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Comparison of Catches of Two Pound Nets Located at Different Distances from the Shore

Shunpei KAKUDA and Takashi ONBE

Department of Fisheries, Faculty of Fisheries and Animal Husbandry, Hiroshima University, Fukuyama, Japan

(Text-figs. 1–8; Tables 1–2)

INTRODUCTION

Being nearly closed inshore waters, Kasaoka Bay seems to be the most favorable area for pound nets. A great many *masu-ami* (a kind of the pound net) are operated throughout the coastal regions there. The majority of the fish landings of the bay are taken almost exclusively by *masu-ami* fishing. In 1960, the total catch of the *masu-ami* fishery in Kasaoka Bay was 265* metric tons, about 65%** of the gross weight of landings in the bay except shellfishes and the laver.

Since a *masu-ami* is a stationary gear, the catch made by this gear may be regarded as adequately reflecting the composition of the fishes and other animals occurring in the fishing ground. The investigation of the catch of *masu-ami*, therefore, will afford some fundamental informations for the ecological study of the fishes in the bay[1)]. Moreover, it may be expected that the behaviors of fishes in the bay will be made clear by analyzing the data concerning the catch of *masu-ami*.

The data on which this paper is based were obtained from investigating the catches of two *masu-ami* located at different distances from the shore respectively. And in the present paper, these data were compared with each other and were statistically analyzed in order to clarify how the species composition of the catch of *masu-ami* is affected by the location of the net. Moreover, the subject about the behaviors of fishes in Kasaoka Bay is discussed from the comparative study of the species compositions of the catches of the two *masu-ami*.

DESCRIPTION OF THE AREA

Kasaoka Bay in which this investigation was carried out is situated in the middle of Seto Inland Sea. The bay is rectangular in shape and bordered by the land and an island except the open mouth at the part of the south and a narrow pass at the east end of the bay. It is a small inner bay having an area of about 40 km^2., small water depth and muddy bottom. Water depth does not exceed 10 m. at the

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*, ** These values were calculated from the catch statistics of Hiroshima Statistical Survey Office and Kasaoka Branch Office of Okayama Statistical Survey Office, Ministry of Agriculture and Forestry and from information obtained by inquiry.

lowest low water except the area off Misaki of Kônoshima (Fig. 1). Water in the bay is relatively turbid. Seasonal variation in water temperature is great, but it is not great in chlorinity except surface water in the rainy season (June, July). Tidal current is not very fast, though tidal range is comparatively great (ca. 3m. in the spring tide[2)]). The exchange of water with the outside is mostly effected by the tide[2)3)].

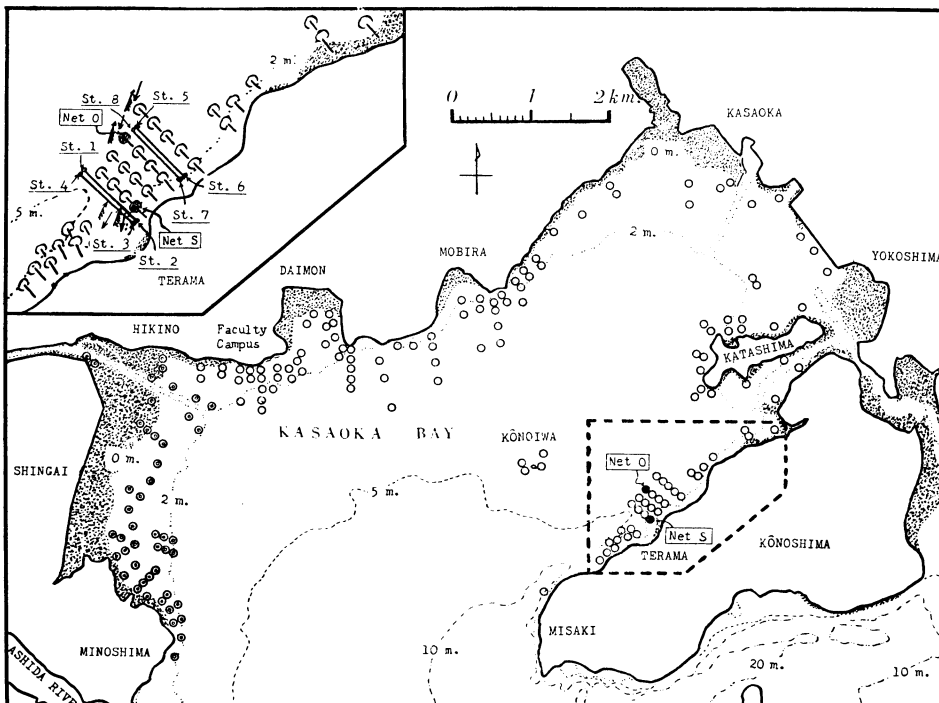

Fig. 1. Map of Kasaoka Bay showing location of *masu-ami*. o Location of *masu-ami* investigated by us in June, 1961; ◎ Location of *masu-ami* investigated by MATSUDAIRA, T. *et al.* in October, 1961.[2)]
The area enclosed with the thick broken line is reproduced at the left upper part of this figure.

Though *masu-ami* fishing is the most important method of catching fishes in the bay, the catch of *masu-ami* is seasonally changeable in nature. Landings are generally greatest from April to December, and much reduced from January to March. Most of *masu-ami* are not operated in the coldest season owing to the rough weather and decrease of the catch. The maximum number of *masu-ami* operated during the pressent investigation was about 180 as shown in Fig. 1. Locations of the nets are fixed, in general, all over the fishing season. Most of all are located along the shore of the bay except those which are set around the sunken rocks of Kônoiwa in the center of the bay. The nets are usually set in the shallow coastal area with 0 and 5 m. depth at the lowest low water. In some cases several nets are set in a row from the shore towards the offshore, as is seen in Fig. 1.

