Technical Paper Series
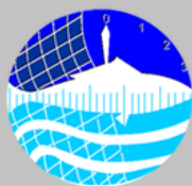
December 2009

ASSESSMENT OF COMMERCIAL FISHERIES OF WESTERN AND CENTRAL VISAYAN SEA

May R. Guanco
Sheryll V. Mesa
Prudencio B. Belga
Dino Raphael M. NuÑal

National Stock Assessment Program

ASSESSMENT OF THE COMMERCIAL FISHERIES OF WESTERN AND CENTRAL VISAYAN SEA

MAY R. GUANCO
SHERYLL V. MESA
National Stock Assessment Project
Bureau of Fisheries and Aquatic Resources
Regional Field Office 6
Iloilo City

PRUDENCIO B. BELGA
DINO RAPHAEL M. NUÑAL
National Stock Assessment Project
Bureau of Fisheries and Aquatic Resources
Regional Field Office 7
Cebu City

ASSESSMENT OF THE COMMERCIAL FISHERIES OF WESTERN AND CENTRAL VISAYAN SEA

MAY R. GUANCO
SHERYLL V. MESA
National Stock Assessment Project
Bureau of Fisheries and Aquatic Resources
Regional Field Office 6
Iloilo City

PRUDENCIO B. BELGA
DINO RAPHAEL M. NUÑAL
National Stock Assessment Project
Bureau of Fisheries and Aquatic Resources
Regional Field Office 7
Cebu City

CONTENTS

TABLES

FIGURES

ABBREVIATIONS, ACRONYMS AND SYMBOLS

ABEE	-	a software program
AFRD	-	Aquatic and Fisheries Resource Database
BFAR	-	Bureau of Fisheries and Aquatic Resources
B/R	-	biomass per recruit
C_i	-	4catch from a population during a unit time period (i)
cm	-	centimeter
CPUE	-	cath per unit effort
CRMP	-	Coastal Resource Management Project
CY	-	current year
DA	-	Department of Agriculture
Dept.	-	department
DS	-	Danish seine
e	-	Naperian logarithm
E	-	exploitation rate/east
eds.	-	editors
ELEFAN	-	Electronic Length Frequency Analysis
E_{opt}	-	optimum exploitation
eqn	-	equation
e^{Zi-1}	-	fraction of total deaths
F	-	fishing mortality, instantaneous fishing mortality
FAO	-	Food and Agriculture Organization of the United Nations
Fig.	-	figure
FISAT	-	FAO-ICLARM Stock Assessment Tools
Fish.	-	fisheries
F_i/Z_i	-	fraction of death caused by fishing
GIS	-	Geographic Information System
Gov't.	-	government
GTZ	-	German Technical Corporation
hr	-	hour
ICLARM	-	International Center for Living Aquatic Resources Management
Invest.	-	investment
J.	-	journal
k	-	growth coefficient , growth rate
kg	-	kilogram
km^2	-	square kilometer
L	-	mean length
lb	-	pound
LGU	-	local government unit
L_{max}	-	maximum length
Log	-	logarithm
L_t	-	length of fish at age t
L'	-	initial length of sample
L_∞	-	asymptotic length, length infinity
L_{25}	-	length at first captivity

L_{50}	-	length at 50 percent probability of capture, length at first maturity
m	-	meter
M	-	natural mortality, instantaneous natural mortality
MSY	-	maximum sustainable yield
mt	-	metric ton
MWT	-	mid-water trawl
N	-	north
N_{ai}	-	numbers of available catch
N_i	-	numbers of observed catch, population size at the beginning of the time period
NSAP	-	National Stock Assessment Program
p	-	page/s
Philipp.	-	Philippines
P_i	-	points for probabilities of capture
PS	-	purse seine
RA	-	Republic Act
Res.	-	research
Rf	-	raising factor
Ser.	-	series
T	-	annual mean habitat temperature
T_c	-	age at first catch
Tech.	-	technical
t_o	-	hypothetical age the fish would attain at length zero
T_r	-	age at first recruit
U.S.	-	United States
VBGF	-	von Bertalanffy growth function
VisSea	-	Visayan Sea Coastal Resources and Fisheries Management Project
VPA	-	virtual population analysis
W_∞	-	weight at infinity
yr	-	year
Y'/R	-	relative yield per recruit
Z	-	total mortality, instantaneous total mortality
Δt	-	change of time
^{o}	-	degree
^oC	-	degree Celsius
Ø'	-	growth performance index
%	-	percent
>	-	greater than

ACKNOWLEDGMENTS

ABSTRACT

The Visayan Sea commercial fisheries for the years 1998 to 2002 showed an annual decrease of 24 percent for fish harvest and 11 percent for catch per unit effort (CPUE). In 1998, the total catch was 2,694.83 thousand metric tons and the CPUE was 17,014.11 kg/day. Compared to year 2002, the fish catch was only 1,401.28 thousand mt, while the CPUE was 12,842.54 kg/day. Squid, as an indicator of overfishing, ranked fifth among the species caught by otter trawl, and 15th by Danish seine. Out of the 282 identified fish species, 15 dominant species comprised 67 percent of the total fish harvest.

Growth overfishing and recruitment overfishing were observed on the major fish species analyzed. Biological parameter estimates showed that terminal exploitation exceeded E_{opt} of 0.5 for mortalities and $E_{.1}$ for the relative yield per recruit. Length at first captivity was smaller than length at first maturity.

INTRODUCTION

In the Philippines, as well as globally, the fisheries system is facing collapses. Among 54 top fish-producing countries, the Philippines ranked 12th in 1998 with fish production of more than 200 thousand metric tons. This contributed to 1.8 million mt of fish or 2.1 percent to the total world catch of 86.3 million mt (FAO 1998). Total marine landings showed accelerated growth during the periods 1962-1975 and 1985-1991, but leveled off to around 1.65 million mt in the early 1990s. This was brought about by the decline in municipal fisheries landings being compensated by the commercial fisheries sector, which may be indicative of increasing resource depletion and competition in nearshore fishing grounds (Barut *et al*. 2004).

Visayan Sea is one of the country's major fishing grounds with abundance of pelagic and demersal fisheries resources. It contributes a significant volume of fish catch, generating income and employment to a considerable number of fisherfolk whose main source of livelihood is fishing. In 1995, Visayan Sea ranked third in the commercial fisheries sector with 13.46 percent contribution (equivalent to 120 thousand mt) to the country's total fish harvest, and first in the municipal sector with a share of 11.28 percent (89 thousand mt) (BFAR 2000).

Reports in 1998 indicating widespread coastal degradation and intense conflict over the resources of Visayan Sea were confirmed by results of stock assessment studies of Armada in 1999 on small pelagic fish species. Although local initiatives had been implemented, still the problems on resource depletion were not addressed. Solutions to the issues can be

reached thru collaborative efforts among the government units concerned (Hermes *et al.* 2004). Republic Act 8550 (the Philippine Fisheries Code of 1998) and RA 7160 (the Local Government Code of 1997) entrust the jurisdiction of municipal waters to the local government units (LGUs).

The Study Site

Visayan Sea, a vast fishing resource, is surrounded by three regions (Regions 5, 6 and 7) covering four provinces (Cebu, Iloilo, Masbate and Negros Occidental) and is shared by 22 municipalities. Geographically located at latitudes 11° to 12°N and longitudes 123° to 124°E, it covers an approximate area of 10,000 km^2. It is bounded by Masbate Island on the north, Cebu Island on the southeast, Negros Island on the south and Panay Island on the west. The southwest sector has a depth range of 20-40 m, while the northeast sector is relatively deeper with a range of 41-180 m.

The bottom topography of Visayan Sea is generally level, with gently rolling seabed with minimum ascents and descents. Certain areas are studded with coral reefs and rocky shoals which are most dense at 0.5 m and 6 m depths (Aprieto 1976). Coral reef shoals and other obstructions are concentrated west of Bantayan Island and proliferate toward the northern tip of Negros Island into the entrance of Guimaras Strait. Numerous islets are also found on the northeastern coast of Panay Island.

Review of Literature

A lot of studies – from major trawl explorations to species-specific studies, and to resource assessment studies – have been published. These have laid down results and importance that have been used as basis of recent studies being conducted in the Visayan Sea. Exploratory studies include those conducted by Warfel and Manacop (1950) on otter trawl explorations in the Philippine waters; Rasalan (1957) on marine fisheries of Central Visayas; Aprieto and Villoso (1979) on catch composition and relative abundance of trawl-caught fishes in the Visayan Sea; and the Visayan Sea cruise in 2003 (unpublished) on plankton research and trawl survey conducted by the University of the Philippines in the Visayas- Miagao Campus, and sponsored by the Visayan Sea Coastal Resources and Fisheries Management Project (VisSea) of the Bureau of Fisheries and Aquatic Resources Regional Field Office VI (BFAR 6) and the German Technical Corporation (GTZ). Species-specific studies include those conducted by Arce (1986) on the distribution and relative abundance of nemipterids and carangids caught by trawl in the Visayan Sea; and Ordonez (1985) on the study of the trash fish caught by otter trawl in Visayan Sea. Resource management studies include the study of Hermes *et al.* (2004) on overexploitation in the Visayan Sea: designing a project solution.

Objectives

This study is part of the Regional Stock Assessment Project which aims to generate reliable data vital in the formulation of policies for the proper

management and conservation of the region's coastal resources for the sustainable development of its marine fisheries.

This study specifically aims to generate the following information as basis in assessing the status of the commercial fisheries of Visayan Sea:

- types of fishing gear operating in the area;
- annual fish catch estimates;
- catch per unit of effort;
- relative abundance and species composition of the major gear;
- relative abundance and seasonality of selected major fish species; and
- population parameters such as growth, mortality, recruitment pattern, probabilities of capture, virtual population analysis, and yield and biomass per recruit of selected major fish species in the Visayan Sea.

Limitations of the Study

The results presented in this study were mainly from the commercial fisheries data collected from Western Visayas (Region 6) and Central Visayas (Region 7) with established monitoring sites. Identified commercial fish ports in the areas were also used as monitoring stations. Data from the Masbate area (Region 5) were projected from the estimated total annual fish harvest using the number of commercial fishing boats operating in the area, since no monitoring site was established.

Projection of the specific commercial fishing gear type count for Region 5 in 2002, as reference year for the total fishing boats inventory, was not specified because gear specific was unaccounted. Instead, fishing boat count in the area was added directly to the total fishing boat count (N) regardless of gear type to give representation.

Results presented in this study focused on the commercial fisheries sector, as the municipal fisheries data collected by the project were very minimal that they could not represent the total municipal fisheries of Visayan Sea. The data for the total fishing boats inventory for the municipal fisheries sector were partial.

Exact geographical locations of fishing areas under this study were not included since fishing boats personnel were reluctant to reveal their fishing areas. Thus, the study used the nearest surrounding island/islets as reference points to identify fishing operation areas.

MATERIALS AND METHODS

Landing Centers/Sampling Sites

Figure 1 shows the major commercial fish landing sites/ports established by the National Stock Assessment Project in Regions 6 and 7.

The monitoring areas in Region 6 include the Iloilo Fishing Port Complex (Iloilo City), San Salvador Fish Landing Site (Banate), Concepcion Municipal Fishing Port (Concepcion) and Estancia Fishing Port Complex (Estancia) – all in the Province of Iloilo; Roxas City Fishing Port, Roxas City, Capiz; and Poblacion Fish Landing Site, Cadiz City, Negros Occidental.
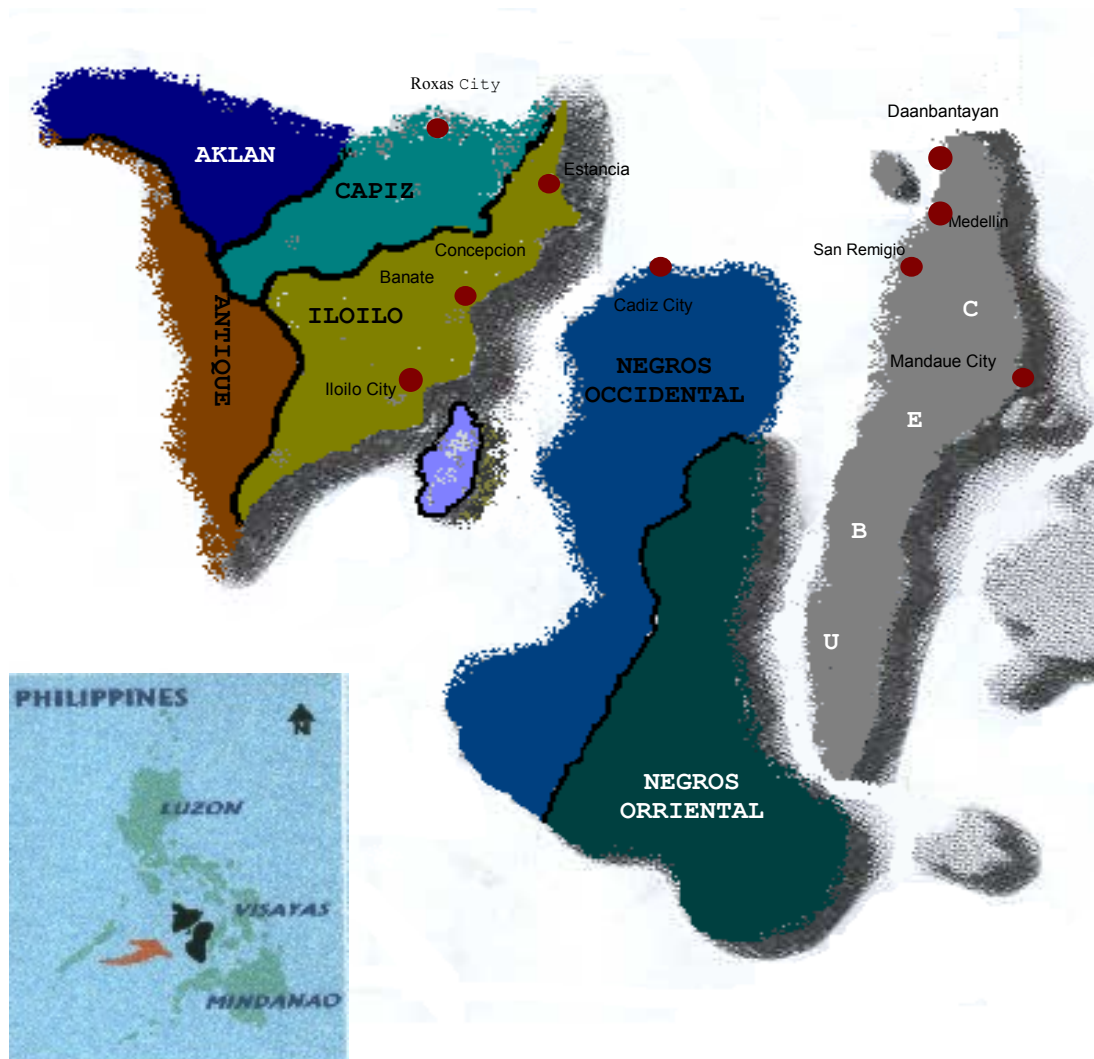
Figure 1. Visayan Sea map showing the fish landing areas monitored by the National Stock Assessment Project implemented in Regions 6 and 7.

