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Population Parameters of Common Small Pelagic Fishes Caught by Ringnet in Manila Bay, Philippines

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Abstract

The growth and mortality parameters, exploitation ratios, and annual recruitment patterns of sardines (*Sardinella gibbosa* and *Sardinella fimbriata*) and mackerel (*Rastrelliger brachysoma*) caught by ring net in Manila Bay were estimated based on raised length-frequency data collected for one year (January to December 2014). Data were regularly collected in selected fish landing sites where ring netters regularly unload their catch. Results of the length frequency analysis are summarized. The growth parameters for the three species are as follows, *Sardinella gibbosa* ($L\infty$ = 18.49 cm, K = 0.88 yr^{-1}); *Sardinella fimbriata* ($L\infty$ = 18.5 cm, K = 0.95 yr^{-1}); and *Rastrelliger brachysoma* ($L\infty$ = 28.67 cm, k = 1.3 yr^{-1}). The results showed only a slight difference from previous studies conducted in Manila Bay. For the mortality parameters, L_{50} and *E*-values, results showed increased values compared to previous studies. The E-values of the three species already exceeded the optimum exploitation value of *E*=0.5, indicating that overfishing is occurring.

Keyword: Growth parameters, mortality parameters, exploitation rate, recruitment pattern

INTRODUCTION

Manila Bay is one of the major fishing grounds of the Philippines. It is a multi-gear and multispecies fishery with moderately flat bottom contour particularly suited for trawl and other similar fishing operations involving dragging or pushing nets. Manila Bay is located in the western part of Luzon bounded by the provinces of Cavite, Metro Manila, Bulacan, Pampanga, and Bataan.

Sardines and mackerels are the most abundant species caught in Manila Bay using various fishing gears. Ringnet is one of the major gears that exploit the small pelagic stocks of the Bay, particularly *Sardinella gibbosa* (82.76 %), *S. fimbriata* (12.31 %), and *Rastrelliger brachysoma* (2.41 %) comprising the top three dominant catch of the gear in 2014. The ring netters use a 15-25 gross ton motorized fishing boats (also known as small-scale commercial fishing vessels) with a 3.0 cm stretched mesh size net.

Up until 1958, there was a rapid increase in the total production of Manila Bay (Muñoz, 1991) making it the country's second-biggest source of fish catch until the 1970s. Previous studies also reported the Bay to be abundant in demersal and invertebrates species based on trawl survey (Ronquillo et al., 1960; Ronquillo *et al*., 1989; BFAR, 1995). However, recent studies already show that the Bay's resources are experiencing overfishing as proven by the declining fish catch and in the change of the quality of fish caught to lesser valued species. There was a change in species composition and the abundance of small pelagic species, dominated by sardines (*Sardinella gibbosa* and *S. fimbriata*) and mackerel species (*Rastrelliger brachysoma*) (Lopez *et al*., 2013 annual report, unpublished). In addition, the Bay is also suffering from habitat degradation and its water quality deteriorating due to pollution (PEMSEA and MBEMP TWG-RRA, 2004; Su *et al*., 2009; Chang *et al*., 2009).

Studies on the population parameters of these species in Manila Bay are very limited. The knowledge of the fish mortality parameters is significant to fishery scientists studying the dynamics of fish population (Youngs and Robson, 1978; Marshall, 1993). Estimates of the mortality and exploitation rate are vital in determining the status of the sardine and mackerel fisheries in Manila Bay. This study will provide estimates of population parameters of *Sardinella gibbosa*, *Sardinella fimbriata,* and *Rastrelliger brachysoma*. Results will serve as baseline information for the proper management of these fish resources in Manila Bay.

MATERIALS AND METHODS

Study Area and Data Collection

This study analyzed the length frequencies of the three species namely, *Sardinella brachysoma*, collected monthly at random from ringnet catches. Data gathering was every after two days or 10-11 days per month in the selected fish landing sites in Manila Bay (except in PFDA Market 3 and Fisherman's Wharf which was 20-21 days per month), where ring netters regularly unload their catch (Figure. 2.1). Data were collected for one year from January 2014 to December 2014 and individual fish specimens were measured to total length (cm) using a measuring board.

Analysis of Data

The pooled monthly length-frequency data coming from the nine fish landing sites were grouped into ascending midlengths, using 0.5 cm class interval for the sardines and 1.0 cm class interval for the mackerel species.

The accumulated length-frequencies were raised to estimate the number of pieces in

