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Seasonal Fluctuations in Abundance and Species Composition of Fishes in Cheonsu Bay Using Trap Net Catches

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小型定置網資料에 의한 淺水灣魚類의 季節에 따른 種組成 및 量的 變動

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Abstract: Fish samples were collected by a trap net during 1981～82 at the mouth of Cheonsu Bay to determine seasonal fluctuations in abundance and species composition. Examination of a series of trap net catches indicated that trap net data could be used, at least, for a qualitative analysis of a fish community and for a quantitative study of some pelagic fishes of Cheonsu Bay.

Of the 64 species collected, a few temporal components predominated in abundance because of great seasonal fluctuations of water temperature. The early spring catch showed a low abundance value, and two cold weather seasonals, juvenile *Enedrias fangi* and *Ammodytes personatus* predominated in number and in weight. The number of species, abundance value in number and in biomass showed a peak in late spring when fishes move into bay for spawning and feeding after over-winterinig in the sea. Three pelagic species or warm weather seasonals, *Harengula zunasi, Engraulis japonica* and *Konosirus punctatus,* predominated in abundance values. In this period. night catch was significantly larger than day catch in terms of number of species, abundance in number and in weight. Summer data showed a marked reduction of the number of species and abundance due to the loss of spawners probably by mortality or wide dipersion after spawning. A slight increase in abundance was observed in autumn by recruitment of the young-of-the-years. This catch was predominated by three juvenile fishes, *H. zunasi, E. japonica* and *K. punctatus,* which were the same species as in spring. The autumn catch showed no significant difference between day and night compositions.

要約：1981年에서 1982年 사이 淺水灣入口에서 小型定置網으로 蒐集한 魚類群集의 種組成과 量的 變動을 季節別로 分析하였다.

총 64種의 魚類가 採集되었으며, 小數種이 魚類群集을 優占하였다. 이른봄에는 漁獲量이 적었으며, 베로라치(*Enedias fangi*)와 까나리(*Ammodytes personatus*)가 優占하였다. 魚類의 種數, 個體數 및 漁獲量은 늦봄에 年中最大값을 보였으며. 이는 魚類들이 產卵 혹은 攝餌를 위하여 灣으로 回遊하여 들어오기 때문인 것으로 보인다. 이 시기에는 3種의 浮泳性魚類, 밴댕이(*Harengula zunasi*), 멸치(*Engraulis japonica*) 및 전어(*Konosirus punctatus*)가 우점하였으며, 種類, 個體數 및 어획량이 낮에 비하여 밤에 훨씬 많았다. 여름에는 種數 및 漁獲量이 크게 감소하였으며, 이는 產卵후 成魚가 죽거나, 널리 퍼져기 때문인 것으로 보인다. 가을에는 그 해에 태어난 魚類가 再介入하여 어획량이 증가하였다. 이 시기에는 봄, 여름에 產卵한 밴댕이, 멸치 및 전어의 幼魚가 우점하였다. 또, 낮과 밤의 種組成도 큰차를 보이지 않았다.

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INTRODUCTION

Many studies have been carried out on the seasonal variations in abundance of bay-estuarine fishes (e.g., Oviatt and Nixon, 1973; Livingston, 1976; Hillman et al, 1977; Horn, 1980; Allen, 1982). The studies on these species were based on data obtained with some form of trawl or seine because of the problems associated with quantification using a passive net. Since sampling of pelagic fish populations remains a particularly difficult problem, most of the data that are available have come from studies of demersal fishes. Considerable short-term variation in the number of species and abundance were noted for coastal or littoral fishes (Livingston, 1976; Horn, 1980; Lasiak, 1984). In some case, short-term variations in various community parameters exceeded the long-term variability observed in seasonal studies of this fish assemblage (Lasiak, 1984).

A trap net is a passive net which permits the capture of fish that moves. The area or volume of water covered with a trap net is not easy to quantify. However, the gear is easy to operate and to sample for longer period of time. These advantages of the trap net permit the collection of pelagic fish and overcome problems due to the short-term variation.

This report presents the fish data obtained with a trap net on the monthly surveys of 1981~82. The main purpose of the study was to determine in terms of abundance, diversity and species composition, the diurnal and seasonal variations of the fishes in Cheonsu Bay.

