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Key words: flatfish, seasonal assemblage, species dominance, fishing pressure.

ABSTRACT

The seasonal dynamics of flatfish assemblage in the coastal waters off northeastern Taiwan was examined based on samples collected between March 2004 and March 2005 taken by bottom trawlers and landed at Da-Shi fishing port, Yilan county. A total of 28 species from 5 families and 18 genera were found. The Bothidae was the most dominant family, accounting for 81% of the total catch, while the most dominant species was the *Pseudorhombus pentophthalmus*. Species richness and diversity were high between the end of fall and the end of spring, but low in summer. Multivariate analyses based on cluster and nonparametric multi-dimensional scaling identified three seasonal assemblages as follows: late-spring to summer, fall to mid-winter, and late-winter to mid-spring. The two dominant species in each assemblage were the same, namely *P. pentophthalmus* and *Cynoglossus kopsii*. Rare or less abundant species were found to account for most of the differences among seasonal assemblages. The overwhelming dominance of one or two species suggests that monitoring of ecosystem change may be possible using these species. In addition, in this region a striking increase has been observed in both flatfish catch (3.5 folds from 2001 to 2007) and catch percentage (2.5 folds from 2002 to 2008), during the period when total landings of trawl fisheries either remained stable (2002-2007), or declined (after 2007). These findings may be due to the increase of fishing pressure and may reflect changes in the community structure of demersal fish in the region.

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I. INTRODUCTION

Flatfish are one of the important components in several demersal communities around the world [25, 26]. They are also an important commercial catch species [11]. Over the past 10 years, the global catch of flatfish has exceeded 1 million MT per year [11], most of them were used for human consumption. In the North Pacific Ocean, the total fish catch was 2.42 million MT in 1995, of which about 12% (~300,000 MT) was flatfish. In the North Sea, 29% of the demersal fish catch was flatfish [25], outnumbering other demersal species in the region.

Flatfish are also important predators in many demersal communities [18]. Several species feed on demersal invertebrates, while larger species may feed upon other fish and mollusks, as well as detritus descending from the upper layers of the ocean [19, 36]. They may thus serve as an important link between demersal production and human consumption [18]. In addition, because of their relatively sedentary nature (they don't migrate great distances), extended life span, and sensitivity to changes in the benthic environment [4, 10], they may also serve as an indicator species for monitoring structure changes of the ecosystem [31].

The waters around Guei-Shan Island are a traditional and important trawl fishing ground in northern Taiwan. Total catch from these waters accounts for about 1/6 of the Taiwan's coastal trawl catch. This region has been intensively fished over the past few decades, resulting in changes in the size and composition of fish species landed [35]. Large-size flatfish are sold separately at the market, while small-size and low value species (such as *Pseudorhombus pentophthalmus*) are the major component of by-catch from small trawlers, especially during the fall-winter period (varying from 50-80%). Due to their small size and/or low value, they are often sold

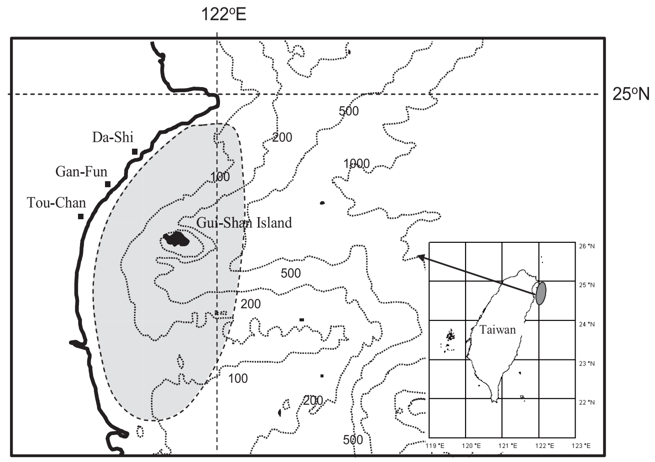

Fig. 1. Map showing bathymetric contour of the sampling site of the study. Numbers are isobaths in meter.

together with other low-value by-catch species as "trash fish" [33]. In 2010, the trash fish catch alone was 1770.2 MT, about 18% of the total landings in the region. Although there are no historical catch statistics available for "trash fish" before 2010, the above data suggests that flatfish may be one of the most important components of the demersal fish community in this ecosystem.

