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Shrimp "utase" net fishery in Notsuke Bay, Hokkaido. "Amamo" (Zostera marina) seaweed grows densely in areas of the bay at a depth of 2 to 5 meters. These areas are a prime habitat for northern shrimp. In utase net fishery the outboard motor is tilted up to prevent seaweed from fouling the propeller and the boat driven by a sail as the net is pulled. Notsuke Bay was first developed as a fishing ground after fishermen settled here in early 1870s. The Amamo beds are a feeding ground for shrimps and other fish fry. In order to preserve fishery resources, shrimp fishery is performed only from sail-driven boats even today, with motors used only in traveling to and from the fishing grounds. For local fishermen, utase fishery boats at work have become a symbol of resource conservation (related article on pages 4 and 5).

Separated from the eastern extremity of the Asian Continent by the Sea of Japan and extending north and south over a large range of latitude, the Japanese archipelago has been home to prosperous fisheries since olden times. This prosperity has been the result of a coastal geography with good conditions for the propagation of marine life and the Japanese propensity for making full use of marine products.

(1) The Japanese archipelago was created by a complex set of orogenic movements. As a result it possesses a long, winding coastline combining outer sea, inland sea and bay type marine environments, each providing a wealth of different varieties of fishing grounds.

(2) The strong, large-scale warm Kuroshio current flows north along the Pacific coast and the Tsushima warm current, a branch of the Kuroshio, along the Japan Sea coast of the Japanese archipelago. This Kuroshio system carries all varieties of fish eggs and fry from the southern spawning grounds and distributes them throughout Japan's coastal waters. It also serves to bring large migrating fish like skipjack and tunas in schools to Japan's coastal waters.

(3) The cold Oyashio current flows south from the Bering Sea and the northern Pacific to wash the northern half of the archipelago's Pacific coast from the eastern coast of Hokkaido to the Sanriku coast of Honshu. This Oyashio is rich in nutrient salts that nourish large quantities of planktons that in turn support the propagation of fishes.

(4) In the waters where the Kuroshio and Oyashio currents meet, large and complex tidal zones are formed to make extremely rich fishing grounds.

(5) The Japanese islands are very mountainous, with plains and flat valleys constituting only 14% of the total land area of the country. Due to this limited usable land area, animal husbandry never developed in Japan until recent years. Thus, the Japanese sought sources of protein for their diet in the fishes, shellfishes and crustaceans and even seaweeds of the abundant sea, all of which they refer to as "umi-no-sachi" or "gifts of the sea".

(6) The Japanese have also used fishes for other purposes. Until the development of chemical fertilizers in recent years, mass-catch fish such as sardine, saury and herring were an important source of fertilizer for agriculture. Today they are used in large quantities as feed for aquaculture and as bait.

The commercial value of marine products does not remain constant but changes with the demands of the times. These changes, however, are not limited to the economic laws of supply and demand. It is not unusual for improvements in fishing technology to lead to changes in supply structure that in turn cause changes in product value. An example is tuna, which in olden days did not command a high price in the fish market. The development of on-board freezing and refrigeration technology made tuna a viable product for the high-priced "sashimi" (raw fish fillets) market.

This made tuna an object for highly profitable fishery and led to the growth of an ocean-going longline tuna fishery industry.

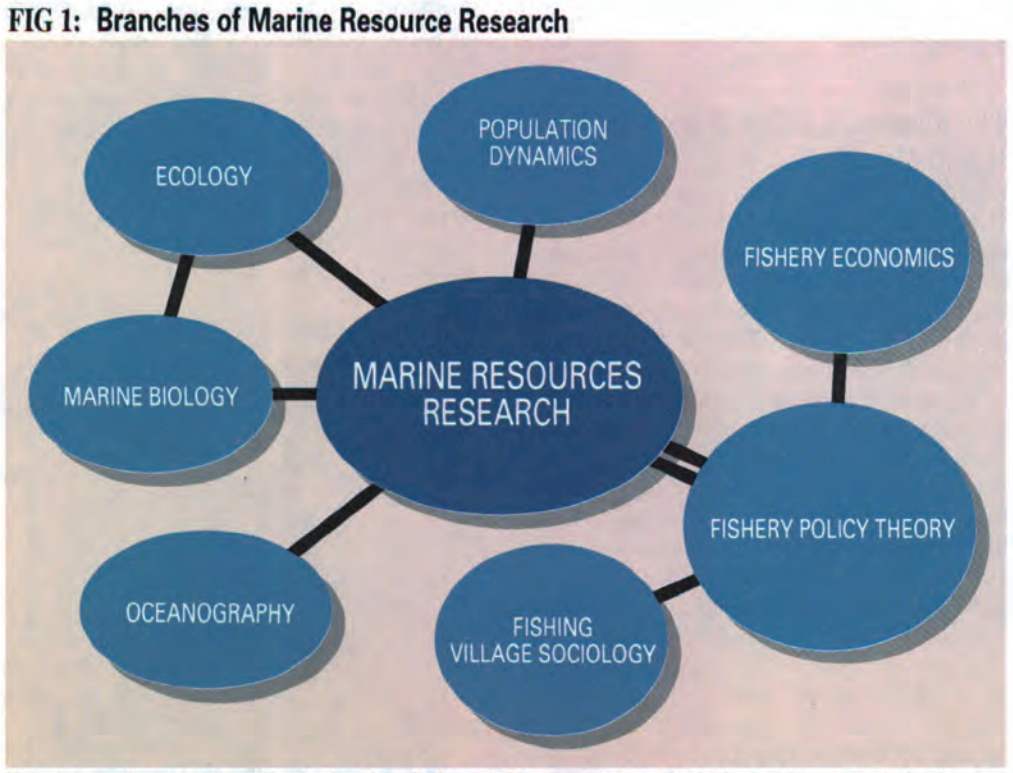
In the case of surume squid, most of which used to be processed into dried squid, the development of freezing and refrigeration enabled a distribution network that now supplies fresh surume squid throughout the country, thus leading to a dramatic increase in market price.

On the other hand, kuruma prawn, which was once a high-priced delicacy has undergone a big market expansion and is becoming a moderately priced popular food thanks to the import of cultured prawns from overseas in recent years.

One of the main characteristics of fishery as an industry is the cyclical fluctuations in production as a result of alternating good and poor annual catches. Some species are particularly susceptible to overfishing that can deplete the fishery resources, while in other cases large-scale changes in the sea environment can also cause drastic changes in resources. With fishery and marine food processing developed into large industries as they are today, such changes in marine resources can have a major effect on human society.

Research in the two areas of resource conservation and stabilization of fishery industry economics has taken on an extremely important role today. Depending on the species and life environment, each fishery product has its own unique resources structure and characteristics. Furthermore, the amount of consumption and commercial value of marine products varies from country to country and culture to culture, meaning that problems of marine resources must be approached from a multi-faceted, overall viewpoint that includes scientific, social, economic, political and cultural considerations. (**FIG. 1**) When this study is undertaken, it reveals a grand-scale drama of mutual interaction between the productivity of nature and the productivity of man. In this issue we will look at some aspects of this grand drama by investigating some of the topics involved in the problem of marine resources.

FIG 1: Branches of Marine Resource Research



Maintaining a close connection with other branches of science enables one to increase the depth of one's research. And, it is only through repeated integration with research on social and economic issues that one can offer truly practical theories to society.

The mystery of nishin

Overfishing, or changes in the ocean environment?

The name Hokkaido means the land of the northern sea. And as the name suggests, it is Japan's northland. When you travel along the west coast of Hokkaido today through such towns as Esashi, Yoichi, Otaru and Mashike, you will see here and there large old homes called "Nishin (Pacific herring) Goten (mansion)". These mansions are usually built on high land overlooking the sea. Larger and more extravagantly built than most homes, these were the homes of the "oyakata" or masters of the set net nishin fishing operations that once prospered all along the west coast of Hokkaido, and included boarding rooms for the "wakaishu," or hired fishermen. But when the nishin fishery failed both the "oyakata" and the "wakaishu" were driven from their livelihood and most of the mansions fell into disrepair. A few, however, have been restored as local attractions visited by sightseeing tour groups.

The first records of nishin fishery in Hokkaido date back to about the middle of the 15th century. In the latter half of the 19th century set net became the main fishing method and the catch grew year by year, recording a peak of 975,000 tons in 1897. Beginning around the year 1910, however, drastic fluctuations appeared in the annual catch and the overall trend shifted toward smaller catches. Gradually the fishing grounds in the southern areas of Hokkaido stopped yielding viable catches and finally, in the year 1954, with a catch of only 100,000 tons the nishin fishery industry went completely out of business on the western coast of Hokkaido. (**FIG. 2**)

Here is a school composition written by the 12-year-old son of a fisherman in the days when the nishin industry was suffering from successive years of poor catch.

"The nishin catch is so bad at Bekkari village that father and mother have given up all hope. The school trip that we were looking forward to every day has been cancelled because of the poor catch. Everyone is so disappointed. The young people have started going back to their home towns. They have had such a hard time that they all say as they leave that they won't come back to Bekkari at all next year. The nishin have just stopped coming to Bekkari completely." (From the report of Mr. Tsuguo Ando, a reporter)

Was it true that the nishin had stopped coming to Bekkari completely? Let us begin this report by questioning this boy's anguished protest.