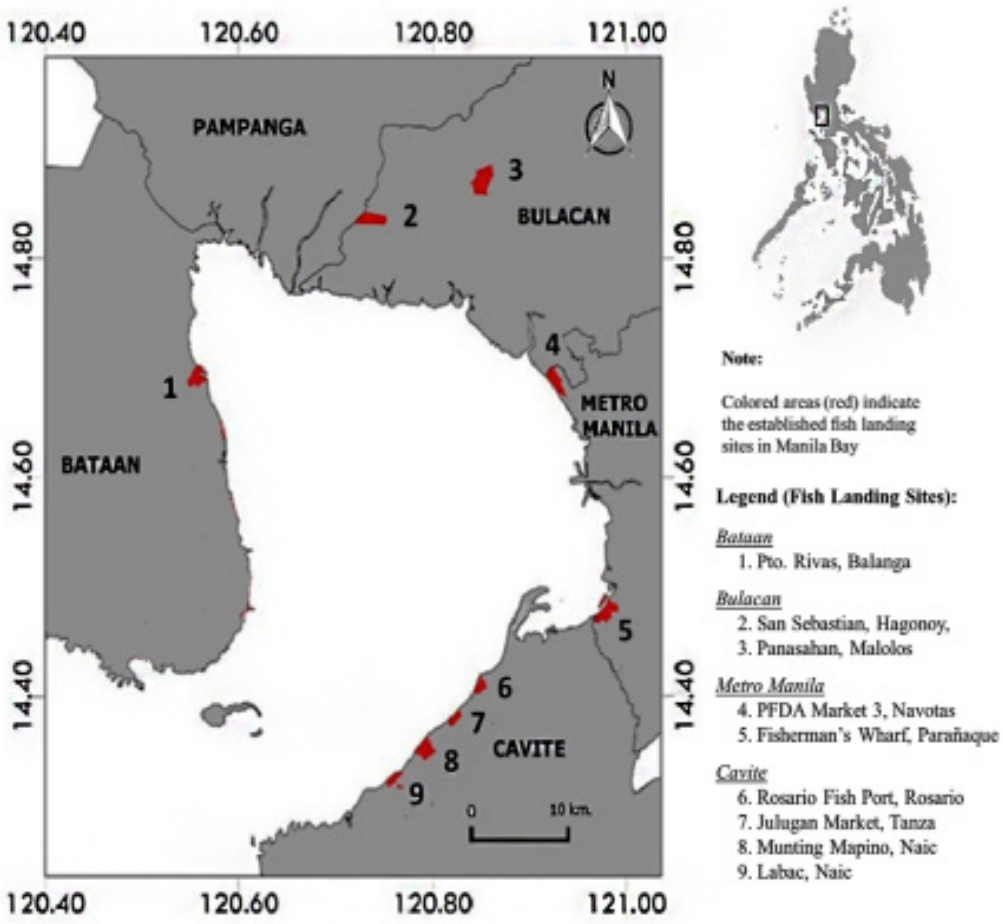

Figure 2.1. Map of Manila Bay Showing the Data Collection Fish Landing Sites.

the entire population per species per day using the weighted value using the formula:

$$Raising\ Factor = \frac{Total\ sample\ weight}{Total\ sub - sample\ weight}$$

$$Raised\ Length\ Frequency = Frequency\ per\ mid - length\ x\ RF$$

The raised length frequencies per species were encoded and processed using the FAO-ICLARM Stock Assessment Tools (FiSAT II) (Gayanilo *et al*., 2005) to estimate growth, mortality, exploitation rate, recruitment pattern, and probabilities of capture for each species. Several routines (e.g. ELEFAN I) incorporated in the software were used to estimate the population parameters:

Growth Parameters Estimation:

Growth parameters were determined first by estimating the initial asymptotic length (L_∞), and the ratio of the total mortality to growth coefficient (Z/K) using Powell-Wetherall method (Gayanilo and Pauly, 1997) based on the equation of Beverton and Holt method (1966), except for *Sardinella fimbriata* wherein the L_∞ value used

in the estimation was from the previous study of BFAR (1995). The initial seed value of L_∞ was further analyzed in ELEFAN I (Electronic Length Frequency Analysis) where the growth constant (k) was estimated from k-scan routine that combines finding the best fitting growth curve. The estimated values of L_∞ and k were visually assessed for progression of modes in the growth curve utilizing the von Bertalanffy Growth Function or VBGF (Pauly, 1982).

Mortality Parameters Estimation:

The mortality parameters (Z, M, and F) and Exploitation Rate (E) were estimated via the Length Converted Catch Curve method (Pauly, 1984) and using a mean annual habitat temperature of 28°C. Z is total instantaneous mortality, M is natural mortality and F is mortality caused by fishing. The instantaneous Total Mortality (Z) was estimated following the formula:

$$Z = M + F$$

Expanding the equation for mortality would lead to the estimation of Exploitation Rate (E) via the following equation:

$$E = \frac{Z}{F}$$

Recruitment Pattern Estimation:

The Annual Recruitment Pattern was determined through a backward projection of the restructured data onto the time axis using the estimated values of L_∞ and k.

Probabilities of Capture Estimation:

Estimation of the Length at First Capture (~equivalent to L_{50}) was derived from probabilities of capture generated from the Length Converted Catch Curve Analysis.

Growth Performance Index Estimation:

The Phi-Prime Index ($Ø'$) was estimated from Growth Performance Index using the $L\infty$ and k values. This was used to compare the growth performance index of species studied with previous estimates in Manila Bay.

RESULTS AND DISCUSSION

Ringnet is one of the major gears that operate in Manila Bay which contributes about 82% of the total landed catch (Figure 2.2). In terms of species composition, *Sardinella gibbosa* was the most dominant comprising about 83% of the ringnet catch followed by *Sardinella fimbriata* (about 12%) and *Rastrelliger brachysoma* (about 2%) (Figure 2.3). These three dominant species are the focus of this study.

Size Frequency Distribution

A total of 17,991 individuals taken from ringnet catches in Manila Bay were measured and analyzed. The minimum and maximum "midlength" sizes of the samples range between 5.75 cm and 18.75 cm out of the 12,607 *Sardinella gibbosa* measured. Majority of the samples collected (14%-17%) had midlength sizes ranging from 12.25 cm to 13.75 cm and the midlength size mode was 13.25 cm. In the case of *Sardinella fimbriata*, a total of 3,561 samples measured with a size range of 9.75 cm-17.75 cm. Most of the samples collected (11%-18%) had midlength size ranging 11.75 cm-13.25 cm. For *Rastrelliger brachysoma*, a total of 1,823 samples were collected with midlength sizes ranging 10.5 cm-27.5 cm. The bulk of the samples collected (10%-12%) had midlength sizes that range from 16.5 cm to 20.5 cm (Figure 2.4).

