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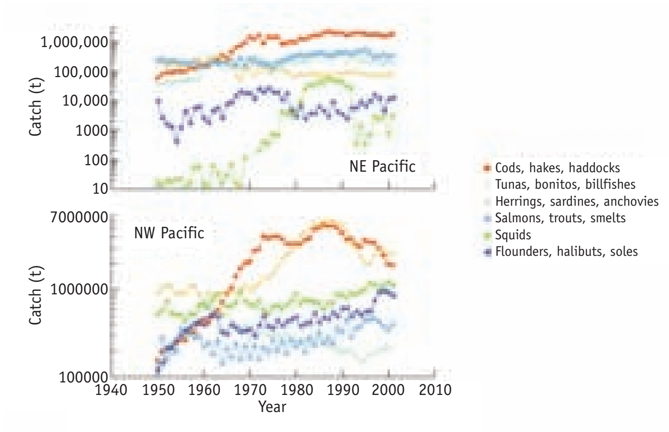
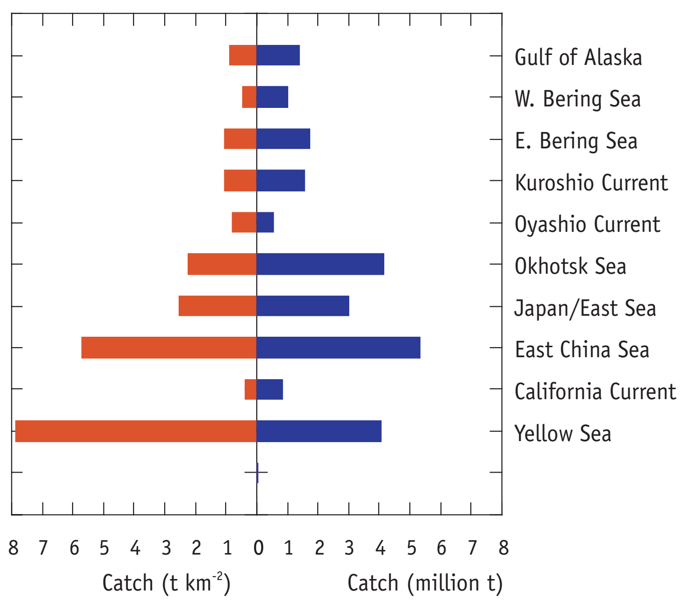
Considerably more data exist on commercially-fished species than on other species, therefore this review focuses on patterns displayed by the predominant commercial species in each region.

The United Nation Fisheries and Agriculture Organisation (FAO) compiles official records of catches from all waters of the globe; FAO statistical areas 67 (Pacific, Northeast) and 61 (Pacific, Northwest) include most of the PICES region. The pattern of total catches of semi-demersal species such as cods and hakes from 1950 to 2000 were similar in both regions, with landings increasing dramatically during the 1960s, peaking in the early 1970s and the mid-1980s (Figure 10). Since then, landings have declined 50% in the western Pacific while they have remained high in the eastern Pacific. Landings of small fishes such as Pacific herring (*Clupea harengus*), Pacific sardine (*Sadinops sagax*) and northern anchovy (*Engraulis mordax*) were very large in the western Pacific, peaking in the mid-1980s (coinciding with the second peak of the semi-demersal species), and then abruptly declining. In the eastern Pacific, FAO Region 67 does not include California, therefore this group of small pelagic fishes represents mostly Pacific herring. This group remained low and stable throughout this period.

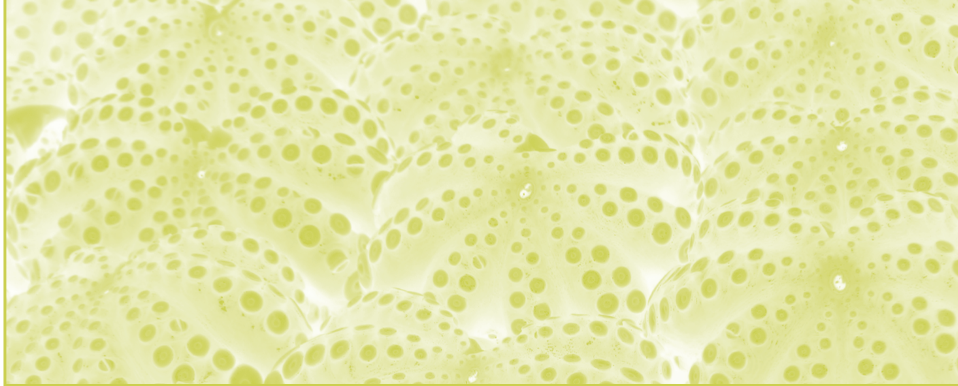
A new method that dis-aggregates the FAO statistics from 1990 to 2000 indicates that the East China Sea produced the highest average catch, whereas the northern portion of the Oyashio Current produced the lowest average catch (Figure 11). When the size of each region is taken into account, the southern part of the Yellow Sea produced the highest catch per km^2, and the California Current System produced the lowest catch.



