Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 24 (7): 931- 941 (2020)
www.ejabf.journals.ekb.eg

Species composition and biodiversity index of gobiid assemblage in estuarine areas of the Mekong Delta, Vietnam

Dinh Dac Tran[1], Vang Thi Nguyen[1], Hoang Thi My To[1], Tin Trung Nguyen[1], Quang Minh Dinh[2*]

1. Department of Fisheries Management and Economics, College of Aquaculture and Fisheries, Can Tho University, Ninh Kieu, Can Tho 900000, Vietnam
2. Department of Biology, School of Education, Can Tho University, Xuan Khanh ward, Ninh Kieu District, Can Tho 900000, Vietnam

[*]Corresponding Author: dmquang@ctu.edu.vn

ARTICLE INFO

Article History:
Received: Aug. 25, 2020
Accepted: Nov. 27, 2020
Online: Dec. 21, 2020

Keywords:
Biodiversity index,
estuaries,
gobiid composition,
Mekong River,
Vietnam

ABSTRACT

The interaction between environmental factors and the distribution of gobiid fishes was investigated at 16 sampling sites in estuarine areas of the Mekong Delta, Vietnam. Fish specimens were mainly collected by using trawl net, push net, and bag net every two months, from August 2017 to August 2019. Data analysis showed that 40 fish species belong to three families in the gobiid assemblage in the studied area. The most common family was Gobiidae (62%), followed by Oxudercidae (25%) and Eleotridae (13%). The number of fish species decreased gradually from estuary to midstream of river systems. The gobiid assemblage was more diversified in the river system controlled by the West Sea (37 species and 696 individuals) than in the river planned by the East Sea (17 species and 225 individuals). The fish species and biodiversity indexes decreased with the reduction of salinity from the estuary to the midstream of the river system. In the wet season, the fish assemblage was more abundant and diverse than in the dry season due to the environmental factors influenced by the Mekong River. The highest biodiversity index was recorded in Bay Hap and Ong Trang (77.38%). Moreover, the analyzed result of biodiversity indexes revealed that the diversity of fish species in the study area was relatively high. The study outcome will be useful in fisheries management and biodiversity conservation, especially for estuaries.

INTRODUCTION

The Mekong Delta's marine region, one of the four main fish grounds of Vietnam, plays a vital role in the country's fisheries industry **(Pomeroy *et al.*, 2009)**. As Chung *et al.* (2001) estimated, the Mekong Delta's coastal areas are most abundant, accounting for 50% of both pelagic and demersal fisheries resources compared to the rest three regions. Even though playing essential roles, fisheries resources in the Mekong Delta's coastal area have faced numerous threats. The rapid development of the coastal economy, i.e., large-scale reclamation of the coast and mangrove deforestation, has posed the coastal environment under degradation **(Anthony *et al.*, 2015)**. Besides, land-sourced pollution, including plastic waste, elevated concentration of heavy metals are accumulated in this region, which causes a decrease in the hatching and survival rates of the marine species leading to reductions in their population and abundance **(Cui *et al.*, 2003; Jambeck *et al.*, 2015)** including gobiid fish. The other fish species also face many risks originating in uncontrolled fishing and using destructive fishing methods **(Pomeroy *et al.*, 2009)**.

According to **Fricke *et al.* (2020)**, the Gobiidae family recorded as one of the largest fish families worldwide consists of more than 2,000 described species. Five subfamilies belonged to Gobiidae in Vietnam: Amblyopinus, Gobiinae, Gobionellinae, Oxudercinae, and Tridentigerinae **(Mai, 1992)**. They can adapt to diversified habitats from seashore to brackish and freshwater, where they account for about 35% of a total fish number and 20% of the diversity of fish species **(Winterbottom *et al.*, 2011)**. Most of oxudercine species are mudskippers **(Jaafar and Murdy, 2017)** and can breathe the air **(Ishimatsu, 2017)**. In Mekong Delta, particularly, many recorded species belong to the Gobiidae family. For example, in Tra Vinh province, **Binh (2009)** found 11 goby species; in Mekong Delta, **Tran *et al.* (2013)** recorded 59 gobiid species; in Soc Trang, **Diep *et al.* (2014)** also found the same number of 59 species but not in the region of Hau, Bay Hap and Ong Trang rivers. Consequently, the present study was conducted to evaluate composition, diversity, and abundance of gobiid assemblage from estuary to midstream of Hau, Ong Trang and Bay Hap Rivers, Mekong delta, which information will be very useful for fishery management, especially for the cause of climate change and sea level rate in the Mekong Delta.

