J. Fac. Fish. Anim. Husb.
Hiroshima Univ. (1962), **4**:21~45.

Ecology of Fishes of Kasaoka Bay as Observed from the Catch of Pound Nets

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(Text-figs. 1–11; Tables 1–6)

INTRODUCTION

Kasaoka Bay is located along the northern part of Seto Inland Sea (Seto Naikai). A considerable number of works concerning this area have been undertaken from both hydrographical and biological points of view. Works of MURAKAMI (1954) and of MATSUDAIRA, KOYAMA and ENDO (1961) are two of the most detailed hydrographical contributions. Biological works are chiefly made on benthic communities (KAWAGUCHI and SHIRAI, 1944; KAWAGUCHI, 1945), on shrimps (YASUDA, 1957) and on chaetognaths (MURAKAMI, 1957, 1959). In spite of their abundance and commercial importance, however, little attention has been paid on the fishes of Kasaoka Bay.

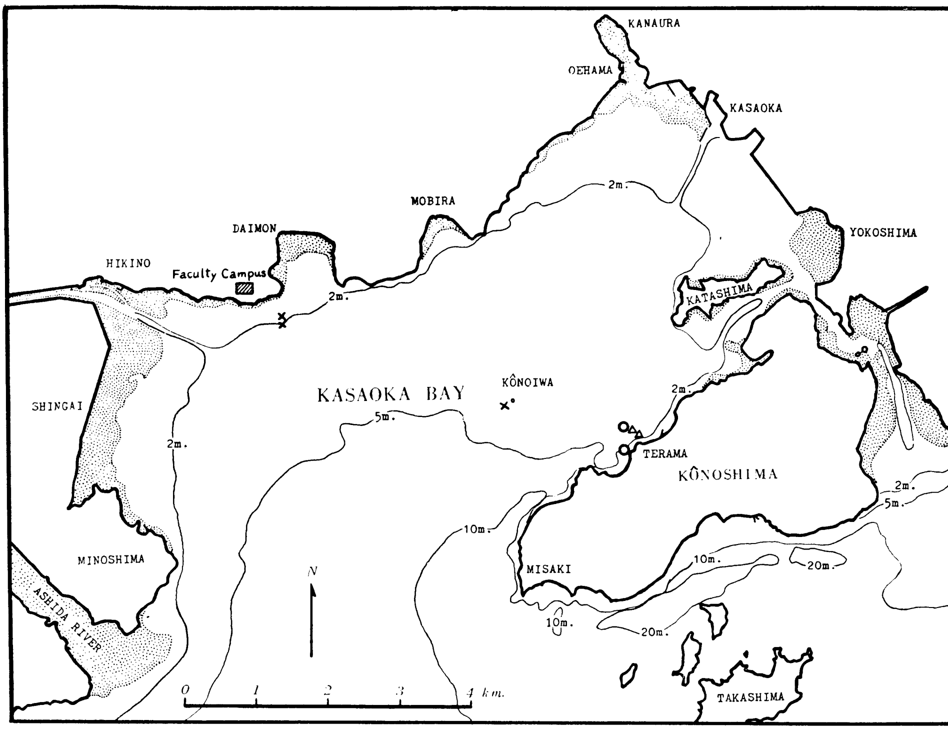
In order to make clear the ecological aspects of fishes in such inshore waters as well as to add information to our insufficient knowledge on the fishes of this area, the present work was initiated based on analyses of the catch of pound nets called *masu-ami*.

The majority of the fishes of this area are taken almost exclusively by the *masu-ami* fishery. The fishes coming in contact with the nets are trapped rather indiscriminately irrespective of species. Similarity in structure and size of the nets, together with a regular once-a-day hauling, makes the data of catch fairly suitable for quantitative analysis. These are the major reasons why the catch of *masu-ami* have been treated with for this kind of study.

Before going further, we wish to express our sincere appreciation to Prof. Yasuo MATSUDAIRA for his generous help in many ways and to Assist. Prof. Yutaka MURAKAMI for his constant guidance and encouragement. Our grateful acknowledgments are also due to Prof. Iwao TAKI who was kind enough to identify some of the cephalopods found in the catch.

KASAOKA BAY AND ITS FISHERIES

Essentially rectangular in outline, Kasaoka Bay is about 10 km. long and about 4 km. wide, covering an area of about 40 km^2. The mouth of about 6 km. wide and a very narrow passage open respectively in the south and in the north-eastern part of the bay. The bottom contours are gradual and with the exception of a deeper portion near Misaki, Kônoshima, do not exceed 10 m. at the lowest low water. Bottom sediments consist generally of soft mud. Tidal flats are developed in the western and the eastern coasts. The shape, extent and other geographical features are shown in Text-fig. 1.



Text-fig. 1. Kasaoka Bay, showing bottom contours and location of the *masu-ami* investigated.
○: Locations of nets for regular investigation.
△: Locations of nets for occasional investigation.
×: Locations of test-nets for supplemental observation.

The greater part of the commercial catch of aquatic animals in Kasaoka Bay are taken by the *masu-ami*, a kind of stationary pound net. The rest is caught by small trawlers and other primitive fishing methods. The season of the *masu-ami* fishery extends for almost a year round, except the coldest months. As many as two-hundred *masu-ami* are set all over the coastal region of the bay from summer to fall. A typical *masu-ami* operated in Kasaoka Bay is illustrated in Text-fig. 2. Since the structure of the *masu-ami* and its distribution in Kasaoka Bay in 1961 season are detailed in another paper (KAKUDA and ONBE, 1962), description of the net is omitted here to avoid duplication. Judging from the characteristics in structure, it may be said that the *masu-ami* exerts little selectivity as to the species and size of fishes to be caught.

Other important fisheries in the bay are the cultures of the ark shell, *Anadara subcrenata* (LISCHKE), and the laver, *Porphyra tenera* KJELLMAN. The culture

Text-fig. 2. A typical *masu-ami* operated in Kasaoka Bay.

grounds of the former lie mainly in the eastern coast, while those of the latter are restricted to the western part of the bay.

MATERIALS AND METHODS

Collections of the catch of *masu-ami* were made from June 1961 to June 1962 at almost weekly intervals. The suspension of the *masu-ami* fishery during the coldest season due to rough weather and paucity of catch made our collecting of material completely impossible.

Each collection comprises of the total catch of the day including all the fishes, crustaceans and cephalopods. For reasons described elsewhere (KAKUDA and ONBE, 1962), collections were made regularly from the two nets located at different distances from the shore, and occasionally from the two nets very close to the former. They are located off Terama, Kônoshima. In late October 1961 and April 1962, collections were made from a net near Kônoiwa rocks situated at the center of the bay and the two nets set just off the site of the faculty campus, respectively: these materials were used only as supplemental data for growth studies. The locations of the *masu-ami* investigated were shown in Text-fig. 1.

Length and weight measurements were done, in most cases, on all the materials obtained. In some cases, when several hundreds or thousands of individuals of a single species were caught, measurements were made on their random samples.

Hydrographical observations were carried out regularly on the date of collection at the stations where the nets in question were located for such items as air and water temperatures, chlorinity, dissolved oxygen, velocity and direction of surface currents, etc.

RESULTS

I. Environmental Conditions

Although the results of hydrographical observations made on each date of collection are given elsewhere in a graphic form (see Fig. 3, KAKUDA and ONBE, 1962), some basic features of the physical environment are reviewed here.

Water temperature is thoroughly subjected to air temperature because the bay is shallow. Seasonal variations in water temperature are, therefore, great ranging from 8° to 30°C. The lowest temperature was recorded in January, while the highest in August. Observations in February are lacking when the water temperature drops as low as 7°C. (MURAKAMI, 1954; MATSUDAIRA, KOYAMA and ENDO, 1961). Chlorinity varied from 12 to 18‰. Excepting the case in June, the rainly season, when surface chlorinity became as low as 12‰, changes in chlorinity were small in all depths throughout the year ranging from 16.5 to 18.3‰. Oxygen content in water was as high as 90% saturation or more irrespective of depths, except that in summer those of bottom water showed around 70–80% due to stratification.

II. A List of Species Found in the Catch

The fishes and other animals found in the catch of the *masu-ami* throughout the period of the present investigation are listed below, with indications of their abundance and season of occurrence. Abundance expressed in terms of number of individuals taken during the period is classified into the following six grades.

aa: very abundant, over 1,000 individuals
a: abundant, 500–999
cc: very common, 100–499
c: common, 10–99
r: rare, 2–9
rr: very rare, 1.

Eighty-three species of fishes belonging to 48 families are contained in the list, with 11 species of cephalopods belonging to 5 families, 11 species of crustaceans belonging to 3 families and 1 species of Xiphosura.

