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SPECIES COMPOSITION, DISTRIBUTION, BIOMASS TRENDS AND EXPLOITATION OF DOMINANT FISH SPECIES IN MANILA BAY USING EXPERIMENTAL TRAWL SURVEY

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ABSTRACT

An experimental trawl fishing survey was conducted in Manila Bay from March 2014 to October 2015 at sixteen (16) pre-established dragging stations adapted from an earlier study (MADECOR, 1995). Using a commercial otter trawl, the average trawling speed during fishing operations was 6-7 km/hour. Analysis of catches focused on biomass trends, species composition, distribution and exploitation of dominant species. A total of 146 fish and invertebrate species belonging to 48 families were recorded during the survey period wherein most of the catches were dominated by small pelagic species such as anchovies and sardines. Exploitation rates (E) for the six (6) dominant species (*Sardinella gibbosa, Sardinella fimbriata, Valamugil seheli, Mugil cephalus, Encrasicholina devisi* and *Stolephorous commersonnii*) shows signs of overfishing. The estimated demersal fish biomass of the bay revealed that the relative decline was about 90% from the 1947 baseline study.

Keywords: Manila Bay, overfishing, demersal fish biomass, trawl

INTRODUCTION

Manila Bay is a semi-enclosed body of water located in the southwest coast of Luzon, bounded by the provinces of Cavite and Metro Manila in the east, Bulacan and Pampanga in the north, Bataan peninsula in the west and by Corregidor and Caballo islands in the southern portion near its mouth. Its harbor is considered as one of the busiest national and international port in the country that provides livelihood for millions of Filipinos. The hydrographic condition of the bay especially its water circulation is greatly affected by wind-driven forces (De las Alas and Sodusta, 1985; Villanoy and Martin, 1997). A large volume of freshwater influx is contributed by the two main river systems (Pampanga and Pasig) that drain into the bay. Jacinto et al. (2006) estimates that almost 49% of freshwater in the bay comes from the discharge of the Pampanga River. The bottom substrate of the entire bay is classified as sandy muddy with a few patches of coral reefs in Cavite and Bataan. Fisheries and aquaculture are major sources of livelihood in areas surrounding the bay (PEMSEA, MBEMP-MBIN, 2007).

The bay is a multispecies and multi-gear fishery, wherein, most of the species caught are representatives of various families/species groups. During the 1970s, the bay was the second most productive fishing ground in the country (Muñoz, 1991) and from the period 1982–1987, belongs to the top 10 most productive fishing grounds for small pelagic fishes (Zaragoza et al., 2004). In an earlier period, Ronquillo et al. (1960) reported that the bay possibly reached its maximum sustainable yield during the second half of the 1950s. The decrease in average annual catches/landings even with an increase in the number of fishing vessels operating in the area is an evidence of declining biomass. Fox (1986) also considered the bay as one of the most heavily fished areas in the country and needs to reduce the fishing effort to one-third of its 1983-1984 levels to attain an economic rent of US$ 1.5–4.8 million (Silvestre *et al*., 1986). The demersal resource was also subjected to economic and biological overfishing as evidenced by fluctuations in annual production, decreasing CPUE and a decline in the number of species caught per fishing operation (Muñoz, 1991). The 1993 study conducted by MADECOR and National Museum also shows a decrease in the volume of its demersal biomass and a change in species composition. The disappearance of apex predators and the increase in biomass of small pelagic species was also noticed. A change in species composition implies the collective action of fishers and their subsequent effects on the function in the ecosystem (Sherman and Alexander, 1986). Another factor which influences species change and exploitation is the industrialization that degrades the water quality and rapid urbanization.

In 1947, the first trawl research survey in Manila Bay was conducted by Warfel and Manacop (1950) which is exploratory in nature, with no pre-established dragging stations and standard trawling duration. Other studies that followed were the demersal trawl surveys done by Ronquillo *et al*, (1960), Cases- Borja *et al*., (1963), Cases-Borja (1972), and Bautista and Rubio, (1981). The last comprehensive demersal survey was conducted by MADECOR and National Museum (1995) from 1992 – 1993 covering all the coastal municipalities around Manila Bay. After that, no further study, especially on demersal biomass, was conducted in the bay.

To assess the current condition of the demersal stocks in Manila Bay, a trawl fishing survey was conducted.

This study examined the current status of the demersal biomass in the bay and compared it with previously recorded biomass, including species composition, distribution, and levels of exploitation.

MATERIALS AND METHODS

Study area and sampling

The trawl fishing survey was conducted from March 2014 to October 2015 at 16 pre-determined fishing stations adapted from a previous study executed under the BFAR-Fisheries Sector Program in 1993 (MADECOR and National Museum, 1995). A commercial otter trawl weighing more than 15 gross tons equipped with a V10 engine (525 horsepower) was used during the survey. Trawling was done only during daytime with fishing duration varying from 30 to 60 minutes depend ing on the prevailing sea condition (a standard 60-minute drag is done whenever possible) at an average trawling speed of 6 to 7 km/hour. A total of 156 tows were made in depths ranging from 3.0 – 46.0 meters (Figure 3.1). Information such as distance trawled, species catch composition, fishing effort and individual length measurements were also gathered and subsequently recorded in specific forms.

Data Analysis

The species list was based on all 156 hauls made at the pre-determined fishing stations throughout the duration of the survey. To estimate the demersal fish biomass in the bay, the swept area method was used. This method is based on the total area (a) swept by the gear, (D) is the distance swept, (V) is the velocity of the trawl, (t) is the time spent trawling, (hr) is the head rope length, and X_2 is that fraction of the head rope length equal to the width of the path swept (the wing spread), whose suggested compromise value is 0.5. The mathematical equation is as followed;

$$a = D^{*}hr^{*}\, X_2,$$

where $D = V^{*}t$

To estimate the catch per unit area, we estimate the mean catch per unit area of all hauls Cw/a, then estimate the average biomass per unit area, is computed as;

$$\text{Б} = \frac{(\overline{Cw/a})}{X_1}$$

X_1 is the fraction of the biomass in the path being swept which is actually retained in the gear.

To compute for the total biomass (B) of the area, let A be the total size of the area being investigated. Then the total biomass estimate is expressed as,

$$\text{Б} = \frac{(\overline{Cw/a})}{X_1}$$

The value of X_1 is usually chosen between 0.5 and 1.0. Dickson (1974) suggests $X_1 = 1.0$, since using $X_1 = 0.5$ doubles the estimate biomass compared to that obtained by using $X_1 = 1.0$.

The Shannon-Wiener diversity index (*H'*) and Pielou's evenness index (*J*), which includes the data on species richness (number of species) and biomass was calculated using the PRIMER 5 statistical software.

