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ASSESSMENT OF THE FISHERIES OF LAGONOY GULF (REGION 5)

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National Stock Assessment Program

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ABBREVIATIONS, ACRONYMS AND SYMBOLS

BAS	-	Bureau of Agricultural Statistics
BCDC	-	Bicol Cooperative Development Council
BFAR	-	Bureau of Fisheries and Aquatic Resources
BN	-	bagnet
BS	-	beach seine
BSLL	-	bottom set longline
CBRMP	-	Community-Based Resource Management Project
$CL\infty$	-	carapace length infinity
CLN	-	crab liftnet
cm	-	centimeter
CP	-	crab pot
CPUE	-	cath per unit effort
CRM	-	Coastal Resource Management
$CW\infty$	-	carapace width infinity
DA	-	Department of Agriculture
DENR	-	Department of Environment and Natural Resources
Dept.	-	department
DGN	-	drift gillnet
DS	-	Danish seine
E	-	exploitation rate
eds.	-	editors
ELEFAN	-	electronic length frequency analysis
Emax	-	maximum exploitation
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
FRMP	-	Fisheries Resource Management Program
FSP	-	Fishery Sector Program
GN	-	gillnet
HL	-	hook and line
ICLARM	-	International Center for Living Aquatic Resources Management
J	-	jigger
K	-	growth rate
kg	-	kilogram
km^2	-	square kilometer
LGU	-	local government unit
L_{max}	-	maximum length
L_{50}	-	length at 50 percent probability of capture

L∞	-	length infinity, asymptotic length
M	-	natural mortality
Mar.	-	marine
MFARMC	-	Municipal Fisheries and Aquatic Resources Management Council
MS	-	Microsoft
mt	-	metric ton
NGO	-	non-government organization
NORMSEP	-	normal separation
NSAP	-	National Stock Assessment Program
OT	-	otter trawl
p.	-	page/s
PE	-	potential effort
PRRM	-	Philippine Rural Reconstruction Movement
PY	-	potential yield
RA	-	Republic Act
REA	-	resource and ecological assessment
Rep.	-	report
RHS	-	round haul seine
RP	-	recruitment pattern
RSA	-	regional stock assessment
RSAP	-	Regional Stock Assessment Program
Ser.	-	series
SLN	-	stationary liftnet
SM	-	size at maturity
Tech.	-	technical
TN	-	trammel net
TWINSPAN	-	Two-Way INdicator SPecies ANalysis
VBGF	-	von Bertalanffy growth function
VPA	-	virtual population analysis
yr	-	year
Y'/R	-	relative yield per recruit
Z	-	total mortality
Ø'	-	growth performance index
%	-	percent

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ABSTRACT

A fishery assessment was conducted, from July 1997 to June 2002, to evaluate the effects of fishing as basis for the management and sustainability of the fisheries of Lagonoy Gulf.

Catch and effort data were analyzed using MS Excel. Seasonality of species, through the TWINSPAN program and length frequencies, was analyzed using the FAO-ICLARM Stock Assessment Tools (FISAT).

Tunas and oceanic pelagics are the most important finfishes in Lagonoy Gulf. Eight species of tunas and mackerels contributed 56.54 percent of the total production, while other large pelagic species such as sailfish, blue marlin, wahoo and dolphinfish also contributed 8.68 percent of the gulf production. Production trends and seasonality did not vary considerably for each year. Average catch rate consistently decreased as effort increased. Preliminary estimate of the potential yield (PY) showed that fishery exploitation of the Gulf was beyond the sustainable level of the resource by 31 percent, which is an indication of a very high fishing pressure.

Results of the analysis of population parameters showed high growth rates (K = 0.97-1.70) and high mortality coefficients (Z = 4.60-7.59). These values indicate a very high turnover rate of biomass but low survival rate in the Gulf. Recruitment patterns derived were mostly unimodal in most species (90 percent) sampled. The exploitation ratios obtained were relatively high (E = 0.59-0.75), indicating a high fishing pressure on the resource. Comparison of the probabilities of capture (L_{50}) with the known sizes at maturity, ratio to their L_∞, virtual population analysis (VPA) and size distributions revealed that all species caught by ringnet were not yet mature enough to spawn or contribute to the biomass. These were substantiated with the observations on the relative yield per recruit that F values have surpassed by 43 percent (F_{max}) the allowable limit of exploitation.

The overexploitation of Lagonoy Gulf was due to heavy fishing pressure and growth overfishing, especially for pelagic species of which the Gulf is known for. This calls for a serious management and regulatory intervention on the part of policy makers to allow the Gulf to recover from overfishing.

INTRODUCTION

Lagonoy Gulf is one of the country's major fishing grounds. It is situated in Southern Luzon and covers the provinces of Camarines Sur, Albay, and Catanduanes (Fig. 1). Its boundaries extend up to Caramoan Peninsula and Catanduanes Island in the north; while Batan, San Miguel and the Cagraray Group of Islands border the southern portion of the Gulf. It is semi-enclosed and elliptically-shaped, with an approximate area of 3,071 km^2 and a coastline of about 225 km. The portion within seven to 15 km from the shoreline is considerably deep; the deepest is 569 fm.

The Gulf is considered as the largest and most important fishing ground for large tuna, tuna-like and elasmobranch species in the Bicol Region. Both municipal and commercial fisheries are characterized by multi-species fishery and multi-fishing gear activity. About 8,379 fishermen, residing in the 164 coastal barangays of the 15 municipalities bordering Lagonoy Gulf, are directly dependent on capture fisheries as a means of their livelihood.

The Bureau of Fisheries and Aquatic Resources (BFAR) and the Bureau of Agricultural Statistics (BAS) estimated the Gulf's annual production from 7,737.28 mt in 1980 to 24,292 mt in 1992.

Soliman et al. (1995), in their resource and ecological assessment (REA) of Lagonoy Gulf, estimated an annual production of 33,380 mt or about 11 $mt/km^2/yr$. Thirty-four types of gear were identified, of which handline was the major gear used. Lagonoy Gulf is a multi-gear fishery with a total of 10,709 units of various types in which handlines and gillnets comprised 75 percent of the total number of gear units in the area (Garces et al. 1995).

In 1992, Lagonoy Gulf was one of the priority areas under the Fishery Sector Program (FSP) of the Department of Agriculture (DA) and BFAR. Several projects were undertaken such as the installation of artificial reefs, establishment of fish sanctuary and marine reserve, community organizing for people empowerment, and in-depth campaign on the conservation and management of marine resources. The conduct of REA was contracted to the International Center for Living Aquatic Resources Management (ICLARM) and academe, while mangrove reforestation was undertaken by the Department of Environment and Natural Resources (DENR) as one of the components of FSP (Silvestre et al. 1995). These interventions are being continued through the Fisheries Resource Management Program (FRMP), Community-Based Resource Management Project (CBRMP), and awareness and consciousness campaign on Coastal Resource Management (CRM) initiated by some non-government organizations (NGOs) such as the Philippine Rural Reconstruction Movement (PRRM) and the Bicol Cooperative Development Council (BCDC).

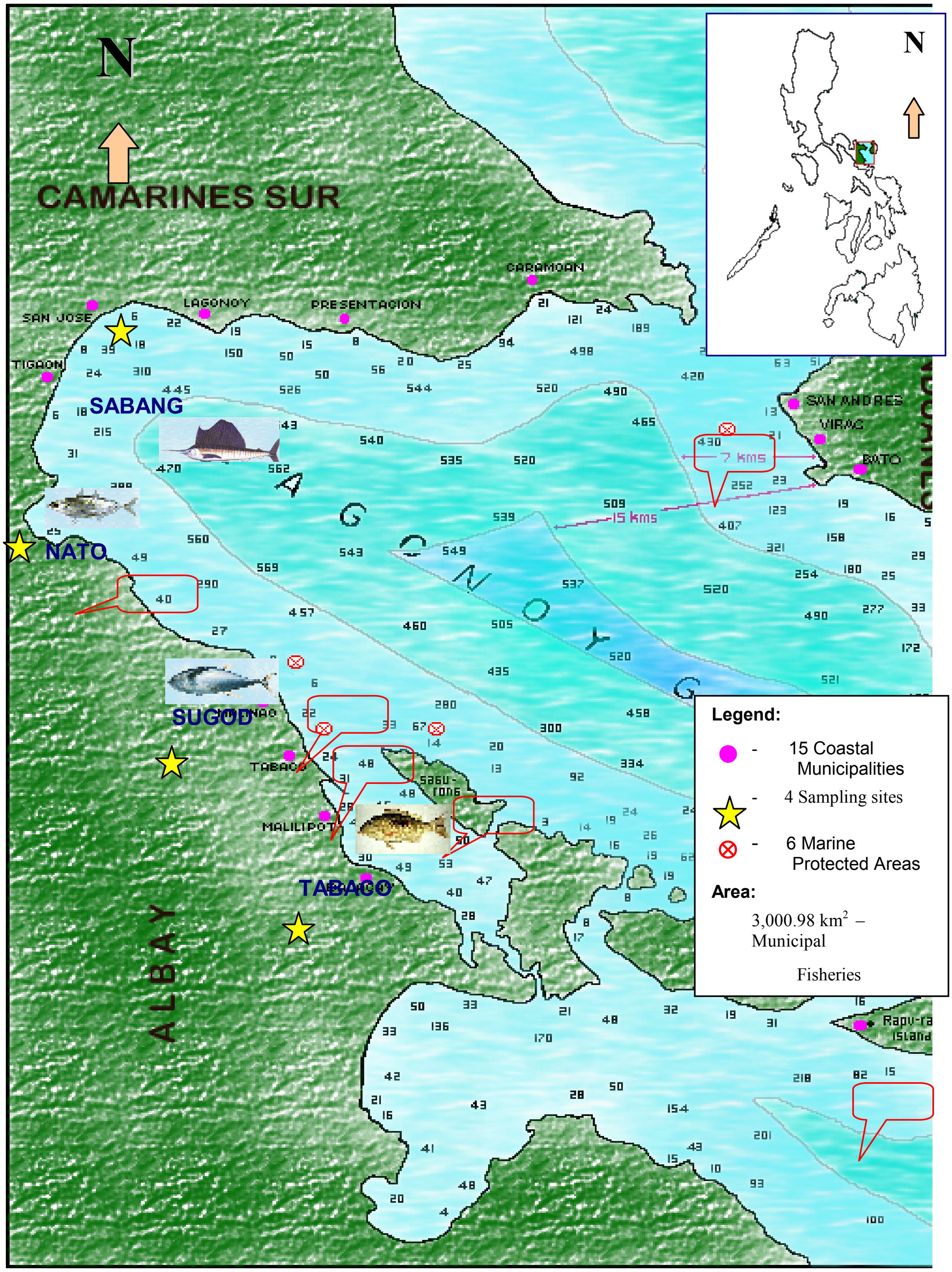

Figure 1. Map of Lagonoy Gulf showing the NSAP landing sites and related information.

