
REPRODUCTIVE BIOLOGY OF COMMON SMALL PELAGIC FISHES IN MANILA BAY, PHILIPPINES

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ABSTRACT

Reproductive biology of the three dominant species (*Sardinella gibbosa*, *Sardinella fimbriata*, and *Rastrelliger kanagurta*) were studied in Manila Bay from January 2014 to December 2015. The data were collected from landed catch (coming from gillnet, lift net, purse seine, ringnet, and trawl) and during the actual trawl fishing survey. A total of 2,383 *Sardinella gibbosa*, 2,334 *Sardinella fimbriata*, and 549 *Rastrelliger kanagurta* were analyzed by pooling the two years data. The overall female to male ratio conformed to the expected 1:1 sex ratio. These species spawn throughout the year with major peak in March and April and minor peak in October to December for *Sardinella gibbosa*; with major peak in February to May and minor peak in October to December for *Sardinella fimbriata*; and for *Rastrelliger kanagurta*, with major peak in October to December and minor peak in May and June. The GSI values correlate with the maturation of the gonads of these species. The length at maturity (Lm_{50}) was calculated at 12.75 cm in males and 13.25 cm in females for *S. gibbosa*; 12.25 cm in males and 12.75 cm in females for *S. fimbriata*; and 25.5 cm in males and 24.5 cm in females for *R. kanagurta*.

Keyword:

I NTRODUCTION

Manila Bay, one of the traditional fishing grounds in the Philippines, has a multi-gear, multi-species fishery. It is also one of the busiest national and international ports of the country. Previous studies reported the Bay to be abundant in demersal fishes and invertebrates (Ronquillo *et al.*, 1960; Ronquillo *et al.*, 1989; BFAR, 1995) however, recent studies already showed a shift in species dominance to pelagic species (Zaragosa, 2005; Lopez *et al.*, 2012, annual report). Sardines and mackerels are presently the most abundant catch in Manila Bay specifically, *Sardinella gibbosa* (Goldstripe sardinella), the most dominant, followed by *Sardinella fimbriata* (Fringescale sardinella) then, *Rastrelliger kanagurta* (Indian mackerel) (Lopez *et al.*, 2014). The sardines' peak of productivity and spawning in Philippine water soften occur during southwest monsoon (Dalzell *et al.*, 1990; Olaño *et al.*, 2009) while in the Visayan Sea it occurs in October, November, and December (Mesa, 2014).

Understanding the fish reproductive biology is very important for fish culture and for science-based fishery management. It is the reproductive success that allows a species to persist thus, it is vital to any population (Gervasi, 2015). Species like *R. kanagurta* (Indian mackerel) is a prolific breeder utilizing favorable environmental conditions i.e. suitable temperature and availability of food for spawning (Yohannan and Abdurahiman, 1998 as cited by Zaki *et al.*, 2016). Maturity is reached in two to three years for many Philippine sardine species but, as little as one year for some *Sardinella* species (as cited by Willette *et al.*, 2011).

Fish have developed reproductive strategies and traits that ensure their survival under variable and often unfavorable conditions (cited by Tsikliras and Antonopoulou, 2006), expressed by certain characteristics. This study is important in order to understand the reproductive sta-

tus of the three selected species (*Sardinella gibbosa*, *S. fimbriata*, and *Rastrelliger kanagurta*) especially with the rapid fish exploitation combined with the present poor water quality of Manila Bay. Different reproductive parameters such as Gonadosomatic Index (GSI), sex ratio, length at maturity ($L_{m_{50}}$), and spawning season were investigated to provide scientific advice for the proper management of these fish resources in Manila Bay.

M ATERIALS AND METHODS

A total of 2,383 *Sardinella gibbosa*, 2,334 *Sardinella fimbriata*, and 549 *Rastrelliger kanagurta* were collected for two years (January 2014 to December 2015) from landed catch in selected fish landing sites and during the actual trawl fishing surveys conducted in Manila Bay (Figure 4.1). The fish samples (Figure 4.2) were collected at random from gillnet, liftnet, purse seine, ringnet and trawl for the *Sardinella* species, and from gillnet and ringnet for the *Rastrelliger kanagurta*. Before dissection, the total length (cm) and weight (g) of the fish were taken first. Dissection was done by opening the abdominal cavity to determine the sex and degree of gonad maturity through visual examination of the gonad in fresh individuals. The gonads were removed (particularly stages II to IV) and weighed to the nearest 0.01 g. The data were analyzed by pooling 2014 & 2015 data.

Sex Ratio

The proportion of the two sexes relative to one another was used to calculate the sex ratio. The sex ratio values obtained every month were subjected to chi-square (X^2) analysis to test the significant deviations from an expected 1:1 sex ratio for male and female fishes by employing the formula:

