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Advancement and adaptation in fishing technology

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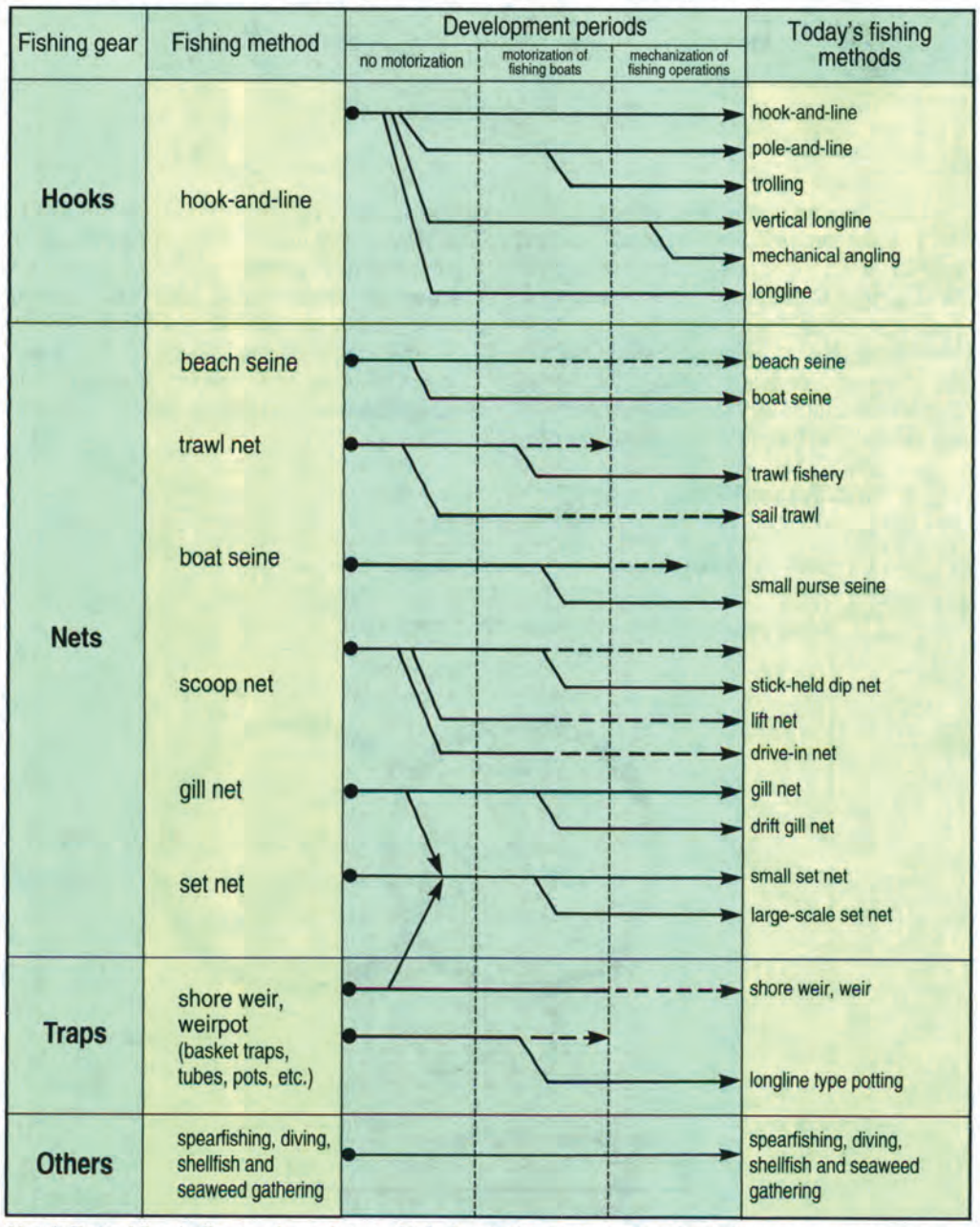
A fishing industry is like one big "integrated circuit." It functions on the basis of a continuing interaction of three basic elements: ① the reproductive capacity of the natural resources, ② fishery and ③ the effective use of what is produced; in other words the catch. It is only when these three elements are in an appropriate balance that we can expect a fishing industry to develop and grow in a healthy, productive way.

As for fishery, it is a multi-faceted activity that involves fishing grounds, boats and labor and is ultimately dominated and restricted by the fish-catching capabilities of the fishermen, which we will refer to here as fishing technology.

As with hunting on land, fish-catching techniques began as a process of outsmarting the natural prey. All of mankind's fishing technology began by first understanding the life mode and the patterns of movement of the fish and, from this understanding, devising ways to introduce some effective kind of artificial stimulation. Mankind has always invented tools to make up for his physical limitations, and we now know that even prehistoric man had invented a wide range of fishing methods and gears, including boats and fish hooks as well as nets and fish weirs. The basic principles on which today's fishing gear and methods are based can all be traced back to these primitive methods.

Angling is the first fishing method mankind invented, and by nature it is an ecologically sound one. The fact that it survives to this day as a commercial fishing method is truly extraordinary. The man in this picture, Mr. Kenichi Himeno, went to Tokyo when he was younger to seek work. He soon became disenchanted with city life, however, and returned to his home town and took up fishing as his livelihood. On pages 3 ~ 5 we will see how he makes a living for himself and his family with the primitive fishing method of angling.

Fig. 1: Classification of fishing methods and their development



Note) Dotted line indicates the point at which the method largely goes out of use, remaining only in specific localities.

When man became proficient in one method, he naturally began to use his creative facilities to begin improving on that method by a process of trial and error. In this process, the introduction of new materials often led to big advances in proficiency. In fact, it is possible to say that, to a large degree, the history of the development of fishing technology has been the history of advancement in materials.

There was one more element that played a major role in the development of fishing technology. That element was information. Fishermen have always had to be well informed about the distribution of the fish resources, the timing of their migrations and the seasonal changes in the amount of resources. Man is not a creature that chooses his own environment, but one that lives and produces within an environment handed down from past generations. For this reason, he lives and maintains his production by constantly taking measures to adjust himself to changes in the natural environment and other factors that influence fishing production. In the distant past, when man lived on subsistence fishing and gathering, major changes in the natural environment often caused big changes in the zone of life. And, even today, changes in the sea conditions or resource conditions often lead to major changes in the type of fishery undertaken in coastal fishing towns, to the degree that it is not unusual to see major changes in local fishing industries in even as short a period as 30 to 40 years.

It is probably not realistic to believe that life was always a hand-to-mouth existence for primitive peoples. They surely used their intelligence and their tool-making abilities to fashion a life based on a yearly calendar of fishing, hunting and gathering. When man developed methods for preserving food, he was then able to produce surplus food, which then led to the birth of societies that expanded beyond the family unit. When this happened, the distribution of produce and trade with other regions became important social functions. When these factors led to the formation of hierarchies in society in which different people were assigned to different jobs, the job of fishery production became specialized and fishery took on a commercial nature for the first time.

In Japan, it was in the early to middle feudal period in the 17th and 18th centuries that various types of net fisheries began to flourish, and all of the basic forms of net fishery in use today can be traced back to this period. Since then, fishermen have used their creative energy to develop these basic fishing technologies in two directions: increasing the catch volume and increasing the catch selectivity of the fishing methods and gear. During the Edo Period (16th to 19th centuries) we see the development of specific fishing methods aimed at specific species of fish, and with this, the appearance of certain representative types of fishery in the different regions of the country. **(Fig.1)**

When we look at the overall history of the development of fishing technologies, we see that the biggest advancements have come with the advent of mechanization in modern times. The invention of motors forever changed the relationship between man and

his tools. The overwhelming power and capability for continuous operation of motors compared to manual labor brought true "industrialization" to fishery, and along with it the advent of capital investment in it as an industry and a changed relationship to society in terms of labor demand. Motorization led to an expansion of fishing grounds and the ability to select the grounds to be fished, which caused a dramatic increase in fishery production. At the same time it increased the ability of the fishermen to choose what kinds of fish they would catch. However, because production was still limited by the reproductive capacity of the natural resources, this led to a new set of problems for the fishing industry. In the following pages we will take a look at the problems that mechanization and the resulting increase in productivity brought to the fishing industry.

The technology of fishery as we speak of it here is a conglomerate of technologies related to all the elements involved in fishery. It involves using available financial resources to build a boat, acquire the necessary fishing gear and labor and then establishing an operating plan. But, at the same time, the fishery productivity gained in this way must also be integrated with the reproductive capacity of the resources in the fishing grounds as well as the capability to sell that production as commodities on the market.

In Japan there are roughly a dozen basic fishing methods operated on a commercial basis. Fishermen involved in small-scale coastal fishery generally choose three or four of these fishing methods, which they engage in on a rotating schedule during the course of a year. In this way they are able to maintain a stable year-round fishery income. Based on the fishing technologies they have gained through experience, the fishermen put together a fishing business that best fits the distinct social and economic environment in which they live.

