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Fisheries Resources in Garolim Bay*

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Garolim Bay is not only important fishing ground but also expected area for the tidal power plant. The construction and operation of tidal power plant will make change the ecosystem of this bay. Therefore, the actual fisheries stocks should be precisely understood for the effect estimation and overall utilization of the bay after the construction of the tidal power plant.

During the study period from January through December in 1981, forty-six adult fishes species, 3 species of fish egg and 25 fishes larvae species have occurred in the bay.

Considering the result on monthly distribution of eggs and larvae, the inner area of the bay seems to be important as nursing ground of larvae spawned at the outside bay in winter, *e.g.*, *Ammodytes personatus*, and *Enedrias* sp. This inner bay is also major spawning ground for many species spawning in spring and summer, *e.g.*, Gobiidae, *Konosirus punctatus*, *Engraulis japonica*, etc.

Taking into consideration the annual mean production for three years(1978~1980), there are two major fishing seasons. The one is in May-June for *Enedrias* larvae stock, and the another in October-November for big eyed herring stock.

For the mariculture stocks, short necked clam, oyster and laver are important species. After construction of the tidal power plant, the migratory species, *i.e.*, larvae of *Enedrias* and *Ammodytes personatus*, *Mugil cephalus*, *Konosirus punctatus*, etc. will be directly damaged by the interuption of migration route.

On the other hand, the change of physico-chemical factors of seawater will also affect the ecosystem of the bay. Consequently, for the overall utilization of the bay after construction, the actual ecosystem including the fisheries stocks, must be precisely revealed, and the mechanical designs, *e. g.*, sluice position and its demension, should be also considered with these biological characters of the bay.

I. Introduction

The coastal areas of the Seosan-Gun, including Garolim Bay is the most important fishing ground in the west coast of Korea. Furthermore, there is the program to establish the tidal power plant at the mouth of Garolim Bay. The construction and operation of the tidal power plant will manipulate the tidal regime, and this will concomitantly affect the fisheries resources of Garolim Bay. Thus, the actual situation of fisheries resources should be precisely understood. This know-

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ledge will be indispensable to estimate the influence of tidal power plant on the fisheries, and for reasonable management and overall utilization of this bay after construction. Therefore, the object of this survey is to provide the basic infor mations on fisheries resources in Garolim Bay before the construction.

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Ⅱ. Materials and Methods

Monthly survey *in situ* was carried out from January to December, 1981. Six sampling stations from the entrance into the bay to the inner bay were determined by considering the local condition (Fig. 1).

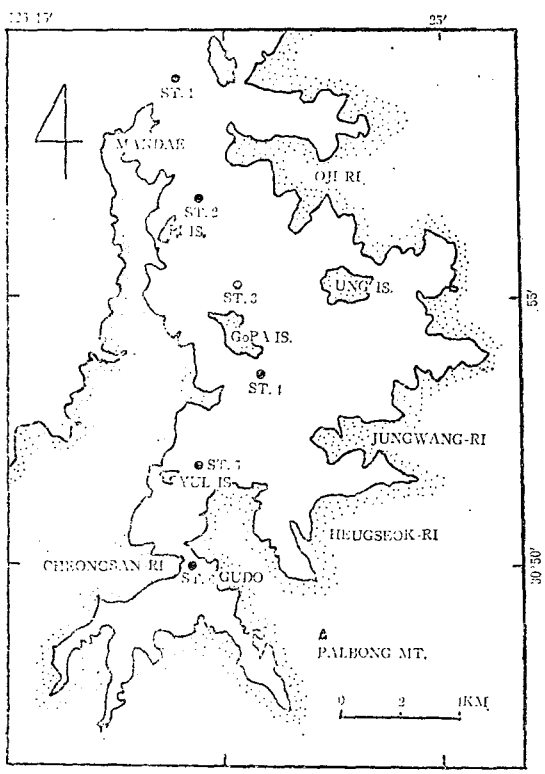

Fig. 1. Sampling stations in Garolim Bay.

For the investigations of fish eggs and larvae, standard net(mouth diameter: 1*m*, mesh size: 240 *μm*) was towed for about 15 minutes at the surface at each station. The samples fixed in 10% neutral formalin were identified according to the taxonomical keys of Russell (1976), Chyung (1977), Abe (1978), etc. The numbers of eggs and larvae were computed in individual numbers per 1,000m^3.

