Bull. Inst. Zool., Academia Sinica **24**(1): 147-154 (1985)

PRELIMINARY SURVEY ON LARVAL FISHES OF YEN-LIAO BAY, NORTHEASTERN TAIWAN[1]

CHIH-CHII HUANG,

WANN-NIAN TZENG

Department of Zoology, National Taiwan University, Taipei, Taiwan, Republic of China

and

SIN-CHE LEE[2]

Institute of Zoology, Academia Sinica, Taipei, Taiwan, Republic of China

(Received September 24, 1984)

Chih-Chii Huang, Wann-Nian Tzeng and Sin-Che Lee (1985) Preliminary survey on larval fishes of Yen-Liao Bay, northeastern Taiwan. *Bull. Inst. Zool., Academia Sinica.* **24**(1): 147-154. The present report is based on the larval fishes collected at a depth of 2.5 m from nine sampling stations in Yen-liao Bay on the northeastern coast of Taiwan from October 1980 to September 1981. Among 1,704 larval fishes collected, 1,341 were identified to species, of which, 53.54% were produced by pelagic species and 46.46% by demersal species. Scombridae is the most abundant family represented, predominately by *Scomber australasicus*, and is followed by Mullidae (mostly *Upeneus bensasi*) and Carangidae (mostly *Decapterus*), making up 48.5% of total larval fishes obtained. This in turn, reflects the real abundance of major usable stock in the offshore immediately beyond the bay. It is then suggested that Yen-liao Bay is an important nursery ground for most economically important pelagic fish and abundance of larvae in the bay depends on the recruitment of the adult stock in the offshore. Number of species, and abundance of larval fishes are higher during March and May with the peak in May, and lowest in January. Production of plankton is generally higher all year round in such warm waters, although, it may peak at a certain period. Seasonal abundance of larval fish populations of some species may therefore coincides with the timing of adult spawning season and the production cycle of plankton.

Yen-Liao Bay is located in the northeastern coast of Taiwan, covering the area between 25°01′-25°06′N latitude and 121°55′-122°00′E longitude (Fig. 1). It is an inshore waters rich in plankton owing to the outlet of the Shuang-chi River where the upstream nutrients are discharged into the bay, as well as the influence of the Kuroshio current due to the bay which is more or less exposed to the East China Sea in the western Pacific Ocean. Fishes of rocky and sandy habitats, as well as some shore-ward offshore pelagic breeding stocks are likely to occur in the bay since the bottom is composed of muddy sand near the estuary of the above river and scattered rocky patches along the coast of the bay. During the spawning season,

1. Paper No. 260 of the Journal Series of the Institute of Zoology, Academia Sinica.
2. To whom reprint request should be sent.

larvae and juveniles of offshore pelagic fishes, along with other plankton, are drifted toward the inshore area by the action of current, wave or tidal movement. The coastal water beyond the bay has been a traditional fishing ground for anchovies of adult and larval forms, and other offshore pelagic species, *e.g.*, young mackerels and scads. Larval fishes of other kinds are also caught substantially during spring and summer. They are mostly recruited from offshore spawning grounds around the edge of continental shelf. Larval fishes of inshore residential species also appear in catches. The study of larval fishes of the bay is very important to monitor the fishing condition in the northeastern Taiwan since dominant year class of larval fishes usually reflects the size of usable stock. Despite increasing information on the ecology of commercially exploited fishes, knowledge of larval stages of most species is still lacking in Taiwan. The only study so far dealing with the young fishes from the same waters was that of Chen (1980) on anchovies. A continuing survey on the young fish communities of this inshore bay is necessary. The main objective of this study is to understand the ichthyoplankton of the area and will be concerned provisionally with their possible variability in time and space on the basis of the results of eight cruises at nine sampling stations from October 1980 to September 1981.

