ECOLOGICAL MONOGRAPH OF THE JAPANESE ANCHOVY, ENGRAULIS JAPONICA (HOUTTUYN) - THE PERSPECTIVE, METHODOLOGY, RESULTS AND PROBLEMS FOR THE FUTURE

by

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ABSTRACT

The Cooperative Investigations on the Important Neritic-Pelagic Fisheries (formerly known as the Cooperative Iwashi Resource Investigations) has worked closely with the local Fisheries Experiment Stations in a study of the Japanese anchovy. The basic approach to this study has been to examine the mode of life of these species. The size of the population is distinguished as the basis of the developmental stage and yearly cycle of life as follows: Japanese anchovy population ⟷ Pacific sub-population along Honshu ⟷ Space-time group (spring, summer-autumn migration group) ⟷ Gyogun (1st, 2nd .....nth shoal). The series may be considered to describe the historical process of speciation of the Japanese anchovy.

Based on the current study "fishing charts" have been prepared for each of the steps described in the series. These "fishing charts" contribute toward the forecasting and assessment of the Pacific sub-population of the Japanese anchovy.

1. INTRODUCTION

The Japanese anchovy, Engraulis japonica (Houttuyn), inhabits the coastal waters around Japan and the mixing area between Kuroshio and Oyashio Currents off the Pacific coast of east Japan. The catch of this species has increased recently in contrast to a decline in the catch of sardine, Sardinops melanosticta (Temminck and Schlegel). The annual anchovy catch for 1951-1968 ranged between 250,000 and 450,000 metric tons, constituting about 7% of the total output of the fisheries. This species has been caught by many varieties of fishing gear, such as purse seines, boat seines, lift nets, set nets, and so forth, which are commonly used in the coastal regions of Japan.

The anchovy is one of the important prey for large fish, such as skipjack, Katsuwonus pelamis (Linnaeus), bluefin tuna, Thunnus thynnus (Linnaeus), mackerel, Scomber japonicus (Houttuyn) and S. tapeinocephalus (Bleeker), yellowtail, Seriola quinquaradiata (Temminck and Schlegel), horse mackerel, Trachurus japonicus (Temminck and Schlegel), scads, Decapterus maruadsi (Temminck and Schlegel), etc. These species are closely associated with one another through the food web. The anchovy is exploited not only in adult form but also at post-larval stage which is referred to as shirasu. The succeeding immature and sub-adult stage fish are fished mainly for the use as bait for the pole angling fisheries for skipjack and mackerel. Since anchovy is commonly used as food for the Japanese in the form of boiled or dried products, namely, Shirasu-bosi, Tatsukuri, Noboshi, and Mezashi, the rational utilisation of this resource to obtain maximum sustained benefit from it has been envisaged, and studies on the anchovy population have been carried out.

Since the Cooperative Investigations on the Important Neritic-Pelagic Fisheries Resources (formerly known as the Cooperative Iwashi Resource Investigations) started in 1949, the biological data of the fish, including the amount and compositions of the commercial catch, the numbers of eggs and larvae in the sea, and the environmental conditions have been collected through systematic surveys. Since 1964, a project for forecasting the distribution and abundance of important fishery resources has coincided with the abovementioned cooperative investigations.

The Iwashi Resource Investigations group with which I am involved has cooperated with local Fisheries Experimental Stations in Japan in developing suitable methodology for practical investigations of this fish resource. The basic approach to this study has been to examine the mode of life of these species.

2. METHODOLOGY

The study of fishery biology should start from an approach to the life of a species, because the basic conditions inherent to biological production may be unified in different ways depending upon peculiarity of each species. The study should clarify the relationship between the basic conditions in biological production and the production process of the species.

Speaking of the fish aggregation, for instance, we distinguish the size of populations on the basis of developmental stage and yearly cycle of life as follows: species population $\rightleftharpoons$ sub-population $\rightleftharpoons$ migration shoal $\rightleftharpoons$ school $\rightleftharpoons$ individual. For each concept of fish gathering the time, space, quantity, and quality of aggregation are examined.

2.1 Hypothesis concerning the Japanese anchovy populations

The Japanese anchovy population consists of four sub-populations:

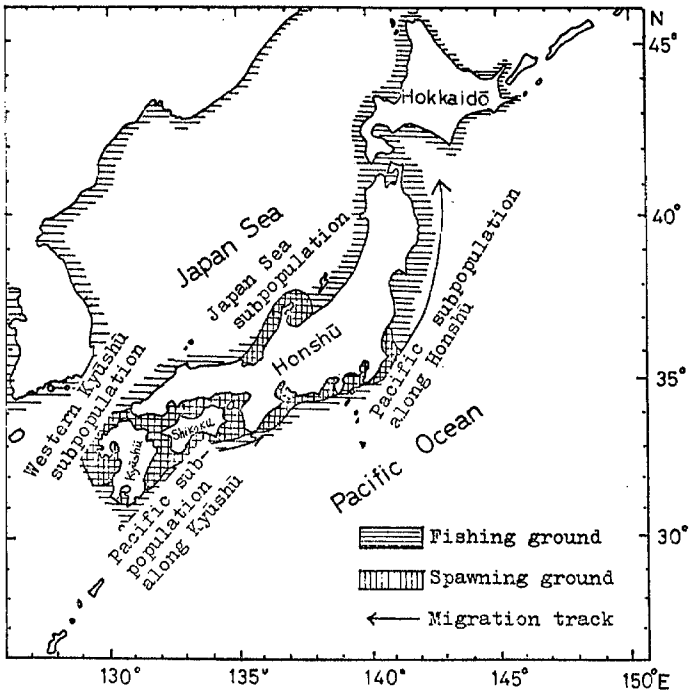

Fig. 1 Geographical distribution of four different subpopulations of Japanese anchovy (from Hayashi, 1961; Hayashi, 1966)