Numerous studies have been done on the distribution, abundance and fisheries biology of flatfish in many different places around the world [1, 9, 21, 23, 34]. However, with the exception of a few taxonomic studies, a population structure of *Engyprosopon grandiaquama* [31], and a recent study on the reproductive biology of *P. pentophthalmus* [33], very limited information is available regarding the occurrence, species composition, temporal and spatial distribution, population structure and fisheries biology of any of the flatfish in the waters off Taiwan. To address this issue, our study aimed to examine the species composition and assemblage of these abundant flatfish species in the northeast coast of Taiwan, and so further our understanding of an understudied group of fish.

II. MATERIALS AND METHODS

Samples of flatfish species were randomly collected on a bi-weekly basis, where possible, between March 2004 and March 2005, from the catches of small bottom trawlers operating in the waters around Guei-Shan Island off northeastern Taiwan (Fig. 1). The mesh size used by these vessels is 2.54 cm in the cod end. However, some vessels may, on a seasonal basis, use smaller mesh sizes at the cod end when targeting Sakura shrimp *Sergia lucens*.

The samples were brought back to the laboratory, rinsed and identified using the illustration handbooks produced by Shen [29], Shao and Chen [28] and Nakabo [22]. The FishBase on the website of the Academic Sinica, Taiwan was used as a supplemental guide for identification purposes. Once species was identified, the species were counted, and the length (TL in 0.1 cm) and weight (W in 0.01 g) of each individual were measured for all samples, except for abundant species, where only the first 30 individuals were recorded. All data were then digitized and saved for later analyses.

In addition to the fresh samples taken from the market (including those deposited in the trash fish), catch statistics for the period 2001-2010 were also obtained as an index for understanding the relative abundance of, and changes in, different groups of fish and species. As small-size and low value flatfish tended to be deposited as trash fish, their long term statistical records are lacking. However, sampling of trash fish in the region indicated that the seasonal abundance of small-size flatfish was the same as that of large-size (marketable) flatfish (recorded in the market as "flatfish") [33]. Moreover, large-size flatfish also contain significant amounts of adult *P. pentophthalmus*, depending upon the season. We therefore assumed that the annual abundance of "flatfish" category is representative of the overall abundance of flatfish in this region.

Indices of species diversity (H′ [27]), evenness (J′) [24], and richness (d) [20] were obtained for monthly pooled samples taken from different sampling dates, and were calculated as:

$$H' = -\sum_{i=1}^{s}(P_i \ln P_i) \quad (1)$$

where P_i is the proportion of total samples belonging to *i*th species.

$$J' = H'/\ln S \quad (2)$$

$$d = (S-1)/\ln N \quad (3)$$

where S is the number of species in the samples, and N is the number of individuals.

To reduce the influence of abundant species, the data from each sampling month was fourth-root transformed and subjected to cluster analyses using the Bray-Curtis Index of similarity and the group-average linkage method [6]. The relationships were further investigated using non-metric multidimensional scaling (MDS) to produce a two-dimensional representation of the relationships between samples. Analysis of similarity (ANOSIM) was used to test the significance ($p < 0.05$) of observed differences between different sets of data or assemblages. Similarity percentage analysis (SIMPER) was used to identify those species which typified and differentiated different assemblages in the region [5]. The cyclicity of seasonal patterns was tested using the RELATE correlation procedure. All multivariate analyses were performed using the PRIMER analytical package [6].

III. RESULTS

The catch statistics of Da-Shi fish market, where most

Table 1. List of taxonomic groups of flatfish species (by month) collected at Da-Shi fishing port from March 2004 to March 2005.

