COMMERCIALLY-IMPORTANT FISH AND INVERTEBRATES

More is known about finfish than most other species groups because of their generally larger size, and because they are subject to intense commercial fishing. Statistics on fish catches are reported regularly to the Fisheries and Agriculture Organisation (FAO) of the United Nations. These statistics indicate that the number of taxonomic families and species of fish in the North Pacific are similar to those in other non-tropical waters. i.e. 690 finfish species in the NE Pacific and 4,760 in the NW Pacific including the South China Sea (Figure 1). These species represent 138 finfish families in the NE Pacific, and 326 families in the NW Pacific (Figure 2).

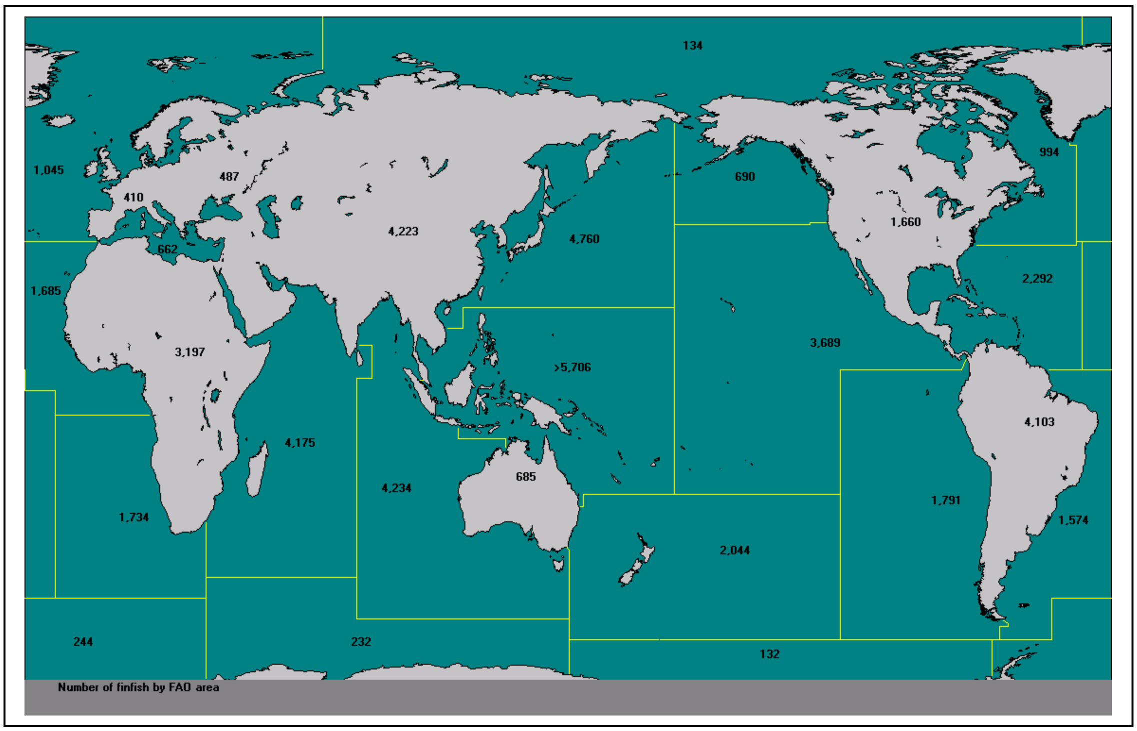


FIGURE 1 NUMBER OF FINFISH SPECIES CAUGHT IN FAO REPORTING REGIONS AROUND THE WORLD.

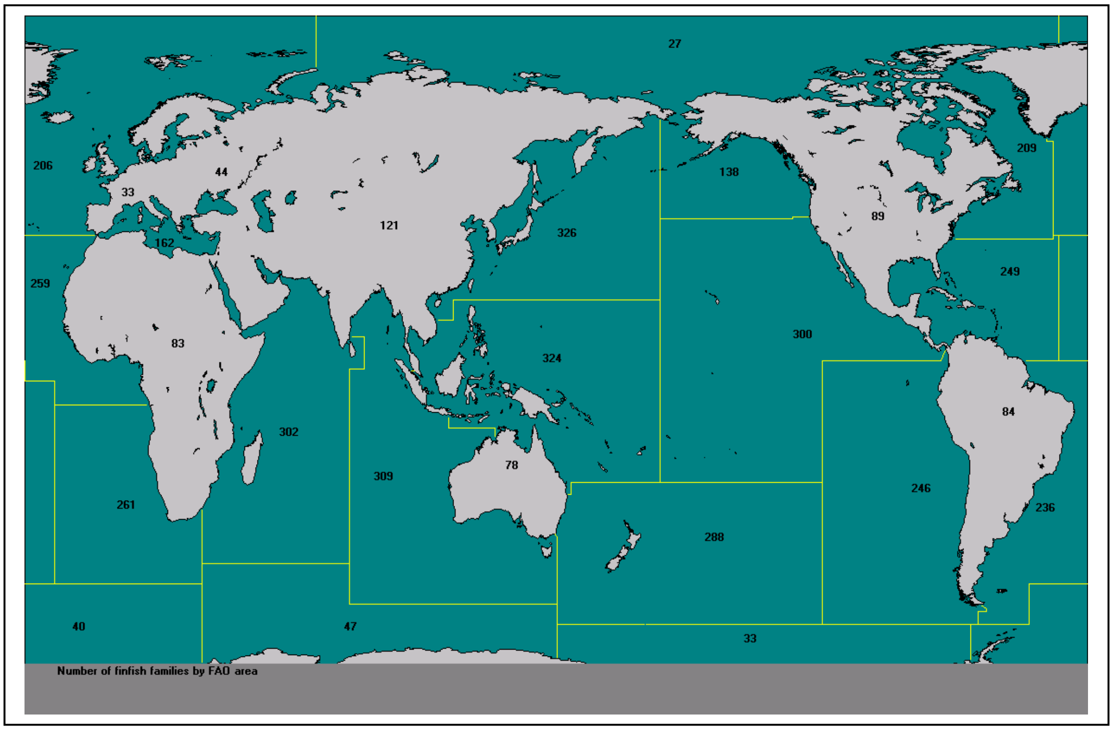


FIGURE 2 NUMBER OF FINFISH FAMILIES CAUGHT IN FAO REPORTING REGIONS AROUND THE WORLD.

Sixty-two large marine ecosystems (LME's) have been defined around the world. They are relatively large (>200,000 km^2) regions characterized by distinct bathymetry, hydrography, productivity, and interacting marine animal populations (http://www.edc.uri.edu/lme). The area, number of finfish species, surface and 100 m temperatures, and primary productivity for each of these LME's have been calculated by the Fisheries Centre of the University of British Columbia (http://saup.fisheries.ubc.ca/lme/lme.asp). These data indicate that a significant relationship exists between the area (in km^2) of each LME and the number of non-tropical reef finfish species that occur in each LME (non-tropical reef finfish were excluded because of their very high species numbers, and because the North Pacific – the subject of this report – contains few tropical reef systems). This relationship is

$$S = 1.4\ A^{0.40}$$

in which S is the number of finfish species and A is the area in km^2, although the explanatory power of this relationship is small ($r^2=0.11$, $P=0.009$). The explanatory power of this relationship can be increased considerably if temperature is included as a co-variate:

$$S = 1.74\ A^{0.20}\ (T_{sfc}+1)^{0.94}$$

in which S is the number of finfish species, A is the area (km^2), and T_{sfc} is the mean annual surface temperature ($r^2=0.66$, $P<<0.001$) . Since the constant (1.74) is not significantly different than 0 (parameter estimate is 1.74 ± 4), and the temperature exponent (0.94) is close to 1, this equation approximates to

$$S \approx A^{0.2} * T_{sfc}\ ,$$

i.e., the number of species is a function of area to the 0.2 power, all scaled by temperature. This means that warmer waters contain more species than colder waters for the same area (excluding tropical reef species – including these would increase the number of species in warm waters even more). This exponent is similar to other marine finfish studies of area and species numbers in temperate waters, which estimate an exponent for area of 0.175 (Frank and Shackell. 2001. Canadian Journal of Fisheries and Aquatic Sciences 58:1703-1707). The eleven Large Marine Ecosystems in the North Pacific all fit randomly within the range of variability around these relationships; they do not occur preferentially above or below these expected relationships. This means that the number of finfish species in the LME`s of the North Pacific are what should be expected based on global relationships between species number and area. However, the number of species in these North Pacific LME`s can be predicted with better accuracy if other parameters are included:

$$S = 690\ A^{0.4}\ T_{sfc}^{0.59}\ PP^{-0.69}\ Z^{-0.45}$$

in which S is the number of finfish species, A the area (km^2), T_{sfc} the mean annual surface temperature, PP the estimated mean annual primary production (mgC m^{-2} d^{-1}), and Z is the variability of bottom depth within the area concerned (the standard deviation of bottom depth). This relationship has high predictability (r^2=0.98, P<<0.001); the number of finfish species that can be expected to occur in other areas of the North Pacific can be estimated from this relationship.

Commercially important crabs, shrimps and lobsters that occur in the North Pacific are listed in Table 1. Precise information on their abundances is not available, in large part because the methods for managing these fisheries do not require abundance estimates. Estimates of their status are shown in Table 2.

TABLE 1

Table 1.

A taxonomic list of species of crabs, shrimps, and lobsters exploited in the PICES Region (major taxon according to American Fisheries Society Special Publication 17, common names per AFS or UN/FAO, if possible). Question marks (?) indicate either uncertainty as to range, importance or general interest, or the need for further definition. Almost all species below have known commercial, recreational or subsistence fisheries that exploit them. * = important species considered by WG12

Phylum, Subphylum, or Superclass: Crustacea

CRABS *et al*:

Class: Malacostraca
Subclass: Eumalacostraca
Order: Decapoda
Suborder: Pleocymata
Infraorder: Brachyura

Table 1.	
Section: Oxyrhyncha	
Superfamily: Majoidea	
Family: Majidae	
(Spider crabs)	
Tanner crab	*Chionoecetes bairdi* *
Snow crab	*C. opilio* *
Angled Tanner crab	*C. angulatus* *
Grooved Tanner crab	*C. tanneri* *
Benizuwai Tanner (Red Snow) crab	*C. japonicus* *
Arctic Lyre crab	*Hyas coarctatus*
Pacific Lyre crab	*H. lyratus*
Sheep crab	*Loxorhynchus grandis*
Section: Cancridea	
Superfamily: Cancroidea	
Family: Atelecyclidae	
(Horse crabs)	
Hair crab	*Erimacrus isenbeckii* *
Helmut crab	*Telmessus cheiragonus*
Family: Cancridae	
(Rock crabs)	
Dungeness crab	*Cancer magister* *
Red Rock crab	*C. productus*
Yellow Rock crab	*C. anthonyii*
Section: Brachyrhyncha	
Superfamily: Portunoidea	
Family: Portunidae	
(Swimming crabs)	
Sand crab	*Portunus pelagicus*
Gazami crab	*P. trituberculatus* *
Mud crab	*Scylla serrata*
Infraorder: Anomura	
Superfamily: Paguroidea	
Family: Lithodidae	
(Stone and King crabs)	
Red King crab	*Paralithodes camtschaticus* *
Blue King crab	*P. platypus* *
Hanasaki King crab	*P. brevipes* *
Golden King crab	*Lithodes aequispinus* *
Scarlet King crab	*L. couesi* *

Table 1.	
Paralomis spp	*Paralomis multispinus*
Paralomis spp	*Paralomis verrilli*
Puget Sound King crab	*Lopholithodes mandtii*
SHRIMPS	
Class: Malacostraca	
Subclass: Eumalacostraca	
Order: Decapoda	
Suborder: Dendrobranchiata	
Superfamily: Penaeoidea (Penaeoid shrimps)	
Family: Penaeidae	
Kuruma shrimp/prawn	*Marsupenaeus japonicus* *
Fleshy prawn	*Fenneropenaeus chinensis* (=*orientalis*)
Shiba shrimp	*Metapenaeus joyneri* *
Yoshi shrimp	*M. ensis* *
Cocktail shrimp	*Trachysalambria curvirostris*
Superfamily: Sergestoidea	
Family: Sergestidae	
Akiami paste shrimp	*Acetes chinensis* *, *A. japonicus* *
Suborder: Pleocyemata	
Infraorder: Caridea	
Superfamily: Pandaloidea (Pandalid shrimps)	
Family: Pandalidae	
Sidestriped shrimp	*Pandalopsis dispar* *
Morotoge shrimp	*P. japonica* *
Northern shrimp	*Pandalus borealis/eos* *
Humpy shrimp	*P. goniurus* *
Dock shrimp	*P. danae*
Coonstriped shrimp	*P. hypsinotus* *
Ocean shrimp	*P. jordani* *
Spot shrimp	*P. platyceros* *
Hokkai shrimp	*P. latirostris* *
Superfamily: Crangonoidea	
Family: Crangonidae	
Northern sculptured shrimp	*Sclerocrangon boreas* *
Uneven sculptured shrimp	*S. salebrosa* *
San Francisco Bay shrimp	*Crangon franciscorum*
Arctic argid shrimp	*Argis dentata*
Kuro shrimp	*A. lar*

Table 1.

SPINY LOBSTERS

Class: Malacostraca
Subclass: Eumalacostraca
Order: Decapoda

Suborder: Pleocyemata
Superfamily: Palinuroidea
(Palinurid lobsters)
Family: Palinuridae

California spiny lobster	*Panulirus interruptus*
Japanese spiny lobster	*P. japonicus* *

MANTIS SHRIMPS

Class: Malacostraca
Subclass: Hoplocarida
Order: Stomatopoda
Suborder: Unipeltata
Superfamily: Squilloidea
Family: Squillidae

Chinese mantis shrimp	*Oratosquilla oratoria**

TABLE 2

Important PICES Region crab, shrimp, and lobster stocks classified as to stock size, abundance trends, type and degree of fishery development. Current stock abundance is intraspecific relative to its historical level: small (s), medium (m) and large (l). Long-term trends are periodically fluctuating (P), decreasing (D) and increasing (I). Fishery types are characterized as commercial (C), recreational (R) and subsistence (S). Fishery status is characterized as undeveloped (U), developing (D), fully developed (F) or closed to commercial fishing(*).