Distribution and life cycle of Pacific herring

Nishin is a cold current migrating fish that originates in the Arctic Ocean and is divided into two genera, Pacific herring, *Clupea pallasii*, and Herring, *Clupea harengus*, in the Atlantic. Pacific herring inhabit the coastal waters of both the Asian and American sides of the north Pacific, with their area of distribution extending from the Pacific through the Bering Sea and into the Arctic Ocean.

With regard to the location of spawning grounds and migration routes, the nishin are divided into a large number of distinct groups, or populations.

First of all, the populations can be divided into two major groups depending on their life cycles. These include: **1)** populations that migrate over large offshore areas and show large fluctuations in the amount of resources, known in Japan as offshore type nishin and **2)** regional nishin that migrate over a smaller, confined area and represent only a small amount of the resources. The regional type can further be divided into lake type nishin that spawn and migrate in the low-salinity waters of lakes, the inner parts of bays or marshes and the coastal type which limit their habitat to a specific area of coastal water. The Hokkaido spring nishin that we will investigate in this issue are designated as offshore type nishin resources that are believed to spawn along the Japan Sea coast of Hokkaido, the coasts of the Okhotsk Sea and the east and west coasts and southern end of Sakhalin and to migrate through the Japan Sea, the Okhotsk Sea and the Pacific. This particular population is named the Hokkaido Sakhalin Population.

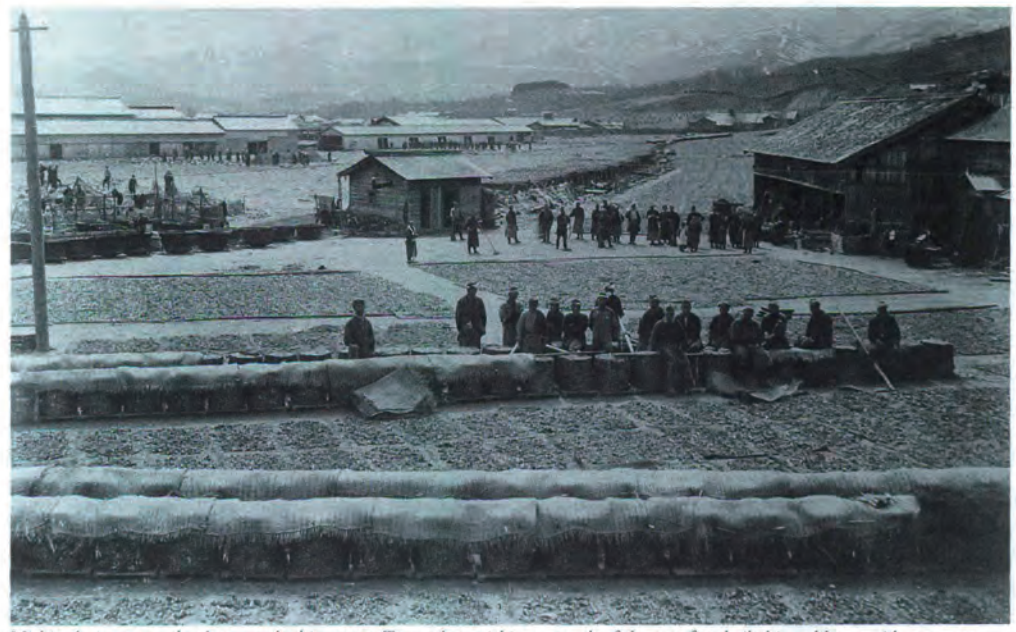
Nishin migrate to their spawning grounds in schools in the northern hemisphere's spring months of March through May. The spawning grounds they choose are rocky and gravelly bottom areas with seaweeds at a depth of less than 15 meters. The females lay their eggs on seaweeds and the males release their sperm in the surrounding water to fertilize them. When the spawning school is large enough the males' sperm turns the water of a whole area whitish in color.

When the larva reach a body size of 9~10 mm they begin to move about actively and leave the seaweed where they hatched and begin migrating in search of food. Much of the life cycle after that has been proposed but is still unknown. However with regard to the Hokkaido Sakhalin Population the hypothesis Yamaguchi, M (1926) is most widely accepted.

According to his theory, the larva that hatch along the west coast of Hokkaido migrate east along the Okhotsk coast and then out through the Kurile Islands into the Pacific where they migrate over a large area in a clockwise direction along the coasts and offshore waters from Hokkaido down to the Sanriku coast of Honshu for a period of about two years.

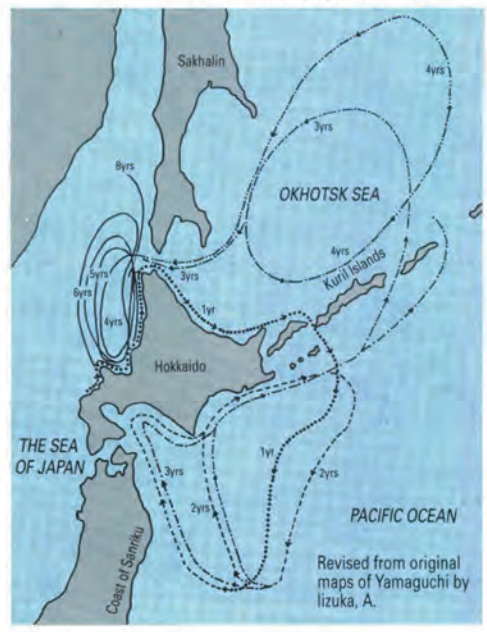
After this the fish return to the Okhotsk Sea where one group will return to the Japan Sea to spawn the following spring as three year-olds while the other remains for one more year in the Okhotsk Sea before entering the Japan Sea the next year to join the spawning stock.

After spawning, the fish spend the summer in the offshore waters of the Japan Sea before migrating south in the fall and returning to the coastal spawning grounds once again in the spring. This pattern is then repeated every year, making the nishin the object of fishery every spring.(**FIG. 3**)



Nishin drying grounds photographed in 1917. To produce nishin scrap, the fish were first boiled in caldrons with sea water, pressed to remove the oil and finely chopped up with knives before being spread out on the drying grounds to be sun-dried for several days. Five tons of fish were required to produce one ton of dried scrap. The dried scrap was then used as fertilizer, the demand for which continued from all parts of Honshu well into the 20th century.

FIG. 3: Proposed migrating courses
for Hokkaido-Sakhalin population nishin



Nishin are surface water migraters by character, but in the cold water season both the immature and mature nishin will move to deeper waters to spend the winter. As for feeding habits, from the larva and juvenile to fry stages nishin feed primarily on the crustacean *nauplius* or the *copepoda* and as adults they mainly feed on *copepoda* and krill as well as small crustaceans and fish fry. Nishin have a life span of about 17 years, but they only form the schools that make them a viable object of fishery until about their eighth year.

The history of nishin fishery in Hokkaido

In the past Hokkaido was Japan's frontier. The native Ainu people of the island lived mainly on fishing and hunting in the times before recorded history, which began with the arrival of people from Honshu at the end of the 16th century. The first governor, Yoshihiro Matsumae, ruled from his castle in the Matsumae area of southern Hokkaido and had a monopoly on trading rights with the Ainu. One of the principal goods traded was nishin, which the Ainu caught using their canoes and scoop nets. The trade led to territorial exploitation and disputes and eventually, the governor established a system to allocate fishery operating territories by contract to individual merchants and exact an operating tax. This system encouraged operators to develop new fishing grounds in remoter areas and to hire Ainu laborers or bring in laborers from Honshu to expand their production. In the nishin fishery scoop nets were soon replaced by gill nets and seine nets, and by the end of the 18th century the seine nets had evolved into simple set nets. These set nets had a much better catching capacity than gill nets and this fact often led to conflicts between their operators and other fishermen using gill nets. However, by the middle of the 19th century set nets were officially recognized.

There are two main factors that caused nishin fishery to prosper in Hokkaido.

(1) Increase in the demand for fish fertilizer. In the 17~19th centuries commercial agriculture for cash crops like cotton, indigo and mandarin oranges that developed in the Osaka and Kyoto areas of Western Japan required large quantities of fertilizer. Scrap nishin along with scrap sardine were considered valuable fertilizers.

(2) The development of marine shipping.

In the middle of the Edo period (1603~1867) a sea route on the Japan Sea was developed connecting Hokkaido with the main island, Honshu. Ships called "Kitamaebune" and sailing ships sailed regularly carrying Hokkaido products from the three ports of Matsumae, Esashi and Hakodate to Kyoto and Osaka. The Kitamaebune reached the peak of their activity from the late 18th century to the late 19th century. The resulting influx of culture from Kyoto and Osaka caused these three southern Hokkaido ports to flourish.

The defeat of the Tokugawa rulers in 1868 brought an end to Japan's fuedal system of government. The new Meiji government soon did away with the old order of things, including priviledged operators in the Hokkaido nishin trade. This freed the industry from restrictions, resulting in a sharp increase in the number of set net operations along the west coast of Hokkaido (**FIG. 4**)

Furthermore, under the new government's policy of "respect for traditional values," the old operators under the privileged territory system were given an advantageous position in the new system that enabled many of them to expand their fishing grounds to new areas.