Adult fishes were sampled using three types of fishing gear: trammel net, small bottom trawl and stow net. The external and internal mesh size of the trammel net which was used to collect the pelagic fishes were respectively 190 *mm* and 25 *mm*. The length, width and mesh size of the small bottom trawl for the sampling of demersal fishes were respectively 5.5*m*, 2.5*m* and 38*mm*. On the other hand, fish samples of stow net were directly collected from the commercial stow net vessels.

The data of fisheries activities and catches statistics in Garolim Bay were collected from the county office of Seosangun, National Federation of Fisheries Co-operatives, and Office of Statistics of Ministry of Agriculture and Fisheries, and were analyzed for the study of fisheries resources.

Ⅲ. Results and Discussion

1. Species composition of adult fishes

During the survey period, forty six species of adult fishes have occurred. All of them were Teleost except two species: *Triakis scyllia* and *Raja kenojei* (Table 1). The most abundant species appeared in April(22 spp.), and the least specie in Decembe (5 spp.). Generally, gobies and flounders occurred through the year, but other species seem to be presented seasonally in Garolim Bay.

Because of the insufficiency of unified fishing effort and different fishing gears, it was not possible to analyse the structure of each stock.

Table 1. Occurrence of adult fish species in Garolim Bay in 1981

Species \ Fishing gear / Month	Trammel net												Bottom trawl												Stow net											
	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
Triakis scyllia						+		+																												
Raja kenojei				+		+	+				+							+						+	+										
Konosirus punctatus			+	+		+			+																						+		+		
Harengula zunasi																															+		+		
Trissa hamiltoni																																	+	+		
Engraulis japonica																									+											
Plecoglossus altivelis																									+	+			+	+						
Anguilla japonica																					+								+	+	+					
Astroconger myriaster						+												+	+										+	+			+			
Syngnathus schlegeli																				+		+							+	+						
Hippocampus coronatus																																	+			
Sphyraena pinguis																									+											
Lateolabrax japonicus							+													+																
Hapalogenys mucronatus								+																												
Nibea albiflora								+																												
Acanthopagrus schlegeli				+	+	+																							+							
Azuma emmnion																													+	+	+	+				
Ammodytes personatus																														+						
Erysistemma otohime						+									+	+	+								+	+	+	+	+							
Enedrias fangi				+	+	+	+								+	+	+										+									
Zoarces gillii																						+	+				+	+				+				
Callionymus richardsoni																			+		+						+									
Gobius pflaumi	+							+										+																		
Acanthogobius flavimanus	+	+	+	+					+	+	+	+	+	+										+												
A. hasta				+											+		+		+	+	+	+											+	+		
Chaeturichthys stigmatias																		+				+														
Trizenopogon barbatus																							+				+	+								
Tridentiger trigonocephalus							+	+	+	+	+	+							+		+															
Sebastes oblogus						+	+													+		+														
S. hubbsi																																				
Inimicus japonicus						+		+	+											+																
Hexagrammos otakii				+	+	+	+		+	+	+							+			+							+	+	+						
Platycephalus indicus						+			+	+	+																									
Trachidermus fasciatus	+														+	+	+	+			+			+				+	+							
Liparis tanakai																			+	+																
L. punctulatus okadai																	+																			
L. tessellatus	+														+																					
Bothidae gen. sp.																																	+			
Verasper variegatus				+	+		+	+	+	+								+		+	+	+		+	+										
Kareius bicoloratus				+	+												+																			
Limanda herzensteini					+		+	+							+	+	+			+	+															
L. yokohamae	+								+	+	+									+		+	+	+												
Zebrias zebrinus							+																													
Areliscus joyneri							+	+												+		+		+												
A. rhomaleus									+	+																										
Fugu rubripes									+																											

2. Eggs and larvae

2.1. Eggs

During the survey period, the eggs appeared from May to September, and three species of eggs were identified (Table 2). The eggs of *Konosirus punctatus*, *Engraulis japonica*, and *Callionymus* sp. occurred in May-July. Eggs occurred from May attained at maximum in June, and decreased continuously until September. In May eggs of *Konosirus punctatus* were representative species. These eggs occurred at all stations of the bay, but its concentrative areas were around stations 4, 5 and 6. Eggs of *Callionymus* sp. and *Engraulis japonica* appeared in small number, and were concentrated in the inner bay (st. 4, 5 and 6). Unidentified eggs occurred also at the stations 5 and 6.