	Abundance		Long-term		
	Historical	Current	Trend	Type	Status
Crab *et al*:					
Tanner crab (*C. bairdi*)					
SE Alaska	s	s	D	C,R,S	F
Cook Inlet	m	s	D	C,R,S	F
Kodiak	l	s	D	C,R,S	F
S Al. Peninsula	l	s	D	C,R,S	F
E Aleutians	s	s	D	C,R,S	F
W Aleutians	s	s	D	C,S	U
E Bering Sea	l	m	D	C	F
NW Bering Sea	s	s	D	C	F
Koryak Coast	m	?	?	C	F
Olyutorskiy Bay	l	?	?	C	F
W Kamchatka	m/l	?	?	C	F
Angled Tanner crab (*C. angulatus*)					
Canada	?	?	?	C	U
Gulf of Alaska	?	?	?	C	U
Aleutian Islands	?	?	?	C	U
E Bering Sea	?	?	?	C	U
N Sea of Okhotsk	m	?	?	L	U
Grooved Tanner crab (*C. tanneri*)					
Calif.-Washington	?	?	?	C	U
Canada	?	?	?	C	U
Gulf of Alaska	?	?	?	C	U
Aleutian Islands	?	?	?	C	U
E Bering Sea	?	?	?	C	U
W Bering Sea	s	?	?	L	U
Snow crab (*C. opilio*)					
E Bering Sea	l	l	P	C	F
W Bering Sea	l/m	l/m	?	C	F
Koryak Coast	m	?	?	C	F
Olyutorskiy Bay	s	?	?	C	F
E Kamchatka	s	?	?	C	F?
W Kamchatka	m	?	?	C	D
N Sea of Okhotsk	l	m	P	C	F
E Sakhalin Is.	l	m/l	D	C	F
W Sakhalin Is.	s	?	?	C	F
Japan/East Sea	l	m	D	C	F
Benizuwai Tanner crab (*C. japonicus*)					
E Japan/East Sea	l?	m?	?	C	F?
W Japan/East Sea	l	l	?	C	D

Yellow Sea / East China Sea

A total of 276 species of fish have been identified on the Korean side of the Yellow Sea, and approximately 100 species have been utilized as resources. Over 90 % of these species are warm water or warm-temperate water species. Currently, about 30 species are commercially targeted. Many important commercial fish species (i.e., small yellow croaker, largehead hairtail, chub mackerel, and anchovy) show the typical migration pattern: spawning in coastal areas during the spring, and overwintering in the southern Yellow Sea and the northern East China Sea during winter.

Based on scientific bottom surveys, 149 and 177 species of fish were collected from Chinese waters in autumn 2000 and spring 2001, respectively.[1] The biomass of pelagic species in autumn was higher than that of demersal fish, whereas it was the reverse in spring. From bottom trawl surveys in Korean waters, 134 demersal species were collected in summer 1967, while only 51 species were sampled in 1980/81 survey, revealing a 62 % reduction in the number of species. In addition, there was an obvious distribution shift by the major species. Among the top 15 abundant species in the 1980/81 survey, 8 species were not found in the list of 20 abundant species in the 1967 survey (Table 3).[2]

TABLE 3 ABUNDANCE CHANGES IN DEMERSAL SPECIES IN KOREAN WATERS BETWEEN THE 1960S AND THE 1980S BASED ON BOTTOM TRAWL SURVEYS.

1967			**1980/81**	
Rank	Fish species	**(%)**	Fish species	(%)
1	*Raja kenojei*	11.8	*Navodon modestus*	23.3
2	*Areliscus trigrammus*	9.4	*Trichiurus leptulus*	15.7
3	*Tanakius kitaharae*	7.2	*Raja kenojei*	14.0
4	*Eopsetta grigorjewi*	5.4	*Zeus japonicus*	6.6
5	*Lophiomus setigerus*	5.3	*Zoarces gillii*	3.9
6	*Helicolenus hilgendorfi*	5.3	*Doderleinia berycoides*	3.8
7	*Collichys niveatus*	5.2	*Pampus argenteus*	2.7
8	*Liparis tanakai*	4.3	*Eopsetta grigorjewi*	2.1
9	*Platyrhina sinensis*	3.9	*Heterodontus japonicus*	1.9
10	*Branchiostegus japonicus*	3.8	*Lophiomus setigerus*	1.5
11	*Lepidotrigla microptera*	3.2	*Liparis tanakai*	1.4
12	*Raja porosa*	2.7	*Chrysophrys major*	1.1
13	*Pampus argenteus*	2.4	*Branchiostegus japonicus*	1.0
14	*Pseudosciaena polyacits*	2.2	*Sebastes inermis*	1.0
15	*Scyliorushinus torazame*	1.9	*Collichthys fragilis*	1.0
16	*Taius tumifrons*	1.9		
17	*Fugu pardalis*	1.8		
18	*Trichiurus leptulus*	1.7		
19	*Fugu niphobles*	1.6		
20	*Pseudohombus cinnamoneus*	1.5		

Japanese anchovy is widely distributed in the northwestern Pacific Ocean, and is the most abundant pelagic species in the Yellow and East China seas. Research surveys during the winters of 1986-1995 indicated that anchovy biomass fluctuated from 2.5 to 4.3 million t in the Yellow and East China seas. However, recent overexploitation seems to have depleted anchovy stocks in the Yellow Sea. Changes in the pelagic community are also obvious. In 1959, demersal fish species were dominant in Chinese waters. However, they have mostly been replaced by small pelagic fish and invertebrates over the past two to three decades.

Major fisheries in these areas are large trawls, large pair trawls, large purse seines and offshore stow nets. Major target species of this fishery are hairtail, filefish and common squid. Both catch and CPUE of the large trawl fishery increased continuously from the mid-1970s with the sudden increase in the catch of filefish. The catch showed a peak in 1990 at 170 thousand t, but thereafter decreased with the decreased catch of filefish in the early 1990s. However, the catch started increasing from 1995 with the increase in the catch of common squid (Figure 3). Major target species of the large pair trawl fishery are hairtail, small yellow croaker, corvenia and blue crab. Annual catches were pretty stable at about 110 thousand t in recent years.

Major species of the large purse seine fishery are chub mackerel, horse mackerel and sardine. Annual catch of the fishery showed some fluctuations ranging from 70 thousand t in 1975 to 460 thousand t in 1986, while annual CPUE was fairly constant, compared to catches. After 1986 catches started declining with the decrease in the catches of sardine and filefish. Catches increased again with the rising of chub mackerel catch in the late 1990s (Figure 3).

Major target species of the offshore stow net fishery are hairtail, small yellow croaker, corvenia, pomfret and blue crab. Annual catches of the fishery declined after 1987, and the catch was about 120 thousand t in 1997.

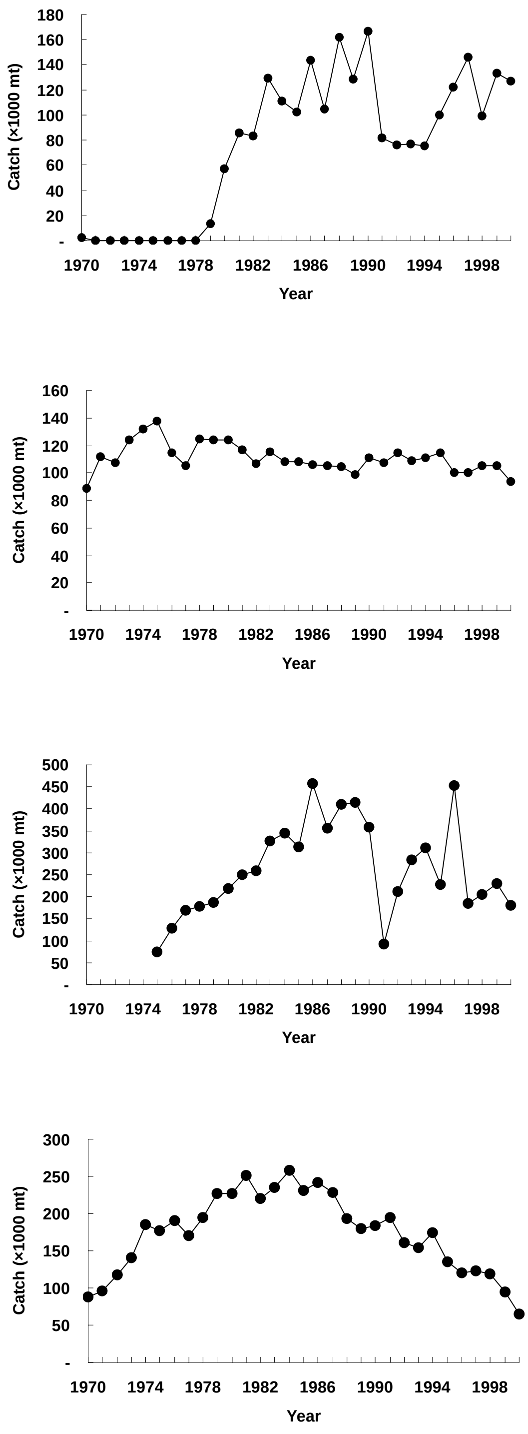


FIGURE 3 YIELD OF MAJOR FISHERIES IN THE YELLOW SEA AND THE EAST CHINA SEA: LARGE TRAWL FISHERY (TOP), LARGE PAIR TRAWL FISHERY (UPPER MIDDLE), LARGE PURSE SEINE FISHERY (LOWER MIDDLE) AND STOW NET FISHERY (BOTTOM).

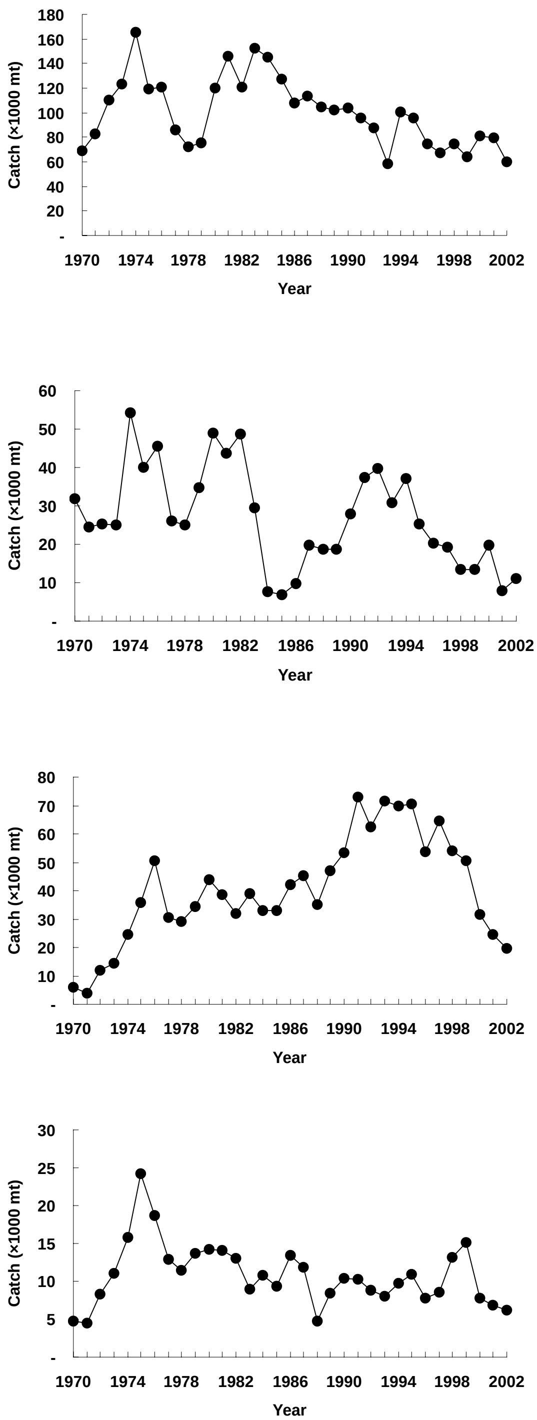


FIGURE 4 YIELD OF MAJOR DEMERSAL SPECIES IN THE YELLOW SEA AND THE EAST CHINA SEA: HAIRTAIL (TOP), SMALL YELLOW CROAKER (UPPER MIDDLE), CORVENIA (LOWER MIDDLE) AND POMFRET (BOTTOM).

Annual catches of small yellow croaker have fluctuated widely (Figure 4). In the early 1970s, the annual catch of small yellow croaker was about 30 thousand t, but it decreased below 10 thousand t after the mid-1980s. Recent catches were about 15 thousand t. The annual CPUE was higher in the 1970s, but lower after the 1980s. Annual catch of hairtail was relatively high, over 150 thousand t, from the mid-1970s to the mid-1980s. The decreasing trend was apparent in the late 1980s. However, the annual CPUE showed a high level in the mid-1970s, and declined continuously until recent years. Corvenia and pomfret catches showed similar patterns.

Yields of some major pelagic species (anchovy, chub mackerel, and horse mackerel) are shown in Figure 5. Annual catches of anchovy started increasing from 1970 and they remained around 150-200 thousand t from 1975 to 1993.

The catch increased to about 240 thousand t in recent years. However, CPUE was remarkably low after showing a peak in 1975. Annual catches of chub mackerel showed an increasing trend in recent years.