Pre-industrialized and post-industrialized fishery

How the relationship between man and nature has changed

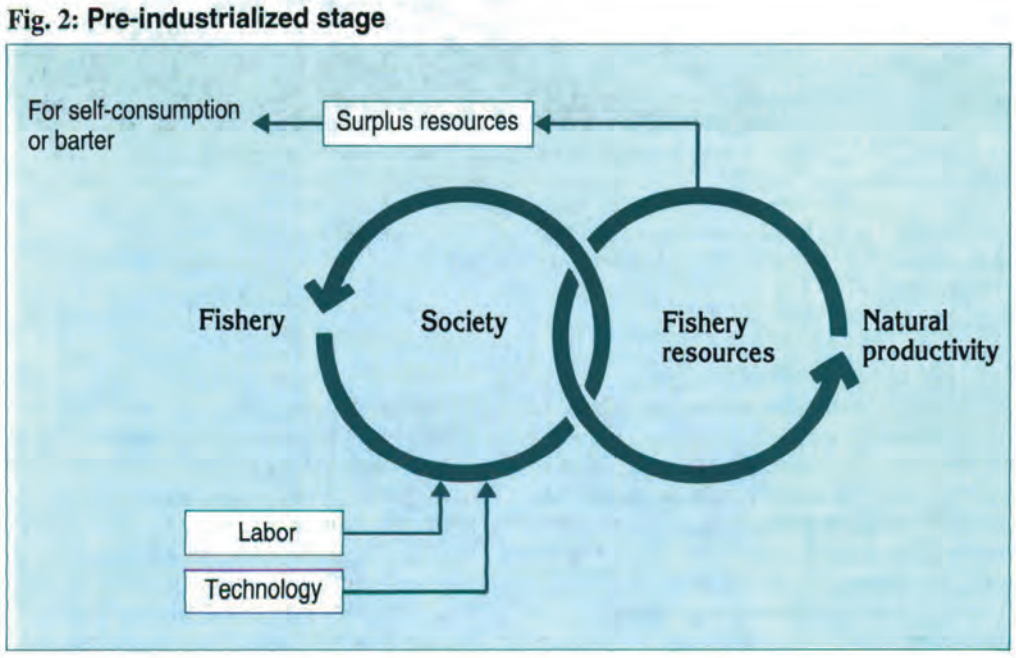
The economics of human society has always been concerned with the pursuit of the conditions for stability and the conditions for progress. When the conditions for both stability and progress are satisfied, a state of order is formed in the social economics.

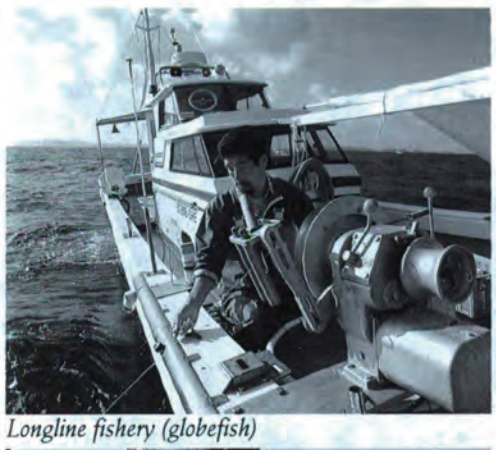
However, at times when these two sets of conditions become sharply opposed to each other, a state of contradiction is born. In fishery as well, there is a long history of development based on surmounting the dilemmas resulting from the conflicting forces of stability and progress.

Because fishery resources replenish themselves within the natural environment, fishing activities, if conducted on a suitable scale within the limits of the reproductive cycles of nature, should be sustainable with regard to the fishery resources. In fact, fishery activities can actually serve to increase the growth rate of the fish by what is known as the "thinning-out effect (reduction of density effect)." However, when excessively large "fishing intensity" is applied by fisheries to a certain resource over an extended period of time, the natural ecological balance breaks down and the resources will sooner or later be exhausted.

Fig. 2 depicts fishery in the pre-industrialized stage. By applying labor and technology in the form of fishery operations, man exploits the surplus production of the natural fish resources. In this stage fishery production is small and is used either for the fishing family's own consumption in a subsistence type life, or for barter for other goods. At this stage man's techniques for adapting to nature play an important role.

Fig. 2: Pre-industrialized stage





Longline fishery (globefish)

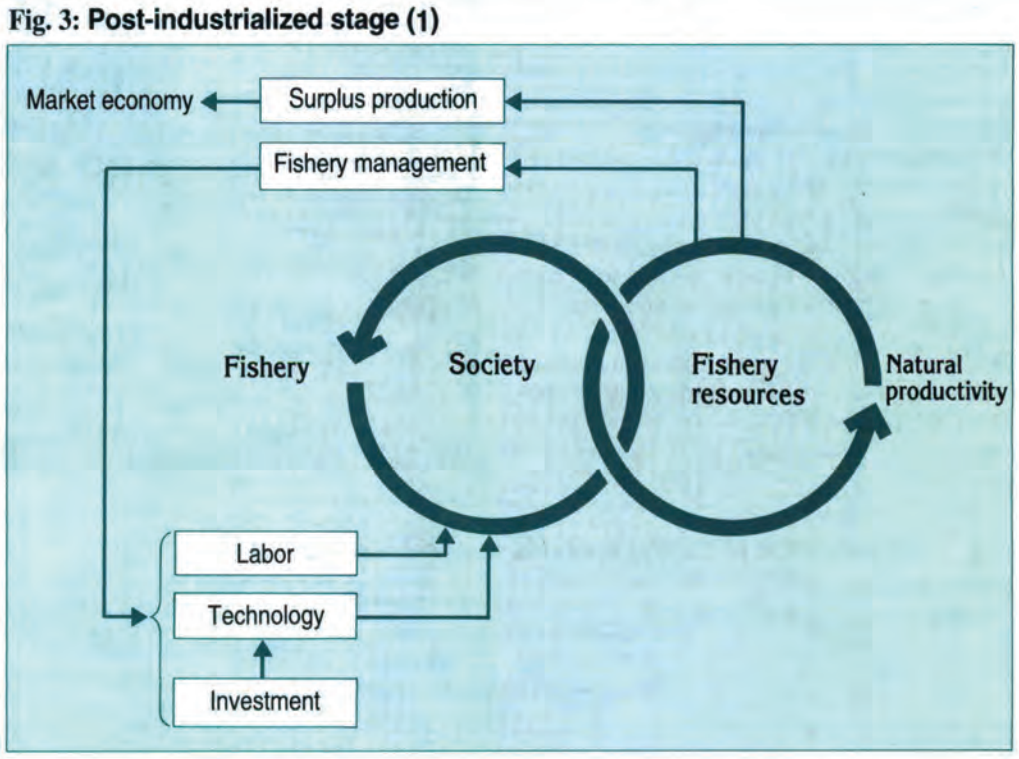
Gill net fishery (lobster)

Pole-and-line (sea bass)

Set net fishery (cod)