*1) Fishes**

Order Chondrichthyes

Family Triakidae

1. *Triakis scyllia* MÜLLER et HENLE — r, Aug.

Family Dasyatidae

2. *Dasyatis akajei* (MÜLLER et HENLE) — r, Aug.

Order Osteichthyes

Family Dorosomatidae

3. *Konosirus punctatus* (TEMMINCK et SCHLEGEL) — cc, May–Dec.

* Arrangement and nomenclature of each species according to MATSUBARA (1955).

Family Clupeidae

4. *Harengula zunasi* (BLEEKER) a, May–Nov.

Family Engraulidae

5. *Engraulis japonica* (HOUTTUYN) a, May–Sept., Nov.

Family Plecoglossidae

6. *Plecoglossus altivelis* TEMMINCK et SCHLEGEL c, Jan., May–June, Sept.

Family Synodontidae

7. *Saurida elongata* (TEMMINCK et SCHLEGEL) cc, June–Nov.

Family Anguillidae

8. *Anguilla japonica* TEMMINCK et SCHLEGEL c, Aug.–Sept., Nov.–Dec.

Family Congridae

9. *Conger japonicus* BLEEKER rr, Aug.
10. *Astroconger myriaster* (BREVOORT) c, June–Jan.

Family Belonidae

11. *Ablennes anastomella* (CUVIER et VALENCIENNES) r, May–June
12. *Tylosurus melanotus* (BLEEKER) r, Sept.

Family Scombresocidae

13. *Cololabis saira* (BREVOORT) rr, July

Family Hemiramphidae

14. *Hemiramphus sajori* (TEMMINCK et SCHLEGEL) r, May–June

Family Exocoetidae

15. *Cypselurus starksi* ABE c, June–July

Family Atherinidae

16. *Allanetta bleekeri* (GÜNTHER) aa, May–Sept.
17. *Hypoatherina tsurugae* (JORDAN et STARKS) r, June

Family Mugilidae

18. *Mugil cephalus* LINNÉ c, May–Jan.
19. *Liza haematocheila* (TEMMINCK et SCHLEGEL) c, June–Sept., Nov.–Dec.

Family Sphyraenidae

20. *Sphyraena pinguis* GÜNTHER c, June–Oct.

Family Scombridae

21. *Scomberomorus niphonius* (CUVIER et VALENCIENNES) rr, Aug.

Family Trichiuridae

22. *Trichiurus leptulus* LINNÉ cc, May–Dec.

Family Carangidae

23. *Decapterus maruadsi* (TEMMINCK et SCHLEGEL) aa, July–Oct.
24. *Trachurus japonicus* (TEMMINCK et SCHLEGEL) c, June–July
25. *Seriola quinqueradiata* TEMMINCK et SCHLEGEL r, July

Family Leiognathidae

26. *Leiognathus nuchalis* (TEMMINCK et SCHLEGEL) aa, May–Dec.

27.	*Leiognatus rivulatus* (TEMMINCK et SCHLEGEL)	rr, May
	Family Menidae	
28.	*Mene maculata* (BLOCH et SCHNEIDER)	rr, Sept.
	Family Stromateidae	
29.	*Psenopsis anomala* (TEMMINCK et SCHLEGEL)	c, Aug.
	Family Pampidae	
30.	*Pampus argenteus* (EUPHRASEN)	r, June–July, Sept.–Oct.
	Family Apogonidae	
31.	*Apogon lineatus* (TEMMINCK et SCHLEGEL)	aa, May–Jan.
	Family Serranidae	
32.	*Lateolabrax japonicus* (CUVIER)	aa, June–Dec.
33.	*Lateolabrax latus* KATAYAMA	rr, June
	Family Sciaenidae	
34.	*Nibea albiflora* (RICHARDSON)	rr, Sept.
35.	*Argyrosomus argentatus* (HOUTTUYN)	a, May–Nov.
	Family Sillaginidae	
36.	*Sillago sihama* (FORSKÅL)	cc, May–Dec.
	Family Sparidae	
37.	*Mylio macrocephalus* (BASILEWSKY)	cc, May–Dec.
38.	*Mylio latus* (HOUTTUYN)	r, June, Nov.
39.	*Chrysophrys major* TEMMINCK et SCHLEGEL	c, Aug.–Oct.
	Family Pomadasyidae	
40.	*Hapalogenys mucronatus* (EYDOUX et SOULEYET)	rr, May
41.	*Plectorhynchus cinctus* (TEMMINCK et SCHLEGEL)	r, Sept.–Oct.
	Family Theraponidae	
42.	*Therapon oxyrynchus* TEMMINCK et SCHLEGEL	c, June–July, Oct.
43.	*Therapon jarbua* (FORSKÅL)	r, Oct., Dec.
	Family Callionymidae	
44.	*Callionymus lunatus* TEMMINCK et SCHLEGEL	c, Aug.
45.	*Callionymus richardsoni* BLEEKER	cc, May–Dec.
46.	*Callionymus flagris* JORDAN et FOWLER	r, May, Sept.
	Family Pholidae	
47.	*Enedrias nebulosus* (TEMMINCK et SCHLEGEL)	r, Nov.–Jan.
	Family Gobiidae	
48.	*Tridentiger trigonocephalus* (GILL)	r, Dec.
49.	*Rhinogobius pflaumi* (BLEEKER)	c, July–Dec.
50.	*Cryptocentrus filifer* (CUVIER et VALENCIENNES)	r, June–July, Sept.
51.	*Acanthogobius flavimanus* (TEMMINCK et SCHLEGEL)	cc, May–Jan.
52.	*Glossogobius giurus brunneus* (TEMMINCK et SCHLEGEL)	c, July–Dec.
53.	*Parachaeturichthys polynema* (BLEEKER)	r, June, Nov.–Dec.
54.	*Chaeturichthys hexanema* BLEEKER	r, Dec.

Family Embiotocidae

55. *Ditrema temmincki* BLEEKER c, June, Aug.–Jan.

Family Labridae

56. *Halichoeres poecilopterus* (TEMMINCK et SCHLEGEL) c, May–Dec.

Family Siganidae

57. *Siganus fuscescens* (HOUTTUYN) r, Oct., Dec.

Family Aluteridae

58. *Rudarius ercodes* JORDAN et FOWLER a, June, Aug.–Jan.
59. *Navodon modestus* (GÜNTHER) c, July–Oct.

Family Tetraodontidae

60. *Lagocephalus lunaris* (BLOCH et SCHNEIDER) rr, Sept.
61. *Fugu xanthopterus* (TEMMINCK et SCHLEGEL) r, June
62. *Fugu rubripes* (TEMMINCK et SCHLEGEL) c, July–Aug.
63. *Fugu niphobles* (JORDAN et SNYDER) c, June–Jan.
64. *Fugu poecilonotus* (TEMMINCK et SCHLEGEL) c, Nov.–Dec.
65. *Fugu pardalis* (TEMMINCK et SCHLEGEL) c, May–June, Sept.–Oct., Dec.

Family Scorpaenidae

66. *Sebastes inermis* CUVIER et VALENCIENNES cc, May–Jan.
67. *Sebastes oblongus* GÜNTHER c, May–July, Oct.–Jan.
68. *Sebastes pachycephalus nigricans* (SCHMIDT) r, Dec.–Jan.
69. *Sebastiscus marmoratus* (CUVIER et VALENCIENNES) rr, Jan.

Family Synanceiidae

70. *Minous monodactylus* (BLOCH et SCHNEIDER) r, June
71. *Inimicus japonicus* (CUVIER et VALENCIENNES) r, June, Sept., Dec.

Family Congiopodidae

72. *Hypodytes rubripinnis* (TEMMINCK et SCHLEGEL) r, May–July

Family Hexagrammidae

73. *Hexagrammos otakii* JORDAN et STARKS cc, June–Sept.

Family Platycephalidae

74. *Cociella crocodila* (TILESIUS) r, Sept.–Nov.
75. *Platycephalus indicus* (LINNÉ) c, May–Dec.

Family Cottidae

76. *Pseudoblennius cottoides* (RICHARDSON) c, May–Aug., Nov.–Dec.

Family Bothidae

77. *Pseudorhombus pentophthalmus* GÜNTHER r, May–June

Family Pleuronectidae

78. *Verasper variegatus* (TEMMINCK et SCHLEGEL) r, July, Dec.
79. *Pleuronichthys cornutus* (TEMMINCK et SCHLEGEL) c, May–Aug., Oct.
80. *Limanda yokohamae* (GÜNTHER) cc, May–Aug., Oct.–Dec.
81. *Kareius bicoloratus* (BASILEWSKY) cc, May–Sept., Dec.

