日水研報告，(35)：11−22，1985.
Bull. Jap. Sea Reg. Fish. Res. Lab., (35) : 11−22, 1985.

Some Aspects of the Biology of Young Frog Flounder, *Pleuronichthys cornutus* in Coastal Waters of San-in District, the Japan Sea

TAKASHI MINAMI[1], TETSUYA TAMAKI[2] AND TOSHIO KOBAYASHI[2]

Abstract

The general ecology of young frog flounder, *Pleuronichthys cornutus*, in their nurserygrounds was studied in the waters of the San-in district and the western Wakasa Bay, the Japan Sea.

The growth rate of 0-age fish is rather rapid throughout spring and summer, but becomes slower during autumn and winter. 0-age fish reach a mean length of about 11 cm by the end of their first year.

The main populations were found in the shallower waters in April, and from May to August they show wide ranges in a vertical distribution.

During the period of this survey, only one example of predation on young frog flounder was observed. The conger eel was observed to be the active predator.

Analyses of the stomach contents showed that food items included polychaeta and amphipods.

It is necessary to investigate the significance of shallow water areas in relation to the management of the resources of economically important fishes. Many such fishes live in shallow waters during their juvenile and young stages. Especially, the young of various commercial flatfishes inhabit shallow waters and such areas have been known as their nursery grounds.

Little is known about the biology of the young frog flounder, *Pleuronichthys cornutus* (TEMMINCK et SCHLEGEL), although its importance as commercial species in Japan.

The present paper is one part of general study on the early life history of flatfishes and deal with growth, distribution, and feeding habits during the first (0-group) year of life of the frog flounder.

Materials and methods

The majority of the survey was carried out along the coast of Hyogo

Received : 14 January 1985. Contribution A No. 423 from the Japan Sea Regional Fisheries Research Laboratory

1) Japan Sea Regional Fisheries Research Laboratory, Suido-cho, Niigata 951, Japan
2) Research Laboratory, Tajima Regional Fisheries Office of Hyogo Prefecture, Kasumi-cho, Hyogo 669-65, Japan

Prefecture and the western Wakasa Bay, the Japan Sea (Fig. 1). Materials examined in this study were caught from 1971 to 1978 and the monthly catches are given in Table 1. The gears used for sampling were a 4-m wide beam trawl, a 3-m wide dredge net and others gear including a gill net, a set net and a Danish seiner. Specimens were preserved in 10% formarine of sea water and all subsequent analyses took place in the laboratory. Stomach contents were examined and food organisms were classified according

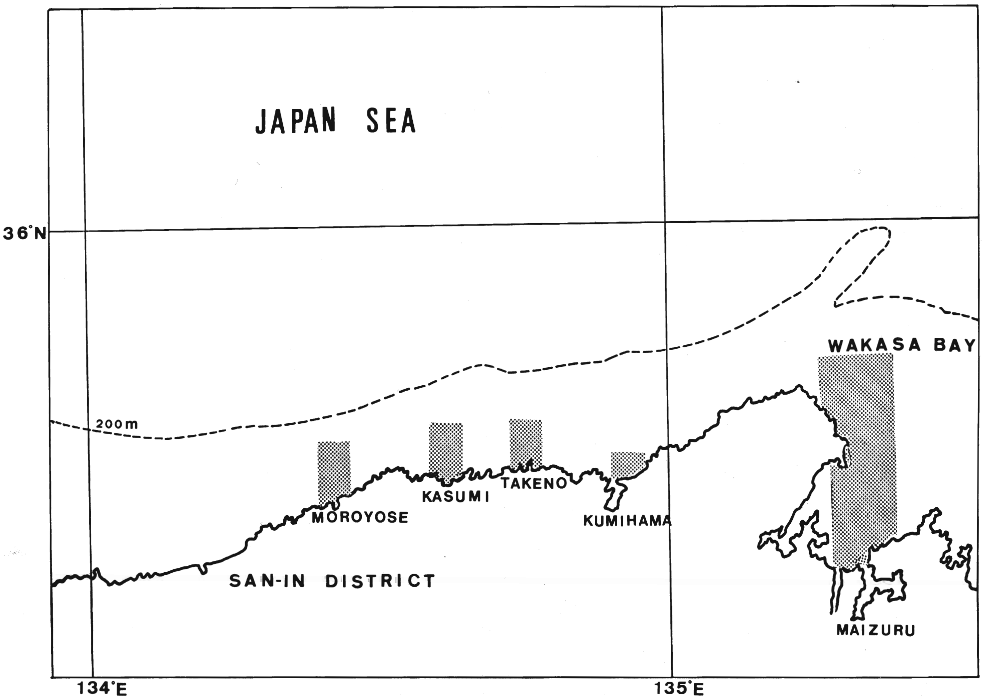

Fig. 1. The coast of San-in district where this study was carried out. Shaded part shows surveyed area

