

On the Food Habits of the White Croaker

Argyrosomus argentatus

Shunpei KAKUDA and Kenji MATSUMOTO

*Department of Fisheries, Faculty of Fisheries and
Animal Husbandry, Hiroshima University, Fukuyama.*

Received September 22, 1978

(Figs 1-5; Tables 1-3)

The white croaker, *Argyrosomus argentatus* (HOULTUYN), is abundantly distributed in the coastal waters of the southern mainland and southward of Japan. This fish is a common demersal fish of commercial value there, and one of the most important fishing resources for the trawl fishery in the East China Sea and in the Yellow Sea. In the Seto Inland Sea and its adjacent sea regions, too, the white croaker is an important resource for fishery, and is caught in considerable quantity for commercial purposes.

Food habits of demersal fish have been investigated by many researchers in order to approach the problems on the production structure of the demersal fish community, through investigation on the feeding relationship in the food chain of the demersal fish. In another paper, the food organisms in the stomach of the white croaker have been elucidated, and it has been concluded that this fish is a benthos-feeder. Namely, the food items of the white croaker caught in the East China Sea and the Yellow Sea have been listed up.¹⁾²⁾ And also the percentage compositions of the food organisms occurring in the stomach of this fish have been reported based upon the samples caught in the Seto Inland Sea.³⁾⁻⁸⁾ In these reports, it is reported that the white croaker chooses the sort of prey by length.⁴⁾⁷⁾ But it doesn't necessarily follow that the detail of the food composition of the stomach contents and the size of the predator has been elucidated completely, nor that the size-relation between the white croaker and its prey has been made clear.

This study on the white croaker has been carried out as a part of the studies of the important kinds of fish interesting for fishery that populate the Seto Inland Sea. The informations on the age and growth of this species have been already reported.⁹⁾ In this study, the food habits of the white croaker have been made clear by examining the stomach contents of this fish, and especially it has been intend to elaborate about the species- and size-preference of prey in order to gain exact information on the fishery biology of this species.

MATERIALS AND METHODS

Materials used for the analysis on the stomach contents were the 310 white croaker consisting of 8 samples. Of the 310 fish sampled, the stomach of 94 fishes was empty.

The food organisms in each stomach of the 216 specimens were examined for food analysis. The collecting of all these fishes was performed in March, September, November and December, 1976 and April, May and June, 1977 in Hiuchi-nada and Kojima Bay of the Seto Inland Sea. They were captured by a small beam trawl and a small set net.

Each specimen was put in a 10-percent formalin solution immediately after they were sampled. They were measured for standard length and body weight, then the stomachs were carefully removed from the body cavity. The individual food organisms removed from the stomachs of predators were sorted and identified, and number of individual food organisms were counted. Of the 216 fish examined, the stomach of 113 fishes was sampled before digestion had proceeded very far. Then the stomach contents of each and the food organisms in it were weighed in wet. On the other hand, each prey that had kept its body form in the stomach of the predators was measured for total length.

Food habits of the white croaker were analyzed by the frequency of occurrence, the numerical method and the gravimetric method for evaluation of food specificity.¹⁰⁾ And also, the importance of each item in the diet of the 113 specimens was estimated as frequency of occurrence of the samples with few ($\leq 10\%$), intermediate (11–49%), or abundant ($\geq 50\%$) quantities of an item judged by percentage of stomach content by item in weight.

The 216 white croaker examined was 20–244mm in standard length and 0.15–308.3g in body weight. The length frequency of them is shown in Fig. 1.

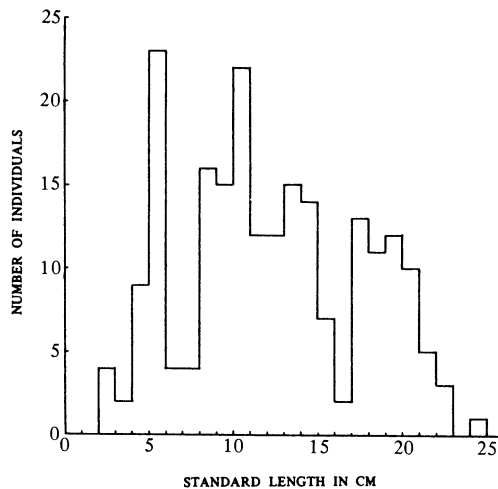


Fig. 1. Length frequency of white croaker of which stomach contents were examined.

