A Comparative Life Historical Study on the Two Sciaenoid Species, White Croaker and Nibe Croaker, Inhabiting Sendai Bay

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A Comparative Life Historical Study on the Two Sciaenoid Species, White Croaker and Nibe Croaker, Inhabiting Sendai Bay

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Summary

The life histories of the two sciaenoid species, white croaker *Argyrosomus argentatus* (HOUTTUYN) and nibe croaker *Nibea mitsukurii* (JORDAN et SNYDER), caught by set nets and coastal trawlers in Sendai Bay from March, 1979 to January, 1980 were studied. The results are summarized as follows.

1. White croaker: The age is discernible by the scale. It is estimated that one ring of scale is formed annually. Bertalanffy's growth equation is shown as $L_t=229.7(1-e^{-0.301(t+0.236)})$. Judging from the change in GSI, the spawning period seems to be from June to September. It is estimated that the white croaker is a multiple spawner having two groups of yolky oocytes in the ovary. Biological minimum body length is estimated to be 140–160 mm for both sexes. The fecundity of fish about 180 mm long is $14\text{–}38\times10^4$. The white croaker are usually found to inhabit an offshore area around 100 m isobath and move to the coastal area shallower than 30 m deep in the spawning period. Major foods for the white croaker are the crustaceans, such as macrurans, and the fishes.

2. Nibe croaker: The age is discernible by the scale. A ring on a scale is supposedly formed once a year. The growth equation of the nibe croaker is shown as $L_t=208.1\,(1-e^{-0.446(t-0.188)})$. Judging from the change in GSI, the spawning period may be from June to August. It is inferred that the nibe croaker is a multiple spawner with two oocyte groups like the white croaker. Biological minimum size is 130 mm in length in both sexes. The regression of fecundity (F) on length (L) in mm is shown as $F=0.0126\times L^{3.251}$. The nibe croaker is supposed to be distributed in a coastal area shallower than 60 m deep and migrates extremely close to the area shallower than 20 m in the spawning period. Major foods for the nibe croaker are the crustaceans, mainly macrurans, and the fishes.

While the two croakers have life historical features analogous to each other, it is suggested that they avoid competition through habitat segregation, and it has been discovered that the growth of the white croaker in Sendai Bay is much slower than it is in the Yellow and East China Seas which are the main range of this species.

White croaker *Argyrosomus argentatus* (HOUTTUYN) and nibe croaker *Nibea mitsukurii* (JORDAN et SNYDER) are closely related species of Sciaenidae. While the two species resemble each other in some morphological characteristics, they differ in others. The nibe croaker has a big and strong second anal spine, but the white croaker has a short one nearly equal to its eye diameter, and the latter is distinguished from the former by a black spot on the operculum. The nibe croaker has many narrow, dark and oblique lines on the dorsal side of the body from the ventral margin of pectoral fin.

Major sciaenoid fishes called croakers are caught by trawling in the East China, Yellow and Seto Inland Seas and a number of papers concerning them have been published. White croaker and nibe croaker have been lumped commercially on the coasts of Sendai Bay under the name "ishimochi" because of their similar appearance, and we have had few works concerning them. The present study intends to grasp the ecological characteristics of the two croakers in Sendai Bay by making clear their life histories and comparing them with each other.

Materials and Methods

Materials were collected at Haragama Fish Market, Fukushima Pref., from March, 1979 to the following January, except during July and August which are closed for the coastal trawlers. Specimens were also obtained at small set nets off Yuriage and Hanabuchi, Miyagi Pref., from May to August, 1979. Collected specimens had been carried to the laboratory in cold storage to measure the body length* and to weigh the whole body, gonad, liver and stomach along with its contents that were to be examined. Ctenoid scales were removed from between the anal fin and the lateral line for age determination.

Ovaries were preserved in ten per cent formalin solution for counting oocytes and measuring their diameter. A piece had been removed from a fixed part of an ovary, weighed and diluted with water of 250 ml, of which a 1 ml sample was examined to count oocytes. After counting five times, the mean value excluding the maximum and minimum was multiplied by the ratio of the weight of the piece to the whole ovary to obtain fecundity. The major axis of the oocytes was measured as "oocyte diameter".

Results

Growth

White croaker

In order to use the scale ring as an age determiner, it is necessary that a ring is formed at regular intervals. In a bid to know when a ring is formed, the month-to-month change in the marginal increment ratio of scale α, $100 \times \Delta R/R$, where ΔR is the marginal increment beyond the last ring and R is the distance between the

* Body length is the distance from the tip of the snout to the hindmost margin of the hypural bone.

