Bull. Fish. Exp. St. Ibaraki-ken, 22, 7～17 (1978)

ON THE PREDATOR-PREY RELATIONSHIPS AROUND LARVAL AND JUVENILE-FISHES IN SHALLOW SEA COMMUNITY

Akihiro OKATA, Koki ISHIKAWA and Kazuhiro KOSAI

Fisheries Experimental Station of Ibaraki-Ken Hiraiso-cho, Nakaminato City, JAPAN

The present investigation has been designed to clear up the biological production mechanism of larval and juvenile fishes in the food web constructed by animal community, and intended to present some basic information for the actual management of the fishery resources and for the propagation of useful fish population.

The research work has been performed in the Kashima-nada Joban coast area located on the Northeast Pacific coast of Honshu, the main island of Japan.

In order to make clear the production system of the larval and juvenile fishes living in the shallow sea areas from 5 to 15m in depth, samples were collected by gill-nets, an otter trawl-net, a beam trawl-net, a shirasu-seine and a zooplankton-net, during the period from 1975 to 1977.

Each sample obtained at each station was investigated in regard to the species composition and the stomach content species.

Based on the results, a production system in the community as the predator-prey relationships was determined. The anchovy, *Crangon affinis* (macruran), mysidaceans, amphipods and copepods were abundantly eaten in all the year round by the various predators; however, among those preys *Crangon affinis* and mysidaceans were far frequently found compared to the anchovy. Namely, the larger-sized fishes, as the higher food niche predators, rarely prey on fishes in the areas. And also the majority of fishes caught in the shallow sea are outnumbered by the small-sized or the larval and juvenile fishes which mainly prey on the smaller crustaceans.

In the cold season, during the period from December to March, a great many species of fishes in the larval or juvenile stages were sampled in the areas. In regard to the prey organism at the higher category of taxon, most fishes were feeding on copepods. Sometimes we can observe that a single species were predated in large quantities by some plural species; however, the species composition in the stomachs of the larval predators were not uniform.

Dividing these lower production system in the area into the larval or juvenile fishes and the small sized crustaceans, the biomass correlations between both groups are almost stable in each period throughout the year.

The phenomena mentioned above reveals that there is a certain stable equilibrium between the fishes as lower niche predators and the crustaceans. And, it may be considered that species populations within a community share the nutritive substance with others in order to keep the production level of each species, in the limitation of the total biological production of the community restricted by space and time.

Recently, several studies concerning the propagation of useful fish populations in shallow sea areas have been promoted in Japan. They aim at the establishment of techniques for a step-up in fishery production, by means of making some suitable conditions for an increase of the species population. On the other hand, several pollution problems concerning fishery resources in the coastal ecosystem have been investigated.

Both research areas have a common theme concerning the marine animal community as a functional system of interacting populations. Namely, it is necessary to clarify the problems of "how this system of species is organized, how the various species are interrelated, how they fit together into the whole, and how the niche of each species is determined in the functional whole (Whittaker and Levin 1975)".

Most marine fishes in the early stages of life occur in the coastal shallow sea areas; however, we scarcely know anything about the concrete life of species within a community.

The present investigation has been designed to make clear the biological mechanism of larval and juvenile fishes in the food web, and intended to present some basic information for the actual management of the fishery resources.

The research has been performed in the Kashima-nada Joban coast area located on the Northeast Pacific coast of Honshu, the main island of Japan. The Kuroshio branch (warm water masses) and the first Oyashio intrusion (cold water masses) are in this area; accordingly several fishes from southern and northern areas migrate there.

Materials and Methods

In shallow sea areas 5-15m in depth along the sandy coast of Kashima-nada Joban, animal samples were collected by gill-nets (60mm mesh, 2m x 150m), an otter trawl-net (3mm mesh), a beam trawl-net (3mm mesh, 2m x 1m), a shirasu-seine (3mm mesh) and a zooplankton-net, during the research period from 1975 to 1977.

The gill-nets were set at two stations located in the areas of 11-15m in depth for 24 hours. At the six stations the trawl-net and the beam trawl-net were operated along the coast line for 10 minutes per haul by sailing a fishing boat at the rate of 2 miles an hour, and the plankton-net was vertically operated from the bottom to the surface at the six stations.