Table 1. Monthly catches of materials

Month	No. of specimens
January	23
February	37
March	82
April	54
May	186
June	224
July	182
August	34
September	21
October	13
November	121
December	44
Total	1021

to the following categories : polychaetes, copepods, gammarids, caprellids, nematods, mysids, anomura, bivalvia, isopods, ostracods, algae, and others. Whenever possible, or feasible, the specific identification of an individual organisms was made.

Results and discussion

(1) General feature of the region

The work was carried out in the easternmost of the San-in district and the western Wakasa Bay, located near the middle part of the Japan Sea coast of the Japan Archipelago (Fig. 1). A sand bottom extends along the coast of eastern San-in district and a mud bottom area locates in the off-shore region. The bottom of Wakasa Bay is coverd with mainly three types of sediment : sand locates on the east and west sides of mouth region ; mud locates offshore the mouth region ; and sandy mud locates in the central part of the Bay. The sublittoral slope is gentle on the coast of the San-in district and is relatiely gentle in Wakasa Bay.

(2) Growth

The spawning of the frog flounder appears to occure during December and January in the western Wakasa Bay (Minami and Nakamura, 1978 ; Minami,1982a), and newly settled fish found a few in January and many in February. The size of the frog flounder at metamorphosis was estimated to be about 20 mm in total length, and the poor catches of such metamorphosed fish in shallower water may be due to the fact that the demersal way of life is taken up before they move inshore (Uchida, 1932).

Monthly average lengths of the young are shown, based on monthly samples from the San-in district (Fig. 2). There is a remarkable seasonal variation in the growth rate. A sampling for 13 months indicates that the growth rate is rather rapid throughout spring and summer, but becomes slow during autumn and winter. It appears to be a common feature of these seasonal growth curves that they are sigmoid in shape (Iles, 1974). Hardy (1924) and Hodgson (1925) remarked on the great overall similarity of seasonal changes between feeding and growth in herring. This indicates that feeding and somatic growth are very closely related. However, the direct effect of other environmental factors is not easily discernible in at least this instance.

0-age group frog flounder reach a mean length of about 11 cm by the end of their first year. Growth data from the Seto Inland Sea (Tomiyama, 1956), the East China Sea and the Yellow Sea (Chen and Ootaki, 1974), together with our data from the San-in district are provided in Table 2. Growth is rapid in the first year, but becomes slower in the second and third years.