[Figure 10] FAO catches statistics by major area and species groups (1950-2001) in the northeastern (above, FAO Area 67) northwestern (below, FAO Area 61) Pacific Ocean.

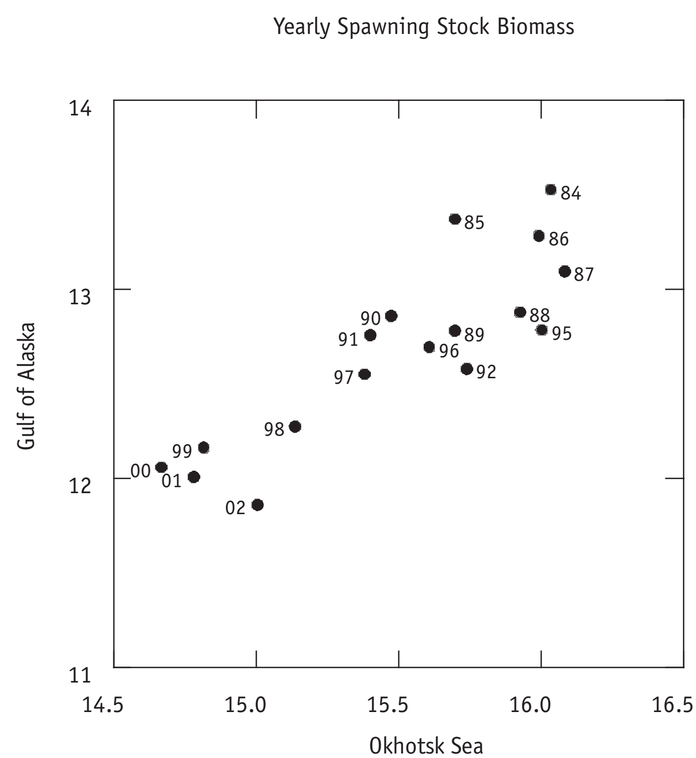


[Figure 11] Disaggregated FAO catches in the North Pacific by region (million t - blue) and adjusted by area within each region (t per km^2 - red).[4]

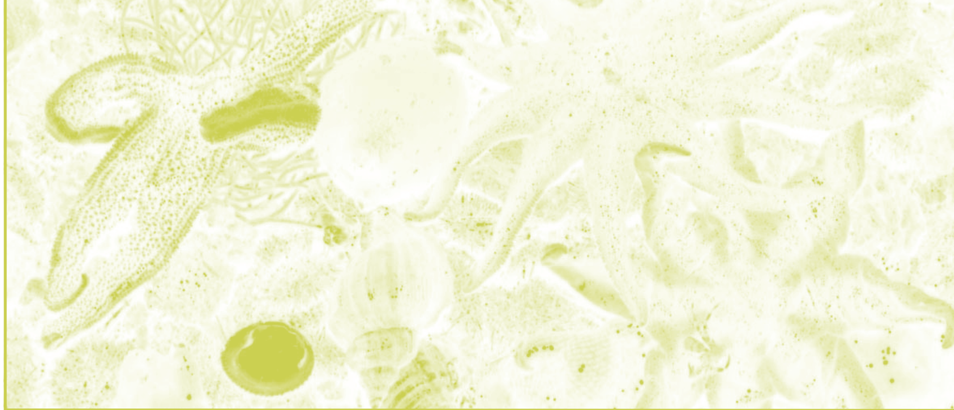


Subarctic Coastal Systems

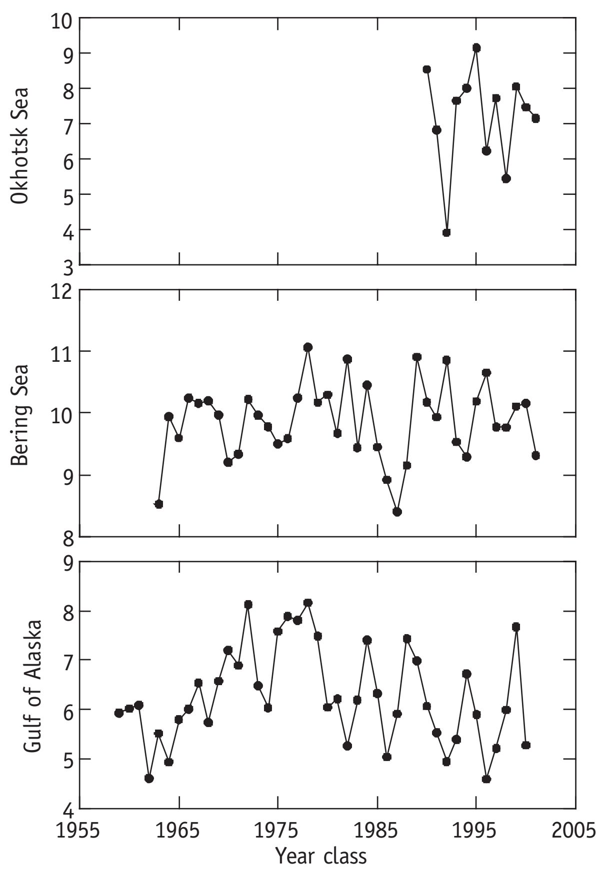
The fish fauna of subarctic coastal systems is dominated by gadids, flatfishes, and crustaceans. Walleye pollock (*Theragra chalcogramma*) has been the major species caught but its overall abundance is lower now than 15 years ago. In the Okhotsk Sea, walleye pollock spawning stock biomass declined by 75% between the late 1980s and 2000 but has started to increase very recently. In the Oyashio Current and coastal Gulf of Alaska, catches of walleye pollock declined by 50%. The timing of the declines is highly correlated among regions (Figure 12). A large spawning aggregation of walleye pollock used to occur off the east coast of North Korea but it has now almost disappeared. Only in the eastern part of the Bering Sea has walleye pollock maintained a relatively stable biomass of about 10 million t over the period from 1985-2000.



