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Mesh size selectivity of boat seine and stationary lift net for catching anchovy and white sardine in Sorsogon Bay, Philippines

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Abstract
In the Philippines, fishing for naturally small-sized species is an open-access fishery and guidance for harvesting is still unavailable. The study was aimed to determine the suitable capture size and the appropriate mesh size for sustainable exploitation of anchovy *Stolephorus* spp. and white sardine *Escualosa thoracata* resources in Sorsogon Bay. By use of boat seine and stationary lift net, the study examined the efficiency of square mesh sizes employed (8, 12 and 16 mm). Population parameters on length at first maturity (Lm) and length at maximum possible yield (Lopt) for *Stolephorus commersonii* were calculated at 7.1 and 6.4 cm while for *E. thoracata* at 7.9 and 7.2 cm, respectively. Selectivity parameters were estimated following the methods of Jones (1976) to obtain probability retention lengths. The resulting selectivity of boat seine at 50% retention length (L50) for anchovy was estimated at 2.94, 5.0 and 5.96 cm for the mesh sizes of 8, 12 and 16 mm, respectively. Also, white sardine was estimated at 2.63, 3.77 and 7.16 cm for the mesh sizes of 8, 12 and 16 mm, respectively. By correlating the relationship of ideal size at first capture (Lopt) along with L50, 16 mm was determined as the corresponding best mesh size for sustainable fishing of relatively adult-sized anchovy and white sardine resources.

Keywords: selectivity, anchovy, sustainable exploitation, boat seine, stationary lift net.

Introduction
In the Philippines, fishing for naturally small-sized species is a traditional practice that involve the use of fine meshed nets and has been exempted from the prevailing minimum mesh size regulation of 3 cm. Specialized fisheries targeting post larvae or early juveniles of various aquatic species are commonly exploited using a wide variety of fishing gears and methods that are locally marketed and exported as delicacies. Some of the well-known species include goby fry (tabios, ipon or sinarapan), Stolephorid anchovy (dulong or lobo-lobo) and rabbit fish (danggit or kuyog). Also, the collection of fry from the wild (i.e., the wild seed fishery) as stocking materials for aquaculture is also prevalent in municipal waters under the management of the Local Government Units (LGUs) with the enactment of the Local Government Code in 1990 (Republic Act 7160). Local fishery ordinance concerning mesh size regulation has been adapted from the prescribed legal minimum mesh size by the Department of Agriculture (Sec.3 of the Philippine Fisheries Code of 1998 or R.A. 8550). In Sec. 89 of the same code, however, an exemption was made for collection and harvesting of fry and other naturally small-sized species. The taxonomic identity of the supposed naturally small-sized species exempted from the ban has not yet been specified by the Department as required under the Fisheries Code till date.

Management interventions related to harvest of wild fry and the operations of specialized fisheries for juveniles remain unregulated and uncontrolled, thus, still left an open-access resources to fishermen.

Limited information is available regarding the nature, extent, environmental and social implications of these specialized and wild fry fisheries to harvested fish stocks. It is important for fishery managers and researchers to find ways to improve assessment, desirable exploitation level and to recommend precautionary management guidelines for these critical species. Without the safeguard of resource monitoring and constant assessment, overexploitation may lead to extinction of species (Dulvy *et al*., 2003) [1] and species loss (Lavides *et al*., 2010) [2].

Anchovy is a small-sized forage fish belonging to family 'Engraulidae'. The fish is commercially exploited and marketed in fresh, dried or processed forms. Both the municipal and commercial fishing sectors contributed to its production utilizing different types of fishing gear. In 2013, the bulk of anchovy production was sourced from Region V or the Bicol Region with a volume of 9,636.5 metric tons (MT) or an equivalent of 40.7% of the total production volume of 23,679.81 metric tons (MT) nationwide (Philippine Statistics Authority, 2014)3. It was observed from the said data that the anchovy production trend has been receding. Historical production record and the production level difference of at least 10,026.19 MT could be observed from total annual volume of 33,706 MT in 2002 to its current level at 23,679.81 MT in 2013 (Appendix A).

In the Bicol Region, Pauly (1982) [4] had reported that anchovies form part of the seasonal catch of trawl fishery and a fine meshed net of 0.8 mm stretched were used to catch both the adult and very young anchovies. In Lagonoy Gulf and Tabaco Bay, the three species of anchovy available were *Stolephorus heterolobus* Rüppell, 1837, *Stolephorus zollengerii* Bleeker, 1849 and *Stolephorus indicus* van Hasselt, 1823 caught by beach seine and bagnet (lift net) with seasonal abundance during March to April and August to September (Jane, 1985) [5].

Stolephorid anchovies are widely distributed in Philippine waters and different species have different distribution centers and attraction to special hydrographic conditions. In Manila Bay, the most abundant species are *S. heterolobus*, *Stolephorus commersonii* Lacepède, 1803 and *S. indicus* caught by basnig (lift net) while *Encrasicholina punctifer* Fowler, 1938 is the dominant species in Batangas Bay. The minimum size at maturity was 60-mm in *S. heterolobus*, in *E. punctifer* at 65 mm, *S. commersonii* at 65 to 70 mm and *S. indicus* that appeared to move out of the fishing grounds into deeper waters to breed at 90 mm (Tiews *et al*., 1971) [6].

Elmer *et al*. (2013, unpublished) 7 had identified twelve (12) types of fishing gear exploiting anchovy resources in Region V. The study confirmed the susceptibility of very young anchovies in catches due to fine meshed net employed i.e., mostly polyethylene (PE) minnow nets with mesh size of 1.5 x 1.5 mm and PE/polyamide (PA) braided nets of 2x3 mm mesh size.

The species (*Escualosa thoracata*) belonged to family 'Clupeidae' and distributed along the Indo-West Pacific region from northern Indian Ocean to Thailand, Indonesia (Java Sea), the Philippines, Papua New Guinea, and Australia. This fish forms school in shallow waters with life zones ranging from brackish, freshwater and marine (Froese and Pauly, 2014) [8]. In Sorsogon Bay, Philippines, this was the most dominant species as reported by Olaño *et al*. (2009) [9]. The said species shared 24.3% of the overall catch of the bay while anchovy (Engraulidae) ranked 8th with 2.42% among top landed species from data collected from years 1999 to 2003. Further, information sourced from the same study identified gillnet as the major producing gear for catching white sardine while other small-sized finfish were caught by stationary lift net.