STRUCTURE OF *MASU-AMI*

Masu-ami are the most prevalent type of stationary gear to catch the aquatic animals in inshore waters. Many factors must be taken into account in selecting a site and positioning the net. Among these are the availability of fishes, the contours of the shore, the slope of the land beyond low water mark and the direction and strength of tidal currents.

To set *masu-ami* in Kasaoka Bay, bamboo poles of about 13 m. in length are first driven into the bottom at 5 to 10 m. intervals. Rope is horizontally stretched between those poles above high tide level. The netting is fastened to the rope, and it is held down with heavy chain along the bottom. The *masu-ami* consists essentially of a leader net, a fence net and four pocket nets, as is seen in Fig. 2. The leader net is run towards shore or shoaler water and may extend for distances from 40 m. to 70 m. The fence net is set so as to surround the offshore end of the leader net. Extensions of the fence net form a playground as the fishes which come into it swim around inside. Four pocket nets with flappers are fitted to the four corners of the fence respectively. Fishes are firstly led into the fence by the leader and finally fall into the pocket through a funnel-shaped entrance of it. Fishermen loosen the pocket nets once a day at dawn to take out the catch.

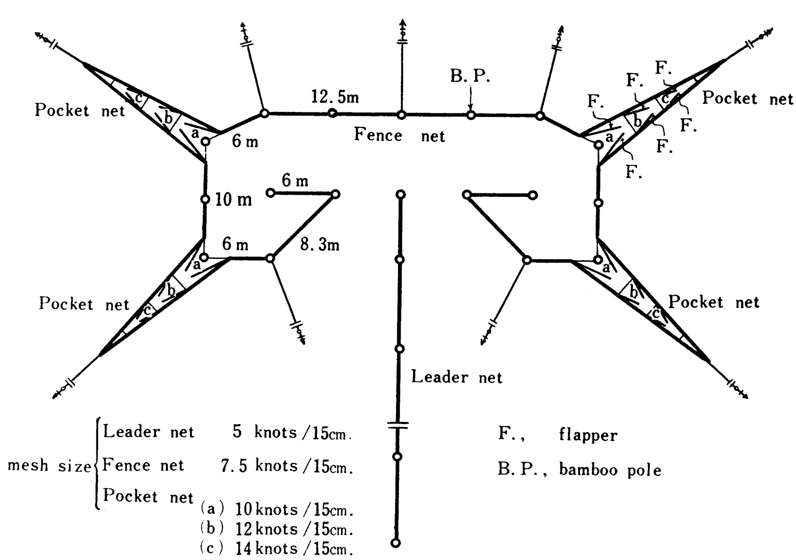

Fig. 2. Schematic representation of *masu-ami* used in this investigation.

The outline of *masu-ami* used in this investigation is shown in Fig. 2. This is the most common type in structure and size among the *masu-ami* operated in Kasaoka Bay.

METHODS OF INVESTIGATION

The two *masu-ami* which had located at different distances from the shore were chosen for the comparative study of the catch. They were located off Terama village of Kônoshima. It has been expected by hydrographic observations[3)] that there is good exchange of water between this region and the waters outside the bay. Therefore, it may be expected that the catch of the *masu-ami* located in this area is abundant in species and in amounts as compared with those in other regions of the bay.

For the purpose of the present study, we thought it most desirable to investigate the catches of the two nets that are located at the inshore and the offshore end of a single row. There was some difficulty in finding a fisherman who was operating such a pair of nets and was willing to sell to us all the catches for research purposes for an entire fishing season. As a result, we adopted an alternative method, in which one of the two nets to be situated was located at the offshore end of a row and the other was located at the inshore end of a neighboring row, as seen in Fig. 1. In the two nets, the net near the shore was called net S and the offshore one net O. Those two nets were located at the distance of 60 m. and 350 m. from the shore respectively. Water depths of the locations of nets S and O were approximately 3.5 m. and 5.5 m. below the mean sea level respectively. The bottom was muddy. This investigation was carried out from June 21, 1961 to June 21, 1962. Since the weather, however, was rough in winter, the both nets were not operated as usual, from February to April, 1962. There is no datum, therefore, to discuss the catches of the two nets in the coldest season. All the catches of both nets were collected at 5 to 10 days intervals four times a month. On November 24, 1961, however, net S could not be hauled and only the catch of net O was collected. Hence, the data of the catch of net O on that day were omitted from the present report. Immediately after every collection at about 6 a.m. the following factors were measured in order to compare the conditions of environment in the locations of the two nets. They are water temperature, chlorinity, dissolved oxygen and the direction and velocity of tidal currents.

RESULTS AND DISCUSSION

1) Comparison of the general features of the locations of the two nets.

In Fig. 3 are seen the seasonal variations in water temperature, chlorinity, and dissolved oxygen in each location where nets S and O were set.

The directions of the tidal currents in each location of the two nets are shown in Fig. 1, and the velocity was from 0 to 8m. per minute at both locations.

The curves indicating the characteristic features of the location of net S are in good agreement with those of net O in trends and fluctuations. It may be considered, therefore, that nets S and O were operated in the same water mass.