The species composition was investigated in regard to the number and weight of each species contained in each sample.

Each species found in the stomach of fishes and crustaceans sampled was identified, and predator-prey relationships were determined according to the rate of the occurrences of food species in the stomachs of predators.

Results and Discussion

Arranging the number of all species sampled at each station by the use of each gear, the following results were obtained in the areas; by the beam trawl-net 19 fishes and 34 crustaceans, by the otter trawl-net 40 fishes and 12 crustaceans, by the shirasu-seine 13 fishes, and by the gill-nets 16 fishes.

Species composition varied in accordance with the efficiency of the sampling gear and with abiotic environmental conditions changing seasonally; however, the anchovy (Engraulis japonica), Crangon affinis (macruran), Ovalipes punctatus (brachyuran), Acanthomysis mitsukurii (mysidacean) and Pontocrates altamarinus (amphipod) appeared typically in the areas in all the year round.

Predator-Prey Relationships

Starting from the larger-sized fish sampled, the stomach content organisms of all the fish were researched and identified. For each predator contained in each sample a numerical value, showing the ratio of the number of stomachs containing each food species to the total number of stomachs examined, was calculated according to the method by Hatanaka and Iizuka 1962. Based on the above results, food web charts were obtained connecting predator and prey by arrows. Only some of the results will be presented here. Figure 1 shows an example of the production system in shallow sandy sea areas,observed on the sample obtained at a station of 10m in depth by the use of an otter trawl-net in December. The position of each organism show its relative level in the food niche in the interspecies relationships of food compositions among the fishes. The direction of an arrow represents the direction of the energy flow from the prey organism to the predator in higher food niche. Referring to organism other than fish, in cases when their food species were uncertain, the orders were determined with regard to their body lengths, in due consideration of the movement capacity.

Among the animals appearing in all the year round, the anchovy, *Crangon affinis* and some species in the categories, mysidacea, amphipoda and copepoda were abundantly eaten by the various predators. Seeing the frequencies of food organisms found in the predators stomachs, *Crangon affinis* and mysidaceans were found in much greater numbers than the anchovy. *Acanthomysis mitsukurii* was the dominant species among the food organisms.

In this way, the larger-sized fishes in the higher niche prey mainly on fishes are rarely found. And the majority of the fishes caught in the coast areas are outnumbered by the small-sized or the larval and juvenile stage fishes which mainly prey on the smaller crustaceans.

Within the prey fishes, those found most frequently were the anchovy or the shirasu, juvenile stage of anchovy, and the individual numbers of the other fishes found in the stomachs of predators were very small.

From the facts given above, it can be considered that, for the smaller-sized fishes or the larval and juvenile fishes of rather small species population, the shallow sea areas have suitable conditions of life necessary for sustaining an adequate survival rate.

Feeding Relationships among the Larval and Juvenile Fishes

Classifying the food organisms, eaten by the smaller-sized fishes, into the higher taxon such as macrura, amphipoda, mysidacea, copepoda and cumacea, it seems as if the fishes were severely struggling with one other around the same food organism living in the same time and space. However, to be sure, the food organisms were researched to the level of each species.

A considerable number of species of fishes of similar-size were sampled in the areas during the cold season. In January, for example, most of the fishes were feeding on copepods.

The juvenile of common sea bass (*Lateolabrax japonicus*) within the range of 0.6-1.3cm in body length were preying mainly on *Acrocalanus gibber* and *Paracalanus parvus*, and the sand lance (*Ammodytes personatus*)0.8-1.5cm in body length were mainly preying on *Acrocalanus longicornis*. Other fishes such as the greenlings(*Hexagrammos otakii*) 4.0-4.5cm, the cottoid fish (*Pseudoblennius percoides*) 1.0-1.5cm and the rock fish (*Sebastes pachycephalus pachycephalus*) 0.7-0.8cm were taking a little of the same food species as the above mentioned copepods, and the numbers of species contained in their stomachs were large.

On the contrary, in the stomachs of the stone flounder (*Kareius bicoloratus*), 0.8-1.2cm in body length, in the stage of premetamorphosis, very few crustaceans were found except for diatoms and some detritus-like fragments, as shown in Figure 2.