Information related to the study area (i.e., Sorsogon Bay) generally reported an excessive fishing pressure and most of the species caught were below sizes that could still maximize its biological yield (Cinco *et al*, 1995 [10]; Silvestre and Hilomen, 2004) [11]. Moreover, the Bay was already declared as biologically overfished as early as 1972 (Ordoñez *et al*., 1975) [12].

Various management strategies are applied in other countries with huge anchovy production to protect extreme depletion of anchovy stocks. Peru is the largest exporter of fishmeal sourced from anchoveta *Engraulis ringens* regularly caught by purse seine vessels (International Fishmeal and Fish Oil Organisation, 2009) [13]. Fishery regulations are in form of statutory closed season; set the minimum mesh size of purse seine at ½ inch or 13 mm; and rapid closure is being done when more than 10% of juveniles has been reached and by catch control is set at 5%. In Thailand, the mesh size limit is set at 2.5 cm. Although for anchovy fishery, a mesh size of not less than 0.6 cm (6 mm) is allowed by the government (Supongpan *et al*., 2000) [14].

The present study was aimed to evaluate three (3) different net mesh sizes using boat seine and stationary lift net fishing gear for harvesting anchovy resources, through: (a) conduct full-scale fishing trials using the two (2) gears fitted with experimental net mesh sizes of 8, 12 and 16-mm at the cod-end or net panel; (b) determine and compare the efficiency of net mesh sizes based from species composition, weight and total length sizes of catch, catch rate and relative catch abundance of anchovy and white sardine from other catches; (c) characterize the population parameters and selectivity of mesh sizes from length size frequency distribution of retained catches from covered cod-end experiments; and, (d) recommend management options related to appropriate mesh size for sustainable fishing of anchovy and white sardine. Information gathered could be used as management benchmark for formulation or revision of policies involving fishery regulatory measures and strategies for ensuring sustainability of naturally small-sized but matured species like anchovy and white sardine.

Materials and Methods

Research design

This study utilized an experimental fishing method of research, where the comparative effect of meshes was investigated directed to the general condition of catch i.e., species composition, weight and size of catch, catch rate and the relative abundance of target species or species concerned from other catches. Method of operations and test-fishing conditions were treated similarly at random for each independent variable (i.e., net mesh size). Length-based model assessment was primarily used as a tool to relate mesh size to fish length (total length (in cm) of unsexed samples) of susceptible target species. The length-frequency distribution data were used to generate population parameters and to estimate selection curve of the different meshes. The resulting length parameters in association with the selective parameters of mesh sizes at fifty (50) percent length, i.e. the length of fish at which 50% are retained and 50% released were used as the basis for determining the best mesh size.

Study area

The study was carried out in Sorsogon Bay, Philippines from May 2013 to May 2014. The bay is about 39,913 hectares with a coastline of 146 km. The average water depth is 7 meters and the deepest portion is 27 m along the approaches off Ticao Pass. The test fishing areas were conducted along inner portions of the Bay specifically covering coastal waters of Sorsogon City and the Municipality of Casiguran, where, local fishermen normally frequented. Fishing positions were situated at Latitude 12o 58' 30" and Longitude 123 o 57' 20" to Latitude 12o 48' 00" and Longitude 124 o 02' 00.2" (Fig.1).

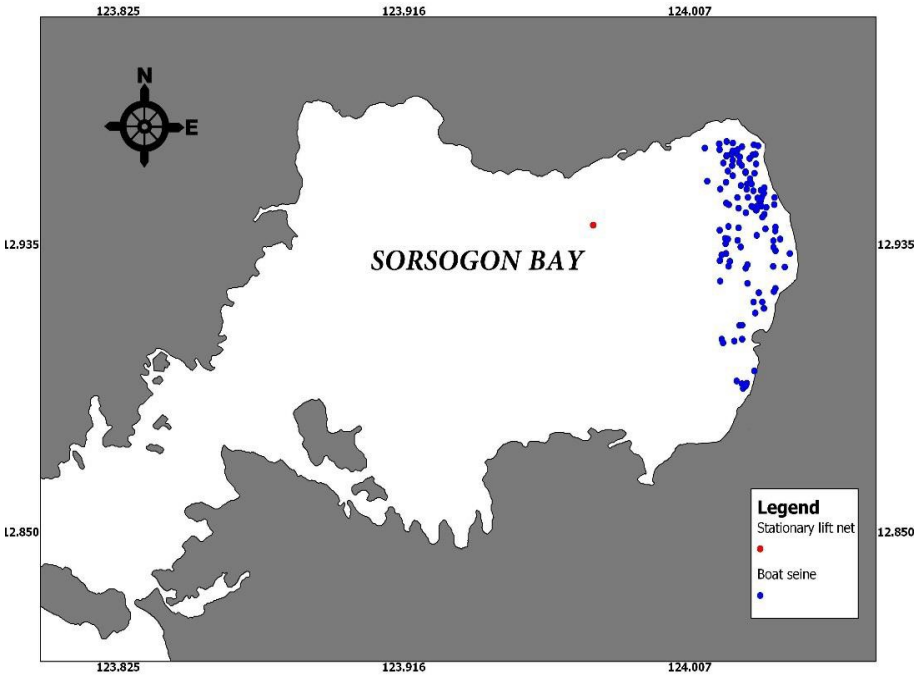


Fig 1: Map of the studied area.

The experimental gears and mesh sizes

Two (2) types of fishing gears and three (3) mesh sizes were used in the study. A boat seine net was a conical mobile gear with two long wings on each side measuring 102 m long, net height of 4.4 m while the forward main net body has a length and width of 11 m that gradually tapers to cod-end. It was devoid of scareline and tom weights (Fig.2). A stationary lift net, on the other hand, is a static box-type gear that measures 11 m long, 11 m wide and 3 m deep (Fig.3).

For each gear, three (3) sets of replicate were constructed to represent the experimental net mesh sizes (MS). The netting consisted of polyethylene (PE) braided knotless and square-meshed netting materials with specific dimensions as follows: 8 mm (2.5 x 3.2 mm i.e., length of each side bar), 12 mm (3 x 4 mm) and 16 mm (4 x 4 mm) with uniform twine size of 400d/3. For boat seine, cover cod-end method was applied to determine sizes of escaped recruits. The impounding bag was enclosed with a cover net made from PE minnow net material using 400d/5 twine size and mesh opening of 2.25 mm (i.e., 1.5 x 1.5 mm side bar length). The net has a length of 12 m and with total net circumference of 19 m. With the stationary lift net, the entire net panel separately represented each mesh size tested. No cover was affixed from the net to eliminate bias from net stretching and to observe the retained catches of the gear on "as is" basis.

