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# YELLOWTAIL CULTURE

# Pioneering the culture of saltwater fishes

*Because of its fast growth and easy feeding characteristics, yellowtail was the first saltwater fish to become the object of culture fishery. These yellowtail have been raised to a weight of 3kg. About 2000 fish are kept in this 10 meter×10 meter wire cage with a depth of 8 meters.*

In Japan today, approximately 3000 coastal fishing families are engaged in the culture of Japanese amberjack (yellowtail), *Seriola quinqueradiata*, accounting for an annual production of 150,000 tons of mature fish. This is by far the largest production for any type of cultured fish, saltwater or freshwater, in Japan. Japan's coastal fishermen also catch yellowtail by hand-and-line angling, trolling, gillnet and stationary net methods. But the catch of these "natural" yellowtail does not exceed 30 to 50 thousand tons per year. In contrast, the annual production of cultured yellowtail in recent years has reached a level several times this amount.

The culture of saltwater fishes, by the way, happens to be the most recent addition to Japan's varied culture fisheries. The culture of such fishes as carp, eel and trout has been conducted abundantly in Japan's freshwater areas since olden times. In saltwater areas, however, culture fisheries have traditionally been limited to shellfish and seaweeds such as oyster and laver. Unlike freshwater fishes, the raising of saltwater fishes, that habitually live in large open sea areas, within a confined area presented a number of problems. For example, building facilities and developing the technology necessary to feed large populations of fish until they reached a marketable size that could be sold profitably. Prior to the end of World War II, short-term stocking of certain saltwater fishes was being carried out in the various regions of Japan. But full-scale culture activities aimed at the raising and fattening of marketable fish was only seen in certain fishery experimental stations or in the independent efforts of a few adventurous private fishermen. After World War II, as Japan's post-war economy stabilized and entered the period of high growth rate in the '60s, culture industries in saltwater areas entered a period of full-scale development and growth.

Roughly at the same time that the existing oyster and laver culture industries began to show outstanding growth, new yellowtail, undaria and tangle laminaria culture began to show rapid growth as commercial industries. Entering the 1970s, commercial culture of such fishes as red sea bream, jack mackerel, silver salmon and shellfish like scallops sprung up. And, all showed excellent initial growth in production. Among these, it was yellowtail that became the vanguard in the development of saltwater culture fishery as a whole.

From here on, let us devote this issue to a study of the history of the development of yellowtail culture. At the same time we will look at the basic conditions necessary for sound and prosperous culture of fishes in general.

**FIG.1: Culture fishery production by species (figures for 1987)**

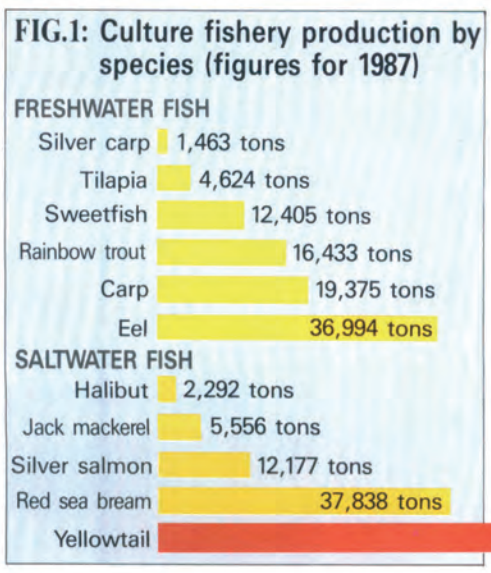
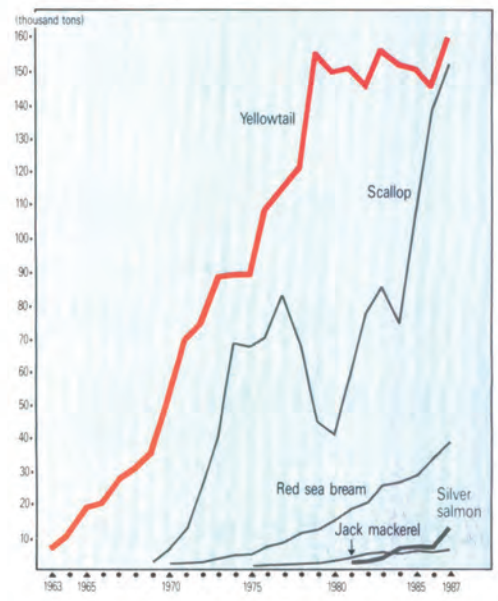



**FIG.2: Production of saltwater culture fisheries**



# Living conditions and life cycle

Yellowtail is a close relative of the greater amberjack, *S. dumerili* and Amberjack, *S. aureovittata* that are found distributed widely through the tropic and subtropic waters. This particular species is found in abundance primarily in the warm coastal water regions of an area stretching from the southern part of the Kamchatka Peninsula through the waters of Japan and Korea to the southern part of the Maritime Littoral Province of Siberia.

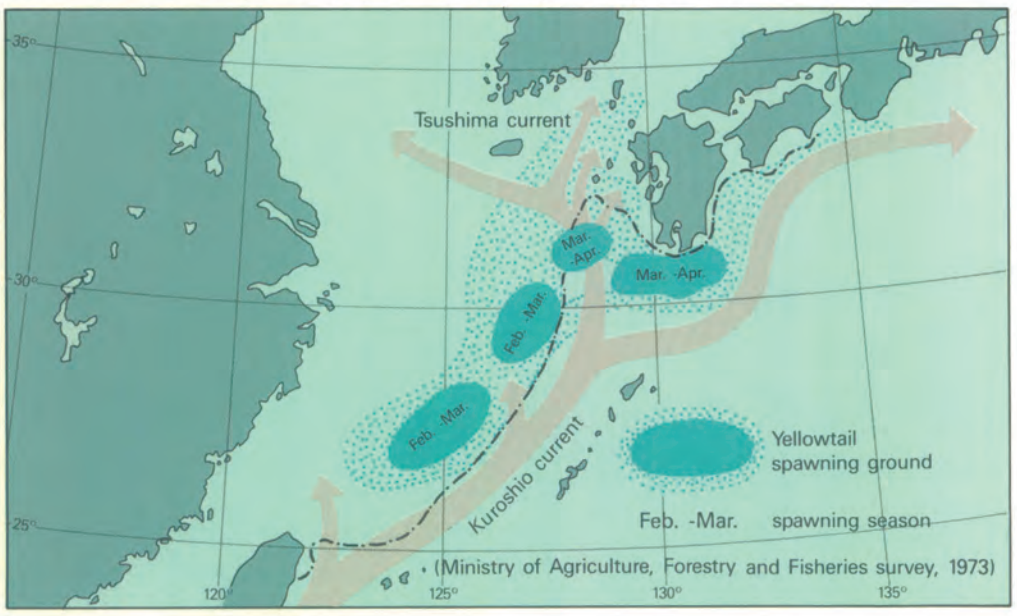
The spawning grounds for yellowtail are found around the Noto Peninsula (lat. 37°N) and the Bohso Peninsula (lat. 35°N), and waters south of these points. Particular concentration is seen in the waters of the East China Sea between 27° and 30° lat. N. **(Fig. 3)**. Once the fry have hatched, their growth pattern involves attaching themselves to the drifting seaweeds that gather in oceanic fronts. These drifting seaweeds are fragments of the coastal seaweeds that have come loose and float in the surface waters, and they are a gathering point not only for the yellowtail fry but for the fry of many kinds of species. The yellowtail fry that gather among these seaweeds gradually drift northward with the warm currents until they reach a body length of some 10cm. At this time they leave the current and migrate to the shore waters of central and southern Japan. Here they search out primarily bay and inland sea waters in which to feed and grow. It can be said, therefore, that drifting seaweeds function as the vehicle which distributes yellowtail resources through the Japanese waters.

During immaturity the yellowtail remain in the coastal waters to which the sea currents brought them. But, when they reach the age of 2 (body length approx. 40cm) they leave these waters to begin migrations over large open sea areas. During the spring and summer months they migrate north in search of food. In autumn and winter they migrate south in search of spawning and wintering grounds.

Upon reaching a size of about 10mm, the young yellowtail begin to feed on animal planktons. These planktons continue to be their main food source until they reach a length of about 10cm. But in the meantime, after reaching a length of about 3cm, they begin to feed also on the fry of such species as sand launce, anchovy and mackerel pike. By the time they reach a length of about 8cm, their consumption of planktons begins to decrease. When they reach a size of about 13cm, they are feeding entirely on other fishes.

Yellowtail are a fast growing species of fish. After hatching the fry are said to double their body length about every 20 days. From the fingerling stage until maturity, it has been recognized that the growth rate varies from region to region depending on such environmental conditions as water temperatures. But, in the case of cultured yellowtail, yearlings (the first year after birth) reach a length of 30～50cm with a body weight of 1～1.5kg, second year fish (between 1 and 1 1/2 years of birth) reach a length of 100～130cm and a weight of 3～5kg, and third year fish (two years from birth and after) grow to a length of 150cm and a weight of 4～6kg.

**FIG.3 :Yellowtail spawning grounds and spawning seasons**




# Three reasons for the choice of yellowtail

There are three major factors that explain why yellowtail was the first saltwater fish to become the object of culture fishery efforts. And, why their culture spread to all parts of the country in a short period of time as a commercial fishery with substantial economic importance.