Nevertheless, in March, in the stomachs of the stone flounder 1.1-1.6cm in body length in the mid or post stages of metamorphosis, some copepods such as *Acartia clausi* and *Acrocalanus longicornis*, copepodid, cumaceans and diatoms appeared. These species were considerably different from those found in the stomachs of the sand lance, 1.2-1.9cm in body length, the gunnel (blennoideans), 2.7-3.1cm in body length, and the kusauwo (*Liparis tanakai*), 1.6-3.0cm in body length, as shown in Figure 3.

In this manner, as in the case of prey organisms such as *Acrocalanus gibber*, sometimes we can observe that a single species of organism was predated in large quantities by some plural species; however, the species composition in the stomach of each predator was not the same as the others. This phenomena shows that each species of fish has a specific physiological requirement and a feeding capacity, and has a peculiar sphere of life which never overlaps entirely with the other species (Okata, 1975·1976).

When a prey species population is highly abundant and widely spreads over the living space, several predators having different life spheres may take on that prey species population, sharing the space with each other.

This corresponds to a principle that no two species living in a common community hold the same ecological niche (Elton, 1927). Namely, it seems to be quite all right to assume that two species in a situation of the predator-prey relationship are not rigidly connected with each other, but the predators, in a limitation of their ecological potential, flexibly select some prey organisms within a community constructed by several species having some similar life forms and some different micro-habitats.

Biomass Relationship between the Larval Fish and Small Crustaceans

We divided the rather lower production system into the two animal groups, namely the larval and juvenile fishes under 5cm in body length and the small-sized crustaceans under 1cm in carapace length or under 2cm in breadth, and both groups were compared each other their seasonal variations concerning the number of species and the biomass per unit space.

As previously stated, we obtained a considerable number of species of small crustaceans by the use of a beam trawl-net Accordingly, in the present section, we will propose to deal with the results obtained by the beam trawl-net, and to investigate the animal aggregation in a lower production level. Table 1 shows the seasonal occurrence of each species of main fish larvae and crustaceans, and Figure 4 shows the seasonal variations of species numbers of fishes and the crustaceans during the period from January to December. ~~White~~ Black circles represent the fishes and the ~~black~~ white circles, the crustaceans. Numbers of species of fishes showed a marked peak in March, and that of the crustaceans showed two peaks in March and September.

According to these findings, the seasonal variations of the correlations between fishes biomass and crustaceans biomass were investigated, dividing a year into five periods, January-February, March, April-July, September and October-December.

As shown in Figure 5, the biomass correlations between both groups of fishes and crustaceans in each period throughout the year can be seen. This phenomena reveals that there is a certain stable equilibrium between the larval or juvenile fishes as ecologically lower niche predators and the smaller-sized crustaceans. Most of the crustaceans are situated on the niche preyed on by the larger-sized animals.

Accordingly, it may be considered that species populations within an animal aggregation share the nutritive substances with others in order to keep the production level ofeach species population, in the limitation of the total biological production of the community restricted by space and time.

When we intend to propagate a specific species population within a complex community, for example, by releasing the larvae or the juvenile, it is necessary to form a clear view of the production process through the community in which the larvae or the juvenile is included, and to pass fair judgment concerning the carrying capacity of the field after due consideration of the biological environment.

Acknowledgments

The authors wish to express their thanks to Mr. Toru Watanabe, Director of the Experimental Station of Ibaraki-ken, for his constant advice. Thanks are also due to Dr. Masayoshi Hatanaka, Professor Emeritus of Tohoku University, for his valuable criticism and encouragement.

References

Elton C. S. 1927. Animal Ecology, Sidgwick & Jackson, Ltd. London. (a Japanese translation by Shibuya T., 1955.)

Hatanaka M. and Iizuka K. 1962. Studies on the fish community in the zostera area-1, Bull. Japan. Soc. Sei. Fish. vol.28 No.1, 5-16.

Okata A. 1975. Ecological studies on the biological production of young amberfish community in the Sendai Bay - 1, ibid. vol. 41 (12), 1247-1262.

Okata A. 1976. Ecological studies on the biological production of young amberfish community in the Sendai Bay - 2, ibid. vol.42 (1), 29-44.