[Figure 12] Spawning stock biomass (females) in the western part of coastal Gulf of Alaska versus spawning stock biomass in the Okhotsk Sea, transformed to log (million t) scale.



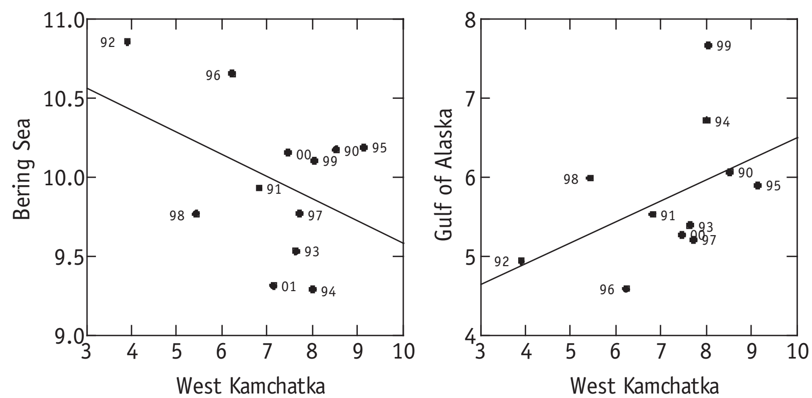
Strong recruitment of walleye pollock occurs infrequently. Although the Okhotsk Sea time series is relatively short, there is a suggestion of that recruitments in coastal Gulf of Alaska and the Okhotsk Sea are positively correlated, while recruitment in the Okhotsk Sea and the eastern part of the Bering Sea are negatively correlated (Figure 14). Additional years of observation will be needed to confirm or reject this hypothesis. Recruitments in the Bering Sea and coastal Gulf of Alaska are uncorrelated.



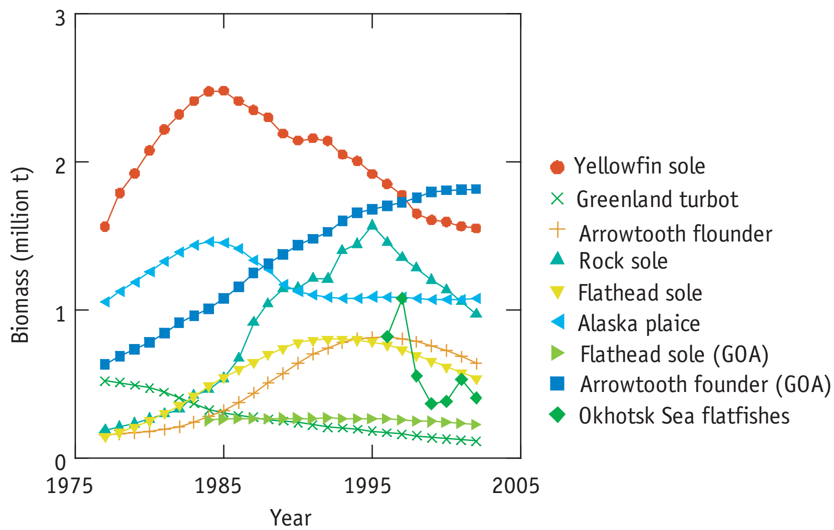
[Figure 13] Walleye pollock recruitment patterns in the eastern Okhotsk Sea, eastern Bering Sea and western part of coastal Gulf of Alaska by year-class (year hatched). Eastern Bering Sea values are millions of age 1 pollock while the others are age 2 pollock. All have been log transformed.

Walleye pollock recruitment has been generally low during the 1990s, therefore recent declines in the abundance of walleye pollock in most regions are likely the result of unfavourable environmental conditions. The similarity of recent environmental conditions in these subarctic coastal regions with those over the past 20 years suggests that no major increase in recruitment can be expected in the near future. The relative stability of walleye pollock biomass in the eastern part of the Bering Sea is important. Stringent fisheries management regulations have been in place in this region, including conservative harvest rates and spatial closures. This suggests that while recruitment patterns for walleye pollock may be largely driven by environmental forces, it is important to recognise years of good recruitment and to manage them conservatively.

