Text/Reference Book Series No. 26
March, 1982

CATCH AND EFFORT DATA

SHIGEO HAYASE

Training Department
Southeast Asian Fisheries Development Center

CONTENTS

Page

INTRODUCTION 1

1. HOW TO TREAT THE LANDINGS DATA 1

1.1 The long-term fluctuation of landings 1

1.2 How to approach established reputation 3

1.2.1 The trophic level analysis 3

1.2.2 The unit stock analysis 3

1.2.3 The habitat segregation analysis 5

2. HOW TO TREAT THE EFFORT DATA 6

2.1 Definition of fishing effort 6

2.2 Unit of fishing effort 7

2.3 Standardization of fishing effort 7

2.4 Distribution of fishing effort 8

2.5 How to obtain reliable statistics of fishing effort .. 8

2.6 An example of calculating standardized effort 9

3. STOCK ASSESSMENT PROBLEMS 10

4. FORECASTING FISHING CONDITION AND PRESENTATION OF FUTURE SITUATIONS OF STOCK 13

5. REFERENCES 14

INTRODUCTION

The objectives of studies on fish population are as follows; firstly, to make a diagnosis of the past and present situation of a stock and give an adequate foundation for optimum yield; secondly, to make a good estimate of the future situation of a stock, and thirdly, to enhance the productivity of a stock if possible.

In order to diagnose the present situation of a stock, information on fluctuations in productivity of fisheries is of vital importance. Such information can be obtained from the fisheries statistics data which are mainly compiled by the Statistics Section of the Department of Fisheries of a country. These data consist of two main components, i.e., catch and effort data on populations of commercially important fishes. These data also provide some indications on the mechanism of stock fluctuations.

The present textbook has been prepared to give the SEAFDEC trainees a basic knowledge of fish population and show a brief guideline on how to evaluate "the current situation of fisheries" and how to treat catch and effort data. It is based on revisions and summeries of several working papers presented by the author at technical workshops and seminars held at SEAFDEC, Bangkok, in 1979-81. Most of the references cited in this book are from Japanese technical papers mainly related to selected pelagic fish species around Japanese coastal waters.

The author is greatly indebted to Professor Syoiti Tanaka of the Ocean Research Institute, University of Tokyo, for his many helpful comments.

1. HOW TO TREAT THE LANDINGS DATA

1.1 The long-term fluctuation of landings

The typical migratory pelagic fishes in Japanese coastal waters are such species as anchovy, sardine, mackerel, saury and squid. The annual landings of each species vary considerably from one year to another and in the long term. It is, therefore, essential to treat and assess the landings data in order to diagnose the present status of a stock so as to provide an adequate basis for management of the resources.

Figure 1 shows long-term fluctuations of landings of pelagic resources in Japanese coastal waters.