### (1) The fact that they are a fast-growing fish species

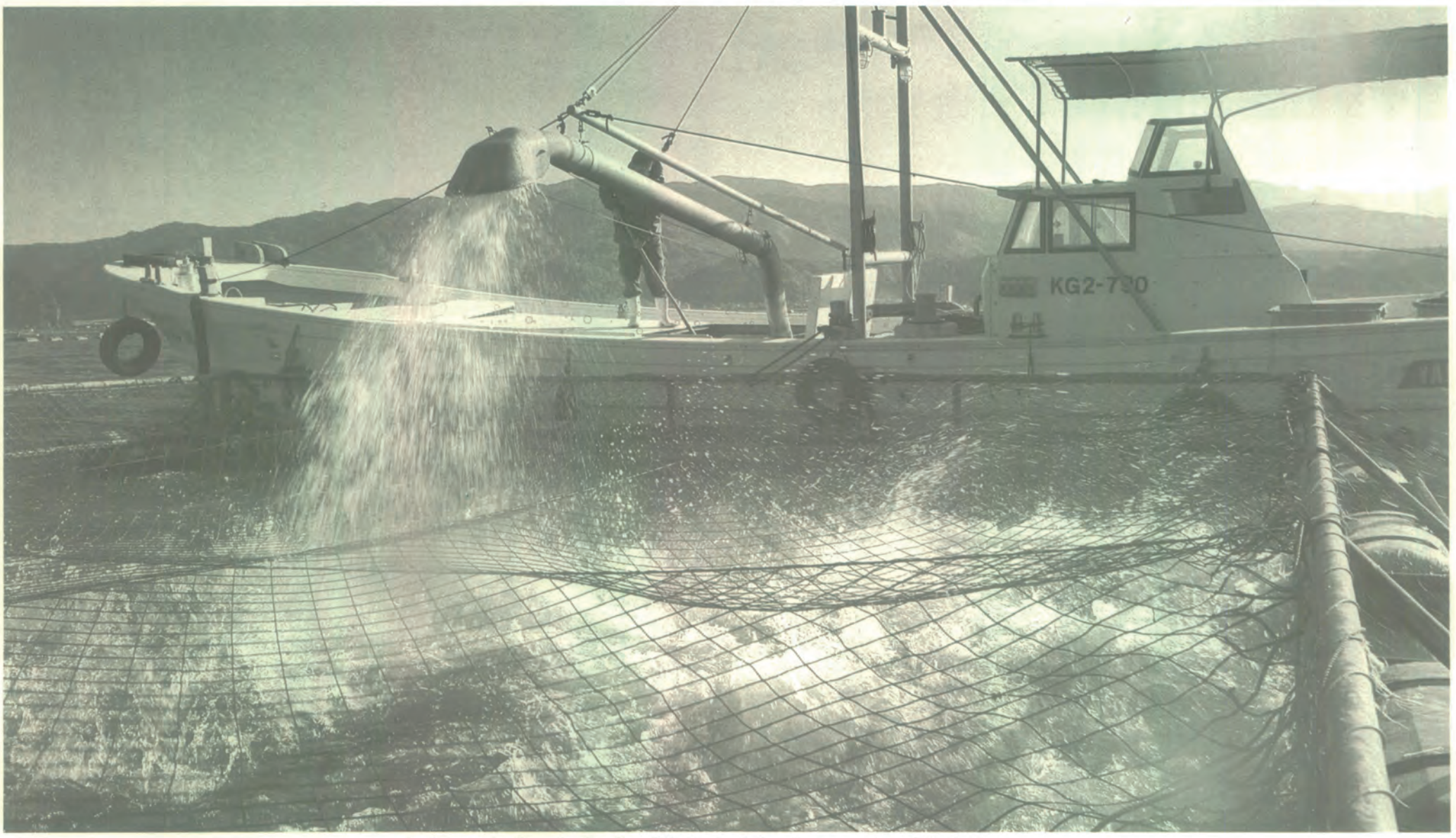
In the case of yellowtail culture, young fry with a body length of 1～17cm, called "mojako", released in the culture cage between April and June will grow to a marketable size, called "hamachi", of about 1kg within a few months. If the culture period is extended for another year the fish will go on to reach a weight of 3～5kg. When compared with red sea bream, which take 3～4 years to reach a marketable size of 1kg and jack mackerel which take 2 years to reach 150 grams, yellowtail are obviously a fast-growing fish species which bring a superior return on culture fishery investments.

### (2) It is an easy-to-feed saltwater fish

In spite of the fact that it is a migrating species, it was discovered quite early on that yellowtail could easily be tamed to thrive on feed scattered on the water surface. Proof of this fact came from Kagoshima and Nagasaki Prefectures in Southwestern Japan. Since olden times yellowtail taming practices have been in use here. Fishermen learned to scatter feed fish like pilchard or mackerel on the water everyday at a given time from autumn into winter at an appropriate location in the coastal waters, such as a reef, and get a school of yellowtail to gather and stay there. Then at an appropriate time the school was caught with a hand-and-line method in a group fishing effort. In another case, it became well known that fishermen in Central and Southwestern Japan were often troubled by yellowtail who got into the fish cages used by local fishermen to raise sardines as bait fish for their skipjack fishery and fed on their sardines. As we will see later, there was a specific pioneer in the development of the first organized culture fishery effort. And, the above-mentioned observations of the habits of yellowtail are said to have been important hints suggesting that he should try yellowtail culture in the first place.

### (3) It is a fish with a high product value

Yellowtail is a fish that has long been caught in the warm current water areas of Central and Southwestern Japan. And it has traditionally been consumed by the Japanese people as a delicacy among fishes. Natural yellowtail demonstrate rather complicated migrating patterns that bring them into the coastal waters of the different regions at such stages of their development as fingerling, young and mature fish, and they have been caught and marketed at each of these stages. As a result, each different region has traditionally had its own representative market size for yellowtail. Among these, the 1～1.5kg yearling yellowtail referred to as "hamachi" and common in the largest consuming center of Western Japan, Osaka, has had the highest market value. Thus, in their early development, yellowtail culture fisheries targeted their production at this "hamachi" demand by engaging in the short-term raising of yearling yellowtail.




*An increase in the scale of culture fisheries has led to the automation of the feeding process.*

# The history of yellowtail culture fisheries

The first experiment in the culture of saltwater fish for commercial purposes in Japan was undertaken in 1928 in Adoike (Ado Pond) of Hikida Town, Kagawa Prefecture, by a local fisherman named Sakichi Noami. Adoike is a lagoon surrounded by sand dunes that receives an inflow of water at high tide. At the time it was populated primarily by eel and striped mullet. Seeing the possibility of utilizing this pond for the culture of fishes, Mr. Noami purchased fishing rights from the local fisheries cooperative and, stringing a cotton fishing net across the mouth of the lagoon, proceeded to stock it with mackerel, jack mackerel, sea bream and hamachi fingerlings caught by local fishermen.

Having become confident enough to begin full-scale culture activities through experimental stocking, in 1930, he improved the divider system for the pond and undertook the culture of 30,000 yellowtail. His seed fish were rather large fingerlings with a body length of 15cm (about 50 grams) obtained by an angling method.

The culture operation proceeded to develop well, with shipments of mature fish going primarily to Osaka. But, with the initiation of price controls after the start of World War II, it no longer became possible to make a profit. As the war condition worsened and it was no longer possible to obtain feed fish, Noami was forced to abandon the operation in 1943.

As the country began to emerge from the social/economic confusion following World War II and price controls were lifted in 1949, Noami wasted no time in resuming his culture business. Preparing a new culture pond facility by building embankments, he stocked it with 65,000 yellowtail and 60,000 sea bream.

Beginning around 1960, yellowtail culture operations sprung up one after another in Kagawa, Kochi, Miyazaki, Ehime and Mie Prefectures. Behind this rapid development were a number of factors. For one, Japan's economic growth and the corresponding increase in the average family's spending power led to an increased demand for higher quality fishes. This fact strongly impressed Japanese fishermen with the advantages of engaging in the culture fishery of those types of fishes. Secondly, as a measure to help improve the relatively poor income of coastal fishing families, fishing agencies adopted the policy of promoting surface water culture fisheries because of their high profitability. Thirdly, the country's fishery experimental stations began to devote research efforts to the development of culture fishery technologies.

And, as a fourth and especially important factor, the development of a highly practical cage net culture method influenced the spread of yellowtail culture fisheries.

# Conditions essential to culture fisheries and supporting economic factors

Natural yellowtail are caught in all the coastal waters of Japan. And, as shown in **Fig. 4**, the warm currents around Japan play a vital role in the forming of good coastal fishing grounds. On the other hand, the culture grounds used for yellowtail culture are distributed as shown in **Fig. 5.** The culture grounds are found in Southwestern Japan and a part of Central Japan and roughly correspond with the main fishing grounds for natural yellowtail. But, they also show a tendency to be concentrated in specific areas. This is a reflection of the fact that, in addition to natural conditions, certain social and economic conditions also become strong factors in the location of yellowtail culture grounds.

Generally speaking, there are four main requirements that must be met for successful marine culture operation. These include suitable culture grounds, a supply of seed fish, a supply of feed and a suitable consumer market.

**(1) Suitable culture grounds: The waters must be flat but at the same time have a good tidal circulation of water. The water temperature should be suitable to the particular species being cultured for a large part of the year.**

Among the yellowtail culture grounds shown in **Fig. 5,** the main production areas with annual hauls of over 10,000 tons are ① Mie Pref., ② Kagawa Pref., ③ Ehime Pref., ④ Nagasaki Pref. and ⑤ Kagoshima Pref. In each case the culture grounds here are found in calm-water bays, inland seas or coasts with a large number of deep-water inlets. And, with the exception of ② Kagawa, all of these are outer coast areas touched directly by the warm currents, or inner bays reached by branches of the warm currents. The preferred water temperature range for yellowtail is 18°C to 29°C. When the water temperature falls below 13°C their feeding habits become inactive. Even if they do continue to feed, they will not show any weight gain at temperatures below 13°C. When the water temperature drops to 7°C, yellowtail enter a state of suspended animation. If continued for some period of time, it will result in death.

