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Fish diversity and abundance in Bidong Island, South China Sea, Malaysia

M. Piah Rumeaida, Shariff M. M. Daud, Faez M. I. Badri

School of Fisheries and Aquaculture Sciences, Universiti Malaysia Terengganu, Terengganu, Malaysia. Corresponding author: M. P. Rumeaida, rumeaida@umt.edu.my

Abstract. The diversity and abundance of fish species in any ecosystems is an indicator of ecosystem wellbeing and should be characterized for conservation and management purpose. This study aims to identify the number of species and their diversity in Bidong Island in relation to different types and intensity of human activities carried out in the island. Three approaches of fish survey and sampling were conducted; SCUBA diving observations and fish collection by baited portable traps deployment and gill netting. This present study found that the dominant fishes of Bidong Island are *Dascyllus trimaculatus, D. reticulatus, Pomacentrus moluccensis, Scolopsis monogramma* and *Nemipterus furcosus*. The fish in coral reefs areas in all parts of Bidong Island are equally diverse, even and rich but there are variability of indices observed in the areas ouside reef. This study shows that human activities alone may not influence the number of species in a population. It is suggested that studies on the physical characteristics of the island should be investigated.
Key Words: fish communities, coral reef, fisheries management, human activities.

Introduction. The diversity and community structure of fishes in any water bodies are important to be characterized for conservation and management purpose. Biodiversity information within an area is vital for the development of adequate conservation strategies (Pino-Del-Carpio 2014).

The health of fish community reflects conditions of entire aquatic community, but information on fish species diversity and abundance should be first investigate before any assessment on fish health community can be carried out (Foltz 1982). The number of species present and their abundance structure are two fundamental attributes of a community and their diversity promotes the stability of communities and ecosystem processes (Taylor et al 2006). Information on the number of fish in a population is necessary to determine the effects of fishing, other human activities or natural climatic variations to detect any changes in the population (Cappo & Brown 1996; Jalal et al 2012). Fish diversity is threatened by many human activities, but the most significant impacts are from habitat modification, overharvest and introduced species (Safina & Duckwort 2013).

The South China Sea is known for its high productivity and the rich diversity of plants and animals (Matsunuma et al 2011), with more than 3365 species of marine fishes listed by Randall & Lim (2000), 710 species by Mohsin & Ambak (1996) and 441 species by Matsunuma et al (2011). Bidong Island is located in South China Sea, known for its history as Vietnamese refugee settlement. The island also comprises of well developed coral reef ecosystems which attract variety of coral and rocky reef associated fishes (Matsunuma et al 2011). The island however was not listed as a marine park, which contribute to the various activities carried out at the island. A university research centre was build in this island, resulting in boat visits and variety of leisure activities which put pressure to the natural characteristics of the area. Other part of the island that was formerly occupied by Vietnamese refugees received frequent tourist visits as well as fish farming activities. Fish farming activities may contribute to the changes of diversity and community structure of fishes in this island. Aquaculture has caused public concern on its influence on the environment where some aquaculture practices are harmful to

biodiversity (Goldburg & Triplett 1997). Diana (2009) listed eight possible threats of aquaculture activities to biodiversity including escapement of aquatic crops and their potential hazards as invasive species, the relationships among effluent, eutrophication of water bodies and changes in the fauna or receiving waters, and antibiotic and hormone use which may influence aquatic species near aquaculture facilities.

The distribution and composition of the fish species were closely associated with various factors such as the availability of food, breeding sites, water current, depth, topography and physicochemical properties of water (Harris 1995) and long term change in hydrological and meteorological parameters may reduce fish species diversity (Hossain et al 2012). Various activities carried out in this island may strongly influence its fish diversity and community structure. Based on this, the study on the diversity and abundance of fishes in Bidong Island was carried out to investigate whether various human activities may influence the diversity and abundance of fish. Even though some studies have been done to observe fish species occupied reef areas in Bidong Island (Matsunuma et al 2011), no documented study has been found on the diversity and abundance of fish at different parts of the island. Hence, this study aims to observe and quantify the number of fish and its diversity in Bidong Island in relation to various human activities which can be used as a reference for future management plan of the island.

