Asian Fisheries Science **19**(2006):293-307
ISSN: 0116-6514
https://doi.org/10.33997/j.afs.2006.19.3.009

Asian Fisheries Society, Manila, Philippines

Fish Assemblages in Abandoned Ponds and Waterways Surrounding Brackish Water Aquaculture Ponds in Panay Island, the Philippines

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Abstract

Fish assemblage structure in abandoned ponds and waterways in Panay Island, Philippine, were investigated and compared with those in mangrove fringed habitats. Juvenile and small resident fishes were collected using a seine net set along the beach, creeks, waterways and abandoned culture ponds. Sampling stations were characterized by the absence or presence of mangrove vegetation. Fish diversity was higher on beaches and in creeks with mangroves and in creeks without mangrove compared with abandoned ponds and waterways. Gobiidae was the most diverse species group, being abundant in most stations. More species of juveniles occurred in mangrove habitats and river banks than in abandoned ponds and waterways. However, fish abundance and biomass were not clearly different between stations. The results suggest that fish diversity decreases in areas with culture pond constructions, but these still provide habitat for gobies and juveniles of a few other species.

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Introduction

The conversion of mangrove forests into brackish water aquaculture ponds for shrimp and fish is considered as one of the major causes of mangrove destruction in many tropical countries (Primavera 1997, Alongi 2002). Although the precision of the estimate is still controversial, 20 to 50 % of mangrove forests worldwide have been lost in recent decades as a result of culture pond construction (Primavera 1997). For example, in the Philippines around half of the mangrove lost from 1951 to 1988 was converted culture pond development, meanwhile national policy and international aid was encouraged brackishwater pond culture, and in consequence the mangrove loss was facilitated in 1970s to 1980s (Primavera 2000).

The loss of mangrove habitat may be detrimental to coastal fish stocks because mangrove estuaries are important nursery or feeding grounds of various groups of fishes, including the commercially exploited species (Robertson and Blaber 1992; Blaber 2000). Conversion of mangrove forests into culture ponds is generally considered a complete loss of nursery habitats for fishes and shrimps (e.g. Nickerson 1999; Naylor et al. 2000). However, waterways connecting culture ponds and abandoned ponds caused by the spread of diseases and self-pollution of shrimp farms (Primavera 1997), are shallow and sheltered intertidal habitats. These altered habitats may also provide a nursery function for juvenile fishes because shallow water habitats are not usually inhabited by many predatory fishes (Ruiz et al.1993; Paterson and Whitfield 2000). Non-vegetated shallow habitats, such as mud flats and creeks, also support abundant juvenile fishes (Ruiz et al. 1993; Weerts and Cyrus 2002). Hajisamae and Chou (2003) showed that juvenile fishes are still abundant even in heavily impacted shallow habitats of Johor Strait, Singapore. However, almost no information is available on how various fishes use altered habitats like abandoned ponds or waterways, or how the construction of aquaculture ponds influence estuarine fish assemblages. This study was undertaken to investigate the fish assemblage structure in abandoned culture ponds and waterways. In addition, fish assemblage structure was compared with habitats having mangroves.

Materials and Methods

Study area and sampling stations

The study was conducted in two estuarine sites: Leganes estuary (10°47'N, 122°37'E); and Batan Bay estuary (11°34'N, 122°26'E) in Panay Island, The Philippines (Fig. 1). The Leganes site was originally a mangrove habitat but had been converted into salt farms and brackish culture ponds for milkfish (*Chanos chanos*, Chanidae) and shrimps (*Penaeus monodon*, Penaeidae). Although scattered stands of mangrove trees, like *Rhizophora*, were found, there was no mangrove fringe and forest remaining in the estuary of Leganes. The main creek of the estuary was still open as a water path but most areas were covered with bank protection. In Batan Bay, the majority of the mangrove habitat had been converted into milkfish and shrimp ponds. However, narrow fringe (10 ~ 30 m widths) of mangrove trees (*e.g.*; *Rhizophora*, *Avicennia*, and *Bruguiera*) still remained along the shore and creeks in the bay.