Family	Scientific name	No. of specimens													Total
	Month	M	A	M	J	J	A	S	O	N	D	J/2005	F	M	
Bothidae	*Arnoglossus polyspilus*	0	0	0	0	0	0	0	0	1	0	0	0	0	1
	Arnoglossus tenuis	0	0	0	0	0	0	0	0	2	2	0	0	0	4
	Bothus myriaster	8	3	0	0	1	0	2	0	3	21	18	16	3	75
	Chascanopsetta lugubris	0	0	0	0	4	0	0	1	1	2	1	0	0	9
	Crossorhombus kanekonis	2	1	0	0	0	0	0	0	0	0	0	1	0	4
	Crossorhombus kobensis	0	0	0	0	6	16	0	0	6	7	9	1	0	45
	Engyprosopon grandisquama	0	0	0	2	1	3	1	2	5	3	4	0	0	21
	Engyprosopon nacroptera	2	78	4	5	2	57	3	8	3	4	3	6	1	176
	Japonolaeops dentatus	2	1	3	2	1	1	2	4	6	3	3	2	3	33
	Parabothus taiwanensis	4	14	2	2	2	0	0	0	1	0	0	2	2	29
	Psettina gigantea	1	2	0	0	0	0	0	1	2	1	3	1	0	11
	Psettina iijimae	0	0	0	0	0	0	2	4	6	3	2	0	0	17
	Psettina tosana	3	6	0	0	0	0	0	0	1	2	3	2	1	18
	Pseudorhombus dupliciocellatus	0	0	0	0	0	0	0	0	2	0	0	0	0	2
	Pseudorhombus pentophthalmus	92	94	85	68	62	85	96	86	152	167	115	88	68	1258
	Tarphops oligolepis	4	1	0	0	0	0	0	15	5	4	3	1	0	33
Cynoglossidae	*Cynoglossus gracilis*	0	0	0	0	0	0	0	3	0	0	0	0	0	3
	Cynoglossus kopsii	30	26	25	25	18	16	16	14	20	33	25	33	19	300
	Paraplagusia bilineata	0	0	0	0	0	0	0	1	2	2	1	0	0	6
Pleuronectidae	*Plagiopsetta glossa*	0	0	0	0	1	0	0	0	0	0	0	0	0	1
	Pleuronichthys cornutus	1	8	0	0	1	0	11	0	0	0	5	2	0	28
Psettodidae	*Psettodes erumei*	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Pleuronectidae	*Samariscus filipectoralis*	1	0	0	0	0	0	0	0	0	0	2	1	0	4
	Samariscus latus	0	0	0	0	0	0	0	0	0	2	0	0	0	2
Soleidae	*Aseraggodes kobensis*	0	0	3	0	0	6	0	0	0	5	2	1	0	17
	Pardachirus pavoninus	0	1	0	0	0	0	1	0	0	1	0	0	0	3
	Zebrias quagga	0	5	0	0	8	3	4	4	5	3	2	0	0	34
	Zebrias zebra	2	2	0	0	0	0	0	0	0	0	1	3	1	9
Total		152	243	122	104	107	187	138	143	223	265	202	160	98	2144

vessels land their catches, showed that total catch increased significantly from 2001 to 2002 (Fig. 2(A)), remained steady between 2002 and 2006, and decreased thereafter. Average catch over this period was about 10,000 MT, with the lowest catch occurring in 2001, and the highest in 2006. However, the flatfish catch exhibited a different pattern, increasing about 3.5 folds from 2001 to 2007 before declining to its lowest point in 2009 (Fig. 2(B)). As a percentage of the total catch, flatfish increased from 2002 onwards, reaching a peak in 2008 (2.5 folds), and falling slightly thereafter. This pattern suggested a possible change in the relative dominance of fish species in the ecosystem. Most of the flatfish in the region were caught during the fall–winter period (Fig. 3) and the influence of these fish, and the impact on the ecosystem of any change in their relative abundance, will be greater during this time.

A total of 5 families, including 28 species (Table 1) were recorded in this study. The Bothidae, which included 9 genera and 11 species, was the most abundant family, accounting for about 81% of the total. The most dominant species was the *P. pentophthalmus* (58.7%). Other abundant species were *Cynoglossus kopsii* (14%) and *Engyprosopon nacroptera* (8.2%).

The number and richness of species caught were generally higher in late fall to mid-spring (Nov.-Apr.), and lower from late-spring to summer (May-Aug.), except for the July sample which was taken 2 days after a typhoon struck the area (Fig. 4). Species evenness varied only slightly over the study period, while species diversity fluctuated seasonally, but was lower from late-spring to summer.