To survey the bottom slope and the feature beyond low water mark, the sea

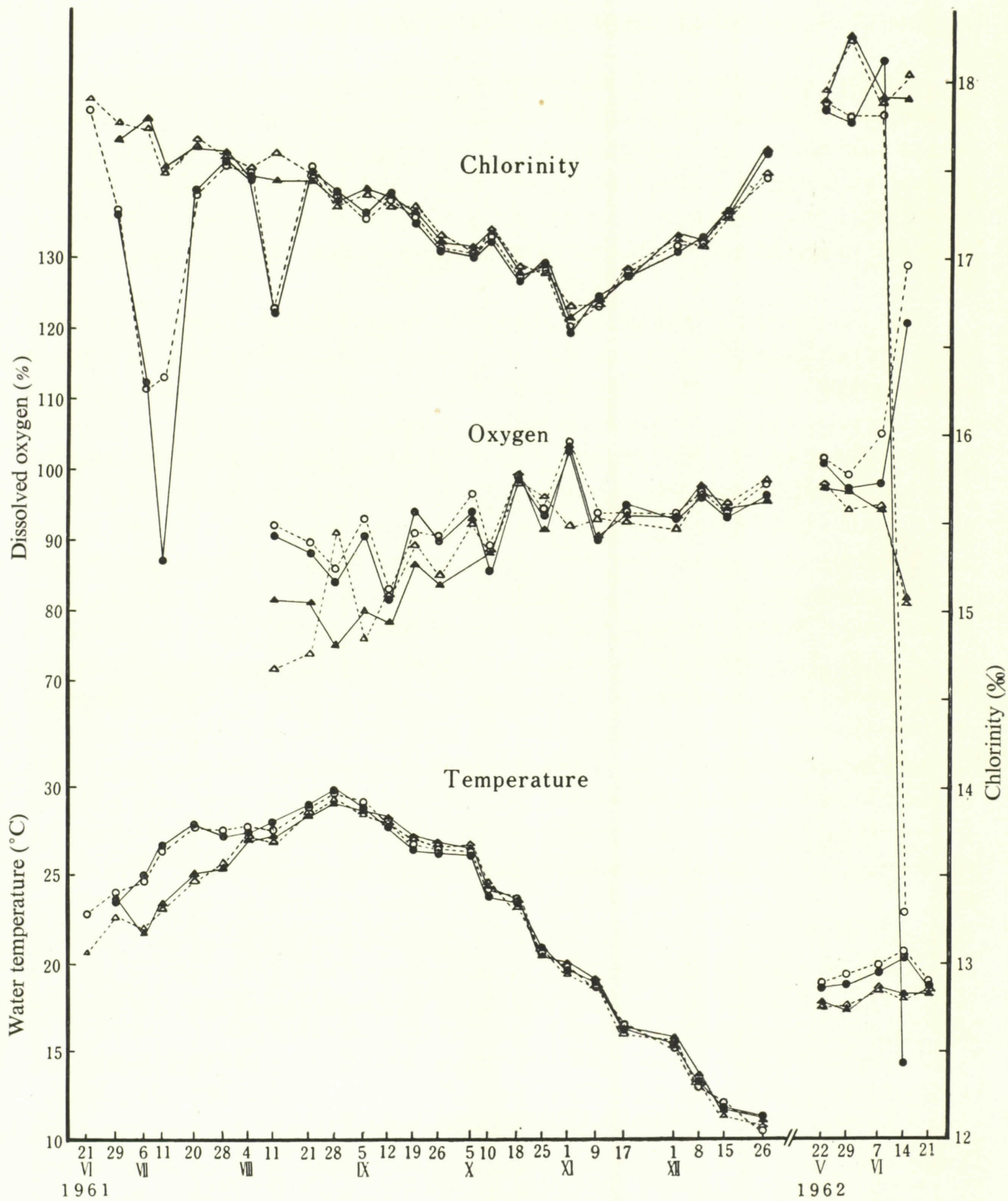

Fig. 3. Seasonal variations in water temperature, chlorinity and dissolved oxygen of each location of the two nets.
● Surface water in the location of net S; ▲ Bottom water in the location of net S;
○ Surface water in the location of net O; △ Bottom water in the location of net O.

bottom between St. 1 and St. 4 through St. 2 and St. 3 and that between St. 5 and St. 8 through St. 6 and St. 7, which are shown in Fig. 1, were detected by a precision echo sounder. From the two recording figures presented in Fig. 4, it is seen that no significant difference was recognized in the slope of the bottom around the locations of the two nets.

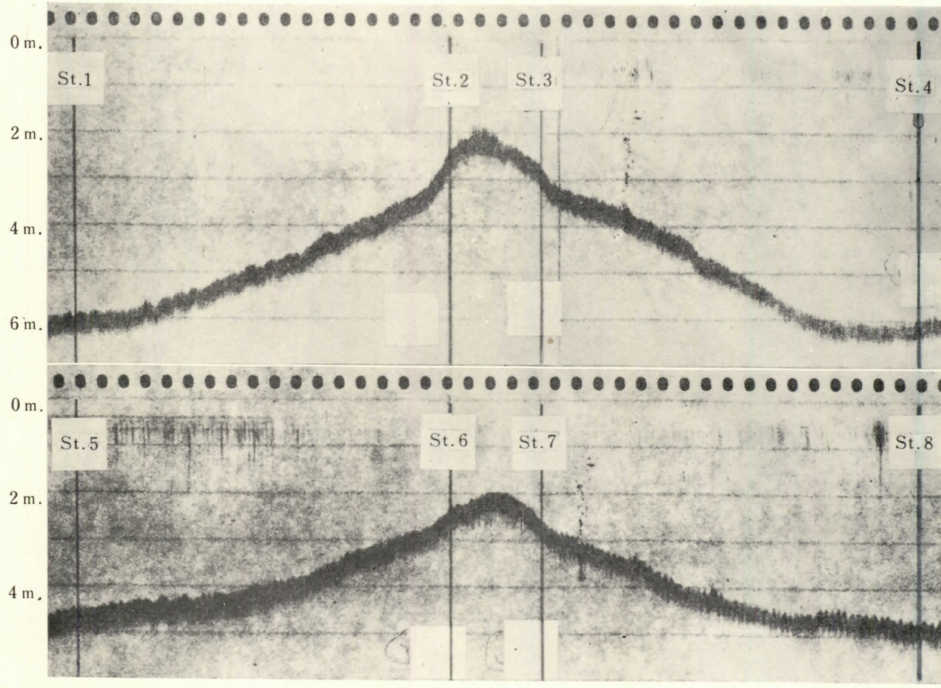

Fig. 4. Recordings of sea bottom around each location of nets S and O. Each station marked in this figure is seen in Fig. 1.