Fishing operations and data collection

Full-scale test fishing operations were conducted for seven (7) successive months in boat seine covering the months of May to November 2013 and another six (6) successive months for stationary lift net held from December 2013 to May 2014. For each month, the sampling frequency involved six (6) nights of fishing operation, where, individual nets were alternately operated in random sequence for two (2) consecutive nights per mesh size. For boat seine, three (3) haul sets per night were conducted and two (2) haul sets per night were undertaken for stationary lift net.

For each operation, information gathered for each data set included the date of fishing, fishing position (Latitude and Longitude) sourced from the global positioning system (GPS), registry of water depth (in meters) through use of a depth sounder gauge, individual setting and hauling time (in minutes). Other at-sea observations include notes of the prevailing sea and weather condition at the time of operation.

Boat seine operations utilized a wooden-hull motorized boat with L x W x D dimension of 10.36 m x 0.91m x 0.91 m powered by 16 hp Briggs and Stratton engine. Method of operation included visual scouting of fish shoal at night using a handheld flash light, net setting and manual closing of net ends as held together by fishermen while others herd the fishes towards the main body and collecting cod-end area and, finally, collection of catch from the cod-end or bag. A total of five (5) fishermen were involved in boat seine operations. Time entailed from shooting to hauling of the net has an average duration of 15 min. The water depth of areas fished ranged from 0.6 to 1.6 m at an average depth of 1.32 m.

The stationary lift net was rigged in a bamboo platform with a dimension of 13 x 13 m height and width. It was set at 4.56 m water depth. Operation commenced after dusk, wherein, the net was deployed and hung as a typical inverted mosquito net and lighting period began indicating the start of operation. The light source consisted of three (3) units of Petromax fed with liquefied gas with light intensity of 500-candle power per unit. After 2 hours of lighting and net soaking time, the hauling ropes attached to the net perimeter were retrieved and manually hauled by two (2) fishermen. The retained catches were scooped using a scoop net that concentrated at the central part of the net.

Treatment of the catch included sorting, identifying, weighing, and recording using catch data form, and the net was deployed again for another set of operation.

For small-catches, the number and weight of all species from the entire catch were measured and recorded. For large-catches, sub-sampling of the catch was applied. The total length and body depth of fish were measured to the nearest centimeter (cm) while the individual weights were recorded in grams (g) to the nearest hundredths using a digital weighing scale. Samples taken from cod-end and cover nets were treated separately and labelled accordingly.

At the end of the collection period, the length frequency distribution data of selected target species were encoded and re-sorted according to size class and the resulting middle length class for length-based parameter model estimation using the length frequency wizard program of fishbase.

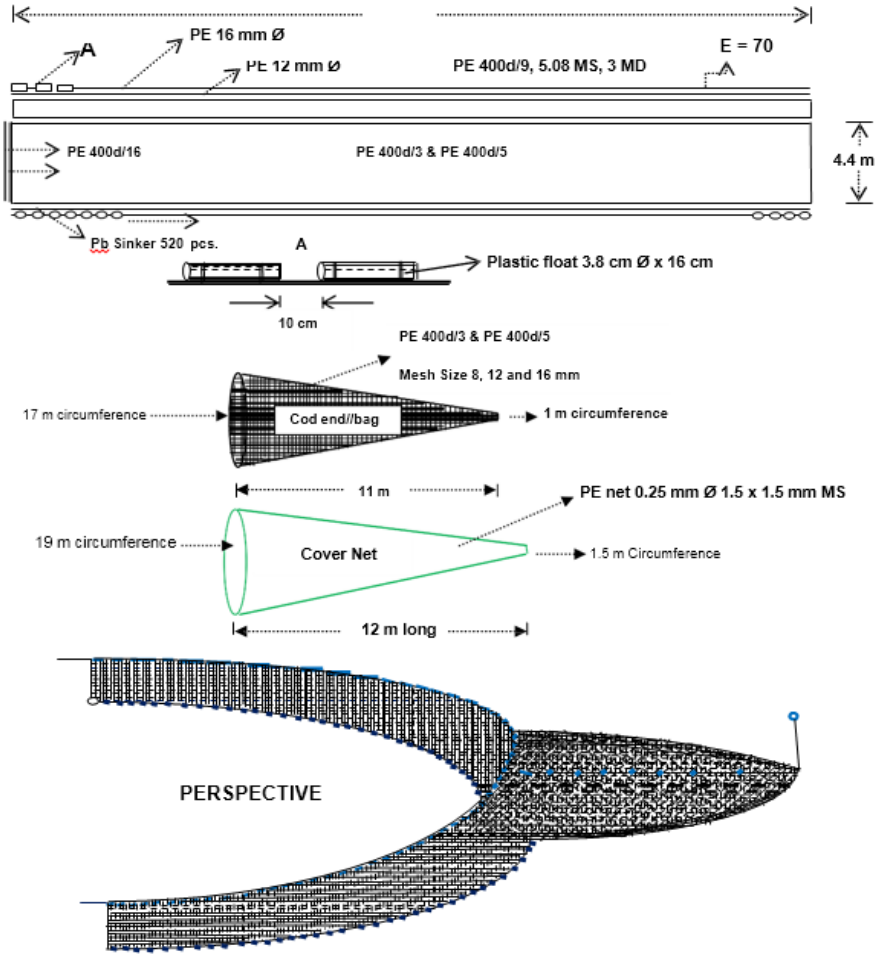


Fig 2: Structural design and gear dimension of boat seine.

