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# Fisheries Resources and Optimum Utilization

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Fisheries in General

# Fisheries Resources and Optimum Utilization

Shigeaki Shindo

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# LECTURE 1

## The Exploitation of Fish Stocks and the Historical Development of Fishery.

### 1.1 Introduction

I propose in this series of four lectures to consider how the sea fish population is affected by fishing operations. This is a question of great practical importance. We have a lot of natural wealth of food in the sea, which is there for the catching.

(i) "How can we best exploit these riches, to get the maximum steady yield, without waste of effort?"

(ii) "Are we in danger of so depleting the fish stocks that the yield must fall? In another words, "Are we in danger of over-fishing?"

(iii) "In general, what is the relation between yield (catch) and intensity of fishing?"

These are some of the practical questions which occur, and fishery research attempts to find answer to them. My series of lectures will deal with these problems.

We may distinguish between two main kinds of fishery, that for the fish that swim near the surface, and that for the fish living on or near the bottom. The principal fish in the first category are the sardine and the mackerel, and in the second category the snapper, plaice, rays, shrimps and so on. We will now concentrate on bottom fishing, which is carried out mainly with otter trawls, which are strong nets towed along the bottom of the sea by specially constructed vessels named trawlers.

Modern trawling, as it is practised today, is the outcome of a long historical development, the outlines of which we will now proceed to consider. Then we will consider how the population of fish is affected by fishing operations. In tracing the development of a fishery, I will discuss the history of the development of certain typical fisheries in England (North Sea), Japan (East China Sea) and in Thailand (the Gulf of Thailand).

## 1.2 History of the trawl fishery in England

My first example is the history of trawl fishery in England. In the 1870's, bottom fishing in England was carried out entirely by sailing boats, and the principal methods employed were trawling and lining. The trawl used was not the otter trawl, but the beam trawl. In those days, 1,000 sailing wooden beam trawlers (up to 70 gross tons) were working the offshore grounds of the North Sea down to a depth of 50 fathoms.

Then, the steam powered engine was introduced in 1882, and these new steam trawlers gradually ousted the sailing trawlers and from about 1894 onwards, the beam trawl gave place to the more efficient otter trawl.

The introduction of steam greatly increased the range and power of the trawlers. The use of ice for maintaining the catch in good condition had come in about 1865, and enabled the steamers to bring in fresh fish from distant grounds beyond the North Sea, such as Icelandic waters (in 1892), the Faroe grounds shortly after, and both areas soon became important sources of British fish supplies. The trawlers went as far south as the coast of Morocco in 1904, and fishing in the rich northern grounds of the Barents Sea and the waters off the coasts of Norway and Russia commenced in 1905, as shown in Figs. 1 and 2.

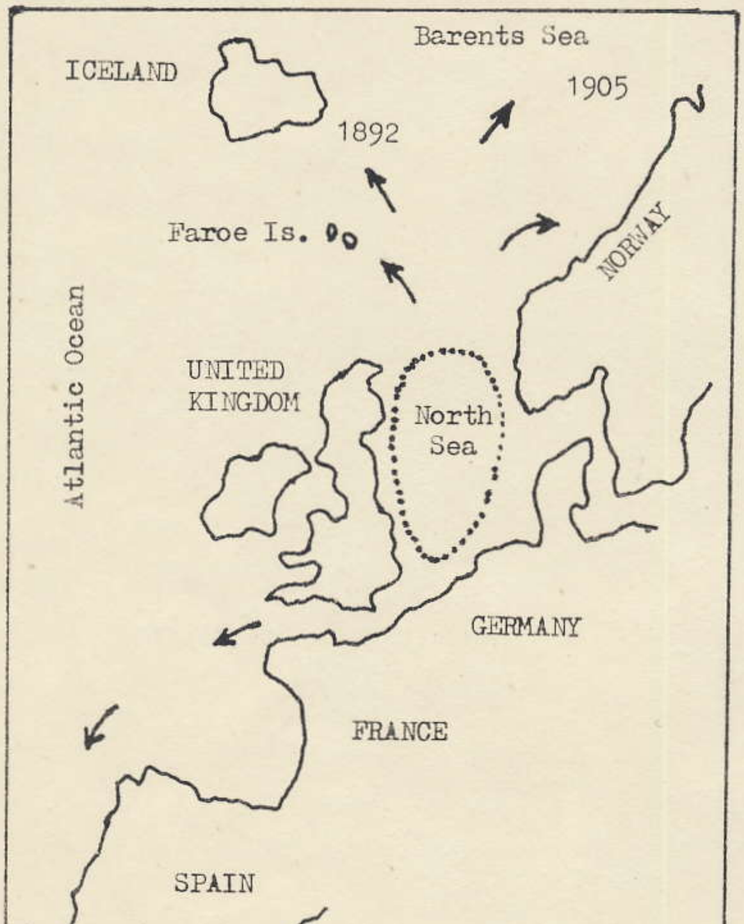



Fig. 1. The expansion of fishing grounds of English steam trawlers fleet.