MATERIALS AND METHODS

Fish samples were collected between September 1981 and September 1982 by a trap net at the mouth of Cheonsu Bay. The trap, net called "Jumokmang", used for the collection of data, was 45m long, 20m wide and 20m deep. The net was coarse in the mouth (33cm stretched mesh) and very fine in the cod end (1mm stretched mesh). The gear was operated by the strong tidal current and fish was effectively caught only during the flood tide. The sampling gear and the study area have been detailed previously (Lee, 1983).

To eliminated bias from diurnal and tidal influences, one day and one night samples were taken during the spring tide. As there are two spring tides in a month, the two day and two night samples were combined in order to estimate the species composition of a given month. In some months, only 2 or 3 catches were analysed due to scheduling problems and the weather. In any case, the data were standardized with respect to effective catch duration and expressed in terms of catch per a tidal cycle by a trap net Sampling dates were chosen so that the times of high water were in the early morning and late afternoon in order to compare day-night catches.

All of the large fishes caught with a trap net were sorted by species, counted and weighed. The small fish was subsampled, frozen in plastic bags and examined in the laboratory. Identification of the fish was based on Lindberg and Legeza(1959 and 1965), Lindberg and Krasyukova(1969), Chyung(1977) and Abe(1978).

Water samples were taken at the surface and the salinity was measured with an inductive salinometer. Temperature data, which were taken weekly by Gunsan Branch of the Fisheries Research and Development Agency in Daecheon located 5km south from the sampling site, were utilized for this study.

To determine an adequate sampling size, the cummulative number of species and diversity values were plotted against sample number (Pielou, 1966) from a series of samples obtained in October 1981.

Paired day and night abundances of each

species were tested for significant difference ($\alpha=0.05$) using the Wilcoxon signed-ranks test.

The degree of specific change between samples from one period to the next was calculated using the percentage similarity index (*PS*) developed by Whittaker and Fairbanks (1958). This index is calculated as,

$$PS=100(1.0-0.5\sum|p_{ia}-p_{ib}|)$$

where p_{ia} is the proportion of individuals (or biomass) in the i-th species of sample '*a*' and p_{ib} the same for sample '*b*'.

The species diversity index was calculated using a modified Shannon-Wiener formula (Pielou, 1966),

$$H'=-\sum_{i}^{s} p_i \log p_i$$

where S is the number of species and p_i is the proportion of individuala (or biomass) in the i-th species.

For the analysis of association between species, those species occurring in less than 30% of the samples (3 months) were eliminated reducing the usable number to 24. A similarity matrix was calculated based on the Jaccard index (Jaccard, 1900, 1908 in LeGendre and LeGendre, 1979). A dendrogram was constructed by selecting the pair of species having the highest value of similarity, linking each in turn the highest remaining value with further species and continuing the process until all species were included.

RESULTS

Adequate sample size

The cumulative species curve for Octover 1981 is shown in Fig. 1. The curve became asympototic at a relatively early stage of collection. The diversity curve approached the asymptote by the 5th sample of a 9 trap series. However, two new species were sampled through observation of another 5 trap net catches. The curious shape of the diversity curve between the 1st

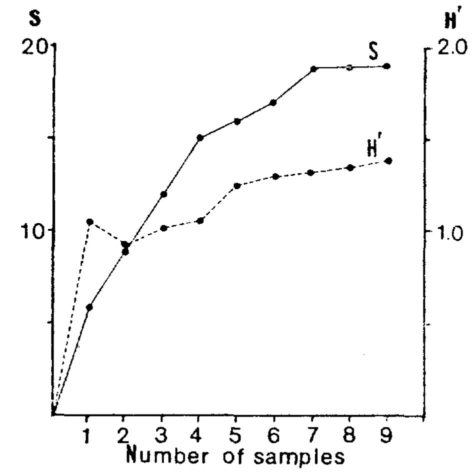

Fig. 1. Cumulative number of species(S) and diversity(H') as a function of the number of samples taken with a trap net in Cheonsu Bay in October 1981.

and 2nd collections seems to be related to the attributes of the Shannon-Wiener divesity formula. The term "p_i log p_i" has a peak when p_i approaches 0.3. When a community is composed of a small number of dominant species and several rare species, the addition of an extremely large value to one of the dominant species by accumulation of samples leads to a diminishing value of "p_i log p_i" and, consequenlty, to a reduced value of "$-\sum p_i$ log p_i".

Four sample collections were considered to be adequate for fish captured by the trap net in Cheonsu Bay. A series of 4 collections of the 9 collections contained approximately 80% of the information on the species number and the diversity index. In this study, four collections, two each during the new moon and full moon, were made in order to maximize the variance of data.