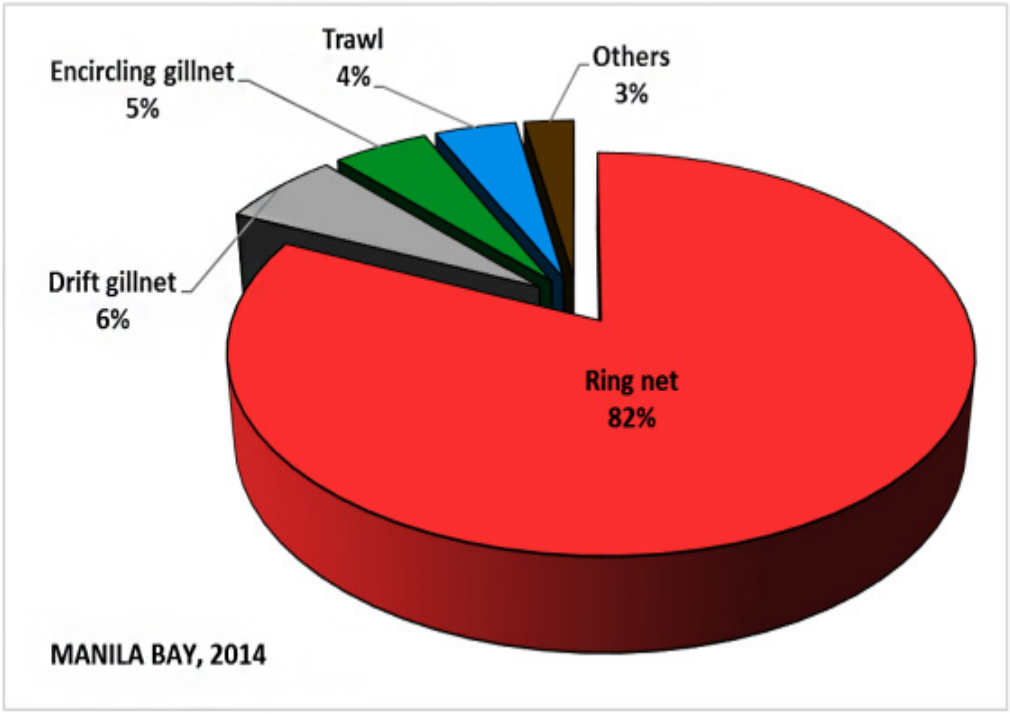

Figure 2.2. Percentage contribution of gears in terms of catch in Manila Bay, 2014.

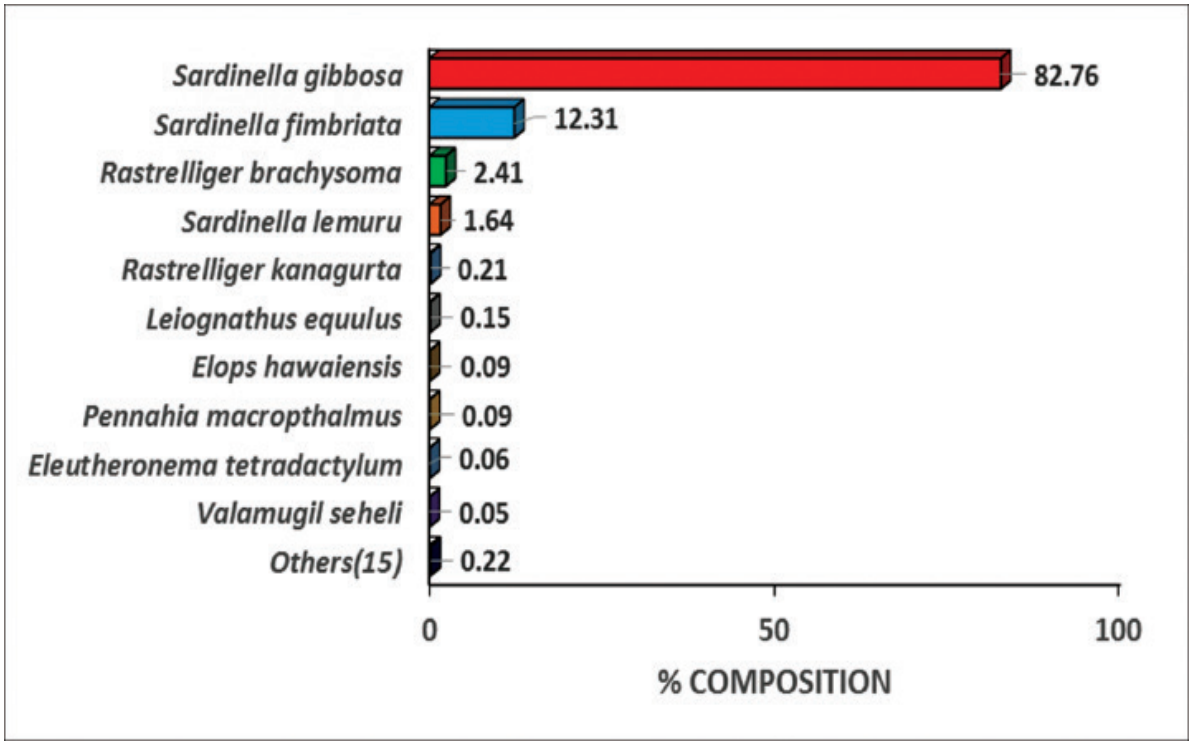

Figure 2.3. Relative abundance of major species caught by ringnet in Manila Bay, 2014.