Four sampling stations were set in Leganes: P1, abandoned ponds of around 30 m x 30 m; W1 and W2, waterways surrounding culture ponds, 6 to 12 m width; and CR, creek with no mangroves, about 30 m width. These sites were located about 400 m upstream from the mouth of the creek along the coast (Fig. 1). Four sampling stations were also set in Batan Bay estuary: P2, abandoned ponds, 60 x 100 m; W3, waterway surrounding culture ponds, 8 m width; MB, mangrove fringed beach in the bay; and MC, mangrove fringed creek. Mangrove vegetation of stations at MB and MC are dominated by *Avicennia* sp. All stations are influenced by tide and the substratum at all sampling stations was mud.

Sampling was done during spring tide in November 2000. A small seine net (6 m wide, 2 m deep), with 5 and 3 mm mesh size in wing and cod end, respectively, was used to collect mainly juvenile and small resident fishes. They were collected during daytime at high tide. The net was dragged 4 times over 30 m tow at each station over the bare substrate in waterways and ponds, and over bare substrate and pneumatophores in mangrove stations.

Fish were preserved in 10% formalin, identified to species level if possible, counted, and their weight was measured. Several species of gobies and some species of juveniles were identified up to genus or family level only. Among unidentified species, *Leiognathus* spp. (Leiognathidae), were not counted as a separate unit of species since they were presumed to appear most likely as juveniles of the species in areas where larger individuals were also found. Water temperature, salinity and dissolved oxygen concentration were recorded during sampling at each site using YSI meter Model 85. Secchi depth was also measured.

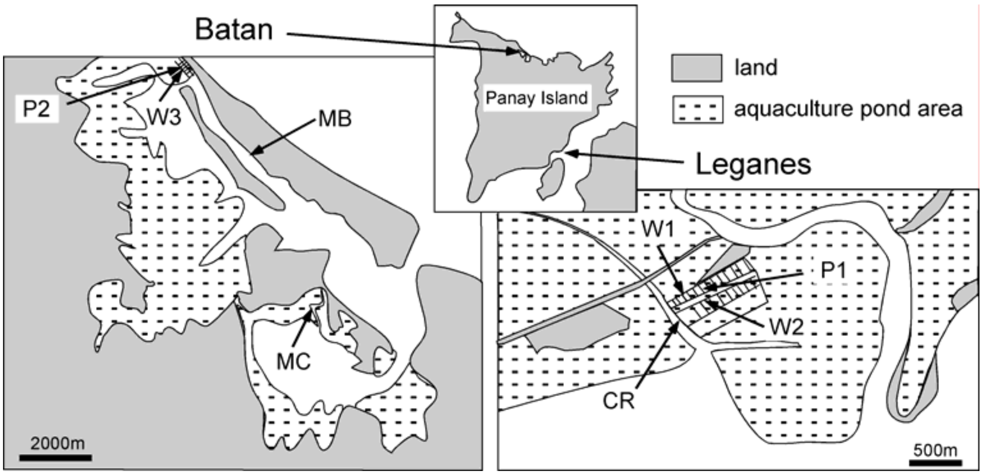

Figure 1. Map of the sampling sites in Leganes and Batan Bay, Panay Island, the Philippines

Data analysis

Species richness, abundance, and biomass were expressed as the mean number of species, individuals, and weight per 30m tow, respectively. The mean at each sampling station was calculated by averaging four replicate tows; and a one-way analysis of variance (ANOVA) was used to determine whether or not species richness, abundance, and biomass differed significantly among sampling stations. The Tukey-Kramer test was used for *a posteriori* multiple comparison of means (Zar 1999). Before statistical analysis, abundance data were transformed into log(x) values to improve the homogeneity of variance.

The degree of similarity of fish assemblages among stations were calculated using the Bray-Curtis similarity coefficient, based on the number of individuals for each species. Prior to analysis, the data were transformed to log(x+1) values to normalize distribution and stabilize variances. The obtained similarity matrix was subjected to cluster analysis (group-average mean linkage) and non-metric multidimensional scaring (MDS) to classify samples and to display sample relationship (Clark 1993). Species, which contributed substantially to the average similarity within a group using cluster and MDS analysis, were identified using SIMPER analysis (Clark 1993).These analyses were performed using the CLUSTER, MDS and SIMPER programs on the PRIMER computer package (Clark & Warwick 1994).

Results

Water temperature differed slightly among stations, ranging from 28.7 to 31.1˚C. Salinity varied from 6.5 to 30.9 but there was no clear difference with habitat types. Dissolved oxygen concentrations at all stations were high > 60%. Secchi depth was higher at mangrove fringed habitats (MB, MC) than in other sites (Table 1).

