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Spatio-Temporal Distribution of Ichthyoplankton in Manila Bay in Relation to Oceanographic Conditions

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Abstract

Manila Bay faces serious problems today such as pollution, coastal area reclamation and infrastructure, overfishing, and other activities that worsen the present condition of the bay. It is considered as one of the major fishing grounds in the Philippines. Fish eggs and larvae collection was carried out to determine their distribution, abundance, and composition in the bay. Eight established sampling stations were placed throughout the bay with an average distance of 5-6 nautical miles apart and sampled every other month on a monsoonal basis. Bongo net (360 microns mesh size, 1.5 meters in length, and a diameter of 50-centimeter mouth opening) with attached calibrated flowmeter was used in collecting fish larvae. Physical (salinity, temperature,), chemical (nitrite, nitrate, phosphate, silicate, dissolved oxygen), and biological (phytoplankton, zooplankton) parameters were also carefully studied to be able to explain such uncommon event within the bay. In spite of the current status and worsening condition of water quality of the bay, high abundances of fish eggs and larvae were consistently observed during the northeast monsoon surveys (March) from 2012 to 2015. A total of 3,008 individuals were identified belonging to 34 fish families. The highest fish egg density was observed during March 2013 with 1,550 ind./100m^3, followed by March 2012 and 2015 with 1,484 ind./100m^3 and 1,182 ind./100m^3, respectively. An abundance of fish larvae was observed during March 2015 with 414 ind./100m^3, followed by March 2012 (329 ind./100m^3), and March 2014 (311 ind./100m^3). The lowest density observed was in September 2012 with a density of 132 ind/100m^3 fish eggs and 46 ind/100m^3 fish larvae. The results were consistent that most fish eggs aggregate in the middle part of the bay especially in Stations 4 and 2 from 2012-2015. For fish larvae, they were consistently found in the eastern part of the bay (stations 6, 8, and 7) throughout the duration of the study, it was also the areas where high concentrations of phytoplankton, zooplankton, and nutrients were observed. A high abundance of fish eggs and fish larvae was observed during northeast monsoon than southwest monsoon. In addition, fish larvae family was dominated by small pelagic fish such as sardines, slipmouths, and mullets. The most dominant fish families found were Clupeidae, followed Leiognathidae, and Nemipteridae. Sillaginidae and Mugilidae were also included in the top five abundant families that occur during every sampling period were.

Key words: Ichthyoplankton, Manila Bay

INTRODUCTION

A key role in understanding the ecology and evolution of fish fauna and their constituent population is through ichthyoplankton research (Moser and Smith, 1993). Koutrakis *et al*. (2004) also added that the relationship between the spatial and the temporal distribution of ichthyoplankton in relation to geographic and oceanographic conditions is important to ecological and economic perspectives. The importance of the interaction between physical and biological processes need specific studies on spawning and life cycle of fish larvae for a better understanding of recruitment variability in fisheries resources and for an enhancement in the knowledge of life cycles of fish species (Nonaka *et al*. 2000). A seasonal examination of species composition of ichthyoplankton in coastal marine waters and in-depth study of seasonal variations in the distribution patterns and possible effects of hydrographic and climatological conditions on larval transport are therefore needed.

Ichthyoplankton studies are important for stock assessment purposes. The timing and intensity of spawning in fishes are believed to be adaptive, reflecting the phase of the mean seasonal cycle of the environment favorable for offspring survival (Somarakis *et al*. 2000). Fish eggs and larvae occurrence and abundance facilitate the location of probable spawning and nursery grounds of fishes. Ichthyoplankton data provide a base for research into population dynamics of major fishery species (Brodeur *et al*.,1995; Rutherford *et al*., 1997; Butler *et al*., 2003), and information on ichthyoplankton ecology comprise an important component of stock assessment and fishery management plans (Rutherford, 2002).