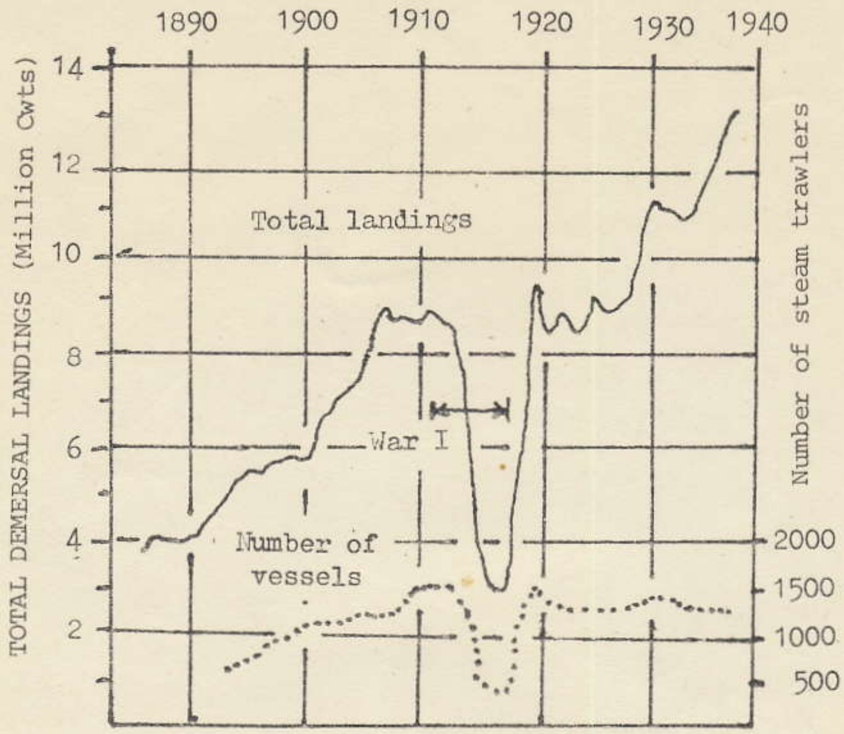



Fig. 2. General statistics of the English demersal fisheries.

1.3 History of the Japanese demersal fishery in the East China and the Yellow Seas

My second example is the history of the Japanese demersal fishery operating in the East China Sea and the Yellow Sea. Up to the 1980's, a very small-scale hand-lining fishery using small sailing vessels of around 5 gross tons had been carried out in the coastal waters off the west coast of Kyushu Island. Afterwards, this handlining developed into long-lining with a single boat. Then they introduced the "mother-boat system" in this long-line fishery around 1900.

This mother-boat was a fairly big wooden sailing vessel of about 50 gross tons carrying 4 to 8 very small row boats which operated long-lining. The fish caught by these big sailing long-liners were yellow sea-bream which is still one of the highest priced fishes in Japan.

In the early stages of this long-line fishery, the fishing grounds were not far from the shore, but after the "hot-bull engine" was introduced into these mother-boats, the fishing grounds suddenly expanded along the Ryukyu archipelago to Taiwan, where large stocks of yellow sea-bream existed.

Around 1910, the primitive one-boat trawl driven by an engine using the "Japanese style Danish seine" was introduced in these waters. In 1918, the first pair trawl, the epoch making gear, appeared in these waters. This pair trawl is, at present, one of the most important types of nets used in the offshore waters of Japan. It was developed from the primitive one-boat type trawl. In its early stage, the gear and vessel did not differ from the original type and the main difference existed in the method of operation; that is, in the case of the pair trawl, the trawl warps were pulled by two vessels at the same time instead of one.

Because of their very strong fishing power, the number of pair trawls in these waters increased rapidly and long-liners were gradually replaced by this new effective fishing method. They were fishing not only for yellow sea-bream but also fro croaker, hair tail, conger eel, etc. and their fishing grounds also gradually extended to the coast of Mainland China during the period from 1920 to 1930. They discovered good shrimp grounds in the Yellow Sea, and their landings reached their first maximum around 1940 as shown in Figs. 3 and 4.

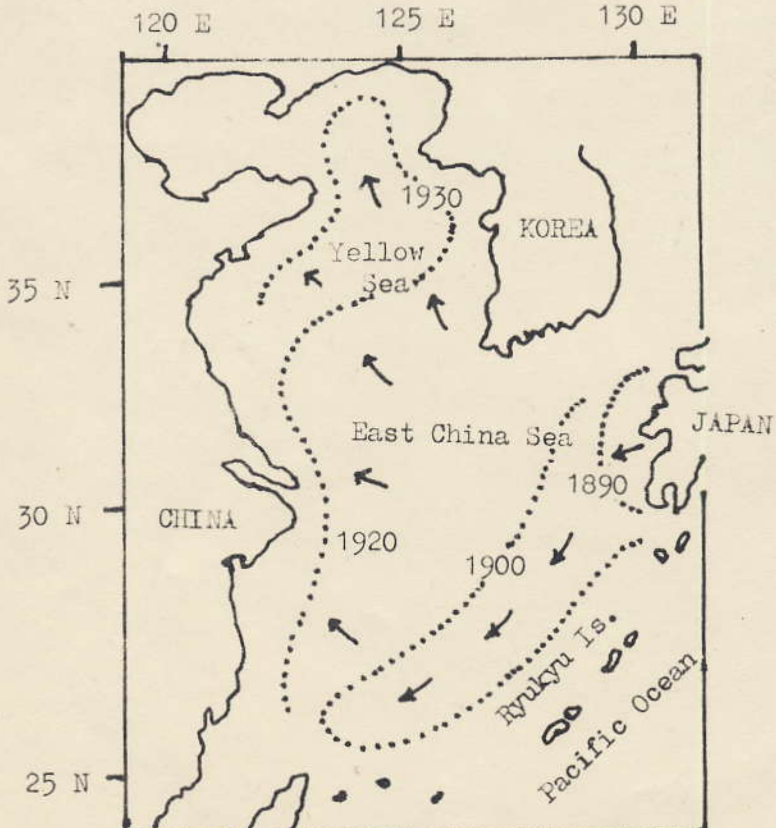



Fig. 3. The expansion of fishing grounds of Japanese trawl fishery in the East China Sea and the Yellow Sea.