**(2) Seed fish: healthy seeds must be readily available**

In Japan, yellowtail culture fisheries have continued to rely on the gathering of natural fry for its seeds, without resorting to artificially induced hatching practices. As shown in **Fig. 6,** the gathering grounds for yellowtail fry stretch over a long line corresponding to the warm currents on both the Pacific and Japan Sea sides. They generally overlap the prime fishing grounds for adult natural yellowtail. The leading yellowtail fishery prefectures of Kochi, Mie and Nagasaki were the first to make advances into the field of yellowtail culture. In its early stages, families engaged in culture did their own seed gathering. But, as the industry grew in scale, there evolved a division in each region between fishermen engaged in culture and those engaged specifically in fry gathering in the waters where the fry migrated in high-concentration schools.

During the period of highest production, about 70 million fry were stocked each year, but beginning in 1988 a limit of 40 million fry per year was set in order to prevent over-

**Fig.6: "Mojako" (fry) gathering grounds and seasons (1976)**


production.

Research concerning artificial hatching techniques was begun in 1954, and by 1961 researchers had succeeded in raising 30,000 artificially hatched fry. The Japan Sea-farming Association began business producing artificially hatched fry in 1977 and up until the present they have succeeded in reaching a production level of one million fry per year.

**(3) Securing a stable source of feed materials**

According to figures compiled by the Ministry of Agriculture, Forestry and Fisheries, the yellowtail culture industry used 1.266 million tons of feed fishes and 64 thousand tons of composed feed for a total of 1.331 million tons of feed to produce a yellowtail harvest of 159 thousand tons. Rough calculation shows that it takes about 8.4kg of feed to yield 1 kg of yellowtail.

With regard to freshwater fish culture, composed feed developed in the 1960s have gradually been introduced to replace natural feeds, but the use of such composed feed in saltwater fish culture has been slow to be adopted. Particularly in yellowtail culture, there has been almost a complete reliance on such mass-catch fishes as pilchard, sand launce, mackerel and mackerel pike. Beginning about 1980, research and development of composed feed for saltwater fish culture use were undertaken out of concern for marine environmental protection. In yellowtail culture, too, composed feeds and moist pellets made from minced fish have begun to be used and are steadily gaining acceptance.

One of the most important characteristics of saltwater fish culture in Japan has been the exceptionally large difference in price between feed fish and the sale price of the culture fish. Up until today, culture fisheries have been made possible by the high market prices of middle and high-class fish that have accompanied the rise in Japan's standard of living and the low prices of feed fishes that have resulted from the development of surrounding net fisheries.

**FIG.4: Catch of natural yellowtail by prefecture**

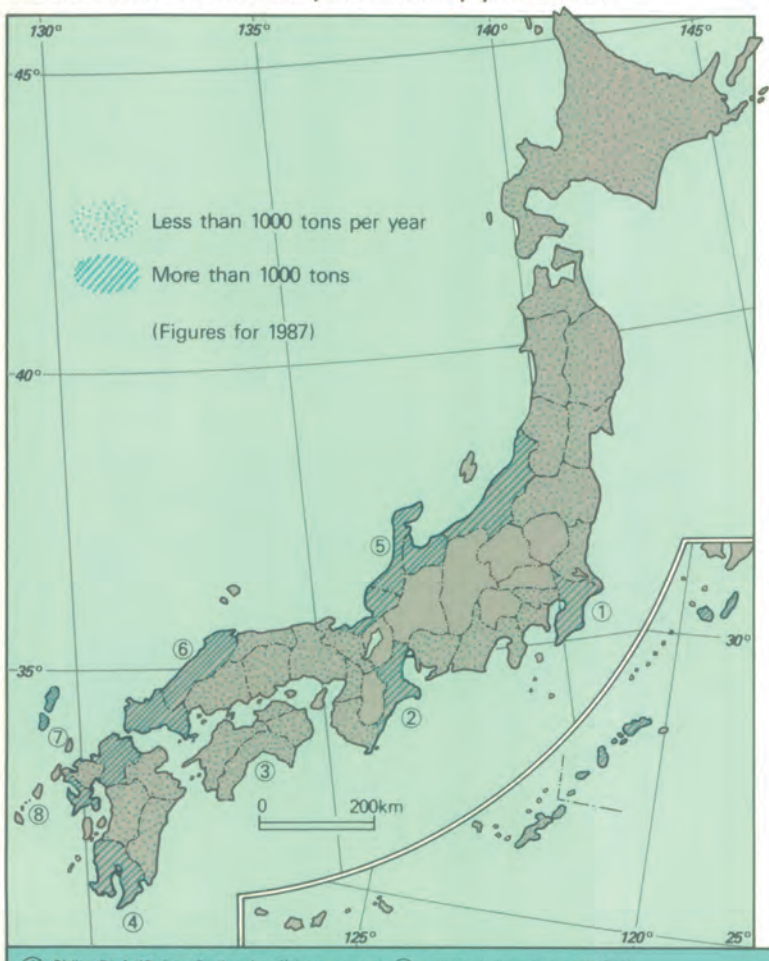



**FIG.5: Yellowtail culture fisheries production by prefecture**

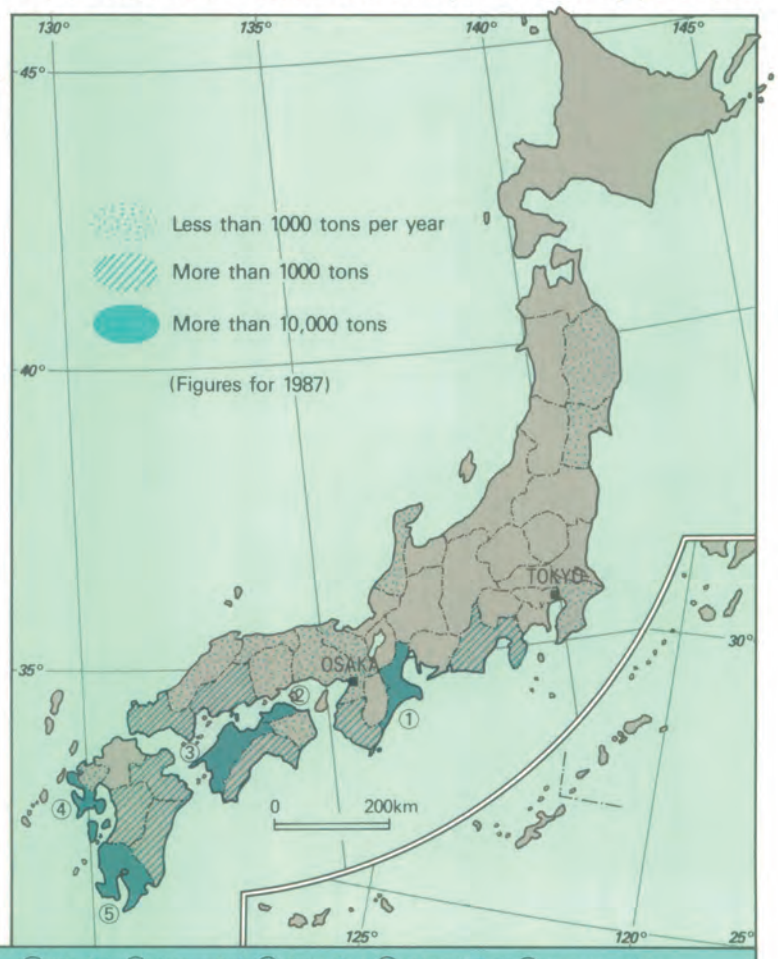



**TABLE 1: National average landing prices (per kg) -1987**

| | | |
|---|---|---|
| Culture fish | Yellowtail | 751 yen |
| 〃 | Red sea bream | 1,352 yen |
| 〃 | Horse mackerel | 832 yen |
| 〃 | Halibut | 2,728 yen |
| Feed fish | Pilchard | 15 yen |
| 〃 | Mackerel | 92 yen |
| 〃 | Sand launce | 71 yen |
| 〃 | Mackerel pike | 152 yen |

**(4) Consuming area market: access to cities must be secured**

Culture fisheries can yeild high profits when they can supply fresh fish through a direct link to the consumer market of a large city. After the developmental stage in the 1960s, yellowtail culture production began to increase at a tremendous rate in the '70s. This was in large part due to the success of the producers' efforts to open up a lucrative sales route in the Tokyo market, which previously had not demonstrated a large demand for yellowtail. **(Fig. 2 and Fig. 11)**

In the days before the spread of refrigerated shipping, yellowtail used to be shipped to more remote inland areas as a salt-preserved fish. But today, all yellowtail are shipped as fresh fish. In addition, in recent years there has been a trend to seek a still higher priced market by shipping yellowtail live to restaurants in the cities. Some producing areas are also experimenting with shipments of frozen processed yellowtail fillets to high-volume supermarkets.

# Yellowtail Culture Technique

## Gathering seed fish

From April into June each year, schools of yellowtail fry attached to drifting seaweeds appear in the coastal waters of Japan's Pacific and Japan Sea coasts. These drifting seaweeds tend to be strung out in meandering patterns at the boundary between the coastal waters and the offshore warm currents, or in patches dotting water areas at the junction of two ocean currents.

