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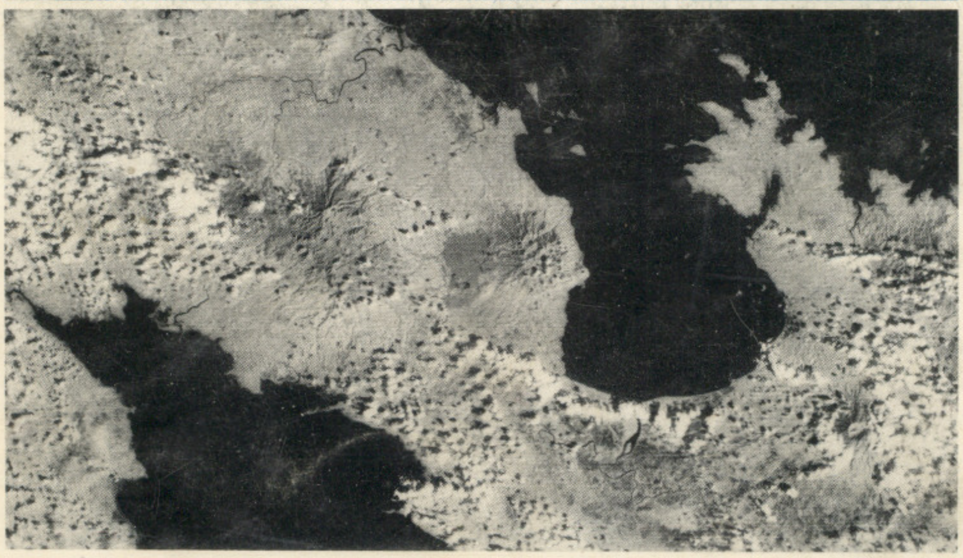
Small-scale fisheries of San Miguel Bay, Philippines: biology and stock assessment

Edited by

Daniel Pauly and Antonio N. Mines



INSTITUTE OF FISHERIES DEVELOPMENT AND RESEARCH, COLLEGE OF FISHERIES, UNIVERSITY OF THE PHILIPPINES IN THE VISAYAS;
INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT; THE UNITED NATIONS UNIVERSITY

Small-scale fisheries of San Miguel Bay, Philippines: biology and stock assessment

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1982

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Cover: *Upper: Abo (Otolithes ruber),* the most important demersal fish of San Miguel Bay. [Photo, N. Navaluna]. *Lower:* satellite view of the Bay, to the right of center. [Photo, NASA, U.S.A.].

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Preface

The research project "Small-Scale Fisheries of San Miguel Bay: A Multidisciplinary Analysis" was conducted jointly by the Institute of Fisheries Development and Research (IFDR) of the College of Fisheries, University of the Philippines in the Visayas and the International Center for Living Aquatic Resources Management (ICLARM), both based in Metro Manila, Philippines.

In addition to funding from IFDR and ICLARM the project received grants from the United Nations University (UNU), Tokyo, Japan and the Philippine Council for Agriculture and Resources Research and Development (PCARRD), Los Baños, Laguna, Philippines. IFDR and ICLARM are both grateful for this support because completion of this research project would have been impossible without it.

The project has produced four technical reports which cover the biological, economic and sociological aspects of the San Miguel Bay fisheries. A fifth report synthesizes these complementary aspects and discusses their implications for managing the San Miguel Bay fisheries.

In this technical report the biological aspects of the fisheries of San Miguel Bay are analyzed. It represents the results of data collection and analysis over approximately a two-year period, 1979-1981.

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Director
Traditional Fisheries Program
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Project Leader and Director
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Abstract

San Miguel Bay is a major fishing ground on the Pacific coast of the Philippines. The Bay is exploited by trawler operators and small-scale fishermen competing for the same resources.

A multidisciplinary research project involving fishery biologists, economists and sociologists was conducted from 1979 to 1981 to obtain a factual base from which options for the management of the Bay's fishery—including the allocation of its catch—could be derived. This paper, which presents the objectives and methodology of the biological section of the project, serves as a background to seven other papers, which discuss aspects of the Bay, its fishes and fisheries.

Introduction

In 1979, the Institute of Fisheries Development and Research (IFDR) of the University of the Philippines in the Visayas, College of Fisheries (UPV-CF) and the International Center for Living Aquatic Resources Management (ICLARM) joined hands in a concerted effort to conduct an in-depth analysis of the socioeconomic conditions of small-scale fishermen in the Philippines.

San Miguel Bay in the Bicol Region, one of the country's most productive fishing grounds, was selected as the study area. Besides being an important fishing ground for shrimps, a variety of fish species, such as croakers, herrings, mullets, juvenile Spanish mackerels, anchovies and crevalles are also commonly caught in the Bay by fishermen using a variety of fishing gear, e.g., stationary fish traps, gill-nets, fish corrals, beach seines, liftnets and trawls.

In the Philippines, fisheries regulations and statistics distinguish between the commercial sector, which uses vessels of more than 3 gross tons (GT), and the municipal sector, which uses smaller boats and may operate in inshore waters. The latter are under the jurisdiction of the municipalities, while the commercial sector is regulated at the national level.

During the 1970s, there arose conflicts among fishermen in the Bay, especially between the gill-netters and the operators of commercial trawlers. The gill-netters sought the help of the authorities concerned to ban commercial trawlers from fishing inside San Miguel Bay, since under existing legislations, most of the fishing area in the Bay is within municipal waters. In 1978, a workshop conducted by the Bureau of Fisheries and Aquatic Resources (BFAR) and the South China Sea Fisheries Development and Coordinating Programme (SCSP) using secondary catch data, concluded that San Miguel Bay was overfished (Simpson 1978). This was contested by certain fishermen in the area.

The primary objective of the research project envisioned by IFDR and ICLARM was to conduct a multidisciplinary study in San Miguel Bay to examine the problems of the municipal fishery and the fishing communities around the Bay. It was recognized that biological, technological, economic and sociological factors all influence the income of municipal fishermen, and in order to understand fully the problems of these fishermen, the interrelationships of these factors must be determined. Because a multidisciplinary approach has not been applied before to fisheries research in the Philippines, an underlying rationale for the project was to develop such an approach which could also be used in other areas. It was envisioned that the results of this study should serve as a basis for government policymakers and planners to include the fisheries sector of San Miguel Bay in the integrated area development plan coordinated by the Bicol River Basin Development Program (BRBDP).

The three distinct, but complimentary components or modules of this IFDR/ICLARM project were: Biology (fish stock assessment); Economics; and Sociology (including mobility).

While each of these modules had its own specific research objectives, the overall goal was to determine options for improving the household incomes of the small-scale fishermen in the area.

Objectives of the Biology Module

The specific objective of the biology module was to assess the status of the fishery resources of San Miguel Bay, that is, to assess (i) whether the Bay as a whole is overfished or not, and (ii) the performance of the various parts of the fishery. This entailed the estimation of catch by gear type, species group, the seasonality of the total catch and of the catch per unit of effort of the various gears to describe the major biological characteristics of the fishery.

Methodology

In the following, a summary review is given of the methods used to achieve these objectives (see Table 1).

- Catch and effort data: It was considered a primary task to obtain a reliable estimate of the present combined catches of all San Miguel Bay fishermen. This was accomplished by making an estimate of the total number of the different types of fishing gear used in the Bay. The catch per unit of effort by gear, by month and species groups over a 12-month period was then determined. The total catch from the Bay was estimated by multiplying the total effort by the catch per effort figures by gear, month and species group.

Catch per unit of effort by gear type was obtained by direct monitoring of the fishing activities of the particular gear at selected landing places. A team of research assistants assigned to the module boarded trawlers twice a month to gather catch data during operations of the trawlers around San Miguel Bay to supplement available data on this particular type of fishing gear.

Counts of the number of larger gears (fixed gears, trawlers, etc.) were made along the beaches and offshore. The number of smaller gears (push nets, handlines, etc.) was obtained in the course of the household survey conducted by the sociology module of the project. The average catch per unit of effort of these gears was estimated either by direct monitoring or from recall interviews of respondent fishermen.

The results of these computations are reported by Pauly et al. (this report) for the small-scale fishery and by Vakily (this report) for the trawl fishery.

Throughout this report, what are usually called "baby trawlers" (generally [illegible]) and larger trawlers (of up to 117 t) are grouped into a single trawl fishery, while all other gears belonging to the municipal sector are considered parts of the small-scale fishery. Pauly (this report) gives a rationale for the separation of the San Miguel Bay fishery into these two categories.