MATERIALS AND METHODS

Study site and fish collection

This study was conducted in the estuarine areas of Hau river (East Sea), and Bay Hap and Ong Trang rivers (West Sea). The dry season with little rain (January to May) and the wet season with heavy rain (June to December) are two main seasons in these provinces **(Le *et al.*, 2006)**.

The fish specimens were collected directly using various fishing gears such as trawl net, push net, and bag net at 16 sampling sites. These sites are Cha La (1; 8°55'59.7"N 105°05'52.4"E), Dam Cung (2; 8°51'26.8"N 105°01'25.9"E), Rach Cheo (3; 8°47'58.5"N 104°53'54.7"E), Bay Hap (4; 08°47'28"N 104°52'20.9"E), Right Bay Hap (5; 08°46'47.5"N 104°50'35.1"E), Left Bay Hap (6; 8°45'31.7"N 104°50'44.6"E), Right Ong Trang (7; 8°43'44.4"N 104°49'12.3"E), Left Ong Trang (8; 8°42'39.6"N 104°49'24.4"E), Mui Ong Trang (9; 08°41'45.9"N 104°50'53.3"E); Ong Trang (10; 8°41'36.8"N 104°51'23.6"E), Nhung Mien (11; 8°41'37.8"N 104°55'28"E), Sa Pho (12; 8°44'27.7"N 104°58'18.8"E), Cua Tran De (13; 9°29'58.23"N 106°13'25.00"E); Dai Ngai (14; 9°43'37.55"N 106°5'19.32"E), An Lac Tay (15; 9°51’55.5"N 105°58’4.26"E) and Cai Cui (16; 9°57'7.12"N 105°52'36.59"E). At each sampling site, the fishing gears were used to collect fish specimens continuously for 30 minutes. After collection, the fish specimens were stored in cool box for species identification in the labs. In addition, environmental parameters (water temperature, pH, DO, water depth, salinity) and fishing operation (operation time, speed) were also recorded.

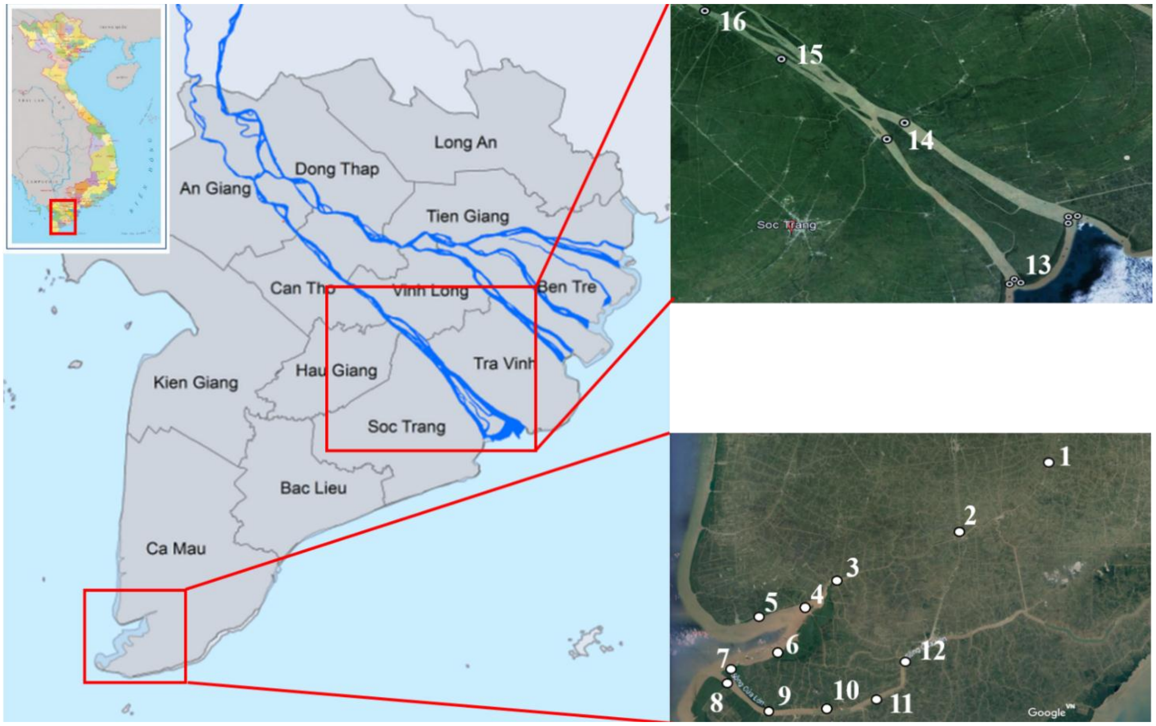

Fig. 1 Fish collection and analysis

1: Cha La, 2: Dam Cung, 3: Rach Cheo, 4: Bay Hap; 5: Right Bay Hap, 6: Left Bay Hap, 7: Right Ong Trang, 8: Left Ong Trang, 9: Mui Ong Trang; 10: Ong Trang, 11: Nhung Mien, 12: Sa Pho, 13: Cua Tran De, 14: Dai Ngai, 15: An Lac Tay and 16: Cai Cui (Source: Google Map)