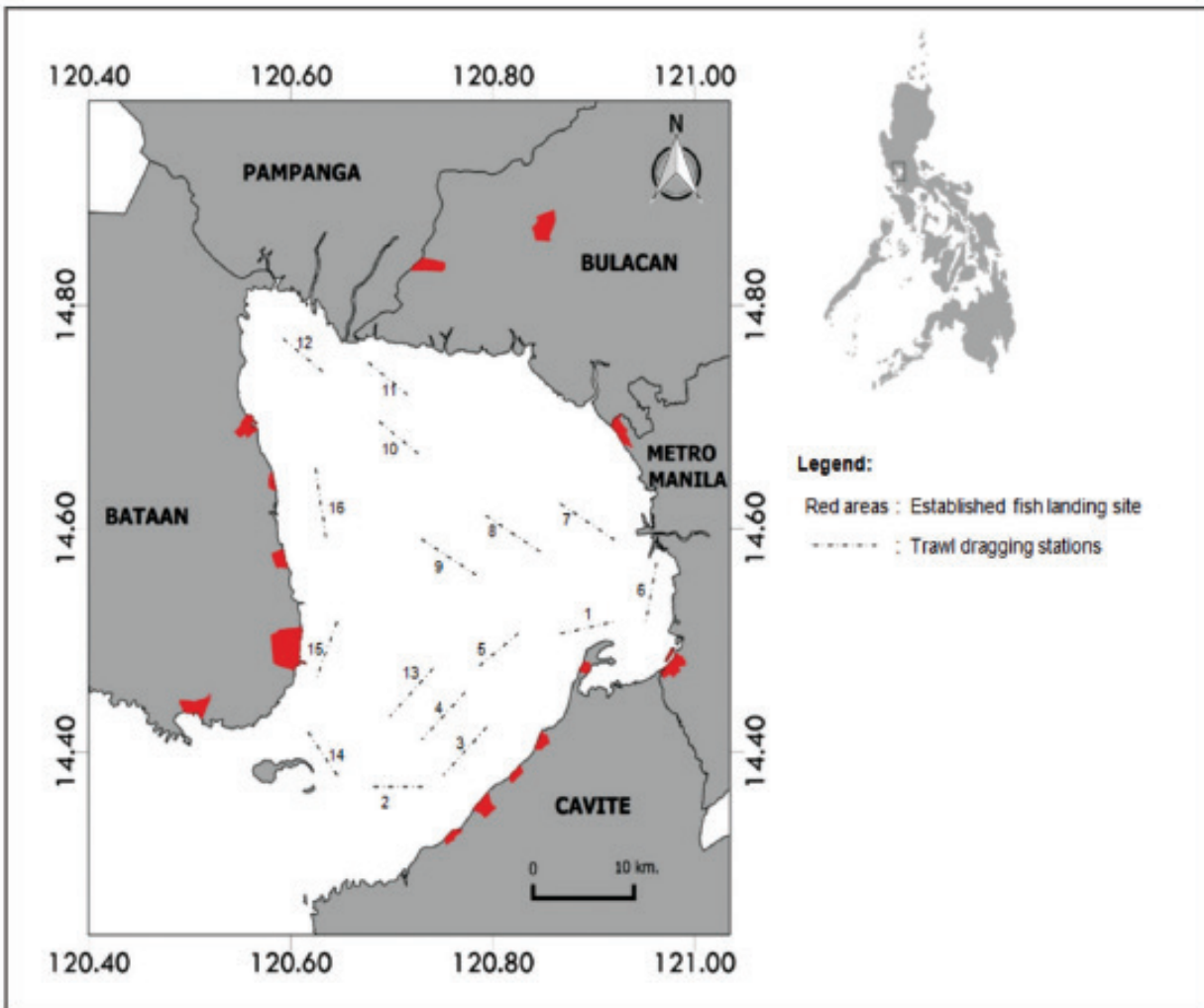


Figure 4.1. Data Collection Sites in Manila Bay, Philippines.

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

Where O is the observed frequency and E is the expected frequency.

Gonad Maturity Determination and Spawning Season

The degree of gonad maturity stages was determined by visual examination of the female gonads based on the five-point gonad maturity scale of Holden & Raitt (1974) (Table 4.1). Seasonal distribution of gonads by maturity stages

was determined monthly and the overall percentage frequencies observed were used to indicate the seasonal distribution of the gonad maturity stages. The average duration for the spawning season was identified as the time when at least 50% of the adult population has reached maturity.

Gonadosomatic index

Gonadosomatic index (GSI) gives an indication of the percentage of the fish weight used in egg production. Only female gonads in stage