Notwithstanding these significant interventions, the impact of management efforts has not yet been realized. Hence, it is imperative to continue the assessment study, as a component of the National Stock Assessment program (NSAP) of the BFAR, to provide reliable scientific data that would serve as basis in the formulation of policy options and management plans for the sustainability of Lagonoy Gulf. The province of Catanduanes is not included in this assessment study due to budgetary constraints.

Objectives

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 waters for the attainment of sustainable development.

Specific

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

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

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

- Estimate the probabilities of capture for key species of finfishes;

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

- Estimate the fishing mortalities in relation to sizes through virtual population analysis (VPA);

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

METHODOLOGY

Monitoring of catch and effort of the different types of commercial and municipal gear was conducted from July 1997 to June 2001 in the following landing sites: Sugod, Tiwi and Tabaco City in the province of Albay; and Sabang, San Jose and Nato, Sagñay, in the province of Camarines Sur (see Fig. 1). The criteria of choosing the sites were (a) representativeness of the gear, (b) bulk of catch landings, (c) willingness of the fishermen to cooperate, and (d) accessibility of the site. Monitoring was done every other two days, including weekends and holidays. Catch by species and effort, in terms of boat landings and length measurements for major species, were recorded in the standard monitoring forms.

A boat and gear inventory was conducted in the 15 municipalities comprising of 162 barangays bordering the Gulf. 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. The seasonality of species was analyzed using the TWINSPAN program for ecological community structure analysis. The data used were the unraised monthly monitored catch landing per species as caught by five major gear. Pseudospecies based on the appropriate class intervals of data were made prior to the analysis using the program.

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:

$$\textit{Estimated production} = \textit{catch per unit effort (CPUE)} \times \textit{estimated number of boats} \times \textit{number of trips}$$

and the effort was standardized, thus:

$$\textit{Standardized effort (per gear)} = \frac{\textit{average catch per unit effort}}{\textit{average CPUE of HL}} \times \textit{estimated no. of boats.}$$

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

Population parameters were computed using the routines incorporated in the FAO-ICLARM stock assessment tools (FISAT). Prior to analysis, the data were first screened for their suitability for analysis based on the progression of modes exhibited, number of samples and the number of months with data. Adjustments of class intervals and smoothing of data using running average by five were undertaken whenever necessary.

The growth parameter, L_∞, was estimated using the Powell-Wetherall plots; the value of L_{max} from the Extreme Value Theorem was used whenever the value of L_∞ was not compelling. The growth constant, K, as described by the von Bertalanffy growth function (VBGF), was generated using the K-scan routine of ELEFAN I. Optimization of the growth parameters was performed thru the other options presented in ELEFAN I. The natural mortality (M) was derived from Pauly's M empirical equation, while the total mortality (Z) and fishing mortality (F) were derived from the length-converted catch curve. The number of recruitment pulses was determined from the decomposition of normal distributions using Hasselblad's NORMSEP.

The relative yield per recruit (Y'/R) was generated using the selection ogives of the Beverton and Holt Model; the exploitation (E) values from the Y'/R became the basis for computing the excess catch or fishing mortality based on the equation $E = F/Z$. The length-structured virtual population analysis (VPA) derived from Gulland's equation was used to project the catch-at-length data and the population size at different levels of fishing mortalities.

RESULTS AND DISCUSSION

Boat and Gear Inventory

The boat and gear inventory, conducted from June to December 2001 in the 15 coastal municipalities and 162 barangays bordering Lagonoy Gulf, recorded a total of 4,315 boats operating in the Gulf of which 26 percent were motorized and 74 percent were non-motorized. There were 8,379 fishers monitored, compared to 7,500 fishers only in the resource and ecological assessment (REA) conducted by *Garces et al*. (1995) – an increase of 12 percent after six years. About 21 kinds of gear were used, with ringnet, hook and line, gillnet, multiple hook and line and bottom set longline as the commonly used gear. The number of gear operating in the Gulf increased by 76 percent – from only 10,709 units (Garces *et al*. 1995) to 18,895. The increase was due to the expansion of municipal fishing operations, in the area, of hook-and-line gear which are simple and inexpensive. Handlines and gillnets comprised 80 percent of the total gear units monitored; Garces *et al.* (1995) reported 75 percent only.

Production Estimates

The estimated annual production of Lagonoy Gulf was 37,012 mt, compared to 33,380 mt (Garces *et al*. 1995). There was an increase of 11 percent after six years. Eighty-nine percent of the production was contributed by the commonly used gear (Table 1).

Catch Composition

A total of 96 fish and elasmobranch families (consisting of 620 species) and 10 families of invertebrates (consisting of 38 species) were identified in the samples taken from four landing sites in Lagonoy Gulf. In contrast, the REA reported a total of only 79 families of fish with 480 species, and 35 species of invertebrates in 17 landing sites in the Gulf (Dioneda *et al*. 1995).

Present enumerations showed a significant increase of 24 percent for fish families, 29 percent for fish species, and nine percent for species of invertebrates. The increase might be due to the frequency in sampling and in the multispecies characteristic of the Gulf. Slight variations in the identified families and species of both fish and invertebrates were observed, indicating that there was little or no migration of fishery stocks especially for demersal species.

Dominant Fish Families

Out of 89 fish families identified in this study, Scombridae and Carangidae dominated the catch in terms of aggregate weight in metric tons. These two families have a major contribution of 71.58 percent or 1,349.92 mt of the total average landed catch. These were followed by Istiophoridae, Engraulidae, Coryphaenidae, Belonidae, Siganidae, Lethrinidae, Lutjanidae and Exocoetidae which comprised 15.18 percent of the catch. The less dominant species caught, including invertebrates, contributed 13.24 percent of the average total catch monitored (Fig. 2). These findings were consistent with the results of the REA wherein Scombridae and Carangidae comprised 71.89 percent of the computed average annual production of Lagonoy Gulf (Soliman *et al.* 1995).

Table 1. Production estimates by gear based on boat and gear inventory in Lagonoy Gulf (June to December 2001).

Fishing Gear	Ave. CPUE (kg/trip)	Number of trips/ year	Estimated No. of Gear	Estimated Production (mt)	Relative Contribution (%)
Major Gear					
A. Hook and line					
Hand line	11.56	189	11,439	24,992.38	67.52
Multiple hook and line	9.39	208	1,082	2,113.27	5.71
Bottom set longline	5.7	217	297	367.36	0.99
B. Surrounding Net					
Ringnet	81.5	323	66	1,737.42	4.69
C. Gillnet					
Drift gillnet	9.8	206	857	1,730.11	4.67
Bottom set gillnet	4.7	209	1,596	1,567.75	4.21
Encircling gillnet	21.26	130	32	88.44	0.24
Surface gillnet	6.5	384	116	289.54	0.78
Minor Gear					
Beach seine	27.4	243	180	1,198.48	3.24
Stationary/crab lift net	12.21	162	419	828.79	2.24
Crab/fish pot/trap	3.25	195	956	605.87	1.64
Spear gun	3.17	192	974	592.82	1.60
Jigger	3.1	248	624	479.73	1.30
Bagnet	36.4	178	24	155.50	0.42
Fish corral	6.9	279	59	113.58	0.31
Seine net	13.29	152	30	60.60	0.16
Scoop net	3	180	68	36.72	0.10
Troll line	3	180	61	32.94	0.09
Squid trap	6.75	228	7	10.77	0.03
Round haul seine	21.35	61	8	10.42	0.03
TOTAL		**4,164**	**18,895**	**37,012.49**	**100.00**

Dominant Fish Species

There were 37 dominant species of fish and invertebrates of economic importance found and observed in four landing centers of Lagonoy Gulf (Table 2).

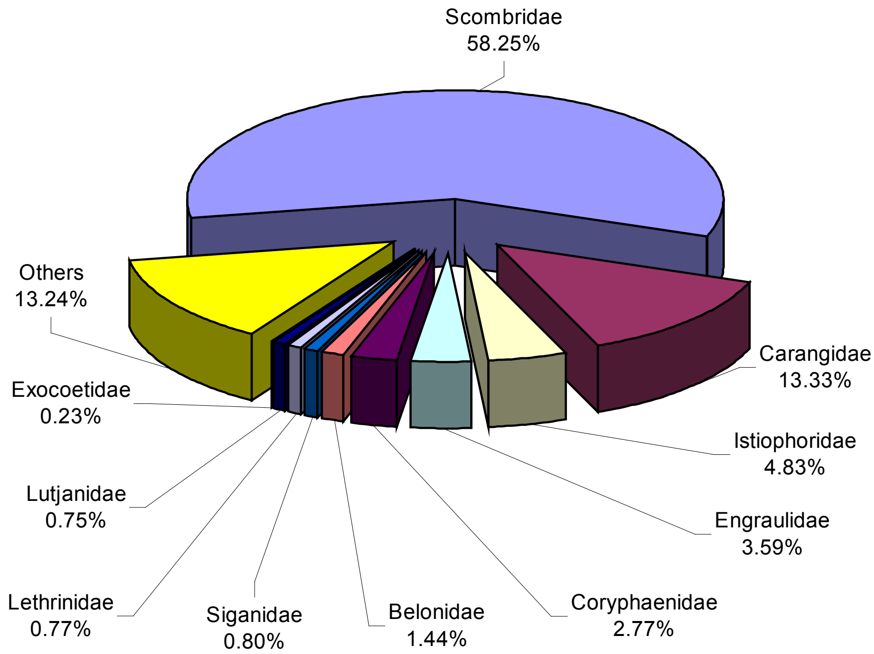

Figure 2. Dominant fish families caught by major types of gear in Lagonoy Gulf (July 1997-June 2002).

The 10 dominant species were *Katsuwonus pelamis* and *Thunnus albacares* (with an aggregate weight of 868.46 mt or 46.05 percent contribution to the average annual production for five years); *Selar crumenophthalmus*, *Istiophorus platypterus*, *Rastrelliger faughnii, Coryphaena hippurus, Stolephorus* spp., *Euthynnus affinis*, *Decapterus russelli* and *Decapterus macrosoma*, which comprised 24.60 percent of the production. The remaining 29.35 percent was contributed by other species of fish and invertebrates (Fig. 3).

Catch Composition of the Major Types of Fishing Gear

There were 18 gear types operating in the Gulf with ringnet, hook and line, gillnet, bottom set longline, and multiple hook and line as the major gear used.

The most productive gear was ringnet, catching mostly *Katsuwonus pelamis* (50.59 percent). *Rastrelliger faughni, Selar crumenophthalmus, Decapterus russelli, Euthynnus affinis*, *Decapterus macrosoma, Stolephorus commersoni, Rastrelliger kanagurta* and *Thunnus albacares* comprised 26.23 percent of the catch, while other species gave a share of 23.18 percent (Fig. 4).

Table 2. Dominant fish and invertebrate species caught by major gear in Lagonoy Gulf (July 1997-June 2002).