Cluster analyses identified three assemblages (with a similarity of 62%), which corresponded to the late-spring/summer (LSp-S), fall/mid-winter (F-MW) and late-winter/mid-spring (LW-MSp) seasons (Fig. 5). Samplings conducted in July 2004 were not grouped into the LSp-S assemblage as they were presumed to have been affected by a typhoon occuring around the sampling date. The k-dominance curves for F-MW and LW-MSp assemblages were below that for LSp-S (Fig. 6) indicating higher species diversity during cooler seasons (Sept.-Apr.).

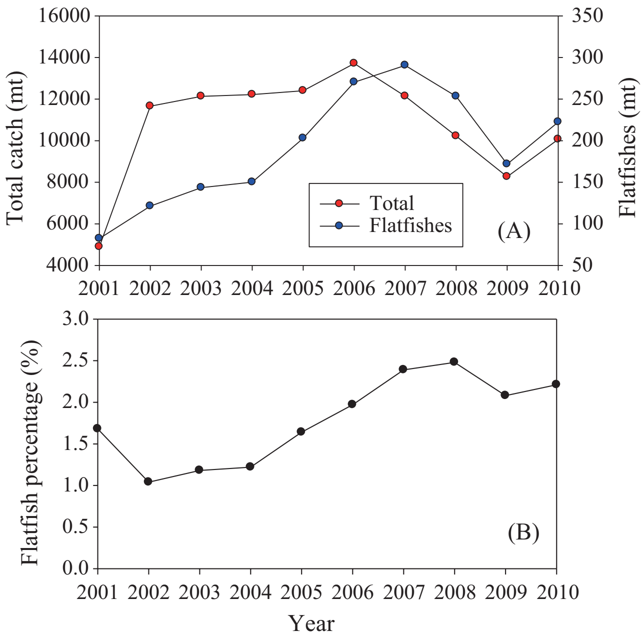

Fig. 2. Total and flatfish catches (mt) (A), and catch percentage of flatfish (B) from small bottom trawlers operate in waters off northeastern Taiwan between 2001 and 2010.

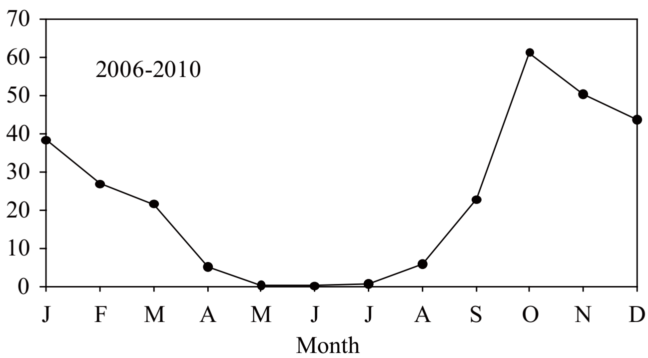

Fig. 3. Mean monthly catches (mt) of flatfish between 2006 and 2010 in waters off northeastern Taiwan.

