資源衰退期における日本産マアジの資源構造

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Confirmation of Spawning Groups of Japanese Jack Mackerel *Trachurus japonicus* in the Low Stock Level Period

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Spawning groups of Japanese jack mackerel *Trachurus japonicus* in the low stock level period were segregated. Segregation was done by the visual examination of monthly changes of the frequency distribution of fork length and/or partly the monthly changes of the mean gonad index.

In the Kuroshio Current System, two spawning groups were recognized: the spring spawning group spawns in spring mainly from February to April and distributes from southern Kyushu to Kanto region; the summer spawning group spawns in summer mainly from June to August and is present only in Kanto region.

In the East China Sea and Tsushima Current System, two spawning groups are recognized: the winter spawning group spawns in winter mainly December to January and is present in Wakasa Bay and Noto regions; the spring-summer spawning group spawns from spring to summer mainly April to June and is present in northwestern Kyushu region.

Comparison of the population structure of both high stock level (former studies) and low level (present study) shows that basically no differences between the two periods exist.

The intraspecific variations of Japanese jack mackerel *Trachurus japonicus* (Temminck et Schlegel) have been studied for the stocks in the high stock level period (mainly 1950's and 1960's).[1–15] Especially, two subpopulations of Japanese jack mackerel 'kuroaji' and 'kiaji' were studied in Wakasa Bay region.[5] Another intraspecific study was done in the area from western Japan to East China Sea where three or four intraspecific groups were segregated.[10–15]

In the early 1970's, when the stock level has begun to decline, the presence of some spawning groups in the Sagami Bay region was suggested by means of the analysis of frequency distributions of fork length and maturing condition.[16,17]

After mid 1970's when the stock has decreased, as far as we know only two studies on the intraspecific variations of *T. japonicus* were presented. In the Kii region, the spawning season was estimated[18] and the presence of 'kuroaji' and 'kiaji' was reconfirmed in the Wakasa Bay region.[19] Thus, the population structure of Japanese jack mackerel in the present low stock level period is scarecely recongnized as compared with the high stock level period.

In this article, we try to segregate the spawning groups in the waters around Japan waters based on the monthly changes in the frequency distribution of the fork length and partly on maturing condition in order to grasp the intraspecific variations in the period of low stock level.

The morphological characteristics of those segregated spawning groups will be treated in Suda *et al.*[20]

Materials and Methods

The monthly changes in frequency distribution of fork length (*FL*) were examined on the totally 3506 specimens collected from the eleven regions around Japan and of adjacent waters (Fig. 1) from May 1982 to Aug. 1984. The samples were collected mainly by commercial fishing including set-net, purse-seine, bottom trawl, hook and line, etc.

Segregation procedure of the spawning group is as follows. The sequence of the assemblage of frequency distribution which are thought to be on a single growth curve is defined as a 'group'. This procedure was done by the visual examination of the figures representing the monthly frequency distribution changes (Fig. 2).