Fry that have been caught are placed in the live hold of the boat. On return to harbor they are placed immediately in net cages in the sea water. During this process of moving the fry from the fish hold to the cages, net sieves with suitable sized meshes are used to separate the fry according to size into several groups and placed each in a different cage. This is a rather important part of the fry gathering operation. Because, if fry of different sizes are placed in the same cage they will begin to feed on each other, sharply decreasing the survival rate of the seed fish in the initial stage of culture.

The fry are fed on the type of animal planktons or mysids that are found in abundance in bay waters, and later minced meat of anchovy or sand launce, etc. to get them used to feeding on fish.

## The culture facilities

There are three types of facilities used in yellowtail culture: pond type, enclosing stationary net type and cage net type. Among these, for reasons we will go on to explain, the vast majority of facilities in use today are of the cage net type.

**TABLE 2: Number of facilities and facility area by culture method (1987)**

Total number of yellowtail culture operations in Japan: 3,079

| | Number of facilities | Facility area |
|---|---|---|
| Pond culture | 2 | 48,000m$^2$ |
| Enclosing stationary net culture | 58 | 679,000m$^2$ |
| Cage net culture | 25,652 | 2,694,000m$^2$ |

**Pond culture:** Taking advantage of natural topography, a certain water area is blocked off by a retainer and a water gate is made to allow the circulation of sea water. In one divided man-made pond, fish are raised from fry to mature fish. In the early stages of saltwater fish culture this was the most common method, but it gradually disappeared with the development of enclosing stationary net and cage net methods.

**Fig. 7 - 2** is a diagram of the culture fishing ground at Adoike pond in Kagawa Prefecture, the site of the first commercial yellowtail culture operation in Japan.

**Enclosing stationary net culture:** With advances in marine construction technology and improved materials, the more advantageous enclosing stationary net culture method appeared and began to replace pond culture methods. This new method was divided into two types, a pole type and a hanging type. The pole type involved driving a line of concrete poles or steel piles into the sea bottom in a shallow water area to create the outer boundary for a culture area. Then, nets were hung from these poles to divide up the waters inside the area. On the other hand, the hanging type involved stretching a cable across the water and hanging netting from the cable, or using floats, sinkers and stays to hang the netting vertically in the water. With this enclosing stationary net method, nets could also be hung in a circular pattern out from the shoreline to create a culture area. This allowed for the selection of better culture waters than possible with the pond culture method. Water circulation was also superior to that of the pond culture method.

**Cage net culture:** The cage net culture method was introduced in 1957 and soon spread rapidly throughout the country. This method involved building a raft framework from logs, bamboo or iron pipes and hanging netting down from its edges. The rafts are then floated out in the water on lines of floats linked together. The raft framework is usually made in a rectangular or square shape, but some steel-construction frames are also made in hectagonal or octagonal shapes. Although there are no set standards for frame size, they are usually either 6 meters × 6 meters with a 4-6 meter net hanging depth or 8m × 8m × 8m or 10m × 10m × 10m.

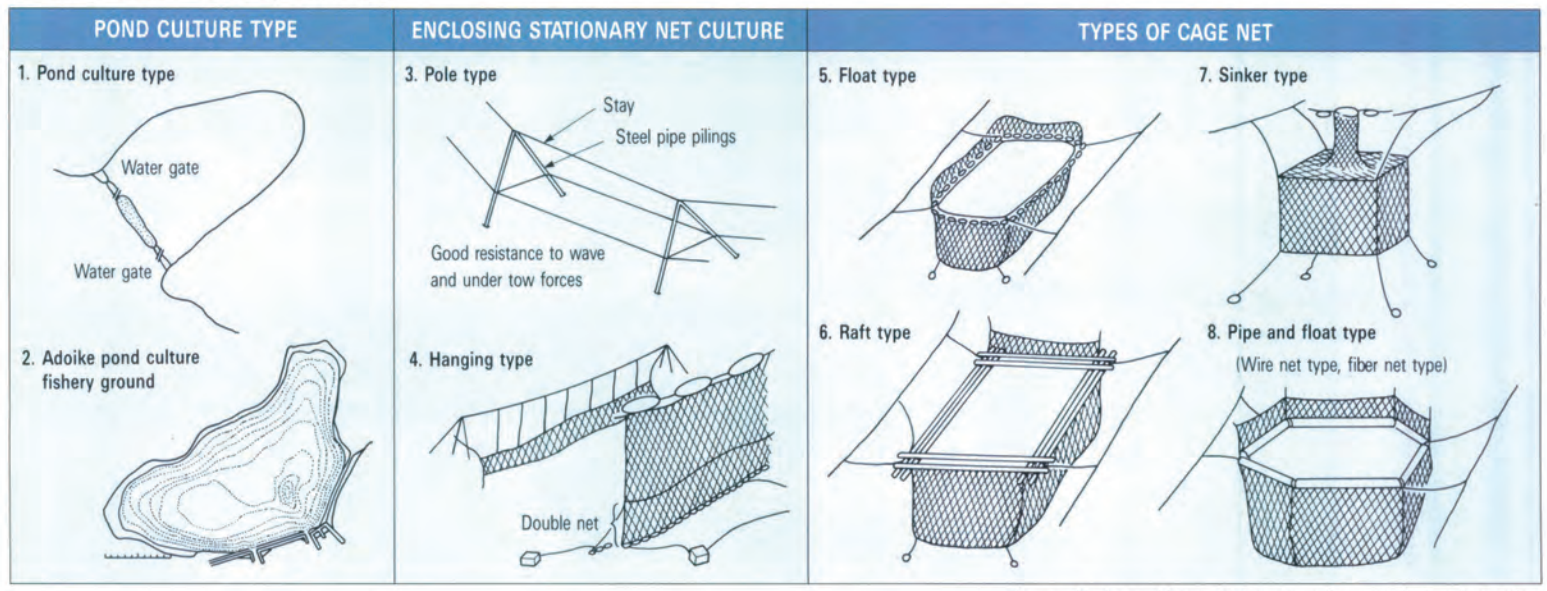
Hear are the main advantages of the cage net method:

1. The facilities can be built with a relatively small capital investment.
2. Culture activities can be begun on a small scale.
3. Water circulation within the cage is extremely good.
4. The fish can be moved readily from one cage to another as they grow, making for efficient, high-intensity culture operation.
5. The culture facility can be moved from one water area to another.

On the other hand, the cage net method has the following disadvantages:

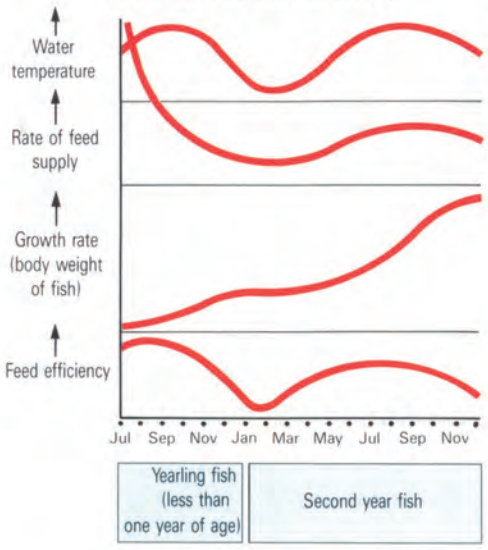
1. Damage to the net can cause fish to escape.
2. Because of the high dencity of fish, disease resulting from net abrasion etc. can occur more easily, and parasites and fish diseases spread more quickly among the culture population once they appear

**FIG.7: Culture fishery facilities**




(Source: Mr. Nobuo Matsui, Adviser, Japan Sea-water Culture Association)

**FIG.8: Relationships of water temperature, feed rate, growth rate and feed efficiency**




(Note)
(Feed rate): The ratio of the weight of feed given in one day and the total weight of the fish in the culture facility (weight of feed ÷ weight of fish)
(Feed efficiency): A measure of the amount of weight gain shown by the fish for a given weight of feed as,

$$\frac{\text{Weight gained in one month}}{\text{Weight of feed given in the month}} \times 100$$

3. The feeding operation becomes more laborious.
As for the netting, in the early stages hemp palm nets were used, but today most of the nets are made of synthetic fibers such as nylon and cremona or wire nets (coated with vinyl or galvanized). The nets are changed 5 to 10 times with a progressively increased mesh size during the culture process as the fish grow in size.

## Raising

Operating schedules for yellowtail culture can be classified into the following categories:

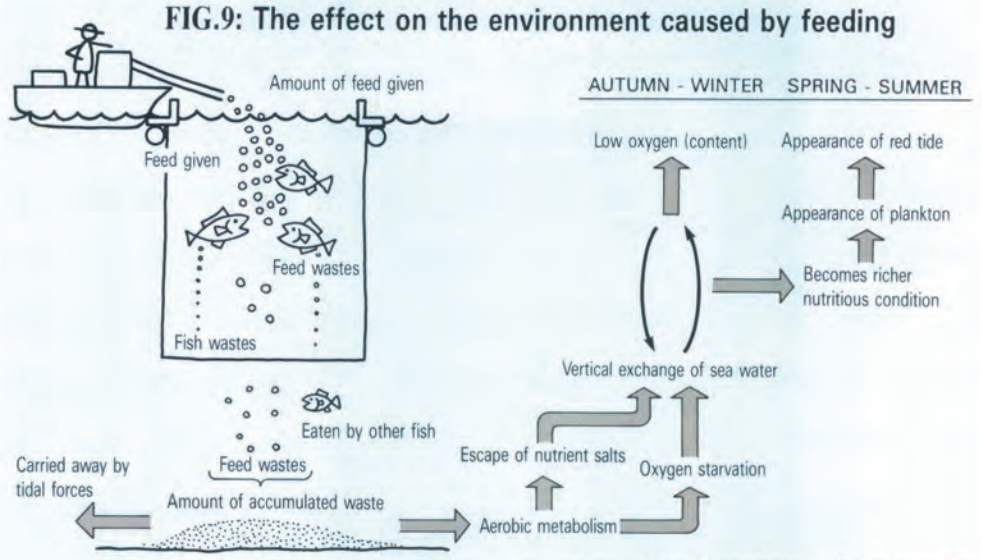
**1. Fish harvested and shipped as yearlings...**
Seed fish released in the culture area (cage) in May or June are raised to a size of roughly 1kg and shipped to market at the end of the same year.