METHODS

The study was carried out at nine sampling stations (Fig. 1). Environmental data of these stations were also measured simultaneously throughout the sampling period (Su, *et al.*, 1981). Mean surface water temperature during the study period ranged between 18°C (January) and 29°C (August). Mean surface salinity ranged between 32.9‰ (August) and 34.9‰ (November). Sampling took place at an interval of one or one

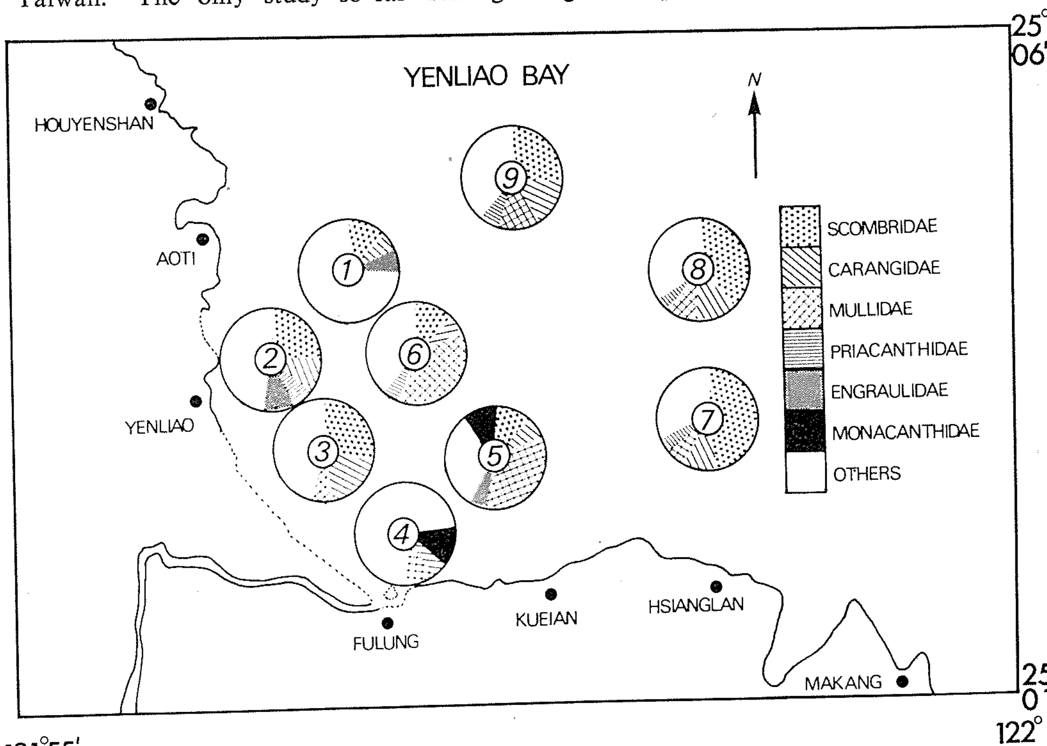

Fig. 1. Map showing the sampling stations and species composition of larval fishes of each sampling stations.

and half month over the sampling period between October 1980 and September 1981. A Maruchi D-type larval net (Nakai, 1962) with a flow-meter attached to the net mouth, was used. The net was trawled during the day (except the tow in January during 17.00–19.00) in a stationary position about 2.5 m below the surface at a speed of 2–3 knots for 5–10 minutes. Larval fish specimens recovered from each netting were preserved in 10% neutral formalin and identified and counted thereafter. Useful references for identification of larval fish species were Mito (1975), Ochiai and Amaoka (1963), Okiyama (1979a–c) and Uchida *et al.* (1958). The volume of seawater filtered by the larval net was calculated according to the formula: $V = \pi r^2 d Sw$, $r =$ radius of net mouth, $d =$ the distance of tow and $Sw =$ the filtering coefficient (The oceanographical society of Japan, 1970). Then, the abundance of larval fish was expressed as number of individuals/10^6 ℓ sea water.

RESULTS

Species composition and abundance

The overall larval fishes collected during the study period are given in Table 1. Among 1,704 larval fish caught, 50.82% were identified to species, 7.5% were identified to genera and 20.31% to families with a total of 78.6% thus identified. They were almost exclusively in postlarval stage (99.12%), the remainders included 0.53% prelarvae (3 Triglidae and 6 Scombridae) and 0.35% juveniles (1 for each of *Navodon modestus*, Syngnathid, Apogonid, *Sillago japonicus* and 2 for *Omobranchus japonicus*). As for the habitat of adults, among 1,341 identified larval fishes, 53.54% were produced by pelagic forms and 46.46% by demersal forms. Among the latter, 80.26% was known to inhabit sandy bottom while the remaining 19.74% were rocky species.