Fish analysis

All specimens were identified from species to genus using criteria described by **Rainboth (1996)**. The fish was (1) observing for whole body shape and color, the size of the mouth, eyes, nose, barbells, gill, fins, lateral organs; (2) measuring total length, standard length, head length, body height, eye diameter, the distance between eyes; and (3) counting the number rays in dorsal, pectoral, ventral, anal fins; a number of scales on the lateral side, above lateral side and below lateral side.

The fish specimens were classified using the taxonomic key provided by **Mai (1992)**; **Rainboth (1996)**; **Nguyen (2005)**; and **Tran *et al.* (2013)**. The Order, Families, Genus, and Species were sorted using the fish taxonomic system suggested by **Fricke *et al.* (2020)**.

Data analysis

Biodiversity indexes such as Shannon-Weaver's diverse index $H' = -\sum_{i=1}^{n} p_i \log p_i$ **(Shannon and Weaver, 1949)**, Simpson's dominant index $\lambda = \sum_{i=1}^{n} (p_i)^2$ **(Simpson, 1949)**, Margalef's abundant index $d = \frac{S-1}{\ln N}$ **(Margalef, 1958)** ($p_i = n_i/N$, n_i: number of individuals of i^{th} species; S: number of species; N: total number of individuals of all species in a research sample) were estimated by PRIMER v.6 **(Clarke and Gorley, 2006)**. According to **Aditya *et al.* (2010)**, the fish assemblage species were categorized as either dominant or rare. If it is proportional to the sample's representation, it was either larger or smaller than the average of species' evenness value (λ). In this study, the value of 0.020 was used for such a division. Lastly, the fish assemblage on 16 sampling sites was determined using the S17 Bray Curtis similarity index performed by PRIMER v.6 **(Bray and Curtis, 1957; Clarke and Gorley, 2006)**.

RESULTS

The analysis of environmental factors on temperature, pH, clarity, depth, the salinity of the surface layer, and the salinity in 16 study sites show no difference between wet and dry season (t-test, $P > 0.05$ for all cases). Regarding the study site, there was a change in clarity, depth, surface salinity, bottom salinity in the study sites (One-way ANOVA, $F_{Clarity}$=4.21, F_{Depth}=81.72, $F_{SurfaceSalinity}$=50.81, $F_{BottomSalinity}$=52.63). However, no differences in temperature and pH were found in the study sites (ANOVA, $F_{temperature}$=0.414, F_{pH}=0.795, $P > 0.05$) (Table 1).