Material and Method

Sampling area. This study was carried out at Bidong Island, South China Sea, Malaysia (Lat. 5.62°, Long. 103.07°). Fish sampling was conducted at three stations of Bidong Island in August and September 2013 and March 2014 and the selection of the station was based on the type and intensity of the activities carried out at each station (Figure 1). Station 1 was at Pantai Pasir Cina (5.61795° N 103.05634° E), the station where a university research station was located. Station 2 was Pantai Limau Purut (5.61236°N 103.05889° E), where a marin culture activity was located and also received frequent boat visits for tourism purposes. Station 3 was Teluk Belanga (5.60765°N 103.05834° E), that received minimal human activities except for small gill net operations by subsistence fishermen.

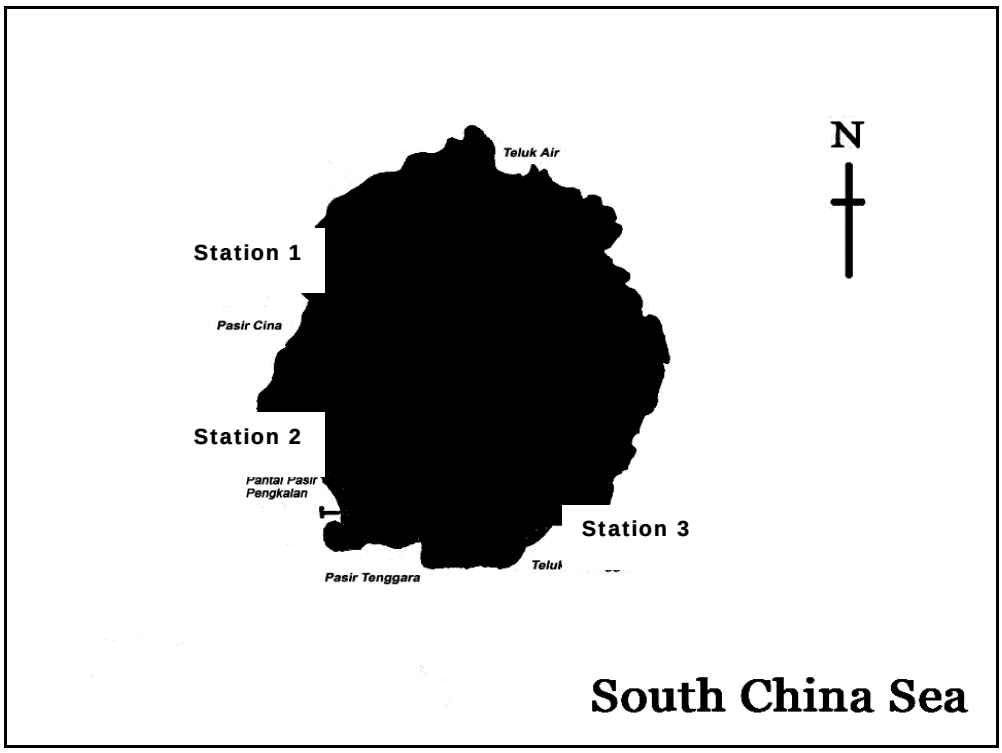

Figure 1. The location of three sampling stations of Bidong Island, South China Sea which were determined based on the types and the intensity of human activities occuring at each station (Map courtesy of Bidong Island Marine Research Station, Universiti Malaysia Terengganu).