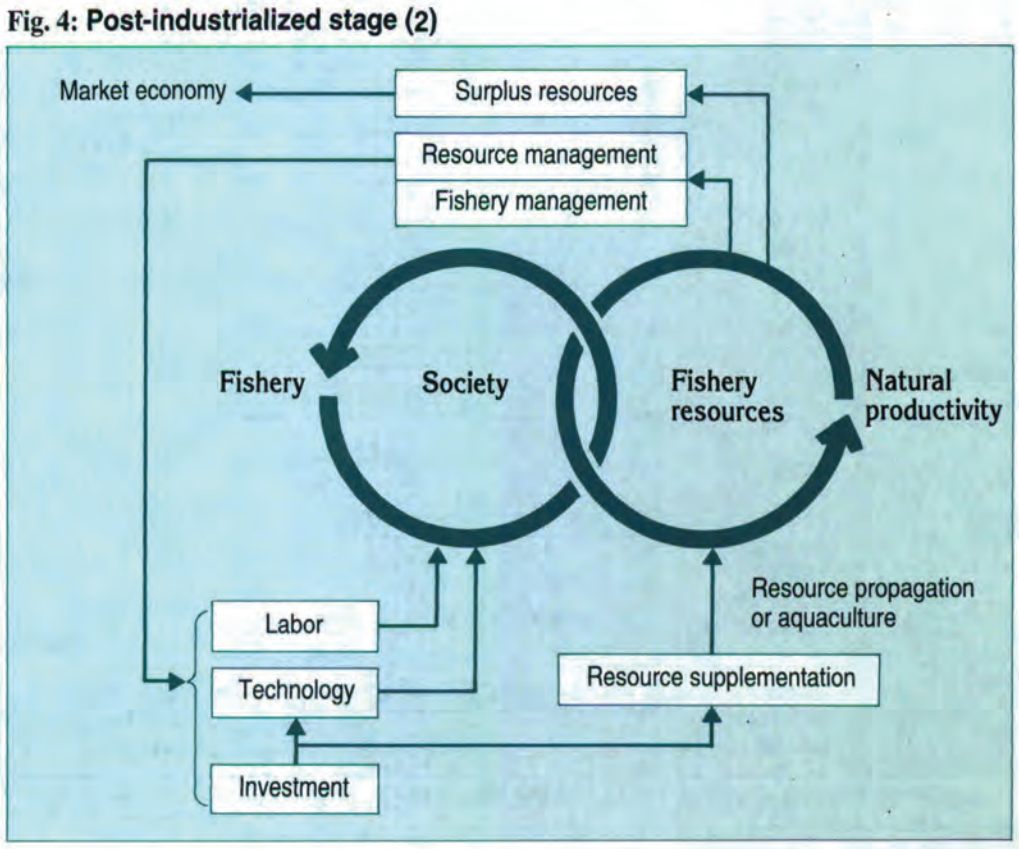
Fig. 3 depicts the post-industrialized stage of fishery. In addition to labor and technology, man applies capital investment to the fishery process. With the introduction of technological advancements in the form of motorization of the boats and mechanization of the fishing operations, there is a big leap in productivity and the produce is distributed through the market economy. The introduction of motorization brings on industrialization and fishery takes a big step forward from a stable, cyclical nature to a stage of revolutionary development. At the same time, fishing pressure on the natural resources increases, thus making it necessary to control the fishery production through the establishment of a fishery management structure which utilizes information from surveys of the resources.

Fig. 3: Post-industrialized stage (1)



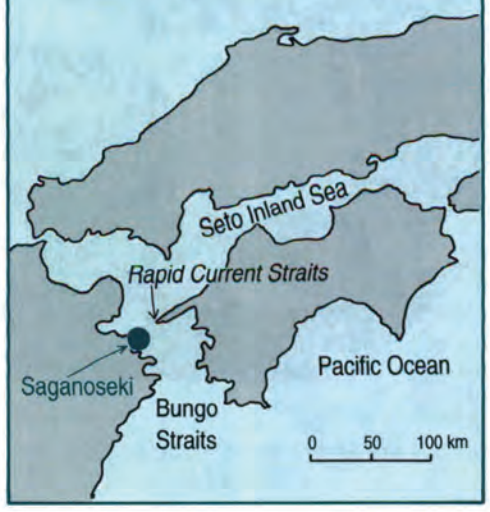
Finally, the structure of fishery advances to the present and/or future stage shown here in **Fig. 4.** At this stage the concept of "culturing" to increase fishery resources through artificial means has been introduced. By releasing artificially hatched fry in the sea or inland waters, the fishing industry attempts to respond to changes in the natural environment in order to ensure a stable production for the future, or to actively promote the propagation of particularly useful marine resources. However, since marine creatures continue to depend on the growth environment of the natural marine world, the roles of resource management and fishery management become increasingly important.

Fig. 4: Post-industrialized stage (2)



EXAMPLE 1

Fig. 5: Geographical location of Saganoseki



Conditions for a regional industry based on angling

Saganoseki-machi Fisheries Cooperative, Oita Prefecture

Catching jack mackerel. The fish caught have a body length of 15 - 30 cm (1 to 4 years old). This species is characterized by its gold color overall, a small head and thick body. It also has a strongly developed tail. Jack mackerel has a weak mouth structure, so a scoop net is used when landing them to prevent the hook from tearing out of the mouth.

The Saganoseki-machi Fisheries Cooperative is an example of a place where angling (hook-and-line) fisheries for fish like red sea bream, yellowtail, Japanese (common) mackerel and jack mackerel has long prospered. In particular, the Japanese mackerel and jack mackerel caught by the fishermen of this area have won a reputation for quality in recent years that enables them to command high prices at the fish markets of Tokyo and Osaka as "Seki mackerel" and "Seki jack mackerel."

Of the roughly ¥1.9 billion worth of fishery production landed by these fishemen in 1992, about 90% was caught by the angling method. The important species of fish caught here by angling are Japanese mackerel, jack mackerel, red sea bream, yellowtail, scabbard fish, grunt and globefish, with these seven species accounting for 86% of the total catch by volume and 84% in terms of sales value. **(Fig. 6)** Considering the fact that angling fishery accounts for only 8% by volume and 10% by sales of Japan's total fishery production, we can see what an unusually high percentage of Saganoseki's production comes from angling fisheries.

Let's take a look at the reasons behind the unusually successful angling fisheries of Saganoseki from a number of perspectives.

Marine geography

The township of Saganoseki is located on the tip of a peninsula jutting out from the eastern coast of the island of Kyushu. In combination with the opposing Sada Point sticking out from the western coast of the island of Shikoku, the peninsula constitutes the western end of the Seto Inland Sea and creates different sea conditions in the Inland Sea from those of the Bungo Straits. This narrow strait, known as *Fast Current Straits*, is also scattered with numerous underwater bank areas. **(Fig. 7)**

There is no ocean current that flows through the Seto Inland Sea. Exchanges of water between the waters of the Inland Sea, including the waters of the coast, and the high-salinity ocean waters occur only by way of the tidal currents in this strait. As a result, numerous shiome (mixed waters) are formed along opposing currents in this strait. The underwater banks also cause the formation of upwelling in their vicinities. All of these factors make for excellent conditions for the propagation of planktons and other organisms at the lower end of the marine food chain.

The marine resources found in the Seto Inland Sea and the Bungo Straits are quite different. Whereas the waters of the Inland Sea have abundant resources of crustaceans and shellfish in addition to fishes, the resources of the Bungo Straits are dominated primarily by sardine, Japanese mackerel, jack mackerel, yellowtail and other fishes. Situated right at the boundary of these two water systems, Saganoseki has accessible fishing grounds for sea bream, scabbard fish, and shrimp, etc., on the Inland Sea side of the peninsula and fishing grounds for Japanese mackerel, jack mackerel, yellowtail and squid, etc., on the Bungo Straits side.

Of particular importance are the resources of "Seki mackerel" and "Seki jack mackerel" that stay year-round in the waters around the banks off the peninsula in a phenomenon called a "permanent resident fish population." This is said to be a unique rapid-current type population that gets a supplementary supply of eggs during the spawning season each year from populations that migrate into the area from the Satsunan and Hiuga Sea areas.

Although this is an unusual life mode for migratory species like these, it can be explained in large part by the great amount of swimming activity demanded by the fast currents of these waters, the abundant supply of food and the fact that the water temperature remains fairly constant throughout the year.

Fig. 6: Fishery production for the Saganoseki Fisheries Cooperative (1988-92 average)