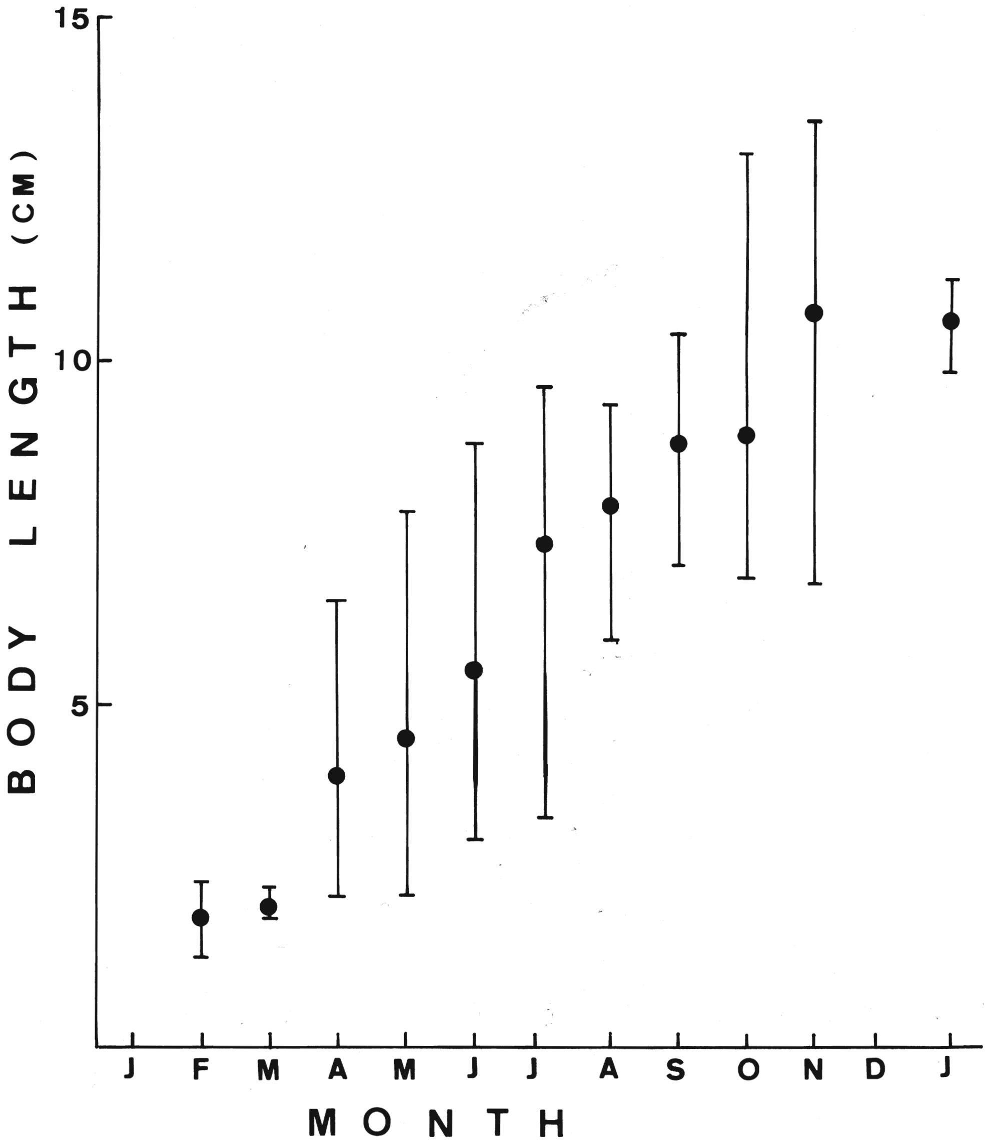

Fig. 2. Growth of 0-age group frog flounder in the coast of San-in district from 1971-1972

Table 2. Summary of growth data on 0-, 1- and 2-group frog flounder

Author	Tomiyama (1956)	Chen・Ootaki (1975)	Present article
Locality Age	Seto Inland Sea	East China Sea, Yellow Sea	Coast of San-in
1	17-18	♂ 9.9 ♀ 11.3	11.0
2	21-22	♂ 16.9 ♀ 17.2	17.5
3	24-25	♂ 21.1 ♀ 21.2	22.0
	(Total length)	(Body length)	(Body length)

(3) Vertical distribution

In order to estimate the vertical distribution of young fish, a 4-m wide beam trawl was towed parallel along the shore line at 10, 20, 30, 40, and 50-m depths in the Japan Sea coast of Moroyose, Hyogo Prefecture (Fig. 1). These surveys were made at monthly intervals from April to September 1972. The number of fish caught on the five transects varied monthly in proportion to the size of the population. Thus, the numbers are best expressed as percentages of the total catch caught in each month on all the transects. The main populations are found in the shallower waters in April, and from May to August they show wide ranges in a vertical distribution. At the end of September, they were found in the deeper waters and it is probable that the population begins to migrate into deeper waters at this time (Fig. 3).

According to fishermen's information, many young fish are caught at a depth of about 100 m by Danish seine in early November in Wakasa Bay. The size distributions of the 0-age group fish caught in November, 1978, from about 100m depths around the western Wakasa Bay, and shallower waters about 30 m in depth in Wakasa Bay are given in Fig. 4. It shows a remarkable relationship between the size of the fish and the depths at which the fish were caught. The larger fish seem to be inhabiting the deeper water regions. There is a possibility of an offshore migration as fish grow. Furthermore, the poorer catch of fish in shallower water regions after November may support this suggestion. The purpose of the offshore movement is not clear, but several things may be suggested : namely, the avoidance of low temperatures in winter and the movement to a different feeding ground (Gibson, 1973).