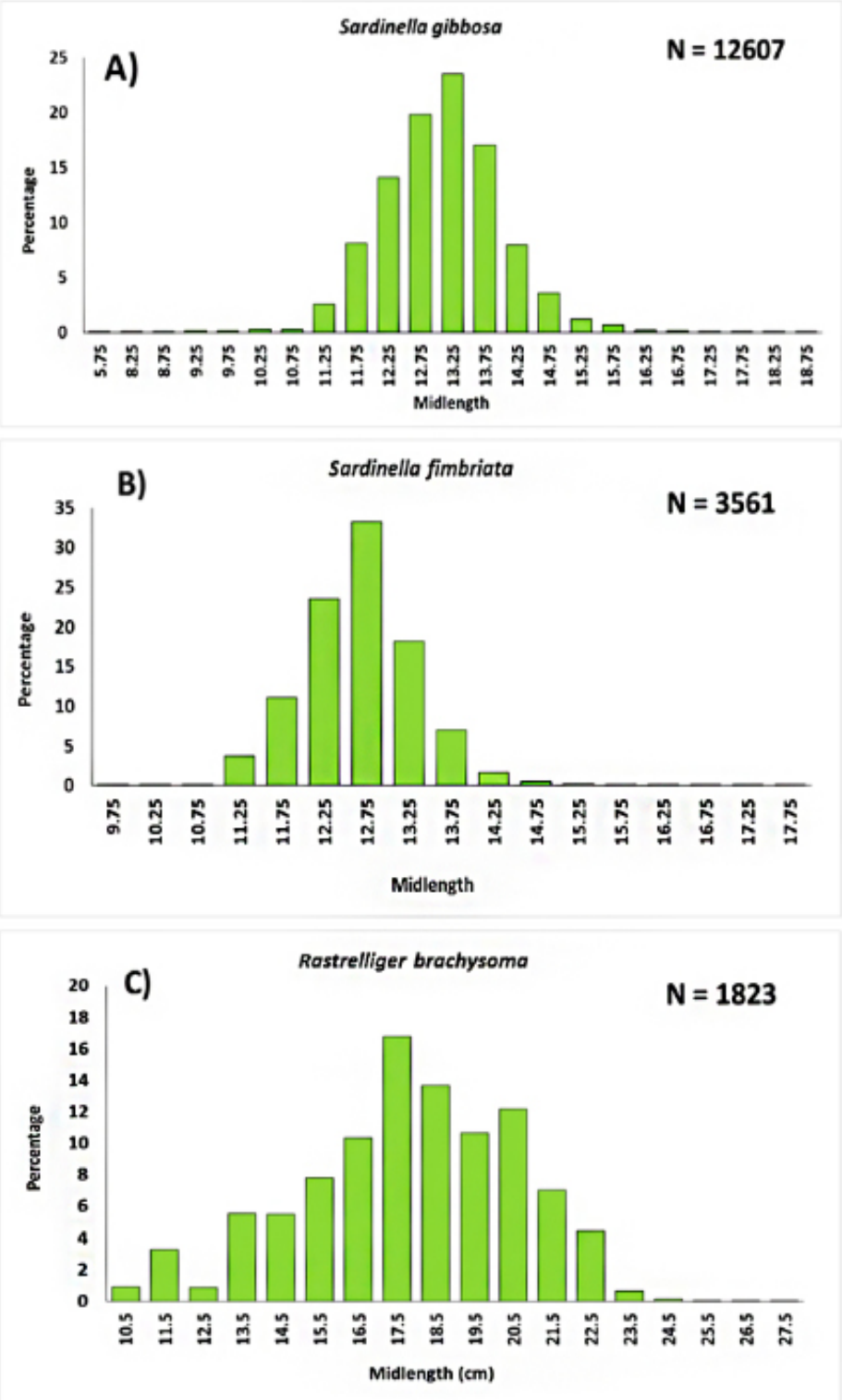

Figure 2.4 Midlength frequency distribution of (A) *Sardinela gibbosa,* (B) *S. fimbriata* and (C) *Rastrelliger brachysoma* caught by ringnet in Manila Bay, 2014.

Growth Parameter Estimates

The comparison of the growth parameter estimates of the three species is shown in Table 2.1. While there is quite a difference in the computed value of $L\infty$ for *Sardinella gibbosa* from Manila Bay (which was smaller at 18.5 cm) against the 20.6 cm from Guimaras Strait, this could be compensated by the growth coefficient (*k*) value of Manila Bay (which was higher at 0.88 cm/year-1) than the value estimated for Guimaras Strait which was only 0.8 cm/year-1. Thus, the growth performance indices (Ø′) are nearly equal at 2.47 and 2.53, respectively. In addition, there is no significant difference in the estimated Lmax values for Manila Bay at 16.84 cm with the 17.0 cm for Guimaras Strait.

In the case of *Sardinella fimbriata*, a slight difference was observed in the growth parameters from this study compared to the previous studies (Ingles et al., 1984 and MADECOR, 1995) however, the performance index (Ø′) values are comparable. The result showed that the *S. fimbriata* from Manila Bay has slower growth rate and much smaller in size compared to the same species from other fishing grounds (i.e. Palawan, Leyte Gulf, Guimaras Strait, and Tayabas Bay).

For *Rastrelliger brachysoma*, the growth performance index (Ø′) value of 3.03 in this study showed no significant difference compared with previous studies. However, the *Lmax* (27.5 cm) and L_∞ (28.7 cm) values are quite lower compared to the previous results in Manila Bay at 34.5 and 34.0, respectively (Ingles et al., 1984). However, the L_∞ result in 1993 was much lower at 24.5 cm (MADECOR, 1995) than this latest study. L_∞ results conducted in other fishing grounds also showed smaller values.

Mortality Parameter Estimates

The mortality parameter values obtained using FiSAT are shown in Table 2.2. The fishing mortality (*F*) values (derived after subtracting *M* to *Z*) of the three species were very high compared to their estimated natural mortality (*M*) indicating a high extraction of these species through fishing. The length at first capture (~L_{50}) for the two sardines were quite similar (*Sardinella gibbosa*, 11.0 cm and *Sardinella fimbriata*, 11.5 cm) but still below the reported length at first maturity of 12.7 cm and 13.8 cm for *S. fimbriata* and *S.gibbosa*, respectively. Although the estimated length at first capture for *Rastrelliger brachysoma* was 17.4 cm. which is above the reported length at first maturity of 17 cm. the estimated fishing mortality is more than twice the estimated rate of natural mortality.

The Exploitation rate

The Exploitation rate (*E*) generally indicate the state of exploitation of a stock via the proportion of fishing mortality rendered alongside that of the natural mortality. Results showed that the three species (*Sardinella gibbosa*, 0.76; *Sardinella fimbriata*, 0.66; and *Rastrelliger brachysoma*, 0.71) already exceeded the desired exploitation value of 0.5. This suggests that these stocks are experiencing overfishing or are being harvested unsustainably (Figure 2.8).