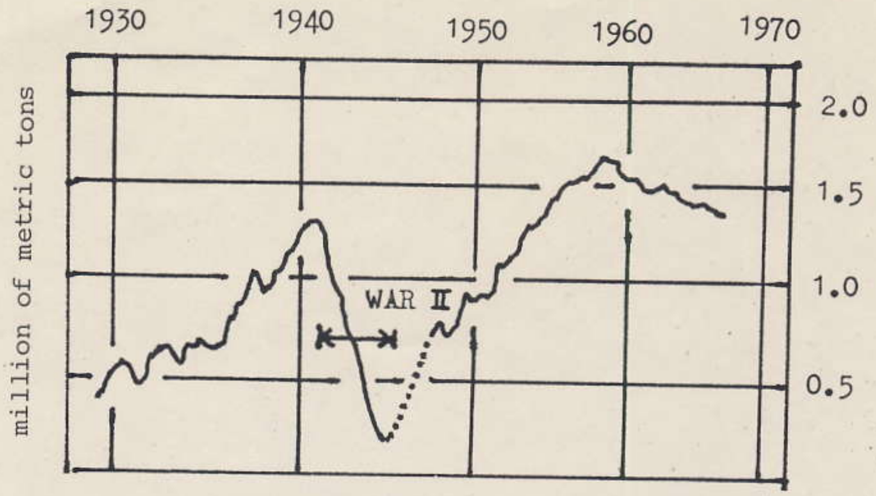



Fig. 4. General statistics of Japanese trawl fishery operating in the East China Sea.

## 1.4 History of the Trawl fishery in Thailand

My third example is the history of the demersal fishery in Thailand. In its early period, the Thai fishery was almost all limited to fresh waters. There was only a little fishing in the shallow sea waters near the shore and the production was quite insignificant.

Later, sea fisheries developed using bamboo stake traps and there was Chinese purse seining for some species of pelagic fishes. Demersal fisheries did not exist until the early 1950's.

In 1952, trawling was first introduced into Thai waters. Four wooden vessels from 47 to 90 gross tons equipped with otter board trawl nets were used. They made several experimental hauls in the Gulf, but the results were not satisfactory due to the lack of experience of the crews and the trials were discontinued.

In 1953, another fishing company conducted experimental trawling trials in the Gulf; however, their attempts were also not successful because of lack of technical experience as well as difficulties of selling the catches in local markets.

These attempts described above, however, gave a good hint to the local fishermen. In the following year, Thai fishermen invented a new kind of beam trawl for shrimps in very shallow waters using very small vessels of less than 20 gross tons.

In 1961, experimental otter trawling was conducted again in the Gulf by the Thai Government with the assistance of Germany. After testing several types of demersal gear, they came to the conclusion that otter trawling was most suitable for these waters.

| Year | Total landings (L) (metric tons) | Trawl units (T) | (L)/(T) (metric tons) |
|---|---|---|---|
| 1961 | 123 077 | 201 | - |
| 1962 | 151 403 | 1 103 | 137 |
| 1963 | 277 150 | 2 327 | 119 |
| 1964 | 371 642 | 2 457 | 151 |
| 1965 | 392 666 | 2 606 | 151 |
| 1966 | 448 554 | 2 870 | 156 |
| 1967 | 582 980 | 3 201 | 182 |
| 1968 | 784 164 | 3 311 | 237 |
| 1969 | 907 850 | 3 403 | 267 |
| 1970 | 961 395 | 3 450 | 279 |
| 1971 | 1 140 194 | 3 608 | 316 |

Table 1. The Thai trawler statistics from 1961 to 1971 (Unit: metric ton)

Encouraged by Government, otter trawl fishery in the Gulf expanded very rapidly as shown in Table 1. The total annual landings from these trawlers in the Gulf amount to more than 70 percent of the total marine production of Thailand.

### 1.5 General trends in the development of a fishery

Looking back over my three examples of the development of demersal fisheries described above, which I have given you in the very broadest outline, omitting all unnecessity detail, we see that they are essentially the same process. We have the same story of continued expansion of fishing grounds, with improvement in technical methods; that is, improvement of fishing gear and vessels.

In the case of the English demersal fishery, they started from lining with small sailing boats to the sailing beam trawl, then to the old style otter board trawl with a steam vessel, and finally to the modern otter board (V.D. system) trawl with a motor vessel. Fishing grounds in the early stages were limited in depth to only 50 fathoms in the North Sea. Then they expanded to the entire area of the North Sea and finally beyond their traditional waters to the Northern Atlantic, and to such waters as those off Iceland, Norway and Russia in the north, and to the coastal waters of Morocco in the south.

In the Japanese demersal fishery in the East China Sea, they started from hand-lining with small sailing vessels, progressed to long-lining with single vessels, then long-lining using big wooden sailing vessels with the mother-boat system; then, that system with the hot-bull engine, then the Danish seine (Japanese style of one boat trawl), and finally they invented the pair trawl with a motor driven winch for tackling the warp.

Their fishing grounds in the early days were limited to the coastal waters of Kyushu Island. Then they expanded to the southern parts of the East China Sea between Japan and Taiwan, to the coastal waters of Mainland China, and finally to the Yellow Sea in the northern part of that area.

The fishing grounds of the modern Thai trawler fleet have also expanded beyond their home waters of the Gulf of Thailand to more distant areas, such as the offshore waters of Burma, Bangladesh and so on.

# LECTURE 2

## The Depletion of the Older Fishing Grounds

### 2.1 Introduction

In my second lecture I propose to consider first of all what has happened in the North Sea, East China Sea and the Gulf of Thailand, where the trawl fisheries have developed greatly as I explained in my first lecture. What has happened in these waters, as a result of the intensive fishing for demersal fishes? How has this affected the stocks of fish? Has the total yield (catch) diminished? Is the yield per unit of fishing effort (catch per haul) the same as it used to be? These are some of the questions we must try to answer.

