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A comparison of fish assemblages from seagrass beds and the adjacent bare substrata in Lake Hamana, central Japan

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Abstract: The fish species richness and abundances were compared between the seagrass beds and the neighoboring bare sand substrata at two sites i.e. Megaura and Yokoyama in Lake Hamana, central Japan from March to May each year in 1998, 1999 and 2000. The species richness in seagrass beds were higher than those in the bare substrata and the species composition and the relative abundance of each species differed between them. The mean numbers of individuals and the species diversity, however, did not differ between the two habitat types. Such phenomena may be due to the seasonal changes in habitat structure of the studied seagrass beds.

Key words: Seagrass bed; sand flat; species richness; fish abundance

Introduction

It is widely accepted that seagrass beds support large numbers of fish species and individuals, and provide nursery habitat for juveniles of many species, compared to adjacent unvegetated areas which have different fish assemblages, usually characterized by fewer species and fewer individuals (e.g., Kikuchi, 1974; Adams, 1976; Weinstein and Heck, 1979; Beckley, 1983; Pollard, 1984; ; Sogard, 1989; Connolly, 1994; Edgar and Shaw, 1995). The structural complexity composed by seagrass leaves is considered one of the major factors responsible for such differences in habitat use, because it provides varied microhabitats and protection from predators, and enables food to be supplied in ways not available in the absence of seagrass. Some workers have shown, however, that seagrass may not necessarily support a larger number of fish individuals than adjacent bare substrata (e.g., Heck and Thoman, 1984; Howard et al., 1989; Ferrell and Bell, 1991). To date, there have been few studies which have compared the relative importance for fishes of seagrass and adjacent sand habitats in Japanese coastal systems.

In this study, the hypothesis that seagrass beds in Lake Hamana, Japan, supported a relatively larger number of fish species and individuals than adjacent unvegetated areas, was examined.

Materials and Methods

The study was carried out over seagrass beds (*Zostera marina*) and adjacent shallow sand substrata at Megaura and Yokoyama bordering Lake Hamana in the western part of Shizuoka Prefecture (Fig. 1). The study period was from March to May each year in 1998, 1999 and 2000. At the study sites, the seagrass which constituted the beds was annual, growing heavily during March through May, but dying back in other months. The areas of seagrass beds at Megaura and Yokoyama were ca. 1.5 ha and 16 ha, respectively, being in 2−5 m depth. The adjacent sand flats studied were 0.5−2 m depth.

Visual censuses using SCUBA were made monthly between 10:00 and 16:00. At each site, five transects 10 m long and 1 m wide were randomly established in both the seagrass bed and adjacent sand flat, using a scaled tape. The transect width was estimated visually, these transects being at least 10 m apart from each other. All fish individuals within each transect were counted and, if possible, the total length (TL) of each individual estimated to the nearest 5 mm with a transparent ruler.

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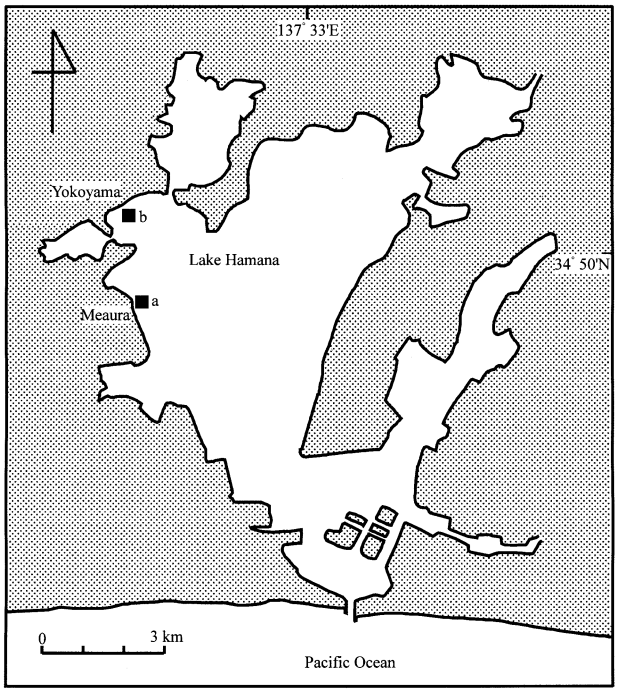

Fig. 1. Map of the study sites. a: census area at Megaura; b: census area at Yokoyama.

To evaluate the species diversity of fish assemblages, the Shannon-Wiener diversity index (H') was calculated using the relative abundance of each species in each assemblage.

A four-way ANOVA was employed to test whether or not fish species richness and total fish abundance differed between the seagrass habitat and adjacent sand flat, with habitat type, site, month and year as fixed factors. All data were log-transformed. Such transformation, however, did not produce homogeneous variances. Therefore, in order to compensate for the increased likelihood of Type 1 error, the significance level was set at $\alpha = 0.01$ (Underwood, 1981).