Nishin set net operation requires a large investment and a large labor force. To operate one set net requires from 20~25 fisher-

FIG. 2: Historical change in the catch of nishin

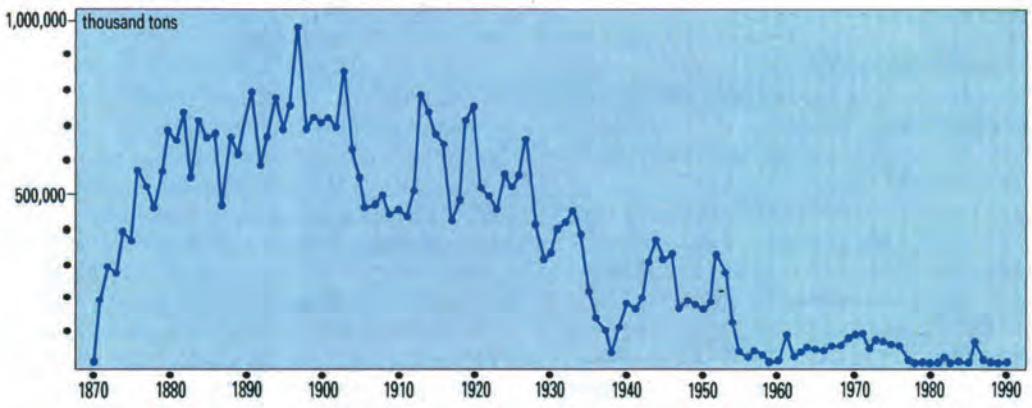
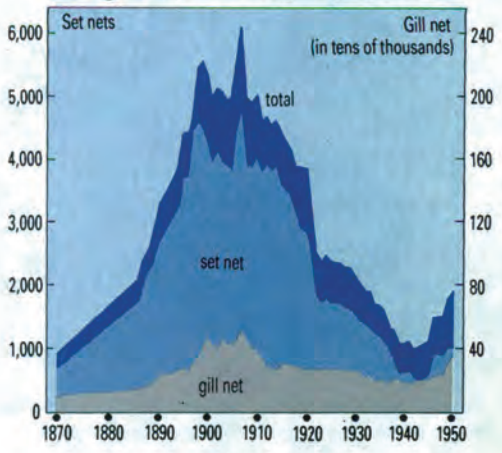


FIG. 4: Changes in number and type of gears (Hokkaido herring fishery) (After Ishida, A)



All of the work of set net fishery was performed manually. Strong younger men pulled in the nets at the instruction of the master fisherman, herded the fish into bag nets and transfered them by means of scoopnets to framed nets for transporting. The working song "soran bushi" sung by these fishermen to keep their actions in unison lives on today as a Japanese folksong.
(Photos courtesy of the Yoichi Fisheries Museum)

men and boat operators. The "oyakata" who managed a fishing operation would hire seasonal workers from Hokkaido or Honshu to work his nets. A powerful "oyakata" would manage as many as 20~30 sets of nets and hire as many as 500~600 fishing hands each season. In time, small investors turned the nishin fishery into a commercial industry. In the era when catches were constantly good year after year, a syndicate of investors in Otaru supplied financing for the nishin set net industry. In contrast to the "nishin fishing ground oyakata", these investors were called the "financing oyakata".

At the same time, a class of fishing labor that engaged in gill net or longline fishery part of the year and were hired by the "oyakata" during the nishin season was formed.

What caused the onset of drastic fluctuations in catches

What causes increases and decreases in fishery resources. Is it caused by effects of fishery catches or by changes in the natural environment? This question has constantly been a point of contention between marine resource researchers over the years. This is also true in the case of Hokkaido spring nishin. On the one hand there are specialists who believe the Pacific herring resources were destroyed by fishery. According to this theory years of excessive catching depleted the spawning grounds of the Hokkaido Sakhalin Population to the point that the population's ability to reproduce at a sufficient rate to replenish the population was destroyed. On the other hand, there is a theory that ascribes the resource depletion to changes in the sea environment. According to this theory, changes in the size of the cold-current nishin resources have been inversely proportional to changes in the warm-current sardine resources. This theory is based on the assumption that global-scale patterns of ocean cooling or warming have resulted in the increase in resources of well-adapted species and decrease of species poorly adapted to these changes.

Of these two theories, the former is based on the concept of a "density dependent function," which hypothesizes that the size of a population for a certain species is determined by the relationship between the numbers of adult and young. As long as the size of fishery catches corresponds sufficiently to the size of the annual population increase, the natural reproductive potential of the resources is maintained.

However, when catches exceed this limit and adults are caught in excessive numbers, the spawning magnitude decreases, the supply of new larva and juveniles becomes restricted and the growing grounds for the young become reduced in area. In other words, the reproductive potential of the resources depends basically on the density of the population.

In contrast to this, the latter theory hypothesizes that the size of the resources is controlled by the magnitude of year classes in the population. This is based on the theory proposed by Hjort, J. concerning Atlantic herring. It was made clear, after investigating the age-structure of herring or sardine catches, which are usually accompanied by large fluctuations, that once a large year class appears, it will remain an outstanding component of catches throughout its life. This large year class is called a dominant year class (**FIG. 5**)

When dominant year classes appear in successive years, the size of resources increase dramatically as a result. On the other hand, when only small year classes appear for several years, the resources decrease rapidly. The question, then, is what causes a dominant year class to appear. If a particular year class is blessed with suitable water temperatures and plentiful food in the fry stage, the mortality rate will drop and a large year class population will result.

If these requirements are not met the size of the year class population will be reduced greatly. Since the size of resources is determined largely by the conditions of the sea environment in the fry stage, it is said that the relationship between parent and young generations can be virtually ignored.

Researchers on both sides of the fishery effect theory and environmental change theory argument have continued to work to find evidence to support their respective theories. All marine animals have evolved to fit the requirements of their respective natural environments, and every species has secured its own ecological niche in order to survive. (**FIG. 6**) Fish like nishin and sardine that feed on planktons have a high reproductive capacity but their ecological niche is relatively unstable and subject to unpredictable patterns of large, cyclical changes. In contrast, fish higher up on the food chain like tuna and flounder are less productive but have a more secure ecological niche. Although they are not subject to large natural fluctuations, they are more susceptible to mortality caused by fisheries. These two hypotheses, concerning resource fluctuations, each contains a certain amount of truth.

A researcher at the Hokkaido Prefectural Fisheries Experiment Station at Wakkanai, Mr. Shuka Maruyama, feels that there is some evidence of a recovery in the Hokkaido spring nishin resources. Since the disappearance of the large spawning schools of the Hokkaido Sakhalin Population, some localized catching of Pacific herring has continued at places like Lake Akkeshi, Atsuta and Lake Kumatori, but the total catch has remained at levels from several thousand up to 40,000 tons. However, in 1985, the Hokkaido Sakhalin Population began to reappear. According to a report from the Wakkanai Fisheries Experimental Station, the fishing conditions are as follows:

The population appeared that year, 1985, on the Japan Sea side of Hokkaido, after which it moved out into the Okhotsk Sea. The following year, in 1986, about 70,000 tons were caught by offshore bottom trawlnet fisheries in the Okhotsk Sea. Then, in 1987, an additional 2,000 tons were caught primarily in the Japan Sea. However, in 1988 no spawning population appeared. The fish caught were from the large year class of 1983. This year class yeilded a total catch of about 100,000 tons by 1989.

In the past, spring nishin fishery was conducted by means of set nets or gill nets waiting to catch mature fish that came to the coasts for spawning. In recent years, however, about 90% of the nishin catch is caught by offshore trawlnet fishery. Because this fishing method catches immature fish in offshore waters, it is thought to have some detrimental effect on the population in this critical period of resource recovery.

In the future, fishery resource research will surely evolve in a direction which can explain the dynamism between the biological characteristics of each fish species and the sea environment. This will then enable researchers to propose methods of fishery management that fit the characteristics of each species and its resource structure. When this happens, however, the most difficult problems will involve settling the sharp conflicts of interest that are sure to arise between different fisheries.

Economic survival in the fishing community

In the years from the 1940s to the mid-50s, spring nishin fishery accounted for 20% by volume and 10% by market value of the total fishery output for Hokkaido. This nishin industry employed aproximately 60,000 workers, half of which were seasonal laborers from other regions. With the collapse of the nishin fishing industry shortly thereafter, the "oyakata" went out of business and the seasonal laborers moved to other parts of the country.

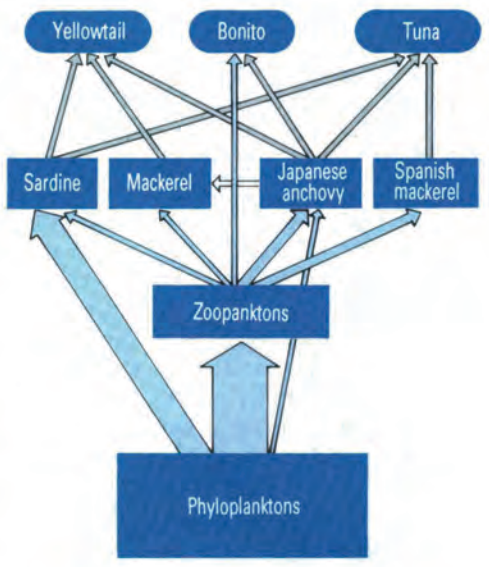
Those who remained in the area were local fishermen who had no other alternative but to stay on their home shores. Having lost the major income from nishin, these fishermen engaged in other fisheries for half the year and went off to seek other jobs for the remaining half. The alternative employment they found during the coastal fishery off-season included work at farms harvesting potatoes or at starch factories in the interior or work on ocean-going north sea fishing boats.