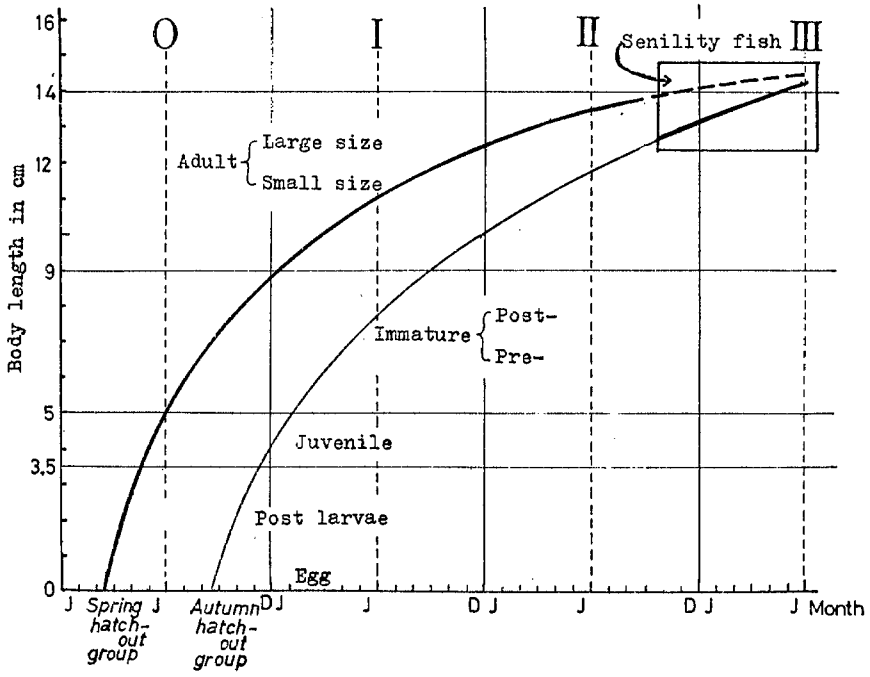

Fig. 2 Relationship between the growth and the developmental stage for the Pacific subpopulation along Honshu.

(1) The Pacific sub-population along Honshu, which spawns in coastal waters between the Kii Peninsula and the Boso Peninsula. The habitat of this sub-population covers a wide area from Kii Peninsula northward to the southern region of Hokkaido, and in the range from the inlets to the high sea in a distance of some 1,000 miles from the coast.

(2) The Pacific sub-population along Kyushu. Their spawning area and habitat are the coastal waters between southern Kyushu and the west coast of Kii Peninsula, and also in Seto Inland Sea.

(3) The western Kyushu sub-population which spawns around Goto Islets and the west coast of Kyushu; and

(4) The Japan Sea sub-population which spawns around the Noto Peninsula; its habitat extends over the northern and western regions of the Japan Sea (Fig. 1).

The Pacific sub-population along Honshu has its nursery grounds on the continental shelves between Tokyo Bay and Kii Peninsula yielding a sufficient amount of post-larval and juvenile stocks to support the most prolific fisheries for young anchovy in Japan. Since the spawning season extends throughout the warmer months of the year, several space-time groups are distinguished within a stock. The post-larval and juvenile stocks exploited in the Sea of Enshu-Nada and Kikawa Bay comprises of several space-time groups occurring in different seasons of the year. Among them, only the spring group can always easily be distinguished from the others by its remarkably large stock size. Therefore, the stocks are generally divided into the spring group and the summer-autumn group. Each space-time group again consists of several shoals fairly distinct from one another in the time of hatching.

2.2 Hypothesis concerning the life history of the Japanese anchovy

2.2.1 Relationship between developmental stages and growth (age)

Age study is one of the most important approaches to the analyses of the life history of a fish. The growth stages based on the relationship between the development and growth of the Japanese anchovy may be classified as follows:

Egg stage: Hatching takes place about three days after fertilisation at a temperature between 16-18°C (Hattori, 1966). The shape of the Japanese anchovy egg is ellipsoid with the major diameter from 1.4 to 1.6 mm and the minor diameter from 0.6 to 0.7 mm.

Larval stage: The larva immediately after hatching ranges between 3.2 and 3.6 mm in total length (Fig. 2). The larva starts to take food, mainly nauplii and eggs of copepoda, as soon as the yolk is absorbed.

Post-larval stage: The post-larval stage (one-three months old) ranges between 3.6 mm and 35 or 40 mm in total length (Fig. 2). The post-larvae locally referred to as shirasu are usually fished by boat seines.

Juvenile stage: This stage ranges between 3.5 and 4.0 cm in total length or is approximately 5.0 cm in body length at three or four months old (Fig. 2). Japanese fishermen named this stage, Kaeri.

Immature stage: This stage ranges between 5.0 and 9.0 cm in body length. I propose to divide it into two sub-stages namely, the pre-immature sub-stage ranging between 5.0 and 7.0 cm, and the post-immature sub-stage ranging between 7.0 and 9.0 cm in body length. Age is 0 at this stage.

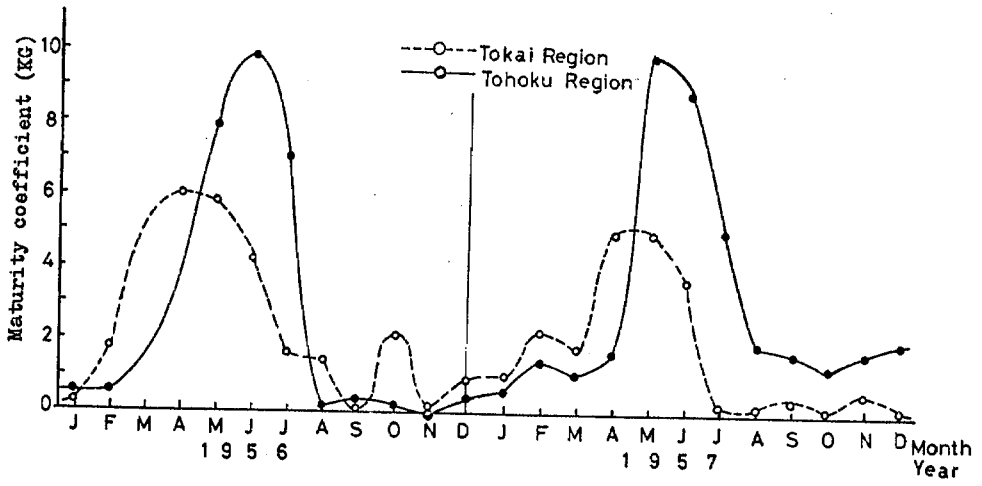

Fig. 3 Seasonal fluctuation of the maturity coefficient in Tokai and Tohoku regions, 1956, 1957.