A total of 3707 individuals, comprising 62 species in 28 families was collected. Gobiidae was the most dominant species group (16 species) and the most abundant with 1919 individuals (Table 2). Mugilidae and Ambassidae were abundant in abandoned ponds and waterways; while Leiognathidae was abundant in mangrove fringed habitat (MB).

The total number of species was high in two mangrove fringed stations (MB, MC) and in the creek with no mangrove (CR); but lower in abandoned ponds and water ways (P1,2; W1,2,3) (Table 2). The mean number of species showed similar trends with the total number of species but varied significantly among the stations ($F = 3.89$, $P < 0.01$). The value was significantly higher in station MB than in two waterways (W2, W3) and in an abandoned pond (P2) (Fig. 2). The mean abundance differed significantly among stations ($F = 3.28$, $P < 0.05$). The value was significantly higher at P2 than at station W2, but no clear difference among habitat types was found. Significant difference in biomass was also found among stations ($F = 2.99$, $P < 0.05$), but significant difference was found only between stations MB and W2 by *a posteriori* test.

The cluster analysis based on abundance of each species showed that assemblages at each station could be divided into two major groups with a similarity value of 25% (Fig. 3): Group I abounded ponds and waterways; while Group II are the mangrove fringed habitats and a creek with no mangrove (CR) . The MDS gave results that were highly comparable with the cluster analysis (Fig. 4). The abovementioned two groups, found in the cluster analysis, were well separated from each other on the MDS

Table 1. Temperature, salinity, dissolved oxygen, secchi depth and depth at each sampling station. Abandoned pond (P1), waterways (W1, W2) and creek with no mangrove (CR) in Leganes; Abandon pond (P2), waterway (W3), creek with mangrove (MC) and beach with mangrove (MB) in Batan Bay.

Site	Leganes				Batan Bay			
Station	P1	W1	W2	CR	P2	W3	MC	MB
Temperature (°C)	31.1	31	29.1	28.7	29.4	28.7	30.5	29.6
Salinity	30.9	14.2	24.4	30.7	11.0	6.5	24.9	17.4
Dissolved Oxygen (%)	79.8	67.1	58.7	70.1	85.5	60.2	73.2	61.3
Secchi depth	50	40	75	60	70	30	170	150
Depth	40-80	50 - 120	50 - 100	50 - 150	50 -80	50 - 80	50 - 80	60 - 100

Table 2. Number of individuals in each fish species collected from each station in Leganes and Batan Bay estuaries

Family	Species	P1	P2	W1	W2	W3	RB	MB	MC	Total
Elopidae	*Elops hawaiensis*	4								4
Muraenidae	*Uropterygius concolor*			6			1			7
Engraulidae	*Stolephorus indicus*				34		56			90
Synodontidae	*Saurida gracilis*						1	52	1	54
	Trichonotus setiger								1	1
Mugilidae	*Moolgarda engeli*	22		8	13		3			46
Phallostethidae	*Neostethus amaricola*	11	22	21	37	47			1	139
Adrianichthyidae	*Oryzias* sp.		1			1				2
Hemiramphidae	*Hyporhamphus limbatus*		1				2		4	7
	Zenarchopterus buffonis					2			9	11
	Zenarchopterus dunckeri	1	1	6	1	2	12	25		48
	Zenarchopterus rasori				14			6	2	22
Cyprinodontidae	*Poecilidae* sp.	5								5
Syngnatidae	*Hippichthys spicifer*						2		4	6
Scorpaenidae	*Vespicula trachinoides*						2			2
Platycephalidae	*Inegotia* sp.						3			3
Ambassidae	*Ambassis kopsii*	7						48	1	56
	Ambassis urotaenia		145	6		139		10	12	312
Apognidae	*Apogon lateralis*							9		9
Sillaginidae	*Sillago sihama*						5			5
Cichlidae	*Oreochromis niloticus*	1		2						3
Leiognathidae	*Leiognathus* sp.			1			9	31	15	56
	Leiognathus aureus							3	1	4
	Leiognathus spp. (juvenile)							786		786
	Secutor sp.							1		1
Lutjanidae	*Lutjanus* sp.1							2	2	4
	Lutjanus sp.2							3		3
Gerreidae	*Gerres* sp.		8	9		3	8		1	29