- Biological and oceanographic data: Little emphasis was given to purely biological work on the fishes of San Miguel Bay. However, Navaluna (this report) collected morphometric, meristic and fecundity data on the croaker *Otolithes ruber* in the course of his investigation on the population dynamics of what turned out to be the most important finfish of San Miguel Bay. Cinco (this report) studied length-weight relationships of a number of fish species.

Based on earlier records in the taxonomic literature (notably Herre 1953), Pauly (this report) compiled a list of the fish of San Miguel Bay which was augmented by 28 new records obtained in the course of the project. Biological characteristics of these fishes (188 species in all) were obtained from the available literature, which allowed grouping the species into various feeding guilds and building a model of the trophic interrelationships in the Bay.

Crude assessments were then made of the potential impact of the selected exploitation of the various groups of species on the multispecies stock as a whole (Pauly, this report). Also, the list of species was divided into different groups depending on the reported extent of their ability to withstand salinity fluctuations. This made it possible to characterize San Miguel Bay fauna as typically estuarine, markedly separate from the hard bottom/reef fish fauna occurring off the mouth of the Bay.

Collection of oceanographic data was very limited. However, available secondary data on tidal amplitudes, river runoff into the Bay, rainfall, wind run and some salinity measurements were combined to provide a coherent picture of the Bay's water budget and to describe the Bay's estuarine character (Mines et al., this report).

A bathymetric survey of the Bay was conducted using a portable echosounder. The results were used to deduce a minimum rate of siltation in the Bay (using the chart of the Bureau of Coast and Geodetic Survey as reference) which has implications both to the biological productivity of the Bay and to the accessibility of certain parts of San Miguel Bay to fixed and mobile fishing gears, hence to fishery management issues (Mines et al., this report).

- Length-frequency data: These data were collected in order to compare the sizes of fish caught by the small-scale fishery with those caught by the trawl fishery, and to estimate the values

Table 1. Major data sources and sampling methodology used for the assessment of the San Miguel Bay fisheries.

Phase		Duration	Data collected	Sampling methodology	Sample size
I	a) Catch and effort	2 years	catch, effort and catch/effort data for all gears	– small-scale fishery; actual gear counts and beachside sampling of catch-per-trip data	very large, i.e., giving annual mean catch/effort for some, and on monthly basis for most gears
				– trawl fishery; sampling on board trawlers, complemented with in-depth analysis of adjusted catch statistics	about 2 trips per month
	b) Length-frequency data	2 years	length-frequency data on 15 different species of fish	measurement of length-frequency samples on board trawlers	about 2,500 fish measured
II	Bathymetric survey	1 day	present depth contours of San Miguel Bay	echosounding of San Miguel Bay with portable echosounder fitted on small boat	transects used for drawing isolines covering 40% of the Bay
III	Survey of previous literature and historical data	2 years	list of fish species occurring in and general hydrography of San Miguel Bay. Previous estimates of effort and of catch/effort of trawlers. Early catch composition and anecdotal information on changes in the Bay's fishery	scanning of all likely sources of primary and secondary data, including files containing unanalyzed data, theses, published and unpublished reports, etc.	

of the growth and mortality parameters of the fish population in San Miguel Bay. These data were gathered mainly on board trawlers during fishing operations but also from the different landing places around the Bay.

• Yield-per-recruit analyses: The yield-per-recruit models of Beverton and Holt (1957, 1966) were used to demonstrate the impact of the use of very fine mesh nets to trawl for anchovies, as well as to identify optimal fishing mortalities for penaeid shrimps (Pauly, this report) and for the croaker, *Otolithes ruber*. The yield-per-recruit model was also used to estimate absolute recruitment into the stock of *O. ruber* (Navaluna, this report).

• Historical data: Because of the importance of time series data in stock assessment, special efforts were exerted to secure historical data on the resources of San Miguel Bay. These sources include unpublished reports, theses and raw data on files at various institutions. The data were used after thorough checking and standardization to complement the original data and those available in the published literature.

Acknowledgements

I would like to thank all those researchers who contributed directly to this study, notably Dr. Pauly, ICLARM, the members of the biology module, Estrella Tulay, Noli Navaluna, E. Cinco and M. Vakily, the members of the economics and sociology modules, as well as the officers of the Research Division of the Bureau of Fisheries and Aquatic Resources, Manila, whose historical data on San Miguel Bay proved crucial in our study of the present condition of the Bay.

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San Miguel Bay Fishing Gear and Catch

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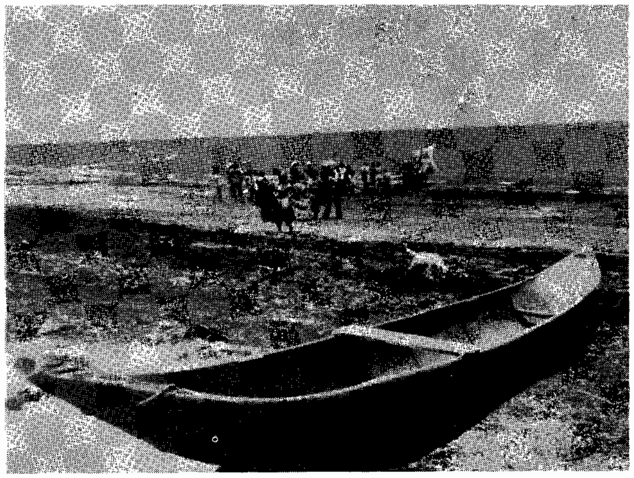

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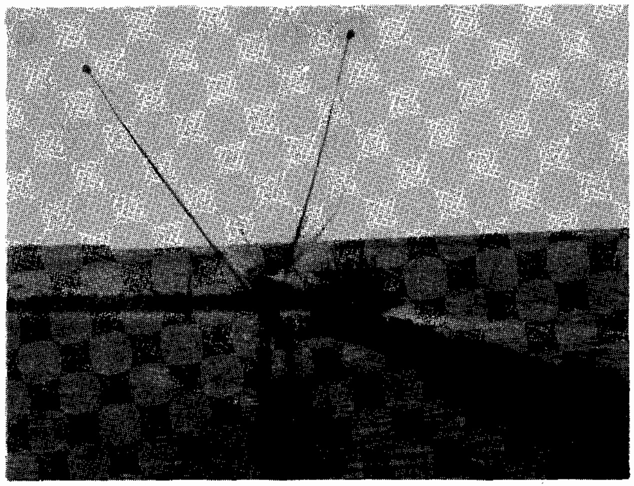
1. The most simple fishing gear is the hook and line. It accounts for about 0.15% of the Bay's total catch.
2. Dug-out, non-motorized *bancas* are widely used by small-scale fishermen. There are about 150 such boats in the Bay.
3. The scissor net is used in shallow waters, pushed ahead of the fisherman. Main catch is *balao* (small sergestid shrimp) and other small shrimp. About 500 tonnes of these shrimp are caught annually by this gear.
4. The scissor net can be used in deeper water with the help of a *banca.*
5. A large fish trap. About 100 are used in the Bay, mostly smaller than the one shown. Together they catch 50 tonnes of fish annually.



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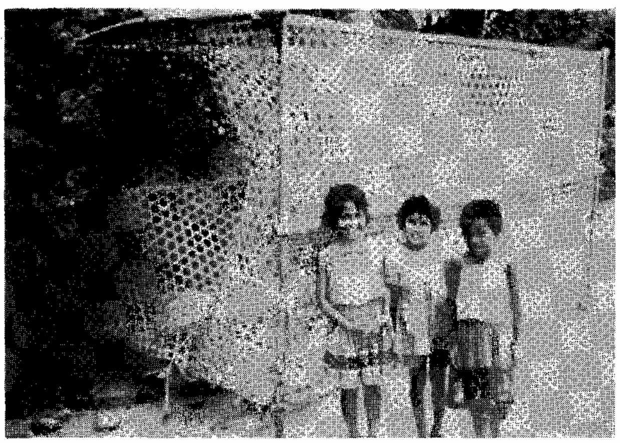

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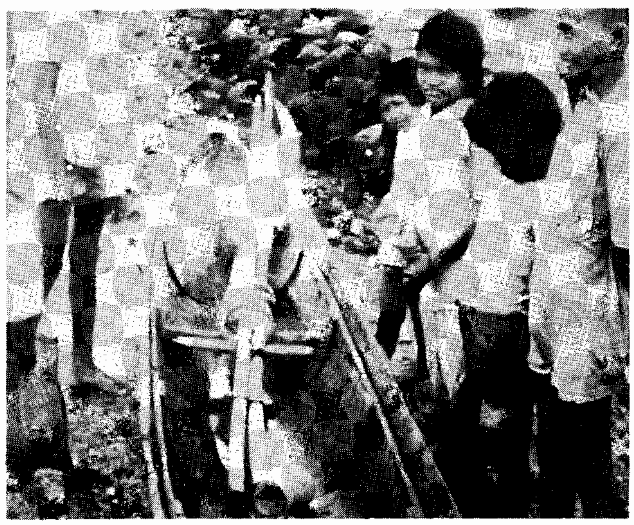