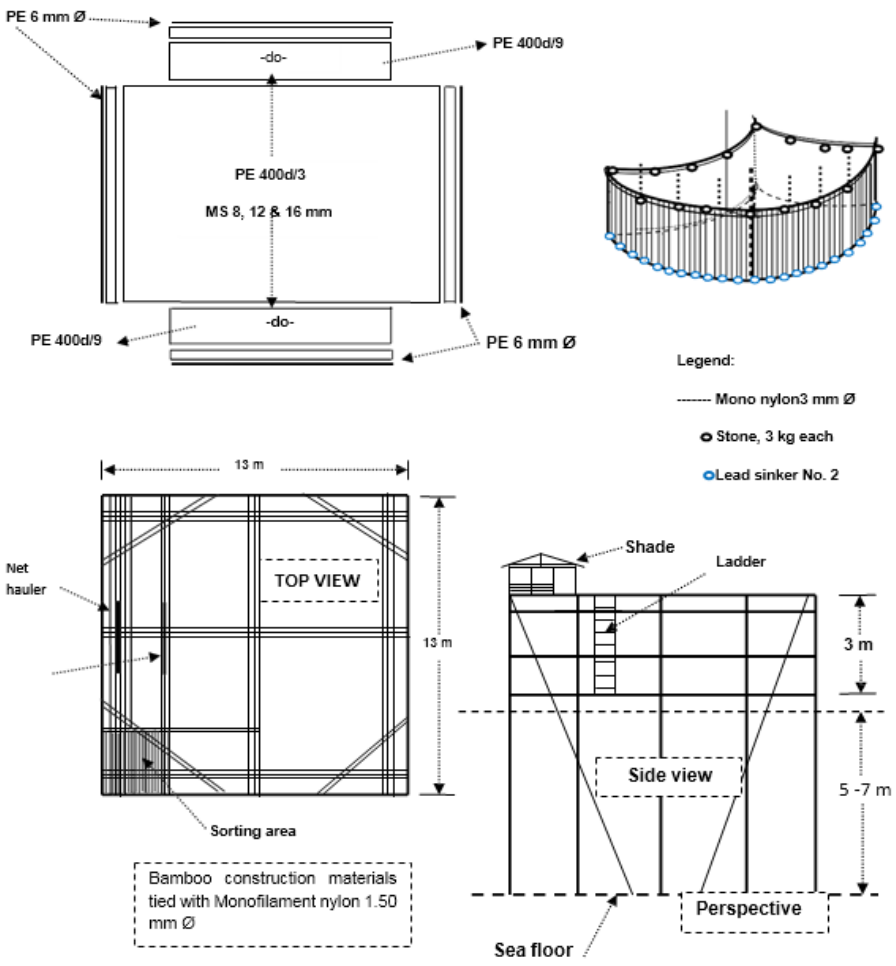


Fig 3: Structural design and gear dimension of stationary lift net.

4.5 Mesh size selectivity analysis

Consolidated length frequency distribution data sets from boat seine covered cod-end experiments were used to determine the selectivity of meshes for a particular species. The selection parameters were calculated using the methods of Jones, 1976 (Sparre and Venema, 1998) [15] as follows:

$$S_L = \frac{1}{1 + exp\,(S_1 - S_2 L)} \qquad (1);$$

where, *S*L has been determined as the ratio between *M* and *N* ((*S*L= *M*/*N*); *M* – the number of fish with the length *L* caught in the cod-end (retained); *N* – the total number of fish with the length *L* caught in the cod-end and cover net (retained+escaped); *L* – mean length (*L* = (*L*1 + *L*2)/2); equation (1) can also be expressed as an equation of a straight line shown as follows:

$$-\frac{ln\left(\frac{1}{SL} - 1\right)}{y} = \frac{S_1}{a} - \frac{S_2}{b}\frac{L}{x} \qquad (2);$$

Where, *S*1 = *a* and *S*2 = *b* are two constants. Further, the estimated retention length distribution of a particular species in a proportion of 25, 50 and 75%, (i.e., *L*25%, *L*50% and *L*75%) was computed as:

	$L25\% = (S1 - \ln 3)/S2$	(3);
	$L50\% = S1/S2$	(4);
and,	$L75\% = (S1 + \ln 3)/S2$	(5).

The values of constants a and *b* has been determined and generated through linear regression analysis which was the most usual method used in the fishery biology. The calculation Formulas for this method are as follow:

$$b = \frac{\Sigma x(i)y(i) - \Sigma x(i)y(i)}{\Sigma x_i^2 - \frac{1}{n}(\Sigma x_i)^2} \qquad (6);$$

where, $a = y - x\,b$; *n was* the number of paired observations (*xi* and *yi*); and,

$$\bar{x} = \frac{\Sigma x_{(i)}}{n} \quad and \quad \bar{y} = \frac{\Sigma y_{(i)}}{n} \qquad (7).$$

The calculation of fifty percent retention length or *L*50% for various mesh sizes (2*a*) has
been treated and done using the formula for selectivity factor (SF) as follows:

$$SF = \frac{L_{50\%}}{2a} \qquad (8).$$

Results and Discussions

Species selectivity and catch efficiency

Boat seine. A total of one hundred twenty six (126) hauls were completed for boat seine from seven (7) months of fishing operations covering May to November 2013. The total catch reached 3,257 kg, where, 2,360 kg (72.5%) were retained in the cod-end while 897 kg (27.5%) were collected in the cover as escaped catches (Fig.4).

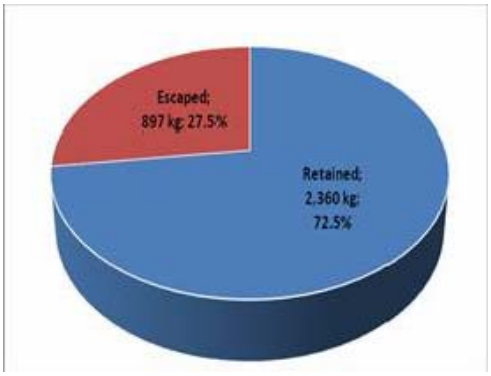


Fig 4: Percent portion of retained and escaped catches in boat seine

Out of thirty-six (36) taxa accounted, twenty-nine (29) of these belonged to finfish group and seven (7) taxa were composed of invertebrates. Anchovy *Stolephorus* spp. had the highest percentage with 1,511.06 kg or a relative abundance of 46.73% total retained catches. The adult specimens identified consisted of two species, namely: Commerson's anchovy *Stolephorus commersonii* Lacepède, 1803 and the Indian anchovy *Stolephorus indicus* van Hasselt, 1823. However, specimens at post-larval to juvenile stages were collectively identified only at the genus level *Stolephorus* spp. The 2nd top ranking species was the white sardine *Escualosa thoracata* Valenciennes, 1847, a co-shoaling species of anchovy, with total of 1, 292.47 kg or 39.97%. Both species shared 86.7% of overall catch while the remaining 13.3% were distributed among other species in minor portion (Fig.5). Based from catch composition analysis and abundance, boat seine exhibited a high- selection level for anchovy and white sardine species, thus, it was regarded as highly-selective or a directed fishery especially for early recruits of previously mentioned species in Sorsogon Bay area.

Escaped catches were composed largely of anchovy (62.2%) and white sardine (26.7%) with only 11.1% portion of minor species (Fig.6).

