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THE PRESENT STATUS AND PERSPECTIVES OF THE YELLOWTAIL FISHERIES IN JAPAN

by

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ABSTRACT

The yellowtail *Seriola quiqueradiata* is one of the most important fish for the coastal fishery and aquaculture in Japan. The fish are caught not only by means of trap-nets, purse seines, pole anglings, gill-nets, but also in mariculture.

In this paper the general fishery biology and mariculture of yellowtail are described in detail. The perspective and some problem of mariculture of the fish are discussed including tuna culture in relation to heavy mortalities.

L'ETAT PRESENT ET LES PERSPECTIVES DES PECHERIES DE SERIOLE AU JAPON

La sériole *Seriola quiqueradiata* est l'un des poissons les plus importants pour la pêche et l'aquaculture au Japon. Les poissons sont pris à la madrague, la senne, la canne, le filet maillant. Mais, ils sont aussi obtenus par aquaculture.

Dans ce papier, la biologie générale et l'aquaculture de sériole sont décrites en détail. Les perspectives et quelques détails de l'aquaculture du poisson sont décrits, incluant la culture du thon et les fortes mortalités qui y sont liées.

KEY WORDS : Mariculture - biology - *Seriola* - Japan.

MOTS CLES : Aquaculture - biologie - Sériole - Japon.

INTRODUCTION

The yellowtail, *Seriola quinqueradiata Temminck* et *Schlegel*, is one of the most important fish for the coastal fishery and aquaculture in Japan. This fishery of this species dates back to 1490. In the 19th century the annual catch amounted to about 15 000 metric tons. In recent years the fish are caught mainly by means of trap-nets, purse-seines, pole anglings, gill-nets and some other types of fishing gear and their annual catch are increasing, being about 40 000 to 60 000 metric tons. The annual products by aquaculture of this fish is attaining to about 100 000 metric tons or 40 million fish in number.

I. BIOLOGY

A. Distribution and migration

The fish usually lives in warm waters indicating a temperature of more than about 10°C around Japan and its neighbouring islands approximately between lat. 25°N and lat. 54°N of the Pacific Ocean as well as of the Japan Sea.

The fish migrates seasonally to the north or to the south ; it spends the autumn and winter in the warm waters of the southern region and migrates to the north in spring and summer. Northerly journey may be feeding migration, while southerly one for spawning.

The vertical distribution of the fish is probably influenced by both oceanographical condition and the feed which the fish get. During their southerly journey the fish go swimming within several decameters of the sea surface, but during their northerly journey they may sink to the layers over 100 meters depth.

B. Stock unit

To illustrate the distributed range of a fish population, or the state of mixture of the population with another of the same species, is one of the most important problems in fishery biology.

The yellowtail inhabiting the waters of Japan is grouped into the following three stock units, mainly based upon some evidences of the age composition, the patterns of seqular variation of the catch and the oceanographical conditions of the waters around Japan.

a. The yellowtail distributed in the waters around the Korean Peninsula.
b. The yellowtail distributed in the Okhotsk Sea, the Japan Sea and the East China Sea.
c. The yellowtail distributed along the Pacific coast of Hokkaido, Honshu, Shikoku and Hyushu. This stock may be divided into two substock units, one being a substock found distributed in the sea to the north of the Kii Peninsula and the other, a sustock found distributed in the sea to the south of the peninsula.

C. Maturity and spawning

From the state of maturity of onad of the fish, we can say that those fish whose size is between 60 and 70 cm in length, or 3.0 and 4.9 kg in weight probably begin spawning. On other words, most of the yellowtail reach their reproductive maturity when they become 3 years old. Some precocious individuals, usually males, first spawn half a season earlier and other either male or female, half a season later.

On the basis of examining (1) the monthly changes in the degree of development of the gonads throughout the year, (2) seasonal changes of fatness in the fully matured body in the spawning season and thereabout, (3) sex ratio in shoals of the fish obtained in several different regions around Japan, (4) the geographical distribution of the eggs and larvae of the fish in each month of the year, and (5) the oceanographical conditions in the waters around Japan, the spawning seasons and areas have been summarized as follows :

the spawning of the fish occurs extending over a long period of time, ranging from January or February to August or September, but the prime season for spawning of the fish in the area is during the period between mid-April and early May.

the sea area lying to the west and the south of Kyushu is one of the principal spawning places for this fish.

the favourable water temperature for the fish to spawn at ranges from 16.0 to 29.0°C, the optimum being 19.0 to 21.0°C, from the frequency distribution of surface water temperature in those localities where the fish eggs or larvae less than 20.0 mm long were taken.

D. Growth and age

Figure gives the average growth curve obtained from the opercular marks, that is, the fish respectively attains about 29 cm in fork length in a year ; about 49 cm in two years ; about 63 cm in three years ; about 73 cm in four years ; about 81 cm in five years and about 86 cm in six years. But those figures might be rather underestimated compared with those of the fish cultured.