In the order of overall abundance, the Scombridae was by far the most abundant family (24.5%) represented, predominately by *Scomber australasicus*, together with the less important *S. japonicus*, *Auxis thazard* and perhaps *A. rochei.* The second largest group was the Mullidae (12.27%) with mostly *Upeneus bensasi.* The third largest group was the Carangidae (11.68%) which included several species of *Trachurus*, *Decapterus* and *Seriola.* The above three dominant groups comprised 48.6% of larval fishes caught. The remaining minor groups (30%) with rather low frequencies are represented in order of decreasing importance, by *Navodon modestus* (4.34%), *Priacanthus macracanthus* (3.29%), Engraulidae of mostly *Engraulis japonicus* (3.29%); *Paraplagusia* sp. (2.58%); Gobiidae (2.52%); Synodontidae including *Synodus variegatus*, *Trachinocephalus myops* and *Saurida* sp. making up 2.23%; Scorpaenidae (1.53%) including *Sebastiscus marmoratus*; Tetraodontidae of mostly *Lagocephalus gloveri* (1.47%); *Pseudorhombus* and *Crossorhombus* (1.11%); *Epinephelus diacanthus* (1.11%); *Myctophus* (1%); Triglidae (1%); Soleidae and *Sillago japonicus* each with 0.65%; *Bregmaceros japonicus* (0.47%); *Harengula zunas* (0.41%); *Trichiurus lepturus* and *Etremeus teres* each with 0.35%; blennies including *Omobranchus japonicus* and *Petroscirtes breviceps* with 0.23%; *Sphyraena pinguis* and *Mene maculata* each with 0.18%; Brotrulidae, Parapercidae and Pleuronectidae each with 0.12%; other items including Ophichthyidae, Gonorhynchidae, *Gerres* sp., Apogonidae, *Acanthopagrus schlegeli*, *Fistularia* sp., *Coryphaena hippurus* and *Leiognathus* sp., comprised 0.06% respectively.

Temporal variation in quantity and quality

Number of species was greater in the spring samples than other seasons (Table 1). The overall number of larval fishes caught was concentrated in spring (March 9.1%, April 20.19%, May 60.27%) with 89.56% of total catches while in January the catch was lowest with only 9 individuals (0.53%) taken. The remaining 10% of larval fishes were contributed by the catches from July, August, September and November. The overall density of larval fishes was also higher in spring with the peak in May (348.21 larvae/10^6 ℓ sea water) and the lowest

TABLE 1
Numbers of larval fishes of different species caught in Yen-Liao Bay during November 1980 and September 1981

Family, Genus or Species	No. of individuals								Total	Eco-type
	(1980)	(1981)								
	Nov.	Jan.	Mar.	Apr.	May	July	Aug.	Sept.		
Ophichthyidae sp.						1			1	SB
Dussumieriidae										
Etrumeus teres	2	3				1			6	P
Clupeidae										
Harengula zunasi			4		2			1	7	P
Engraulidae sp.			11						11	P
Engraulis japonicus		3	39	3					45	P
Gonorhynchidae										
Gonorhynchus abbreviatus	1								1	SB
Synodontidae										
Synodus variegatus			2	2					4	SB
Trachinocephalus myops			1	29	1	2			33	SB
Saurida sp.			1						1	SB
Myctophidae										
Myctophus sp.			17						17	SB
Bregmacerotidae										
Bregmaceros japonicus	2		3		3				8	SB
Brotulidae sp.			1		1				2	SB
Bothidae										
Pseudorhombus sp.					1				1	SB
Crossorhombus valderostratus				7	11				18	SB
Pleuronectidae sp.			2						2	SB
Soleidae sp.			9		2				11	SB
Cynoglossidae										
Paraplagusia bilineata			1		1				2	SB
P. sp.			1		41				42	SB
Monacanthidae										
Navodon modestus				72	2				74	P
Tetraodontidae sp.				2					2	P
Lagocephalus gloveri				8	15				23	P
Syngnathidae sp.						1		1	2	SB
Priacanthidae										
Priacanthus macracanthus					60				60	SB
Scorpaenidae sp.			1	1	20		2	1	25	RB
Sebastiscus marmoratus					1				1	RB
Sphyraenidae										
Sphyraena pinguis			1	2					3	P
Scombridae										
Scomber australasicus			3	43	288	4	12		350	P
Auxis thazard				1	8		1		10	P
A. sp. (type 1)					30	2	7		39	P
A. sp. (type 2)						7	12		19	P

TABLE 1
Numbers of larval fishes of different species caught in Yen-Liao Bay during November 1980 and September 1981 (Continued)