To examine the overall patterns in similarities of species composition in these habitats, the Bray-Curtis similarities were calculated based on the mean density data of each species, and were applied to a cluster analysis with group-average linking. As a basis for grouping the assemblages, a level of similarity value of 60 (relatively high overlap value) was arbitrarily adopted, so as to avoid grouping assemblages by chance.

In these analyses, *Chaenogobius* spp. or *Gymnogobius* spp. were regarded as single species, because they often occurred as mixed species schools.

All of these analyses were carried out on SPSS for Windows, Release 12.0 J.

Results

Fish species richness and abundance. A total of nineteen species were recorded, most of the individuals being juveniles of relatively small body size (Table 1). Eighteen species occurred in the seagrass habitat, and 9 in the bare habitat. Ten species were restricted to the seagrass beds, and 1 species to the sand flats, the remainder occurring in both habitats.

Table 1. List of fish species occurring over *Zostera* beds and adjacent sand flats at Megaura and Yokoyama study sites and size ranges (mm TL) of individuals of each month. Data were pooled for sites and years because of the lack of any significant differences in size ranges of individuals of each species.
-, no individuals observed; + size not measured.

	Seagrass beds			Sand flats		
Species	March	April	May	March	April	May
Anguilla japonica	+	-	-	-	-	-
Plecoglossus altivelis altivelis	-	-	-	66–70	-	-
Hippocampus coronatus	-	66–70	-	-	-	-
Mugil cephalus cephalus	-	46–50	-	-	-	-
Sebastes inermis	-	-	36–40	-	-	-
Gerres equulus	-	+	-	-	-	-
Pseudoblennius cottoides	36–40	36–40	46–50	-	-	-
Pholis nebulosa	36–50	46–50	66–100	36–40	-	-
Petroscirtes breviceps	<10	-	-	-	-	-
Gymnogobius macrognathos	-	-	16–20	36–40	+	46–50
Acanthogobius flavimanus	171–180	-	16–30	-	-	16–30
Favonigobius gymnauchen	-	36–40	36–60	26–50	26–60	51–60
Chaenogobius spp.	<10	11–30	+	<10	11–30	-
Gymnogobius spp.	<10	6–20	-	-	11–30	-
Acentrogobius pflaumii	-	66–70	-	-	-	-
Sphyraena sp.	<10	-	-	-	-	-
Kareius bicoloratus	-	-	+	-	16–30	-
Pleuronectes yokohamae	21–35	21–45	31–70	<20	16–35	36–75
Rudarius ercodes	16–20	-	-	-	-	-

Four-way ANOVA revealed that the mean number of fish species in the seagrass beds was significantly higher than that in a bare habitat overall ($P < 0.01$) (Fig. 2a). Interactions among fixed factors, in all cases except the pair of months and sites, were significant (all $P < 0.01$).

Four-way ANOVA detected no significant difference in the mean number of fish individuals between the seagrass and bare habitats overall ($P > 0.8$), but found significant interactions between habitat type and other fixed factors (all $P < 0.001$) (Fig. 2b).

Species diversity of fish assemblages. H' value ranged from 0 to 1.93 for seagrass fish assemblages, and from 0 to 1.50 for sand-flat fish assemblages, the mean values not differing between the two habitat types (0.88±0.64 S. D. for seagrass fish assemblages and 0.51±0.44 S.D. for sand-flat fish assemblages; t-test, $P > 0.07$) (Fig. 3).

Similarities among assemblages. At the similarity value of 60, fish assemblages were divided into 21 groups (Fig. 3). Of them, only five groups contained plural members. The rests were grouped separately from each other.