**2. Fish shipped as second-year fish...**
The fish are shipped in autumn or winter of the next year at a size of 2.5-3kg.

**3. Fish shipped as third-year fish...**
The fish are shipped two years after the start of culture at a weight of over 4kg.
In the shortest cases, the culture process takes 6 months, and in the longest cases over 2 years. During this time the work of the culture fisherman involves feeding, net changing and the prevention and treatment of fish diseases.

**(1) Feeding**
The growth rate of fishes depends on their feeding habits, which are largely determined by water temperature. Proper feeding of culture fishes involves maintaining a suitable feed rate based on the fish's appetite at the time and a suitable feed volume based on the rate of weight gain. When the amount of feed is insufficient you will begin to see a difference in growth rate between the individual fishes of a given culture group. In the fry stage you will see the fish feeding on each other. After the fingerling stage you will see a tendency for the weaker and smaller fish to die from malnutrition. On the other hand, when the amount of feed being given is too large you will see a pollution of the culture water with left-over feed debris. Also considerable economic loss will occur. **(See Fig. 8 & Fig. 9)**.
With regard to yellowtail culture fisheries, researchers have developed charts of appropriate feed volumes at different water temperatures and different fish sizes. But, concerning the frequency of feedings and the amount of feed to be given at each feeding, fishermen still have to rely on their own experience.
In yellowtail culture up until the present, live or fresh feeds have been by far the predominant type. From now on, however, we will probably see a spread in the development and use of composed feeds, for the following reasons:
1. the pursuit of better nutrition for the fish
2. efforts to decrease the feed overhead costs in culture fisheries
3. efforts to protect the environment by reducing feeding wastes to an absolute minimum.
In recent years, we have seen an increased use of a pellet form of feed made from a combination of fresh feed fish and fish powder, called Oregon Moist Pellets, in yellowtail culture fisheries in Japan.

**FIG.9: The effect on the environment caused by feeding**




(Source: Mr. Nobuo Matsui, Advisor of Japan Sea-water Culture Association)

**(2) Net changing**
The growth of clinging organisms such as seaweeds causes a gradual clogging of the net mesh. If this clogging is allowed to progress it causes an obstruction to the proper exchange of sea water within the cage. It also becomes a cause of net damage due to wind and wave activity. And, because larger mesh nets allow for better water exchange, it is advantageous to change the net mesh size as the fish grow in size.

**(3) Fish diseases**
There are basically two categories of fish diseases; those caused by poor feed quality and those that occur as a result of the sea environment. To counter these diseases, practices of adding nutrients such as vitamins to the feed and giving the fish "medicinal baths" are conducted in all types of culture fisheries. With the spread of cage net culture methods, the number of fish being raised in a given water area has increased. And several factors such as the decreased size of the life environment and the pollution of the water with feed debris have made for more problems in the area of fish disease prevention. This disease prevention has become the primary problem to which culture fishermen must devote themselves. And the concensus in the industry today is that the ultimate answer lies in the reduction of culture intensity to a level that best fits the natural productive capacity of the fishing grounds, and then seeing that those levels are maintained.

*Yellowtail seed fish are caught with a small one-boat operated purse seine. Paying attention to the water color, the fishing boat cruises along the boundary of the warm current waters looking for drifting seaweeds. When a patch of drifting seaweed is found, the net is thrown in starting on the downwind side and one circumnavigation of the patch is made catching the fry along with the seaweeds.*

*Moist Pellets*
*Minced fish meat and fish powder are mixed together and pressed into cylindarical pellets with a length of about 10mm and a diameter of 3-20mm. (Photo by Nihon Nosan Kogyo KK)*

*An automatic feed distributor used for moist pellets*

*Overall view of a steel pipe frame facility*

*Steel pipe raft type cage net facilities*

*The hauling of the fish is performed by 9 men. An eight-hand lift net is fed under the bottom of the cage and the net is hauled in hand-over-hand from the gunwale side to gather the fish in so that they can be scooped up by the landing net and placed in the boat's fish hold.*

*A medicinal bath used to rid fish of parasites clinging to the skin.*

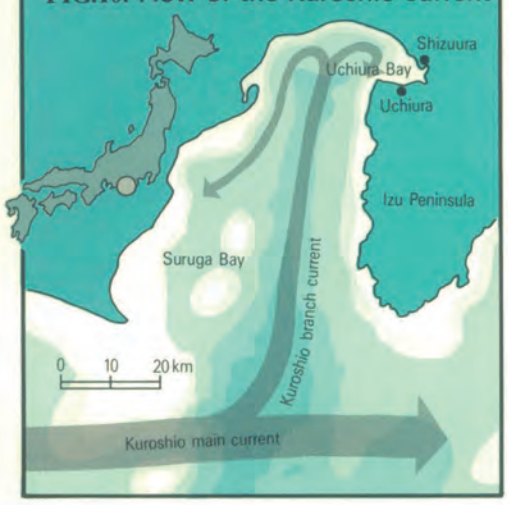
*Frozen sardine used for feed*

# A diversified, market-oriented fish culture industry

## EXAMPLE 1

### UCHIURA BAY
Shizuoka Pref.

FIG.10: Flow of the Kuroshio current




The various yellowtail culture producing areas can be classified into a number of types depending on what market they are linked to.

1. **Osaka market type** - areas which concentrate their production on yearling fish harvested within the first year of culture for shipment to the three major cities of the Kinki region, Osaka, Kobe and Kyoto.(Eastern sector of the Seto Island Sea)

2. **Western Japan market type** - areas that concentrate on the production of large second and third year fish for shipment to a wide-ranging market in Western Japan that includes the cities of Osaka, Kobe, and Kyoto. (Kagoshima, Ehime, Kochi, Wakayama and Mie Pref.)

3. **Tokyo market type** - areas that produce for the Tokyo market. In addition to yellowtail, this type of culture fishery also devotes considerable efforts to the production of red sea bream, jack mackerel and other fishes. (Shizuoka and Chiba Pref.)

**TABLE 3: Fish culture production in Shizuoka Pref. (1987)**

| | Production volume (% of previous year) | Total product value (% of previous year) |
|---|---|---|
| Yellowtail | 2,071 tons (89%) | 1,661 mil. yen (66%) |
| Red sea bream | 574 tons (151%) | 1,037 mil. yen (140%) |
| Jack mackerel | 1,807 tons (105%) | 1,381 mil. yen (66%) |

*Note: The production of Uchiura area culture fisheries accounts for 67% of the yellowtail, 68% of the red sea bream and 66% of the jack mackerel production for the entire prefecture shown in the above table.*

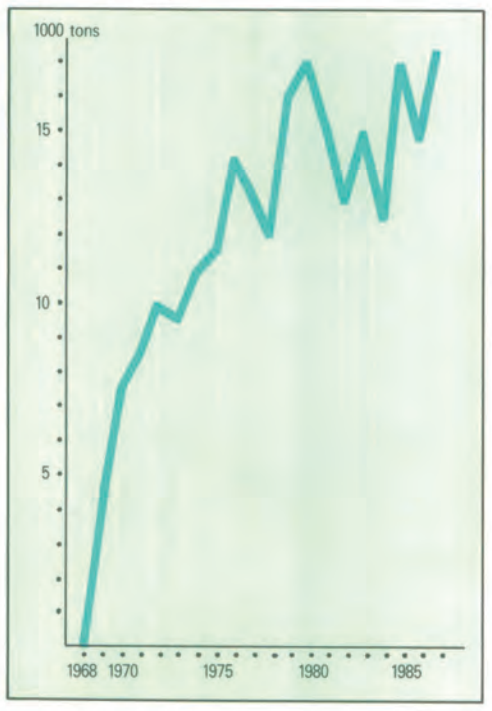
4. **Local market type** - small scale culture operations concentrating mainly on local markets (Western section of Seto Inland Sea and Japan Sea).

However, all of these regional types are showing the same three trends in recent years: 1. A change of culture emphasis from yearling fish to second and third year fish, 2. a shift away from strictly yellowtail culture to multi-fish culture activities, and 3. increased sales to the Tokyo market (the Tokyo Metropolitan area). With regard to this last trend, while tuna has traditionally been the preferred fish for "sashimi" (raw slices of fresh fish eaten with soy sauce) in Tokyo, in recent years yellowtail sashimi is growing in popularity. This factor has been of great importance in the development of yellowtail culture fisheries. Entering the 1970s, Shizuoka, Mie and Kagawa Prefectures all made efforts to promote sales of yellowtail in the Tokyo market, and in little time at all they succeeded in establishing an annual demand there of over 10,000 tons. As a direct result of this development, there was a change in the main target market size from smaller fish to middle-size fish, thereby effecting an increase in the overall yearly production tonnage. **(Fig. 11)**

### 60% of annual production shipped as live fish

Uchiura Bay is located on the west shore of Izu Peninsula and forms a deep indentation in the inner part of Suruga Bay. Suruga Bay has a large mouth and an underwater mountain range corresponding to the Izu archipelago that directs a branch of the warm Kuroshio current into the Bay, reaching as far as Uchiura Bay. As a result, the waters of Uchiura Bay are blessed with not only coastal water fishes but also offshore migrating fishes. This has made the bay an active fishing area since olden times.