In Region 7, the monitoring areas include Barangay Maya Poblacion (Daanbantayan), Mahawak (Medellin), Hagnaya (San Remigio) and Tulay/Opao (Mandaue) – all in the Province of Cebu. The commercial fishing gear operating in these areas were Danish seine, otter trawl, mid-water trawl, ring net, and purse seine. Figure 2 shows the extent of fishing operation of the various commercial fishing gear in Visayan Sea.

Data Collection

Two field enumerators collected data from each sampling site every other two days. The information gathered include total number of fishing boats that landed per sampling day, type of gear and specification, number of hauls per fishing operation, number of fishing days, total catch per fishing operation, species composition, and data on size (length) of selected major fish species. All information were recorded on the prepared data forms; these were submitted monthly for collation and processing.

Data Processing and Analysis

Fishing Boat Inventory

The total number of commercial fishing boats per fishing gear was taken from the CY 2002 data. The enumeration was based on the monitored boats in the sampling area, as well as fishing vessel and gear registry of the Leasing and Licensing Division of BFAR 6 and the Monitoring, Control and Surveillance Division of BFAR 7. Data on fishing boat units operating in Region 5 were based on the Aquatic and Fisheries Resource Database (AFRD) of the Visayan Sea Project of BFAR 6.

For the annual inventory of fishing boats, back calculation process was done using the ratio of the CY 2002 total fishing boats count to sample count of fishing boats from 1998 to 2001, thus:

$$\text{Rf} = \bar{X} \, (N_{CY2002}/Ni_{(CY\ 1998\ to\ 2001)}) \times \text{Annual specific gear count} \qquad \textbf{(eqn. 1)}.$$

Production Estimates

Projection of the total fish harvest was based on the fish landed at the various commercial fish ports and fish landing sites in Regions 6 and 7. Extrapolation of the estimated total fish harvest for the entire commercial sector of Visayan Sea was considered in the annual gear count, rather than raising it to the number of commercial monitoring sites. This was done considering that all the commercial fish landing sites of Visayan Sea had been monitored by the project. Production estimates used standardized values by direct relationship between catch per unit effort (CPUE), actual fishing days, and boat units, thus:

$$\text{Production Estimate} = \text{Annual CPUE} \times \text{Actual fishing days} \times \text{Number of fishing boat units} \qquad \textbf{(eqn. 2)}.$$
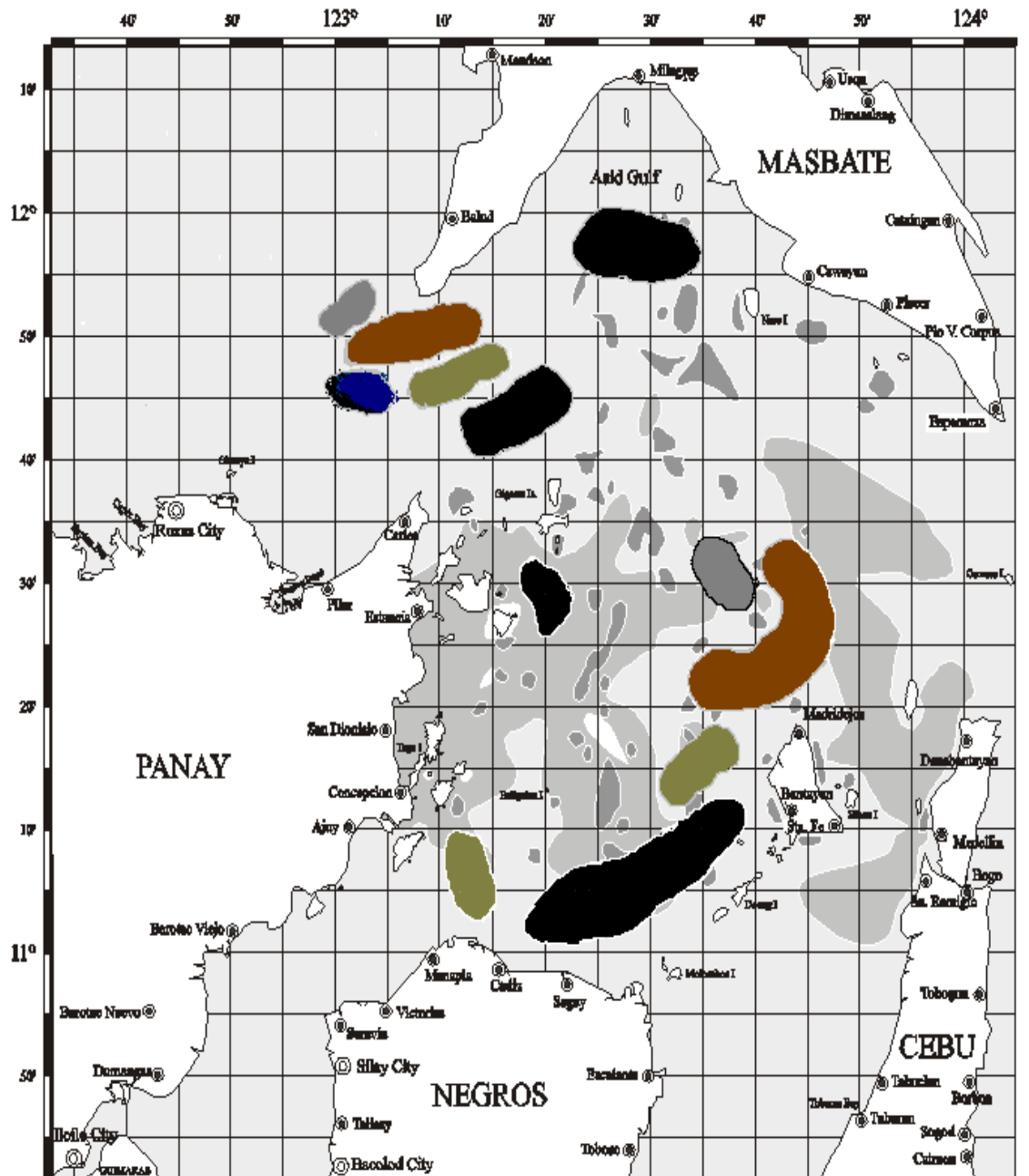
Figure 2. Extent of fishing operation of commercial fishing gear in the Visayan Sea, 1998-2002 (based on the monitoring data of the National Stock Assessment Project).

Catch Per Unit Effort

Monthly catch per unit effort (CPUE) per gear was computed and standardized as kilograms per day (kg/day). The annual mean CPUE was obtained by the summation of the monthly fish harvest versus the summation of the number of fishing days per month and per year. The total number of

fishing days was obtained by averaging the number of fishing days operation per year, taking into account the days without any fishing activity (*e.g.*, days with weather disturbances, number of fishing rest days, and special holidays).

Dominant Species

Fish species of each major commercial gear were ranked from highest to lowest, based on their contribution to total gear fish harvest, that is, summing up the total catch of each fish species by gear from 1998 to 2002. Ranking the percentage contribution of each fish species to total gear catch was done to determine the 15 major fish species. Ranking was also done, using combined gear types and years, to determine the 15 major commercial fish species; the results were compared with those in the literature.

Relative Abundance/Seasonality of Selected Major Fish Species

The factor used in the determination of seasonality distribution is the monthly catch (in mt) of the major fish species. Table 1 shows the list of fish species analyzed for seasonality distribution using the 2002 monthly catch data.

Length Frequency

Data processed for biological parameters were taken from the same major species used in determining seasonality changes. Thirteen sets of length-frequency data on the species listed in Table 1 were processed. Five-year length frequency data sets were processed yearly from 1998 to 2002, except for *Rastrelliger kanagurta* with 2002 data sets that were used to compare results from catches of three gear types. Data presented were averaged to come up with a one-year data set. Actual length-frequency data were raised in each sampling day using the equation:

$$\text{Rf} = \frac{\text{Total weight of species measured}}{\text{Total weight landed (of sampled species)}} \qquad \textbf{(eqn. 3)}.$$

The resulting Rf values were then multiplied with the actual length frequency in each class mid-length per sampling day and accumulated monthly to get the resulting raised frequency. The same data were then entered and processed utilizing the FAO-ICLARM Stock Assessment Tools (FISAT) to determine growth, mortality, exploitation rate, recruitment pattern, probabilities of capture, virtual population analysis, relative yield per and biomass per recruit of each species analyzed. The same sets of data were converted to percent frequency, and were used as data entry for the ABEE software program. This software program allows us to determine the intercept (a) and slope (b) values used as factors for the virtual population analysis.

Table 1. List of major commercial fish species in the Visayan Sea, analyzed for seasonality and biological parameter estimates (1998-2002).

Gear	Fish Species	English Name	Local Name	Remarks
Danish seine	*Selaroides leptolepis* (Cuvier, 1833)	Yellow stripped crevalle	Salay ginto/ dalinu-an/ karabalyas	Merged data (NSAP 6 & 7)
	Scolopsis taeniopterus (Cuvier, 1830)	Lattice monocle bream	Opos-opos/ lagaw	Merged data (NSAP 6 & 7)
	Atule mate (Cuvier, 1833)	Yellowtail scad	Bagudlong/ kalapato/ yamarong	Merged data (NSAP 6 & 7)
	Upeneus sulphureus (Cuvier, 1829)	Sunrise goatfish	Salmonete/ timbugan/ saramulyete	Merged data (NSAP 6 & 7)
	Leiognathus splendens (Cuvier, 1829)	Splendid ponyfish	Lawayan/ miralla	NSAP 6 data
Mid-water trawl	*Pennahia anea* (Bloch, 1793)	Bigeye croaker	Abu/ilak/ alakaak	NSAP 6 data
	Sardinella gibbosa (Bleeker, 1849)	Goldstripe sardine	Tabagak/tunsoy	NSAP 6 data
	Sardinella fimbriata (Valenciennes, 1847)	Fimbriated sardine	Tabagak-hubad/tunsoy	NSAP 6 data
	Leiognathus bindus (Valenciennes, 1835)	Orangefin ponyfish	Sap-sap/palid-palid	NSAP 6 data
Purse seine	*Rastrelliger kanagurta* (Cuvier, 1816)	Indian mackerel	Bulaw/buraw/ alumahan	NSAP 6 data
	Sardinella longiceps (Valenciennes, 1847)	Indian oil sardine	Tuloy/tunsoy/ tabagak	Merged data (NSAP 6 & 7)
Danish seine and Purse seine	*Decapterus macrosoma* (Bleeker, 1851)	Long-bodied scad	Marot/ tamodios/ galunggong	Merged data (NSAP 6 & 7)
Mid-water trawl	*Rastrelliger kanagurta* (Cuvier, 1816)	Indian mackerel	Bulaw/buraw/ alumahan	Merged data (NSAP 6 & 7)

Growth parameters were determined first by estimating L_∞ (asymptotic length) using the Powell-Wetherall method (Gayanilo and Pauly 1997) based on the equation of Beverton and Holt (1956):

$$Z = k\,((L_\infty - L)\,/\,(L - L')) \qquad \textbf{(eqn. 4)}$$

where Z is the total instantaneous mortality, k is the growth coefficient, L is the mean length, L_∞ is the asymptotic length, and L' is the initial length of sample.

The estimated values of L_∞ were further processed in ELEFAN I (ELectronic LEngth Frequency ANalysis) for the verification of the value for L_{oo} and k. Analysis in the estimation of growth parameters and mortality uses the von Bertalanffy (1934) growth equation:

$$L_t = L_\infty \ (1 - e^{\ -k(t-to)}) \qquad \textbf{(eqn. 5)}$$

where L_t is the length of fish at age t, e is the Naperian logarithm, t_o is the hypothetical age the fish would attain at length zero.

Mortalities and exploitation rate were then calculated using the equation:

$$Z = M + F \qquad \textbf{(eqn. 6)}$$

where Z is the instantaneous total mortality, M is the instantaneous natural mortality due to predation, aging and other environmental causes, and F is the instantaneous fishing mortality caused by fishing.