Shannon-Wiener diversity index (H') is calculated as follows;

$$H' = -\sum_{i=1}^{s} p_i \log_2 p_i$$

Where s is the total number of species and *Pi* is the relative abundance of the **i** species, calculated as the proportion of individuals of a given species to the total number of individuals recorded in the community.

Species evenness can be represented by Pielou's evenness index (*J*) which is calculated as,

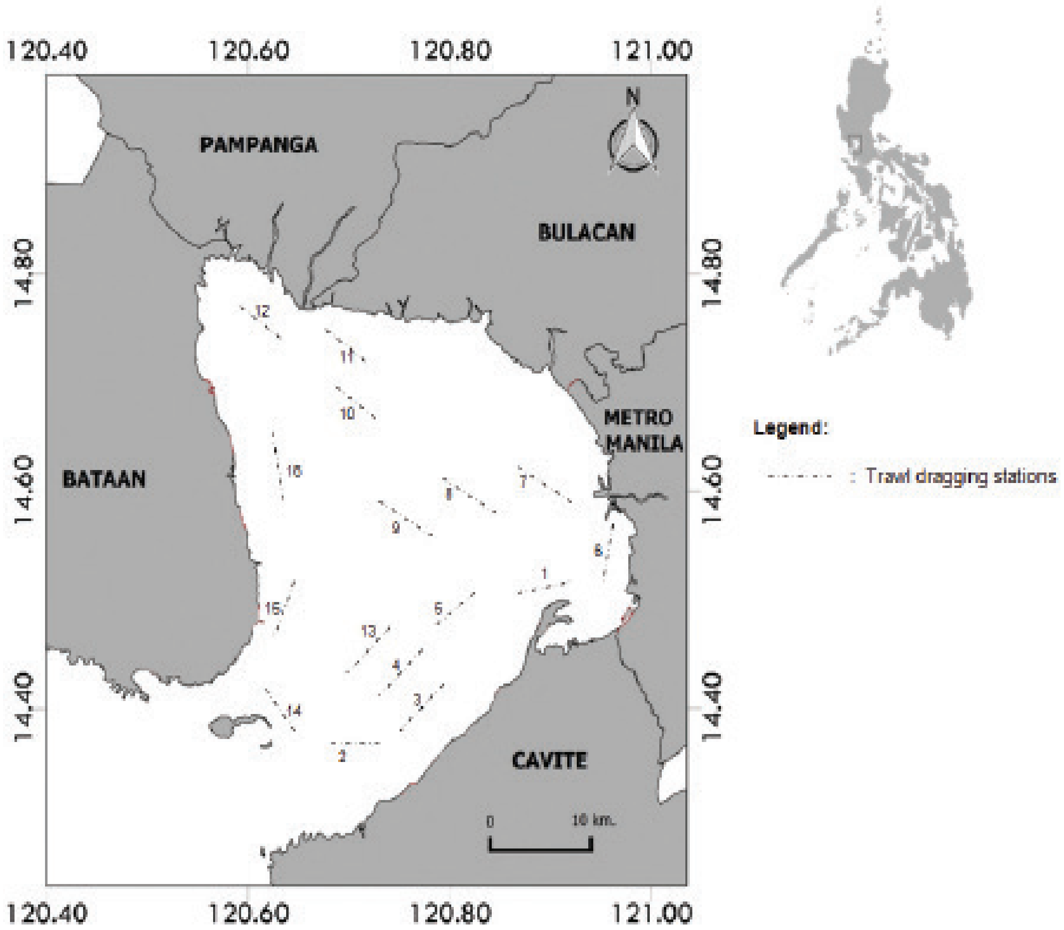


Figure 3.1. Map of the study area showing the trawl dragging stations.

$$J = H' / \log_2 S$$

Where H' is the Shannon-Wiener diversity index and S is the total number of species.

In addition, the exploitation rates (E) of the six dominant species (*Sardinella fimbriata, S. gibbosa, Mugil cephalus, Valamugil seheli, Stolephorous commersonnii* and *Encrasicholina devisi*) were estimated using the FAO ICLARM Stock Assessment Tools (**FiSAT**) utilizing the collected length frequency data. To estimate the exploitation rates, the formula used was

$$\mathbf{E = F/Z}$$

Where **F** is the fishing mortality component estimated after subtracting the natural mortality estimate (**M**) from (**Z**), the total mortality estimate, with all units expressed in (yr-^{1}).

RESULTS AND DISCUSSION

Species Composition and Distribution

Small pelagic species such as anchovies (Family Engraulidae) and sardines (Family Clupiedae) were the dominant fish species recorded during the duration of the survey. These species are in the low trophic level category and considered mostly as planktivorous species. E*ncrasicholina devisi* (devi's anchovy) dominated the catch having the mean biomass of 59.89 kg/km^2 or a relative abundance of 15.23%. It is followed by *Sardinella gibbosa* (51.16 kg/km^2), *Sardinella fimbriata* (40.25 kg/km^2), *Rhabdamia cypselurus* (39.63 kg/km^2), *Sardinella lemuru*, (25.69 kg/km^2) and *Photololigo edulis*, (23.70 kg/km^2). The large volume of non-commercially important species (i.e. swallow-tail cardinalfish *Rhabdamia cypselurus,* and pufferfish *Lagocephalus lagocephalus*) caught in the eastern part during the month February and in northern part during the month of April, respectively, significantly contributed to the estimated total biomass of the bay. It was notable that jellyfish would amass during the warm months, as evidenced by the large quantity caught during February and April, that would have contributed a relative abundance of 32% and 38%, respectively (excluded in Table 3.1). However, their volume would be almost negligible during the months of June, August, and October.