2) Differences in seasonal variations between the catches of the two nets.

The species taken by the nets S and O consisted of the wide variety of aquatic animals which generally inhabit inshore waters[1]. They were 79 species of fishes, 11 species of crustaceans and 11 species of cephalopods. The numbers of the species taken by nets S and O are compared with each other on every date of sampling in Fig. 5. As may readily be seen in Fig. 5, the species taken by net S were generally more numerous than those of net O. It may be considered, as a result, that a greater variety of aquatic animals were apt to come into the *masu-ami* set near the shore than the one built offshore. As might be reasonably expected, the number of the total species taken by nets S and O and that of the species common to both nets were comparatively numerous in July and August when water temperature was high. After September they were reduced with dropping of water temperature and became nearly constant in November and December (Fig. 5). The ratio of the number of the species common to both nets to that of the total species was greatest in July ranging between 57 and 67%, and was smallest in October between 28 and 41%. In general, the similarity between the species caught by net S and those caught by net O is more pronounced in summer (June, July, August) than in autumn (September, October, November). It seems noteworthy that the catches of nets S

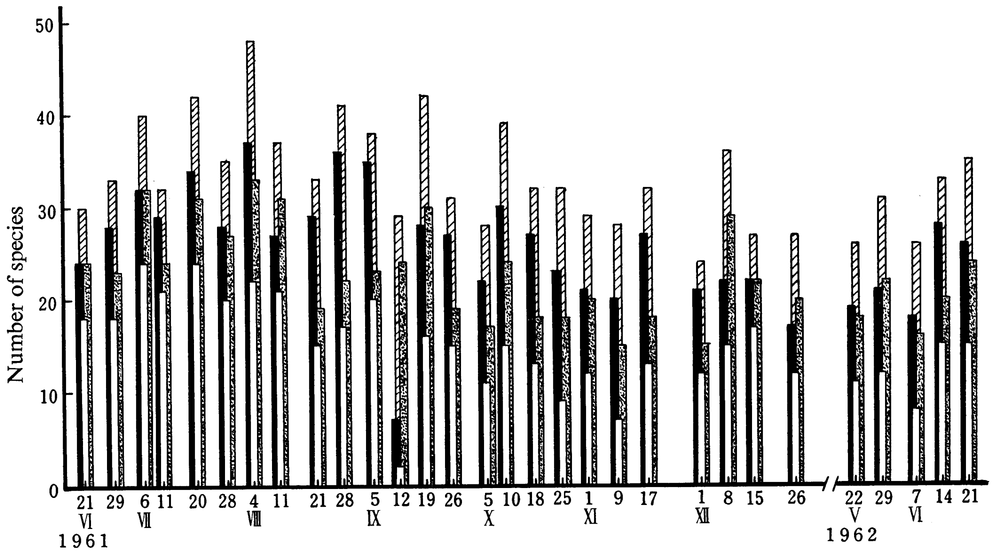

Fig. 5. Seasonal variations in number of species taken by the two nets.
■ Number of species taken by net S; ▨ Number of species taken by net O;
□ Number of the species taken by nets S and O in common; ▩ Total number of the species taken by nets S and O.

and O, in spite of the short distance between the two nets, always differed from each other to considerable extents. On the whole, it may be said that the species composition of the catch of a *masu-ami* shows considerable seasonal variations and much greater local differences than we had expected.

In Fig. 6 A are illustrated the seasonal variations in the catches of nets S and O respectively. The figure shows that the catch of net S was generally more abundant than that of net O except in August and September. The reason why in August and September the catch of net O was exceedingly abundant in comparison with that of net S and with that in other months can be explained from the following fact, namely, *Decapterus maruadsi* came into Kasaoka Bay in large group of migratory schools, and they were taken mainly in August and September by *masu-ami* operated offshore in the bay, while any of them were scarcely caught by the nets operated inshore.

Fig. 6 B shows the curves obtained by use of three-place moving averages for each catch except *D. maruadsi* of the two nets. In this figure, it is obvious that if *D. maruadsi* was not taken only by net O, the catch of net S would be expected to be almost always more abundant than that of net O.

In *masu-ami* fishing, the great variation in catch from day to day and from place to place seems to be comparatively apparent as a whole. However, it is clearly seen in Fig. 6 A that the weight of the catches of nets S and O fluctuated in a very similar manner except in August and September. This relation is more manifest in Fig. 6 B. The correletion coefficient between the weight of catches of the two nets (except August and September when *D. maruadsi* was caught in large a-

