W. T., J. E. Reeves, and R. G. Bakkala (principal investigators). 1976. Demersal fish and shellfish resources of the eastern Bering Sea in the baseline year 1975. Processed rep., 619 p. Northwest and Alaska Fisheries Center, Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

[2]Law Enforcement Division. 1974, 1975, and 1977. Foreign fishery activities Bering Sea and Gulf of Alaska, 1972-1974. Unpubl. manuscr., var. pag. Alaska Regional Office, Natl. Mar. Fish. Serv., NOAA, P.O. Box 1668, Juneau, AK 99802.

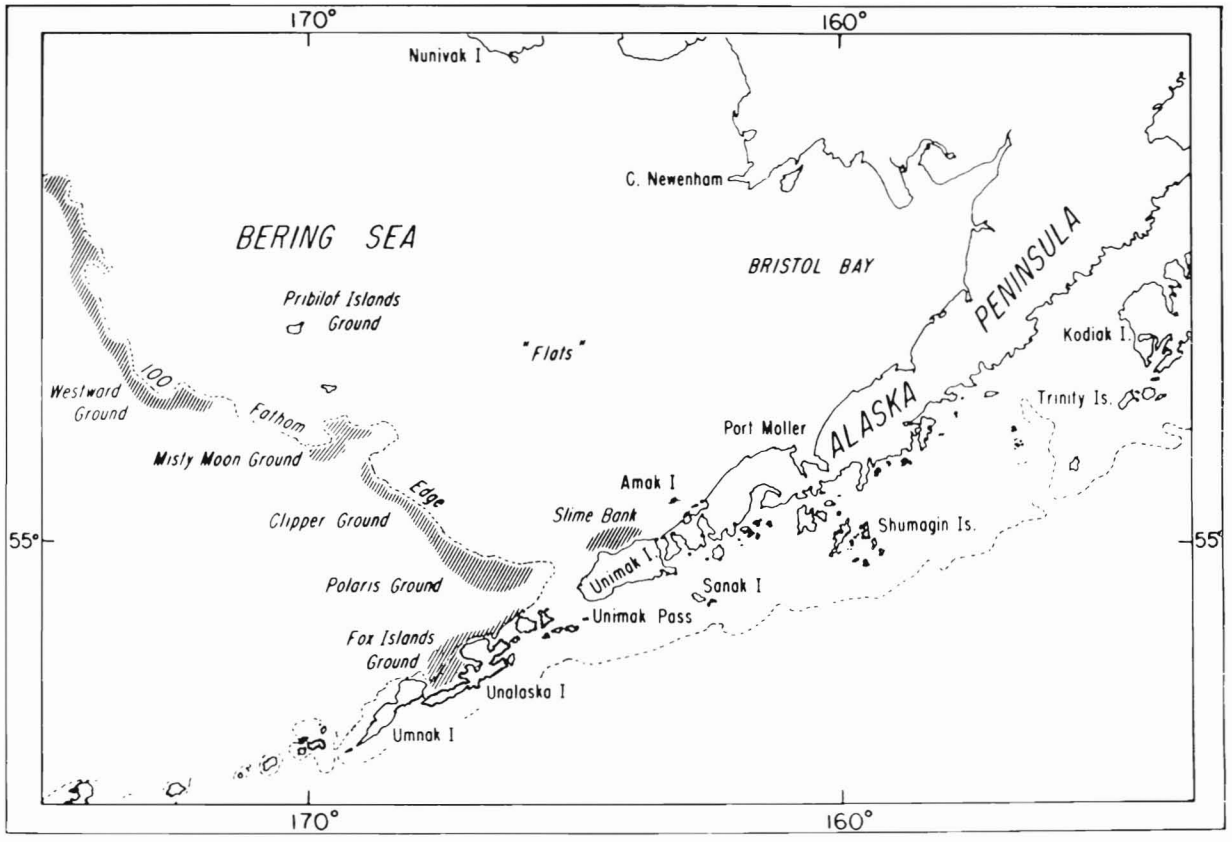


Figure 4.—Traditional halibut fishing grounds (shaded areas) in the southeastern Bering Sea. (Figure after Dunlop et al., 1964.)

fishing power in the North Pacific. With the signing of the peace treaty between the United States and Japan in 1952, restrictions on Japanese distant-water fisheries were removed and, in 1954, fishing in the eastern Bering Sea was resumed.

The Japanese postwar fishery for groundfish in the Bering Sea developed into four principal components: The mothership fishery, the North Pacific trawl fishery, the North Pacific long-line-gillnet fishery, and the landbased trawl fishery. These fisheries contributed 64, 31, 0.3, and 5 percent, respectively, to the total Japanese catch in the Bering Sea during 1971-76 (Sasaki, 1977[3]).

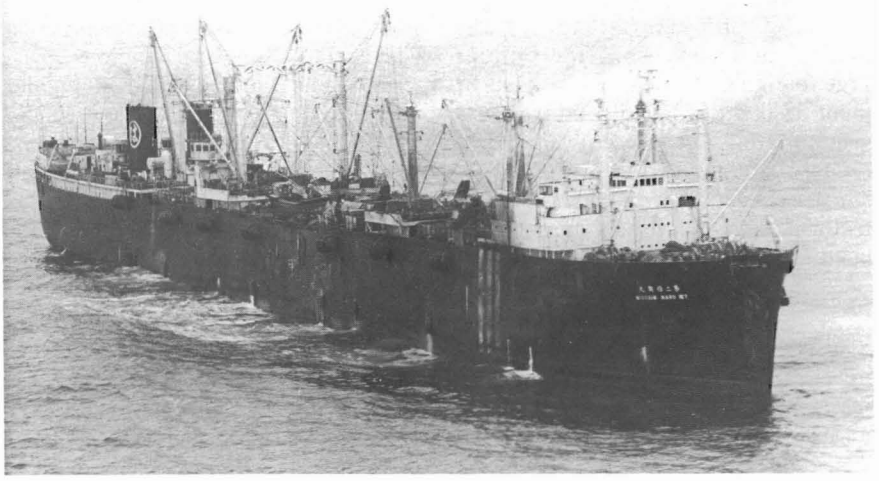


Figure 5.—Japanese mothership *Nisshin Maru*, 193 m in length and 27,000 gross tons.

[3]Sasaki, R. 1977. Outline of the Japanese groundfish fishery in the Bering Sea, 1976 (November 1975-October 1976). Unpubl. manuscr., 11 p. Fisheries Agency of Japan, Far Seas Fish. Res. Lab., Shimizu 424, Japan.

Mothership Fishery. A mothership (Fig. 5) receives and processes catches supplied by a fleet of catcher vessels. The Japanese mothership fishery for groundfish has consisted of these components: 1) Freezing fleets, 2) meal and

minced fish fleets, and 3) longline-gillnet fleets. The history of these fisheries has been divided into three time periods based on target species, methods of processing catches, and expansion of the fishing grounds (Forrester et al., 1978).

In the first period (1954-57), the fishery was relatively small, involving two to four 8,000-gross ton motherships and 200- to 300-ton catcher boats. The fleets operated for only about 1 month between August and October, between the salmon driftnet and Antarctic whaling seasons. Fishing was off Bristol Bay and the catch, consisting of flounders (primarily yellowfin sole), was frozen.

In the second period (1958-63), the mothership fisheries expanded throughout the Bering Sea with diversification of fishing and processing methods and target species. The flounder freezing fleets extended their operations to include Pacific halibut, sablefish, and Pacific ocean perch and areas of operation to the continental slope in the central and northern Bering Sea and to Aleutian Island waters. The fishing season which had previously only been about 1 month was lengthened to 4-9 months. Winter fishing was initiated by part of the fleet in 1961-62.

Fish meal operations by motherships were initiated in 1958 and soon became the major user of yellowfin sole and other flounders. They operated from April through September on the eastern Bering Sea shelf. Catches of yellowfin sole by the Japanese fish meal and freezing fleets and by the U.S.S.R. reached their peak during 1960-62 ranging between 420,000 and 554,000 t.

The longline-gillnet mothership fishery also began operations in the 1958-63 period. The fleet consisted of 500-gross ton motherships and 100-gross ton catcher vessels. They fished for Pacific halibut and sablefish (for freezing) along the continental slope off Cape Navarin starting in 1958, and in 1960 they extended operations to the continental slope between the Pribilof Islands and Cape Navarin.

The third period of the Japanese mothership fishery (1964 to present) is characterized by the development of the walleye pollock fishery. With the decline in abundance of yellowfin sole (due to overfishing in the early 1960's) and the development in 1964 of techniques for processing minced fish (surimi) on board motherships, the main Japanese effort shifted to pollock. Fish meal and frozen products became a by-product of surimi operations. Pollock has dominated Japanese catches since 1963, and from 1970 to 1976 formed over 80 percent of the total Japanese groundfish catch in the eastern Bering Sea and Aleutian Islands areas. The pollock fishery has become a year-round effort while the flounder fishery, principally for yellowfin sole, became a winter fishery in 1969-70 with the season generally lasting from October to March.

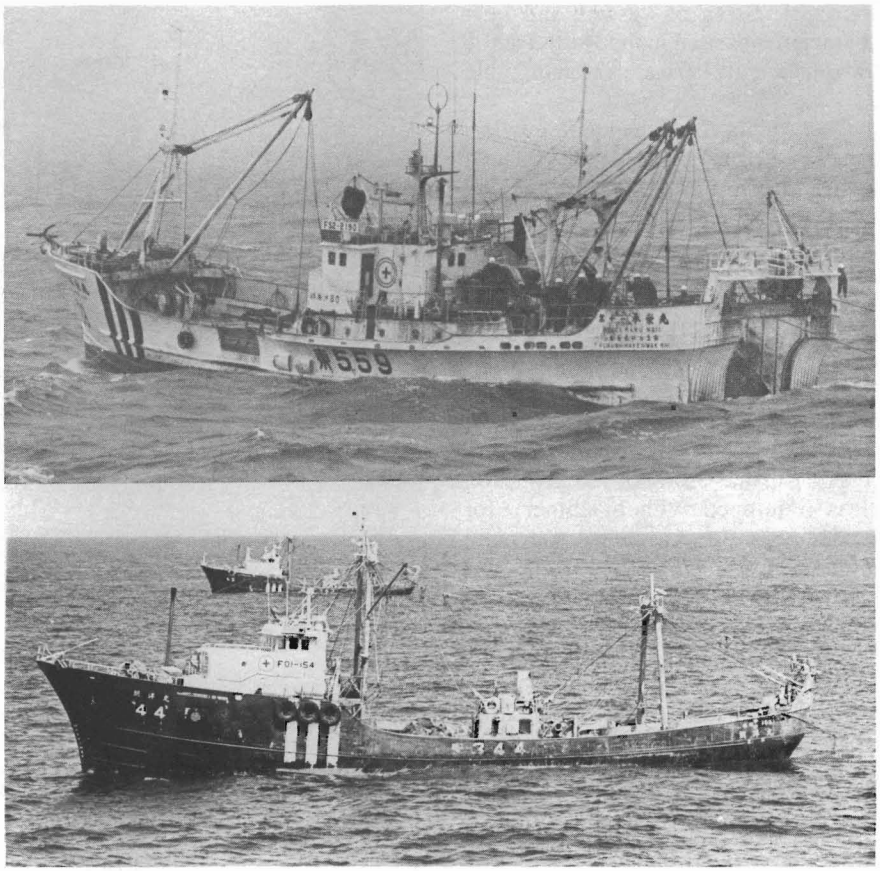


Figure 6.—Japanese Danish seiner (upper photo), 32 m in length and 124 gross tons, and pair trawlers (lower photo), about 36 m in length and 180 gross tons.