The trend of annual CPUE was similar to that of catch. Filefish catches increased from 1975 and recorded a higher level in the mid-1985. But the catch has decreased rapidly since the early 1990s. Annual catches and CPUE of horse mackerel reached their highest levels in 1988, and then declined markedly. In the early 1990s, they increased again until 1994, and then declined again.

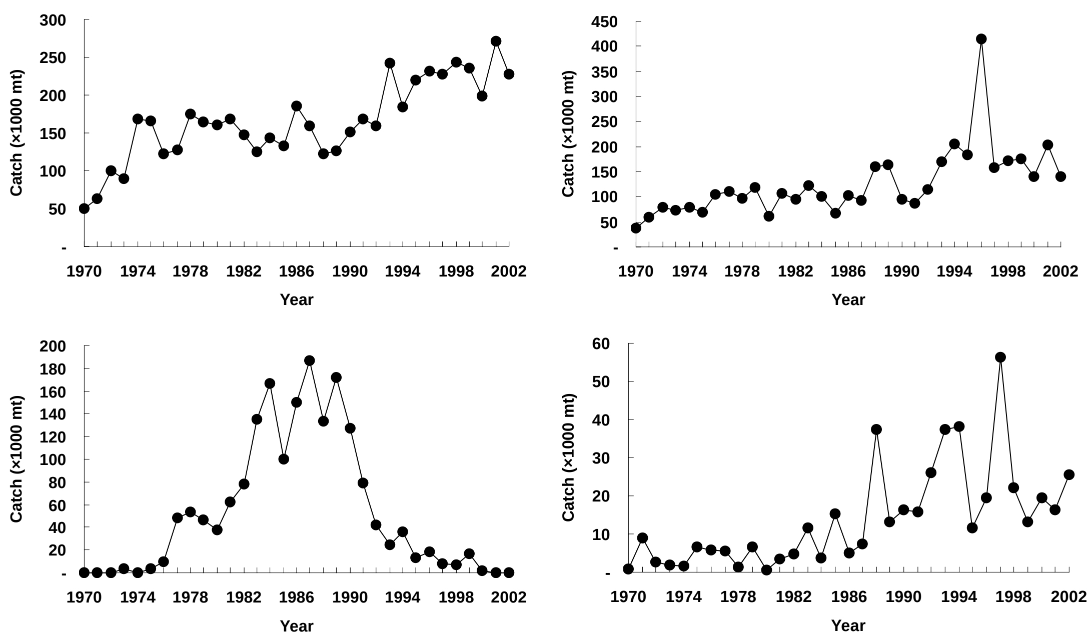


FIGURE 5 YIELD OF MAJOR PELAGIC SPECIES IN THE YELLOW SEA AND THE EAST CHINA SEA: ANCHOVY (UPPER LEFT), CHUB MACKEREL (UPPER RIGHT), PACIFIC SARDINE (LOWER LEFT) AND HORSE MACKEREL (LOWER RIGHT).

Demersal fish were more important fisheries resources in the Yellow Sea, but pelagic fish were dominant in the East China Sea. The seven major target species in the Yellow Sea during the last 40 years were as follows: (1) hairtail, (2) corvenia, (3) anchovy, (4) small yellow croaker, (5) blenny, (6) pomfret, and (7) flounder. The species composition in the catch of small pelagics has changed remarkably during the period of the 1960s to the 1990s. Hairtail were most dominant, followed by small yellow croaker in the 1960s and the 1970s. Thereafter, the catch of small yellow croaker decreased with an increase in corvenia, flounder and anchovy in the 1980s and the 1990s (Figure 6).

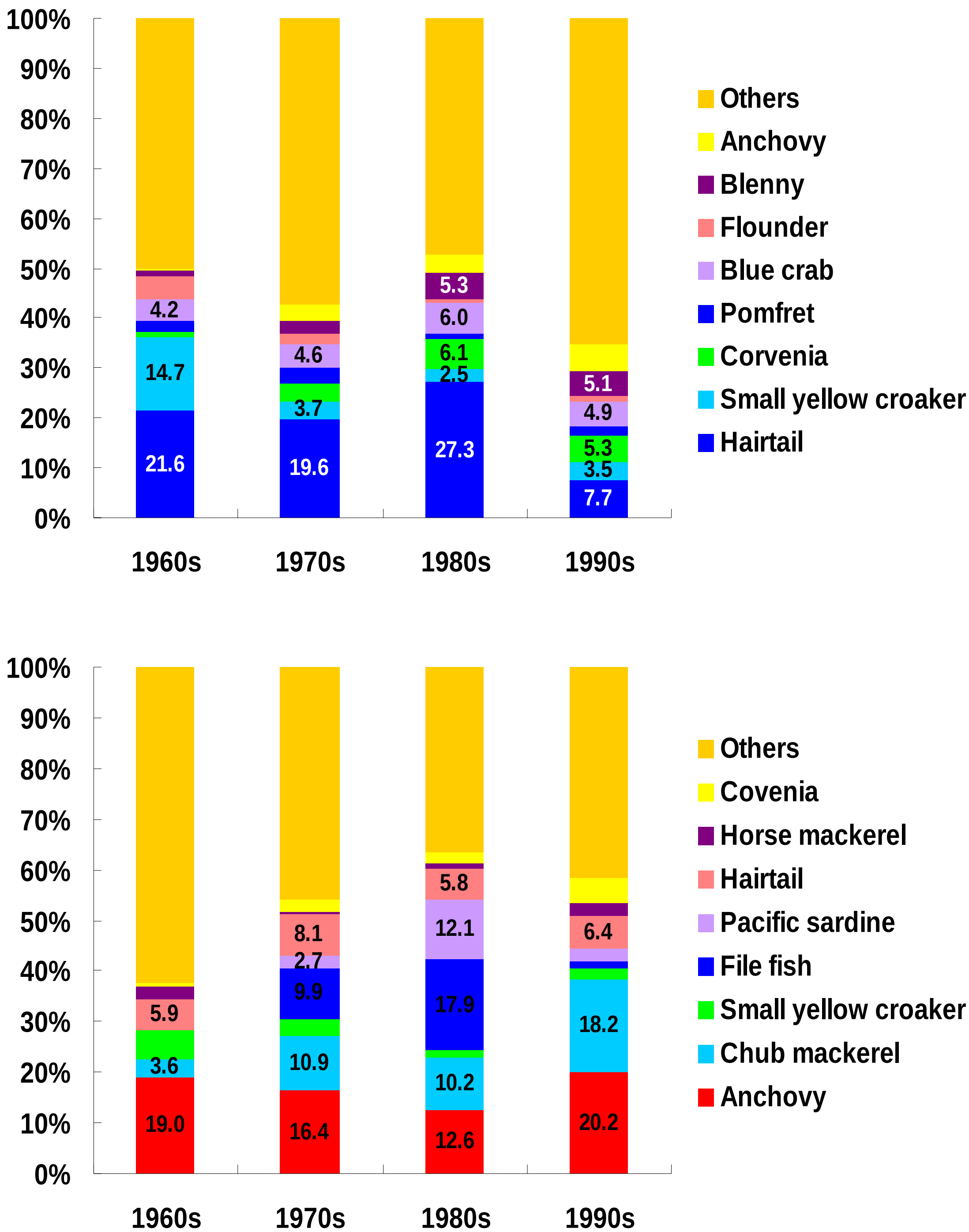


Figure 6 Catch percentages by species (1961-2000) in the Yellow Sea (Upper) and East China Sea (Lower).

The seven major target species in the East China Sea during the last 40 years were as follows: (1) anchovy, (2) chub mackerel, (3) filefish, (4) hairtail, (5) Pacific sardine, (6) corvenia, and (7) common squid. Anchovy, hairtail and small yellow croaker dominated in the 1960s, but the catch of small yellow croaker almost disappeared in the composition after the 1960s. The relative compositions of chub mackerel, filefish and Pacific sardine increased in the 1970s and the 1980s. In the 1990s, filefish and Pacific sardine disappeared and anchovy, chub mackerel, and common squid dominated in the composition (Figure 6).

The trophic levels of resource organisms in the catches from the two seas showed significant decreasing trends from 1967 to 2000 (Figure 7). Mean trophic levels were 3.43 and 3.46 in the Yellow Sea and the East China Sea, respectively. The decline was steeper in the Yellow Sea than in the East China Sea. This result showed that demersal fish such as small yellow croaker, which were at higher trophic levels, gradually decreased, while small pelagics such as anchovy, common squid and blenny, which were at relatively lower trophic levels, increased during the four decades.

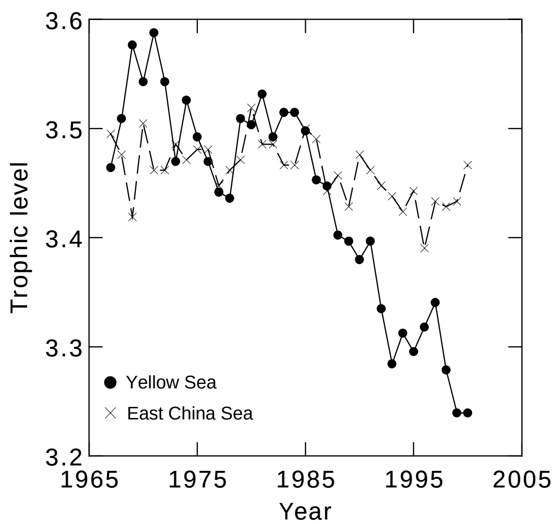


FIGURE 7 TROPHIC LEVEL OF RESOURCE ORGANISMS IN THE CATCHES OF THE YELLOW SEA AND THE EAST CHINA SEA.

Sea of Okhotsk

Fisheries in the Okhotsk Sea account for 50% of total Russian harvests in the Pacific Ocean. From 1999-2001, walleye pollock accounted for 74% of the biomass, despite declines through the late 1990s which took walleye Pollock harvests in 2000 to their lowest level in the 20 year record (Figure 8). Various flatfishes, mostly yellowfin sole (11.5%), Pacific cod (4.7%) and saffron cod (4%) are important but account for far less of the total biomass removed. Some species make seasonal use of the Okhotsk Sea. During the 1980s, biomass estimates for Japanese sardine exceeded 1 million t. The dramatic decline of this species throughout the northwestern Pacific was also observed in the Okhotsk Sea and after 1993, no sardines were caught. Summer migrants from the south are now dominated by anchovy and arabesque greenling.[3] Their abundance appears to depend on the warmth of the southern Okhotsk Sea and the magnitude of the Soya Current.

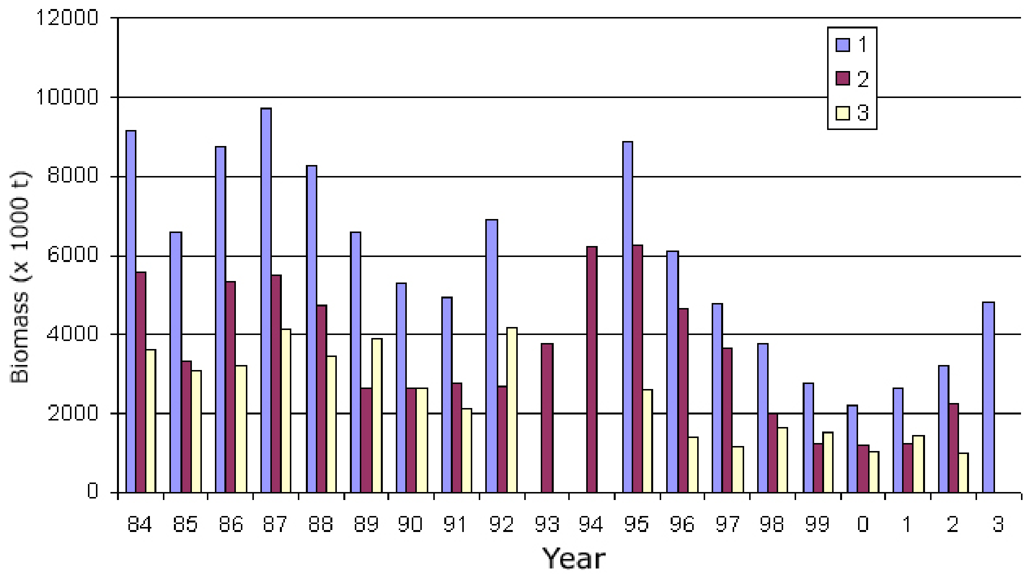


FIGURE 8 ESTIMATES OF WALLEYE POLLOCK SPAWNING STOCK BIOMASS IN THE OKHOTSK SEA FROM 1984-2003, DETERMINED FROM ICHTHYOPLANKTON SURVEYS IN (1) ENTIRE NORTHERN OKHOTSK SEA, (2) WESTERN KAMCHATKA, AND (3) NORTHWESTERN OKHOTSK SEA.