Entering the 1960s, the Japanese government undertook a program to strengthen productivity in coastal fishery as part of its fishery policy. This program helped fishermen gradually increase their productivity through the modernization of their small-size fishing boats and improvement of fishing port facilities. Presently there are some 66 fishery cooperatives along the west coast of Hokkaido with a total of about 14,000 member fishermen. This represents 51% of Hokkaido cooperatives and 46% of total members. Their annual catch, however, represents only 17% by volume and 28% in terms of market value of the Hokkaido fishery total. Because this region lacks a main fishery such as salmon set net, sardine purse seine or scallop beam trawl, the fishery scale tends to be small. In the coastal fishing grounds here, fishermen engage in a wide variety of fisheries including basket net fishery for shrimp, gill net fishery for flounder and cod, octopus fishery, abalone diving and sea urchin diving.

The efforts by the local fishermen to establish new fisheries since the nishin decline include: **1)** changing from longline to gill net fishing methods, **2)** developing shrimp resources through the basket net fishing method, and **3)** releasing salmon and flounder fry in an attempt to increase resources of those fish. **FIG. 7** shows the structure of Hokkaido's total fishery production by type of species. Individually, the various resources show ups and downs, but taken as a whole these trends can also be seen as part of a larger cycle of change that involves both changes in the natural environment and the history of man's fishing efforts. Some day spring nishin will probably return to the shores of western Hokkaido.

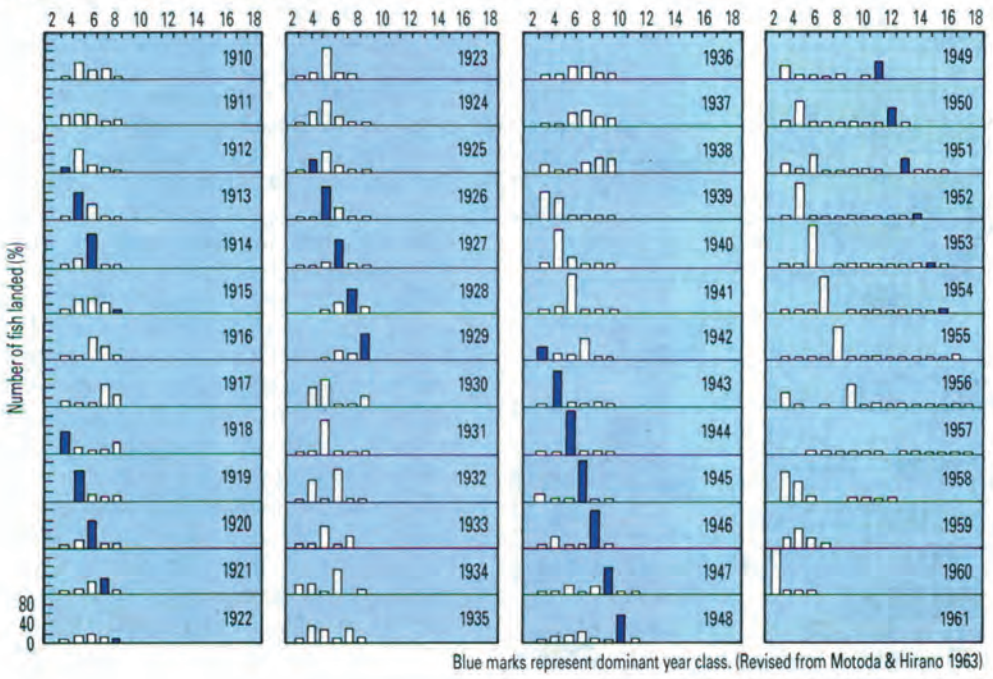
But never again will grand "Nishin Goten" be built on the profits of nishin fishery. The social structure of the fishing villages has changed too much for that. To make effective use of the restored nishin resources will require a new fishery system and a new system of processing and consumption.

FIG. 6: Food chain for marine organisms



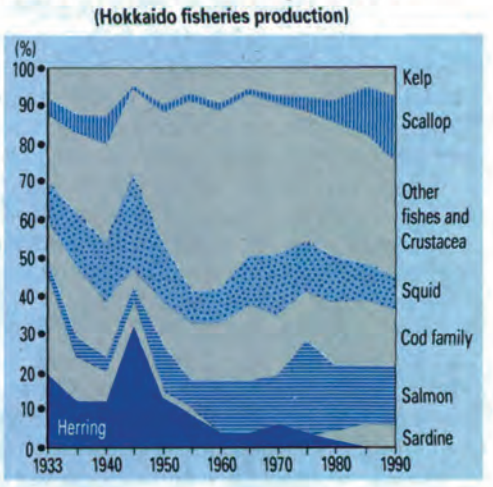
For the pelagic fish community in Sanriku offshore waters
(By Kawasaki, T.)

FIG. 5: Change in age composition of Hokkaido-Sakhalin nishin



Blue marks represent dominant year class. (Revised from Motoda & Hirano 1963)

FIG. 7: Economic yield by species
(Hokkaido fisheries production)



EXAMPLE 1

The Notsuke Fisheries Cooperative Association of Hokkaido

Fisheries nurtured by t

FIG. 8: Location of Bekkai Township.

About a hundred years ago the east coast of Hokkaido was nothing but an expanse of virgin forests of fir, silver fir and Japanese oak, and wetlands covered with different-colored flowers in summers. For the native Ainu people whose villages dotted the area, the salmon that climbed its rivers in autumn were an important source of food.

With the change of government in Japan in 1868 and the beginning of the country's modernization, the east coast of Hokkaido became a base for two new undertakings. For one thing, it became a base for north sea fisheries venturing out into the Pacific and the Okhotsk Sea, with Nemuro and Kushiro flourishing as the region's main ports. Secondly, the region became a transit base for settlers headed for the northern islands of Kunashiri and Etorofu. The Notsuke area in the town of Bekkai that will be discussed here was once such a transit port for boats carrying settlers to the northern islands.

Situated in the center of the plain that lies between the Shiretoko and Nemuro Peninsulas, Bekkai has an area of some 1,320 square kilometers, the largest of any township in Japan. Having a low average temperature of 4~6° C for the year and a relatively low annual rainfall, the inland areas of the township have been developed for dairy farming. In 1973, a national government project invested some ¥93.5 billion to clear virgin forest to make pasture land for a large-scale dairy farming community.

The result was a total of 94 farms of 50 ha. each on which each farming family cared for some 60 to 70 cattle under a modern dairy farming system.

The township's other industry comparable in size to this dairy industry is coastal fishery. At present there are 262 full-time fishermen among the registered members of the Notsuke Fisheries Cooperative Association. In All, the cooperative has 530 registered fishing boats, all of which are under 20 tons and used for various types of coastal fishery. In recent years, the town's farming industry has a total production of about 40 billion yen, while the coastal fishing industry has a production of about ¥10 billion.

Fishery has a longer history than dairy farming in Bekkai. In about 1887, some 20 families settled in what is today the Notsuke area of Bekkai and began fishery. Off the coast of Bekkai lies a peninsula that looks something like a shrimp when seen on a map. This 28 km-long peninsula is in fact a sandbank created by sands carried there by the ocean currents.

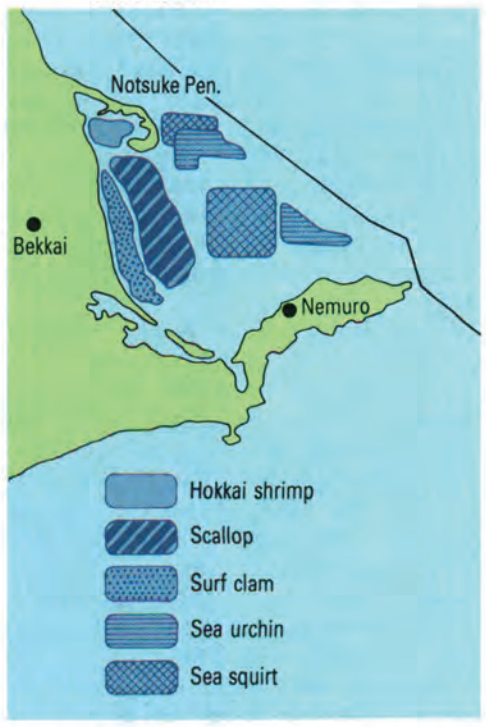
On the landward side of the peninsula is a large, quiet bay that attracts many kinds of fish. Also, the inner portion of the bay is thickly covered with seaweed beds in which shrimp proliferate. The original settlers used gill nets or small-scale set nets to catch herring, salmon, flounder and other miscellaneous fish. Later they developed a fishing method called "ho-utase-ami" sail trawling fishery to catch shrimp.

The fishermen here organized themselves into a producers cooperative very early on, in 1908. But, due to their limited capital resources they were unable to undertake any substantial cooperative projects. As a result, they remained confined to a very difficult existence which involved working part of the year as hired laborers for the large-scale salmon set net fisheries operated by small investors from Nemuro and conducting their own small fishing operations during the rest of the year while buying food supplies and fishing gear on credit against the money they received for their catches from merchants in Nemuro. This situation continued from the late 19th century until the end of World War II in the 1940s. However, throughout this period the fishermen of Bekkai continued to develop new fishery resources and new fishing methods for new species of fish, opening the way toward the viable self-employment in fishery they enjoy today. (**FIG. 9**)

In coastal fishery the primary objective is to make use of the greatest potential of the available fishery resourses while maintaining a sustainable state of balance with the reproductive capacity of the limited coastal fishing grounds. In order to do this it is necessary to establish regulations concerning the use of the fishing grounds and, at the same time, to improve the productivity of the individual fishermen. In the following, we will look at some of the developments and disappointments, and eventual recoveries experienced by the Notsuke Fisheries Cooperative over the years in their attempts to fulfill the goals of coastal fishery.