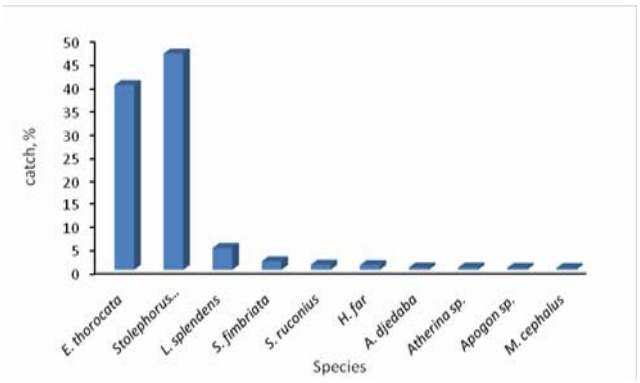


Fig 5: Retained catch composition and catch percentage in boat seine.

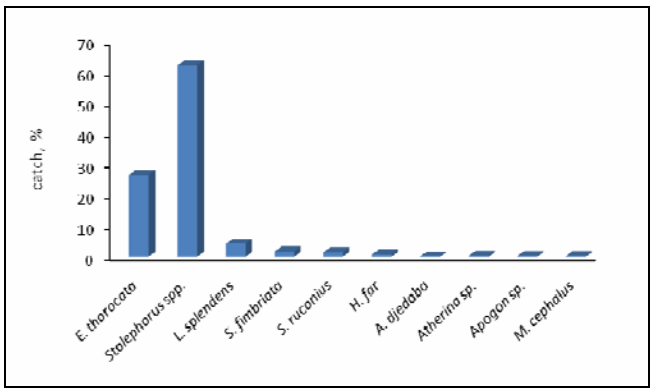


Fig 6: Escaped catch composition and catch percentage in boat seine.

Among the mesh sizes used, retained catch and the catch-per-unit of effort in kg/h (CPUE) registered highest at 8-mm mesh size with noticeably lowest portion of escapement at 5.43%. The 12 mm mesh size obtained 35.21% escapement while the highest escapement was observed for 16 mm mesh size at 61.47% (Table 1). The effect of mesh size on catch efficiency of boat seine demonstrated greater sieving or filtering effect of smallest sized mesh used and, in contrast, greater escapement chance for small fishes through use of larger mesh size (i.e., 16 mm mesh size).

Table 1: Boat seine catch (in kg), CPUE (kg/h), percent retained and percent escapement by mesh size.

Particulars		Mesh Size		Total/ Percent
8 mm		12 mm	16mm	
Retained (kg)	1,343.57	683.89	332.05	2,359.51
Escaped (kg)	50.37	333.31	513.29	896.97
Percent retained (%)	94.57	64.79	38.43	65.93
Percent escapement (%)	5.43	35.21	61.57	34.07
Average CPUE kg/h)	18.38	12.46	9.41	13.42

Stationary lift net. A total of seventy-two (72) valid haul sets were completed from 6- month fishing trials using stationary lift net from month of December 2013 and May 2014. The total catch recorded for stationary lift net was 495.95 kg and the average catch rate for all meshes was 3.35 kg/h. Catch rate level was almost similar for all meshes.

Table 2: Stationary lift net catch (in kg), CPUE (kg/h) and percent portion of anchovy.

Particulars		Mesh Size		Total/ Percent
	8 mm	**12 mm**	**16 mm**	
Retained (kg)	187.27	173.42	135.27	495.95
Average CPUE (kg/h)	3.58	3.36	3.11	3.35
Anchovy Percentage (%)	16.92	10.25	3.64	10.27

The composition of stationary lift net catches consisted of thirty-eight (38) taxa segregated into twenty-six (26) fish taxa and twelve (12) invertebrates. The majority of catches were composed of cardinal fish *Apogon* spp. with 35.22% relative abundance followed by silverside *Atherina* sp. with share of 12.89%, splendid pony fish *Leiognathus splendens* Cuvier, 1829 ranked 3rd with 10.5%, Commerson's anchovy *S. commersonnii* ranked 4th with share of 9.8% and Indian squid *Loligo duvauceli* Orbigny, 1848 with 6.8% share as 5th top ranking species (Figure 7). Closer scrutiny of catches disclosed that almost half of the entire catch (48%) consisted of low value species marketed commonly as trash fish and used as direct feed for aquaculture or raw materials for feed mill industry.

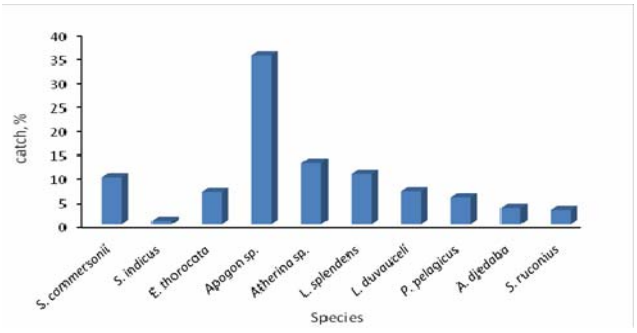


Fig 7: Top 10 species of stationary lift net and relative percent distribution.

As in boat seine, two species of anchovy were present in stationary lift net catches. Between the two species, the more dominant portion of catch was Commerson's anchovy with 9.8% relative share while Indian anchovy had only 0.7% share. As to size, anchovy caught from stationary lift net was generally larger while boat seine caught anchovy consisted more of smaller-sized population. White sardine *E. thoracata* was also present in stationary lift net catches with only 6.7% relative abundance.

In a stock assessment study of Sorsogon Bay, Olaño *et al.* (2009) [16] have reported the dominance and contribution of *S. commersonii* from stationary lift net catches at 19.92% of the total landings from years 1999 to 2003. In this study, the occurrence of *S. commersonii* was validated in stationary lift net catches. Likewise, the presence of *S. indicus* was included among other occurring Stolephorid resources of the bay. However, less proportion of anchovy and white sardine was observed in stationary lift net catches. The most common species found in the catch were non-commercial fishes like cardinal fish and silverside and, for commercial species, higher portions of invertebrate species like squid and crabs consisted the catch. It was possible that landing observations from resource and ecological assessment studies has not fully accounted non- commercial portion of catches of the gear or the fishers may already have segregated such portions prior to inspection of catches from landing areas. The stationary lift net characterized a multi- species nature of harvest and exhibited a low level of species selectivity towards anchovy and white sardine resources.