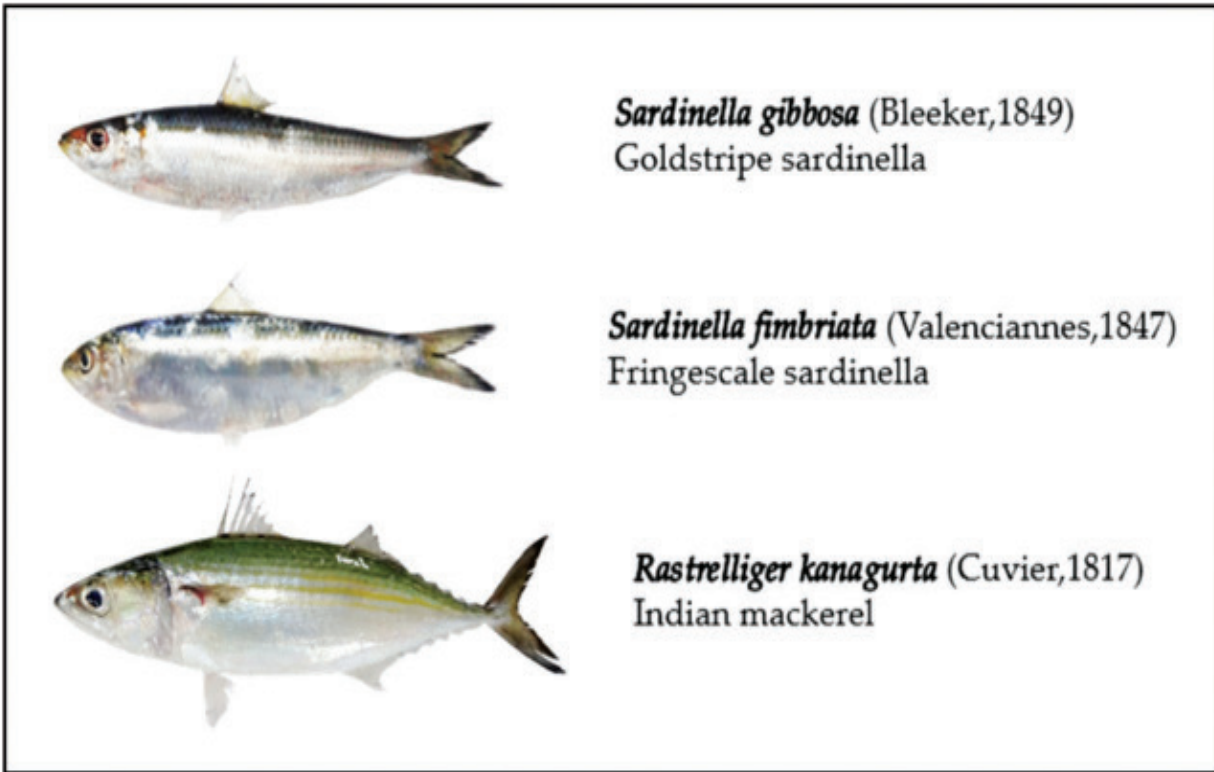


Figure 4.2. Common Small Pelagic Fishes in Manila Bay.

IV (mature/spawning) were used in the analysis to verify the strength of spawning during the biological months. The GSI was computed as follows:

$$\text{GSI} = \frac{\text{Gonad weight}}{\text{Body weight}} \times 100$$

Length at Maturity (Lm_{50})

Gonads in stages III and IV were considered sexually mature. They were used to determine the length at 50% maturity (Lm_{50}). The frequency of occurrence of samples having mature gonads was plotted against the length class of 0.5 cm interval for *Sardinella* species and 1.0 cm interval for *Rastrelliger kanagurta*. The Lm_{50} was deduced from the size class at which the cumulative maturity percentage is 50% mature (Ekokotu and Olele, 2014).

RESULTS AND DISCUSSION

A total of 1,204 (50.52%) female & 1,179 (49.48%) male *Sardinella gibbosa*; 1,275 (54.62%) female & 1,059 (45.37%) male *Sardinella fimbriata*; and 272 (53.15%) female & 257 (46.85%) male *Rastrelliger kanagurta* were collected for two years. The size of the female *Sardinella gibbosa* ranged from 8.0-17.6 cm while the male ranged from 8.1-17.5 cm. For *Sardinella fimbriata*, the size of the female ranged from 7.5-19.0 cm while the male ranged from 7.9-16.5 cm. In the case of *Rastrelliger kanagurta*, the size of the female ranged from 11.3-29.9 cm while the male ranged from 11.5-29.9 cm.

Table 4.1. Five-point gonad maturity scale (Holden & Raitt, 1974).

Stage	Classification	Description	
		Testis	Ovary
I	Immature/Virgin	Testis is very small close under vertebral column about 1/3 of the body cavity; transparent, colourless to grey.	Ovary is very small close under vertebral column about 1/3 of the body cavity; transparent, colourless to grey; Eggs invisible to naked eyes.
II	Maturing virgin/ Recovering spent	Testis translucent, grey-red or empty (recovering spent). Length is 1/2 or slightly more than half the length of ventral cavity.	Ovary translucent, grey-red, Length is 1/2 or slightly more than half the length of ventral cavity. Individual eggs can be seen with magnifying glass, and or A few eggs in the state of resorption (recovering spent).
III	Developing/ Developed	Testis opaque, reddish-white with blood capillaries, occupy about half to 2/3 of ventral cavity. No milt drops appear under slight pressure (developed).	Ovary opaque, orange-reddish with blood capillaries, occupy about half to 2/3 of ventral cavity. Eggs clearly visible to naked eyes as whitish granular. Eggs clearly discernible & opaque (developed).
IV	Mature/ Spawning	Testis filling ventral cavity. Testis is white, milt run with slight pressure. Milt run with slight pressure (spawning).	Ovary filling ventral cavity. Eggs completely round, some already translucent and ripe. Most eggs translucent with few opaque eggs left in ovary (spawning).
V	Spent	Testis shrunken to about 1/2 length of body cavity; wall loose. Not yet fully empty. Testis blood shot and flabby.	Ovary shrunken to about 1/2 length of body cavity; wall loose. Not yet fully empty; Ovary may contain remnants of disintegrating opaque and ripe ova, darkened or translucent.