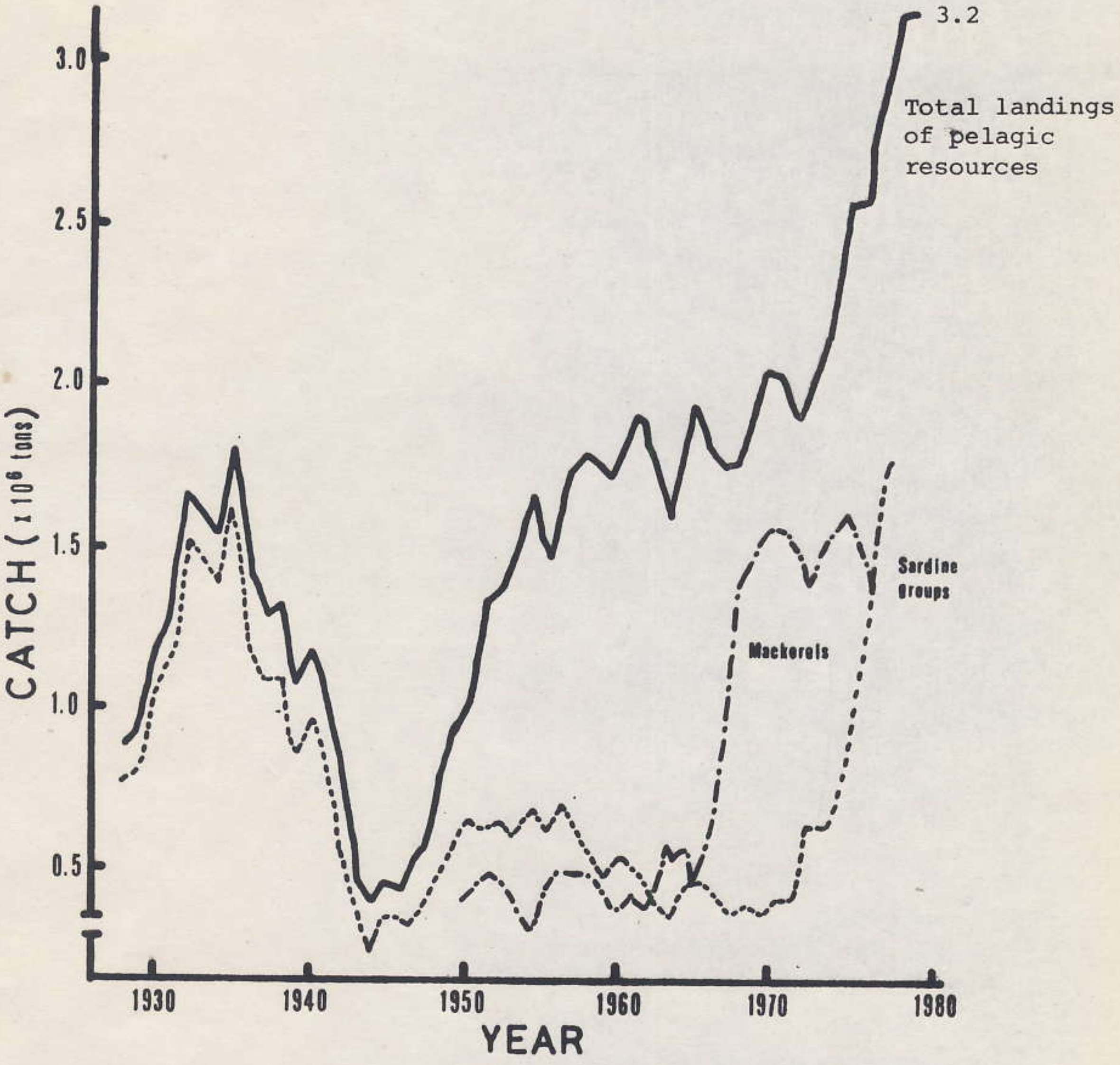

Fig. 1 Annual landings of pelagic resources (Source, adapted: Mitani, 1970).

Up to 1950s, small-scale fisheries had been carried out with a view to catch sardine, therefore the annual fluctuation of total landings coincided with that of sardine. During the period between 1950-1970 the total landings were gradually increasing with a slight fluctuation, in spite of the fact that the landings of sardine itself were at a rather low level. In other words, this kind of fluctuation may have been caused by a change in catching effort; while the sardine catches decreased the landings of other kinds of fishes such as mackerels increased. In the last decade, total landings have grown again in accordance with the rapid increase in sardine landings.

1.2 How to approach established reputation of stock size by using landings data

There are only three possible methods by which information on landings can be obtained. They are: 1) data collection method categorized by each trophic level, 2) data collection method analysed by species or unit stock, and 3) data collection method grouped according to habitat segregation.

1.2.1 The trophic level analysis

Generally speaking, sardine and anchovy belong to the phyto- and zoo-plankton feeders, saury and squid belong to the zoo-plankton and fish larvae feeders, while jack-mackerel and common mackerel are omnivorous feeders. Consequently, the trophic level of scad, mackerel and saury is higher than that of sardine and anchovy. The comparison of landings of the two trophic level groups in Fig. 1 reveals that the landings of the higher trophic level group increased steadily year by year in the 1960s up to the beginning of 1970s. On the other hand, the lower trophic level group kept a low abundance level until 1972, but with the recent growth reached the same abundance level as the higher trophic level group. In other words, both stocks of plankton and small fish feeders have kept the same high level in recent years.

1.2.2 The unit stock analysis

The second approach is the unit stock analysis. Theoretically, a unit stock of a species is a population of fish that is essentially self-contained, occupies a particular area and lives independently of other similar population, and usually, environmental factors (current, temperature, salinity, etc.) delimit a unit stock of a species. In the case of Japanese coastal waters, two unit stocks of species are observed; "the Pacific Ocean unit stock" and "the Japan Sea unit stock". In other words, the former is "the Kuroshio-current unit" and the latter is "the Oyashio-current unit".

The main unit stocks of pelagic resources inhabiting the Pacific Ocean Current are the sardine stock, the anchovy stock and the saury stock. The landings of these stocks have fluctuated remarkably during the last 30 years (Fig. 2).