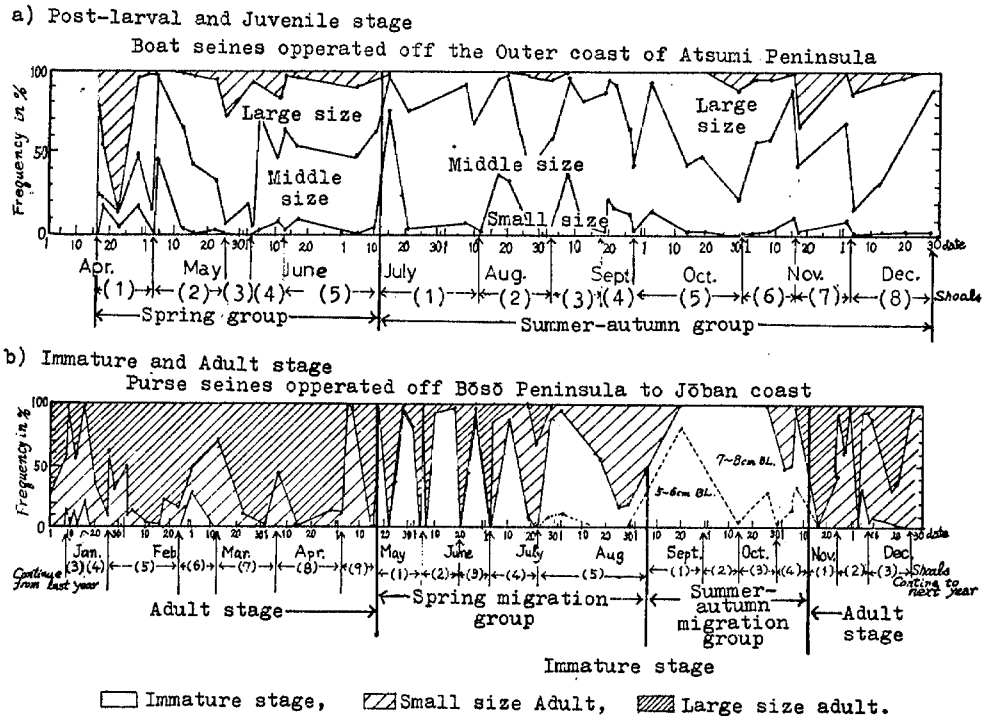

Fig. 4 Changes in the different developmental stages of the Japanese anchovy by season, 1966.

Adult stage: The adult Japanese anchovy ranges between 9.0 and 14.0 cm in body length. I propose to divide the adult stage into two sub-stages: the small-sized adult fish ranging between 9 and 12 cm, and the large-sized adult ranging between 12 and 14 cm. The former is the fish at the end of 0- to early I-age, the latter being at the end of I- to early II-age. In the spring time the majority of the spawners are II-age fish.

The annual life cycle of the adult fish may be divided into three major periods, that is, pre-spawning, spawning, and feeding periods.

Senility stage: From the estimation of the growth rate of the Japanese anchovy of Pacific sub-population along Honshu, Hayashi and Kondo (1957) concluded that the life span of the species is two years. However, huge anchovy were caught by round haul in the Sea of Kashima Nada and off Boso Peninsula during the 1968-69 fishing seasons. These fish ranged between 14 and 16 cm in body length and were estimated to be at the end of II-age to early III-age on the average (Fig. 2). These big anchovy may be in the senility stage (Kondo, 1972).

2.2.2 Maturity and spawning

Eggs and larvae of the Japanese anchovy are distributed all around Japan in all seasons, but the main spawning area is separated into four regions according to the segregation of the four sub-populations (Fig. 1). The major spawning season is spring as the autumn spawning attains only about one-third of the spring spawning amount.

The maturity coefficient (indicated by KG = GW/BL.10)[1/] of the adult is higher in spring (Fig. 3), and decreases in summer. Then the coefficient slightly increases again in autumn before it shows a very low value in winter (Fig. 3).

Five basic attributes, i.e., growth, reproduction, regeneration, movability and reaction are common among living organisms (Oparin, Platonov et al., 1963). The biological information of the Japanese anchovy has been organised in compliance with the developmental stages and the abovementioned basic qualities. We call this scheme "Life pattern of the Japanese anchovy", the study of which was published (Kondo, 1969).

3. MATERIALS AND METHODS

The project for the forecasting of the distribution and abundance of important fisheries resources has been carried out in cooperation with six federal regional fisheries research laboratories and 34 prefectural fisheries experimental stations. These prefectural fisheries experimental stations were assisted by fishermen, who operate in the coastal waters of their localities. The fishermen keep daily records of their catch by each haul. These records are sent to the regional laboratories by mail. The materials from which the mode of segregation of the fish is assessed are from these daily reports from the fishermen.

Furthermore, biological surveys of the important neritic-pelagic fish have been undertaken by the prefectural fisheries experimental stations. These data are also sent to regional fisheries research laboratories. We use these data for the life study of the Japanese anchovy population. The catch reports from fishermen and the length composition data of the anchovy form the basis for hypothesis set forth in Section 2. Based on this information we prepared a diagram of seasonal fluctuation in body length composition by developmental stage of the fish (Fig. 4), and the seasonal fluctuation in maturity coefficient of the adult (Fig. 5). These two diagrams (Figs. 4 and 5) serve as a basis for the classification of migration groups and shoals within the Pacific sub-population along Honshu. According to these data, we set up the period of appearance of shoals and migration groups (Table I).

1/ KG: maturity coefficient, GW: Gonad weight in gram, BL: body length in cm.

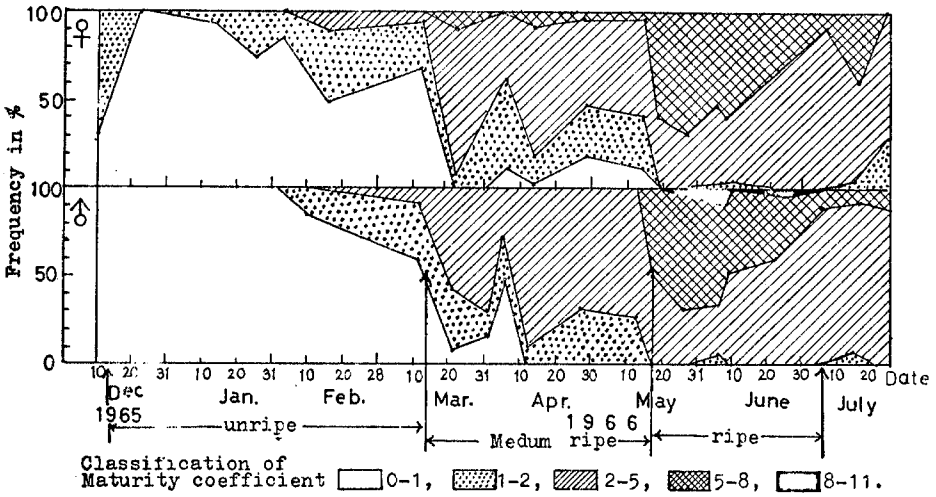

Fig. 5 Changes in the maturity coefficient of the Japanese anchovy by season, 1966 (from Hiramoto, 1968)