The total groundfish biomass was estimated as 3.5 million t in the Okhotsk Sea shelf in the 1980s and the average concentration was 5.4 t km^{-2}. Among them 50 % are flatfish, 21 % cods, and 11 % sculpins. These three groups of groundfish play the main role in the fish productivity of the Okhotsk Sea shelf. The relative share of other species is not so large, though the biomass of families as Liparidae, Zoarcidae, Rajidae can be high. The main groundfish resources are concentrated in the northeastern part of the Okhotsk Sea. The West Kamchatska shelf is the most important region in terms of fish productivity, where the catch of the fish was equal to 21.4 - 21.7 t km^{-2} during the late 1970s, with a high quantity of cods, flatfish and crabs. In the 1980s, catches of yellow-finned sole (*Limanda aspera*) and Pacific cod (*Gadus macrocephalus*) were predominant in this region. (Table 4)

Table 4 Dynamics of groundfish biomass (,000 t) West Kamchatka shelf 1996-2002

Groups	1996	1997	1998	1999	2000	2001	2002
Gadidae (except pollock)	213.6	199.5	153.2	107.1	63.4	53.3	67.9
Pleuronectidae	822.9	1076.3	554.1	368.3	383.2	531.3	405.3
Cottidae	111.5	114.5	105.4	101.8	121.2	179.0	182.1
Agonidae	8.7	19.0	18.1	15.7	36.6	35.6	29.2
Liparidae	7.3	5.2	3.9	3.0	4.3	17.3	64.7
Rajidae	3.9	9.2	5.6	7.2	8.7	9.0	5.7
Zoarcidae	1.3	3.0	2.8	4.4	3.4	4.8	11.5
Other fishes	5.2	10.3	6.2	16.1	24.2	54.4	109.3
Total	1174.4	1437.0	849.3	623.6	645.0	884.7	875.7

The average macrozoobenthos biomass is 384 g m^{-2} in the Okhotsk Sea (shelf). The average biomass of the second trophic level (Rhizopoda, Spongia, Hydroidea, Priapuloidea, Echiuroidea, Sipunculoidea, Bryozoa, Bivalvia, Cirripedia, Ophiuroidea, Echiuroidea, Holoturoidea, Ascidia, 90% of Amphipoda and Gastropoda biomass and 70% of Polychaeta biomass) is equal to 352 g m^{-2} in the shelf of the Okhotsk Sea. The highest concentration of this level (up to 491-535 g m^{-2}) is found in the Shelihov Bay. There are some regions where predatory species concentration is above the average one. In the West Kamchatka shelf and in the Terpenie Bay the predatory species constitute 10-15%, while in the other regions their quantity is at the most 6.6 - 10 %.

The average biomass of the third trophic level (Asteroidea, Nemertini, Decapoda, Anthozoa, 10% Gastropod and Amphipod biomass and 30% Polychaeta biomass) is almost 10 times less than the biomass of the second level at 32 g m^{-2} or 8.3 % of the total benthos biomass. The average production of the second trophic level is 534 g m^{-2}. The total production of this community is estimated to be 466 g m^{-2}. An analysis of biological production rates showed that the P/B coefficient of the second trophic level varies from 1.18 to 1.164 and 1.02-1.31 at the third level.

Kuroshio / Oyashio

Japanese fishers have been harvesting various marine organisms in the Kuroshio and its adjacent regions for a very long time. Among them, Japanese sardine (*Sardinops melanostictus*), Japanese anchovy (*Engraulis japonicus*), chub mackerel (*Scomber japonicus*) and Japanese common squid (*Todarodes pacificus*) have constituted the major fraction of commercial landings since the early 20th century but the landings are vary considerably (Figure 9).[4,5] These species undergo seasonal north-south migrations between spawning grounds during autumn-winter-spring and feeding grounds in the Oyashio region mainly in summer.[6] The spawning grounds of these species usually extend from Kyushu Island (southern Japan) to Cape Inubo (36ºN), except for the common squid (major putative spawning grounds in the East China Sea) and for anchovy whose spawning grounds extend from southern Japan to the extensive area of the Transition Zone, presumably beyond the international date line in recent years when stock level is high.

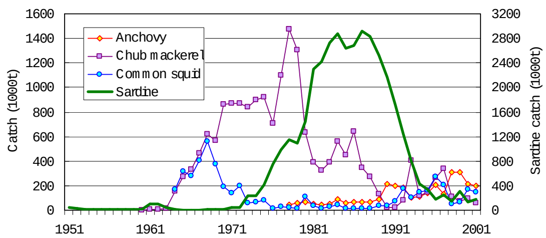


FIGURE 9 JAPANESE CATCH OF SARDINE, ANCHOVY, CHUB MACKEREL AND COMMON SQUID ALONG THE PACIFIC COAST OF JAPAN.

On the Pacific coast of Japan, the Pacific stock of walleye pollock (*Theragra chalcogramma*) is distributed from Cape Inubo (36ºN) to Etorofu Island. The biomass of this stock has decadal-scale fluctuations with a minimum (0.9 million t) in 1989 and a peak (1.7 million t) in 1997, declining in recent years (Figure 10). The Japanese annual commercial catch of this stock fluctuated between 0.2 and 0.3 million t from the 1970s until 1988, however, it gradually decreased to 148,000 t in 1996. In 1995, a strong year-class appeared and catches recovered to 265,000 t in 1998, but have decreased again to 129,000 t in 2001.

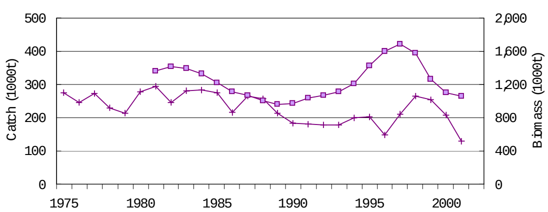


FIGURE 10 BIOMASS AND JAPANESE CATCH OF WALLEYE POLLOCK (PACIFIC STOCK).

Western Subarctic Gyre

In the western Subarctic Gyre, pink salmon (*O. gorbuscha*) is the most abundant species of Pacific salmon, followed by chum (*O. keta*), sockeye (*O. nerka*), coho (*O. kisutch*), chinook salmon (*O. tshawytscha*), and steelhead trout (*O. mykiss*) (Figure 11). Masu salmon (*O. masou*) are distributed only in coastal waters off Japan and Russia in the western North Pacific.[7]

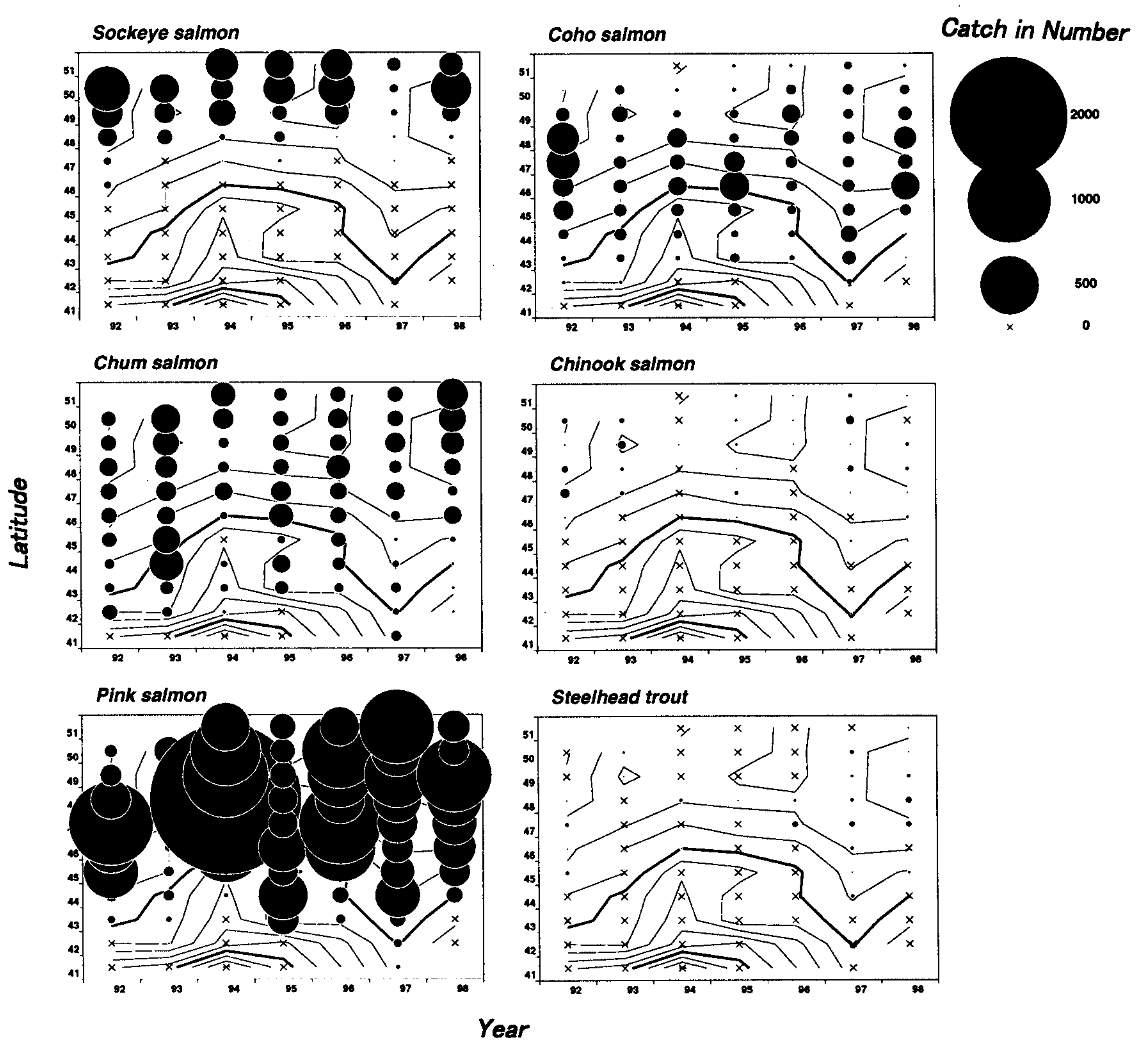


FIGURE 11 DISTRIBUTION OF PACIFIC SALMON ALONG A TRANSECT AT 165°E FROM 41°N TO 51°N IN JULY FROM 1992 TO 1998.[8] THE THICKER CONTOUR IN THE CENTRE OF EACH PANEL IS THE 10° C SEA SURFACE TEMPERATURE CONTOUR. TEMPERATURE CONTOURS INCREASE (DECREASE) BY 1° C INTERVALS TOWARD THE SOUTH (NORTH).

Fishes and squids have been collected using surface gillnets along a north-south transect at 165°E longitude, between 41°-51°N latitude during the summers of 1992-1998. The transect crosses the Subtropical North Pacific (STNP), the Transition Domain (TD), and the Western Subarctic Gyre (WSG). Twenty-six fish species, 4 squid species, 1 marine mammal species and some other unidentified fish and seabirds were collected. Pacific salmon were the most abundant (68% by number), followed by Pacific saury (*Cololabis saira*, 16%), Atka mackerel (*Pleurogrammus monopterygius*, 5%), Pacific pomfret (*Brama japonica*, 3%), and blue shark (*Prionace glauca*, 1%). Abundant squid species included neon flying squid (*Ommastrephes bartramii*, 2%), boreal clubhook squid (*Onychoteuthis borealijaponica*, 2%), and boreopacific gonate squid (*Gonatopsis borealis*, 1%). Pacific salmon were distributed in the TD and WSG; sockeye salmon (6%), chum (7%), pink (50%), and coho salmon (5%) were distributed in this order of dominance from north to south. Boreopacific gonate squid were distributed mainly in the WSG at sea surface temperatures (SST) below 10°C, but also occurred in the TD in 1997. Neon flying squid were distributed in the TD at 10-15°C SST, and were abundant in 1994 and 1996. Boreal clubhook squid and Pacific pomfret occurred in the TD, and Pacific saury were distributed south of the 10°C SST isotherm. In 1994 Atka mackerel were abundant at 51ºN, where the northern part of WSG flows westward, and blue sharks were caught at 42ºN in 1993. These results indicate that each species has a specific distribution pattern related to oceanographic structure (Figure 11, Figure 12, Figure 13).

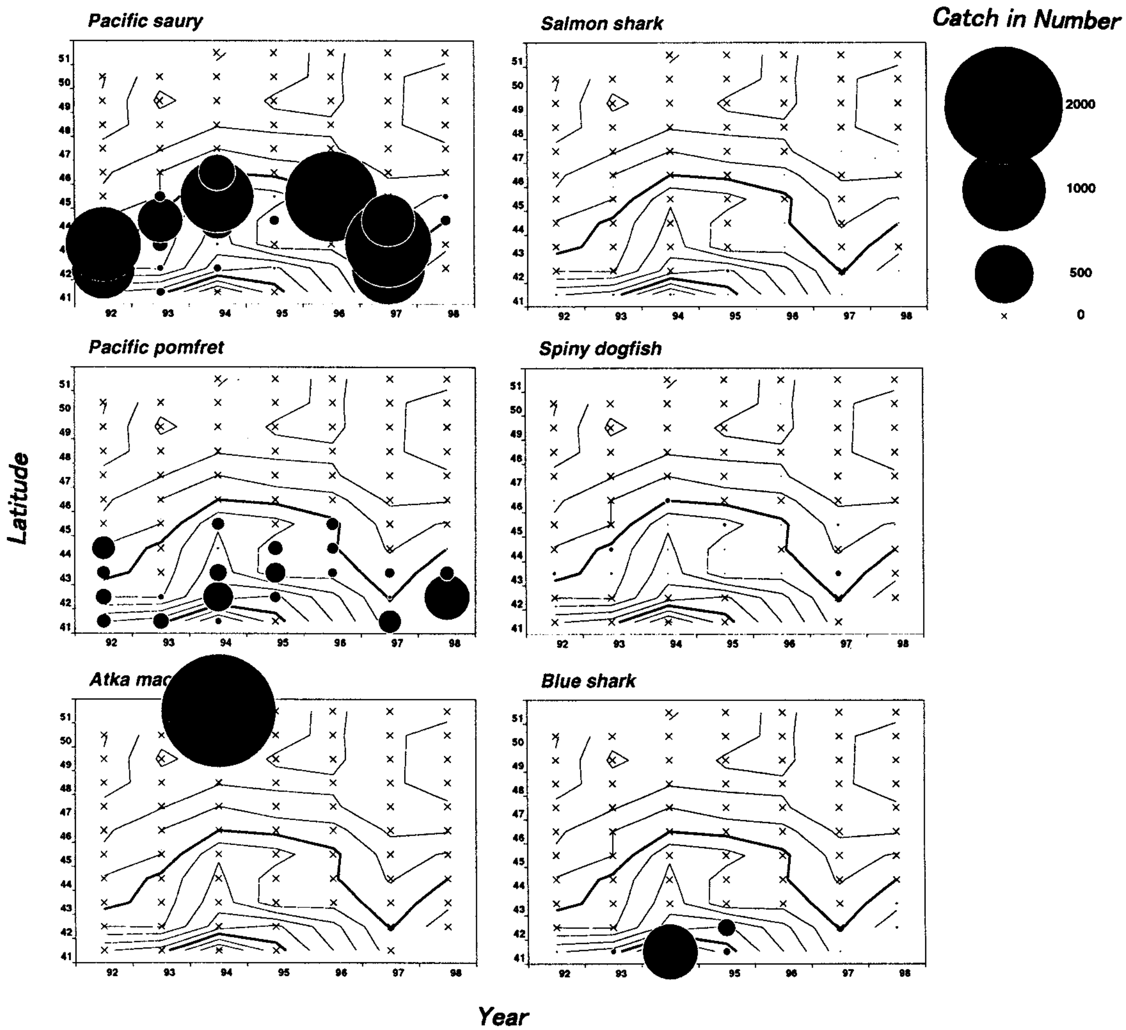


FIGURE 12 DISTRIBUTION OF PELAGIC FISHES ALONG THE TRANSECT AT 165°E FROM 41°N TO 51°N IN JULY FROM 1992 TO 1998. THE THICKER CONTOUR IN THE CENTRE OF EACH PANEL IS THE 10° C SEA SURFACE TEMPERATURE CONTOUR. TEMPERATURE CONTOURS INCREASE (DECREASE) BY 1° C INTERVALS TOWARD THE SOUTH (NORTH).