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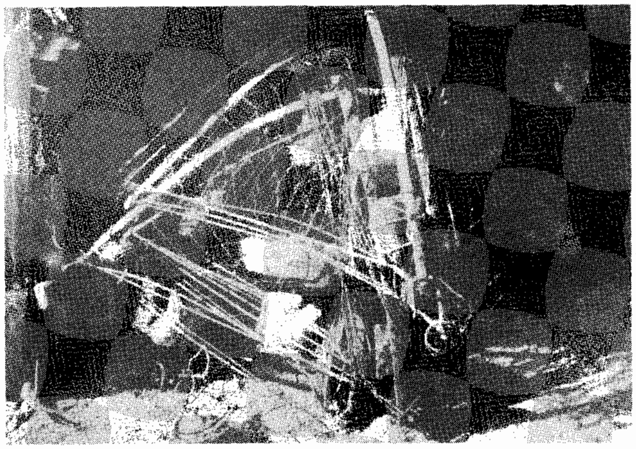

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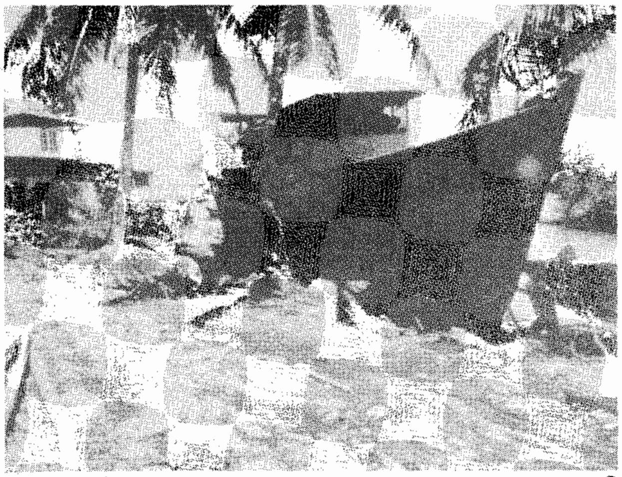
6. A specialized gear, the crab trap, used for catching swimming crabs.

7. Hauling in a beach seine. A dozen operate around the Bay.

8. A gill-netter, the major gear of the Bay's small-scale fisheries, accounting for half the small-scale catch, or about one-quarter of the whole San Miguel Bay fishery.

9. Medium-sized trawler under construction.

10. A large trawler. They generally do not operate inside the Bay, although their home port is several kilometers upstream on the Bicol River.



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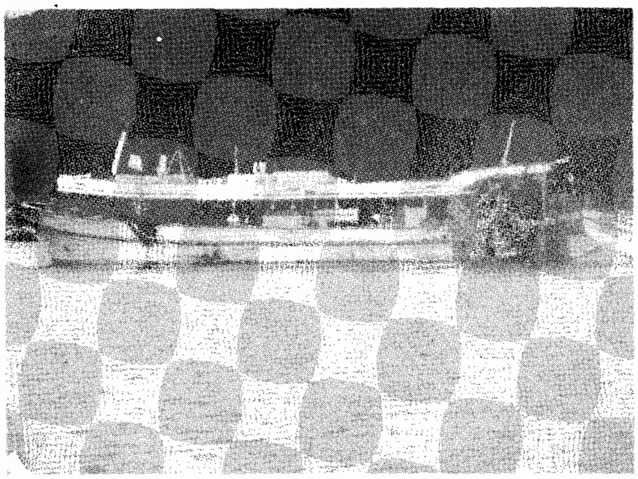

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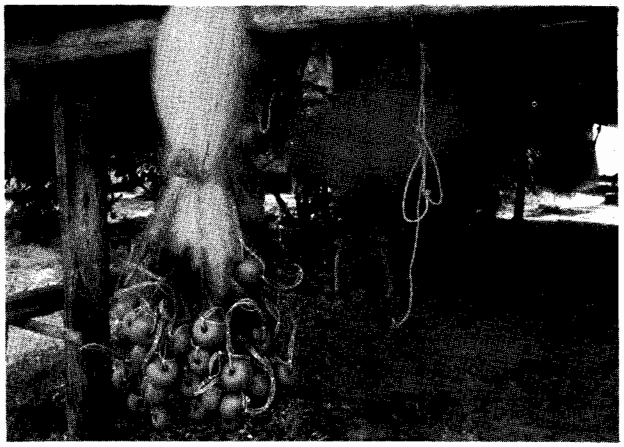

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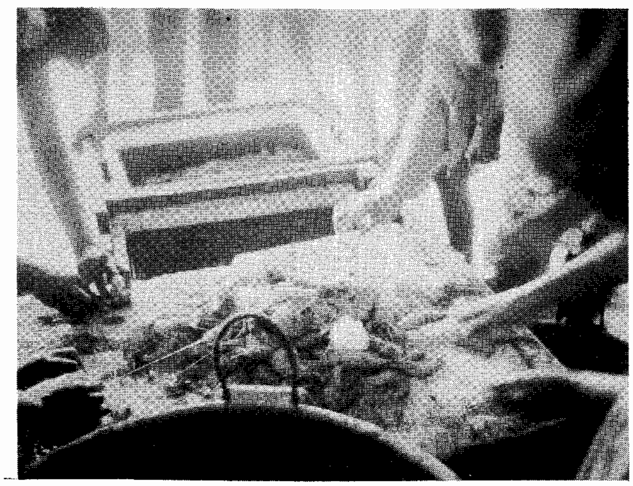
11. A new trawl net ready for operation.
12. Small dried fish for sale. Much of the catch of trawlers in the Bay consists of such small fish. Ballpen indicates size.
13. A gill-net fisherman selling his catch of croakers. A research assistant *(right)* records the details.
14. Fresh penaeid shrimps. Fifteen penaeid species occur in the Bay.

13



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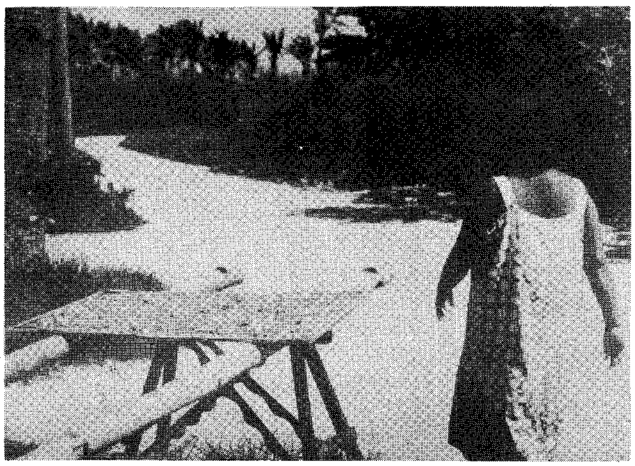

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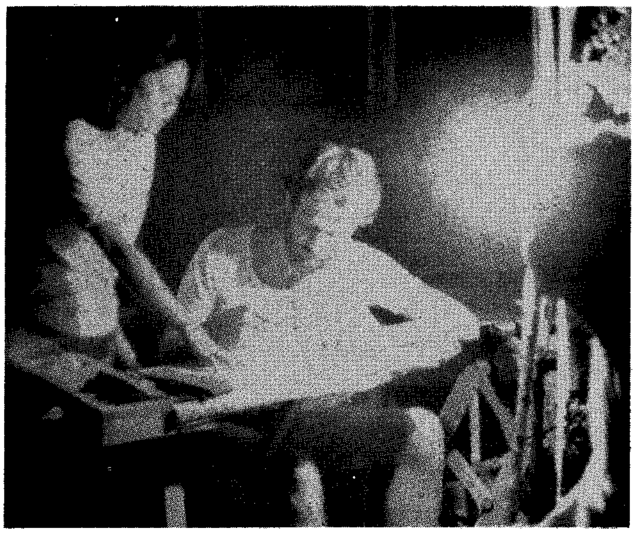
15. Penaeid shrimp are also dried before selling.
16. A vendor carrying large squid. Some 250 tonnes of squid are caught annually by trawlers in the Bay.
17. Mangrove crabs, a highly valued species, bundled up for sale.
18. Conditions for the project team were sometimes spartan. Here biologist Jan Vakily and senior research assistant, Luz Yater record data using an ironing board for their desk.

