ASSESSMENT OF THE FISHERIES OF SORSOGON BAY (REGION 5)

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ABBREVIATIONS, ACRONYMS AND SYMBOLS

BFAR	-	Bureau of Fisheries and Aquatic Resources
BSLL	-	bottom set longline
CL_∞	-	carapace length infinity
CLN	-	crab liftnet
cm	-	centimeter
Coll.	-	college
CP	-	crab pot
CPUE	-	cath per unit effort
CSK	-	Cooperative Sympoisum on the Kuroshio
CW_∞	-	carapace width infinity
DA	-	Department of Agriculture
DANIDA	-	Danish International Development Agency
Dept.	-	department
DGN	-	drift gillnet
DS	-	Danish seine
E	-	exploitation rate
ed./eds.	-	editor/s
ELEFAN	-	electronic length frequency analysis
F	-	fishing mortality
FAO	-	Food and Agriculture Organization of the United Nations
FC	-	fish corral
Fig.	-	figure
FISAT	-	FAO-ICLARM stock assessment tools
Fish.	-	fisheries
fm	-	fathom
F_{max}	-	maximum level of fishing mortality
FP	-	fish pot
fPY	-	maximum fishing effort
FSP	-	Fisheries Sector Program
GN	-	gillnet
HL	-	hook and line
ICLARM	-	International Center for Living Aquatic Resources Management
J.	-	journal
K	-	growth rate
kg	-	kilogram
L_{50}	-	length at 50 percent probability of capture
LGU	-	local government unit
L_∞	-	length infinity, asymptotic length
L_{max}	-	maximum length
M	-	natural mortality
Mar.	-	marine
MFARMC	-	Municipal Fisheries and Aquatic Resources Management Council
MS	-	Microsoft
M. Sc.	-	Master of Science

mt	-	metric ton
NGO	-	non-government organization
NORMSEP	-	normal separation
NSAP	-	National Stock Assessment Program
OT	-	otter trawl
p.	-	page/s
Pap.	-	paper
Philipp.	-	Philippines
Proc.	-	proceedings
PY	-	potential yield
RA	-	Republic Act
REA	-	resource and ecological assessment
Rep.	-	report
RP	-	recruitment pattern
SLN	-	stationary liftnet
SM	-	size at maturity
sq km	-	square kilometer
Tech.	-	technical
TN	-	trammel net
UB Tech. Inc.	-	United Business Technologies, Incorporated
Univ.	-	university
UPV	-	University of the Philippines in the Visayas
VBGF	-	von Bertalanffy growth function
Vol.	-	volume
VPA	-	virtual population analysis
yr	-	year
Z	-	total mortality
Ø’	-	growth performance index
%	-	percent

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ABSTRACT

An analysis of four years of catch, effort and length-frequency data of Sorsogon Bay (from April 1999 to March 2003) was made to characterize the fisheries of the bay. Results of the analysis are useful as basis for the management and conservation of the bay's resources.

Data on catch, effort and seasonality of species were analyzed using the MS Excel program, and the length-frequency data by FISAT (FAO-ICLARM stock assessment tools).

Sorsogon Bay is known for commercially important invertebrates, as well as small pelagic and demersal species of fish. The invertebrate species, particularly portunids and penaeids, contributed 33.77 percent of the bay production; the small pelagics, 26.41 percent; and the demersal species, 15.08 percent. Production trend and seasonality of species vary each year. The average catch rate consistently decreases as the effort increases. The estimated potential yield (PY) was observed to be 45 percent beyond the sustainable level of the resource, which strongly suggests that heavy fishing pressure has been exerted in the bay.

Results of the analysis of population parameters of eight species showed high growth rates (K = 0.66-1.58) and high mortality coefficients (Z = 3.21-8.62). These values indicate a very high turnover rate of biomass but low survival rates in the bay. The exploitation rates were relatively high (E = 0.49-0.75) which indicate that the stocks are overfished. Recruitment patterns derived were unimodal and bimodal. Comparison of the probabilities of capture (L_{50}) with the known size at maturity, ratio to their length infinity ($L\infty$), virtual population analysis (VPA), and the size ranges revealed that most of the species caught by trammel net and stationary liftnet were still immature. The relative yield per recruit showed that the current fishing mortality (F) was higher than the maximum level by 12 percent, and that all the dominant species have already exceeded their allowable limit of exploitation.

Fishery management and regulatory intervention are thus necessary to help resolve the problems on heavy fishing pressure and growth overfishing of Sorsogon Bay.

INTRODUCTION

Sorsogon Bay is situated in the southern part of the Bicol Peninsula. Its area is approximately 201 sq km, bounded by longitudes $123^0$50' and $124^0$0' East and latitudes $13^0$0' and $13^0$5' North. It opens to a narrow channel leading to Ticao Pass (Fig. 1). The bay is generally shallow with depths ranging from 0.25 fathom to five fathoms. The deeper portion is located at the mouth of the bay with depths of 5.5-16 fm. The bottom is generally characterized by very soft mud and accumulated silt. However, there are areas with sandy bottom and some with coarser sediments. Incarizan River is the major tributary draining into Sorsogon Bay.

Sorsogon Bay is considered as an important fishing ground in the Philippines for small pelagics, demersal fishes, and shellfishes. It is an enclosed bay surrounded by five coastal municipalities, namely, Casiguran, Castilla, Magallanes, Juban and Sorsogon. Castilla and Sorsogon are the biggest fish-producing municipalities, both for capture fisheries and aquaculture. The resource and ecological assessment (REA) of Sorsogon Bay, conducted by Cinco *et al.* (1995), estimated the production of Sorsogon Bay at about 5,585.62 metric tons, with gillnets as the commonly used gear. There was no report of commercial fishing activity in Sorsogon Bay, although illegal fishing methods, such as blast fishing, use of air compressor and gear with fine-meshed nets, are still rampant.

The Provincial Board of Sorsogon unanimously approved on January 14, 1972, Resolution No. 24 declaring Sorsogon Bay as a conservation area and banning the use of trawl and other apparently destructive fishing operations. This consequently led to the exploration of the benthic biomass of the Bay, and started the dominance of shellfish collection in the area, with *Paphia undulata* as the dominant species (Del Mundo *et al.* 1987). However, in 1989 there was a noticeable decline in the production of *P. undulata*, reportedly due to overcollection of the species (R. Dioneda, pers. comm.).

As early as 1972 Sorsogon Bay was already declared as biologically overfished, according to Ordoñez *et al.* (1972) in their study regarding the relevance of the proposed trawl ban. The results of the REA conducted in the bay also showed high exploitation rates and high fishing mortalities of several dominant demersal fishes. All these suggest overexploitation of the limited resources of the bay.

However, there are also interventions from the government and non-government organizations (NGOs), which are geared towards the rehabilitation of the bay. The different Municipal Fisheries and Aquatic Resource Management Councils (MFARMCs) and the respective local government units (LGUs) implement mangrove reforestation and alternative livelihood programs, as well as apprehend illegal fishing operations in the bay. Various NGOs are also involved in the preservation of the bay's resources.

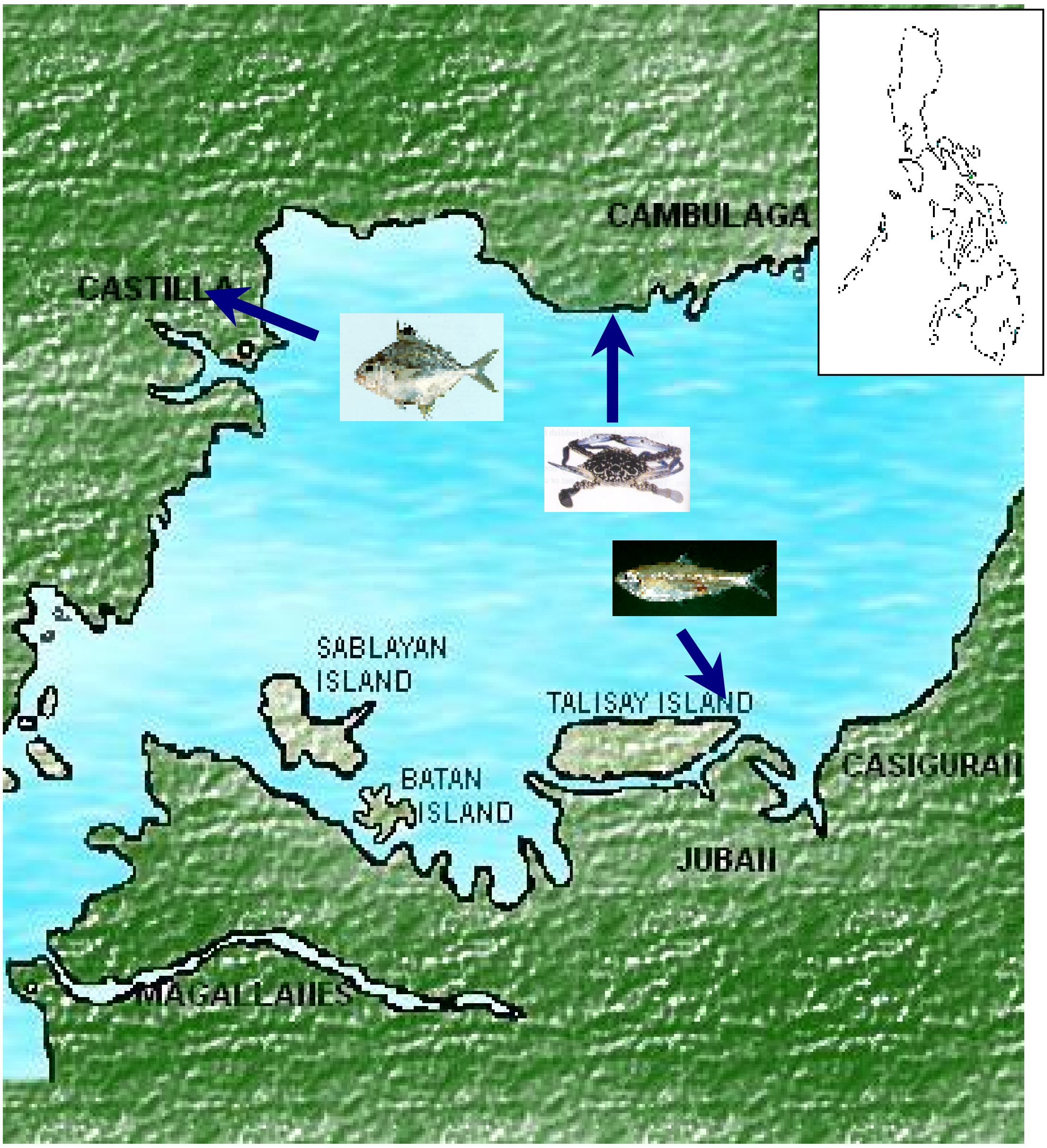


Figure 1. Map of Sorsogon Bay showing the location of fish landing centers in the area.

Studies on the assessment of the status of capture fisheries of Sorsogon Bay are very limited. This study aims to establish reliable fisheries statistics and baseline data which are useful as basis in the formulation of policy options and management plans essential for the development and sustainability of the bay's resources.

Objectives of the Study

General

- Develop institutional capability of regional fisheries manpower in resource assessment, management and development;

- Generate reliable data for the formulation of policies, management and conservation of marine resources to achieve sustainable development.

Specific

- Determine the catch composition, effort, and catch per unit effort by gear, of fish and invertebrate resources of Sorsogon Bay;

- Estimate the potential yield (PY) using the Schaefer and Fox models;

- Provide estimates of growth, mortality, exploitation ratio and recruitment pulse of key species of finfishes and invertebrates;

- Estimate the probability of capture of key species of finfishes and invertebrates;

- Determine the relative yield per recruit of key species of finfishes and invertebrates;

- Estimate the fishing mortaliy in relation to size through virtual population analysis (VPA);

- Recommend options to improve fishing for the sustainability of the bay.

METHODOLOGY

The fish landing sites in barangays Cambulaga (Sorsogon), Cawit (Casiguran) and Poblacion (Castilla) were selected as major sampling sites based on the volume of catch being landed, accessibility of the area, and willingness of fishermen to cooperate. Fish landings in these sites were monitored every other two days, including Saturdays, Sundays and holidays, from April 1999 to March 2003. Sampling time coincided with the landing time which usually started early in the morning. Two enumerators were assigned in each landing site to gather information on the total number of fishing boats operating, volume of catch by gear type, length measurements of major species of fish and invertebrates caught by specific fishing gear, etc.

An inventory of fishing boats and gear was conducted in the five municipalities, comprising of 67 barangays bordering the bay. Using the catch per unit effort (CPUE) or catch per trip/boat given by the respondents, the estimated production was computed using the equation:

$$\textit{Estimated Production} = \textit{Catch per unit effort (CPUE)} \times \textit{annual frequency of operation} \times \textit{number of gear units.}$$

Data on the catch composition for each gear by family and by species were stored, and sorted using a commercial spreadsheet program. However, for the seasonality of species, the Excel program was used for the unraised monthly monitored catch landing of the major gear and species.