The occurrence of the eggs is the highest in June, and they were more abundant at the inner bay than at the entrance into the bay. Eggs of *Engraulis japonica* were the dominant species, and its occurrence was concentrated at the station 5 (6,946 eggs./1,000m^3). The eggs of *Konosirus punctatus* and *Callionymus* sp. have been appeared at all stations. The eggs of *Callionymus* sp. were rich at the entrance into the bay(st. 1, 451 eggs /1,000m^3), and poor at the inner bay(st. 6, 17 eggs/1,000m^3).

Eggs of *Konosirus punctatus* in June were decreased as compared with those in May, but the inner stations were concentrative areas for this species as in May. The unidentified eggs occurred at all stations except station 2, and its major habitat seems to be near station 6.

In July, only two species have been found. Eggs of *Engraulis japonica*, which were the most abundant, were concentrated at the center of the bay(st. 3, 6,344 eggs /1,000m^3). Eggs of *Konosirus punctatus* were less abundant than those in June, and its occurrence numbers at station 5 were the highest.

The eggs presented in August were not identified. The egg diameter of these eggs was about 1.16*mm*. They had one oil glouble, and its diameter was about 0.24*mm*. They occurred dominantly at the station 6(193 eggs/1,000m^3).

In September, unidentified eggs were found in station 2, but its occurrence numbers were very poor(2 eggs/1,000m^3).

2.2. Larvae

Concerning the larvae, twenty six species presented during the study period. Eight species appeared in April were the highest, and one species occurred in March and November was the lowest. As regard to total occurrence number of larvae, it was the most abundant in February, and the poorest in November.

From January to March larvae of *Enedrias* sp. were dominant species. They occurred most abundantly in February through the year. In March, small numbers of these larvae have been found. In January and February, these larvae seem to be concentrated at the entrance into the bay. In addition to this species, *Hexagrammos otakii*, *Hemitripterus villosus* and *Lateolabrax japonicus* occurred at the st. 1 and 2 in January and February, but their occurrence numbers were small under 7 ind./1,000m^3.

Larvae of Gobiidae presented from April through September, and they were always dominant species in each month except in April. In April and May, they occurred at the inner stations(st. 4, 5, 6). The most concentrative area of these larvae was always station 6 except in August. These larvae in August were the most abundant through their occurrence period, and station 3 seems to be major habitat in this month. In April *Pseudoblennius* sp., which was dominant, occurred abundantly at station 4(433 ind./1,000m^3). Except this species, *Ernogrammos* sp. and *Limanda yokohamae* have occurred abundantly at the inner bay, particularly at station 6, and the larvae of *Ammodytes personatus* and *Anguilla japonica* presented at the entrance into the bay in a small numbers. On the other hand, the larvae of *Liparis* sp. were found in the center of the bay(st. 3, 70 ind./1,000m^3). In May, larvae presented

Table 2. Abundance of fishes eggs and larvae in Galorim Bay in 1981 (No. of individuals/1, 000m^3)

Species	Station	Jan. 1	2	3	4	5	6	Feb. 1	2	3	4	5	6
Larvae													
Konosirus punctatus													
Harengular zunasi													
Engraulis japonica													
Hemitripterus villosus								7					
Syngnathus schlegeli													
Lateolabrax japonicus									5				
Anguilla japonica													
Hippocampus aterrimus													
Enedrias sp.		894	99	4	2		17	387	1, 295	2, 516	638	2, 571	1, 821
Ernogrammus sp.													
Ammodytes personatus													
Pseudoblennius sp.													
Callionymus sp.													
Trachidermus facciatus													
Gobiidae													
Sebastes sp.													
Hexagrammos otakii		3	2										
Limanda yokohamae													
Liparis sp.													
Unid.													
Eggs													
Konosirus punctatus													
Engraulis japonica													
Callionymus sp.													
Unid.													