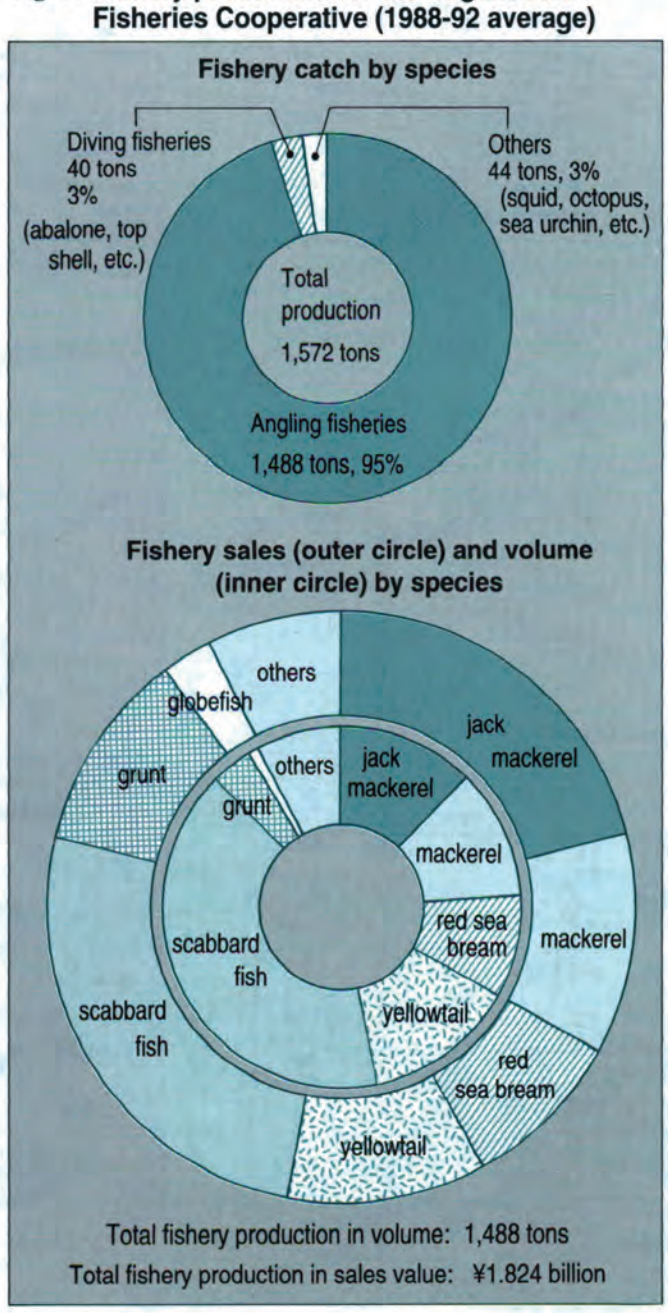
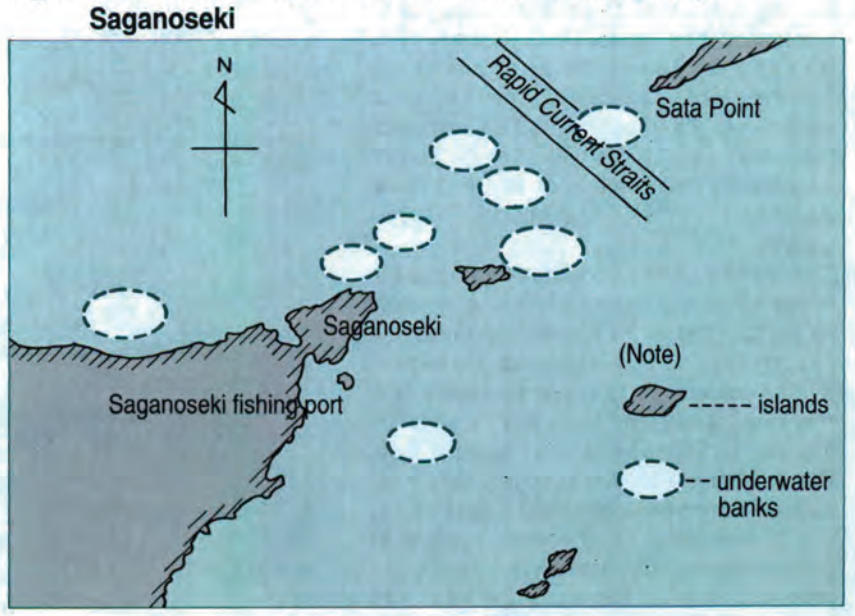


Fig. 8: Fishing calendar for Saganoseki hand line angling fisheries

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
mackerel	■	■	■	■	■	■	■	■	■	■	■	■
jack mackerel	■	■	■	■	■	■	■	■	■	■	■	■
red sea bream	■	■	■	■	■	■	■	■	■	■	■	■
yellowtail	■	■	■	■	■	■	■	■	■	■	■	■
scabbard fish	■	■	■	■	■					■	■	■
grunt						■	■	■	■			

Fig. 7: Main islands and underwater banks in the vicinity of Saganoseki



A tradition of fishing technology

The Nippo coast area of Oita Prefecture that includes Saganoseki is traditionally called Amabe District, a name that means literally the "Fisherman Villages." As this name indicates, the area has long been settled by fishing communities, and records tell us that diving and angling fisheries were developed here very early on. Due to the strong currents of the area's waters, which run as fast as 5 – 6 knots, it is virtually impossible to operate net fisheries effectively in the waters around this narrow strait.

As a result, the fishermen of this region have depended on a variety of species of fish which they catch with their own unique tradition of fishing technologies developed primarily around the angling method. Although for various reasons it has now been discontinued, the fishermen of this region at one time engaged in deep-water angling around offshore banks as far away as Tosa, Kagoshima, the Izu Islands and even Okinawa, using mid-sized fishing boats of the 10-ton class or larger ones of the 50-ton class.

The traditional angling techniques of Saganoseki can be divided into three basic types: 1. hand line, 2. trolling and 3. set line. A common characteristic of all three of these methods is that they make use of sea currents. Method 1. involves allowing the boat to drift with the current while the fisherman works a line by hand, pulling it in and letting it out again as he waits for a strike. Method 2. involves trolling up current at a slight angle pulling a main line stretched out in the sea horizontally with numerous branch lines hanging down from it. A line-hauling winch is used when it is time to pull in the main line. In method 3. a drum float is set adrift in the current with a long, multiple-hook line hanging down from it vertically. In order to increase the catching rate, the fishermen set out 15 to 30 drums at a time. **(Fig. 9)**

The trolling operation. After the line has been completely fed into the water, the boat proceeds to troll slowly for about 30 minutes before hauling in the main line by means of a line hauler.

A line hauler.

Marketing

Because they live in waters with constantly strong currents, the "Seki mackerel" and "Seki jack mackerel" of this area are characterized by their firm meat and low fat content. Although mackerel tends to lose its freshness quickly and is, thus, not considered suited for eating fresh or raw, the people of the Saganoseki area have long had a custom of eating mackerel as raw "sashimi" fillets.

Traditionally, the mackerel and jack mackerel caught by the fishermen of Saganoseki have been sold by local wholesalers in the nearby cities in the prefectures like Oita and Beppu as "tsurimono," or fish caught by angling instead of offshore net fisheries. It was due to a particular incident, however, that they later came to be sold in the larger markets of Tokyo and Osaka as Seki mackerel and jack mackerel. In 1982, a certain university professor who had become famous nationwide as a result of his writings and repeated TV appearances, was invited to Saganoseki to give a lecture. At a dinner after the lecture, he was surprised to be served mackerel as sashimi. The taste impressed him so much that later, after returning to Tokyo, he raved about the mackerel caught in Saganoseki on a nationwide TV program. A fish merchant from the Tsukiji fish market in Tokyo happened to take notice of this and made an inquiry with the Saganoseki Fisheries Cooperative.

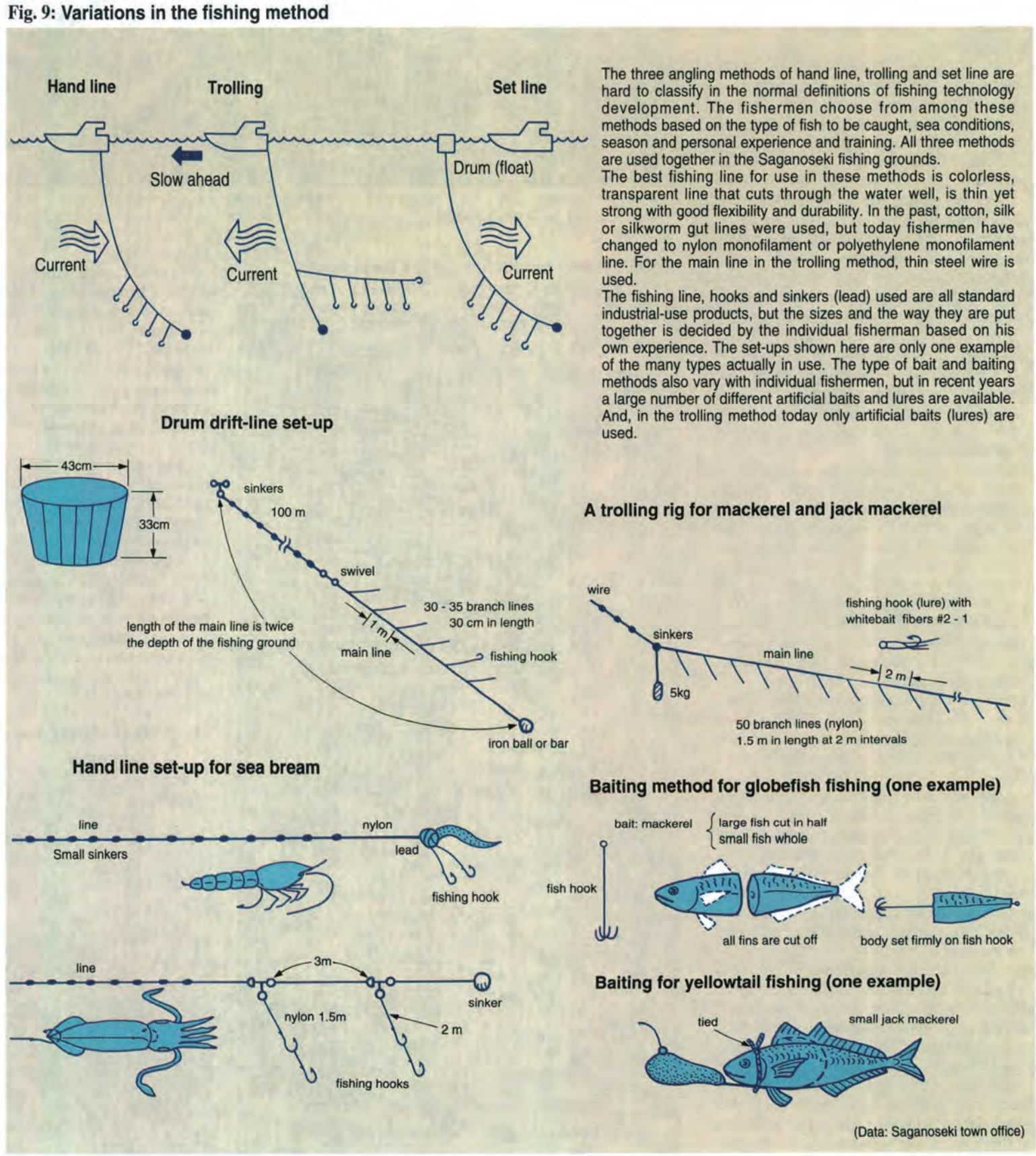
The leaders of the cooperative seized the opportunity, and the efforts that they made to expand the sales routes for their fish turned out to be very important. In the past, the red sea bream, Japanese mackerel, jack mackerel, grunt and yellowtail caught by angling in Saganoseki were bought from the fishermen by local wholesalers on mutual agreement, while the rest of the catch was sold by the cooperative as commissioned shipments. As a result, the price structure for the important species of catch were effectively controlled by the four major local wholesale companies. In 1988, after several years of surveys, research and negotiations, it was decided by the cooperative that they would buy up all the catch landed by its members of red sea bream, Japanese mackerel, jack mackerel and grunt, and then act as sales agent for that part of the catch. In other words, by entering the wholesale business itself, the cooperative sought to make the market more competitive in a way that would raise the price of its catches and, at the same time, use its collective buying power to help stabilize prices in the market. As of the present, this policy has led to very favorable results.