Sex Ratio

Females usually outnumbered males in the collected fish samples in Manila Bay. The ratio between female and male ranged from 1:1 to 1:1.63 for *Sardinella gibbosa*, 1.09:1 to 1.67:1 for *S. fimbriata*, and 1:1 to 2.13:1 for *Rastrelliger kanagurta*. Monthly sex ratio significantly departed from the expected 1:1 ratio in the months of April and September for *S. gibbosa*; during April, May, July and August for *S. fimbriata*; and during February, May, and June for *R. kanagurta* ($P < 0.05 = 3.84$). During these months, the females significantly outnumbered the males except for *S. gibbosa* in April, which was the other way around. However, the overall female to male sex ratio was 1.02:1, 1.2:1, and 1.13:1, respectively. An overall balanced sex ratio (Table 4.2) was observed in this study, which is in agreement with the results of other related studies (Kudale and Rathod, 2016; Arrafi et al., 2015;).

Spawning Season

Monthly observation of the gonad maturity stages of the female gonads of *Sardinella gibbosa*, *S. fimbriata*, and *Rastrelliger kanagurta* from 2014-2015 shows varying gonadal maturity level indicating that they tend to spawn as partial spawners and thus spawn throughout the year. A similar result was also observed in other related studies (Bhendarkar et al., 2013; Jufaili, 2012). The prolonged spawning may be associated with the availability of planktonic prey (Chang et al., 2009, Jose et al., 2015) and Manila Bay's zooplankton biomass and composition may possibly influence the seemingly untiring spawning behavior of these species in the bay. Mature/spawning male and female (Stage IV) species were recorded in most months with two spawning peaks. For *Sardinella gibbosa*, the major spawning peak occurred in March and April and the minor spawning peak in October to December. For *Sardinella fimbriata*, the major peak occurred

in February to May and the minor spawning peak in October to December. In the case of *Rastrelliger kanagurta*, the females were dominant during the minor spawning (May & June) but were replaced by the males during the major spawning (October to December) (Figure 4.4).

Table 4.2. Monthly variation in sex ratio of *Sardinella gibbosa*, *S. fimbriata*, and *Rastrelliger kanagurta* in Manila Bay Philippines (pooled data C.Y: 2014-2015)

Months	<i>Sardinella gibbosa</i>					<i>Sardinella fimbriata</i>					<i>Rastrelliger kanagurta</i>				
	♀	♂	Total	F:M	Chi square Value	♀	♂	Total	F:M	Chi square Value	♀	♂	Total	F:M	Chi square Value
January	113	87	200	1.3:1	3.38	105	95	200	1.11:1	0.50	30	20	50	1.5:1	2.00
February	108	92	200	1.17:1	1.28	113	87	200	1.3:1	3.38	33	17	50	1.94:1	5.12
March	101	99	200	1.02:1	0.02	81	74	155	1.09:1	0.32	12	13	25	1:1.08	0.04
April	76	124	200	1:1.63	11.52	119	81	200	1.47:1	7.22	23	27	50	1:1.17	0.32
May	107	93	200	1.15:1	0.98	122	78	200	1.56:1	9.68	21	10	31	2.1:1	4.84
June	91	92	183	1:1.01	0.01	92	108	200	1:1.17	1.28	34	16	50	2.13:1	6.48
July	110	90	200	1.22:1	2	125	75	200	1.67:1	12.50	27	22	49	1.23:1	0.51
August	107	93	200	1.15:1	0.98	110	69	179	1.59:1	9.39	30	20	50	1.5:1	2.00
September	116	84	200	1.38:1	5.12	108	92	200	1.17:1	1.28	25	25	50	1:1	0.00
October	88	112	200	1:1	2.88	105	95	200	1.11:1	0.50	19	31	50	1:1.63	2.88
November	88	112	200	1:1	2.88	109	91	200	1.2:1	1.62	18	32	50	1:1.78	3.92
December	99	101	200	1:1	0.02	86	114	200	1:1.33	3.92	23	27	50	1:1.17	0.32
Total	1204	1179	2383	1.02:1	0.02	1275	1059	2334	1.2:1	1.67	295	260	555	1.13:1	0.19
* P <0.05 = 3.84															