Family Soleidae

82.	*Zebrias japonicus* (BLEEKER)	rr, Dec.
	Family Cynoglossidae	
83.	*Areliscus joyneri* (GÜNTHER)	r, May, Dec.

2) *Cephalopods*

Order Octopoda

	Family Octopodidae	
1.	*Octopus vulgaris* CUVIER	c, July–Aug., Oct.–Dec.
2.	*Octopus ocellatus* GRAY	rr, June
3.	*Octopus minor variabilis* (SASAKI)	c, May–Aug., Dec.

Order Decapoda

	Family Sepiidae	
4.	*Sepia esculenta* HOYLE	c, May–Oct., Dec.
5.	*Sepia subaculeata* SASAKI	r, May–June, Aug.
6.	*Sepiella japonica* SASAKI	aa, May–June, Aug.–Nov.
	Family Loliginidae	
7.	*Loligo japonica* HOYLE	aa, June–Dec.
8.	*Loligo kobiensis* HOYLE	cc, May–July
9.	*Sepioteuthis lessoniana* LESSON	c, July–Nov.
	Family Sepiolidae	
10.	*Euprymna morsei* VERRILL	cc, May–Sept., Nov.–Jan.
	Family Ommastrephidae	
11.	*Ommastrephes sloanei pacificus* (STEENSTRUP)	r, June

3) *Crustaceans*

Order Decapoda

Suborder Brachyura

	Family Portunidae	
1.	*Charybdis japonica* (A. MILNE-EDWARDS)	cc, May–Jan.
2.	*Portunus hastatoides* (FABRICIUS)	c, July–Aug., Oct., Dec.
3.	*Portunus trituberculatus* MIERS	c, July, Sept.–Oct., Dec.

Suborder Macrura

	Family Penaeidae	
4.	*Trachypenaeus curvirostris* (STIMPSON)	c, June–Oct., Dec.
5.	*Metapenaeopsis barbata* (de HAAN)	c, June–Oct., Dec.
6.	*Metapenaeus monoceros* (FABRICIUS)	a, May–Dec.
7.	*Metapenaeus joyneri* (MIERS)	cc, June–Dec.
8.	*Penaeus semisulcatus* de HAAN	cc, June–Nov.
9.	*Penaeus japonicus* BATE	c, May–Dec.

Order Stomatopoda

	Family Squillidae	
10.	*Squilla oratoria* de HAAN	cc, June–Dec.

11. *Squilla fasciata* de HAAN rr, Aug.

4) *Xiphosura*

Family Tachypleidae

1. *Tachypleus tridentatus* (LEACH) r, Sept.

III. Composition of the Catch

Sixty-seven hauls were made in 37 days of investigation from June 1961 to June 1962, excluding the period February–April. A wide variety of species was obtained as seen in the foregoing list, and the catch for all hauls totaled 26, 214.

Monthly fluctuations in the average catch per haul are tabulated in Table 1, in which the animals taken are grouped into fishes, cephalopods and crustaceans. It can be noted from this table that the catch was greater in summer months than in other seasons. It is further shown that the fishes dominated in number and mass. Cephalopods ranked second and crustaceans comprised the residual component. Average percent numbers per haul of these three components were 82.3, 10.6 and 7.1, respectively, while the percent weights were 71.4, 17.0 and 11.5 in average, respectively.

Table 1. Monthly fluctuations in the catch per haul of *masu-ami*.

Month	Number of individuals				Weight (g.)			
	Fishes	Cephlopods	Crustaceans	Total	Fishes	Cephalopods	Crustaceans	Total
June, '61	132. 0	7. 5	55. 0	194. 5	3, 532. 6	1, 533. 4	1, 296. 6	6, 362. 6
July, 〃	304. 4	13. 4	80. 8	398. 6	6, 329. 0	1, 580. 8	1, 712. 5	9, 622. 3
Aug., 〃	1, 134. 3	133. 3	19. 0	1, 286. 6	9, 170. 9	1, 280. 0	398. 9	10, 849. 8
Sept., 〃	322. 3	87. 3	19. 1	428. 7	6, 999. 5	1, 079, 9	511. 6	8, 591. 0
Oct., 〃	171. 9	9. 1	23. 1	204. 1	4, 214. 7	218. 4	478. 6	4, 911. 7
Nov., 〃	208. 0	14. 9	13. 4	236. 3	2, 852. 5	173. 3	606. 7	3, 632. 5
Dec., 〃	273. 9	91. 4	30. 5	395. 8	3, 712. 5	1, 475. 6	1, 609. 7	6, 797. 8
Jan., '62	132. 0	4. 0	3. 0	139. 0	1, 660. 0	18. 9	166. 0	1, 844. 9
May, 〃	124. 4	5. 2	1. 0	130. 6	2, 516. 0	1, 478. 0	14. 4	4, 008. 4
June, 〃	95. 6	7. 4	5. 6	108. 6	1, 767. 6	1, 366. 8	106. 8	3, 241. 2
Mean	289. 9	37. 4	25. 1	352. 3	4, 275. 5	1, 020. 5	690. 2	5, 986. 2
%	82. 3	10. 6	7. 1	100. 0	71. 4	17. 0	11. 5	99. 9

Details of the species composition of the catch are presented in Table 2. *Decapterus maruadsi* (a kind of scad) was the most numerous fish captured. More than 7,000 were obtained in only 21 hauls. *Apogon lineatus* (the cardinal fish) which ranked second in number of fish was taken in almost all hauls. The third numerous fish, *Lateolabrax japonicus*, occurred in 43 hauls.

These three numerous species and *Argyrosomus argentatus* which ranked eighth in number of fish are to be described in some detail in the next section.

Table 2. Catch of 67 hauls of *masu-ami* from June 1961 to June 1962.

Species	Total number	Frequency of occurrence	Number per haul
I. Fishes			
1. *Decapterus maruadsi*	7, 136	21	106. 7
2. *Apogon lineatus*	3, 170	62	47. 3
3. *Lateolabrax japonicus*	2, 562	43	38. 2
4. *Leiognathus nuchalis*	1, 699	60	25. 4
5. *Allanetta bleekeri*	1, 020	33	15. 2
6. *Engraulis japonica*	801	20	12. 0
7. *Rudarius ercodes*	662	29	9. 9
8. *Argyrosomus argentatus*	567	33	8. 5
9. *Harengula zunasi*	523	41	7. 8
10. *Limanda yokohamae*	323	31	4. 8
11. *Kareius bicoloratus*	281	34	4. 2
12. *Mylio macrocephalus*	271	35	4. 0
13. *Acanthogobius flavimanus*	261	39	3. 9
14. *Konosirus punctatus*	239	41	3. 6
15. *Sebastes inermis*	205	34	3. 1
16. *Saurida elongata*	174	25	2. 6
17. *Hexagrammos otakii*	148	21	2. 2
18. *Trichiurus lepturus*	132	25	2. 0
19. *Sillago sihama*	125	41	1. 9
20. *Callionymus richardsoni*	107	43	1. 6
21. *Sphyraena pinguis*	99	20	1. 5
22. *Mugil cephalus*	86	24	1. 3
23. *Ditrema temmincki*	71	22	1. 1
24. *Fugu niphobles*	65	26	1. 0
25. *Platycephalus indicus*	61	30	0. 9
26. *Liza haematocheila*	52	16	0. 8
27. *Pseudoblennius cottoides*	51	18	0. 8
28. *Astroconger myriaster*	48	30	0. 7
29. *Chrysophrys major*	39	10	0. 6
30. *Sebastes oblongus*	38	20	0. 6
Others (53 spp.)	387		
II. Cephalopods			
1. *Sepiella japonica*	1, 371	31	20. 5
2. *Loligo japonica*	1, 188	36	17. 7
3. *Euprymna morsei*	205	26	3. 1
4. *Loligo kobiensis*	111	22	1. 7
5. *Sepioteuthis lessoniana*	40	15	0. 6
Others (6 spp.)	94		
III. Crustaceans			
1. *Metapenaeus monoceros*	780	41	11. 6
2. *Squilla oratoria*	326	43	4. 9
3. *Charybdis japonica*	250	51	3. 7
4. *Metapenaeus joyneri*	148	32	2. 2
5. *Penaeus semisulcatus*	125	28	1. 9
Others (6 spp.)	171		
IV. Xiphosura			
1. *Tachypleus tridentatus*	2	2	1

In animals other than fishes, a cuttlefish, *Sepiella japonica*, a squid, *Loligo japonica*, and a penaeid shrimp, *Metapenaeus monoceros*, were most numerous in the catch of *masu-ami*.