E. Feeding habits

The feeding habits of the fish in their juvenescent stage have been examined from the samples collected during May. Although alimentary canals of several postlarvae have been carefully examined, nothing has been found in them. From this fact, the larvae must feed on organism, which are easy of digestion.

Juveniles measuring 2 to 3 cm in fork length feed chiefly on zooplankton, such as *Caprella* sp. and floating eggs (probably fish eggs), and those measuring 3 to 4 cm in length begin to make a prey of fish larvae. For those more than 4 cm in length, Copepods, such as *Calanus, Paracalanus, Eucalanus, Acrocalanus, Temora, Oncaea* and *Corycaeus*, form dominant part of prey, and among those copepods the first one is by far the most important. The fish in their late juvenescent stage turn their attention more to small fishes of various species living under floating seaweed, and begin to make a cannibalistic struggle.

II. AQUACULTURE

A. Outline

Nowadays 95 % of the total production of the yellowtail is from net-cage culture. Aquaculture is the most important form of the yellowtail fishery in modern times. The yellowtail aquaculture is carried on in the suitable places along the coast of the central part of Japan. Present annual production has reached about 60 million pieces or about 100,000 tons in weight. This quantity is twice that of the yellowtail caught naturally. Aquaculture of the yellowtail has contributed to the great advance in coastal fisheries from an ecological point of view and has also led to the development of culture techniques. On the other hand, many problems have appeared as discussed later.

B. Seed

The seed for culture is all produced by catching natural juveniles from the sea. Seed with a body length of about 15 mm gathers together under floating *Sargassum* near the coast of Southern Honshu, Shikoku and Kyushu. From March to July large masses of floating *Sargassum* are present in this area, and groups of juvenile yellowtail swim along slowly among or under the *Sargassum*. The fishermen catch these juveniles using small type of purse-seine nets or large dip-nets. Juveniles with a length of less than 4 cm are not suitable as seed, as they are not yet able to feed on minced raw fish which is the feed for culture. The most suitable size is more than 4 cm in body length weighing more than 1 gr, but recently seed has been in short supply, and the usual size of seed actually used has been getting smaller year by year. For instance, most of the seed used in 1977 was between 25 mm and 30 mm.

After catching juveniles in the open sea they are put into small net-cages. There occurs some cannibalistic behaviour due to high stocking densities, and therefore separation into several size groups is an important procedure for early culture. After size selection they are put into net-cages with sizes ranging from several cubic meters - to several tons of cubic meters, and are fed on minced sand eel, anchovy, saury, etc. For several weeks after reaching a length of about 10 cm, that is, about 50 grams weight, they are changed to standard size for net-cages.

C. Farming grounds and facilities

About 50 years ago, when culture was just starting, natural inlets were used as culture grounds by closing the entrance with either a dike or a net. At the present time, almost all culture is done using floating net-cages, the most common type is covered and can be moved up and down from the sea surface to 1 or 2 meters below the surface. By using this system the fish are protected from attacks by birds and can be kept in water layers having most suitable temperature in summer and winter.

The number of the yellowtail culture units is limited by the prefectural governments, and fishermen need permission to carry on aquaculture activity. The most suitable sites for net-cage culture should conform to the following conditions.

a. They should be protected from rough water and storms, typhoons, etc.
b. Water temperature should not fall below 14°C, otherwise the fish become inactive and stop feeding and their growth is slow. At less than 10°C there is a danger of mortality, and at less than 7°C high mortalities occur.
c. Good water ventilation is necessary and areas affected by river water, industrial pollution, and sewage from urban areas are not suitable.
c. Other conditions are the availability of easily obtained feed, good communications for delivery of cultured fish to markets and purchase of culture equipment, etc.

D. Feeding procedure

Raw sand eel, anchovy, saury, scomber and sardine are used as feed. After chopping these fished into suitable sizes, they are fed twice a day in summer and once a day in winter, and in the case of low water temperatures, once every two days. The growth rate is better using mixed fishes as feed than just one species. Recently some artificial feeds have been developed, but they are not yet commonly used. The conversion ratio using the natural feed ranges from 6:1 to 10:1, usually about 7-8:1. Recently there has been much discussion among researchers having opposed opinions concerning the use of raw fishes as feed. One opinion is that it is wasteful to use times the amount of small fishes as feed in order to produce one kilogram of the yellowtail. These researchers feel it is a misuse of marine animal protein. The other opinion is that in Japan people do not like to eat small cheap fishes but prefer high quality fishes such as the yellowtail. If the small fish were not used as feed for culture they would have no market and would be wasted completely. Therefore, these researchers feel that the small fishes are well used as feed. Which opinion is correct is a question which has nos clear answer at this time, but this is a problem always arises when people use such a culture system.