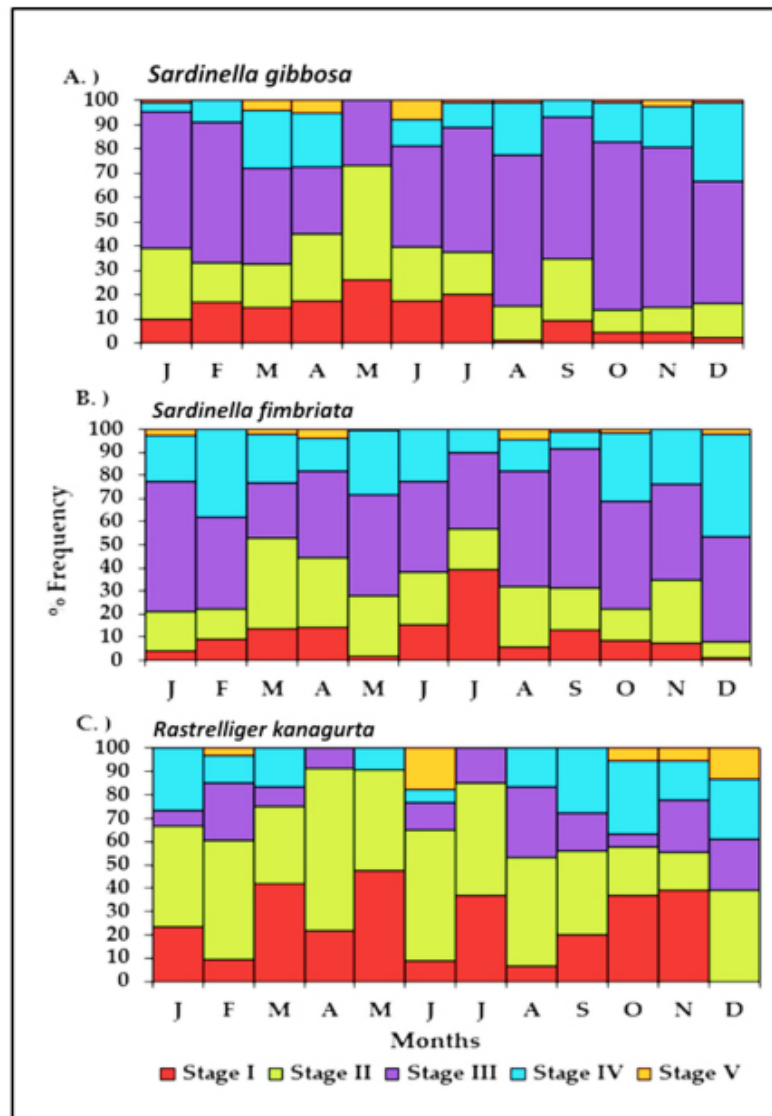


Figure 4.3. Monthly Distribution of Gonad Maturity Stages of female *Sardinella gibbosa*, *S. fimbriata*, and *Rastrelliger kanagurta* in Manila Bay (2014-2015).

Gonado Somatic Index (GSI)

The monthly mean GSI values of the three species ranged from 3.29 (+ 1.94) to 7.30 (+ 4.22) for *Sardinella gibbosa*, with the lowest GSI value recorded in January and the highest in March; 2.80 (+ 1.57) to 16.72 (+ 9.13) for *Sardinella fimbriata*, with the lowest GSI value recorded in September and the highest in May; and 2.66 (+ 1.89) to 8.10 (+ 9.84) for *Rastrelliger kanagurta*,

with the lowest GSI value recorded in March and August and the highest in October. GSI values showed correlation with the maturation of gonads of these species (Figure 4.5).

Length at Maturity (Lm_{50})

The collected female fish with mid-length 9.25 cm and less (*Sardinella gibbosa*), with