The potential yield (PY) was generated using the surplus production models by Schaefer and Fox. The production was estimated per gear type following the equation:

$$\textit{Estimated Production} = \textit{Catch per unit effort (CPUE)} \times \textit{estimated number of boats} \times \textit{number of trips.}$$

Effort was standardized using the equation:

$$\textit{Standardized effort (per gear)} = \frac{\textit{Average Catch per Unit Effort}}{\textit{Average CPUE of GN}} \times \textit{Estimated number of boats.}$$

The estimated production and standardized effort per gear type were then summed up to get the total production and effort of the whole bay.

Growth parameters (L_∞ and K) and mortality coefficients (M, F and Z) of the major species were estimated using the FISAT (FAO-ICLARM stock assessment tools) software (Gayanilo *et al.* 1996). Length infinity (L_∞) was estimated using the Powell-Wetherall Plot (Powell 1979, Wetherall 1986), while maximum length (L_{max}) was approximated using the extreme value theorem (Formacion *et al*. 1991). The K-Scan routine of the ELEFAN I method (Pauly and David 1981) was used to estimate the growth curvature parameter (K) of the von Bertalanffy growth function (VBGF), while the Shepherd's Method was used to confirm the results of the latter which were incorporated in the FISAT software. The number of recruitment pulses was determined from the decomposition of normal distributions using Hasselblad's NORMSEP.

RESULTS AND DISCUSSION

Boat and Gear Inventory

Results of the inventory of boats and gear in Sorsogon Bay revealed a total of 6,012 units of fishing gear, belonging to 19 types, operating in the bay (Table 1). The bay's limited resources are shared by 64 barangays from the five municipalities surrounding the bay. The municipality of Sorsogon has more number of fishermen than the other coastal municipalities, and consequently registered the highest number of gear units. There are still gillnets being used with mesh sizes less than three centimeters (when stretched). All boats operating within Sorsogon Bay are classified as municipal or small scale with a capacity of less than three gross tons.

Based on the resource and ecological assessment (REA) conducted by Cinco *et al.* (1995), the number of fishing gear operating in Sorsogon Bay was 2,926 consisting of 47 types. Compared to the result of the present boat and gear inventory, it shows that in six years time the number of gear units had increased by 105 percent. For trawl alone, for instance, the BFAR in 1972 reported only 24 units; the REA (Cinco *et al.* 1995), 36 units; and this study, 45 units. Similarly, fish corral/stake trap increased from 44 units in 1972 to 235 in 1995, then to 352 units (this study). Despite the increased number of gear units, the estimated production decreased by 4.54 percent – from 5,585.62 mt (Cinco *et al.* 1995) to 5,332.22 mt. The tremendous increase in the number of fishing gear and at the same time a decrease in catch reflects the overfished status of the bay's resources.

Dominant Families

From April 1999 to March 2003, a total of 73 families were recorded – 56 fish families comprising of 223 species, five families of elasmobranchs with 11 species, and 12 invertebrate families with 36 species. Of these, family Clupeidae consistently dominated the catch, sharing 32.59 percent of the total catch (Fig. 2). The voluminous catch of family Clupeidae in Year 1 was boosted by the increased catch of two seasonal species, *Sardinella longiceps* and *S. fimbriata*, which contributed 34.29 mt to the total production. Families Ariidae and Sillaginidae consistently occupied the two top ranks for finfishes.

Families Penaeidae and Portunidae also ranked first and second for invertebrates for four years, with a total landed catch of 87.85 mt and 99.10 mt, respectively (Table 2). Indeed, Sorsogon Bay harbors an abundance of invertebrates, with these two families ranking second and third to Clupeidae in terms of overall dominance in catch.

Dominant Species

Selection of dominant species was based on consistency and volume of catch. Twenty-five fish species and 10 invertebrate species were dominant in Sorsogon Bay. *Escualosa thorocata* of the family Clupeidae dominated the catch, contributing 129.96 mt or 24.30 percent of the total catch. *Portunus pelagicus* gained over-all dominance for invertebrates with a production of 90.13 mt or 18.35 percent of the total landed catch (Fig. 3).

The bivalve *Paphia undulata*, locally known as "badoy", has now regained abundance after its noticeable decline in production starting 1989. Harvesting of "badoy" has been regulated and conservation efforts have been done by different sectors to manage this threatened species. There were only 1,538.80 kg of *P. undalata* monitored from November 1999 to April 2001. However, from May 2001 to March 2003 there was a disappearance of *P. undulata* in the designated NSAP sampling stations due to the succession of *Placuna placenta* and *Anadara* spp.

Table 1. Production estimates of the different types of fishing gear used in Sorsogon Bay (based on boat and gear inventory as of December 2001).

Fishing Gear	Number of trips per year	Ave. CPUE (kg/trip)	Est. No. of Gear	Estimated Production (mt)	Relative Contribution (%)
Gillnet				**2,273.35**	**42.63**
Encircling gillnet	140	19.15	117	313.68	
Bottom set gillnet	252	5.39	803	1,090.70	
Drift gillnet	252	3.54	314	280.11	
Trammel net	528	3.73	299	588.86	
Lift net				**1,891.47**	**35.47**
Stationary liftnet	252	8.14	65	133.33	
Portable liftnet	198	3.01	2950	1758.14	
Hook and line				**324.66**	**6.09**
Handline	204	2.48	403	203.89	
Multiple hook and line	168	2.94	8	3.95	
Bottom set longline	198	6.21	67	82.38	
Jigger	552	2.08	30	34.44	
Traps				**302.83**	**5.68**
Stake trap	200	3.67	352	258.37	
Fish pot	200	2.07	35	14.49	
Squid pot	504	3.13	19	29.97	
Seine net				**203.81**	**3.82**
Danish seine	228	3.81	211	183.29	
Beach seine	204	4.19	24	20.51	
Miscellaneous gear				**196.63**	**3.69**
Spear gun	216	2.67	23	13.26	
Compressor	168	29.5	37	183.37	
Push net				**101.87**	**1.91**
Man push net	198	2.45	210	101.87	
Trawl				**37.58**	**0.70**
Otter trawl	144	5.8	45	37.58	
TOTAL			**6,012**	**5,332.22**	**100.00**

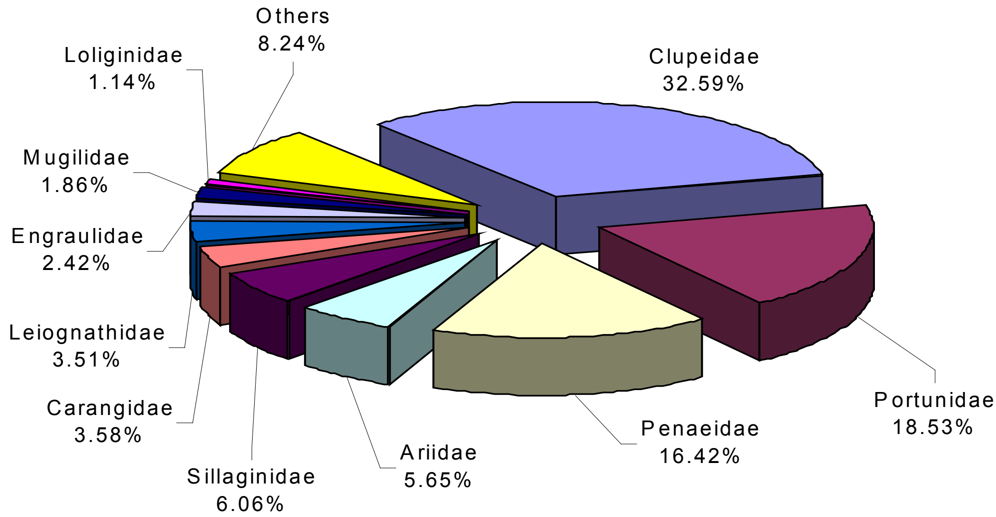


Figure 2. Dominant families of finfishes and invertebrates caught by major types of fishing gear in Sorsogon Bay, April 1999-March 2003.

Table 2. Catch data on the dominant fish and invertebrate families in Sorsogon Bay (April 1999-March 2003).

Family	Catch (kg)				Total Catch (kg)	Relative Abundance (%)
	Yr 1	Yr 2	Yr 3	Yr 4		
1 Clupeidae	67,150.00	38,840.04	42,101.53	26,224.09	174,315.66	32.59
2 Portunidae	15,897.41	17,427.75	23,445.76	42,331.58	99,102.50	18.53
3 Penaeidae	17,032.87	21,031.37	22,151.94	27,632.20	87,848.38	16.42
4 Ariidae	14,175.72	13,921.09	879.06	1,270.31	30,246.18	5.65
5 Sillaginidae	14,027.35	5,604.77	5,346.97	7,407.23	32,386.32	6.06
6 Carangidae	4,179.05	6,683.70	5,382.84	2,914.14	19,159.73	3.58
7 Leiognathidae	5,876.30	5,274.69	5,141.34	2,459.30	18,751.63	3.51
8 Engraulidae	7,134.22	2,086.19	1,714.22	2,000.52	12,935.15	2.42
9 Mugilidae	2,447.11	2,770.54	2,783.16	1,958.55	9,959.36	1.86
10 Loliginidae	2,286.48	743.36	1,711.16	1,369.11	6,110.11	1.14
Others	10,025.98	11,766.67	12,469.42	9,786.43	44,048.50	8.24
Total	**160,232.49**	**126,150.17**	**123,127.40**	**125,353.46**	**534,863.52**	**100.00**

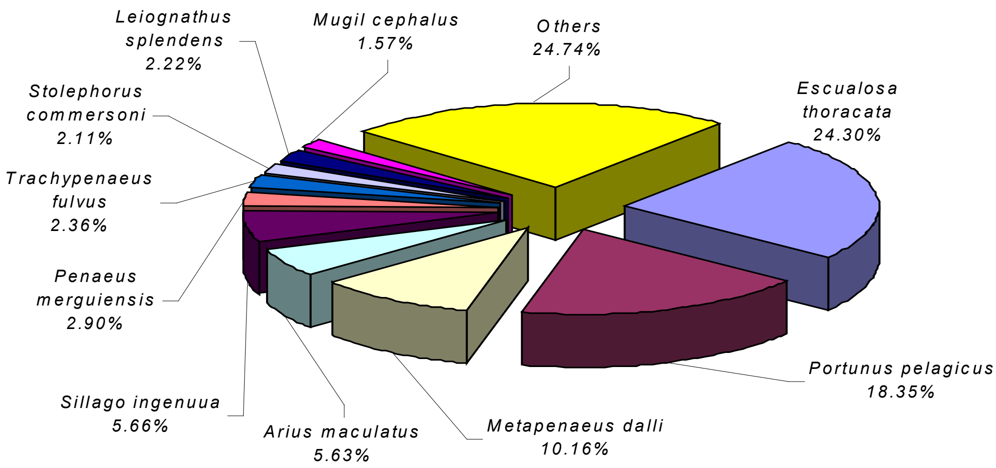


Figure 3. Dominant species of finfishes and invertebrates caught by major types of fishing gear in Sorsogon Bay, April 1999-March 2003.

Catch Composition of Major Fishing Gear

Escualosa thorocata dominated the catch of gillnet for four years, contributing 35.59 percent to the total catch (Fig. 4). The invertebrates, *Portunus pelagicus* and *Penaeus merguiensis*, were included in the 10 dominant species caught by gillnet.

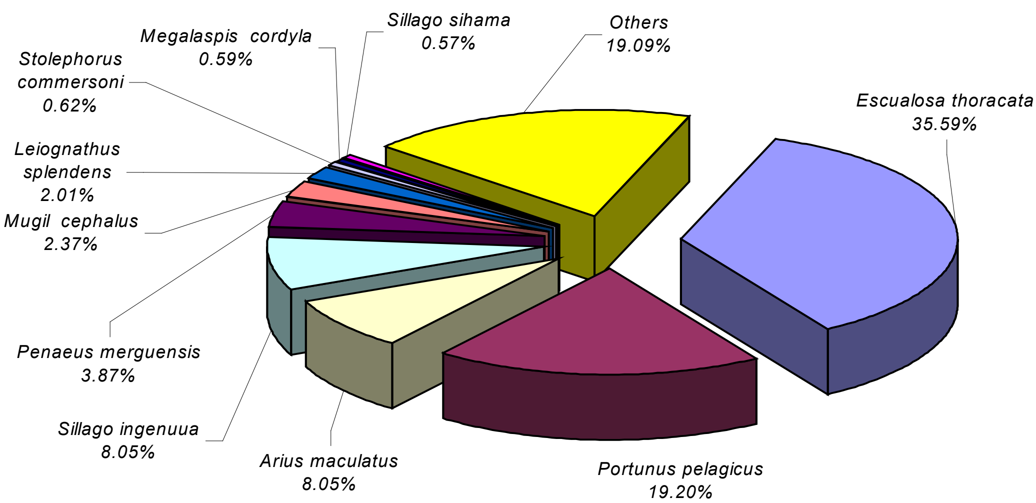


Figure 4. Dominant species caught by gillnet in Sorsogon Bay, April 1999-March 2003.