Species	Station	July 1	2	3	4	5	6	Aug. 1	2	3	4	5	6
Larvae													
Harengular zunsi					9	10	39						
Engraulis japonica							5						
Syngnathus schlegeli		3	6		3	3	7			23			
Hippocampus aterrimus										6			
Enedries sp.													
Stichaeus grigorjewi													
Ammodytes personatus													
Callionymus sp.			3			8	5	29	6	17	44	21	
Cottidae							10						
Gobiidae		145	173	485	383	288	748	596	407	3074	515	130	1353
Hexagrammos otakii													
Pleuronectidae													
Pleuronichthys cornutus													
Areliscus sp.								11		63	22		
Fugu niphobles											5		
F. sp.					3								
Unid.													
Eggs													
Konosirus punctatus		96	136	280	128	253	51						
Engraulis japonica		250	294	6344	1927	562	15						
Unid.								11	6	47	37		193

Mar.						Apr.						May						June					
1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
																	19					7	101
																			28				
																		43	28			15	
																		152	188	9	8		17
						3																	
																			9				
18	11	11	11		18	516	25				6												
									3	13	160												
						13					11						3						
								18	433	129	120												
																3	29						
																3							
									16		320				4	18	195	161	366	4	32	114	993
																	6						
											154												
								70															
												18	10	225	13667	6388	1606	97	253	32	1845	1307	303
															17	17	6	2618	3622	792	2656	6946	278
																23		451	375	80	277	190	17
																135	139	6		4	171	828	917

Sept.						Oct.						Nov.						Dec.					
1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
																				3			
	2																						
			2																		2		
																			8	5	2		
																	3	13			88	65	21
	2																						
			8	8	14																		
													11	3	6	8	23		8	86	10	13	18
						4																	
						4																	
						4																	
	2																						

at the only inner stations (st. 4, 5, 6), particularly at station 6. In addition to Gobiidae, *Konosirus punctatus*, *Sebastes* sp., *Callionymus* sp. and *Trachidermus fasciatus* have appeared newly, but its occurrence numbers were generally in small.

In June, the larvae of Gobiidae have appeared at all stations, and station 6 was again the most concentrative area. Other species occurred newly in June, *e. g.*, *Engraulis japonica*, *Harengular zunasi*, *Syngnathus schlegeli*, *Hippocampus aterrimus*, were generally found at the entrance into the bay. However *Konosirus punctatus* occurred since May was abundant in the inner bay.

In July, *Fugu* sp. appeared at the first time in small number. In August, larvae of *Callionymus* sp. showed the maximum occurrence number since May, and these larvae were found at all stations except station 6. *Fugu niphobles* and *Pleuronichthys cornutus* appeared newly in this month.

In September, occurred species and numbers of larvae were distinctly decreased. Only four species occurred in the previous month were found in small numbers.

In October, *Pleuronichthys cornutus* and one species of Pleuronectidae occurred at the entrance into the bay in a few number.

In November, only one species, *Hexagrammos otakii*, appeared at all stations except station 1, and its occurrence number was the highest at the station 6(23 ind./1,000m^3).

In December, among six species occurred, the dominant species was *Ammodytes personatus*. Larvae of *Hexagrammos otakii* were abundant at station 3. On the other hand, *Hemiramphus sajori* and *Stichaeus grigorjewi* occurred at the first time, and the larvae of *Enedrias* sp. were found again after April. But the occurrence numbers of these species were small.

2.3. Spawning season and ground

Considering the occurrence place, time and number of fishes eggs and larvae, spawning season of the fishes in Garolim Bay can be devided into two groups. The one is spawning groups in winter, and the another in summer. The representative species of winter spawning group are *Enedrias* sp. and *Ammodytes personatus*. It seems that the spawning time of *Ammodytes personatus* will be a little earler than that of *Enedrias* sp. The major spawning time of the former seems to be in December, however, that of the latter in January. Except these two species, *Hexagrammos otakii*, *Stichaeus grigorjewi*, *Lateolabrax japonicus* seem to be spawned in winter.

The representative species of summer spawning groups are Gobiidae, *Aleliscus* sp., *Engraulis japonica*, *Harengular zunasi*, *Callionymus* sp. etc. The major spawning time of these species except Gobiidae and *Aleliscus* sp. will be in June, but these two stocks seem to be mainly spawned in August.

With respect to spawning ground, winter spawning groups spawn at the outside of the bay, however, spawning ground of summer spawning groups seem to be inner place of the bay. Particularly, the inner place near station 5 and 6 seems to be most favorable spawning ground for many species in June. But, in August, the place near station 3 will be more favorable than the most inner station for the spawning. The inner station (st. 6) seems to be also as the nursing ground of larvae of *Enedrias* sp. and *Ammodytes personatus* The warm water and plentiful food organisms of the inner place seem to be reasons as its favorable spawning and nursing ground.