SPECIES	CATCH (mt)					GRAND TOTAL	RELATIVE ABUNDANCE (%)
	July '97-June '98	July '98-June '99	July '99-June '00	July '00-June '01	July '01-June '02		
1 *Katsuwonus pelamis*	141.14	53.00	170.79	112.00	84.10	561.02	29.75
2 *Thunnus albacares*	49.45	68.62	55.51	61.97	71.88	307.44	16.30
3 *Selar crumenopthalmus*	19.03	23.75	12.59	24.21	30.74	110.32	5.85
4 *Istiophorus platypterus*	32.59	12.37	14.03	6.57	16.37	81.93	4.34
5 *Rastrelliger faughnii*	8.09	13.46	8.79	7.57	16.95	54.85	2.91
6 *Coryphaena hippurus*	19.55	13.00	5.41	5.69	8.53	52.17	2.77
7 *Stolephorus* sp.	0.07	0.25	36.56	8.67	2.58	48.13	2.55
8 *Euthynnus affinis*	1.31	5.70	16.00	13.43	5.49	41.93	2.22
9 *Decapterus russelli*	9.72	12.15	2.76	5.34	10.52	40.48	2.15
10 *Decapterus macrosoma*	6.74	16.27	0.40	5.88	4.90	34.19	1.81
11 *Auxis thazard*	9.38	3.99	4.26	4.66	8.37	30.66	1.63
12 *Rastrelliger kanagurta*	3.22	6.89	5.55	3.41	6.49	25.57	1.36
13 *Tylosurus crocodilus*	3.94	3.23	6.29	8.35	3.72	25.53	1.35
14 *Atule mate*	7.60	4.07	1.40	1.60	7.93	22.61	1.20
15 *Acanthocybium solandri*	6.33	7.79	2.36	2.03	2.73	21.24	1.13
16 *Auxis rochei*	5.41	0.59	2.14	0.85	7.20	16.19	0.86
17 *Elagatis bipinnulata*	0.11	2.15	4.65	5.73	3.10	15.74	0.83
18 *Thunnus alalunga*	2.29	5.38	2.21	2.74	0.94	13.56	0.72
19 *Siganus canaliculatus*	2.48	2.43	1.55	1.36	4.88	12.71	0.67
20 *Thunnus tonggol*	0.10	0.12	5.03	2.59	1.47	9.31	0.49
21 *Lutjanus malabaricus*	0.44	2.03	2.30	1.68	1.96	8.41	0.45
22 *Makaira mazara*	0.24	1.04	3.19	0.85	2.95	8.26	0.44
23 *Sardinella longiceps*	2.57	0.68	0.01	0.12	2.51	5.89	0.31
24 *Lethrinus lentjan*	2.06	2.22	0.32	0.23	1.00	5.81	0.31
25 *Thunnus obesus*	1.01	3.02	0.18	1.34	0.09	5.64	0.30
26 *Cheilopogon furcatus*	0.01	0.08	3.60	0.35	0.06	4.10	0.22
Invertebrates							
1 *Sepiotheuthis lessoniana*	0.50	0.62	2.31	3.22	6.90	13.55	0.72
2 *Portunus pelagicus*	0.18	0.74	0.56	0.14	1.04	2.67	0.14
3 *Sepia lycidas*	0.10	1.13	0.65	0.01	0.02	1.90	0.10
4 *Octopus macropus*	-	1.82	0.05	-	0.01	1.88	0.10
5 *Loligo uyii*	0.88	0.41	0.00	0.00	0.01	1.30	0.07
6 *Sepia pharaonis*	0.91	0.11	0.01	0.02	0.01	1.06	0.06
7 *Octopus aegina*	-	-	0.79	0.00	0.00	0.80	0.04
8 *Portunus sanguinolenthus*	0.09	0.26	0.23	0.04	0.08	0.70	0.04
9 *Scylla serrata*	0.01	0.03	0.04	0.01	0.05	0.14	0.01
10 *Charybdis feriata*	-	-	0.04	0.02	0.03	0.10	0.01
11 *Sepia recurvirustra*	0.01	0.07	-	-	-	0.08	0.00
Others	69.33	66.49	26.80	46.47	89.09	298.17	15.81
TOTAL	406.91	335.98	399.36	339.12	404.68	1,886.05	100.00

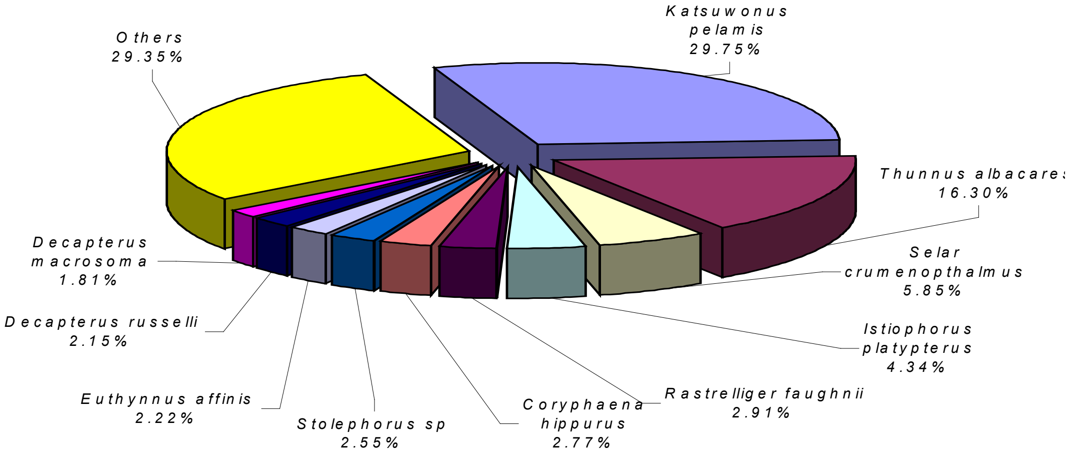

Figure 3. **Dominant fish species caught by major gear in Lagonoy Gulf (July 1997-June 2002).**

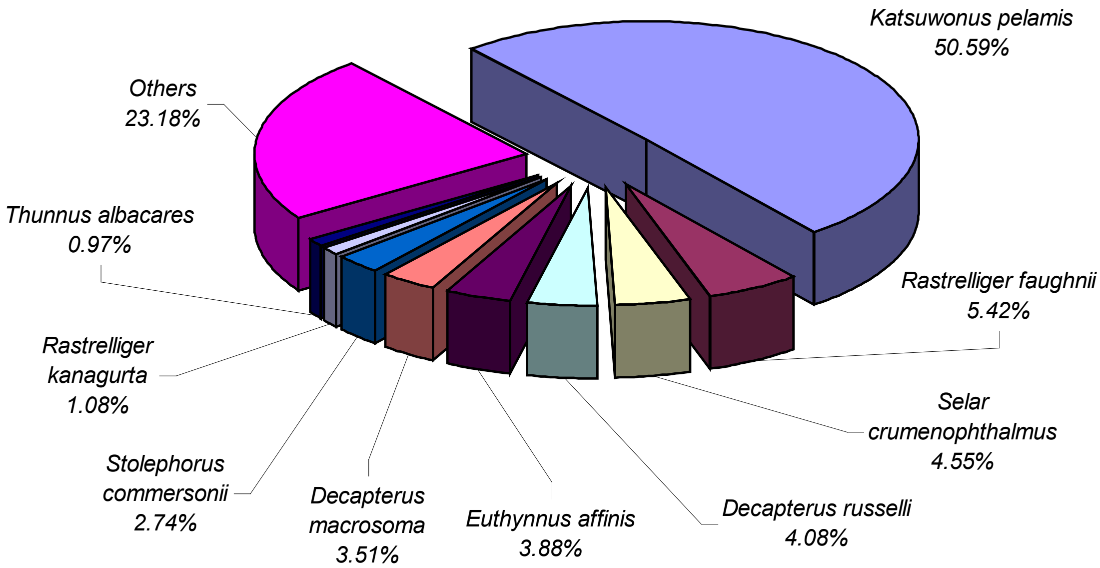

Figure 4. Catch composition of ringnet in Lagonoy Gulf (July 1997-June 2002).

The second most productive gear was hook and line, with a total catch dominated by *Thunnus albacares* and *Katsuwonus pelamis* which contributed 68.13 percent. *Coryphaena hippurus, Istiophorus platypterus, Acanthocybium solandri, Thunnus alalunga, Thunnus obesus, Elagatis bipinnulata* and *Makaira mazara* contributed 21.98 percent; while the minor species caught accounted for 9.89 percent (Fig. 5).

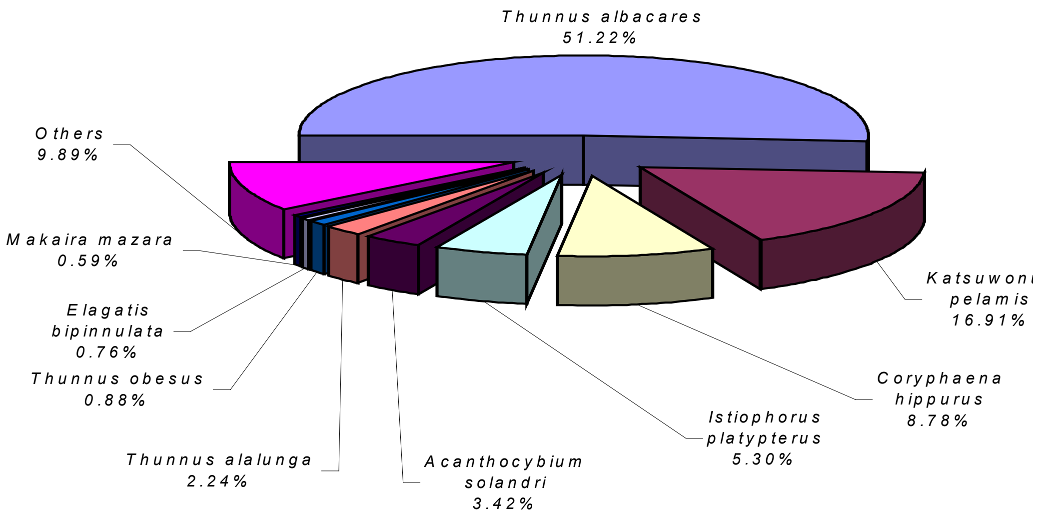

Figure 5. Catch composition of hook and line in Lagonoy Gulf (July 1997-June 2002).

The third most productive gear was gillnet. Its production was dominated by *Istiophorus platypterus*, *Selar crumenophthalmus* and *Tylosorus crocodilus* which comprised 39.31 percent. *Rastrelliger kanagurta, Siganus canaliculatus*, *Sepiotheuthis lessoniana, Makaira mazara, Cheilopogon furcatus* and *Auxis thazard* contributed 18.32 percent; the minor species accounted for 42.37 percent (Fig. 6).

The bottom set longline was also considered a productive gear. Majority of the species caught by this gear were *Lutjanus malabaricus*, *Lethrinus ornatus*, *Nemipterus celebicus*, *Lethrinus lentjan*, *Lethrinus atkinsoni*, *Lethrinus harak*, *Dasyatis kuhlii*, *Nemipterus virgatus* and *Nemipterus isacanthus* which comprised 43.57 percent. Other minor species, including elasmobranchs, contributed 56.43 percent of the average annual production in five years (Fig. 7).