Manila Bay is a semi-enclosed body of water facing the West Philippine Sea. It is situated in the western part of Luzon and is bounded by Cavite and Metro Manila on the east, Bulacan and Pampanga on the north, and Bataan in the west and northwest. It has 190 km of coastline, sa urface area of 1, 700 km^2, and 2.89 x 1010 m^3 and has an average depth of 17 m. Pampanga River and Pasig River was the major contributor of freshwater influx into the bay (Jacinto et al. 2006). It plays an important role in the country's economy in terms of industry and commerce, agriculture, aquaculture, and tourism (Perez et al. 1999). Moreover, it is one of the most important bodies of water in the Philippines because of its historical, cultural, and economic value (Jacinto et al. 2006). Human-related activities such as conversion of mangrove and mudflat areas into fishponds change the physical properties of the bay particularly its shoreline (MADECOR and National Museum, 1995 and MBEMP TWG-RRA 2004). Densely populated coastal communities around the bay rely mainly on fishing for their living which resulted in continuous depletion of fisheries resources due to an increase in fishing pressure.

MATERIALS AND METHODS

Collection of ichthyoplankton was carried out on board motorized fishing vessel (ca. >7 gross tonnage) in Manila Bay every other month starting January 2012, given a representative sampling period during tradewinds/southeast monsoon(May), southwest monsoon (July and September) and northeast monsoon (November, January, and March). Eight sampling stations were established strategically in the entire bay with a distance of about 4-5 nautical miles away from each other (Figure 6.1). Horizontal towing of Bongo net (50 cm diameter, 2.5 length, and 364 μm mesh size) in the water that was partially submerged about half a meter below the surface was done for 10 minutes at a speed of 2-3 knots in each station to collect ichthyoplankton samples. The bongo net was attached with a calibrated flowmeter to estimate the volume of water being filtered. All samples were preserved in 10% sea-water buffered formalin solution. The preserved samples were brought to the laboratory for further processing, sorting, and identification of fish eggs and larvae up to the lowest possible taxa (SEAFDEC, 2004). To ensure good quality data, replicate samples were also collected for ichthyoplankton. All densities were reported as individuals (fish eggs or larvae) per 100m^3. As an aid to the identification, taxonomic publications of Ahlstrom (1965), Fahay (1975, 1983), Moser *et al.* (1984), Richards (2006), and Baldwin (2013) were used.

RESULTS

Species composition of total fish larvae assemblage

A total of 3,008 individual specimens of fish larvae represented by 34 families were collected in all sampling stations in Manila Bay. Fish larvae family was dominated by Clupeidae throughout the entire duration of the study which comprises 27% of the total population, followed by Leiognathidae and Mugilidae (mullets) with 15% and 10%, respectively (Figure 6.2). The order of abundance of the rest of the families were Nemipteridae (sea breams), Sillaginidae (whitings), Mullidae (goatfishes), Carangidae (jacks and pompanos), Gobiidae (gobbies), and Engraulidae (anchovies).

From the first year of the project (2012), up to the last year (2015), the Clupeidae were consistently the most abundant fish family in Manila Bay every sampling period (Figure 6.3). However, the top two to five families varied in rank every sampling month but mostly Leiognathidae and Mugilidae switch places from top two and three, respectively. The Carangidae which ranked 2nd during the early part of 2012