Family, Genus or Species	No. of individuals								Total	Eco-type
	(1980)	(1981)								
	Nov.	Jan.	Mar.	Apr.	May	July	Aug.	Sept.		
Trichiuridae										
Trichiurus lepturus	2				4				6	SB
Mullidae sp.					54				54	SB
Upeneus bensasi	1				133			21	155	SB
Apogonidae										
Apogon sp.						1			1	SB
Serranidae										
Epinephelus diacanthus				4	12	1	2		19	RB
Sillaginidae										
Sillago japonicus	3	1		1	5	1			11	SB
Gerridae										
Gerres sp.	1								1	SB
Sparidae										
Acanthopagrus schlegeli	1								1	SB
Fistulariidae										
Fistularia sp.	1								1	SB
Triglidae sp.	2		16	1					19	SB
Coryphaenidae										
Coryphaena hippurus					1				1	P
Carangidae										
Trachurus japonicus	2		4	8	23				37	P
Decapterus maruadsi				6	16		1		23	P
D. sp.				4				2	6	P
Seriola purpurascens					14		1		15	P
S. quinqueradiata					5			1	6	P
S. sp.				3	105	2	2		112	P
Leiognathidae										
Leiognathus sp.					1				1	SB
Menidae										
Mene maculata					3				3	P
Blenniidae										
Omobranchus japonicus	2				1				3	RB
Petroscirtes breviceps			1						1	RB
Unidentified blennies			7	52	45		4		108	?
Parapercidae sp.	1		1						2	SB
Gobiidae sp.	4	2		12	20	1	3	1	43	SB
Gobiesocidae			5	47	8		3		63	?
Other undetermined species	11		24	36	90	3	25	3	192	?
Total	36	9	155	344	1027	27	75	31	1704	

S, sandy bottom; R, rocky bottom; B, benthic; P, pelagic.

(2.52/10^6 ℓ) in January.

As the higher catches of specific fishes are concerned, *Scomber australasicus* appeared in catches during March and August with the peak production in May. *Navodon modestus* peaked in April. *Upeneus bensasi* was caught mostly in May, occasionally in September and November. *Engraulis japonicus* occurred during January and April with the large, peak abundance in March. *Trachinocephalus myops* occurred during March and July with the peak in April. Other species (Table 1) were also mostly present during spring and summer with very few exceptions that the occurrence of larval fishes may extend into autumn or winter.

Spatial distribution

Only limited conclusions can be drawn about spatial distribution because of the infrequent sampling which was unable to account in detail for the observed vertical and horizontal distribution of larval fishes. Here, we can give only a preliminary comparison of the species composition and abundance of larval fishes among stations. The overall abundance of larval fishes of each station (Table 2) varied month by month and showed no consistent implication. In the case of the most abundant sample available in May, there was decreasing overall larval fish abundance in the order of stations 3, 5, 2, 7, 8, 9, 6, 4 and 1. Fig. 1 demonstrates the proportion of some dominant group at each station. When Scombridae and Carangidae were combined as a whole, the proportion became almost exclusively higher at all stations (except station 4), particularly the outermost stations 7–9. When considering *Scomber australasicus* alone, the larval fishes occurred first at station 2 (5.26%) in small numbers in March, and dispersal intensified moderately until spreading over all stations (except station 4). By May, the abundance of larval fishes increased abruptly to the maximum at most of the stations except stations 4 and 6 which were otherwise lowest. *Priacanthus* was caught only at stations 2, 6, 7, 8 and 9. Abundance of Mullidae (mostly *Upeneus bensasi*) was higher in the middle section of the bay (station 5 and 6) and lower

TABLE 2

Seasonal abundance (individuals/10^6 ℓ sea water) of larvae and early juveniles of each station in Yen-Liao Bay during November 1980 and September 1981.

Date	Stations									Mean
	1	2	3	4	5	6	7	8	9	
1981 Mar. 6	10.33	45.61	41.52	23.99	71.79	44.22	—	—	—	39.58
Apr. 22	76.45	46.06	86.00	131.47	152.55	0	74.64	59.22	27.17	72.62
May 31	44.66	480.92	818.02	126.66	530.05	154.00	421.40	325.70	232.44	348.21
Spring (mean)	43.81	190.86	315.18	94.04	251.46	66.07	248.02	192.46	129.81	
July 5	0	11.96	0	1.29	0	16.73	0	8.85	0	4.31
Aug. 24	7.24	7.41	15.61	8.70	2.65	5.33	4.04	44.07	10.15	11.69
Summer (mean)	3.62	9.69	7.81	5.0	1.33	11.03	2.02	26.46	5.08	
Sept. 26	0.89	0	13.39	9.62	11.74	1.48	6.39	1.79	3.48	5.42
1980 Nov. 12	3.42	3.47	3.09	7.51	1.05	0	—	—	—	3.09
Autumn (mean)	0.45	1.74	8.24	8.57	6.40	0.74	6.39	1.79	3.48	
1981 Jan. 12	0	7.05	1.83	1.18	—	—	—	—	—	2.52
Winter (mean)	0	7.05	1.83	1.18	—	—	—	—	—	
Overall (mean)	17.87	75.31	122.48	38.80	109.98	31.68	101.29	87.93	54.65	60.93