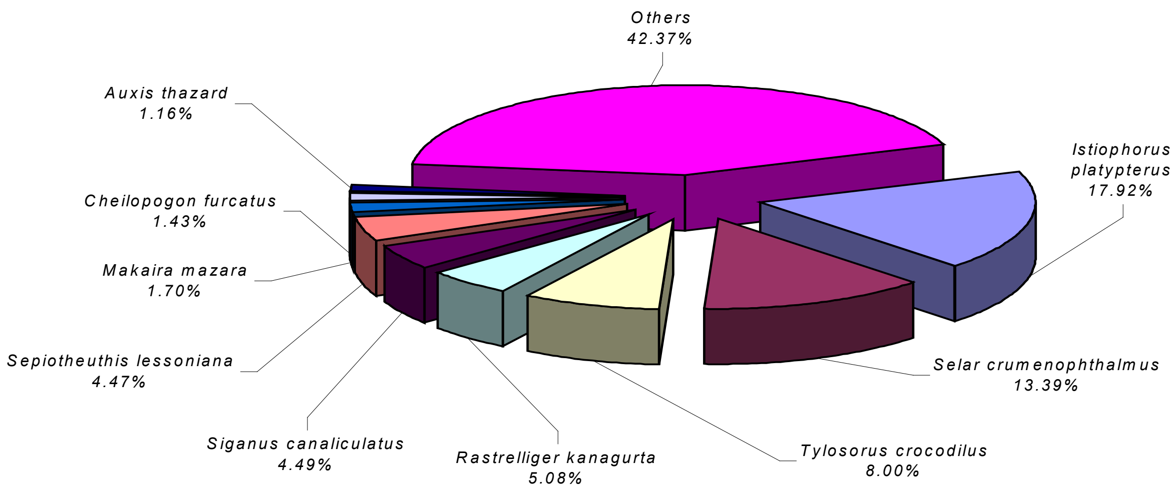

Figure 6. Catch composition of gillnet in Lagonoy Gulf (July 1997-June 2002).

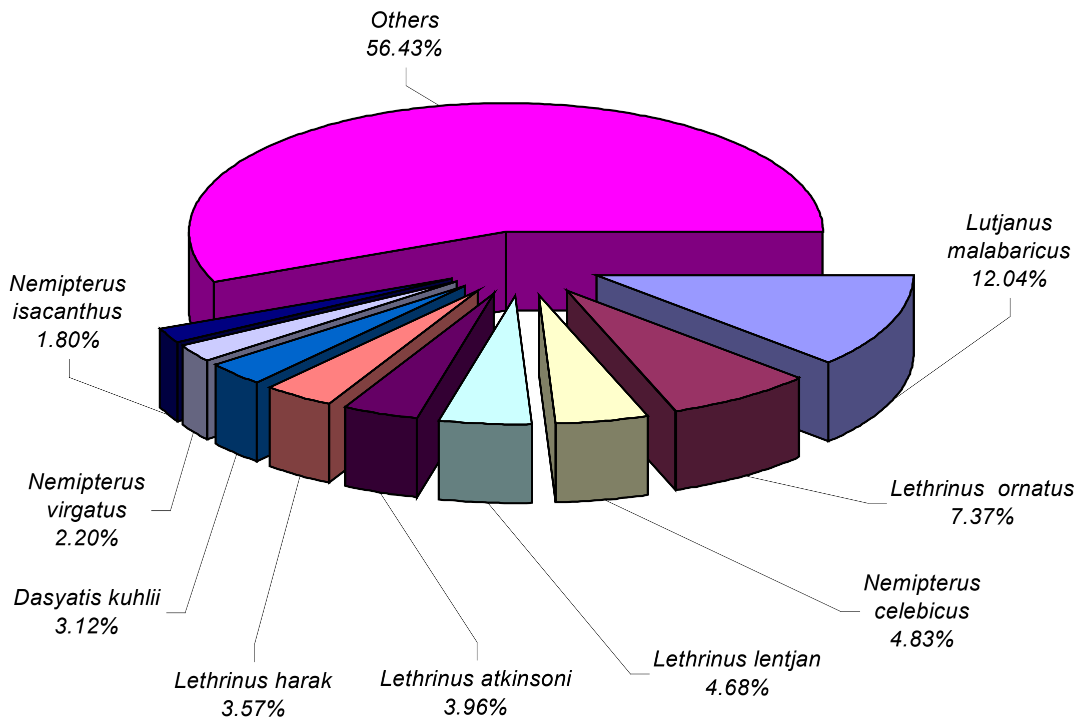

Figure 7. Catch composition of bottom set longline in Lagonoy Gulf (July 1997-June 2002).

Multiple hook and line registered the lowest production of mostly *Selar crumenophthalmus* (56.16 percent), *Euthynnus affinis* and *Auxis thazard* (6.68 percent). *Selar boops, Rastrelliger kanagurta, Auxis rochie, Atule mate, Pterocaesio diagramma* and *Pterocaesio chrysozona* contributed 8.52 percent; while other species accounted for 28.64 percent (Fig. 8).

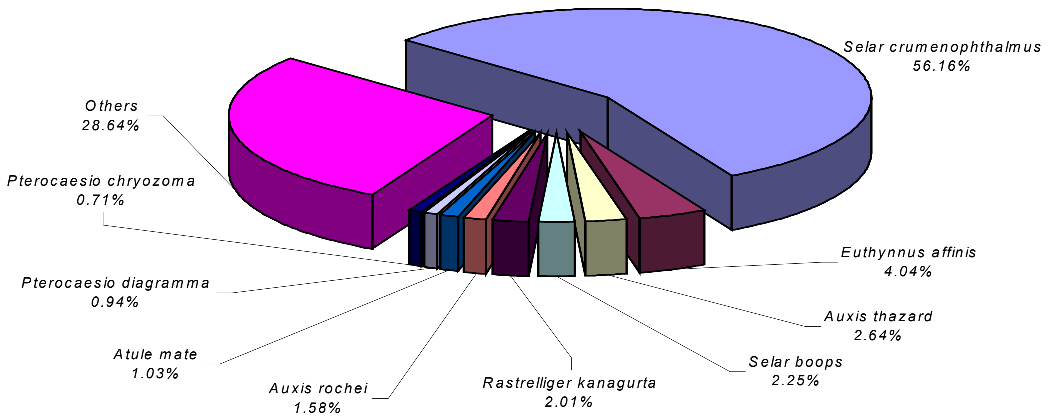

Figure 8. Catch composition of multiple hook and line in Lagonoy Gulf (July 1997-June 2002).

Catch Contribution of the Major Types of Fishing Gear

The ringnet had a major contribution of 40.02 percent, or a total production of 929.59 mt. Hook and line came next with a production of 566.69 mt or 24.40 percent; while the gillnet contributed 12.03 percent or 279.42 mt and bottom set longline, 2.66 percent or 61.75 mt. The least productive gear was the multiple hook and line which contributed only 2.09 percent or 48.58 mt. The major gear contributed 81.20 percent of the total average annual production during the study period (Fig. 9). Data on the annual average number of common and minor gear monitored per month at the four landing sites are shown in Table 3.

The production trend for line fishing is shown in Figure 10. Line fishing contributed 29.15 percent of the total landed production. The annual harvest shows that there was no great variation for five years but the effort continuously increased. This simply suggests that if the effort will not be corrected, time will come that the resources of the Gulf will no longer be sustained.

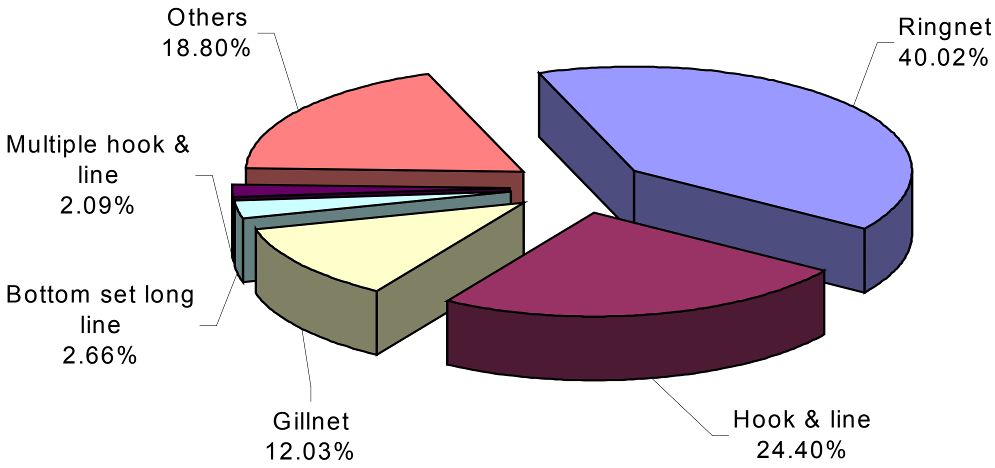

Figure 9. Catch contribution of major types of gear in Lagonoy Gulf (Jul 1997-June 2002).

Table 3. Annual average number of common and minor gear monitored per month at four landing centers in Lagonoy Gulf (July 1997-June 2002).

Para-meter	**Average number of units per gear per month**						**TOTAL**
	Major Gear					**Minor Gear**	
Inclusive Year	**Ringnet**	**Hook and line**	**Gillnet**	**Bottom set longline**	**Multiple hook and line**	**(BN, CP, CLN, J, BS, RHS, *et al.*)**	
Year 1	151	2240	219	56	79	140	2885
Year 2	177	3990	299	257	121	246	5090
Year 3	225	4816	406	198	111	376	6132
Year 4	183	3703	344	186	131	385	4932
Year 5	312	4543	684	225	231	907	6902

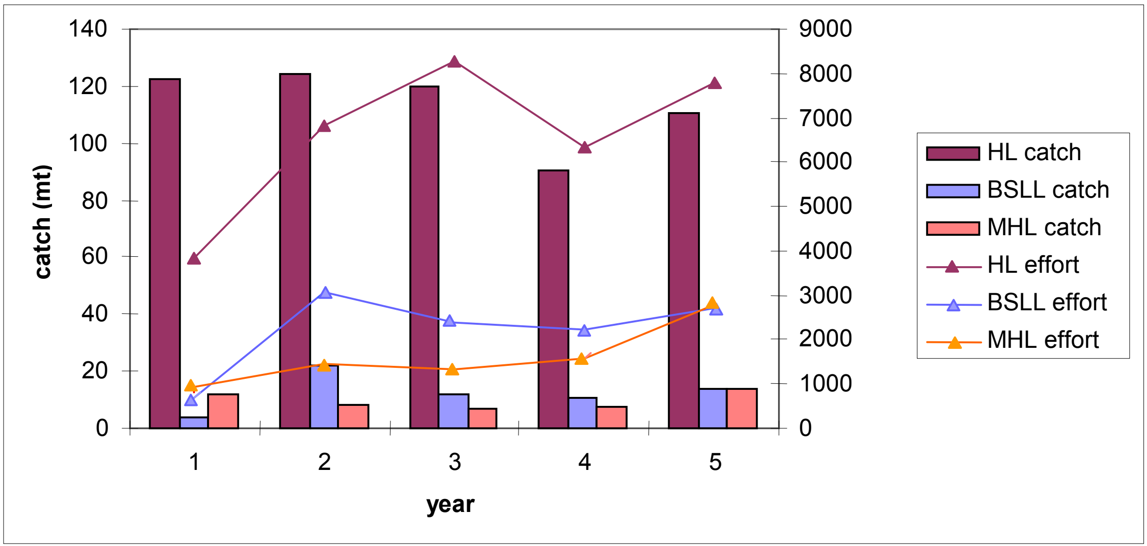

Figure 10. Trend of line fishing in Lagonoy Gulf (July 1997-June 2002).