IV. Ecological Notes on Some Abundant Fishes of Kasaoka Bay

As shown in the foregoing list and Table 2, the fishes caught abundantly or very abundantly were represented by only 9 species. They were the most conspicuous members of the catch of *masu-ami*. In this spection, 4 species of them will be treated with from an ecological standpoint. Accounts of growth and weight-length relationship of each species are based on measurement investigations*.

1) *Apogon lineatus* (TEMMINCK et SCHLEGEL)

Apogon lineatus seems to be a typical year-round "resident" in Kasaoka Bay. The occurrence of this species in the catch of *masu-ami* extended all over the period of the present investigation (Text-fig. 3A). Number per haul, however, changed with season. There were two major peaks in occurrence, namely in May–August and in November–December. The fish corresponding to the peak in May–August was larger in size than that in November–December, as shown in Table 3. It was understood from more detailed observations that the larger group in spring and summer seasons consisted of the spawners of 1-age, while the smaller one in fall and winter was the offspring of the former.

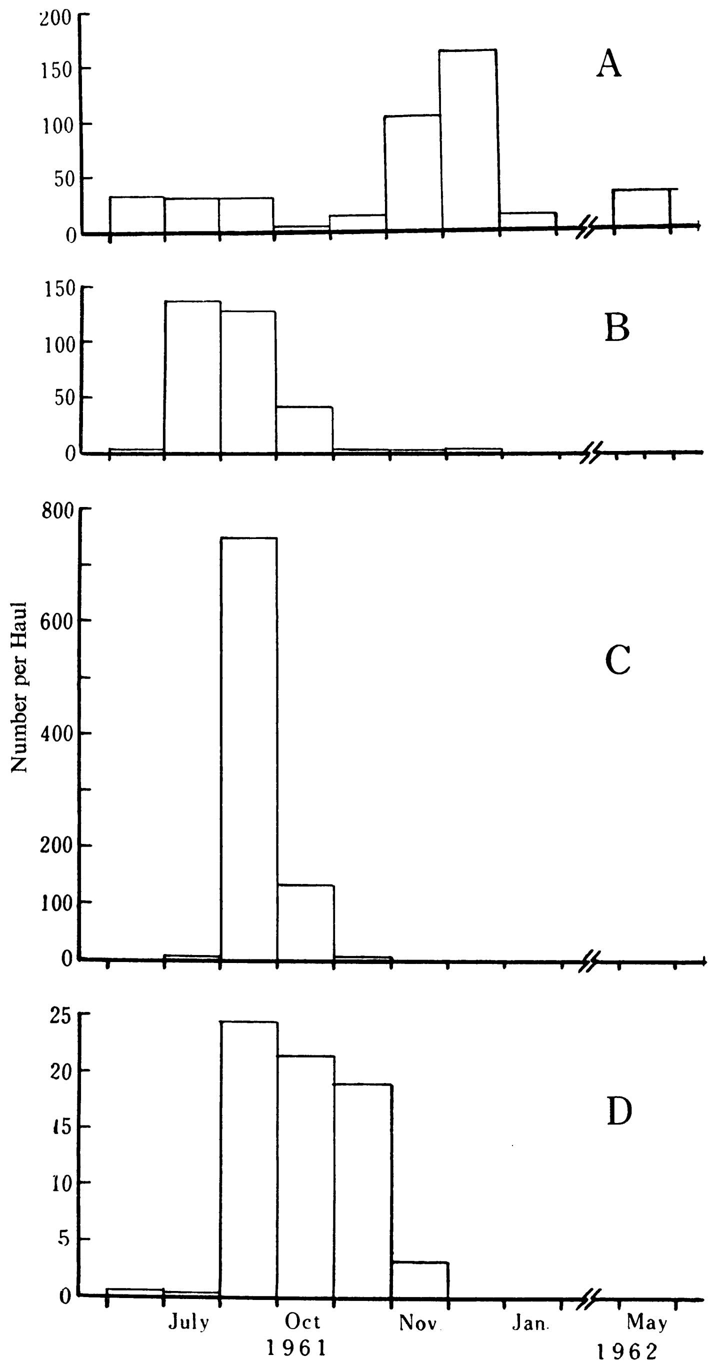
Growth curve of *Apogon lineatus* is presented in Text-fig. 4. The smaller fish first appeared in the September-19 sample. The rate of growth through fall and winter was rather retarded. Until May next year no significant increase in length and weight could be observed. A very rapid growth occurred from late June to late July, which is probably a reflection of rapid body development associated with maturity.

YAMADA (1957a) studied the same species of *Apogon* of Ômura Bay, western Kyûshû. In Text-fig. 4, his data are placed in juxtaposition with the present results. The growth processes of these two data agree well with each other, indicating a striking similarity in growth rate despite of the difference in sources from which these data were derived.

From the results of monthly changes in the mean length, it may be concluded that the life-span of *Apogon lineatus* of Kasaoka Bay is annual or a little more than that, which is essentially the same as YAMADA has already postulated on Ômura Bay samples.

In order to know weight-length relationship, standard length measurements were grouped into 2 mm. intervals, and the average weight was calculated for the midpoint of each interval. The regression of weight in grams on length in millimeters was then determined by the method of least squares using the exponential equation $W = cL^n$ in its logarithmic form. The resulting weight-length formula was

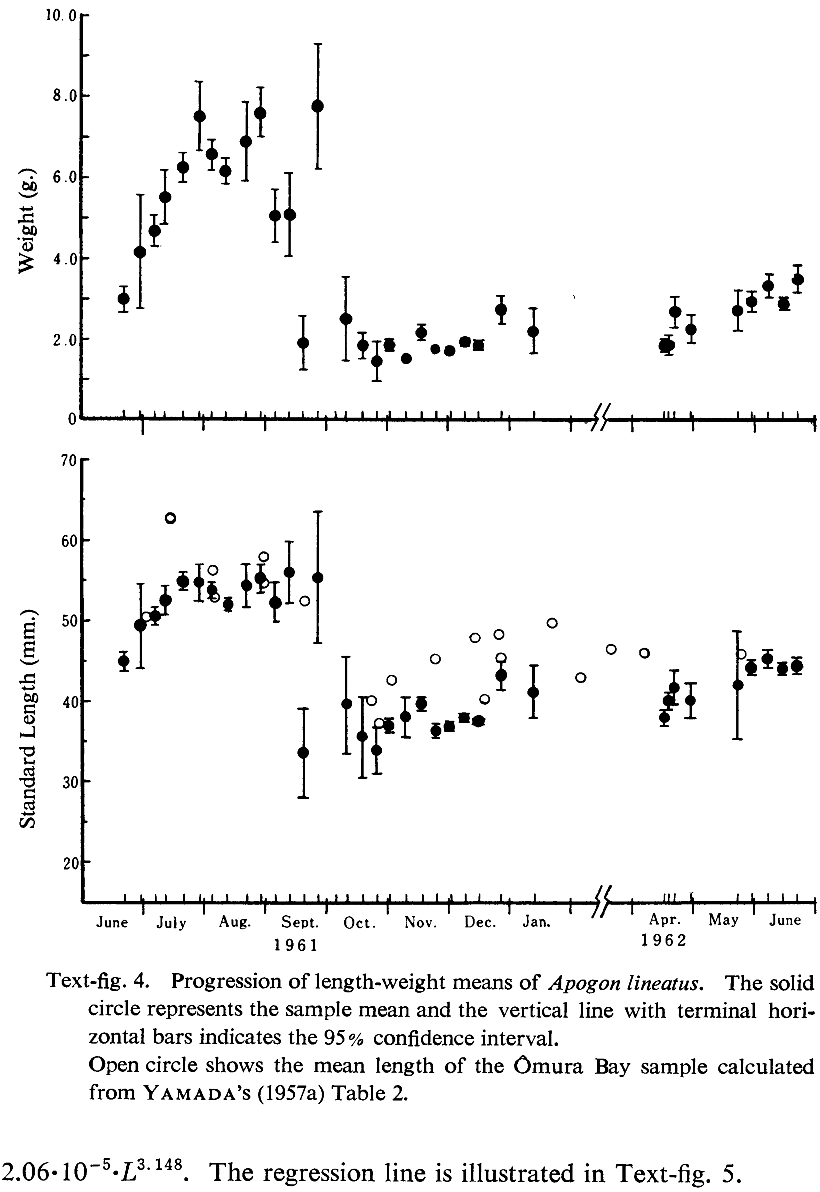
* The standard length taken is the distance from anterior tip of snout to the end of hypural. The latter point is determined by bending the caudal fin sidewise at a sharp angle, noting the crease thus formed.



Text-fig. 3. Monthly changes in number per haul of 4 abundant species of fishes.
A: *Apogon lineatus*, B: *Lateolabrax japonicus*,
C: *Decapterus maruadsi*, D: *Argyrosomus argentatus*.