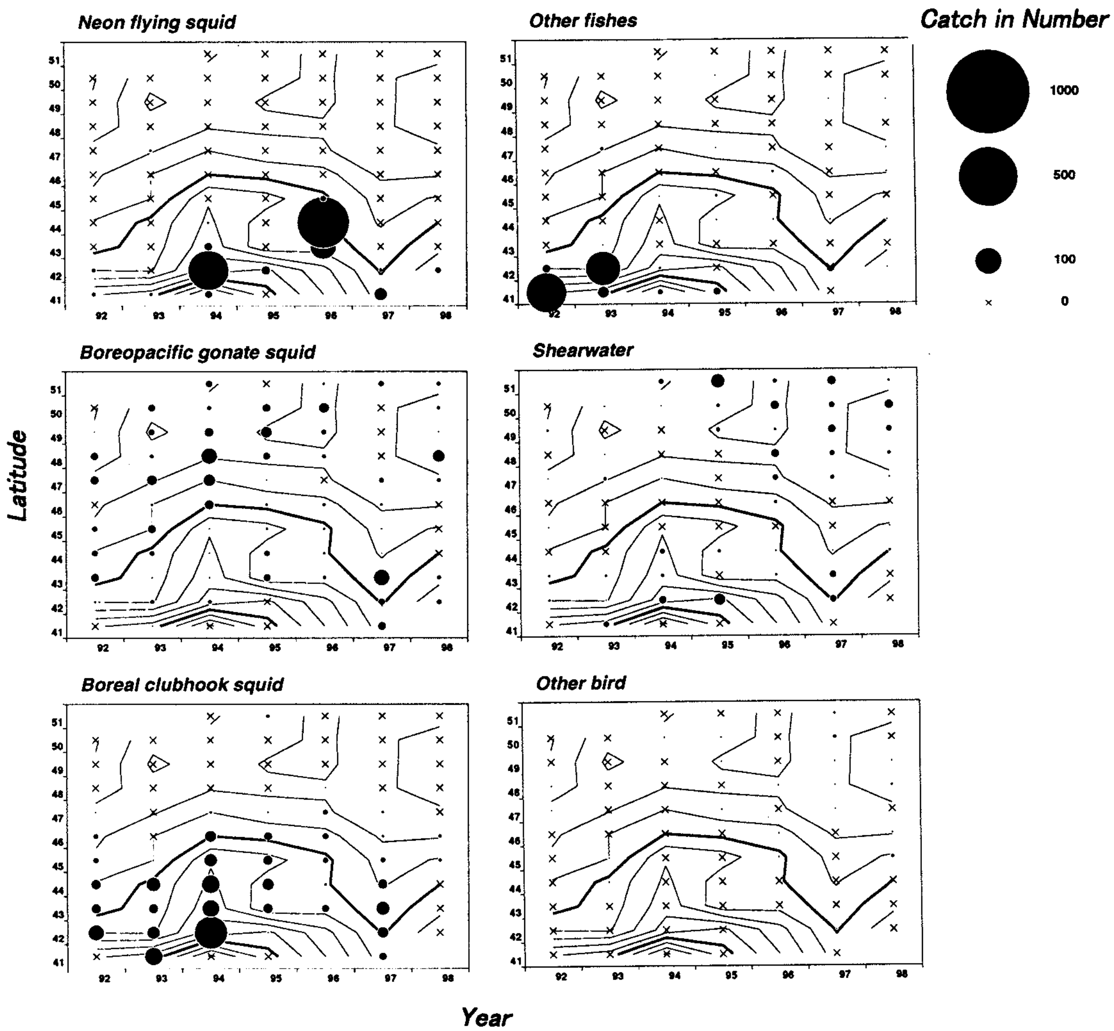


FIGURE 13 DISTRIBUTION OF PELAGIC SQUIDS AND OTHER ANIMALS ALONG THE TRANSECT AT 165°E FROM 41°N TO 51°N IN JULY FROM 1992 TO 1998. THE THICKER CONTOUR IN THE CENTRE OF EACH PANEL IS THE 10° C SEA SURFACE TEMPERATURE CONTOUR. TEMPERATURE CONTOURS INCREASE (DECREASE) BY 1° C INTERVALS TOWARD THE SOUTH (NORTH).

Eastern Bering Sea

Shifts in demersal fish and benthic invertebrates on the eastern shelf began around 1980 (Figure 14).[9] There were strong increases in the biomass of walleye pollock, Pacific cod, Pacific ocean perch and Atka mackerel. Rock sole, flathead sole and arrowtooth flounder increased in abundance while Greenland turbot and other flatfish declined. Biomass of commercially important crab species on the eastern shelf had strong peaks around 1980 and 1990, mainly due to increases in snow crab abundance. Groundfish and shellfish fishery catches in the eastern Bering Sea have been relatively stable over the last 20 years with total catch approaching two million t (Figure 15).

Recruitment for most Bristol Bay sockeye salmon stocks other than Kvichak has been moderate to strong in the last decade. Some weak runs due to poor recruitment events have been observed for Yukon and Kuskokwim River chinook and chum salmon. Pink salmon catches have been moderate to high in most regions over the last 20 years. Coho catches have been moderate to high in all regions.

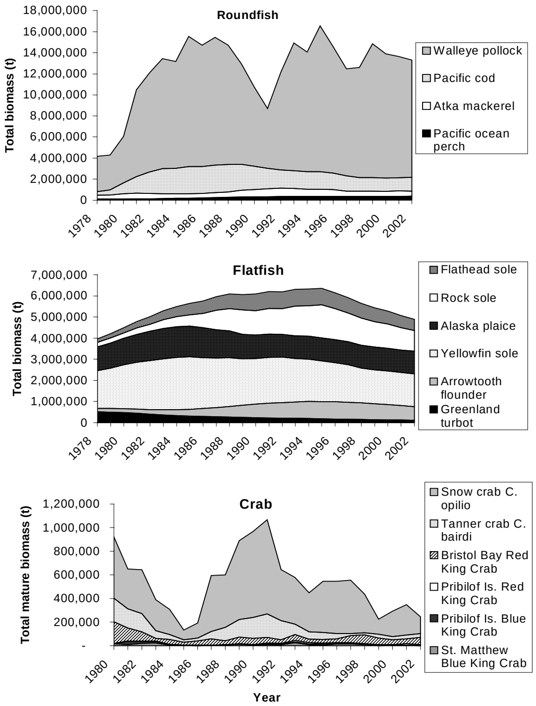


FIGURE 14 TIME SERIES OF FISH[10] AND INVERTEBRATE[11] RESOURCE ABUNDANCE IN THE SOUTHEASTERN BERING SEA.

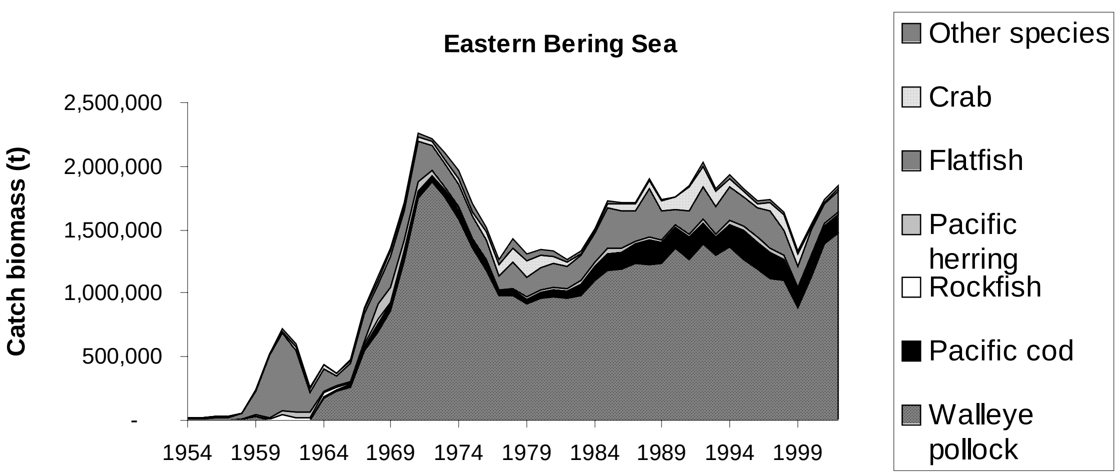


FIGURE 15 TOTAL CATCH BIOMASS OF FISH (EXCLUDING SALMON) AND SHELLFISH IN THE EASTERN BERING SEA.[12]

In the western Bering Sea (Figure 16), cooling of shelf waters during the 1990s has resulted in unfavorable conditions for walleye pollock.[13] Pacific cod abundance declined from an estimated 766,000 t in 1989 to 172,000 t in 2000.[14] Yellowfin sole biomass is estimated at 78,000 t on the southwestern shelf, much lower than on the eastern shelf, due to the narrow area of the western shelf. Greenland turbot are not abundant in the western Bering Sea and abundance was higher in the northern part of the Bering Sea in the 1990s compared with the 1980s. However, the total biomass and overall distribution of this flatfish decreased in the western Bering Sea as in the eastern region.

Since 1989, runs of pink salmon to the eastern Kamchatka coast have been in good condition during odd years. The average pink salmon catch (38,390 t) for 1989-2001 is more than twice the level calculated for 1952-1993 (15,996 t). Similarly, chum salmon catches were also stable at 11,000-12,000 t in 2000-2001 compared to 5,250 t for 1952-1993.[15]

Walleye pollock catches in the northwest shelf region declined due to poor stock condition and fishery management changes. Total pollock catch in the Russian EEZ declined from 1,327,000 t in 1988 to 393,180 t in 2000. Cod harvest peaked at 117,650 t in 1986 and has since declined due to decreases in cod abundance. The flatfish fishery did not exist in the northwestern region until the 1990s.

Capelin aggregations along the northwestern coast exhibit a stable distribution during the warm season. Biomass was estimated at 200,000 t on the western Bering shelf in 1986-1990. Polar/Arctic cod (*Boreogadus saida*) extended their summertime range southward on the shelf in the western Bering Sea during 1999-2000.

Snow crab and Tanner crab fisheries were not conducted in the western Bering Sea in 2000-2001. Research surveys indicated some improvement in stock condition allowing a small commercial fishery in 2002.

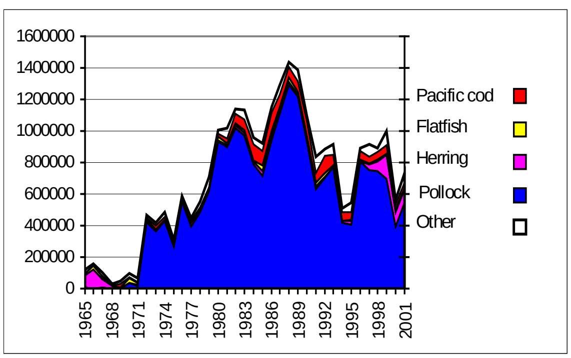


FIGURE 16 COMMERCIAL FISHERY CATCHES IN THE WESTERN BERING SEA.

Gulf of Alaska

The Gulf of Alaska shelf is highly productive and supports a number of commercially important fisheries such as walleye pollock, salmon, Pacific halibut, other flatfish, Pacific herring, crab, and shrimp. Annual landings from 1999-2002 for the Alaska portion of the shelf averaged approximately 250,000 mt of groundfish,[16] 290,000 mt of salmon, and 20,000 mt of herring and shellfish.[17] Salmon catches and groundfish species composition and abundance in the nearshore areas of the Gulf of Alaska changed dramatically during the late 1970s and early 1980s[18],concurrent with a pronounced shift in a number of climatic and oceanographic indicators [19] A number of marine mammal and bird populations, in particular Steller sea lions and harbour seals, have substantially declined in the Gulf of Alaska following the 1977 regime shift.[20]

The fish fauna of the Gulf of Alaska consists of a mix of temperate and subarctic species, resulting in a large gradient in species composition along the shelf from the eastern to the western Gulf of Alaska. At least 383 species belonging to 84 families of marine and anadromous fishes have been reported from the Alaska continental shelf, slope, and offshore areas.[21] The shelf and slope support a large biomass of groundfishes, particularly the wide shelf and banks around Kodiak Island. The largest catch-per-unit-effort (CPUE) during summer typically occurs at or below the shelf break and there are strong cross-shelf gradients in species composition and diversity. The 10 most abundant groundfish species make up more than 75% of the biomass caught in bottom trawl surveys, dominated by arrowtooth flounder (*Atheresthes stomias*), Pacific Ocean perch (*Sebastes alutus*), walleye pollock (*Theragra chalcogramma*), and Pacific halibut (*Hippoglossus stenolepis*). Shellfish like crab and shrimp currently make up a relatively small proportion of the survey CPUE on the shelf and support comparatively small fisheries. Little is known about demersal species on the deeper parts of the slope, continental rise, in the deep central basin and on the numerous seamounts.