Table 1. The change of environmental factors in the research sites

Category	Temperature	pH	Clarity	Depth	Surface salinity	Bottom salinity
Dry	29.34±1.85	7.83±0.62	24.90±16.59	4.17±4.60	19.99±11.37	20.35±11.30
Wet	29.73±2.15	8.53±6.16	24.60±12.32	3.95±4.60	16.95±10.79	17.52±10.79
Sa Pho	29.80±1.56^{a}	8.12±0.40^{a}	16.79±8.21^{a}	2.60±1.10^{a,b}	25.08±4.50^{a}	26.00±4.07^{a}
Nhung Mien	29.65±1.83^{a}	8.08±0.41^{a}	18.38±9.07^{a}	2.65±1.70^{a,b}	25.67±3.94^{a}	25.75±3.79^{a}
Ong Trang	29.53±2.21^{a}	8.09±0.36^{a}	21.50±9.36^{a}	3.95±2.03^{a,b}	25.25±5.12^{a}	25.83±4.41^{a}
Mui Ong Trang	29.99±2.51^{a}	8.06±0.45^{a}	20.73±11.03^{a}	1.63±0.62^{a,b}	25.08±5.37^{a}	25.25±4.83^{a}
Right Ong Trang	29.97±2.55^{a}	7.93±0.62^{a}	20.85±13.39^{a}	2.52±1.26^{a,b}	25.50±3.94^{a}	26.50±3.75^{a}
Left Ong Trang	29.17±2.08^{a}	8.02±0.48^{a}	21.13±17.17^{a}	1.83±1.08^{a,b}	25.83±3.43^{a}	26.00±3.72^{a}
Cha La	29.93±2.22^{a}	8.00±0.49^{a}	19.75±8.43^{a}	1.73±1.23^{a,b}	20.50±8.59^{a}	21.25±8.58^{a}
Dam Cung	29.07±2.70^{a}	8.08±0.51^{a}	14.13±5.77^{a}	2.17±1.62^{a,b}	22.92±7.19^{a}	23.25±6.38^{a}
Rach Cheo	29.50±2.05^{a}	7.99±0.49^{a}	25.88±9.85^{a,b}	0.65±0.43^{a}	22.33±6.27^{a}	23.08±6.60^{a}
Bay Hap	29.42±2.55^{a}	7.85±0.50^{a}	23.53±13.72^{a,b}	0.97±0.31^{a}	22.92±5.96^{a}	22.83±5.27^{a}
Right Bay Hap	29.21±2.56^{a}	8.07±0.53^{a}	26.04±15.54^{a,b}	0.70±0.23^{a}	24.33±5.85^{a}	24.42±5.47^{a}
Left Bay Hap	29.01±1.93^{a}	8.00±0.55^{a}	25.58±14.00^{a,b}	0.57±0.18^{a}	24.58±5.48^{a}	25.08±5.16^{a}
Tran De	28.83±1.54^{a}	7.63±0.75^{a}	28.54±10.87^{a,b}	7.32±0.76^{c}	5.50±4.80^{b}	7.08±6.44^{b}
Dai Ngai	30.00±1.22^{a}	7.29±0.69^{a}	30.79±14.18^{a,b}	7.63±2.08^{c}	0.00±0.00	0.67±2.31^{b}
An Lac Tay	29.68±1.46^{a}	7.30±0.82^{a}	41.39±19.51^{b}	14.01±3.12^{d}	0.00±0.00	0.00±0.00
Cai Cui	29.80±1.51^{a}	7.23±0.78^{a}	40.98±18.83^{b}	14.05±3.92^{d}	0.00±0.00	0.00±0.00

Data analysis of 921 individual fish collected at 16 sampling sites from both Hau, Ong Trang, and Bay Hap rivers show that there were 40 fish species, including one species was classified up to the genus level (*Apocryptodon* sp.), belonged to three families: Gobiidae, Oxudercidae and Eleotridae. Amongst them, *Butis koilomatodon* was the most abundant species with 213 individuals, followed by *Gobiopterus chuno* with 136 individuals (Table 2). Most of the fish species were rarely collected with one or two individuals.

Table 2. Dominant and rare status fishes collected at in Hau and Bay Hap rivers

No.	Species	No. of individual	Frequency (%)	Status
1	*Acentrogobius caninus* (Valenciennes, 1837)	16	1.74	r
2	*Acentrogobius viridipunctatus* (Valenciennes, 1837)	45	4.89	d
3	*Acentrogobius globiceps* (Hora, 1923)	88	9.55	d
4	*Apocryptodon* sp.	7	0.76	r
5	*Aulopareia cyanomos* (Bleeker, 1849)	16	1.74	r
6	*Aulopareia janetae* (Smith, 1945)	10	1.09	r
7	*Aulopareia unicolor* (Valenciennes, 1837)	18	1.95	r
8	*Boleophthalmus boddarti* (Pallas, 1770)	11	1.19	r
9	*Brachyamblyopus brachysoma* (Bleeker, 1854)	5	0.54	r
10	*Butis butis* (Hamilton, 1822)	4	0.43	r
11	*Butis humeralis* (Valenciennes, 1837)	9	0.98	r
12	*Butis koilomatodon* (Bleeker, 1849)	213	23.13	d
13	*Caragobius urolepis* (Bleeker, 1852)	27	2.93	d
14	*Eleotris melanosoma* (Bleeker, 1853)	15	1.63	r
15	*Glossogobius aureus* (Akihito & Meguro, 1975)	55	5.97	d
16	*Glossogobius giuris* (Hamilton, 1822)	10	1.09	r
17	*Glossogobius sparsipapillis* (Akihito & Meguro, 1975)	23	2.50	d
18	*Gobiopsis macrostoma* (Steindachner, 1861)	16	1.74	r
19	*Gobiopterus chuno* (Hamilton, 1822)	136	14.77	d
20	*Mugilogobius chulae* (Smith, 1932)	2	0.22	r
21	*Mugilogobius tigrinus* (Larson, 2001)	3	0.33	r
22	*Oligolepis acutipennis* (Valenciennes, 1837)	1	0.11	r
23	*Oxuderces dentatus* Eydoux & Souleyet, 1850	7	0.76	r
24	*Oxyeleotris urophthalmus* (Bleeker, 1851)	4	0.43	r
25	*Oxyurichthys microlepis* (Bleeker, 1849)	1	0.11	r
26	*Parapocryptes serperaster* (Richardson, 1846)	14	1.52	r
27	*Periophthalmodon scholsseri* (Pallas, 1770)	2	0.22	r
28	*Periophthalmus chrysospilos* Bleeker, 1853	2	0.22	r
29	*Periophthalmus gracilis* Eggert, 1935	1	0.11	r
30	*Pseudapocryptes elongatus* (Cuvier, 1816)	5	0.54	r
31	*Pseudogobius avicennia* (Herre, 1940)	1	0.11	r
32	*Pseudogobius javanicus* (Bleeker, 1856)	2	0.22	r
33	*Pseudogobius melanostictus* (Day, 1876)	1	0.11	r
34	*Pseudogobius yanamensis* (Rao, 1971)	3	0.33	r
35	*Scartelaos histophorus* (Valenciennes, 1837)	2	0.22	r
36	*Stigmatogobius pleurostigma* (Bleeker, 1849)	5	0.54	r
37	*Taenioides gracilis* (Valenciennes, 1837)	75	8.14	d
38	*Taenioides nigrimarginatus* Hora, 1924	8	0.87	r
39	*Trypauchen vagina* (Bloch & Schneider, 1801)	56	6.08	d
40	*Trypauchenopsis intermedia* Volz, 1903	2	0.22	r