Catcher boats in the mothership fishery have been pair trawlers, Danish seiners, side-trawlers, stern trawlers, and longline-gillnetters. Side-trawlers have been phased out of the fishery and the number of Danish seiners (Fig. 6), stern trawlers, and longline-gillnetters has declined with pair trawlers (Fig. 6) becoming the mainstay of the fleet. Characteristics of catcher boats and fishing gear used in the Japanese mothership fishery in 1976 are given in Table 2.

North Pacific Trawl Fishery. This second major type of Japanese fishery consists of factory stern trawlers generally larger than 500 tons that operate independently of motherships and both fish and process their catch (Forrester et al., 1978); products are minced fish, frozen fish, and fish meal, which are transshipped to Japan by refrigerated

transport. Sizes of vessels and gear characteristics used in the North Pacific trawl fishery in 1976 are given in Table 2.

One to three independent trawlers fished in the eastern Bering Sea for yellowfin sole from 1954 to 1959. Since 1961 they have also exploited (for freezing) Pacific halibut, sablefish, Pacific ocean perch, and other species along the continental slope in the central and northern Bering Sea and in Aleutian Islands waters. The number of licensed independent trawlers has ranged from 35 to 57 in recent years. Greater numbers of larger trawlers (Fig. 7) in the 3,000-5,000 gross ton class (equipped with machinery for producing surimi) resulted in a rapid increase in the pollock catch by this fishery. By 1970, 80 percent of the total groundfish catch by these vessels was pollock.

The main effort by the independent trawlers is in the eastern Bering Sea where year-round operations are conducted for pollock. Other species taken are Pacific cod and various flounders.

In the Aleutian Islands the trawlers target on Pacific ocean perch and other rockfish and take lesser amounts of walleye pollock and various other groundfish. Fishing in the Aleutians is concentrated along the shelf edge in the central and western part of the chain with some effort in the eastern Aleutians.

North Pacific Longline-Gillnet Fishery. Pacific herring, *Clupea harengus pallasi,* (taken with gillnets) and sablefish (taken with longlines) have been the principal species taken by this fishery. Reduced quotas on herring to foreign fisheries and closures of nearshore waters of the eastern Bering Sea to foreign gillnetting have essentially eliminated these vessels from the herring fishery. The vessels operate independently and, when filled with fresh fish or frozen products, return to Japan (Forrester et al., 1978). Their hold capacity of about 400 t is normally filled after 2-4 months on the fishing grounds (Law Enforcement Division, footnote 2). The number of licensed longline-gillnet vessels has ranged from 22 to 32 since 1967.

Figure 7.—Japanese large independent stern trawler, 100 m in length and 3,200 gross tons.

Table 2.—Range in size of fishing vessels and gear in the Japanese mothership and North Pacific trawl fisheries based on a sample of the fleets in 1976 (Fisheries Agency of Japan, 1976[1]).

		Vessels			Gear			
Fishery	Target species	Type	Gross tons	Horsepower	Head-rope length (m)	Ground-rope length (m)	Cod-end mesh size (m)	Otter board size (m)
Mothership	Pollock	Danish seine	96-125	450-1,450	90-130	100-143	7.5-9.0	—
		Pair trawl	115-214	650-1,400	57-130	70-160	8.0-9.0	—
		Stern trawl	299-349	1,200-1,900	48-52	57-63	8.0-8.5	1.9×3.2-3.0×4.8
	Yellowfin sole	Pair trawl	214	1,400	127	160	9.0	—
		Stern trawl	314	1,200	36	48	9.0	1.8×2.8
North Pacific trawl	Pollock	Stern trawl	2,455-5,470	3.500-5,700	64-80	65-111	9.0-10.0	2.4×3.8-3.2×5.0
	Yellowfin sole	Stern trawl	349-3,500	1,600-4,000	52-74	60-89	9.0-13.0	2.0×3.1-2.4×3.8
	Rockfish	Stern trawl	349-3,914	1,420-4,400	40-74	51-89	8.0-13.0	2.0×3.2-2.7×3.6

[1]Fisheries Agency of Japan. 1976. Vessel and gear specifications of the Japanese fisheries in the North Pacific in 1976. Unpubl. manuscr., 2 p. Fisheries Agency of Japan, Kasumigaseki Chiyoda-ko, Tokyo, Japan.

Fishing by these vessels (Fig. 8, Table 3) has mainly been in the northeastern Pacific Ocean where the catch has been almost exclusively sablefish with some rockfish taken. Sablefish fishing in the eastern Bering Sea and along the Aleutian Islands has been sporadic with only a few vessels fishing briefly each year.

Landbased Trawl Fishery. The vessels in this fishery (independent trawlers of 100-350 tons) are prohibited by Japanese regulation from transshipping their catch to cargo vessels in offshore waters (Forrester et al., 1978) and, therefore, must return to Japan when storage capacity is filled. Their catches are chiefly flounders, Pacific ocean

Figure 8.—Japanese longline-gillnet vessel, 55 m in length and 424 gross tons.

Table 3.—Range in size of North Pacific longline-gillnet vessels and gear used in the fishery in 1976 (Japan Fishery Agency, 1977[1]).

Vessels		Gear					
		Groundline			Gangion		
Range in gross tons	Range in horsepower	Hachi length (m)	Diameter (mm)	Hooks per hachi	Length	Size hook (mm) or size number	Bait
382-500	540-1,110	70-75	8-12	35-44	1.0-1.6	18-20	Frozen squid

[1]Japan Fishery Agency. 1977. Vessel and gear specifications of the Japanese fishery operated in the northeast Pacific Ocean in 1976. Unpubl. manuscr., 2 p. Japan Fishery Agency, Kasumigaseki Chiyoda-ko, Tokyo, Japan.

perch, and sablefish. The fishery is restricted by Japanese regulation to waters north of lat. 48° N and west of long. 170° W. Major fishing grounds have been along the continental slope from Cape Olyutorskii to Cape Navarin and off the Pribilof Islands, but the fishery has also operated in Aleutian Islands waters. Gear consisted mainly of Danish seines early in the fishery but stern trawls became the major gear in later years. The number of vessels licensed to operate in the fishery since 1969 has been 182 although only 62 vessels operated in the U.S. fishery conservation zone in 1977.

Soviet Fishery

Similar to the Japanese groundfish operations, the Soviet distant-water fishery also employs catcher boats that deliver their catches to factory ships or processing and freezing transport vessels and larger trawlers that operate independently of factory ships and process their own catches. The U.S.S.R. has perhaps utilized the fleet concept of fishing operations to a greater degree than any other nation (Pruter, 1976). To allow the fishing vessels to operate at sea for long periods, they are closely supported by numerous other types of vessels including base ships that carry fleet administrators and staff and provide logistic support; factory ships for processing catches; refrigerator transports to replenish stores and to receive, freeze, and transport catches to home ports; as well as oil tankers, passenger ships, tugs, patrol vessels, and, occasionally, even hospital ships. Refrigerated transports are the mainstays of the support operations. They are of various sizes ranging from 46 to more than 200 m and from 650 to 25,000 gross tons or more (Fig. 9). Base and factory ships are about 110 to 174 m and 4,000 to 18,000 gross tons (Fig. 9).

Two basic kinds of fish vessels have been used by the Soviets—side trawlers and stern trawlers. Pruter (1976) provides an excellent review of the operations and kinds of fishing and support vessels used in the fishery. Basic features of the Soviet fishing vessels are summarized in Table 4, and some of the vessels are pictured in Figures 10 and 11.

Dimensions of typical gear used on Soviet BMRT trawlers fishing for walleye pollock and Atka mackerel in recent years are given in Table 5. Data from U.S. observer reports indicated that vertical openings on trawls used for pollock may range from 5 to 30 m.

The first commercial scale operations by the U.S.S.R. off Alaska, following exploratory work in 1957-58, was a fishery for flounders in the eastern Bering Sea starting in 1958. Like the Japanese, the Soviets expanded their fisheries since their inception in terms

Table 4.—Basic types of fishing vessels employed by the U.S.S.R. in groundfish fisheries off Alaska (Pruter, 1976).

Vessel type	Gross tons	Length (m)	No. in crew	Descriptive remarks
SRT	265-335	38	22-26	Small side trawler of older type
SRTR	505-630	52	26-28	Medium side trawler—usually transships catch to factory ship but may operate independently and process and freeze own catch
SRTM	700	54	30	Large side trawler—frequently operates independent of factory ships and processes and freezes own catch
SRTK	775	—	—	New class of trawler equipped with stern ramp for more efficient trawling
BMRT	3,170	85	90	Factory trawler which normally processes and freezes own catch
RTM	2,657	82	—	Newer type of factory trawler having increased deck area aft for more efficient handling of gear and catch

of effort, target species, and fishing areas. They have carried out three major groundfish fisheries in the eastern Bering Sea and Aleutian Islands: A flounder fishery in the southeastern Bering Sea, a rockfish fishery primarily in the Aleutian Islands, and a pollock fishery along the outer continental shelf from Unimak Pass to northwest of the Pribilof Islands. In describing these fisheries, information is summarized from Chitwood (1969), Forrester et al. (1978), Haskell[4], Office of Enforcement and Surveillance[5], Enforcement and Surveillance Division,[6] and Law Enforcement Division (footnote 2).

Flounder Fishery. The Soviet flounder fishery was a winter operation throughout its history extending usually from November to April with effort peaking in February or March. Timing of the fishery was apparently designed to take advantage of the high density aggregations of flounders that form in winter. The primary target species was yellowfin sole. Other flounders such as rock sole, flathead sole, Alaska plaice, starry flounder, and arrowtooth flounder were also taken. Vessels participating in this fishery have included smaller side trawlers (SRT), medium trawlers (SRTM), large independent stern trawlers (BMRT), and support vessels.

Soviet catches of yellowfin sole reached a peak in early years of the fishery rising from an estimated 5,000 t in 1958 to about 154,000 t in 1961 and 140,000 t in 1962. Although effort of the Soviet flounder fishery increased in subsequent years to reach a maximum (involving 70-100 trawlers during peak months) in the period 1966-68, catches never reached the level of those in 1961 and 1962. There was a sharp drop in abundance of yellowfin sole following the large combined Japanese and Soviet catches of this species (ranging from 421,000 to 554,000 t annually) in the early 1960's (Wakabayashi et al., 1977[7]).

The Soviet effort for flounders generally declined after 1968, presumably because of relatively low abundance of yellowfin sole. The Soviet flounder fishery was discontinued in 1973 and was not resumed until 1978, following recovery of the resource (Wakabayashi et al., footnote 7).