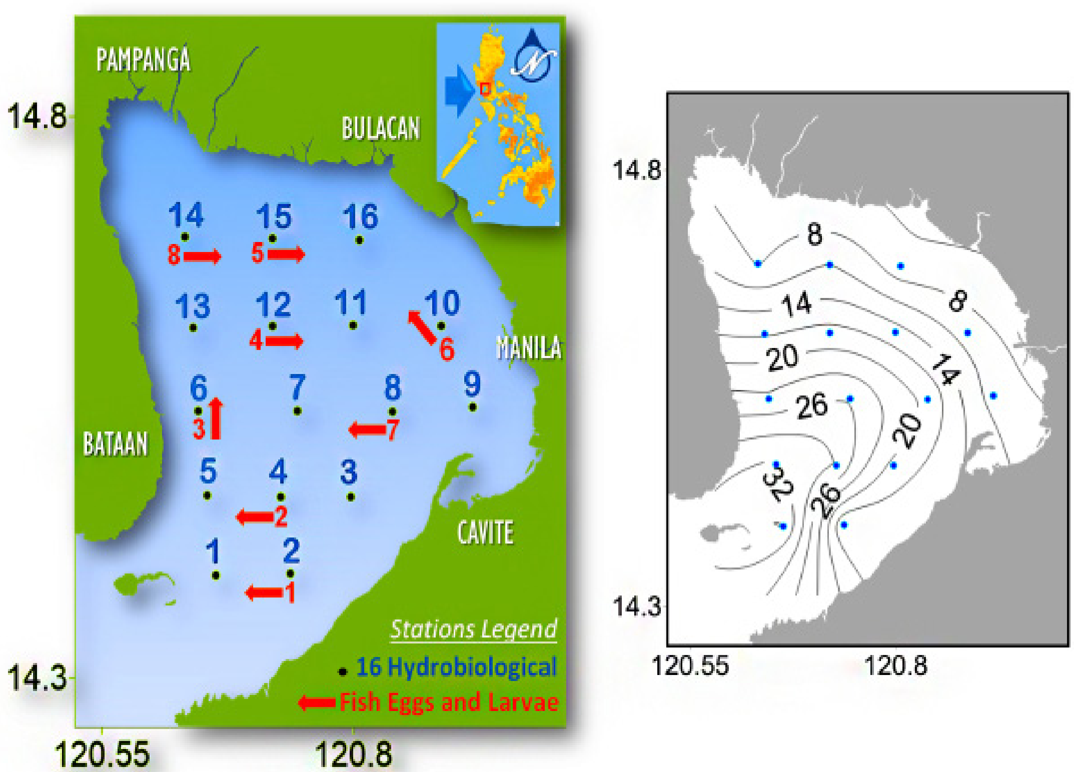

Figure 6.1. Sampling stations (left) and Bathymetric map (right) of Manila Bay

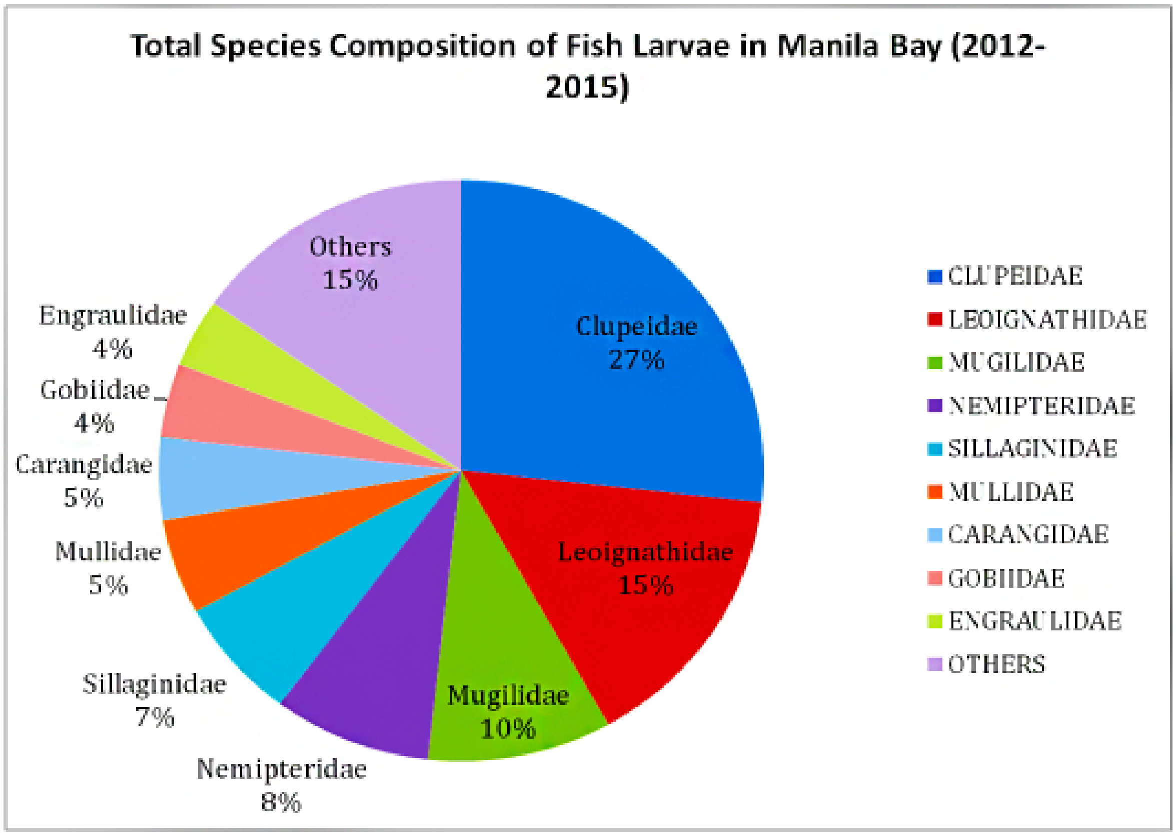

Figure 6.2.Total Species Composition of Fish Larvae in Manila Bay

slowly slides below top five during the latter part of 2012 up to 2015 as it appears in low density. The families rank top six and below every sampling period were identified and clustered as others as they appear in small concentration.

Abundance and distribution of total fish eggs and larvae

Fish Eggs

A high abundance of fish eggs was observed in March 2012 during the northeast monsoon with a total of 1,484.47 ind./100m^3 (Figure 6.4, row 1 column b). Fish egg concentrations were found in station 7, located in the western side (592.8 ind/100m^3), and station 2, near the southwestern side (449.8 ind/100m^3). January and November 2012 surveys recorded 633 ind./100m^3 and 371 ind./100m^3, respectively, which also occurred during the northeast monsoon.

On the following year (2013), the abundance of fish eggs was again observed in March survey, having a total of 1,550.42 ind./100m^3 (Figure 6.4, row 2 column b), slightly higher compared to March of the previous year (2012). The concentrations were found in station 6 (568.8 ind/100m^3) and station 7 (290.2 ind/100m^3), both in the eastern side. The November 2013 survey accounted for 860 ind/100m^3, followed by January 2013 with 531 ind/100m^3; their concentrations aggregate both in station 3, in the western side. The succeeding year (2014), egg abundance was again noticed in high density in March 2014 survey with 1,119 ind/100m^3 (Figure 6.4, row 3 col-