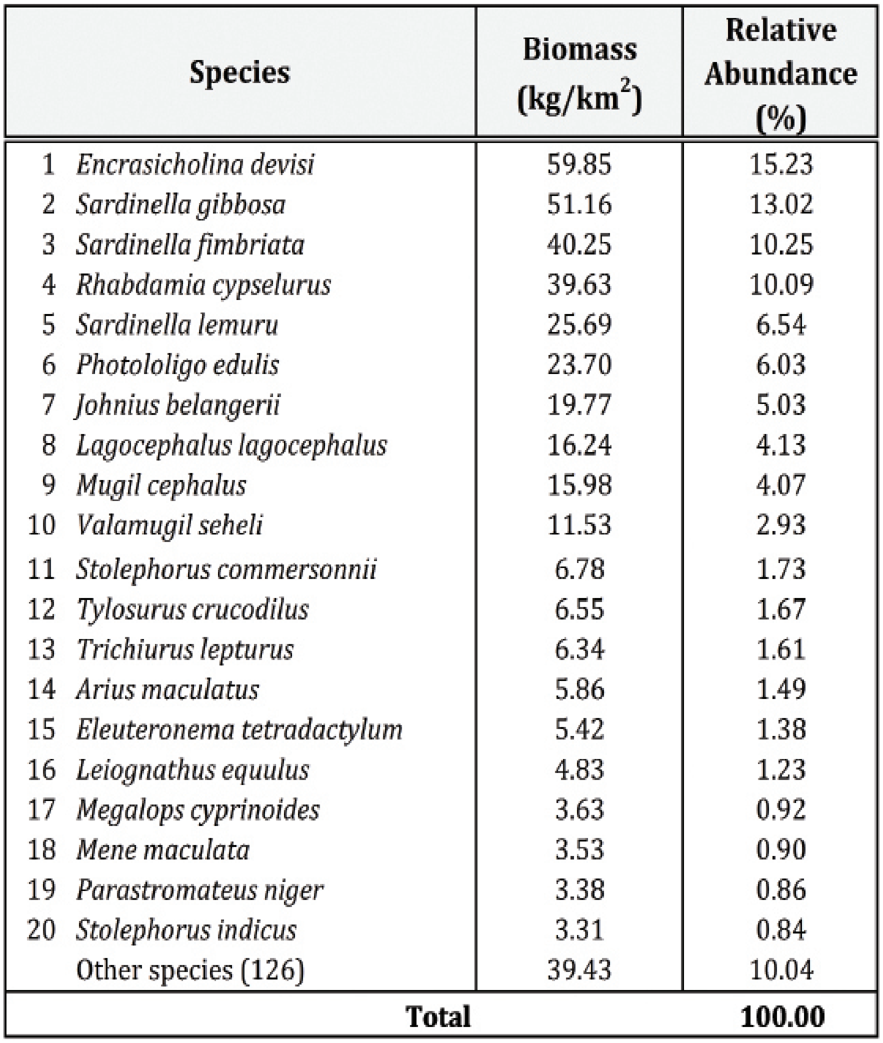
A total of 146 species of fish and invertebrate belonging to 48 families were caught during the survey. The most number of species was recorded in the trawling area near Cavite with 100, followed by stations in the Pampanga – Bulacan area with 93 species while stations near Metro Manila has 80 species. Areas near Bataan recorded a total of 55 species while in the waters near the island of Corregidor there were 42 species recorded. Biomass distribution and species abundance vary within the bay. The dominant species such as devi's anchovies (*Encrasicholina devisi*) and fringescale sardinella (*Sardinella fimbriata*) including the swallowtail cardinalfish (*Rhabdamia cypselurus*) exhibited higher biomass in the eastern portion (Metro Manila) of the bay. In contrast, a higher distribution of goldstripe sardinella (*Sardinella gibbosa*) was recorded in the eastern and southern part, while the squid (*Photololigo edulis*) is more prevalent in the western part. The flathead mullet (*Mugil cephalus*) was abundant in northern part while the hairtail (*Trichuirus lepturus*), the black pomfret (*Parastromateus niger*) and the common ponyfish (*Leiognathus equulus*) were more abundant in the southern part (near Corregidor Island) of the bay (Table 3.2).

Majority of the fishes caught during the survey were immature individuals. It was more evident in species with longer lifespan such as hairtail, needlefish, mackerel, carangids, and groupers. The severe fishing pressure exerted in the bay could be the cause of the noteworthy situation wherein species of sardines, mullets, and ponyfish caught in smaller sizes are already matured, and in some instances have shown evidence of reproduction.

Catches and Biomass

The survey recorded a total catch of 8.14 metric tons of fish and invertebrates (3.24 MT in 2014; 4.9 MT in 2015) during the ten fishing trips done from March 2014 to October 2015 with a mean Catch Per Unit Effort (CPUE) of 79.6 kg/hour (Figure 3.2). While the catches in 2015 would show a higher volume compared to 2014, it may only be coincidental, since the two highest volumes recorded in the months of February and April 2015 was due to the high abundance of the cardinalfish (*Rhabdamia cypselurus*) and pufferfish (*Lagocephalus lagocephalus*), amounting to 67% and 18% of the catch respectively. Unfortunately, these two species are of very low commercial value. In 1991, Muñoz (1991) reported that the bay is experiencing a decline

Table 3.1. List of top 20 species recorded from 2014 to 2015 trawl fishing in Manila Bay.