Figure 9.—Soviet refrigerator cargo transport of 6,100 gross tons (upper panel) and large factory ship of 18,000 gross tons (lower panel).

Pacific Ocean Perch Fishery. The Soviet fishery for Pacific ocean perch and other rockfish began in 1960 when 25-30 trawlers fished along the edge of the continental shelf in the eastern and central Bering Sea. In subsequent years the fishery became centered in the Aleutian Islands and Gulf of Alaska. The Aleutian Island fishery has been mainly by larger BMRT factory trawlers fishing along the continental shelf edge at depths of about 150-275 m. The rockfish were frozen in the round or headed and eviscerated.

[4]Haskell, W. H. 1964. Foreign fishing activities Bering Sea and Gulf of Alaska. 1963. Unpubl. manuscr., 130 p. U.S. Fish Wildl. Serv., Juneau, Alaska. On file at Alaska Regional Office, Natl. Mar. Fish. Serv., NOAA, P. O. Box 1668, Juneau, AK 99802.

[5]Office of Enforcement and Surveillance. 1965, 1967-1970. Foreign fishing activities Bering Sea and Gulf of Alaska, 1964-1969. Unpubl. manuscr., var. pag. Alaska Regional Office, Natl. Mar. Fish. Serv., NOAA, P.O. Box 1668, Juneau, AK 99802.

[6]Enforcement and Surveillance Division. 1971, 1973. Foreign fishing activities Bering Sea and Gulf of Alaska, 1970, 1971. Unpubl. manuscr., var. pag. Alaska Regional Office, Natl. Mar. Fish. Serv., NOAA, P.O. Box 1668, Juneau, AK 99802.

[7]Wakabayashi, K., R. Bakkala, and L. Low. 1977. Status of the yellowfin sole resource in the eastern Bering Sea through 1976. Unpubl. manuscr., 45 p. Northwest and Alaska Fisheries Center, Natl. Mar. Fish., Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

Figure 10.—Soviet medium side trawler of 500 gross tons (upper panel) and large side trawler of 700 gross tons (lower panel).

Table 5.—Size of Soviet (BMRT) factory stern trawlers and trawl dimensions used for fishing walleye pollock and Atka mackerel as shown by data of U.S. observers in 1976 and 1977.

	Range in vessel size			Typical gear dimensions			
Target species	Length (m)	Gross tons	Horsepower	Head-rope length (m)	Ground-rope length (m)	Cod-end mesh size (cm)	Otter boards
Walleye pollock	78-87	2,657-3,837	2,000-2,320	77.4	77.4	3.0-6.0	Round to oval, variable in size, 1,600-1,800 kg
Atka mackerel	78-87	2,581-3,510	2,000	31.0	44.0	3.0-5.0	Round to oval, 1,200 kg

Following concentration of effort for Pacific ocean perch in the Aleutians and Gulf of Alaska in 1963, fishing for this species in the eastern Bering Sea was phased out and catches from this region in later years were a by-catch of the pollock fishery. The early years of the Aleutian Island fishery for Pacific ocean perch were the most productive for the U.S.S.R. with reported catches of 61,000 t in 1964 and 71,000 in 1965. By 1974, catches had declined to about 800 t. Catches in 1975 and 1976 were somewhat higher, ranging from about 7,000 to 8,000 t, but declined again in 1977 to less than 800 t.

Pollock Fishery. The fishery that eventually developed into the pollock fishery began in 1967 but initially targeted on sablefish and large flounders (arrowtooth flounder and Greenland turbot) on the outer continental shelf and slope of the southeastern Bering Sea. This fishery gradually expanded northward along the edge of the continental shelf and by 1969 had become a year-round operation, taking on the general appearance that has characterized the fishery to the present time. Fishing areas became standardized with two principal areas used, the first immediately north of the eastern Aleutian Islands and the other northwest of the Pribilof Islands. Effort normally peaked in late winter when fishing vessels from the Pacific herring and flounder fishery joined the pollock fleet.

Emphasis of the fishery shifted mainly to walleye pollock in 1971 with catches rising from about 36,000 t in 1970 to 234,000 t in 1971. Pollock has remained the predominant target species to the present time. Peak catches of pollock by the Soviets occurred in 1974 when almost 310,000 t were taken. Annual catches of other species have not exceeded 20,000 t since 1972 with the exception of rockfish at 32,000 t in 1974 and rattails (family Macrouridae) at 48,000 t in 1972.

Republic of Korea Fishery

Fisheries by the Republic of Korea (ROK) in the eastern Bering Sea and Aleutian Islands have been of a much smaller scale than those of Japan and the U.S.S.R. (Office of Enforcement and Surveillance, footnote 5; Enforcement and Surveillance Division, footnote 6; Law Enforcement Division,

Figure 11.—Soviet factory stern trawlers: a large (BMRT) trawler of 3,170 gross tons (upper panel) and the newer type (RTM) trawler of 2,657 gross tons with greater deck space aft (lower panel).

Table 6.—Vessel size and fishing gear dimensions of three Republic of Korea independent stern trawlers boarded by U.S. observers in 1977.

	Vessels				Gear				
Name	Length (m)	Gross tons	Horse-power	No. in crew	Head-rope length (m)	Ground-rope length (m)	Verti-cal opening (m)	Cod-end mesh size (cm)	Otter board size (m)
Salvia	84	2,285	3,200	58	59	78	6	10	2.5×3.8
Shin An Ho	106	5,680	6,000	157	80	75	7	10	3.0×5.0
Heung Yang Ho	104	5,377	5,800	92	74	105	38	10	3.0×4.8

footnote 2). Following exploratory fishing in these regions in 1966, an ROK fleet returned to Alaskan waters in September-November 1967 with a commercial operation consisting of a refrigerated transport vessel and eight pair trawlers. The operation was unsuccessful, however, because of bad weather which permitted only 5 days of fishing.

The ROK expedition was more successful in 1968, conducting operations around the eastern Aleutian Islands and west of the Pribilof Islands for walleye pollock. In later years the ROK fishing fleet was enlarged to include factory ships, additional pair trawlers, independent stern trawlers and, eventually, longliners and a Danish seiner. The principal target species in the eastern Bering Sea has continued to be pollock. Some of the trawlers and longliners have also fished in the Aleutian Islands for rockfish, pollock and sablefish. Until 1972, fishing was limited to spring and summer months, but by 1973 the fishery was a year-round operation. Estimates by U.S. surveillance of the ROK fishery indicated that pollock catches ranged between 1,200 and 26,000 t from 1968 to 1975. The pollock catch reported by the Koreans for 1976 was 85,000 t and for 1977, about 40,000 t.

Modernization of the Korean trawl fleet is depicted by Table 6 which indicates that independent stern trawlers in the ROK fleet are comparable in size to the largest trawlers in the Japanese and Soviet fleets with some exceeding 5,000 gross tons. The three vessels observed were targeting on pollock; gear dimensions given in Table 6 are probably representative of trawls used by ROK independent trawlers in the pollock fishery.

Taiwanese Fishery

The Taiwanese fishery, which began in December 1974, has involved only one or two independent stern trawlers. The trawlers have fished in winter and spring months along the continental shelf edge west and southwest of the Pribilof Islands. The vessels are believed to have targeted on walleye pollock and flounders.

Magnitude of Foreign Catches

The total catches of groundfish in the eastern Bering Sea and Aleutian Islands waters during the history of the modern day foreign fishery (1954-78) are illustrated in Figures 12 and 13. Note that the scale of the two figures differ and that catches have always been much greater in the eastern Bering Sea than in the Aleutians. Even during the period of peak catches of groundfish in the Aleutian area (1964-65), when catches were relatively low in the eastern Bering Sea, Aleutian Islands catches were only about a third of those in the eastern Bering Sea. In subsequent years as the fishery for walleye pollock in the eastern Bering Sea developed, the total groundfish catch in the Aleutians fell to

5 percent or less than that of the eastern Bering Sea.

In the eastern Bering Sea, total catches of groundfish have reached two peaks (Fig. 12). The first and smaller peak occurred during 1960-62 when Japan and the U.S.S.R. were intensively exploiting yellowfin sole for production of fish meal. Total estimated catches of yellowfin sole and other species reached a maximum of 715,000 t in 1961. Catches declined, ranging between 310,000 and 390,000 t during 1963-65 because of reduced abundance of yellowfin sole. After the Japanese developed shipboard methods of producing surimi, their fishery for walleye pollock developed rapidly and the total groundfish catches rose again to reach a second much higher peak of over 2.0 million t per year in 1971-73. Since that time, catches have declined because of restrictions stemming from evidence of declining abundance of pollock and other species. By 1977, catches had declined to about 1.0 million t but, based on preliminary data, catches were higher in 1978 at about 1.37 million t.

Flounders (primarily yellowfin sole) were the major species in eastern Bering Sea catches until 1963, after which walleye pollock predominated (Fig. 12). The proportion of pollock in the total foreign catch of groundfish increased from about 44 percent in 1964 to about 72 percent in 1968 and, from 1971 to 1977, represented 81-85 percent of the total groundfish catch.

Japan has taken the major share of the groundfish catches in the eastern Bering Sea (Fig. 12), accounting for at least 68 percent of the total foreign catches annually and usually between 80 and 90 percent of the catches.

Characteristics of the foreign fisheries in the Aleutian Islands region differ from those in the eastern Bering Sea in a number of respects. Overall catches have been much lower, trends in catches and major species in catches have differed, and the U.S.S.R. rather than Japan has taken the greatest share of the catches (Fig. 13). Total groundfish catches in this area reached a peak of 114,000 t in 1965, a few years after the fishery was initiated in 1962.