The nearshore areas serve as important spawning grounds and as nursery grounds for juveniles of numerous demersal and pelagic species, including salmon, pollock, Pacific cod, crab, and over 20 species of flatfishes. The life history of many of these species is closely tied to the cyclonic boundary currents, which transport eggs and larvae, and serve as important migratory pathways for juvenile salmon.

The large nekton of the central Alaska Gyre is dominated by salmon throughout the year, while Pacific pomfret (*Brama japonica*), Pacific saury (*Cololabis saira*), and tuna are common in the summer. The southern part of the central gyre supported large-scale squid (*Ommastrephes bartrami*) driftnet fisheries until a moratorium prohibiting use of this gear was established by the United Nations General Assembly in 1992. The area provides the principal feeding habitat for many species, particularly Pacific salmon.[22] High abundances of several squid species and large zooplankton provide important prey for the larger nekton. Species composition in the nekton displays a strong latitudinal gradient and the distribution of most species correlates with sea surface temperature.[23] With the exception of salmon, which return to and are assessed upon their return to natal streams, only the Hokkaido University time series can be used to assess interannual variability in the nekton of the central gyre.

Catches of the major commercial species in the Gulf of Alaska have fluctuated widely with major peaks in the mid-1960s and mid-1980s (Figure 17). Reported catches during the early part of the century and through 1960 were dominated by Pacific halibut, which have remained relatively stable over the period of record. Pacific Ocean perch was first exploited in the early 1960s, increased rapidly to a peak in 1965, followed by a rapid decline to very low levels in the late 1970s. Exploitation of walleye pollock began in the late 1960s and pollock soon replaced Pacific Ocean perch as the major commercial species. Catches increased exponentially through the 1970s to a peak in 1984, supported by several years of strong recruitment in the late 1970s. Walleye pollock catches declined precipitously after 1984 but continue to dominate total landings. Pacific cod catches increased slowly from 1964 to the early 1990s and have remained at relatively high levels since then. Sablefish catches have undergone relatively large fluctuations with peaks in 1962, 1972 and 1988, and gradually declining catches since 1988.

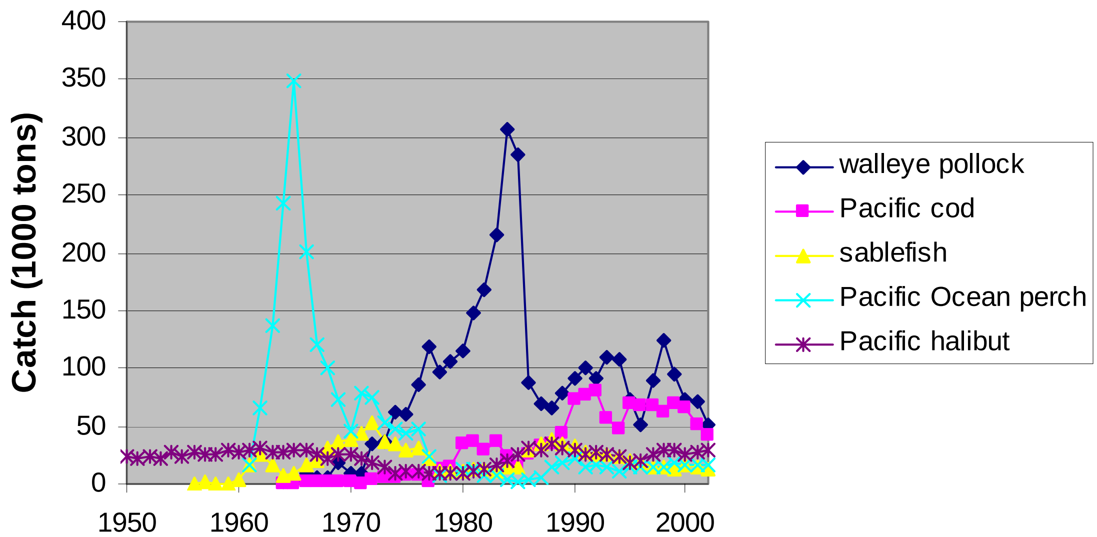


FIGURE 17 CATCHES OF MAJOR COMMERCIAL GROUNDFISH SPECIES IN THE GULF OF ALASKA FROM 1950 TO 2002. CATCHES OF SABLEFISH INCLUDE THE ALEUTIAN ISLANDS AND EASTERN BERING SEA REGION. CATCHES OF PACIFIC OCEAN PERCH AFTER 1978 INCLUDE OTHER SLOPE ROCKFISH SPECIES. PACIFIC HALIBUT CATCHES INCLUDE COMMERCIAL LANDINGS ONLY.

Although changes in survey gear greatly complicate the assessment of long-term trends in abundance, it is generally believed that total groundfish biomass on the Gulf of Alaska shelf increased substantially after the 1976/77 regime shift.[24] However, the increase followed a substantial decrease in heavily exploited Pacific Ocean perch populations and coincided with the collapse of crab and shrimp fisheries, suggesting a replacement of these species by cod and flatfishes due to a combination of overfishing and climate changes. Recent trends based on age-structured stock assessments of commercially important species suggest that the biomass of major commercial groundfish species has undergone a statistically significant decrease between 1984 and 2002 (Figure 18). The trend was largely a result of changes in walleye pollock biomass, which decreased through 2001 but increased substantially in 2002 due to a strong 1999 year class. Arrowtooth flounder, which is currently not the target of a direct fishery and is a major predator of walleye pollock, has replaced pollock as the dominant groundfish species in the last decade.

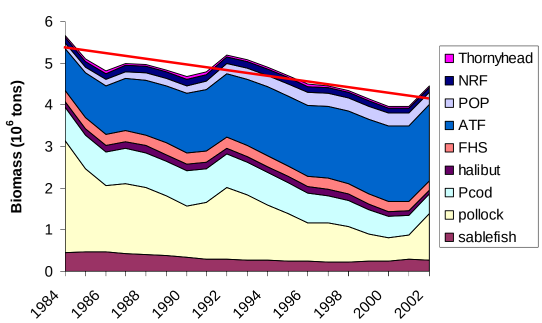


FIGURE 18 Biomass estimates for major commercial groundfish species in the Gulf of Alaska from 2002 stock assessment reports (NPFMC 2002). Sablefish includes Gulf of Alaska and eastern Bering Sea (NRF = Northern rockfish, POP = Pacific Ocean Perch, ATF = arrowtooth flounder, FHS = flathead sole, Pcod = Pacific cod). These species comprise approximately 80% of the total biomass in 1999 bottom trawl surveys. Red line indicates linear trend for total catch, fit by generalized least squares with autocorrelated errors.

The total number of mature salmon that return to systems bordering the Gulf of Alaska has undergone large interannual and decadal-scale fluctuations, as evident in long-term catch series (Figure 19). Decadal-scale trends in total catch have been associated with fluctuations in ocean climate, and marine survival rates of pink, chum, and sockeye salmon in Alaska are on average higher during years with warm coastal temperatures.[25] Catches throughout much of the North Pacific increased after the 1976/77 regime shift and have been high in the Gulf of Alaska for most of the 1980s and 1990s. However, a large portion of the increase can be attributed to massive hatchery releases of sockeye, pink, and chum salmon. The most recent catch trends suggest an approximate 10% decrease in catches of Gulf of Alaska salmon stocks between 1994 and 2002, which is not statistically significant (Figure 20).

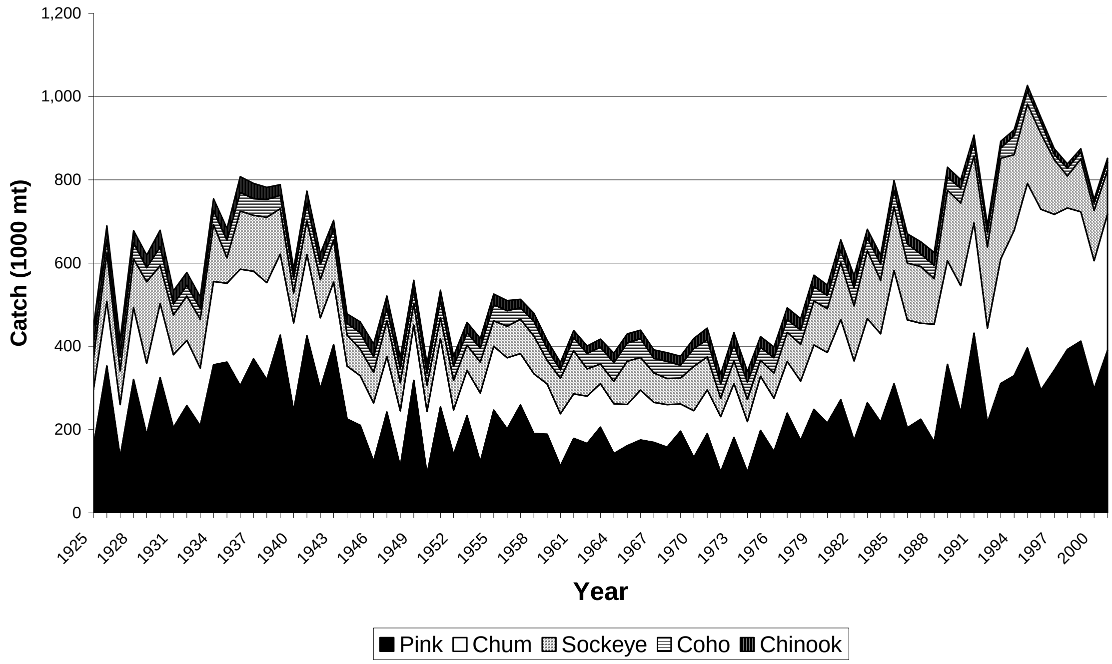
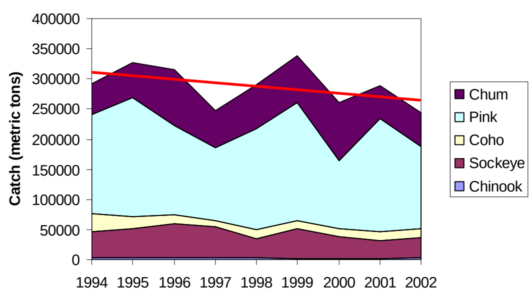


FIGURE 19 COMMERCIAL CATCH OF PACIFIC SALMON IN WEIGHT, 1925 – 2001, IN THE NORTH PACIFIC OCEAN, BY SPECIES.

Large shifts in abundance have also been documented for large epipelagic nekton in the Northeast Pacific, including salmon shark, Pacific pomfret, jack mackerel, albacore, and three squid species.[26] Except for jack mackerel all species had much higher catch rates during surveys done in the late 1980's compared to surveys in the late 1950's, suggesting a higher carrying capacity for these pelagic species in the later period. No recent updates are available due to a lack of monitoring.



CATCH TRENDS FOR FIVE SPECIES OF PACIFIC SALMON IN THE GULF OF ALASKA (COMBINED CATCHES OF SOUTHEAST, PRINCE WILLIAM SOUND, COOK INLET, KODIAK, CHIGNIK, AND ALASKA PENINSULA DISTRICT STOCKS, INCLUDING HATCHERY FISH). RED LINE INDICATES LINEAR TREND FOR TOTAL CATCH OVER TIME.

FIGURE 20

Herring are widely distributed in the North Pacific and spawn in numerous locations around the Gulf of Alaska. Major spawning aggregations, which are believed to reflect distinct populations, occur in SE Alaska near Sitka, in Prince William Sound, and on Kodiak Island. Catches of these populations have fluctuated widely (Figure 21) with the largest catches between 1970 and 1992 occurring in Prince William Sound (except in 1989 when the fishery was closed as a result of the Exxon Valdez oil spill). Catches in Prince William Sound declined precipitously after 1992 and the fishery has been closed in recent years due to very low abundances. Herring populations in the Kodiak area appear to be at low abundances, supporting harvests of only 1,000 – 2,000 t annually, which stand in sharp contrast to the height of the fishery in 1934-1950, when average harvests were more than an order of magnitude higher (31,600 t). Herring abundances in Sitka Sound have been generally stable and have supported the largest herring fishery in the GoA in recent years (Figure 22).

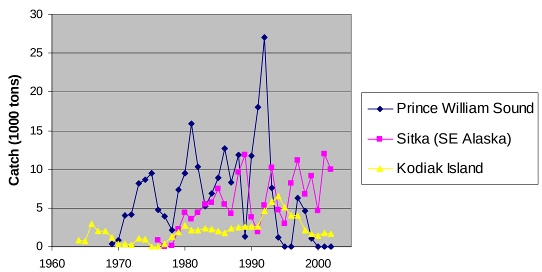


FIGURE 21 CATCHES OF THREE MAJOR HERRING STOCKS IN THE GULF OF ALASKA, 1964-2002. [27]

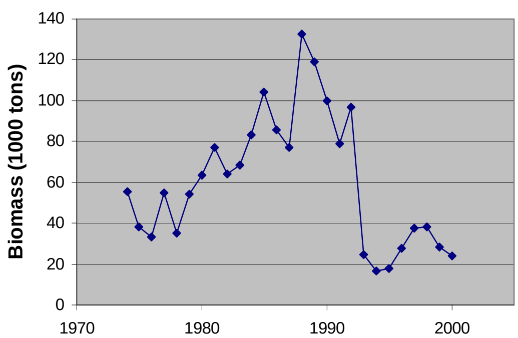


FIGURE 22 ESTIMATED PRE-FISHERY RUN BIOMASS OF PACIFIC HERRING FROM AGE-STRUCTURED ANALYSIS. BIOMASS FOR 1974-1979 WAS ESTIMATED BASED ON A LINEAR REGRESSION OF BIOMASS ON MILE DAYS OF SPAWN.