As the next step, the spawning season of each

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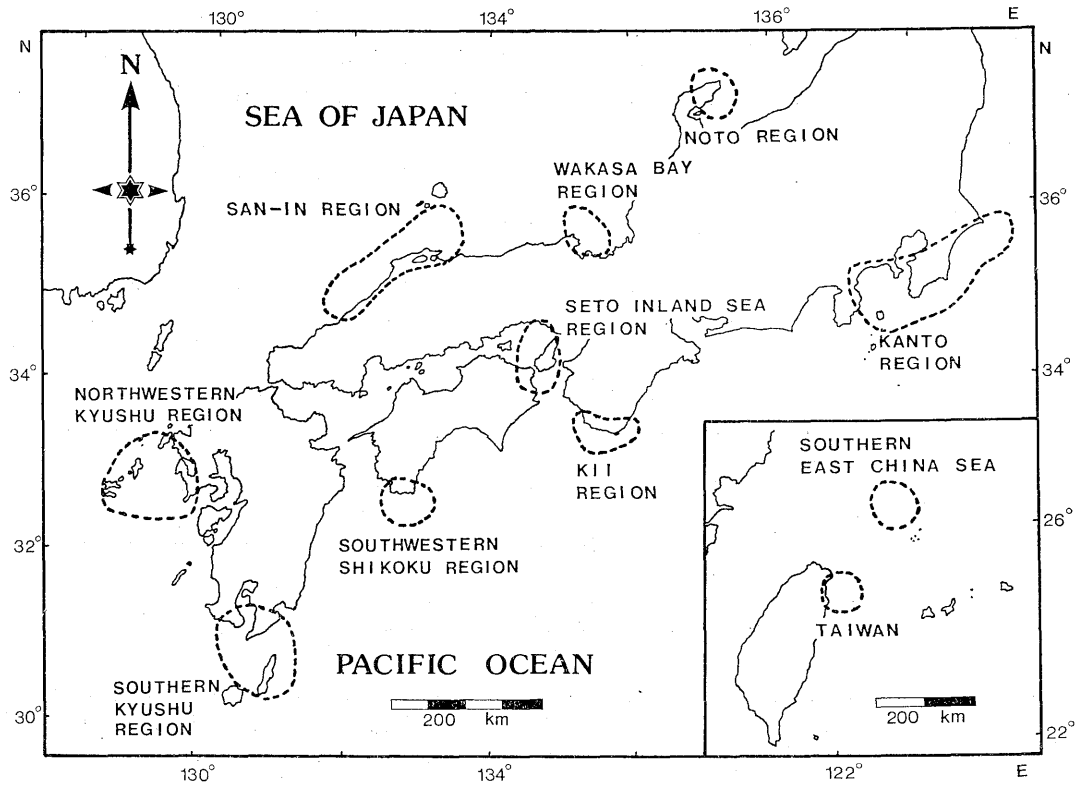

Fig. 1. Eleven sampling regions (encircled by the dotted line).

'group' was assumed by tracing the estimated growth curve. The 'group' of which spawning season was estimated was designated as a 'spawning group,' such as spring spawning group, summer spawning group, etc.

In the following result section, the outline of the segregated groups and/or spawning groups in each of eleven regions are described.

Maturing condition of the gonad was represented by the gonad index (GI, $GI=GW/FL^3 \times 10^4$, GW: gonad weight [g], FL: fork length [mm]). The examination was done only for Kanto and Kii regions where the larger individuals were obtained continuously. Number of specimens are 475 for Kanto region (Sept. 1982–Aug. 1984) and 258 for Kii region (May 1983–Aug. 1984).

Results

Monthly Frequency Distribution of FL

Kanto Region (Fig. 2–1)

Three groups (A, B, C) are segregated. A-group fish might be born mainly from February to April, and B-group in summer season mainly from June to August. A-group is designated as spring spawning group and B-group as summer spawning group.

The spawning season of C-group is thought to be in winter but their succeeding growth was not able to trace. Then the spawning groups designation for C-group was not provided.

The succeeding growth over 200 mm FL of both A and B groups were not traced because of shortage of specimens.

Kii Region (Fig. 2–2, modified from Sakamoto *et al.*[18])

One group (D-group) was segregated and it is thought to be born from February to April. It is designated as spring spawning group.

Seto Inland Sea Region (Fig. 2–3, E-group)

Because only two months samples are available, the growth could not be followed. There are no groups in other Kuroshio Current System regions which have the same length frequency distribution with Seto Inland Sea region in the same month. Consequently it is uncertain whether the fish in this region are included in the spring spanwing group, summer spawning group or the other