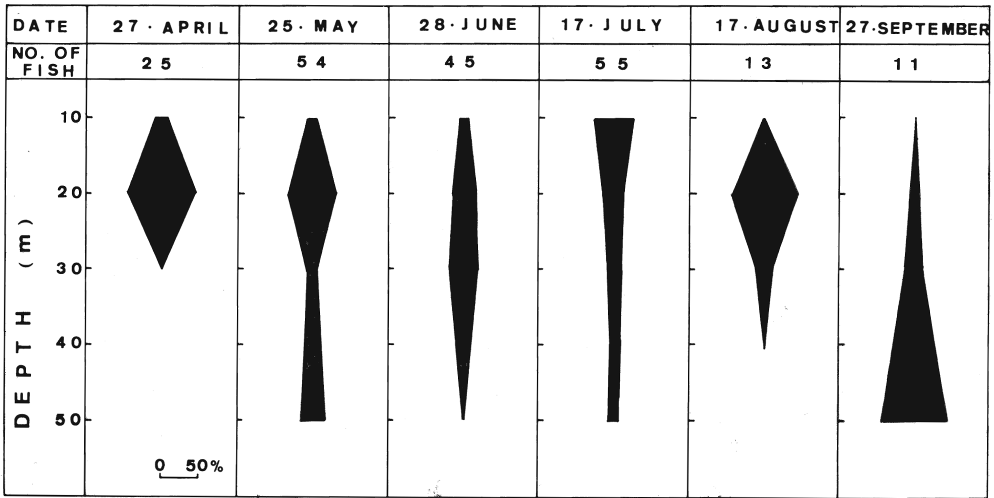

Fig. 3. Vertical distribution of juvenile and young frog flounder in the coast of Moroyose, Hyogo Prefecture

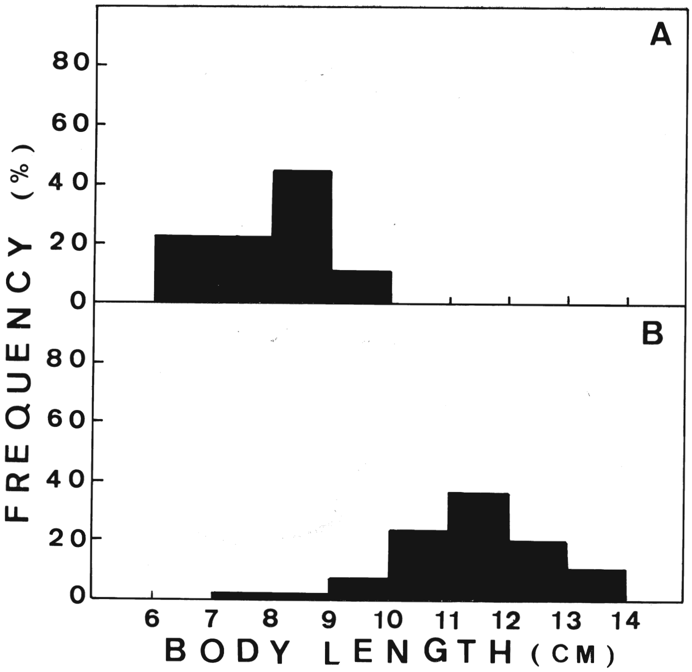

Fig. 4. The size distribution of young frog flounder taken in November, 1978, from about 30m (A) and100m (B) in depth around the western Wakasa Bay

(4) Predation on young frog flounder

The mortalities for plaice, *Pleuronectes platessa* and dab, *Limanda limanda*, are high during the first six months after settlement. This may be attributed, almost entirely, to predation (Edwars and Steele, 1968).

Little is known about the predation of Japanese young flatfishes in their nursery grounds. During the period of this survey, only one example of predation on young frog flounder was observed. The conger eel, *Astroconger myriaster*, measured 47. 8 cm in total length, was observed as the active predator on young frog flounder which were 2.59 through 4.41 cm in standard length. It is an interesting fact that the predator is a night feeder.