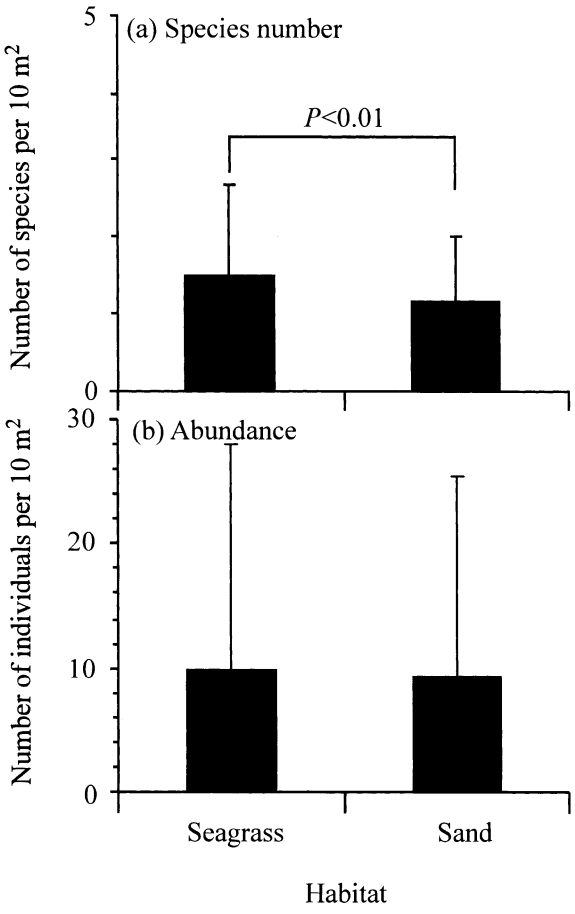

Fig. 2. Mean numbers of fish species (a) and individuals (b) per 10 m^2 in the seagrass and sand habitats. Data were pooled for months, sites and years, because the main purpose of the present study was a comparison of fish species richness and abundance between the two habitat types. Bars indicate standard deviation.

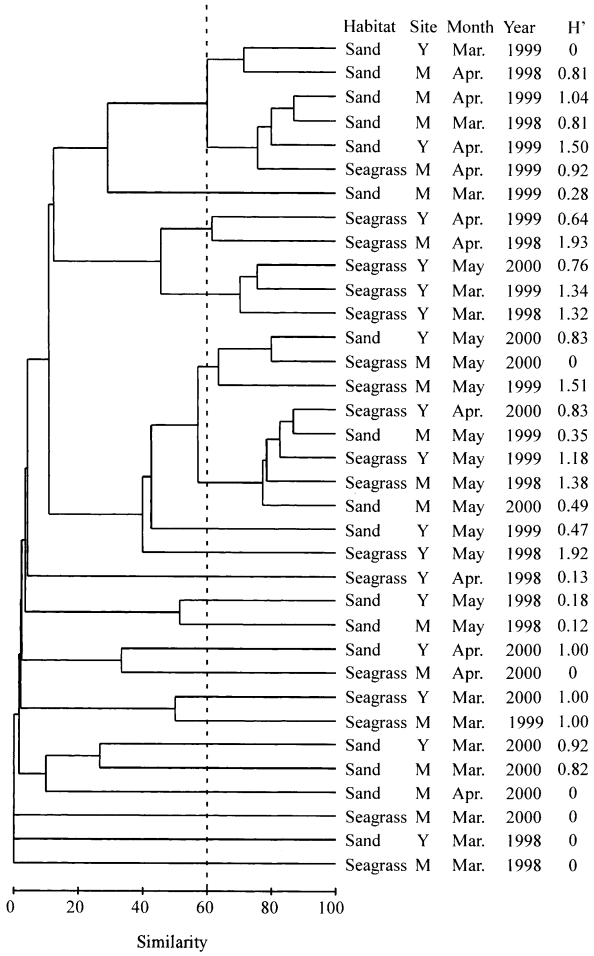

Fig. 3. Dendrogram showing the clustering of the species composition obtained from each habitat at each site in each month of each year based on density data. M, Megaura; Y, Yokoyama. H', Shannon−Wiener index.

Discussion

The results of the present study afforded no evidence for the hypothesis that the seagrass beds support larger number of fish individuals compared to the adjacent unvegetated areas.

While the three-years total and the mean fish species numbers in the seagrass beds were surely higher than those in the sand flats, the mean numbers of individuals and the species diversity index values did not differ between the two habitats overall. The strong interactions suggested that fluctuation patterns of fish specie richness and abundance of the assemblages were highly variable among habitat types, sites, months and years. In addition, few groups containing plural members in the dendorogram indicated the assemblage structures were highly variable in both habitat types at the present study sites. These may have been partly due to seasonal changes in habitat complexity of the studied seagrass beds. At the present study sites, seagrass flourishes almost entirely during March through May each year dying back in other months (M. Horinouchi, per. obs.). Seagrass fish which newly-recruited to the beds, may have to leave them as the seagrass died back. If, on the other hand, the above-ground seagrass biomass maintained a consistent level all year round, such fishes may be able to complete the remainder of their life cycle in such beds. As a result, individuals belonging to various year classes could become permanent residents, contributing to a relatively rich seagrass fish fauna compared to adjacent bare substrata. Such a phenomenon was observed in a *Zostera marina* bed at Aburatsubo, Kanagawa Prefecture, central Japan, where seagrass flourishes all year round (M. Horinouchi, unpubl. data). On the contrary, most individuals seen in the present seagrass beds were new recruits, resulting in a relatively poor fish fauna overall.

The general conclusion provided by the present study

was that seagrass beds do not always support larger numbers of fish individuals, or be characterized by greater fish species diversity, compared to the adjacent unvegetated areas.

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