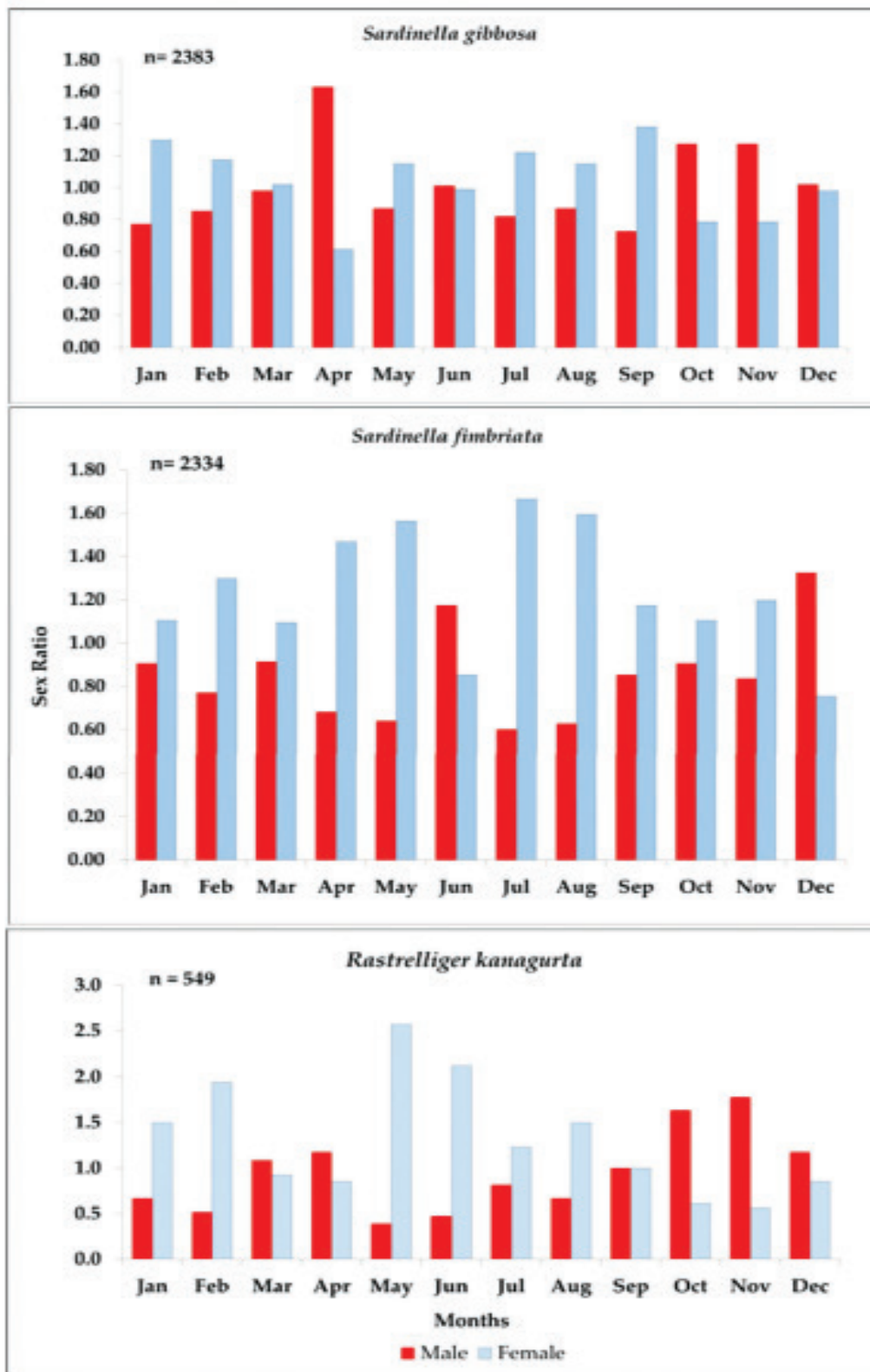


Figure 4.4: Monthly variation in sex ratio of *Sardinella gibbosa*, *S. fimbriata* & *Rastrelliger kanagurta* in Manila Bay, 2014-2015.

mid-length 9.75 cm and less (*Sardinella fimbriata*), and with mid-length 12.5 cm and less (*Rastrelliger kanagurta*) were immature (gonads in Stages I and II) (Figure 4.6). The smallest mature female and male for *Sardinella gibbosa* were at 9.5 cm and 11.1 cm, respectively, 10.4 cm and 9.3 cm for *Sardinella fimbriata*, and 17.2 cm and 22.3 cm for *Rastrelliger kanagurta*. High frequencies of mature/spawning

stage were observed at mid-length size ranges of 13.25-13.75 cm (22%), 12.75-13.25 cm (22%), and 26.5-27.5 cm (31%), respectively. The length at 50% maturity (Lm_{50}) was calculated at 13.25 cm in females and 12.75 cm in males for *S. gibbosa*; 12.75 cm in females and 12.25 cm in males for *S. fimbriata*; and 24.5 cm in females and 25.5 cm in males for *R. kanagurta* (Figure 4.7, Table 4.3)

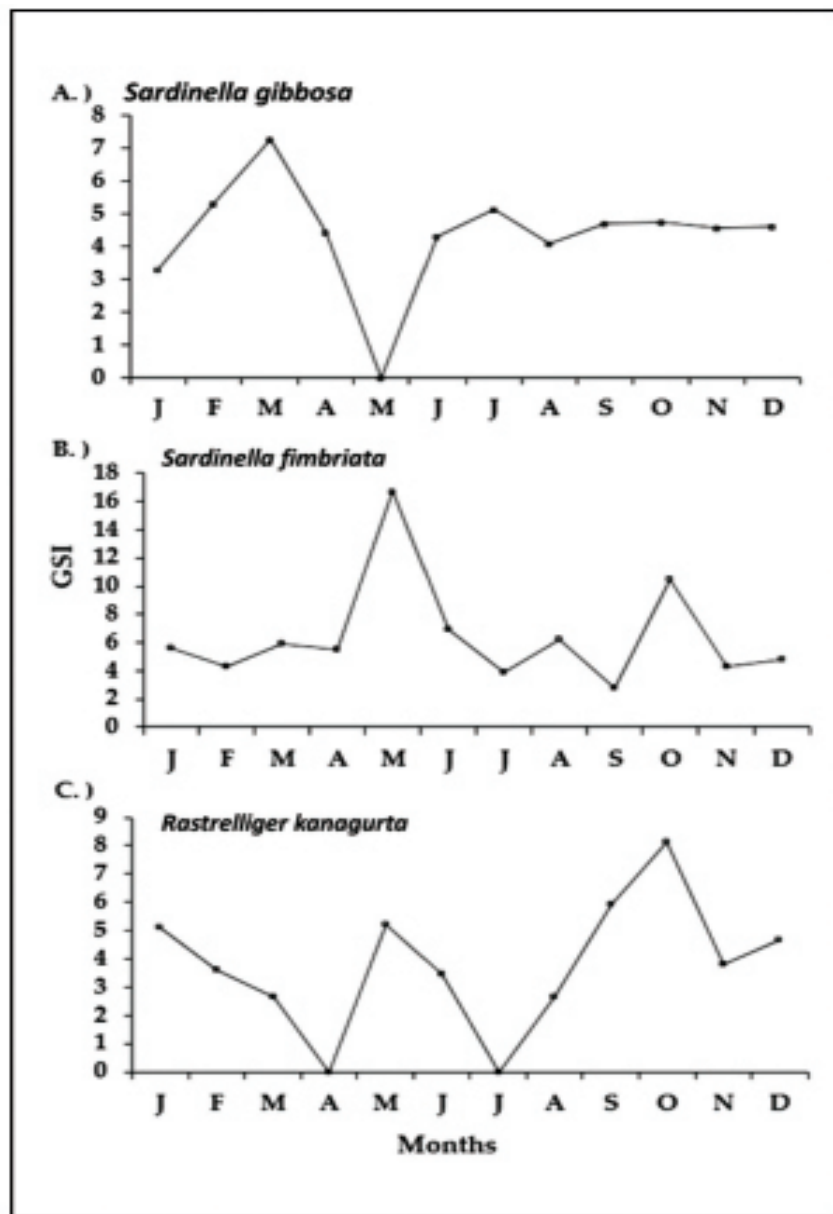


Figure 4.5. Monthly Gonadosomatic Index of Female (FIV) *Sardinella gibbosa*, *S. fimbriata*, and *Rastrelliger kanagurta* in Manila Bay (2014-2015).