(5) Feeding habits

Many investigators have described the feeding habits of adult frog flounder (Hatanaka et al., 1954 ; Okada, 1955 ; Tomiyama, 1956 ; Chen and Ootaki, 1974), but a few for young and larval frog flounder (Uchida, 1932, Minami, 1982 ; Kuwahara and Suzuki, 1983). Hatanaka et al., (1954), reporting on the food of adult frog flounder suggested that annelid worms are dominant for all size-groups of the frog flounder followed by small crustaceans in the northern part of Sendai Bay. Other authors reported almost similar results (Okada, 1955 ; Tomiyama, 1956 ; Chen and Ootaki, 1974). In this paper, we describe the feeding habits of the young frog flounder caught from the coast of the San-in district compared with those from other areas to see if any unique difference exists.

Larval fish, before metamorphosis and during pelagic life, are dependent upon minute planktonic organisms such as appendiculate for food (Table 3). The main food organisms of frog flounder, during their post-larval period in the western Wakasa Bay, are appendiculate and copepods (Minami, 1982a ; Kuwahara and Suzuki, 1983).

The demersal life that follows necessitates a change in diet and feeding habits. The younger metamorphosed fish feed on small animals including copepods, nematodes and polychaeta. After settling to the bottom, the food of the demersal juvenile and young fish consists largely of polychaeta and amphipods, including Gammaridae and Caprellidae. Minor, but important, food organisms are annelid and copepods for small fish, siphon of mollusks and anomura for larger young fish. The results of stomach content analyses for various size fish are shown in Table 4. It is of interest to note that pelagic post-larvae feed on harpacticoid copepod, while the slightly larger demersal juvenile feed on calanoid copepods. This difference may be due to an inability to feed on relatively large calanoids for the smaller fish.

The young fish in their nursery grounds showed distinct seasonal variations in their diet (Table 5). Polychaeta and Gammaridae were the most important foods in April. Caprellidae became the most important during May through July, but became less important when young fish moved offshore into deeper water regions.

Comparing the feeding habits of young fish with those from other areas data from another survey, we can find the common items of food. The diet of the demersal juvenile and young fish from Pusan and Jinhae Man, Korea, was reported by Uchida (1932). He found that smaller juvenile frog flounder, 14.0 mm in total length fed mainly on small polychaeta and small amphipods. This is similar to the food items of young fish about 50 mm in total length.

In order to estimate the maximum weight of stomach contents, the relationships between the weight of food contained in a full stomach and the length of fish in young frog flounder are examined (Fig. 5). As the young fish grows in size, the weight of food eaten increases. It shows a rapid increase in young stages of 2 to 5 cm long. It is equivalent to the period when young fish inhabit the shallower nursery grounds during May through August.

Larvae of some species of flatfish enter the shallower water regions and spend some months of their early life there. In the estuary of the Yura River located on the westernmost region of Wakasa Bay, larvae and juveniles of some species of flatfish including *Paralichthys olivaceus,*

Table 3. Stomach contents of larval and juvenile frog flounder

Body length (*mm*)	Stage	Food items in stomach
7.20	Pelagic	Chaetognatha, Appendiculata
8.00	Pelagic	Appendiculata (*Oikopleura longicauda*)
9.00	Pelagic	Polychaeta
10.30	Pelagic	Appendiculata (*Oikopleura longicauda*)
13.20	Demersal	Copepoda
13.70	Demersal	Copepoda
14.50	Demersal	Polychaeta, Nemaȿoda

Table 4. Stomach contents of the young frog flounder in relation to body length (Percentage composition of food items).