Diel variation of catches

For autumn samples, nearly equal numbers of species were collected during the day and the night (Table 1). The number of individuals and catch weight show an apparent difference between day and night catches. The *PS* values for numbers varied between 43% and 72% and those for the catch weight between 33% and 76%. However, the differences of paired day-night abundance of each species based on the Wilcoxon signed-ranks test were not significant. The discrepancy appeared to be due to the considerably large contribution of two or three major species(more than 80%) ; *Konosirus punctatus*, *Harengula zunasi* and *Engraulis japonica*.

Even though the number of individuals taken during the day in May was greater than that for the night, greater numbers of species and biomass were obtained during the night. This was because of the considerable numbers of juvenile *Enedrias fangi* which were caught during the day. The night catch in number of individuals and in weight were significantly larger based on paired day-night abundance of each species using the Wilcoxon signed-ranks test in spite of large day catch in number of individuals. The Wilcoxon signedranks test accounts not for the absolute value of the difference, but only for its rank, and, therefore, larger numbers of species in the night sample made the sum of the positive (night) ranks increase. In June 1982, 17 species were collected during the night while only 9 species were caught during the day. The night catches in numbers and in weight were larger than the day catches. The Wilcoxon signed-ranks test showed the same results. In May-June, the catches with the trap net were composed mainly of adult fishes whose movement to the bay was related to reproduction. It seems likely that the large catches during the night were related to the behavior of these fishes.

Seasonal variation

The seasonal fluctuations in water temperature and salinity in Cheonsu Bay are shown in Fig. 3a. Increased rainfall during the summer months usually causes reduced salinity throughout the bay, but, during this study, this effect was not pronounced and the salinity varied little. There was a considerable seasonal temperature variation. From September, the temperature declined gradually until November, and reached its minimum value in January (3°C). The water temperature increased steadily during March-April and reached a peak of 26°C in July.

A total of 64 species were captured during the study including five *Fugu* species; *F. rubripes*, *F. niphobles*, *F. poecilonotus*, *F. ocellatus obscurus* and *F. vermicularis radiatus*. The seasonal species compositions are depicted in Table 2. Most dominant species were *K. punctatus*, *H. zunasi*, *E. japonica*, *E. fangi* and *Ammodytes*

Table 1. Comparison of day-night catches using a trap net in numbers and in weight. "n", "S" and "PS" represent the number of species, cumulative species number and percentage similarity value, respectively. "Difference" indicates whether the day catches were significantly (S) or not significantly (NS) different from night catches based on percentage values for each species using the Wilcoxon signed-ranks test for $\alpha=0.05$.

Sampling date		No. of species n	S	No. of individuals	PS(%)	Difference	Catch in weight (g)	PS(%)	Difference
Sept. 28, 1981	Day Night	9 9	13	8,961 6,689	49	NS	15,602 31,421	33	NS
Oct. 26	Day Night	6 7	10	10,452 5,734	43	NS	13,703 30,748	61	NS
Nov. 20	Day Night	6 6	8	68 43	72	NS	382 217	76	NS
May 22, 1982	Day Night	13 26	28	32,025 7,998	22	S(D<N)	73,453 74,052	57	NS
June 5	Day Night	9 17	19	1,527 22,728	39	S(D<N)	24,842 188,575	34	S(D<N)

Table 2. Seasonal changes in the fish abundance of Cheonsu Bay. Values represent the number of individuals taken in a tical cycle with a trap net. The occurence of gobid or *Fugu* species was expressed as "+" and they were not included for the summation.