Among the species caught by otter trawl, *Metapeneaus dalli* had the greatest contribution (42.79 percent), followed by *Portunus pelagicus* (25.09 percent) and *Trachypenaeus fulvus* (10.19 percent) (Fig. 5). Only two demersal fish species were included in the dominant catch of otter trawl – *Sillago ingenuua* which is of commercial importance, and *Brachyamblyophus coecus* which is considered as trashfish.

The trawl survey of Sorsogon Bay by Ordoñez *et al.* (1972) showed that the leiognathids, particularly *Leiognathus splendens*, dominated the catch of trawls. This is a probable indication of ecological overfishing, since leiognathids had a cumulative production of only 11.084 mt, ranking sixth among the dominant finfish.

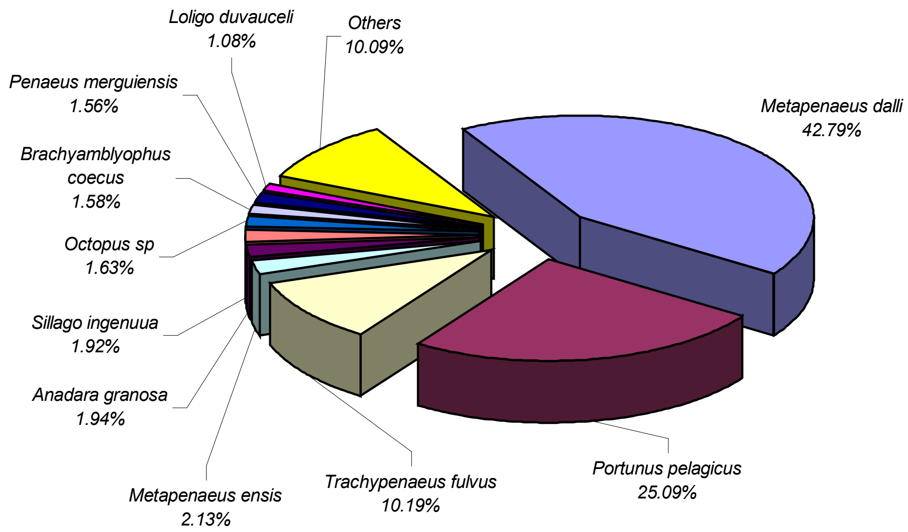


Figure 5. Dominant species caught by otter trawl in Sorsogon Bay, April 1999-March 2003.

The stationary liftnet is the third major gear in Sorsogon Bay. *Stolephorus commersonii* was the dominant species caught by this gear, contributing 19.92 percent to the total catch. This was followed by *Escualosa thoracata,* which accounted for 18.12 percent of the catch (Fig. 6). *Loligo duvauceli* was the only invertebrate among the dominant species caught by stationary liftnet.

Himantura uarnak contributed 25.71 percent, dominating the catch of bottom set longline; followed by *Arius maculatus* (18.55 percent). Another ray species, *Dasyatis kuhlii,* registered 4.35 percent of the catch of bottom set longline; the rest of the dominant catch of this gear were demersal fish species (Fig. 7).

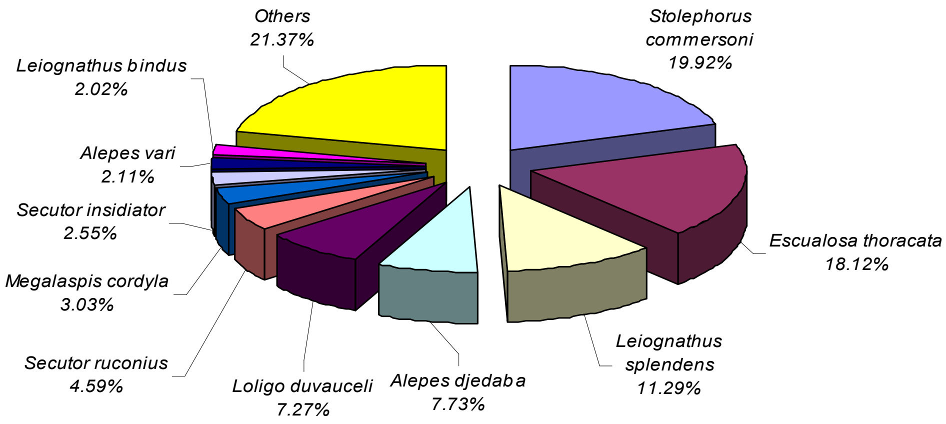


Figure 6. Dominant species caught by stationary liftnet in Sorsogon Bay, April 1999-March 2003.

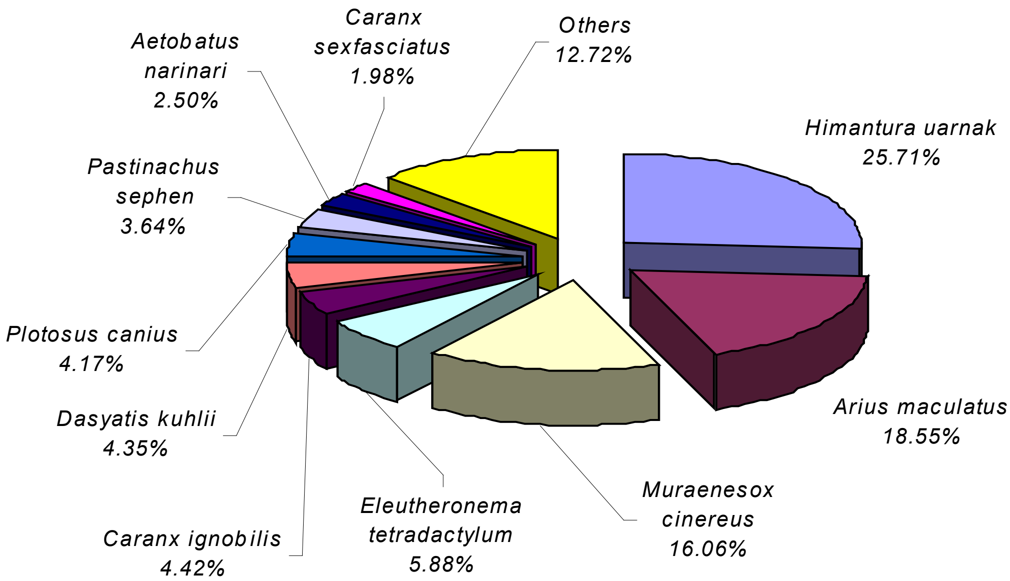


Figure 7. Dominant species caught by bottom set longline in Sorsogon Bay, April 1999-March 2003.

Figure 8 shows the catch composition of fish corrals, with *Alepes djedaba* and *Megalaspis cordyla* giving a combined share of 42.10 percent. The invertebrates *Loligo duvauceli* and *Metapenaeus dalli* gave an aggregate contribution of 6.98 percent.

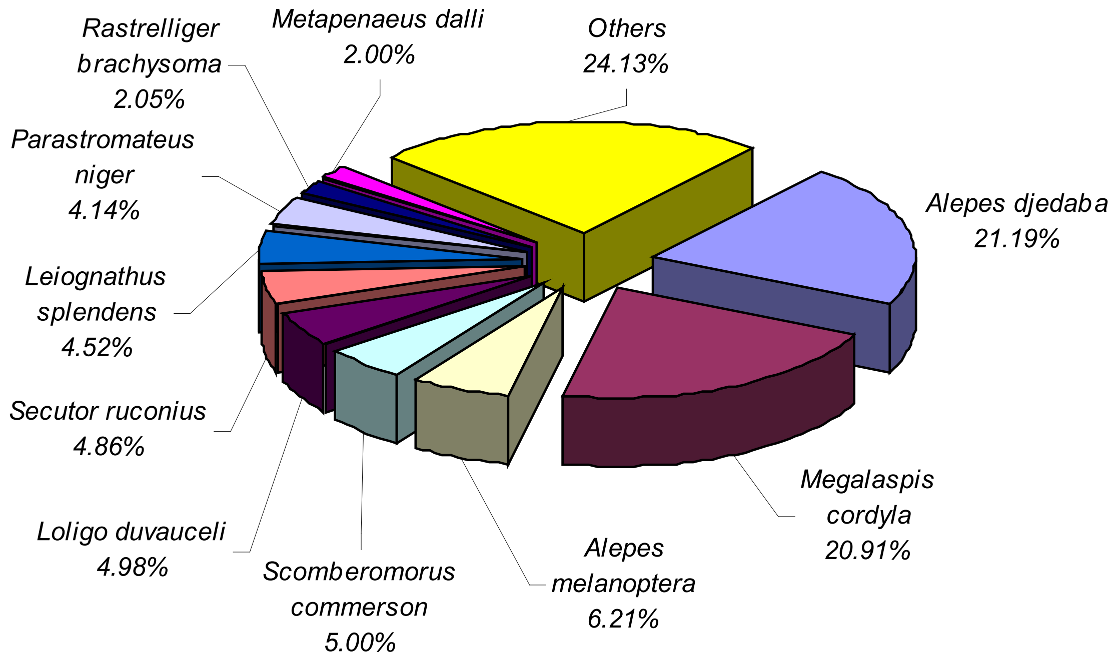


Figure 8. Dominant species caught by fish corral in Sorsogon Bay, April 1999-March 2003.

Catch Contribution of Major Fishing Gear

The total volume of fish landings monitored from April 1999 to March 2003 was 554.23 mt. Based on the production by gear, five types of fishing gear were identified as major gear, namely, gillnet, otter trawl, stationary liftnet, bottom set longline, and fish corral. Gillnets are of different types: bottom set gillnet, drift gillnet, encircling gillnet, and trammel net.

Gillnets contributed 62.38 percent to the total production of Sorsogon Bay. This shows that these gear are widely or commonly used, and are efficient in extracting the resources of the bay. Otter trawl, which is considered as an active gear, is still widely used; it ranked as the second major gear with a contribution of 22.54 percent. Stationary liftnet ranked third, contributing 8.26 percent to the total catch. Bottom set longline gave only 2.04 percent; while fish corral, which is dependent on the onset of tides, generated only 1.28 percent of the total catch. The remaining minor gear contributed 3.49 percent to the total catch (Fig. 9). The annual average number of common and minor types of fishing gear monitored per month from three sampling sites is shown in Table 3.

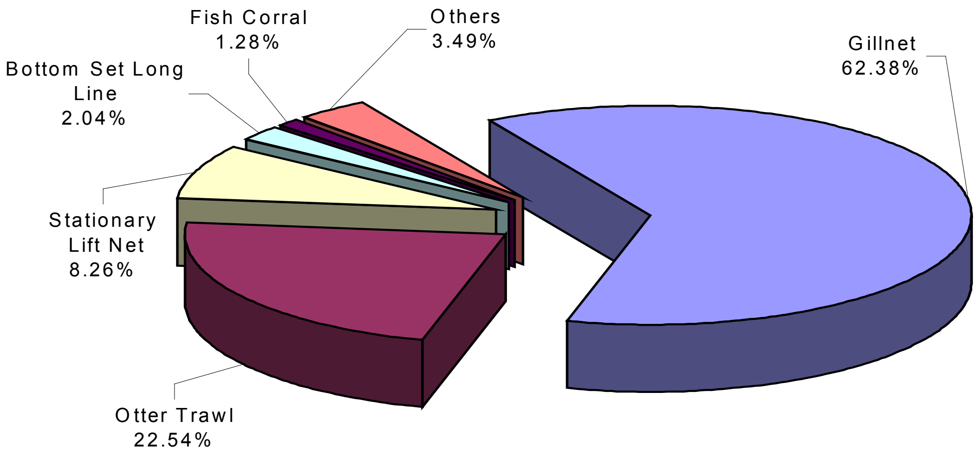


Figure 9. Catch contribution of the major types of fishing gear in Sorsogon Bay, April 1999-March 2003.

Table 3. Annual average number of common and minor types of fishing gear monitored per month at three landing centers in Sorsogon Bay (April 1999-March 2003).

Para-meter	Average Number of Fishing Gear Units per Month						TOTAL
	Major Gear					Minor Gear	
Inclusive Year	Gillnet	Otter trawl	Stationary liftnet	Bottom set longline	Fish Corral	(CLN, HL, DS, CP, FP, etc.)	
Year 1	1,098	144	75	27	25	216	1,585
Year 2	1,028	230	52	56	37	1,691	3,094
Year 3	1,046	390	51	52	27	1,039	2,605
Year 4	1,653	489	32	40	12	221	2,447

NOTE: Stationary liftnet (SLN), bottom set longline, and fish corral (FC) (which is dependent on the onset of tides), were found to be lesser in year 4 due to prolonged occurrence of the northeast wind ("amihan"), accompanied by strong winds and typhoons especially on the last quarter, which eventually destroyed most of the SLN and FC. Some owners shifted to other gear and engaged in upland activities due to financial constraints.

Seasonality of Species Caught by Major Fishing Gear

The seasonal abundance of 18 dominant species of fish and invertebrates is shown in Figures 10 to 12.