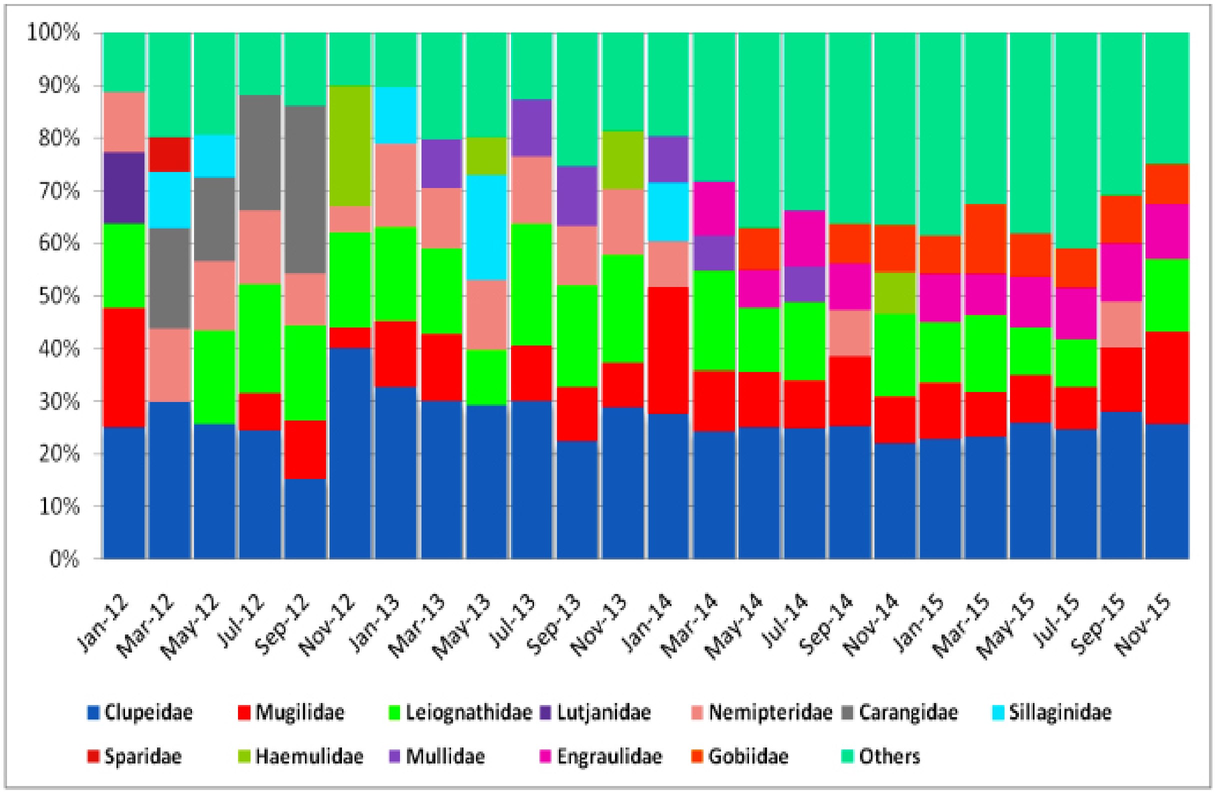

Figure 6.3. Composition of Fish Larvae in Manila Bay

umn b) which is much lower compared to the previous surveys. They were found amassing in the southwestern side (station 2) with 412 ind/100m^3. It was followed by November 2014 (682 ind/100m^3) and January 2014 (566 ind/100m^3).

For the last survey (2015), high abundance of fish eggs was again observed during March with a total density of 1,182 ind/100m^3 (Figure 6.4, row 4 column b) that were concentrated in the southwestern side of the bay in station 3 (347 ind/100m^3) and station 4 (245 ind/100m^3). The results validated all the data from 2012-2015 that fish eggs were abundant every March, as shown in Figure 6.4. However, the lowest recorded number of fish eggs was observed in September 2012 (Figure 6.4, row 1 column e) with only 132 ind/100m^3 because of unfavorable weather conditions during this season. Most fish eggs were found amassing in the middle part towards the eastern part of the bay (Metro Manila and Cavite area). Moreover, fish eggs show a clear shoreward transport as more fish eggs were found amassing offshore.

Fish Larvae

High fish larvae density was observed in March 2012 survey with 329 ind./100m^3 which aggregated in station 7 (150 ind./100m^3) and station 2 (65 ind./100m^3) (Figure 6.5, row 1 column b). The abundance of fish larvae in May 2012 (305.43 ind./100m^3) was closer to March 2012 (329 ind./100m3) and followed by July 2012 with 237 ind./100m^3. The following year (2013), high abundance of fish larvae was again observed in March survey with 306 ind./100m^3. They were amassing in station 6 with 82 ind./100m^3 and station 4 with 78 ind./100m^3, followed by July (232 ind./100m^3) and May 2013 (194 ind./100m^3) both in station 6 (Figure 6.5).