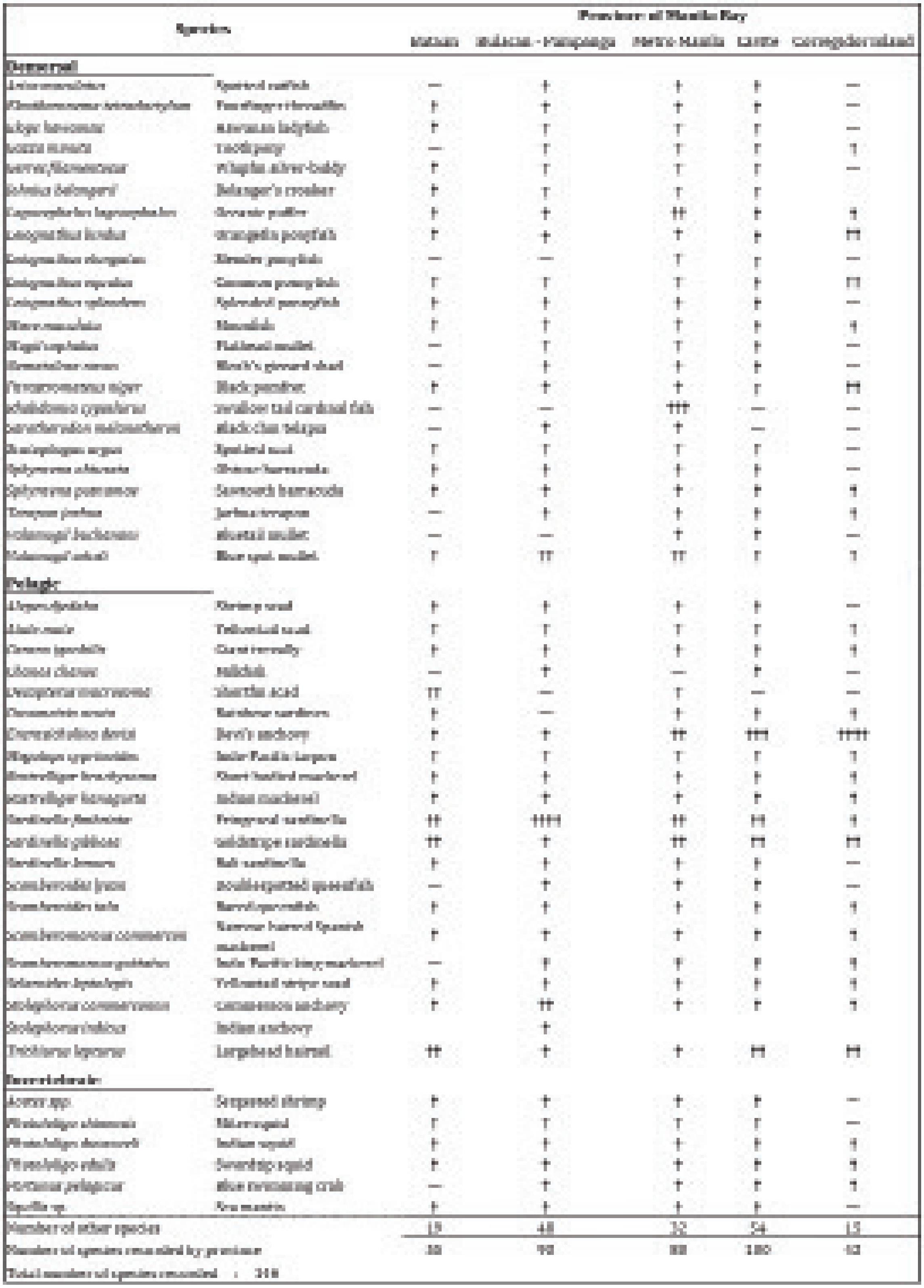


Species	Biomass (kg/km^2)	Relative Abundance (%)
1 *Encrasicholina devisi*	59.85	15.23
2 *Sardinella gibbosa*	51.16	13.02
3 *Sardinella fimbriata*	40.25	10.25
4 *Rhabdamia cypselurus*	39.63	10.09
5 *Sardinella lemuru*	25.69	6.54
6 *Photololigo edulis*	23.70	6.03
7 *Johnius belangerii*	19.77	5.03
8 *Lagocephalus lagocephalus*	16.24	4.13
9 *Mugil cephalus*	15.98	4.07
10 *Valamugil seheli*	11.53	2.93
11 *Stolephorus commersonnii*	6.78	1.73
12 *Tylosurus crucodilus*	6.55	1.67
13 *Trichiurus lepturus*	6.34	1.61
14 *Arius maculatus*	5.86	1.49
15 *Eleuteronema tetradactylum*	5.42	1.38
16 *Leiognathus equulus*	4.83	1.23
17 *Megalops cyprinoides*	3.63	0.92
18 *Mene maculata*	3.53	0.90
19 *Parastromateus niger*	3.38	0.86
20 *Stolephorus indicus*	3.31	0.84
Other species (126)	39.43	10.04
Total		**100.00**

in CPUE, having a maximum of 88 kg/hour in 1985, and drastically decreasing in the next two years at 40 kg/hour and 29 kg/hour, respectively. The CPUE values cannot be directly compared, because of the large variation in the sizes of the gear and boats used.

Biomass analysis of the current trawl survey reveal variations in the distribution pattern when compared to the MADECOR and National Museum (1995) study in 1993. Figure 3.3 shows the distribution of the biomass in the bay. In 2014 a mean biomass of 0.73 mt/km^2 was observed in northern part of the bay (Pampanga–Bulacan area) followed by the eastern part (Metro Manila area) with a mean biomass of 0.349 mt/km^2 and the lowest biomass was recorded in the southern part (near Corregidor) with a value of 0.102 mt/km^2 (Figure3.3a). In the 2015 survey, a slight change was observed in biomass distribution. The water near Corregidor Island now has the second highest biomass with a mean value of 0.797mt/km^2, next only to the waters near Metro Manila with a biomass of 1.254 mt/km^2. The lowest recorded biomass was now in the waters of Cavite with a mean of 0.203 MT/km^2 (Figure 3.3b). Still, the middle part of the bay records lower biomass values in both 2014 and

Table 3.2. Top 50 fish and invertebrate species caught in Manila Bay during the trawl fishing survey from 2014 to 2015by biomass abundance by province. The symbols used for commonness at each provinces are; ††††: 30 – 50% of the hauls; †††: 20 – 30% of the hauls; ††: 5 – 20% of the hauls; †: less than 5% of the hauls and; —: not found.



Species		Provinces of Manila Bay				
		Bataan	Bulacan - Pampanga	Metro Manila	Cavite	Corregidor Island
Demersal						
Arius maculatus	Spotted catfish	—	†	†	†	—
Eleutheronema tetradactylum	Fourfinger threadfin	†	†	†	†	—
Elops hawaiensis	Hawaiian ladyfish	†	†	†	†	—
Gazza minuta	Toothpony	—	†	†	†	†
Gerres filamentosus	Whipfin silver-biddy	†	†	†	†	—
Johnius belangerii	Belanger's croaker	†	†	†	†	
Lagocephalus lagocephalus	Oceanic puffer	†	†	††	†	†
Leiognathus bindus	Orangefin ponyfish	†	†	†	†	††
Leiognathus elongatus	Slender ponyfish	—	—	†	†	—
Leiognathus equulus	Common ponyfish	†	†	†	†	††
Leiognathus splendens	Splendid ponyfish	†	†	†	†	—
Mene maculata	Moonfish	†	†	†	†	†
Mugil cephalus	Flathead mullet	—	†	†	†	—
Nematalosa nasus	Bloch's gizzard shad	—	†	†	†	—
Parastromateus niger	Black pomfret	†	†	†	†	††
Rhabdamia cypselurus	Swallow tail cardinal fish	—	—	†††	—	—
Sarotherodon melanotheron	Black-chin tilapia	—	†	†	—	—
Scatophagus argus	Spotted scat	†	†	†	†	—
Sphyraena obtusata	Obtuse barracuda	†	†	†	†	—
Sphyraena putnamae	Sawtooth barracuda	†	†	†	†	†
Terapon jarbua	Jarbua terapon	—	†	†	†	†
Valamugil buchanani	Bluetail mullet	—	—	†	†	—
Valamugil seheli	Blue spot mullet	†	††	††	†	†
Pelagic						
Alepes djedaba	Shrimp scad	†	†	†	†	—
Atule mate	Yellowtail scad	†	†	†	†	†
Caranx ignobilis	Giant trevally	†	†	†	†	†
Chanos chanos	Milkfish	—	†	—	†	—
Decapterus macrosoma	Shortfin scad	††	—	†	—	—
Dussumieria acuta	Rainbow sardine	†	—	†	†	†
Encrasicholina devisi	Devis's anchovy	†	†	††	†††	††††
Megalops cyprinoides	Indo-Pacific tarpon	†	†	†	†	†
Rastrelliger brachysoma	Short mackerel	†	†	†	†	†
Rastrelliger kanagurta	Indian mackerel	†	†	†	†	†
Sardinella fimbriata	Fringescale sardinella	††	††††	††	††	†
Sardinella gibbosa	Goldstripe sardinella	††	†	††	††	††
Sardinella lemuru	Bali sardinella	†	†	†	†	—
Scomberoides lysan	Doublespotted queenfish	—	†	†	†	—
Scomberoides tala	Barred queenfish	†	†	†	†	†
Scomberomorus commerson	Narrow-barred Spanish mackerel	†	†	†	†	†
Scomberomorus guttatus	Indo-Pacific king mackerel	—	†	†	†	†
Selaroides leptolepis	Yellowstripe scad	†	†	†	†	†
Stolephorus commersonii	Commerson's anchovy	†	††	†	†	†
Stolephorus indicus	Indian anchovy		†			
Trichiurus lepturus	Largehead hairtail	††	†	†	††	††
Invertebrate						
Acetes spp.	Sergestid shrimp	†	†	†	†	—
Photololigo chinensis	Mitre squid	†	†	†	†	—
Photololigo duvaucelii	Indian squid	†	†	†	†	†
Photololigo edulis	Swordtip squid	†	†	†	†	†
Portunus pelagicus	Blue swimming crab	—	†	†	†	†
Squilla sp.	Sea mantis	†	†	†	†	—
Number of other species		19	48	32	54	15
Number of species recorded by province		55	93	80	100	42
Total number of species recorded : 318						