### 2.2 Decrease of fish stock density in the North Sea

As I mentioned already, the total landing of demersal fishes by English trawlers has increased year by year as shown in Fig.2. However, stock density ("yield per unit of fishing effort"; sometimes expressed in "catch per day's absence" or "catch per haul") of each fish species has decreased markedly year after year.

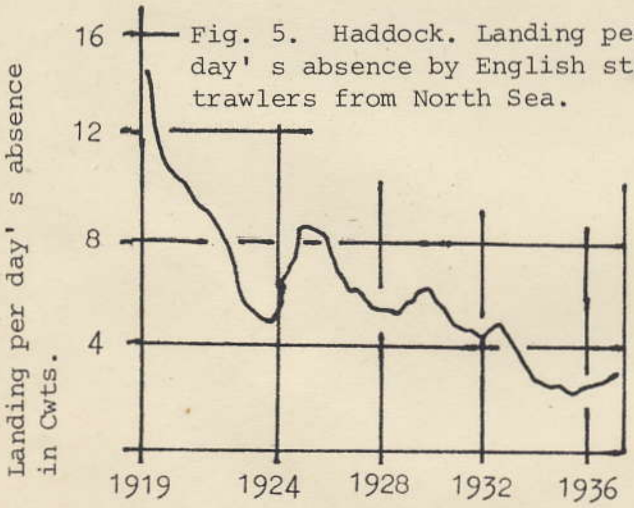



Fig. 5. Haddock. Landing per day' s absence by English steam trawlers from North Sea.

In Fig.5 is shown a curve of the yield per day's absence of "haddock" *(Gadus aeglefinus)* from the North Sea for the period 1919 to 1937. You will see that the trend is very definitely downwards, rapidly at first, then slowing down. Not only this haddock, but also many other fish species, such as, plaice *(Paeuronectes platessa)* etc. showed the same declining curves.

## 2.3 Diminished fish stocks in the East China Sea

Let us turn now to the East China Sea, where the Japanese pair trawler fleet has operated intensively since 1920. I will show you a very typical example. "Yellow sea bream" *(Taius tunifronus)* which belongs to the family Sparide, is an economically important fish found abundantly in the soughern part of the East Sea. It is an established fact that for more than 50 years continuourly from the time long-line fishing was adopted in this area at the beginning of this century, and from the time pair trawl fishery was introduced in these waters around 1920 to 1925, there were much larger catches of yellow sea bream in these waters than of any other kind of fish.

However, since 1925 the catch has markedly and steadily decreased year by year disproportionately with the increase in fishing vessels. The curve of "catch per haul" shows a more drastic decline. This decrease continued up to the beginning of World War II. It is interesting to note that the suspension of fishing operations during the War appears to have benifited the stocks of this fish. In 1947, when fishing operations were resumed, there were large catches of the fish for several years, and the value of "catch per haul" recovered largely. This prosperity however, did not last long as shown in Fig.6. The catches and "catch per haul" followed a similar pattern to the pre-war situation and a remarkable decrease has resulted which is continuing.