Figure 10 illustrates the seasonality of *Escualosa thoracata, Arius maculatus, Sillago ingenuua, Stolephorus commersoni, Leiognathus splendens and Mugil cephalus. E. thoracata* had peak production months in December (in year 4), January (years 2 and 3) and February (year 1). Production of *Arius maculatus* was highest in January (in year 1) and February and April (in year 2), while the lean months were from May to August both in years 3 and 4. These species were caught mainly by gillnet and were observed to be abundant during rainy months.

Other species that dominantly contributed to gillnet production were *Sillago ingenuua* and *Sillago sihama.* The peak season of *Sillago ingenuua* was between May and September, while the lean months were from October to April (throughout the four-year sampling period). *Stolephorus commersoni* had two identified peak periods – August to October, and May to July. The lean period of the species was from January to April.

Leiognathus splendens was abundant in September and October (in year 1). The bulk of production came from the catch of stationary liftnet. Production peak of *Mugil cephalus* was in July of year 2, while the lean period was between December and February (in years 1 to 4). The species was dominantly caught by encircling gillnet.

Figure 11 shows the seasonality of *Alepes djedaba, Megalaspis cordyla, Himantura uarnak, Sillago sihama, Secutor ruconius* and *Eleutheronema tetradactylum. A. djedaba*, which was dominantly caught by stationary liftnet, had the highest catch in August of year 3. The lean months of the species were from November to January (throughout years 1-4). *M. cordyla* highly occurred in August (in years 2 and 3); the species was mainly caught by fish corral.

The peak season of *H. uarnak* was consistent from May to June, except in year 1; the lean period was from August to March (in all years). The species was predominantly caught by bottom set longline and bottom set gillnet. *Sillago sihama* was abundant in April and February in years 1 and 2, which could be attributed to the operation of trammel net.

Secutor ruconius, which was mainly caught by stationary liftnet, yielded the highest catch in year 3. The peak months of *E. tetradactylum* were November and December of year 1, March of year 2, and June of year 3. The species was dominantly caught during these peak periods by encircling gillnet, bottom set gillnet, and bottom set longline, respectively.

Six species of invertebrates played an important role in the production of Sorsogon Bay. Catches of *Portunus pelagicus* were consistently high from 1999 to 2003, except in April and May of year 1 (Fig. 12). Throughout the four-year sampling period, production of *Metapenaeus dalli* was evidently high from May to October, and low during the months of November to April.

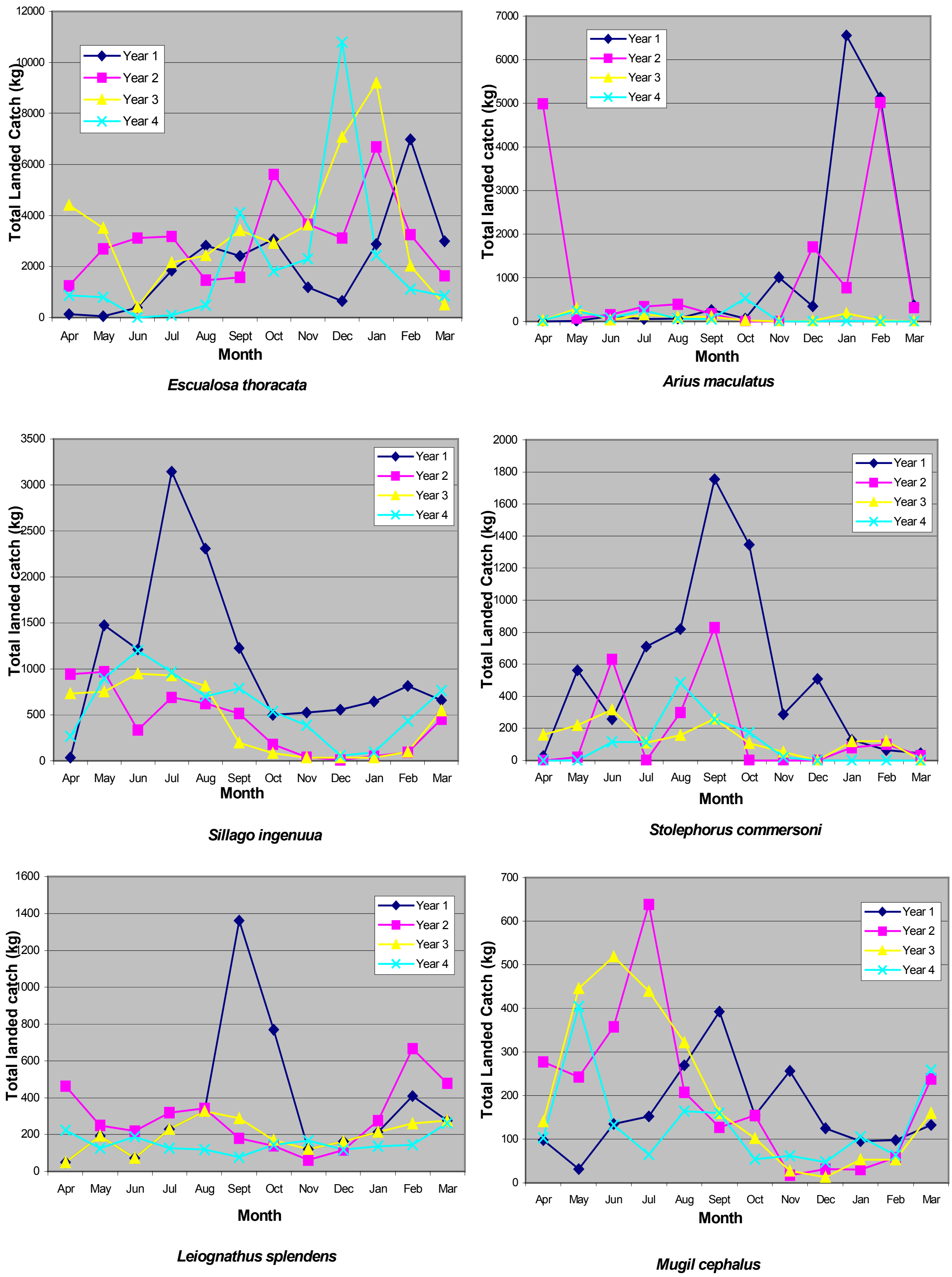


Figure 10. Seasonality of *Escualosa thoracata, Arius maculatus, Sillago ingenuua, Stolephorus commersoni, Leiognathus splendens and Mugil cephalus* in Sorsogon Bay (April 1999-March 2003).

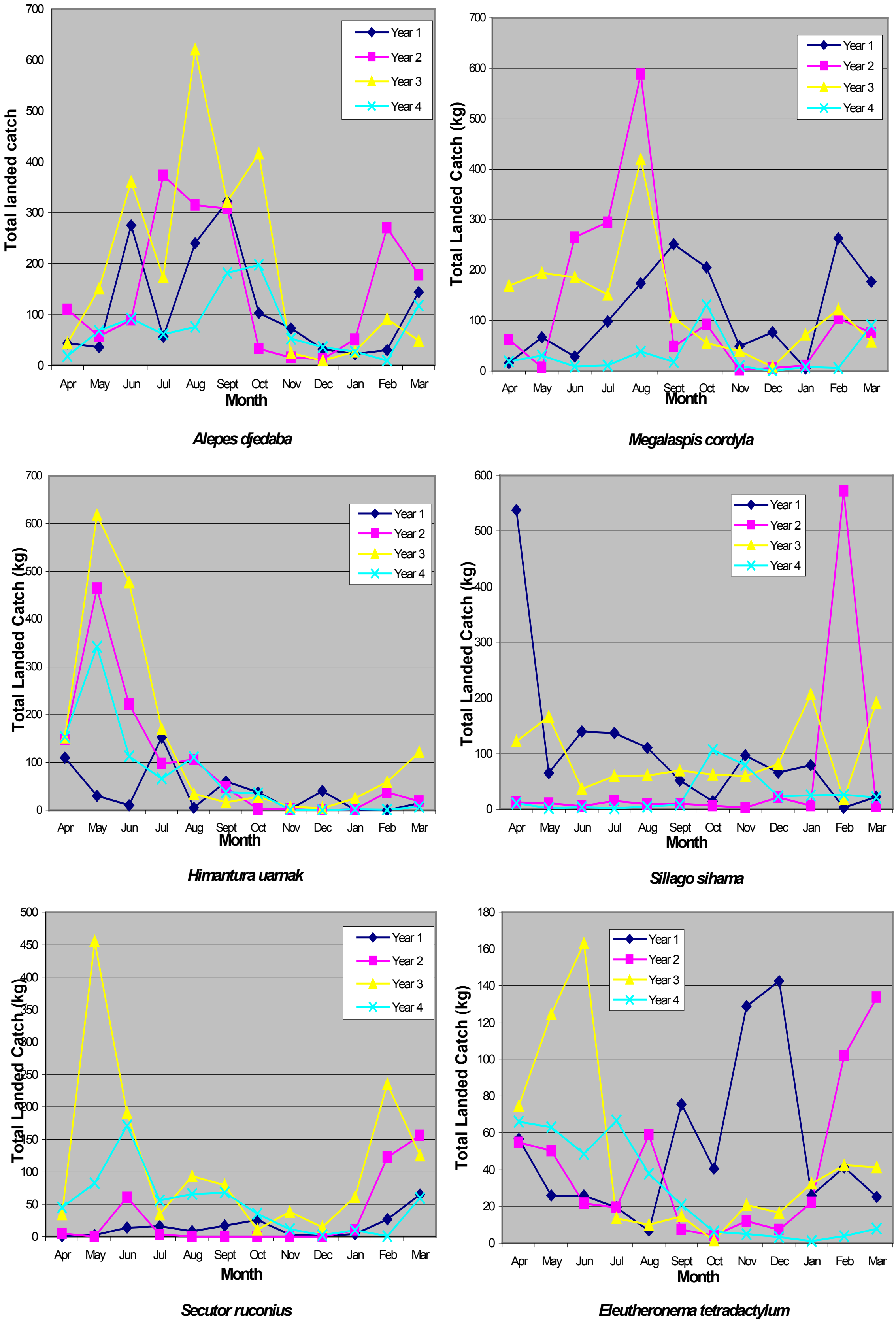


Figure 11. Seasonality of *Alepes djedaba, Megalaspis cordyla, Himantura uarnak, Sillago sihama, Secutor ruconius and Eleutheronema tetradactylum* in Sorsogon Bay (April 1999-March 2003).

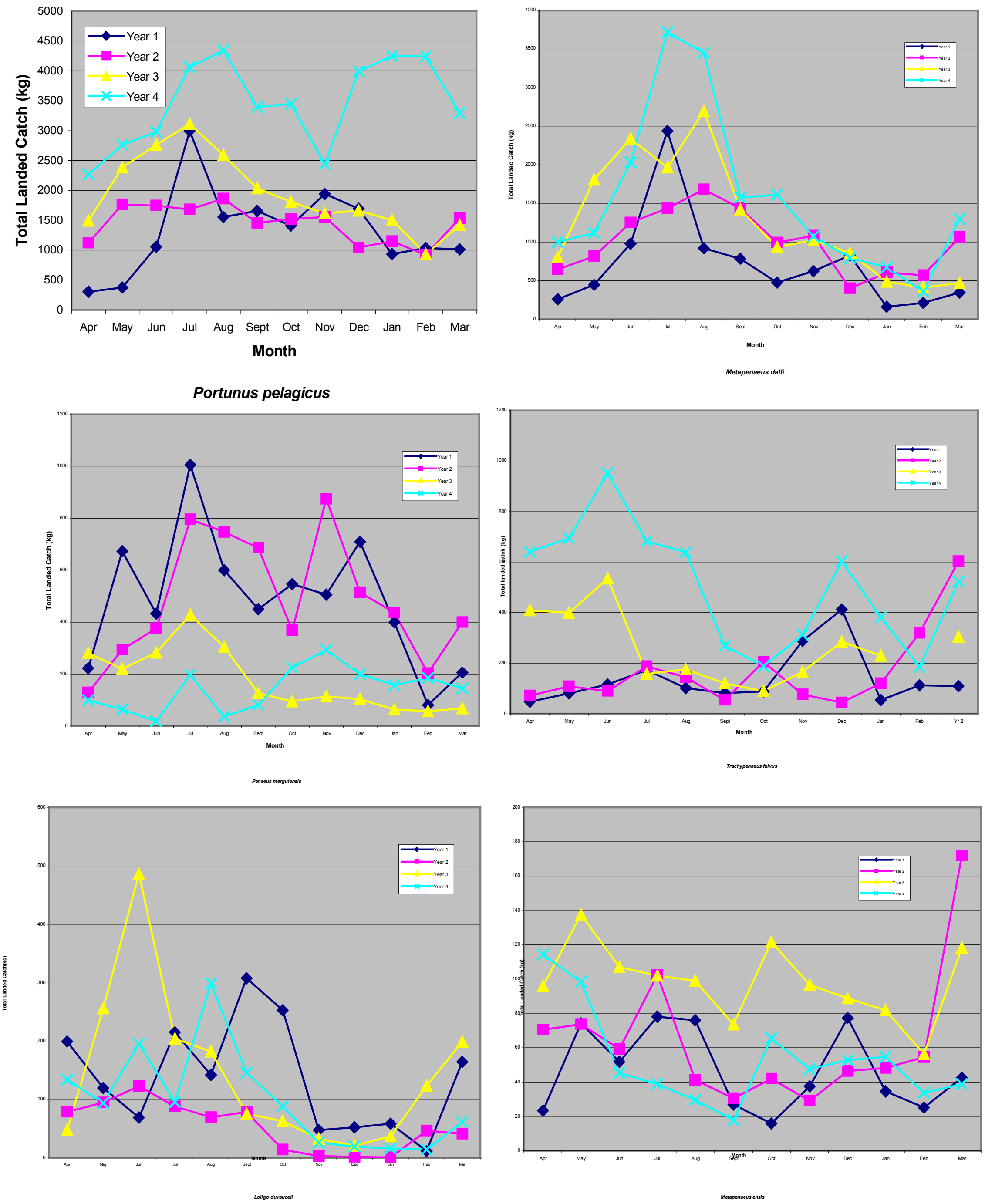


Figure 12. Seasonality of *Portunus pelagicus, Metapenaeus dalli, Penaeus merguiensis, Trachypenaeus fulvus, Loligo duvauceli* and *Metapenaeus ensis* in Sorsogon Bay (April 1999-March 2003).