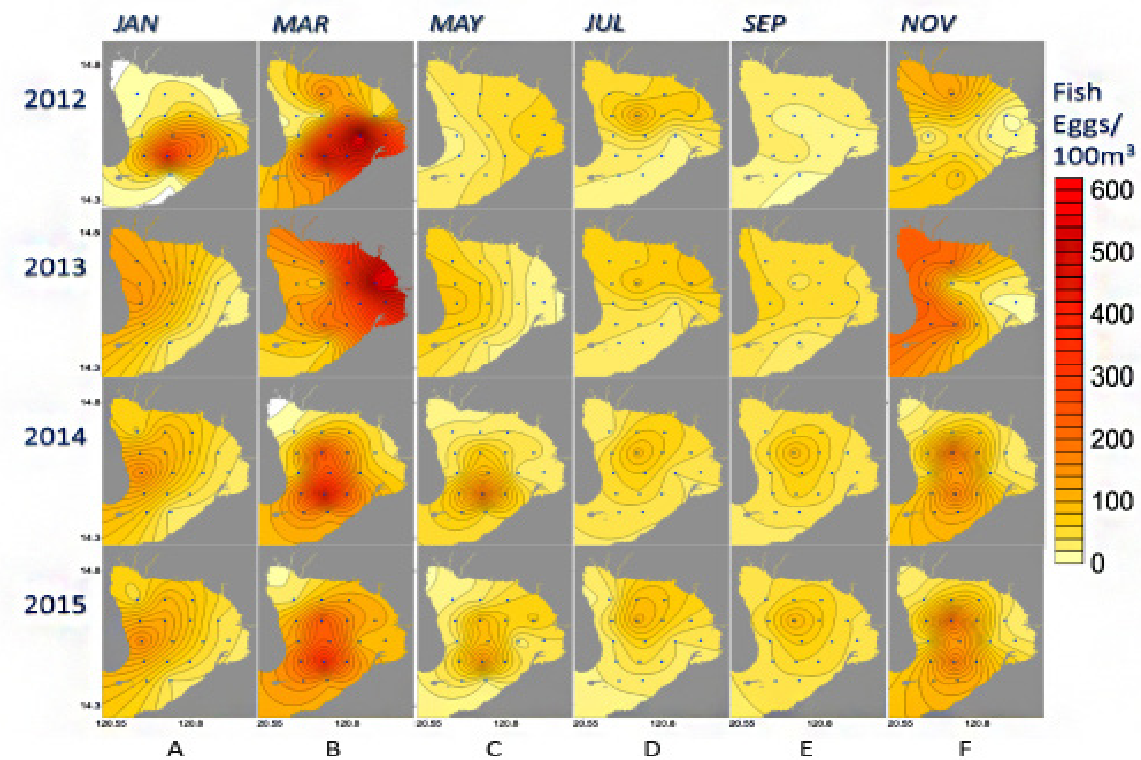

Figure 6.4. Spatial Distribution and Abundance of Fish Eggs in Manila Bay (2012-2015)