Recruitment Pattern

Recruitment pattern refers to the stage in which a stock enters the fishery. The recruitment pattern for most fish stocks in the Philippines usually generates two pulses per year (Ingles and Pauly, 1984). In this study, the three species in Manila Bay showed a year-round recruitment pattern. *Sardinella gibbosa* has two peaks (bimodal pattern, specifically in February and Septem-

ber (Figure 2.5) while *Sardinella fimbriata* has only one peak ant it was in August (Figure 2.6). On the other hand, *Rastrelliger brachysoma* also showed a bimodal pattern with peaks during April and September (Figure 2.7).

Table 2.1. Comparison of Growth Parameter Estimates for *Sardinella gibbosa, S. fimbriata* and *Rastrelliger brachysoma* by Fishing Ground.

Species	Year	Lmax (cm)	L∞	$K_{(yr^{-1})}$	Ø'	Fishing Ground	Reference
Sardinella gibbosa	1991	17.00	20.60	0.80	2.53	Guimaras Strait	*Fishbase.org*
	2014	16.84	18.50	0.88	2.47	Manila Bay	*This Study, 2014*
Sardinella fimbriata	1959	-	18.00	0.70	2.36	Manila Bay	*Ingles, J.et.al 1984*
	1965	-	22.00	1.15	2.75	Palawan	*Ingles, J.et.al 1984*
	1983-1986	23.75	23.70	0.99	2.75	Leyte Gulf	*Lavapie-Gonzales, et.al 1997*
	1984-1986	20.69	22.30	0.90	2.65	Guimaras Strait	*Lavapie-Gonzales, et.al 1997*
	1987	24.00	24.80	1.20	2.87	Tayabas Bay	*Lavapie-Gonzales, et.al 1997*
	1993	13.00	16.50	0.80	2.34	Manila Bay	*MADECOR, 1995*
	2014	18.04	18.50	0.95	2.51	Manila Bay	*This Study, 2014*
Rastrelliger brachysoma	1978-1979	34.50	34.00	1.10	3.10	Manila Bay	*Ingles, J.et.al 1984*
	1979-1980	-	25.00	1.60	3.00	Samar Sea	*Ingles, J.et.al 1984*
	1981	-	24.50	1.28	2.89	Ragay Gulf	*Corpuz, A., et.al 1985*
	1984-1986	29.50	28.50	1.40	3.06	Guimaras Strait	*Lavapie-Gonzales, et.al 1997*
	1993	34.50	24.50	0.85	2.71	Manila Bay	*MADECOR, 1995*
	2014	27.50	28.7	1.30	3.03	Manila Bay	*This Study, 2014*

Table 2.2. Comparison of Mortality Parameter Estimates, L_{50}, and *E*-values for *Sardinella gibbosa*, *Sardinella fimbriata* and *Rastrelliger brachysoma* by Fishing Ground.

Species	Year	Z (yr^{-1})	F (yr^{-1})	M (yr^{-1})	L_{50} (cm)	E	Fishing Ground	Reference
Sardinella gibbosa	2014	7.82	5.94	1.88	10.96	0.76	Manila Bay	*This Study, 2014*
Sardinella fimbriata	1959	3.38	1.75	1.63	-	0.52	Manila Bay	*Ingles, J.et.al 1984*
	1965	6.56	4.44	2.12	-	0.68	Palawan	*Ingles, J.et.al 1984*
	1983-1986	3.29	1.40	1.89	-	0.43	Leyte Gulf	*Lavapie-Gonzales, et.al 1997*
	1984-1986	2.49	0.71	1.78	-	0.29	Guimaras Strait	*Lavapie-Gonzales, et.al 1997*
	1987	5.30	3.18	2.12	-	0.6	Tayabas Bay	*Lavapie-Gonzales, et.al 1997*
	1995	3.60	1.75	1.85	-	0.49	Manila Bay	*MADECOR, 1995*
	2014	5.86	3.88	1.98	11.52	0.66	Manila Bay	*This Study, 2014*
Rastrelliger brachysoma	1978-1979	4.27	2.43	1.84	-	0.57	Manila Bay	*Ingles, J.et.al 1984*
	1979-1980	9.49	6.93	2.56	-	0.73	Samar Sea	*Ingles, J.et.al 1984*
	1981	6.09	3.93	2.16	-	0.65	Ragay Gulf	*Corpuz, A., et.al 1985*
	1984-1986	4.33	2.08	2.25	-	0.48	Guimaras Strait	*Lavapie-Gonzales, et.al 1997*
	1995	4.96	3.23	1.73	-	0.65	Manila Bay	*MADECOR, 1995*
	2014	7.47	5.32	2.15	17.39	0.71	Manila Bay	*This Study, 2014*

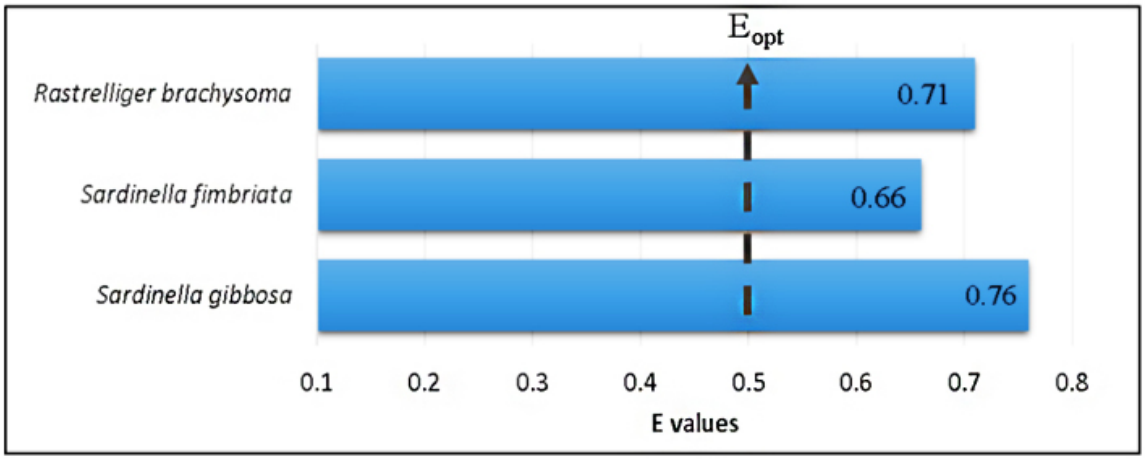

Figure 2.8. Exploitation rate values obtained for *Sardinella gibbossa*, *Sardinella fimbriata*, and *Rastrelliger brachysoma* in Manila Bay, 2014