Yearly Walleye Pollock Recruitment



[Figure 14] Correlations between walleye pollock recruitment on the western Kamchatka shelf versus: (left panel) eastern Bering Sea and (right panel) Gulf of Alaska since the 1990 year-class.



[Figure 15] Stock biomass estimates for flatfish species in the eastern Bering Sea, Gulf of Alaska and from 1996 only, total flatfishes in the Okhotsk Sea.

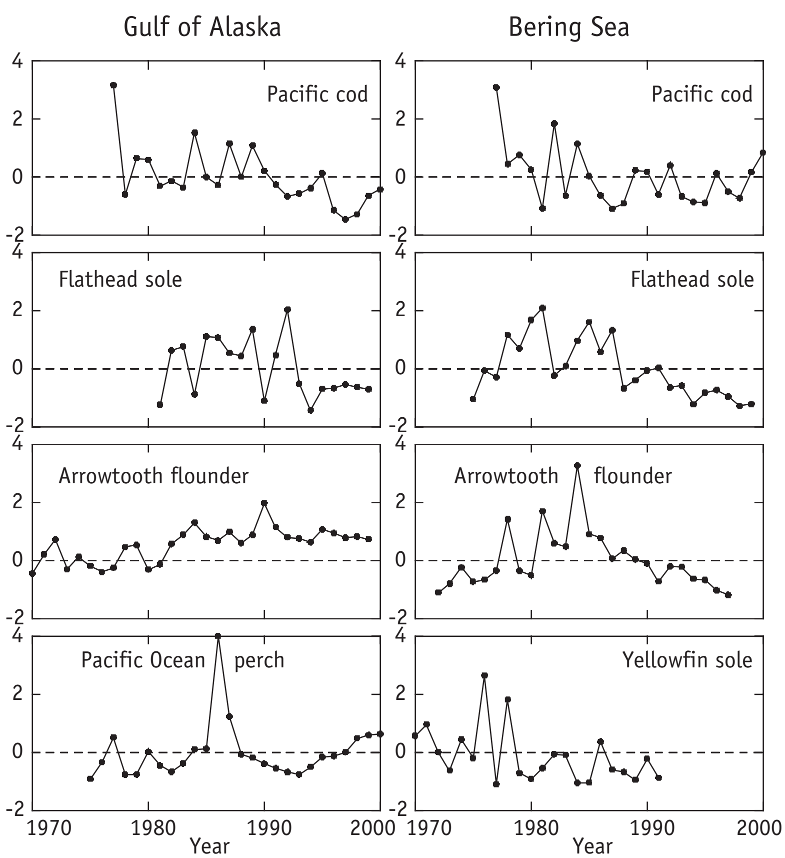
Other groundfish species have declined in subarctic coastal systems. Species of gadids other than walleye pollock have declined in the Okhotsk Sea, the eastern Bering Sea, and Gulf of Alaska. Flatfishes, which are also typically long-lived and respond slowly to environmental variations, have also declined in these regions (Figure 15). The notable exception is the increased abundance of arrowtooth flounder (*Atheresthes stomias*) in the Gulf of Alaska. Recruitment patterns of most groundfish species in the Gulf of Alaska and the eastern Bering Sea (Figure 16) have been below normal throughout most of the 1990s.

Pacific halibut (*Hippoglossus stenolepis*) is the largest flatfish in the world and an important commercial species, particularly in the coastal Gulf of Alaska region. Spawning biomass throughout the 1990s has been the highest since records were started in the 1930s. This high biomass resulted from several years of good recruitment in the 1970s and 1980s, however, recent recruitment has declined. Coinciding with this high biomass of halibut has been a decline in their average weight, in particular in Alaska, so that adult fish now weigh about half of what they did at the same age 20 years ago.

Pacific herring (C*lupea harengus)* is an important pelagic fish in the subarctic North. In the northeastern North Pacific, the spawning biomass of most herring stocks was higher in the late 1990s than over the previous 50 years.[5]