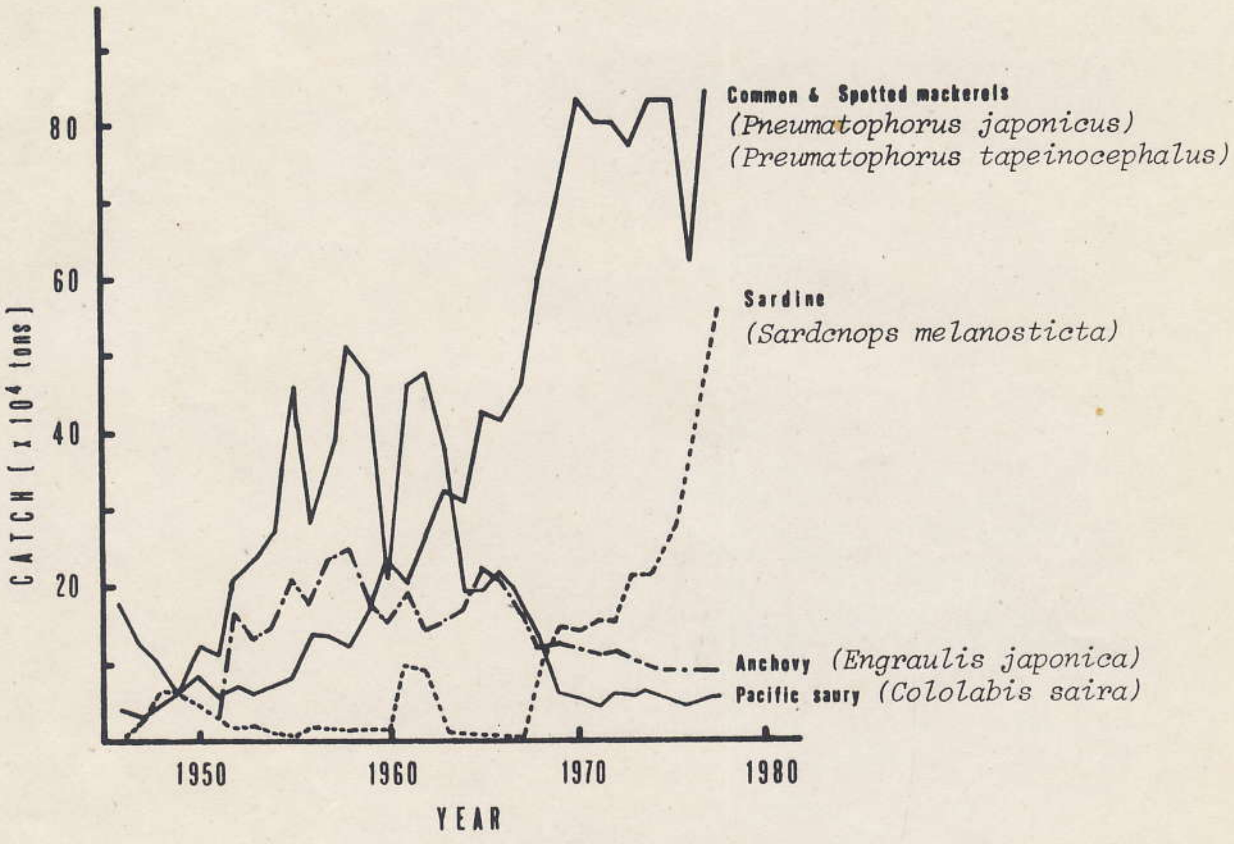

Fig. 2 Annual landings of pelagic fishes inhabiting in the Pacific Ocean Current (Source, adapted: Mitani, 1970).

In the decade from 1952 to 1962, annual landings of the saury and mackerel stocks were growing year by year, especially increase in the saury landings was remarkable. At the same time, landings of the anchovy stock also increased gradually but landings of the sardine stock dropped to nearly 0 catch. During the decade from 1968 to 1977, landings of the saury and anchovy stocks decreased sharply, whereas landings of mackerel and sardine increased dramatically.

We cannot explain clearly the reason for these drastic fluctuations, but at least the following several reasons may be supposed;

The increase in landings of saury may be due to an increase in fishing effort by introduction of stick-held dip net "Bouke-ami" operation. As a result, overfishing the stock of saury population may have caused the downward trend in landings after 1968.

As regards the stock of mackerel population, the fact that the total fecundity of the Kuroshio current mackerel stock has been increasing continuously from 1950s may have led to an increase in the stock. Also, the fishing effort for catching the mackerel population has increased recently by introduction of large or middle scale purse seine operations. Therefore, the recent increase in mackerel catch may be due to simultaneous changes in both abundance and effort.

Interspecific competition between saury and mackerel may effect the abundance fluctuations of both species. Similarly, landings fluctuations of sardine and anchovy may be due to the interspecific competition.