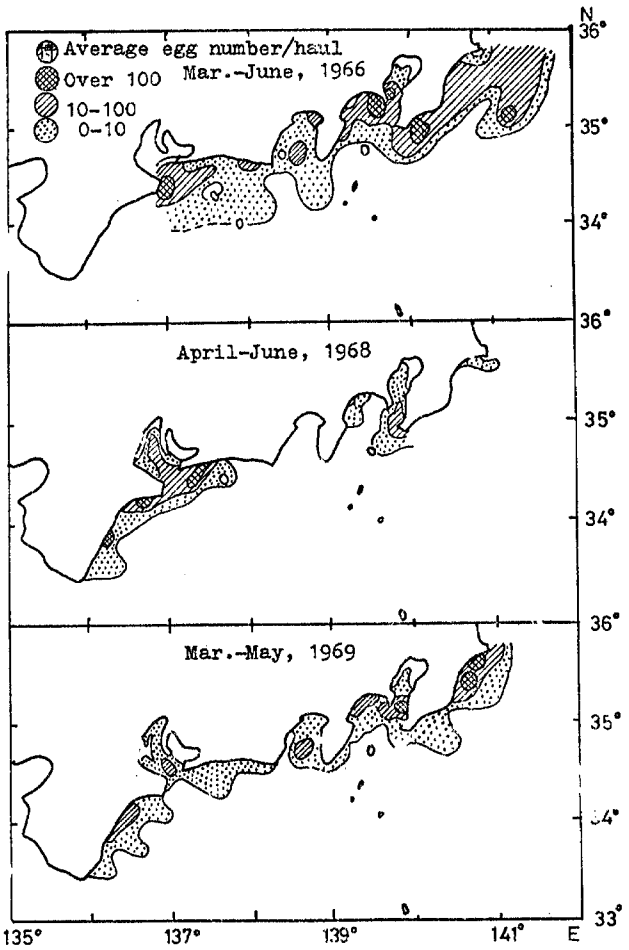

Fig. 6 Spring spawning area of the Pacific subpopulation of Japanese anchovy 1966, 1968, 1969

The daily reports from the fishermen are classified in accordance with Table I. The data of the daily reports are plotted in a chart as the catch per boat and per haul. Such a chart shows the aggregating patterns of fish population and is called the fishing chart by the scientists concerned.

4. RESULTS

As our investigations concentrate mainly on the Pacific sub-population along Honshu, the results presented in this paper are primarily based on the knowledge of this sub-population. From the analysis of the available data mentioned previously the knowledge on stock assessment, abundance, distribution, etc., of the fish stock was obtained.

4.1 Egg stage

One of the important features of the Japanese anchovy is the wide temporal and areal extents of its spawning activities (Fig. 1).

The major spring spawning grounds of the Pacific sub-population along Honshu extends from Kii Peninaula to off Boso Peninsula. The location and formation of areas are characteristic every year. The characteristic formation of the spawning grounds is closely related to the abundance, distribution and movement of the adult population, and moreover, to the interaction between the aggregation of the adult fish and environmental conditions.

The main spring spawning area in 1966 was located in the east and the south regions off the Boso Peninsula and Kujukuri-hama Beach extending westerly to the Tokai Region (Fig. 6a). However, there was another case strikingly in contrast to this. For instance, for the spring spawning in 1968, the grounds were distinctly divided into two areas, i.e., one from along the east coast of the Kii Peninsula extending to the coast of Atsmi Peninsula and Ise Bay, and the other along the west coast of the Boso Peninsula (Fig. 6b). The average extent of the spawning ground was that formed in the spring season of 1969 (Fig. 6c). In this case, the general spawning grounds were extended from Kii Peninsula to off Boso Peninsula, with the centre in the eastern part of the Tokai Region.

4.2 Post-larvae and juvenile stages

One of the most important fishing grounds of the post-larvae and juvenile stocks are the Sea of Enshu-Nada, the open sea coast of Atsumi Peninsula and Suruga Bay, followed by the Sea of Kashima-Nada and Sagami Bay (Fig. 7). The aggregation of the shirasu stock was analysed only for the open coast of the Atsumi Peninsula.

The diagrammatic models were proposed to illustrate the mode of aggregation of post-larval and juvenile stocks of the spring and summer-autumn groups in the open sea coast of Atsumi Peninsula. According to Fig. 8, the spring group first appears off the eastern part of the fishing ground at the end of April or early May. The main fishing ground shifts to the middle part of the open sea coast of the Atsumi Peninsula in the period from early May to late May. In June and July, the fishing grounds are reduced to only the central part and coastal region of the fishing ground (Fig. 8).

The fishing grounds of the summer-autumn group are located mainly on the western part of the general fishing grounds (Fig. 8).