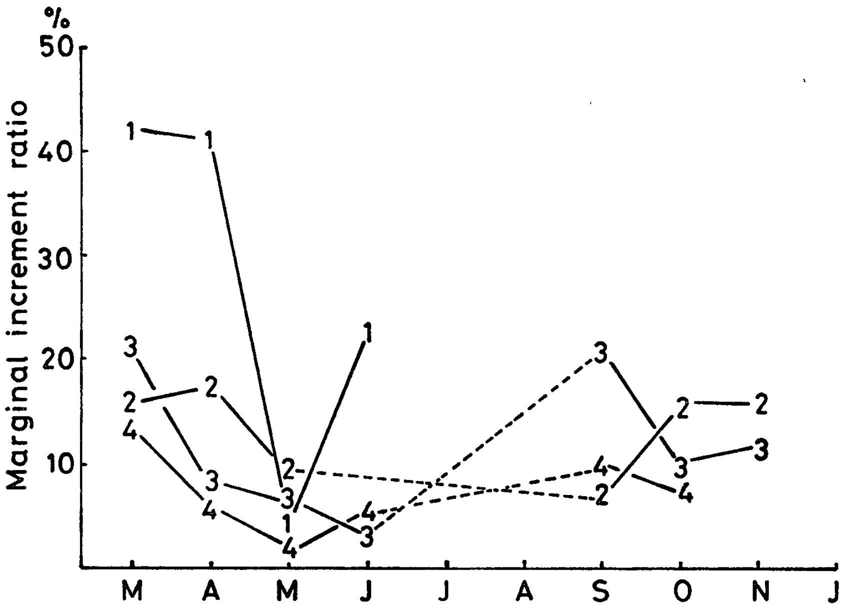

Fig. 1. Month-to-month changes in the marginal increment ratio of scale (α) of white croaker.

nucleus and the margin of a scale, was examined. Fig. 1 shows that the α's of all the ring groups were minimal in May, rose from June to September, and levelled off during the rest of the year, indicating that the scale ring of white croaker is formed once a year from June to September.

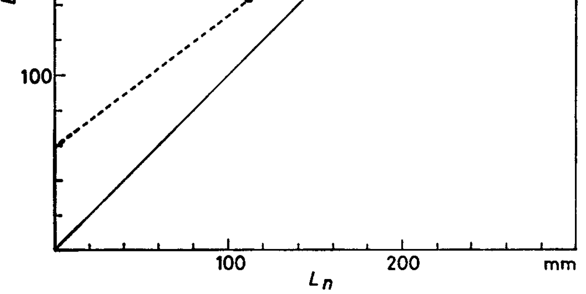

Fig. 2. Walford plots for white croaker.

Here a regression equation of the radius of scale (R) in mm on the body length (L) in mm for combined sexes, because of insignificant differences between them, is given below.

$$R = 0.0289L - 1.485 \quad r;\ 0.888$$

Lengths at ring formation were back-calculated using the above equation as in Table 1, showing no consistent Lee-phenomenon.

Accordingly, Walford's finite difference method was used to define Bertalanffy's growth parameter. In Fig. 2, each plot seems to fit a linear regression. A regression equation was determined by the method of the least squares from plots.

$$L_{n+1} = 59.61 + 0.7434L_n \qquad r;\ 0.996$$

TABLE 1. *Back-calculated Body Length at Ring Formation*

White croaker

Number of rings	Number of specimens	Body length (mm)				
		L_1	L_2	L_3	L_4	L_5
1	31	109.1				
2	54	114.0	147.8			
3	61	115.6	144.5	166.1		
4	12	113.3	143.0	164.4	187.2	
5	2	109.9	140.3	163.4	179.2	189.2
Mean		112.3	143.9	164.6	183.2	—
Standard deviation		2.772	3.127	1.365	5.656	—
Total	160					

Nibe croaker

Number of rings	Number of specimens	Body length				
		L_1	L_2	L_3	L_4	L_5
1	34	125.1				
2	105	117.2	150.2			
3	85	113.6	151.4	172.0		
4	25	108.8	143.0	168.8	183.9	
5	6	112.0	151.4	166.9	183.6	201.0
Mean		115.3	149.0	169.2	183.7	—
Standard deviation		6.238	4.039	2.577	0.212	—
Total	255					

An asymptotic length, L_∞, of 229.3 mm is not inconsistent with an actual maximal length, L_m, that was obtained. A problem occurs in providing the growth equation. As seen in Fig. 2, a remarkable difference is found between the y-intercept of the regression line, 59.61 mm, and the calculated L_1, 112.3 mm. On the other hand, L_1 is estimated to be around 90 mm, because a mode of length is observed at 90 mm in May when ring formation is probable. Moreover, if L_1 were 112.3 mm, the growth of white croaker in their first year would seem to be too rapid compared with that in the subsequent years, as shown in a semi-broken curve in Fig. 3. About the growth of the white croaker, the following alternatives are possible. One is that growth in the first year is extremely rapid as depicted in a semi-broken curve in Fig. 3, and the other is that the first ring is formed in their second year as shown in a solid curve and it meets the Bertalanffy's growth equation as seen in a broken curve. Although the adequacy of the second alternative remains to be proven, a Bertalanffy's growth curve is given below and calculated lengths are shown in Table 2.