Whittaker, R. H. and Levin, S.A. 1975. Niche; Theory and Application. Benchmark Papers in Ecology/3. Ed. by R. H. Whittaker and S.A. Levin. Halsted Press, 448 pp.

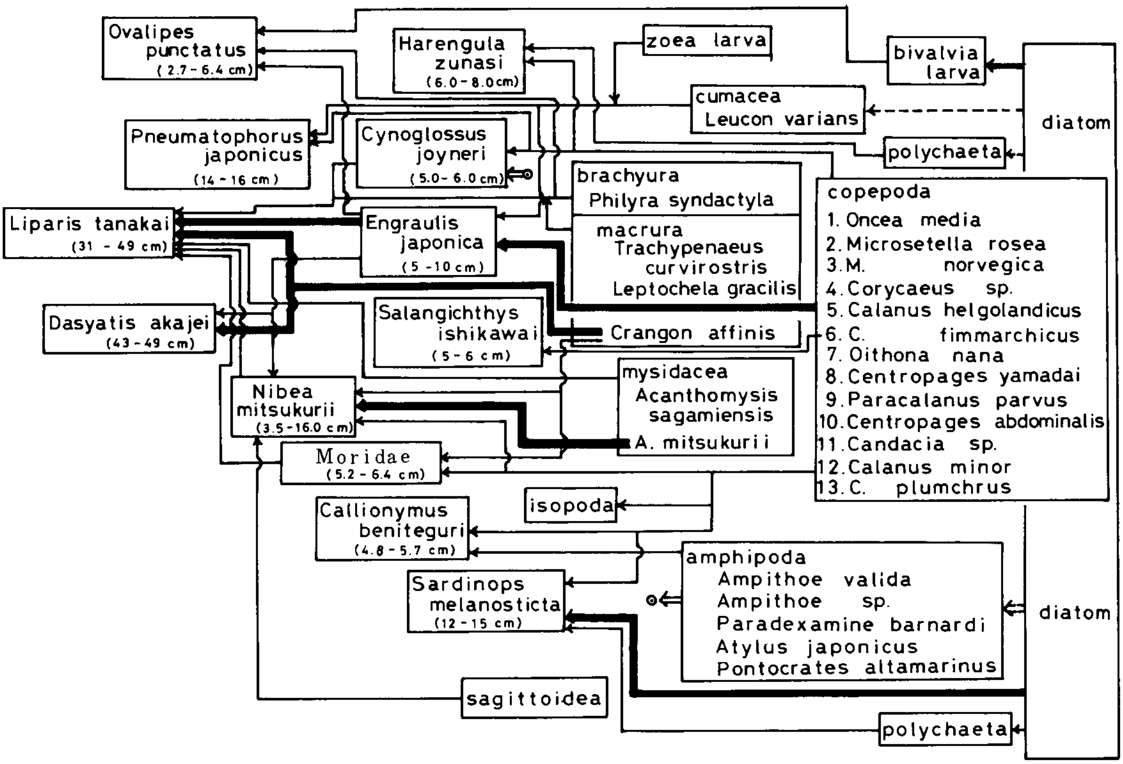

Fig. 1 Showing a production system in shallow sandy sea area, observed on the sample obtained at a station of 10m in depth, by the use of an otter trawl - net in December. The position of each organism shows its relative level in the food niche. The direction of an arrow represents the direction of the energy flow, from the prey organism to the predator. Range of body length of main predators is shown in parenthesis.