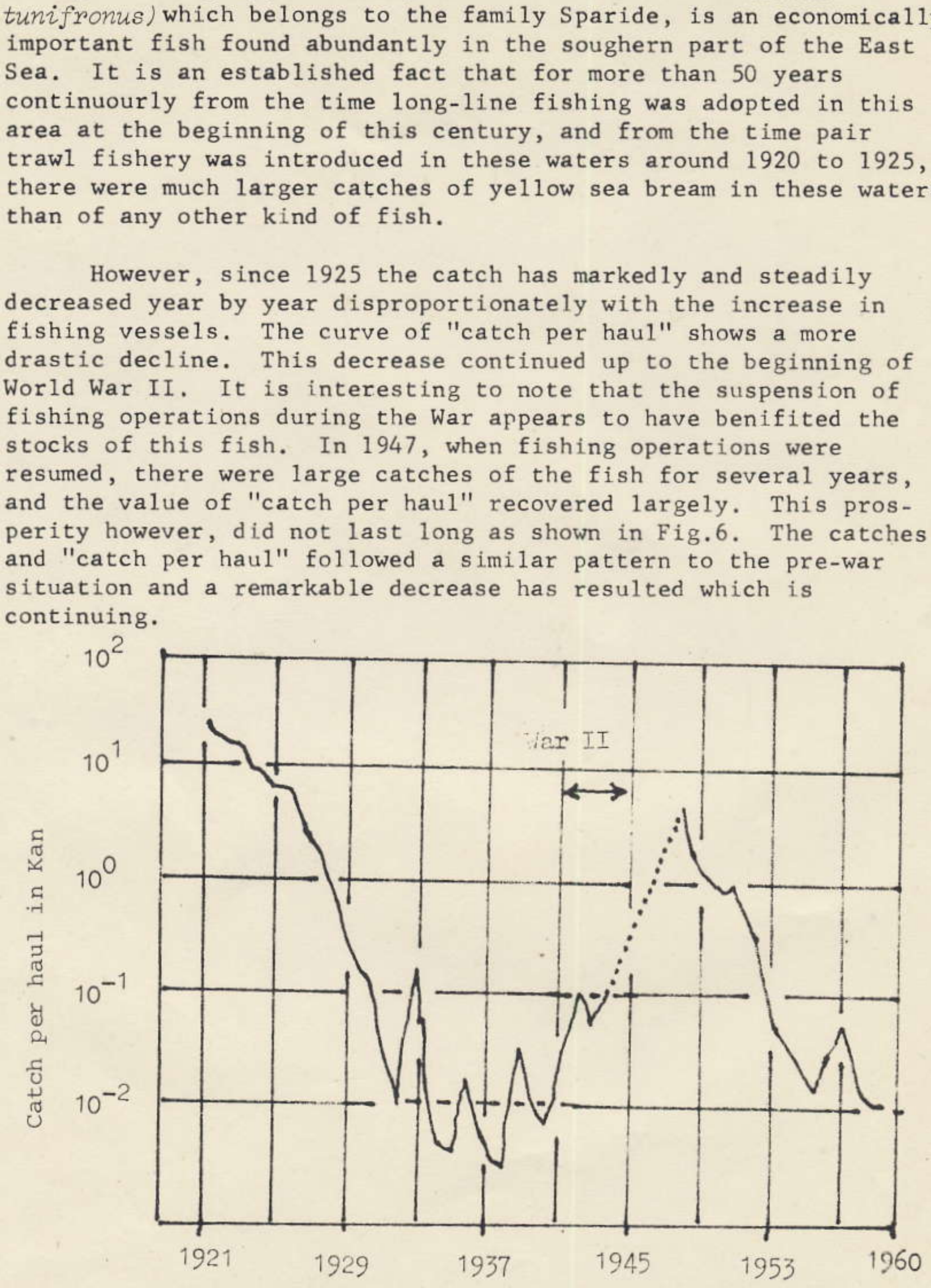



Fig. 6. Annual changes of stock density of yellow sea bream in the East China Sea (Japanese otter trawlers. Unit: Kan = 3.75 kg).

## 2.4 Annual changes of catch rate of research vessel PRAMONG 2 in the Gulf of Thailand

Now, we come to the Gulf of Thailand. With the increase in the number of trawlers in the Gulf of Thailand a monitoring survey in the Gulf has been conducted annually by the Marine Fisheries Laboratory in Bangkok since 1963.

The main purpose of this survey is to detect the change in the density of the demersal fish stocks which are exploited. The regular survey made by PRAMONG 2 (wooden stern trawler, 76 gross tons, 320 HP diesel) covers the entire coastal waters ranging from about 10 to 50 meters in depth in the Gulf from the Thai-Cambodian to the Thai-Malaysian borders.

According to the results of this scientific work, the average catch in Kts. per hour in the Gulf decreased annually from 1961 to 1970 as shown in Table 2. The decreasing trend of catch in Kgs. per hour seems to be more marked from 1963 to 1966, and then becomes gradually slower after 1966.

The general statistics on the North Sea, East China Sea and the Gulf of Thailand mentioned above have shown us a good deal. The" hive shown that in many cases the stocks have become smaller as the intensity of fishing has increased, that the yield per unit of gear has diminished, and also that total catch has declined. They have afforded clear evidence of over-fishing. Up to now, I have used only the statistical information which is available.

In my next lecture, we will study the problem using more scientific and more theoretical methods including biological considerations.

| Year | Number of hauls | Catch rate in kg/h | Catch rate in % of the base year, 1961 |
|---|---|---|---|
| 1961 | 133 | 297.80 | 100.00 |
| 1962 | — | 277.00 | 93.01 |
| 1963 | 200 | 256.00 | 85.96 |
| 1964 | 182 | 225.60 | 75.86 |
| 1965 | 192 | 179.20 | 60.17 |
| 1966 | 713 | 130.77 | 43.91 |
| 1967 | 713 | 115.05 | 38.63 |
| 1968 | 719 | 105.92 | 35.57 |
| 1969 | 720 | 102.74 | 34.50 |
| 1970 | 718 | 97.44 | 32.72 |

Table 2. Annual changes of the catch rate of R/V PRAMONG 2 in the Gulf of Thailand.

## LECTURE 3

## Analysis of a Fish Population

### 3.1 Size-composition of a fish population

It is a very well-known fact that the average size of the fish exploited by fishing becomes smaller in accordance with the decreasing density of fish population, which caused by the increased intensity of fishing.

My first example is the haddock in the North Sea. Changes in the size-composition of the catch of haddock have taken place, as indicated by the relative proportion of the statistical categories, Large, Medium and Small, into which the size of fish are divided. We assume, of course, that the size-composition of the catch indicates the size-composition of the fish population, or rather, of that part of it which is above the minimum size of landing.

If we now look at the average percentage of Small for the pre-World War I eight-year period, we find it to be 50%. But in the period 1922 to 1929 it was just over 70% while in the latest eight-year period it rose to over 85%. In 1936 and 1937 it was over 90%. The percentage of Large fell fairly steadily through the whole post-war period, from over 20% down to 3% and 2% in the last two years. There has therefore been a very big change in the size-composition of the landings, and, by inference, in the size-composition of the stock.

The Second example is the yellow sea bream in the East China Sea. There are four market size categories of this fish, namely, Large (more than 25cm in fork length); Medium (20 to 24cm); Small (15 to 19 cm) and Dead Small (less than 14cm). In 1949, the percentage of Dead Small in the total catch from January to March, was found to be 14%. In 1952 it rose to about 22% in the same season, and it was over 30% in 1957. In 1958, this value went up to nearly 40%. In contrast, the percentage of Large in the total catch in the same season was 13% in 1949, while it decreased to 9% in 1958.

We must remember that the percentages of the market size categories relate to weight of fish, and that if turned into numbers of individual fish, the growing preponderance of "Small" or "Dead Small" would be even more marked.

Now these data, rough and approximate as they are,undoubtedly show that the rate of mortality in the stock has considerably increased as described in the following part of my lecture.

### 3.2 Age analysis of fish population

The data about quantities and size of fish landed give us some information concerning the status of fish stocks. However, in order to make clear the problem under consideration through scientific study, some other factors, namely accurate rate of mortality and rate of growth are essential. They have to be determined by other lines of enquiry.