Production of *Penaeus merguiensis* was consistently high in years 1 and 2. *Trachypenaeus fulvus* was abundant in years 3 and 4. *Loligo duvauceli* had its peak season from May to October, and lean months from

November to January (in all the sampling years). The production of *Metapenaeus ensis* did not vary considerably in four years time, although it was consistently more abundant in year 3 than in the other years.

Seasonality of Catch of Major Fishing Gear

The seasonality of catch of major fishing gear is dependent on the operation of each gear type (Fig. 13). The production of gillnet for four years did not vary much. The peak months were from December to March. The lean months were from April to November, except in year 1 when production was high (in June and July) which could be attributed to the catches of *Sardinella longiceps, Sillago ingenuua, Portunus pelagicus* and *Penaeus merguiensis.*

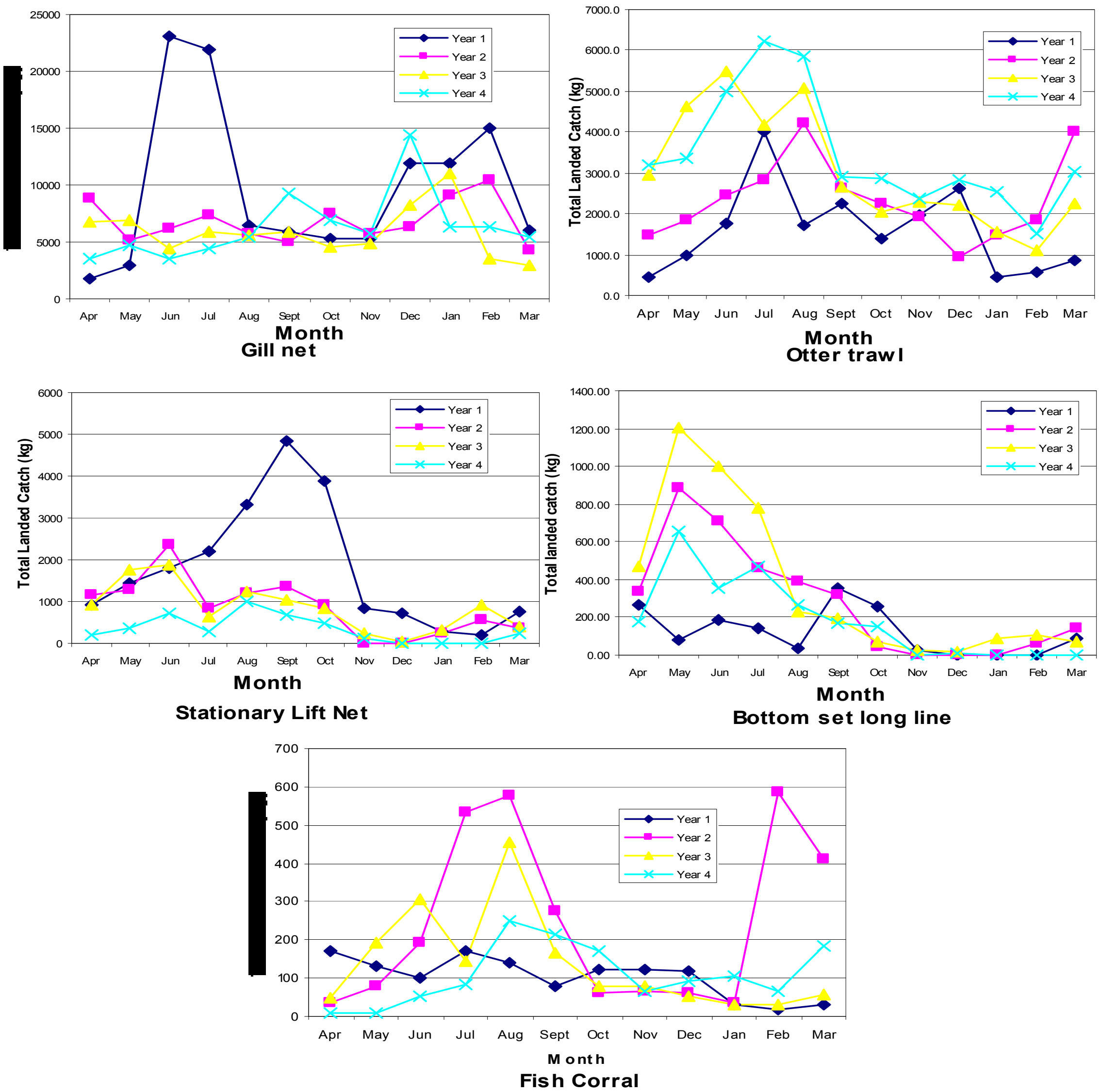


Figure 13. Seasonality of catch of major fishing gear in Sorsogon Bay (April 1999-March 2003).

Production of otter trawl was highest in July of year 4, and was attributed mainly to the landed catches of *Portunus pelagicus* and *Metapenaeus dalli*. The peak season was from March to August when the bloom of penaieds and portunids, such as *Metapenaeus dalli, Metapenaeus ensis, Penaeus merguiensis*, *Trachypenaeus fulvus* and *Portunus pelagicus*, occurred. Production was generally low from September to February.

Abundant catch of stationary liftnet was observed in the first year of the study, from August to October. The bulk of production was attributed to catches of *Stolephorus commersoni, Escualosa thoracata, Leiognathus splendens, Alepes djedaba* and *Loligo duvauceli.*

Production peak of the bottom set longline was in the month of May, except during the first year. Almost 26 percent of the total production in four years was caught by this particular gear, with the bulk of production attributed to the catch of *Himantura uarnak*. The lean period of production of the bottom set longline was between November and March throughout the four-year sampling period, as fishers shifted to other gear suited for the species in abundance.

Catches of fish corral were abundant during the months of July and August, and February to March in the second year of the study. The bulk of fish corral production was attributed to the abundance of *Megalaspis cordyla* and *Alepes djedaba.*

Catch, Effort and Catch Per Unit Effort

The catch per unit effort (CPUE) is an important information which, when correlated, would give the state of catches during the study period. Logarithmic transformation was undertaken whenever the set of monthly CPUE did not follow a normal distribution. The CPUE of five major types of fishing gear in Sorosogon Bay is shown in Fig. 14.

The highest annual average CPUE was gained by stationary liftnet, with CPUE values of 7.96-20.69 kg/boat, due to its production of *Stolephorus commersonii, Escualosa thoracata* and *Loligo duvauceli*. Otter trawl came in second, with CPUE values of 6.78-10.08 kg/boat; followed by fish corral, 4.33-7.07 kg/boat. Gillnet attained low CPUE values ranging from 3.62 kg/boat to 8.48 kg/boat, whereas the bottom set longline had the lowest CPUE values (2.88-6.00 kg/boat).

Theoretically, as the effort increases the catch increases, but only up to a certain level, that is, the potential yield (PY). This had been observed in the catches of stationary liftnet, bottom set longline and fish corral. However, for otter trawl, which contributed 84.92 percent of the total production, the catch continuously decreased with increased effort. The same trend was observed in gillnet production, especially in year 4 with the abundance of *Portunus pelagicus*. These observations clearly indicate high fishing pressure which eventually contributed to the overexploitation of the bay.

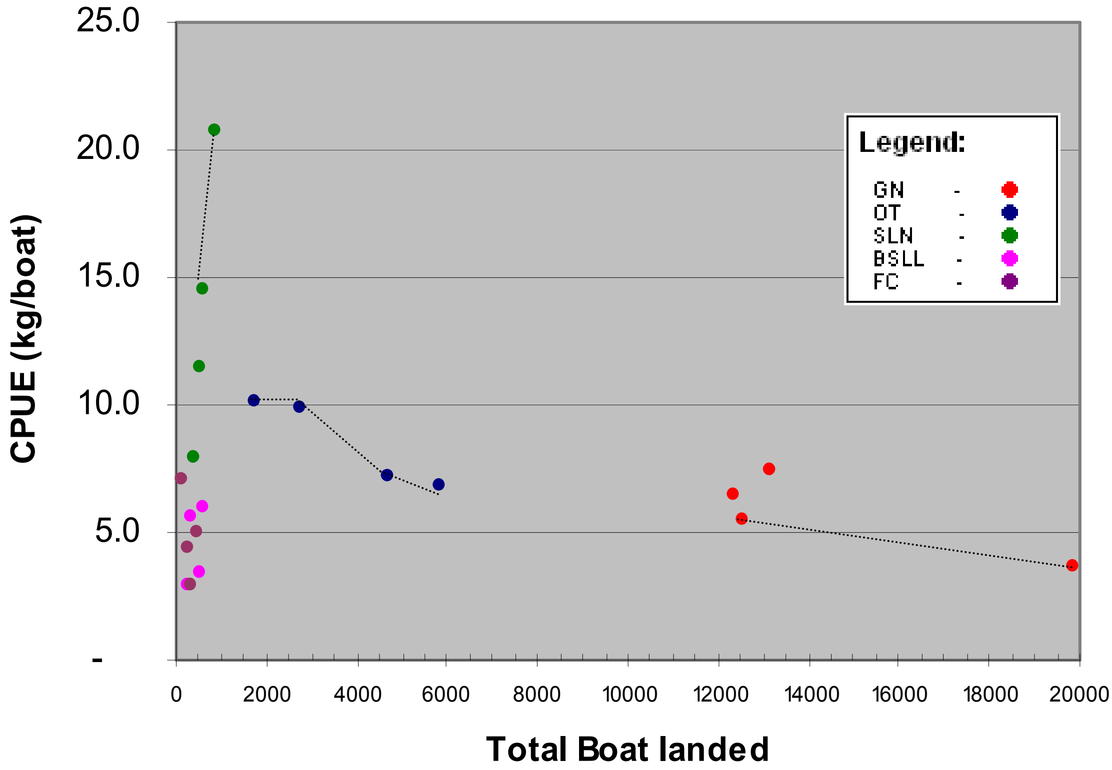


Figure 14. Catch per unit effort of major fishing gear in Sorsogon Bay (April 1999-March 2003). (GN=gillnet, OT=otter trawl, SLN=stationary liftnet, BSLL =bottom set longline, FC=fish corral.)

Surplus Production

The raised data of the production and standardized effort, using gillnet units, were used in the estimation of the potential yield or PY to represent the totality of the production of Sorsogon Bay (Fig. 15). The current annual yield was below the potential yield (PY) and the current level of effort had surpassed the maximum fishing effort (fPY), both in the Schaefer and Fox models, by 37 percent and 54 percent, respectively.

Ideally, the models used require a minimum of 10 years data to be able to generate a reliable analysis. However, only four years data for this study and one-year data from REA (Cinco *et al.* 1995) were available for preliminary analysis of the PY of Sorsogon Bay. Although these are insufficient to arrive at a conclusive analysis, nevertheless a preliminary analysis was done, the results of which point out that heavy fishing pressure was being exerted in the bay. This is evident in the considerable decline of CPUE despite increased effort. The situation, if left unattended, could lead to overexploitation of the bay's resources. Hence, on the part of the policy makers serious management interventions should be done, such as reducing the fishing effort by at least an averqge of 45 percent to allow the bay to recover its sustainable level of the resources.