RESULTS

Food items

The detailed data of all stomach contents examined were obtained during this study and brought together. The results are shown in Table 1. The food organisms found in the stomachs of the 216 white croaker samples are fish, shrimp, amphipoda, polychaeta, cephalopoda, cladocera, brachyura, stomatopoda and isopoda.

Table 1. Relative importance of various food items in the stomach contents of the white croaker.

Food item	Frequency of occurrence		Numerical method		Number of organisms per stomach	Gravimetric method		
	Number of stomachs occurred	%	Number of individuals	%		Weight in mg	%	
Fish	112	51.9	182	21.3	1.6	101,143	65.3	
Shrimp	<i>Alpheus</i> sp.	38	17.6	57	6.7	1.5	30,510	19.7
	<i>Crangon</i> sp.	38	17.6	414	48.5	10.9	2,655	1.7
	Others	93	43.1	158	18.5	1.7	11,464	7.4
Amphipoda	13	6.0	15	1.8	1.2	0	0	
Polychaeta	11	5.1	14	1.6	1.3	3,090	2.0	
Cephalopoda	5	2.3	5	0.6	1.0	4,710	3.0	
Cladocera	3	1.4	4	0.5	1.3	0	0	
Brachyura	2	0.9	2	0.2	1.0	170	0.1	
Stomatopoda	1	0.5	1	0.1	1.0	1,094	0.7	
Isopoda	1	0.5	1	0.1	1.0	0	0	
Number of fishes examined	216					113		

One may safely assume that the food items that are found high in frequency of occurrence, because they are large in number and large in weight, must rank as important foods. Yet, despite the great diversity of organisms in the stomach of the white croaker, only a few of them are of essential importance. Judging from the predominant frequency of occurrence, in number and in weight, it is obvious that the essential food items of the white croaker must be fish and shrimp, as shown in Table 1. Various kinds of shrimp were found in the stomachs of these fish, yet the dominant species was *Alpheus* sp. and *Crangon* sp.. While *Alpheus* sp. is relatively more important for its weight, it ranks lower in quantity than *Crangon* sp., on the other hand whereas *Crangon* sp. is more important for quantity it ranks lower in weight because of its small individual size. It was noticed that *Crangon* sp. had been eaten in larger quantity by the small predators compared with the other kinds of food.

Comparative importance of food items related to the length of the predator

The differences in stomach contents may be due either to change in food preference or to the growing ability to catch and swallow certain organisms as the predator grows in

length. The former is related to the sort of the prey caught, and the latter to a size-relation between the predator and the prey.

For the comparison of food preference and the sorts of prey with the length of the predator, the 216 specimens were divided into five size categories in standard length on the basis of some particular data.⁴⁾⁷⁾* The range of length of the five size categories were 20–59mm, 60–99mm, 100–129mm, 130–169mm and 170–244mm. The details of the data arranged in these five size categories are presented in Table 2.

Table 2. Relationship between the length of white croaker and the number or weight of food organisms in its stomachs.

Size category in standard length of predator (mm)	Number of examined stomachs with contents	Aggregate number of stomachs containing each food item	Total number of food organisms	Number of food organisms per stomach	Number of stomachs with food organisms weighed	Aggregate weight of organisms in stomachs (mg)	Weight of food organisms per stomach (mg)
20– 59	38	58	473	12.4	21	2,727	129.9
60– 99	39	63	79	2.0	23	6,920	300.9
100–129	46	71	92	2.0	23	17,842	775.7
130–169	38	60	97	2.6	25	47,963	1,918.5
170–244	55	65	112	2.0	21	79,384	3,780.2
Total	216	317	853		113	154,836	

This table shows clearly that the weight of food organisms per stomach increases when the size of the predator increases, in spite of a certain constant number per stomach in each size group with the exception of the 20–59mm group. Accordingly, it follows that the white croaker takes in larger prey as they are growing.