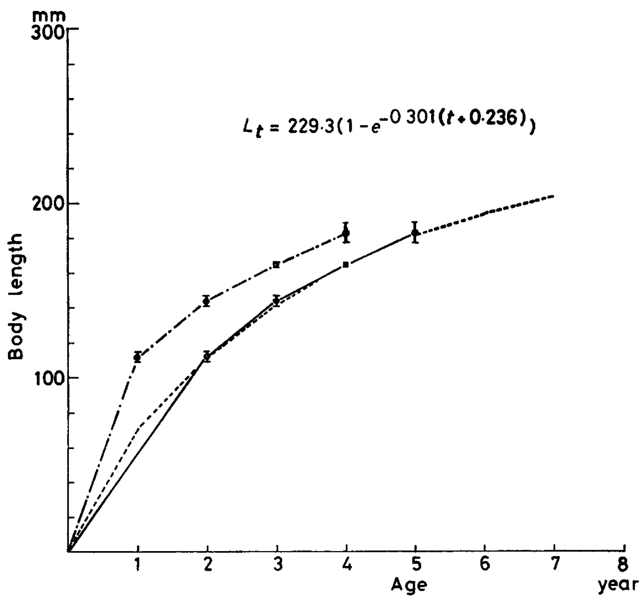

FIG. 3. Examination in growth curves for white croaker. The vertical bar denotes a standard deviation on each side. See text for explanation.

TABLE 2. *Estimated Age-specific Body Length*

White croaker

Age in years	1	2	3	4	5	6	7
Body length (mm)	71.2	112.3	142.7	165.2	181.9	194.2	203.3

Nibe croaker

Age in years	1	2	3	4	5	6
Body length (mm)	63.2	115.4	148.7	170.1	183.8	192.5

$$L_t = 229.3\,(1 - e^{-0.301\,(t+0.236)})$$

Both k and L_∞ are smaller than those found in the East China Sea, the central area of this species' range, given by Kojima (1), 0.726* for k and 272.0* for L_∞, implying that the white croaker in their marginal area of distribution show a biased growth pattern.

Nibe croaker

From Fig. 4 showing the month-to-month change in α, it seems that a scale ring of a nibe croaker is formed once per annum from June to September.

A regression equation of scale radius (R) on the body length (L) for combined sexes is shown as follows.

* These values are converted by body lengths defined in the footnote of page 165 through the relation based on data in Sendai Bay.

$$R = 0.0251L - 1.049 \qquad r;\ 0.810$$

In Table 1 back-calculated age-specific lengths are shown with no evident Lee-phenomenon.

Fig. 5 gives Walford plots of length and the following relation is obtained.

$$L_{n+1} = 74.92 + 0.6392L_n \qquad r;\ 0.998$$

L_∞ is calculated to be 208.1 mm and L_m is 253 mm.

A problem similar to that of the white croaker took place also in defining the growth pattern of nibe croaker. Using the same procedure as with the white croaker, a Bertalanffy's growth equation is obtained.

$$L_t = 208.1(1 - e^{-0.446(t-0.188)})$$

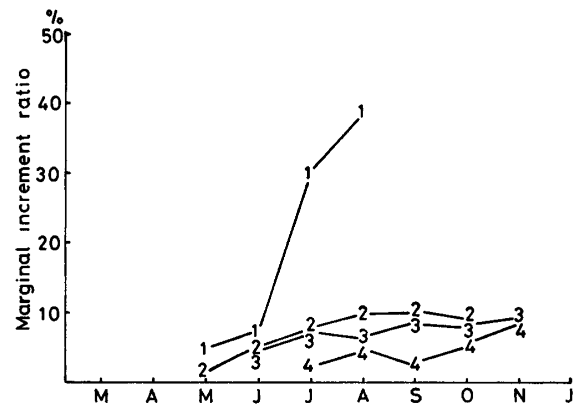

FIG. 4. Month-to-month changes in the marginal increment ratio of scale (α) of nibe croaker.