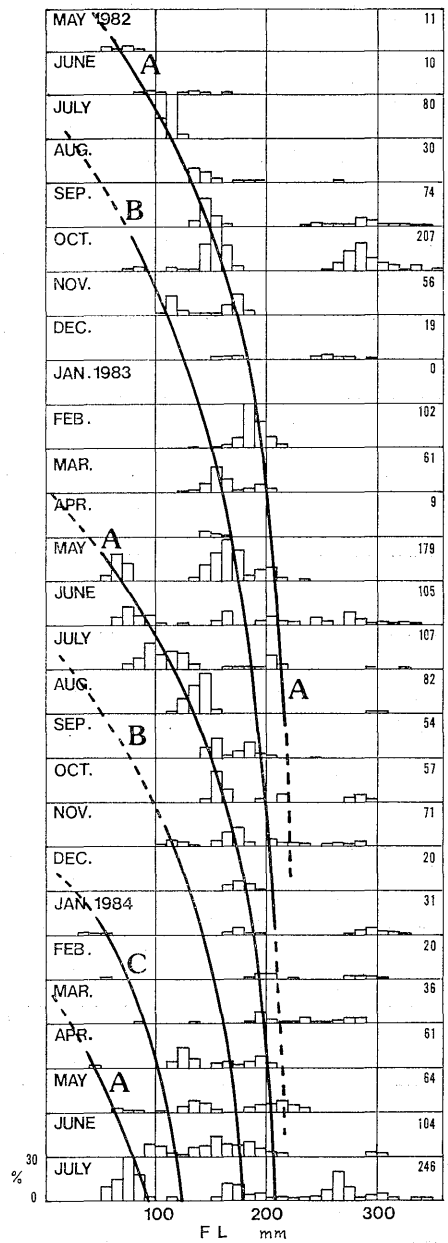

Fig. 2–1. Monthly frequency distribution of fork length in Kanto region. Numbers at the right upper corner of each cell shows the number of samples.

spawning group.

Southwestern Shikoku Region (Fig. 2–4)

Two groups (F and G-groups) were segregated. F-group is thought to be born from February to April and it is designated as spring spawning group. There are no other small fish group than the spring spawning group (F-group), then this

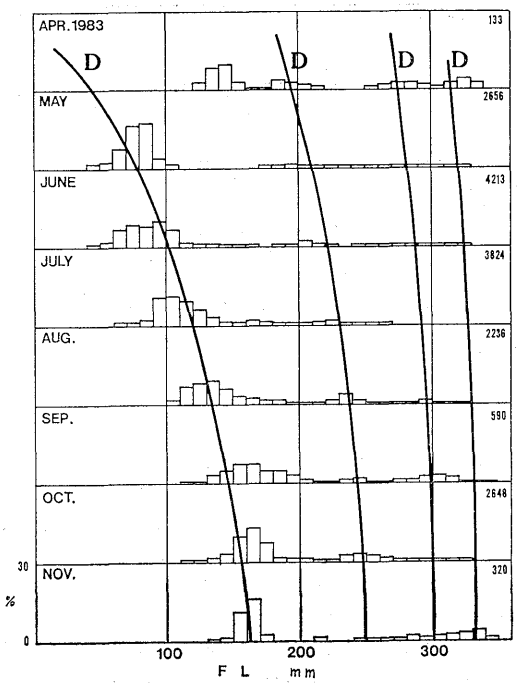

Fig. 2–2. Monthly frequency distribution of fork length in Kii region.

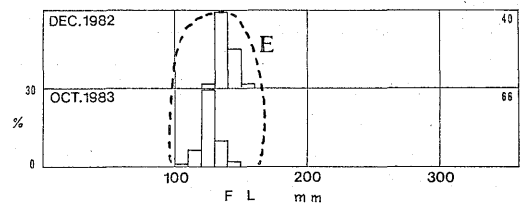

Fig. 2–3. Monthly frequency distribution of fork length in Seto Inland Sea region.

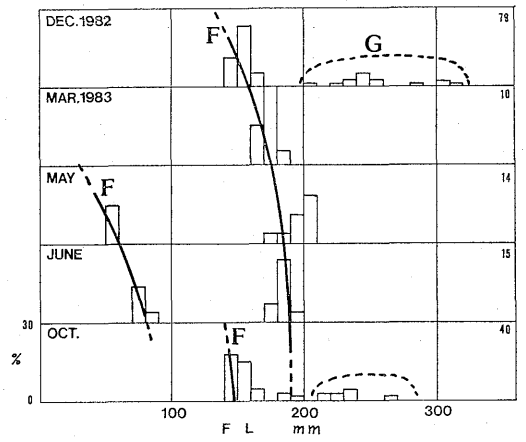

Fig. 2–4. Monthly frequency distribution of fork length in southwestern Shikoku region.