Species	1981			1982						
	Sept.	Oct.	Nov.	Mar.	Apr.	May	June	July	Aug.	Sept.
Triakis scyllia								1		
Raja kenojei					1	1			1	
Dasyatis akajei		1								
Konosirus punctatus	82	843	231		47	1,124	290	1		
Harengula zunasi	1,290	4,908	1,671			2,119	3,666	1,167	1,074	509
Ilisha elongata			1							
Setipinna taty				1	74	1				
Thrissa koreana	65	23	10			295	1,899	1	2,482	27
Thrissa mystax						4				
Engraulis japonica	3,891	5,158	132			159	3,638	12,391		3,294
Coilia ectenes			1	5	4					
Plecoglossus altivelis						8				
Saurida undosquamis						1	1			
Astroconger myriaster		1				667	136			
Tylosurus melanotus						1				
Cololabis saira						1				
Hemiramphus sajori	143			1		2	1		34	
Syngnathus schlegeli				6	113	4	3	128		
Hippocampus coronatus						4				20
Sphyraena pinguis	1	1					1			40
Liza carinata				1						
Lateolabrax japonicus						5	1			
Apogon lineatus						1	25	2		1
Sillago japonica							14			46
Hapalogenys mucronatus							7			
Nibea albiflora							1			
Nibea argentatus	1				27	1	2	1		
Johnius belengerii						6	1			
Pseudosciaena crocea	1					2				
Collichthys niveatus				1						
Collichthys lucidus					1	1				
Acanthopagrus schlegellii		1								
Oplegnathus fasciatus	1	1								20
Trachurus japonicus		26								
Seriola aureovittata	1									
Enedrias fangi		10	20	3,001	5,995	18,879				
Zoarces gillii				1		1	1			
Ammodytes personatus			10	105	627	2,748				
Callionymus flagris			1		28	2	5			
Trichiurus lepturus		1		1	1					
Scomberomorus niphonius	1	2				8	9		1	
Pampus argenteus	1			1		1				
Gobid spp.		+	+							

Gobius pflaumi				+	+					
Gobius gymnauchen				+			+			
Cryptocentrus filifer							+			+
Chaeturichthys stigmatias				+	+	+				
Chaeturichthys hexanema				+	+	+				
Triaenopogon barbatus						+	+			
Tridentiger trigonocephalus				+						+
Aboma tsushime						+				
Sebastes schlegeli	1	1				1				
Inimicus japonicus			1			2	1			
Hexagrammos otakii				13		8				
Platycephalus indicus		1				7	24			2
Liparis sp.				1						
Pleuronichthys cornutus	1									
Zebrias zebrinus						5	21			
Areliscus joyneri					1	1				
Navodon modestus	1	1				8	2			1
Fugu spp.	+	+	+	+	+	+	+			
Totals	5,481	10,979	2,078	3,138	6,919	26,078	9,749	13,692	3,592	3,960
Total species	15	16	10	13	12	34	23	8	5	10

personatus, composing almost 80% of the catches both in number of individuals and in weight (Fig. 2). Of the 64 species collected, 16 species were entraped only once.

Fish abundance and diversity fluctuated markedly during the months of the study (Fig. 3). It is noteworthy that the gobid species and *Fugu* species were excluded, for comparison between samples, both in the summation of the catches in number and in weight and in the calculation of the community parameters, because they were not well quantified during some periods of the study.

In March and April 1982, the low catches were observed. They were composed mainly of the juveniles of *E. fangi* and *A. personatus*, while the catch in weight was dominated by *K. punctatus* (47%) and *Setippina taty* (33%) in April.

The highest number of species (34 species excluding gobid and *Fugu* species) and number of individuals were collected in May 1982. Although catch weight was dominated by *K. punctatus* (48%) and *H. zunasi* (22%), *E. fangi* composed 72% of the catch in number. The PS value was low (9%) for the numbers between March and May, but very high (76%) for weight. The substantial increase of the catch in May appeared to be associated with the bay-ward migration of the fish for spawning and feeding after over-wintering in the sea.

Summer data show a marked reduction in the number of species. Two adult fishes, *H. zunasi* and *E. japonica*, were the dominant species in July. Juvenile *H. zunasi* and *Thrissa koreana* occurred most abundantly in August, and the number of individuals and biomass both reached lower levels. This decrease seemed to be due to the loss of spawners probably by mortality or wide dispersion after spawning. The low PS values between May and July indicate a marked change in numbers (9%), and biomass (16%).

In autumn, the number of species increased slightly up to 16 species. The catches were dominated by *K. punctatus*, *H. zunasi*, and *E. japonica*. The PS values show a similarity of