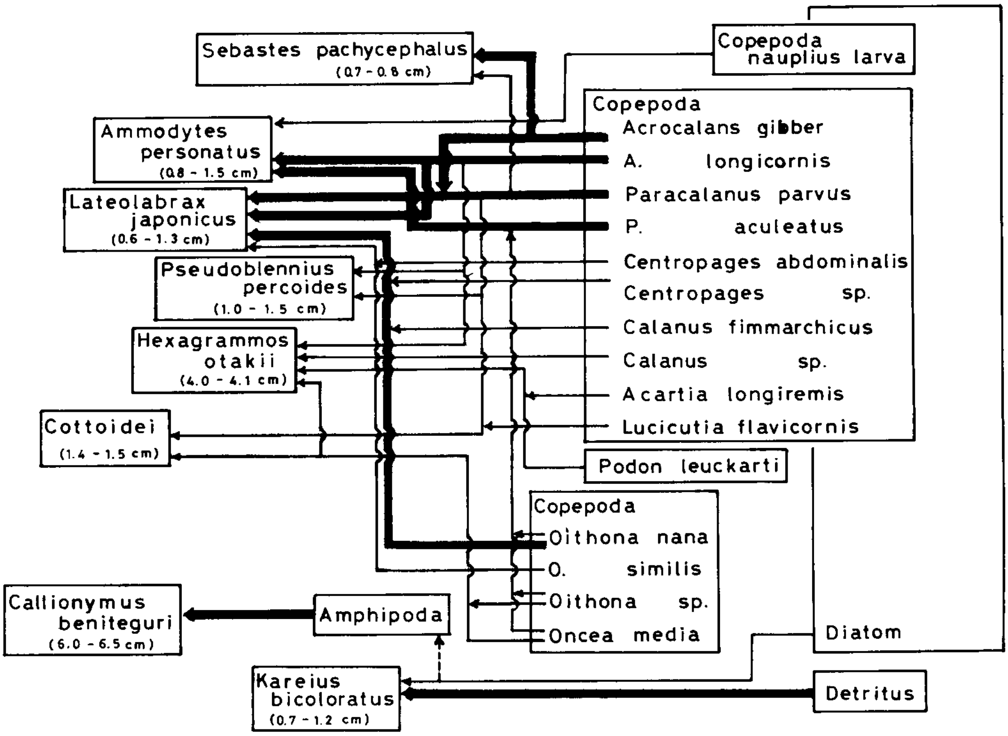

Fig. 2 Showing the production system for the community in shallow sandy sea area, observed on the sample obtained at a station of 10m in depth by the use of a beam trawl-net in January.

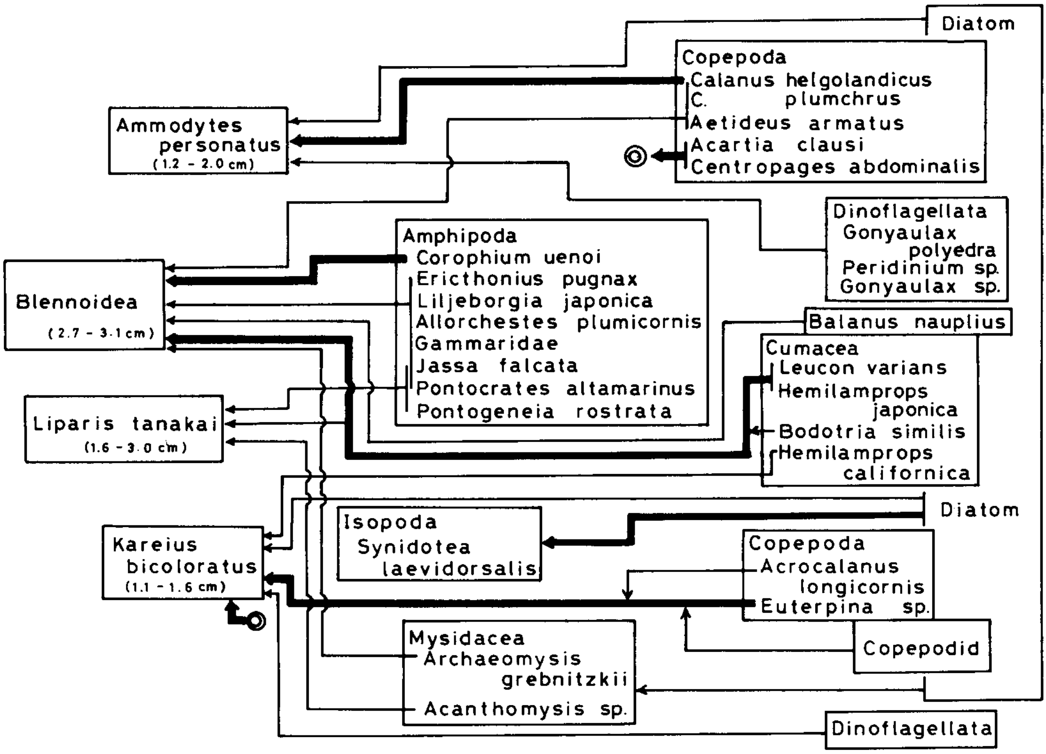

Fig. 3 Showing the production system for the community in shallow sandy sea area, observed on the sample obtained at a station of 10m in depth by the use of a beam trawl-net in March.