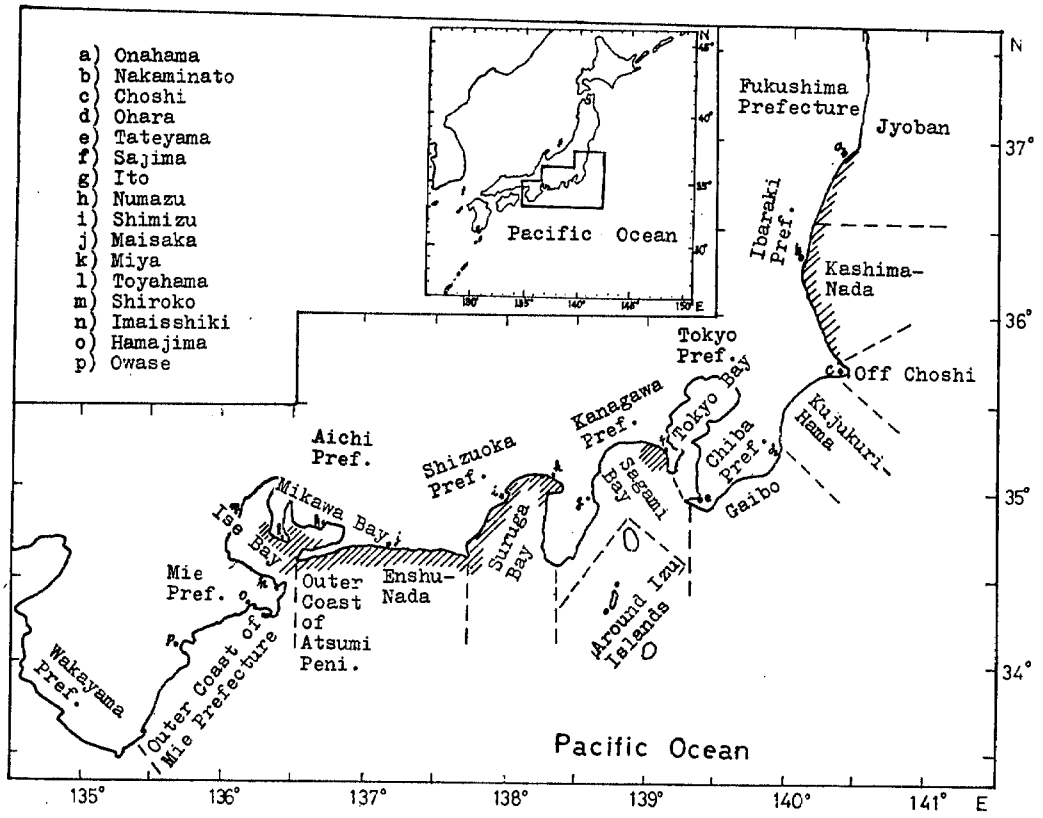

Fig. 7 Map of the main shirasu fishing grounds and the localities

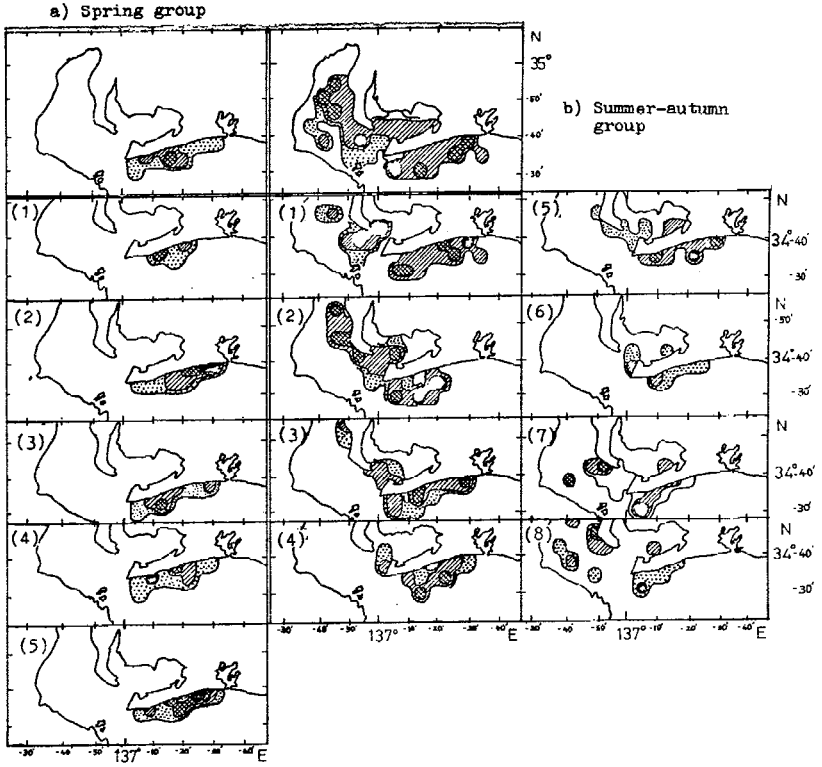

Fig. 8 Mode of aggregation of the postlarval stage in the Open coast of Atsumi Peninsula, 1966

a) Spring group : From 17th April to 13th July
(1) 1st shoal, from 17th April to 3rd May
(2) 2nd shoal, " 4th May - 25th May
(3) 3rd shoal, " 26th May - 3rd June
(4) 4th shoal, " 4th - 12th June
(5) 5th shoal, " 13th June - 3rd July

b) Summer-autumn group : From 14th July to 30th December
(1) 1st shoal, from 14th July to 12th August
(2) 2nd shoal, " 13th Aug. - 3rd September
(3) 3rd shoal, " 4th - 19th September
(4) 4th shoal, " 20th - 28th September
(5) 5th shoal, " 29th Sept. - 31th October
(6) 6th shoal, " 1st - 17th October
(7) 7th shoal, " 18th Nov. - 3rd December
(8) 8th shoal, " 4th - 30th December

heavy little heavy moderate light

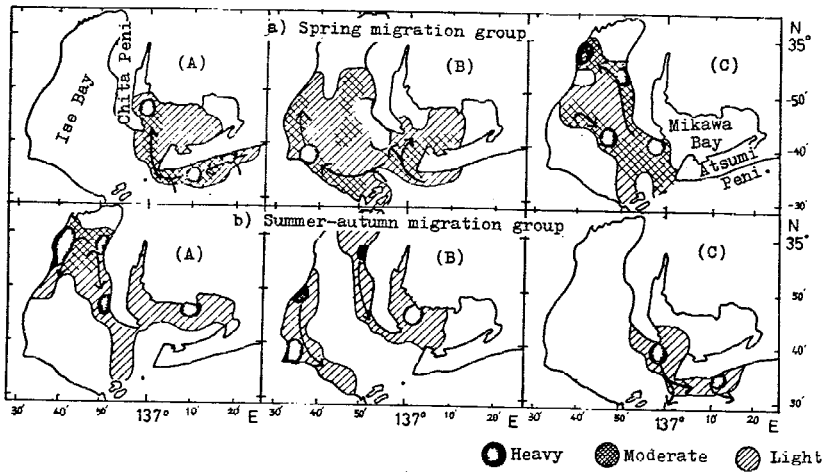

Fig. 9 Diagramatic models of the mode of aggregation and the migration routes of the spring and summer-autumn immature groups in Ise and Mikawa Bays

a) Spring migration group
(A) Beginning fishing season.
(B) Most prosperous fishing season.
(C) Changing period to the summer-autumn migration group.

b) Summer-autumn migration group
(A) Staying period inner most part of the bay.
(B) Remaining period along the coast of Aichi and Mie Prefectures.
(C) Final fishing season.

4.3 Immature stages

4.3.1 Ise and Mikawa Bays

The anchovy stock exploited in Ise and Mikawa Bays is usually constituted of a part of the immatures derived from the Pacific sub-population along Honshu. The stock, furthermore, comprises two space-time groups, namely the spring group and the summer-autumn group, occurring in different seasons of the year even though both of them belong to the same stage and the same sub-population. The respective space-time group comprises several shoals that are aggregations of individuals under the same physiological condition.

Based upon the mode of aggregation at a stratum of the shoal, the movements of fish in Ise and Mikawa Bays may be described as follows:

The shoals consisting of juveniles of the spring group are mainly distributed during the early to middle part of June in the waters along the Atsumi Peninsula and in Mikawa Bay. The majority of the fish then migrate into Ise Bay passing through a channel between Irako Cape and Noma Cape, and few fish move in there along the coast of Mie Prefecture.

The immatures of the summer-autumn group also take the same path when entering into Ise Bay (Fig. 9).

The diagrammatic models were proposed to illustrate the mode of aggregation of the immatures in Ise and Mikawa Bays (Fig. 9). The mode of aggregation of the spring group is characterised by the existence of a densely distributed area in the waters extending from the entrance to the centre of the Bay, and that of the summer-autumn group, by formation of long-staying shoals in the innermost part of the Bay. With a decrease in the stock size in the innermost part, the fishing ground for the shoals of the latter group is finally divided into two areas, one along Mie Prefecture, and the other along Aichi Prefecture. The fish disappear from Ise Bay earlier and remain in the fishing grounds in Mikawa Bay and in the waters along the open sea coast of Atsumi Peninsula. Finally, the fish disappear from the latter areas and, consequently, the fishing operations by Patchi-ami seines cease therefrom.