2015. Analysis of per station data also reveals a high variation of species dominance. High catches of the swallowtail cardinalfish (*Rhabdamia cypselurus*) during the February 2015 survey contributed to the sudden increase of demersal biomass in the eastern part (Metro Manila area) of the bay. Nevertheless, the change in biomass distribution may possibly be due to among other changing climatic conditions and availability of food in the area.

Studies conducted in 1993 (MADECOR and National Museum, 1995) have shown that highest demersal biomass was recorded near Corrigedor Island and Bataan followed by the waters near the mouth of the bay. They also observed a lower density in areas near Metro Manila, Bulacan and Pampanga with values ranging from 0 to 0.25mt/km^2. The current study shows the opposite, wherein, higher demersal biomass was recorded in the latter areas.

The demersal biomass estimate using the swept area method shows a stock density of 0.32 mt/km^2 with standing biomass of 618 mt in 2014 and getting slightly higher in 2015 with a stock density 0.48 mt/km^2 for a standing biomass of 928 mt for the entire bay. The 2014 results are much lower compared to the 1993 survey which registered a 0.47 MT/km^2 and 908 MT standing biomass (MADECOR and National Museum, 1995). Demersal biomass recorded in 2015 when compared to 1993 survey shows a slight increase of 0.2%. Warfel and Manacop (1950) stated that the bay has a stock density of 4.61 MT/km^2 amounting to a standing demersal biomass of 8,908 mt based on their 1947 survey results. The current study would place the relative density to just 10.4% of the 1947 baseline value (Table 3.3). Apparently, the decrease in biomass from 1947 to the present is associated with the more serious problem of increasing number of fishers, habitat destruction, and water quality deterioration.

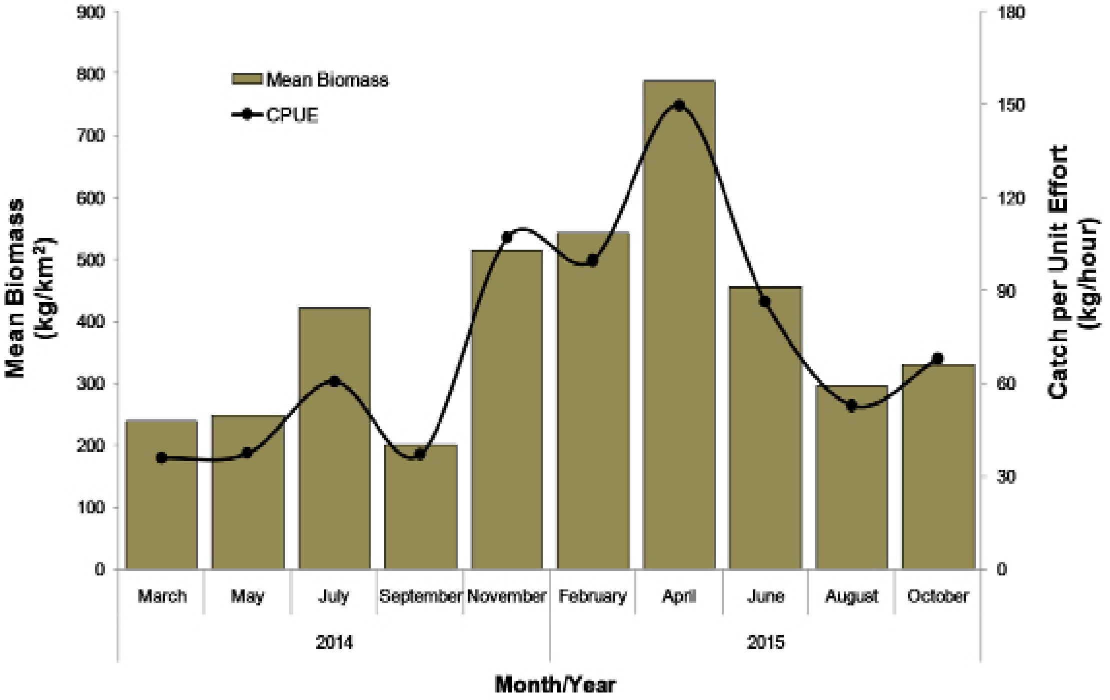


Figure 3.2. Estimated mean biomass and CPUE from 2014 and 2015.