Meanwhile, in order to raise the product value of its "Seki mackerel" and "Seki jack mackerel," the cooperative has made continuous efforts to actively promote these products and expand the sales routes for them to the major metropolitan markets. At present, about 30% of the catches that the cooperative buys are being supplied to a group of regular customers at steady prices on a yearly contract basis.

Let us take a look at the underlying factors that enabled the fundamental hook-and-line fishing method to become the mainstay of a modern fishing industry here in Saganoseki.

(1) Being an area with sea conditions that prohibit the operation of seiner fisheries, the only remaining viable fishing method was angling. For this reason a natural balance has been maintained between the reproductive capacity of the fishery

Fig. 9: Variations in the fishing method

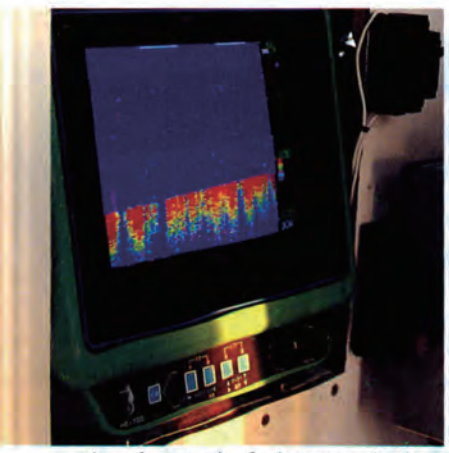


The three angling methods of hand line, trolling and set line are hard to classify in the normal definitions of fishing technology development. The fishermen choose from among these methods based on the type of fish to be caught, sea conditions, season and personal experience and training. All three methods are used together in the Saganoseki fishing grounds.

The best fishing line for use in these methods is colorless, transparent line that cuts through the water well, is thin yet strong with good flexibility and durability. In the past, cotton, silk or silkworm gut lines were used, but today fishermen have changed to nylon monofilament or polyethylene monofilament line. For the main line in the trolling method, thin steel wire is used.

The fishing line, hooks and sinkers (lead) used are all standard industrial-use products, but the sizes and the way they are put together is decided by the individual fisherman based on his own experience. The set-ups shown here are only one example of the many types actually in use. The type of bait and baiting methods also vary with individual fishermen, but in recent years a large number of different artificial baits and lures are available. And, in the trolling method today only artificial baits (lures) are used.

(Data: Saganoseki town office)



An echo sounder for locating schools.

The tank for keeping the catch alive on board. To prevent the water from sloshing around violently when the boat is in motion, a lid made of netting material is placed over the scupper.

Branch lines for trolling. Artificial lures are used for bait.

Fish pens where the catch is kept until shipment. Fish brought to port by the fishing boats are kept here. Fish caught on different days are never kept in the same cage.

The Saganoseki fishing port. The fishing boats used here are primarily of the 1-3 ton class or the 3 - 5 ton class. In all, 600 motorized fishing boats are in operation here.

Fish taken from the fish pens are killed immediately in a way that preserves freshness before shipping.

The entire catch is shipped as fresh fish. The fish are sorted and placed in styrofoam cases by size.

resources and the fishing pressure applied by the industry.

(2) A long tradition of angling-method fishing technology has been fostered in this region over many generations. In the process, a thorough exploitation of the local fishing grounds has been accomplished along with detailed seasonal plans for the optimal use of the resources in each area of the fishing grounds.

(3) Promotion of the high quality of the locally caught mackerel and jack mackerel has led to demand from the major urban markets. At the same time, the local fisheries cooperative has taken the initiative in modernizing sales methods for their fishery production.

In spite of the fact that the Saganoseki area is blessed with good fishing grounds that presently support a profitable fishing industry, there are still numerous problems looming in the future. The most serious of these are the problem of securing enough fishermen to carry the industry into the next generation and, in spite of the inherent richness of the fishing grounds, the problem of managing their use in light of a growing sport fishing industry. As young people continue to be attracted to industries in the cities, the fishing population here continues to decrease year by year. Meanwhile, as the number of sport fishermen from the cities continues to grow, it is causing problems of increasing disorder in the use of the fishing grounds. In the words of one of the representatives of the Saganoseki Fisheries Cooperative, "One of the most important tasks we face at present is creating the blueprint for a healthy fishery industry of the future. If we can do this, we should be able to resolve the problems of fishing ground use and keep our young people here at home where they can serve as the driving energy for a healthy local society. To achieve this goal, we know we will have to work harder and more creatively than ever before."

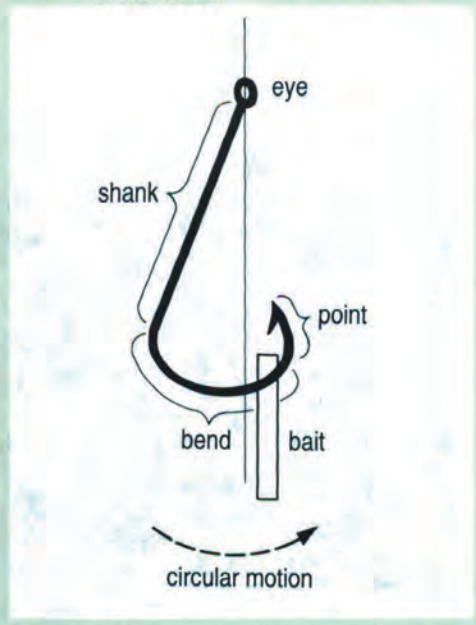
Fishing hooks

— The oldest and most highly perfected fishing gear —

Long ago, when man first began to catch fish, he used the bones, horns or teeth of animals to make two kinds of fishing implements: spearheads and fishing hooks. The spears primitive man made for fishing were of two types: the fixed type in which the spearhead was fixed firmly to the handle (pole) to be thrust or thrown at fish in the water, and the detaching type in which the spearhead would come free from the handle once imbedded in the fish or sea animal. The former was used primarily for spearing fish or shellfish, etc., in the shallow waters of rivers, lakes or bays. The latter was used in the open sea to spear such sea animals as sea lions, seals and walruses, or larger fish like tuna and billfishes. As time went by, both of these fishing methods gradually went out of use, although they can still be found in certain localities around the world today in specialized fisheries such as shellfish gathering, spearfishing and whaling. The use of the fishing hook, on the other hand, has continued to grow in increasingly effective forms as man has accumulated experience and knowledge about the behavior and life patterns of fishes. Especially since man entered the Iron Age and became proficient at making fish hooks of metal, he has continued to improve and rationalize hooks into an increasing variety of shapes for each type of fish to be caught. Particularly in the beginning of the Iron Age, considerable efforts were devoted to perfecting the shapes of fish hooks in ways that increased their performance dramatically.

There are several different ways a fish may take a prey or bait, such as an attack action,

Fig. 10: The circular motion of a fish hook



where the fish approaches its prey rapidly and bites into it, or a sucking action, where it approaches slowly and cautiously and then sucks it in. But in either case, there is a common process to the act of taking in a prey or bait. The mouth is opened as the fish approaches the prey and then sucks it in along with the water around it with the gillcovers open wide on both sides. Once inside the mouth, the water is forced out through the gills and the the prey or bait is taken into the stomach cavity.