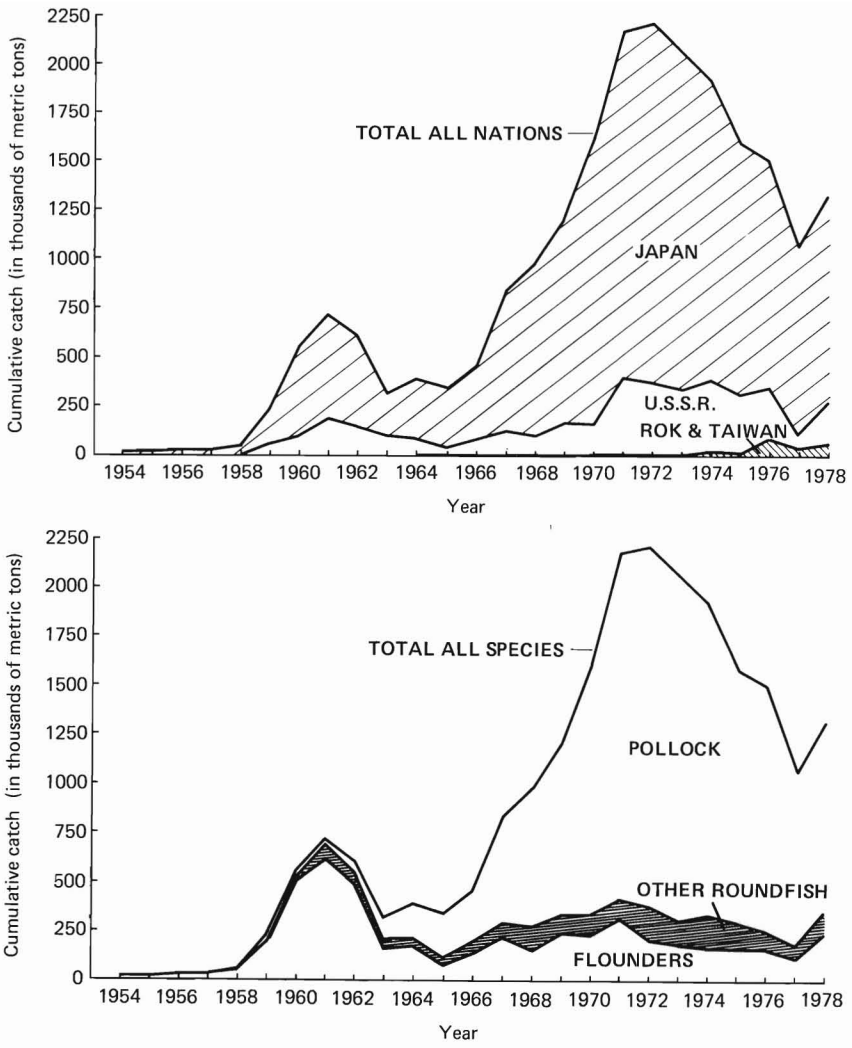


Figure 12.—Foreign catches in metric tons (t) of groundfish in the eastern Bering Sea (east of long. 180°) by nation (upper panel) and by species group (lower panel), 1954-78.

Since then, total catches have fluctuated at a lower level ranging from about 36,000 to 80,000 t annually.

Pacific ocean perch and other rockfish have been the primary target species in the Aleutians until recent years. Rockfish catches reached their peak in 1965 at 109,000 t, but since then have shown an almost continual decline. In 1977 the rockfish catch was 13,600 t. Catches of other roundfish have increased since 1971 with walleye pollock and Atka mackerel accounting for most of this increase. Atka mackerel was the most abundant species in catches in the Aleutian area in 1976 and 1977 at 20,000 and 21,500 t, respectively. Flounders have formed only a minor part of catches in the Aleutians with Greenland turbot and arrowtooth flounder the main species taken.

Current Condition of Resources and Areas of Fishing

Walleye Pollock

Walleye pollock is a member of the cod family (Gadidae) along with Pacific

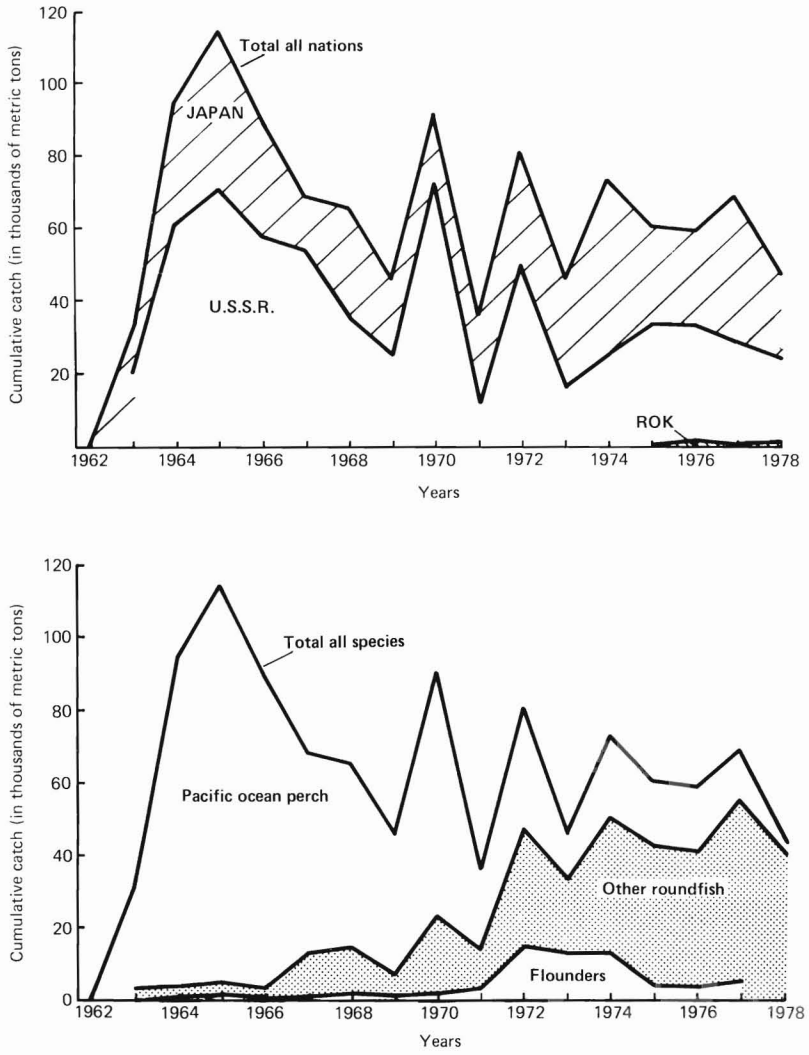


Figure 13.—Foreign catches in metric tons (t) of groundfish in the Aleutian Island area (long. 170°W-170°E) by nation (upper panel) and by species or species group (lower panel), 1962-78.

cod, Pacific hake, *Merluccius productus,* and others. It has a wide distribution extending from off central California northward through the Bering Sea, the Sea of Okhotsk, and the Sea of Japan (Hart, 1973). It is by far the most abundant demersal fish (on a weight basis) in the eastern Bering Sea (Pereyra et al., footnote 1) and has been the major target species of foreign fisheries in this region since the mid-1960's (Fig. 14). It is also taken commercially in the Gulf of Alaska, although its total abundance is apparently lower in the Gulf than in the Bering Sea. There is also a major fishery on the Asian coast, similar in magnitude to the eastern Being Sea fishery. The life span of pollock is about 14-15 years; however, the fishery in the eastern Bering Sea exploits mainly 2-6 year olds. Pollock is a rapid growing species, reaching an average weight of ½ kg (about 1 pound) and 40 cm (about 16 inches) at 4 years of age.

Catches of pollock which ranged from about 1.6 to more than 1.8 million t from 1971 to 1974 apparently caused a decline in abundance of the populations, but catch restrictions placed on the foreign fisheries in later years appear to have arrested this decline (Low et al., 1978[8]). The stock is still capable of producing large catches on the order of 1.0 million t annually.

Although the pollock population remains relatively large, the abundance of older fish has been reduced and catches by the foreign fisheries now consist mainly of young fish 2-6 years old. The size of pollock in the eastern Bering Sea fishery is therefore small (Fig. 15). In 1976, pollock in the Japanese commercial fishery averaged 36 cm (14 inches) and 80 percent of the fish were less than 40 cm (16 inches).

Fishing areas for pollock are illustrated from Japanese commercial catch data (Fig. 16). Pollock were taken throughout the Aleutian Islands area and the outer continental shelf and slope of the eastern Bering Sea, but catches in the Aleutians were relatively small. The largest catches came from the outer shelf and slope of the eastern Bering Sea between the eastern Aleutian Islands and the Pribilof Islands and southwest of St. Matthew Island. From 1973 to 1977, 38 percent of the catch, representing about 510,000 t annually, came from the area between the eastern Aleutians and Pribilofs with almost all the remainder coming from the area north and northwest of the Pribilofs.

Pacific Cod

The Pacific cod is wide-ranging, extending from waters off California northward and westward around the rim of the North Pacific Ocean, to the northern part of the Yellow Sea (Hart, 1973). It is exploited commercially from the coast of Washington State or northern Oregon around the continental shelf to the Sea of Japan (Ketchen,

[8]Low, L., R. Bakkala, H. Larkins, S. Mizroch, V. Wespestad, and J. Akada. 1978. Information on groundfish resources in the Bering Sea and Aleutian region. Unpubl. manuscr., 92 p. Northwest and Alaska Fisheries Center, Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

1961). Adults are found in commercial abundance from depths of 80 to 260 m.

Pacific cod are not abundant enough in the eastern Bering Sea to support a major fishery. They are mainly a by-catch of the pollock fishery although they are occasionally target species when high concentrations are detected during pollock fishing operations. Occasionally they have also been target species of the Japanese longline fishery. Although foreign catches of Pacific cod in the eastern Bering Sea have reached 70,000 t, catches in recent years have averaged about 58,000 t. Because of their minor importance in the overall Bering Sea fishery, they have not been intensively studied, but it appears that the stock is healthy and can sustain catches at the level recently harvested (Low et al., footnote 8).

Similar to walleye pollock, the eastern Bering Sea population of Pacific cod consists of young fish, with the fishery taking mainly 2-4 year olds. However, because Pacific cod grow much faster than pollock, these age groups represent relatively large fish. In the 1975 Japanese fishery, Pacific cod averaged 52 cm (20 inches) and 90 percent were larger than 40 cm (about 16 inches) (Fig. 15). The size composition of Pacific cod may vary considerably from year to year, however, depending on the strength of the various year classes in the fishable population.

Pacific cod were taken by the Japanese fishery in 1977 over much of the Aleutian Islands region and the eastern Bering Sea (Fig. 17). Areas of high catches were located on the outer continental shelf and slope in the areas between Unimak Island and the Pribilof Islands, west of St. Paul Island in the Pribilofs, and southwest of St. Matthew Island.

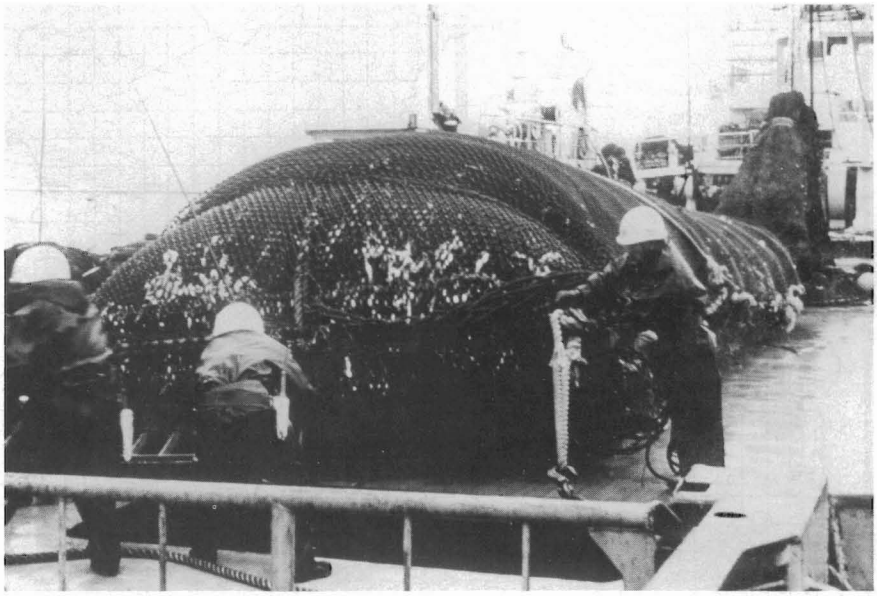


Figure 14.—Large catch of walleye pollock taken by a Japanese independent stern trawler.