Sampling and data analysis. Tropical fish populations associated with coral reefs are among the most difficult groups of fish to survey accurately because of the variety of fish behavioral patterns and the topography of their habitat (Cappo & Brown 1996). In this study, fish collection and survey was conducted in three approaches as follows:

a) Approach 1 (Reef Area). This approach was carried out to observe the fish species in coral reef areas. In shallow waters within the limits of safe SCUBA diving, transect underwater visual survey was carried out. In this approach, two experienced divers conducted survey of fish population within a quadrant of 10 m x 1 m, at 5-10 m depth. The species present in the column of water at each station was identified and individuals of each species were counted and recorded on slates.

b) Approach 2 (Just Outside reef). This approach was carried out to collect fish samples just outside reef areas. In this approach, three portable traps of 4.5 ft long and 3.5 ft width were deployed at each station with scads were used as bait. At each section, three portable traps were deployed just outside the reef areas, approximately 60 metres from shore, 100 metres apart from each trap, for 8 hours during daytime and nighttime sampling.

c) Approach 3 (Outside Reef; Sandy bottom). This approach was carried out to collect fish samples at the sandy bottom and outside reef areas and only suitable for daytime sampling. In this approach, a gill net of 54.86 m long and 1.83 m width with a mesh size of 2 inch was used to collect fish samples and was set up approximately 150 metres from shore at each station.

Fish collected from each section of Bidong Island in Approach 2 and Approach 3 was sorted and identified to the species level based on Mohsin & Ambak (1996), Matsunuma et al (2011) and Ambak et al (2010). The number of fish of each species was recorded. The abundance of fish was expressed in percentage. Fish species diversity was analysed using Shannon-Wiener Index (Shannon & Weaver 1963). The species evenness was calculated using Pielou's Evennes Index (1969) while fish species richness was calculated using the Margalef's Index (1958).

Results and Discussion

Fish abundance. A total of 4747 individual fish was observed inside reef areas of Bidong Island from all three stations with 1428 fish of 38 species from Station 1, 1714 fish of 25 species from Station 2 and 1605 fish of 26 species from Station 3.

This present study shows that *Dascyllus trimaculatus*, *D. reticulatus* and *Pomacentrus moluccensis* were the most abundant fish found in the coral reef areas (Table 1). Six species were dominant in Station 1 while 32 other individual species comprises less than 5% of the total fish observed in Approach 1. Station 2 and Station 3 have more individual species above 5% of the percentage composition compare to Station 1, with 8 species and 9 species for each station, respectively. Overall, the 48 fish species found in coral reef areas of Bidong Island were comprised by small fish and not of commercially important except a few species that are used as aquarium fishes (Mohsin & Ambak 1996; Ambak et al 2010). Interestingly, *Epinephelus fuscoguttatus* which is the cultured species of fish farming activities in this island that may escape from the cages were observed in Station 1 and Station 3 but not in their original areas.

Table 1

Fish species caught and the percentage composition for fish population in Station 1, Station 2 and Station 3 from August and September 2013 and March 2014 by using Approach 1

Fish species	*No. of individual*	*Percentage of catch (%)*
	Station 1	
Dascyllus trimaculatus	197	13.80
Pomacentrus moluccensis	184	12.89
Abudefduf sexfasciatus	181	12.68
Halichoeres chloropterus	149	10.43
Dascyllus reticulatus	128	8.96
Thalasoma lunare	110	7.70
Other species (comprises of 32 individual species less than 5% of the total catch)	479	33.54
	Station 2	
Dascyllus trimaculatus	283	19.51
Pomacentrus moluccensis	263	15.34
Pomacentrus milleri	151	8.81
Dascyllus reticulatus	144	8.40
Halichoeres chloropterus	104	6.07
Neopomacentrus anabantoides	103	6.01
Halichoeres argus	91	5.31
Abudefduf bengalensis	89	5.19
Other species (comprises of 17 species less than 5% of the total catch	486	28.35
	Station 3	
Dascyllus trimaculatus	212	13.21
Pomacentrus milleri	183	11.40
Pomacentrus moluccensis	168	10.47
Abudefduf sordidus	117	7.29
Dascyllus reticulatus	115	7.17
Halichoeres melanurus	100	6.23
Leptojulis cyanopleura	96	5.96
Thalasoma lunare	84	5.23
Neopomacentrus cyanomos	83	5.17
Other species (comprises of 17 species less than 5% o the total catch	447	27.85

Sampling using baited portable traps at the area just outside reef areas collected a total of 72 fish of 21 individual fish from Station 1, 50 fish from Station 2 and only one fish from Station 3. In the non coral areas that are more than 60 metres from the shore, the commercially important fishes was common. *Scolopsis monogramma* was the most dominant species collected with more than 50% of catch composition from Station 1 and Station 2, however absent in Station 3. Only one individual fish of *Parupeneus heptacanthus* was collected in Station 3 throughout this study period (Table 2). According to Mohsin & Ambak (1996), *S. monogramma* usually caught in large quantities along with *Nemipterus* spp. around coral reef areas using handlines, gill nets and traps, and Ambak et al (2010) reported that trawl nets also are use to exploit this species.