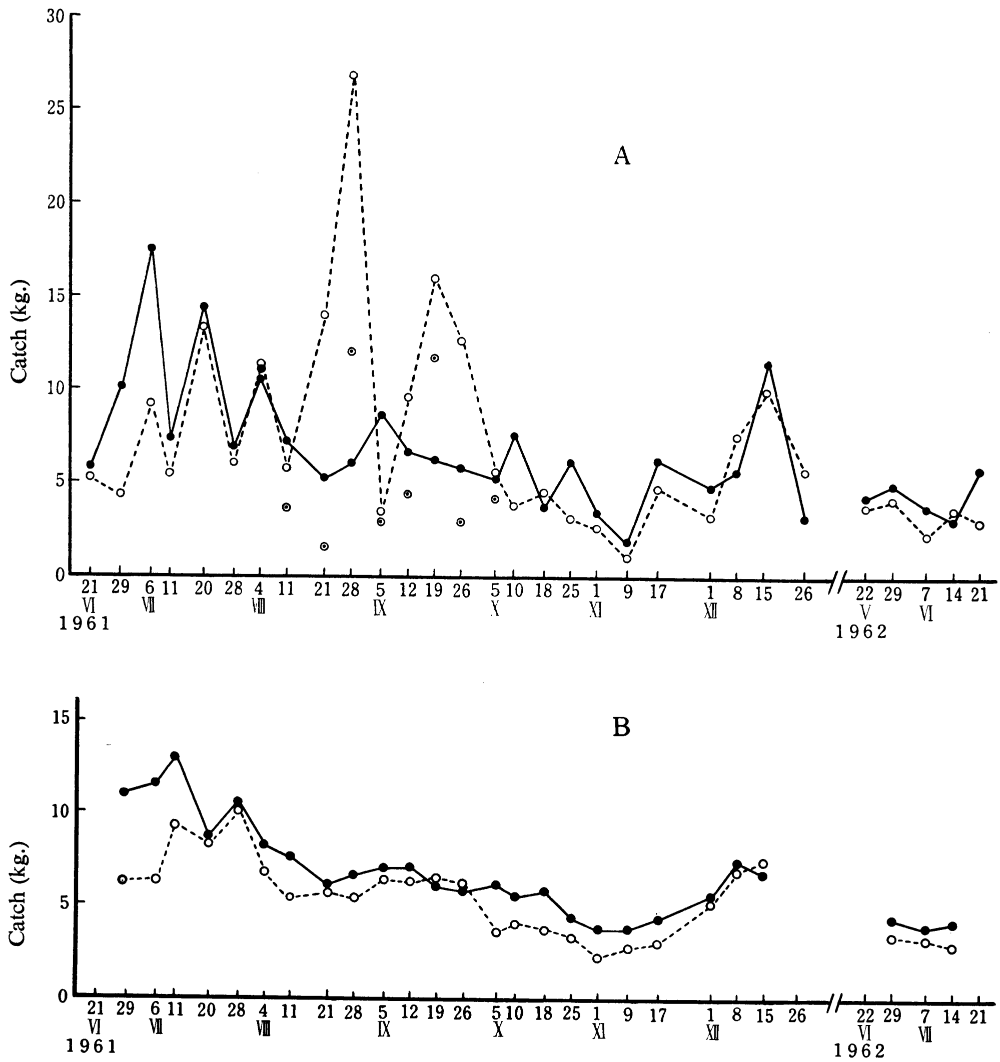

Fig. 6. A. Sensonal variations in the catches of the two nets.
B. Seasonal variations in the catches except *D. maruadsi*, smoothed by using the three-place moving averages.
● Catch of net S; ○ Catch of net O; ⊙ Catch of net O except *D. maruadsi.*

mounts only by net O) is 0.79 and highly significant (t=5.672, d.f.=20).

In Fig. 7 are seen the seasonal variations in the number of individuals of the two nets. It is seen from the figure that the number of individuals taken by net O was generally more numerous than that of net S. This result is in striking contrast to that obtained by comparing the weight of the catches of the two nets mentioned above. From the comparison of Fig. 6 A with Fig. 7, it may be said that small-sized fishes were mainly caught by net O rather than net S, moreover, they were taken in large number at a haul. These tendencies may be taken as the indication that small-

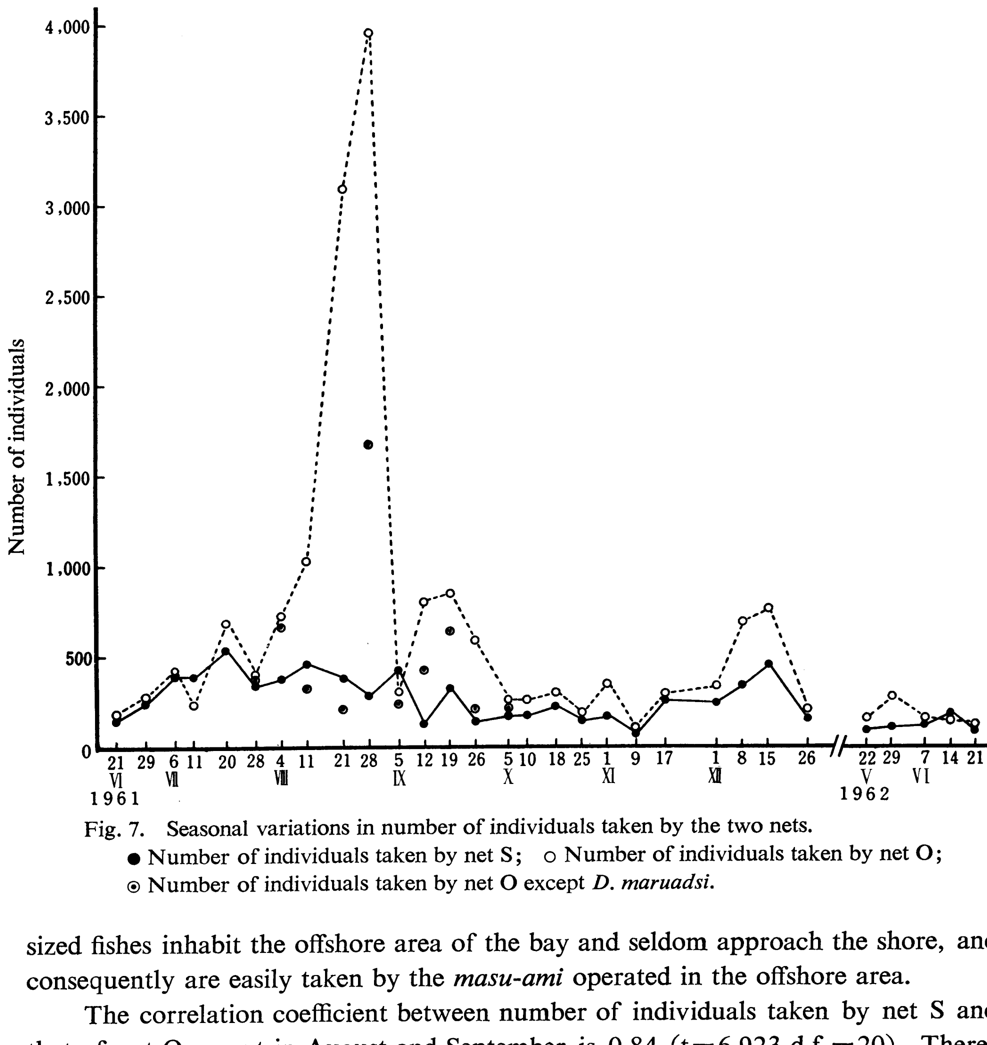

Fig. 7. Seasonal variations in number of individuals taken by the two nets.
● Number of individuals taken by net S; ○ Number of individuals taken by net O;
⊙ Number of individuals taken by net O except *D. maruadsi.*

sized fishes inhabit the offshore area of the bay and seldom approach the shore, and consequently are easily taken by the *masu-ami* operated in the offshore area.