17



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The Physical Environment*

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MINES, A.N., D. PAULY, N.A. NAVALUNA AND J.M. VAKILY. 1982. The physical environment, p. 5-14. *In* D. Pauly and A.N. Mines (eds.) Small-scale fisheries of San Miguel Bay, Philippines: biology and stock assessment. ICLARM Technical Reports 7, 124 p. Institute of Fisheries Development and Research, College of Fisheries, University of the Philippines in the Visayas, Quezon City, Philippines; International Center for Living Aquatic Resources Management, Manila, Philippines; and the United Nations University, Tokyo, Japan.

Abstract

A brief review is given of those physical features of San Miguel Bay, Philippines, which have an impact on the Bay's fisheries. These features are: the climatic conditions, notably the strong winds during the northeast monsoon; the oceanographic conditions, notably the estuarine habitats created within the Bay by the freshwater inflow from the Bicol River and by the heavy rainfall; and the siltation of the Bay by upland erosion which is gradually making the Bay shallower, thus reducing those areas legally and physically accessible to commercial-sized vessels (above 3t).

Introduction

San Miguel Bay and the adjacent waters represent the only trawlable area along the Pacific coast of the Philippines, and the area is one of the most important fishing grounds in the country (Simpson 1978).

*ICLARM Contribution No. 93.

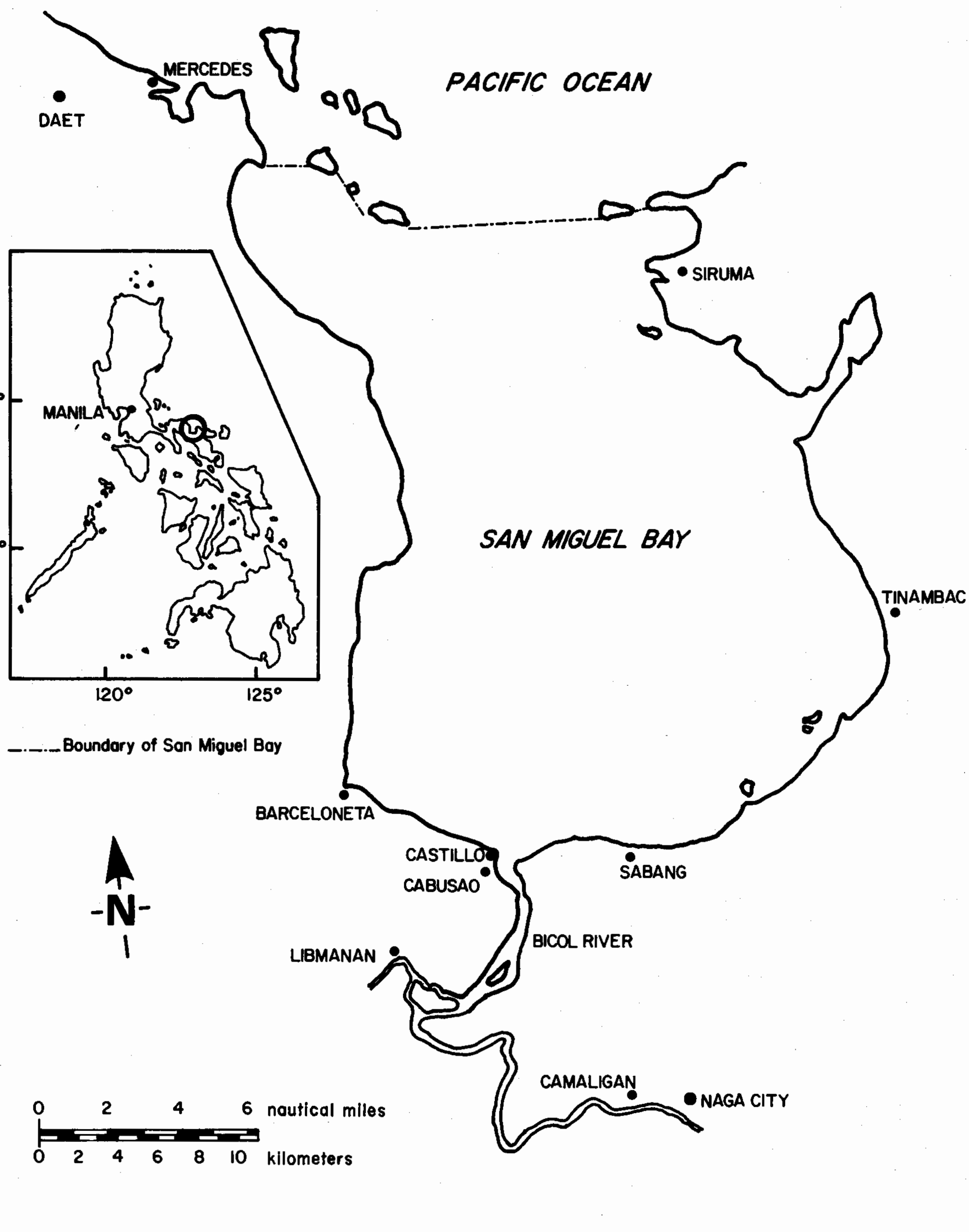


Fig. 1. San Miguel Bay, Philippines.

As elsewhere along the Pacific coast, the fisheries of San Miguel Bay are of a seasonal nature, due to the rough weather prevailing during the northeast monsoon. However, this feature is less pronounced than in other parts of the Pacific coast of the Philippines.

The Bay proper (Fig. 1) is shallow; its average depth at the beginning of the century was 8.9 m (see Table 1 for depth zonation). Due to heavy siltation, mainly from the Bicol River, the average depth has been reduced to 7.4 m, affecting the types of fishing gears that can be physically and/or legally deployed within the Bay. Undoubtedly, the siltation also has a positive effect on the biological productivity of the Bay.

In the following, the major physical features of the San Miguel Bay are briefly reviewed, including climatic factors (winds, rains); hydrography of and freshwater inflow into the Bay; and siltation. The effects of these three features on the small-scale and trawl fisheries are discussed here as background to the detailed presentation of various aspects of the Bay's fisheries included in this report.

Climatic Factors

The major climatic feature along the Pacific coast of the Philippines is the occurrence, in conjunction with the northeast monsoon (October to March), of extremely strong winds which prevent or greatly hinder fishing, especially throughout November and December. Figs. 2 and 3 document the seasonality of the winds and of the rainfall in the area, respectively.

Large trawlers, which generally operate outside the Bay (as defined in Fig. 1) catch fish within San Miguel Bay only during the northeast monsoon in the sheltered northeastern part of the Bay. Small-scale fishermen, on the other hand, sometimes have to stop fishing when the northeast monsoon is at its peak.

The peak of the southwest monsoon (May to July) has no impact on the San Miguel Bay fisheries, and there is no drop in catches during this period (see other contributions in this report).

The annual mean air temperature over the Bay is 27.5°C (Anon. 1975).

Table 1. Past (1907) and present (1980) depth zonation in San Miguel Bay.[a]

Fathom	Past depth zonation[b] (m)	Midrange(m)	Area (km^2)	% of total	Cumulative % of total	Present depth midrange(s)
0 – 3.9	0 – 7.2	3.66	313	37.2	37.2	2.17
4 – 4.9	7.3 – 9.0	8.23	185	22.0	59.2	6.74
5 – 5.9	9.1 – 10.9	10.1	91.3	10.9	70.1	8.61
6 – 6.9	11 – 12.7	11.9	90.0	10.7	80.8	10.4
7 – 7.9	12.8 – 14.5	13.7	41.0	4.9	85.7	12.2
8 – 8.9	14.6 – 16.4	15.6	37.6	4.5	90.2	14.1
9 – 9.9	16.5 – 18.2	17.4	30.1	3.6	93.8	15.9
10 – 10.9	18.3 – 20.0	19.2	19.8	2.4	96.2	17.7
11 – 11.9	20.1 – 21.8	21.0	14.6	1.7	97.9	19.5
12 – 12.9	21.9 – 23.7	22.9	9.0	1.1	99.0	21.4
13 – 13.9	23.8 – 25.5	24.7	4.2	0.5	99.5	23.2
14 – 14.9	25.6 – 27.3	26.5	2.2	0.25	99.75	25.0
15 – 15.9	27.4 – 29.2	28.4	1.7	0.2	99.95	26.9
16 – 16.9	29.3 – 31.0	30.2	0.5	0.05	100.00	28.7
Total	–	–	840	100	100	–
Weighted mean	–	8.9	–	–	–	7.4

[a]Past zonation based on map San Miguel and Lamit Bays, Philippine Coast and Geodetic Survey (PC & GS 4223); present zonation based on bathymetric survey conducted in 1980, and obtained by adding 1.49 m to the midranges of the early depth ranges (see text).