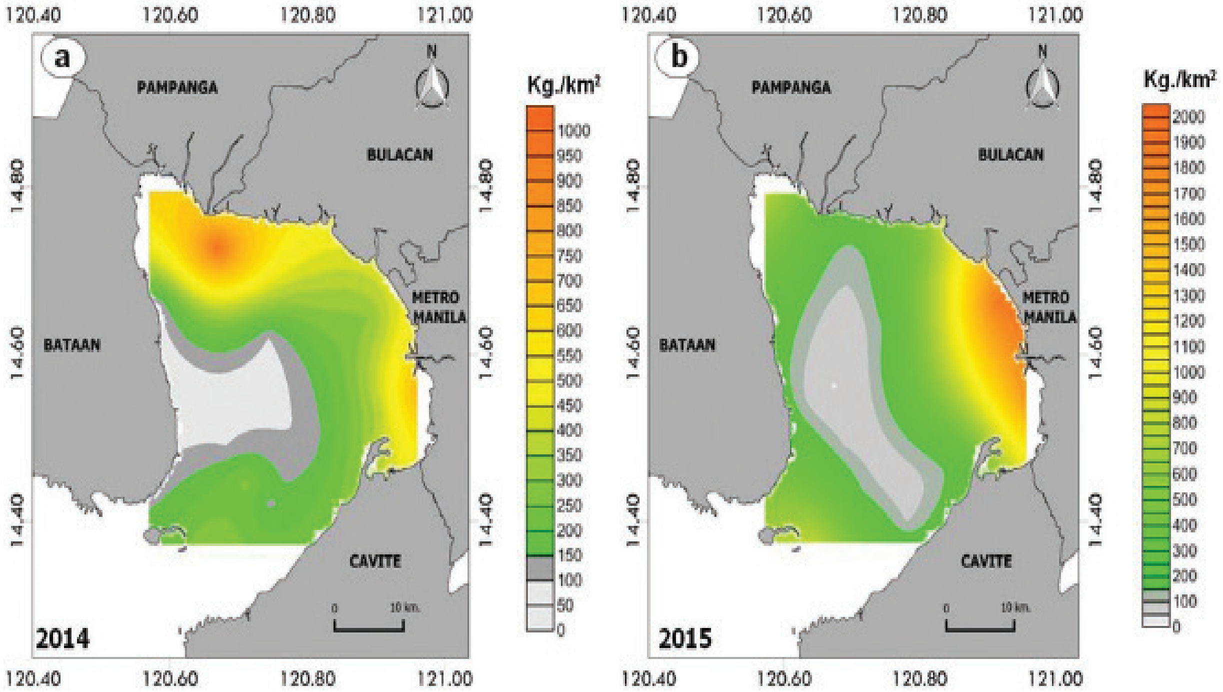


Figure 3.3. Map showing the demersal biomass distribution from the year 2014 and 2015.

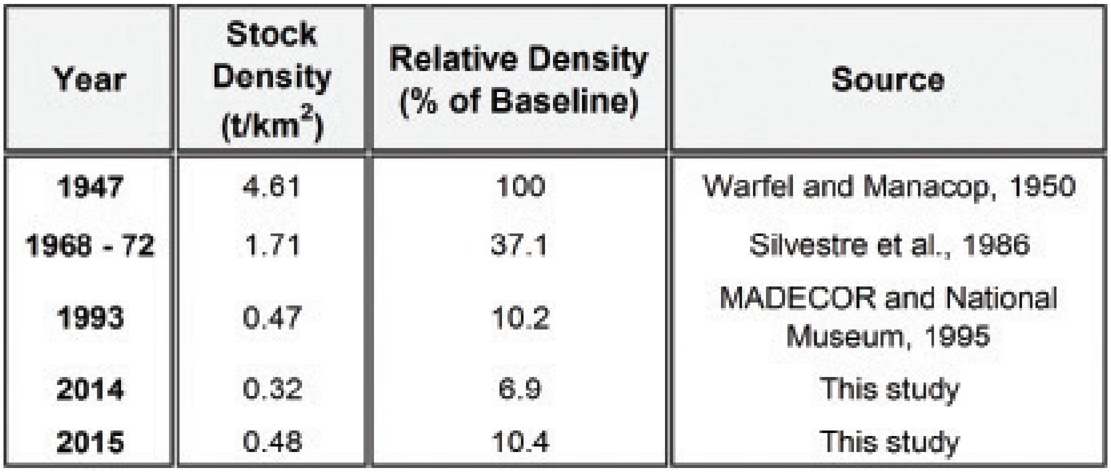
In comparison with the demersal trawl survey conducted by M/V DA – BFAR in various fishing grounds of the Philippines, Manila Bay still has a low biomass, higher than Davao Gulf, which only has a demersal biomass of 0.13 mt/ km^2 in the year 2014. The highest biomass in the country was estimated in Basilan – Sulu with a density of 3.69 t/km^2 followed by Samar Sea having 2.88 t/ km^2 (De la Cruz, 2016).

While significant changes in species dominance were observed in comparison with the previous study done by MADECOR and National Museum in 1993, such as the increasing catch of sardines, anchovies and other species with low commercial value (e.g. cardinal fish and puffer fish), these must be given importance. The problem of overexploitation and degradation of habitat is still happening in the bay. Excessive fishing requires not just a single solution but more holistic and wide-ranging approach that may include biological, cultural, political, economic, and anthropological interventions. Fishers change the habitat and function of the ecosystem (Sherman and Alexander, 1986) including the normal interaction of species among its population. Recent reviews describe the effect of fishing in the ecosystem and its negative impact on resources (Munro *et al*., 1987; McClanahan and Muthiga, 1988; Hutchings, 1990; Russ, 1991; Jones, 1992; Gislason, 1994; Hughes, 1994; Matishov and Pavlova, 1994; Anon, 1995; Dayton *et al*., 1995; McClanahan and Obura, 1995; Roberts, 1995; Jennings and Lock, 1996; Jennings and Polunin, 1996).

Change in Species Composition

Manila Bay is a multispecies and multigear fisheries, wherein, most of the fishes caught are represented by various families and several individual species. The bay is experiencing Malthusian overfishing, which relates to the continued increase in fisher density and the unabated

Table 3.3. Historical information on the demersal stock density of Manila Bay.



Year	Stock Density (t/km^2)	Relative Density (% of Baseline)	Source
1947	4.61	100	Warfel and Manacop, 1950
1968 - 72	1.71	37.1	Silvestre et al., 1986
1993	0.47	10.2	MADECOR and National Museum, 1995
2014	0.32	6.9	This study
2015	0.48	10.4	This study