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Seasonality of Species

The southwest monsoon, northeast monsoon and the transition winds regularly occurred every year and they were considered to be a major factor that influenced the seasonality of species.

For Year 1, *Decapterus russelli, Atule mate, Coryphaena hippurus, Rastrelliger faughni and Sardinella longiceps* were the dominant species during the northeast monsoon (October to January). *Katsuwonus pelamis, Thunnus albacares, Auxis thazard* and *Selar crumenophthalmus* were the most abundant species during the period of southwest monsoon (July to September). Except for *Auxis thazard*, this last group of fish, together with *Coryphaena hippurus, Tylosurus crocodilus* and *Acanthocybium solandri* also dominated the catch during the transition winds from February to June. All other species were moderate to least abundant throughout the year.

For Year 2, *Katsuwonus pelamis, Acanthocybium solandri, Thunnus alalunga*, *Euthynnus affinis, Lutjanus malabaricus, Istiophorus platypterus, Thunnus obesus* and *Tylosurus crocodilus* were the most abundant species during the period of transition winds (January to April). The most abundant species during October to December, which was the onset of northeast monsoon, were *Coryphaena hippurus, Thunnus alalunga, Rastrelliger kanagurta Decapterus russelli, Decapterus macrosoma* and *Siganus canaliculatus.* Most of the species were of moderate abundance, except *Auxis rochei, Selar crumenophthalmus* and *Rastrelliger faughnii* which were the least abundant during the transition winds and northeast monsoon. The species which were most abundant during the southwest monsoon (May to September) were *Rastrelliger faughnii, Thunnus obesus, Selar* *crumenophthalmus, Decapterus russelli, Decapterus macrosoma, Katsuwonus pelamis* and *Atule mate*. Almost all other species appeared in moderate abundance during this season.

In Year 3, the highly abundant species which occurred during the southwest monsoon (May to October) were *Stolephorus* spp*., Tylosurus crocodilus, Rastrelliger faughni, Thunnus albacares*, *Selar crumenophthalmus, Istiophorus platypterus, Rastrelliger kanagurta, Katsuwonus pelamis, Euthynnus affinis* and *Coryphaena hippurus*. The rest of the species were moderate to least abundant. It is also during this period when almost all of the species occurred in moderate abundance. Three species – *Thunnus albacares, Elagatis bipinnulata* and *Katsuwonus pelamis* – were most abundant during the transition winds (February to April). During the northeast monsoon (November to December), the species with the highest production were *Rastrelliger faughnii, Thunnus tonggol, Rastrelliger kanagurta, Coryphaena hippurus* and *Katsuwonus pelamis*.

In Year 4, *Selar crumenophthalmus*, *Istiophorus platypterus, Katsuwonus pelamis, Thunnus albacares, Elagatis bipinnulata, Rastrelliger faughnii* and *Tylosurus crocodilus* comprised the bulk of production during the period of transition winds (March to June). Other species were moderate to least abundant during this period. During the southwest monsoon, the most abundant species were *Thunnus albacares, Stolephorus* spp., *Selar crumenophthalmus, Euthynnus affinis, Decapterus russelli* and *Rastrelliger faughnii*. Most other species exhibited moderate abundance. *Decapterus macrosoma, Euthynnus affinis, Tylosurus crocodilus* and *Stolephorus* spp. were the most abundant during the onset of the northeast monsoon (October to February). Most of the species did not vary significantly in terms of dominance.

In Year 5, *Euthynnus affinis, Thunnus alalunga, Istiophorus platypterus, Coryphaena hippurus, Acanthocybium solandri, Rastrelliger kanagurta, Tylosurus crocodilus* and *Siganus canaliculatus* were the most dominant species during the period of transition winds (May to June). Almost all species occurred in moderate abundance during this period. During the northeast monsoon (December to April) the most dominant species were *Thunnus albacares*, *Selar crumenophthalmus, Rastrelliger faughnii, Decapterus russelli* and *Atule mate*. The species which were abundant during the southwest monsoon (July to November) were *Euthynnus affinis, Katsuwonus pelamis, Istiophorus platypterus, Coryphaena hippurus, Thunnus albacares* and *Acanthocybium solandri*. All other species were moderate to least abundant throughout the year.

The onset of monsoon seasons and transition winds did not vary considerably in five years: the northeast monsoon blew constantly from October to March, the southwest monsoon winds from July to September, and the transition winds or trade winds from April to June. These wind movements greatly affected the annual variation of species in terms of relative abundance. Abundance of the seven most dominant species found in the Gulf, namely, *Katsuwonus pelamis, Thunnus albacares, Selar* *crumenophthalmus, Istiophorus platypterus, Rastrelliger faughii, Coryphaena hippurus* and *Acanthocybium solandri*, was highest during the southwest monsoon, moderate during the transition winds, and least during the northeast monsoon. Generally, fishing appeared to be more favorable during the transition winds and southwest monsoon than during the months of northeast monsoon. In addition, this variation in species abundance was also affected by a host of other causes which include the occurrence of free school, efficiency of gear used, multispecies interactions, predator-prey relationships and other agroclimatic factors such as rainfall intensity, sunshine duration and typhoon occurrence.

Catch Per Unit Effort

The method of knowing the changes in the exploited fish stock is by determining the changes in CPUE. In this study, CPUE for ringnet, hook and line, gillnet, multiple hook and line and bottom set longline was expressed in kg./boat .

The highest annual average CPUE among the major gear was attained by ringnet, with a range of 60.45-102.69 kg/boat. This production was very high although the total number of boats and their operation is less compared to other gear. The CPUE of hook and line ranged from 12.94 kg/boat to 32.11 kg/boat, while that of gillnet ranged from 8.18 kg/boat to 20.14 kg/boat. The less operated gear attained a CPUE of only 4.44 kg/boat to 7.09 kg/boat (for bottom set longline) and 3.26 kg/boat to 11.96 kg/boat (multiple hook and line). Bottom set longline was not much operated since it targets demersal species which are of less commercial importance, compared to pelagic species particularly the oceanic pelagics. Likewise, multiple hook and line was also operated less because it catches mostly small pelagics only.

The production trends for the five major types of gear in Lagonoy Gulf were established for each year. Generally, the CPUE decreases as the fishing effort increases, especially for ringnet, hook and line and gillnet which contributed 77 percent of the total landed catch as illustrated in the scattered diagram for production trends (Fig. 11). The fishing effort tremendously increased in year 5 for gillnet (from Sept to October) due to high production of small pelagics. This suggests that heavy fishing pressure has been observed in the Gulf.

Surplus Production

The production and effort data used for the estimation of potential yield (PY) were the raised data to represent the totality of the Gulf's production. The hook and line, with more units in the gear inventory, was used to standardize the effort. Although, ideally, the models used require a minimum of 10-year data to be able to generate a reliable analysis, the process was still undertaken using the REA (Garces *et al.* 1995, Soliman *et al.* 1995) and the five-year data set of the study for the purpose of preliminary analysis of the PY for Lagonoy Gulf.

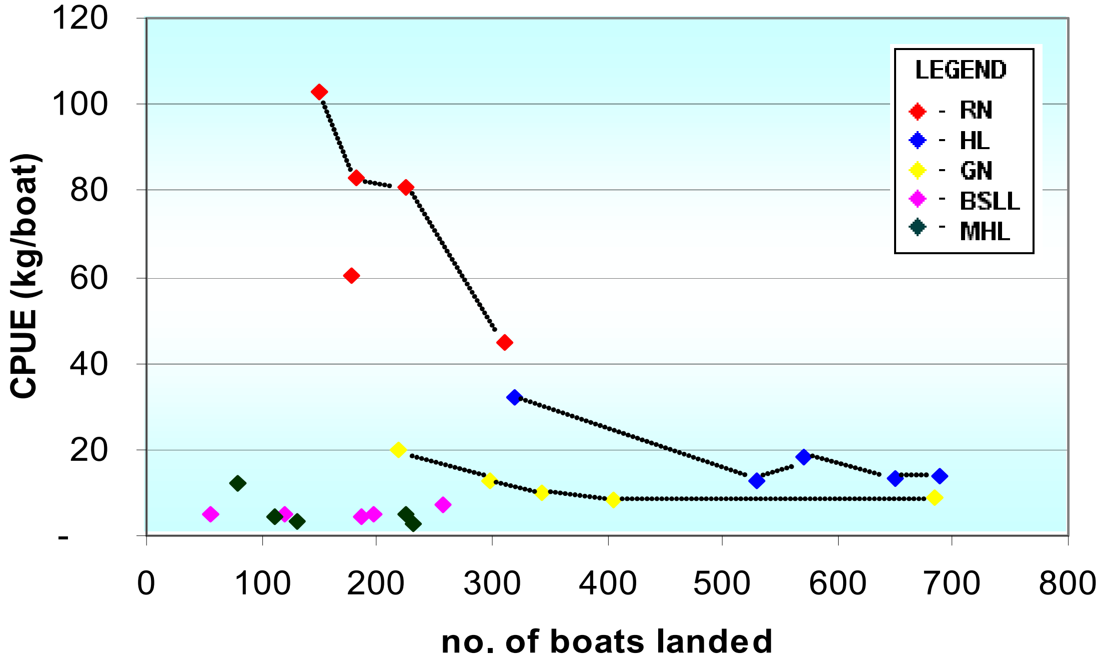
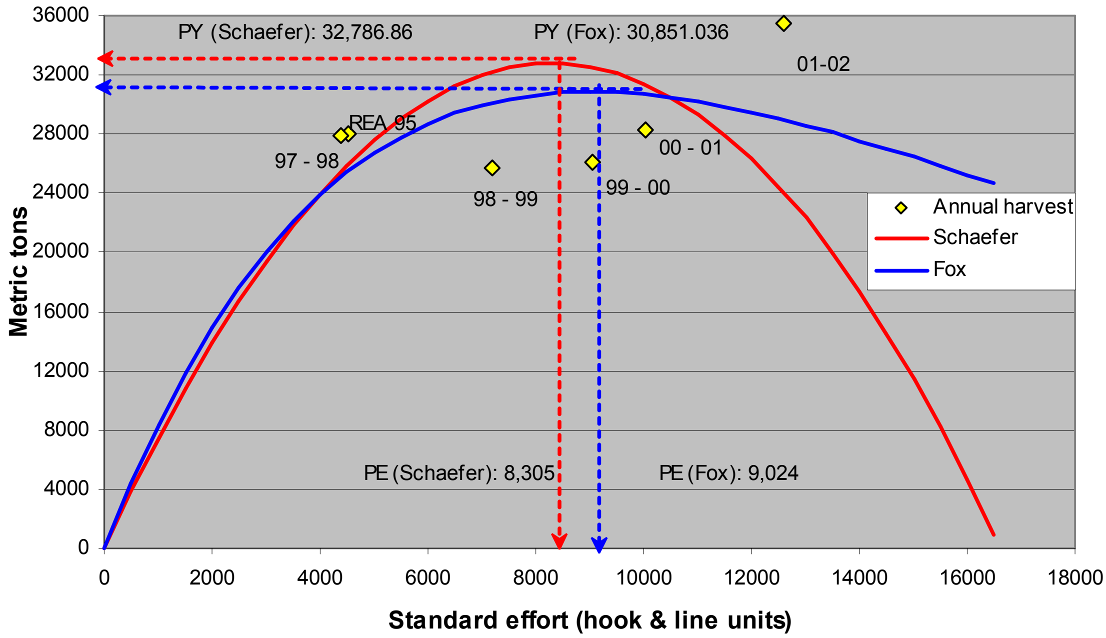


Figure 11. Trends of effort and catch per unit effort of five major gear in Lagonoy Gulf (July 1997-June 2002).