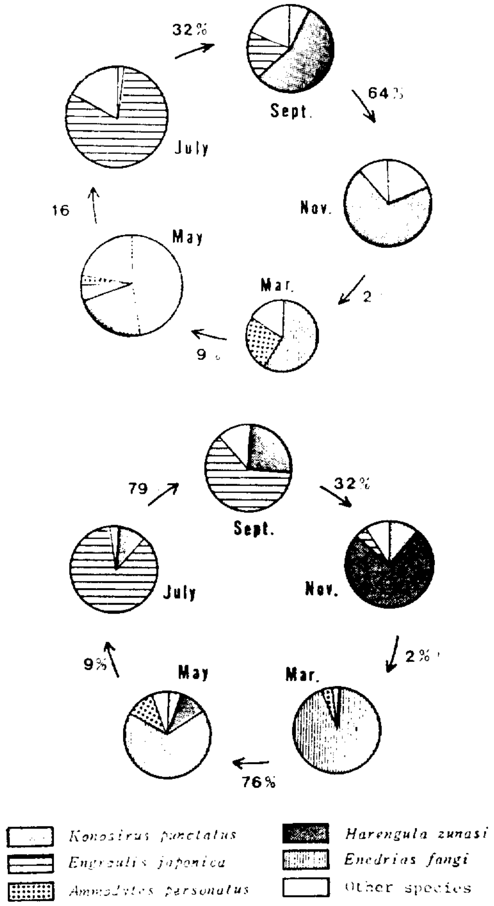

Fig. 2. Annual cycle of fish abundance in weight (upper) and in numbers (lower) collected with a trap net in Cheonsu Bay. The area of each circle is proportional to the catch expressed in logarithm, and the number on the connecting arrow is the percentage similarity index between months.

79% for numbers and 32% for weight between July and September. But the members were radically changed by the offspring of the same species.

Severe weather conditions in winter prevented the planned sampling with a trap net in the study area. Only a few fish could be caught with the trap net during the winter period (personal communication with fishermen). It can be assumed that almost all of the fish migrates into the sea for over-wintering.

Diversity accounts for how the individuals are allocated in species categories in a community. Fish captured with a trap net is not "an assemblage of populations living in a prescribed area or physical habitat" (Odum, 1971).

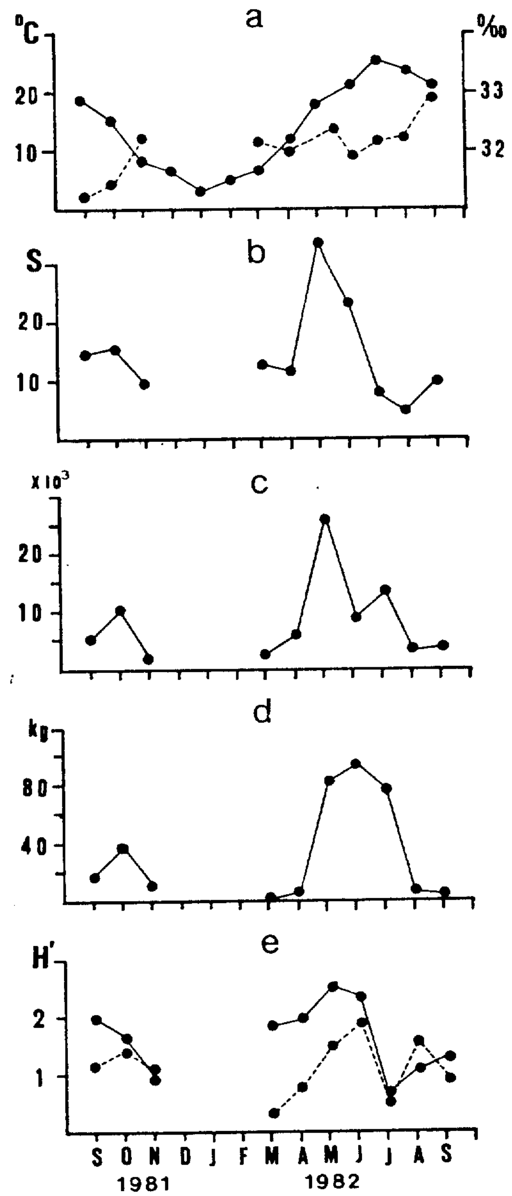

Fig. 3. Monthly variations of (a) temperature (solid line)-salinity (broken line), (b) number of species, (c) catch in numbers and (d) weight, and (e) the diversity index for the number of individuals (broken line) and for the biomass (solid line) of fishes collected with a trap net in Cheonsu Bay.

However, the diversity calculated from serial catches obtained by the same gear can be used to compare the seasonal variation of fish populations. Species diversity, expressed according to the Shannon-Wiener index, showed a similiar variation to that of the number of species (Fig. 3e). H′ values for the spring were generally high with a peak in May for number and in June for weight. This was followed by an abrupt decline in July when 2 species, *E. japonica* and *H. zunasi*, comprised 99% of the catch in both number and weight. Diversity increased slightly in antumn. This increase was related to the recruitment of juveniles.