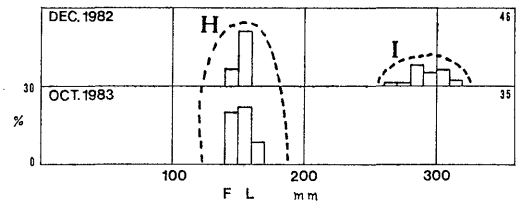

Fig. 2–5. Monthly frequency distribution of fork length in southern Kyushu region.

region probably consists of only one spawning group. The fish group over 200 mm FL in December 1982 and October 1983 was also considered as spring spawning group (G-group).

Southern Kyushu Region (Fig. 2–5)

No small fish from which the spawning season can be estimated were obtained. Fish of ca. 150 mm FL in December 1982 and October 1983 were assumed to be the spring spawning group (H-group), because the length distribution of this group almost coincides with those of Southwestern Shikoku region, the nearest region to Southern Kyushu region. For the fish group over 250 mm (I-group), the growth was not traced but this group is tentatively treated as spring spawning group.

In the Kuroshio Current System, two spawning groups were recognized. The spring spawning group spawns in spring mainly from February to April and distributes in Southern Kyushu, Southwestern Shikoku, Kii and Kanto regions. The summer spawning group spawns in summer mainly from June to August and presents only in Kanto region.

Wakasa Bay Region (Fig. 2–6)

One group (J-group) was segregated. It is thought to be born from December to January and designated as winter spawning group. It is uncertain if the fish groups of December 1982 and February and March 1983 belong to the J-group or other groups having different spawning season.

Northwestern Kyushu Region (Fig. 2–7)

Two groups (K and L-groups) were segregated. K-group was probably born from spring to summer mainly from April to June. It can not be decided whether the groups of 170–230 mm in September 1982 and 210–250 mm in December 1982 are K-group or not. It is also unknown if the group of May 1984 is K-group or another. Fish of May 1984, however, reprsented as another one group having unknown spawning season (L-group),

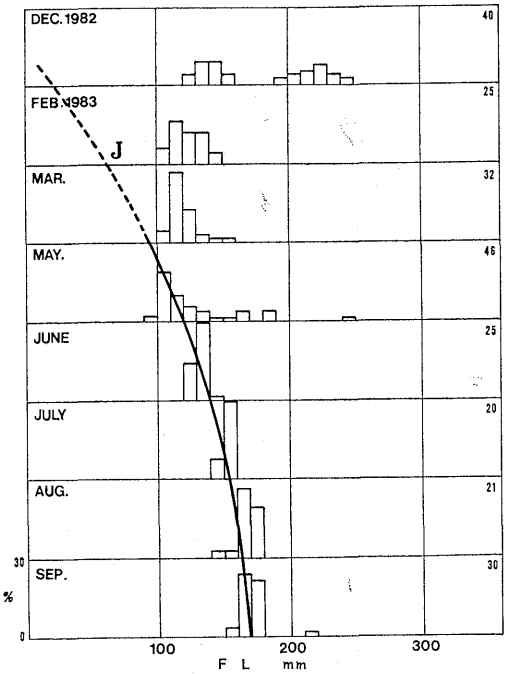

Fig. 2–6. Monthly frequency distribution of fork length in Wakasa Bay region.