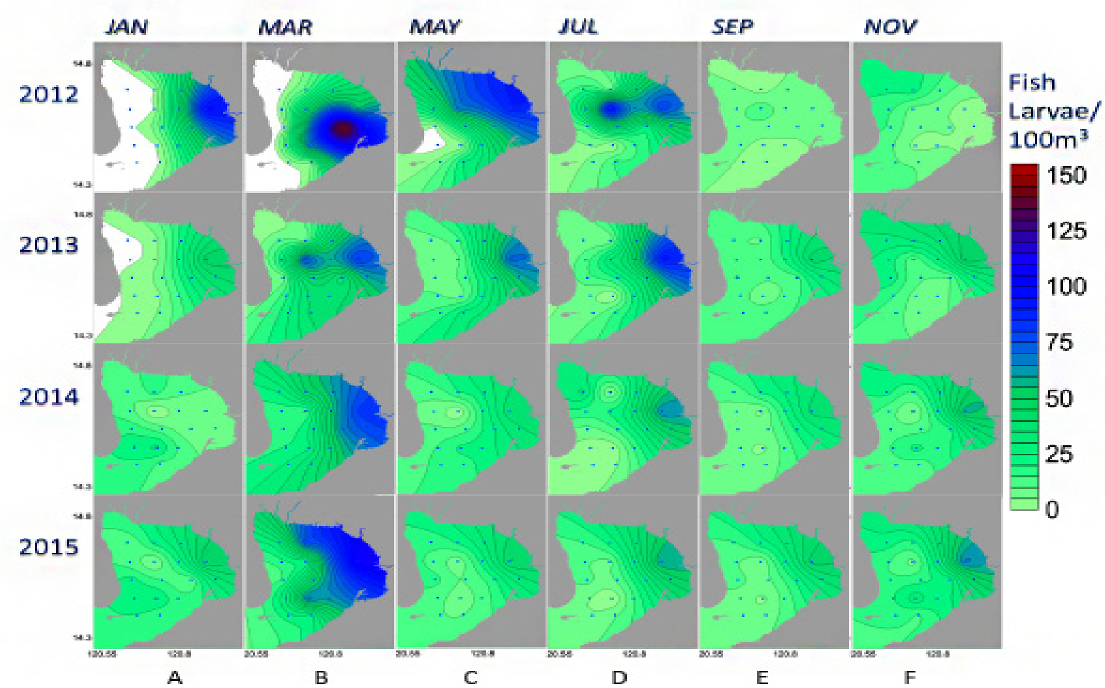

Figure 6.5. Spatial Distribution and Abundance of Fish Larvae in Manila Bay (2012-2015)

The succeeding year (2014), fish larvae were much higher during March survey compared to the other months with 311 ind/100m^3, they were found in station 6 (81 ind./100m^3) and station 7 (67 ind./100m^3) (Figure 6.5, row 3 column b).

The highest concentration of fish larvae was observed during March 2015 with 414 ind./100m^3 compared to the previous surveys. They were noticed in stations 6 and 7 with 107 ind./100m^3 and 76 ind./100m^3, respectively. The abundance of fish larvae was consistently observed every March as shown in Figure 6.5. Fish larvae were usually found in the stations near the shore especially in Metro Manila, Cavite and Bataan areas (Station 6, 8 and 7).

DISCUSSION

A total of 3,008 fish larvae individuals representing 34 families were collected and identified in Manila Bay from 2012-2015. It was observed that during the northeast monsoon (January, November, and March), high density of fish larvae was recorded especially in March 2015 with 414 ind./100m^3. According to Campos *e*t al. (2008), this was the season that many tropical small organisms spawn. Somarakis et al. (2000) also have the same findings and it coincides with the studies in Western Mediterranean Sea wherein during early summer was the reproductive season of summer spawning fishes (Sabates, 1990; Sabates and Maso, 1992; Sabates and Olivar, 1996).

Bone *et al*., (1995) stated that most shallow water fish produce pelagic eggs and carried away by ocean currents, similar to what we observed as fish eggs were distributed throughout the bay. There were two gyres present in the bay, one from the northern part, and another one on the southern part which moves opposite from each other depending on the dominant prevail-

This oceanographic pattern was revalidated by Villanoy and Martin (1997). An abundance of fish eggs was observed in Manila Bay all year round, its highest was recorded during the northeast monsoon in March 2013 with 1,550 ind./100m^3 and found amassing in the middle and northern parts of the bay and can be attributed to the narrow mouth and circulation pattern of the bay. We tested the significant correlation of the abundance of ichthyoplankton to the physical and chemical parameters of the bay using canonical ordination analysis (CANOCO). Of all the parameters tested, only temperature, salinity, and dissolved oxygen showed positive correlation and they fall together with most of the larvae in one quadrant (Figure 6.6). Monte Carlo Permutation test shows the significant correlation of salinity, and nitrate with P values of 0.032 and 0.05, respectively. The significant correlation may not be that strong but the result only means that those environmental parameters in the bay were necessary and needed by the fish larvae in order to survive. Boeing and Duffy-Anderson (2008) said that there were other factors that influence the abundance and distribution of ichthyoplankton such as environmental forcing factors (climate), predation and competition. In conclusion, although we did not find strong significant correlation among physical and chemical parameters in relation to the distribution and abundance of ichthyoplankton in the bay, the result itself will be very useful for biological information and stock assessment purposes in the area. For future study, tidal fluctuation, circulation pattern, and climatological condition must be included in the parameters to determine whether these forcing conditions affect the distribution pattern of ichthyoplankton.