Table 3. Length-weight measurement of *Apogon lineatus* on each sampling date, 1961–1962.

Date of sampling	Sample size	Standard length (mm.)		Weight (g.)	
		Range	Mean±95% conf. int.	Range	Mean±95% conf. int.
June 21, '61	58	36—62	44.9±1.36	1.7— 8.1	2.98±0.327
29	9	43—61	49.3±5.22	2.5— 8.7	4.17±1.411
July 6	61	43—62	50.5±1.24	2.6— 8.7	4.68±0.390
11	44	44—69	52.5±1.78	2.7—12.5	5.50±0.681
20	106	43—65	54.8±1.03	2.8—11.1	6.24±0.367
28	33	44—67	54.7±2.35	4 —13	7.5 ±0.85
Aug. 4	109	45—65	53.7±0.99	3 —12	6.6 ±0.37
11	98	43—64	51.8±0.98	3 —10	6.1 ±0.31
21	16	44—62	54.3±2.70	3 —10	6.9 ±0.97
28	23	49—62	55.3±1.78	5 —10	7.6 ±0.60
Sept. 5	17	44—63	52.2±2.46	3 — 8	5.0 ±0.68
12	9	48—63	56.0±3.77	2 — 7	5.1 ±1.33
19	5	29—39	33.6±5.66	1 — 2	1.9 ±0.68
26	4	53—63	55.3±8.22	6 — 8	7.8 ±1.52
Oct. 5	—	—	—	—	—
10	10	28—55	39.6±5.95	0.5— 5	2.5 ±1.22
18	78	22—66	35.6±4.98	0.3— 7.5	1.81±0.332
25	26	24—51	33.9±2.79	0.4— 4.9	1.42±0.456
Nov. 1	258	22—58	37.0±0.81	0.3— 7.7	1.83±0.133
9	6	35—39	38.0±2.53	1.2— 1.9	1.50±0.000
17	124	28—52	39.7±0.84	0.8— 4.8	2.16±0.183
24	123	28—49	36.4±0.77	0.7— 4.3	1.78±0.128
Dec. 1	253	26—50	36.9±0.61	0.6— 4.7	1.71±0.095
8	245	29—53	38.0±0.57	0.8— 5.9	1.92±0.097
15	503	25—50	37.5±0.40	0.6— 4.4	1.83±0.068
26	35	33—54	43.3±1.81	1.2— 5.5	2.73±0.354
Jan. 12, '62	13	32—46	41.2±3.33	0.9— 2.9	2.19±0.573
Apr. 16	94	30—50	38.0±0.93	0.8— 4.0	1.84±0.143
18	77	31—58	40.2±1.17	0.8— 5.9	1.79±0.200
21	30	31—54	41.9±2.19	1.3— 5.0	2.67±0.381
30	26	31—52	40.2±2.17	1.0— 4.4	2.23±0.334
May 22	20	35—52	42.2±6.78	1.5— 5.5	2.70±0.506
29	110	33—62	44.3±1.11	1 —10	2.9 ±0.25
June 7	92	32—58	45.4±1.23	1.0— 7.0	3.26±0.288
14	120	35—57	44.2±0.73	1.5— 6.0	2.87±0.162
21	73	35—62	44.6±1.27	1.5— 9.5	3.48±0.339



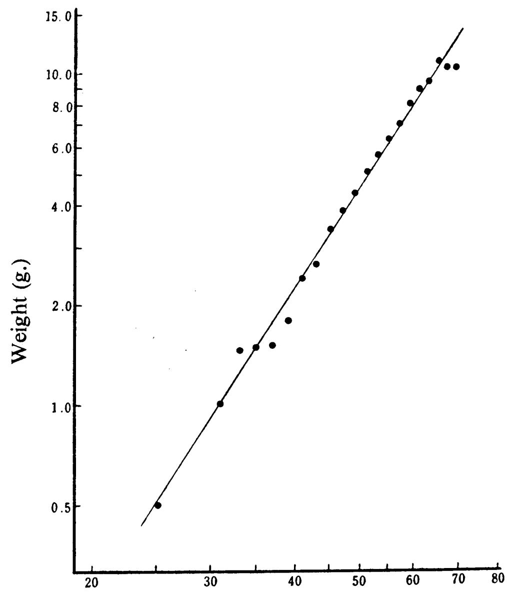
Text-fig. 4. Progression of length-weight means of *Apogon lineatus*. The solid circle represents the sample mean and the vertical line with terminal horizontal bars indicates the 95% confidence interval.
Open circle shows the mean length of the Ômura Bay sample calculated from YAMADA's (1957a) Table 2.

$W=2.06 \cdot 10^{-5} \cdot L^{3.148}$. The regression line is illustrated in Text-fig. 5.

2) *Lateolabrax japonicus* (CUVIER)

One of the most conspicuous species found in the catch was *Lateolabrax japonicus*, a kind of the sea-bass. The fish appeared for successive six months from late June to late December 1961. Monthly changes in number per haul showed that about 96% were taken in the months July–September, the other months' catch reaching only 4% (Text-fig. 3B).

It is noteworthy that the fish thus appeared in the catch were all composed of young of 0-age group, each sample of which consisted of fish of considerably similar



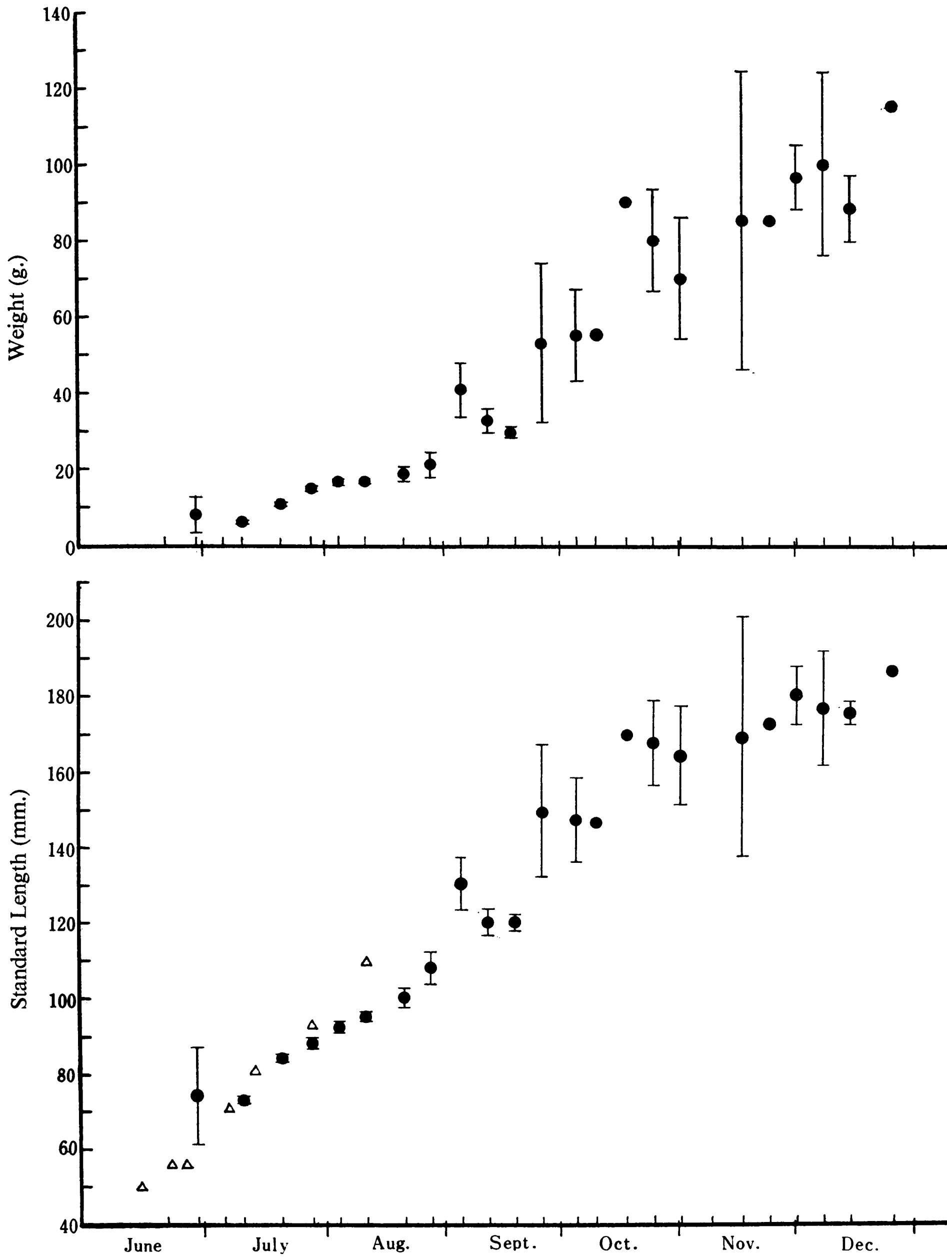
Text-fig. 5. Weight-length relationship of *Apogon lineatus*.