Furthermore M was estimated using the empirical formula of Pauly (1984):

$$\text{Log M} = 0.654 \ \text{Log k} - 0.28 \ \text{Log } L_\infty + 0.463 \ \text{LogT} \qquad \textbf{(eqn. 7)}$$

where L_∞ and k are the VBGF growth parameters and T is the annual mean habitat temperature (^{o}C) of the water in which the stock in question lives.

Expanding the equation for mortality would lead to the computation of exploitation rate using:

$$E = F/Z \qquad \textbf{(eqn. 8)}$$

where E is the exploitation rate. With the equations from growth parameters and mortalities, prediction of recruitment patterns and virtual population analysis could be estimated using the routines found in FISAT programs.

Recruitment patterns were obtained by backward projection onto the length axis of a set of length-frequency data. The steps involved were:

a. projection onto the time axis of the frequencies after they have been divided by Δt, the time needed to grow through the length class, which leads to recruitment patterns with peaks much narrower than when untransformed length-frequency data were used,

b. summation for each month (irrespective of year) of the adjusted frequencies projected onto each month,

c. subtraction (from each monthly sum) of the lowest monthly sum to obtain zero value where apparent recruitment is lowest, and

d. output of monthly relative recruitment (in percent of annual recruitment).

Estimation of the probabilities of capture involves the method of extrapolating the right descending left side of a catch curve such that fish that "ought" to have been caught were added to the curve with the ratio of those "expected" numbers to those that were actually caught. This can be computed as the ratio of the numbers observed over the numbers available (N_i), using the equation:

$$P_i \; = \; \ln (N_i/\Delta t)/ \ln(N_{ai}/\Delta t) \qquad \qquad \textbf{(eqn. 9)}$$

where P_i refers to the points for probabilities of capture, N_i is the numbers of observed catch or the population size, and N_{ai} is the numbers of available catch, and Δt is the change of time.

Virtual Population Analysis (VPA) was used to estimate the catch, to draw inference or a quantity that cannot be readily estimated: the population that produced the catches, which follows the equation:

$$C_i/N_{i+1} \; = \; (F_i/Z_i) \times (e^{\; Z_{i-1}}) \qquad \qquad \textbf{(eqn. 10)}$$

where C_i is the catch from a population during a unit time period (i), Ni is the population size at the beginning of the time period, F_i/Z_i is the fraction of death caused by fishing, and e $^{Z_i - 1}$ is the fraction of total deaths.

The relative yield per recruit and biomass per recruit models of Beverton and Holt (1957) were used in the prediction of yield and standing biomass. Relative yield per recruit model is suitable for assessing the effect of mesh size regulations and it belongs to a length-based model as parameter. Biomass per recruit, on the other hand, expresses the annual average biomass of survivors as a function of fishing mortality, and that average biomass is related to the catch per unit of effort. These prediction models use the equations:

$$(Y/R)' \; = \; E*U^{\; M/k} (1-3U/1+m + 3U^2/1+2m \; - U^3/1+3m) \qquad \textbf{(eqn. 11)}$$

$$\overline{(B/R)} \; = \; \exp^{\; (-M*(Tc-Tr))} *W_\infty * (1/Z - 3S/Z+k + 3S^2/Z+2k - S^3/Z+3k) \qquad \textbf{(eqn. 12)}$$

where E = F/Z, U = 1- L_c/L_∞, m = 1-E = k/Z, T_c is age at first catch, T_r is age

$$\frac{M/k}{}$$

at first recruit, and W_∞ is theweight at infinity.

RESULTS AND DISCUSSION

Fishing Boat Inventory

Figure 3 shows the annual trend in the number of commercial fishing gear (considered active gear) that were monitored operating in the Visayan Sea. Among the five commercial fishing gear, Danish seine had the most number of fishing boat units that operated, with 543 units in 1999 but with only 242 units in 2002. For mid-water trawl, 139 fishing boat units operated in 2001, while only 82 units operated in 1998. For otter trawl, 274 units operated in year 2000 and 112 units in 2002. For purse seine, 88 units operated in year 2002 and only 62 units in 2001. The ring net had the least number of fishing boat units that operated – 28 units in 2002 and only 21 units in 1999. For the entire five-year study period, year 1999 had the most number of fishing boat units that operated, with a total of 889, mostly associated with the increase in the number of Danish seine operating in Visayan Sea.
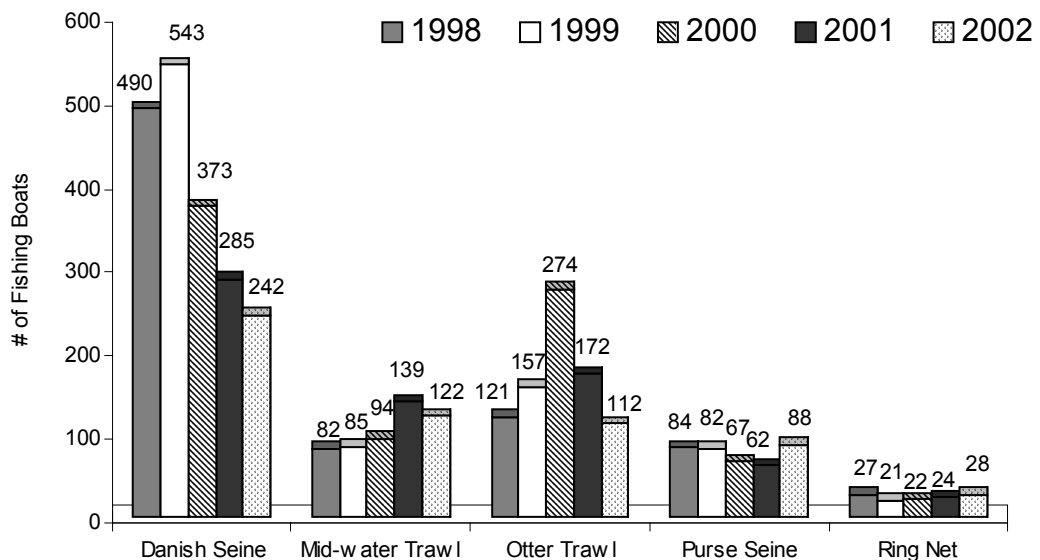
Figure 3. Annual trend in the number of commercial fishing boats per fishing gear operating in the Visayan Sea (1998-2002).

Production Estimates and Catch Per Unit Effort

The total annual fish harvest estimates, as shown in Figure 4, indicate a decreasing trend from 1998 to 2001, followed by an increase in 2002. Year

1998 had the highest total annual fish harvest of 2,694.83 thousand metric tons, while the lowest was in 2001 of 1,209.29 thousand mt.
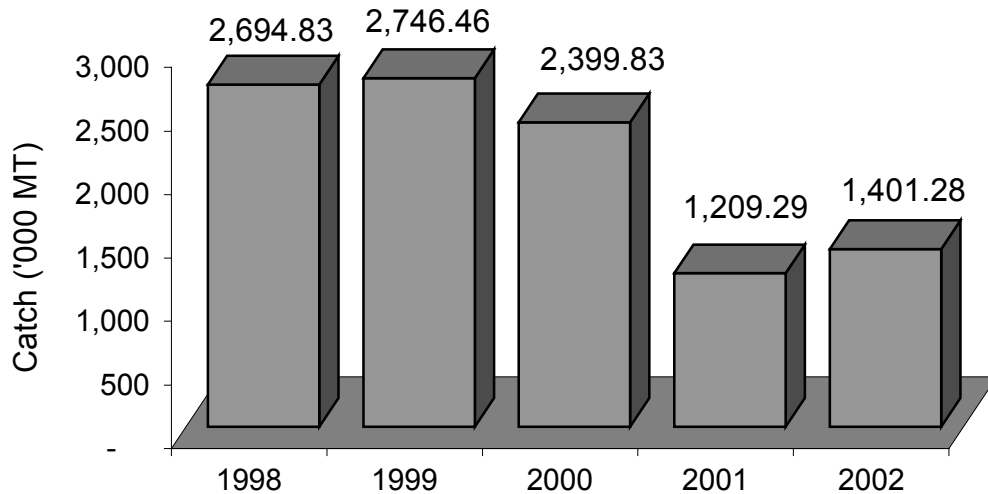
Figure 4. Trend in annual fish harvest (in '000 mt) for the commercial fisheries sector in the Visayan Sea (1998-2002).

Decrease in fish harvest can be associated with decreasing total catch per unit effort (CPUE) and number of fishing boat units that operated per year. Purse seine had the highest contribution, among the commercial gear, of 47 percent to the total fish harvest; followed by Danish seine, 30 percent; mid-water trawl, 12 percent; otter trawl, 10 percent; and ring net, one percent (Fig. 5). Field information revealed that some fishing companies operating purse seine fishing fleet shifted or changed their gear to Danish seine, because the amount they got from fishing operation could not compensate the expenses incurred. For the same reason, some Danish seine operators had stopped their operation. Some fishing companies and operators even sell their catches to other fish port areas in the country opting for a better selling price.

Figure 6 shows the same trend in the decrease of fish catch and CPUE. Year 1999 had the highest fish harvest of 2,746.46 thousand mt (as shown in Fig. 4) and CPUE of 18,300.94 kg per day, while 2001 had the lowest fish harvest of 1,209.29 thousand mt (see Fig. 4) and CPUE of 9,742.59 kg/day.

As shown in Fig. 7a, the annual fish production of Danish seine from 1998 to 2002 decreased. Year 1998 had the highest catch of 99 thousand mt, while 2001 had the lowest catch of 52 thousand mt. For the CPUE, the highest was 951 kg/day in 2002 while the lowest was 668 kg/day in 1999. For otter trawl (Fig. 7b), the highest fish catch was 28 thousand mt in 2000 and

the highest CPUE was 1,141 kg/day in 2002. The lowest fish catch was 15 thousand mt in 1998 and the lowest CPUE was 500 kg/day in 2000.
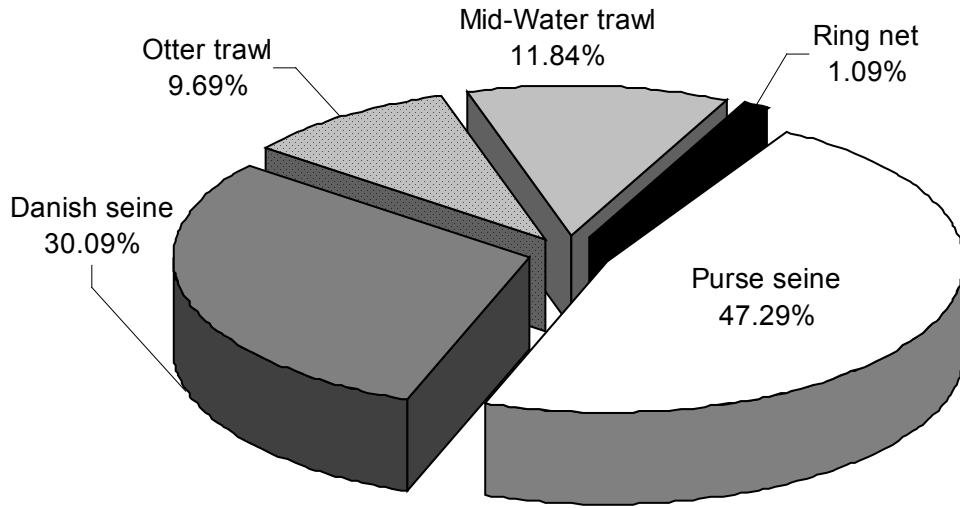
Figure 5. Percentage contribution of the major commercial fishing gear operating in the Visayan Sea (1998-2002).
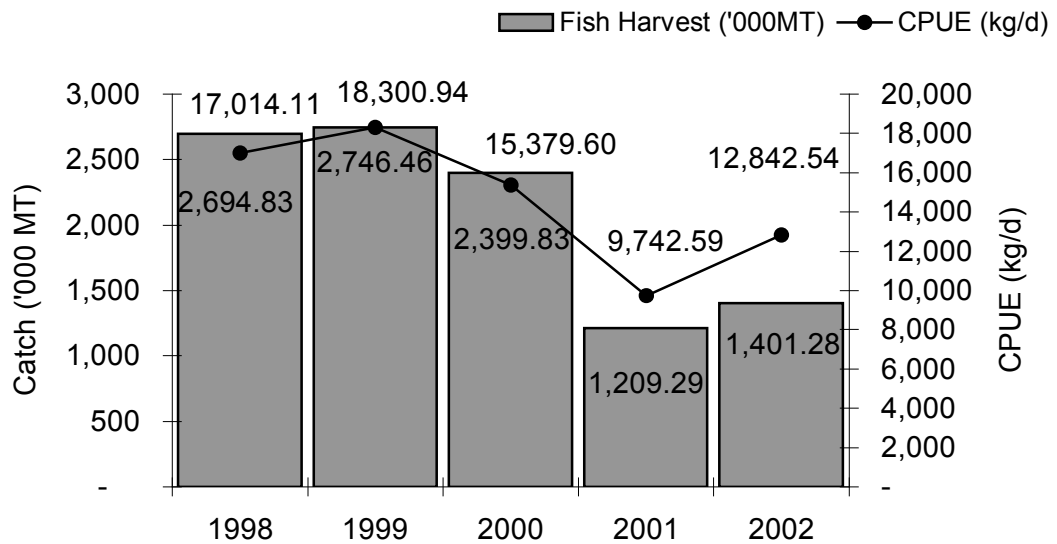
Figure 6. Annual fish harvest and CPUE trend of the commercial fisheries sector of Visayan Sea (1998-2002).
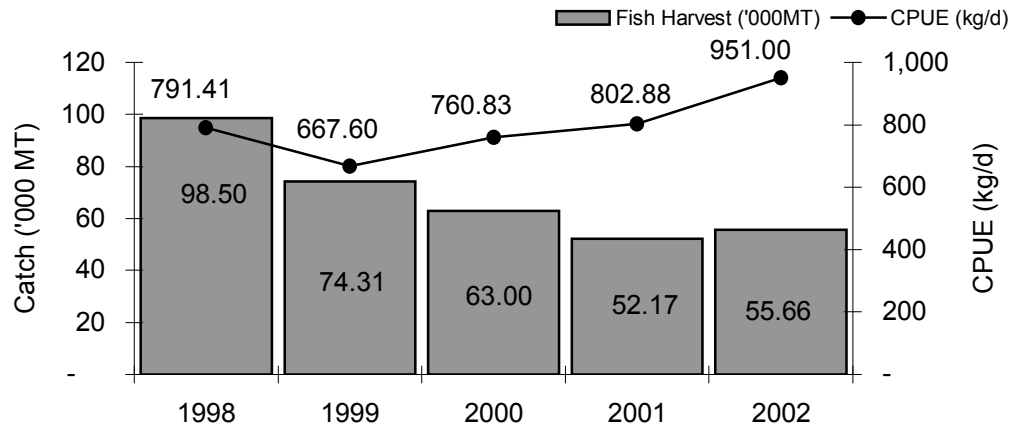
(**a**)
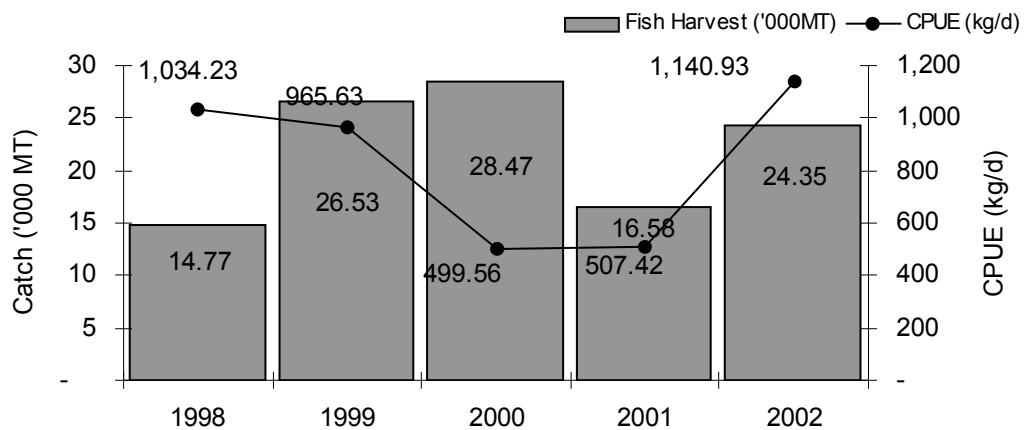
(**b**)