Table 2. Number of individuals in each fish species collected from each station in Leganes and Batan Bay estuaries

Family	Species	P1	P2	W1	W2	W3	RB	MB	MC	Total
Mullidae	*Upeneus sulphureus*						3		3	
	Upeneus vittatus							4		4
Teraponidae	*Terapon jarbua*			3						3
Eleotoridae	*Butis butis*				1		5	10	2	18
Gobiidae	*Acentrogobius caninus*						3	13		16
	Acentrogobius janthinopterus	6		4		1		5	1	17
	Acentrogobius viganensis	81	484	114		507	21		37	1244
	Acentrogobius viridipunctatus	8	10	8					5	31
	Amoya moloanus				3			1		4
	Exyrias puntang					1		7		8
	Glossogobius biocellatus		1	4			16	2	1	24
	Glossogobius sp.		1			2				3
	Gobiopterus sp.	19	255	1		4				279
	Oxyurichthys sp.			1			2		12	15
	Papillogobius sp.						1	33	22	56
	Periophthalmus argentilineatus				2					2
	Pseudogobius javanicus	67	28	1	36	21				153
	Yongeichthys criniger						12	34	13	59
	Gobiidae sp.1			1			2	1		4
	Gobiidae sp.2		1			3				4
Scatophagidae	*Scatophagus argus*			3				14		17
Siganidae	*Siganus* sp. 1								2	2
	Siganus sp. 2							9		9
Cynoglossidae	*Cynoglossus puncticeps*							2		2
Monacanthidae	*Monacanthus* sp.							2		2
Tetraodontidae	*Arothron manilensis*						3		2	5
	Tetraodontidae sp.			1			5		2	8
Total	Number of individuals	232	958	200	141	733	174	1116	153	3707
	Number of species	12	13	19	9	13	26	28	26	62

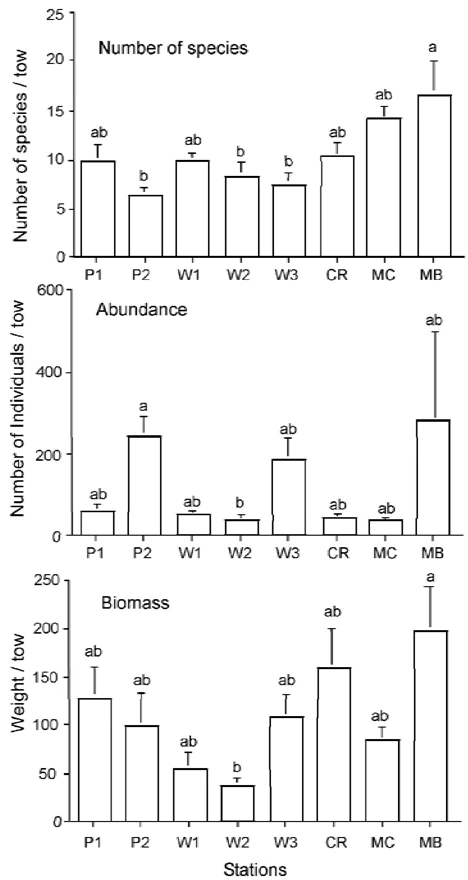

Figure 2. Mean number of species (± SD), individuals, and biomass of per 30m tow at each sampling station. Abbreviation given in Table 1.

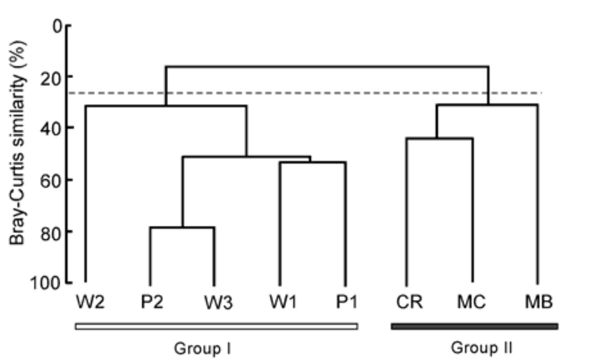

Figure 3. Dendrogram of cluster analysis based on the number of individuals of each species at each site in estuaries in Leganes and Batan Bay, Panay estuaries, Philippines. Abbreviation given in Table 1.