1.2.3 The habitat segregation analysis

The third approach is the habitat segregation analysis of the species concerned. If one looks into the habitat segregation of pelagic resources in Japanese coastal waters, they would be separated into three distribution patterns according to their habitats. That is to say, spotted mackerel, *Preumatophorus tapeinocephalus*, and jack mackerel, *Trachurus japonicus*, inhabit the high temperature zone (Southern district), while Japanese sardine, *Sardcnops melanosticta*, and common mackerel, *Pneumatophorus japonicus*, live in the low temperature zone (northern district) and anchovy, *Engraulis japonicus*, takes a middle position between them.

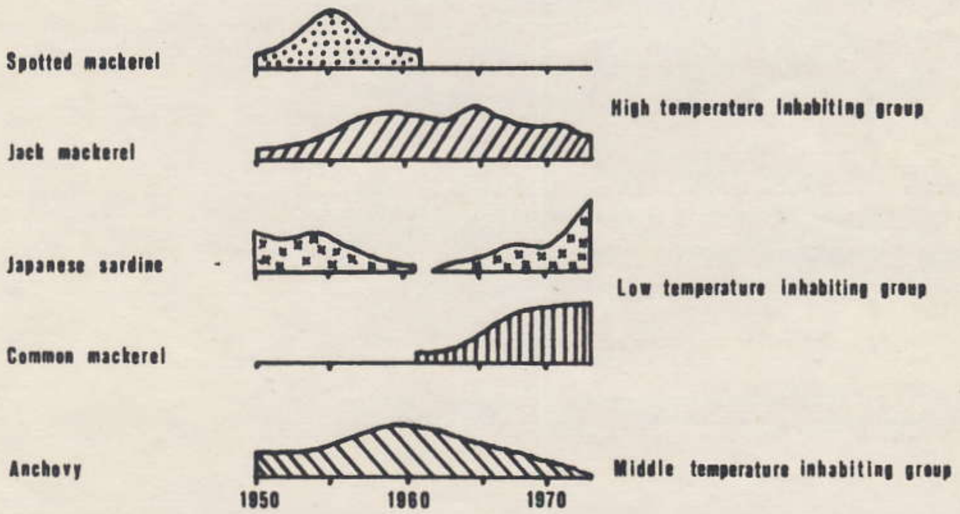

Fig. 3 Schematic diagram for landings of pelagic fishes separated by three distribution patterns (Source, adapted: Asami, 1970).

Schematic diagram of landings of these fishes separated by three distribution patterns (Fig. 3) shows that the low temperature group has surpassed the high temperature group in recent years and the middle temperature group fills the vacant niche covering the decrease of high temperature group. Thus the replacement of species may have happened according to the long-term changes of environmental conditions.

However the three possible methods mentioned here for approaching established reputation of stock size are inseparable from one another. Each analysis may be effective to grasp the outline rather than the essence of landings fluctuation, because the landings fluctuation is a complex phenomenon showing the mutural relationship between fisheries and fish populations.

Thus, the landings fluctuation does not necessarily indicate a fluctuation in the absolute abundance of stock in the sea because the numerical abundance of landings in fisheries is effected directly by the magnitude of fishing effort.

In any study on fish population, it is essential to get the catch and effort statistics for the pupulation. Fishing effort data also provide information on relative fishing intensity.

2. HOW TO TREAT THE EFFORT DATA

2.1 Definition of fishing effort

In the theory of fishing pupulation dynamics, fishing mortality coefficient (F) is assumed to be proportional to fishing effort and that is:

$$F = q \cdot x \qquad (1)$$

where X is the fishing effort and q is the catchability coefficient.

Therefore, fishing effort (X) is defined as a measurable quantity which is proportional to the fishing intensity. Catchability coefficient (q) is defined as fishing rate per unit of fishing effort. It has the meaning of the ratio of area where the fish stock is distributed and in a most simple cases of trawl fisheries it can be denoted as:

$$q = ka/A \qquad (2)$$

where a is the area covered by one haul, A is the area of fishing ground and k is the rate of catch (1-k means the rate of escape).

However in actual cases of pelagic fisheries, there could exist various measures of fishing effort and the area <u>a</u> is only an imaginary area depending on the size of boat or types of gear and fisheries.

2.2 Unit of fishing effort

In a simplest case, the number of fishing boats, the number of trips and hauls could be used as the fishing effort data. In a sophisticated example, fishing effort may be given by the number of fishing operations. Complex measures of fishing effort give a higher correlation coefficient between F and X than the simpler measures, and enable a more accurate analysis. In a particular case of purse seine fisheries, searching time for school may be an effective measure and in an uncommon case of purse seine with luring lamp, luminous power intensity may be an effective measure. Thus the unit of fishing effort has indefinite factors because the unit of fishing is changeable according to the type of gears and fisheries and therefore a common unit valid for various types of fisheries should be established as soon as possible.