4.3.2 An area from Suruga Bay to the Joban Coast

The mode of aggregation of the immatures of the Pacific sub-population along Honshu in the waters extending between Suruga Bay and off Joban coast was examined. The immatures migrating into this area are mainly exploited by purse seiners during the spring through autumn seasons. The immatures are separable into two space-time groups, the spring and the summer-autumn groups. Each group consists of several shoals that represent aggregation of individuals under the same physiological conditions.

The movement and distribution of the shoals in the major fishing grounds are summarised as follows:

The spring group first appears in the eastern part of Suruga Bay and in the western coast of Boso Peninsula. In Suruga Bay, the shoals move counter-clockwise passing through the innermost and western coast of the Bay, and then leave from there. The shoals found along the Boso Peninsula disperse in the area between the mouth of Tokyo Bay and the eastern part of Sagami Bay, occasionally in the whole of these two bays. A few shoals appear in the waters as far north as around Cape Inubo (Fig. 10a).

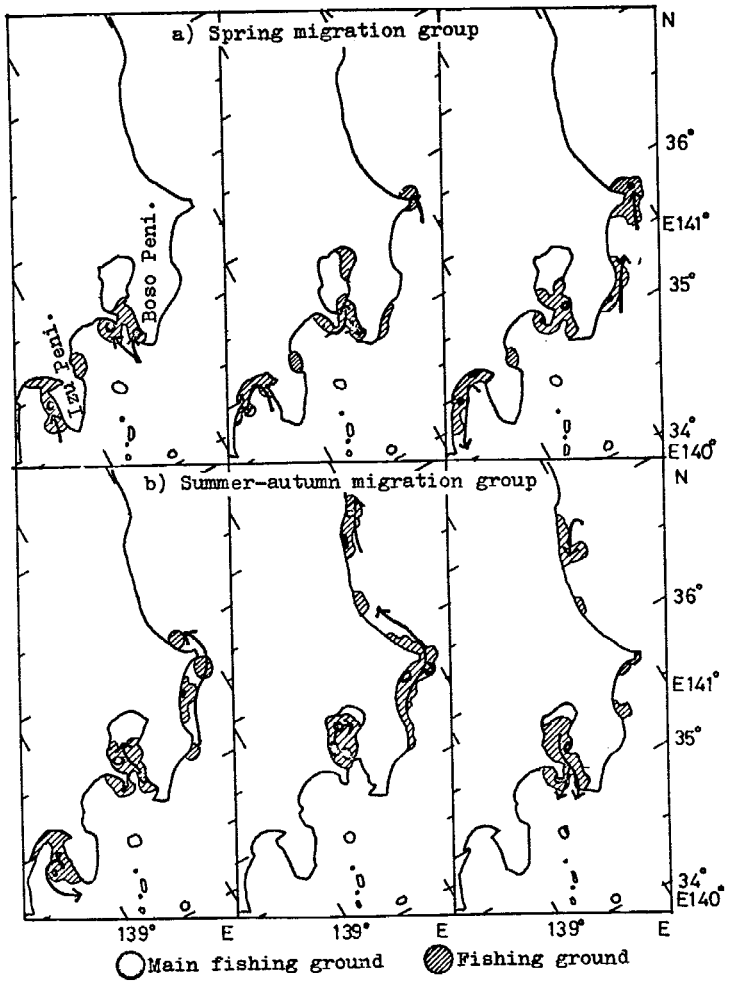

Fig. 10 Diagrammatic models of the mode of aggregation and migration routes of the spring and summer-autumn immature groups from the Suruga Bay to off the Joban coast

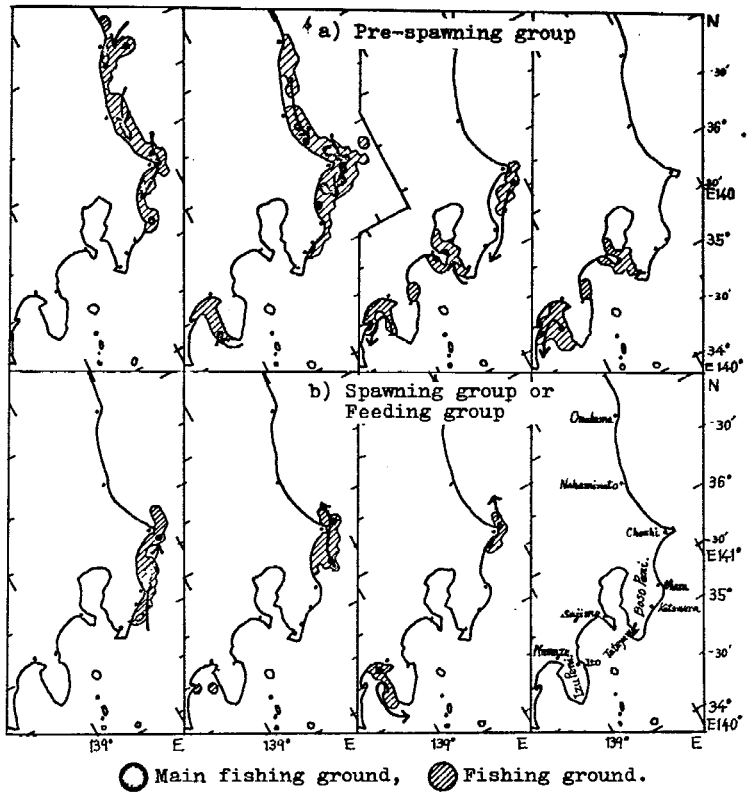

Fig. 11 Diagrammatic models of the mode of aggregation and migration routes of the pre-spawning adult group from the Suruga Bay to off the Joban coast

The summer-autumn group appears mainly in Tokyo Bay and further east, but does not reach Suruga Bay except only a short period before October. In Tokyo Bay, the fish are often abundantly caught by purse seiners in the innermost part. The summer-autumn group migrates out of the bay during late December through the middle of January. The summer-autumn group is also found in the waters around and north of the open sea coast of Boso Peninsula in October and November (Fig. 10b).

4.4 Adult stage

The adults of the Pacific sub-population along Honshu are distributed in the waters between Suruga Bay and the Joban coast. The fish migrate into these waters during autumn through the next spring. They are exploited mainly by purse seines. The adults are comprised of three migratory groups, the pre-spawners with immature gonads, the spawners, and the feeders that move toward the north in early summer (Fig. 11).