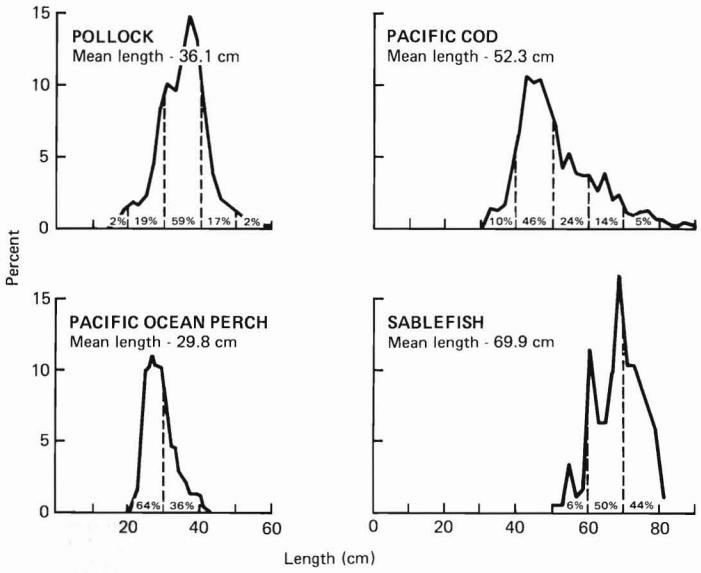


Figure 15.—Length composition of principal commercial species of roundfish in Japanese commercial catches from the eastern Bering Sea-Aleutian Islands regions. Numbers within the figures are percentages of the total numbers of fish within each 10 cm length interval. Data are from 1975 for Pacific cod and 1976 for other species.

Pacific Ocean Perch

Pacific ocean perch is the most abundant species of rockfish in the northeast Pacific Ocean (Alverson et al., 1964) and ranges from California to the Bering Sea and south along the Asian coast to Japan (Hart, 1973). Pacific ocean perch is a slow growing and long lived species that may reach an age of about 30 years and a length of 51 cm (20 inches). Pacific ocean perch commonly occupy waters along the outer continental shelf and slope and commercial concentrations usually occur between 100 and 500 m (Quast and Hall, 1972).

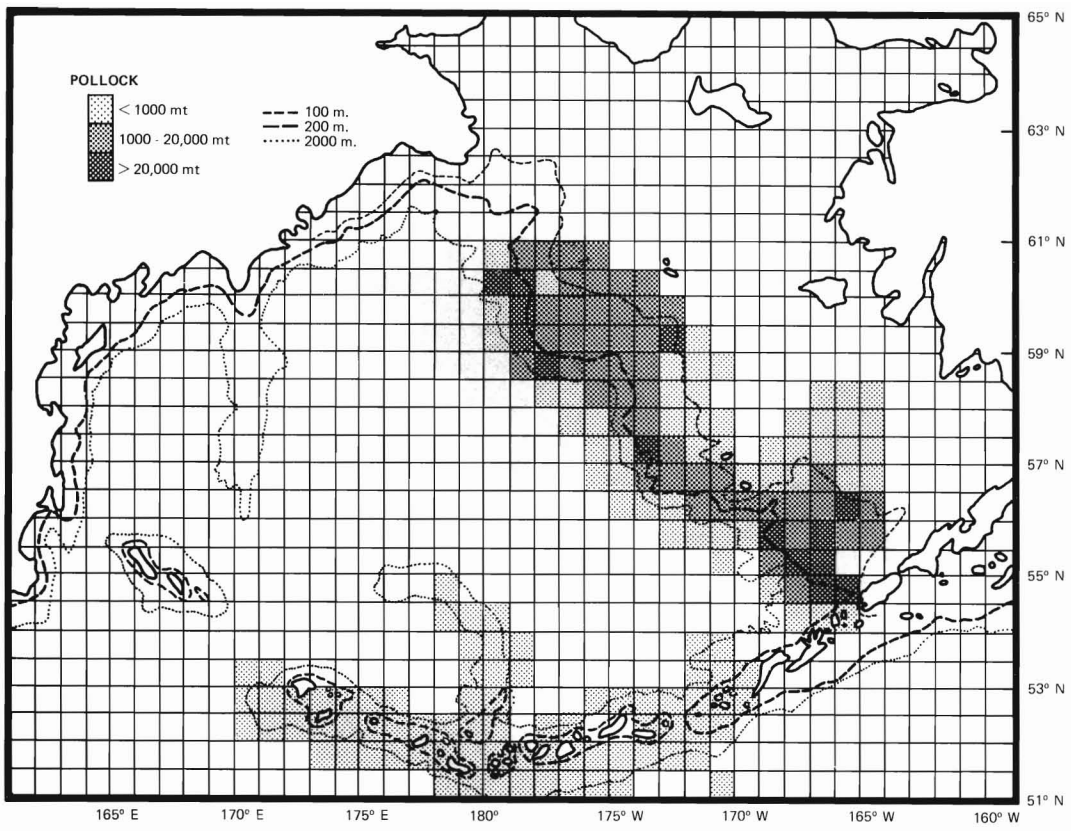


Figure 16.—Distribution of Japanese catches of walleye pollock in 1977.

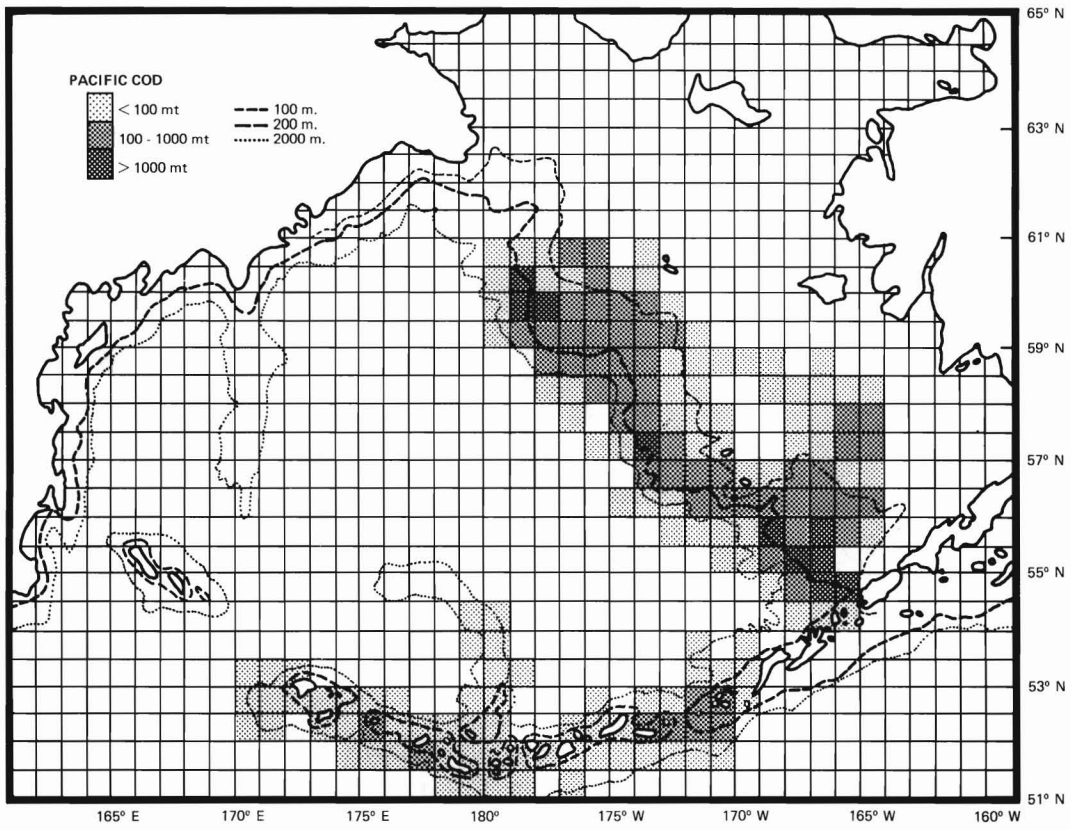


Figure 17.—Distribution of Japanese catches of Pacific cod in 1977.

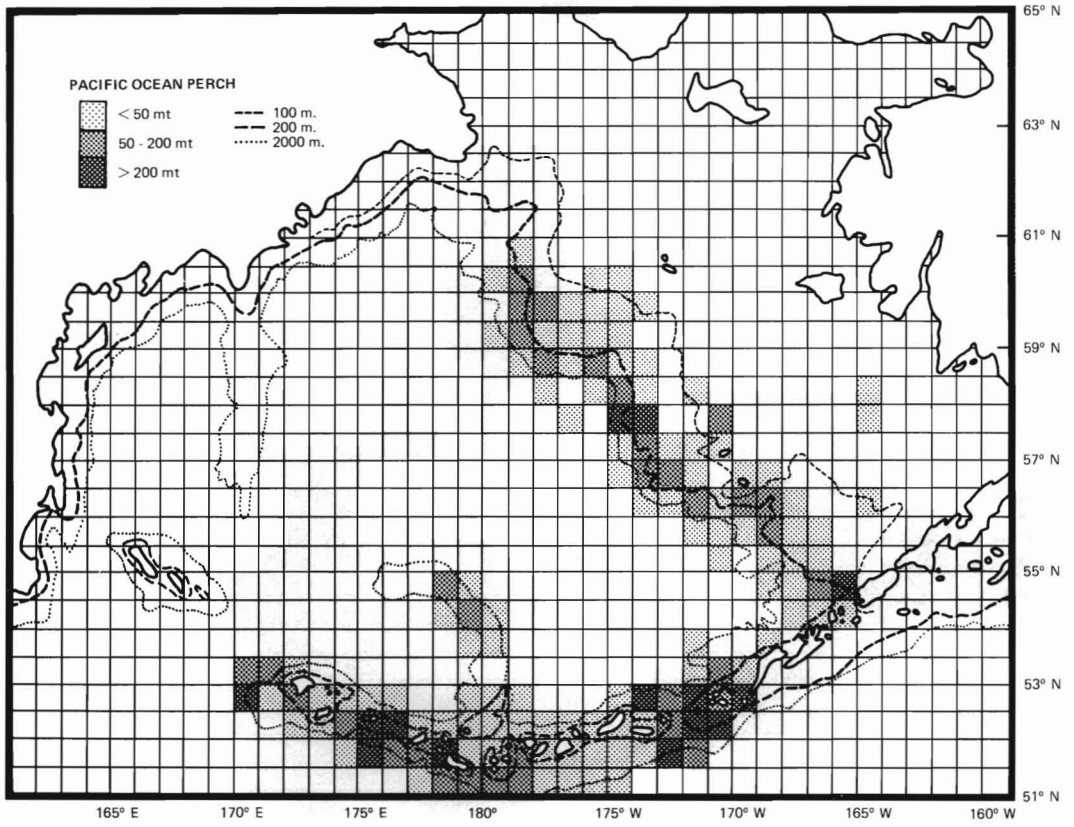


Figure 18.—Distribution of Japanese catches of Pacific ocean perch in 1977.