2.3 Standardization of fishing effort

If a fish stock is exploited with different types of gear, with different sizes of boat or net, there would be a difference in the catchability coefficient between them. Therefore, it is necessary to set the standard of the type or size and to convert data into the standard unit.

Now let us present a simple example. When two different sized boats operate for catching a single fish population (N), and the catches are represented as C_1 and C_2 respectively, the catches are given by:

$$\left.\begin{array}{l} C_1 = q_1 \cdot X_1 \cdot N \\[2ex] C_2 = q_2 \cdot X_2 \cdot N = q_1 \left(\dfrac{q_2 \cdot X_2}{q_1} \right) N \\[2ex] X_{s2} = q_2 \cdot X_2 / q_1 \end{array}\right\} \quad (3)$$

and the ratio of catch per unit of effort (C.P.U.E.) for two different sized boats, is given by:

$$\frac{C_2 / X_2}{C_1 / X_1} = \frac{q_2 N}{q_1 N} = q_2 / q_1$$

The standardized effort is given by:

$$X_{s2} = \frac{q_2}{q_1} X_2 = \frac{C_2 / X_2}{C_1 / X_1} X_2 = \frac{C_2}{C_1 / X_1} \qquad (4)$$

Thus the fishing effort thrown by one boat (X_2) can be converted into the standard unit of another boat (X_1). The result is as follows:

$$X_s = X_1 + X_{s2}$$

$$X_s = X_1 + \frac{C_2}{C_1/X_1} \qquad (5)$$

2.4 Distribution of fishing effort

In the case of putting to use the data of fishery statistics for study of population dynamics, it is necessary that the statistics should be classified by seasons and by fishing grounds as well as by species and by types of fisheries. If the distribution of fishing effort is different from year to year, the catch per unit effort data will give quite an erroneous picture of the fluctuation of fish stock. The information on the spatial distribution of the effort allows to adjust the catch per unit effort.

2.5 How to obtain reliable statistics of fishing effort

It is particulary difficult to gather reliable data on fishing effort if the fishery is operated by a number of small boats of various types. It may be necessary to compile the effort statistics from fishermen's log-books or by interviewing many fishermen. When a fish is exploited by different types of gear it is not necessary to collect data on fishing effort from all types of gear. Let us assume the following situation;

When we have the total catch data from the stock (Y) and the catch per unit effort data for standard fishery (U_s), the standardized total fishing effort (X_s) can be calculated by the formula:

$$X_s = Y/U_s \qquad (6)$$

2.6 An example of calculating standardized effort

Kurogane et al. (1973) provided a report on population dynamics of Indo-Pacific mackerel of the Gulf of Thailand. According to this paper, a number of types of gear were used in 1962-1968 for catching mackerel in Thailand but the majority were Chinese purse seine, Thai purse seine and encircling gill net. Catch and effort data of mackerel by these types of gears were based on the information from log-books compiled by four regions, types of fishing gear and months by the Department of Fisheries and by fishermen (Fig. 4).

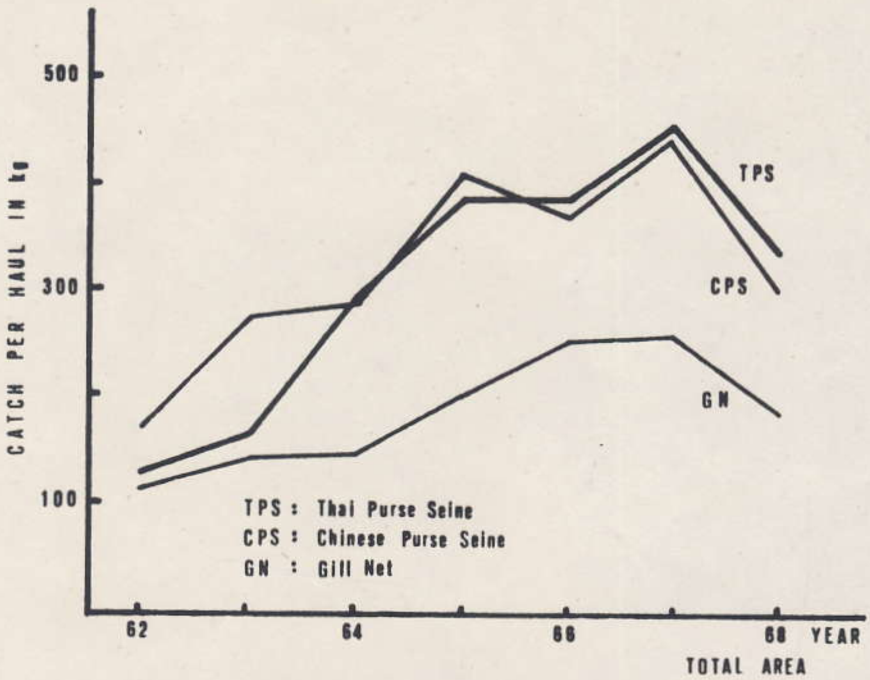

Fig. 4 Average catch per haul of each of the three types of fishing gear used by the mackerel fishery in the Gulf of Thailand from 1962 to 1968. (After Kurogane *et al.* (1973)).