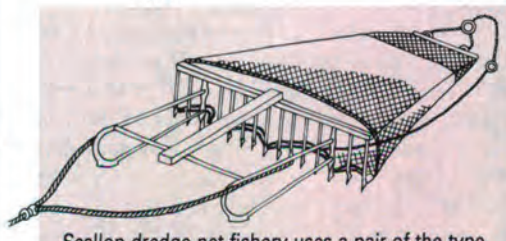
Fishermen haul in a salmon set net. The east coast of Hokkaido is the first area reached by chum salmon returning from migrations in the North Pacific and 30% of the nation's salmon catch is caught by the set nets here on along this coast. (Photo curtesy of Bekkai Township.)

FIG. 9: Distribution of major fishery resources



Fishery in the Notsuke area has long been based mainly on a combination of the main set net fishery for salmon that come to the area's coasts and supplementary fisheries for sedentary species living within Notsuke Bay, such as sea urchin, scallop, surf clam and shrimp plus other fishes like flounder, wachna cod and surf smelt. (**FIG. 10**)

FIG. 11: Fishing gear for scallop dredge net



Scallop dredge net fishery uses a pair of the type of net shown in the above diagram pulled by a 5~10 ton motorized boat along the sea bottom in sand and pebble bottom areas. This net consists of a set of teeth for raking the sea floor, an iron frame to stabilize the net and a bag net to hold the catch. The bottom section of the bag net uses a wire netting. Because this is a highly effective fishing gear, the danger of depleting resources with its use is extremely high. In Japan there are strict regulations governing the fishing season, catch volume and size of mesh used with this net.

FIG. 10: Types of fishery and fishing season

		Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Outside bay area	Salmon set net									■	■		
	Scallop dredge net	■	■	■	■	■	■	■					■
	Surf clam dredge net			■	■	■							
	Tsubugai dredge net				■	■							
	Sea squirt dredge net									■	■		
	Sea urchin dredge net		■	■	■	■							
Inside bay	Hokkai shrimp sail-trawl						■	■			■	■	
	Clam fishery	■	■	■	■	■	■	■		■	■	■	■
	Small-scale set net (miscellaneous fishes)	■	■	■	■	■	■	■					■
	Gill net (wachna cod, ect.)	■	■	■	■	■	■	■				■	■
	Flounder gill net			■	■	■							
	Japanese surfmelt boat seine			■	■	■						■	■

While on the one hand these improvements increased catching ability and extended the fishermen's operational range out into the outer sea areas, it also led to aggressive competition with fishermen from neighboring fishery cooperatives that eventually depleted the resources in the fishing grounds so severely that a complete stop had to be called to all scallop fishery in 1976.

At the same time scallop dredge net fishery was on the decline in the 1970s set net fishery for salmon was growing rapidly. This was the result of a successful government program to increase resources through releases of salmon fry (**FIG. 12**). The Fisheries Cooperative took advantage of this favorable situation to begin efforts in the following way to replenish their scallop fishing grounds and establish a new system of fishing ground use:

1) The first act was to organize their salmon set net operations into a cooperative fishery. Traditionally, salmon set net fishery in the area had been controlled by a small number of operators who held the set net fishing rights. But under their new policy, the cooperative made efforts to subdivide the set net fishing rights in order to include more fishermen every five years when the fishing rights came up for renewal, and in the process revise the fishery management system into a cooperative type. (**FIG. 13**)

2) Next, the cooperative initiated a system

ne environment

FIG. 12: Size of catch by year

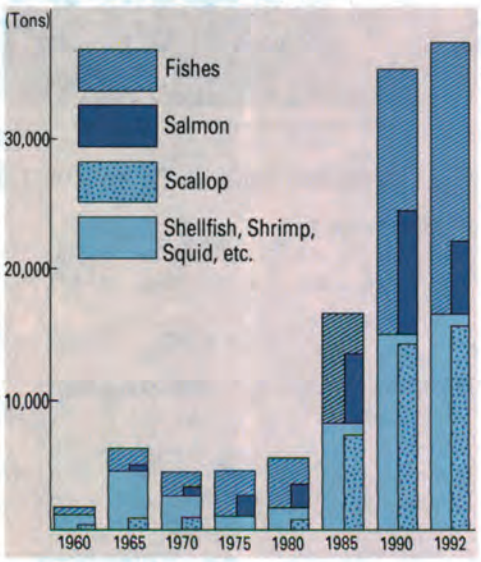
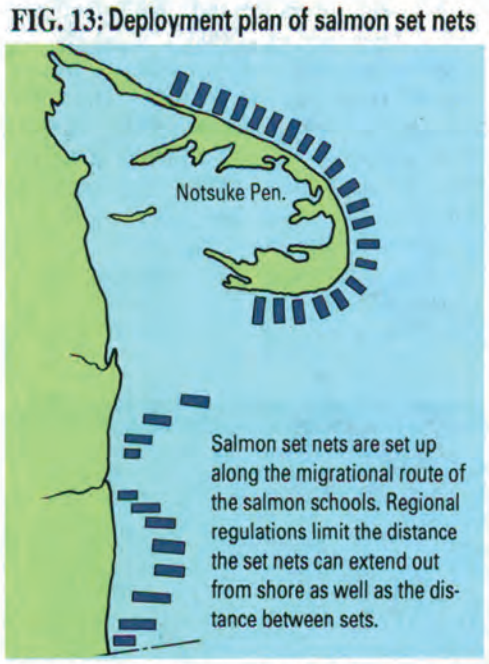
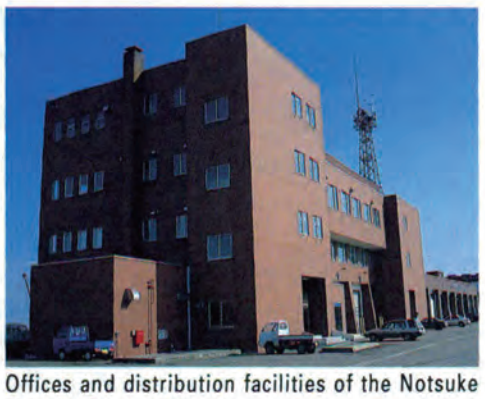


FIG. 13: Deployment plan of salmon set nets



that limited each member's right to engage in the various types of supplementary fishery based on their yearly income from salmon set net fishery. For example, a fisherman whose income from salmon set net over the previous five years exceeded ¥25 million would be prohibited from engaging



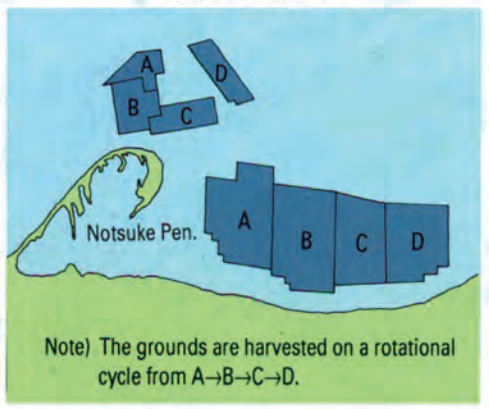
Offices and distribution facilities of the Notsuke Fisheries Cooperative.

Landing a scallop catch. In general, Japan's fishing villages have a problem maintaining a young workforce, as many young people leave to seek work in the cities after their schooling. Thanks to the success of its coastal fisheries, however, one sees many young people at work in Notsuke.

in any other type of supplementary fishery. Under this system, salmon set net income was divided into eight income brackets and the types of supplementary fishery that a fisherman from each bracket could engage in was decided annually by the cooperative's fishery rights management committee.

3) In order to revive the scallop resources of the area, efforts were begun to create designated fishing grounds and the release of scallop seeds was begun in 1973. At this five fishery cooperatives in the area including Notsuke formed a union for the purpose of organizing the area's scallop fishery into one cooperative industry. The fishing grounds were then divided into four sectors to be fished on a rotational basis (**FIG. 14**) by a prescribed number of fishing boats, each carrying a five-man crew and operating under a cooperative management system based on yearly production planning. Furthermore, provisions were made for the scallop catch to be landed only at Notsuke

FIG. 14: Designated fishing grounds for scallop propagation



Note) The grounds are harvested on a rotational cycle from A→B→C→D.

Notsuke Peninsula sandbank

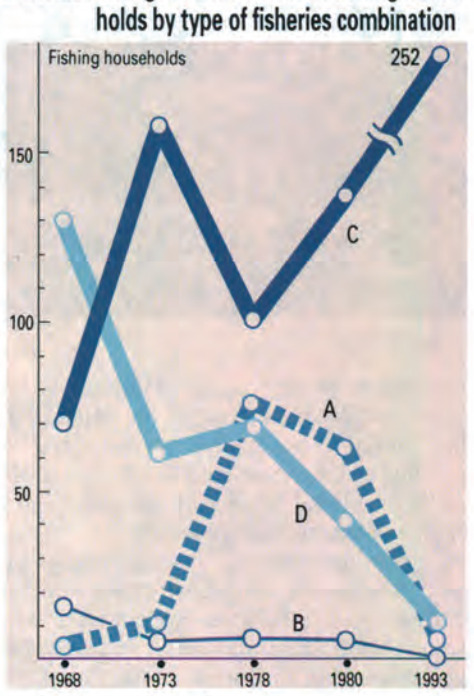
harbor to allow for more complete control and regulation of catches.