3. Fisheries

3.1. Fisheries activities

In general, the fishing in Garolim Bay can be divided into two types. One is the stow net fishing using the nonpowered vessel (10~20ton), and the another is gill net fishing using small powered vessel under 2 ton. The major stocks of stow net fisheries are larvae of gunnels in spring, and big eyed herring in autumn. The major species of the latter fisheries are gobies, mullet, skate ray, flounder, etc. The fishing activity in

the bay continues throughout the year. But major fishing months are May-June in spring and October-November in automn.

According to the statistics of Ministry of Agriculture and Fisheries in 1979, numbers of fishing households and fishermen at the coast of Garolim Bay were 1,344 and 6,453 respectively. On the other hand, fishing vessel power was very poor. Fifty three percentes were non-powered vessels, and the vessels under 5 ton were 79% of total.

On the other hand, twelve fishing villages are distributed at the coast of the bay for the fishing activity and the marketing of products. The largest one is Garolim fishing village where the major products are larvae of gunnels and laver.

3.2. Fisheries resources

The annual mean fisheries production from 1978 to 1980 was shown in Table 3. During these periods, annual mean production was 4,618M/T, and 73% of them was attained by mariculture. The major species of mariculture were short necked clam(53%), oyster(42%) and laver(5%). The precentages of fishes, crustacean, molluscks algae and others to the total production were respectively 15, 4, 74, 5 and 2%(Table 3).

3.2.1. Fishes

The most important fish resource in the bay is the larvae of gunnels fishes. The catch statistics of these larvae in table 3 were computed in dry weight, and the total catch amounts (111, 315*kg*) in dry weight will correspond to about 434M/T. in wet weight. In addition to these larvae stock, gobies, mullet, big eyed herring, hichory shad, skate ray, flounder, etc., are major fish stocks in the bay.

1) Gunnels

Larvae of gunnels (*Enedrias* sp.) in Garolim Bay are traditionally exploited from many years ago by the non-powered vessels with stow net, and this stock is one of the most economic species in Garolim Bay. As the adult of this species did not appear abundantly in Garolim Bay during the study period, its spawning habit was not yet completely known. However, considering the distribution and abundance of larvae in winter and spring season, major spawning seems to be occurred in January or February at the outer bay. These larvae hatched at the outer bay begin to enter into the bay. Fishing ground of this stock is at first formed at Gudo area in March, and then larvae migrate back toward the outer bay.

From the beginning of July juvenile gunnels reach the outer bay. This fishing ground in July is formed at *ca.* 4~6*km* distance from the bay, and the fishing activities continue until the mid-July.

The migration of this young *Enedrias* sp. seems to be a feeding migration.

2) Gobies

Several species of Gobiidae occur in the bay. But taking into consideration the result of catch amount by trammel net in the bay in 1981, the representative gobies are *Acanthogobius flavimanus*, *A. hasta*, and *Chaeturichthys stigmatias*. These three species will occupy nearly 70% of total gobies production. According to annual mean production (Table 3) this stock was about 18.6% of total fishes production in the bay. Gobies are mainly exploited by the trammel net throughout the year, but major fishing season in October. Gobies are not yet much commercial, however, their feeding habit is so carnivorous that they will very important for the small fishes or invertebrates community.

3) Mullet

Mullet (*Mugil cephalus*) stock is also exploited by the trammel net throughout the year. Annual mean production of mullet attained 84.7M/T which was 11.7% of total amount of fish catch, and its major fishing season was from October to December. Its production was the lowest in August except in January and February when the fishing effort is nearly nul because of the cold weather in the bay. Consequently, mullet stock seems to migrate to the outer bay in summer in order to find suitable habitat.

4) Big eyed herring

Big eyed herring is the most important species in autumn fisheries in the bay. In Table 3, the total catch amount of the fish was 11.6% of total fishes production(725.6M/T) in the bay. This stock is also exploited by the stow net, and the fishing method is the same as that of gunnels' larvae. The fishery of this stock begins from August, and the fishing peak is formed at the entrance into the bay in October. It is finished at the outer bay at the end of November.

Big eyed herring caught is dried under the sunshine, and sold as the feed for a domestic animal or plant. Therefore, in spite of abundant species, this fish is treated as the unimportant fishes. However, considering its high production, the reasonable management for this stock will be immediately necessary.