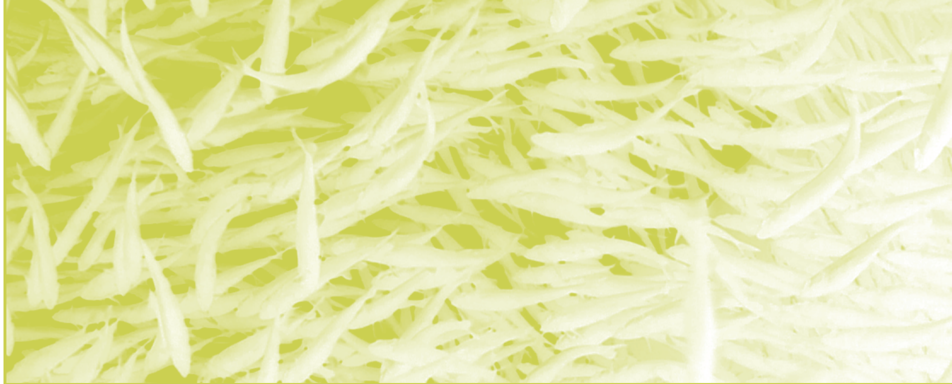
The one notable exception is the stock in Prince William Sound, Alaska, which experienced high mortality from various diseases after the 1989 *Exxon Valdez* oil spill. In the western Pacific, the situation is more variable. Herring stocks in the western Bering Sea appear to be increasing from low levels, and stocks in the Okhotsk Sea appear to be abundant. The Hokkaido west coast stock, which used to be the most abundant herring population in the western Pacific, has not yet recovered from a collapse that occurred over 50 years ago. Herring stocks off the southeast coast of Russia are also severely depleted. The stock in the Yellow Sea has not been abundant since the mid-1970s.

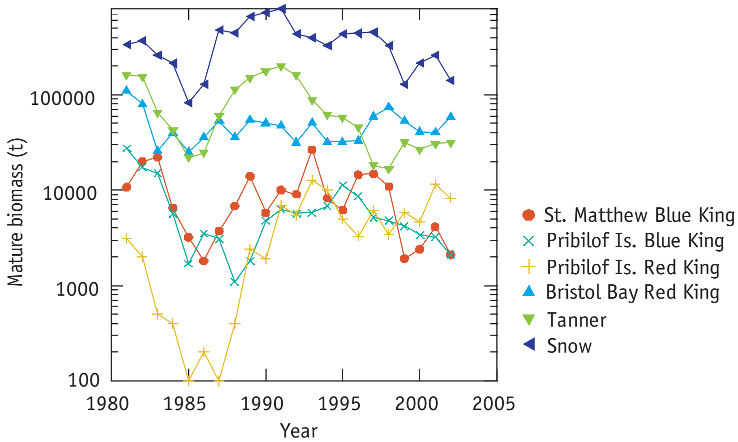
Crab populations have occurred at high abundances in the past. Currently, trends indicate that snow crab and blue king crab landings in the Okhotsk Sea and the biomass of mature animals in the eastern Bering Sea have been declining, whereas red king crabs have been declining in the Okhotsk Sea but increasing in the eastern Bering Sea (Figure 17).



[Figure 16] Normalized recruitment anomalies (above and below long-term averages for each species) in the Gulf of Alaska and the Bering Sea[6]

Synthesis

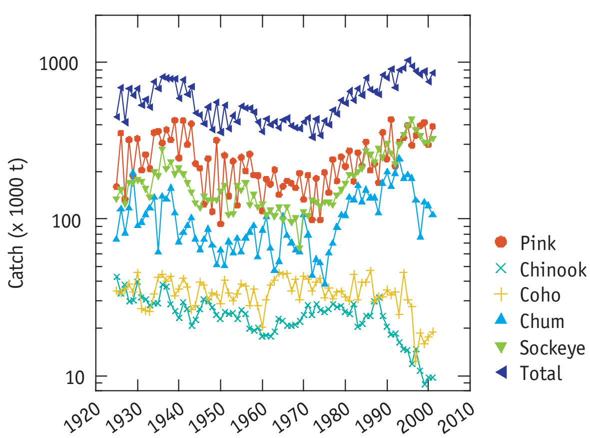




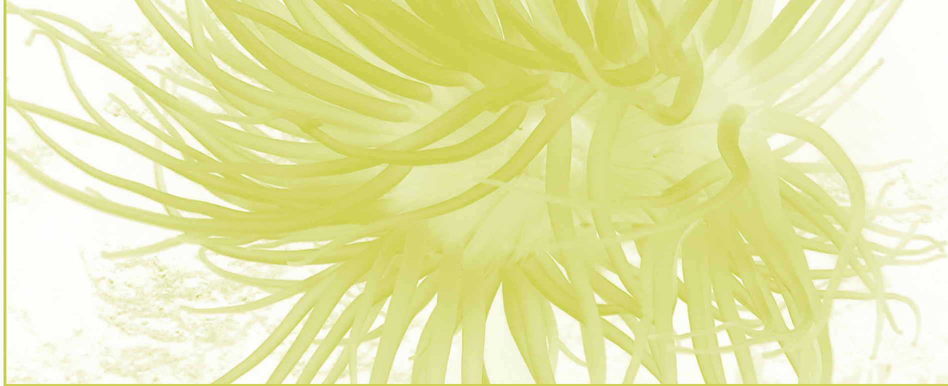
[Figure 17] Total mature biomass (t) of different species of crabs in the eastern Bering Sea.

Central Oceanic Gyres

The subarctic gyres in the western and eastern North Pacific are dominated year-round by Pacific salmon, and they are used as important summer feeding grounds by many warm-water southern species such as pomfret, saury, and tuna. Total catches of Pacific salmon in the North Pacific have been at historical high levels throughout the 1990s (Figure 18), driven in large part by large releases of juveniles (mostly chum and pink salmon) from hatcheries.