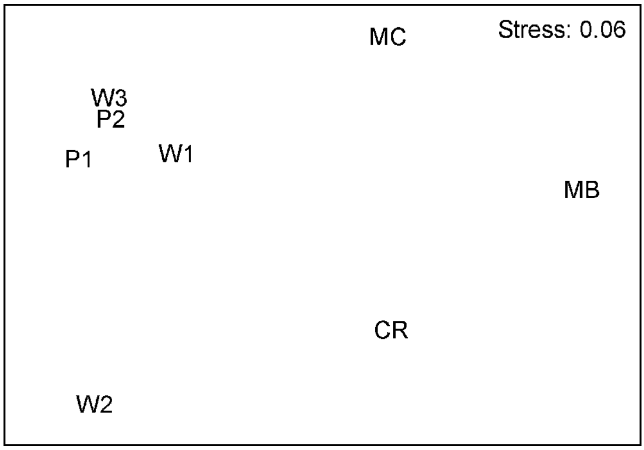

Figure 4. The MDS ordination of fish assemblages at each station in estuaries of Leganes and Batan Bay, Panay estuaries, Philippines. Abbreviations given in Table 1.

plane. Within each group, found in cluster and MDS analysis fish assemblages, showed similarity irrespective of sites (i.e. Leganes and Batan Bay stations were mixed in two groups) or habitat types (i.e. waterway and pond stations were not separated in Group I; creeks with mangrove and without mangrove were clustered in Group II).

The SIMPER analysis revealed that *Neostesus amaricola* (Phallostethidae) and two gobies, *Acentrogobius viganensis* (Gobiidae) and *Pseudogobius javanicus* (Gobiidae), contributed greatly to the similarities within Group I. In Group II, *Yongeichthys criniger* (Gobiidae) and *Leiognathus* sp. largely contributed to the similarities. But contributions by each species are lesser in Group II than in Group I, and 9 species all together contributed over 70% of the total similarity.

Discussion

In the present study, 62 species of juveniles and small fishes were collected. The total number of species is nearly double that reported in a study in Pagbilao Mangroves, Philippines (37 taxa; Rönnbäck *et al.* 1999) and the North Bais Bay, Philippines (39 species; Dolar et al. 1991), or is about two thirds of that reported from Trang, Thailand by three years of sampling using similar sampling gear (89 species; Ikejima *et al.* 2003). This suggests that, despite the limited time of sampling, this study accounted for the diverse fish fauna of the estuaries and is varied for analyzing spatial difference of the juvenile assemblages in these habitats. Of the families collected, Gobiidae was by far the most diverse and dominant in number in most stations. This may reflect the muddy bottom condition of all stations, since gobies often dominate in both diversity and abundance on muddy bottom estuarine habitats (Blaber and Milton 1990; Ikejima et al. 2003). The other abundant families, such as Mugilidae, Phallostethidae, Hemiramphidae and Leiognathidae have also been often recorded as abundant in tropical estuaries (Robertson and Blaber 1992; Blaber 1997; Lin and Shao 1999; Tongnunui et al. 2001)

In the present study we could not collect fishes from well-reserved natural mangrove habitats as a reference site because of the lack of such habitat in Panay Island. However, the fish composition from two mangrove fringed habitats was similar to that reported from well-reserved mangrove sites in the Philippines (Rönnbäck et al. 1999) in spite of the difference in fishing gear used. Of the 21 families listed by Rönnbäck et al. (1999), 16 families (76%) were recorded in Group II (MB, MC and RB) in the cluster analysis. All except coral reef associates collected by a seine net in the mangrove of the North Bais Bay, Philippines (Dolar et al. 1991) were also recorded in Group II of this study. Thus, the fish composition from these sites seems to reasonably represent an original fish fauna of the study sites.