use of destructive fishing methods (Pauly *et al*., 1989). Results of the survey show a significant decline in the quantity and quality of landed catch. Another indication of overexploitation and deterioration of fisheries resources is the apparent decrease of demersal fish biomass. The manifestation of the deterioration in fisheries includes the change in catch composition from economically valuable to less valuable species, increasing relative abundance of pelagic species, the disappearance of large long-lived individual fishes and the dominance of smaller sized species. This situation has also been experienced in the Gulf Thailand, where there was an increase of smaller and less valuable species (Christensen, 1998; Supongpan, 2001). The current results indicate a significant shift in catch composition and an entirely different pattern of distribution compared to previous surveys. Sardines (Family Clupiedae) and anchovies (Family Engraulidae) forms the bulk of catches in 2014 and 2015, with occasional large volumes coming from other groups like the croakers (Family Scienidae) and squids (Loliginidae) in 2014. However, in both 1947 and 1993 surveys, slipmouths (Family Leiognathidae) dominated the catch, with notable contributions from the goatfishes (Family Mullidae) and mojarras (Family Gerreidae). It is noteworthy that in the 1947 catch composition there was the predominance of large, long-lived species such as hairtails (Family Trichiuridae), snappers (Family Lutjanidae) and sweetlips (Family Haemulidae). In contrast, the catches in the 2014 and 2015 survey showed a high abundance of small pelagic species and invertebrates such as sardines, anchovies, shrimps, and squids (Figure 3.4). A comparison of survey results utilizing the proportion of pelagic, demersal and invertebrates' in the catches would show an erratic trend. However, in the majority of surveys conducted, the demersal fish contribution still forms the bulk of catches, ranging from a low of 38% to a high of 76%. Only in the 1981 and 1986 surveys of Bautista and Rubio (1981) and Ronquillo *et al.* (1989) did the contribution of demersal decreased considerably, amounting to only 6% and 24 % respectively. On the other hand, in the 1981 survey, pelagic species dominated the catch (71%) while in the 1986 survey, it was dominated by the invertebrates (squids and shrimps) (Table 3.4). Current catches are dominated by pelagic species with a relative abundance of 57.74%, followed by demersal and invertebrate species having relative abundances of 37.76% and 4.50%, respectively. This shifting of species dominance (from demersal to pelagic species) led us to hypothesize that the bottom part of the bay could probably not support life for a variety of fish species. This hypothesis is

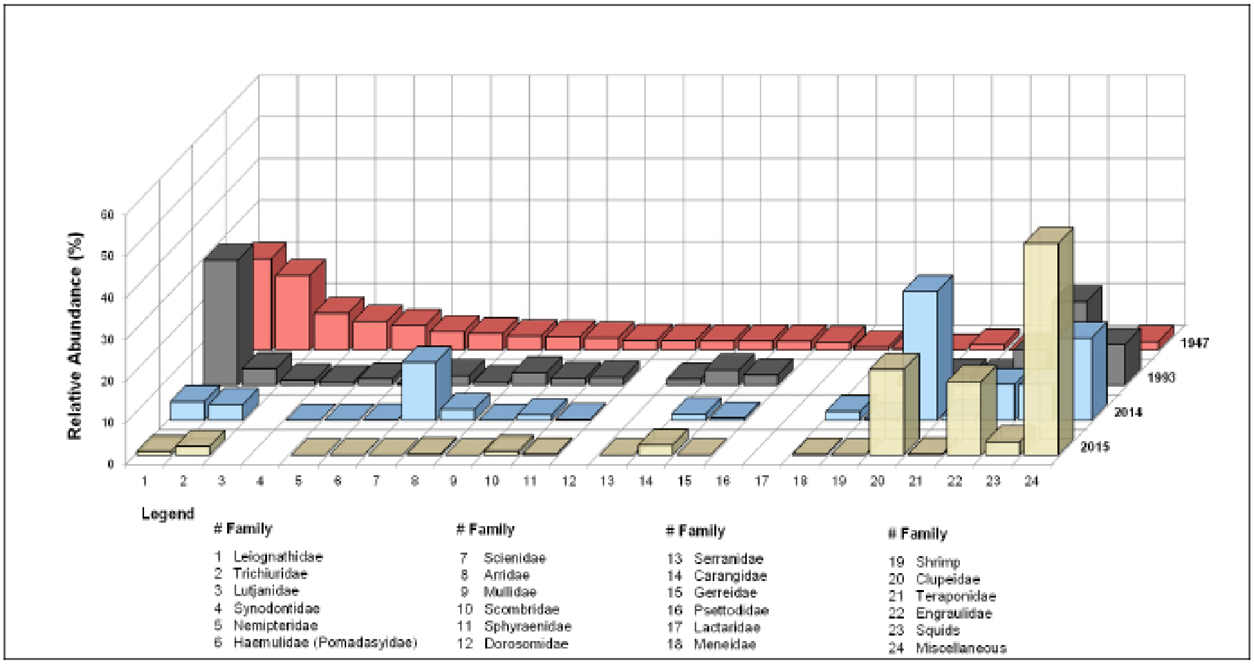
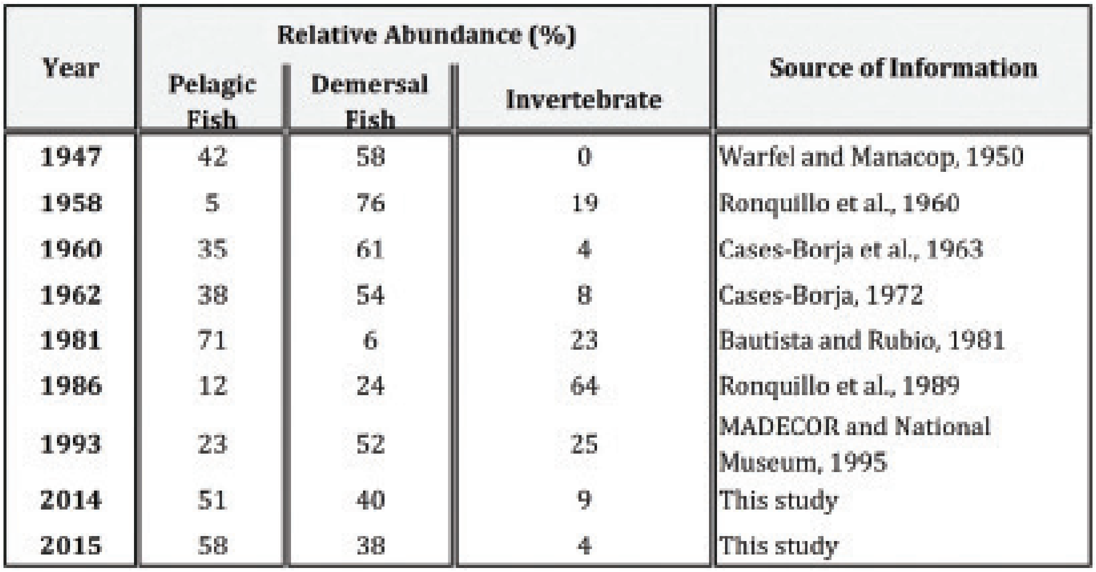


Figure 3.4. Catch composition (families) obtained from four trawl surveys of Manila Bay conducted in 1947, 1993, 2014 and 2015.

Table 3.4. Compilation of information on trawl fishing surveys conducted in Manila Bay.