In the process of analysis on population dynamics, the determination of the total fishing effort was inevitable and the standardized total effort was obtained by following the equation (6) and was given by:

$$X'_s = Y'/U'_s \qquad (9)$$

where Y' was the total catch by all gears and U'_s was catch per haul of the gill net.

Based on the determination of the total fishing effort, they assessed the essential parameters of mackerel population and concluded that the mackerel fishing situation of the Gulf of Thailand in 1962-1968 was at the optimum level.

3. STOCK ASSESSMENT PROBLEMS

In order to make the stock assessment of some species of pelagic fishes, it is essential to determine the biological parameters (data) such as age, growth and mortality of fish population. We can say that these data provide the ecological bases for prediction of population size and forecasting of fishing conditions. Such data can be obtained by employing marketing research methods including the field survey. On the other hand, as already pointed out, catch and effort data are very useful for estimating the relative or absolute abundance of fish population in the sea. Therefore, the two-pronged approach (market and fisheries statistics research) has a considerable contribution to make in the establishment of studies on fish population dynamics.

The general network of population studies by flow diagram was established by Doi (1971, 1981). In practice, however, situations as those shown in the flow diagram are very rare and therefore it is sometimes neccessary to devise a rapid diagnosis method of cooperative research.

The examples treated here are good for handling the catch-effort and market research data.

The basic analysis is divided into two categories as follows;

1. Analysis of age composition
2. Analysis of catch in weight

These analyses were conducted by Kawasaki (1973) and Sato (1976) for studies on stock conditions of common mackerel distributed in the coastal waters of Japan (Figs. 5, 6).

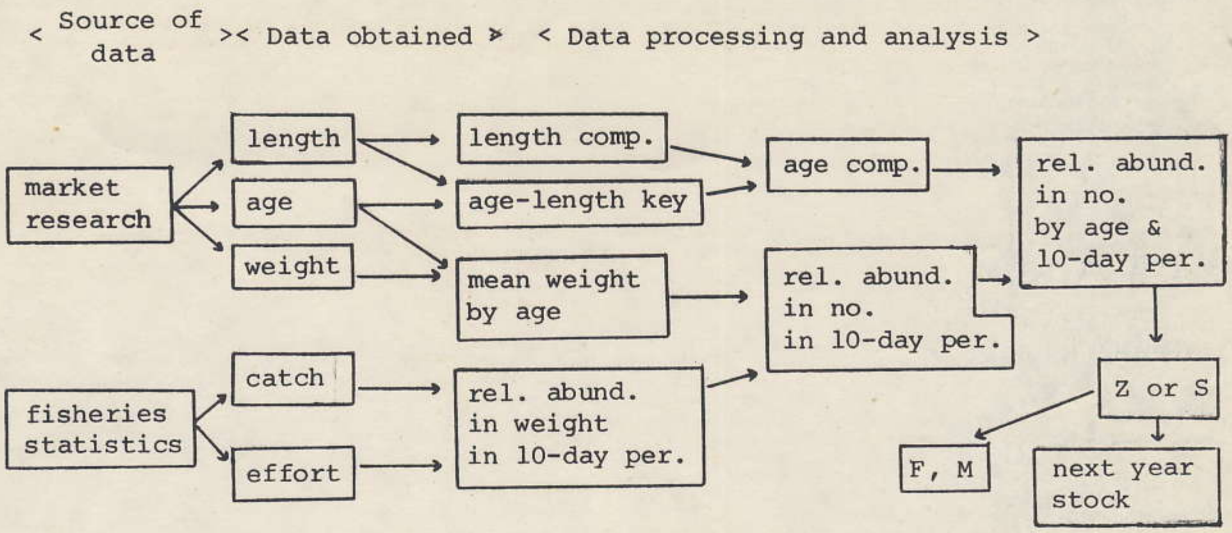

Fig. 5 Analysis of age composition by using the flow diagram (Source, adapted: Kawasaki, 1973).

The rapid diagnosis method on the basis of the procedure for length analysis is known as the cohort analysis (Pope, 1972, Jones 1981).