**FIG.11: Volume of cultured yellowtail reaching the Tokyo Central Market**




Particularly, in recent years there has been an emergence of surrounding net fisheries, based primarily in the port of Shizuura, that specialize in catching sardine and mackerel. **(Fig. 10)**

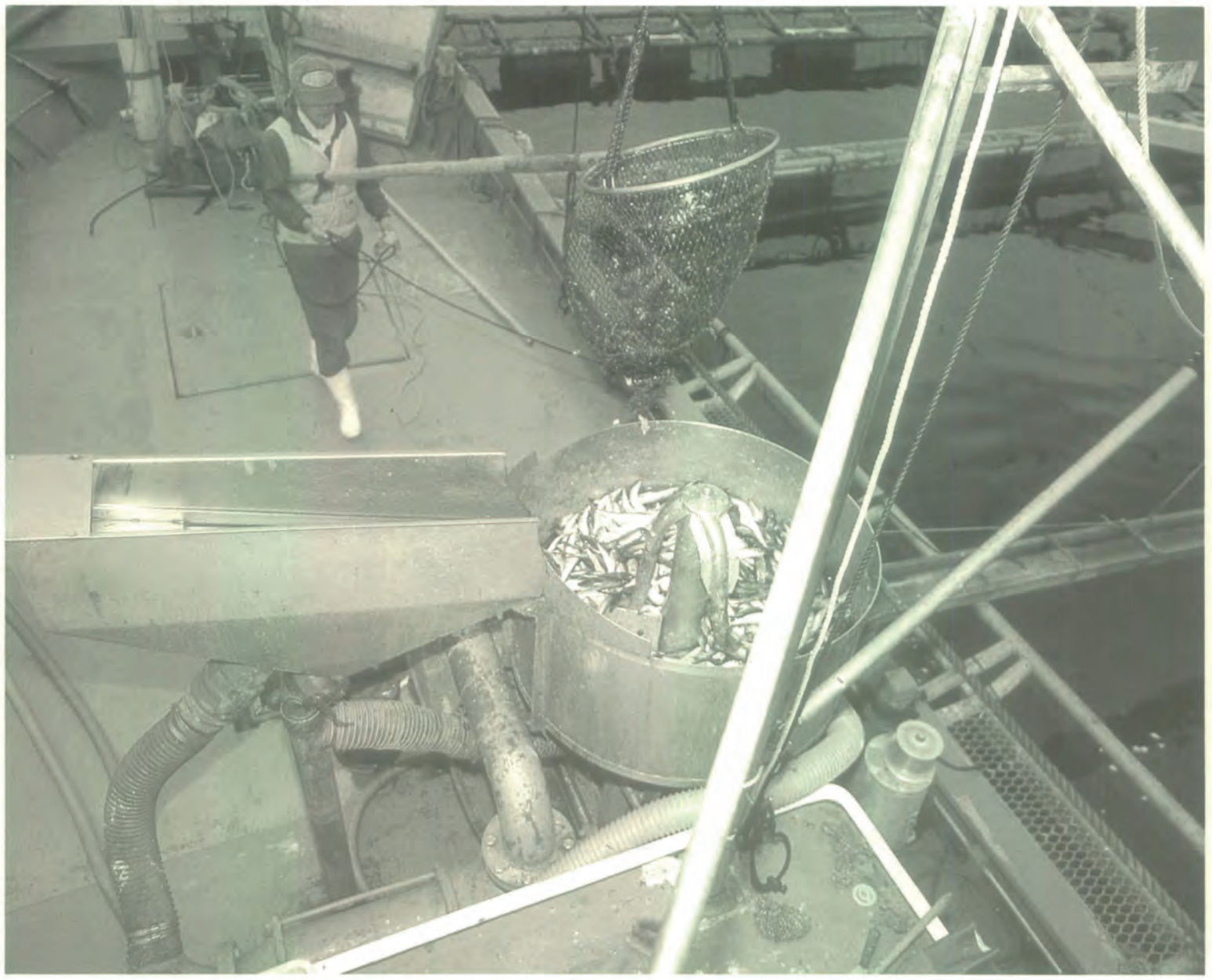
The influence of the Kuroshio warm current keeps the waters of Uchiura Bay warm and suitable for culture fisheries even in winter. However, being an area with excellent fish resources for boat fisheries, there was considerable resistance to the idea of introducing culture fisheries. Culture fishery operations were first introduced in the Uchiura area which was found less favorable for boat fisheries than other areas around Uchiura Bay because it received the predominant northwesterly winds of winter directly.

In 1955 an attempt was made to establish pearl culture fishery. But, as it turned out, the waters here were not suited for the production of quality pearls and the culture efforts were ceased within a few years, before the operations ever reached full scale production. To replace the pearl culture, yellowtail culture was begun in 1960. Yellowtail culture had the important advantage of access to the sardine and mackerel of the local purse seine fisheries as feed materials. Also, because yellowtail seed fish could be caught in nearby sea areas, there soon appeared fishing families who specialized in the gathering of yellowtail fry. The portion of the seed fish demand that could not be met by these local suppliers was bought from suppliers in Western Japan.

What makes the yellowtail culture fisheries of Uchiura unique is their sales organization. The water temperature in Uchiura Bay in summer ranges from 17~22°C, or 1~2°C lower than Western Japan. And, this makes the growth rate of the fishes somewhat slower. In order to make up for the disadvantage of the smaller size of their fish, the producers of Uchiura began to concentrate their efforts on selling their produce as live fish. In 1987, of the 2000 tons of yellowtail produced in Uchiura 60% were shipped via live-fish transport trucks to the Tokyo market 150km away. Main buyers of these yellowtail are restaurants and "sushi" shops.

The culture fishery operators in Uchiura believe that the key to successful development of their culture fisheries is to take the fullest advantage of their close proximity to the country's largest consumer market, Tokyo. In addition, they are making efforts to answer the diverse needs of the fish consumer market of this large urban area by engaging also in the culture of such fishes as red sea bream and jack mackerel, as well.

*Sardines are minced and fed to the culture fish. These sardines have been shipped in from the Japan Sea Coast. In some seasons feed fish have to be bought from other prefectures in this way.*

# EXAMPLE 2

## Kagawa Prefectural Union of Fishery Cooperative Associations

FIG.12: The location of Kagawa Pref.


# Fishermen's efforts to integrate the productive capacity of their fishing grounds

FIG.13: The affiliation between local fishery cooperatives and the prefectural union of cooperatives

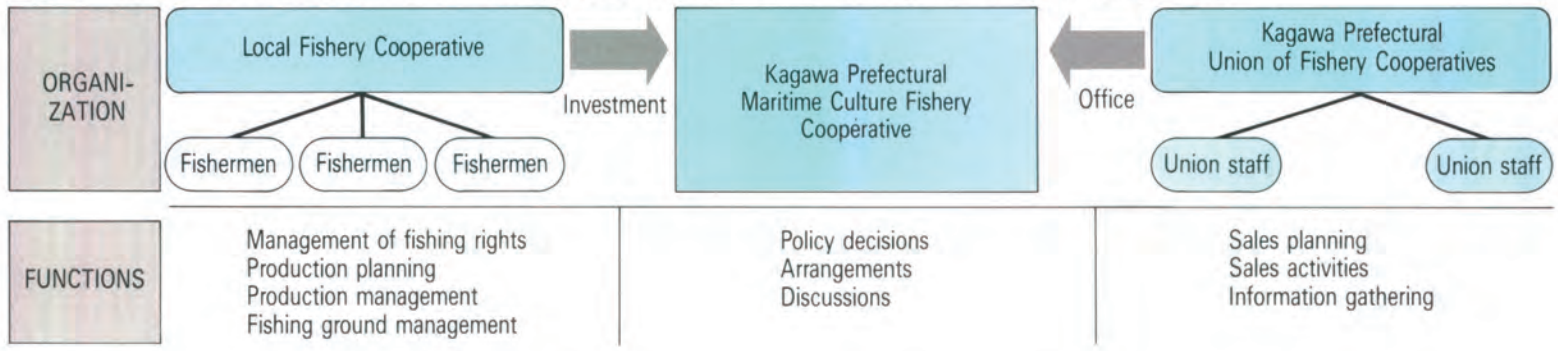



FIG.14: Fluctuation in production value in Kagawa Pref.

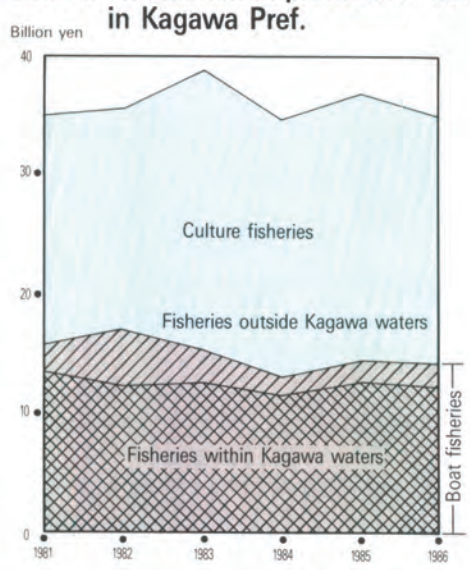



FIG.15: Fishery production by sales value in Kagawa Pref.