Body length (cm)	2	3	4	5	6	7	8	9	10
No. fish examined	56	82	86	102	72	62	34	22	41
No. stomachs with food	50	78	86	97	58	46	25	13	32
Food item	Frequency of percentage								
Polychaeta	60.0	74.4	80.2	74.2	50.0	60.9	68.0	76.9	56.3
Gammaridae	58.0	62.8	48.8	72.2	77.6	43.5	48.0	53.8	40.6
Caprellidae	22.0	35.9	38.4	46.4	34.5	26.1	16.0	15.4	68.8
Nematoda	14.0	2.6	2.3	3.1	0.0	2.2	0.0	0.0	0.0
Mysidacea	0.0	5.1	4.7	2.1	1.7	2.2	8.0	0.0	0.0
Anomura	0.0	0.0	0.0	6.2	6.9	6.5	4.0	0.0	0.0
Siphons of Bivalvia	2.0	1.3	0.0	0.0	5.2	13.0	20.0	0.0	0.0
Copepoda	6.0	5.1	9.3	4.1	3.4	2.2	4.0	0.0	0.0
Isopoda	2.0	2.6	2.3	1.0	6.9	2.2	4.0	7.7	0.0
Ostracoda	0.0	0.0	1.2	1.0	0.0	0.0	12.0	7.7	6.3
Algae	0.0	0.0	1.2	0.0	1.7	0.0	0.0	7.7	6.3
Others	2.0	5.1	4.7	6.2	8.6	15.2	24.0	15.4	21.9

Table 5. Monthly changes of stomach contents of young frog flounder at the coast of Moroyose.

Month	Apr.	May	June	July	Aug.	Sep.
Number of fish	19	50	44	25	8	4
Food item	Frequency of occurrence					
Polychaeta	68.4	54.0	70.5	56.0	87.5	25.0
Gammaridae	84.2	88.0	47.7	80.0	50.0	0.0
Caprellidae	21.1	70.0	61.4	68.0	12.5	0.0
Mysidacea	21.1	0.0	0.0	40.0	0.0	0.0
Copepoda	0.0	12.0	4.5	8.0	12.5	0.0
Anomura	0.0	0.0	0.0	0.0	0.0	75.0
Others	0.0	12.0	4.5	8.0	0.0	0.0

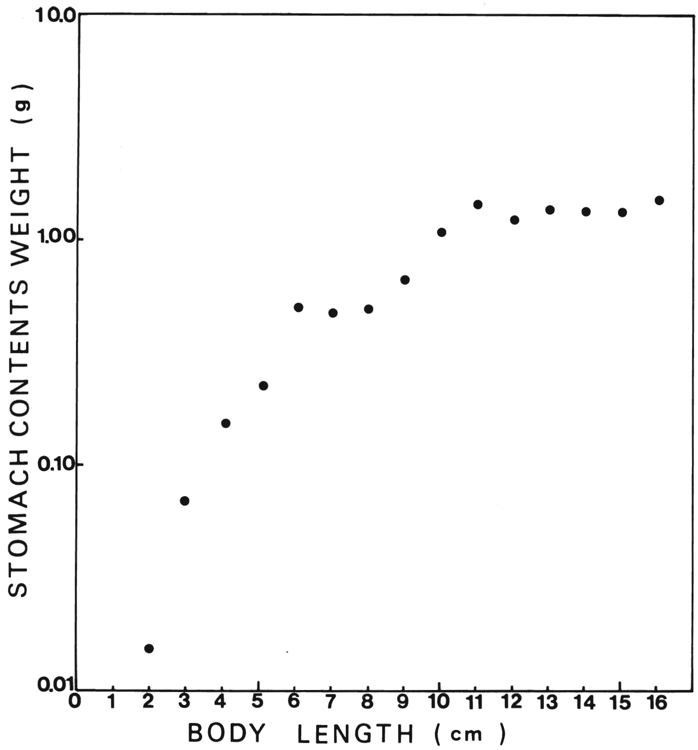

Fig. 5. Relationship between the weight of food contained in full stomach and standard length in young frog flounder

Pseudorhombus pentophthalmus, Tarphops oligolepis, Kareius bicoloratus, Pleuronichthys cornutus, Heteromycteris japonica, Paraplagusia japonica and *Cynoglossus joyneri* live as in a nursery ground (Minami et al., 1977 ; Minami, 1981 a ; 1981 b ; 1982 a ; 1982 b ; 1982 c ; 1983 b ; 1983 c ; 1984). On the contrary, other species of flatfish such as *Hippoglossoides dubius, Glyptocephalus sterelli, Cleisthenes pinetorum herzensteini, Tanakius kitaharai, Eopsetta grigorjewi, Dexistes rikuzenius* and *Limanda herzensteini,* do not seemingly enter the shallower areas around the western Wakasa Bay in their larval, juvenile and young stages (Minami, 1983a ; Minami, unpublished).