[b]Most of the soundings were made in 1907.

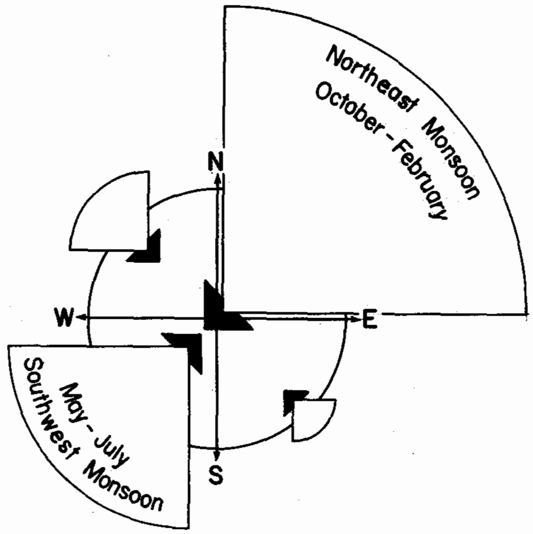


Fig. 2. Schematic representation of wind directions and intensities over San Miguel Bay. Based on daily records (for 1980) obtained from Pili Weather Station, Camarines Sur, near San Miguel Bay.

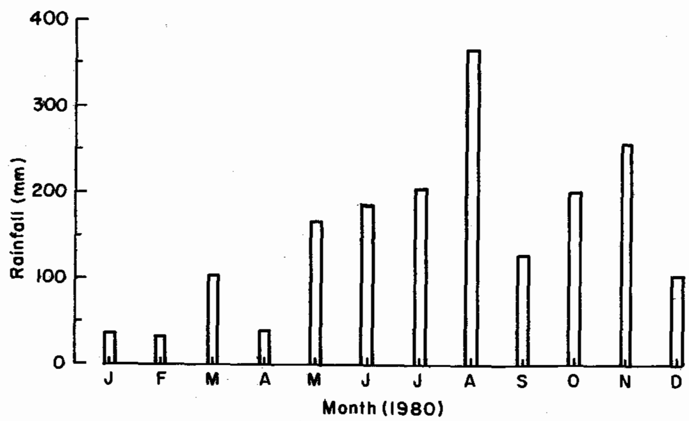


Fig. 3. Rainfall data for 1980, Pili Weather Station, near San Miguel Bay.

Hydrography

Although a number of biological surveys have been conducted in the last decades in the Bay (Pauly, this report), it is only recently that quantitative oceanographic data have been reported from San Miguel Bay. Fig. 4, adapted from Legasto et al. (1975), summarizes the available information on temperature, salinity and oxygen distribution in the Bay; as obtained during a 30-station survey conducted 9-10 November 1974.

Fig. 4C shows the marked impact of the Bicol River water on the water masses within the Bay, a subject to which reference will be made further below.

Fig. 5, which is based on Fig. 4C and 4D is a schematic representation of the vertical distribution of salinity in the inner part of San Miguel Bay. The isohalines in Fig. 5 suggest the existence of a brackishwater wedge high up into the mouth of the Bicol River.

The tides in San Miguel Bay, as along the rest of the Pacific coast of the Philippines are of the semi-diurnal type, with a mean amplitude of 94 cm (Anon. 1979). Fig. 6 shows the tidal oscillations in San Miguel Bay for the 27th of November 1980, as computed from data in Anon. (1979).

Annual water inflow from rivers into the Bay, as computed from data in Anon. (1972) amounts to 2.87 x 10^9 m^3, 96% of which stems from the Bicol River (Table 2). Mean annual rainfall onto the 840-km^2 Bay is about 3.40 m (Anon. 1975), corresponding to 2.86 x 10^9 m^3 of rain water. Thus, about 5.73 x 10^9 m^3 of water is added annually to the Bay, or about 87% of the 6.61 x

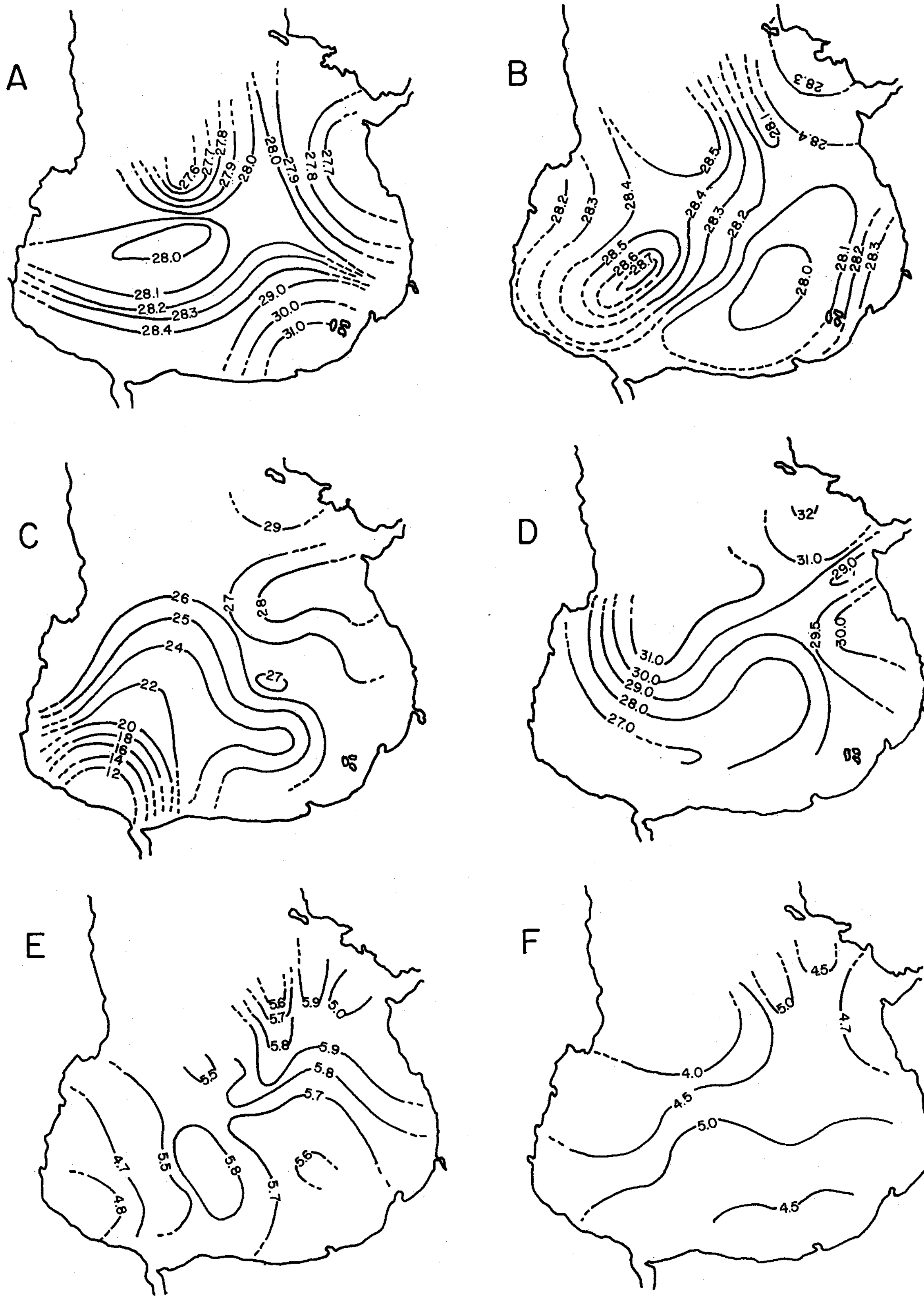


Fig. 4. Hydrography of San Miguel Bay, 9-10 November 1974. Adapted from Figs. 2 to 7 in Legasto et al. (1975) (with permission of F. Gonzales, Director, Bureau of Fisheries and Aquatic Resources, Manila). A: surface temperature (°C); B: bottom temperature; C: surface salinity (‰); D: Bottom salinity; E: oxygen content (ml/l), surface; F: oxygen content, bottom.

10^9 m^3 present at any time in the Bay (on the average) as computed from the present depth of 7.4 m + 1/2 tidal amplitude.