In the past, the Gulf of Alaska shelf has supported significant catches of crustaceans, including tanner crab (*Chionoecetes bairdi*), Dungeness crab (*Cancer magister*), red king crab (*Paralithodes camtschaticus*), and 5 species of shrimp. Many of these fisheries collapsed in the early 1980s and some remain closed today, particularly in the western Gulf of Alaska. While catches exceeded 90,000 tons in the 1960s and 1970s, recent catches of all shellfish combined (1995-2001) ranged from 5,000 t in 2000 to 7,800 t in 1998, with 6,100 tons of shellfish caught in 2001.[28]

Based on small-mesh surveys in the central Gulf of Alaska (Kodiak and Alaska Peninsula), a large shift in species composition was documented in the nearshore groundfish community in the late 1970s and early 1980s and is believed to be associated with the 1976/77 regime shift. The nearshore community was dominated by shrimp and small forage fishes (primarily osmerids) in the 1960s and 70s. In contrast, large piscivorous gadid and flatfish species have dominated catches since the early 1980s. The most recent surveys suggest that shrimp and osmerids began to increase in some nearshore areas in 2001 and 2002, but CPUE is far below levels observed in the 1970s and 1980s.[29,30] At the same time, gadids decreased somewhat in 2001, while flatfish CPUE remained constant.

California Current

The epipelagic and mesopelagic nekton communities of the northern California Current have been sampled by a number of methods over the past four decades.[31] Abundance trends of pelagic nekton from this region demonstrate large-scale ecosystem changes around the times of the proposed regime shifts of 1976 and 1989, and suggestions of a similar shift around 1998. The rapidity of the community composition changes point to fluctuations in migration of distribution patterns, rather than changes in recruitment. The strong El Niño events of 1983 and 1998 led to altered alongshore and cross-shore distributions of many pelagic nekton and micronektonic species.

Annual surveys conducted in the vicinity of the Columbia River since 1999 indicate that forage fish (whitebait smelt, Pacific herring, and northern anchovy) abundance has increased from very low levels in 1999. A decline in abundance in 2002 appears to be directly related to extremely low Columbia River flows in 2001; a year-class of both northern anchovy and whitebait smelt was lost (no 1 year old anchovy or whitebait smelt were found in 2002). The September 2003 survey found extremely large numbers of young-of-year anchovy; many more than seen prevously. There were also large numbers of young-of-year sardines off Oregon and Washington in September, likely a result of successful spawning off Oregon in 2003 (Figure 23)

Commercial fisheries in California landed over 177,000 metric tons of fishes and invertebrates from California ocean waters in 2002, a decrease of 12% from 2001 and a 28% decrease from 2000.[32]

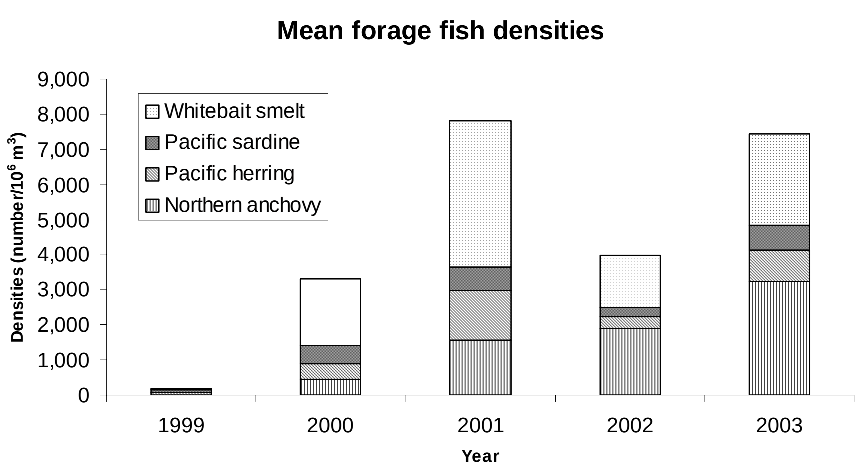


FIGURE 23 THE MEAN DENSITY OF FORAGE FISHES (WHITEBAIT SMELT, PACIFIC HERRING, NORTHERN ANCHOVY, AND PACIFIC SARDINE) OFF N OREGON / S WASHINGTON FROM APRIL TO JULY.[33]

The top three valued fisheries in California in 2002 were invertebrates: market squid, dungeness crab, and sea urchin (Figure 24). Landings of squid (-15%) and dungeness crab (+105%) changed substantially in 2002, while demand for both species led to higher revenue, by 8% for squid and 49% for dungeness crab. The remainder of the top ten California commercial fisheries in 2002 were: chinook salmon (60% increase in value from 2001), swordfish (28% decrease in value from 2001), Pacific sardine, California spiny lobster, albacore, sablefish, and spot prawn. Market squid was the largest fishery in California by volume (72.9 t).

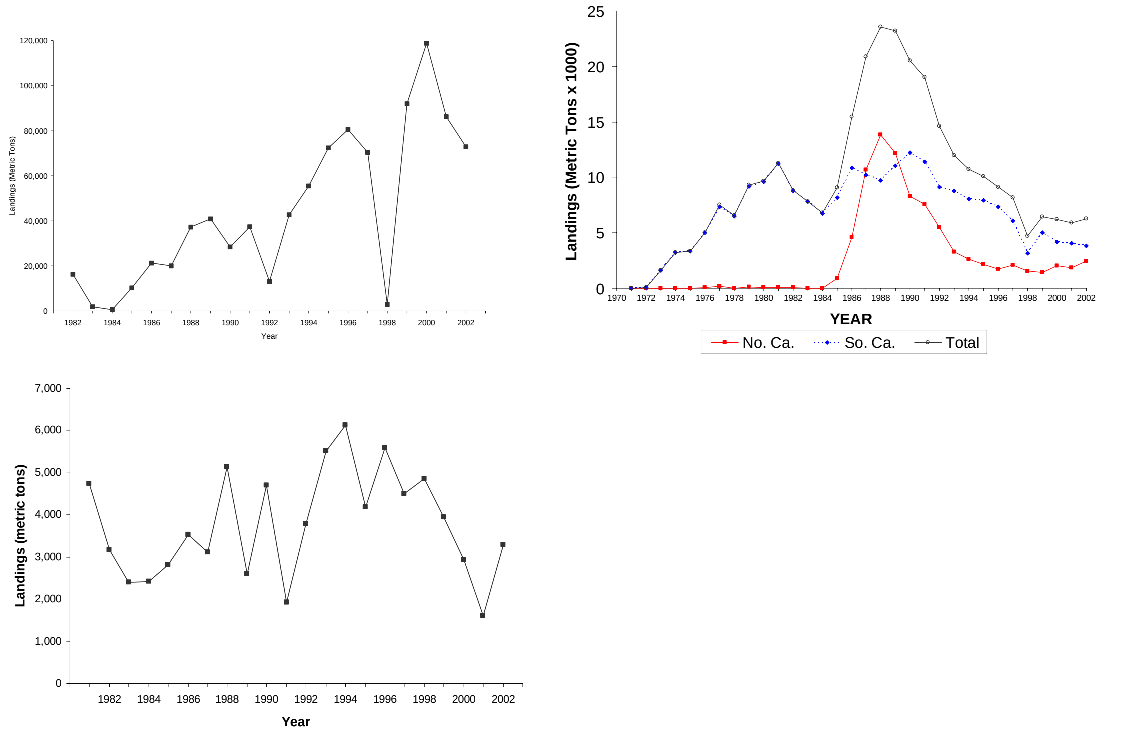


FIGURE 24 COMMERCIAL LANDINGS OF THE TOP THREE VALUED CALIFORNIA FISHERIES: (TOP) MARKET SQUID, 1982-2002, (MIDDLE) RED SEA URCHIN FOR NORTHERN AND SOUTHERN FISHERIES, 1970-2002, AND (BOTTOM) DUNGENESS CRAB, 1981-2002.

Landings of Pacific mackerel, jack mackerel, and northern anchovy all declined substantially in 2002, by 51%, 72%, and 76%, respectively, from 2001. Long-term trends in California Pacific sardine and Pacific mackerel landings are shown in Figure 25.

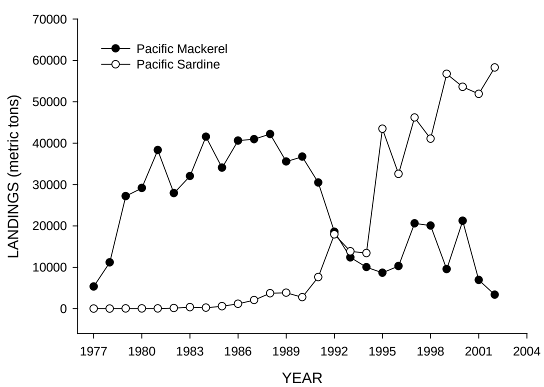


FIGURE 25 CALIFORNIA COMMERCIAL LANDINGS (METRIC TONS) OF PACIFIC SARDINE (*SARDINOPS CAERULEUS*) AND PACIFIC MACKEREL (*SCOMBER JAPONICUS*), 1977-2002.

The NMFS Santa Cruz Laboratory conducts an annual survey of pelagic juvenile rockfish abundance along the central California coast (lat. 36°30' – 38°20' N). This survey is designed to estimate the annual reproductive success of 10 species of rockfish (*Sebastes* spp.) by catching fish that are 80-140 days old during May-June.

For short-lived species like market squid, the affects of El Niño are dramatic but short-lived. Unfortunately, accurate estimates of biomass are not available for a variety of reasons. Only total catch or catch rate (catch per landing) provide an index of squid population response to environmental variability. Over the last 20 years annual catch has increased exponentially, but has been extremely low during and immediately after El Niños. However, usually within 2 to three generations (12 to 18 months), catch rates within the fishery are equivalent to the catch rates immediately prior to the El Niño. The moderate 2002-03 El Niño led to a significant reduction in market squid landings. It should be noted that little is known about market squid ecology and life history, so inferring relationships between the environment and the productivity of this species is still tenuous.

Gulf of California

Shrimp (*Farfantepenaeus californiensis*, *Litopenaeus vannamei* and *Litopenaeus stylirostris*) is one of the most important living marine resources for Mexico in terms of income and employment. This fishery has historically shown very high interannual variability, apparently associated with sea temperature and precipitation.

The fishery for small pelagic species is the largest in México, providing up to 40% of the total national marine catch during some years, most of it from inside the Gulf. It developed during the 1970s, steadily increasing to more than 300,000 t in 1988-89. Between the late 1980s and recent years, the catch decreased to less than 30,000 t in only three seasons, rapidly recovered in two years, decreased again during the 1997/1998 El Niño and since then has been steadily increasing to an historical maximum in 2002. Though this is a multispecies fishery, the most important species has always been the Pacific sardine (*Sardinops caeruleus*). Traditionally the Pacific sardine contribution has decreased during ENSO events while other species such as anchovy (*Engraulis mordax*) and thread herring (*Opisthonema libertate*) increase in proportion. The community has rapidly returned to the normal composition, but in recent years (1998 - 2002) a more sustained change occurred with an increased contribution of a traditionally rare species (*Cetengraulis mysticetus*).

The fishery for giant squid (*Dosidicus gigas*) in the Gulf of California began in the early 1970s and catches increased to more than 22,000 t by 1980. In 1982 the fishery collapsed and the population virtually disappeared from the Gulf for many years. The species reappeared in 1989 and the fishery started again the following year. Catches increased rapidly to 100,000 t in 1997.

Central North Pacific Transition Zone

Much of our present knowledge of the fish and commercial invertebrates in the Transition Zone can be attributed to surveys conducted by Hokkaido University and by a spatially extensive, temporally intensive, but short-lived monitoring by scientific observers of the high-seas commercial driftnet fisheries for flying squid, *Ommastrephes bartramii* (Figure 26), and for tunas and billfishes during 1990-91.

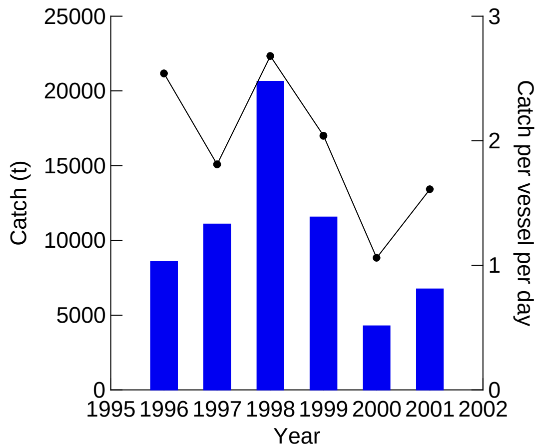


FIGURE 26 CATCH AND CATCH PER VESSEL PER DAY OF FLYING SQUID (*OMMASTREPHES BARTRAMI*) BY JAPANESE JIG FISHERY[34]

Commercial fisheries currently known to operate in the Transition Zone include the Japanese and U.S. longline fishery for tunas and billfishes, the U.S. troll fishery for albacore tuna (*Thunnus alalunga*), and the Japanese (and to a lesser extent, U.S.) jig fishery for flying squid.