Gill net sampling outside reef areas in Approach 3 managed to collect more individual species from Station 3 (Table 3). The area outside reef area was less abundant with only 22 individual fish collected. *Gymnocranius frenatus* and *Nemipterus furcosus* dominated the percentages of catch composition of fish in Station 1 and Station 2 with *Parupeneus heptacanthus* was present at both stations.

N. furcosus is the most abundant species collected at sandy bottom of Bidong Island. Mohsin & Ambak (1996) reported that *N. furcosus* is very important commercial species in Malaysia and normally caught with bottom trawls and lines. The dominance of *N. furcosus* in all parts of the island influence the gill netting activities by artisanal fishermen as well as attract the illegal trawl net operation. Ogawa (2004) reported that

the trawl nets are not permitted to operate below 5 nautical miles from the shore. This illegal bottom trawl net operations may directly affect the condition of the island and indirectly affect fish populations.

Table 2

Fish species caught and the percentage composition for fish population in Station 1, Station 2 and Station 3 from August and September 2013 and March 2014 by using Approach 2

Fish species	*No. of individual*	*Percentage of catch (%)*
	Station 1	
Scolopsis monogramma	16	76.19
Sargocentron rubrum	2	9.52
Cheilinus fasciatus	1	4.76
Symphorus nematophorus	1	4.76
Lutjanus quinquelineatus	1	4.76
	Station 2	
Scolopsis monogramma	25	50.00
Epinephelus areolatus	5	10.00
Lutjanus quinquelineatus	5	10.00
Pseudomonacanthus macrurus	3	6.00
Monacanthus chinensis	2	4.00
Cheilinus trilobatus	2	4.00
Sargocentron rubrum	2	4.00
Other species (comprises of 6 species with one individual for each species)	6	12.00
	Station 3	
Parupeneus heptacanthus	1	100.00

Table 3

Fish species caught and and the percentage composition for fish population in Station 1, Station 2 and Station 3 from August and September 2013 and March 2014 by using Approach 3

Fish species	*No. of individual*	*Percentage of catch (%)*
	Station 1	
Gymnocranius frenatus	4	50.00
Pentapodus caninus	1	12.5
Nemipterus furcosus	1	12.5
Xyrichtys evides	1	12.5
Parupeneus heptacanthus	1	12.5
	Station 2	
Nemipterus furcosus	5	45.45
Parupeneus heptacanthus	2	18.18
Scolopsis monogramma	2	18.18
Carangoides gymnostethus	1	9.09
Xyrichtys evides	1	9.09
	Station 3	
Nemipterus furcosus	1	33.33
Carangoides gymnostethus	1	33.33
Xyrichtys aneitensis	1	33.33

Fish diversity. The present study showed that more individual species were observed and collected in the two stations that received the most human activities of different types and intensity. Station 1 has the highest individual fish species observed and collected by all three approaches followed closely by Station 2 with both stations recorded more than 40 individual species. Meanwhile, only 30 species were recorded from Station 3 (Table 4).

Species diversity is an index of some relation between the number of species and the number of individuals (Spellerberg 1991). This present study found that the relation between the number of species and the number of individuals inside reef areas in all stations was similar where the Shannon-Weaver Index was between 2.72 to 2.81 (Table 4). Meanwhile, evenness expresses how evenly the individuals in the community are distributed over the different species (Heip et al 1998). The Pielou's Evennes Index of fish inside reef areas of Bidong Island was between 0.77 to 0.86 showing that the species in the coral reef areas of Bidong Island are equally diverse and even regardless of the types and intensity of human activities carried out. Species richness on the other hand is a measure of the total number of the species in the community (Heip et al 1998). This study found that the species richness in this station 1 was higher than other areas of Bidong Island.