Pacific ocean perch is the major species of rockfish in the eastern Bering Sea and Aleutian Islands regions, but a number of other species of rockfish are also harvested (Table 1). Based on reports of U.S. observers, Pacific ocean perch represented a high proportion (93 percent) of the total catch of rockfish in the eastern Bering Sea in 1977 but only 60 percent of the total rockfish catch in the Aleutian Islands region. The remaining 40 percent of the catch in the Aleutians was mainly dusky, northern, and rougheye rockfish. Rockfish are more abundant in the Aleutian Islands than in the eastern Bering Sea (Fig. 18), and populations in the two regions are managed as separate stocks. Peak catches of rockfish were made in early years of the foreign fisheries for these species with the maximum annual catch of 47,000 t occurring in the eastern Bering Sea in 1961 and 109,000 t in the Aleutian Islands area in 1965.

Studies have indicated that the large removals of Pacific ocean perch and other rockfish in early years of the fishery and continued exploitation of this species group have severely reduced their numbers (Low et al., footnote 8). The stocks are considered to be badly depleted at present and allowable catches (6,500 t in the eastern Bering Sea and 15,000 t in the Aleutians) have been reduced to low levels, to allow the stocks to rebuild. Because rockfish are long lived, slow growing, and have a low fecundity, restoration of stocks is expected to take many years. Based on data from the 1976 Japanese fishery (Fig. 15), most of the Pacific ocean perch taken ranged in size from 22 to 40 cm (about 9 to 16 inches).

Sablefish

Sablefish is a member of the family Anoplopomatidae and is often referred to as blackcod. It has a wide distribution extending from off Baja California to the Bering Sea and southward along the Asian coast to Japan (Hart, 1973). It also occupies a wide depth range, with juveniles found in surface and inshore waters to a depth of about 150 m, and adults in 150 to 1,200 m. Research vessel survey data and commercial catches indicate that the region of highest abundance is the Gulf of Alaska, especially from the Shumagin Islands to northern Queen Charlotte Sound. The overall biomass has been estimated to be distributed as follows: 67 percent in the Gulf of Alaska, 13 percent in the Vancouver to California region, and the remaining 7 percent in the Aleutian Islands region (Low et al., 1976[9]). Sablefish can live more than 20 years, but the majority taken in the fisheries are from 3 to 8 years of age. They can reach lengths of about 1 m (40 inches).

[9]Low, L. L., G. K. Tanonaka, and H. H. Shippen. 1976. Sablefish of the northeastern Pacific Ocean and Bering Sea. Processed rep., 115 p. Northwest and Alaska Fisheries Center, Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

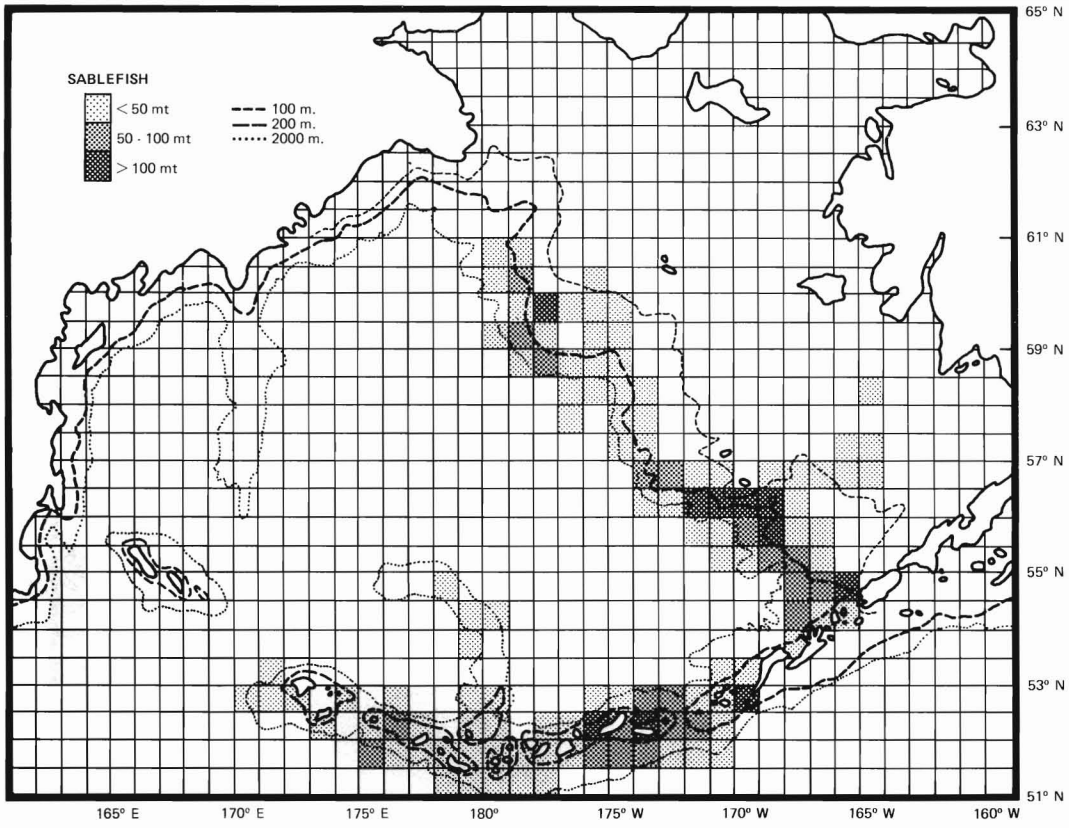


Figure 19.—Distribution of Japanese catches of sablefish in 1977.

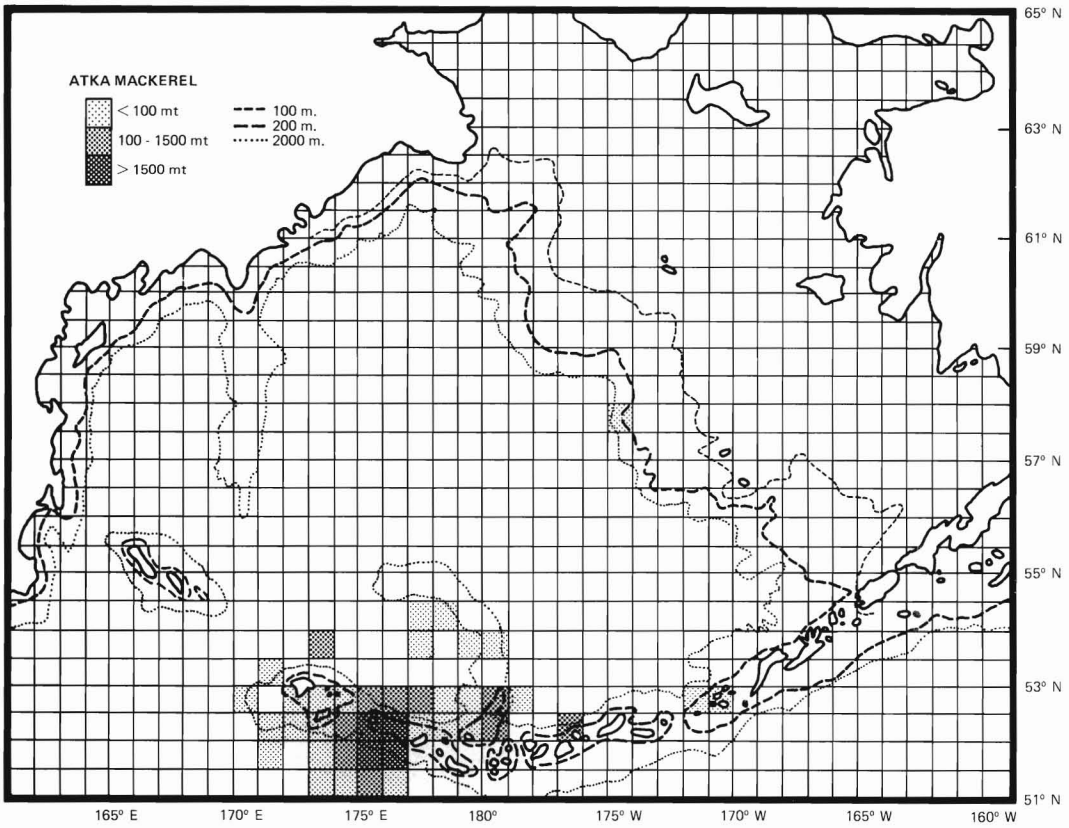


Figure 20.—Distribution of Soviet catches of Atka mackerel in 1977.

Sablefish are managed separately for the eastern Bering Sea and Aleutian Islands regions. They are more abundant in the eastern Bering Sea where catches have reached 28,500 t; catches in the Aleutians have reached a maximum of 3,600 t. Because the stocks have been overfished, allowable catches in 1979 have been reduced to 3,500 t in the eastern Bering Sea and 1,500 t in the Aleutian Islands region. Based on 1976 size composition data from the Japanese commercial fishery, the size of sablefish taken in the Bering Sea averages 70 cm (almost 28 inches), with over 90 percent ranging above 60 cm (about 24 inches) (Fig. 15).

In 1977, the Japanese fishery took the largest proportion of their catch in the southeastern Bering Sea (Fig. 19).

Atka Mackerel

Atka mackerel is a member of the greenling family Hexagrammidae which includes such prized fish as the lingcod, *Ophiodon elongatus*. This species is found from Monterey, Calif., to the Bering Sea and the Sea of Japan (Miller and Lea, 1972). They appear to be most abundant in the Aleutian Islands region and the Gulf of Alaska, as indicated by a substantial foreign fishery in these areas. They can grow to over 48 cm (almost 19 inches) and frequent depths of 4-120 m (Miller and Lea, 1972). Atka mackerel have a seasonal distribution which is influenced by their spawning habits. They move inshore between May and October for spawning, then return to the open ocean in the fall (Macy et al., 1978[10]). After hatching, the juvenile fish migrate to the open ocean, then adopt the seasonal migratory habits of the adults.

Atka mackerel have recently become a target species of Soviet fisheries. In the Bering Sea the fishery is restricted to the Aleutian Islands area with the main fishery in the western Aleutians (Fig. 20). The fishery was initiated in the early 1970's and catches have risen since then to a peak of 21,000 t in 1977. Little is known about the resource but, based on information provided by Soviet scientists, the allowable catch in 1979 has been set at 24,800 t. Data collected by U.S. observers aboard Soviet vessels fishing for Atka mackerel indicated that catches consisted mainly of fish in the narrow size range of 27-33 cm (about 11-13 inches).

Figure 21.—Catch of yellowfin sole being unloaded on the deck of a Japanese mothership.