A first estimate of annual evaporation over the Bay can be computed from the empirical equation

$$E = (0.26 + 0.77v) \cdot (e_w - e_a) \qquad \ldots \qquad (1)$$

where E is the evaporation rate, in mm per cm^2 per day; v is the wind speed in m/sec; e_w is the vapor pressure of water at the temperature of the water surface in millibars; and e_a is the partial pressure of vapor in the atmosphere (Perkins 1974). The following values were used in conjunction with equation (1):

mean annual v = 0.0482, as calculated from a total annual wind run over the Bay of 820 knots, based on data obtained from Pili Weather Station (see also Fig. 2);

e_w = 36.08, as interpolated for a temperature of 27.5°C from Table 29 in Sverdrup et al. (1942);

e_a = 29.22 – 36.08 x 0.81, where 0.81 corresponds to 81%, the mean annual relative humidity over San Miguel Bay (Anon. 1975).

From equation (1), it is estimated that E = 2.04 mm/day, corresponding to 6.25 x 10^8 t of water evaporating annually from the Bay, or about 9.5% of its mean water content.

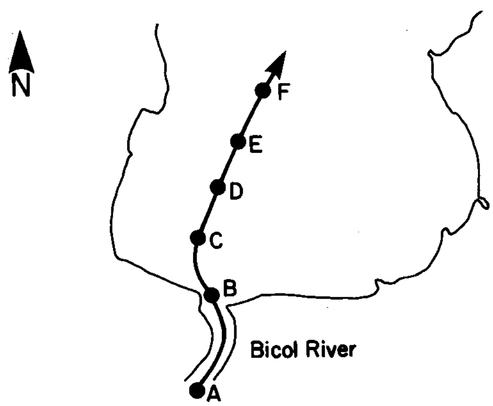
Flushing time (t_f) for the San Miguel Bay as a whole may be estimated from

$$t_f = (V + P) / P \qquad \ldots \qquad (2)$$

where V is the total water volume at low water and P is the volume of water entering at each flood, or "intertidal volume" (Bowden 1967).

The figures given above correspond to P = 7.4 x 840 x 10^9 m^3 and V = 0.94 x 840 x 10^9, which leads to an estimate of t_f = 8.87 tidal periods (of 12.4 hr each) or 4.6 days.

As explained in Bowden (1967), estimates of flushing time based on expression (2) are generally underestimates of true flushing time, because the method incorporates the assumption of complete mixing at each tide. Nevertheless, such estimates may be useful, e.g., to assess the *minimum* time that pollutants or nutrients are likely to remain, on the average, in a given estuary.



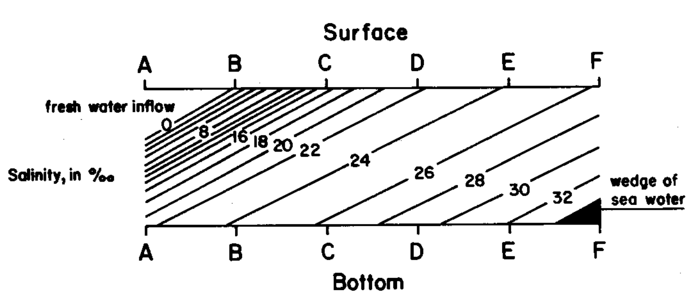


Fig. 5A *(above).* Positions of reference points for interpolation of information in Fig. 4. Fig. 5B *(below).* Schematic representation of salinity distribution, November 1974, as inferred from Figs. 4C and 4D.

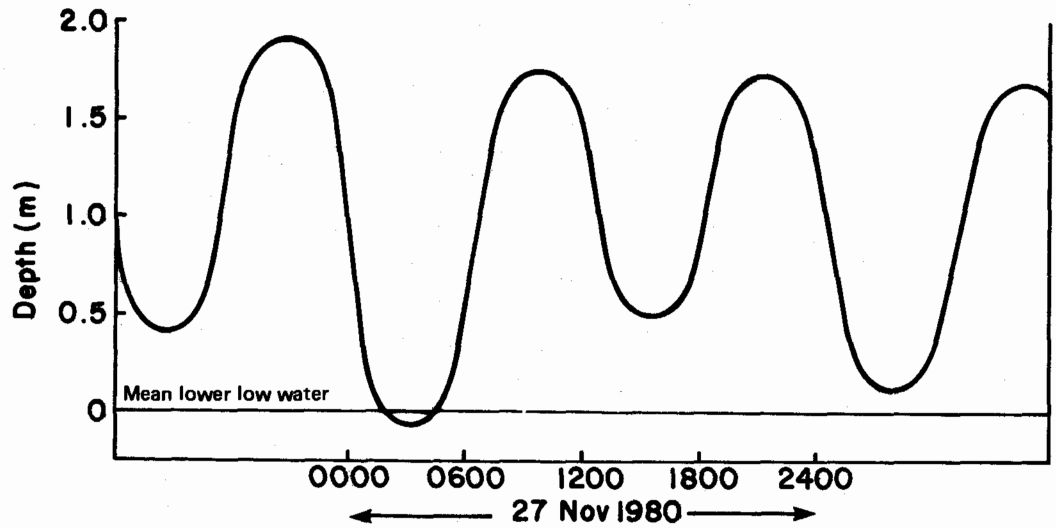


Fig. 6. Tidal cycle in San Miguel Bay, 27 November 1980, based on Philippine Tide Tables for 1980 and used to standardize soundings of bathymetric survey.

Table 2. Annual river water discharge in San Miguel Bay.[a]

RIVERS Months	Bicol River[b] (1966-67) x 1,000 m^3	%	Hinagianan River (1966) x 1,000 m^3	%	Tigman River (1966) x 1,000 m^3	%	Total x 1,000 m^3	%
January	374,054	13.6	6,206	12.1	7,962	10.2	388,222	13.6
February	197,174	7.2	4,513	8.8	6,177	8.0	207,864	7.2
March	170,579	6.2	1,984	3.9	6,201	8.0	178,764	6.2
April	134,883	4.9	1,394	2.7	5,163	6.7	141,440	4.9
May	118,287	4.3	1,991	3.9	5,406	7.0	125,684	4.4
June	104,543	3.8	1,096	2.1	5,610	7.2	111,249	3.9
July	132,314	4.8	3,852	7.5	6,667	8.6	142,833	5.0
August	353,123	12.9	6,682	13.0	6,223	8.0	366,028	12.7
September	299,571	10.9	2,815	5.5	5,323	6.9	307,709	10.7
October	332,441	12.1	3,764	7.3	6,047	7.8	342,252	11.9
November	389,529	14.3	5,731	11.2	7,354	9.5	402,614	14.0
December	137,262	5.0	11,250	22.0	9,475	12.1	157,987	5.5
Total	2,743,760	100.0	51,278	100.0	77,608	100.0	2,872,646	100.0

[a]Adapted from Anon. (1972).
[b]Not including (insignificant) contribution of Libmanan River.

Siltation

Fishermen around the Bay are well aware that it has become much shallower than it was previously. This is also reflected in the fact that landing places, such as Sabang, which were earlier accessible to trawlers have now become so shallow that the trawlers must be unloaded with the help of smaller boats that are dragged through the mud.

No quantitative data were available on the siltation process. For this reason, we conducted, on 27 November 1980, a bathymetric survey in the southeastern part of the Bay (covering 40% of its surface area; see Fig. 7B) using a Furono MG-200* battery-driven echosounder mounted on a fisherman's boat. The depth readings were standardized to mean lower low water by way of the graph in Fig. 6 and isobaths drawn (Fig. 7B) from which a mean depth difference of 1.49 m was estimated with regard to the map of San Miguel Bay showing the greatest bathymetric details (San

*Mention of trade names does not imply endorsement of commercial products.

Miguel and Lamit Bays, Philippine Coast and Geodetic Survey, PC & GS 4223), which has a scale of 1:100,000.

We were informed by personnel for the Philippine Coast and Geodetic survey that the major part of the soundings for this map was made in 1907, or 73 years before our bathymetric survey. Assuming linearity, a rate of silt deposition of 2 cm/yr can thus be estimated, corresponding to a deposition of 1.68×10^7 m^3 of silt per year for the Bay as a whole.

Given the estimated inflow from rivers of 2.87×10^9 m^2 per year, a silt content of the river water of 0.6% (in volume) can be estimated for the Bicol River (which contributes 96% of all inflowing water, see Table 2). This estimate of the silt load of the Bicol River, although seemingly high, is certainly an underestimate. In July 1981, we centrifuged several samples of Bicol River water and separated solids which ranged between 1 and 2% (in volume) of the water samples. The value of 0.6% silt load is based on the assumption of a constant rate of silt deposition from 1907 to 1980.