According to Williams (1982), coral reef areas provide a wide variety of habitats and foods, and Connell (1978) added that the highest production of species diversity in marine environment is coral reef areas. The variability of fish diversity, evenness and richness indices observed in Station 2 where fish cages were located shows that fish farming activities in this island may not influence its fish population characteristics. Even though aquaculture activities may have some negative impacts to biodiversity, some effects of aquaculture on biodiversity may be positive, where effluents and waste from aquaculture can increase local production, abundance and diversity of species (Diana 2009). Cartier & Carpenter (2014) found that pearl farming in French Polynesia has a slightly positive effect on reef fish abundance and no significant impact on fish diversity or community composition. Cartier et al (2012) reported that the community pearl farming in the Federated States of Micronesia has been tested as a way of reducing fishing pressure on reefs.

Table 4

The number of fish species, number of individual fish and the three fish diversity indices at each station at Bidong Island, Malaysia using three different approaches

Stations	*Number of species*	*Number of fishes*	*Shannon-Weaver Index*	*Pielou's Evenness Index*	*Margalef's Richness Index*
			Approach 1		
Station 1	38	1428	2.81	0.77	11.73
Station 2	25	1714	2.72	0.84	7.42
Station 3	26	1605	2.80	0.86	7.80
			Approach 2		
Station 1	5	21	0.87	0.54	3.03
Station 2	13	50	1.83	0.71	7.06
Station 3	1	1	0.00	0.00	0.00
			Approach 3		
Station 1	5	8	1.39	0.86	4.43
Station 2	5	11	1.41	0.88	3.84
Station 3	3	3	1.10	1.00	4.19

Approach 1: Transect Underwater Visual Survey for Reef Areas. Approach 2: Portable trap deployment just outside reef areas, 60 metres from shore. Approach 3: Gill netting outside reef areas (sandy bottom), 150 metres from shores.

Table 4 also shows that the fish in sandy areas of Bidong are also equally diverse, even and rich. However, there are variability of indices value observed for the area 60 metres from the shores. The value of all indices sampled by baited portable traps were highest in station 2 where the fish cages are located, with the lowest indices were detected in the area that receive minimal human activities which is station 3. This shows that human activities may influence fish diversity but its variations also could be because of the differences in food availability, habitat preference of fish (Sweke et al 2013), breeding sites, depth, topography and physicochemical properties of water (Harris 1995). Hossain

et al (2012) reported that the occurence, distribution, abundance dan diversity of fish may influenced by many interacting physical and biological factors.

The small number of fish collected and the variability of all indices observed in this study may because of the use of capture fishing gear which is baited portable traps and gill net. These may relates to the availability of fish to avoid and escape from traps, and mesh size also can select for or against capture of certain sizes of fish or caused by changes in the vulnerability or catchability of fish (Cappo & Brown 1996).

Conclusions. This study found that there are variability in abundance and diversity of fish in the different parts of the island that receives different types and intensity of human activities. This shows that human activities alone may not influence the number of species in a population. Other factors such as the source of food and physical characteristics of the environment may contribute to the diversity and abundance of fish. It is suggested that studies on the physical characteristics of water bodies should be investigated. Sampling using portable traps and gill nets should be improved by using different range of gear sizes and mesh sizes for more effective study

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Authors:
Rumeaida Mat Piah, School of Fisheries and Aquaculture Science, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu, Malaysia, e-mail: rumeaida@umt.edu.my
Mohammad Shariff Mat Daud, School of Fisheries and Aquaculture Science, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu, Malaysia, e-mail: shariff1992@rocketmail.com
Mohd Faez Iqbal Badri, School of Fisheries and Aquaculture Science, Universiti Malaysia Terengganu, 21030 Kuala Terengganu, Terengganu, Malaysia, e-mail:fareast92kid@gmail.com

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