Higher number of species was found in mangrove fringed habitats than in abandoned ponds and waterways. Juveniles of Synodontidae, Leiognathidae, Lutjanidae and Mullidae, Siganidae and Tetraodontidae occurred only in mangrove fringed habitats. On the other hand, a species of Mugilidae, *Moolgarda engeli* (Mugilidae), occurred mainly in abandoned ponds and water ways, suggesting that such altered habitats may be preferred by mugilid juveniles and serve as nursery ground for this species. Higher turbidity indicated by lower secchi depth readings in abandoned ponds and waterways may also provide protection from predators (Cyrus and Blaber 1992). Shallow abandoned ponds and waterways may provide rich detritus and attached benthic algae to detritivorous / herbivorous mugilids. Indeed, the biomass significantly differed only between one of the mangrove sites (MB) and one of the waterways (W2), which may imply that the productivity is not different among stations. Study on feeding habits of fish species and fauna of food organisms in abandoned pond and mangrove habitats may explain at least in part, why the only limited species re-colonized abandoned bond and waterways.

Total number of species was highest in mangrove fringed habitats (MB, MC) and in a creek (CR). Although the mean number of species was higher in MB and MC than in CR, the difference was not significant. In addition, the fish assemblage structure was also relatively similar among these stations, irrespective of the presence (MB and MC) or absence (CR) of mangrove vegetation. We, however, could not conclude that mangrove has no significant influence on fish assemblage structure, because mangrove fringed stations and river bank station were set in different sites (i.e. CR in Leganes; MB, MC in Batan Bay); thus, other factors influencing fish assemblages may also differ. Ikejima *et al.* (2003) showed fish assemblage structures in a mangrove estuary in southern Thailand differ markedly between mangrove beach and mangrove creek sites, but similar between mangrove beach and non-mangrove beach sites, particularly during the season when schooling fishes were abundant. Other factors aside from mangroves such as hydrological or physico-chemical conditions may also strongly influence the assemblage structure in estuarine habitats. Regarding a particular fish species, *Ambassis urotaenia* (Ambassidae) was more abundant in ponds and waterways (P2, W3) than in mangrove stations. This is rather contrary to the previous finding that a species of *Ambassis* was more abundant in mangrove sites than in non-mangrove sites (Ikejima *et al.* 2003), and that *Ambassis* was attracted to artificial mangrove-like structures (Laegdsgaard and Johnson 2001). Several studies which compared the fish composition between mangrove and bare sand habitat showed higher diversity and biomass in mangrove habitat (Blaber, et al. 1989; Robertson and Duke 1987, 1990; Reviewed by Robertson and Blaber 1992), while diversity and abundance of fish assemblages in small patches of mangroves in Sydney Harbor, Australia were similar with those in adjacent mudflats (Clynick and Chapman 2002). The significance of mangroves on the influence of fish assemblage structure in estuaries still needs to be examined.

Table 3. Results of SIMPER analysis showing average total number at each site in each sampling (x) for most important species in each group, found using cluster and MDS analysis, and contribution to average similarity [S_i (%)] within each group (to cumulative contribution of 70 % of total similarity)

Species	x	S_i	S_i/SD_i	S_i(%)
Group I (Average similarity: 45.66)				
Neostethus amaricola	27.6	10.6	5.1	23.2
Acentrogobius viganensis	237.2	9.7	1.1	21.3
Pseudogobius javanicus	30.6	8.3	1.6	18.2
Ambassis urotaenia	58.0	2.9	0.5	6.4
Gobiopterus sp.	55.8	2.8	0.9	6.1
Group II (Average similarity: 35.21)				
Yongeichthys criniger	19.7	5.7	6.7	16.2
Leiognathus sp.	18.3	5.4	7.2	15.3
Papillogobius sp.	18.7	3.2	1.2	9.1
Butil buits	5.7	2.9	4.4	8.2
Acentrogobius viganensis	19.3	2.7	0.6	7.6
Glossogobius biocellatus	6.3	1.8	4.7	5.1
Zenarchopterus dunckeri	12.3	1.7	0.6	4.8
Ambassis urotaenia	7.3	1.6	0.6	4.6

Conclusion

Our study suggests that abandoned ponds and waterways harbor fewer species of juvenile fish than in original mangrove habitats; but they still provide useful habitat for gobies and juveniles of a few species. Further study is needed to reveal whether the result is consistent throughout all season and in other geographical areas, and to quantitatively evaluate the influence of aquaculture pond construction on estuarine fish assemblages.

Acknowledgments

We are grateful to Prof. Hisashi Kurokura for his encouragement during this study. Thanks are due to Mitsuhiko Sano, Masahiro Horinouchi, Tadaomi Nakai, for their assistance in field sampling. This study was supported by JSPS/DOST Core University Program in Fisheries Science.

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