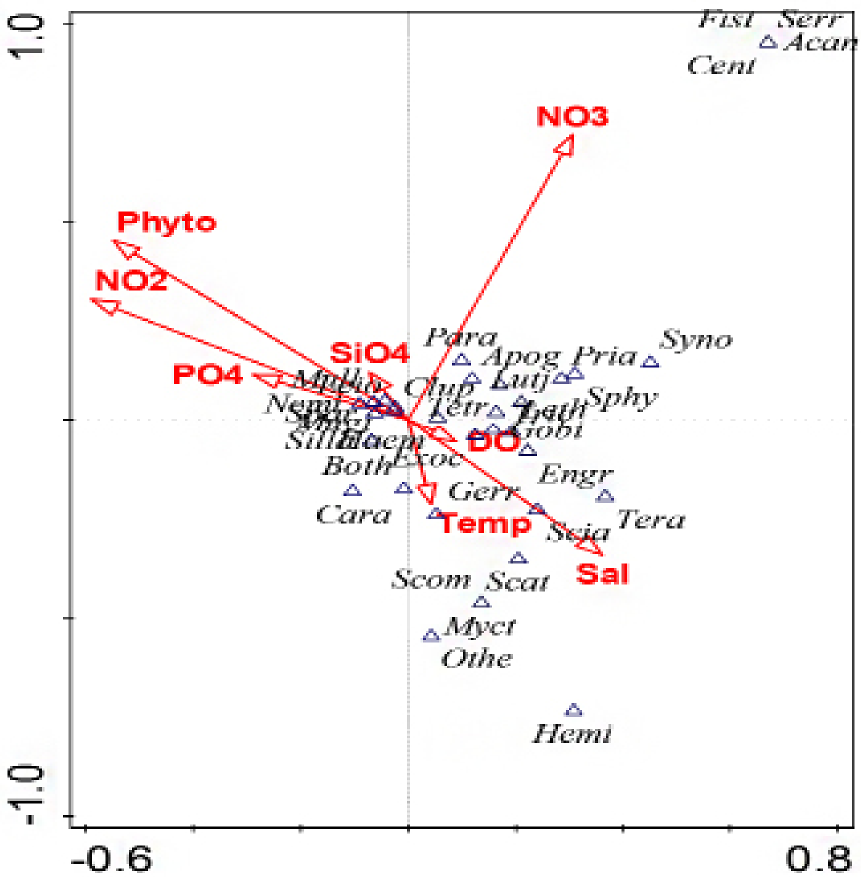

Figure 6.6. Biplot (CCA) of species and environmental parameters (plankton, physical and chemical parameters) in Manila Bay.

Table 6.1. Monte Carlo Permutation Test

	Contri	F	P
Salinity	17.4	1.7	0.032
Nitrate	16.6	1.6	0.05
Phytoplankton	16.1	1.6	0.082

Table 6.2. Legend of Fish Families

Biplot Legend of Fish Families			
Acan	Acanthuridae	**Mull**	Mullidae
Apog	Apogonidae	**Myct**	Myctopidae
Both	Bothidae	**Nemi**	Nemipteridae
Cara	Carangidae	**Othe**	Others
Cent	Centropomidae	**Para**	Paralepididae
Clup	Clupeidae	**Pria**	Priacanthidae
Engr	Engraulidae	**Scat**	Scatophagidae
Exoc	Exocoetidae	**Scia**	Sciaenidae
Fist	Fistulariidae	**Scom**	Scombridae
Gerr	Gerreidae	**Serr**	Serranidae
Gobi	Gobiidae	**Silla**	Sillaginidae
Haem	Haemullidae	**Spar**	Sparidae
Hemi	Hemiramphidae	**Sphy**	Sphyraenidae
Leio	Leiognathidae	**Syno**	Synodotidae
Leth	Lethirinidae	**Tera**	Terapontidae
Lutj	Lutjanidae	**Tetr**	Tetraodontidae
Mugi	Mugilidae	**Tric**	Trichiuridae

Table 6.3. Legend of Environmental Parameters

Legend of Environmental Parameters	
DO	Dissolved Oxygen
NO_2	Nitrite
NO_3	Nitrate
Phyto	Phytoplankton
PO_4	Phosphate
Sal	Salinity
SiO_4	Silicate
Temp	Temperature

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