[Figure 18] All-nation commercial catches of Pacific salmon in the North Pacific Ocean.

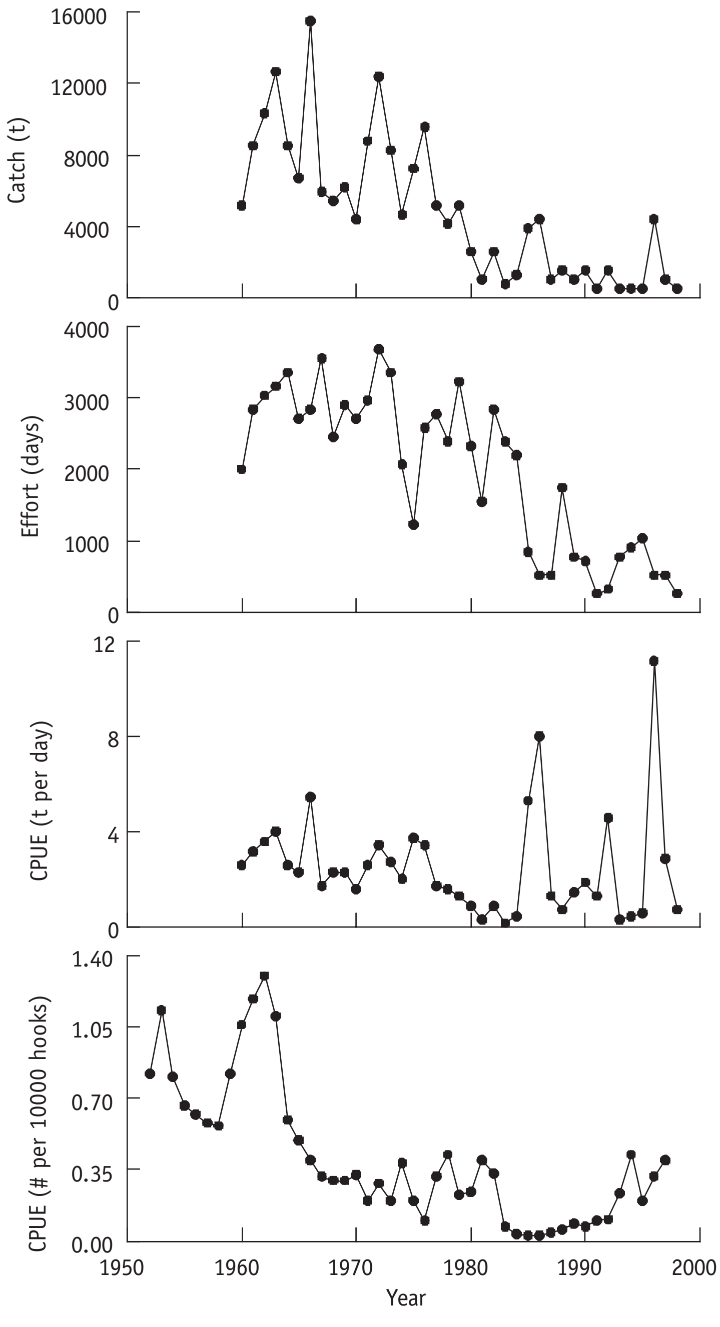


There are regional differences, however. Catches of stocks originating in the California Current System declined in the early 1990s, and some of these have been declared “threatened”, although there are signs of recovery of some stocks since 2000. Catches of salmon originating in Alaska and Russia have generally remained high since the late 1970s. Japanese catches are dominated by hatchery-reared chum salmon. Survival and year class strength of Pacific salmon appear to be determined by regional-scale variability in environmental conditions in early marine and/or freshwater rearing areas. The large abundances of Pacific salmon, however, may be limiting the growth of salmon in the ocean. Studies suggest that salmon of a given age are returning at smaller sizes[7] and that maturity is being delayed in salmon stocks throughout the North Pacific. If generally true, this would be one of the few examples of wide-scale food limitation of open ocean fish predators.

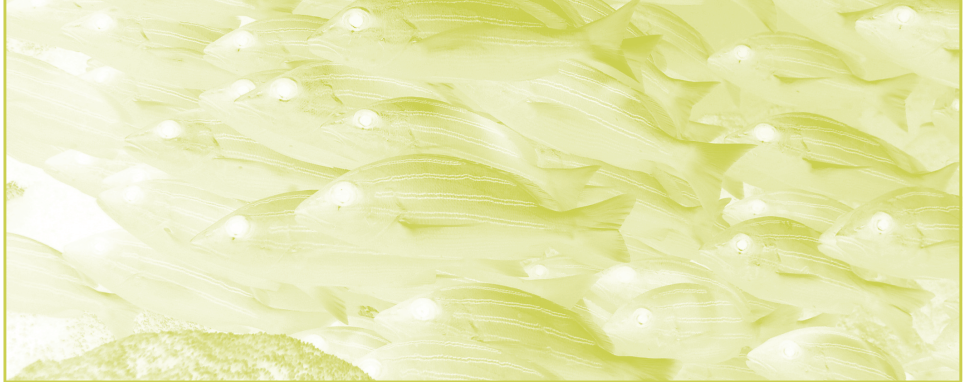
The principal species fished in the central subtropical gyre are tunas and billfishes. Of these, Pacific bluefin and albacore tuna are the most relevant to the region of PICES’ interests in the North Pacific. Time series of fishing and abundance data for northern bluefin tuna from the eastern and western Pacific (Figure 19) indicate a long period of decline since the 1960s, although with recent peaks in catch per unit of effort and abundance estimates during the late 1990s.