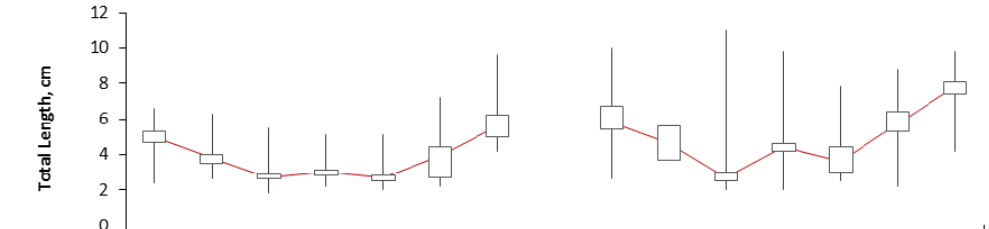
By mesh size, the weight proportion of anchovy caught in 8-mm mesh size was around 17% while 12 mm retained 10.25% and the least amount were found in 16 mm mesh size (3.64%) (Table 2). The same mesh efficiency pattern was observed in stationary lift net and boat seine retained catches.

Length at first-capture

Based from overall analysis of aggregated length samples from thirteen (13) months observation period, anchovy was available to fishery in sizes ranging from 1.8 cm to 10.2 cm total length while the capture sizes of white sardine ranged from 2-cm to 11.4 cm.

In boat seine, the minimum capture size of anchovy was 1.8 cm and with a maximum of 9.6 cm. Stationary lift net, on the other hand, retained a minimum size of 4.1 cm and a maximum of 10.2 cm. From the comparison of susceptible sizes of fish samples from both gears, it was observed that boat seine harvested wider range of anchovy population length size than the stationary lift net. But for white sardine resources, exploitable size pattern indicated similar relative similarity for both gears. This particular observation could be explained by the associated with intrinsic body shape of white sardine with more prominent body depth as compared to a more elongated body form of anchovy.

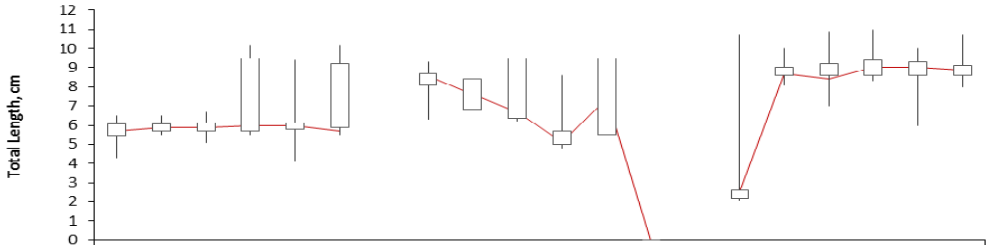
Monthly plot distribution of total fish lengths caught by sampling gears was presented in Figs. 8 and 9. Concentration of young anchovy recruits has been observed from month of July to September during the southwest monsoon season and the largest sized individuals registered its peak in summer months (i.e., from March to May). White sardine depicted the same size structural pattern with the smallest sizes that highly occurred during the southwest monsoon months and an increasing size trend towards onset of northeast monsoon until summer.



	May	Jun	Jul	Aug	Sept	Oct	Nov	May	Jun	Jul	Aug	Sept	Oct	Nov
median	5	3.8	2.7	3	2.7	3.9	5.6	5.8	4.6	2.7	4.4	3.6	5.7	7.8
q1	4.7	3.5	2.6	2.8	2.5	2.7	5	5.4	3.7	2.5	4.2	3	5.3	7.4
min	2.4	2.6	1.8	2.2	2	2.2	4.2	2.6	2	2	2	2.5	2.2	4.2
max	6.6	6.3	5.5	5.1	5.1	7.2	9.6	10	7.4	11	9.8	7.8	8.8	9.8
q3	5.3	4	2.9	3.1	2.8	4.4	6.2	6.7	5.6	3	4.6	4.4	6.4	8.1

Stolephorus spp. *E. thorocata*

Fig 8: Length size characteristics of *Stolephorus* spp. and *E. thoracata* by month from boat seine catches (q1 = 1st quartile and q3 = 3rd quartile).



	Dec	Jan	Feb	Mar	Apr	May	Dec	Jan	Feb	Mar	Apr	May	Dec	Jan	Feb	Mar	Apr	May
median	5.7	5.9	5.9	6	6	5.7	8.55	7.6	6.7	5.15	7.4	0	2.5	8.7	8.4	9	9	8.9
q1	5.45	5.68	5.7	5.7	5.8	5.9	8.1	6.8	6.35	5	5.5	0	2.2	8.6	8.6	8.6	8.6	8.6
min	4.3	5.5	5.1	5.5	4.1	5.5	6.3	6.8	6.2	4.8	5.5	0	2.1	8.1	7	8.3	6	8
max	6.5	6.5	6.7	10.2	9.4	10.2	9.3	8.4	9.5	8.6	9.5	0	10.7	10	10.9	11	10	10.7
q3	6.05	6.05	6.1	9.5	6.1	9.2	8.7	8.4	9.5	5.7	9.5	0	2.6	9	9.2	9.4	9.3	9.1

S. commersonii *S. indicus* *E. thorocata*

Fig 9: Length size characteristics of *Stolephorus* spp. and *E. thoracata* by month from stationary lift net catches (q1 = 1st quartile and q3 = 3rd quartile).

The co-occurrence, mixed or aggregated shoaling patterns of anchovy and white sardine stocks could be further explained by its shared biological features (i.e., similar spawning and/or nursing area and spawning time) common to both species at certain part of their life stages. The fishing operation areas of boat seine were conducted at shallow depths close to shore that served as localized aquatic habitat or nursery areas of juvenile anchovy and white sardine. The application of learned knowledge on determined location, season and timing for fishing of young recruits of anchovy and white sardine made these resources highly accessible and vulnerable to exploitation.

Boat seine operations in Sorsogon Bay specifically targets juvenile shoaling species of anchovy and white sardines, thus, could be assessed as one type of specialized fisheries. Local boat seine fishers developed proficiency in harvesting and accessing appreciable quantities of juvenile anchovy and white sardine populations from determined locations and timing of fishing along shallow and near coastal areas, where, concentration of nursery grounds were located. They made use of fine meshed nettings to sieve or collect as many resources as possible since all species taken has economic value for human consumption, as raw materials for the processing and feed supply in the aquaculture industry.