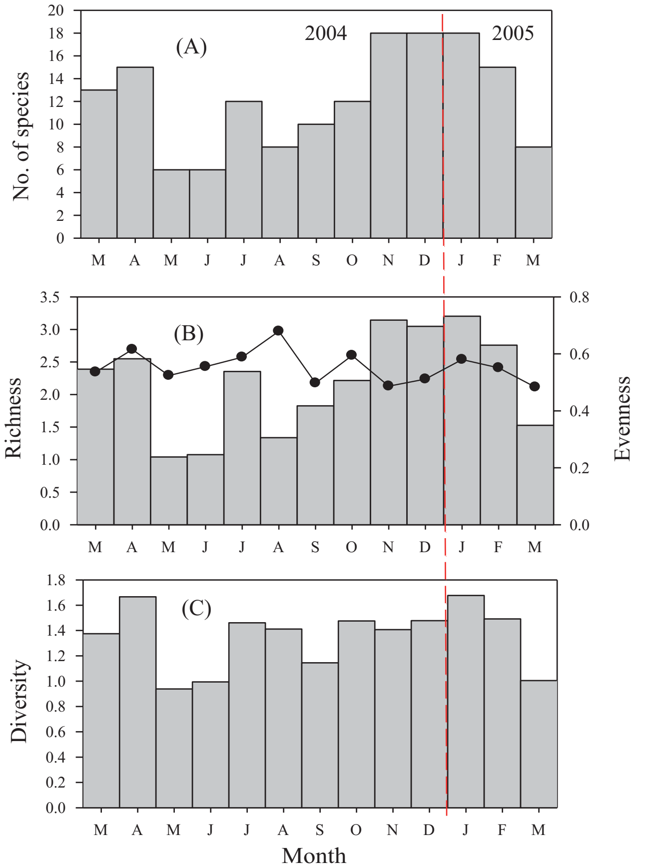

Fig. 4. Monthly changes in (A) no. of species, (B) species richness and evenness (-●-), and (C) species diversity of flatfish collected in waters off northeastern Taiwan from Mar. 2004 to Mar. 2005 (dash line separated samples taken from different years).

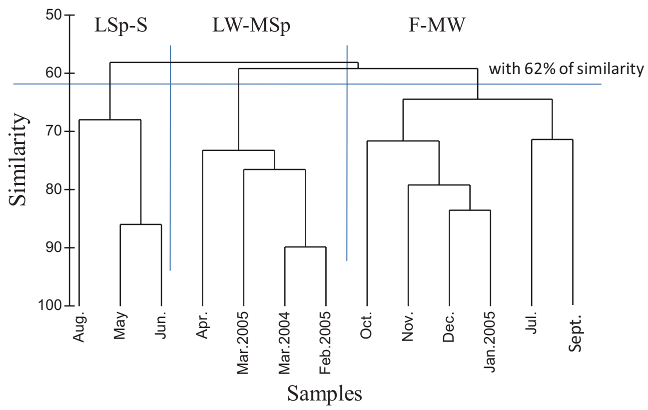

Fig. 5. Dendrograms based on the monthly samplings from Mar. 2004 to Mar. 2005 using group-averaged clustering from Bray-Curtis similarity on fourth root transformed abundances of flatfishes collected in waters off northeastern Taiwan. LSp-S: late spring to summer assemblage; LW-MSp: late winter to mid-spring assemblage; F-MW: fall to mid-winter assemblage.

MDS analysis also showed three distinct assemblages in line with the results obtained by cluster analysis. Again, the July sample was noted as an exception (Fig. 7). The stress level was estimated to be 0.14 indicating an appropriate representation of the distribution of all samples in two dimensions [6]. Differences between assemblages were confirmed by a one-way ANOSIM test (global R = 0.816, p = 0.1%). In addition, correlations of the similarity matrices underlying these ordinations revealed a circular relationship between samples (RELATE procedure, global R = 0.638, p = 0.1%), suggesting that flatfish recruitment follows a predictable annual pattern in the region.

The results of SIMPER analysis showed that the typical species for the F-MW assemblage were: *P. pentophthalmus*, *C. kopsii*, *Zebrias quagga*, *E. nacroptera*, *Japonolaeops dentatus*, *Engyprosopon grandisquama*, *Bothus myriaster*, and *Psettina iijimae* (Table 2). The LW-MSp assemblage was typified by the following species: *P. pentophthalmus*, *C. kopsii*, *B. myriaster*, *Parabothus taiwanensis*, *E. nacroptera*, *Psettina*

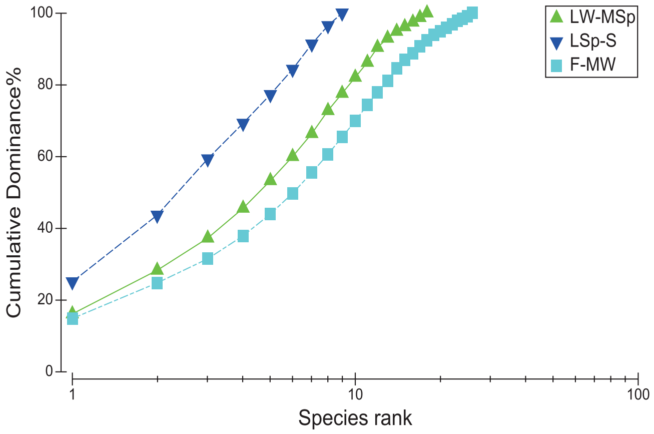

Fig. 6. The cumulative frequency of abundance (i.e., k-dominance plots) of species in three identified seasonal assemblages. LW-MSp: late winter to mid-spring assemblage; LSp-S: late spring to summer assemblage; F-MW: fall to mid-winter assemblage.