The relative importance of the four main food items (fish, *Alpheus*, *Crangon*, and other shrimp) in each size group mentioned above is shown in Fig. 2 for their frequency of occurrence, in Fig. 3 by percentage composition of food items in number of individuals and in Fig. 4 by percentage composition in wet weight. Comparing the percentage of each item in each size group of the five groups in these figures mutually, the three size groups of 60–99mm, 100–129mm 130–169mm possess something that resembles in importance to each main item, whereas there is marked difference among 20–59mm group, 60–169mm group and 170–244mm group. But Fig. 4 shows that the percentage of others is larger in 100–129mm group than that of the same group in Fig. 2 or Fig. 3. The reason was that two squids of 3g and 3.6g in body weight had been unexpectedly eaten by two white croakers belonging to the 100–129mm group, respectively. The main food of the young white croaker between 20mm and 59mm in standard length is shrimp

* The inflection points on the proportions of the body of the white croaker were recognized at 10cm in standard length in many morphological characters and at 6cm in the ratio of head length/caudal peduncle depth. (by unpublished data)

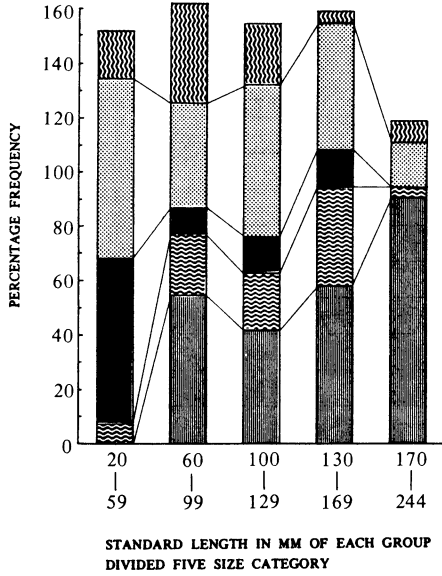


Fig. 2. Frequencies of occurrence by food item in each size group divided by the standard length.

fish, *Alpheus* sp., *Crangon* sp., other shrimp, others.

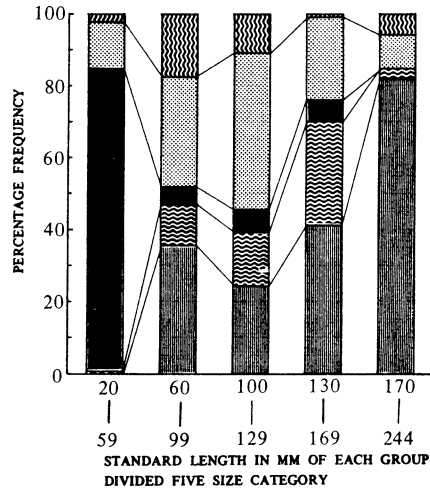


Fig. 3. Food composition in number of individual food organisms in the stomachs of each size group divided by the standard length.

fish, *Alpheus* sp., *Crangon* sp., other shrimp, others.

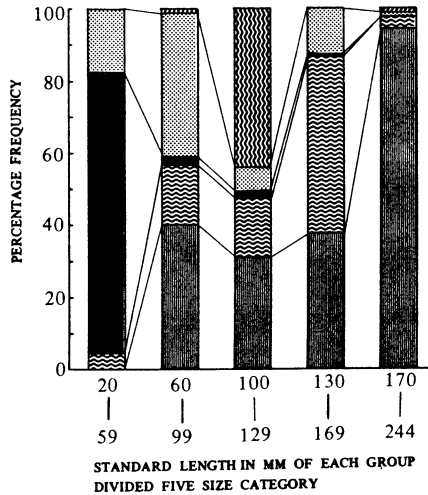


Fig. 4. Food composition in weight of food organisms in the stomachs in each size group divided by the standard length.

fish, *Alpheus* sp., *Crangon* sp., other shrimp, others.

and amongst this, *Crangon* sp. is the most common. The main food of the white croaker between 60mm and 169mm in standard length is fish and shrimp, particularly and mostly *Alpheus* sp.. The main food of adults above 170mm in length is fish alone.