In the spring, the values estimated from the number of individuals showed much lower values than those estimated from catch weight. This was because the fish in the catches varied greatly in size. In a natural community, the species of a very large size represented, in general, by a lower number of individuals, while small sized specied have a higher number, It is natural that diversity expressed in terms of biomass is higher than that estimated by numbers (Daget, 1976). It seems likely that, as Pielou(1975) recommended, the biomass of a species is a more reasonable measure of the quantity of Cheonsu Bay fishes collected with a trap net.

Species association

The hierarchial grouping of species based on the presence-absence of species is presented in the form of a dendrogrm in Fig. 4. All of the species were grouped at the 0.60 fusion level. Two species groups can be distinguished at the 0.70 similarity level. The other species were considered to be of sporadic occurence.

A major group was comprised of 13 species, which could be further divided into subgroups. The first subgroup consists of 4 Clupeiformes fishes; *H. zunasi*, *T. korean*, *E. japonica* and *K. punctatus*. Reference to Table 2 reveals that

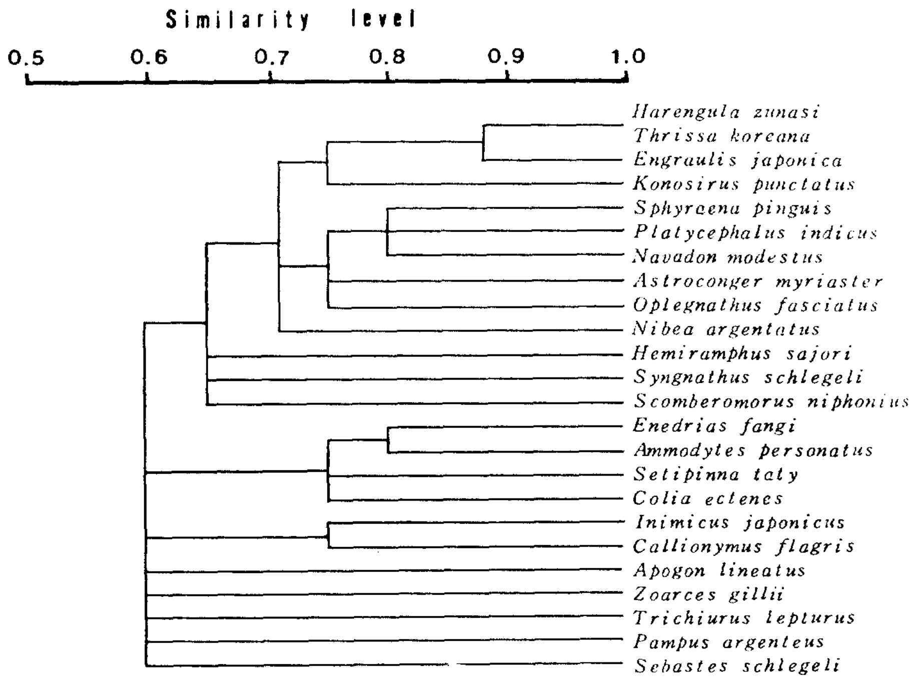

Fig. 4. Dendrogram illustrating the species association of fish collected with a trap net in Cheonsu Bay, according to the Jaccard index of similarity.

these 4 species were not only the most numerically abundant but also the most frequently encountered species in Cheonsu Bay. They entered the Bay in April-May for spawning and feeding and moved out to the sea in late autumn. The second subgroup and the other members of the group shared affinity with the dominant group species, which suggests that there is some relationship between these species and the dominant species in terms of life cycle.

The second group consisted of 4 species. *E. fangi*, *A. personatus*, *Colia ectens* and *S. taty*. The juveniles of *E. fangi* entered the Bay in early spring and moved out to the sea before summer (Huh et al., 1981). *C. ectens* and *S. taty* were seasonally present in spring and in autumn. The presence of *C. ectens* in spring and in autumn can be interpreted as resulting from its migrating behavior. This fish migrates towards the river mouth for feeding and spawning in spring and moves out to the sea for over-wintering in late autumn. The close association of *C. ectens* and *S. taty* with the winter spawner is because Jaccard's similarity index does not account for the abundance of a species, but only for its occurrence in a sample.