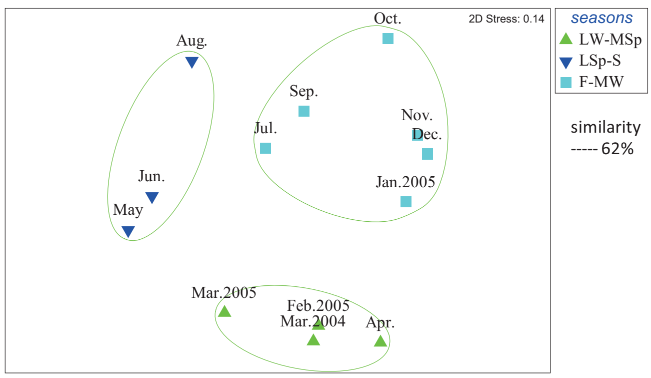

Fig. 7. The MDS ordination of monthly collections of flatfishes in waters off northeastern Taiwan. Symbols correspond to major groups resulting from cluster analysis. LW-MSp: late winter to mid-spring assemblage; LSp-S: late spring to summer assemblage; F-MW: fall to mid-winter assemblage.

tosana, *Zebrias zebra*, and *J. dentatus*. And the LSp-S assemblage was typified by the following species: *P. pentophthalmus*, *C. kopsii*, *E. nacroptera*, *J. dentatus*, and *P. taiwanensis*.

Species which contributed most to the differentiation between LW-MSp and LSp-S assemblages were *B. myriaster*, *P. tosana*, *Z. zebra*, *Aseraggodes kobensis*, *Pleuronichthys cornutus*, *E. grandisquama*, *Tarphops oligolepis*, *Crossorhombus kanekonis*, *Psettina gigantean*, *Crossorhombus kobensis*, and *E. nacroptera* (Table 3). Species which contributed most to the differentiation between LW-MSp and F-MW assemblages were *E. grandisquama*, *Zebrias quagga*, *P. taiwanensis*, *Psettina iijimae*, *Z. zebra*, *C. kobensis*, and *Chascanopsetta lugubris*. And, species which contributed most to the differentiation between LSp-S and F-MW assemblages were *B. myriaster*, *P. iijimae*, *Z. quagga*, *C. kobensis*, *Tarphops oligolepis*, *Chascanopsetta lugubris*, *Aseraggodes kobensis*, *Pleuronichthys cornutus*, and *P. taiwanensis*. The

Table 2. The percentage contribution (>5%) of flatfishes to within group similarity for the identified seasonal assemblages, from SIMPER analysis. F-MW: fall to mid-winter assemblage; LW-MSp: late winter to mid spring assemblage; LSp-S: late-spring to summer assemblage. Av. Sim. = average similarity.

Assemblage	Species	Contribution %
F-MW	*Pseudorhombus pentophthalmus*	21.50
(Av. Sim. = 69.58)	*Cynoglossus kopsii*	13.89
	Zebrias quagga	8.69
	Engyprosopon nacroptera	8.64
	Japonolaeops dentatus	8.16
	Engyprosopon grandisquama	7.70
	Bothus myriaster	5.53
	Psettina iijimae	5.34
LW-MSp	*Pseudorhombus pentophthalmus*	20.63
(Av. Sim. = 77.09)	*Cynoglossus kopsii*	15.41
	Bothus myriaster	9.62
	Parabothus taiwanensis	8.96
	Engyprosopon nacroptera	8.50
	Psettina tosana	8.23
	Zebrias zebra	7.78
	Japonolaeops dentatus	7.37
LSp-S	*Pseudorhombus pentophthalmus*	33.26
(Av. Sim. = 73.97)	*Cynoglossus kopsii*	23.05
	Engyprosopon nacroptera	17.19
	Japonolaeops dentatus	12.04
	Parabothus taiwanensis	5.08

differences among assemblages were mostly accounted for by rare or less abundant species, while *P. pentophthalmus* and *C. kopsii* were the most dominant species seen in each of the assemblages.