We can assess the age of the individual fish with a considerable degree of accuracy. Growth is seasonal and periodic, slowing down or ceasing in the winter months in most cases. This rhythm of growth is mirrored in the structure of certain skeletal parts, such as the scales the otolisks, the vertebrae and the opercular bones. These show in diverse ways alternating bands or rings which indicate summer and winter growth. It is possible, for example, by counting the dark "winter" rings in the scale of a yellow sea bream to ascertain its age in years as shown in Fig.7

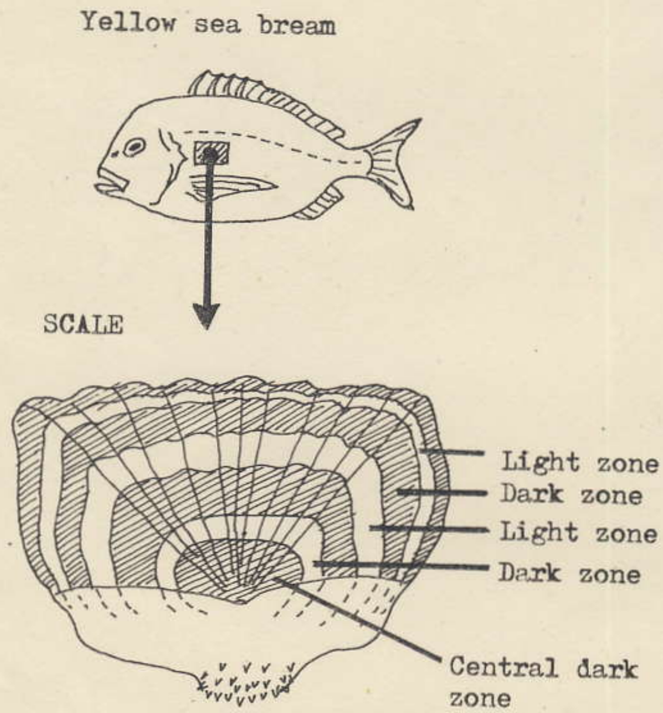



Fig. 7. Light and dark zones appearing in the basal area of scale.

With this powerful technique of age-determination, we can estimate rates of growth and rates of mortality. All that is necessary is to make clear the rate of growth and to establish the age-composition of the stock from year to year. Fig. 8

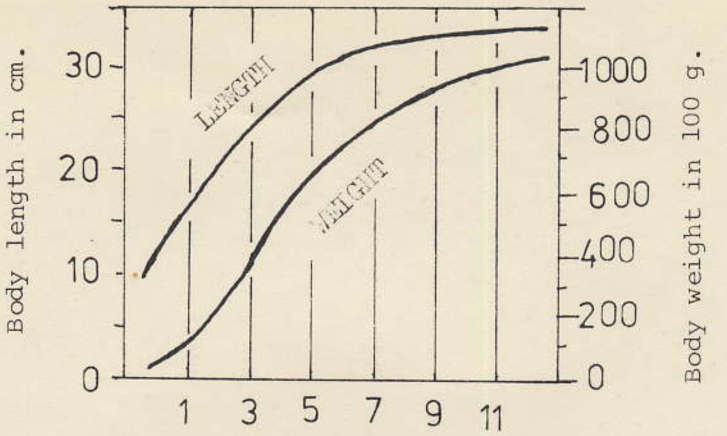



Fig. 8. Growth curves of yellow sea bream. (Variation of size of the fish with age).

shows average rates of growth of the yellow sea bream from the East China Sea, while Table 3 shows the average age-composition of the same fish from the same waters, which were estimated by S. Shindo. In this table, fish of the 0-age-group; that is,

| Age-group | 0 | I | II | III | IV | V | VI | VII |
|---|---|---|---|---|---|---|---|---|
| No.per mile | 4 | 49 | 406 | 345 | 149 | 40 | 6 | 1 |

Table 3. Age-composition of the yellow sea bream. (East China Sea, Region V, Oct.-Nov. 1956)

fish less than a year old, are practically absent from the catch, being too small to be caught. Those of the I-age group are present in considerable numbers, but are exceeded in number by the II-age group fish, those between two and three years old. We see here the effect of net selection. The trawl, like many other fishing instruments, is selective in its action, for the range of size of fish caught depends upon the size of the mesh used in the cod-end. The smallest size of yellow sea bream are not caught in their true proportions, many escaping through the meshes of the trawl. It is considered that the II-age group is still affected by net selection, but not to a marked degree.

From the data given by Shindo, we can determine the percentage of mortality from one age group to the next as follows:

From the II group to the III group, 85 percent, (III/II = 345/406 = 0.849 = about 85%), probably more if some of the II group escape from the net.

From the III group to the IV group, 43 percent.

From the IV group to the V group, 27 percent.

Then from the V group to the VI group there is little apparent mortality, only 15 percent, while from the VI group to the VII group there is a mortality of 17 percent-nearly the same as that of V to VI. However, as I will mention later, the mortality rates described above would not be true because recruitment (young fish which are newly added to the fish stock) is not constant; it was increasing year by year in those years. Therefore, we must examine the number of fish of "same year blood" (fish which hatched out in the same year and we have to trace them by sucessive years after hatching in accordance with their increase in age. Therefore, percentages described above show merely examples of calculations.

## 3.3 Relation between the fishing intensity and the age-composition.

In relation to the effect of fishing on the age-composition of the stock, we may refer here to the significant comparison shown by Thompson between the stocks of haddock in the North Sea and those around the island of Rockall, situated in the open sea off Scotland.