However, each species belonging to both patterns of young life, has its own specific and complex life history. Among the flatfishes distributed around the western Wakasa Bay, frog flounder have a relatively large population and have a wide vertical distribution, from shallower water regions to considerable depths about 100m. Also, adults are caught in various depths within that range. The larval fish may settle in relatively shallower water regions than the living areas of adults and spend their juvenile and young stage in shallower water regions used as a nursery ground. We found that some other species of flatfish show a similar pattern during early life and migrate as young frog flounder. They were

Paralichthys olivaceus, *Pseudorhombus pentophthalmus* and *Eopsetta grigorjewi* along the coast of the San-in district. However, only the young frog flounder feed on mainly polychaeta, and other species feed on crustacea. An explanation of the relationship between the migrating pattern during early life stages and feeding habits has not been included in our considerations.

Recently, two morphological types of *Pleuronichthys cornutus* have been recognized and discussed (Kato and Fujio, 1979 ; Nozawa and Kato, 1981 ; Masaki and Ito, 1984a, 1984b). In Tottori Prefecture, they are conveniently called "Honmeita" and "Bakemeita" by fishermen, and were considered to correspond to MDH-A and MDH-B types respectively. This categorization was made by Kato and Fujio (1979) by means of an isozyme analysis for malate dehydorogenase (Nozawa and Kato, 1981). Due to the colour pattern and the proportional character, specimens from the San-in district have-been identified as "Honmeita". However, we must undertake furtherinve stigations regarding this problem.

Acknowledgements

We wish to express our sincere thanks to Professor Tamotsu Iwai of Kyoto University for his guidance and valuable comments. We are also very greatful to Masaru Fujiya, Yutaka Kitano and Minoru Tanaka of the Japan Sea Regional Fisheries Research Laboratory for their critical readings of the manuscript. The authors are indebted to the crew of the R.V. Shin-Tajima Maru of Hyogo Prefecture for obtaining the materials related to this study.

References

Chen, C. and H. Ootaki (1974) Fisheries biology of the frog flounder, *Pleuronichthys cornutus*, in the East China and the Yellow Sea. *Bull. Seikai Reg. Fish. Res. Lab.*, (46), 1-20.

Edwards, R. and J. H. Steele (1968) The ecology of 0-group plaice and common dab at Loch Ewe I. Population and food. *J. exp. mar. biol. Ecol.*, **2**(2), 215-238.

Gibson, R. N. (1973) The intertidal movements and distribution of young fish on a sandy beach with special reference to the plaice (*Pleuronectes platessa* L.). *J. exp. mar. biol. Ecol.*, **12**(1), 79-102.

Hardy, A. C. (1924) The herring in relation to its animate environment. Part I. The food and feeding habits of the herring with special reference to the east coast of England. *Fish. Invest., Lond.*, Ser. 2, **7**(3), 53pp.

Hatanaka, M, M. Kosaka, Y. Sato, K. Yamaki and K.Fukui (1954) Inter-specific relations concerning the predacious habits among the benthic fish. *Tohoku J. Agr. Res.*, **5**(3), 177-189.

Hodgson, W.C. (1925) Investigations into the age, length and maturity of herring of the southern North Sea. Part I. Some observations on the scales and growth of the English herring. *Fish. Invest., Lond.*, Ser. 2, **1**(8), 36pp.

Iles, T. D. (1974) The tactics and strategy of growth in fishes. In HardenJones, F.R., ed. "Sea Fishery Research" Elek Science, London, pp. 331-345.

Kato, Y. and Y. Fujio (1979) On the sibling species of the flounder, *Pleuronichthys cornutus*. *Suisan- Ikushu*, (4), 10-12.

Kuwahara, A. and S. Suzuki (1983) Vertical distribution and feeding of two larval flatfish *Pseudorhombus pentophthalmus* and *Pleuronichthys cornutus*. *Bull. Japan. Soc. Sci. Fish.*, **49**(6), 875-881.

Masaki, Y. and H.Ito (1984a) Stock identification of finespotted flounder, *Pleuronichthys cornutus* (Temminck et Schlegel) in the western Seto Inland Sea. *Bull. Nansei Reg. Fish. Res. Lab.*, (16), 11-51.