N: total number of fish collected, r: rare status, d: dominant status.

Table 2 shows that 16 dominant species collected in both Hau and Bay Hap rivers, including *Acentrogobius caninus, A. viridipunctatus, A. globiceps, Aulopareia cyanomos, A. unicolor*, *Boleophthalmus boddarti*, *Butis koilomatodon*, *Caragobius urolepis*, *Eleotris melanosoma, Glossogobius aureus, G. sparsipapillis, Gobiopsis macrostoma*, *Gobiopterus chuno*, *Parapocryptes serperaster, Taenioides gracilis, Trypauchen vagina*. Gobiidae was the most common family, followed by Oxudercidae and Eleotridae. The three families of fish that appeared most frequently in the research were Gobiidae (62%), Oxudercidae (25%), and Eleotridae (13%). The number of fish species decreased gradually from 14 in estuarine to five in the midstream of the Hau river regulated by the East Sea (Table 3). Similarly, the number of fish species in both Bay Hau and Ong Trang rivers, which was governed by the West Sea, reached the highest value in the estuary and lowest in the midstream (Table 3). The gobiid assemblage was more diversified in the river system controlled by the West Sea (37 species and 696 individuals) than in the river planned by the East Sea (17 species and 225 individuals).

The biodiversity indexes of the fish assemblage at different ecological regions and seasons were presented in Table 3. This Table illustrates that the value of *d* (Margalef's abundant index) had a wide fluctuation due to the seasons and sampling sites (the highest was 3.877 in the wet season in the left Ong Trang and the lowest was 0.303 in the dry season in Ong Trang). Similarly, H and λ also had wide fluctuations (0.068–0.943 and 0.074–1.000, respectively). It suggested that the diversity of fish species in the study area was relatively high. The d and H' of the fish assemblage in the river systems influenced by the West Sea (5.001 and 1.0607, respectively) were higher than those in the Hau river (2.9542 and 0.7998, respectively).

Table 3. Biodiversity indexes of fish collected from study sites

Category	**No. species**	**N**	**d**	**H'(log10)**	**λ**
Cha La	12	75	2.5478	0.7041	0.7182
Dam Cung	8	56	1.7390	0.4815	0.4831
Rach Cheo	14	167	2.5401	0.8384	0.7997
Bay Hap	12	74	2.5557	0.8402	0.8016
Right Bay Hap	6	16	1.8034	0.4882	0.5417
Left Bay Hap	13	41	3.2314	0.9107	0.8366
Sa Pho	13	24	3.7759	1.0162	0.9167
Nhung Mien	14	28	3.9013	0.8788	0.7857
Ong Trang	8	42	1.8728	0.3961	0.3833
Mui Ong Trang	14	80	2.9667	0.8227	0.7832
Right Ong Trang	14	39	3.5485	0.9574	0.8650
Left Ong Trang	17	54	4.0110	0.8903	0.8036
Tran De	14	190	2.4776	0.8733	0.7980
Dai Ngai	8	15	2.5849	0.8497	0.9048
An Lac Tay	4	9	1.3654	0.5276	0.7500
Cai Cui	5	11	1.6681	0.5622	0.7091
Cha La × Wet	9	46	2.0895	0.5741	0.6145