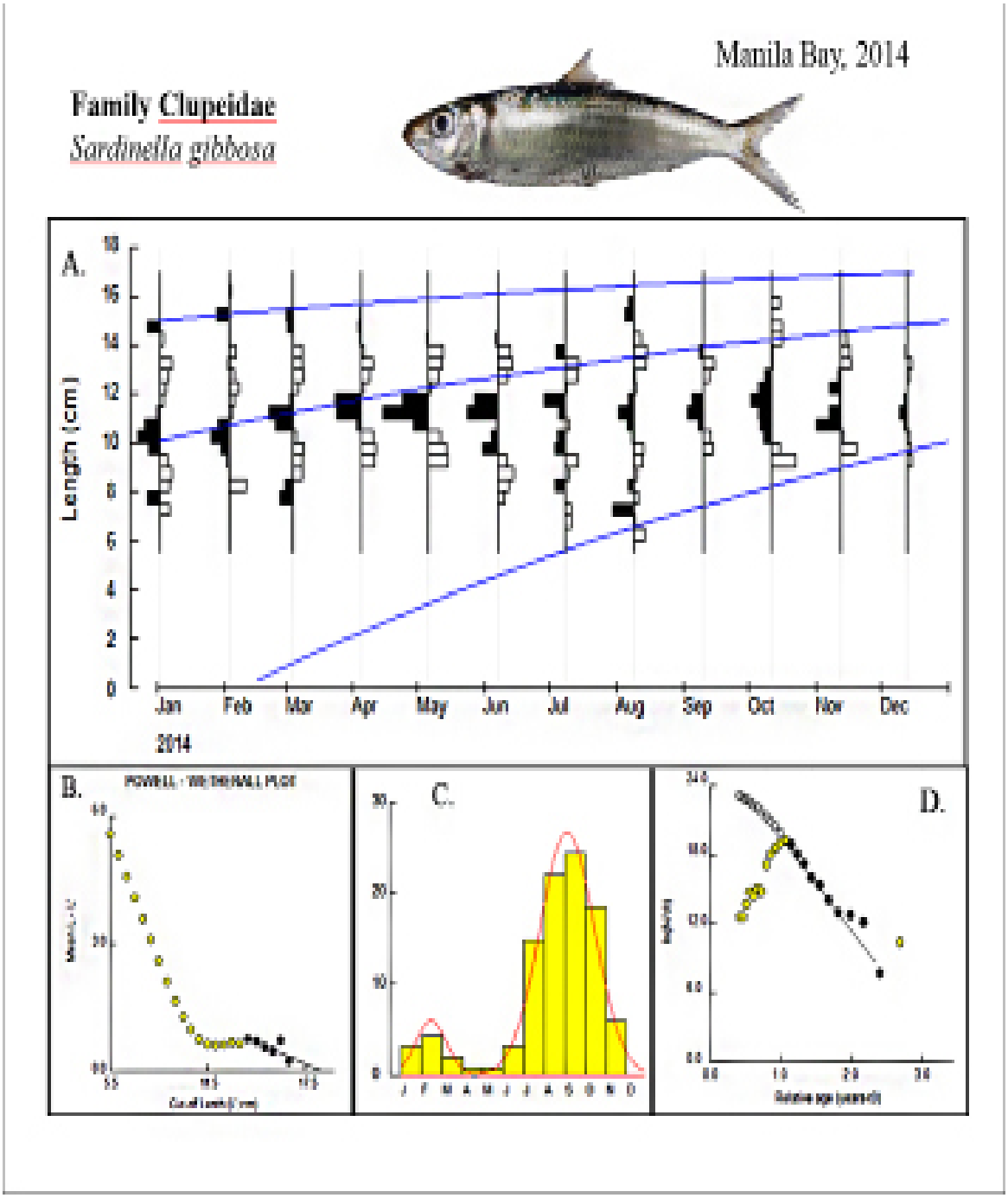

Figure 2.5. Results of analyses using FiSAT II for *Sardinella gibbosa* from Manila Bay, Philippines.
Growth curve superimposed over restructured raised length frequency data;
Powell-Wetherall Plot to estimate $L\infty$ and Z/K value;
Annual Recruitment pattern (bi-modal);
Length-converted catch curve. (See Table 1 and 2 for parameter estimates.)