This is an area rich in haddock which, when Thompson wrote, was little fished by trawlers. From scale samples taken from this area in 1929 it was possible to calculate the relative numbers of the different year classes from the fourth onwards and to compare them with the strengths of the typical year-classes of 1920 in the North Sea in successive years. The data are shown in Table 4.

| Fishing grounds | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| North Sea | 909 | 410 | 149 | 64 | 31 | 4 | 0.6 | 0.1 | 0 | 0 | 0 | 1568 |
| Rockall Is. | 1291 | 757 | 343 | 86 | 211 | 148 | 32 | 158 | 17 | 1 | 12 | 3056 |

Table 4. Haddock. Comparison of numerical catch of older age-classes at Rockall (May. 1929) and of the typical 1920 brood in successive years in the North Sea. (expressed in catch per 10 hours'fishing of age-class)

It will be seen that there were far more old fish in the Rockall population, these occurring in consederable numbers up to about twelve years old; whereas in the North Sea population, which was heavily fished, there were very few over eight years of age.

The rate of reduction was obviously much less in the Rockall stock, (an average of 32 percent) while for the North Sea stock it was 64%. This contrast in age-composition between a lightly fished population and one that is heavily fished is just what one would expect if fishing is the main cause of the reduction in average age of the heavily fished stock.

# LECTURE 4

## Management of Fisheries Resources

### 4.1 The concept of "Maximum sustainable yield"

In my last lecture, at first, I propose to outline in its very simplest form the modern view of the relation between intensity of fishing and total yield. Up to a certain point you can increase yield by increasing fishing, but after this maximum point is reached the more you fish the less weight of fish you catch.

The proposition is almost self-evident, if one considers the fact that intensive fishing must force stocks down to a low level of average size, but the actual demonstration or proof of the thesis has been supplied only in recent years. Various people have contributed to this modern theory of over-fishing.

The idea that there must be for each fish an optimum rate of fishing has been in the minds of fisheries scientists for many years. However, the elaboration of the theory of the optimum catch is due mainly to a few people; first, to the Russian worker Baranov, who in papers published in 1916 and 1925 pointed out that the level of the stock depends mainly upon the amount of fishing, and that the possible yield is limited.

If our conclusion is correct that in the present conditions of intensive fishing, the main factor in the mortality is the effect of fishing operations themselves, and the mortality caused by natural factors is less important, it follows that the age-distribution of that part of the stock which was subjected to fishing operations is essentially determind by the amount of fishing.

We should except in a heavily fished stock to find that the proportion of older fish is less than in a more lightly fished stock, since the mortality rate is higher. That is very clear, and as we have seen, experience bears it out. Let me here recall to your attention the comparison between the Rockall and the North Sea stocks of haddock in my previous lecture.

We should expect also to find in a virgin or unfished stock a very different distribution of sizes and ages from that shown in the well-exploited stocks of the present day. Here again experience confirms expectation. It is a known fact that a virgin stock contains a big proportion of large fish.

It is fairly obvious that if fishing is moderate, taking, say, 30 percent by number of the stock year by year, the average age and weight of the fish in the stock and in the catch will be greater than they would be if fishing were more intense, say, at the rate of 60 percent reduction annually. The age-distribution of the two stocks subjected to continuous fishing at the two rates would be different, on account of the different rates of mortality. There would be a greater proportion of older and heavier fish in the more lightly fished stock. In the stock subjected to a 60 percent reduction there would be fewer of the old and heavier fish, and the catch would consist more of smaller and lighter fish.

If we imagine the intensity of fishing to be continously increased, we see that there must come a time when this will result in a decrease in the total weight of the catch, because the catch will come to consist mainly of quite small fish of low average weight, giving a total weight less than the weight of the smaller number of older and larger fish yielded by a less intense fishery. It follows also that a very intense fishery may actually yield no more than a very moderate fishery, both being well under the possible maximum.

Here, I would like to show you a very simple mathematical model which is shown in Fig. 9 and Table 5. These figure and table show the effect on an original stock of 1,000 fish of annual percentage reduction in number of 50 and 80 percent.

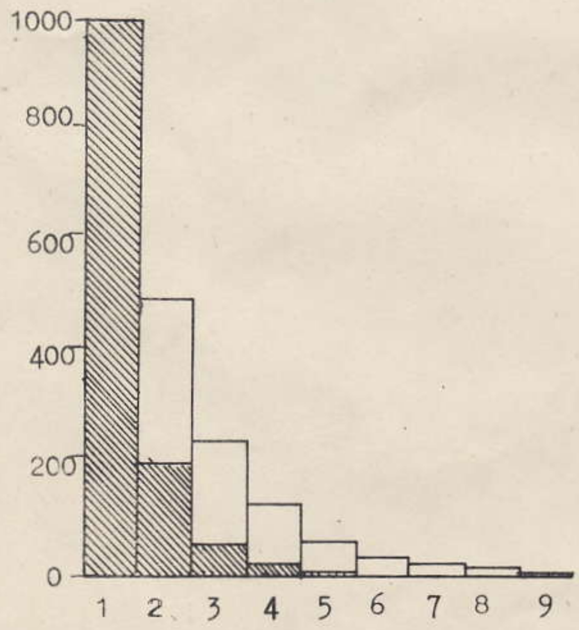



Fig. 9. Reduction of a stock by 50 percent and 80 percent annually.

Let us look first of all at the fate of a single year-group of fish. The fish of age 1 have not been affected at all by fishing, and they have just entered the stock. After one year, if they are subjected to a 50 percent reduction through fishing and natural mortality, their number will be a shown in the second column of this Figure, namely 500 fish. At the end of the next year 250 fish, and so on. Similarly, if the percentage reduction annually is 80, the numbers left at the end of successive years will be 200,40 and so on as shown in Table 5.