The correlation coefficient between number of individuals taken by net S and that of net O except in August and September is 0.84 ($t=6.923$ d.f.$=20$). Therefore, it is highly significant as well as the correlation between the weight of the catches of the two nets.

3) Classification of the species taken by the two nets.

The 42 species, of which the total number of individuals taken by the two nets was more than 30 respectively, were picked up from 101 species. They were classified into the three types as shown below by chi-square test.

I. Species abundant in inshore area.
II. Species abundant in offshore area.
III. Species occurred in both areas.

Chi-square was used to test for equality of the number of individuals taken by each net with respect to each species of the 42 species. The species were grouped in order that chi-square would be significant at the 5 percent level for each species.

Table 1. Three types of the species caught by the two *masu-ami*.

Type	Species	Number of individuals		χ^2	Frequency of catch*		Average number of individuals per catch*		Average body weight
		Net S	Net O		Net S	Net O	Net S	Net O	
I	*Allanetta bleekeri* (GÜNTHER)	942	172	532.226	15	16	62.8	10.8	6.0
	Mylio macrocephalus (BASILEWSKY)	229	5	214.427	27	5	8.5	1.0	112.1
	Rudaris ercodes JORDAN et FOWLER	438	140	153.640	14	11	31.3	12.7	2.2
	Limanda yokohamae (GÜNTHER)	236	65	97.146	16	12	14.8	5.4	15.1
	Mugil cephalus LINNÉ	72	2	66.216	17	2	4.2	1.0	316.1
	Kareius bicoloratus (BASILEWSKY)	180	81	37.552	16	14	11.3	5.8	14.4
	Therapon oxyrhynchus T. et S.	29	2	23.516	6	2	4.8	1.0	65.5
	Ditrema temmincki BLEEKER	49	12	22.443	14	4	3.5	3.0	25.8
	Liza haematocheila (T. et S.)	32	4	21.778	9	3	3.6	1.3	372.0
	Pseudoblennius cottoides (RICHARDSON)	41	9	20.480	12	5	3.4	1.8	10.7
	Sebastes inermis C. et V.	104	53	16.567	18	12	5.8	4.4	25.2
	Fugu niphobles (JORDAN et SNYDER)	34	11	11.756	15	8	2.3	1.4	18.6
	Hexagrammos otakii JORDAN et STARKS	91	56	8.333	11	9	8.3	6.2	29.2
	Penaeus japonicus BATE	58	24	29.641	18	12	3.2	2.0	27.3
	Loligo japonica HOYLE	587	426	25.588	16	17	36.7	25.1	13.3
	Sepioteuthis lessoniana LESSON	29	11	8.100	7	8	4.1	1.6	26.8
	Sepia esculenta HOYLE	24	9	6.818	10	7	2.4	1.4	152.8
II	*Decapterus maruadsi* (T. et S.)	63	7073	6886.225	9	11	7.0	643.0	7.2
	Engraulis japonica (HOUTTUYN)	21	781	720.220	10	10	2.1	78.1	7.0
	Apogon lineatus (T. et S.)	720	2041	632.032	26	29	27.7	70.4	3.1
	Leiognathus nuchalis (T. et S.)	313	1269	577.709	24	30	13.0	42.3	8.7
	Argyrosomus argentatus (HOUTTUYN)	40	521	408.986	10	21	4.0	24.8	18.2
	Harengula zunasi (BLEEKER)	127	391	134.548	17	22	7.5	17.8	18.4
	Trichiurus lepturus LINNÉ	32	99	34.267	12	12	2.7	8.3	32.9
	Acanthogobius flavimanus (T. et S.)	74	152	26.920	15	16	4.9	9.5	33.8
	Sillago sihama (FORSKÅL)	43	65	4.481	14	23	3.1	2.8	19.0
	Squilla oratoria de HAAN	70	229	84.552	18	21	3.9	10.9	30.2
	Metapenaeus joyneri (MIERS)	36	96	27.273	9	18	4.0	5.3	8.4
	Metapenaeus monoceros (FABRICIUS)	377	510	19.943	19	23	19.8	22.2	14.5
	Sepiella japonica SASAKI	71	1294	1095.772	12	16	5.9	80.9	10.3
III	*Platycephalus indicus* (LINNÉ)	35	24	2.051	18	11	1.9	2.2	112.2
	Saurida elongata (T. et S.)	78	95	1.671	11	13	7.1	7.3	39.2
	Konosirus punctatus (T. et S.)	109	124	0.966	23	17	4.7	7.3	46.2
	Lateolabrax japonicus (CUVIER)	1253	1291	0.568	24	16	52.2	80.7	17.4
	Astroconger myriaster (BREVOORT)	22	18	0.400	16	11	1.4	1.6	59.3
	Sphyraena pinguis GÜNTHER	52	47	0.253	8	11	6.5	4.3	33.2
	Callionymus richardsoni BLEEKER	49	52	0.089	20	19	2.5	2.7	22.5
	Charybdis japonica (A. MILNE-EDWARDS)	95	121	3.130	23	23	4.1	5.3	75.3
	Penaeus semisulcatus de HAAN	56	71	1.772	14	13	4.0	5.5	26.6
	Euprymna morsei VERRILL	67	91	3.646	12	9	5.6	10.1	12.3
	Loligo kobiensis HOYLE	68	89	2.809	10	11	6.8	8.1	16.2
	Octopus minor variabilis (SASAKI)	19	16	2.571	8	7	2.4	2.3	432.6

$d.f.=1$ χ^2 $.05=3.841$ * "Catch" refers to the haul which contained the stated species.