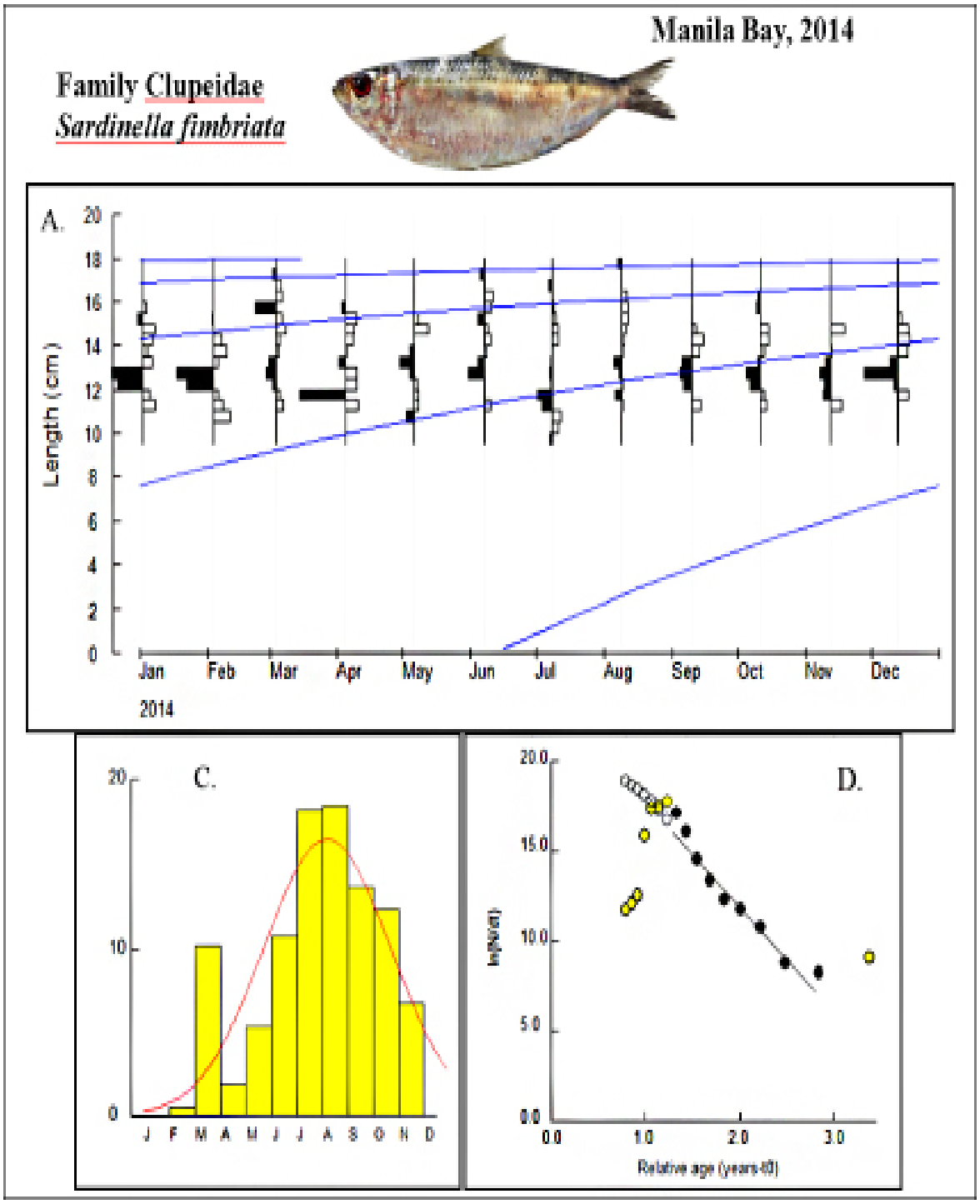

Figure 2.6. Results of analyses using FiSAT II for *Sardinella fimbriata* from Manila Bay, Philippines
Growth curve superimposed over restructured raised length frequency data;
Did not estimate the $L\infty$ ($L\infty$ value used was from the result of BFAR, 1995);
Annual Recruitment pattern (bi-modal);
Length-converted catch curve. (See Table 1 and 2 for parameter estimates.)