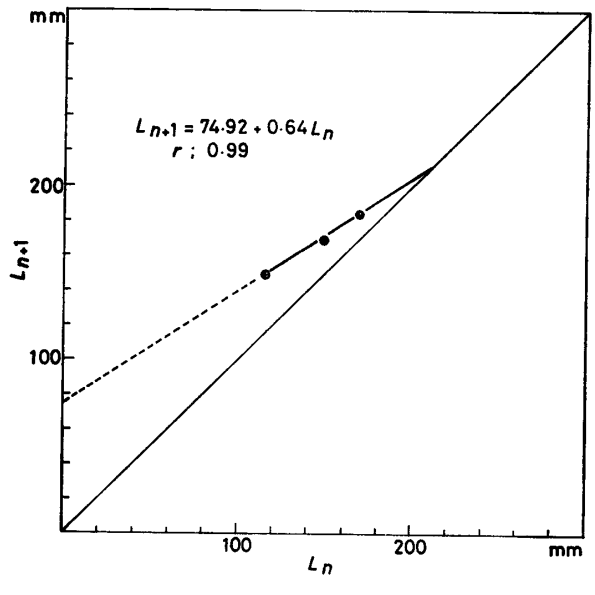

FIG. 5. Walford plots for nibe croaker.

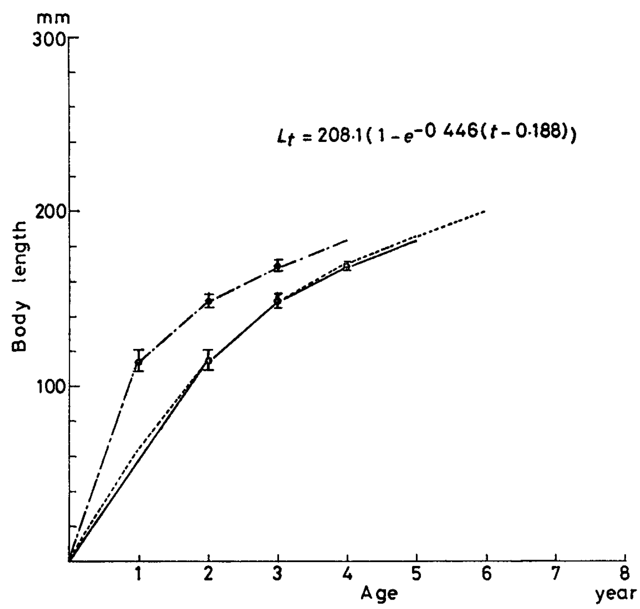

FIG. 6. Examination in growth curves for nibe croaker. The vertical bar denotes a standard deviation on each side. See text for explanation.

A growth curve and age-specific lengths are shown in Fig. 6 and Table 2, respectively.

Maturity and Reproduction

White croaker

1. Biological minimum size: The smallest female, 153 mm long, having oocytes visible with the naked eye and the smallest male, 159 mm long, having

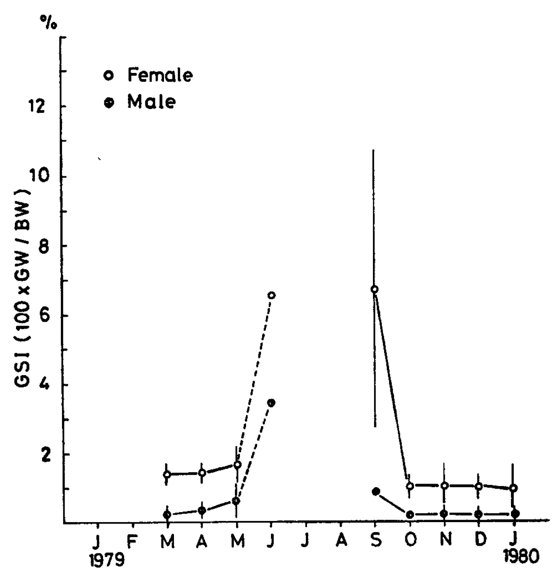

FIG. 7. Month-to-month changes in the GSI of adult white croaker. The vertical bar denotes a standard deviation on each side.

testis were observed among the specimens examined. So the present authors define 150 mm as a biological minimum size that corresponds to 3 years in age.

2. Spawning period: Seasonal changes in the GSI of both sexes over 150 mm long are shown in Fig. 7. From Fig. 7 and also from the external appearance of the gonad, the spawning period is estimated to be from June to September, although its peak is not distinct due to a lack of data during July and August.