Temperate Coastal & Oceanic Systems

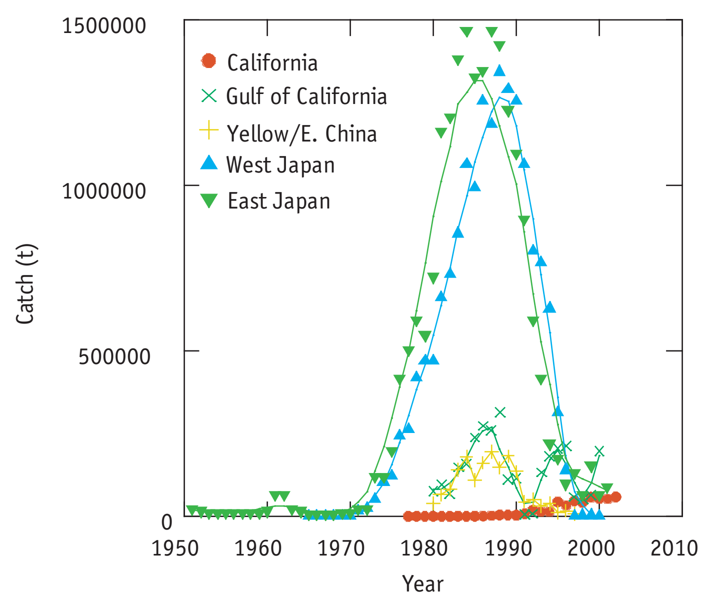
In contrast to the subarctic coastal systems which tend to be dominated by large and long-lived bottom fishes, the coastal and adjacent oceanic systems in temperate mid-latitude regions have very important fisheries for short-lived small pelagic fishes, in particular Pacific sardine and northern anchovy. Past abundances of these species have had large fluctuations,[8] often with replacements of one dominant species by others.



[Figure 19] Catch (t), effort (days), and catch per unit effort (cpue) of northern bluefin tuna in the eastern Pacific (top 3 panels) and numbers of tuna caught per 10,000 hooks in the Japanese longline fishery (bottom panel).

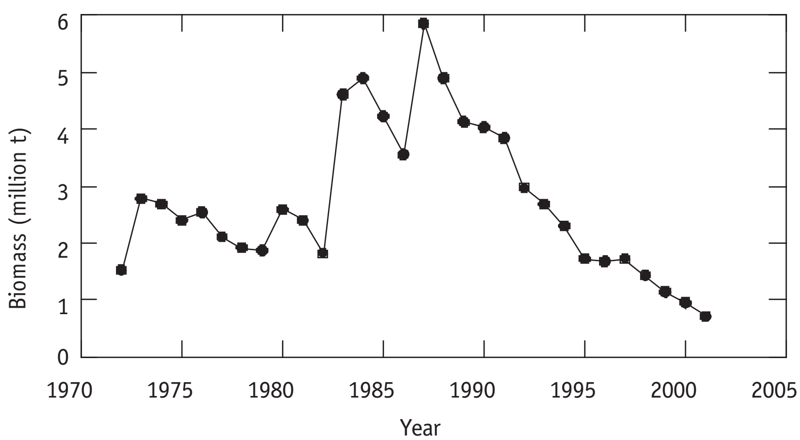


Sardine abundance in particular reached very high levels in the western Pacific (off the east and west costs of Japan, in the Yellow Sea / East China Sea) and in the Gulf of California in the late 1980s (Figure 20), then collapsed in the early 1990s and were replaced by anchovy in many regions. Sardine has remained at low biomass except in Gulf of California, where it has undergone oscillations and, as of 2000, is again increasing to relatively high abundance (although with increasing proportions of tropical sardines present). Sardine abundance in the California Current System is out-of-step with this pattern. Prior to the 1970s, the sardine off California fluctuated in phase with those populations off Japan. However, the increase in sardines that appears to have occurred almost everywhere in the North Pacific in the 1980s did not occur in the California Current System. This population began to increase in the early 1990s when the other populations were collapsing, i.e. it has moved out of phase and has been delayed by about 10 years compared with these other populations. The reasons for this are unknown, although it may be that heavy fishing in earlier decades reduced the natural resilience of this stock and delayed its increase when conditions over the North Pacific again became favourable.