Pacific bluefin tuna (Figure 27) are exploited by various gears in the Western Pacific Ocean from Taiwan to Hokkaido. Catch distributions of bluefin by Japanese longliners during 1952-1997 in the Pacific Ocean are shown in Figure 28.[35]

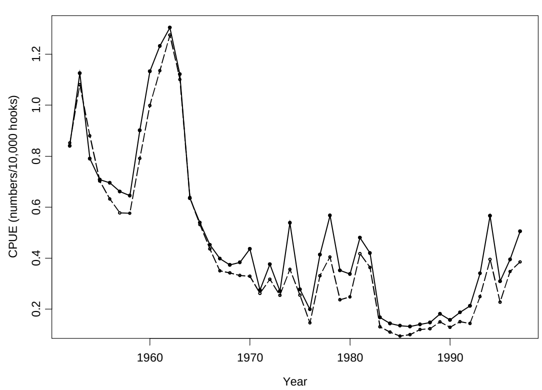


FIGURE 27 TIME SERIES OF REGIONAL ABUNDANCE INDICES FOR THE PACIFIC BLUEFIN TUNA CORE AREA. THE TREND WITH A DASHED LINE IS THE TIME SERIES ESTIMATED FROM THE SAFE ABUNDANCE INDICES. THE TREND WITH A SOLID LINE IS THE TIME SERIES ESTIMATED FROM POOLING THE SAFE AND THE EXTRAPOLATED ABUNDANCE INDICES.

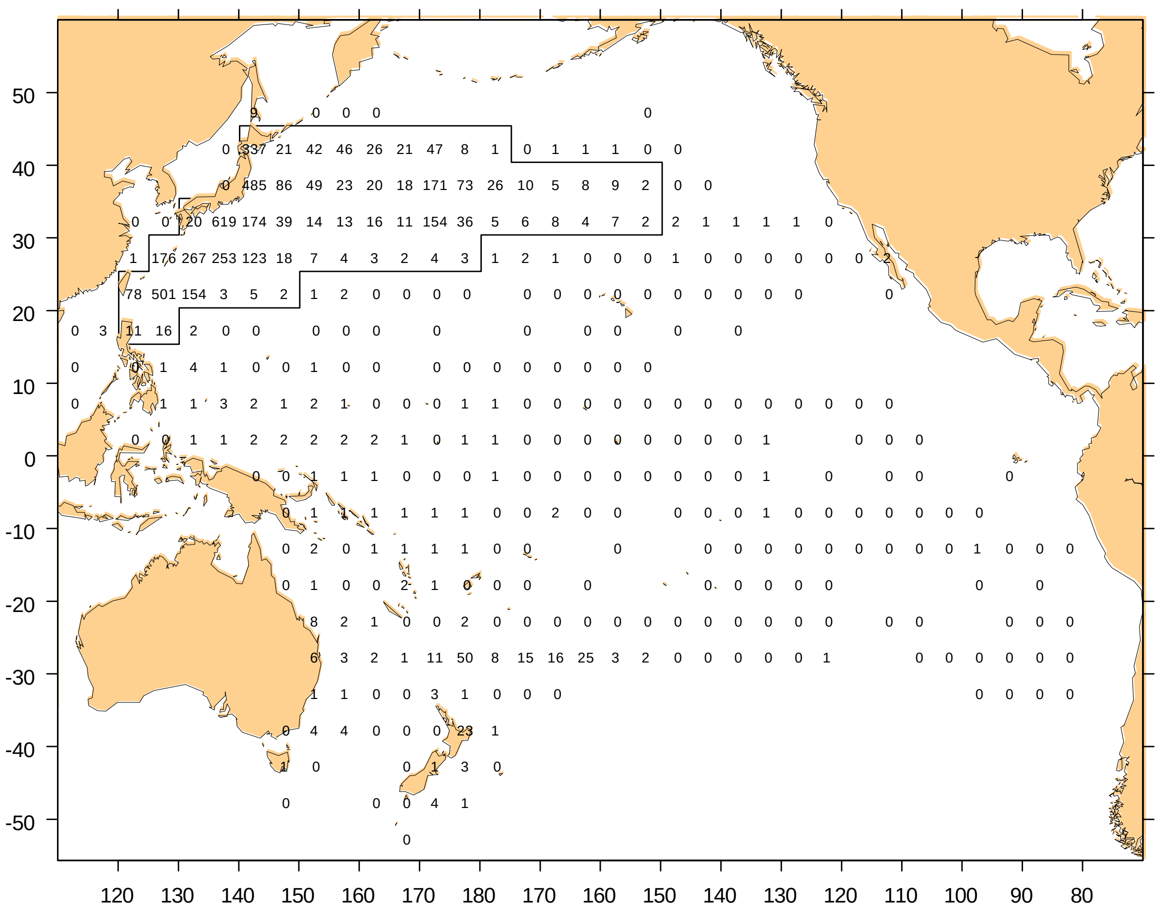


Figure 28 Five degree areas in which Pacific bluefin tuna were captured by the Japanese longline fleet during January 1952–December 1997. The numbers indicate the total number of Pacific bluefin tuna (100s) removed from each quadrangle during this period (zeros indicate catches of less than 51 fish). The quadrangles inside the polygon extending from Japan to 150°W constitute the core area.[36]

Most of the catches of Pacific bluefin tuna in the Eastern Pacific Ocean are taken by purse seiners. Nearly all of this catch is made west of Baja California and California, within about 100 nautical miles of the coast, between about 23° and 33°N. Lesser amounts of Pacific bluefin are caught by recreational, gillnet, and longline gear. They are caught during every month of the year, but most of the fish are taken from May to October. The distributions of purse-seine catches of Pacific bluefin tuna in the EPO during 1970-1989 are shown in Figure 29.

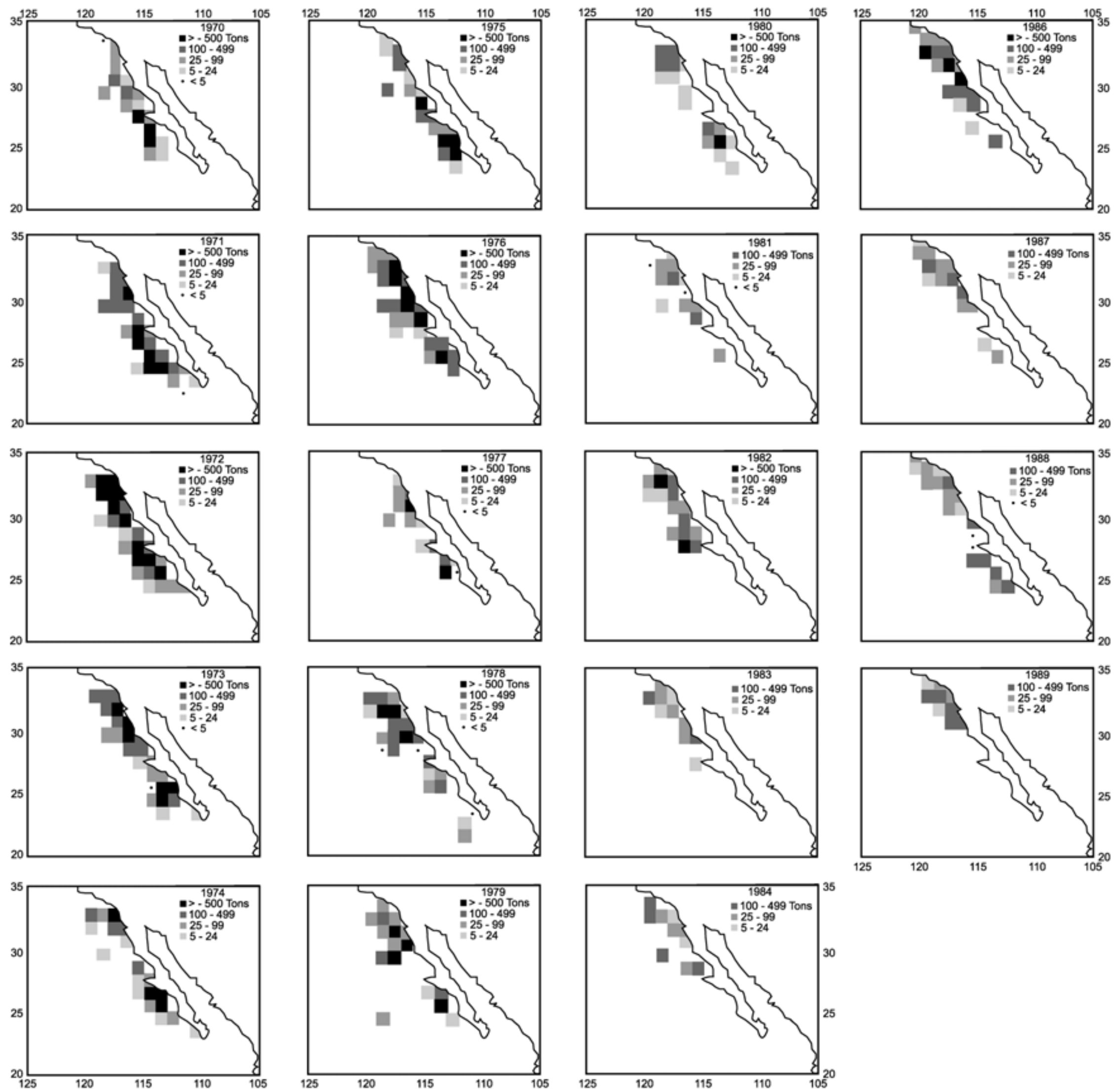


FIGURE 29 ANNUAL DISTRIBUTIONS OF PACIFIC BLUEFIN TUNA CATCHES IN THE EASTERN PACIFIC OCEAN, 1970-1989.[37]

There are two stocks of albacore in the Pacific Ocean, one occurring in the northern hemisphere and the other in the southern hemisphere. In the North Pacific, the adults are apparently most abundant in the Kuroshio Current, the North Pacific Transition Zone, and the California Current, but spawning occurs in tropical and subtropical waters.[38]

There appear to be two subgroups of albacore in the North Pacific Ocean. The fish of the northern subgroup occur mostly north of 40°N when they are in the EPO.[39] There is considerable exchange of fish of this subgroup between the troll fishery of the EPO and the baitboat and longline fisheries of the WPO (Figure 30). The fish of the southern subgroup occur mostly south of 40°N in the EPO (Figure 31), and relatively few of them are caught in the WPO. Fish that were tagged in offshore waters of the EPO and recaptured in the coastal fishery of the EPO exhibited different movements, depending on the latitude of release. Most of the recaptures of those released north of 35°N were made north of 40°N, and most of the recaptures of those released south of 35°N were made south of 40°N.

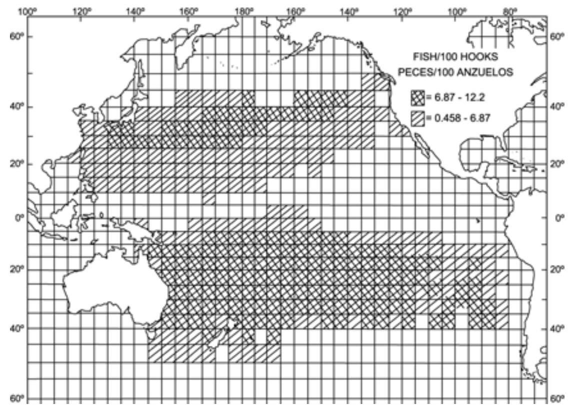


FIGURE 30 DISTRIBUTION OF CATCHES OF ALBACORE PER HOOK BY JAPANESE LONGLINERS AVERAGED OVER THE 1952-1976 PERIOD.

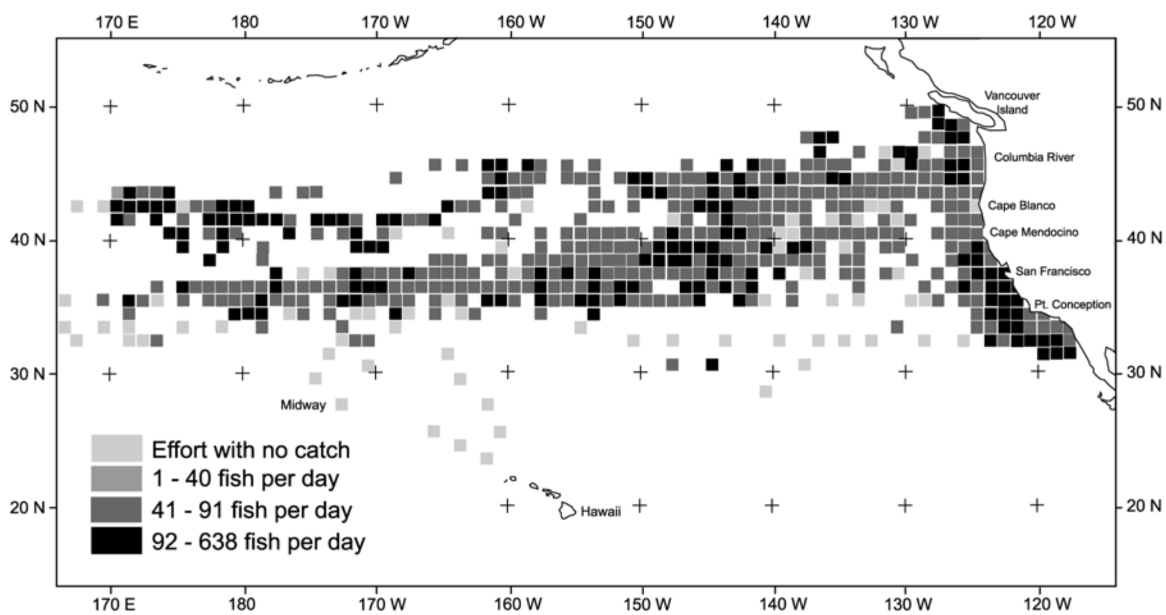


FIGURE 31 DISTRIBUTION OF ALBACORE CPUES BY U.S. TROLL VESSELS IN THE NORTH PACIFIC OCEAN DURING 1999.

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