Table 3 shows the relative importance of the main items in each specimen evaluated by frequency of occurrence in quantities judged by the percentage of contents of each item in the stomach of each specimen. These data are all based on the values the item-weight of each specimen of the 113 white croaker. From this table we may conclude that the importance of shrimp in the diet decreases gradually and that of fish increases in reverse as the predator grows.

Table 3. Relationship between length of the predator and importance of each food item shown by frequencies of occurrence of abundance in the stomach divided in three ranks.

Food item	Size category in standard length of predator														
	20-59mm			60-99 mm			100-129mm			130-169mm			170-244mm		
	Few	Inter- mediate	Abun- dant	Few	Inter- mediate	Abun- dant	Few	Inter- mediate	Abun- dant	Few	Inter- mediate	Abun- dant	Few	Inter- mediate	Abun- dant
<i>Alpheus</i> sp.	-	-	5	-	-	26	-	-	22	-	8	48	-	-	5
<i>Crangon</i> sp.	-	-	76	4	-	-	5	-	9	4	-	4	-	-	-
Other shrimp	24	24	19	-	9	48	9	5	27	20	24	12	14	-	5
Fish	-	-	-	9	-	26	9	9	27	12	12	36	-	-	91
Others	-	-	-	4	4	-	-	-	18	-	-	-	-	5	-

(NOTE) In percent of each food item for stomach contents by weight in each specimen, Few is under 10%, Intermediate 11-49% and Abundant above 50%.

Size preference

As the ability of the predator to swallow its preys depends probably on the body length of the predator, we may conclude that the range in size of the eatable preys may vary according to the length of the predator.

In order to clarify the size-relation between the predator and the prey, the relationship between the standard length of the white croaker and the total length of the food organisms present in the stomach of each one is shown in Fig. 5. In this figure, we can recognize that the length of prey increases gradually in accordance with the increase of length of the predator without particular relation to the different sorts of prey. It may be said in other words that the white croaker changes in the sort of food organisms for its prey as it grows longer and that a larger predator looks for larger prey. The white croaker seems to prey on large organisms that are about one-third in length of its own length in maximum. As a conclusion, we may declare that the white croaker has a size-preference in its feeding habits.

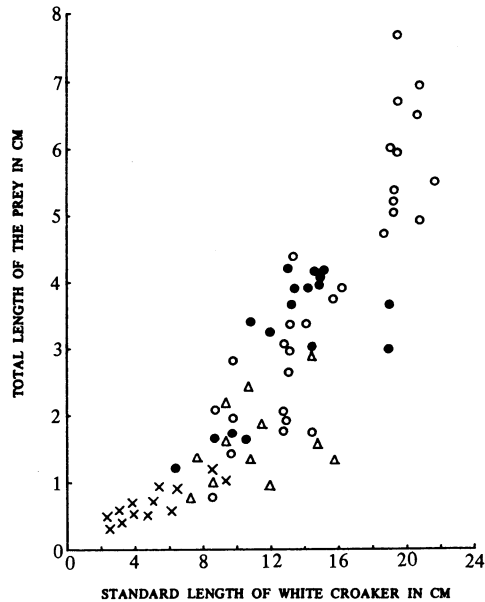


Fig. 5. Size-relation between white croaker and the prey.

○ fish, ● *Alpheus* sp., × *Crangon* sp., △ other shrimp.

DISCUSSION

RICKER¹⁰⁾ reports that the food habits of the fish are influenced by habitat, preferences, season, temperature, fish size, daily feeding periodicities, competitor species and so on. In this study, the preference of the white croaker for special species and size of prey has been investigated by examining the stomach contents. As the results, we were able to conclude that this fish selects its prey and changes the species and size of prey according to its own growth in body length. Actually, the young white croaker under 60mm in standard length eats preferably small shrimps such as *Crangon*. The white croaker above 60mm under 170mm feeds mainly on larger shrimp such as *Alpheus* than *Crangon* or small fish. The adult above 170mm eats mainly larger fish and only a little shrimp.