5) Other fishes

Except for the fish stocks discussed above, hickory shad, skate ray, flounder, etc., are also commercial fish stocks in the bay. Hickory shad seems to be occurred in spring and automn in the bay. The inner bay(Gudo area) is known as the flounder's spawning ground in spring. The major species of flounders are *Limanda yokohamae* and *Verasper variegatus*. Skate ray (*Raja kenojii*) is mainly exploited at the inner bay in May and June.

3.2.2. Crustacea

According to the statistics of Ministry of Agriculture and Fisheries from 1978 to 1980, total annual mean crustacean production was 176.1M/T which was 3.8% of total fisherie production in the bay. Crustacean was composed of shrimp, crab and squilla. Monthly variation of crustacean production was similar to that of fish production. The major fishing months of crustacean were May and October, and the production in autumn was higher than that in spring.

1) Shrimps

During the survey period in 1981, twelve species of shrimps were caught by the small bottom trawl and trammel net. These species were *Leptochela gracilis*, *Alpheus japonicus*, *Trachypenaeus curvirostris*, *Metapenaeopsis joyneri*, *Penaeus orientalis*, *Crangor hakodatei*, *C. atlinis*, *Pandalopsis japonica*, *Acetes japonicus*, *Acantomysis* sp., *Palaemon gravieri* and *Caridina* sp. However, the shrimps exploited commercially in the bay were mainly *Metapenaeopsis joyneri*, and *Penaeus orientalis*. According to the statistics in Table 3, shrimp medium was 8.1% of total crustacean.

2) Crabs

The species of crabs exploited commercially in the bay are *Portunus trituberculatus*, *Charybdis japonica* and other crabs. The major species of crabs is blue clab (*Portunus trituberculatus*) which was 20.6% of total Crustacean production. Blue crab appeared from March to November, but the peak of this species was in May.

3) Squilla

This species(*Squilla oratoria*) was mainly caught in April at the inner bay, and its mean production was 2.3M/T which was the least among crustacean groups.

3.2.3. Molluscs

The total mean production of molluscs was 279.7 M/T which were composed of 119.6M/T of cephalopods and 160.1M/T of shellfishes.

1) Cephalopods

The major species of this group were *Octopus variabilis*, *O. ochellatus* and *Loligo* sp. The most important species occuping 45.3% of total cephalopods was *Octopus variabilis*. This species was mainly caught in April and October at the east side of the bay, where intertidal zone was well developed.

2) Shellfishes

Natural shellfishes stocks were oyster and short necked clam. The mean productions of these species were 26.4M/T and 127.9M/T respectively. These productions were only 1.9% and 7.2% of mariculture species. These natural shellfish stocks were mainly caught at the inner bay.

Table 3. **Mean fisheries production in Garolim Bay during three years**(1978~1980) (unit: *kg*)

Group	Species	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Fishes	Gunnels*			1,170	4,408	34,953	37,877	32,907						111,315
	Gobies	4,033	1,850	7,860	3,358	14,750	10,817	8,417	15,250	15,950	20,367	12,310	10,970	134,932
	Mullet	1,483	2,867	8,897	5,273	9,467	9,790	5,467	1,533	2,567	17,267	9,190	10,950	84,751
	Big eyed herring					500			2,927	8,233	49,667	22,500		83,877
	Hichory shed				6,833	3,367	900		1,997	767	1,433	1,067		16,364
	Skates ray			667	900	5,533	3,906	133	1,867			333	500	13,839
	Flounder		627	4,983	678	667	1,500					400	1,440	10,304
	Rock trout				3,067	1,333	1,667	1,833	20			900		8,820
	Rock fish				500	800	500	4,900	4,700	3,450	2,583	3,567		21,000
	Sea breams				357		1,167	167	333		133	333		2,490
	Common sea bass		132	667	747	633	333		567	600	1,200	1,767		6,646
	Anchovy					500			5,000	320	13,333	6,667		25,820
	Others	1,507	333		43,900	21,617	26,783	25,700	11,00	12,333	42,183	20,133		205,489
	Sub total	7,023	5,809	24,244	70,030	94,120	95,240	79,524	45,194	44,270	157,165	79,167	23,860	725,647
Crustaceans	Blue crab			2,167	4,700	12,277	6,900	1,193	1,633	1,150	3,333	2,900		36,253
	Shrimp medium				2,833		2,833		777	3,500	3,900	500		14,343
	Sguilla		175	1,430	780									2,385
	Others	1,240	3,045	5,323	4,940	12,517	7,033	8,133	9,573	20,200	33,820	11,570	5,717	123,111
	Sub total	1,240	3,220	8,920	13,253	24,794	16,766	9,326	11,983	24,850	41,053	14,970	5,717	176,092
Cephalopods	Common octopus	1,316	166	2,833	10,960			2,876	4,441	5,676	11,466	7,566	6,873	54,173
	Other octopus		30	3,960	500	1,766	766		7,780	6,226	7,300	6,866	3,873	39,067
	Others					10,133	7,000	5,033	3,436	746				26,398
	Sub total	1,316	196	6,793	11,460	11,899	7,766	7,909	15,707	12,648	18,766	14,432	10,746	119,638