Table 4. Length-weight measurement of *Lateolabrax japonicus* on each sampling date, 1961.

Date of sampling	Sample size	Standard length (mm.)		Weight (g.)	
		Range	Mean±95% conf. int.	Range	Mean±95% conf. int.
June 21	—	—	—	—	—
29	10	61—118	74.2±13.01	4—24	8.0±4.84
July 6	—	—	—	—	—
11	212	60—88	73.2±0.81	3—12	5.9±0.31
20	182	60—113	84.2±1.24	5—27	10.8±0.67
28	220	66—137	88.3±1.68	6—48	15.1±0.98
Aug. 4	237	69—147	92.7±1.49	7—61	16.5±0.98
11	189	74—138	95.4±1.43	8—41	16.8±0.83
21	128	82—190	100.3±2.64	9—122	18.8±2.05
28	57	81—165	108.3±4.34	8—71	21.0±3.20
Sept. 5	68	100—200	130.7±6.92	14—120	40.6±7.20
12	121	84—188	120.6±3.64	10—110	32.4±3.30
19	123	94—155	120.5±2.31	14—65	29.3±1.74
26	5	133—167	149.6±17.44	39—66	53.0±21.23
Oct. 5	12	104—161	147.5±10.88	19—81	55.0±12.12
10	2	132—162	147.0	33—75	55.0
18	2	168—172	170.0	81—91	90.0
25	10	150—190	168.0±11.21	63—115	80.0±13.59
Nov. 1	4	154—174	164.5±13.02	58—75	70.0±15.91
9	—	—	—	—	—
17	4	143—191	169.5±31.73	50—117	85.0±38.97
24	2	164—182	173.0	69—102	85.0
Dec. 1	7	171—192	180.6±7.26	80—102	96.4±8.33
8	12	147—230	177.0±14.81	55—196	100.0±24.00
15	21	152—190	176.0±2.85	58—115	88.3±7.83
26	4	173—207	187.3	85—154	115.0

size and weight. In Table 4, results of measurement of *Lateolabrax japonicus* are shown.

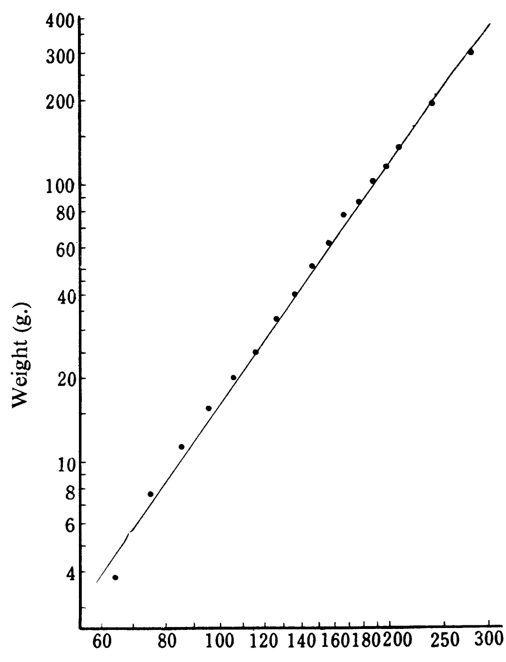
The growth process of the 0-age *Lateolabrax* can be readily observed from Text-fig. 6. It is clear that, during the period from June to December, it increased



Text-fig. 6. Progression of length-weight means of *Lateolabrax japonicus*.
For explanation, see legends of Text-fig. 4.
OHSHIMA's (1954) data are shown with open triangles.

about 115 mm. in size (an increase of 2.6 times of the initial length) and weight, about 95 g. (an increase of 20 times). In Text-fig. 6 the data obtained by OHSHIMA (1954), who studied the fish in *Zostera* zones in Mikawa Bay, central Japan, are also plotted in comparison with the present data. The slight discrepancy between the two may be due to the regional differences in growth rate.

Mean weight was calculated for each 10-mm. interval of standard length. A straight line relationship resulted from plotting these values on a double logarithmic paper (Text-fig. 7) was expressed as $W=2.39\cdot10^{-5}\cdot L^{2.918}$. The regression line fits the data comparatively well.



Text-fig. 7. Weight-length relationship of *Lateolabrax japonicus*.

OHSHIMA (1954) found that the young of *Lateolabrax japonicus* live their early life in *Zostera* region from late February to late September. Since *masu-ami* is usually located at the boundary of, or at least very close to, the *Zostera* region, it is possible that the young fish coming around or gathering in the region are easily trapped by the net. A sudden decrease in number per haul from late September to October may perhaps be attributable to the exit of the fish from the *Zostera* region nearby. From this period downward, the majority of *Lateolabrax japonicus* will leave the bay to enter into their new lives in the open area. The fact that no adult fish has been captured by the *masu-ami* in this investigation gives support to such an assumption.

It shoud be stated here that one specimen of *Lateolabrax latus* KATAYAMA, another recently described serranid (KATAYAMA, 1957) which is very closely related to *Lateolabrax japonicus*, was captured on June 21, 1962. It is certain that this species is very uncommon in Kasaoka Bay and the possible ecological differences between these two species of *Lateolabrax* have not been clarified yet.

3) *Decapterus maruadsi* (TEMMINCK et SCHLEGEL)

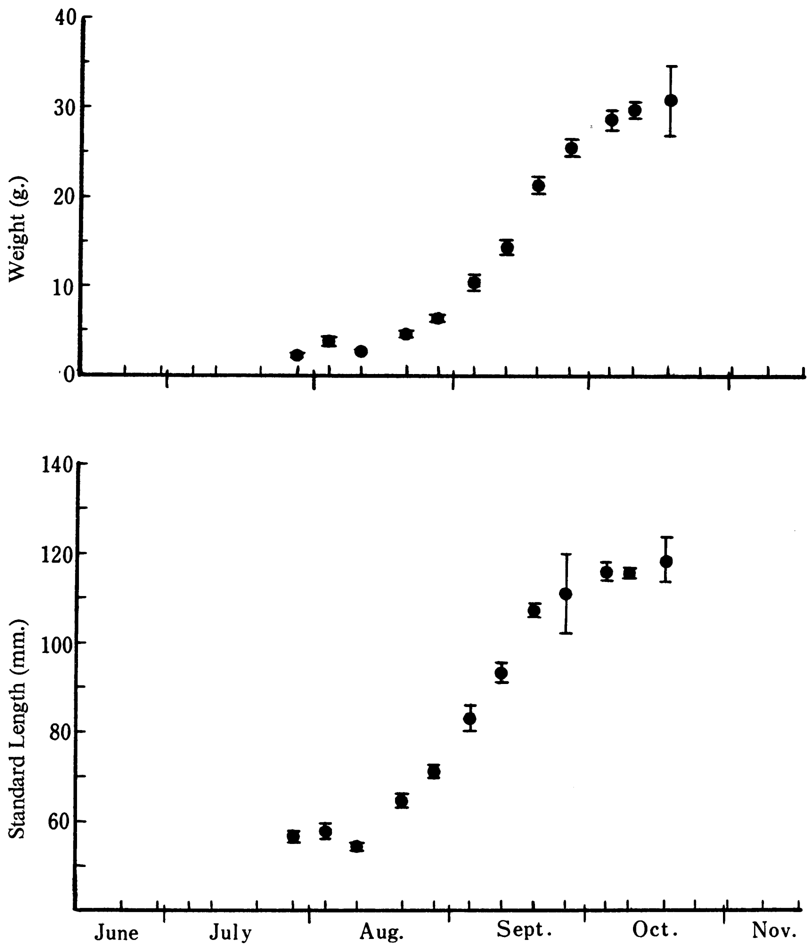
The carangid species appeared were represented by only three species; namely, *Decapterus maruadsi* (a kind of scad), *Trachurus japonicus* (the common jack-macherel) and *Seriola quinqueradiata* (the yellowtail). Though it is the commonest and the most important carangid in the waters adjacent to Japan, *Trachurus japonicus* occurred in a very small number in the present investigation. *Seriola quinqueradiata* was also an infrequent visitor to this area. On the other hand, *Decapterus maruadsi* was the most numerous fish of all the species found in the catch of *masu-ami* (see Table 2). The occurrence, however, was limited to only four months from July to October. Changes in the number per haul are shown in Text-fig. 3C, from which it can be seen that nearly all the fish (98.8%) were caught in only two months, August–September.