The fishing hook is an implement that takes advantage of this sucking-in action to catch the fish. First, the hook with bait attached to the bend portion, as in **Fig. 10**, hangs in a balanced position in the water. Then, when the fish sucks in the bait and hook, the gravity of the shank causes a shift in that balance that sends the point into a circular motion, with the eye as the pivot point, causing it to stick into the upper jaw of the fish.

The shape of a fishing hook varies with the type of fish it is intended to catch, but in Japan, the basic shapes can be roughly divided into three types: angular, round and elongated types. Rather than any kind of specific technological differentiation, these groupings seem to be more an expression of the regional traditions that grew out of the way the hooks were used. **(Fig. 11)**

The reason that the fishing hook with its essentially passive nature was able to win universal acceptance over the essentially active spear as a fishing gear, is because of the following advantages that angling had as a fishing method:

(1) Fresh or live bait or artificial lures could be attached to it to attract the fish.

(2) By attaching a sufficient line to it, fish not only in the surface waters but also the middle and deep water layers could be caught.

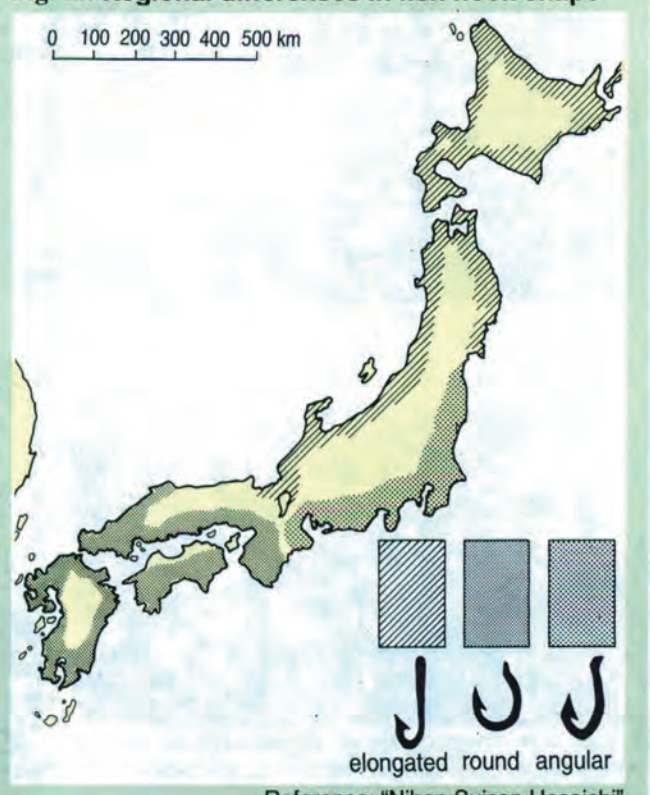
(3) With the addition of accessories like swivels, multiple-hook fishing gear could also be prepared.

(4) By using the longline method, large areas of water could be fished at one time.

(5) Wind power, current flow or mechanical power could be used to conduct trolling fishery.

(6) By varying the type of bait used and the size of the hook, selectivity could be achieved with regard to the type of fish to be caught.

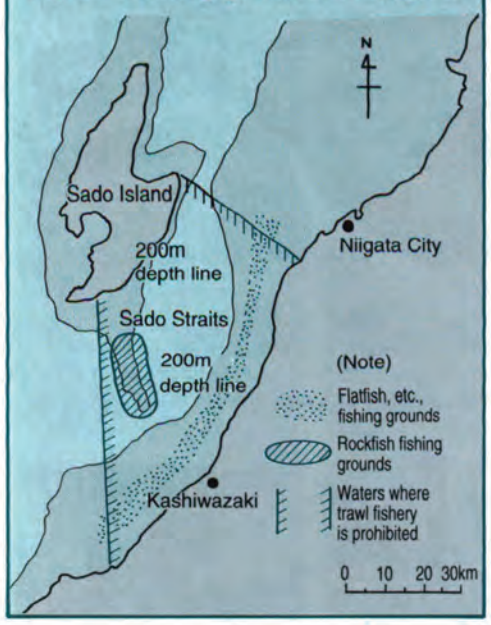
Fig. 11: Regional differences in fish hook shape



Reference: "Nihon Suisan Hosaishi"

EXAMPLE 2

Fig. 12: Fishing grounds of Niigata



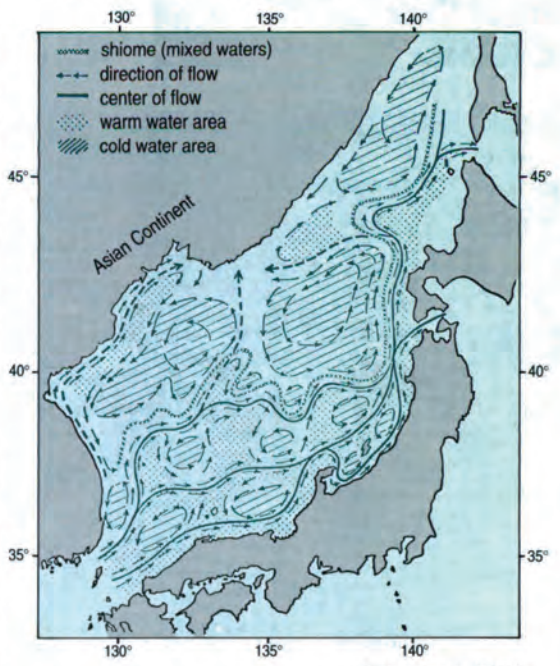
Making a living on gill net fishery in a small fishing village

Kashiwazaki Fisheries Cooperative, Niigata Prefecture

In order to research a group of fishermen who make their living with the gill net fishing method, we visited the fishing port of Kashiwazaki in Niigata Pref., located roughly in the middle of the Japan Sea coast.

The Japan Sea is an enclosed sea bordered on the west and north by the Korean Peninsula, the Asian mainland and Sakhalin Island, and on the east and south by the Japanese Islands. It is connected to the outer ocean by way of four straits. Below a depth of 200 meters is a static Japan Sea water mass, while the middle and surface layer waters are affected variously by the Tsushima warm current that snakes up northward from the Tsushima Straits, and by the Liman cold current that flows south from the Okhotsk Sea through the surface layer forming localized pockets of cold water. **(Fig. 13)** The fishery resources of the Japan Sea consist of overlapping areas of warm-current and cold-current type resources. When the Japan Sea is divided into its northern section and western section, the northern section is dominated by cold-current resources and the western section is dominated by warm-current resources. In the western section we find highly-developed purse seine fisheries for mass-catch fish like sardine, mackerel and jack

Fig. 13: Sea currents in the Japan Sea



By Naganuma (1972)

Table 1: Types of fish caught by gill net fishery (Kashiwazaki, Niigata)

Type of fish	fishing method	layers of netting	mesh size	net material	thickness
rockfish	bottom gill net	one	80 mm	nylon monofilament	#3 - 3.5
flounder	〃	trammel net	110 - 150 mm	〃	#2
flatfish	〃	trammel net	80 - 85 mm	〃	#1
croaker	〃	one	60 mm	〃	#2
salmon	drift net	trammel net	110 - 120 mm	〃	#2.5
kuruma prawn	bottom gill net	trammel net	50 mm	〃	#0.5

The net is hauled in by means of an electric net hauler positioned on the bow of the boat. The operation involves one man to feed the net into the hauler and another to feed the net with the fish still in it into the boat's fish hold. Meanwhile, the boat owner stays at the wheel and steers the boat.

The net hauler (made of hardened plastic) and a stainless steel pipe guide to help guide the net into the hauler.

Retrieving the float marker

The net rope is pulled in by a side roller run directly off the main engine.

The net laying operation. The net, arranged in order on the aft deck the day before, is fed into the sea while running ahead at full speed.

In gill net fishery extra laborers are necessary to help remove the catch from the nets. Depending on the size of the catch, three to five parttime workers are used. After the fishing operation is finished, Mr. Fukai calls his wife by shortwave radio from sea to have her arrange that day's extra labor based on the size of the catch.

mackerel. In the northern section, however, the density of fishery resources tends to be thin and there are no notable fisheries to speak of.

The waters around Kashiwazaki are characterized by a narrow continental shelf and a rough sea-bottom topography including numerous reefs at a depth of 50 - 100 m. Since it is difficult to conduct trawl net in waters like these, fishermen have long practiced fishery by the gill net and angling methods. In the past there were conflicts between local fishermen here and those from surrounding areas who entered these waters and tried to conduct small scale trawl net, but now the prefectural authorities have designated the waters of the Sado Straits as off limits for trawl net fishery. **(Fig. 12)**

There are 72 members in the Kashiwazaki Fisheries Cooperative. Of these, 50 make their living on gill net fishery. The remaining 20 or so are mostly older fishermen who conduct angling fishery.