4.4.1 Pre-spawning groups

The pre-mature adults occur in December in two areas, one along Joban coast and the other between the sea of Kashima-Nada and Kujukuri-hama Beach. The fish move southward in January and February, reaching Suruga Bay. The distribution area abruptly shifts in March from the Joban area and the sea of Kashima-Nada to the waters along Kujukuri-hama Beach, Tokyo Bay and Suruga Bay. The fish move west of Nojima Cape in early summer (Fig. 11).

4.4.2 Spawning and feeding groups

The spawning adults were caught in large quantities during 1964-1966. The spawners migrated into the fishing grounds along the northern Boso Peninsula and Kujukuri-hama Beach in May and June. During the summer months of the year, the spawners gradually moved northward, and disappeared from the area in September. In late August and September 1966, large-sized anchovy, supposed to be at feeding phase, appeared in Suruga Bay (Fig. 11).

4.5 Relationship between fish aggregation and oceanographical conditions

Studies have been conducted in order to determine (1) the aggregation of the fish according to their developmental stage, (2) the relationship between the fish and environment, and (3) the relationship between shoals and the shift among the shoals in the same migration group. From the knowledge thus obtained, the forecasting and assessments of the stock of the fish were made.

4.5.1 Immature stage of the summer-autumn migration groups

The summer-autumn group appears mainly in the area from off Joban coast to the open sea coast of Boso Peninsula during October or November. This fishing ground was covered by three different water masses, namely, the Kuroshio Current, the Oyashio Current and the Coastal water mass. The mutual relationship of these water masses is very unique. It is observed that anchovy inhabits the coastal water mass and do not live in the Kuroshio and Oyashio Currents. This phenomenon is reflected by the fishery. For instance, the main shoal of the summer-autumn group was distributed widely from Joban area to Boso area in the period from the middle of November to early December in 1964. During this period, the fishing ground was covered by the coastal water mass (Fig. 12a). However, in November 1965 the main fishing ground was separated into two parts, one off Joban area, and the other off the southern part of Kashima-Nada to off Kujukuri-hama Beach. It was observed that during this month the warm water tongue of the Kuroshio Current thrusted into the central part of the fishing grounds (Fig. 12b). During the fishing season of 1966, two boat purse seiners did not catch the anchovy in the waters from Joban area to Kashima-Nada, because the Kuroshio Current meandered close to those areas in that season (Fig. 12c).

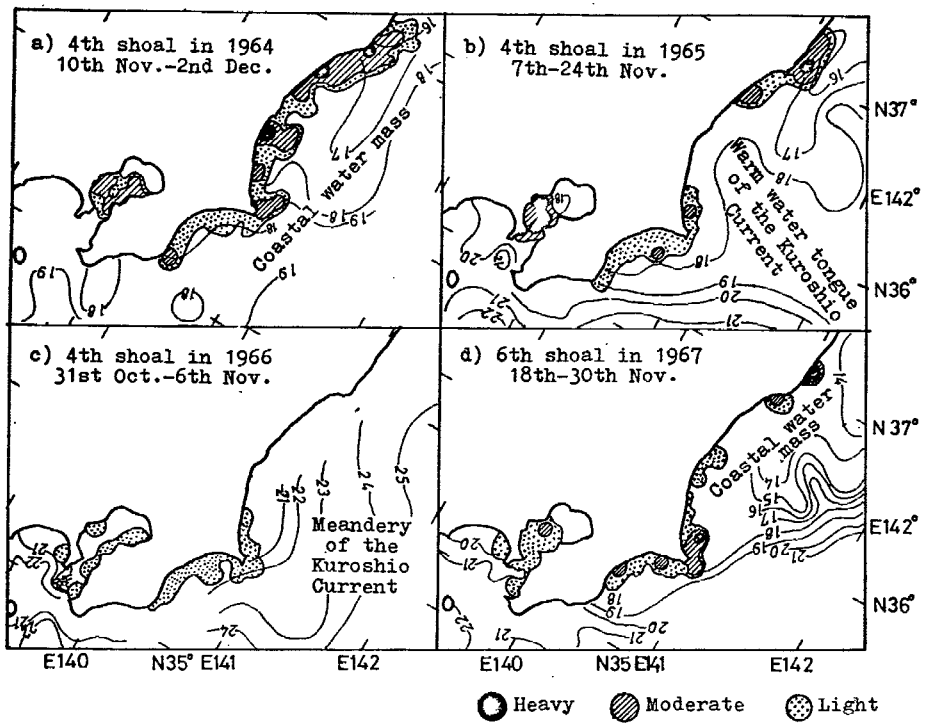

Fig. 12 Relationships between the mode of aggregation of main immature summer-autumn groups and its oceanographic conditions, 1964-1967

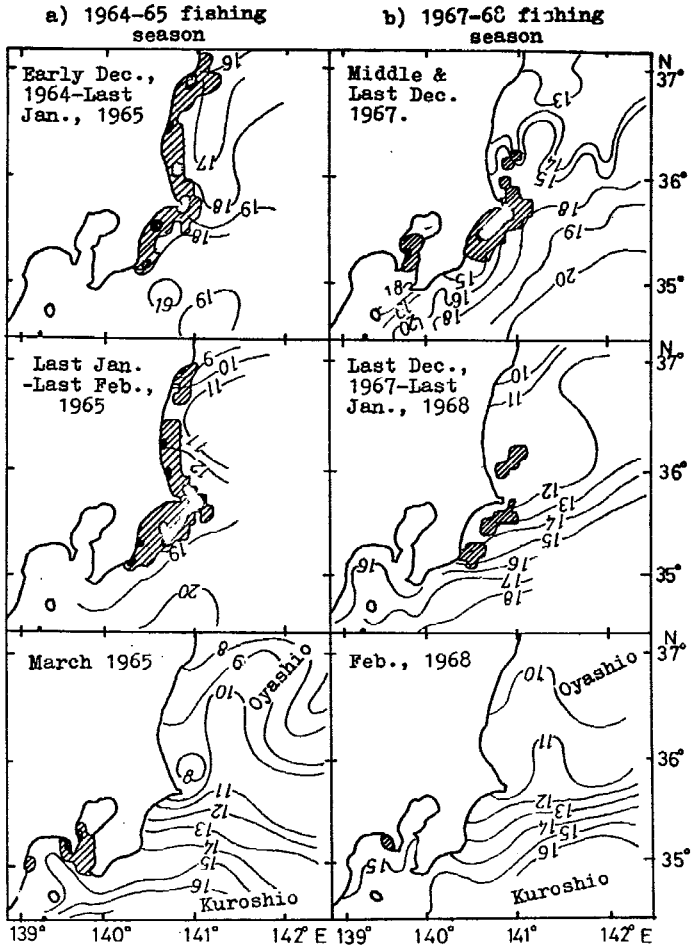

Fig. 13 Relationships between the mode of aggregation of the pre-spawning groups and its oceanographic conditions, 1964-65 and 1967-68 fishing seasons

Such conditions are among important factors that should be taken into consideration in the forecasting of the abundance of the anchovy population for the fishing season.