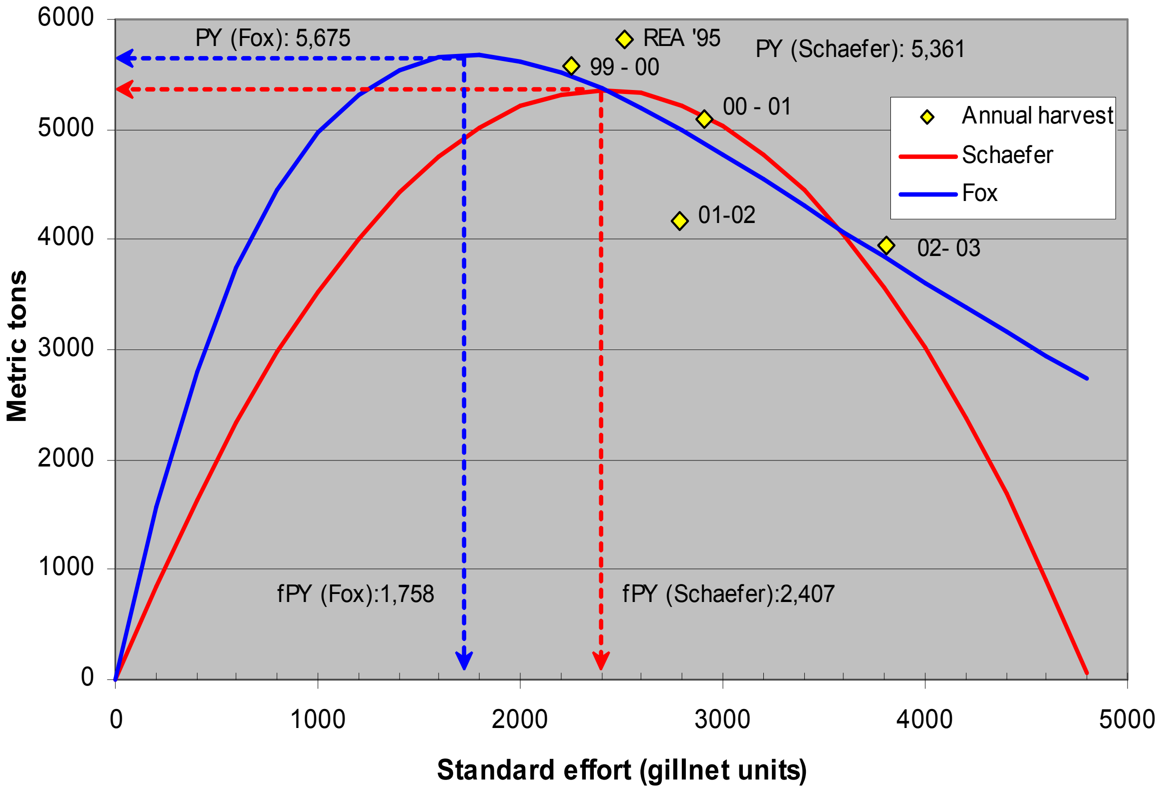


Figure 15. Estimates of potential yield (PY) using standardized effort of gillnet units in Sorsogon Bay (April 1999-March 2003).

Population Parameters

Estimates of population parameters of the eight most dominant species of finfishes and invertebrates are presented in Table 4. The growth coefficient (k) values of six species of finfishes varied from 0.66 $^{-1}$ to 1.50^{-1}. Their growth performance indices (Ø) are within the range reported on the same species in other fishing grounds of the Philippines. All the six species exhibited high Z values (3.21-7.41), implying very low survival rates especially for *Rastrelliger brachysoma* and *Leiognathus splendens*.

There are two species of invertebrates being exploited by otter trawl, a major gear in Sorsogon Bay. These are *Portunus pelagicus* and *Penaeus merguiensis*. The estimated values obtained on carapace width infinity ($CW\propto$), K and Z between male and female *P. pelagicus* showed no significant difference. The high E-values (0.64 to 0.69) indicate high fishing pressure in the area, particularly for *Portunus pelagicus.* The recruitment pattern exhibited was bimodal, which conforms with the results of Del Mundo *et al.* (1990). *Penaeus merguiensis* obtained a $CL\propto$ of 3.91 cm to 4.37 cm. The female *P. merguiensis* were generally larger than the male. There was no significant difference in the K values obtained for male and female *P.*

merguiensis (1.40^{-1} and 1.50^{-1}, respectively). Exploitation rates obtained were high, varying from 0.67 to 0.75, which are above the optimum values of exploitation for tropical fishes.

A comparison of results of this study and that of Cinco (1995) on the growth and exploitation rate of *Leiognathus splendens* and *Sillago sihama* is shown in Table 5. According to Cinco (1995), all species in Sorsogon Bay that were analyzed are fast-growing species with high growth rate but with high E-values.

Fifty percent of the species analyzed showed unimodal recruitment peaks, while the other half exhibited bimodal recruitment pulses. Figure 16 shows the frequency distribution of E-values of the analyzed species. Exploitation rates are high, between 0.55 (for *Rastrelliger brachysoma*) and 0.67 (for *Megalaspis cordyla*). These values are above the optimum values (E = 0.30-0.50) for maximizing biological yield (Pauly 1984). This could be an indication of high fishing pressure being exerted in Sorsogon Bay.

Different types of gear catch different sizes of fish and invertebrates. There are gear that are designed to catch relatively smaller individuals. For example, otter trawl, trammel net and stationary liftnet commonly catch small-sized finfishes.

The increase in the number of gear units in Sorsogon Bay, as confirmed by the result of the boat and gear inventory, has caused so much fishing pressure on the bay, thus affecting its production significantly. The results of the analysis of population parameters support this observation. Thus, management efforts should focus on measures such as the need to reduce fishing effort by at least 45 percent to increase the yield per recurit. Strict enforcement of fishery laws is necessary, to sustain the use of available resources; as well as rehabilitation of degraded ecosystem, which affects the fishery resources of Sorsogon Bay, to regain the loss from degradation.

Probability of Capture

Two fish species (*Sillago ingenuua* and *Leiognathus splendens*) were caught at sizes (lengths at 50 percent probability of capture or L50) less than half of their length infinity (L∞) (see Table 4). *S. ingennua* was caught by otter trawl, and *L. splendens* by stationary lift net. As to their size ratio (L50/L∞), *S. ingenuua* and *L. splendens* were observed at 41 percent and 49 percent, respectively. These species have not reached maturity or spawning stage for them to contribute to production.

Similarly, the rest of the species analyzed were caught at an early stage of maturity, thus contributing to the depletion of future breeders in the biomass. The catch of small sizes of fish was an evidence of the use of fine-meshed nets (from 1.45 cm to less than 3.0 cm). The legal size, under RA 8550, is 3.0 cm.

Table 4. Population parameters of dominant species in Sorsogon Bay (April 2001-March 2002).

Gear	SPECIES	N	Size at Maturity	L_{max} (cm)	L_{oo} (cm)	L_{50}	L_{50}/L_{oo} (%)	K (yr^{-1})	Z (yr^{-1})	M (yr^{-1})	E (yr^{-1})	E_{max}	F (yr^{-1})	F_{max}	No. RP
	FINFISHES														
TN	*Leiognathus splendens*	29,410	8.0 - 14.30	15.97	15.81	8.84	56	1.00	4.23	2.14	0.49	0.61	2.09	3.54	2
SLN	*Leiognathus splendens*	60,650		17.82	18.67	9.24	49	0.81	7.41	1.78	0.76	0.62	5.63	2.90	2
OT	*Leiognathus splendens*	319		14.05	15.36	8.34	54	1.50	7.28	2.76	0.62	0.58	4.52	3.81	1
GN	*Megalaspis cordyla*	1,243	27.1 - 48.60	38.09	38.09	21.23	56	0.90	4.71	1.57	0.67	0.63	3.14	2.67	2
OT	*Sillago ingennua*	2,994	9.60 - 17.30	26.70	26.40	10.74	41	1.15	5.09	2.06	0.60	0.56	3.03	2.62	1
HL	*Sillago sihama*	6,591	12.5 - 22.40	29.32	30.96	17.19	56	0.97	4.82	1.76	0.63	0.63	3.06	3.00	1
TN	*Rastrelliger brachysoma*	247	11.5 - 20.70	25.89	25.60	17.29	67	0.66	3.21	1.45	0.55	0.64	1.76	2.58	2
SLN	*Alepes djedaba*	54,722	17.8 - 31.90	17.59	17.21	9.98	58	0.78	4.96	1.77	0.64	0.63	3.19	3.02	1
	INVERTEBRATES														
OT	*Portunus pelagicus (M)*	6,964	10.60	20.84	21.09	12.46	59	1.58	8.62	2.70	0.69	0.63	5.92	4.60	2
	Portunus pelagicus (F)	5,878	10.4 - 13.65	19.41	19.39	11.57	60	1.58	7.68	2.77	0.64	0.62	4.91	4.72	2
OT	*Penaeus mergueinsis (M)*	2,732	No data	3.84	3.91	2.22	51	1.40	7.84	1.98	0.75	0.63	5.86	3.37	1
	Penaeus mergueinsis (F)	1,931	No data	4.17	4.37	2.25	52	1.50	6.24	2.05	0.67	0.61	4.19	3.21	1

Source of data on size at maturity: Froese and Pauly (2002).

Table 5. Comparative results on population parameters K (growth) and E (exploitation rate) of *Leiognathus splendens* and *Sillago sihama*.

Parameters/Species	This Study	Cinco (1995)
K (Growth) *Leiognathus splendens* *Sillago sihama*	 0.81-1.50 0.97	 0.8 1.4
E-values *L. splendens* *S. sihama*	 0.49-0.76 0.63	 0.48 0.59

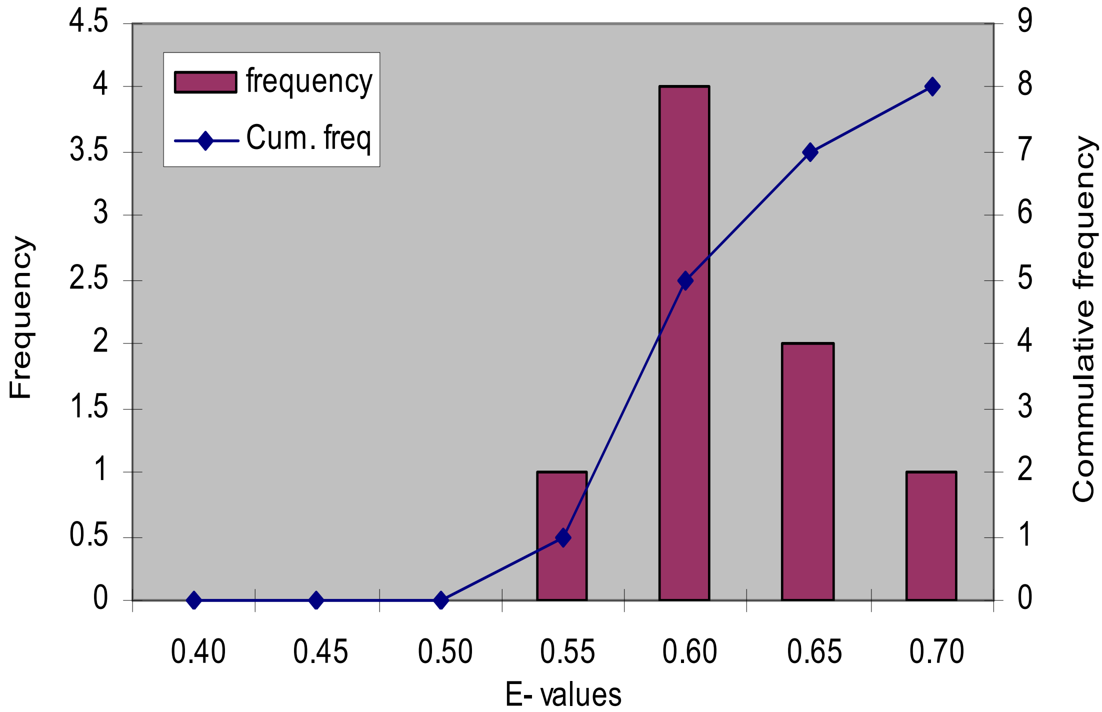


Figure 16. Frequency distribution of E values of eight species of finfishes and invertebrates in Sorsogon Bay.

Virtual Population Analysis

Results of the virtual population analysis (VPA) showed that there is a reduction in biomass as fishing intensifies. The results also supported the observations on the 50 percent probability of capture. Fishing mortality was high, with a considerable catch at length classes below 50 percent of the length infinity ($L\infty$) of a number of species caught by otter trawl (OT) and stationary liftnet (SLN). This was observed in *Sillago ingenuua, Portunus pelagicus*, *Loligo duvauceli* and *Sepioteuthis lessoniana* with high fishing mortality at sizes 12.0 cm (OT), 7.13 cm (OT), 5.5 cm (OT) and 8.0 cm (SLN), and 13.0 cm (SLN), respectively. *Loligo duvauceli* was already caught at 2.25 cm and *Sepioteuthis lessoniana* at 5.63 cm. This is alarming, since the known sizes at maturity of these species are 11.50 cm and 10.0 cm, respectively.