Table 1 shows the list of species grouped and the difference of number of individuals of each species by net. Most of the species varied in the number of individuals taken by each net. In Kasaoka Bay large-sized fishes, namely *Mylio macrocephalus*, *Mugil cephalus* and *Liza haematocheila*, were numerous in net S and seldom came into net O. Moreover, they were scarcely caught in a large number at a haul. On the contrary, the migratory or the small-sized fishes were numerous in net O. For example, 99% of *D. maruadsi* taken were occurred in net O and the rest in net S. The result described in section 2 of "Differences in seasonal variation between the catches of nets S and O" can be confirmed from this table, i.e. the "species abundant in inshore area", which were taken mainly by net S, are large in size and few in number of individuals per haul in comparison with the "species abundant in offshore area", which were taken mainly by net O.

4) Comparison of the catches of school-forming fishes made by the two nets.

A total of 7136 individuals of *D. maruadsi* were caught in the hauls covered by the present investigation. The catch of this species began in late July and continued until late October. The number taken by each net at each date of investigation is shown in Table 2. During the above-mentioned period the catch of *D. maruadsi* followed the following trend. In both nets the first catch occurred nearly in the same season, namely about late July or early August; then the catch increased steadily for a period of about a month until the peak was reached; thereafter, the catch decreased progressively until the last catch was observed in late October. This pattern of variation may be taken as indicating that *D. maruadsi* migrated into the waters under consideration in schools. It appears that the following species also migrated into Kasaoka Bay in schools, since their catches were similar in the pattern of seasonal variation to the catch of *D. maruadsi*: *Engraulis japonica*, *Saurida elongata*, *Allanetta bleekeri*, *Sphyraena pinguis*, *Lateolabrax japonicus*, *Argyrosomus argentatus*, *Limanda yokohamae* and *Kareius bicoloratus*. Out of those fishes whose catches showed typically this type of seasonal variation, six species were selected so as to represent the three types as mentioned in the previous section, and the seasonal variations of their catches in each net are illustrated in Fig. 8. Each curve in Fig. 8 has been smoothed by means of the three-place moving averages of the number of individuals taken on each day, in order to facilitate the comparison between the variation patterns of the catches of the two nets. It has already be shown in

Table 2. Records of the catch of *D. maruadsi* by the two nets.

Date	July 28	Aug. 4	11	21	28	Sept. 5	12	19	26	Oct. 5	10	18	Total
Net S	0	0	7	25	4	3	0	17	3	1	2	1	63
Net O	35	63	706	2899	2288	69	375	210	378	46	0	4	7073
Total	35	63	713	2924	2288	72	375	227	381	47	2	5	7136

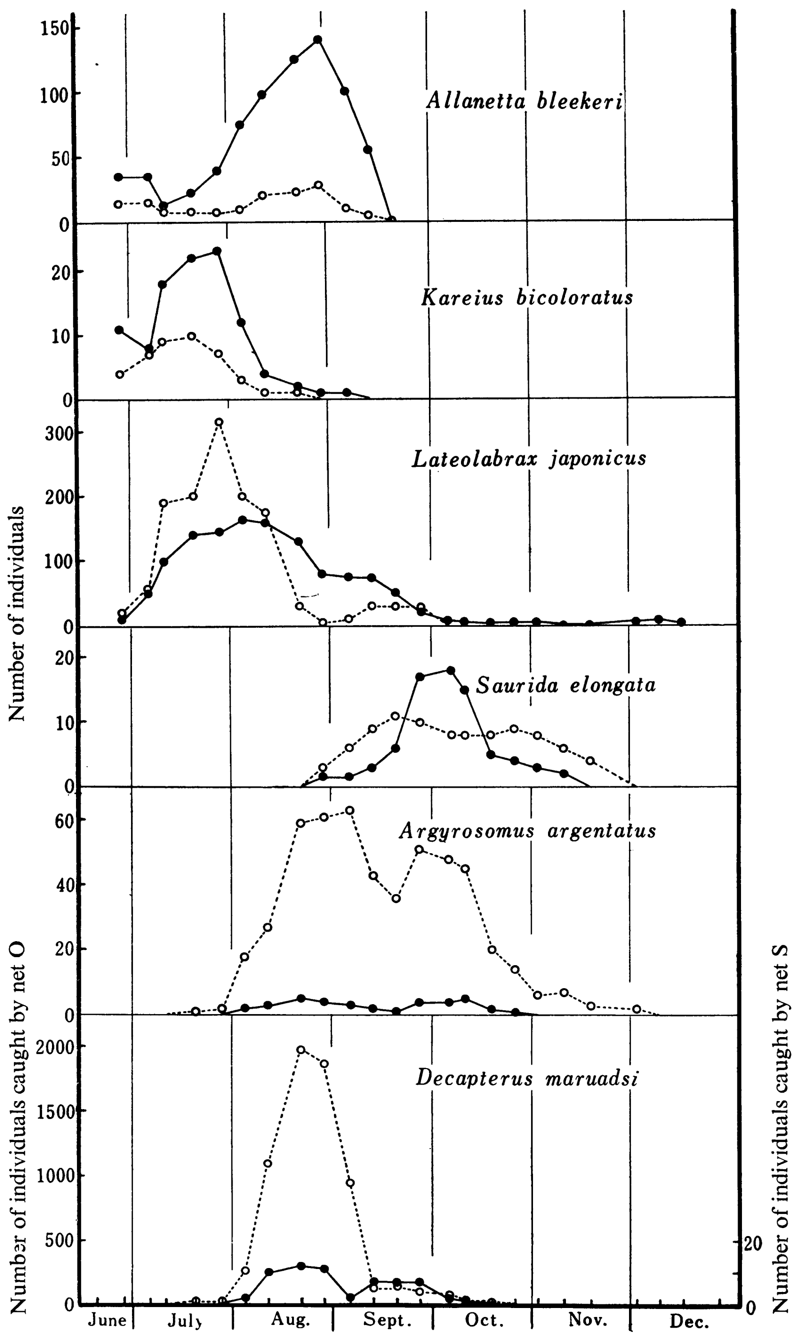

Fig. 8. The variation patterns in the catch of school-forming fishes.
● Net S; ○ Net O.