Category	No. species	N	d	H'(log10)	λ
Cha La × Dry	5	29	1.1879	0.5613	0.6921
Dam Cung × Wet	5	43	1.0635	0.2832	0.2979
Dam Cung × Dry	6	13	1.9494	0.7260	0.8590
Rach Cheo × Wet	10	112	1.9074	0.6693	0.6996
Rach Cheo × Dry	9	55	1.9963	0.8230	0.8431
Bay Hap × Wet	7	42	1.6053	0.8003	0.8467
Bay Hap × Dry	7	32	1.7312	0.4324	0.4395
Right Bay Hap × Wet	4	10	1.3029	0.4084	0.5333
Right Bay Hap × Dry	3	6	1.1162	0.3768	0.6000
Left Bay Hap × Wet	9	25	2.4853	0.8696	0.8800
Left Bay Hap × Dry	6	16	1.8034	0.5415	0.6167
Sa Pho × Wet	9	15	2.9542	0.8951	0.9143
Sa Pho × Dry	8	9	3.1858	0.8873	0.9722
Nhung Mien × Wet	9	22	2.5881	0.6887	0.7013
Nhung Mien × Dry	6	6	2.7906	0.7782	1.0000
Ong Trang × Wet	7	15	2.2156	0.6863	0.7714
Ong Trang × Dry	2	27	0.3034	0.0688	0.0741
Mui Ong Trang × Wet	8	31	2.0384	0.7447	0.7957
Mui Ong Trang × Dry	9	49	2.0556	0.5877	0.6531
Right Ong Trang × Wet	12	26	3.3762	0.9431	0.8800
Right Ong Trang × Dry	5	13	1.5595	0.5488	0.6923
Left Ong Trang × Wet	15	37	3.8771	0.9122	0.8258
Left Ong Trang × Dry	6	17	1.7648	0.6056	0.7059
Tran De × Wet	4	7	1.5417	0.5011	0.7143
Tran De × Dry	14	183	2.4954	0.8516	0.7865
Dai Ngai × Wet	4	8	1.4427	0.5737	0.8214
Dai Ngai × Dry	6	7	2.5695	0.7591	0.9524
An Lac Tay × Wet	1	3	0.0000	0.0000	0.0000
An Lac Tay × Dry	4	6	1.6743	0.5396	0.8000
Cai Cui × Wet	1	3	0.0000	0.0000	0.0000
Cai Cui × Dry	5	8	1.9236	0.6489	0.8571

N: total number of fish collected; d: Margalef's abundant index, H'(log10): Shannon-Weaver's diverse index; λ: Simpson's dominant index

The similarity index for fish species by location was presented in Table 4. In 16 places, the highest index was found in the species composition between Right Bay Hap and Ong Trang (77.38%), Bay Hap and Left Bay Hap (68.23%), Right Ong Trang and

Left Ong Trang (67.52%). This index is lowest between Left Ong Trang and An Lac Tay (1.85%) (Table 4).

Table 4. The similarity index (%) of the fish assemblage in the studied sites

Site	Cha La	Dam Cung	Rach Cheo	Bay Hap	Right Bay Hap	Left Bay Hap	Sa Pho	Nhung Mien	Ong Trang	Mui Ong Trang	Right Ong Trang	Left Ong Trang	Tran De	Dai Ngai	An Lac Tay	Cai Cui
Cha La																
Dam Cung	63.62															
Rach Cheo	44.74	23.87														
Bay Hap	34.76	15.69	28.02													
Right Bay Hap	31.58	15.18	29.00	65.54												
Left Bay Hap	45.07	25.83	33.07	68.23	53.96											
Sa Pho	42.83	32.14	29.82	24.78	22.92	28.86										
Nhung Mien	39.62	19.64	36.10	49.04	57.14	58.36	33.93									
Ong Trang	37.24	18.45	29.86	48.33	77.38	50.87	24.41	61.91								
Mui Ong Trang	66.58	43.93	30.15	56.86	46.25	64.51	49.17	49.64	50.54							
Right Ong Trang	42.26	16.62	36.94	63.86	48.40	50.66	24.36	46.61	37.91	49.65						
Left Ong Trang	35.71	12.63	28.37	54.61	45.14	53.03	19.91	48.02	42.33	47.04	67.52					
Tran De	8.74	3.37	16.66	13.76	5.79	14.88	22.46	12.82	11.10	14.47	18.75	18.21				
Dai Ngai	25.33	7.14	23.95	24.05	20.00	24.88	16.67	23.57	22.38	23.75	27.69	30.37	36.32			
An Lac Tay	-	-	-	-	-	2.44	4.17	3.57	-	-	2.56	1.85	2.63	13.33		
Cai Cui	-	-	-	2.70	-	2.44	13.26	3.57	-	-	2.56	3.70	13.30	24.85	53.54	