at the outermost stations 7–9 and innermost stations 3 and 4, but none was found at stations 1–2. Occurrence of *Engraulis japonicus* was evenly low and was only confined to stations 1, 2 and 5. *Navodon modestus* appeared only at stations 4–5 facing the river outlet.

DISCUSSION

Number of larval fishes obtained during this study period is probably underestimated since day time collection for larval fishes from upper surface water (Eldridge, 1977) and from the depth of 20–30 m (Herman, 1963) all represent much low values than night hauls. Number of earlier stages of larvae *e.g.*, prelarvae, should be the greatest soon after hatching. However, it was much lower than that of postlarvae, probably owing to the sampling, *i.e.*, the larger mesh size of net used, or perhaps because the bay is a nursery ground rather than the actual spawning grounds of these species as the case in Narragansett Bay (Herman, 1963). Thus, it is difficult to generalize for the entire picture of larval fish estimation in the area. Neverthless, this report is concenrned superficially with species composition of planktonic stages of larval fishes as well as their variability in time and space confined to the vicinity of the bay. A further survey must be done, in particular for more precise information on diurnal, vertical and horizontal changes in larval fish occurrence.

Owing to insufficient physico-oceanographical data measured simultaneously during the larval sampling, only very limited conclusions can be drawn to explain the possible influences of the population dynamics of larval fishes.

Basically, temporal and spatial changes of larval fishes are influenced by both physical and biological factors. For the first one, tidal current and light are the most important factors in determing the density of larval fishes (Eldridge, 1977) since it is well known that the planktonic larval fishes produced by the offshore parents are drifted into the bay by current what is in turn correlated to the intensity of light. The strong northeastern offshore wind during winter and early spring may accelerate the dispersal of larvae toward the inshore area. The higher larval fish production during spring period may also be linked with water temperature of around 24°C in May which is within the range of optimum temperature for the development of most larval fish species. In terms of biological factors, occurrence of most larval fish species is usually in close association with the production cycles of plankton, as in the case of herring that seasonal occurrence of larvae are in relation to seasonal cycles of phytoplankton showing that the different spawing period of various population could be linked with the timing of the production cycles of adult stock (Cushing, 1967). In Yen-Liao Bay, plankton is abundant throughout the year, although, phytoplankton peaks in May, July and September while copepods are much more abundant during January and July with the peak in July (Su *et al.*, 1981). These features are in fact linked with the spring spawning period of some commercially exploited fish species, for example: *Scomber australasicus* (January–May) (Chang and Wang, 1970), *Upeneus bensasi* (May–December) (Oshima, 1975), *Auxis thazard* (May–July) (Jones and Kumaran, 1964). Their timing of spawning is adaptable to ensure the higher survivorship of the stock. Although *Engraulis japonicus* spawns all year round (Oshima, 1975), there is, as stated previously no shortage of plankton for fish larvae in the bay. Although, Yen-Liao Bay is an important nursery ground for several marine offshore species, *Scomber australascus* is the most abundant larval fish species, which agrees well with the high proportion of mackerel production in the adjourning offshore fishing ground (Su *et al.*, 1981). Thus, the abundance of larval fishes may trully reflect the stock size of the commercially exploited species.

Acknowledgements: This study was financially supported by the National Scientific

Committee on Problems of the Environment (SCOPE/ICSU), Academic Sinica, Republic of China. The authors are grateful to Mr. K. Y. Lee, Mr. S. L. Yeh and Miss T. T. Se for their assistances in field and laboratory works. Thanks are also to Dr. C. S. Chen of the Department of Aquaculture, National Pingtung Junior College of Agriculture for confirming the identification of species.