Deforestation, which is a cause for erosion and siltation, greatly accelerated in the last decade, for which reason one should expect a silt load higher than average in recent years, possibly as much as, for example, the 2.5% reported in Banerji and Singh (1979) from the Sone River in Bihar State, India.

The Bicol River, in addition to coursing through deforested areas also goes through several cities, the major one of which is Naga City (ca. 100,000 inhabitants), the commercial center of Camarines Sur Province. This should add considerably to the material transported by the river waters, notably in terms of domestic sewage.

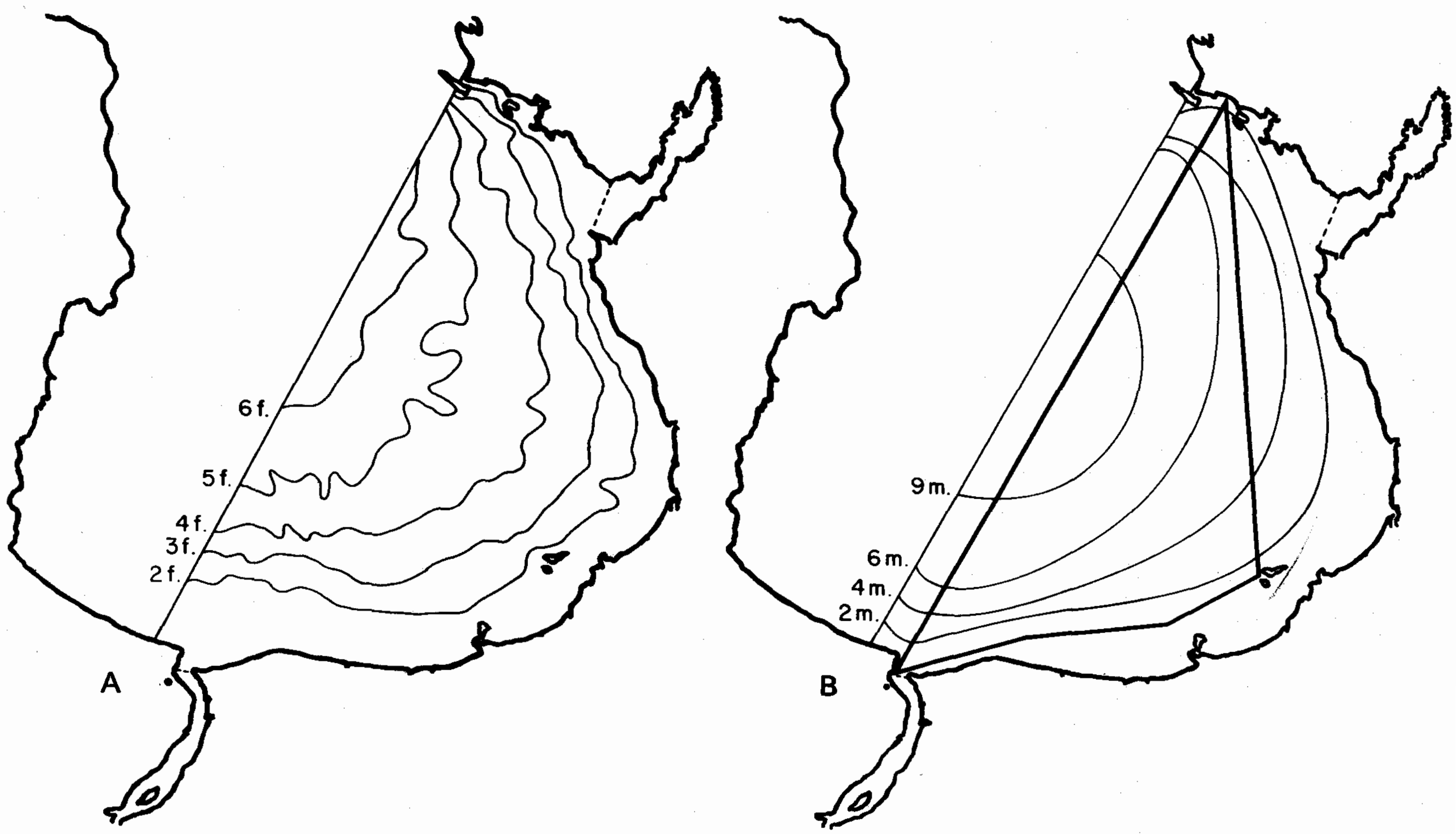


Fig. 7. Depth distribution in San Miguel Bay. A. Adapted from map PC & GS 4223, most of whose soundings were taken in 1907 (note that depths are expressed in fathoms). B. Derived from the records of a bathymetric survey conducted on 27 November 1980 (depths expressed in meters). Thick lines represent the actual transects.

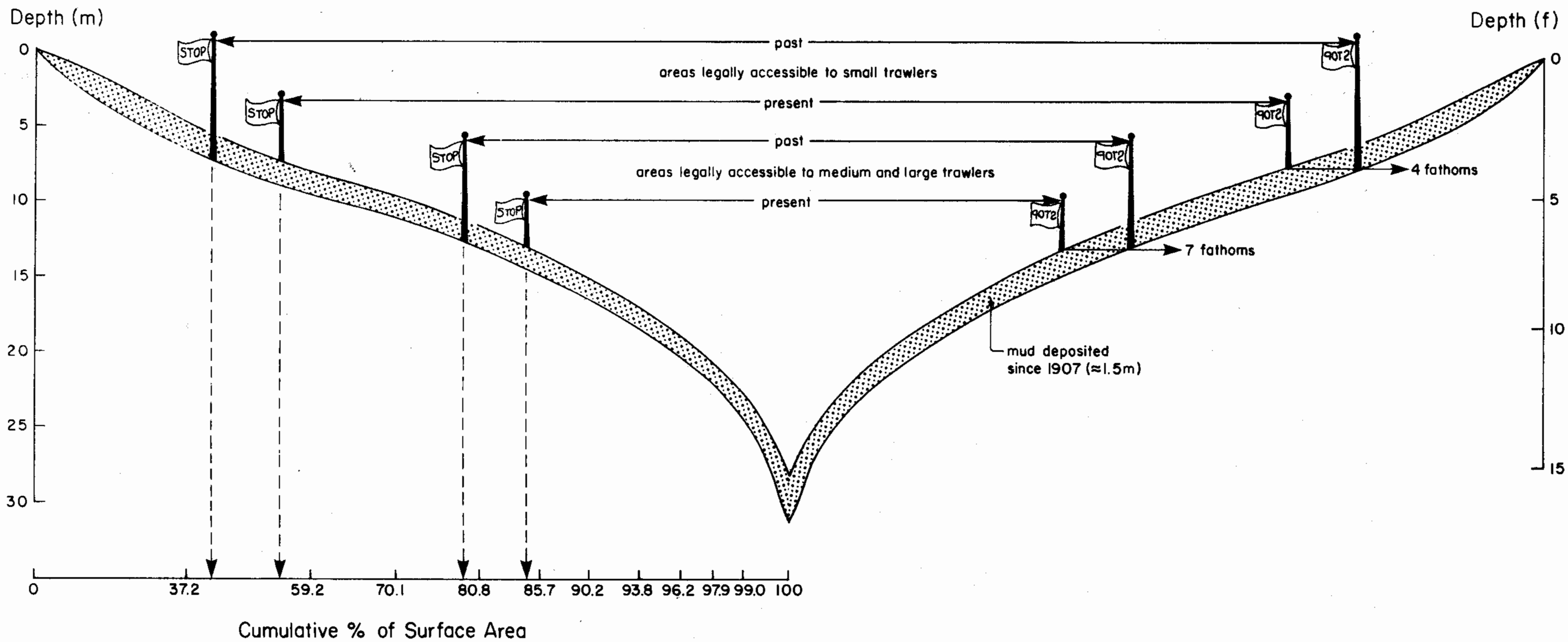


Fig. 8. Schematic representation of the surface area of San Miguel Bay legally accessible to trawlers below 3 GT (small tralwers) and above 3 GT (medium and large trawlers). Note impact siltation, which reduces the area legally accessible to trawlers of all kinds.

Discussion

The effects of the northeast monsoon on the fisheries of San Miguel Bay are rather straightforward and are demonstrated in several other papers included in this report. The estuarine conditions prevailing in the Bay have a major effect on the faunal composition and are one of the causes, for the very high productivity of the fishery. Both of these features are discussed in Pauly (this report). Emphasis here is on the implications of the fact that the Bay is becoming shallower with regard to the depth-related fishery regulations, and the deployment of passive and active fishing gears within the Bay.