The annual harvest as well as the fishing effort for five years in the Gulf have exceeded the PY at 10 percent and potential effort (PE) at 31 percent, in both Schaeffer and Fox models (Fig. 12). The catch per unit effort (CPUE) shows a declining trend as fishing effort is increased. The production for years 4 and 5 had increased due to the abundance of *Stolephorus* spp. caught by bagnet, beach seine and round haul seine. Although the data were insufficient for a conclusive analysis, there was already an initial indication that the Gulf is in the state of overexploitation due to heavy fishing effort. Hence, the situation calls for serious interventions on the part of the policy makers, particularly to reduce the fishing effort to an average of at least 31 percent.

Estimation of Population Parameters

Analysis of the population parameters and exploitation ratios showed that the small and large pelagics were relatively fast growing, as indicated by the high K values ranging from 0.97 to 1.70 (Table 4). The growth performance indices (∅') which are a function of the L_∞ and K of individual species were within the range of growth performances of the same species studied in different fishing grounds in the Philippines. This gave credence to the L_∞ and K values obtained in this study. One species exhibited a bimodal recruitment peak which is associated with the two major monsoon pulses in the Philippines (Pauly and Navaluna 1984). The rest of the species suggested a unimodal recruitment pulse, conforming with the results of the REA and other works in Lagonoy Gulf (Sia III *et al.* 1995).



	Standard effort	Production (mt)	CPUE (kg/boat)
REA 1995	4509	27,986.50	6.21
Year 1	4393	27,918.58	6.36
Year 2	7188	25,759.63	3.58
Year 3	9055	26,084.09	2.88
Year 4	10024	28,275.55	2.82

Figure 12. Potential yield estimates using standardized effort of hook and line units in Lagonoy Gulf (July 1997 to June 2002).

The high total mortality coefficients (Z), ranging from 4.60 (*Selar crumenophthalmus)* to 7.59 (*Rastrelliger faughni*), indicated a high turnover rate of biomass but low survival rates, considering also that the estimates obtained for the fishing mortalities (F) were higher than the values of natural mortality (M) (Sia III *et al.*, 1995).

In general, the species investigated were experiencing high fishing pressures as indicated by the high exploitation ratios (E) which were all above the 0.3 to 0.5 optimal level of maximizing biological yield (Gulland 1971, Beddington and Cooke 1983, and Pauly 1984). Of particular interest are the species which registered very alarming E values, such as *Rastrelliger kanagurta* (0.68) and *Selar crumenophthalmus* (0.75) mostly caught by surface and drift gillnet, and *Rastrelliger faughni* (0.70) and *Auxis rochei* (0.76) by ringnet in the fish shelter. This leads to a high mean exploitation level of 0.65 for Lagonoy Gulf. The distribution of E-values of the 10 species investigated is shown in Figure 13.

Table 4. Population parameters of some dominant species in Lagonoy Gulf (July 2001-June 2002).

Gear	SPECIES	n	Size at Maturity	Lmax (cm)	Loo (cm)	L50	L50/Loo (%)	K (yr^{-1})	Z (yr^{-1})	M (yr^{-1})	E (yr^{-1})	Emax	F (yr^{-1})	Fmax	No. RP
RN	*Selar crumenopthalmus*	222,710	25.5 - 45.70	28.53	29.37	16.40	56	0.99	4.60	1.89	0.61	0.57	2.79	2.40	1
GN	*Selar crumenopthalmus*	93,714		29.50	30.34	14.61	48	1.05	7.42	1.87	0.75	0.61	5.55	2.92	1
MHL	*Selar crumenopthalmus*	72,063		28.91	31.21	16.83	54	1.00	5.27	1.8	0.66	0.61	3.47	2.70	1
GN	*Selar boops*	4,841	12.80 - 23.0	28.20	28.20	17.27	61	1.10	6.59	1.97	0.70	0.63	4.62	3.35	2
RN	*Rastrelliger kanagurta*	25,798	11.40 - 20.50	31.10	32.23	11.29	35	1.00	4.66	1.78	0.62	0.51	2.88	1.85	1
GN	*Rastrelliger kanagurta*	20,938		32.03	31.80	16.41	52	1.15	6.13	1.96	0.68	0.61	4.17	3.07	1
RN	*Rastrelliger faughni*	416,413	11.60 - 20.80	28.75	29.27	11.92	41	1.40	7.59	2.28	0.7	0.54	5.31	2.68	1
RN	*Atule mate*	133,963	14.50 - 26.10	31.22	31.22	9.16	29	0.97	5.03	1.76	0.65	0.50	3.27	1.76	1
RN	*Decapterus kurroides*	70,487	15.80 - 28.40	21.16	22.49	10.56	47	1.10	5.63	2.09	0.63	0.58	3.54	2.89	1
RN	*Decapterus macrosoma*	331,443	14.40 - 25.90	22.13	23.32	6.69	29	1.70	7.55	2.76	0.63	0.48	4.79	2.55	1
RN	*Decapterus russelli*	365,609	16.10 - 28.90	24.56	23.28	8.84	38	1.10	5.10	2.07	0.59	0.52	3.03	2.24	1
RN	*Auxis rochei*	37,580	21.70 - 38.60	51.97	53.94	11.80	22	1.10	5.83	1.64	0.72	0.43	4.19	1.24	1
RN	*Auxis thazard*	30,405	21.50 - 38.60	54.34	55.35	11.66	21	1.20	6.25	1.72	0.72	0.46	4.53	1.47	1

Note: Source of data on size at maturity: Froese and Pauly

Some of the exploitation ratios attained in this study were close to the results of the REA (Sia III *et al*. 1995) and the resource stock assessment (RSA) conducted in 2004. This is an indication that heavy fishing pressure is continually being experienced in the Gulf.

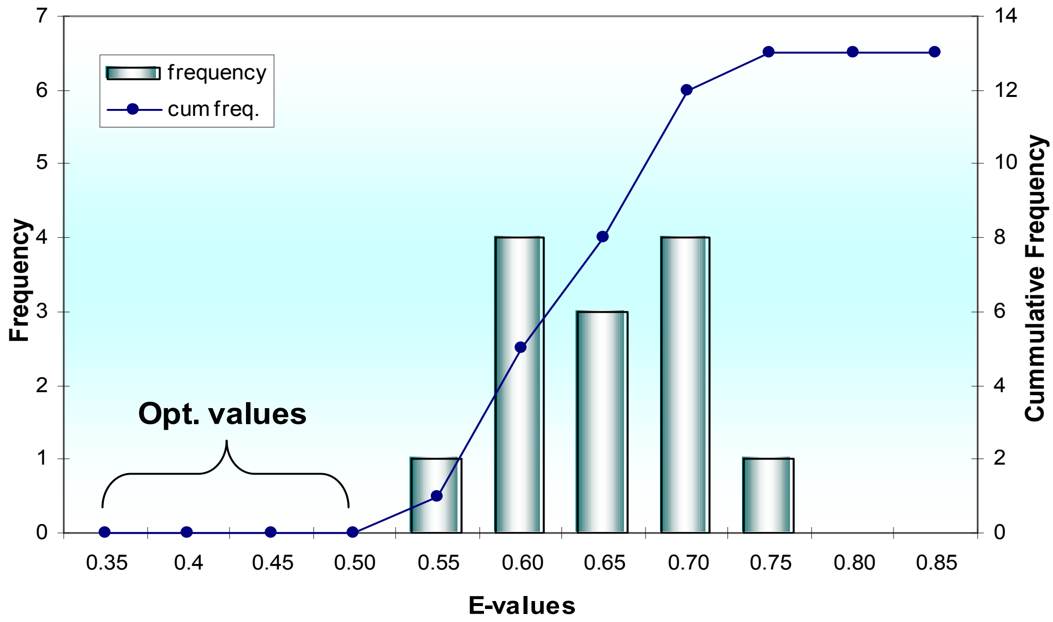


Figure 13. Exploitation (E) values of 10 species in Lagonoy Gulf (2001-2002).

Relative Yield per Recruit

The current E values had exceeded by 21 percent than the maximum exploitation (Emax) values. A comparison of the values of current fishing mortality (F) and maximum fishing mortality (F_{max}) indicates that F was already higher by 43 percent than F_{max} (see Table 4). The ratios of natural mortality (M) and F were 33 percent and 67 percent, respectively (Fig. 14).

The results obtained for the species which comprise the bulk of the production for Lagonoy Gulf are strong indicators of the current status of the fishing ground. Observations all point out to the overexploitation of the Gulf's resources because of heavy fishing pressure and growth overfishing which eventually would adversely affect subsequent recruitment of pelagic species for which the gulf is known for. This conforms or agrees with the pattern of some pelagic fish stock in the country which have shown to be severely overfished (Dalzell and Ganaden 1987). It should be noted that the active gear, particularly ringnet, are those that exploit more of the resources in terms of volume of catch and size of species caught.