Figure 7. Annual fish catch and CPUE (kg/day) of (**a**) Danish seine and (**b**) otter trawl operating in the Visayan Sea (1998-2002).

An increasing trend for mid-water trawl is shown in Fig. 8a. The highest fish catch was about 38 thousand mt in 2002 and the highest CPUE was about 1,333 kg/day in the same year. The lowest fish catch was about 18 thousand mt in 1999, while the lowest CPUE was about 974 kg/day in 2001. For ring net (Fig. 8b), the highest fish catch was about five thousand mt in 1998 and the highest CPUE was 909 kg/day. The lowest fish catch was about two thousand mt in 1999, and the lowest CPUE was about 463 kg/day in 2000.
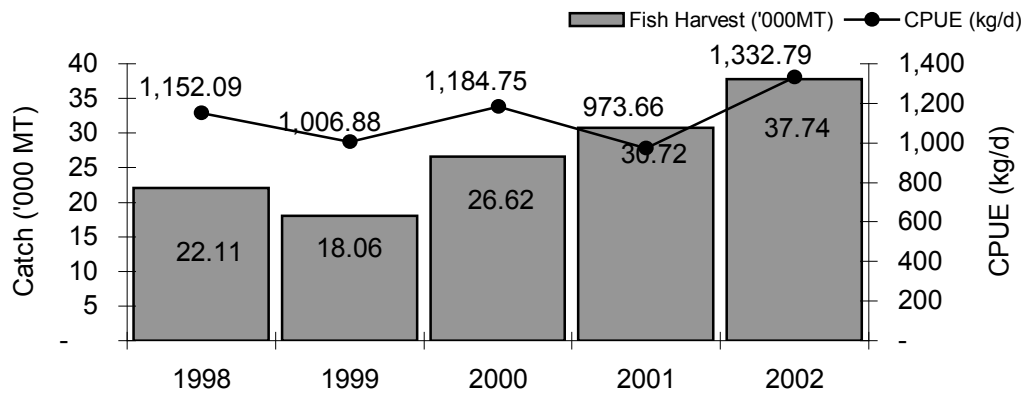
(a)
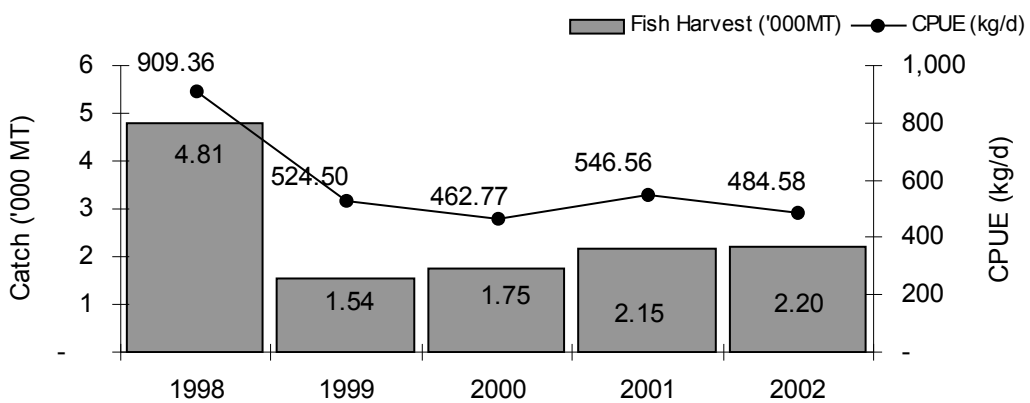
(b)
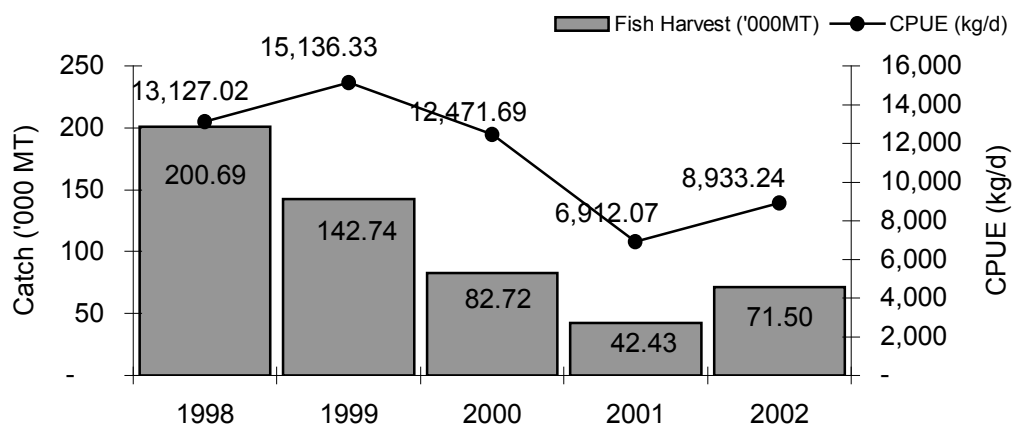
(c)

Figure 8. Annual fish catch and CPUE (kg/day) of (**a**) mid-water trawl, (**b**) ring net and (**c**) purse seine operating in the Visayan Sea (1998-2002).

Purse seine, on the other hand, had the highest percentage contribution to total fish harvest in comparison to other commercial gear (as shown in Fig. 5). The highest fish catch was about 201 thousand mt in 1998 while the highest CPUE was more than 15,000 kg/day in 1999 (Fig. 8c). The lowest fish catch was more than 42 thousand mt in 2001, while the lowest CPUE was about 7,000 kg/day.

Table 2 shows the different catch rates obtained from different studies conducted in Visayan Sea. The trawl survey conducted by Warfel and Manacop (1950) showed that computed catch rate was 615 lb/hr or 279.21 kg/hr. After 29 years, based on the trawl study conducted by Aprieto and Villoso (1979), the catch rate was only 59.7 kg/hr, a decrease of 79 percent from the 1950 trawl survey. In this present study, the otter trawl data from 1998 to 2001 showed a decreasing trend in the CPUE with the lowest value of 36.24 kg/hr in 2001. It, however, increased to 81.5 kg/hr in 2002. Average CPUE values for otter trawl showed a catch rate of 59.13 kg/hr that is almost the same with the CPUE obtained in 1979. Mid-water trawl, a modified gear of trawl, showed a much higher average CPUE of 150.7 kg/hr. This can be associated with a different mode of operation of the mid-water trawl compared to the otter trawl; both types of gear even have different catch composition.

Table 2. Comparative values of mean catch rates (kg/hr) of trawl in the Visayan Sea (from different studies of the commercial fisheries sector in the area).

Gear/Author	CPUE (kg/hr)				
	1998	**1999**	**2000**	**2001**	**2002**
Otter trawl (this study)	73.87	68.33	35.68	36.24	81.50
Mid-water trawl (this study)	153.61	134.25	157.97	129.82	177.71
Trawl survey – Warfel and Manacop (1950)			279.21 kg/hr		
Trawl survey – Aprieto and Villoso 1979)			59.70 kg/hr		
Otter trawl data – This study (1998-2002)			59.13 kg/hr		
Mid-water trawl data – This study (1998-2002)			150.67 kg/hr		

Dominant Species

Visayan Sea is considered as a multispecies fishing area. Marine resources include a wide range of marine fishes, invertebrates, cartilaginous fishes, and armored fishes. Ninety-six families of aquatic fauna – 90 vertebrates and six invertebrates – were identified (Fig. 9). Of the vertebrates identified, 79 are bony fishes and 11 are cartilaginous (sharks, rays, skates, ratfishes). A total of 149 genera – 138 vertebrates and 11 invertebrates – and 282 species – 264 vertebrates and 18 invertebrates – were identified.

```
                    ┌────────────────────┐      ┌──────────────────────────────────┐
              ┌────▶│  Invertebrates (6) │────▶ │ Squids (3), shrimps (2), crab (1)│
┌──────────┐ │     └────────────────────┘      └──────────────────────────────────┘
│ Families │─┤
│   96     │ │     ┌────────────────────┐      ┌──────────────────────────────────┐
└──────────┘ └────▶│  Vertebrates (90)  │────▶ │       Cartilaginous (11)         │
      │            └────────────────────┘      └──────────────────────────────────┘
      │                                        ┌──────────────────────────────────┐
      ▼                                        │        Bony fishes (79)          │
┌──────────┐      ┌────────────────────┐       └──────────────────────────────────┘
│  Genus   │─────▶│ Invertebrates (11) │
│   149    │      │ Vertebrates (138)  │
└──────────┘      └────────────────────┘
      │
      ▼
┌──────────┐      ┌────────────────────┐
│ Species  │─────▶│ Invertebrates (18) │
│   282    │      │ Vertebrates (264)  │
└──────────┘      └────────────────────┘
```
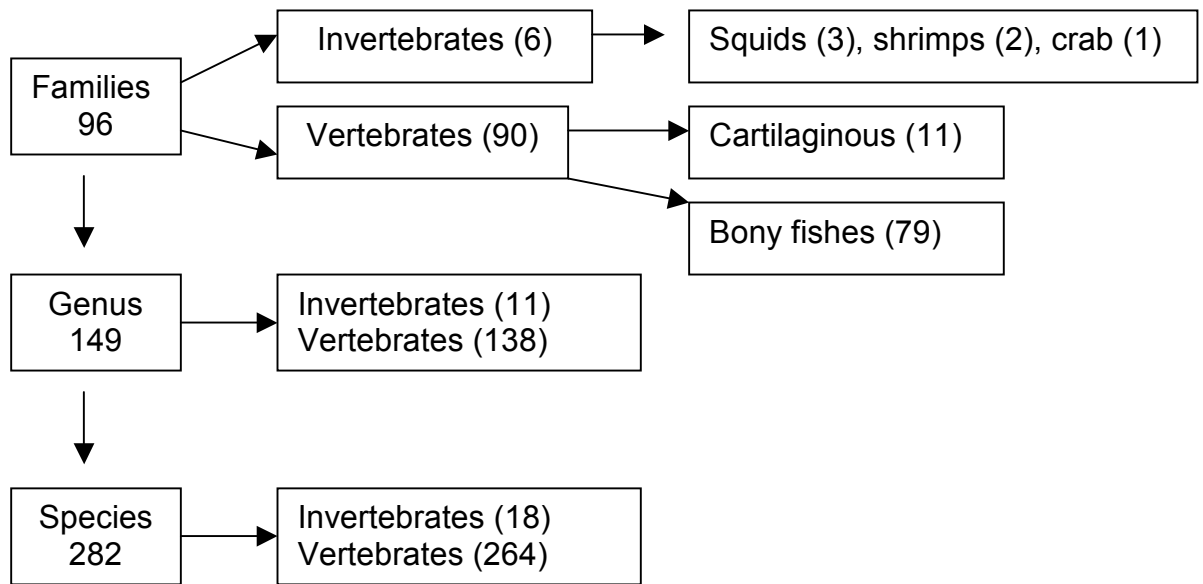
Figure 9. Schematic diagram on the number of fish families, genera and species identified from five commercial fishing gear operating in the Visayan Sea (1998-2002).