Table 3. Continued

Group	Species	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Shellfishes	Short necked clam	7,000	1,000	20,066	24,376	32,593	21,833	10,733	4,400	5,866				127,867
	Oyster	1,000	8,333	693	9,344	1,466	400		1,800	266	400	2,500	266	26,468
	Others					4,250					1,500			5,750
	Sub total	8,000	9,333	20,759	33,720	38,309	22,233	10,733	6,200	6,132	1,900	2,500	266	160,085
Sea-Weeds	Laver		100	166			1							267
	Green laver	5,300	3,133	3,733	11,533	2,600	666					1,243	5,700	33,908
	Sea mustard				166	8,383		233						8,782
	Others		566	233								83		8 82
	Sub total	5,300	3,799	4,132	11,699	10,983	667	233				1,326	5,700	43,839
Others	Polychaetes**													78,000
Mariculture	Short necked clam	42,717	77,083	86,297	97,783	115,400	154,233	100,800	103,533	80,366	161,667	392,547	3 74,166	1,786,592
	Oyster	169,416	60,576	117,773	89,233	34,667	15,233	233	1,000	12,650	74,300	301,116	544,633	1,420,830
	Laver	39,433	38,833	9,567	3,667							6,500	82,124	180,124
	Sub total	251,566	176,492	213,637	190,683	150,067	169,466	101,033	104,533	93,016	235,967	700,163	1,000,923	3,387,546
Total		274,445	198,849	278,485	330,845	330,172	312,138	208,758	183,617	180,916	454,852	812,558	1,047,212	4,690,847

Sources of data: Ministry of Agriculture and Fisheries, Office of Statistics

*: Data collected from fishermen,

**: Data collected from National Federation of Fisheries Co-operatives in 1979.

3.2.4. Others

Concerning the macroalgae, the natural mean production of sea weeds in the bay was 43.8㌧. Main species were green laver and sea mustard. These species were exploited in small scale at the inner bay. On the one hand, the polychaetes worms in the bay are also important for the fishermen. In 1979, total production was 78㌧.

3.3. Mariculture resources

There are three main species (short necked clam, oyster and laver) for the mariculture in the bay. In 1980 the total ground area for these maricultures was 334.3*ha*. Except for this palces, there was 40*ha* for the sea mustard culture. However, the production of this species is stopped because of the decline of the price. On the other hand, 7.9*ha* of mariculture ground for the sea cucumber and abalone was permitted in 1980, however, the production is not yet commenced. The mariculture mean production form 1978 to 1980 was 3387.5㌧ composing 72% of total fisheries production in the bay. Among them the production of short necked clam, oyster and laver were respectively 38.1%, 30.3% and 3.8% of total fisheries production.

There were 10 mariculture grounds with 113.8*ha* for short necked clam in 1980. The annual mean production per *ha* was about 15.7㌧. Its major production has been achieved at the inner bay where the intertidal zone was well developed. Forty three percentage of total production of this species has been made during two months from November to December.

For the oyster culture, there were 19 culture grounds with 169.7*ha* in the bay in1980. The annual mean production per *ha* was about 8.4㌧.

Laver culture grounds (50.8*ha*) were mainly located at the coast of fishing villages. The annual mean production per *ha* was about 3.5 ㌧, and major catch months were from December to March.

4. Effects of tidal power plant on fisheries

The construction of the tidal power plant could affect the fisheries of Garolim Bay in various ways. This construction will modify entirely the environmental factors in the bay (Electricité de France, 1980). The artificial barrage will interrupt directly the migration route of migratory species. The most important fisheries stock in the bay, *Enedrias* sp., will be, therefore, greatly dammaged.