Masaki, Y. and H. Ito (1984b) Re-examination of the identification of stock units of finespotted flounder, *Pleuronichthys cornutus* (Temminck et Schlegel) in the Sea of Iyo. *Bull. Nansei Reg. Fish. Res. Lab.*, (17), 159-182.

Minami, T. (1981a) The early life history of a flounder, *Pseudorhombus pentophthalmus*. *Bull. Japan. Soc. Sci. Fish.*, **47**(7), 849-856.

Minami, T. (1981b) The early life history of a sole, *Heteromycteris japonicus*. *Bull. Japan. Soc. Sci. Fish.*, **47**(7), 857-862.

Minami, T. (1982a). The early life history of a flounder, *Pleuronichthys cornutus*. *Bull. Japan. Soc. Sci Fish.*, **48**(3), 369-374.

Minami, T. (1982b) The early life history of a tongue fish, *Paraplagusia. japonica*. *Bull. Japan. Soc. Sci. Fish.*, **48**(8), 1041-1046.

Minami, T. (1982c) The early life history of a flounder, *Paralichthys olivaceus*. *Bull. Japan. Soc. Sci. Fish.*, **48**(11), 1581-1588.

Minami, T. (1983a) The early life history of a flounder, *Tanakius kitaharai*. *Bull. Japan. Soc. Sci.* Fish., **49**(4), 527-532.

Minami, T. (1983b) The early life history of a flounder, *Tarphops oligolepis*. *Bull. Japan. Soc. Sci Fish.*, **49**(4), 533-539.

Minami, T. (1983c) The early life history of a tongue fish, *Cynoglossus joyneri*. *Bull. Japan. Soc. Sci. Fish.*, **49**(5), 719-724.

Minami, T. (1984) The early life history of a flounder, *Kareius bicoloratus*. *Bull. Japan. Soc. Sci. Fish.*, **50**(4), 551-560.

Minami, T. and I. Nakamura (1978) Seasonal occurrence of pelagic stages of flatfishes (Pleuronectiformes) in the coastal waters of western Wakasa Bay, the Japan Sea. *Mem. Colledge Agr., Kyoto Univ.*, (112) ,29-47.

Minami, T., T. Nakabo, Y. Uozumi and S.Kiyono (1977) Benthic fish fauna off the river mouth of Yura, Wakasa Bay. *Rep. Kyoto Pref. Fish. Exp.* Sta., (1975), 74-100.

Nozawa, M and F. Kato (1981). Morphological comparison of two types of frog flounder, *Pleuronichthys cornutus*, collected off Tottori Prefecture, in the Japan Sea. *Bull. Japan Sea Reg. Fish. Res. Lab.*, (32), 1-8.

Okada, Y. (1955) Fishes of Japan. Maruzen Co, Ltd., Tokyo. 458pp.

Tomiyama, A. (1956) Ecological studies on the useful sea animals off Yamaguchi prefecture, Inland Sea 13. Length composition and stomach contents of the sole, *Pleuronichthys cornutus* (Temminck et Schlegel). *Rep. Yamaguchi Pref. Inland Sea Fish. Exp. Sta.*, **8**(1), 59-62.

Uchida, K. (1932) Metamorphic stages of the flatfishes of Japan. I. *Pleuronichthys cornutus*. *Zool. Mag.*, **44**(525), 234-241.

山陰沿岸におけるメイタガレイ幼稚魚に関する生物学的知見

南　卓志・玉木　哲也・小林　敏男

日本海の山陰沿岸において，メイタガレイ幼稚魚の成長，分布域の変化，食性，被捕食について調査した．成育場におけるメイタガレイ幼稚魚は，春と夏には急速に成長し，秋以降は緩やかな成長をする．また，成長にともなって成育場における分布水深は，深い海域に広がるが，秋にはさらに深い水深100

m付近に移動すると推定された.

幼稚魚の餌生物は，体長 2 cmから10cmでは多毛類が主で，端脚類がこれに次ぐ．量的には体長 3 cmから 6 cmで急激に摂食量が増す.

山陰沿岸の同海域にはヒラメやムシガレイなどの異体類が成育場を形成し，メイタガレイと同様の分布域の拡大，深所への移動を行なうが，食性は甲殻類食である.