3. Type of spawning: Although the oocyte size had been investigated in four parts of an ovary, the anterior, central and posterior parts of the right ovary and the central part of the left one, no difference was found among them. Therefore, a piece was removed from the central part of a right ovary to obtain a representative oocyte diameter distribution, change of which with the increasing GSI is shown in

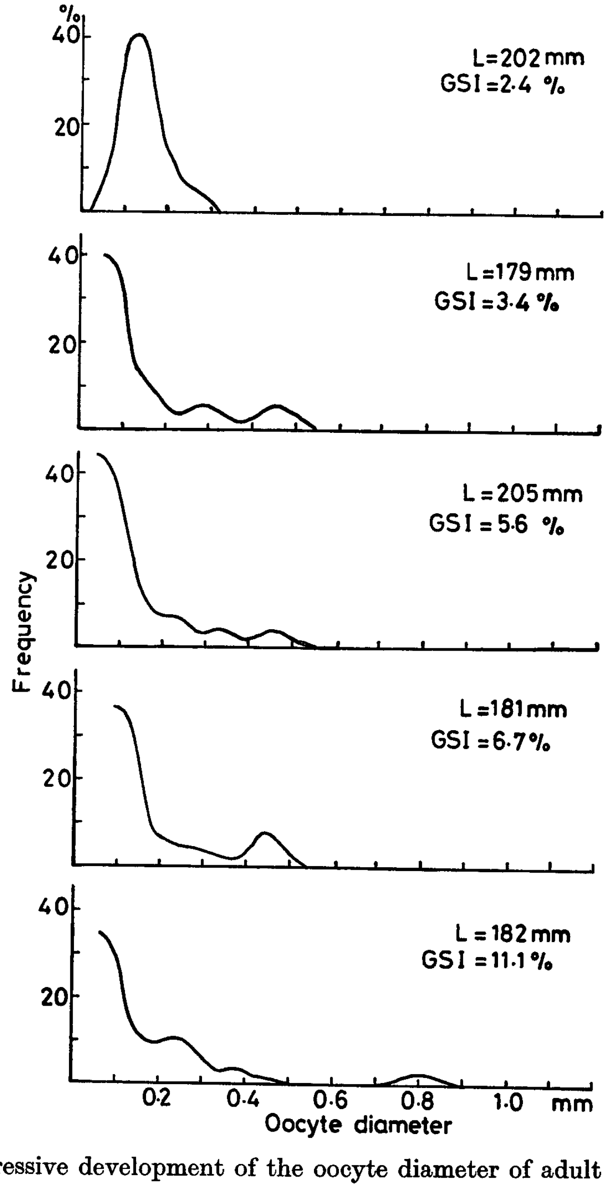

FIG. 8. Progressive development of the oocyte diameter of adult white croaker.

Table 3. *Fecundity of White Croaker by Size*

Body length (mm)	Body weight (g)	Ovary weight (g)	Fecundity × 10^3
179	122	4.10	138
181	131	8.72	311
182	141	15.75	377
202	186	4.46	171
205	162	9.10	306

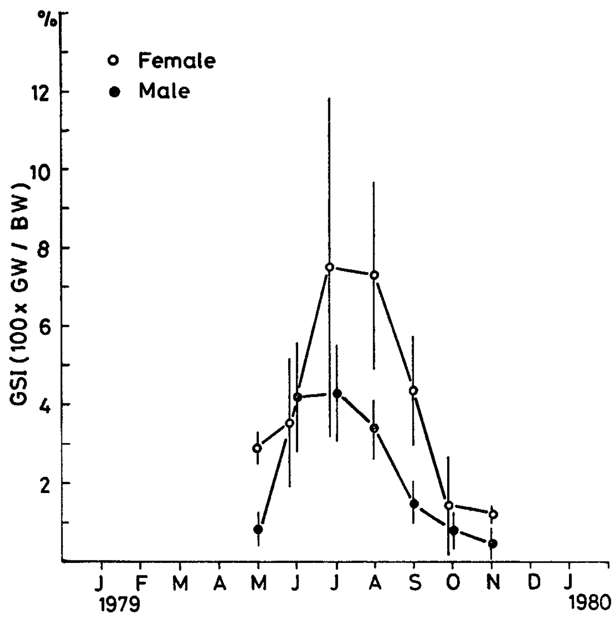

Fig. 9. Month-to-month changes in the GSI of adult nibe croaker. The vertical bar denotes a standard deviation on each side.

Fig. 8. Though oocytes smaller than 0.2 mm always exist, their size becomes large with the increase in the GSI (Fig. 8). When the GSI rises from 3 to 6 per cent, an oocyte group is formed around 0.4 mm. Moreover, another group of oocytes that are translucent and have a mode around 0.8 mm is formed for a fish of 11 per cent GSI. Because of discontinuity between the two oocyte groups, it seems that the growth of oocytes in this stage is very rapid. From the above facts the white croaker is considered a multiple spawner with two groups of yolky oocytes in an ovary, one growing and the other maturing (2).

4. Fecundity: The number of oocytes over 0.2 mm in diameter defines fecundity, since they all seem to grow and mature and eventually to be laid. The fecundity of the white croaker of 170–205 mm long is estimated to be 140–380 × 10^3 (Table 3).