Figure 10 shows the ranking of the 15 dominant commercial fish species of Visayan Sea, based on the 1998-2002 data. These fish species constitute 67 percent of the total computed catch. Small pelagic fish species dominated the catch, with the sardine species *Sardinella gibbosa, S. longiceps and S. melanura* occupying the first three ranks. Together with *S. fimbriata*, the sardine species comprised 35 percent of the total catch. Other dominant species include *Rastrelliger kanagurta* and *R. brachysoma* of the family Scombridae which comprised 10 percent; *Selaroides leptolepis, Selar crumenophthalmus, Decapterus macrosoma, D. kurroides* and *Atule mate* of the family Carangidae, 13 percent; *Scolopsis taeniopterus* of the family Nemipteridae, three percent; *Saurida tumbil* of the family Synodontidae, two percent; and *Upeneus sulphureus* of the family Mullidae, 1.5 percent contribution to the total catch. The remaining 267 fish species identified comprised 33 percent of the total fish harvest.

Table 3 shows the 15 dominant fish species by gear identified for the commercial fisheries of Visayan Sea from 1998 to 2002. For Danish seine, the 15 dominant fish species comprised 60 percent of the total gear catch with the top three species *R. kanagurta*, *S. leptolepis* and *S. taeniopterus* contributing 10 percent, 7.2 percent and 6.7 percent, respectively (Table 3a). There were 71 families, 136 genera and 264 species identified from catches of this gear.
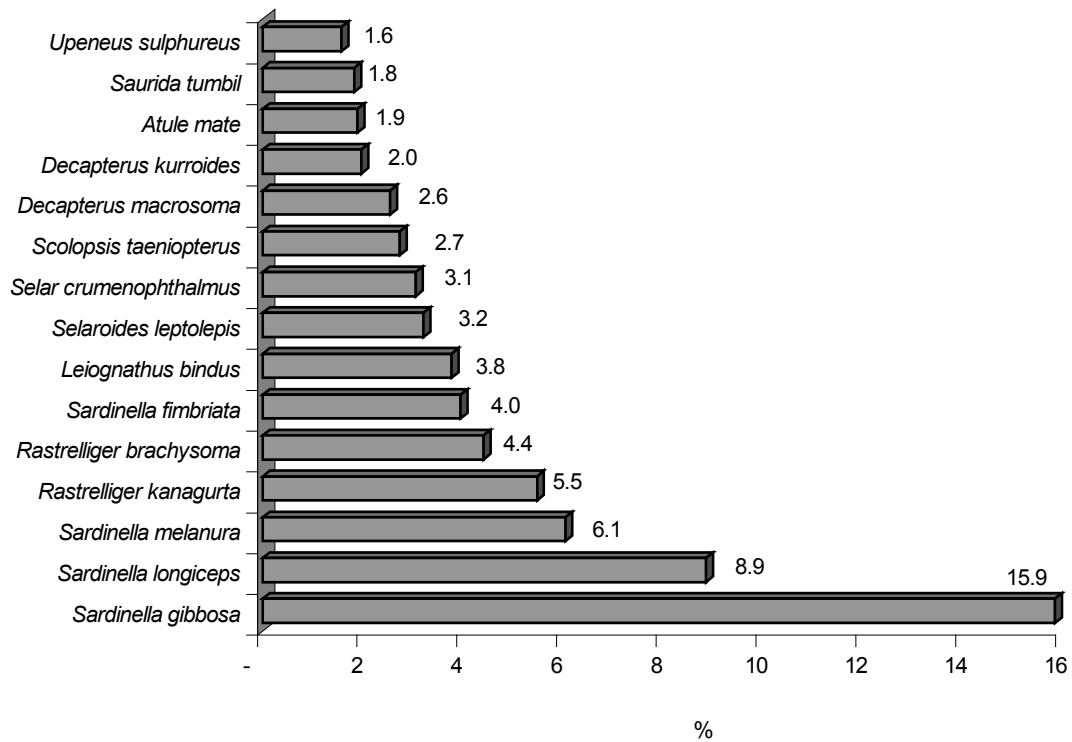
Figure 10. Ranking of the 15 dominant fish species identified for the commercial fisheries of Visayan Sea (1998-2002).

For purse seine, the 15 dominant fish species comprised 92 percent of the total gear catch (Table 3b). The three major fish species include *Sardinella longiceps* (25 percent), *S. melanura* (20 percent), and *Selar crumenophthalmus* (8 percent). Forty families, 66 genera and 104 species were identified.

Trawl data showed that 15 dominant fish species comprised 62 percent of the total catch of otter trawl (Table 3c), and 85 percent of mid-water trawl catch (Table 3d). For otter trawl, the three major fish species include *Leiognathus bindus* (11 percent), *S. tumbil* (eight percent), and *U. sulphureus* (six percent). A total of 241 species, belonging to 136 genera and 65 families, were identified. For mid-water trawl, the three major fish species include *Sardinella gibbosa* (52 percent), *S. fimbriata* (10 percent), and *L. bindus* (five percent). A total of 158 species, belonging to 90 genera and 55 families were identified.

For ring net, the 15 dominant fish species comprised 98 percent of the total gear catch (Table 3e). The three major fish species were *R. brachysoma* (35 percent), *R. kanagurta* (14 percent) and *S. longiceps* (13 percent). Fish species identified include 104 species belonging to 28 genera and 16 families.

Table 3. Fifteen dominant fish species by gear: (a) Danish seine, (b) purse seine (c) otter trawl, (d) mid-water trawl, and (e) ring net, identified for the commercial fisheries of Visayan Sea (1998-2002).

(a) Danish seine

	Dominant Species	Catch (mt)	%
1	*Rastrelliger kanagurta*	3,200.86	9.94
2	*Selaroides leptolepis*	2,303.53	7.15
3	*Scolopsis taeniopterus*	2,164.56	6.72
4	*Atule mate*	1,542.72	4.79
5	*Rastrelliger brachysoma*	1,420.01	4.41
6	*Leiognathus bindus*	1,173.45	3.64
7	*Sphyraena forsteri*	1,139.27	3.54
8	*Saurida tumbil*	1,071.94	3.33
9	*Sphyraena obtusata*	984.51	3.06
10	*Upeneus sulphureus*	915.16	2.84
11	*Priacanthus macracanthus*	861.16	2.67
12	*Decapterus maruadsi*	806.37	2.50
13	*Secutor ruconius*	665.11	2.06
14	*Decapterus macrosoma*	629.56	1.95
15	*Loligo duvauceli*	550.45	1.71
	TOTAL FISH HARVEST	**32,217.98**	**60.30**

(b) Purse seine

	Dominant Species	Catch (mt)	%
1	*Sardinella longiceps*	6,505.51	24.70
2	*Sardinella melanura*	5,300.22	20.12
3	*Selar crumenophthalmus*	2,115.03	8.03
4	*Decapterus kurroides*	1,584.26	6.01
5	*Decapterus macrosoma*	1,433.18	5.44
6	*Rastrelliger kanagurta*	995.34	3.78
7	*Auxis rochei*	984.31	3.74
8	*Sardinella brachysoma*	934.25	3.55
9	*Mene maculata*	922.44	3.50
10	*Sardinella gibbosa*	715.06	2.71
11	*Euthynnus affinis*	676.53	2.57
12	*Decapterus tabl*	640.08	2.43
13	*Rastrelliger faughni*	562.56	2.14
14	*Rastrelliger brachysoma*	562.17	2.13
15	*Decapterus russelli*	341.67	1.30
	TOTAL FISH HARVEST	**26,341.84**	**92.14**

(c) Otter trawl

	Dominant Species	Catch (mt)	%
1	*Leiognathus bindus*	699.62	11.06
2	*Saurida tumbil*	502.27	7.94
3	*Upeneus sulphureus*	374.86	5.93
4	*Priacanthus tayenus*	315.55	4.99
5	*Loligo edulis*	283.13	4.48
6	*Priacanthus macracanthus*	264.87	4.19
7	*Trichiurus lepturus*	264.43	4.18
8	*Scolopsis taeniopterus*	253.99	4.02
9	*Sardinella fimbriata*	198.68	3.14
10	*Selaroides leptolepis*	162.84	2.58
11	*Nemipterus marginatus*	144.21	2.28
12	*Decapterus macrosoma*	128.82	2.04
13	*Rastrelliger kanagurta*	124.52	1.97
14	*Loligo duvauceli*	119.05	1.88
15	*Apogon fasciatus*	104.12	1.65
	TOTAL FISH HARVEST	**6,323.64**	**62.32**

(d) Mid-water trawl

	Dominant Species	Catch (mt)	%
1	*Sardinella gibbosa*	13,079.60	51.59
2	*Sardinella fimbriata*	2,620.26	10.34
3	*Leiognathus bindus*	1,325.46	5.23
4	*Rastrelliger brachysoma*	951.49	3.75
5	*Sardinella longiceps*	617.84	2.44
6	*Encrasicholina devisi*	405.63	1.60
7	*Dussumieria acuta*	363.97	1.44
8	*Selaroides leptolepis*	363.37	1.43
9	*Sardinella albella*	307.51	1.21
10	*Sardinella brachysoma*	293.10	1.16
11	*Decapterus maruadsi*	279.66	1.10
12	*Dussumieria elopsoides*	259.84	1.02
13	*Encrasicholina punctifer*	216.60	0.85
14	*Caranx para*	202.11	0.80
15	*Gazza minuta*	200.69	0.79
	TOTAL FISH HARVEST	**25,350.73**	**84.76**

(e) Ring net

	Dominant Species	Catch (mt)	%
1	*Rastrelliger brachysoma*	949.70	34.88
2	*Rastrelliger kanagurta*	386.11	14.18
3	*Sardinella longiceps*	343.40	12.61
4	*Sardinella fimbriata*	253.14	9.30
5	*Sardinella gibbosa*	237.11	8.71
6	*Decapterus kurroides*	123.26	4.53
7	*Caranx para*	60.28	2.21
8	*Decapterus macrosoma*	55.22	2.03
9	*Pseudocaranx dentex*	53.14	1.95
10	*Secutor ruconius*	40.14	1.47
11	*Selaroides leptolepis*	39.78	1.46
12	*Auxis rochei rochei*	33.97	1.25
13	*Trichiurus lepturus*	33.13	1.22
14	*Selar crumenophthalmus*	32.75	1.20
15	*Pelates quadrilineatus*	18.46	0.68
	TOTAL FISH HARVEST	**2,722.70**	**97.68**

27

Based on the study of Warfel and Manacop (1950), the major fish composition of Visayan Sea trawl catch includes pomadasids or sweetlips (Pomadasidae), slipmouths (Leiognathidae), breams (Nemipteridae), goatfishes (Mullidae) and croakers (Scianidae). On the other hand, the study of Aprieto and Villoso (1979) revealed the following major fish species: lizardfishes (Synodontidae), slipmouths (Leiognathidae), breams (Nemipteridae), big eyes (Priacanthidae) and goatfishes (Mullidae). Trash fish accounted to 14 percent of the total fish harvest. Furthermore, the study concluded that the Visayan Sea trawl fishery is typical multi-species fisheries of over 170 species which are mainly of poor quality with relatively low market value. Quality fishes, which are vulnerable to other gear, occur as incidental catches.

In this study, Danish seine and otter trawl catches are comprised mostly of carangids, ponyfishes, breams, squids, lizardfish and goatfishes. Mid-water trawl, purse seine, and ring net catches are composed mostly of sardines, mackerels, ponyfishes, herrings, and anchovies. These major fish species are considered as small pelagic resource of the country (Dalzell and Ganaden 1987). The bulk of catch of bottom dragging gear is comprised of squids. Danish seine catch (Table 3a) showed that squids ranked 15th among the dominant species and contributed to 1.7 percent (550.45 mt) of the gear catch. On the other hand, squids ranked fifth in the catch of otter trawl, sharing about 4.5 percent (283.13 mt) to the total gear catch. Abundance of shrimps and squids in relation to fish biomass indicates decline of catch as this group replaces finfish stratum in the food web (Armada 2004).

Seasonality and Relative Abundance

A total of 16 fish species, belonging to seven families, were analyzed for seasonality and biological parameters. Figure 11 shows the seasonal distribution and relative abundance of the major fish species monitored in the Visayan Sea in 2002. Production peak of *S. leptolepis* is in February and the lean month is in October (Fig. 11a); *A. mate,* peak month in July and lean month in January (Fig. 11b); *D. macrosoma,* peak month in February and lean month in October (Fig. 11c); *S. taeniopterus,* production peak in February and two lean months in March and October (Fig. d). Figure 10e shows the seasonality of *U. sulphureus*, with production peak in February and lean month in October. Production peak of *Pennahia anea*, on the other hand, is in April and the lean month is in February (Fig. 11f). These fish species are all caught by Danish seine.

For the sardine species (family Clupeidae) which are caught by mid-water trawl, *S. gibbosa* has its production peak in August and lean month in January (Fig. 11g), and *S. fimbriata* has its production peak in June and lean month in January (Fig. 11h).