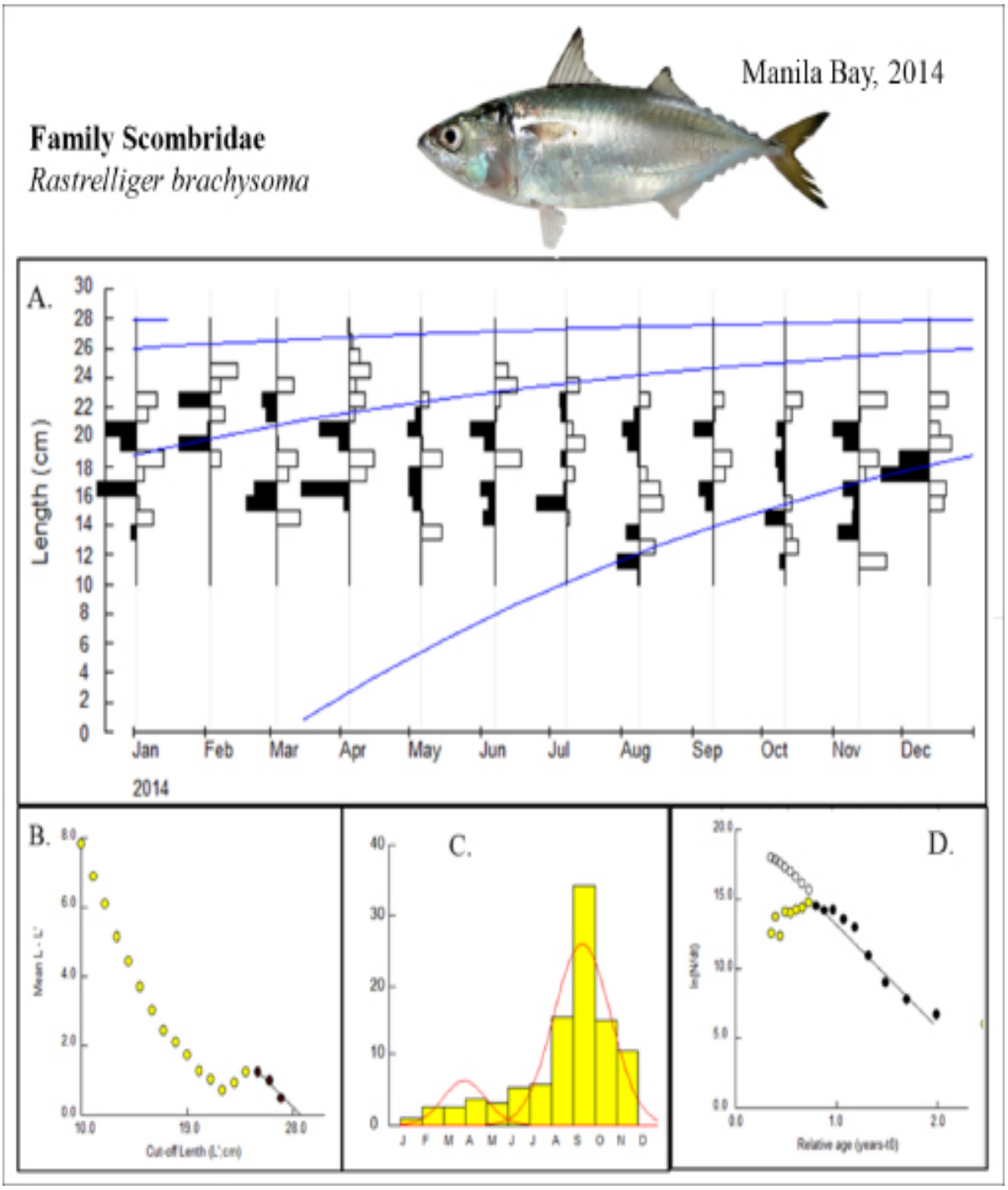

Figure 2.7. Results of analyses using FiSAT II for *Rastrelliger brachysoma* from Manila Bay, Philippines
Growth curve superimposed over restructured raised length frequency data;
Powell-Wetherall Plot to estimate $L\infty$ and Z/K value;
Annual Recruitment pattern (bi-modal);
Length-converted catch curve. (See Table 1 and 2 for parameter estimates.)

REFERENCES

Agasen, E.V. and C.M. Del Mundo 1986. Growth, Mortality and Exploitation Rates of Penaeus indicus in Manila Bay, Philippines and Southeast India. Bureau of Fisheries and Aquatic Resources, Philippines. 89-100p.

Aripin, I.E. and P.A.T. Showers 2000. Population Parameters of small pelagic fishes caught off Tawi-Tawi, Philippines. ICLARM Fishbyte: 21-26p.

BFAR, 1995. Fisheries Sector Program-Resource and Ecological Assessment of Manila Bay. Final Report. Bureau of Fisheries and Aquatic Resources (BFAR), Dept. of Agriculture, Quezon City, Philippines.

Chang, K-H, A. Amano, T. Miller, T. Isobe, R. Maneja, F. Siringan, H. Imai and S-I. Nakano. 2009. Pollution Study in Manila Bay: Eutrophication and Its Impact on Plankton Community. Interdisciplinary Studies on Environ mental Chemistry — Environmental Research in Asia, Eds., Y. Obayashi, T. Isobe, A. Subramanian, S. Suzuki and S. Tanabe, pp. 261–267. TERRAPUB.

Corpuz, A., J. Saeger and V. Sambilay Jr. 1985. Population parameters of commercially important fishes of Philippine waters. Tech. Rep. Dep. Mar. Fish. (6): 1-99.

Dalzell, P. and R.A. Ganaden. 1987. A review of the fisheries for small pelagic fishes in the Philippine waters. BFAR Tech Paper Ser. 10(1):54 p.

Froese, R. and D. Pauly. Editors. 2011. FishBase. World Wide Web electronic publication. www.fishbase.org, (08/2013)

Gayanilo, F.C. Jr., P. Sparre and D. Pauly. 2005. FAO-ICLARM Stock Assessment Tools (FiSAT II) User's Manual. FAO Interna tional Center for Living Aquatic Resources Management (ICLARM), Rome.

Ingles, J. and D. Pauly. 1984. An Atlas of the growth, mortality and recruit ment of Philippine fishes. ICLARM Technical Reports 13, 12p. Institute of Fisheries Development and Research, College of Fisheries, Univ. of the Philippines in the Visayas, Q.C., Phil. and International Center for Liv ing Aquatic Resources Managment, Manila, Phil.

Jabat, M. and P. Dalzell. 1988. Preliminary stock assessment of the Davao ring net fishery for bullet tunas and small pelagic fishes in the Camotes Sea, Central Visayas, Philippines. BFAR Tech. Pap. 11(1)34p.

Lavapie-Gonzales, F., S.R. Ganaden and F.C. Gayanilo, Jr. 1997. Some Population parameters of commercially important fishes in the Philippines. Bureau of Fisheries and Aquatic Resources, Philippines, 114p.

Lopez, G., F. Gonzales, F. Torres Jr., E. Bognot, E. Jaen, A. Bendaño, and M. Santos. Resource and Biological Assessment of Commercially Important Finfishes in Manila Bay. Annual Report (January – December 2013) Submitted to BFAR.

Madecor and National Museum, 1995, Resources and Ecological Assessment of Manila Bay. Final Report (244p.). Fisheries Sector Program. Bureau of

Fisheries and Aquatic Resources, Department of Agricultures. Quezon City Philippines.

Marshall, B.E., 1993. The biology of the African Clupeid Limnothrisa miodon with special reference to its small size in artificial lakes. Rev. Fish Biol., 3: 14-22.

Munoz, J. 1991. Manila Bay: Status of its fisheries and management. Marine Pollution Bulletin 23:311-214, Dec. 1991.

PEMSEA and MBEMP TWG-RRA. 2004. Manila Bay: Refined Risk Assessment. PEMSEA Technical Report No. 9, 169 p.

Ronquillo, IA, Caces-Borja, P and A Mines (1960) Preliminary observations on the otter trawl fishery of Manila Bay. Philippine Journal of Fisheries 8(1):47-56.

Ronquillo I. A., M.E. GabralLlana and J.C. Muñoz, 1989. The Proposed 20km ban on trawl and purse seine fishing: A Deterrent to National Economic Recovery. Fish.Res. J. Philipp. 14(1-2): 37 – 48.

Su, G.S., K.J. Martillano, T.P. Alcantara, E. Ragragio, J. de Jesus, A. Hallare and G. Ramos. 2009. Assessing Heavy Metals in the Waters, Fish and Macroin vertebrates in Manila Bay, Philippines. Journal of Applied Sciences in Environmental Sanitation, vol. 4, No. 3: 187-195, Sept-Dec, 2009. ISSN 0126-2807.

Youngs, W.D. and D.S. Robson, 1978. Estimation of Population Number and Mortality Rates. In: Methods for Assessment of Fish Production in Freshwaters. T.B. Bevgenal, (Ed.). 3rd Edn. Blackwell Scientific Publications, London, pp: 137-164.