Yellowfin Sole

Yellowfin sole is the most abundant flounder in the eastern Bering Sea (Fig. 21). It ranges south along the North American coast to waters off northern British Columbia, but its abundance in the Gulf of Alaska is low and nowhere forms concentrations sufficient to warrant a commercial fishery. On the Asian coast, they range from the Gulf of Anadyr southward to the coast of the Republic of Korea (Fadeev, 1970), and are fished commercially in Asia off the east and west coasts of Kamchatka and in certain areas of the Okhotsk Sea. Yellowfin sole are mainly confined to depths less than 200 m and in summer major concentrations in the eastern Bering Sea are found at depths less than 100 m. They reach a maximum age of about 19 years and a maximum length of 45 cm (about 18 inches) in the eastern Bering Sea (Pereyra et al., footnote 1).

Yellowfin sole were harvested very intensively from 1959 to 1962 with annual catches in this period averaging about 400,000 t. The stock may have been reduced to 40 percent of its original size in the early 1960's and declined further in the middle and late 1960's (Wakabayashi et al., footnote 7). Signs of improvement in the resource began to appear in the early 1970's and have continued to the present time. The resource was underutilized during 1975-77 when allowable catches were 106,000 t and actual annual catches

[10]Macy, P. T., J. M. Wall, N. D. Lampsakis, and J. E. Mason. 1978. Resources of non-salmonid pelagic fishes of the Gulf of Alaska and eastern Bering Sea, Part 1. Unpubl. manuscr., 335 p. Northwest and Alaska Fisheries Center, Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

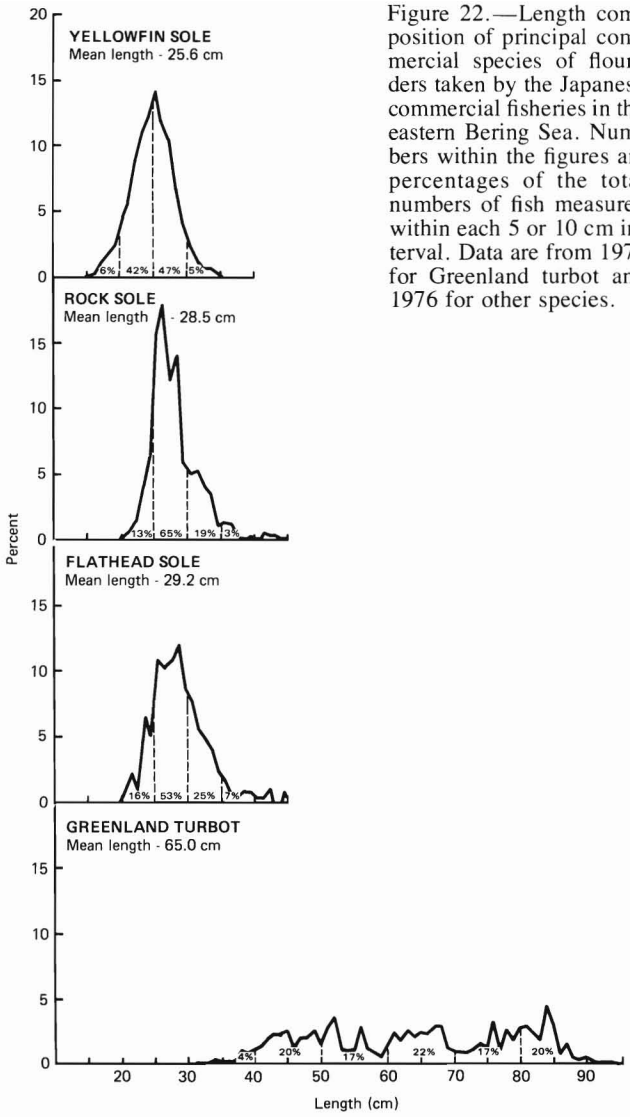


Figure 22.—Length composition of principal commercial species of flounders taken by the Japanese commercial fisheries in the eastern Bering Sea. Numbers within the figures are percentages of the total numbers of fish measured within each 5 or 10 cm interval. Data are from 1977 for Greenland turbot and 1976 for other species.

ranged from 56,000 to 65,000 t. In 1978, however, the full quota was taken with renewal of the Soviet fishery for yellowfin sole.

Yellowfin sole is a slow growing species and does not reach a large size. Over the past several years, the average length of fish in commercial catches has been about 25 cm (10 inches), which represents 8 to 9 year olds. The size composition of yellowfin sole is typified by size data from the Japanese commercial fishery in 1976 (Fig. 22). Most of the fish (89 percent) fell within the size range of 20 to 30 cm (8 to 12 inches).

Yellowfin sole were taken over a large area of the eastern Bering Sea by Japanese fisheries in 1977, but the main area of fishing was east of the Pribilof Islands (Fig. 23). The areas of high catches typify the summer and fall distribution of major concentrations of yellowfin sole. Seasonal migrations result in yellowfin sole occupying deeper water of 100 m or more in winter and early spring with major concentrations located west of the Pribilof Islands and from Unimak Island to the Pribilof Islands (Bakkala and Smith, 1978[11]).

Greenland Turbot and Arrowtooth Flounder

Greenland turbot and arrowtooth flounder are large deep-water flounders that mainly occupy continental slope waters in the Bering Sea during adult life history stages; juveniles generally occupy the continental shelf. Major concentrations of adult Greenland turbot are found in the depth range of 200-700 m in summer and 600-900 m in winter, while main concentrations of arrowtooth flounder are found at depths of 200-400 m in summer and 300-500 m in winter (Shuntov, 1970). Both species are widely distributed, extending around the Pacific rim from California to Japan. Greenland turbot is more abundant than arrowtooth flounder in the Bering Sea while arrowtooth flounder predominates in the Gulf of Alaska. Arrowtooth flounder may reach a maximum length of about 84 cm (33 inches) and Greenland turbot about 99 cm (39 inches) in the Bering Sea.

Catches of Greenland turbot and arrowtooth flounder combined have ranged from 42,000 to 91,000 t in the eastern Bering Sea in recent years with Greenland turbot contributing about 80 percent of the total.

The size range of Greenland turbot in Japanese catches monitored by U.S. observers in 1977 was wide (Fig. 22), extending from about 40 to 90 cm (about 16 to 35 inches). Good size information is not available for arrowtooth flounder taken in the commercial fishery, but they are somewhat smaller than Greenland turbot.

Catches of Greenland turbot and arrowtooth flounder by the Japanese fishery are primarily from waters deeper than 100 m with the largest catches coming from near the shelf edge (Fig. 24). The greatest proportion

[11]Bakkala, R. G., and G. B. Smith. 1978. Demersal fish resources of the eastern Bering Sea, Spring 1976. Processed rep., 234 p. Northwest and Alaska Fisheries Center, Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

Figure 23.—Distribution of Japanese catches of yellowfin sole in 1977.

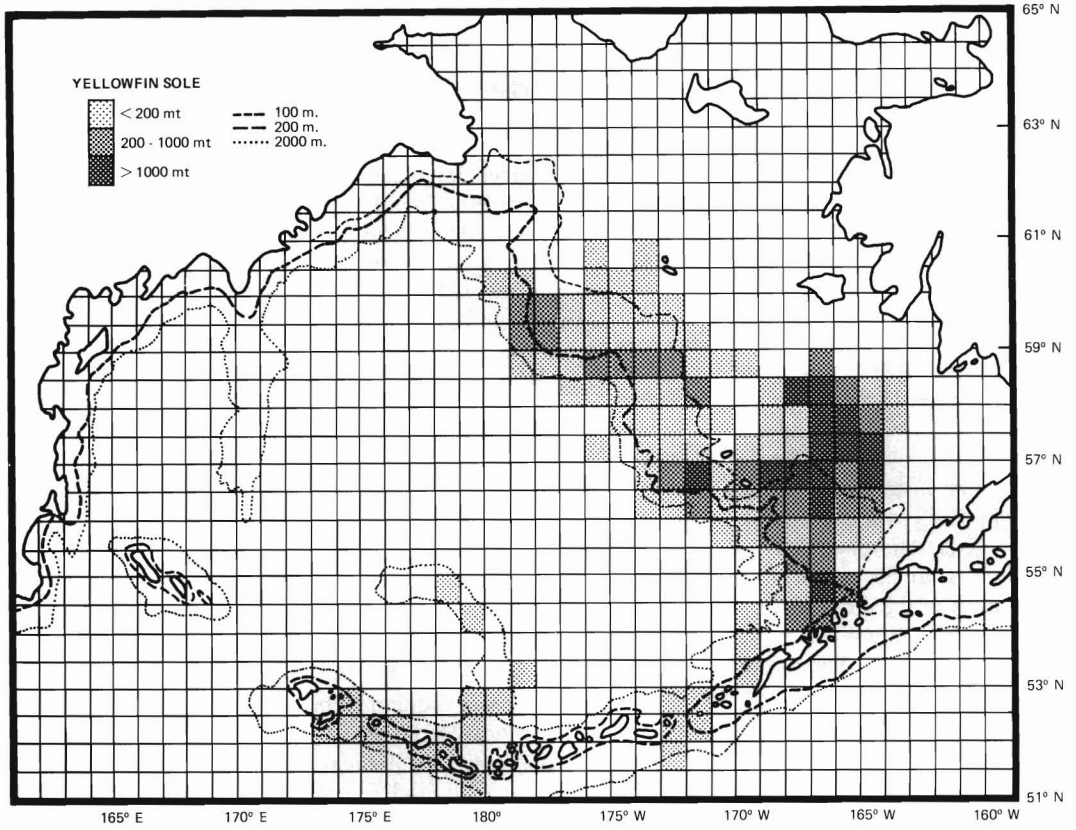
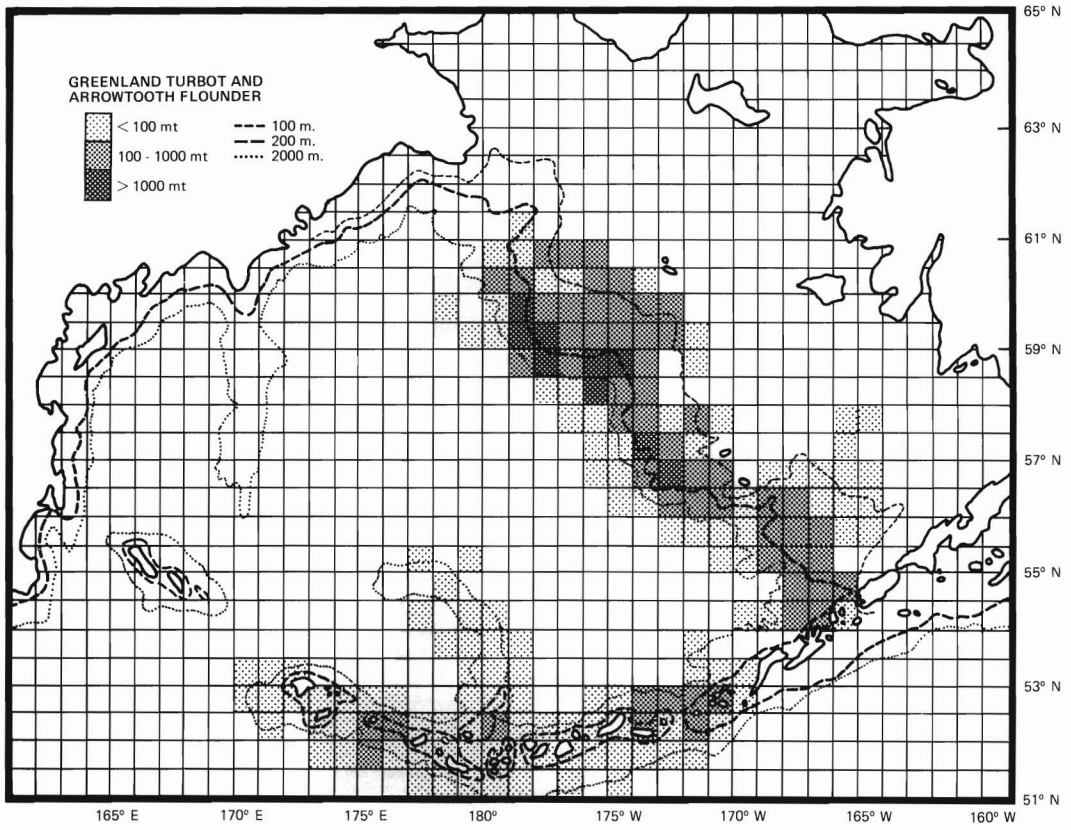


Figure 24.—Distribution of Japanese catches of Greenland turbot and arrowtooth flounder in 1977.



of the total catch came from northwest of the Pribilof Islands.