Figure 12 also shows the seasonal distribution and relative abundance of the other major species monitored in the Visayan Sea in 2002. *Sardinella longiceps*, caught by purse seine, has its production peak in September and lean month in February (Fig. 12a).
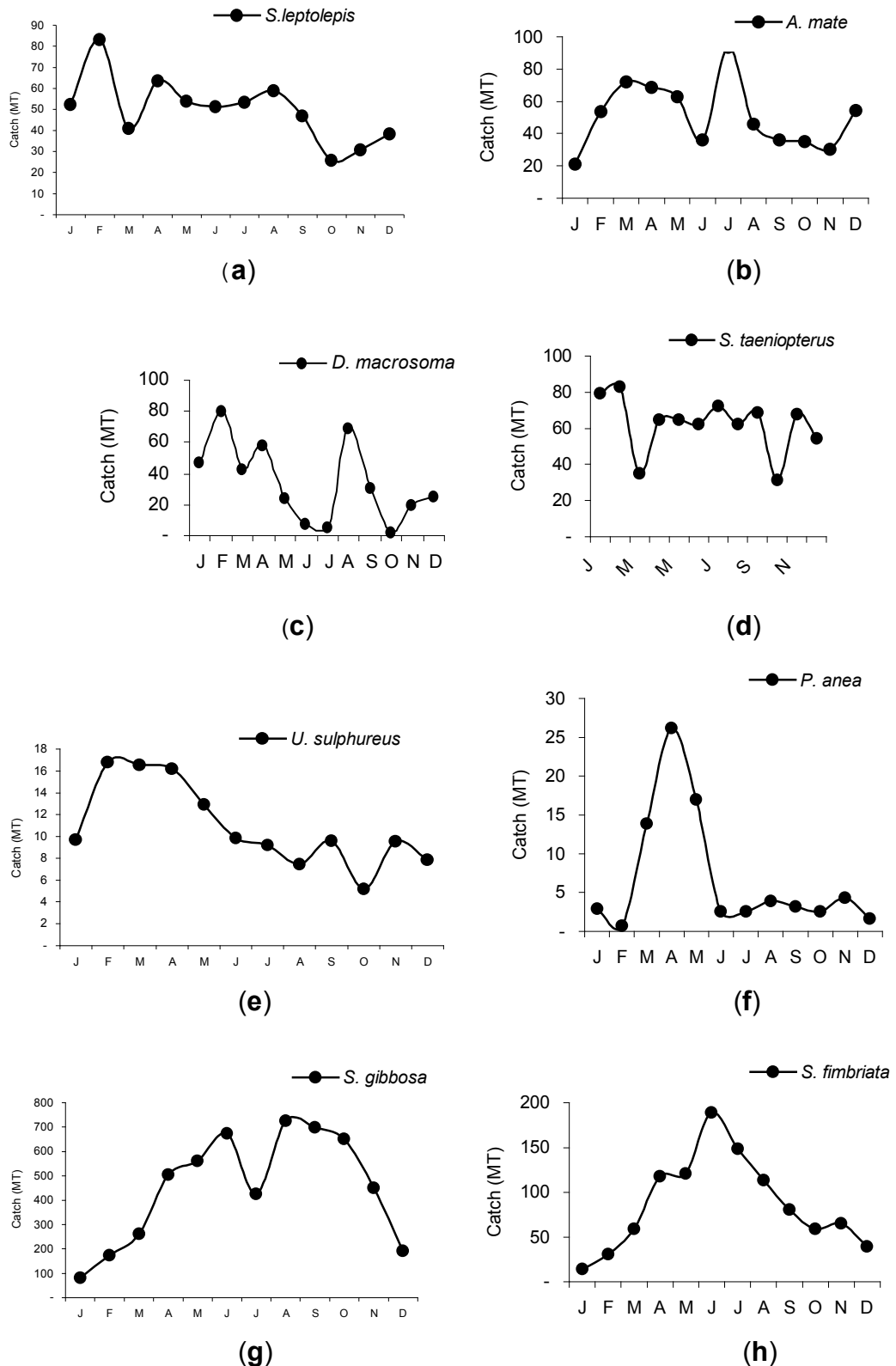
Figure 11. Trend of seasonality of major commercial fish species: (**a**) *Selaroides leptolepis*, (**b**) *Atule mate*, (**c**) *Decapterus macrosoma*, (**d**) *Scolopsis taeniopterus*, (**e**) *Upeneus sulphureus*, (**f**) *Pennahia anea*, (**g**) *Sardinella gibbosa* and (**h**) *S. fimbriata*, in the Visayan Sea (based on monthly catch from 1998 to 2002).
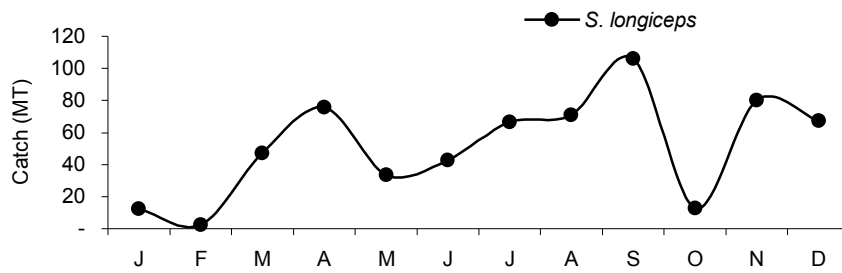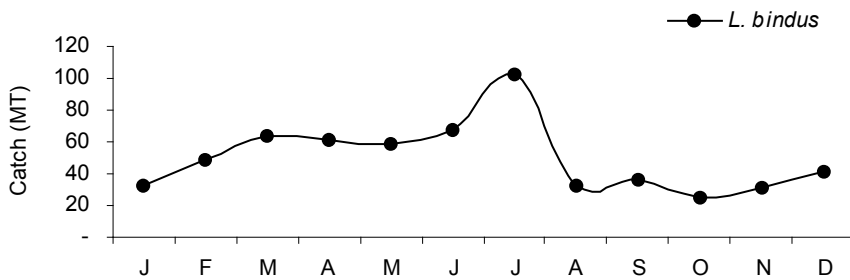
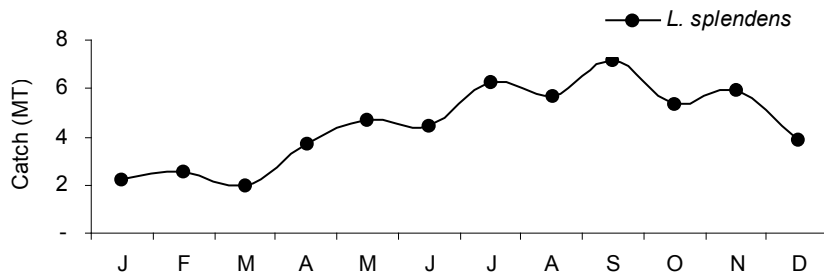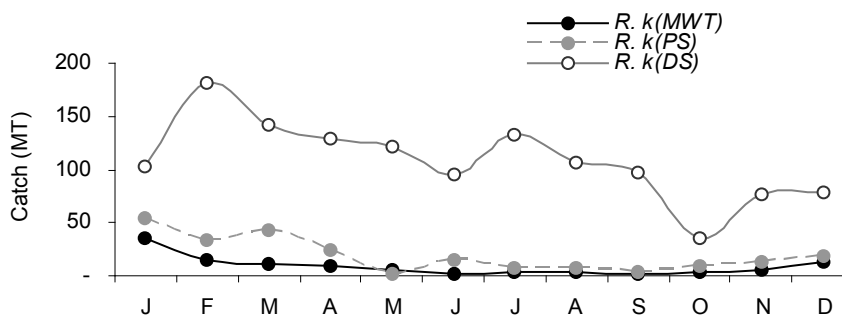**Figure 12.** Trend of seasonality of major commercial fish species: (**a**) *Sardinella longiceps*, (**b**) *Leiognathus bindus*, (**c**) *L. splendens* and (**d**) *Rastrelliger kanagurta*, in the Visayan Sea (based on monthly catch from 1998 to 2002).

For the slipmouths (Leiognathidae), the production peak of *L. bindus* is in July and the lean month is in October (Fig. 12b), while *L. splendens* has its peak in September and lean month in March (Fig. 12c).

For *Rastrelliger kanagurta*, January is the peak month for mid-water trawl and purse seine catches; and February, for the catch of Danish seine. The lean month of production for mid-water trawl and purse seine is September, while that for Danish seine is October. Rasalan (1957) reported that the peak season of mackerels is January to May; herrings and sardines, January to March; and juvenile sardines, December to May.

As observed, catches during the production peak within the northeast monsoon season include the carangid and scombrid groups, and *S. taeniopterus*. The peak season of sardines and leiognathids falls during the southwest monsoon. Intermoonsoon seasonal catch has been observed in *P. anea* and *U. sulphureus.*

Biological Parameter Estimates

Growth

Growth parameter values obtained using FISAT and those from literature are shown in Tables 4 to 8. Groupings of fish species by family include Carangidae, Clupeidae, Leiognathidae, Scombridae and demersal fish group. Literature values used for comparison were obtained from foreign results as no data from local literature are available.

For the carangid fish group, L_∞ and L_{max} values of *S. leptolepis* increased annually except in 1998 and 2001 when the data had no clear modal progression (Table 4). The highest L_∞ value obtained was 23.99 cm in 2002, while the lowest was 20.27 cm in 1999. L_∞ of this species, from literature, ranges from 19.2 cm to 29 cm. Growth coefficient (K) values obtained range from 1.08 to 1.19 cm/year^{-1}; from literature, 0.8 to 1.22 cm/yr^{-1}.

For *A. mate*, L_∞ and L_{max} values also increased, from 28.35 cm in 1998 to 35.37 cm in 2002, except in 1999 when the data had no clear modal progression. The highest L_∞ value was 35.75 cm in 2000; from literature, L_∞ values range from 24.5 cm to 30.5 cm. K values obtained range from 0.78 to 0.98 cm/year^{-1}, while K values from literature range from 0.76 to 1.0 cm/year^{-1}.

For *D. macrosoma*, and L_{max} values increased from 2000 to 2002 while the 1998 data had no modal progression. The highest L_∞ value was 25.89 cm in 2002, while L_{max} was 25.59 cm in 2001. L_∞ values from literature range from 23 cm to 31.7 cm. K values obtained for the species range from 1.07 to 1.28 cm/year^{-1}; from the literature, K values range from 1.25 to 2.3 cm/year^{-1}.

Table 4. Growth parameter estimates for the carangid fish group in the Visayan Sea (1998-2002).

Species/Year	L_{max}	L_∞	k	Ø'
Selaroides leptolepis				
1998		No modal progression		
1999	19.74	20.27	1.19	2.69
2000	20.57	21.58	1.08	1.91
2001		No modal progression		
2002	21.01	23.99	1.11	2.81
Values from literature	-	19.2-29.0	0.8-1.32	-
Atule mate				
1998	28.10	28.35	0.78	2.80
1999		Data insufficient		
2000	35.42	35.75	0.91	3.06
2001	33.64	33.90	0.94	3.03
2002	35.46	35.37	0.98	3.09
Values from literature	-	24.5-30.5	0.76-1.0	-
Decapterus macrosoma				
1998	25.19	No modal progression		
1999	24.85	25.41	1.28	2.92
2000	23.76	25.01	1.13	2.85
2001	25.59	25.36	1.12	2.86
2002	25.56	25.89	1.07	2.86
Values from literature	-	23.0-31.7	1.25-2.3	-

For the sardine fish group, values obtained for L_∞ and L_{max} of *S. gibbosa* decreased annually from 1998 to 2000, and slightly increased in 2002 (Table 5). Year 1999 data had no modal progression. The highest L_∞ value obtained was 21.46 cm in 1998 and the lowest was 19.79 cm in 2001. L_∞ values for this species, from literature, range from 13.3 cm to 14.6 cm. K values obtained range from 0.99 to 1.17 cm/year^{-1}; from literature, 1.38-3.9 cm/year^{-1}.

For *S. fimbriata*, L_∞ and L_{max} values decreased from 19.82 cm in 2000 to 18.99 cm in 2002. Year 1998-1999 data had no clear modal progression. L_∞ values from literature range from 17.0 cm to 24.8 cm. K values obtained range from 0.97 to 1.08 cm/year^{-1}; from literature, 0.7-1.2 cm/year^{-1}.

For *S. longiceps*, and L_{max} values varied from 1998 to 2002. The highest L_∞ value obtained was 24.98 cm in 1998; the highest value of L_{max} was 24.33 cm in the same year. L_∞ values from literature range from 15.75 cm to 27.0 cm. K values obtained for the species range from 0.95 to 1.24 cm/year^{-1}; from literature, 0.9-1.1 cm/year^{-1}.

Table 5. Growth parameter estimates for the sardine fish group in the Visayan Sea (1998-2002).

Species/Year	L_{max}	L_∞	K	$\emptyset'$
Sardinella gibbosa				
1998	21.17	21.46	0.99	2.65
1999	20.33	No clear modal progression		
2000	20.82	20.51	1.02	2.63
2001	19.49	19.79	1.06	2.62
2002	20.88	20.38	1.17	2.69
Values from literature	-	13.3-14.6	1.38-3.9	-
Sardinella fimbriata				
1998				
1999		No clear modal progression		
2000	19.34	19.82	1.08	2.63
2001	19.69	19.41	0.97	2.56
2002	19.34	18.99	1.04	2.57
Values from literature	-	17.0-24.8	0.7-1.2	-
Sardinella longiceps				
1998	24.33	24.98	0.95	2.77
1999	22.09	22.92	0.97	1.95
2000	22.35	23.70	0.96	2.73
2001	23.25	23.65	1.09	2.78
2002	21.78	23.28	1.24	2.83
Values from literature	-	15-75-27.0	0.9-1.10	-

For the leiognathid fish group, estimates of L_∞ and L_{max} of *S. gibbosa* varied yearly from 1998 to 2002 (Table 6). The highest L_∞ value obtained was 13.89 cm in 2002 and the lowest was 12.54 cm in 2000. L_∞ values from literature range from 8.2 cm to 13.75 cm. K values obtained range from 0.91 to 1.03 cm/year[-1]; from literature, 0.88-1.3 cm/year[-1].