Year	Relative Abundance (%)			Source of Information
	Pelagic Fish	Demersal Fish	Invertebrate	
1947	42	58	0	Warfel and Manacop, 1950
1958	5	76	19	Ronquillo et al., 1960
1960	35	61	4	Cases-Borja et al., 1963
1962	38	54	8	Cases-Borja, 1972
1981	71	6	23	Bautista and Rubio, 1981
1986	12	24	64	Ronquillo et al., 1989
1993	23	52	25	MADECOR and National Museum, 1995
2014	51	40	9	This study
2015	58	38	4	This study

supported by the study of Sotto *et al.*, (2014), wherein the near-bottom waters experience a hypoxic condition. High sedimentation rates (Siringan and Ringor, 1998) and wind-driven water circulation (Villanoy and Martin, 1997) could also influence the survival and distribution of the fish, especially the recruits/juveniles in the bay. At present, the status of the resources in the bay is alarming, probably because of overfishing (Silvestre *et al.*, 1986) and of the different climatic condition and species preference (Sutcliffe *et al.*, 1976).

The interaction to any climatic condition induces species fluctuation and stabilized biomass (McCann *et al.*, 1998, Berlow, 1999).

In addition, the deterioration of water quality could possibly contribute to the shifting of species and eventual exploitation of the fisheries resources.

Species Diversity

The Shannon diversity index (*H'*) and Pielou's evenness index (*J*) are presented in Table 3.5. Higher diversity was observed during the southwest monsoon (Habagat), as compared with the computed indices during the northeast monsoon (Amihan) in 2014 and 2015. Fluctuation in *H'* index seems to correspond with the decrease of species evenness through both monsoons.

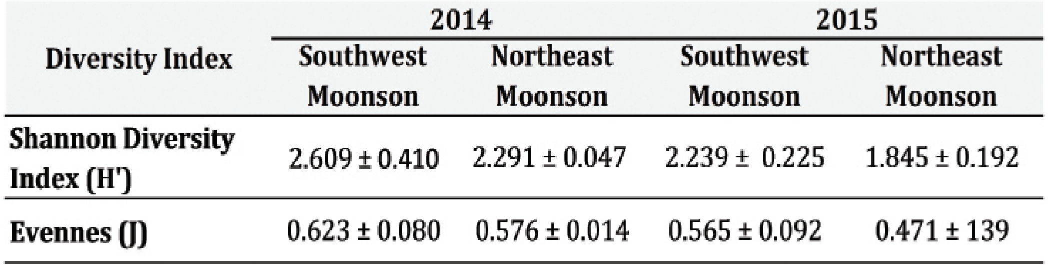
Exploitation

Most scientific literature states a threshold of fishing mortality value that is half of the total mortality endured by the stock, so as to be able to reproduce and replenish itself. Simply put the fishing mortality should be equal to the natural mortality or the exploitation rate should be 0.5. Pauly and Ingles (1984) also suggested that the optimum exploitation a rate for marine fishes (Eopt) is 0.5 year^{-1} and when exceeded, overfishing is certainly happening.

Exploitation rates of the six dominant species were investigated to evaluate if overfishing is occurring in the bay. Results of the survey show that *Sardinella gibbosa, Sardinella fimbriata, Valamugil seheli, Mugil cephalus* and *Encrasicholina devisi* is experiencing overfishing with the *E* values of 0.55 year^{-1}, 0.51 year^{-1}, 0.66 year^{-1}, 0.67year^{-1} and 0.6 year^{-1}, respectively. Stocks of Stolephorous commersonnii have a slightly lower *E* value of 0.47 year^{-1} (Figure 3.5), much closer to the estimated value by MADECOR and National Museum of 0.45 year^{-1} from their trawl survey in 1993 (MADECOR and National Museum 1995).

However for the mullet species such as *Mugil cephalus* and *Valamugil seheli*, the computed *E* values of 0.66 year^{-1} and 0.71 year^{-1} during the 1993 trawl survey were very much the same, but nevertheless still above the recommended threshold.

Table 3.5. Results of the Shannon – Weiner diversity index and Evenness.



Diversity Index	2014		2015	
	Southwest Moonson	Northeast Moonson	Southwest Moonson	Northeast Moonson
Shannon Diversity Index (H')	2.609 ± 0.410	2.291 ± 0.047	2.239 ± 0.225	1.845 ± 0.192
Evennes (J)	0.623 ± 0.080	0.576 ± 0.014	0.565 ± 0.092	0.471 ± 139

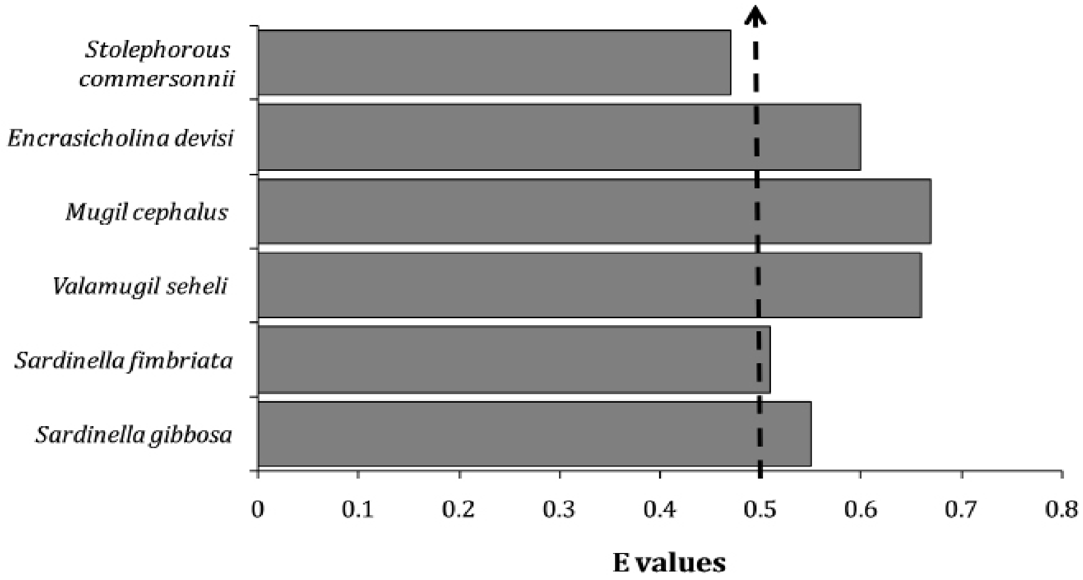


Figure 3.5. Exploitation values of the dominant species caught during the trawl fishing survey from 2014 to 2015.

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