DISCUSSION

The spatiotemporal change of environmental factors could regulate the variation of species composition and biodiversity indexes of gobiid assemblage in the present study. Indeed, the number of fish species decreased with the salinity decline from the estuarine regions to the midstream of the Hau river, which was similar to the change of *d* and *H'* value of the present gobiid assemblage. **Chung *et al.* (2001)** and **Dao and Pham (2003)** reported that species abundance was higher in the dry season than the wet one due to coastal regions in the southern part of Vietnam having characteristics of the tropical climate. However, the present study found that the number of fish species in the wet season diversified than that in the dry season, being resulted from the Mekong river brings 475,000 million m^3 of water in the wet season and sedimentation in the study area **(Sokheng *et al.*, 1999)**.

As more sediment drawn by the Mekong River in the wet season leading to high nutrient, an optimal condition for the growth of juveniles **(Hortle, 2009)**, the juvenile fish density was too abundant in the estuaries of the wet season **(Nguyen, 2013)**. It indicates that the Mekong Delta's coastal area is a critical spawning ground, so fishing activities should be taken into account for these features to ensure sustainable exploitation. Our findings agree with these results and genuinely reflect our previous study on species composition in the Mekong Delta's estuarine areas.

The building of numerous hydropower dams on the mainstream **(Dugan *et al.*, 2010)** and global warming **(Minderhoud *et al.*, 2019)** could be related to the lower species composition of the present study compared to the previous one **(Tran *et al.*, 2013; Diep *et al.*, 2014)**. The primary purpose of fisheries management is to sustain the fisheries' resources by balancing exploiting and recovering fish resources **(Restrepo *et al.*, 1992)**. What fisheries managers have to do is control the fishing capacity, e.g., input control and output control, based on scientific advice coming from stock assessment **(Hilborn and Ovando, 2014; Melnychuk *et al.*, 2017)**. However, the interaction between management implementations and dynamic resources creates challenges for management. Therefore, monitoring should be done frequently to ensure proper management.

CONCLUSION

The study identified 40 fish species belonging to three families, with the more abundant and diverse in the wet season than the dry season. The number of fish species decreased gradually from estuary to midstream of river systems. The gobiid assemblage was more diversified in the river system controlled by the West Sea than in the river planned by the East Sea. These differences may be because of the distinct characteristics of the environmental factors influenced by the Mekong River. Our findings contrast with the previous surveys, which can instruct the local government in fisheries management, especially for very close coastal water. Besides, the future monitoring activities should be focused on the coastal areas, vulnerable regions, both in the frequency of surveys and density of sites.

ACKNOWLEDGMENT

This study was funded by the Can Tho University Improvement Project VN14-P6, supported by Japanese ODA loan.

REFERENCES

Aditya, G.; Pal, S. and Saha, G. K. (2010). An assessment of fish species assemblages in rice fields in West Bengal, India: implications for management. Journal of Applied Ichthyology, 26(4): 535-539.

Anthony, E. J.; Brunier, G.; Besset, M.; Goichot, M.; Dussouillez, P. and Nguyen, V. L. (2015). Linking rapid erosion of the Mekong River delta to human activities. Scientific reports, 5(1): 1-12.

Binh, N. T. (2009). Biological characteristics of goby fishes in Tra Vinh Province. Master thesis. Can Tho University,

Bray, J. R. and Curtis, J. T. (1957). An Ordination of the Upland Forest Communities of Southern Wisconsin. Ecological Monographs, 27(4): 325-349.

Chung, B. D.; Vinh, C. T. and Duc, N. (2001). Marine fisheries resources-basic development of marine fisheries industry in Vietnam. Proceedings of Marine Fisheries Research, 2: 200-210.

Clarke, K. R. and Gorley, R. N. (2006). PRIMER v6: User Manual/Tutorial. United Kingdom: PRIMER-E, Plymouth.

Cui, Y.; Ma, S.; Li, Y.; Xing, H.; Wang, M.; Xin, F.; Chen, J. and Sun, Y. (2003). Pollution situation in the Laizhou Bay and its effects on fishery resources. Marine fisheries research, 24(1): 35-41.

Dao, M. S. and Pham, T. (2003). Management of coastal fisheries in Vietnam. In: Assessment, management and future directions for coastal fisheries in Asian countries. (eds. Silvestre, G., Garces, L., Stobutzki, I., Ahmed, M., Valmonte-Santos, R. A., Luna, C., Lachica-Alino, L., Munro, P., Christensen, V.and Pauly, D.), WorldFish Center Conf. Proc., 957-986.

Diep, A. T.; Dinh, Q. M. and Tran, D. D. (2014). Species composition of Gobiidae distributed in the coastal areas, Soc Trang Province. VNU Journal of Sciences: Natural Sciences and Technology, 30(3): 68-76.