All of these measures have been adopted for the purpose of dividing up the fishing rights of these important high-profit fisheries in a way that evens out incomes while also coordinating fishing efforts in such a way as to prevent overfishing with regard to the different fishery resources.

These policies of the union are all based on a philosophy of sharing the wealth of the region's fishing grounds in a spirit of mutual cooperation without sacrificing the independence of the individual fishermen.

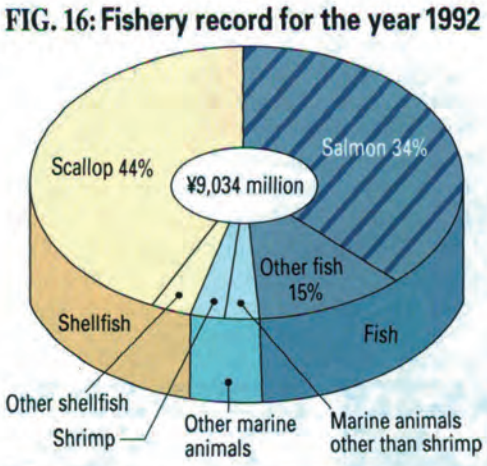
In the past, the principal combinations of fishery that fishermen of the Notsuke region engaged in included A) only salmon set net B) salmon set net plus offshore fishery (salmon drift net), C) salmon set net plus scallop dredge net, etc. and D) fishery combinations that included no salmon set net. As shown in **FIG. 15 & 16**, however, a central core of fishing families engaging mainly in

FIG. 15: Change in the number of fishing households by type of fisheries combination



A. Salmon set net only
B. Salmon set net plus offshore fishery
C. Salmon set net + coastal fishery
D. Fisheries not including salmon set net.

FIG. 16: Fishery record for the year 1992



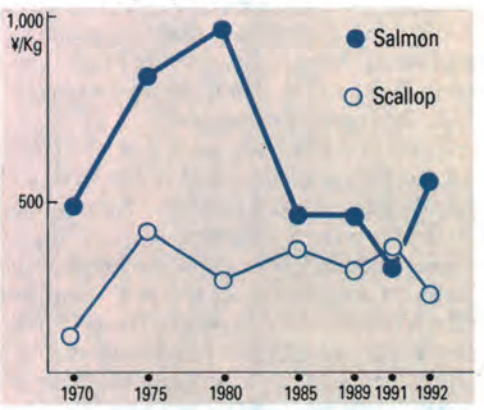
type C with 3~5 ton or 5~10 ton boats has emerged in recent years.

Presently some 94% of the fishery cooperative members take part in the area's salmon set net fishery and there is a provision that allocates a certain amount of the salmon set net income to cooperative members who are still unable to take part in the salmon fishery.

Thanks to the recent growth in resources, and the high market value of the fishery products involved, so far the measures taken by the Notsuke Fishery Cooperative have led to positive results. Looking toward the future, the Notsuke Fisheries Cooperative is applying itself to the following problems:

1) A decline in catch size is beginning to be seen in the salmon and scallop fisheries, leading to the assumption that production may have to be reduced in order to achieve environmental sustainability. Furthermore, increased domestic production and imports of the fishery products involved have caused their market value to stabilize at a lower level than before. (**FIG. 17**) For these reasons the cooperative has shifted its fishery objectives from increasing production to increasing the product value of its catches, and consideration is being given to the possibility of processing catches at the cooperative's own factory in order to sell the products at a higher price.

FIG. 17: Change in market prices for major products



2) In an attempt to develop a new source of fishery income, the cooperative created 5 ha. of "asari" clam fishing grounds and began the release of fry to propagate resources. In the spring of 1992 the first harvest of the clam was made, at which time a total work force of 830 people gathered 82 tons.

3) Attention is now being focussed on the problem of a successful coexistence between Bekkai's fishery and dairy farming industries. The felling of forests to create large areas of dairy farmland has reduced the water retention capacity of the township's inland areas. When the water level of rivers decrease it causes losses in populations of salmon climbing their native rivers and newly released seed populations. It is also feared that the polluted water from the dairy farms will result in eutrophication in the waters of Notsuke Bay, causing a negative effect on the life environment of the marine resources. In order to protect the area's coastal fisheries there are major problems that must be dealt with like building water purification facilities on the rivers or replanting forest areas on land. Lately the town government offices have taken on the role of intermediary and a series of regularily scheduled meetings between representatives of the fishery cooperative and the dairy farmers cooperative is held to discuss problems.

		Catch in tons	Value in million yen	% in value
Fish	Salmon	5,543	3,099	34%
	Other fishes	15,542	1,381	15%
	Sub total	21,085	4,480	
Shellfish	Scallop	15,910	3,914	44%
	Other shellfish	470	246	3%
	Sub total	16,380	4,160	-
Other marine animals	Shrimp	59	202	2%
	Others	214	191	2%
	Sub total	273	393	-
Total		37,738	9034	100%

EXAMPLE 2
Seto Inland Sea
Hinase Fisheries Cooperative

Zostera beds
The cradle of marine reproductivity

Photo courtesy of Nansei Kaiku Fishery Research Lab.

FIG. 18: Location of Hinase Township

Seaweed beds are the infant cradles of the sea. These beds where seaweeds or seagrasses grow densely over a sufficiently large area of the sea bottom often play a vital role as spawning and nurturing grounds or habitats for marine organisms. Seaweed beds can be divided into a number of types, including Zostera beds made up mainly of seagrass as well as Sargssum beds made up mainly of gulfweed, laver beds, Eisenia bicyclis and kelp beds, etc. In this issue we will investigate the typical Zostera bed.

Zostera is a flowering plant that proliferates in the waters of inland seas and bays with gentle currents and sand and mud bottoms at depths up to 5~6 meters.

The principle Zostera species found in the seas of Japan are *Zostera marina* and *Zostera japonica Aschers*. These Zostera beds with their bright green grasses give a special appearance to shallow sea areas and serve as the nurturing grounds for numerous fishes such as black sea bream, sea bass, black rockfish and swimming crab during their fry stage.

Some fish like black sea bream and black rockfish continue to make the Zostera bed part of their habitat even after reaching maturity. For such fishes the Zostera beds serve both as a feeding ground rich in small marine animals that live on the grass surface or species like sand worm and small shrimps, as well as a place to hide themselves from predators. Also, cuttlefish and certain species of fish spawn by attaching their eggs to the surface of the Zostera grasses. In addition to this, Zostera beds serve the dual purpose of preventing eutrophication of the sea by absorbing harmful nitrogen and phosphorus and absorbing carbon dioxide and releasing oxygen through the process of photosynthesis, thus functioning to maintain a cleaner sea environment.

* * *

The Seto Inland Sea is a water area of about 9,500 square kilometers extending east-west for some 440 km and north-south for 5 to 50 km between Honshu, Shikoku and Kyushu in western Japan. Throughout the course of Japanese history the Inland Sea has served as a corridor for water traffic, playing an important role in Japan's political and cultural sectors. It has also been a source of coastal fishery wealth.

Its coastline topography is extremely varried. Alternating are narrow straits with fast currents and open water areas dotted with some 3,000 large and small inlands. The great variety of marine resources that thrive in this diverse sea environment have contributed to the flourishing of coastal fishing culture all along its shores since ancient times.

In the past, the rich Zostera beds that thrived in the shallow waters of the Seto Inland Sea were the symbol of its rich marine resources, but in recent years these beds have decreased rapidly in area. The two main reasons for this decrease are **1)** large-scale landfill projects in shallow sea areas to create industrial land in the 1960's and '70s and **2)** the inflow of industrial and household wastes from land which caused eutrophication of the sea water, reducing water transparency and decreasing sunlight in the water, thus detrimentally effecting the bottom quality.

In 1976 and 1977 a survey of the seaweed beds of the Seto Inland Sea by the Nansei Kaiku (Southwest Sea Region) Fishery Research Lab. of the Fishery Agency showed that the area of beds had decreased from 11,174 ha. in 1965 to 6,257 ha. in '76~'77.

The township of Hinase in Okayama includes a group of 14 islands on the Honshu side of the central Seto Inland Sea with a population of 11,000.

These islands have a long history of fishery beginning in the 18th century. The local Hinase Fisheries Cooperative has about 100 members who engage variously in small-scale set net, small bottom seine, Spanish mackerel drift net, etc., as well as oyster and laver aquaculture.

Shallow seas surround the islands of Hinase and records show that from 1945 to 1954 they contained some 590 ha. of Zostera

TABLE 1: The general status of fishery operations by Hinase Fisheries Co-op (1993)

■Number of fishermen

Small-scale set net (120 fishing grounds)	19
Small-scale trawlnet	68
Spanish mackerel drift net	13
Total	100

■Combination of fishing methods

(1) Small-scale set net plus oyster culture
(2) Small-scale trawlnet plus laver culture
(3) Spanish mackerel drift net plus oyster culture

■Fishery earnings

Fish species (including prawn)	¥400 mil.	(US$3.8 mil.)
Culture (laver, oyster, etc.)	¥900 mil.	(US$8.6 mil.)
Total	¥1,300 mil.	(US$12.4 mil.)