IV. DISCUSSION

Regional catch statistics over the past 10 years showed that total landings increased rapidly in 2001 but remained stable between 2002 and 2006, while the flatfish catch increased dramatically from 2001 to 2007. Although both total and flatfish catches declined thereafter, the flatfish catch percentage actually increased substantially by about 2.5 folds from 2002 to 2008, and remained high from 2009-2010. We view these changes to be the result of a change in species dominance in the ecosystem.

Fishing may have multiple effects on an ecosystem through changes in prey-predator interactions, and size distributions, or through a genetic selection for different physical characteristics and life history traits (e.g. earlier size or age-at-maturity). Fishing may also affect populations of non-target species as a result of by-catch [16], and lead to a reduction of habitat complexity and changes in community structure. Substantial reductions in the abundance of commercially

Table 3. The percentage contributions (> 5%) of flatfishes to the average between-assemblage dissimilarity, using SIMPER analysis [5]. F-MW: fall to mid-winter assemblage; LW-MSp: late winter to mid spring assemblage; LSp-S: late-spring to summer assemblage. Av. dissim.=average dissimilarity.

Assemblages	Species	Contribution %
Groups LW-MSp *vs.* LSp-S (Av. dissim. = 41.79)	*Bothus myriaster*	12.41
	Psettina tosana	9.82
	Zebrias zebra	9.20
	Aseraggodes kobensis	6.89
	Pleuronichthys cornutus	6.75
	Engyprosopon grandisquama	6.63
	Tarphops oligolepis	6.11
	Crossorhombus kanekonis	5.68
	Psettina gigantea	5.62
	Crossorhombus kobensis	5.35
	Engyprosopon nacroptera	5.23
Groups LW-MSp *vs.* F-MW (Av. dissim. = 40.83)	*Engyprosopon grandisquama*	7.47
	Zebrias quagga	7.09
	Parabothus taiwanensis	6.61
	Psettina iijimae	6.60
	Zebrias zebra	6.47
	Crossorhombus kobensis	5.79
	Chascanopsetta lugubris	5.61
Groups LSp-S *vs.* F-MW (Av. dissim. = 41.95)	*Bothus myriaster*	8.62
	Psettina iijimae	7.64
	Zebrias quagga	7.59
	Crossorhombus kobensis	6.99
	Tarphops oligolepis	6.77
	Chascanopsetta lugubris	6.48
	Aseraggodes kobensis	6.07
	Pleuronichthys cornutus	5.60
	Parabothus taiwanensis	5.48

important species, as well as changes in fish community structure and species composition due to intensive fishing have been documented for many marine ecosystems [2, 7, 12, 14, 23]. Shin *et al.* [30] stated that fishing is always size-selective. Removing large fish, which are more valuable, modifies the size structure and functioning of fish assemblages. Greenstreet *et al.* [13] showed that exploitation of the North Sea groundfish assemblage has led to a decrease in abundance and a shift in size composition from large to smaller fish.

The northeastern waters of Taiwan are traditional and important trawl fishing grounds. This region has been intensively fished over the past few decades. Catches of several commercially important fish, such as black croaker (*Atrobucca nibe*), bigeye (*Priacanthus macracanthus*), yellow sea-bream (*Dentex tumifrons*), red tilefish (*Branchiostegus japonicus*), lizardfish (Synodontidae), and Japanese barracuda (*Sphyraena japonica*) are now dramatically lower than 20 years ago, while the trash fish catch has increased [32]. Changes in the size and composition of the fish species landed have also been observed [35].

If the top predators decline significantly, the abundant by-catch species may one day become the dominant group in the ecosystem. Jiang and Cheng [15] and Lin *et al.* [17] have noted the dominance of many small and commercially low-value fish in the East China Sea, Bohai Sea and Yellow Sea. They found that mean trophic levels in the Bohai and Yellow Seas have decreased after decades of exploitation. Large piscivorous fish have been replaced by smaller planktonivorous and other small-size fish in these waters. The *Acropoma japonicum*, a small-size fish, has become one of the most abundant species in the East China Sea, accounting for about 15% of the biomass. It also ranks in the top 3 of overall catches in that region. The authors attributed the increase in abundance of these fish to the over-exploitation of large and top predator fish.