For *L. splendens*, L_∞ values increased yearly from 2000 to 2002. Year 1998 data were insufficient. The highest L_∞ value obtained was 16.8cm in 2002 and the lowest was 16.07 cm in 2000. L_∞ values from literature range from 10.2 cm to 15 cm. K values obtained range from 0.98 to 1.03 cm/year[-1]; from literature, 0.7-1.5 cm/year[-1].

Growth parameter estimates for the scombrid and demersal fish groups are shown in Table 7. Values obtained for L_∞ and L_{max} of *R. kanagurta* caught by mid-water trawl varied yearly from 1998 to 2002. The highest L_∞ value obtained was 35.17 cm in 1998 and the lowest was 32.33 cm in 2000. L_∞ values for this species, from literature, range from 26.5 cm to 39 cm. K values obtained for the species range from 1.09 to 1.32 cm/year[-1]; from literature, 0.7-2.0 cm/year[-1].

Table 6. Growth parameter estimates for the leiognathid fish group in the Visayan Sea (1998-2002).

Species/Year	L_{max}	L_∞	k	Ø'
Leiognathus bindus				
1998	13.42	13.54	1.03	2.28
1999	12.09	12.81	0.93	2.18
2000	12.28	12.54	0.94	2.17
2001	12.26	12.69	0.94	2.15
2002	12.81	13.89	0.91	2.24
Values from literatures	-	8.2-13.75	0.88-1.3	-
Leiognathus splendens				
1998		Data insufficient		
1999	16.95	16.65	1.00	2.44
2000	15.06	16.07	1.03	2.42
2001	15.64	16.76	0.93	2.42
2002	16.40	16.80	0.98	2.44
Values from literatures	-	10.2-15	0.7-1.5	-

The demersal fish species analyzed for biological parameters include *Scolopsis taeniopterus, Upeneus sulphureus* and *Pennahia anea.* For *S. taeniopterus,* L_∞ values obtained increased yearly. The highest value obtained was 30.13 cm in 2002, while the lowest was 27.1 cm in 1998. L_∞ value obtained literature for this fish species is 31.5 cm. K values obtained ranged from 0.76 to 0.95 cm/year[-1]. For *U. sulphureus,* the highest L_∞ value obtained was 26.14 cm in 2000 and the lowest was 20.94 cm in 2001. Year 1999 data had no modal progression. K values obtained range from 1.05 to 1.38 cm/year[-1]; K values from literature range from 1.3 to 1.32 cm/year[-1]. For *P. anea,* the highest L_∞ value obtained was 23.87 cm in 2000 and lowest was 22.89 cm in 1999. Year 1998 data had no modal progression. K values obtained range from 0.92 to 1.38 cm/year[-1]; from literature, 0.53-1.4 cm/year[-1].

Table 8 shows the multi-gear effect on the growth of caught by Danish seine, purse seine, and mid-water trawl using 2002 data. For Danish seine catch, L_∞ of *R. kanagurta* is 32.92 cm and K is 1.03 cm/year[-1]; for purse seine catch, L_∞ is 32.46 cm and K is 1.06 cm/year[-1]; and for mid-water trawl catch, L_∞ is 32.5cm and K is 1.32 cm/year[-1]. Three-gear effect on the growth of the species showed similarity as their sizes of length at infinity and growth coefficient are almost the same.

Table 7. Growth parameter estimates for the scombrid and demersal fish groups in the Visayan Sea (1998-2002).

Species/Year	L_{max}	L_∞	k	Ø'
Rastrelliger kanagurta				
1998	34.98	35.17	1.16	3.16
1999	33.93	33.95	1.18	3.13
2000	31.89	32.33	1.09	3.06
2001	32.71	33.26	1.10	3.09
2002	32.20	32.50	1.32	3.14
Values from literature	-	26.5-39.0	0.7-2.0	-
Scolopsis taeniopterus				
1998	26.74	27.10	0.93	2.83
1999	27.22	27.60	0.90	2.84
2000	26.80	27.47	0.89	2.83
2001	27.60	28.18	0.95	2.88
2002	29.34	30.13	0.76	2.84
Values from literature	-	31.50	-	-
Upeneus sulphureus				
1998	21.29	21.06	1.19	2.72
1999		No modal progression		
2000	24.10	26.14	1.06	1.82
2001	20.40	20.94	1.05	2.66
2002	20.37	21.24	1.38	2.77
Values from literature	-	15.3-23.5	1.3-1.32	-
Pennahia anea				
1998	26.08	No modal progression		
1999	22.65	22.89	0.92	2.68
2000	22.46	23.87	0.99	2.75
2001	21.63	23.11	1.10	2.77
2002	22.86	23.18	1.38	2.87
Values from literature	-	20.0-34.8	0.53-1.4	-

Table 8. Growth parameter estimates for *Rastrelliger kanagurta* monitored in the Visayan Sea in 2002.

Species/Year	L_{max}	L_∞	k	Ø'
Rastrelliger kanagurta				
Danish seine	32.13	32.92	1.03	3.05
Purse seine	31.58	32.46	1.06	3.05
Mid-water trawl	32.20	32.50	1.32	3.14
Values from literature				

Mortality

The easiest way to describe the change in numbers in a fish stock is often to follow the fate of fish spawned approximately at the same time (Sparre and Venema 1992). The mortality of a cohort is composed of mortality due to fishing (F), and mortality caused by predation, disease, and deaths due to aging, which is known as natural mortality (M). With these factors, exploitation rate (E) can be known using the ratio of fishing mortality (F) over total mortality (Z), and that this value indicates the fishing condition of a certain area.

Pauly and Ingles (1984) stated that the optimum fishing mortality in an exploited stock should be approximately equal to natural mortality, or optimum exploitation rate is approximately equal to 0.50. A predominance of estimates of values of E >0.5 in a number of stocks should be suggestive of over exploitation.

Figure 13 shows the frequency distribution of exploitation rate as biological parameter indicator of the 12 fish species analyzed from 1998 to 2002. All exceeded optimum exploitation (E_{opt}) at 0.5 $^{year-1}$, which suggests an overfishing status of the commercially dominant marine fish stocks of Visayan Sea. Exploitation rate values cluster dominantly at 0.55 $^{year-1}$ and the range reaches to as high as 0.8 $^{year-1}$. For a comparison of exploitation rate values of *R. kanagurta* caught by three different gear in 2002, those caught by Danish seine had the highest E value of 0.7, while those caught by purse seine and mid-water trawl had E values of only 0.63 and 0.53, respectively (Figure 14).
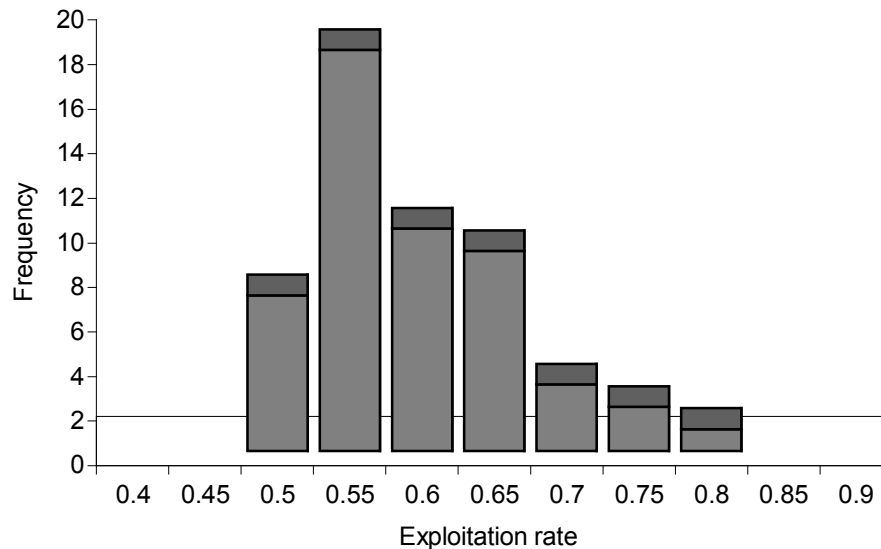

Figure 13. Frequency distribution of exploitation rate values of commercial fish species in the Visayan Sea (1998-2002).
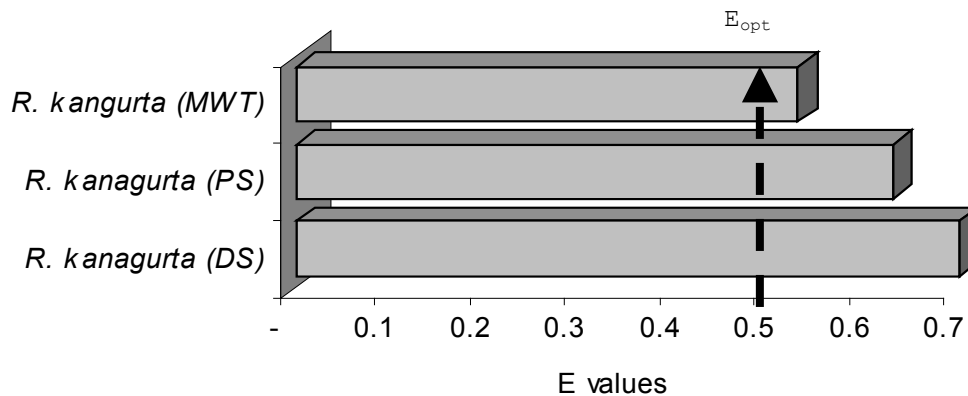
Figure 14. Comparative exploitation rate values obtained for *Rastrelliger kanagurta* monitored for the commercial fisheries of Visayan Sea in 2002.

Recruitment Pattern

Recruitment in relation to this study refers to the stage in which a stock enters a certain fishing area. Recruitment patterns have a bell-shaped normal distribution when recruitment occurs as a single event. When annual recruitment occurs as two major events, however, this results in a strongly asymmetric graph with a single mode or in a bimodal pattern. For most stocks, the recruitment pattern suggests that two pulses of recruits are generated each year (Pauly and Navaluna 1983, Pauly and Ingles 1984). All species analyzed for recruitment pattern exhibit bimodal recruitment pulses (Table 9). Strong pulse of recruitment occurred at the first semester of the year for the carangids and leiognathids; and either first or second semester for the sardines, scombrids and demersal fish groups.

Table 9. Annual recruitment pulses of major commercial fish species in the Visayan Sea (1998-2002).

Species	Number of pulses per year	Strong Pulse Semester	Peak Month (Strong Pulse)
S. leptolepis	2	1st	March - June
A. mate	2	$1^{st}/2^{nd}$	March - July
D. macrosoma	2	1st	March - April
S. gibbosa	2	1st	February - June
S. fimbriata	2	2nd	July - September
S. longiceps	2	1st	March - May
L. bindus	2	1st	March - May
L. splendens	2	1st	March - April
S. taeniopterus	2	$1^{st}/2^{nd}$	April - July
U. sulphureus	2	$1^{st}/2^{nd}$	February - July
P. anea	2	2nd	July - August
R. kanagurta (DS)	2	Equal	April/September
R. kanagurta (PS)	2	1st	April
R. kanagurta (MWT)	2	2nd	September

Probability of Capture

Probability of capture of fish by length class, as estimated from ELEFAN program, used data from mortalities to which L_c or length at first capture are being determined. Table 10 shows the probability of capture of major fish species monitored in the Visayan Sea from 1998 to 2002, particularly data on length at first maturity (L_{50}) and length at first captivity (L_{25}). As indicated in the table, from year 2000 to 2002 almost all species were captured even at a size when they are still immature. For *R. kanagurta,* those caught by purse seine were smaller in size and immature ones than those caught by Danish seine and mid-water trawl. This point can be critical since major fish species are caught at an immature stage and stocks could not be replenished, and such condition may result in recruitment overfishing.

Table 10. Comparative values of length at first maturity (L_{50}) and length at first captivity (L_{25}) of major commercial fish species in the Visayan Sea (1998-2002).

Species	Length at first captivity (L_{25})					Length at first maturity (L_{50})*
	1998	1999	2000	2001	2002	
S. leptolepis	-	12.08	12.38	-	13.92	13.20
A. mate	16.29	-	17.89	19.08	22.62	19.50
D. macrosoma	-	20.03	16.78	19.29	14.52	19.30
S. gibbosa	12.90	-	11.93	12.49	10.17	14.50
S. fimbriata	-	-	11.75	11.36	10.24	13.00
S. longiceps	15.96	17.15	16.34	13.95	13.38	16.10
L. bindus	8.58	8.04	8.08	6.93	7.89	10.00
L. splendens	-	9.44	9.39	9.05	9.01	10.70
S. taeniopterus	14.52	14.87	16.33	17.79	19.77	18.50
U. sulphureus	8.82	-	8.98	12.51	12.65	12.70
P. anea	-	15.43	11.33	12.50	11.72	14.20
R. kanagurta	20.69	23.77	14.23	12.47	19.03	15.30
R. kanagurta (DS)					26.01	15.30
R. kanagurta (PS)					14.59	
R. kanagurta (MWT)					19.03	

*Source: Froese and Pauly (2000).