[Figure 20] Pacific sardine catch trends by region around the North Pacific.

Catches of various species of squid have been increasing over the past ten years and they are important fisheries in the Yellow Sea, between Korea and Japan, in the Okhotsk Sea, off the coast of California (where it is the highest valued fishery), and in the Gulf of California. Squid catches in all of these regions show similar increasing trends, even though they represent different species. It is not clear whether these represent true increases in squid population abundances, or increased exploitation of previously unfished squid stocks.

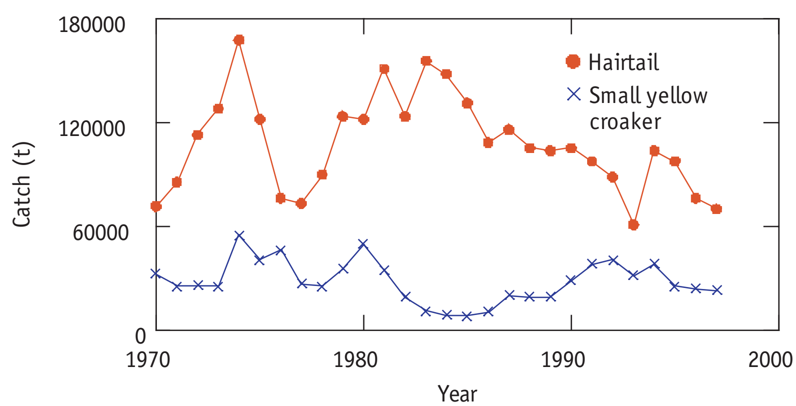


[Figure 21] Biomass of hake (Pacific whiting) in the California Current system.

In the California Current System, Pacific hake (*Merluccius productus*; also called Pacific whiting) is in the same family as the cods, but undertakes extensive seasonal migrations from California to British Columbia and has an ecological role somewhat similar to walleye pollock in the subarctic coastal systems. The biomass of hake in the California Current System has declined 80% since the mid-1980s (Figure 21). In California, total groundfish landings (excluding Pacific hake) in 2001 declined 16% from that in 2000, and declined 59% from that in 1991[9]. Rockfish (*Sebastes* spp.) in particular have shown dramatic declines since 1991 (83% decline as an aggregate group), and some species have been formally declared overfished.[9]

On the continental shelves of temperate systems, bottom living fishes are important components of ecosystems and of fisheries. In the Yellow Sea / East China Sea, catch rates (catch per unit of effort; CPUE) of hairtail (*Trichiurus leptulus*) have declined 75% since the 1980s; catch rates of small yellow croaker tripled over this same time period, but appear to have levelled off in the late 1990s (Figure 22).

In summary, it appears that stocks of most bottom-dwelling, long-lived fish in the North Pacific have declined over the past 10-20 years, and declined further within the past five years. This may be a result of both unfavourable environmental conditions affecting recruitment, such as many of the stocks in the subarctic coastal systems, and heavy human exploitation, as seen in the Yellow Sea and with rockfish in the California Current System. The two major commercial stocks that have defied this trend and remained relatively stable for the past 10 years have been Pacific halibut in coastal Gulf of Alaska and walleye pollock in the eastern part of the Bering Sea. The increase in halibut is likely due to several years of good recruitment associated with favourable environmental conditions. The stability of walleye pollock in the eastern Bering Sea may be a result of directed and very conservative management policies. In contrast, there has been remarkable synchrony in the fluctuations and their timing of small fishes in the North Pacific, in particular with warm water species such as Pacific sardine. This synchrony over such a large area suggests control by environmental factors, although the delayed recovery of sardine in the California Current System suggests that over-exploitation can have an important modulating role. Total abundances of Pacific salmon have also been very high in the North Pacific over the past 20 years, driven in large part by hatchery programs. Total abundances, however, hide significant regional differences in the health of Pacific salmon stocks. Many stocks in the California Current System experienced marked declines through the 1990s but now (since 2000) appear to be showing signs of recovery.



[Figure 22] Annual catches of hairtail (•) and small yellow croaker (x) in the Yellow Sea / East China sea.

Synthesis

Marine Mammals

Steller sea lion occur in most of the subarctic coastal regions. Most populations have declined sharply over the past 30-40 years and are currently at very low levels of abundance. Slight increases in abundance have been observed recently in the western part of coastal Gulf of Alaska. The Steller sea lion in the eastern Gulf of Alaska has not declined, but it comprises a very small proportion of the overall abundance. The cause of the decline of the Steller sea lion and other marine mammal species remains unresolved but is thought to be a combination of both human impacts and natural changes in the ecosystem.

Three mass mortalities of marine mammals have occurred in the Gulf of California within the past 10 years (1995, 1997, 1999), possibly in association with increasing incidences of harmful algal blooms. Such blooms along the California coast were responsible for mass mortalities of California sea lions (*Zalophus californianus*) in 1998.[10]