Pacific Halibut

The Pacific halibut is a wide ranging species extending from off southern California to Norton Sound in the northern Bering Sea, across the Bering Sea, and along the Asian coast from the Gulf of Anadyr to Hokkaido Island in Japan (International Pacific Halibut Commission, 1978). Pacific halibut have been taken in depths of 1,100 m but are mainly found from 27 to 275 m. They are the largest of all flounders and range in size in the fishery from 2 to over 90 kg (5 to over 200 pounds) with the average size ranging from 14 to 16 kg (from 31 to 35 pounds). Halibut fishing areas in the eastern Bering Sea are shown in Figure 4.

Pacific halibut has been one of the two demersal species (the other being Pacific cod) sought by North American fishermen in the eastern Bering Sea. Combined catches of halibut by North American and foreign fisheries peaked in 1962 and 1963 at about 12,000 t annually. Abundance of halibut subsequently declined, perhaps aggravated by the incidental catch of juvenile halibut in foreign trawl fisheries. The current abundance of adult halibut is low and only small catches are presently allowed (225 t in 1979) so that the stock can rebuild.

Area closures have also been implemented in the southeastern Bering Sea in winter to reduce the incidental catch of juvenile halibut by foreign trawl fisheries. These measures appear to be responsible for the increase in abundance of juvenile halibut that has been noted in recent years. It will be some time, however, before these juveniles will be recruited to the adult stock and available to the fishery.

Other Flounders

The remaining flounders in the Bering Sea have been combined into a single group for management purposes. Two of these species, rock sole and flathead sole, make up most of the foreign catches of this group. Of the other species in this category, Alaska plaice may be nearly as abundant as rock sole and flathead sole in the Bering Sea but has not been utilized extensively by foreign fisheries while other species such as rex sole, Dover sole, starry flounder, longhead dab, and butter sole are only found in low abundance in the Bering Sea. The three major species of this group are relatively shallow water species with main concentrations confined to depths less than 200 m.

These species are rarely targeted on because of their comparatively low abundance and are mainly taken incidentally in the pollock and yellowfin sole fisheries. Catches as large as 92,000 t have been harvested but have declined to around 20,000 t annually in the last few years. The main reason for the decline is thought to be the reduced effort for major target species, particularly yellowfin sole. The "other flounder" complex is thought to be healthy and can provide catches of 61,000 t per year. Rock sole and flathead sole are relatively small flounders with similar size compositions in the commercial fishery (Fig. 22). In 1976, 84 percent of the rock sole and 78 percent of the flathead sole taken in the Japanese fishery ranged from 25 to 35 cm (about 10 to 14 inches).

Table 7.—Proposed allowable catches in 1979 for species of groundfish and squid in the eastern Bering Sea and Aleutian Islands regions (North Pacific Fishery Management Council, 1978[1]).

Species	Management area	Allowable catch (metric tons)
Walleye pollock	E. Bering Sea	1,000,000
Pacific cod	E. Bering Sea	58,700
Pacific ocean perch, other rockfishes	E. Bering Sea, Aleutians	6,500 15,000
Sablefish	E. Bering Sea, Aleutians	3,500 1,500
Atka mackerel	Aleutians	24,800
Yellowfin sole	E. Bering Sea	117,000
Greenland turbot, arrowtooth flounder	E. Bering Sea	90,000
Pacific halibut	E. Bering Sea	225
Other flounders	E. Bering Sea	61,000
Squid	E. Bering Sea	10,000
Other species	E. Bering Sea	55,500
Total		1,443,725

[1]North Pacific Fishery Management Council. 1978. Fishery management plan and draft environmental impact statement for the groundfish fishery in the Bering Sea-Aleutian Island area, Vol. 1. Unpubl. manuscr., 224 + 69 p. North Pac. Fish. Manage. Counc., Suite 32, 333 W. 4th Ave., Anchorage, AK 99510.

Catches of "other flounders" by Japan in 1977 occurred mainly between the 100 and 200 m isobaths from Unimak Island to lat. 60°N (Fig. 25). This species group was also taken in fairly high abundance at depths less than 100 m off Bristol Bay. Catches northwest of the Pribilof Islands were almost all rock sole and flathead sole while catches southeast of the Pribilof Islands and off Bristol Bay also included Alaska plaice.

Total Allowable Catches in 1979

Allowable catches of the various groundfish resources in 1979 as given in the fishery management plan for groundfish of the eastern Bering Sea-Aleutian Islands regions (North Pacific Fishery Management Council, 1978[12]), are summarized in Table 7. Two species categories not previously discussed (squid and other species) are listed in the table. Although not a demersal species, squid has been included in the management plan because it has been targeted on by the Japanese groundfish fishery. Little is known about the Bering Sea squid resource, but it may be large. Catches have reached 10,000 t per year in recent years and allowable catches have been set at that level until more is known about the resource.

The "other species" category consists of miscellaneous incidentally caught species such as sculpins, poachers (family Agonidae), eelpouts (family Zoarcidae), skates (family Rajidae), rattails, and numerous other species that occur in the Bering Sea. During the past 5 years of record, these species have composed about 4 percent of the total weight of the catch of species or species groups (designated by name in Table 7) in the eastern Ber-

[12]North Pacific Fishery Management Council 1978. Fishery management plan and draft environmental impact statement for the groundfish fishery in the Bering Sea/Aleutian Island area, Vol. 1. Unpubl. manuscr., 224 + 69 p. North Pac. Fish Manage. Counc., Suite 32, 333 W. 4th Ave.. Anchorage, AK 99510.

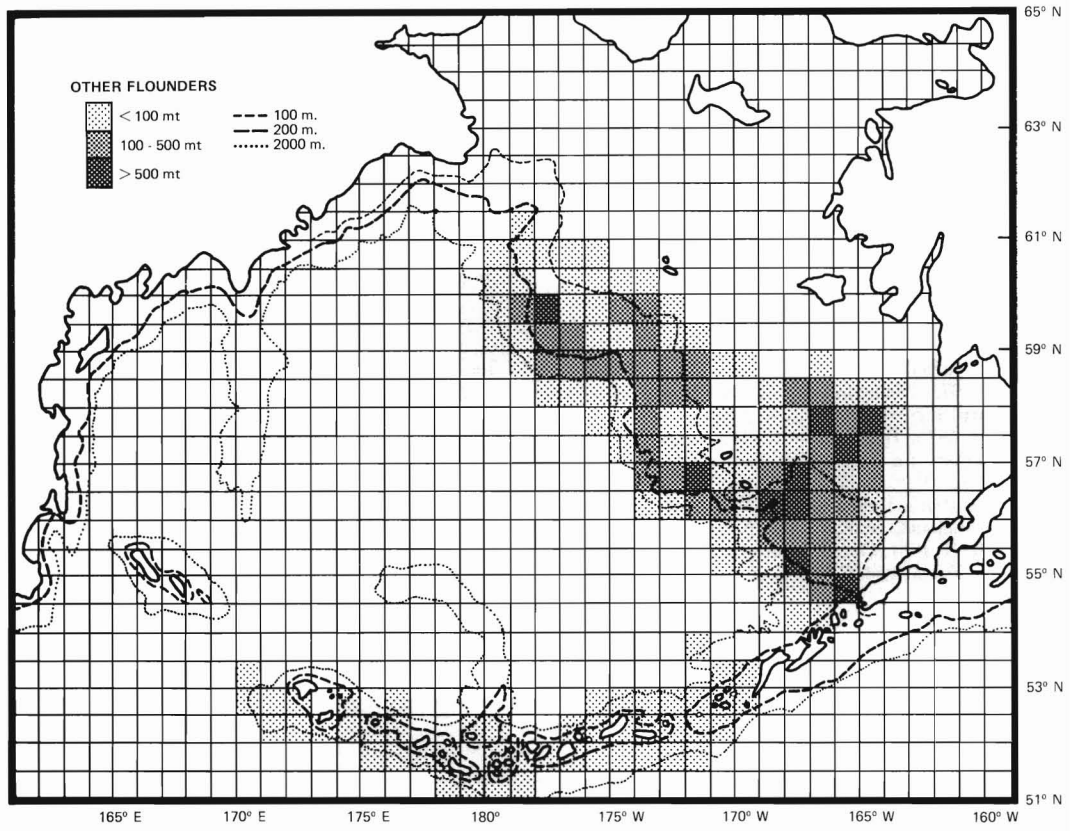


Figure 25.—Distribution of Japanese catches of "other flounders" in 1977.

ing Sea-Aleutian Islands regions. The allowable catch of "other species" was derived by applying the 4 percent figure to the total allowable catch of all designated species in 1979.

The combined allowable catch of all demersal species in the eastern Bering Sea and Aleutian Islands regions is slightly over 1.4 million t (Table 7). This catch will be divided among the various user nations, with the needs of the U.S. fishing industry met first and the remainder apportioned among the foreign fishing nations according to the magnitude of their past catches. In 1979 the domestic allocation is 24,600 t (excluding Pacific halibut) and the foreign allocation 1,346,475 t. An additional 72,425 t has been set aside as a reserve to satisfy any unexpected needs of the domestic fishery. If the reserve is not utilized by the domestic fishery, it will be allocated to foreign fisheries during the year.

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slope) and some aspects of the geomorphology of the Bering Sea [In Russ.] Tr. Vses. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 48 (Izv. Tikhookean. Nauchno-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 50). (Transl. by Isr. Prog. Sci. Transl., 1968. *In* P. A. Moiseev (editor), Soviet fisheries investigations in the northeastern Pacific Part 1, p. 9-78. Avail. Natl. Tech. Inf. Serv., Springfield, Va., as TT 67-51203.)

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