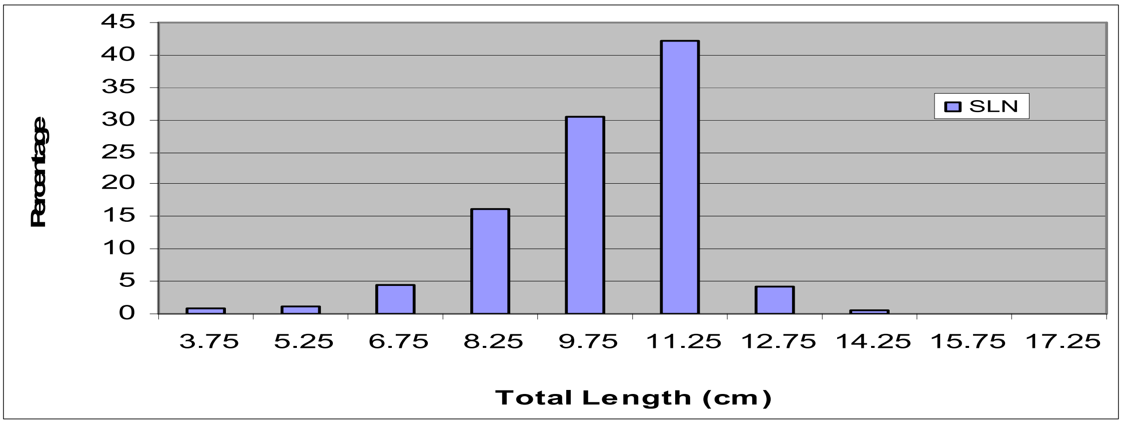
However, fishing mortality peaks were also observed for larger sizes although catch was minimal. The same results came out in the use of trammel net and bottom set gillnet; both gear types utilized netting materials with smaller sizes (0.95-10.16 cm). Hooks of small sizes (#572-# 554) were used in the hook and line.

The results are substantiated by the size distribution of some species caught by different types of fishing gear (Figs. 17-21). Both finfishes and invertebrates registered a high percentage (21-100 percent) at length below the known maturity size.

Relative Yield Per Recruit

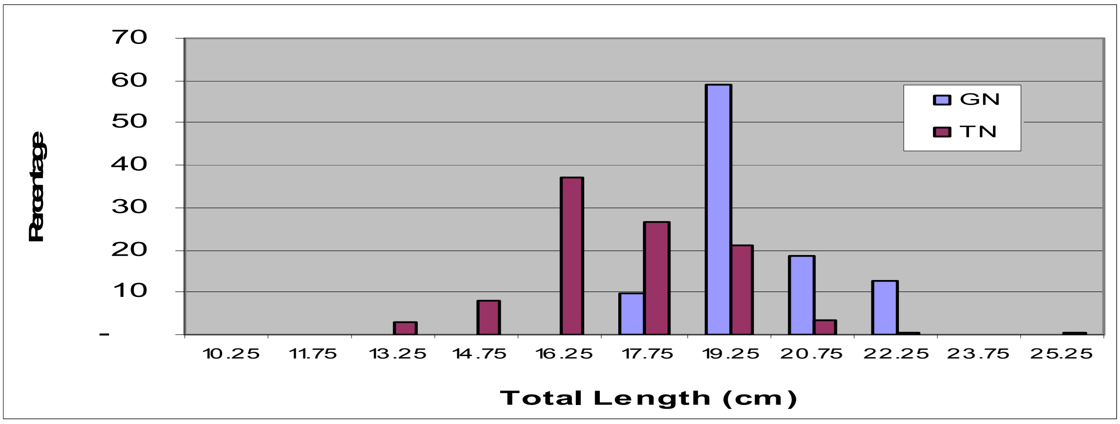
The current fishing mortality (F) exerted was higher by 12 percent than the maximum level of fishing mortality (Fmax). This was observed in eight dominant species in which 64 percent of the total mortality was attributed to fishing mortality (F) and 36 percent to natural mortality (M) (Fig. 22). This suggests that all species have already surpassed the allowable limit of exploitation or fishing activities critical in sustaining the resources of the bay.

SM: 17.8-31.9 cm



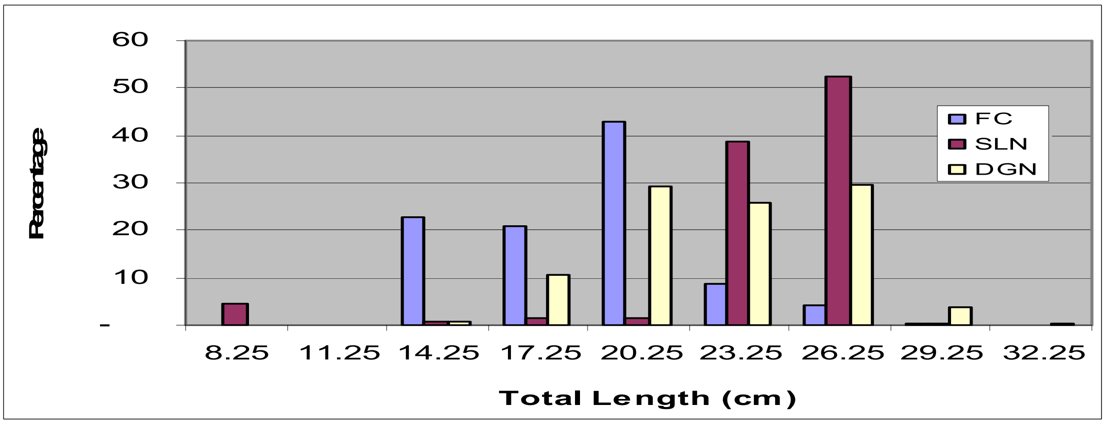
Alepes djedaba

SM: 11.5-20.7 cm



Rastrelliger brachysoma

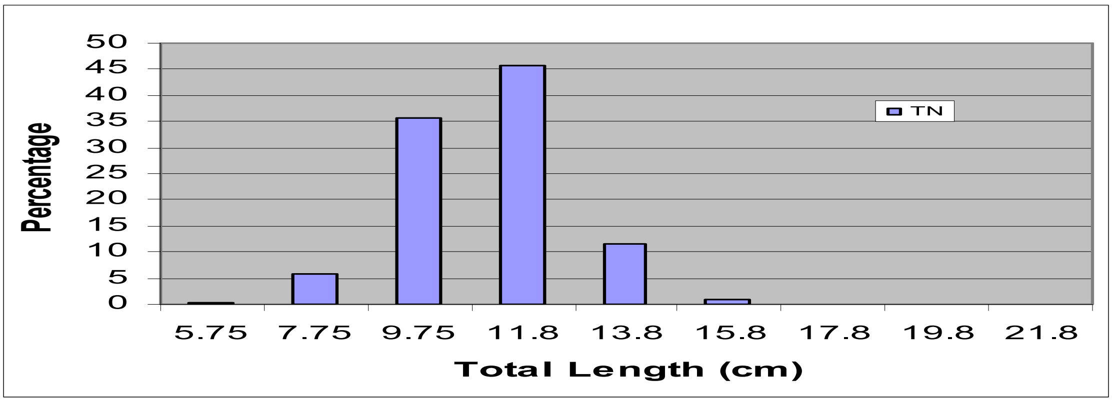
SM: 27.1-48.6 cm



Megalaspis cordyla

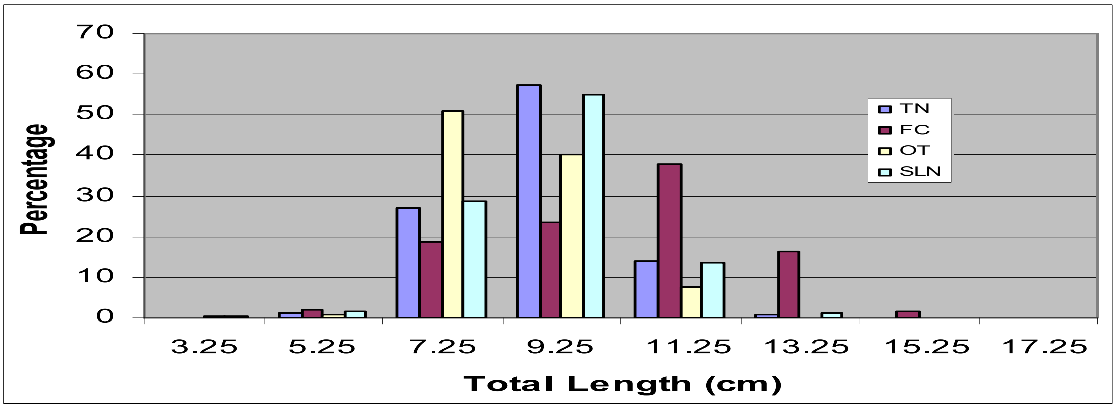
Figure 17. Size distribution of *Alepes djedaba, Rastrelliger brachysoma* and *Megalaspis cordyla* in Sorsogon Bay. (SLN=stationary lift net, GN=gill net, TN =trammel net, FC=fish corral, DGN=drift gillnet.)

SM: 13.8-24.8 cm



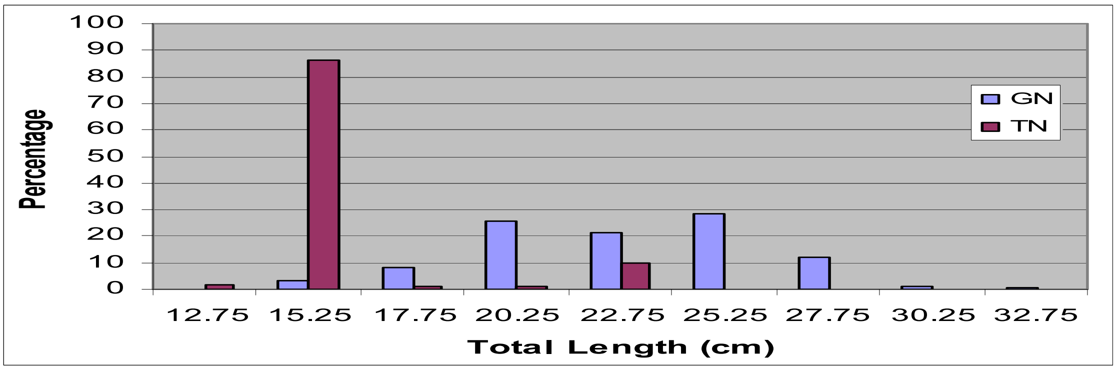
Gerres oyena

SM: 8.0-14.3 cm



Leiognathus splendens

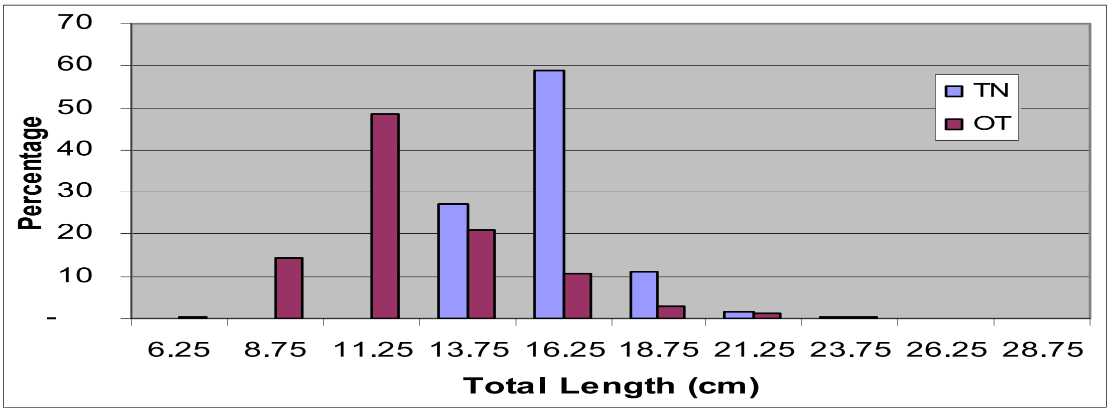
SM: 40.7 - 73.1 cm



Mugil cephalus

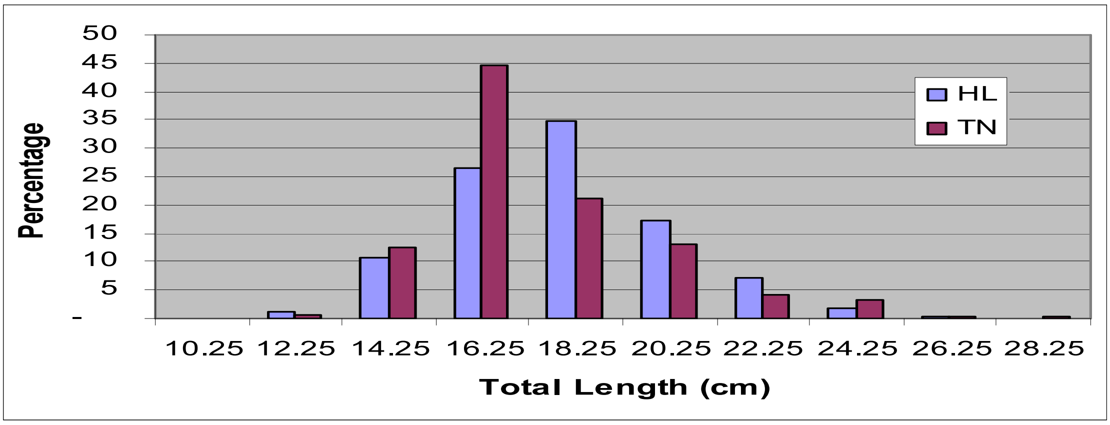
Figure 18. Size distribution of *Gerres oyena, Leiognathus splendens* and *Mugil cephalus* in Sorsogon Bay. (TN=trammel net, FC=fish corral, OT=otter trawl, SLN=stationary liftnet, GN=gillnet.)