By prefectural standards, the fishermen of Kashiwazaki operate on a small scale. In the northern part of the prefecture, fishermen use the trawl net method to catch walleye pollack, Atka mackerel and shrimp on the wide continental shelf or the continental slope that borders it, but the Kashiwazaki area is not blessed with these kinds of fishing grounds. Also, on the offshore island of Sado, a fleet of squid-jigging boats was built up about twenty years ago to catch the common squid that migrate into the area's waters, but the fishermen of Kashiwazaki lacked the financial resources to outfit their own boats with the necessary squid jigging machines and high-powered fish-luring lights necessary for this fishery.

Throughout Japan there are many fishing villages like Kashiwazaki that are not blessed with any particularly good fishery resource and lack any kind of clear specialization in their fishery activities. It is in this kind of fishing village that fishermen make effective use of the gill net fishing method. The gill net fishing method requires less capital investment for the necessary boat and fishing gear, its operation costs are low and it requires few laborers. Besides this, it also offers a stable catching efficiency. The case of Mr. Kinichiro Fukai, a fisherman of Kashiwazaki who allowed us to research the gill net method on board his fishing boat, should serve as a helpful example in understanding this fishery method.

Mr. Fukai was born and raised in Kashiwazaki. His family were farmers, but as a boy he often went fishing and became familiar with the sea. After finishing his schooling, he worked for two companies, but in both cases he lost his job when the companies went bankrupt. It was after experiencing these failures that he decided to go into business for himself as a fisherman. He bought a small boat and began angling alone at first.

After marrying and saving money while both he and his wife worked, he was finally able to buy a 3-ton fishing boat and switch to gill net fishery. The gill net work could be performed by two people. In the inshore waters with a depth of 50 - 100 m and a muddy sand bottom he caught flatfishes, sole and kuruma prawns, and near reefs he caught fish like croaker and tilefish with a bottom gill net. Also, in the spring he used the floating gill net method to catch salmon that migrated along the coast. By gradually buying different kinds of nets, he was able to increase the variety of fisheries he could engage in.

Twenty years after beginning his career as a fisherman, his children had grown and, fortunately, two of his sons decided to carry on in the fishing business. With this, Mr. Fukai decided to venture into offshore fishing grounds. Seven years ago he traded in his boat on a larger 5-ton class boat (powered by a 350 hp engine) that enabled

Rockfish

Walleye pollack are sometimes caught in the nets along with the main catch of rockfish.

The gill net : *its performance and capability*

Gill net fishery is a method that uses the most simply structured of all net fishing gear, and for that reason it requires the smallest initial investment in materials and the lowest operating cost of any type of small-scale fishery. There is also something else that separates gill net from all other types of net fishing methods. Whereas other net fishing methods catch fish by a variety of means such as forming a bag-like structure in which the fish are caught (boat seine, trawl net) or catching them by directing them into a trap made with walls of netting (set net), scooping the fish out of the water by means of nets (stick-held dip net, lift net) or enclosing a school of fish in a large net and then closing it in until they can be caught (seine), it is only with gill nets that the mesh of the net itself serves the fish-catching function.

Generally speaking, a fishing gear must have the dual function of catching fish and selecting the fish to be caught, and in the gill net method, the mesh of the net serves both these functions. In short, ① the mesh size, ② thickness of the net cord, ③ the material the net is made of, ④ its color, ⑤ the tension of the netting cord, and ⑥ the hanging ratio of the nets serve to determine how the nets will perform the above two functions.

The fish catching performance of a gill net is classified according to the following three catching characteristics:

(1) Enmeshing: the fish body is made to push into the mesh and the tension of the net cord holds the body and prevents it from getting through.

(2) Wedging: when a part of the fish like the fins, tail or mouth becomes caught in the net cord and the fish begins to thrash around, the net closes tightly around it.

(3) Entangling: the whole body of the fish becomes entangled in a limply hanging mass of net.

These three types of net functions compensate for differences in the body shape, swimming speed and level of activity of different fishes.

Fish can be divided roughly into 5 types of body shape, each corresponding to different movement characteristics, as follows:

(a) basic shape (salmon, mackerel, sardine, etc.): body is flexible and suitable for active movement

(b) spindle shape (tunas, bonito, billfishes, etc.): the sharp movement of the tail fin gives strong propulsion that enables the fish to swim at high speeds

(c) compressed shape (sea bream, file fish, etc.): swim quietly near the sea floor

(d) depressed shape (flounder, lizard fish, etc.): spends much time lying still on the sea floor, slow moving

(e) elongated shape (scabbard fish, (sea) eel, etc.): hides in silt on the sea bottom or in rock crevices, slow moving.

For this report we put together the data from several studies to see how the way fish are caught in gill nets varies by species. From these studies we find that the basic shape fishes, which make up the largest category of species, are caught by enmeshing, while the spindle shape fishes with their strong swimming capabilities (ie. speed × activity level) are caught by wedging and the slow-moving compressed and depressed shapes as well as the elongated shapes and the irregular shaped crustaeceans and shellfish are caught by entangling. **(Fig. A)**

Which of the three ways a net will perform when a part of the fish's body touches it (enmeshing, wedging or entangling) is determined by the two factors of (1) the tension of the netting cord and (2) the hanging ratio.

Tension of the netting cord: This is the amount of tension on the netting cord when the net is hung in the water. In the case of a bottom gill net it is determined by the buoyancy of the floats, while in the case of a floating gill net it is determined by the sinking force of the sinkers attached to the net.

Hanging ratio: In preparing a net, the netting is attached to a rope with a certain degree of slack to it. The degree of slack is called the hanging ratio. In Japan, this hanging ratio is expressed by the formula

$$S = \frac{\ell - \ell'}{\ell},$$

where S is the hanging ratio, ℓ is the length of the fully extended netting and ℓ' is the length of the rope it is attached to.

The larger the value of S, the more the net will tend to bulge into a bag shape when hung in the water, while the smaller the value of S, the more it will tend to hang flat in the water. For wedging and entangling to occur requires a larger S value. **(Fig. B - C)**

The performance of a net with regard to the two parameters of tension of the netting cord and hanging ratio can be theoretically expressed by the model shown in **Fig. D**. When making a gill net, the fisherman chooses the basic type of net he will hang with this model in mind, and then, according to the type of fish he intends to catch, will proceed to also choose the size of mesh, thickness of cord, the material it is made of and its color.

Mesh: This is an important factor not only for holding the fish in the net but also for selecting the type of fish that will be caught. Data from catches show that the circumferences of the fish trunk will fall into a bell-shaped curve with the center of the bell falling at the size of the mesh.

Cord qualities: Gill nets must be made of cord that is light and strong and with good elasticity. Today synthetic fibers are used exclusively, with polypropylene being the most common fiber used for gill nets in Japanese fishery.

Thickness of the cord: Although the cord must be sufficiently strong, at the same time it is best if it is also thin and hard to see. Particularly for the function of enmeshing, monofilaments are preferred over multifilaments.

Color: According to whether the net will be used in shallow or deep water, at night or in the day, in rocky reefs or sand bottoms, it is always important to choose a color that does not stand out from its surroundings.