The change ef environmental factors, *e. g.*, salinity, dissolved oxygen and water temperature, will indirectly affect the fisheries. The barrage at the entrance to the bay will change the salinity. Because of the interruption of sea water, salinity will be higher in dry season by the evaporation, however, it will be lower in rainy season. The reduced rate of water exchange makes dissolved oxygen relatively low. These phenomena will give the high influence, particularly, on the benthic invertebrate fisheries. Furthermore, reduced intertidal zone due to the decreased tidal ranges will affect directly on the ecosystem of this area. Consequently, the varicus change of production of invertebrate fisheries stock, *e. g.*, short necked clam, polychaetes worm, oyster, etc., will occur.

In other respects, during the construction, the extraction of sands near the proposed barrage site may destroy the spawning ground of habitat of some sandy species in the bay (*e. g.*, shrimp, *Amodytes personatus*). Modified physical environment near the proposed barrage site could upset also the habitat of demersal fish stock in the bay (*e. g.*, *Raja* sp., *Limanda yokohamae*, etc.).

More quiet, hydrological condition after the construction could provide favorable environment for the fixation of seeds, and promote the growth for some bivalves species.

The aquaculture situation will be also affected by the artificial barrage in various ways. Firstly,

modification of wave and depth, and violent sluicing of water will damage culture ground invading the installation by overrun sediment or drifting sea-weeds. In other connection, increasing of the water turbidity will be bad influence for the culture organism especially on the shellfishes species.

Damming could promote the primary production in the bay because of high water temperature, and submersed zone will be more extensive. Therefore, ostreiculture and pisciculture using drifting cage will be favorable in the bay. In addition, the stagnated water by the insufficient water circulation could provoke easily the red-tide or other water pollution in the bay. Furthermore, high thermal difference; too high in summer or too low in winter, and insufficient dissolved oxygen will be in general defavorable effect for the pisciculture in the bay.

Consequently, such ecological aspects should be considered with the mechanical design *e. g.*, the position and dimension of sluice for the construction of tidal power plant. Otherwise, it will not be possible to utilize this bay overally after construction.

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가로림만 어업자원에 관하여

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瑞山郡 해안의 加露林灣은 沿岸漁場으로서 뿐만 아니라 우리 나라 제 1의 潮力發電所 후보지로 전망되고 있어 매우 중요한 海域이다. 조력발전소가 設立될 경우 이 海域의 모든 海洋生態界는 변하게 될 것이므로, 조력발전소 設立 이후의 影響評價와 綜合的인 灣의 利用開發을 위해서는 건설이전의 漁業資源은 정확히 파악되어야만 할 것이다. 1981년 1년간 이 해역에서의 魚類 出現分布調査結果 46種의 成魚魚類와 3 種의 魚卵 및 25 種의 稚魚가 同定分類되었다. 月別 定點別 卵稚魚의 出現分布를 볼 때 加露林灣의 내만은 겨울철에 産卵한 베도라치류, 까나리 등의 成育場뿐 아니라 봄이나 여름에 産卵하는 망둑어류, 멸치, 밴댕이, 동갈양태류, 가자미류 등의 중요한 産卵場으로 판단된다. 1978년부터 1980년까지의 種別 漁獲資料를 參考할 때 加露林灣에서의 漁業은 봄철 어업과 가을철 어업으로 크게 구분되며 중요한 魚種은 베도라치류 稚魚와 망둑어류, 숭어, 밴댕이 등이며 중요 養殖種으로는 굴, 김, 반지락 등이다. 加露林灣 入口에 潮力發電所가 設立될 경우 베도라치류 및 까나리 稚魚資源과 숭어, 밴댕이, 전어 등과 같은 回游性 魚種은 回游路가 차단되어 직접적인 피해를 입을 것이며, 해수의 物理·化學적 環境變化는 底棲生物 資源에 큰 피해를 줄 것이다. 따라서 潮力發電所 建設 이후 灣의 合理的 利用發을 위해서는 現在의 漁業資源을 포함한 전반적인 生態系를 보다 정확히 파악해야 하며 潮力發電所의 水門의 位置 및 크기 등의 工學的인 설계는 이러한 生態學的 特性을 고려하여야만 할 것이다.