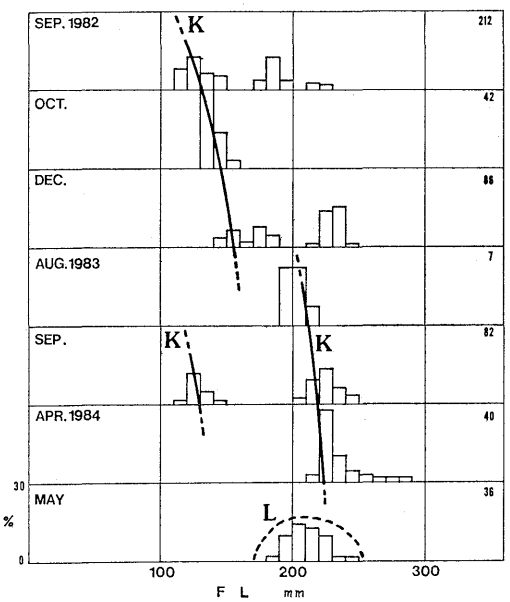

Fig. 2–7. Monthly frequency distribution of fork length in northwestern Kyushu region.

because they are samples from the catch of a single trawl operation and thought to be homogeneous.

Noto Region (Fig. 2–8)

Only one group (M-group) was observed.

In the following three regions, we have obtained

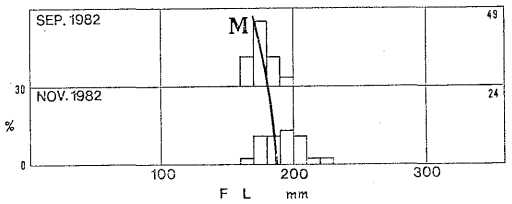

Fig. 2-8. Monthly frequency distribution of fork length in Noto region.

only one month samples and their growth could not be traced. Each length distribution group, however, was designated as follows just for the purpose of morphological analyses in another article[20]: San-in region (October 1983), N-group (90–140 mm), O-group (130–170 mm), P-group (180–230 mm); Southern East China Sea (July, 1984), Q-group (230–260 mm); Taiwan (January, 1984), R-group (260–320 mm).

In the East China Sea and Tsushima Current System, two spawning groups are recognized: the winter spawning group was born in winter mainly from December to January and the spring-summer spawning group was born in spring to summer mainly from April to June. The former distributed in Wakasa Bay region and Noto region and the latter in Northwestern Kyushu region. In addition to above two spawning groups, however, other spawning group(s) probably present in this area.

Allocation of the groups A to R to the spawning groups is summarized as follows:

Kuroshio Current System
Spring spawning group.....A, D, F, G, H, I
Summer spawning group.....B
East China Sea and Tsushima Current System
Winter spawning group.....J, M
Spring-Summer spawning group.....K
Unknown spawning group(s) .....
.....C, E, L, N, O, P, Q, R