Dugan, P. J.; Barlow, C.; Agostinho, A. A.; Baran, E.; Cada, G. F.; Chen, D.; Cowx, I. G.; Ferguson, J. W.; Jutagate, T. and Mallen-Cooper, M. (2010). Fish migration, dams, and loss of ecosystem services in the Mekong basin. Ambio, 39(4): 344-348.

Fricke, R.; Eschmeyer, W. and Fong, J. (2020). Species by family/subfamily. Accessed: 23/02/2020. http://researcharchive.calacademy.org/research/ichthyology/catalog/SpeciesByFamily.asp.

Hilborn, R. and Ovando, D. (2014). Reflections on the success of traditional fisheries management. ICES Journal of Marine Science, 71(5): 1040-1046.

Hortle, K. G. (2009). Fisheries of the Mekong River Basin. In: Campbell, I. C. (Eds.) The Mekong. San Diego, United States: Academic Press, 197-249.

Ishimatsu, A. (2017). Respiratory and circulatory adaptations. In: Jaafar, Z. and Murdy, E. O. (Eds.) Fishes Out of Water. CRC Press, 111-136.

Jaafar, Z. and Murdy, E. O. (2017). Fishes out of water: biology and ecology of mudskippers. CRC Press, 390.

Jambeck, J. R.; Geyer, R.; Wilcox, C.; Siegler, T. R.; Perryman, M.; Andrady, A.; Narayan, R. and Law, K. L. (2015). Plastic waste inputs from land into the ocean. Science, 347(6223): 768-771.

Le, T.; Nguyen, M. T.; Nguyen, V. P.; Nguyen, D. C.; Pham, X. H.; Nguyen, T. S.; Hoang, V. C.; Hoang, P. L.; Le, H. and Dao, N. C. (2006). Provinces and City in the Mekong Delta. Ha Noi: Education Publishing House, 575.

Mai, D. Y. (1992). Identification of freshwater fishes of South Vietnam. Ha Noi (in Vietnamese): Science and Technology Publishing House, 351.

Margalef, R. (1958). Information theory in ecology. General Systems: Yearbook of the International Society for the Systems Sciences, 3: 1-36.

Melnychuk, M. C.; Peterson, E.; Elliott, M. and Hilborn, R. (2017). Fisheries management impacts on target species status. Proceedings of the National Academy of Sciences, 114(1): 178-183.

Minderhoud, P.; Coumou, L.; Erkens, G.; Middelkoop, H. and Stouthamer, E. (2019). Mekong Delta much lower than previously assumed in sea-level rise impact assessments. Nature communications, 10(1): 1-13.

Nguyen, V. H. (2005). Freshwater fish of Viet Nam. Ha Noi (In Vietnamese): Agriculture Publishing House, 655.

Nguyen, V. N. (2013). Report on Evaluation of marine fisheries resources in Vietnam between 2011 and 2013. Ha Noi, 1-36.

Pomeroy, R.; Nguyen, K. A. T. and Thong, H. X. (2009). Small-scale marine fisheries policy in Vietnam. Marine Policy, 33(2): 419-428.

Rainboth, W. J. (1996). Fishes of the Cambodian Mekong. Roma: FAO, 265.

Restrepo, V. R.; Hoenig, J.; Powers, J. E.; Baird, J. W. and Turner, S. C. (1992). A simple simulation approach to risk and cost analysis, with applications to swordfish and cod fisheries. Fishery Bulletin, 90(4): 736-748.

Shannon, C. E. and Weaver, W. (1949). The mathematical theory of communication. University of Illinois Press, 144.

Simpson, E. H. (1949). Measurement of diversity. Nature, 163: 688-688.

Sokheng, C.; Chhea, C. K.; Viravong, S.; Bouakhamvongsa, K.; Suntornratana, U.; Yoorong, N.; Tung, N. T.; Bao, T. Q.; Poulsen, A. F. and Jorgensen, J. V. (1999). Fish migrations and spawning habitats in the Mekong mainstream: A survey using local knowledge. Cambodia Mekong River Commission, 1-57.

Tran, D. D.; Shibukawa, K.; Nguyen, T. P.; Ha, P. H.; Tran, X. L.; Mai, V. H. and Utsugi, K. (2013). Fishes of Mekong Delta, Vietnam. Can Tho: Can Tho University Publisher, 174.

Winterbottom, R.; Alofs, K. M. and Marseu, A. (2011). Life span, growth and mortality in the western Pacific goby *Trimma benjamini*, and comparisons with *T. nasa*. Environmental biology of fishes, 91(3): 295-301.