4.5.2 The fishing grounds of the pre-spawning group

The pre-spawners aggregated in the fishing ground extending from Joban coast to the open sea coast of Boso Peninsula in 1966. The adult stage of this year yielded very large-sized stocks, and at the same time, the fishing ground was covered by the coastal water mass through December/January. The surface temperature ranged between 10° and 19°C. The first branch of Oyashio Current appeared at the end of January or early February, 1966 (Fig. 13). Thus, the adult anchovy migrated to the southern area for their spring spawning.

For the 1967-68 fishing season (December 1967 to March 1968) the pre-spawners concentrated in the restricted waters extending from southern Kashima-Nada to off Kujukuri-hama Beach (Fig. 13). During this period, the catch of two boat purse seiners was very high in respect of the catch per boat and per haul, but, as mentioned above, the fishing grounds were very limited in extent. Their southward movement, the spawning migration, was extraordinarily rapid then. Therefore, the value of the relative stock size which is represented by catch per unit effort, was small (Table II).

In 1967, the fishing ground changed very rapidly from the coastal water to the first branch of Oyashio Current at the end of the year. The cold waters covered to a considerable extent the fishing ground during January and February 1968. Therefore, the spawning migration of the adult took place at the beginning of the fishing season.

The unusually early spawning migration was reflected by the western concentration of the spawners in the spring spawning grounds shown in Fig. 6.

5. PROBLEMS FOR THE FUTURE

The relationship between living organisms and environmental conditions is quite concrete at the level of shoals or individuals. In interacting with the environment, the fish may react as individuals or on a community basis. However, the traditional studies of the life history deal only with the individual biological attributes, such as growth, maturity, reproduction, distribution and movement, etc. They are all unified in the life of fish. Therefore, we have to analyse the life of fish in relation to time, space, quantity and quality of the aggregations on the basis of developmental stage and yearly cycle. In our studies, the following steps are adopted: Japanese anchovy population ⟷ Pacific sub-population along Honshu ⟷ Space-time group (spring, summer-autumn migration groups) ⟷ Gyogun (1st, 2nd, 3rd, ...nth shoals). The series of the abovementioned steps may be considered to describe the historical process in the speciation of the Japanese anchovy. Based on such organisation of the concept, we prepare the fishing charts corresponding to each step. By the fishing charts we have contributed to the knowledge usable for forecasting and assessments of the Pacific sub-population along Honshu of the Japanese anchovy. The fishing charts are prepared from the knowledge of growth, reproduction, regeneration, movement and reaction of the fish (Sato, 1965). It should be emphasised that the study of the developmental stages and the yearly cycle of the life of the fish is indispensable in order to clarify the population structure of the fish.

TABLE I The fishing period of shoals and migration groups of the Japanese anchovy from 1955 to 1966 fishing seasons

Developmental stage	Migration groups	Shoals	Fishing period of a shoal
Post-larvae and Juvenile	Spring-group	1st shoal	11th Apr. - 3rd May, 1966
		2nd "	4th -25th May, "
		3rd "	26th May - 3rd June, "
		4th "	4th -12th June, "
		5th "	13th June -13th July, "
	Summer-group	1st shoal	14th July -12th Aug., 1966
		2nd "	13th Aug. -19th Sept., "
		3rd "	4th -19th Sept., "
		4th "	20th -28th Sept., "
		5th "	29th Sept.-31st Oct., "
	Autumn group	1st shoal	1st -17th Nov., 1966
		2nd "	18th Nov. - 3rd Dec., "
		3rd "	4th -30th Dec., "
Immature	Spring-group	1st shoal	17th May - 3rd June, 1966
		2nd "	4th -20th June, "
		3rd "	21st June - 3rd July, "
		4th "	4th -22nd July, "
		5th "	23rd July -29th Aug., "
	Summer-autumn group	1st shoal	30th Aug.,-30th Sept.,1966
		2nd "	1st -14th Oct., "
		3rd "	15th -30th Oct., "
		4th "	31st Oct. -12th Nov., "
Adult	Pre-spawning group	1st shoal	25th Nov. 14th Dec., 1965
		2nd "	15th Dec.,1965-9th Jan.,1966
		3rd "	10th -16th Jan., 1966
		4th "	17th -26th Jan., "
		5th "	27th Jan. -24th Feb., "
		6th "	25th Feb. -12th Mar., "
		7th "	13th Mar. -16th Apr., "
		8th "	17th Apr. - 3rd May, "

TABLE II Coefficients of relative stock size of the Pacific subpopulation along Honshu, 1964-1969

Area	Developmental stage	Migration group	1964	1965	1966	1967	1968	1969	Average
Ise & Mikawa Bays	Immature	Spring	395	900	152	594	103	316	410
		Summer	188	323	108	210	112	231	195
		Autumn	117	42	21	31	134	102	75
	Adult	Feeding	-	-	376	-	206	-	291
From Suruga Bay to off Joban coast	Immature	Spring	1447	1129	701	1291	1372	2277	1370
		Summer-autumn	1410	1570	442	1813	794	1114	1191
	Adult	Pre-spawner	3060	7343	3373	1782	948	1237	2957
		Spawner	147	535	972	92	67	-	363
		Feeding	-	-	224	-	-	-	224

Footnotes:

1) Coefficient of the relative stock size was calculated by multiplying the area of the fishing ground with daily catch per unit effort per the grid of 5 degree latitude and longitude for the Suruga Bay to off Joban coast, or daily catch per unit effort per the grid of 4 degree latitude and longitude for the Ise and Mikawa Bays.

2) The season of the spring migration group for Ise and Mikawa Bays is from June to August; Summer migration group from August to October; Autumn group from November to December. For the Suruga Bay - off Joban area, Spring group comes in the middle part of May to August; Summer-autumn group, from September to November.

We have already completed the fishing charts only for the density distribution by developmental stages. Thereafter, we will proceed to analyse the interaction between the aggregation of fish and the oceanographic conditions of the waters in which they live, mainly from the viewpoint of their distribution and movement. Hereafter, we will consider other aspects mentioned above. This is the advancement to clarify the basic interactions in the community of living organisms, such as, the relationship between offspring and adults, between male and female, between species and species, etc.

Problems of biological production, as far as our fields are concerned, are determined mainly by the characters of and relations among exploited organisms, their food organisms and water mass. In the process of biological production we find two major aspects: (a) the production process of a species, and (b) the circulation process of diverse species in a biclogical community. Although these two processes simultaneously exist in nature, we must distinguish one from the other in the study in order to find out the process in which the life of a single species, being relatively independent from the other, must exist in a biological community, i.e., the motive force of adaptation or evolution of the species concerned (Sato, 1965).

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