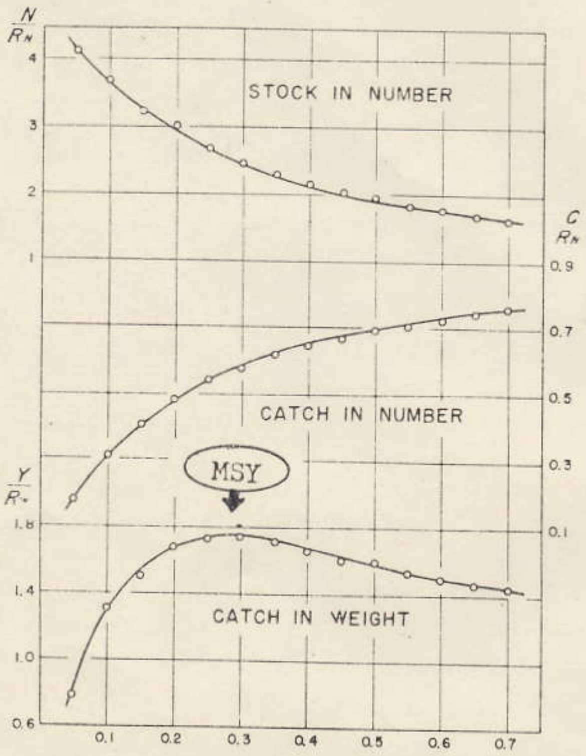
| Age | Stock | Withdrawals of 80% annually | Stock | Withdrawals of 50% annually |
|---|---|---|---|---|
| 1 | 1,000 | - | 1,000 | - |
| 2 | 200 | 800 | 500 | 500 |
| 3 | 40 | 160 | 250 | 250 |
| 4 | 8 | 32 | 125 | 125 |
| 5 | 2 | 6 | 62 | 62 |
| 6 | - | 2 | 31 | 31 |
| 7 | - | - | 16 | 16 |
| 8 | - | - | 8 | 8 |
| 9 | - | - | 4 | 4 |
| 10 | - | - | 2 | 2 |
| 11 | - | - | 1 | 1 |
| Total | 1,250 | 1,000 | 2,000 | 1,000 |

Table 5. Reduction of a stock by 50% and 80% annually. (after Thompson, 1937)

If the process is carried on until the orginal 1,000 are eliminated through capture or natural causes, the distribution by number and age of the fish thus removed from the stock is as shown in columns 2 and 4 in Table 5 for the two rates of reduction. If we make the safe assumption that the majority are caught, i.e. that the rate of natural mortality is considereably less than the rate of fishing mortality, the withdrawals may be taken to represent with approximate accuracy the age-distribution of the yield of this year-group. If we know the average weights of fish in each year of life (as shown in Fig.8), we can calculate the total weight of fish lost to this year-group each year, of which the bluk will be catch.

It is of interest to note that the evidence about total mortality which is available from studies in Scotland and in the East China Sea indicate that the annual percentage reduction from all causes is of the order of 60 to 70 percent. There is direct statistical evidence that the haddock stock in the North Sea and the yellow sea bream stock in the East China Sea are being overfished; that is, increased expenditure of effort has resulted in decreased total catches.

The general conclusion which we may draw from these considerations is that "there must be for every fish species an optinum rate of fishing". When the rate exceeds this optinum, the yield will fall, in spite of the increased effort expended. This rate of fishing which gives The maximum sustainable (steady) yield (MSY) is the most important concept for the management of fisheries resources in the sea. The lower curve in Fig. 10 shows one of the examples of MSY which was calculated by Shindo for yellow sea bream stock in the East China Sea.




Fishing Mortality Coefficient

(Rate of fishing)

Fig. 10. Diagram showing the MSY (Maximum sastainable yield).

## 4.2 The management of the sea fisheries

In my series of lectures firstly, I traced in a few typical cases the growth and expansion of a fishery, showing how it gradually extended its geographical range and improved its technical methods of fishing. Human beings as predators have exploited the fishery resources of the environment more and more fully.

Secondly, I have shown that this process of exploitation has gone too far, especially on the older and nearer fishing grounds which have been fished intensively for many years, and that a state of overfishing, implying sheer waste of fishing effort, has set in. I have tried to explain the very simple principles underlying overfishing.

Now I return to the starting point of my lectures, with the enquiry:

What has man done about this overfishing problem, what steps have to be taken, and what steps can be taken to remedy this unsatisfactory state of affairs?.

It is clear that many fish stocks are being exploited in a wasteful and uneconomic manner— What action should be taken?

I do believe that you can find out answers to these questions in my short lectures given here.

At present, many international fisheries agreements on conservation of fishery resources have been established in the Pacific and Atlantic Oceans. The basic idea of these agreements is the conception of MSY (Maximum sustainable yield) described above. However, the most important things is "how to realize the MSY" through the actual implementation of political and technical measures on conservation of fishery resources.

## POSTSCRIPT

In these four lectures, it is not possible to cover more detailed matters concerning the system of biological and statistical surveys, such as population study, method of calculation of MSY points, etc. because more theoretical explanation would be needed. Here, the author only wishes to give an introduction to the problem and to indicate very briefly the best way to utilize our fishery resources.

This lecture is based mainly upon the following literature:

1. Russell, E.S., 1942: The Overfishing Problem. 130 pp. Cambridge University Press. (London)

2. Shindo. S., 1960: Studies on the Stock of Yellow Sea Bream in the East China Sea. Bulletin of the Seikai Regional Fisheries Research Laboratory, No. 20. 198 pp. Nagasaki (Japan)

3. Shindo S. , 1973: General Review of the Trawl Fishery and the Demersal Fish Stocks of the South China Sea. FAO Fisheries Technical Paper, No. 120. 49 pp. FAO (Rome)