Table 1 Seasonal variation of marine organisms in lower food niche in a community, collected by the use of a beam trawl net in the sandy shallow sea area of 5-15m in depth, during the period from 1975 to 1977.

Appearing period			
All year round	Jan. ~ Mar.	May ~ July	Sep. ~ Dec.
Mysidacea	Pisces	Pisces	Macrura
Acanthomysis mitsukurii	Sardinops melanosticta	Salangichthys ishikawai	Lucifer reynaudi
A. tamurai	Salangichthys ishikawai	Lateolabrax japonicus	Pisces
Gastrosaccus vulgaris	Lateolabrax japonicus	Ammodytes personatus	Nibea mitsukurii
Isopoda	Ammodytes personatus	Callionymus beniteguri	Soleoidea
Synidotea laevidorsalis	Blennoidea	Triglidae	
Amphipoda	Cottoidei	Liparis tanakai	
Pontocrates altamarinus	Liparis tanakai	Paralichthys olivaceus	
Macrura	Limanda yokohamae	Limanda yokohamae	
Acetes japonica	Kareius bicoloratus	Verasper variegatus	
Leptochela gracilis	Pleuronectoidea		
Latreutes planirostris	Sebastes pachycephalus pachycephalus		
Crangon affinis			
Brachyura			
Philyra syndactyla			
Ovalipes punctatus			
Pisces			
Engraulis japonica			
Gobiidae			

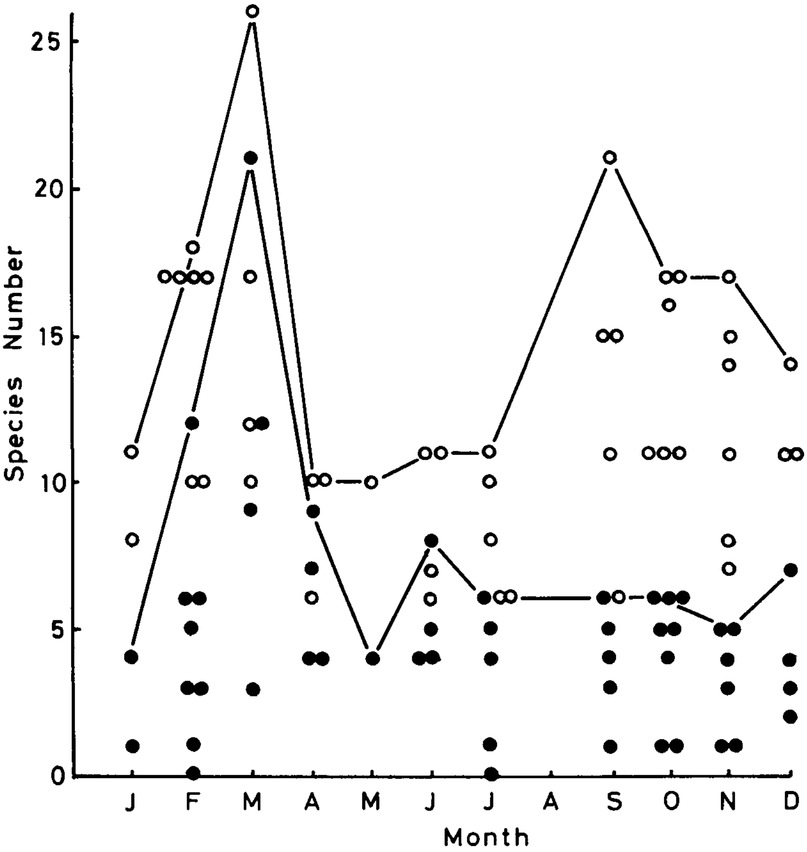

Fig. 4 Seasonal variations of species numbers of fishes under 5cm in body length and the crustaceans under 1cm in carapace length or under 2cm in breadth, sampled by the use of a beam trawl-net, during the period from January to December. ~~White~~ Black circles represent the fishes and the ~~black~~ white circles, the crustaceans.