Population parameters

Population parameters from length frequency distribution of anchovy *S. commersonii* and white sardine *E. thoracata* were generated from processed clustered length class of samples and its summary was shown in Table 3. The asymptotic length (length infinity, L∞) estimated from maximum length (Lmax) was calculated at 10.9-cm for anchovy and 12.1 cm for white sardine. Length at maximum yield (Lopt) was 6.4 cm and 7.2 cm for anchovy and white sardine, respectively. The derived information on maximum yield length (Lopt) obtained for white sardine in this study was similar with the findings of Nabi, *et al*. (2009) [17] in Bangladesh. The calculated unsexed length at first maturity (Lm) from this study was 7.1 cm for *S. commersonnii* and 7.9 cm for *E. thoracata* (Table 3). The result of Lm was comparable with the report of Raje *et al*. (1994) [18] that the size at first maturity of female *E. thoracata* was 82 mm or 8.2 cm.

Table 3: Population parameters of Stolephorus commersonii and Escualosa *thoracata* from length frequency distribution analysis.

Specific Population Parameter		Species	
S. commersonii			**E. *thoracata***
Asymptotic length (L∞)	10.9 cm		12.1 cm
Growth coefficient (K)	0.13 1/year		0.11 1/year
Maximum Length (Lmax)	10.2 cm (TL)		11.4cm (TL)
Length at maximum yield (Lopt)	6.4 cm		7.2 cm
Length at first maturity (Lm) (unsexed)	7.1 cm		7.9 cm

Mesh size selectivity curves

Length population distribution of anchovy and white sardines were analysed across various meshes fished. The selectivity of boat seine was obtained from plots of 44,066 individual length samples of anchovy and 17,669 length samples of white sardine.

Tabulated summary of selection curves of three different mesh sizes for anchovy and white sardine was shown in Table 4. Fifty percent retention length (L50) of anchovy was established at 2.94 cm in 8 mm mesh size, 5 cm in 12 mm mesh size and 5.96 cm in 16 mm cod-end mesh sizes. Thus, the probability of retaining large proportion of juvenile or

immature catches was high at 8 mm mesh size while the use 16 mm mesh size could retain larger adult fish. Using population parameter on length at maximum yield (Lopt) of 6.4 cm for *S. commersonii* as the desirable minimum landing size of anchovy from meshes examined, the closest value of L50 was obtained from 16 mm mesh size (i.e., 5.96 or 6 cm).

Table 4: Mesh size selection parameters of anchovy and white sardine

Species	Selectivity Estimates	Mesh Size		
		8 mm	12 mm	16 mm
	selection factor (SF)	1.84	3.0	4.76
	a	6.29	7.01	4.0
Stolephorus spp.	b	2.14	1.40	0.67
	L25%	2.42	4.21	4.32
	L50%	2.94	5.0	5.96
	L75%	3.45	6.0	7.59
	selection factor (SF)	1.05	2.26	5.73
	a	8.31	4.07	4.05
Escualosa thoracata	b	3.15	1.08	0.57
	L25%	2.29	2.75	5.22
	L50%	2.63	3.77	7.16
	L75%	2.98	4.78	9.10

(a: intercept; b: slope; L25%, L50% and L75% of retained proportion)

For white sardine, the 50% retention length was placed at 2.63-cm in 8 mm mesh size, 3.77 cm in 12 mm mesh size and 7.16 cm in 16 mm mesh size. Similarly, young fish will be retained using 8 mm and 12 mm cod-end mesh sizes while at 16 mm mesh size, L50 was estimated at 7.16 cm that corresponded with the optimum length at maximum yield (Lopt) of 7.2 cm for white sardine.

The comparative selection curves of the different meshes for *Stolephorus* spp. and *E. thoracata* were plotted and shown in Fig.10, where, the fraction retained of the expected values were fitted against the middle-class length of fish samples. From the figure, capture probability of sigmoid curve or S-curve of mesh sizes specific for species examined provided an overview of the differences in capture size of meshes tested. Comparative efficiencies related to mesh dynamics has been explicitly demonstrated using the results generated from the fish length-based model assessment. Thus, the obtained fifty (50) percent length probability of capture (L50%) could be used as an important length size standard for optimum harvestable landing size of anchovy and white sardine in consonance with use of an optimum mesh size (i.e., 16 mm). Other relevant technical descriptions of the boat seine and stationary lift net fishing activities could provide assist the Sorsogon City FARMC related to selective catching of anchovy and white sardine resources and for future integration in their coastal resources management plans and succeeding fishery programs. Application of vital research information would enable the fishery management groups to harmonize both fisheries environmental and economic development objectives.