■Fish farming (number of fry released annually)

Kuruma prawn	1.5 mil.
Yoshiebi	0.7 to 0.8 mil.
Chinu	0.1 mil.
Kijihata	10,000
Blue crab	0.7 to 1.0 mil.

FIG. 19: Changes in Zostera bed areas

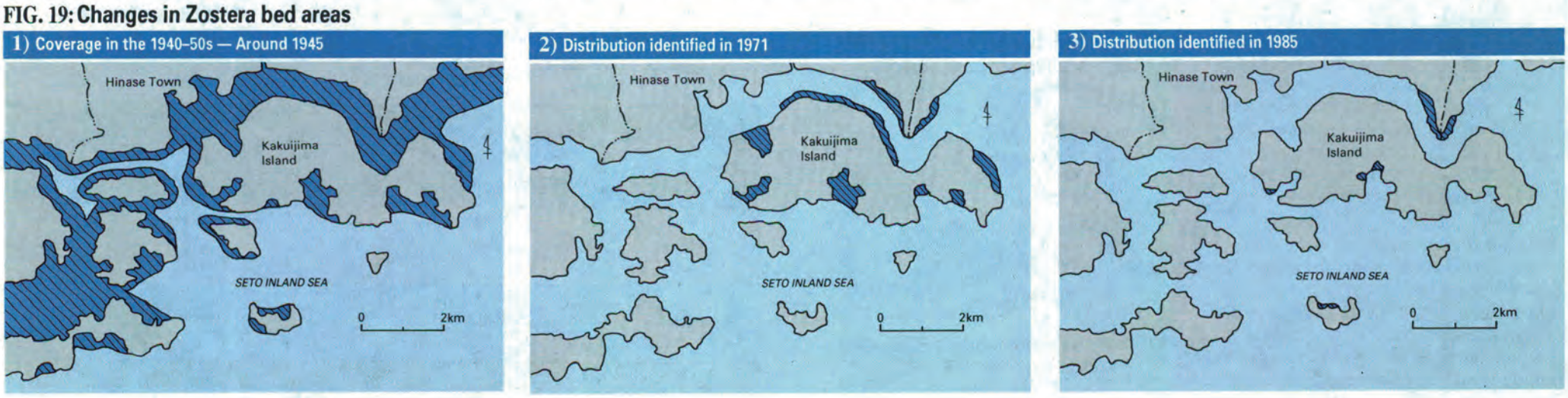
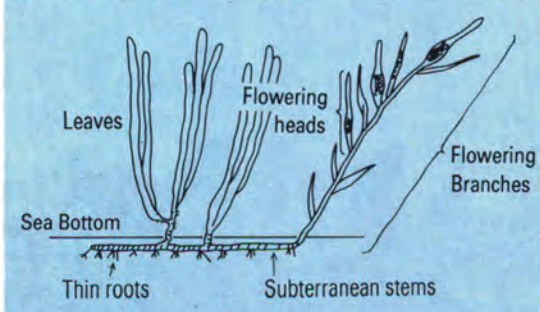
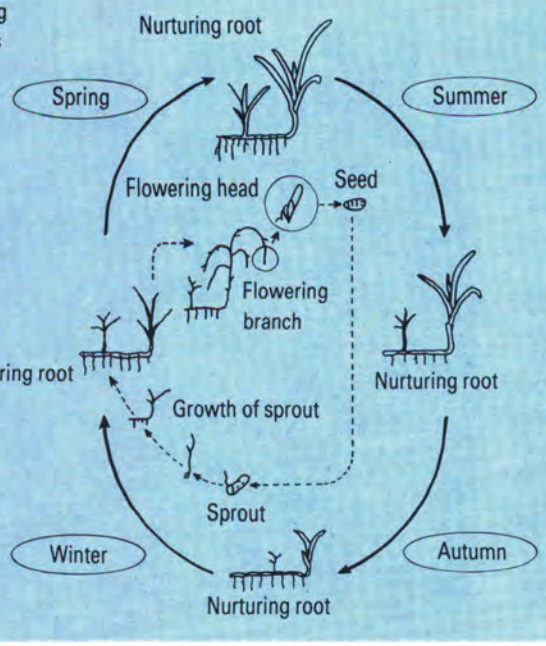


FIG. 20: The composition of Zostera



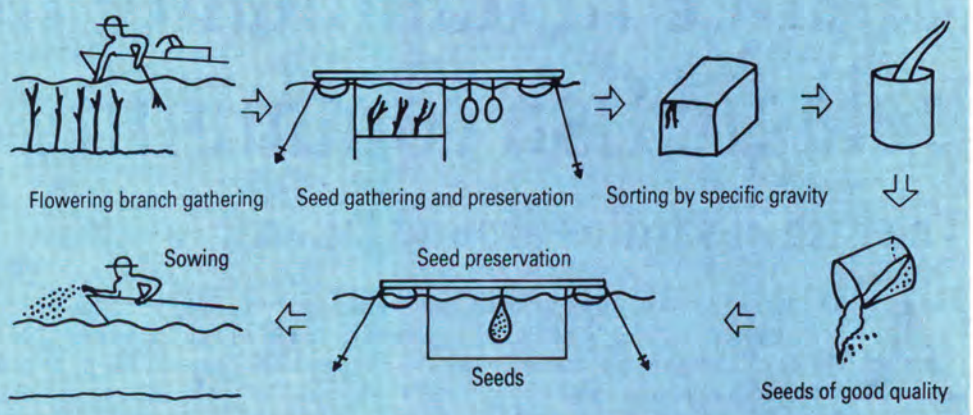
Zostera is composed of three parts, leaves, roots and subterranean stems. From the end of the stem a flowering branch will grow and produce flowers and seeds. From each section of the stem a cluster of thin roots grow downwards, while long, thin leaves grow upwards into the water.

FIG.21: The life history of Zostera



Zostera propagates itself by means of seed sprouting on the bottom of the sea or by means of its subterranean stem spreading into a number of finer roots. In spring the flowering branch grows to put forth flowers. The seeds of these flowers go down to the sea bottom in or about June. They sprout and grow over the period from November to January of the following year.
The subterranean stem rapidly grows by spreading into a number of finer roots during the spring to summer period. It ceases to grow when the water temperature rises in summer. And its growth is resumed when the water temperature begins to fall in autumn.

FIG. 22: Seed gathering and sowing



Zostera beds can be created by means of seed sowing or by means of root transplanting. In the case of root transplanting, however, the original Zostera bed can be ruined by the removal of roots. Therefore, the fishermen of Hinase have adopted the seed sowing method.
In the latter half of June, before seeds drop from the flowering branches, they pluck out these branches at low tide. Gathered branches are kept in a partitioned net arranged on the surface of the sea.
In late August these branches die after releasing all seeds. Then seed sorting begins. The whole net is washed in water to make a clean sweep of dirt after relatively large-size extraneous matters are removed. Next, the seeds are put into a bucket. Seawater is poured into the bucket as the seeds are churned. Good quality seeds are left on the bottom of the bucket because of their higher specific gravity even when the seawater is thrown out with one rush. This practice is repeated several times to collect a sufficient amount of good quality seeds. These seeds are placed in small bags and hung in the water. In or about November, when the tide is on the ebb, the fishermen sow these seeds from a boat.

(Reference material credit: Okayama Prefectural Institute for Fishery Improvement & Promotion)

beds. The beds began to decrease in area after 1955 to the point that now only a few small areas of beds remain (**FIG. 19**).
In 1984 a youth group within the local fishery cooperative proposed the idea of attempting to use artificial means to restore the Zostera beds.
In 1967 the cooperative here had joined a prefectural pilot program for fish farming under which fry of species such as kuruma prawn, black sea bream and black rockfish were released. This program was effective until about 1975, after which catches began to decrease in size. This led to the realization that in order to increase the survival rate of releases in the future it would be necessary to increase the size of the Zostera beds in the region. With the youth group assuming leadership, actual work was begun principally by households engaged in set net fishery to create new Zostera beds in 1985.
Based on the results of a survey by the local fisheries experimental station, seeds were distributed at three specified points and signs of sprouting and growth were found the next year. In the year 1985 some 150,000 seeds were gathered. In successive years the timing and technique of their seed gathering improved until they were able to gather 2.2 million seeds in 1989. With seeds now planted at 8 different sites, the growth progress in each planting site is being checked regularly. The sites where the artificial propagation results are going well are ones where the current is weak and does not wash the seeds away, ones where Zostera formerly grew, areas where the bottom composition is sand and mud and areas near the low tide line. It has also been verified that Zostera will grow in areas where a thick mud/silt sea bottom has been improved by sreading *zeolite* .
The experiment which the fishermen of Hinase are engaged in is too small in scale to measure any beneficial effect on fishery resources with certainty. However, the fact that their efforts have proved relatively successful has attracted the attention of others from around Okayama and other prefectures, and inquiries and observation teams come in regularly.
Says the cooperative's managing director Mr. Susumu Hashimoto who directs the Zostera propagation project, "What we aimed at was to change the environmental workings of the natural ecosystem from a negative cycle of deterioration into a positive cycle of recovery. Fishermen have long known the tremendous importance of Zostera beds for their fishery. But to put that knowledge to practical use in fishery activities required a great deal of courage and cooperative effort."