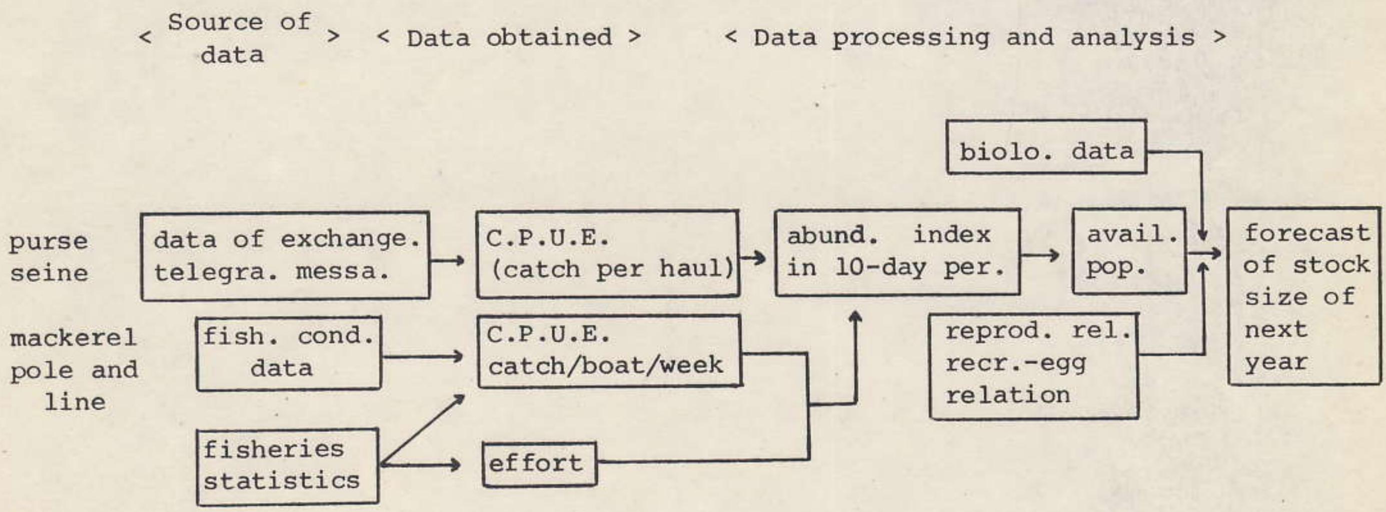

Fig. 6 Analysis of catch in weight by using the flow diagram (Source, adapted: Sato, 1976).

Although these diagrams give a basic idea of data processing, in actual cases some modifications would be needed, depending on the situation. For example in the saury population, C.P.U.E. does not indicate the stock size because the size of the fishing grounds of this species varies from time to time according to the oceanographical conditions (water temperature, etc.).

Matsumiya and Tanaka (1978) calculated the abundance index taking the distribution of the saury population into consideration. C.P.U.E. in each of the small blocks of 30' x 30' is summed up to obtain the index. The flow diagram of information is shown as Figure 7.