As observed from Table 5 and Text-fig. 8, the fish first appeared in early July as young of 56.3 mm. in mean length and of 2.23 g. in mean weight. The rate of growth thereafter was strikingly great, especially in September. Retardation of growth occurred in October, and late in that month the fish disappeared completely from the catch. On October 18, they attained an average length of 118.1 mm., weighing 31.0 g.

Table 5. Length-weight measurement of *Decapterus maruadsi* on each sampling date, 1961.

Date of sampling	Sample size	Standard length (mm.)		Weight (g.)	
		Range	Mean±95% conf. lim.	Range	Mean±95% conf. lim.
July 28	33	49— 61	56. 3±1. 26	2. 2— 4. 1	2. 23±0. 323
Aug. 4	63	44— 78	57. 2±2. 03	1. 4— 9. 2	3. 78±0. 576
11	213	34— 77	54. 1±1. 07	0. 7— 8. 4	2. 68±0. 209
21	233	39— 91	64. 4±1. 54	0. 7—12. 8	4. 63±0. 366
28	106	50— 87	70. 9±1. 45	2. 3—11. 4	6. 26±0. 402
Sept. 5	72	44—112	82. 9±3. 04	2 —21	10. 3 ±0. 98
12	75	74—111	93. 1±2. 53	5 —22	14. 3 ±1. 11
19	67	94—120	107. 1±1. 78	9 —30	21. 2 ±0. 96
26	80	68—121	110. 9±8. 98	6 —32	25. 4 ±1. 15
Oct. 5	47	100—132	116. 0±2. 22	20 —38	28. 6 ±1. 16
10	106	92—130	115. 5±1. 36	15 —43	30. 0 ±1. 02
18	25	88—134	118. 1±4. 58	12 —47	31. 0 ±3. 82

The relationship between weight and length was obtained by treating with the weight-length data in the same way as done in the foregoing species. Mean weight calculated was for each 2-mm. interval of standard length. The formula expressing



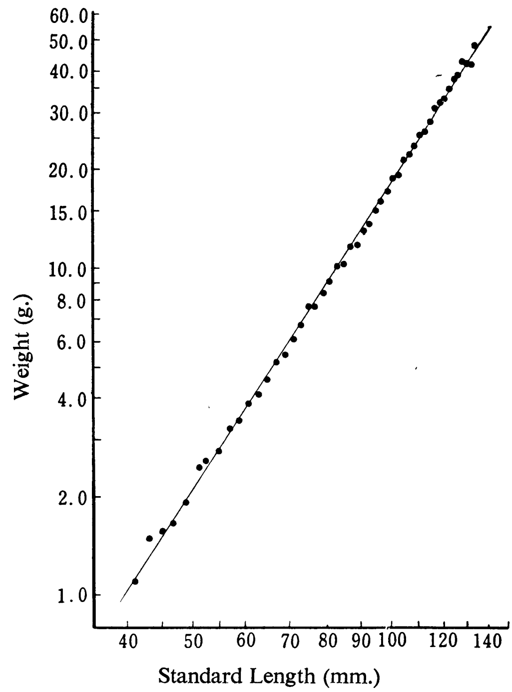
Text-fig. 8. Progression of length-weight means of *Decapterus maruadsi*. For explanation, see legends of Text-fig. 4.

the relation was $W=1.13\cdot10^{-5}\cdot L^{3.101}$ (Text-fig. 9).

4) *Argyrosomus argentatus* (Houttuyn)

The fishes belonging to the family Sciaenidae are known as demersal fishes. The commonest sciaenid in the Inland Sea is *Argyrosomus argentatus* (a kind of croaker). In the catch of *masu-ami*, several individuals of larger fish, probably of 1-age group, were sporadically obtained in June and in July. From August to November, however, a considerable large number of young *Argyrosomus* appeared. Monthly changes in occurrence are illustrated in Text-fig. 3D. About 94% of the total were captured during the three successive months, August–October.

Beginning in early August, when the first new-born group were taken, an increase in length and weight took place that was maintained till October, as seen from Table 6 and Text-fig. 10. The rate dropped down in November when the

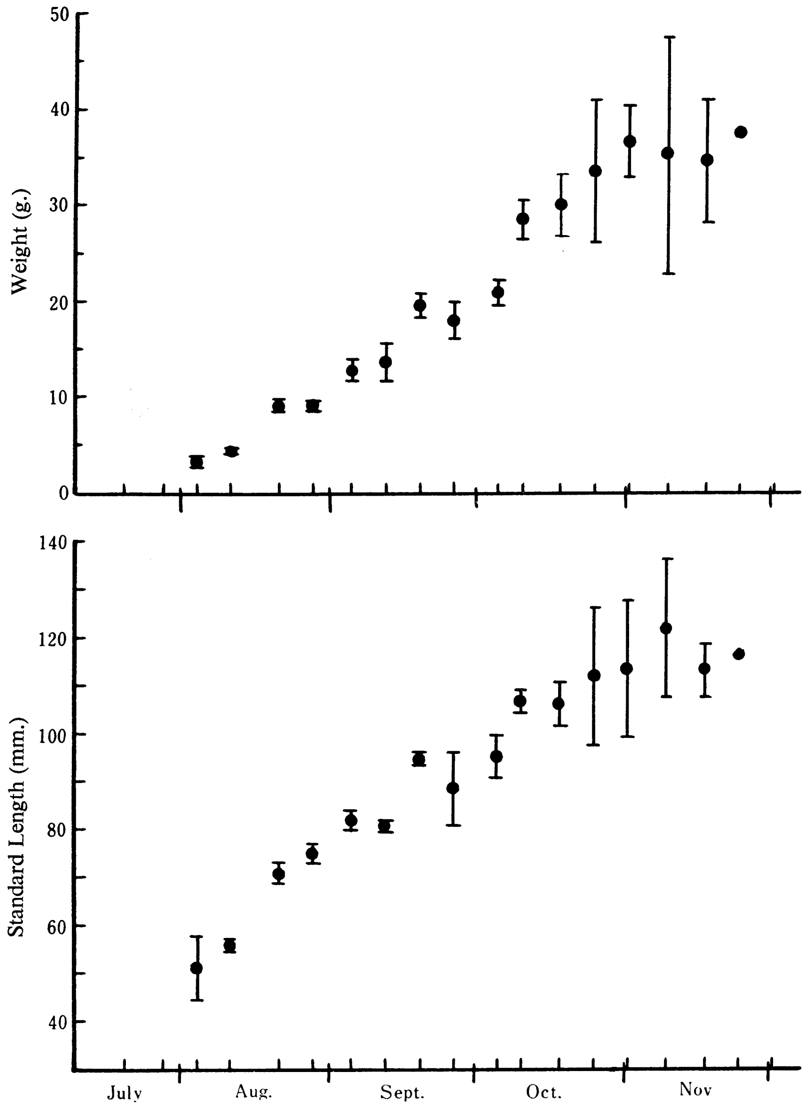


Text-fig. 9. Weight-length relationship of *Decapterus maruadsi.*

number per haul sharply decreased. From December onward the fish disappeared completely from the catch.

Table 6. Length-weight measurement of *Argyrosomus argentatus* on each sampling date, 1961.

Date of sampling	Sample size	Standard length (mm.)		Weight (g.)	
		Range	Mean±95% conf. lim.	Range	Mean±95% conf. lim.
Aug. 4	5	43— 55	51.0± 6.80	2.0— 3.9	3.10± 0.680
11	57	46— 68	55.4± 1.58	2.3— 7.7	4.41± 0.302
21	28	62— 80	70.7± 2.46	5 —12	9.0 ± 0.76
28	57	50— 90	74.8± 2.21	2 —14	8.9 ± 0.79
Sept. 5	60	54— 96	81.7± 2.21	4 —19	12.7 ± 0.90
12	34	55—105	80.6± 0.89	5 —27	13.7 ± 2.11
19	42	75—106	94.5± 1.43	10 —28	19.5 ± 1.36
26	36	68—105	88.3± 7.88	8 —26	17.9 ± 1.98
Oct. 5	87	82—120	95.0± 4.53	12 —39	20.8 ± 1.36
10	33	92—115	106.5± 2.68	17 —35	28.5 ± 2.12
18	29	88—121	106.0± 4.59	17 —43	29.9 ± 3.16
25	3	105—114	111.7±14.38	30 —36	33.5 ± 7.45
Nov. 1	13	101—127	113.1±14.07	27 —45	36.6 ± 3.79
9	3	110—123	121.7±14.38	29 —38	35.2 ±12.26
17	5	103—119	113.0± 5.55	25 —37	34.7 ± 6.42
24	1	—	116	—	37.5