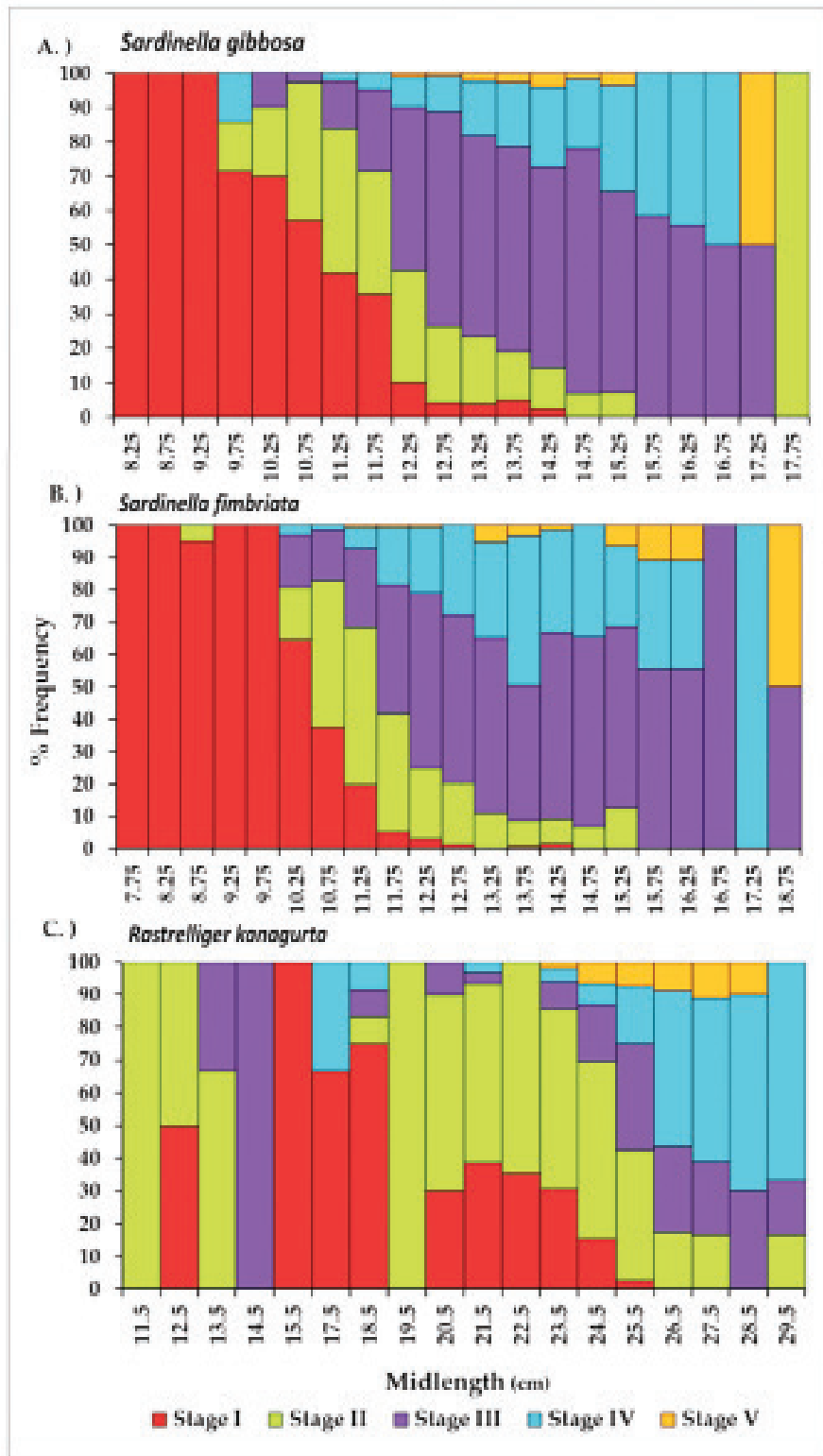


Figure 4.6. Length distribution by maturity stages of Female: *Sardinella gibbosa*, *S. fimbriata*, and *Rastrelliger kanagurta* in Manila Bay, 2014-2015).