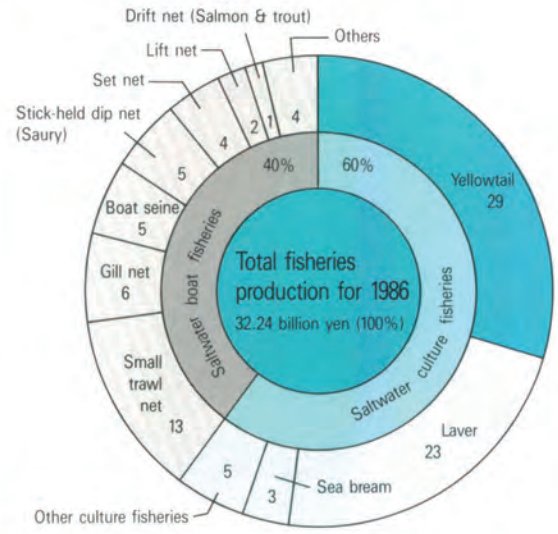
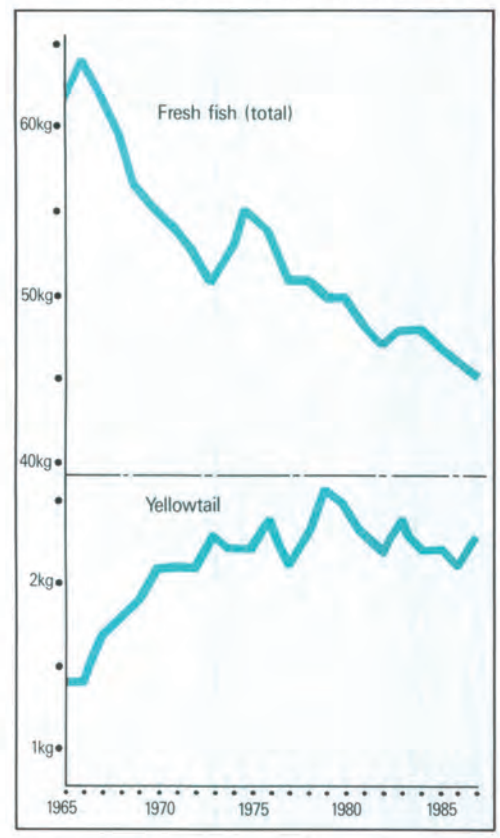



FIG.16: Annual consumption per household (national average)




Source: Annual Statistical Report of Household Economy by The Prime Minister's Office

Since the latter part of the 1960s, household consumption of fresh fish in Japan has been on the decline. Yellowtail, however, like other high-grade fishes, showed a steady increase from about 1965 to 1975 **(Fig. 16).** Reflecting this demand, the producer's price for yellowtail, although showing fluctuation from year to year, was on the rise constantly from 1965 to 1978. This was a direct reflection of the rise in the national standard of living during this period.

In 1979, there was a sharp drop in the wholesale price of yellowtail. Since then, the supply of yellowtail has remained fairly constant and there has been a gradual decrease in the wholesale price. The decline in yellowtail culture production in recent years might be accredited to changes in the eating habits and diversification of tastes of the Japanese people that have led to increased competition from other foods for the market once enjoyed by yellowtail.

However, in fact, it is most likely a reflection of the fact that yellowtail production has entered a stage of over-supply. Based on the competitiveness of their production methods, the weeding out of some culture fishery operators is expected to continue for some time to come.

In the face of such conditions, the problems to which culture fishery must address itself are;

1. Achieving a stable production of high-quality yellowtail, 2. achieving a degree of organization that will enable the culture fishery operators to make well-calculated shipping schedules that correspond to favorable market conditions in the consuming areas, and 3. maintaining culture ground environment in ways that will ensure continued culture ground productivity. In other words, culture fishery is in a situation where it must now deal systematically with three vital elements of their business; production, sales and the environment.

### Winning bargaining power in the market

The culture fishery operators of the eastern part of the Seto Inland Sea in Kagawa Prefecture have succeeded in integrating the productive capacity of their local fishing grounds through initiatives taken by two organizations, Fishery Cooperative Associations and the Union of Fishery Cooperative Associations. In short, Fishery Cooperative Associations are responsible for supervising marine production — by such means as setting limits on the number of cages in use for culture fishery and the number of seed fish they are stocked with, and the allotment of culture grounds — through their authority as the controllers of culture rights for their individual areas of jurisdiction. On the other hand, the Union of Fishery Cooperative Associations is responsible for sales activities, acting as the central agent for the sale of the combined yellowtail and other culture fishery production for almost the entire prefecture. Furthermore, as an organization to coordinate the activities of these two, the "Kagawa Prefectural Maritime Culture Fisheries Cooperative Association" (voluntary) was also established. **(Fig. 13).** In 1964, yellowtail culture fishery was about to enter its period of growth and development, and the competition to get sufficient seed fish and feed fish getting more heated in all sectors. At this time, a "Maritime Culture Fisheries Cooperative" was formed to alleviate such problems through the collective purchase of seed fish and feed fish.

In time, the Union of Fishery Cooperatives began to show interest in handling sales, and by 1968 it had begun collective sales of the combined produce of participating cooperatives. The aim of this collective sales system was to win bargaining power with the wholesalers in the Osaka market, through the ability to control and stabilize the shipment of their products.

The Union of Fishery Cooperatives went on to establish its own sea shipping route to the market by outfitting a live-fish transport ship. This led to a practice of buying up culture fishery produce from producing areas outside the prefecture as well. The reason for this move originated in the fact that the water temperature in the Seto Inland Sea drops below 10°C in the winter months, thus creating the danger of killing a considerable portion of the yellowtail culture population. For this reason, all culture fish are sold during the 4-month period from September to December. This created an 8-month period from January to August during which there were no shipments of Kagawa-produced yellowtail. The practice of buying from other prefectures grew out of the need to make use of the facilities and labor that would otherwise be idle during this period, and thereby make them profitable.

By buying up produce from other prefectures, the Union strived not only to increase their sales volume, but also to open up new sales routes to other urban markets besides Osaka. Special mention should be made of the fact that through these efforts they were able to open up a substantial market in Tokyo, a city which previously was a low-consumption market with regard to yellowtail. Through persistent efforts that often met with failure, they continued to make shipments to Tokyo until a profitable route was finally established around 1975.

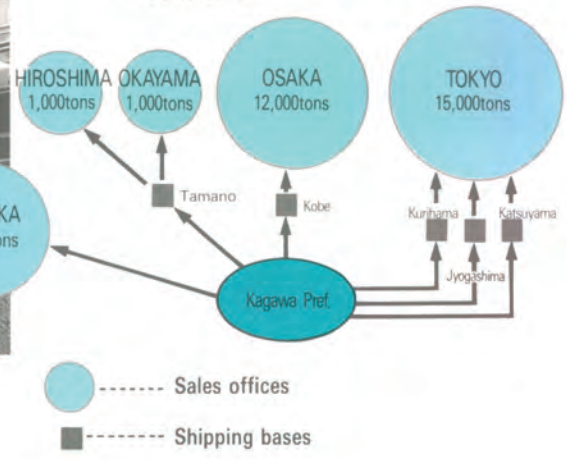
The Union has branch offices in the major urban areas from which it dispatches union members to gather market information and conduct sales promotion activities. They also secure water areas near the cities to set up culture cages and keep a stock of fish from which they can swiftly fill orders from the consumer area.

As the Union's sales capabilities became well established in the market, more and more local fishery cooperatives began to participate in their collective sales system. It thus came to encompass a large combined productive capacity that included virtually all the yellowtail culture fishing grounds in the prefecture.

At present the Kagawa Prefectural Union of Fishery Cooperatives administers the sales of about 40,000 tons of cultured fish per year. Of this, 10,000 tons are actually produced in Kagawa Prefecture and 30,000 tons are from other prefectures. Also, seeing as the annual culture fisheries production for Kagawa totals 13,000 tons, the Union now controls the sales of 77% of the production of the entire prefecture.

*A shipping base in Kurihama, Yokosuka City, about 100km from Tokyo. Live yellowtail transported by a 199-ton class transport ship from the producing areas in Kyushu and Shikoku are kept in the culture cages here for 2 or 3 days before being shipped again to their destination market.*

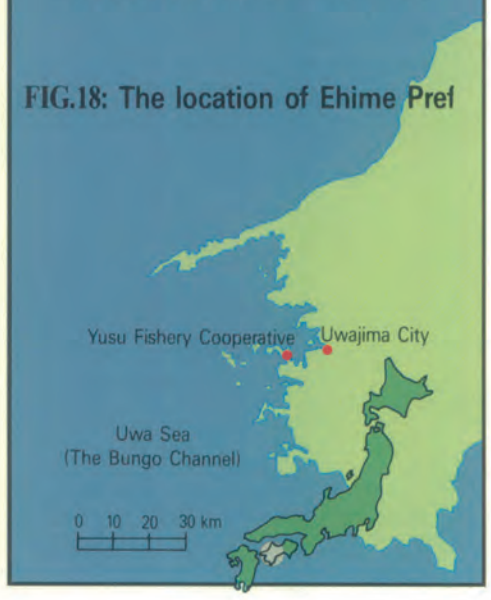
FIG.17: Sales network and shipping bases of the Kagawa Prefectural Union of Fisheries



# EXAMPLE 3

**Yusu Fishery Cooperative Association, Ehime Pref.**

**FIG.18: The location of Ehime Pref**




# Fishery Cooperative Association activities that bring out the enterprizing spirit in fishermen

In an inlet in the middle of a peninsula that juts out into a sea with numerous islands, lies a small fishing village of 344 homes and a population of 1,530 people. Being a region famous for sardine fishery since olden times, the people of this village have engaged in net fisheries on an equal investment, equal labor and equal division of profits basis for years. With the spread of marine diesel engines after World War II, middle-sized surrounding net fishery methods became predominant here. However, with the onset of such unfavorable factors as a decrease in the natural sardine resources, a decline in the price of sardine and financial burden resulting from a too-rapid investment in facilities, in 1960, 5 of the 8 existing purse seine fleets in this village went out of business, and the remaining three were faced with severe economic difficulties. Turning out an annual deficit 4 times the amount of the earnings on their annual catch, the villagers amassed a debt that could not be payed off even by selling their lands, forests and homes, much less their boats and nets. In the resulting economic confusion, villagers left to seek employment in the cities one after another. Even so, the leaders of the fishery cooperative were determined to try culture fishery as a means to rebuild their fishery industry. First, they convinced the village fishermen to try raising mother oysters for pearl culture, and 140 people joined the effort. Then, in 1963, experiments in yellowtail culture were begun. In this way the fishermen of the Yusu Fishery Cooperative of Ehime Pref. made the big change from boat fishery to culture fishery.