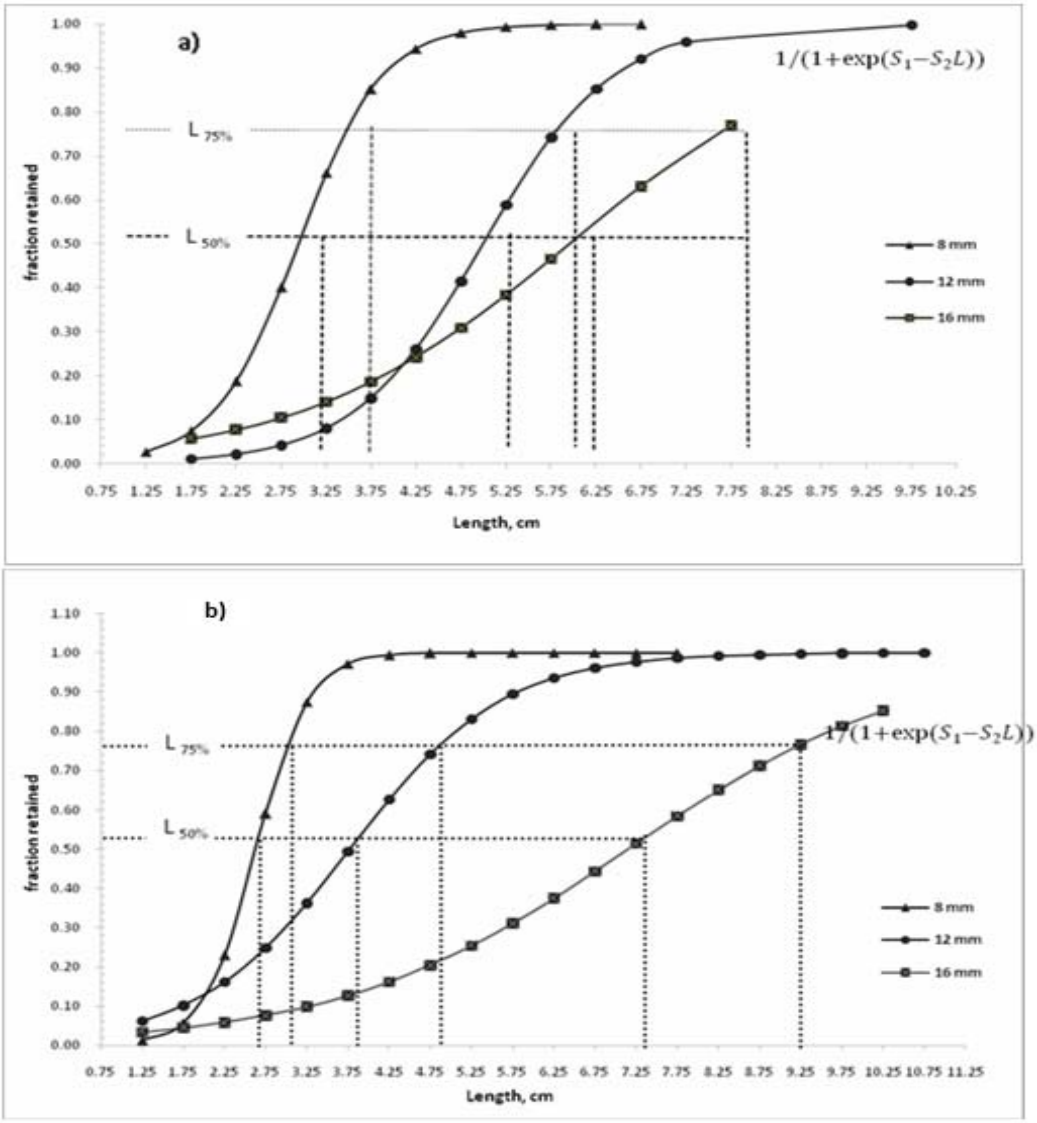


Fig 10: Selection curves of boat seine representing three mesh sizes (8 mm, 12 mm and 16 mm): (a) *Stolephorus* spp. and (b) *Escualosa thoracata.*

Conclusions

Based from the analysis of population length sizes, both the anchovy and white sardine follow the same pattern of being larger during the first and last quarters of the year while young recruits appear during onset of the southwest monsoon (July to September).

Observed population length sizes between two sampling gears used also varied with boat seine harvesting more efficiently early recruits or juvenile sizes of anchovy than stationary lift net.

Based on the results of the study, the estimated economic length size at maximum yield was 6 cm for anchovy and 7 cm for white sardine, thus, the appropriate mesh size for selective catching of relatively adult anchovy and white sardine was 16 mm mesh size.

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References

1. Dulvy NK, Sadovy Y, Reynalds JD. Extinction vulnerability in marine populations. Fish and fisheries 2003; 4(1):25-64.
2. Lavides MN, Polunin NVC, Stead SM, Tabaranza DG, Comeros MT, Dongallo Jr. Finfish disappearances around Bohol, Philippines inferred from traditional ecological knowledge. Environ. Conserv. 2010; 36(3):235-244.
3. Philippine Statistics Authority. Country STAT Philippines. Commercial Fisheries: Volume of Production by Species, by Region and by Province by Species, Geolocation, Quarter and Year http://countrystat.bas.gov.ph, 2014.
4. Pauly D. History and status of the San Miguel Bay Fisheries. Fish. Res. J Philipp. 1982; 14:95-124.
5. Jane MR. Study on seasonal abundance and biology of anchovies at Lagonoy Gulf and Tabaco Bay. Bicol University College of Fisheries, Tabaco, Albay. PCARRD online access catalog, 1985; 32.
6. Tiews K, Ronquillo I, Santos L. On the biology of anchovies (*Stolephorus* Lacepede) in Philippine waters. Philipp. J Fish. 1975b, 1971; 9:92-123.
7. Elmer A, Marites C, Marnelli C. Assessment of fishing gears used for catching juvenile and adult anchovy in Region V. NFRDI. Quezon City, Philippines. Unpublished 2013; 1-28.
8. Froese R, Pauly D. (eds.) 2014. Fish Base. World Wide Web electronic publication. www.fishbase.org,version. April, 2014.
9. Olaño V, Vergara M, Lavapie-Gonzales F. Assessment of the Fisheries of Sorsogon Bay (Region 5), BFAR, Regional Office No. 5, San Agustin Pili, Camarines Sur, Philippines. Bureau of Fisheries and Aquatic Resources, Technical Paper Series, 2009, 1(4).
10. Cinco EJ, Diaz R, Gatchalian G. Silvestre. Results of the San Miguel Bay trawl survey. In: Multidisciplinary assessment of the fisheries in San Miguel Bay (1992-1993) Silvestre G, C. Luna and J. Padilla (Eds). ICLARM Technical Report (CD-ROM). 1995, 47.
11. Silvestre GT, Hilomen VV. Status of fisheries in San Miguel Bay. In p.292-299. In DA- BFAR (Department of Agriculture-Bureau of Fisheries and Aquatic Resources). In turbulent seas: The status of Philippine marine fisheries. Coastal Resource Management Project, Cebu City, Philippines. Ref Id 24656; 2004; 378.
12. Ordoñez JA, Arce FM, Ganaden RA, Metrillo M. Jr. On the hydro-biological and fisheries survey of Sorsogon Bay, Luzon Island. Proc. 3rd CSK Symposium, Bangkok, Thailand. Philipp. J Fish. 1975; 13(2):178-204.
13. International Fishmeal and Fish Oil Organisation datasheet. www.iffo.net. May, 2009.
14. Supongpan M, Chamchang C, Boongerd S, Laowapong A. Technical report on the anchovy fisheries in the Gulf of Thailand. FAO/FISHCODE Project GCP/INT/648/NOR. Field report F-6 Suppl. 2000, 105.
15. Sparre P, Venema SC. Introduction to tropical fish stock assessment. Part 1: Manual. FAO Fisheries Technical paper, No. 306.1, Rev. 2. Rome FAO, 1998, 185.
16. Olaño V, Vergara M, Lavapie-Gonzales F. Assessment of the Fisheries of Sorsogon Bay (Region 5), Bureau of Fisheries and Aquatic Resources, Regional Office No. 5, San Agustin Pili, Camarines Sur, Philippines. Bureau of Fisheries and Aquatic Resources, Technical Paper Series, 2009, 1(4).
17. Nabi MR, Hoque MA, Rahman RA. Population dynamics of *Escualosa thoracata* from estuarine set bag net fishery of Bangladesh. J. Sci. Technol. (Dinajpur) 2009; 7:1-12.
18. Raje SG, Deshmukh V, Thakurdas D. Fishery biology of white sardine, Escualosa *thoracata* Valenciennes at Versova, Bombay. J Indian Fish. Assoc. 1994; 24:51-62.