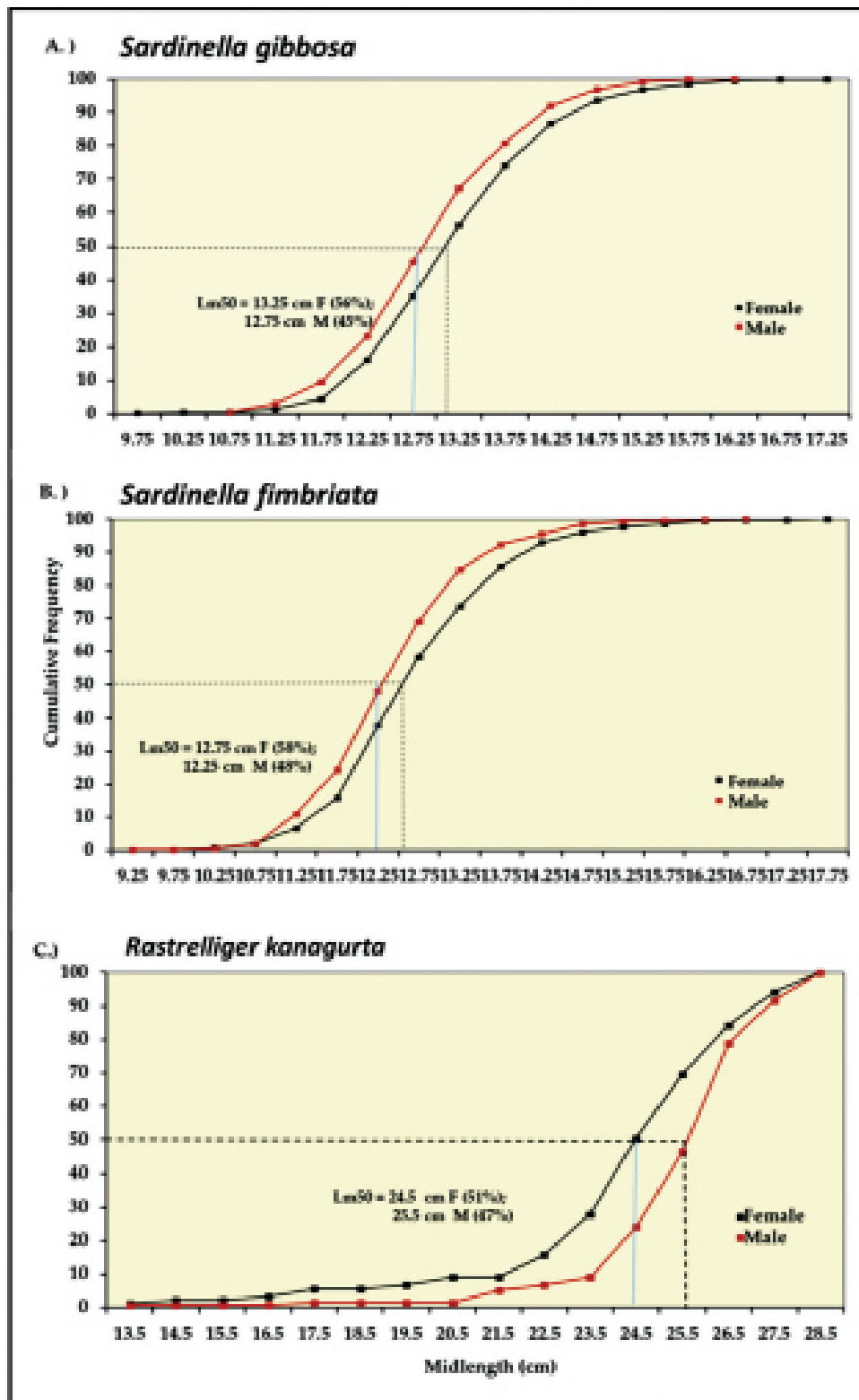


Figure 4.7. Cumulative Frequency of Length at First Maturity (L_{m50}) of Female and Male Dominant Species in Manila Bay (2014-2015).

Table 4.3. Cumulative Percentage of Female and Male *Sardinella gibbosa*, *S. fimbriata*, and *Rastrelliger kanagurta* in Manila Bay (2014-2015).

<i>Sardinella gibbosa</i>				<i>Sardinella fimbriata</i>				<i>Rastrelliger kanagurta</i>			
Size group	Midlength (cm)	Cumulative (%)		Size group	Midlength (cm)	Cumulative (%)		Size group	Midlength (cm)	Cumulative (%)	
		♀	♂			♀	♂			♀	♂
9.5-10	9.75	0	—	9-9.5	9.25	—	0	13-14	13.5	1	1
10-10.5	10.25	0	—	9.5-10	9.75	—	0	14-15	14.5	2	1
10.5-11	10.75	1	0	10-10.5	10.25	1	1	15-16	15.5	2	1
11-11.5	11.25	1	3	10.5-11	10.75	2	2	16-17	16.5	3	1
11.5-12	11.75	4	9	11-11.5	11.25	7	11	17-18	17.5	6	2
12-12.5	12.25	16	23	11.5-12	11.75	16	24	18-19	18.5	6	2
12.5-13	12.75	35	45	12-12.5	12.25	38	48	19-20	19.5	7	2
13-13.5	13.25	56	67	12.5-13	12.75	58	69	20-21	20.5	9	2
13.5-14	13.75	74	81	13-13.5	13.25	74	85	21-22	21.5	9	5
14-14.5	14.25	87	92	13.5-14	13.75	86	92	22-23	22.5	16	7
14.5-15	14.75	94	97	14-14.5	14.25	93	96	23-24	23.5	28	9
15-15.5	15.25	97	99	14.5-15	14.75	96	99	24-25	24.5	51	24
15.5-16	15.75	98	100	15-15.5	15.25	98	99	25-26	25.5	70	47
16-16.5	16.25	100	100	15.5-16	15.75	99	100	26-27	26.5	84	79
16.5-17	16.75	100	—	16-16.5	16.25	100	100	27-28	27.5	94	92
17-17.5	17.25	100	—	16.5-17	16.75	100	100	28-29	28.5	100	100
				17-17.5	17.25	100	—				
				17.5-18	17.75	100	—				

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