DISCUSSION

The area or volume of water covered with a passive net is not easy to quantify. However, prolonged catching with a trap net may compensate for the disadvatages of the passive net, e.g., short-term variations of the catch. This can be confirmed by the fact that the cumulative curve became asymptotic at relatively early stages of collection. It seems likely that the information obtained from a trap net can be used at least for the qualitative study of a fish community in a given habitat. The trap net used for this study was operated by the strong tidal currents (with a velocity of up to 6 km/hr). This gear can be compared to an active net drawn at speed of 6 km/hr for pelagic fish. It suggests that data on some pelagic fishes obtained by using this gear could be used for a quantitative purpose.

There was a difference in diel variation according to the season. The autumn catches showed no significant difference between day and night. In the spring, higher numbers of species and individuals and a greater biomass were usually collected during the night. Data obtained by a trawl or seine in shore waters showed that a larger number of species, individuals or higher biomass were also observed at night (Livingston, 1976; Horn, 1980; Lasiak, 1984). Little is known about the diurnal-nocturnal activity which produces a day-night difference in the abundance and composition of net-caught fishes (McCleave and Fried, 1975). They and Horn (1980) considered that gear avoidance was one of the factors causing the generally smaller daytime catches. However, Horn (1980) doubted that larger fishes could more effectively avoid the seine in the daytime than smaller ones. In Cheonsu Bay, the data indicated that there was a difference in diurnal-nocturnal activity patterns between adult and juvenile fishes. In the autumn when there was no significant day-night difference, catches were composed mainly of juveniles. Night catches in the spring were generally more abundant than day catches in the number of species, catches weight or number, when catches were composed of adults. It seems likely that the juveniles did not show a day-night activity difference, but that the adults, which occurred in the bay mainly for reproduction, were more active at night.

Fish populations collected with the trap net in Cheonsu Bay were dominated by a few, low trophic level species. Similar situations were observed in many bay-estuarine fish communities sampled by a trawl or seine (e.g., Oviatt and Nixon, 1973; Allen and Horn, 1975; Hoff and

Ibara, 1977), or by a gill net (Recksiek and McCleave, 1973). Seasonal succession of dominant species could be clearly defined for Cheonsu Bay pelagic fishes. In the early spring, a winter spawning fish, *E. fangi*, predominated in abundance. In May, the movement to the bay of spring-summer spawning adult fishes maximized the abundance in fish species, number and diversity index. The timing of migation may be such that the juveniles of winter spawners and their associates move out to the sea and adults of spring-summer spawers enter the Bay, causing a minimal co-occurrence period of two groups of fishes. Huh(1984) observed the distinct seasonal abundance patterns with different times of peak recruitment among fish species in sea grass meadows, resulting in apparent reduced competition. In the spring, three fish species, *H. zunasi*, *E. japonica* and *K. punctatus*, predominated in abundance, and a fourth species, *T. koreana*, contributed in some degree.

The slight increase of the autumn catch was mainly due to the recruitment of iuveniles. As in the spring, three species, *K. puncsaus*, *H. zunasi* and *E. japonica*, were dominant in numbers and weight, but they were composed mainly of the first year class fishes. Oviatt and Nixon (1973) observed the largest number of juveniles in the autumn. This confirmed the idea that bay-eatuarine areas perform a major nursery function-young fish apparently congregates in these areas and benefits from the availability of food and protection from predators (Gunter, 1938; McErlean et al, 1973; Warburton, 1978; Allen, 1982).

The terms "periodic" and "regular components", proposed by Tyler (1971), were largely used in dealing with estuarine and coastal fish communities (Chesney and Iglesias, 1979; Allen, 1982). Tyler noted that the formation of the temporal component is largly related to the temperature regime and that with greater seasonal temperature fluctuation, more species are in the temporal component than in the regular component. The dominant fish species in Cheonsu Bay, where temperature varied greatly between 3°C in January and 26°C in July, were wholly temporal. Recksiek and McCleave (1973) obtained similiar results from gill net data. Species groupings showed two distinct periodic components in Cheonsu Bay fishes captured by the trap net. Juvenile *E. fangi* and *A. personatus* were cold weather seasonals. The major species, *K. punctatus*, *H, zunasi* and *E. japonica*, were warm weather seasonals. The data indicate that cold weather seasonals predominated the fish community of Cheonsu Bay in early spring, adults of warm weather seasonals in late spring-early summer and their juveniles in late summer-autumn.

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