**FIG.19: Cooperative members' money accounts**

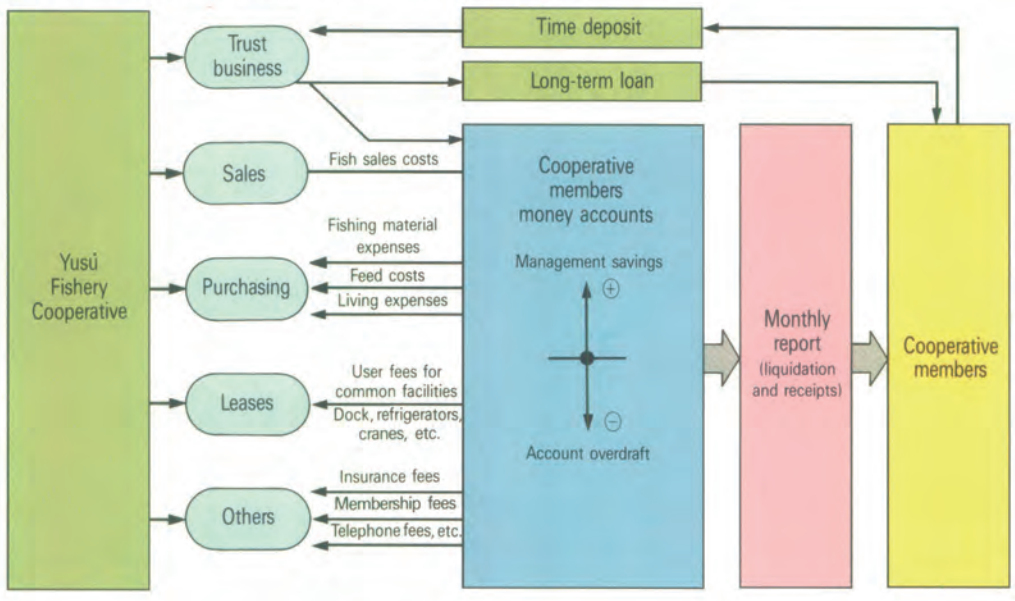
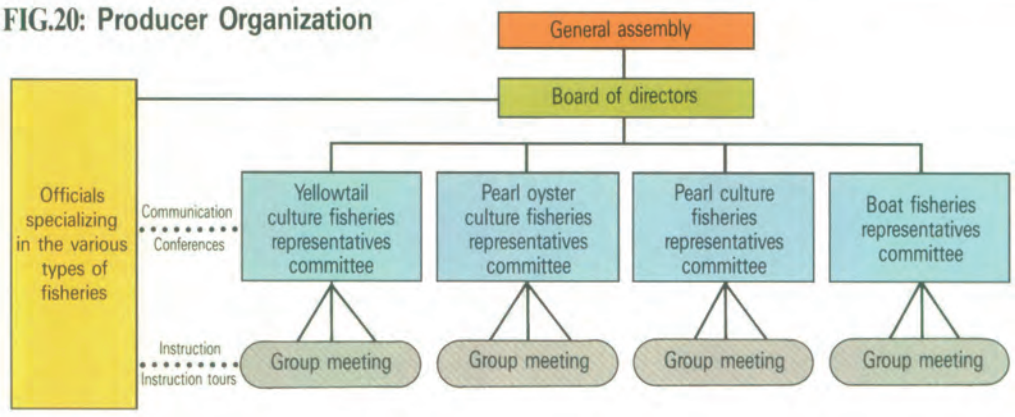



**FIG.20: Producer Organization**




At present, there are 310 members in the Yusu Fishery Cooperative engaged in a variety of fisheries, including the culture of saltwater fishes, pearl oysters, pearls, and boat fisheries (small scale set net, gillnet, pole-and-line angling). Among these, the culture of saltwater fishes, with 88 families raising yellowtail and 8 raising sea bream, is the largest category and forms the base of the village's fishery industry.

## The fishing grounds are the joint asset of the entire fishing village

The Yusu Fisheries Cooperative ships a total of 1.2 million yellowtail per year. Each family produces between 13,000 and 14,000 fish per year for a total harvest weight of about 40 tons. In Japan, this qualifies as small-scall yellowtail culture fishery. However, while it is not a large production, their annual catch sells for about 40 million yen. This is roughly 10 times their yearly living expenses. Achieving such an income, needless to say, requires a great deal of business prowess on the part of these culture fishery operators. The leaders of the Fishery Cooperative have long stressed this point and have always placed importance on independent business efforts by the fishermen in the rebuilding of the village's fishing economy.

This rebuilding process took roughly 15 years, from 1961 to 1975, and included the following elements: **1.** the securing and maintenance of licensed fishing grounds on the part of the Fishery Cooperative, **2.** organizing the producers involved in each category of fishery, **3.** equalizing the fishery scale and establishing rules for fishing ground use among the producers, **4.** educating the fishermen in planned management techniques and establishing a money account system for cooperative members.

**1)** At one time almost all the shoreline water areas in Yusu were being leased for pearl oyster culture enterprises. Efforts had to be made to reverse this situation and secure fishing grounds for other fishermen.

**2)** The daily work of culture fishery can be handled by family labor, but there are several vital stages such as shipment and changing of nets that require a large number of workers. To answer these needs, they worked to strengthen the ties between Cooperative members and to build a producer organization that could initiate mutual help practices.

As shown in **Fig.20,** each block of homes is divided into cell groups of 5 households each. Each cell group choses a cell leader to represent them on the "representatives committee". The roll of this committee is to put together the demands of the fishermen and present them to the board of directors. And, according to policies set by the board of directors, the distribution of culture cages, planning of shipments, shipping the produce and receiving feed supplies are performed communally at the cell group level.

**3)** Concerning the use of fishing grounds, the Cooperative has built its policies on the idea that "the fishing grounds are a joint asset of all the residents of the area". Thus they have pursued equalization of fishing ground use among the various types of fisheries. The system of equalization is not based on the value of the catch or produce, but on the income that the fishery provides for the fishing family. Their aim is to achieve fishery incomes for all its members that equal pay levels of city workers. Although the degree of fishing ground use granted to each fisherman may change with the conditions of the times, at present each household involved in yellowtail culture fisheries is allowed to operate eight cage net facilities with 10m × 10m × 6m dimensions, and are allowed to raise a total of 15,000 yearling fish and 13,000 second year fish in these facilities.

**4)** The Cooperative's business is based on the individual fishing family economy. To strengthen the management effectiveness of the fishing family, the Cooperative adopted a system by which each Cooperative member submitted a "member's operating plan". This, then, was a means to instruct the fishermen in the planning of their culture fishery operations and effective statistical accounting practices for their business. Furthermore, in 1977, a "Cooperative members money account" system was introduced. Each member opened a money account with the trust department of the Cooperative through which, with the exception of a time deposit and long-term loan, all short-term operating capital was processed. This system created a collective operating fund. Money transactions between the Cooperative members and the Cooperative are balanced on a monthly basis, and when there is a surplus in the balance this money goes into a "management savings account". If there is a deficit it is processed as an "account overdraft". Each month the members receive a report on their accounts which they are supposed to compare with their yearly operating plans to assess the condition of their business. **(Fig. 19)**

Through the maintenance of this highly integrated relationship between the Cooperative members' personal finances and fishery production and the Cooperative's business functions, the fishermen here in the Yusu Fishery Cooperative are attempting to integrate the use of their fishing grounds, capital and labor resources in the most productive way possible.

**TABLE 4: Statistics regarding the Fisheries Cooperative**

■ Cooperative members ..... 310
■ Production

| Kinds of fishing | Operating households | Amount of catch (in tons) | Value of catch (in mill.yen) |
|---|---|---|---|
| Fish culture | 96 | 5,985 | 4,100 |
| Pearl oyster culture | 45 | | 200 |
| Pearl culture | 40 | | 1,600 |
| Boat fisheries | About 50 | | 2 |
| | | | Total 5,902 |

■ Fishery materials (supplied by the Cooperative)

| | |
|---|---|
| Fishery materials | 476 mill.yen |
| Household items | 4 mill.yen |
| Fuel & oil | 107 mill.yen |
| Feed | 1,782 mill.yen |
| Culture seeds | 427 mill.yen |
| | Total 2,796 mill.yen |

*The shipping operation is performed by joint labor, with the elderly and women sharing the lighter jobs.*

*Weighing. Each fish is weighed individually.*

*The fish are kept in styrofoam crates with ice until they reach the consuming area market.*