TōRIYAMA *et al.*⁷⁾ have investigated the feeding relationship in the food chain of demersal fish caught by the small beam trawl in Hiuchi-nada in the Seto Inland Sea. According to this investigation, the young white croaker under 6cm in total length preys upon *Crangon* only, and in the white croaker above 9cm the quantity of *Crangon* in the diet decreases and that of *Alpheus* increases in reverse as they grows.

KITAMORI *et al.*⁴⁾ have summarized that white croakers under 12cm in total length prey mainly upon small crustaceans and that those of 12–16cm eat small fish of benthos feeder such as goby and those over 16cm feed on fish of plankton feeder such as anchovy or small crustaceans feeder such as *Apogon lineatus*.

In this study, it has been elucidated that the white croaker shows a size-preference and

preys upon large organisms about one-third the length of his own measure in maximum. REINTJES *et al.*¹¹⁾ have reported a similar fact for the yellow fin tuna which feeds on large squid or fish one-third the length of himself in maximum.

SUMMARY

The food habits of the white croaker, *Argyrosomus argentatus* (HOULTUYN), which is an important resource for fishery in the Seto Inland Sea, were investigated through the qualitative and quantitative analysis of the stomach contents. This study, based on 216 fishes caught in the Seto Inland Sea that had a standard length from 20mm to 244mm, is one of the serial studies on the fishery biology of the white croaker in the Sea.

General conclusions obtained in this study are as follows:

- 1) Food organisms occurred in the stomach were fish, shrimp, amphipoda, polychaeta, cephalopoda, cladocera, brachyura, stomatopoda and isopoda. But fish and shrimp constituted the main food items.
- 2) In frequency of occurrence, the main food organisms were fish for 52 percent of the 216 stomachs, 78 percent was shrimp and 17 percent were other organisms. *Alpheus* sp. and *Crangon* sp. which were the dominant species in shrimp occupied both 18 percent.
- 3) By numerical method, 21 percent of food organisms of 216 stomachs was fish, 49 percent *Crangon* sp., 7 percent *Alpheus* sp. and 19 percent other shrimp.
- 4) The 113 stomachs contained a total weight of 154, 836mg of food organisms, of which 65 percent was fish, 20 percent *Alpheus* sp., 2 percent *Crangon* sp. and 7 percent other shrimp.
- 5) The main food organisms of young white croakers above 20mm and under 60mm in standard length were shrimp, and the most common was *Crangon* sp.. *Crangon* sp. occupied 61 percent of food organisms in stomachs in frequency of occurrence, 84 percent by numerical method and 78 percent by gravimetric method.
- 6) The white croaker above 60mm and under 170mm in standard length has preied mainly upon shrimp and fish. In frequency of occurrence, shrimp occupied 87 percent and fish 50 percent. *Alpheus* sp. was dominant in shrimp and occupied 27 percent in 87 percent. By numerical method, shrimp occupied 57 percent (*Alpheus* sp. 19%) and fish 34 percent. By gravimetric method, shrimp occupied 53 percent (*Alpheus* sp. 38%) and fish 36 percent.
- 7) The main food organisms of the adult above 170mm in standard length were fish. The fish occupied 91 percent of the stomach contents in frequency of occurrence, 82 percent by numerical method and 94 percent by gravimetric method.
- 8) The length of the prey in the stomach of the white croaker increased as the length of the predator himself increased. The total length of the largest prey in the stomach was about one-third of the standard length of eater himself, generally.