Nibe croaker

1. Biological minimum size: The smallest male and female were 130 mm and 125 mm, respectively.

2. Spawning period: The spawning period of nibe croaker is estimated to be from June to August with its peak in July, judging from the month-to-month change in the GSI (Fig. 9) and by a continuing observation of gonads with the naked eye.

3. Type of spawning: Since no difference was found among the size distributions of oocytes from various parts of an ovary, a sample from the central part of a right ovary was used as a representative of the overall distribution of the oocyte size of ovaries, change of which with the increasing GSI is shown in Fig. 10. In the figure oocytes under 0.2 mm in diameter are always seen. While an oocyte group with its mode of diameter around 0.45 mm is found in a fish of 6 per cent GSI,

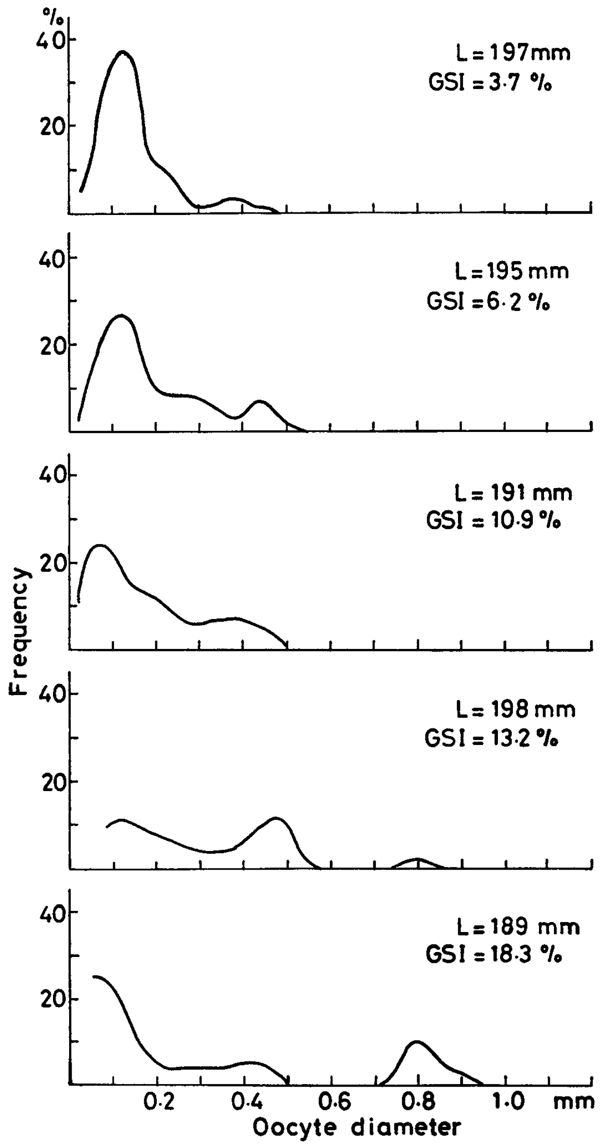

FIG. 10. Progressive development of the oocyte diameter of adult nibe croaker.

another one with mode of 0.8 mm is found in a fish of 13 per cent GSI. Transfer from the smaller group to the larger one seemingly occurs quickly for the same reason as in the white croaker. A fish of 14 per cent GSI holding translucent oocytes in its ovaries was in or near the end of spawning. The nibe croaker is also considered a multiple spawner with two yolked oocyte groups (2).

4. Fecundity: The numbers of oocytes over 0.2 mm in diameter from 23 females were used to obtain the relationship between fecundity and length given in Fig. 11.

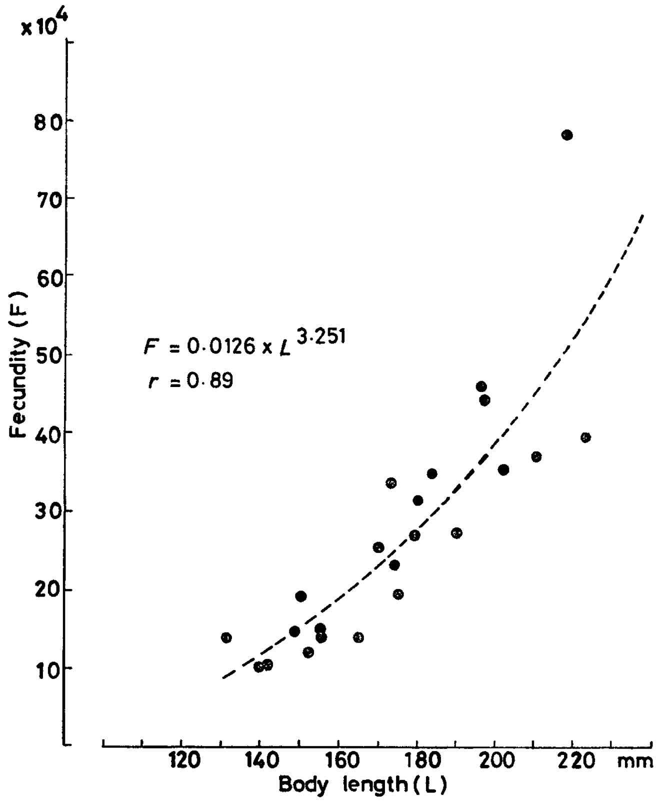

FIG. 11. Regression of fecundity on body length of nibe croaker.