Zostera beds


Flowering branch gathering


Zostera


Flowering branch


Sowing operation

Photo courtesy of Okayama Prefectural Institute for Fishery Improvement & Promotion

Change in dominance in pelagic fish community

The case of sardine around Japan

A decrease in sardine resources has been noticed in Japan's offshore waters. The sardine catch in Japanese waters reached a record high of 4.49 million tons in the year 1988 but has been decreasing since then.

Japanese sardine fishery has been marked by a history of large-scale fluctuations in the size of catches.

FIG. 23 shows the historical changes in the catch. In the years 1936~37 the catch in Japanese waters was recorded at about 1.5 million tons. After 1940 the catches continued to decrease until they reached a low of just 10,000 tons in 1965, leading even to speculation that the sardine resources had been depleted. Following the occurrence of an enormous year class in the Pacific Population in 1972, however, an increase in resources was seen once again in all parts of the Japanese waters.

With the exception of some areas of the Hokkaido coast, sardine are distributed evenly throughout the waters of the Japanese Islands. The main spawning grounds for sardine are 1) Kumano Sea - Izu Islands - Kashima Sea, 2) Satsunan waters - Hyuga Sea - Tosa Bay, 3) Amakusa Sea - Goto Islands - Sanin offshore waters and 4) Noto Peninsula waters. The adult fish that come to these four spawning grounds are believed to belong to different populations. For this reason the sardine resources of the Japanese waters are divided into four groups; 1) the Pacific Population, 2) the Ashizuri Population, 3) the Kyushu Population and 4) the Japan Sea Population. (**FIG. 24**) Although sardine tend to form regionally distinct groups, they are also known to have a free-moving character that enables them to absorb or be absorbed into members of different groups, thus resulting in increases or decreases in the size of populations. At the time of the large catches of the 1930's the main sardine fishing grounds were located from the East China Sea into the western part of the Japan Sea. As the resources grew, however, the fishing grounds expanded to include the waters off the Korean Peninsula and the offshore waters of the Maritime Province of Siberia and southern Sakhalin. At the peak of this period some 2.7 million tons of sardine were caught in the waters of the Far East.

Sardine are born from isolated floating type eggs and grow to maturity while migrating in the surface waters of the sea. Being a typical plankton-eating fish, the size of sardine resources is closely dependent on the distribution and density of organisms they feed on and thus the life environment that the sea conditions provide them with. The large catches of sardine in Japanese waters in the 1970s and '80s were due to a dominant year class population that occurred in the offshore waters of the Kanto region of Japan's Pacific coast in the spring of 1972. As to how this population occurred, we will refer here to the hypothesis proposed by Kondo, K.

The first thing sardine fry feed on after hatching is the crustacean nauplius. Nauplius proliferates in large quantities in the spring in areas where the Kuroshio current mixes with coastal waters. Although in general the parent fish migrate to choose spawning grounds that will be suitable feeding grounds for the fry in their early stages of growth, when the sea conditions don't happen to provide a good food supply at the time of hatching, the death rate of the fry is high. The sardine that survive migrate north along the Kuroshio current in search of food. The water areas where the Kuroshio current mixes with the cold Oyashio current offer the most plentiful supply of both phyloplanktons and zooplanktons. It is during the summer season spent in these waters that the sardine reach the peak of their fatness. In the fall when the Oyashio current pushes south, the change in temperature causes the sardine to begin southward migration in search of food. The fat stored by the sardine in the summer enables the maturation of the gonads as they migrate south toward their spawning grounds.

The Kuroshio warm current has an important effect on the fishery resources of the Japanese waters. The course that the Kuroshio current follows along the Pacific coast of Japan is constantly changing. These changes in course follow a number of different patterns which can be roughly grouped into the "coastal type" and the roundabout type" shown in **FIG. 25**. The "roundabout type" results from a cold water mass formed somewhere between the Kishu and Enshu offshore waters.

In general, about 90% of the sardine catch is made with the purse seining method. Especially, large-scale purse seines operated by boats of over 40 tons and mid-size seines by 5~40 ton boats are extremely effective fishing gear for pelagic fish species.
In Japanese waters this fishing method is used for catching sardine, horse mackerel and mackerel, with operators choosing which species to catch based on strategic analysis of fishing conditions. On the other hand, in coastal waters sardine is usually caught by seine net or set net. The photo shows sardine being collected from a large scale set net. This was a particularly large catch that yielded 100 tons from one net emptying.

Since the year 1964, the Kuroshio current had followed a roundabout type course from winter to spring. Then, in the winter of 1972 it changed to a coastal type which continued for an unusually long time until the summer of 1975. The occurrence of this coastal type course happened to bring together a sardine fry population and a noprilus population in the waters off the Kanto region just at the time the fry were beginning to feed along the tidal rift between the Kuroshio current and the coastal waters. With this abundant food source, there was a very low mortality rate among the sardine fry, thus resulting in a dominant year class population. Once a dominant year class poulation has been formed, the following year will bring an exceptionally large volume of eggs at the spawning season. As it happened, such good sea conditions were maintained that dominant year class populations occurred again in the years 1974, 1977 and 1980. This caused sardine resources in Japanese waters to continue to increase in a geometric series for some period.

What, then, eventually caused the resources to begin to decrease again?

When the course pattern of the Kuroshio current changes and disturbances occur in the boundary waters where the warm current mixes with the cold current, inhibiting the sardines' northerly feeding migration, it can result in a disruption of their life cycle, badly effecting a population's reproductivity. In his discussion of the period in the 1930s when sardine fishery went from good catches to poor, Kondo tried to find some relation with the conditions of the spawning grounds in the southern sea areas. When spawning migrations became restricted the spawning grounds were observed to shrink in size and eventually become partitioned in the sea areas from the Satsunan waters to Hyuga Sea and the waters off Tosa.

And, observing such phenomena as a decline in the magnitude of the Oyashio, a southward shift in the position of spawning grounds, a slowing of the northerly food-seeking migrations and a tendency for the sardine population to stay in the Kanto area waters, Kondo predicted the present decrease in sardine resources in 1990.

The northern part of Japan's Pacific coastal waters extending from the east coast of Hokkaido down through the offshore waters of the Sanriku, Joban and Boso areas, are the site of purse seine fisheries for mass-catch fishes like mackerel, sardine and anchovy as well as dipnet fishery for saury. Each of these species favors slightly different sea conditions and seeks out habitats in different parts of these waters in accordance with the distribution of water temperature.

Certain changes in sea conditions favor some species and are detrimental to others. So, it seems that when sardine resources are decreasing other species move into their waters and literally drive the sardines away. This phenomenon is called "change in dominancy". (**FIG. 26**) Kondo explains the change in dominancy as an ordered phenomenon in which the different species react with great sensitivity to the changes in sea conditions and seek out different habitats or migration patterns as a part of each population's ongoing struggle for existence.

FIG. 23: Historical change in the sardine catch

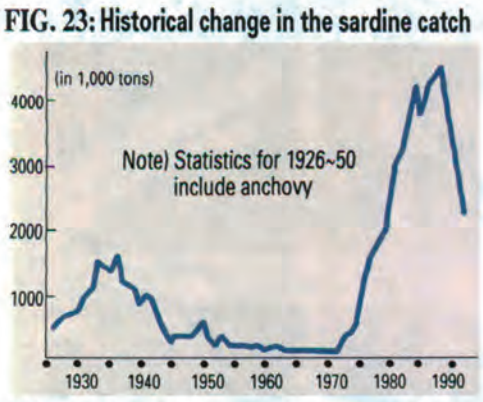
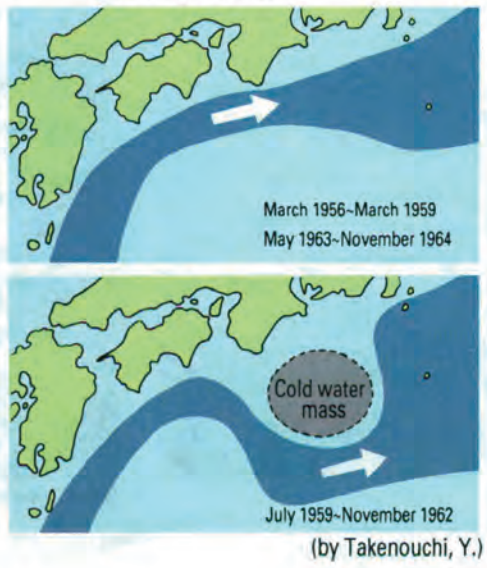


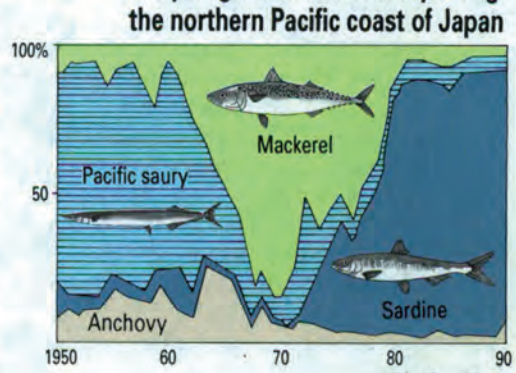
FIG. 24: Sardine spawning grounds

FIG. 25: Two basic Kuroshio current route patterns



(by Takenouchi, Y.)

FIG. 26: Change in dominancy in the pelagic fish community along the northern Pacific coast of Japan



(by Kawai, T.)