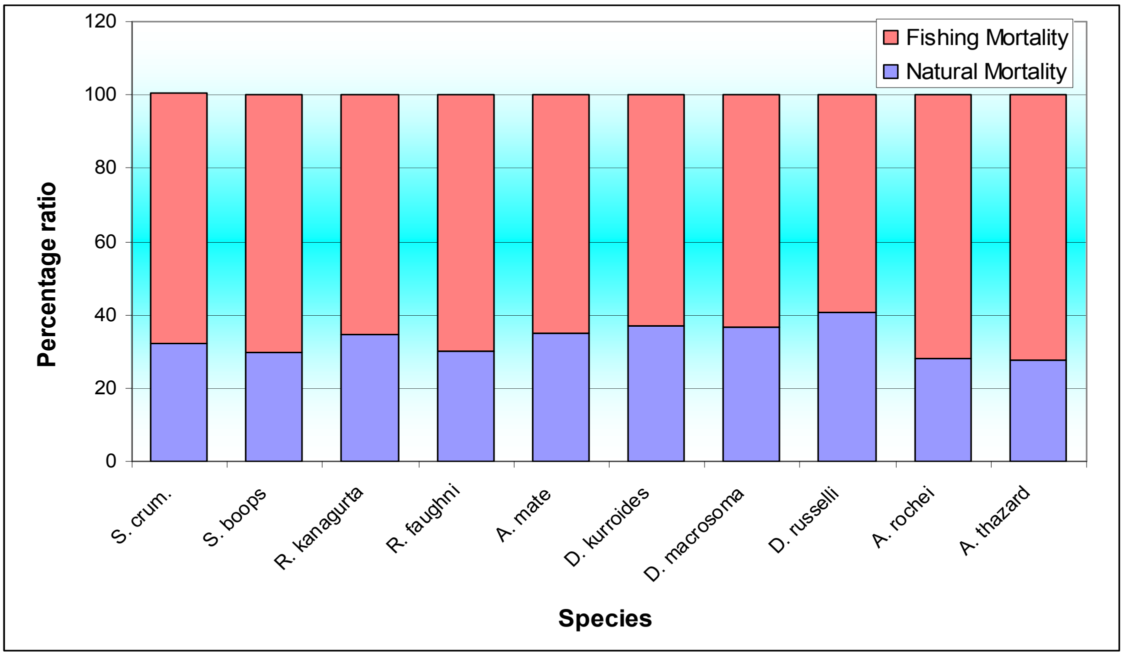


Figure 14. Mortality ratios of dominant species in Lagonoy Gulf (2001-2002).

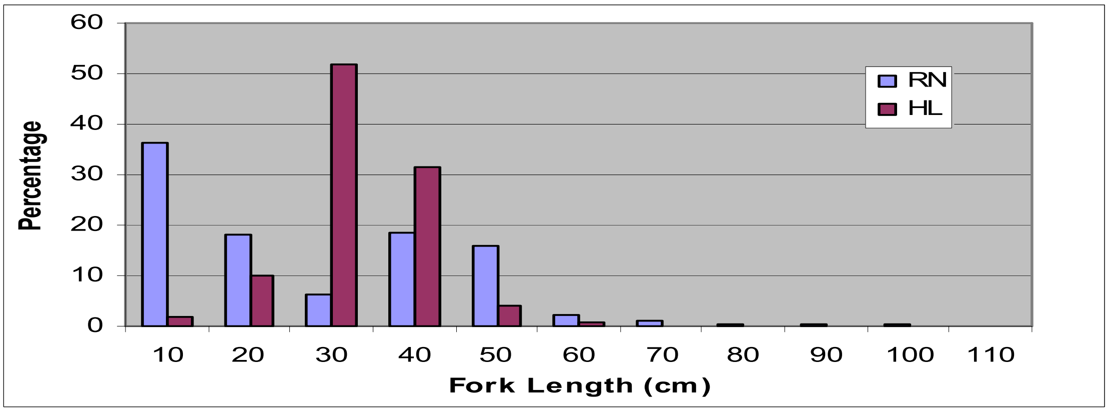
Probability of Capture and Virtual Population Analysis

A comparison of the 50 percent probability of capture (L_{50}) with the known size at maturity showed that some species were caught even at sizes not mature enough to spawn or to contribute to the biomass (see Table 4). In fact, they are caught at sizes less than half of their L_{oo}. This was particularly true to species caught by ringnet such as *Atule mate, Decapterus macrosoma, Decapterus russelli, Rastrelliger kanagurta* and *Rastrelliger faug*hni.

Generally, the ratios of probability of capture (L_{50}) to their Length infinity ($L_{oo)}$ for species caught by ringnet were low, from 21 to 61, as substantiated by the results of their sizes at maturity and $L_{50.}$ Seventy percent of the analyzed species with the known size at first maturity were still in the immature stage (less than half of their L_{oo}) and only 30 percent were of mature stage. This is a strong evidence of growth overfishing in the Gulf.

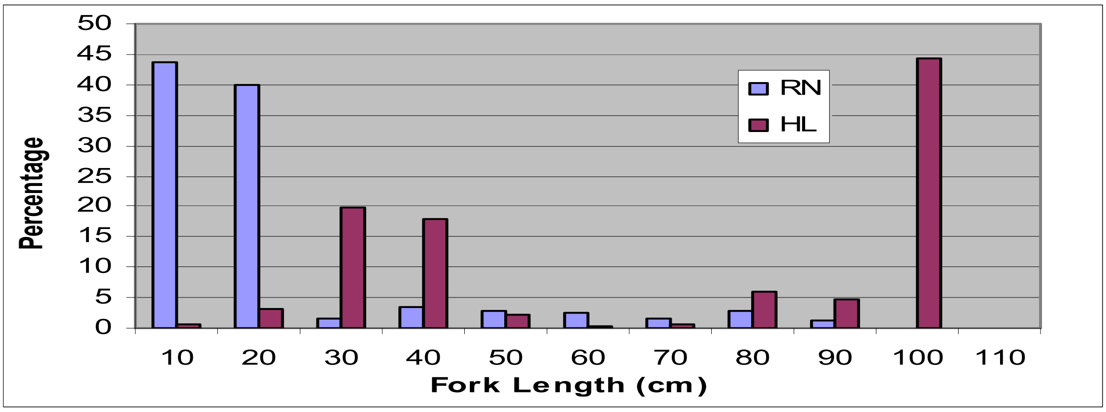
The results of the virtual population analysis (VPA) showed that all the species of finfish analyzed had high fishing mortality at length classes below 50 percent of their length infinity (L_{oo}). This was substantiated by the results of the analysis on size distribution (Figs. 15-18). Ninety-five percent to 100 percent of *Decapterus* spp., *Selar crumenophthalmus*, *Atule mate* and *Thunnus albacares* caught by ringnet, surface and drift gillnet with less than three-cm mesh size, and hooks and liners with #566 above, were still juveniles or in the immature stage, and were not yet capable of breeding or spawning so as to contribute to the biomass.

SM: 31.6-56.7 cm (TL) Lmax: 108 cm (FL)



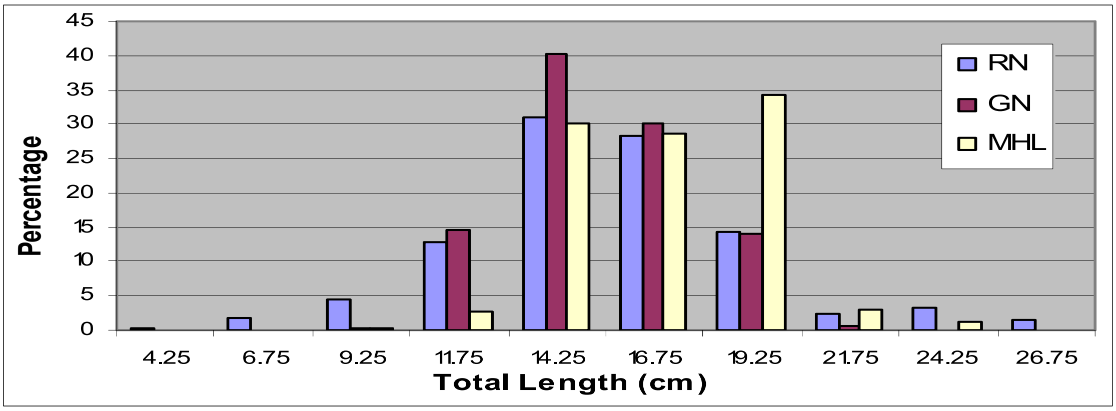
Katsuwonus pelamis

SM: 74.9-134.5 cm (TL) Lmax: 280 cm (TL)



Thunnus albacares

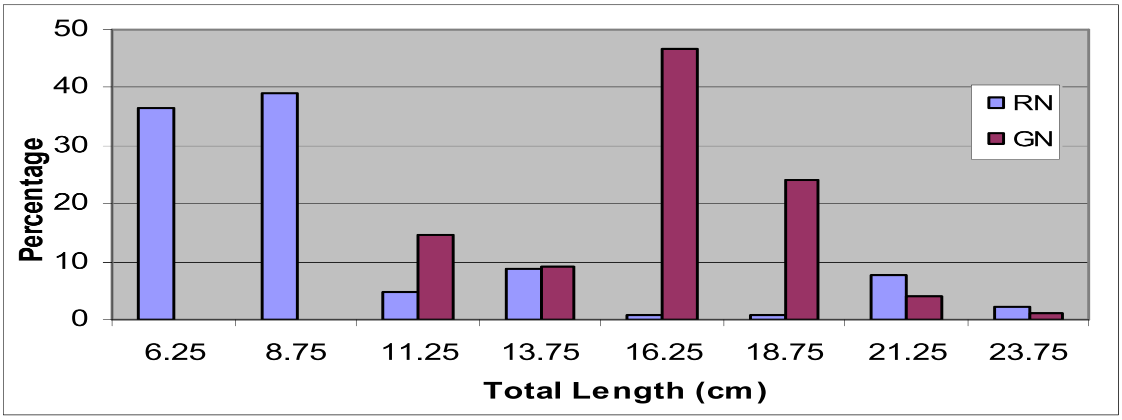
SM: 25.5-45.7 cm (SL) Lmax: 60 cm (SL)



Selar crumenophthalmus

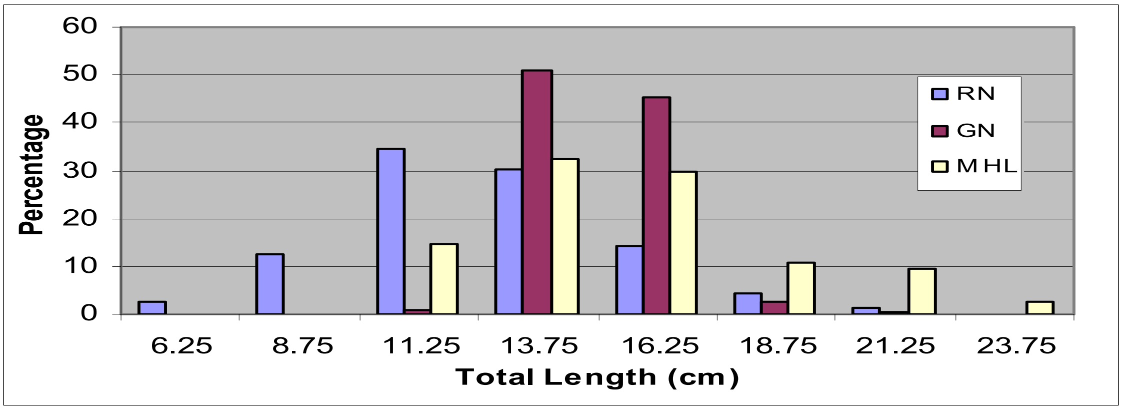
Figure 15. Size distribution of *Katsuwonus pelamis, Thunnus albacares* and *Selar crumenophthalmus* caught by ringnet, gillnet and multiple hook and line in Lagonoy Gulf.