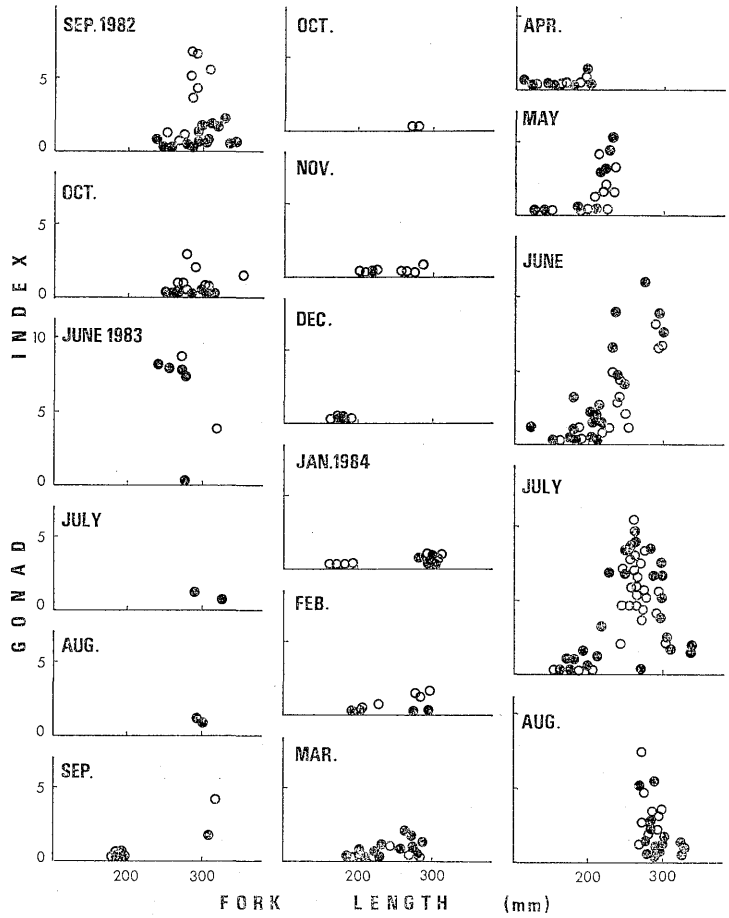

Fig. 3-1. Monthly changes in gonad index in Kanto region. Open circle: female, solid circle: male.

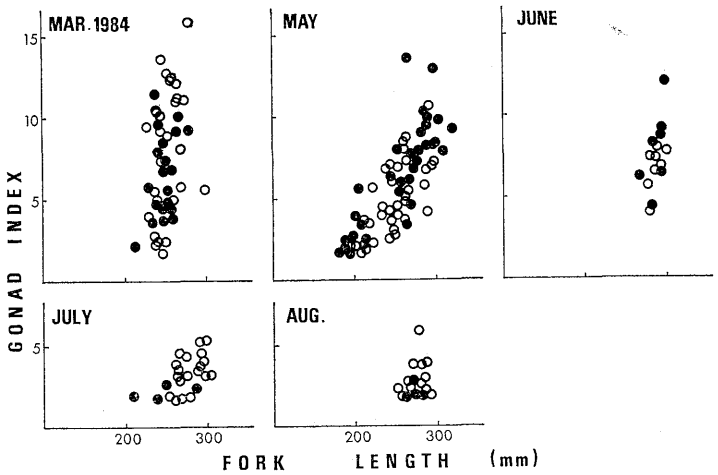

Fig. 3–2. Monthly changes in gonad index in Kii region. Open circle: female, solid circle: male.

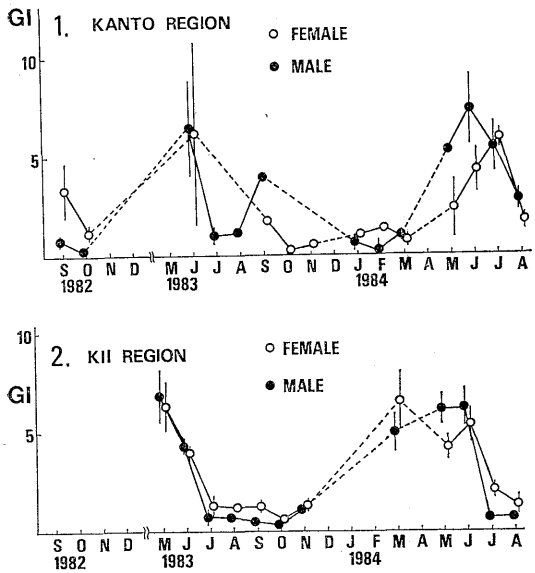

Fig. 4. Monthly changes in mean gonad index and their 95% confidence limits for larger individuals over 230 mm in fork length. 1. Kanto region, 2: Kii region.

Monthly Changes in Gonad Index (GI)

Monthly changes in developmental condition of the gonads of Kanto and Kii regions of the Kuroshio Current System were examined.

Figure 3 indicates the relationships between the fork length (*FL*) and the gonad index (*GI*) in each month.

In Kanto region (Fig. 3–1) there are individuals with high *GI* values in September 1982 and June 1983. They are larger than 230 mm *FL*. On the other, in Kii region (Fig. 3–2) individuals with high *GI* values are present from March to June 1984 and also they are over 230 mm *FL*. From these results individuals of 230 mm *FL* are thought to be of biological minimum size.