REFERENCES

- 1) MISU, H., SAISHU, K., ENOMOTO, Y. and KOJIMA, K.: Inv. Demersal Fish Resources East China Sea Yellow Sea, (2), 104–106 (1955). (In Japanese).
- 2) IKEDA, I.: *ibid.*, (4), 70–79 (1957). (In Japanese).
- 3) KITAMORI, R.: Bull. Naikai Reg. Fish. Res. Lab., (21), 61–75 (1963). (In Japanese with English summary).
- 4) KITAMORI, R., TATARA, K. and HAYASHI, T.: Rep. Naikai Reg. Fish. Res. Lab., (C-2), 1–18 (1964). (In Japanese).
- 5) TÖRIYAMA, M., KUDÖ, S., ASAMI, T. and KONISHI, Y.: Reserch on the Circulation of polluting Materials and the Indicator Organisms in the Agricultural and Forestry and Fishery Ecosystems, 144–151 (1974). (In Japanese).
- 6) ——— : *ibid.*, 161–174 (1975). (In Japanese).
- 7) TÖRIYAMA, M., KUDÖ, S., KONISHI, Y., MITANI, F. and ASAMI, T.: *ibid.*, 135–146 (1976). (In Japanese).
- 8) TÖRIYAMA, M., KUDÖ, S., KONISHI, Y. and MITANI, F.: *ibid.*, 195–202 (1978). (In Japanese).
- 9) KAKUDA, S. and MATSUMOTO, K.: J. Fac. Fish. Anim. Husb., Hiroshima Univ., 16, 115–122 (1977).
- 10) RICKER, W.E.: Methods for Assessment of Fish Production in Fresh Waters, 2nd ed., 216–218 pp., Blackwell Scientific Publications Oxford and Edinburgh. (1971).
- 11) REINTJES, J. W. and KING, J. E.: U. S. Fish and wildlife Ser., 54, Fishery Bull. (81), 88–110 (1953).

イシモチ *Argyrosomus argentatus* の食性

角田俊平・松本健二

瀬戸内海で1976年2月から77年6月までの間に採集した8標本、310尾のイシモチについて、空胃であった94尾を除き、体長が20–244 mmの216尾の胃内容物を調べ、次の結果を得た。

1) 胃内に出現した生物は魚類、エビ類、端脚類、多毛類、頭足類、枝角類、カニ類、口脚類、等脚類であったが、特に多く出現した魚類とエビ類が最も重要な餌生物である。

2) 胃内容物組成は出現頻度によるとエビ類78%、魚類52%であったが、エビ類ではエビジャコとテッポウエビが特に多く、共に18%を占めた。個体数ではエビ類75% (エビジャコ49%、テッポウエビ7%)、魚類21%であった。

3) 胃内容物が未消化でその重量を測定することができた113尾のイシモチの重量による胃内容物組成は、魚類65%、エビ類29% (テッポウエビ20%、エビジャコ2%)であった。

4) イシモチの生長に伴う餌生物組成の変化を明らかにするために、216尾のイシモチを体長で20–59; 60–99; 100–129; 130–169; 170–244 mmの5グループに区分し、各グループ間で胃内容物組成を比較検討した。出現頻度、個体数および重量は共に60–99; 100–129; 130–169 mmの3グループ間ではほぼ類似した組成を示したが、これら3グループと他の2グループとの間には、互いに顕著な差異が認められた。すなわち20–59 mmのグループではエビジャコが最重要種で、出現頻度で61%、個体数で84%、重量で78%を占めた。60–169 mmのグループではエビ類と魚類が重要な餌生物であって、出現頻度で魚類50

%, エビ類 87% (テッポウエビ 27%, エビジャコ 12%), 個体数で魚類 34%, エビ類 57% (テッポウエビ 19%, エビジャコ 6%), 重量で魚類 36%, エビ類 53% (テッポウエビ 38%, エビジャコ 0.7%) を占めた。170–244mmのグループの餌生物は魚類が大部分であって, 魚類は出現頻度で 91%, 個体数で 82%, 重量で 94% を占めた。

5) イシモチは上述のように成長に伴って餌生物の種類をかえながら選択的にこれを捕食しているが, 同時に餌生物の大きさに対しても選択的である。すなわち, 大きい捕食者ほど同じ種類の餌生物の中ではより大きい個体を捕食しており, 餌生物の大きさは全長で最大限, 捕食者の体長の約 3分の1 であった。