Fig. 6 that the use of the three-place moving averages preserves the form and phase of the fluctuation occurring over a period of four or more successive dates of investigation but eliminates the irregularities of a single date. The characteristic pattern of the seasonal variation in the *D. maruadsi* catch, to which mention has been made above, is clearly seen in Fig. 8. It may be seen in Fig. 8 that some species were taken mainly by the offshore net and some mainly by the nearshore net. This fact may be explained as that different species of school-forming migratory fishes keep different distances from the shore. According to this hypothesis, *A. bleekeri* and *L. yokohamae* seem to approach relatively close to the shore in schools, *L. japonicus* and *S. elongata* does not approach so close to the shore, *A. argentatus* stays comparatively offshore and *D. maruadsi* stays in the most offshore area of these fishes. The inference that *D. maruadsi* tends to stay in the offshore area is further supported by the fact that this species was caught more abundantly by the *masu-ami* operated around Kônoiwa (Fig. 1) than by net O.

SUMMARY

The whole daily catches by the two *masu-ami* (a kind of the pound net) operated in Kasaoka Bay were investigated, with reference to the species and size composition, at about weekly intervals during the one-year period from June, 1961 through June, 1962, for the purpose of clarifying the difference between the catches. These nets, which were selected as the sample out of the many *masu-ami* operated in this region, were located off Terama village of Kônoshima, one 60 m. and the other 350 m. from the shore. Water depths at the locations of these nets were 3.5 and 5.5 m. below the mean water level respectively. There was no significant difference in such hydrographic conditions as water temperature, chlorinity and dissolved oxygen between the locations of the two nets. From comparison of the catches of the two nets, the following results were obtained:

1) The species composition of the catches of these *masu-ami* showed considerable seasonal variations and local differences.

2) The catch of the nearshore net was, in general, richer in species, greater in weight and fewer in number of individuals than that of the offshore net. The correlation coefficient between the catches of the two nets either in weight or in number of individuals, was highly significant except in August and September.

3) The number of the captured species was relatively numerous in July and August when water temperature was high. Thereafter, it gradually decreased with the falling water temperature, and remained nearly constant during November and December. The species composition of catches of the two nets, however, always differed from each other.

4) The fishes, larger in size and higher in market value in the catches of *masu-ami*, such as *Mylio macrocephalus Mugil cephalus* and *Liza haematocheila* except *Platycephalus indicus* were mainly caught by the nearshore net and seldom came into the offshore net. The number per haul of these fishes was usually small.

5) A large number of young *Decapterus maruadsi* were caught almost exclusively by the offshore net, practically none of them appeared in the catch of the near-

shore net. They occurred in Kasaoka Bay in large schools from July through October.

6) There was an indication that small-sized or young fishes are taken more numerously by the offshore net than the nearshore net.

7) The following fishes were presumed to come into Kasaoka Bay in schools. They are *Engraulis japonia*, *Saurida elongata*, *Allanetta bleekeri*, *Sphyraena pinguis*, *Lateolabrax japonicus*, *Argyrosomus argentatus*, *Limanda yokohamae* and *Kareius bicoloratus*.

We wish to express our hearty thanks to Professor Yasuo MATSUDAIRA, under whose kind encouragement this investigation was carried out. Our thanks are also due to Assistant Professor Yutaka MURAKAMI for his guidance and kind co-operation given in this work. We are indebted to Mr. Hisao SASAOKA and Mr. Kazuhiko NOGAMI of Naikai Regional Fisheries Research Laboratory, by whom the precision echo sounder was operated and the recording of the sea bottom was taken.

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設置場所の異なる桝網の漁獲物の比較

角田俊平・遠部　卓

内湾に設置された桝網について，その設置場所と漁獲物組成との関係を明らかにするために，瀬戸内海の小内湾である笠岡湾の桝網群の中より，岸に近い網と，同一漁場の沖側の網とを選び，1961年6月から1年間冬期を除いて毎週1回，それらの網の全漁獲物について調査を行ない，次の結果を得た．

1）桝網の漁獲物は種類数，尾数，漁獲量の何れにおいても，設置場所により，又季節によって可成り変動した．

2）岸の網の漁獲物の種類数は一般に沖の網のそれよりも多く，季節的には夏季が最も多かった．

3）漁獲物の尾数の点については岸の網より沖の網が多かった．然し，漁獲量では非常に多量のマルアジが沖の網でのみ漁獲された8月と9月を除くと，漁獲尾数と反対に，沖の網より岸の網が多く，両網間の漁獲尾数についても，又漁獲量についても相関々係は非常に有意であった．

4）桝網漁獲物の中では比較的魚体が大きく，重要魚と考えられるクロダイ，ボラ，メナダは主として岸の網によって漁獲された．然しこれらの魚種は一度に多数漁獲されることはなかった．

5）主として沖の網によって漁獲されたものは，マルアジ，カタクチイワシ，イシモチ，テンジクダイ，ヒイラギ等の魚体の小さい魚，若しくは若年魚群であった．漁獲尾数で第1位に位したマルアジはその99％が沖の網で漁獲された．

6）湾内に群をなして来游する魚種としてカタクチイワシ，トカゲエソ，トウゴロイワシ，アカカマス，マルアジ，スズキ，イシモチ，メイタガレイ，マコガレイ等が考えられる．