SM: 12.8-23.0 cm Lmax: 25 cm (FL)



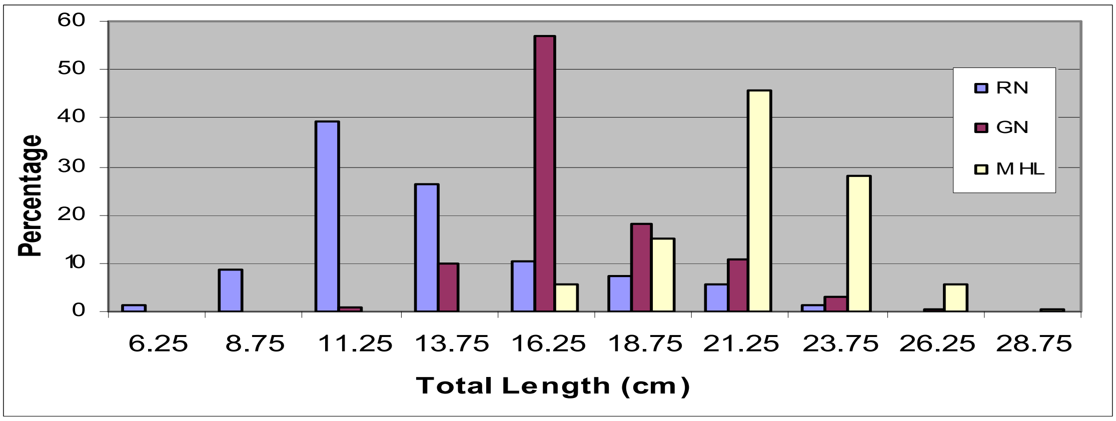
Selar boops

SM: 11.6-20.8 cm (SL) Lmax: 60 cm (SL)



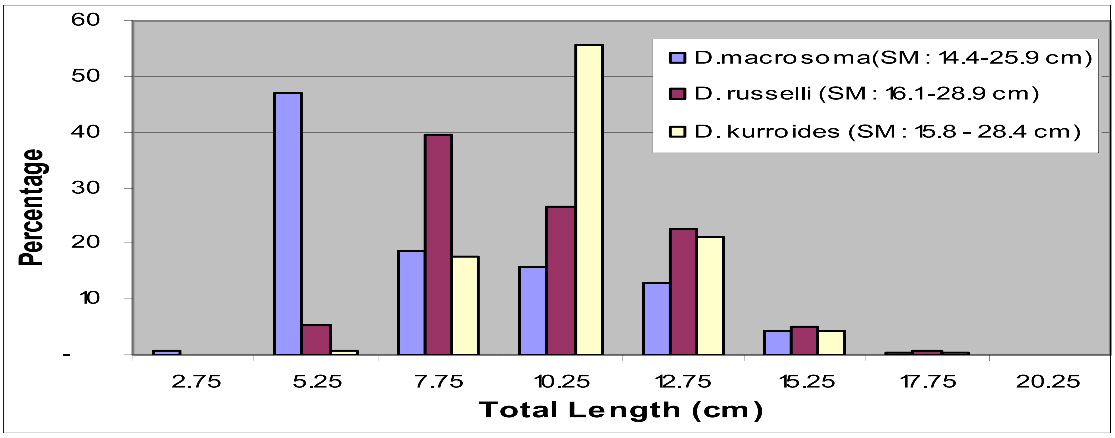
Rastrelliger faughni

SM: 11.4-20.5 cm (TL) Lmax: 35.0 cm (TL)



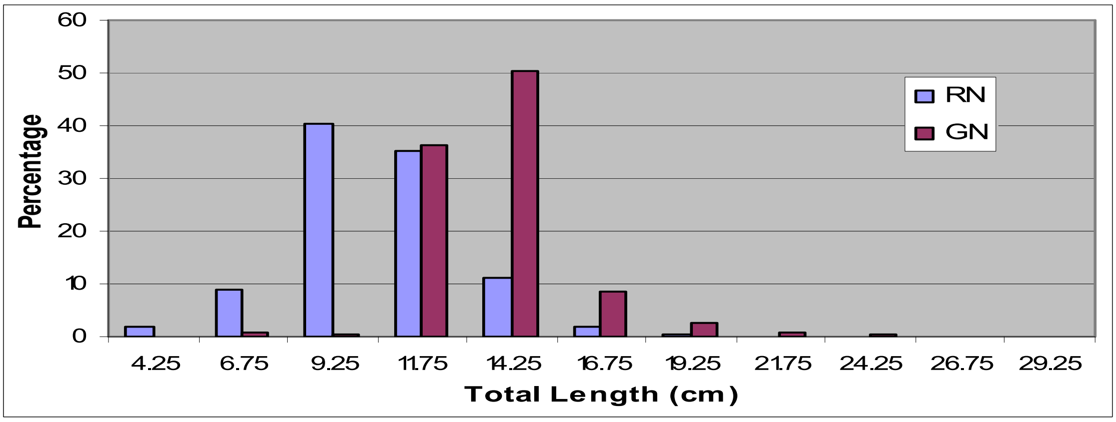
Rastrelliger kanagurta

Figure 16. Size distribution of *Selar boops, Rastrelliger faughni* and *R. kanagurta* caught by ringnet, gillnet and multiple hook and line in Lagonoy Gulf.



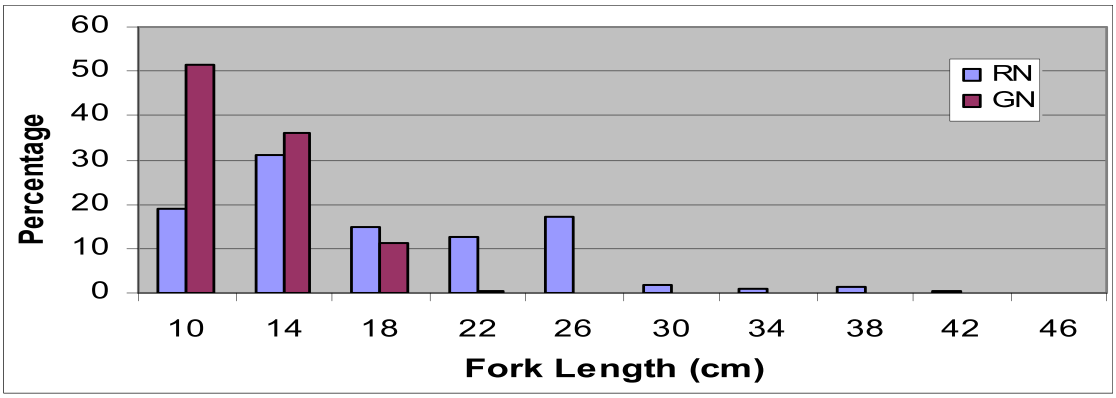
***Decapterus* spp.**

SM: 14.5-26.1 cm (TL) Lmax: 30 cm (TL)



Atule mate

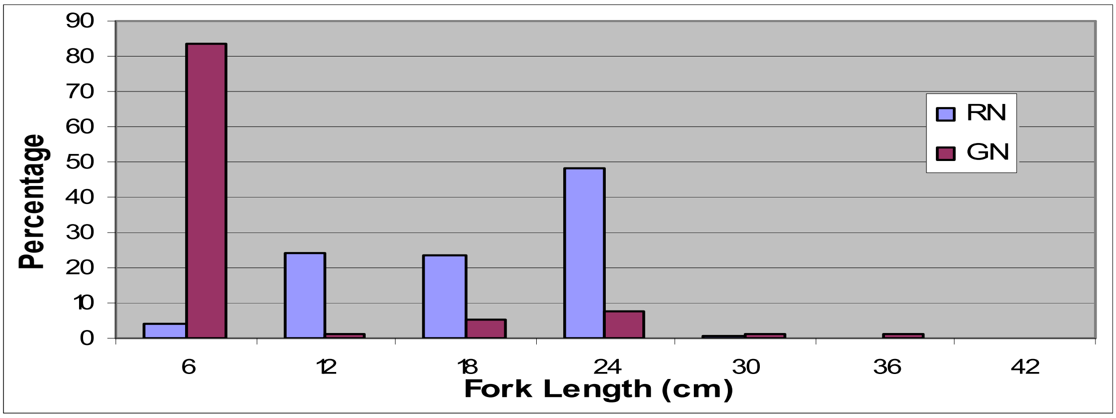
SM: 21.5-38.6 (TL) Lmax: 65 cm (FL)



Auxis thazard

Figure 17. Size distribution of *Decapterus* spp., *Atule mate* and *Auxis thazard* caught by ringnet and gillnet in Lagonoy Gulf.

SM: 21.7-38.9 (TL) Lmax: 50 cm (FL)



Auxis rochei

Figure 18. Size distribution of *Auxis rochei* caught by ringnet and gillnet in Lagonoy Gulf.

CONCLUSIONS AND RECOMMENDATIONS

Lagonoy Gulf is heavily exploited due to excessive fishing which is often closely related with capture of undersized and immature fishes. The alarming decline of fishery resources and the continuing environmental degradation due to intense fishing effort, growth overfishing, rampant illegal fishing on open access fishery, and other legal and institutional issues are the serious concerns in Lagonoy Gulf. The plight of small-scale fishers in coastal areas stresses the need to properly employ efficient management and regulatory interventions to help resolve the dwindling productivity, stability and sustainability of Lagonoy Gulf.

The following management and regulatory measures are then suggested:

- Provide an Integrated Coastal Zone Management Plan;
- Institutionalize the operation of Lagonoy Gulf Integrated Fisheries Management Council (IFARMC);
- Strictly enforce fishery laws for commercial and municipal fisheries, thru RA 8550 particularly:

    - Section 18 - Stop intrusion of commercial fishing vessel in municipal waters
    - Section 88 - Prohibit fishing through explosives, noxious or poisonous substance and/or electricity
    - Section 89 - Prohibit the use of fine-meshed net
    - Section 90 - Strictly ban the use of active gear in municipal waters of La gonoy Gulf
    - Section 96 - Prohibit fishing in fishery reserves, refuges and sanctuaries;

- Regulate access regime through licensing by reducing fishing effort to 31 percent (boat and gross tonnage);

- Regulate the use of fish aggregating device (FAD) in municipal waters through licensing;

- Prohibit fishing operation in FADs from May to October (for ringnets, gillnets, and hook liners using hooks #566 above;

- Prohibit the catching of juveniles and spawning fishes from May to November (for pelagic fishes);

- Establish and maintain marine reserves, sanctuaries and mangrove reforestation;

- Increase public awareness on the conservation and protection of Lagonoy Gulf thru IEC campaign;

- Provide alternative livelihood projects.

These management activities should be done through:

- close collaboration and active discussion with LGUs and various stakeholders regarding the status of Lagonoy Gulf;

- presentation of the results of the project to various stakeholders;

- preparation and integration of resource management plan (include those with responsibility, dependence and interest in the fishery resource):

    - CRM planning
    - drafting of ordinances and fishery regulations
    - enforcement of fishery ordinance and regulations;

- monitoring and evaluation of programs and related activities.

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