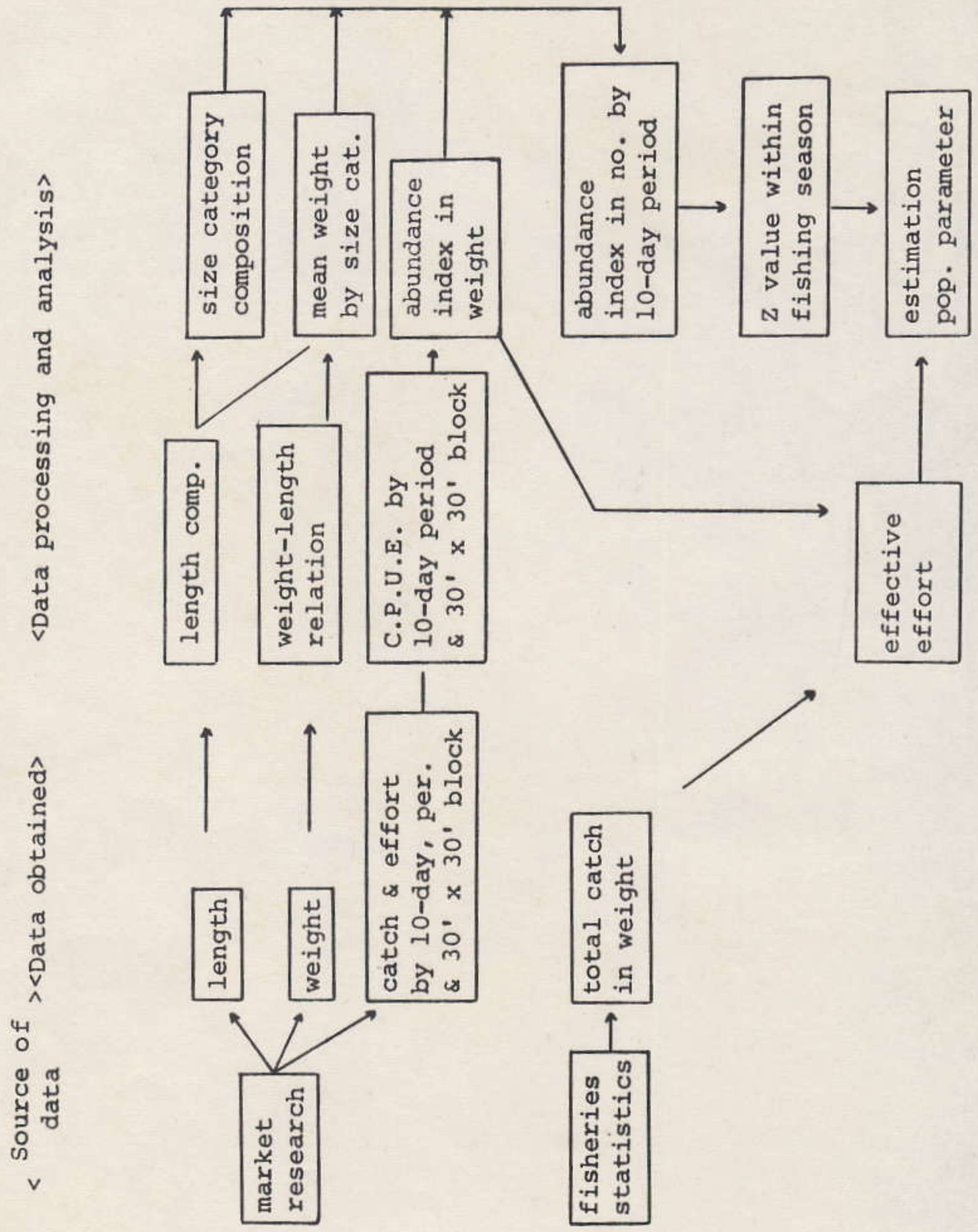

Fig. 7 Flow diagram of population study on saury population (Source;adapted: Matsumiya and Tanaka, 1978).

As it is clear from the above-mentioned examples, the statistics of both catch and effort are of vital importance for monitoring the status of stocks and for forecasting the future of stocks. If the statistics are accompanied by age or size composition data, a great improvement in precise assessment of the stock would be achieved.

4. FORECASTING FISHING CONDITION AND PRESENTATION OF FUTURE SITUATIONS OF STOCK

The target of population studies is to forecast the fishing condition and to present the future situation of stocks. The following table shows some examples of methods of forecasting the situation of stocks in unit of time (Table 1, after Asami, 1970)

Unit of time	Methods of forecasting
Long term: Over the period of one generation (2-4 years)	Time series analyses on catch in weight and abundance index Long term fluctuations of environmental factors Population or community fluctuations
Middle term: Interval of up to one generation (0.5-2 years)	Population dynamics by each species and by each unit stock
Short period: For several days or weeks	Mechanism of movement and stagnation of fish schools Relationship between the fishing grounds and their environments Utilization of fishing forecast

In the case of middle period forecasting, the analyses have been conducted by calculating such parameters as fecundity, survival rate in early stages, recruitment, survival rate by each year class, catching rate, natural mortality and stock-recruit relation etc. by the unit stock of fish. But the unit stock itself has a different life cycle year by year, namely, these parameters do not have fixed values every year (even within the unit stock). The values of these parameters may be changeable through the environmental disturbances. Therefore, the main problem would be how to file these changeable parameters which correspond with the environmental variations in fishing forecasting studies.

5. REFERENCES

<u>Reference cited</u>

T. Asami : Bull. Japan. Soc. Fish. Ocea., 16, 195-202 (1970).

T. Doi : Bull. Tokai Reg. Fish. Res. Lab., 66, 89-143 (1971).

T. Doi : Text and Reference Book in SEAFDEC. 18, 1-86 (1981).

R. Jones : FAO Fisheries Circular No. 734 (1981).

T. Kawasaki : Bull. Tokai Reg. Fish. Res. Lab., 74, 45-65 (1973).

K. Kurogane *et al*:
FAO Fisheries Technical paper
Proc. Indo-Pacific Fish. Coun., 14(II), 67-69 (1973).

Y. Matsumiya and S. Tanaka :
Doctoral thesis, University of Tokyo. (1978).

F. Mitani : Bull. Japan. Soc. Fish. Ocea., 16, 187-191 (1970).

J.R. Pope : Res. Bull. ICNAF, (9), 65-74 (1972).

Y. Sato : Bull. Tohoku Reg. Fish. Res. Lab., 36, 9-40 (1976).