Distribution and Migration

White croaker

The distribution of fishing operations for the white croaker by coastal trawlers and small set nets is shown in Fig. 12. A migratory pattern of an adult white croaker is given below by examining the fish size and interviewing with fishermen. Fish have been found in the offshore area around 100 m deep from the autumn to the next spring and approach the coastal area shallower than 30 m prior to spawning in late May. As spawning nears its end in September, they move to the area around 60 m deep and eventually reach one around 100 m where they stay from October to the next spring.

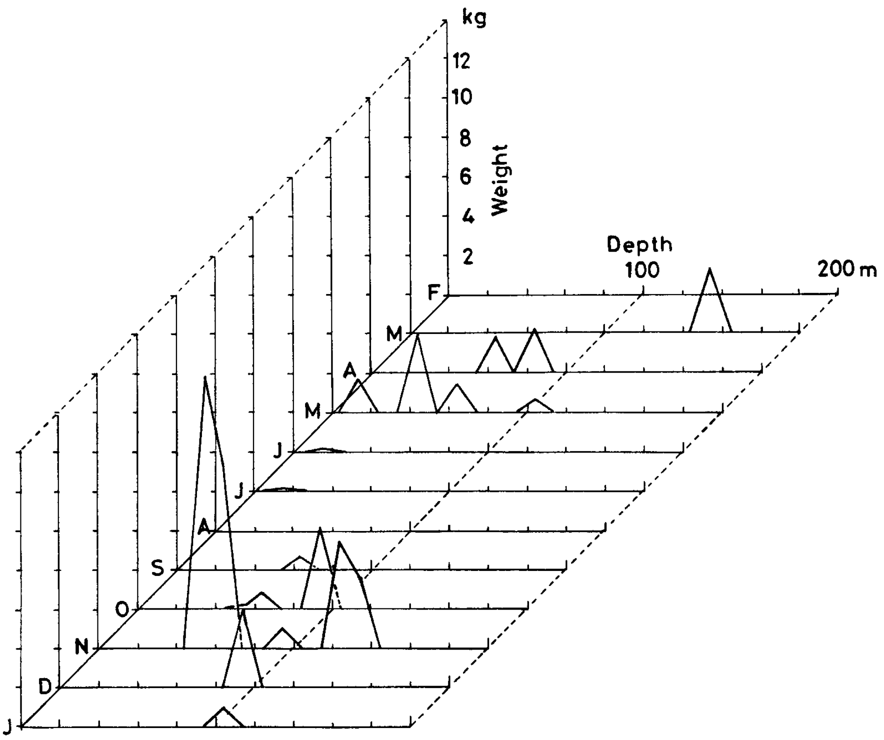

FIG. 12. Month-to-month changes in the weight of specimens of white croaker in 10 m depth intervals.

Nibe croaker

Fishing operations for the nibe croaker are depicted in Fig. 13. Through the same procedure as with the white croaker, the migration of an adult fish was suggested below. While their range has been an area shallower than 60 m isobath from the autumn to the next spring, they move to a nearshore area less than 20 m deep for spawning.

Food Habits

White croaker

The stomach contents of adult fish from September to November were mainly fishes and crustaceans, especially macrurans, indicating that they are epi- and in-fauna feeders, with an occasional eating of pelagic anchovy *Engraulis japonica* (Fig. 14).

Nibe croaker

Nibe croakers ate a considerable quantity of small crustaceans, especially kishiebi-shrimp *Metapenaeopsis dalei*, from September to November, indicating that they are epi- and in-fauna feeders. Occasionally some pelagic fishes were found in their stomachs, supposedly suggesting that they make vertical movement.