Virtual Population Analysis

The method of virtual population analysis (VPA) used in this study is length base-structured that requires the necessary assumption of a stable age distribution which is not required in an age-structured VPA. A stable age distribution can be simulated in the case of length-structured VPA or length cohort analysis by averaging catch data for a length of time during which recruitment and fishing mortality can be assumed to have been constant (Pauly *et al.* 1987). Table 11 shows the values to which terminal mortality refers to the total fishing mortality of the fish population, mean F refers to the average fishing mortality per length group that is observed to be fully recruited.

Table 11. Length at full recruitment and respective fishing mortality (F) values of major commercial fish species in the Visayan Sea (1998- 2002).

Species	Length at full recruitment (in cm)	F value at full recruitment
S. leptolepis	15.63 – 16.50	6.77
A. mate	28.25 – 29.30	5.07
D. macrosoma	21.68 – 22.48	9.77
S. gibbosa	16.88 – 17.80	3.96
S. fimbriata	15.83 – 16.67	4.17
S. longiceps	19.70 – 21.18	6.87
L. splendens	11.40 – 11.90	5.02
L. bindus	13.38 – 14.00	4.88
S. taeniopterus	23.94 – 25.00	2.53
U. sulphureus	17.25 – 18.25	3.75
P. anea	19.43 – 20.23	5.28
R. kanagurta	28.34 – 29.44	5.80
R. kanagurta (DS)	28.49 – 29.24	4.98
R. kanagurta (PS)	18.00 – 19.50	3.88
R. kanagurta (MWT)	28.50 – 30.00	6.41

For the carangid group, *S. leptolepis* is fully recruited at a length class of 15.63-16.5 cm and a mean F value of 6.77; *A. mate*, 28.25-29.3 cm and a mean F of 5.07; and *D. macrosoma*, 21.68-22.48 cm and a mean F of 9.77.

For the sardine group, *S. gibbosa* is fully recruited at a length class of 16.88-17.8 cm and a mean F of 3.96; *S. fimbriata*, 15.83-16.67 cm and a mean F of 4.17; and *S. longiceps*, 19.70-21.18 cm and a mean F of 6.87.

For the leiognathids, *L. bindus* is fully recruited at a length class of 13.38-14 cm and a mean F of 4.88; while *L. splendens*, at 11.4-11.9 cm and a mean F of 5.02.

For the demersal group, *S. taeniopterus* is fully recruited at a length class of 23.94-25 cm and a mean F of 2.53; *U. sulphureus*, 17.25-18.25 cm and a mean F of 3.75; *P. anea*, 19.43-20.23 cm and a mean F of 5.28; and *R. kanagurta,* 28.34-29.44 cm and a mean F of 5.8.

For *R. kanagurta*, those caught by purse seine are fully recruited at a smaller class range of 18-20 cm and a mean F value of 0.87. Compared to those caught by Danish seine, the length class at full recruitment is bigger at 28-29 cm and the mean F value is 0.31; and by mid-water trawl, at 29-30 cm full recruitment and a mean F value of 0.55.

Relative Yield and Biomass Per Recruit

Table 12 shows the terminal exploitation rate obtained in the determination of mortalities compared with the optimum exploitation for the relative yield per recruit ($E_{.1}$) and for the relative biomass per recruit ($E_{.5}$). As indicated in the table, terminal exploitation rate exceeded E.1 in almost all

species analyzed for biological parameters. We can associate these results with that of length at first captivity that further indicates that there is really a growth overfishing, particularly of the fish species analyzed.

Table 12. Exploitation rate for relative yield per recruit and biomass per recruit of major fish species in the Visayan Sea (1998-2002).

Species	Terminal E	E.1 (Y/R)'	E.5 (B/R)'
S. leptolepis	0.68	0.61	0.37
A. mate	0.59	0.57	0.42
D. macrosoma	0.66	0.61	0.37
S. gibbosa	0.60	0.58	0.36
S. fimbriata	0.61	0.58	0.36
S. longiceps	0.69	0.64	0.38
L. splendens	0.60	0.59	0.35
L. bindus	0.62	0.60	0.36
S. taeniopterus	0.56	0.59	0.36
U. sulphureus	0.62	0.53	0.34
P. anea	0.59	0.57	0.35
R. kanagurta	0.61	0.57	0.35
R. kanagurta (DS)	0.70	0.65	0.40
R. kanagurta (PS)	0.53	0.56	0.34
R. kanagurta (MWT))	0.53	0.60	0.36

SUMMARY

Visayan Sea is one of the major fishing grounds in the country where multiple gear types are exploiting multiple stocks of demersal and pelagic fish species. Overfishing status can be determined by the following factors: declining catch and catch rates, increasing effort, increasing mortalities and exploitation rates, changes or shift in species composition, leveling off of marine landings, and concentration of fishing effort within a small area (Armada 2004).

These indicators of overfishing, as mentioned by Armada (2004) can be associated with the current status of the commercial fisheries of Visayan Sea. Results of this present study indicate that catch and catch rates in the Visayan Sea have declined. The decline can be related with the "voluntary reduction" in the number of fishing boats operating in the Visayan Sea where income generated from fishing cannot compensate the cost of fishing operation expenses. Another indicator of overfishing in the area is the appearance of squids in the bulk of catch of Danish seine and otter trawl, which indicates a shift in the fish species composition of Visayan Sea. Growth and recruitment overfishing among major fish species is proven with the following results: exploitation rate is greater than E_{opt} at 0.5, length at first captivity is smaller than length at first maturity, and terminal E values from mortalities exceeded $E_{.1}$.

RECOMMENDATIONS

Based on the results of this study, the following points are considered to address the current fisheries status of Visayan Sea:

1) There is a need to conduct a data system profiling such as the Geographic Information System (GIS), and assessment of the municipal fisheries of Visayan Sea for Regions 5, 6 and 7, including the conduct of a total inventory of fishing boats and gear in all coastal areas. These data will be incorporated with the commercial fishery assessment studies to draw a more general picture of the fisheries status of Visayan Sea.

2) Species-specific results, such as biological parameter estimates, showed the exploited status of small pelagic resources of Visayan Sea. The multispecies nature of the fishing ground poses difficulties related to resource management measures. Mesh size selectivity studies are necessary in the formulation of more appropriate control measures to safeguard the stability of a certain fishery. Another point to consider is the reduction of fishing effort in terms of the number of fishing boats operating in the Visayan Sea. Since the maximum sustainable yield (MSY) is not yet established, reduction of effort could be done thru controlling the number of fishing boat license for new and renewal licensees. Operation of a certain fishing vessel in terms of number of fishing days is another point to consider. This could be addressed thru the implementation of a coding system.

3) To address the fishery resource depletion of Visayan Sea, there should be a collaborative effort among local government units (LGUs) and other concerned agencies to come up with an inter-regional approach and policies for the proper management and conservation of the Visayan Sea fisheries resources.

REFERENCES

Allen, G. R. and R. Swainston. 1998. The Marine Fishes of the Northwestern Australia. A Field Guide for Anglers and Divers. Western Australian Museum, Perth, Western Australia. 201 p.

Aprieto 1976

Aprieto, V., J. Saeger and D. Pauly (eds.). 1986. Selected papers on Philippine marine fisheries resources (1947-1986). Technical Reports of the Department of Marine Fisheries No. 9. College of Fisheries, University of the Philippines in the Visayas. p. 3-60, 125-136.

Aprieto, V. L. and E. Villoso. 1979. Catch composition and relative abundance of trawl-caught fishes in the Visayan Sea. Fish. Res. J. Philipp. 4(1): 9-18.

Arce, F. M. 1986. Distribution and relative abundance of nemipterids and carangids (Pisces: Nemipteridae and Carangidae) caught by trawl in the Visayan Sea with notes on the biology of *Nemipetrus oveni* and *Selaroides leptolepis*. Philipp. J. Fish. 19(1-2): 24-75.

Armada, N. B. 2004. State of demersal fisheries. In: Department of Agriculture-Bureau of Fisheries and Aquatic Resources (DA-BFAR), In Turbulent Seas: The Status of Philippine Marine Fisheries, p. 42-46. Coastal Resource Management Project (CRMP), Cebu City, Philippines. 378 p.

Barut, N. C., M. D. Santos and L. R. Garces. 2004. Overview of the Philippine marine fisheries. In: DA-BFAR, In Turbulent Seas: The Status of Philippine Marine Fisheries, p. 22-31. CRMP, Cebu City, Philippines. 378 p.

Beverton, R. J. H. and S. J. Holt. 1956. A review of methods for estimating mortality rates in exploited fish populations with special reference to sources of bias in catch sampling. Rapp. P.v. Reun. CIEM 140: 67-83.

_____. 1957. On the dynamics of exploited fish populations. Fish. Invest. Ser. II 19: 533 p.

BFAR (Bureau of Fisheries and Aquatic Resources). 2000. Philippine fisheries profile for year 2000. BFAR, Quezon City.

BFAR Regional Office 6. 2001. National Stock Assessment Project (NSAP) files, 1998-2001. BFAR Regional Field Office 6, Iloilo City.

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

FAO (Food and Agriculture Organization of the United Nations). 1998. Yearbook of Fisheries Statistics. FAO, Rome, Italy.

Froese, R. and D. Pauly (eds.). 2000. Fish Base 2000: concept, design, and data sources. ICLARM, Los Baños, Laguna, Philippines. 344 p.

Gayanilo, F. C. Jr. and D. Pauly. 1997. FAO-ICLARM Stock Assessment Tools, Reference Manual. FAO and International Center for Living Aquatic Resources Management (ICLARM), Rome. 219 p.

Gayanilo, F. C. Jr., P. Sparre and D. Pauly. 1996. FAO-ICLARM Stock Assessment Tools (FISAT): User's Manual. FAO Computerized Information Series (Fisheries) No. 8. Rome, FAO. 126 p.

Gonzales, C. L., J. C. Muñoz, A. R. Tañedo and F. N. Lavapie. 1981. Report on the first fishery survey of the Visayan Sea.

Guanco, M. R. 1991. Growth and mortality of Indian mackerel, *Rastrelliger kanagurta* (Scombridae) in the Visayas Sea, Central Philippines. Fishbyte (Newsletter of the Network of Tropical Fisheries Scientists) 9(2): 13-15.

Hermes, R., N. B. Armada, R. A. Aparri, E. C. Zaragoza and U. Lohmeyer. 2004. Overexploitation in the Visayan Sea: designing a project solution. In: DA-BFAR, In Turbulent Seas: The Status of Philippine Marine Fisheries, p. 312-317. CRMP, Cebu City, Philippines. 378 p.

Lavapie-Gonzales, F., S. R. Ganaden and F. C. Gayanilo, Jr. 1997. Some Population Parameters of Commercially Important Fishes in the Philippines. Bureau of Fisheries and Aquatic Resources, Philippines, 114 p.

Mansor Mat Isa. 1998. Field Guide to Important Commercial Marine Fishes of the South China Sea. Marine Fishery Resources Development and Management Department. South-East Asian Fishery Development Center, Chendering, 21080 Kuala Terengganu, Malaysia. 285 p.

Ordoñez, J. A. 1985. A study of the trash fish caught by otter trawl in the Visayan Sea. Philipp. J. Fish. 18(1-2): 1-76.

Pauly, D. 1984. Length converted catch curves: a powerful tool for fisheries research in the tropics (part II). ICLARM Contribution No. 173. ICLARM, Metro Manila, Philippines, p. 74-76.

Pauly, D. and J. Ingles. 1984. Atlas of the Growth, Mortality and Recruitment of the Philippine Fishes. Institute of Fisheries Development and Research, College of Fisheries, University of the Philippines, Diliman, Quezon City, and ICLARM, Metro Manila, Philippines.

Pauly, D. and N. A. Navaluna. 1983. Moonsoon-induced sseasonality in the recruitment of Philippine fishes. FAO Fish. Rep. 291(10): 823-833.

Pauly, D., M. L. Palomares and F. C. Gayanilo. 1987. VPA estimates of the monthly population length composition, recruitment mortality, biomass and related statistics of Peruvian anchoveta, 1951-1981. In: D. Pauly and I. Tsukayama (eds.), ICLARM Studies and Reviews 15: 142-166.

Rasalan. S. B. 1957. Marine fisheries of Central Visayas. Philipp. J. Fish. 5(1): 53-89.

Sparre, P. and C. Venema. 1992. Introduction to tropical fish assessment. Part I - Manual. FAO Fish. Tech. Paper No. 306.1, Rev.1, FAO.1992. 376 p.

Tandog-Edralin, D., S. R. Ganaden and P. Fox. 1988. A comparative study of fish mortality rates in moderately and heavily fished areas of the Philippines. In: Contributions to Tropical Fisheries Biology: Papers by the Participants of FAO/DANIDA Follow-up Training Courses, edited by S. Venema, J. Moller-Christensen and D. Pauly. FAO Fisheries Report (389): 468-481.

von Bertalanffy, L. 1934. Untersuchungen über die Gesetzlichkeiten des Wachstums 1. Allgemeine Grundlagen derTheorie. Roux' Arch. Entwicklungsmech. Org. 131: 613-653.

Warfel, H. E. and P. R. Manacop. 1950. Otter trawl explorations in Philippine waters. Research Report 25, Fish and Wildlife Service, U.S. Dept. of the Interior. Wash. D. C.: U.S. Gov't. Printing Office. 49 p.