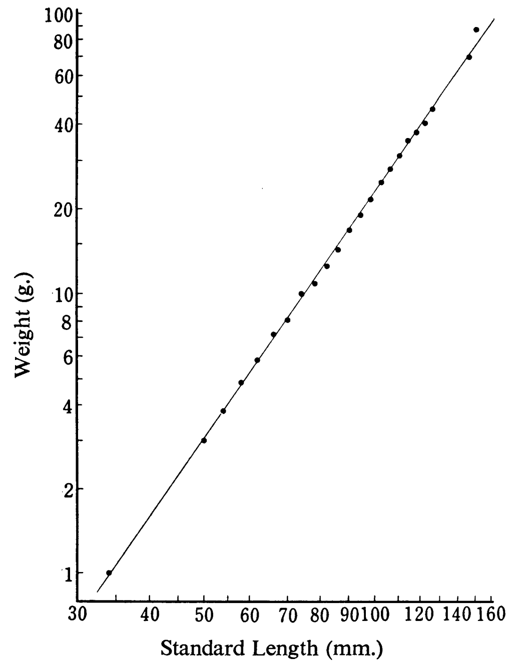


Text-fig. 10. Progression of length-weight means of *Argyrosomus argentatus*. For explanation, see legends of Text-fig. 4.

The relationship between weight and standard length was calculated. Mean weight was obtained for each 4-mm. interval of standard length. The formula expressing the relationship was calculated as $W = 3.15 \cdot 10^{-5} \cdot L^{2.935}$. This formula fits the data quite well as shown in Text-fig. 11.

DISCUSSION

The fish fauna in Seto Inland Sea has not been satisfactorily investigated thus



Text-fig. 11. Weight-length relationship of *Argyrosomus argentatus*.

far. KATAYAMA and FUJIOKA (1958) recorded 253 species including 7 fresh-water forms in the waters in and around Ôshima, Yamaguchi Prefecture, located in the western part of the Inland Sea. As there seems to be no record on the fishes from the central Inland Sea, it is interesting to compare the fish species of Kasaoka Bay, though not exhaustive, with those of Yamaguchi Prefecture. Out of 83 species recorded from Kasaoka Bay, 77 are already known from Yamaguchi Prefecture. The remaining 6 species are *Tylosurus melanotus*, *Hypoatherina tsurugae*, *Decapterus maruadsi*, *Lateolabrax latus*, *Nibea albiflora* and *Sebastes pachycephalus nigricans*. Except *Decapterus*, all were species rarely occurred in this area. In general, most species of fishes of Kasaoka Bay can be said to belong to temperate forms with a little admixture of subtropical ones.

It is revealed from the present investigation that as many as 83 species of fishes have been recorded together with 23 species of animals other than fishes. However, those successively occurred all the year round were restricted to only a small number of species. Major part of fishes appeared only in a certain period of the year with those occurred sporadically or infrequently.

Similar results have already been known on the fishes in such enclosed areas of the sea as Matsushima Bay (TANITA, HOTTA and SUGANAMI, 1957), Ariake Sound (UCHIDA and TSUKAHARA, 1955) and Ômura Bay (YAMADA, 1957b). On the basis of seasonal occurrence and abundance, the fishes of Kasaoka Bay can be divided into the following three ecological categories.

i. Year-round "residents"

ii. Temporary "visitors"
  a) Those coming to spawn
  b) Those visiting the area in their young stages only
iii. Infrequent or accidental "visitors".

Those in the first category are typical inhabitants of the area throughout the year. This category contains such small fishes as *Apogon lineatus*, *Leiognathus nuchalis*, *Rudarius ercodes*, *Harengula zunasi*, *Acanthogobius flavimanus*, *Callionymus richardsoni*, etc.

Those belonging to the second category are the members most important and interesting from the viewpoint of fisheries biology. Occurrence of adult forms for spawning in this area chiefly takes place in spring-summer season. No important fish is contained in this group. *Allanetta bleekeri* occurred relatively abundant only in summer. Two species of Belonidae, *Ablennes anastomella* and *Tylosurus melanotus*, were observed to spawn in this area. They appear only in summer spawning season, having fully matured eggs. Those live their lives in their young stages only contain many species of commercial importance. In the present investigation, young of *Decapterus maruadsi* and *Lateolabrax japonicus* are two of the most numerous fishes occurred. Other species of this category which appeared considerably abundant are represented by *Argyrosomus argentatus*, *Limanda yokohamae*, *Kareius bicoloratus*, *Saurida elongata*, *Sphyraena pinguis*, etc. Beside these species, young forms of the fishes of high market value appeared in smaller number. They are represented by *Chrysophrys major*, *Navodon modestus*, *Fugu rubripes*, etc.

The fishes belonging to the last category are the species very uncommon in this area. They are represented by *Conger japonicus*, *Cololabis saira*, *Mene maculata*, *Lateolabrax latus*, etc.

It should be admitted here that the categories above mentioned are somewhat provisional ones. Nevertheless, the classification may be useful at present in understanding some features of the seasonal abundance of fishes within Kasaoka Bay.

As already described, the most conspicuous members in terms of abundance of the fishes of Kasaoka Bay are young forms of a variety of species. They stay in the bay during their young stages to grow. Examples of the growth of some species are clearly shown in the foregoing section. It can be understood from these facts that Kasaoka Bay plays an important role in the production of fishes as a nursery ground for young forms.

The examination of the feeding habits of fishes, which is now in progress, will throw some light on further detailed aspects of the ecology of the fishes of this area.

SUMMARY

1) Almost year-round investigation was carried out on the catch of *masu-ami*, a kind of pound net, in Kasaoka Bay located in the central part of Seto Inland Sea.

2) A list of species found in the catch was presented, in which 83 species of fishes belonging to 48 families were contained, with 11 species of cephalopods, 11

species of crustaceans and 1 species of Xiphosura.

3) Characteristics in the composition of the catch of *masu-ami* were shown. Among the animals caught fishes dominated in number and weight, comprising 82% and 71% of the total catch, respectively. The catch per haul fluctuated with seasons, being greater in summer and smaller in winter.

4) Growth as deduced from length-weight measurements and weight-length relationships were described on several fishes captured abundantly during the present investigation.

5) On the basis of seasonal occurrence and abundance, the fishes of Kasaoka Bay can be grouped into the following three ecological categories.

i. Year-round "residents" : *Apogon lineatus, Leiognathus nuchalis, Rudarius ercodes, Harengula zunasi, Acanthogobius flavimanus, Callionymus richardsoni*, etc.

ii. Temporary "visitors":

a) Those coming to spawn : *Allanetta bleekeri, Ablennes anastomella*, etc.

b) Those visiting the area in their young stages only : *Decapterus maruadsi, Lateolabrax japonicus, Argyrosomus argentatus, Limanda yokohamae, Kareius bicoloratus, Saurida elongata, Sphyraena pinguis*, etc.

iii. Infrequent or accidental "visitors": *Conger japonicus, Cololabis saira, Mene maculata, Lateolabrax latus*, etc.

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桝網漁獲物よりみた笠岡湾における魚類の生態

遠部　卓・角田俊平

1) 内湾における魚類の生態を明らかにすることを目的として，瀬戸内海中央部の笠岡湾において，湾内に極めて濃密に設置される桝網の漁獲物を，ほぼ周年にわたって調査した．

2) 桝網漁獲物中に出現した魚類は48科83種に達した．この外，頭足類11種，甲殻類11種，剣尾類1種をえた．

3) 漁獲物の組成では魚類が数量共に首位を占め，個体数，重量はそれぞれ，全漁獲物中の82%および72%に達した．漁獲量には季節的変動があり，夏期に多く，冬期に少ない．

4) 期間中ひきつづいて，かなり大量に漁獲された魚類4種（テンジクダイ，スズキ，マルアジ，イシモチ）について，その出現時期，湾内における成長，その他二，三の生態的事項について述べた．

5) 出現時期および数量から，笠岡湾内に出現する魚類は，生態的に次の三者に分類することができる．

i) 湾内に定住するもの：テンジクダイ，ヒイラギ，アミメハギ，マハゼ，サツパ等．

ii) 湾内に一時的に滞留するもの：

a．産卵のため成体が来遊するもの：魚類ではみるべきものが少ないが，トウゴロイワシ，ダツ科の2種（ダツ，テンジクダツ）等がある．

b．幼期にのみ来遊し，湾内で成育するもの：マルアジ，スズキ，イシモチ，マコガレイ，イシガレイ，トカゲエソ，アカカマス等．

iii) きわめて稀に出現するもの：クロアナゴ，サンマ，ギンカガミ等．