REFERENCES

CHANG, K. H. and T. S. WANG (1970) A preliminary report on studies of spotted mackerel resources. II. Studies on maturity and fecundity of *Scomber tapeinocephalus* Bleeker (1). Maturity and spawning. *China Fish. Month.* **209**: 3-8.

CHEN, T. S. (1980) Study and investigation of Bull-ard and anchovy fisheries in coastal waters of Taiwan. *Bull. Taiwan Fish. Res. Inst.* **32**: 219-233.

CUSHING, D. H. (1967) The grouping of herring populations. *J. Mar. Biol. Ass. U. K.* **47**: 193-208.

ELDRIDGE, M. B. (1977) Factors influencing distribution of fish eggs and larvae over eight 24-hr samplings in Richardson Bay, California. *Calif. Fish. Game.* **63**(2): 101-116.

HERMAN, S. (1963) Planktonic fish eggs and larvae of Narragansett Bay. *Limnol. Oceanogr.* **8**: 103-109.

JONES, S, and M. KUMARAN (1964) Eggs, larvae and juveniles of Indian Scombroid fishes. *Mar. Biol. Ass. India. Proc. Symp. Scomb. Fish., Mandapum Camp.* **1**: 343-378.

MITO, S. (1975) Fish eggs and larvae. In *Illustrations of the marine plankton of Japan* (Motoda ed.). Vol. 7. Sôyo-Sho, Tokyo. 74pp.

NAKAI, Z. (1962) Apparatus for collecting macroplankton in the spawning survey of *Iwashi* (Sardine, anchovy and round herring) and others. *Bull. Tokai Reg. Fish. Res. Lab.* **9**: 221-237.

Oceanographical Society of Japan (1970) *Guide to Marine Observation.* 427 pp.

OCHIAI, A. and K. AMAOKA (1963) Description of larvae and young of four species of flatfishes referable to subfamily Bothidae. *Bull. Jap. Soc. Sci. Fish.* **29**(2): 127-134.

OKIYAMA, M. (1979a) Manuals for the larval fish taxonomy. 1. Definition and classification of larval stages. *Mar. & Biol.* **1**(1): 54-59.

OKIYAMA, M. (1979b) Manuals for the larval fish taxonomy. 2. General aspects of larval characters that aid identification. *Mar. & Biol.* **1**(2): 53-59.

OKIYAMA, M. (1979c) Manuals for the larval fish taxonomy. 3. Metamorphosis of the clupeoid fishes and problems of larval convergence. *Mar. & Biol.* **1**(3): 61-67.

OSHIMA, Y. (1975) Record of spawning season of the fishes in Japan. Jap. Fish. Farm. Ass., Tokyo. 69pp.

SU, J. C., T. C. HUNG, Y. M. CHIANG, T. H. TAR, Y. S. LIN, W. N. TZENG, R. T. YANG and J. C. CHEN (1981) Environmental and ecological studies on Yen-Liao coastal area. *Spec. Publ. SCOPE., Academia Sinica* **12**: 1-198.

UCHIDA, K., S. IMAI, S. FUJITA, M. UENO, Y. SHOJIMA, T. SENTA, M. TAHUKU and Y. DOTU (1958) *Studies on the eggs, larvae and juvenile of Japanese fishes* (*Ser 1*). 2nd Lab. Fish. Biol., Fish. Dept. Fac. Agric. Kyushu Univ. 89 pp.

臺灣東北部鹽寮海域仔稚魚之初步調查

黃治綺　曾萬年　李信徹

本篇係根據1980年10月～1981年9月間在臺灣東北部之鹽寮海域九個測站水面下2.5公尺深度所採集之仔稚魚調查結果。所採獲之1,704尾幼魚中，1,341尾已能鑑定到種（其餘的只能鑑定到科或屬爲止），其中53.54%爲表層性魚類所產者，46.46%爲底棲性魚類所產者。鯖科爲數量最多之一科（多爲花腹鯖 *Scomber australasicus*），其次爲鬚鯛科（大都爲秋姑魚 *Uneneus bensasi*）及鰺科（多屬 *Decapterus*）。以上總計佔漁獲尾數之48.5%，這些仔稚魚魚種組成與外海之經濟魚類魚種組成頗爲類似。幼魚之種類，數量及密度3～5月間較高，（五月爲顛峯期），1月份則最低。該海域浮游生物之生產量，雖然經年均很高，然亦呈現出若干顛峯期。顯而易見地，某些魚種之仔稚魚在春天之大量出現，很可能配合某些成魚生殖期及浮游生物之顛峯期之時序。