Fig. B: Hanging ratio

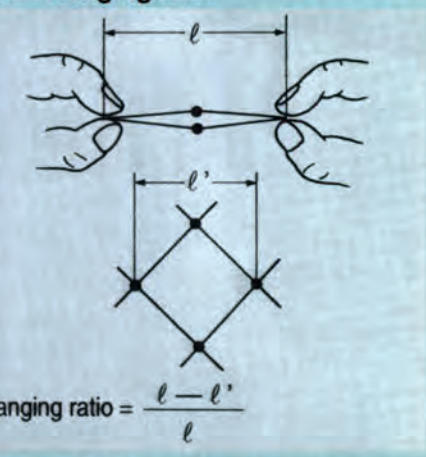


Fig. C: Tension of the net cord

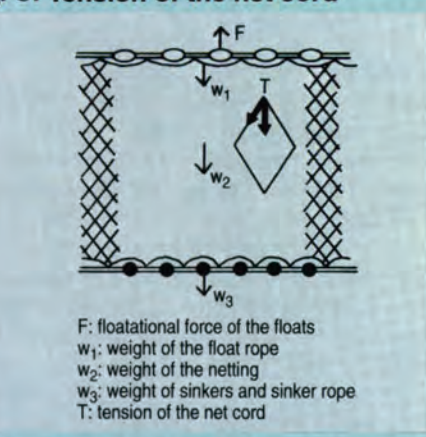


Fig.D: Model of performance changes in gill nets

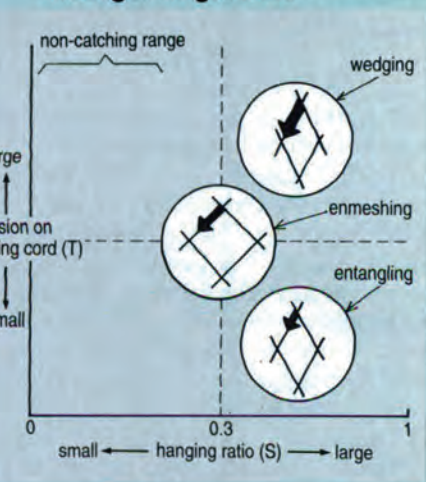


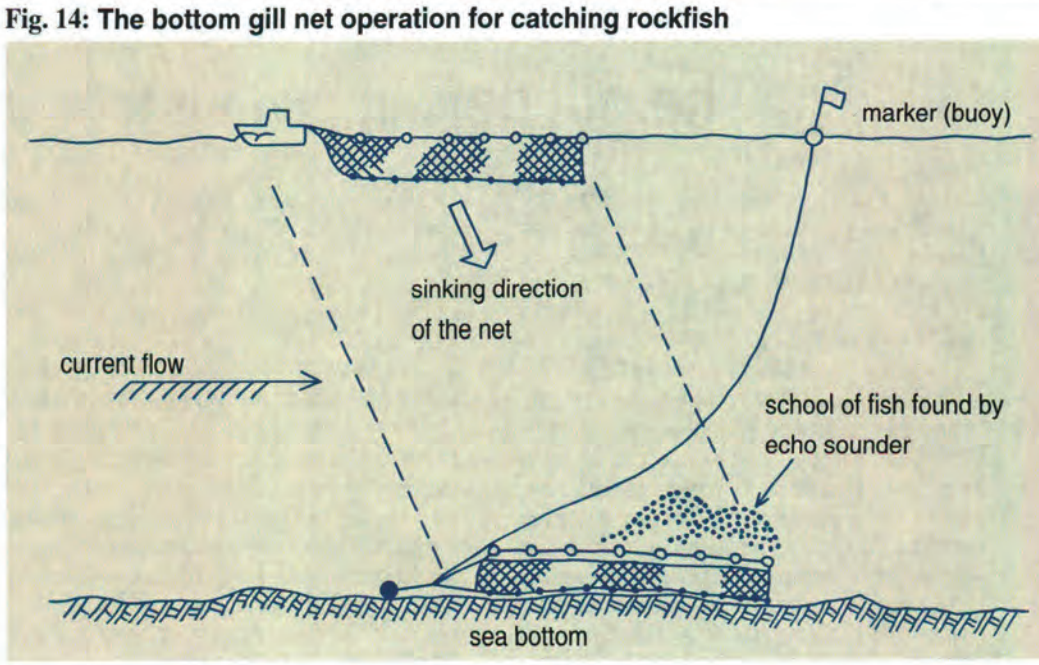
Fig. A: Gill net catching conditions by body shape (Note: Shaded area = is caught, blank area = is not caught)

Body shape / Ways the fish are caught	Basic shape	Spindle shape	Compressed shape	Depressed shape	Elongated shape	Crustaceans	Shellfish and other marine creatures
enmeshing	■		■	■			
wedging		■					
entangling			■	■	■	■	■
sample species	salmon, herring, sardine, Japanese mackerel, Jack mackerel, yellowtail, sea bass, etc.	tuna, skipjack, billfishes, shark, etc.	red sea bream, opaleye, etc.	flatfish, sole, lizard fish, etc.	scabbard fish, sea eel, etc.	spiny lobster, Gazami crab, crabs, kuruma prawn, mantis crab, etc.	top shell, etc

him to begin bottom gill net fishery for rockfish. This fishery is done in waters with a depth of 150 - 200 m and rocky reef bottom areas near the island of Sado, and it takes about one hour to reach the fishing grounds from Kashiwazaki. The net hauling operation requires two laborers while a third maneuvers the boat. Since the peak fishing season is from January to June, a larger 5-ton boat is necessary to withstand the rough winter seas of the Japan Sea. **(Fig. 14)**

Because rockfish classifies as a high class fish in this area, the fishery earnings offset the higher operating costs of offshore fishing. In the off-season for rockfish, Mr. Fukai returns to the inshore gill net fisheries he has always pursued. After long years of hard work, Mr. Fukai has finally in recent years established a strong and stable base for his fishing business.

Fig. 14: The bottom gill net operation for catching rockfish



When the water temperature drops in winter, the rockfish move to rock beds in deeper offshore waters to spend the winter. Upon reaching the fishing grounds, an echo sounder is used to search for schools of fish and a spot is chosen to lower the net. The net is laid out parallel to the current flow, starting from a down-current position and running up-current at full speed while the net is fed into the water.

The development of fishing traps

Fishing traps such as basket traps and fish weirs have been used extensively by man to catch fish in the world's rivers and lakes since primitive times. The large numbers and varieties of fish traps unearthed in archeological digs around the world offer sound evidence of this fact. The fishing traps used in today's fisheries are compact, portable variations of the fishing traps used by man since the Stone Age, and they have enabled modern man to expand his trap fishing activities beyond the freshwater realm into the saltwater fishing grounds of the world.

Since the fishing gear used in trap fishery is simple and easy to use and requires very little on-board equipment to operate, it is an easy fishery to adopt for a small-scale coastal fishery or middle-scale offshore fishery operation. Normally, traps with some kind of bait inside are set out on the sea floor and then left overnight, or in some cases for two or three days, before being collected again and emptied of the catch. Trap fishery has the following advantages not found in other types of fisheries:

(1) Because the prey is lured into the trap and then kept there alive, the freshness of the catch is excellent.

(2) For things like lobster, crabs and shellfish that live in the deep waters of the ocean where food is scarce, the bait inside a trap acts as a very potent lure that gives this method a high catch efficiency.

(3) The fisherman is free to wait for good sea and weather conditions to perform the trap laying and gathering operations.

(4) Trap fishery can be done in areas with a sea bottom that is too rough for trawl net or bottom gill net fisheries.

(5) Today's traps are made of synthetic fiber netting and plastic or steel flames in lightweight, durable designs that make them capable of withstanding long, constant use.

(6) Large numbers of collapsible traps can be carried on board the fishing boat at one time and laid out over a large area of sea by means of a longline set-up.

(7) Furthermore, traps can be used to exploit fishery resources in deep waters where trawl net fishery is impossible.

In Japan, the marine resources caught by trap fisheries include various crabs, shrimps and shellfish, with the principle species being tanner crab, Pacific tanner crab, Gazami crab, blue crab, shrimp, Toyama shrimp and top shell. A number of different trap designs have been developed for the different types of species to be caught and often differ by region.

While trap fishery is an energy-efficient fishing method with a high catching efficiency as well, on the other hand, it presents some problems with regard to resource conservation that must be addressed:

◀▲ *A crab trap used on the coast of Hokkaido. In order to make sure that the trap sits firmly on the sea bottom, the trap is designed with a bottom diameter of 100 cm and a height of 30 cm. The bottom frame loop is made of metal rod, while the upper frame is made of plastic tubing. The netting is cremona with a mesh of 23 mm. The circular plastic ring that forms the mouth of the trap where the crab enters at the top has a diameter of 20 cm.*

▼ *This is a collapsible trap used for catching Gazami crab that live in bays. After sticking the bait fish on the metal prong inside the trap, it is folded up and stacked neatly on the deck of the fishing boat for the trip to the fishing grounds. The frame for the netting is made of steel rod and the netting is nylon monofilament with a mesh of 12 cm. The traps are attached to a main line at intervals of a few meters, with 60 to 100 traps per line.*

◀ *A trap for catching blowfish from Kyushu. In order to prevent the fish from eating their way through the netting, metal netting is used. The blowfish carries a powerful poison in its ovary and liver, but when its meat is prepared with just a trace of that poison remaining it is considered one of the greatest seafood delicacies of all by Japanese gourmets. Thus blowfish is one of the highest priced fish in Japan.*

1) There is a need to regulate the mesh size of the netting used in the traps so that it is large enough to allow individuals that are too small or immature to escape from the trap.

(2) The growth rate of the species usually caught by the trap method tend to be slow and the reproductive capacity of the resources consequently weak. So, a reliable system of fishery mangement is necessary to set suitable limits on fisheries.

(3) There is always the danger that traps that are lost at sea due to such accidents as branch lines broken in rough seas will continue to carry on "ghost fishing" indefinitely.

For this reason it is necessary to make one portion of the trap with a material that will deteriorate in a given period of time in order to provide the creatures trapped inside with a natural "escape hatch."