SM: 9.6-17.3 cm



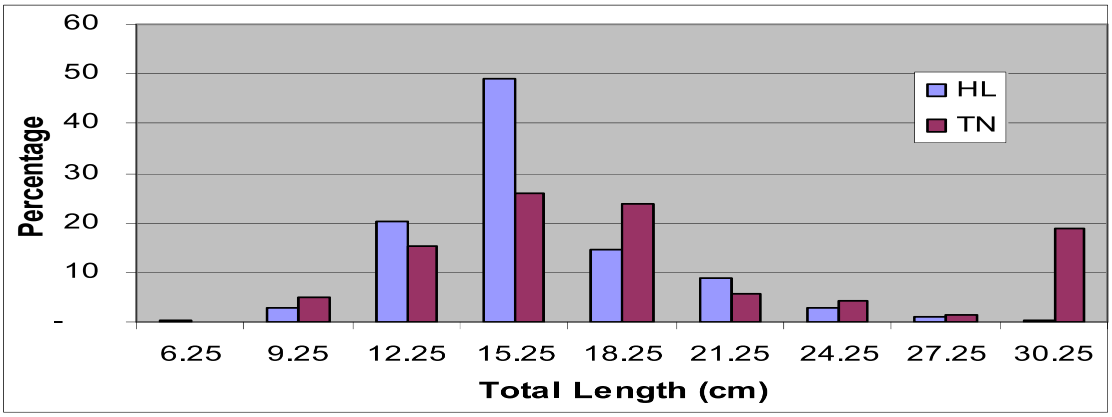
Sillago ingenuua

SM: 12.5-22.4 cm



Sillago sihama

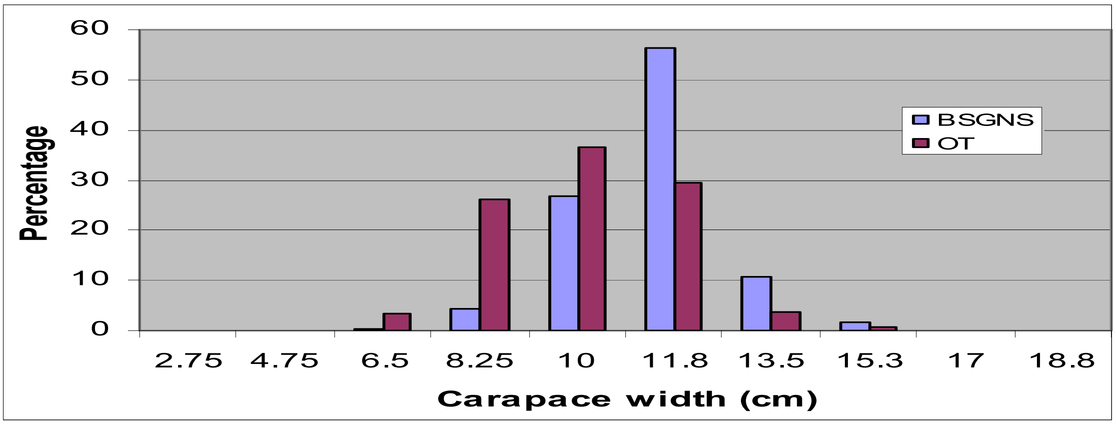
SM: 16.2-29.1 cm



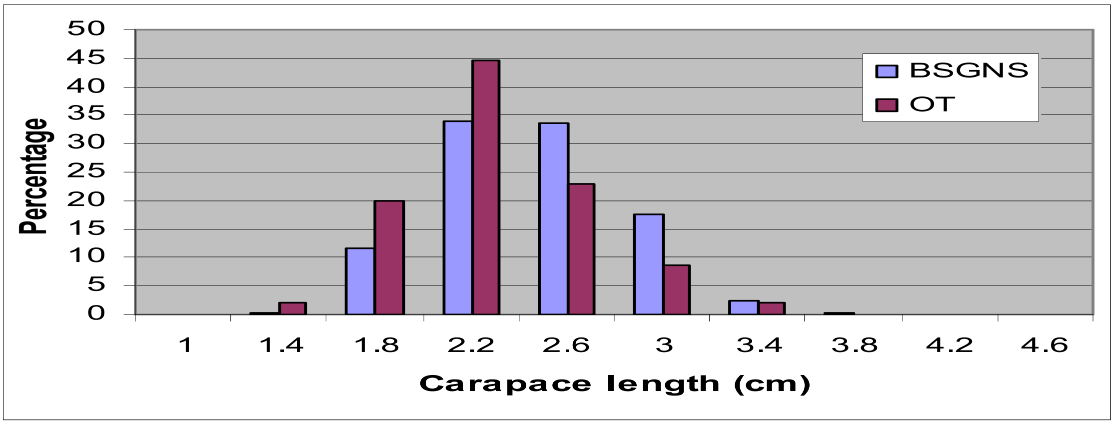
Terapon jarbua

Figure 19. Size distribution of *Sillago ingenuua, S. sihama* and *Terapon jarbua* in Sorsogon Bay. (TN=trammel net, OT=otter trawl, HL=hook and line.)

SM: 10.4-13.65 cm

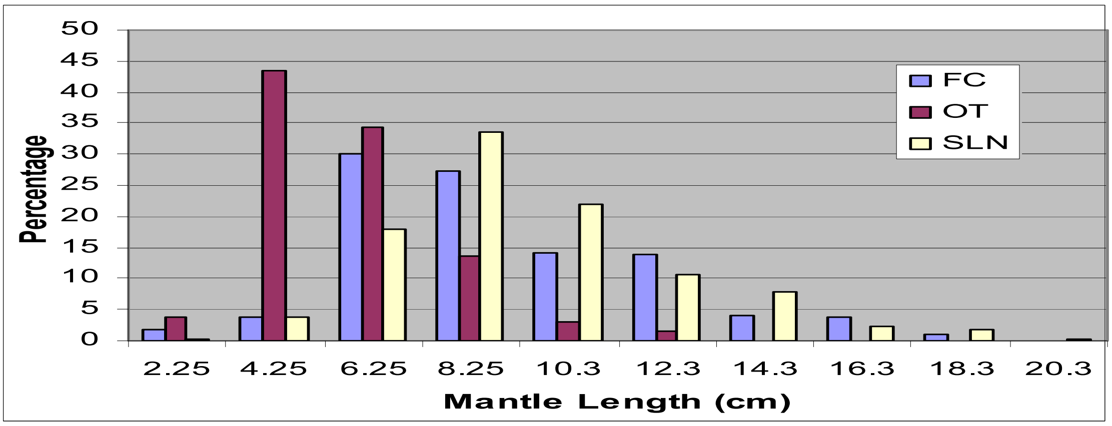


Portunus pelagicus



Penaeus merguiensis

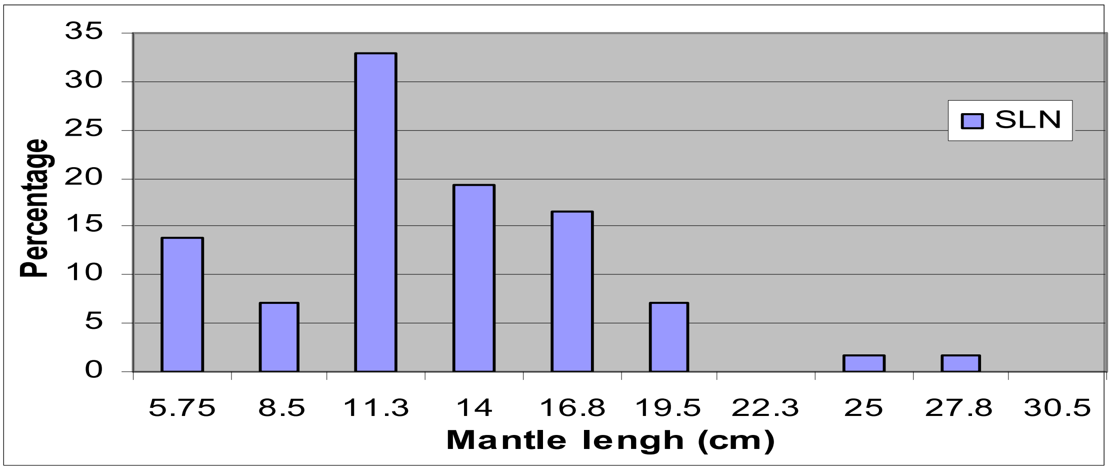
SM: 11.50 cm



Loligo duvauceli

Figure 20. Size distribution of *Portunus pelagicus, Penaeus merguiensis* and *Loligo duvauceli* in Sorsogon Bay. (BSGN=bottom set gillnet, OT=otter trawl, FC=fish corral, SLN=stationary liftnet.)

SM: 10 cm



Sepioteuthis lessoniana

Figure 21. Size distribution of *Sepioteuthis lessoniana* in Sorsogon Bay. (SLN=stationary liftnet.)

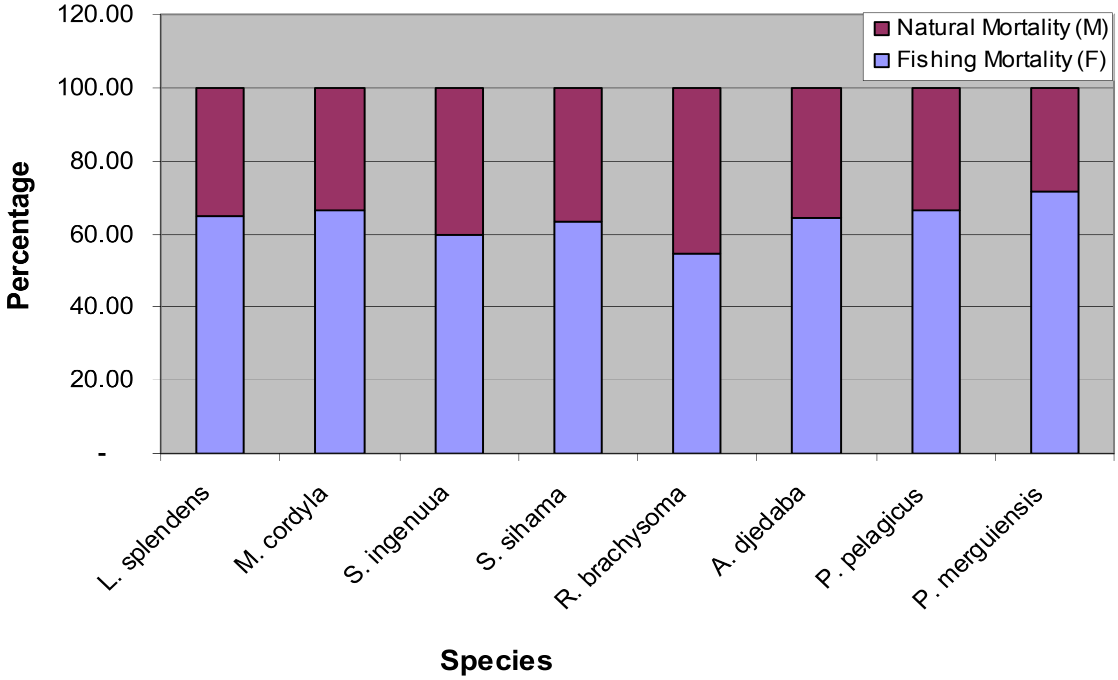


Figure 22. Mortality parameters of key species from three landing centers in Sorsogon Bay.

CONCLUSION AND RECOMMENDATIONS

The present study revealed observations of heavy fishing pressure and growth overfishing in Sorsogon Bay. These observations confirm earlier findings that the bay is biologically overfished (Ordoñez *et al.* 1972) and that several dominant demersal fishes have high exploitation rates and fishing mortalities (Cinco 1995, Cinco *et al*. 1995). The situation is a result of laxity in the implementation of fishery laws, most especially on the operation of otter trawl and the use of fine-meshed nets (0.95-10.16 cm) in gillnet, fish corral and stationary liftnet fishing operations.

To address the problems of overexploitation and growth overfishing of Sorsogon Bay, the following measures are recommended:

a) institutionalization of the Integrated Sorsogon Bay Management Council;

b) provision of an Integrated Coastal Zone Management Plan;

c) institutional building (strengthening the fisherfolk organizations, and cooperative creation of special bodies, committees/technical working groups and other groups/organizations relevant to fisheries);

d) installation of the following resource management options:

- reduction of fishing effort to an average of 45 percent (number of boats and gross tonnage)
- strict enforcement of fishery laws (regarding the use of fine-meshed nets, active gear and other destructive fishing operations).
- provision of alternative livelihood programs
- advocacy towards resources conservation and sustainable development.

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