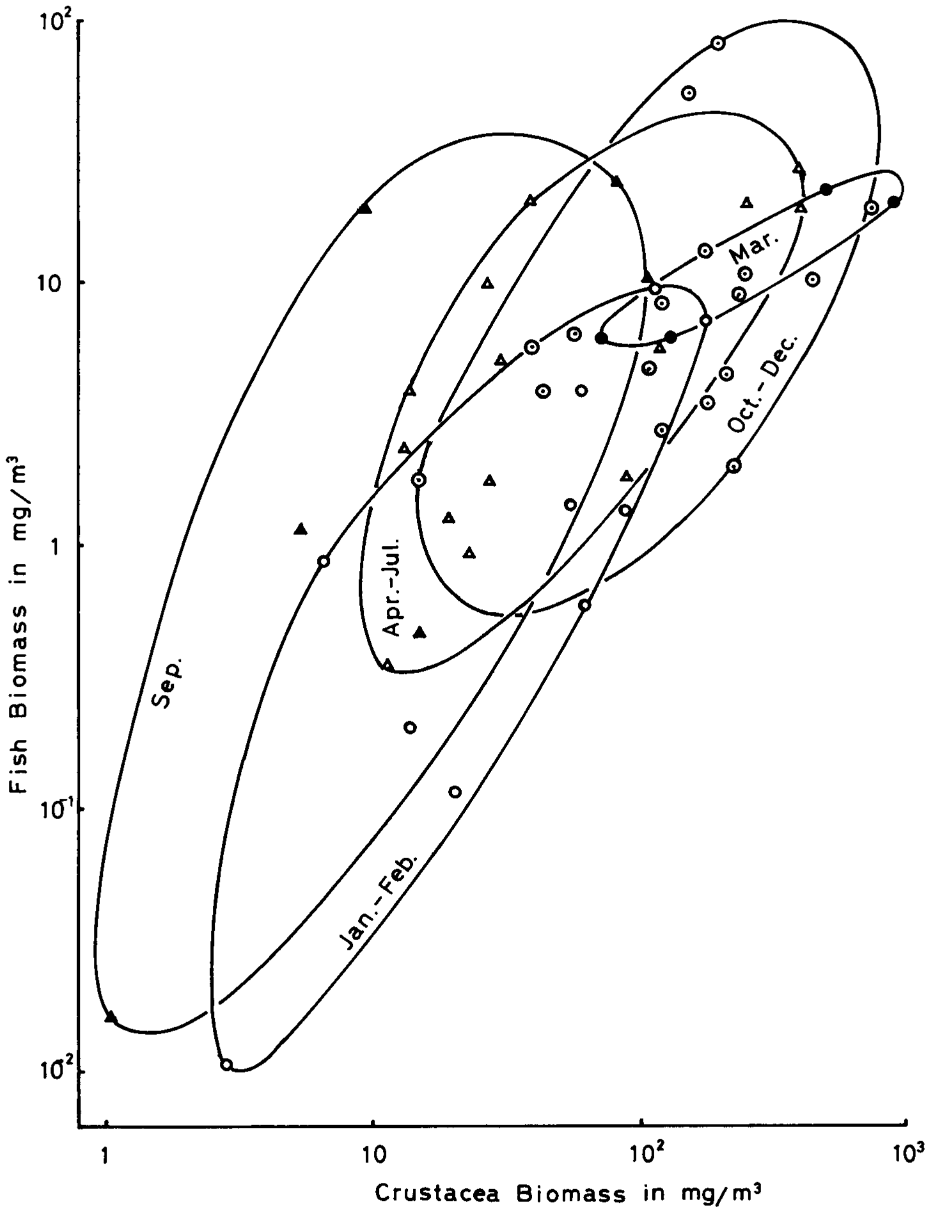

Fig. 5 Showing the wet biomass correlations between both groups fishes and crustaceans in each period throughout the year. Samples were obtained by the use of a beam trawl-net, operated along the coast line for 10 minutes per haul by sailing a boat at the rate of 2 miles an hour. A year is divided into five periods, January-February, March, April-July, September and October-December.