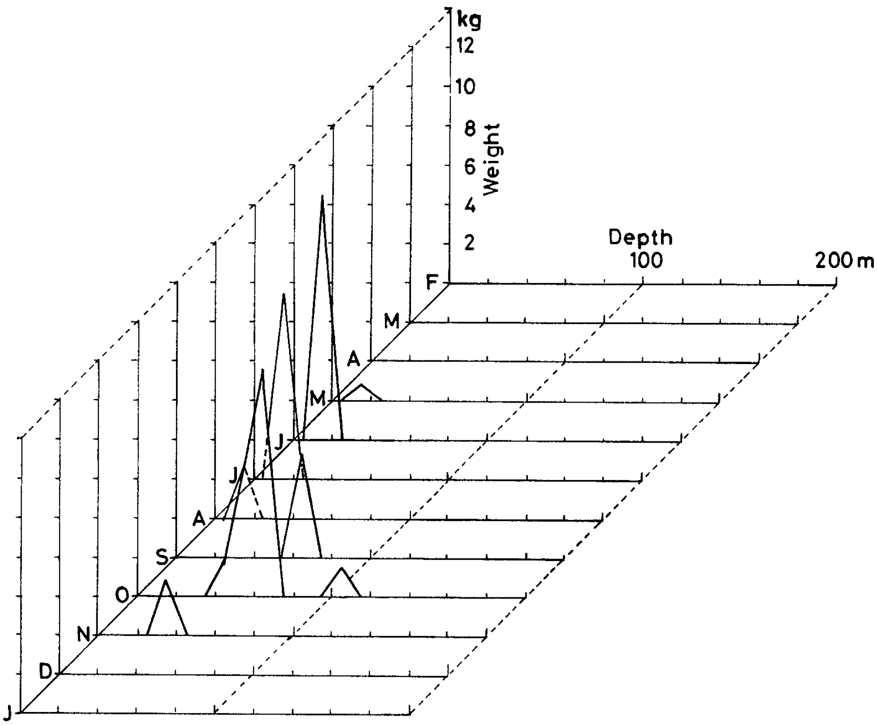

FIG. 13. Month-to-month changes in the weight of specimens of nibe croaker in 10 m depth intervals.

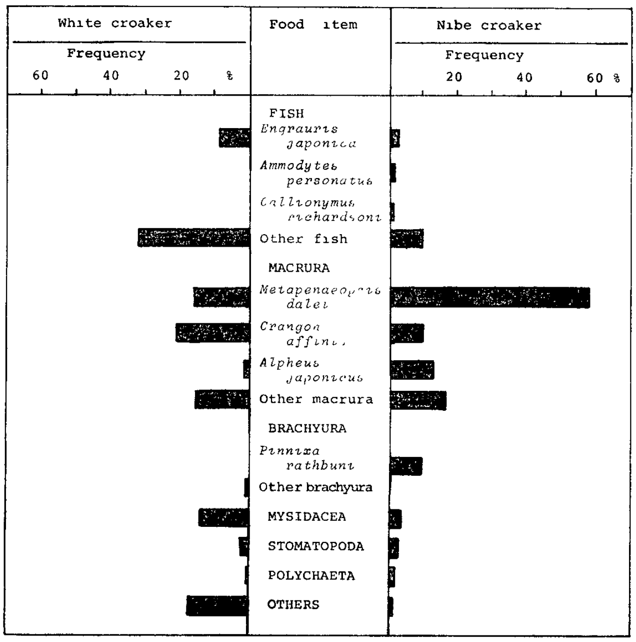

FIG. 14. Occurrence frequency of food ingested for white and nibe croakers.

Discussion

Comparison between Life Histories of the Two Species

The life historical features, viz., growth, reproduction, distribution, migration and food habits, in the adult and late preadult stages of the two species, white and nibe croakers, are compared (Table 4). Although the white croaker grow more slowly in their young stage and eventually become larger than the nibe croaker, the general growth patterns are similar in both species. The spawning seasons, spawning patterns and fecundities of both species also resemble each other. A difference in biological minimum size between the two species seems to come from a difference in growth parameter k. When examining the ranges and migrations, the two species appear to segregate their habitats in Sendai Bay. While both species occupy nearly the same food niche judging from their food habits, the nibe croaker seems to preferably depend on macrurans when compared with the white croaker.

TABLE 4. *Life Historical Features of White and Nibe Croakers*

	White croaker	Nibe croaker
Biological minimum	140–160 mm	<115 mm
k	0.301	0.446
L_∞	229.3 mm	208.1 m
L_m	283.0 mm	253.0 mm
T_m	7 years	6 years
Range	Offshore around 100 m deep	Inshore<60 m
Spawning season	June–Sep.	June-Aug.
Main foods	Macrurans and fishes	Small crustaceans, mainly macrurans

In spite of a general similarity in the life histories between the two species, they conceivably avoid competition through habitat segregation.

We would like to thank the staff of the Section of Fishery Biology, Tohoku University, for their help in sampling and the members of Haragama, Yuriage and Hanabuchi Fisheries Cooperative Association for collecting samples.

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2) Kawasaki, T., "*Ukiuo-Shigen*", Koseisha-Koseikaku, Tokyo, p. 107 (1982) (in Japanese)