E. Growth

Growth by aquaculture is about twice as fast as natural growth. This is shown in the followings : about 1,400 gr in weight in a year ; about 2500gr in two years and about 5,800 gr in three years.

F. Diseases and parasites

The most common diseases and parasites are following :

- Fish diseases : vibriosis, pseudo-tuberculosis, nocardia infection, pseudomonas disease, ichthyophonus.
- Parasites : myxosporidia, benedia, heteraxine, caligus.

G. Some problems and perspectives of the yellowtail aquaculture

Following the high level of technical development in the yellowtail culture, several difficult problems have emerged.

a. The recruitment of the natural yellowtail population has shown a tendency to decrease due to heavy fishing of juveniles for culture, the fisheries catches have decreased and also catches of juveniles have shown the same tendency.
b. Serious outbreaks of disease and occurence of parasites and even abnormally shaped fishes.
c. Poor conditions in culture areas due to build up of biodeposits from culture and eutrophication caused by industrial and urban pollution have caused outbreaks of the red tide phenomenon which has killed large quantities of fish.

d. Large amounts of chemicals used to combat fish deseases give rise to anxiety that they may be harmful to humans eating the fish treated in this way.

There are several solutions to these problems in the case of a. Development of techniques for the mass production of seed. Many researchers are working on systems of mass production. Within the next few years, an effective system should be established. At the present time our group is aiming to be able to produce 1 million juveniles of 3 cm by 1981. After establishing the technique for mass production, it may be possible to use the seed for restocking coastal waters and increasing natural population.

In the case of b., c., and d. the main reason for all these problems is the build up of biodeposits in the culture grounds and industrial and urban pollution. This is a very difficult problem to solve and the best remedy is to move the culture sites to clean areas.

For this it will be necessary to improve the design of net-cages so that they can be located in areas affected by rough water, tiphoons etc... Researchers in Kochi prefecture are already experimenting with this in Sukumo bay. In the near future this system may be applied to bluefin tuna culture.

III. SOME PROBLEMS OF TUNA AQUACULTURE WITH SPECIAL REFERENCE TO HEAVY MORTALITIES

During the pas few years, several experiments have been undertaken using net-cages made of artificial fiber nets or wire netting for tuna culture. Some of the trials have been successful on a small scale. But they have not rearched the large scale needed for commercial production. One principal bottleneck has hindered progress in this research. That is the phenomenon of mass mortality.

A. Mass mortality at the time of catching seed

Off the coast of Kochi prefecture, fishermen catch juvenile tuna with a body length of 15-20 cm, weighing about 150 gr, during July and August, which are suitable seed for culture. These juveniles are caught by angling and transported to the culture grounds in tanks within two hours from the time of catching and transferred to relatively small sized net-cages. Heavy mortalities occur during the first two weeks. The reasons for the great mortality are :

a. Wounds caused by the hooks used to catch them. The hooks damage the maxillary region and also pull out eyes and damage gills or brood vessels.
b. Skin abrasions occur.
c. The method of transportation in small tanks weakens the juveniles.

The ways to avoid these problems are, in the case of a., to use hooks without barbs and to pull in the lines more slowly, in the case of b. and c., to employ an anaesthetic to stop the fish from damaging themselves during transportation.

The following research themes are important for the purpose of suring seed in good condition.

a. Research to investigate the possibility of obtaining smaller juveniles as seed.
b. Research to establish techniques for mass indoor culture of seed. This is also necessary for the repopulation of tuna in the future.

B. Mass mortality due to changing nets of net-cages

This phenomenon accurs during the first month. There are many method for changing the net of the cages. For instance, one method is to fix the clean net around the outside of the net to be changed, and then detach the old net and pull it out slowly leaving the fish in the new net. Another method is to sew one side of the new net to one of the sides of the old net and pull up the old net tipping the fish into the new net or leaving an opening for them to swim through into the new net. Heavy mortalities occur after the net are changed and this is a very delicate operation. The larger juveniles have a higher mortality than the smaller ones.

According to examinations of the fishes that have died at this time, some have their snout caught in the meshes of the net and are left hanging and some have sunk to the bottom. The former are found after changing the net and probably have seen frightened by the movement of the net causing them to try to escape through the meshes and getting caught there. The latter are found for quite a long period after the changing of the nets has been carried out, and death is probably due to skin abrasions. The fish are frightened at the irregular shape of the net and its movement during the changing procedure and swim around at great speed damaging themselves against the net. Sometimes fishermen find dead fishes on the bottom having no wounds and the reason for their death is obscure. Researchers think death may be caused by shock, or lack of oxygen due to overactivity. In the near future it is necessary to investigate the physiology of the respiratory system to check this.

The net changing procedure has to be carried out every few months to improve the flow of water and promote the growth of the fish. Improvement of this procedure is needed especially in the case of bluefin tuna.