In the next place, the monthly changes in *GI* mean values and their 95% confidence limits were presented for the individuals over 230 mm *FL* (Fig. 4).

GI of the male of the Kanto region shows the peaks in June 1983 and June 1984 and that of female in June 1983 and July 1984 (Fig. 4–1). Consequently, the spawning season of larger individuals over ca. 230 mm *FL* in this region is thought to be in summer mainly from June to July. It coincides with the spawning season of the summer spawning group estimated by the analysis of frequency distributions of *FL*.

In the Kii region other than the materials examined in the present study the data of 945 individuals examined from May 1983 to November 1983 by Wakayama Prefectural Fishery Experimental Station (the original data used in Sakamoto *et al.*[18]) were considered (Fig. 4–2). Male has peaks in May 1983 and March 1984 and females has peaks in May 1983 and June 1984. The result of another study showed the spawning season of this region was from February to April.* From this examination the spawning season of the larger individuals over 230 mm *FL* in this region is thought to be May or other spring seasons before May. This estimation agrees well with

* T. Sakamoto, Y. Takeda, and J. Takeuchi: Abstracts of the meeting of Japan. Soc. Sci. Fish., p. 24, (148), April, 1984.

that of the spring spawning group designated by the frequency distribution of *FL*. The spawning area of the spring spawning group was not determined, because the larger individuals under spawning condition were not collected from other than Kii region. Hitherto, however, the main spawning area of the spring group has been thought to be in southern Kyushu.[7,16]

Discussion

In 1950's to early 1970's, when the stock began to increase, attained highest level and began to decline, mainly two groups which have different spawning seasons and area have been considered to consist of stock in the Kuroshio Current System.[7,16,17] One of them has been treated as a main group in the Kuroshio Current System and spawns from February to April in the area of southern Kyushu and the other has been a local group which spawns from May to July in the Kanto and adjacent waters.

In the present study in the low stock level period, two spawning groups, spring and summer, were recognized in the Kuroshio Current System. The spring spawning group widely distributed from southern Kyushu to Kanto region, while the distribution of the summer spawning group was restricted within the Kanto region.

Comparing the composition of spawning groups or populations of both high level (previous studies) and the low level period (present study), it is clear that there is basically no differences between the two periods. Thus, the two spawning groups have been presented in the Kuroshio Current System regardless the stock size.

The constitution in East China Sea and Tsushima Current System seems rather complicated than that in the Kuroshio Current System. In the high stock level period (1950's to early 1970's) several studies showing the complexity of intraspecific variations in this area were done as following: one group spawning in the upper Tsushima Current in winter to spring and one or more local group(s) constitutes the stock in the Tsushima Current System[1]; the two subpopulations, kuroaji-type and kiaji-type, present in the Wakasa Bay region[5]; there are three or four subpopulations in western Kyushu to East China Sea.[10-15]

In the present study, the spawning seasons were roughly estimated and the distributions of these spawning groups could not be shown because of lack of sequential data of the frequency distribution of fork length and the maturing conditions through the whole area of the East China Sea and the Kuroshio Current System. Consequently, judging from only the spawning seasons the winter spawning group of the present study corresponds to the off-shore migrating group[1] or the kuroaji-type[5] and the spring-summer spawning group corresponds to the local group in the western Kyushu[1] or the kiaji-type.[5] Nevertheless it is unknown if the two spawning groups of the present study exactly correspond to the kuroaji and kiaji, because there are no conspicuous morphological differences between them formerly mentioned.[5] Fishermen and fish market interests also said that recently they have not recognized the morphologically different Japanese jack mackerel easily distinguished in the high stock level period. However one study recognized kuroaji and kiaji is presented recently.[19]

Other than above mentioned studies, a genetic study is treating a breeding structure of Japanese jack mackerel.[21] It showed the genetic divergence of this species was slightly lower among fish species and hypothesized that *T. japonicus* formed a genetically large population but at the time of breeding a large number of units were formed. It is necessary to research widely and sequentially over the whole range of distribution to clearly recognize the population structure of *T. japonicus*.

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