Fogarty and Murawski [8] studied the Georges Bank ecosystem and observed a switch in species dominance linked to competitive release caused by commercial fishing. The gadid and flounder species were replaced by small elasmobranches including dogfish sharks and skates. We believe that the apparent increase in flatfish reported in our study may also be due to a large reduction in commercially important predator fish in the region, although biotic interactions may also play a significant role in the dynamics of demersal fish communities [2]. Such a change deserves close attention, as the majority of flatfish biomass in this ecosystem is accounted for by *P. pentophthalmus*, a low-value, medium to small-size species. The increase in flatfish may therefore represent a shift in the whole system towards an assemblage dominated by smaller fish and a reduction in the economic value of fishing in the region.

Our results showed a clear seasonal pattern to the number, richness and diversity of flatfish species in the region, with a peak in the fall/winter, and a trough in the late spring/ summer. Cluster and MDS analyses identified three seasonal assemblages, more or less corresponding to these patterns. In addition, the k-dominance plot showed that the diversity of the LSp-S assemblage was clearly lower than those of both the F-MW and LW-MSp assemblages, when seasonal catch (or biomass) of flatfish was also at its highest. This indicates that a continuous recruitment of flatfish species in the region is possible, but that the majority of them remain in the fall to winter periods.

This study reveals that two flatfish species, *P. pentophthalmus* and *C. kopsii* comprise the major component of each seasonal assemblage, and can be found throughout the year. The differentiation among seasonal assemblages was accounted for mostly by rare or less abundant species. A previous study has shown that the *P. pentophthalmus* collected in the region are mainly in the juvenile to adult stages (10.1~20.0 cm in total length) [33], while the size of the *C. kopsii* collected ranged from 5.2 to 19.8 cm, possibly including late larval and/or juvenile to adult stages despite the fact that mesh size may have limited the catch of smaller individuals. It is very likely that *C. kopsii* recruits to this ecosystem soon after the pelagic phase, while *P. pentophthalmus* recruits somewhere else before migrating to this site. Due to the relatively sedentary nature of flatfish and their sensitivity to changes in the benthic environment [4, 10], we suggest that it may be possible to monitor ecosystem changes using these species.

Due to sampling limits in this study (e.g. only sub-samples were examined), potential bias may be an issue, especially as large variations in catch were observed among vessels. However, since our samples were taken randomly from different catches deposited in the market, we believe such bias was minimized. We cannot exclude the possibility that rare flatfish species were under-represented in our study (in terms of their number and abundance) because many of these species are small in size and deposited as trash fish (especially during the fall-winter period) and so could not be examined completely.

Our findings indicated that for flatfish alone, the number of species in this region is high (28 species), and this may be related to the subtropical location of the sampling site. Wu [35] has also reported a high diversity of fish species in the same region based on quarterly samplings. A recent study by Wang *et al*. [32] on the by-catch fish of the trawl fisheries in the region indicated that, while bony fish dominate the trash-fish catch for most of the year, the elasmobranches (mostly small-size sharks and rays) may seasonally comprise a large proportion of the catch. Because of their potential competitive interaction [8], the ecological role and composition of small elasmobranches, and their interactions with flatfish deserve further examination.

To sum up, the occurrence, diversity and seasonal assemblages of the abundant, yet understudied, flatfish species have been described for the first time in this ecosystem. It was surprising to find that the flatfish in this location are dominated by just a few species, particularly *P. pentophthalmus* and *C. kopsii*. The results also reveal a possible change in the community structure of this region, since the absolute and relative abundance of flatfish has increased noticeably, while total landings have remained relatively stable. Flatfish make up one of the most dominant groups in the region and we suggest that they can be used to monitor changes in the ecosystem in response to anthropogenic disturbance, in particular fishing. In addition, further research on the interactions between dominant fish groups, including flatfish, is required to produce a more holistic approach to the assessment and management of demersal fishery resources and the ecosystem as a whole in this region.

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