Fig. 8 shows the surface area available to trawlers below and above 3 GT. As might be seen from Fig. 8, the siltation has the effect of noticeably reducing the area *legally* accessible to trawlers (both "municipal" and "commercial"); also the siltation has the effect of reducing the area *physically* accessible to trawlers (particularly those with deep draught). The accuracy of the values given in Fig. 8 should not be overestimated because all calculations are simply based on a uniform mud layer of 1.5 m superimposed onto the depth zonation extracted from the map. All that is intended here, indeed, is to point out the need for an accurate bathymetric survey of the whole Bay, as the basis to help settle the various claims on the Bay's water.

The siltation of the Bay in recent years seems to have affected gear deployment in that fixed gears, which were gradually replaced by mobile gears (especially trawls) in the sixties and early seventies are becoming popular again. Of course, increased fuel costs probably also contributed to this phenomenon.

Acknowledgements

We wish to thank Mr. E. Cinco for his participation in the bathymetric survey of San Miguel Bay, and Mr. R. Regalado (Bureau of Fisheries and Aquatic Resources) for his assistance in locating and tabulating the water discharge data in Table 2.

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The Fishes and their Ecology*

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Abstract

An annotated list of 188 species of fishes recorded from San Miguel Bay, Philippines is presented. Of these, 48% are euryhaline marine species. The most abundant fishes belong to marine species whose representatives are known to seek brackish waters, especially when young. Such fish fauna characterizes San Miguel Bay as an estuary. A brief discussion follows of the distribution with regard to salinity of the Philippine fish fauna as a whole.

The fish species of San Miguel Bay can be arranged into the following trophic groups: piscivores (23%), zooplankton feeders (18%), meiobenthos feeders (22%) and macrobenthos feeders (37%). The same ichthyofauna can also be split into the following groups: coastal pelagics (22%), oceanic pelagics (3%), soft-bottom demersals (55%) and reef/hard-bottom demersals (20%). The role of the Bay as a nursery ground for fishes is discussed.

Annotated List of Fishes Recorded in San Miguel Bay, 1868-1981

The first record of a fish from the San Miguel Bay area in the scientific literature is that of the white goby *Glossogobius giurius* from the Libmanan River (Fig. 1) by Peters (1868). However, as is the case for Philippine fish taxonomy in general, most fish records from San Miguel Bay stem from the work of Albert W. Herre and his Philippine associates (notably Agustin F. Umali). Their work can be easily accessed (through Herre 1953) and most of it has also been reprinted in four handy volumes.** From this literature stems 86 (46%) of the first records of San Miguel Bay fishes.

Another source of records is the National Museum of the Philippines in Manila, whose fish collections comprise a number of specimens from San Miguel Bay, identified by several specialists. These fishes were all collected between 1947 and 1953, and provided 35 (19%) new records. Records of fishes were also obtained from earlier papers on the fish resources of the Bay, notably those written in the frame of investigations conducted by K. Tiews and collaborators in the late 1950s,

*ICLARM Contribution No. 94.

**"The Philippine Bureau of Science Monographic Publication on Fishes," 1910. Dept. of the Interior, Bureau of Science, Manila, including 3 monographs (1 volume, reprinted 1965 by TFH Publications for the Smithsonian Institution, Washington, D.C.) and "Selected Ichthyological Papers from the Philippine Journal of Sciences" (3 volumes, also reprinted by TFH Publications for the Smithsonian Institution).

and by Legasto et al. (1975b) in November 1974. These papers provided 11 (6%) new records. Ms. P.V. Conlu, Professor at the College of Fisheries, University of the Philippines, kindly put at my disposal the six volumes of her manuscript checklist of Philippine fishes (Conlu 1977, 1978, 1979a, 1979b, 1980a, 1980b). This source provided 28 (15%) additional records of San Miguel Bay fishes.

During the course of the IFDR/ICLARM project, a further 28 new records of fishes from San Miguel Bay were generated, or 15% of the species now known to occur in San Miguel Bay. Some may be doubtful, having been collected just outside the Bay.

Common names in Bikol, i.e., in the language spoken in the San Miguel Bay area, were obtained from Herre and Umali (1948). It will be noted that in several cases, the Bikol names given to the fishes of a given species depend on the size of the fish in question (e.g., *piyak* for sardine fry, *tamban* for juveniles and adults sardines, or *gisao* for mullet fry, *banak* for market-sized mullets and *aguas* for large spawners). This phenomenon, which is reported from many languages through-

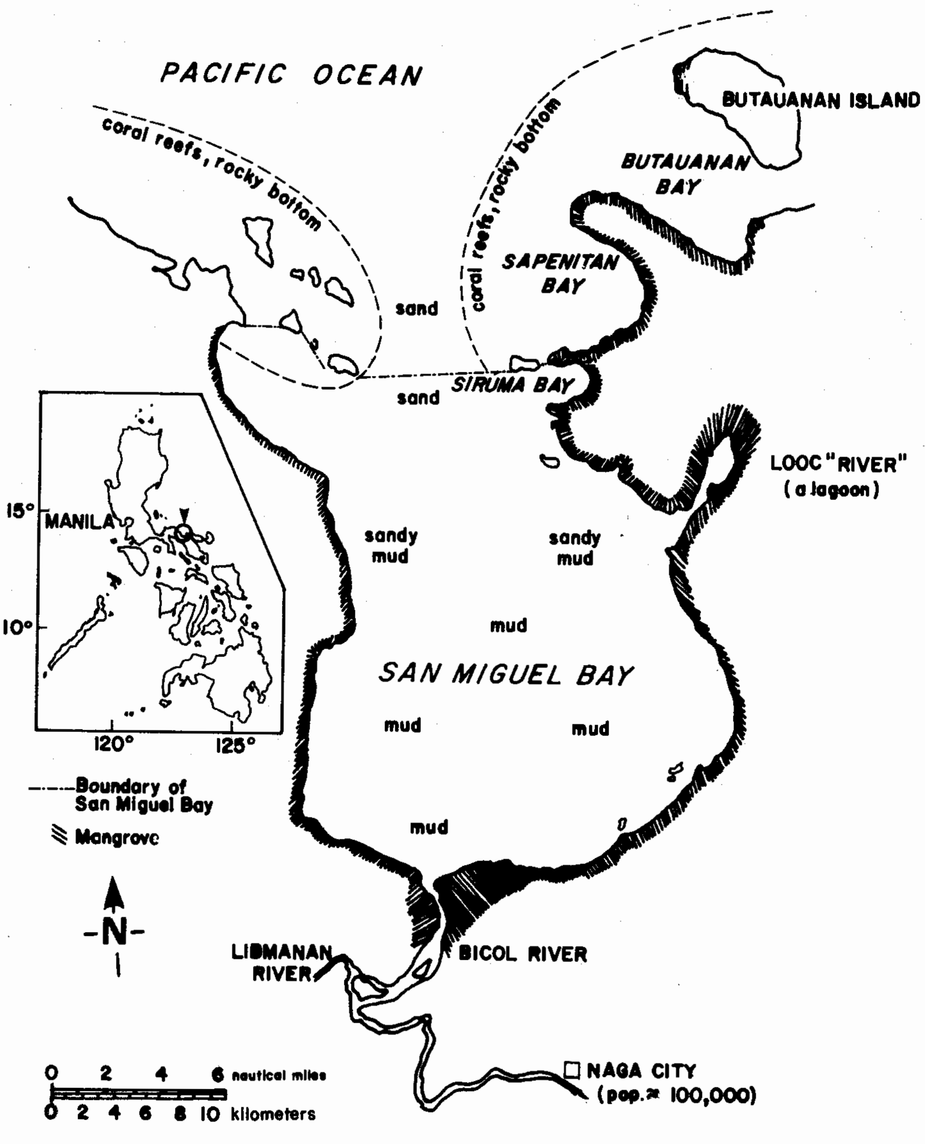

Fig. 1. Major features in and around San Miguel Bay affecting the ecology of the Bay.

out the world is discussed in Pollnac (1981). English common names were obtained from various sources, notably Fischer and Whitehead (1974), Munro (1967) and Herre (1953).

The list of fish obtained was arranged by families according to Herre (1953) for the elasmobranchs, and according to Greenwood et al. (1966) for the teleosts.

Finally, for each species included, a check was made as to its salinity tolerance. All records of freshwater or brackishwater occurrence found (mainly in Herre 1953, 1958; Munro 1967 and Whitfield et al. 1981) are cited (see Appendix I).

Euryhaline Fishes of San Miguel Bay

Mines et al. (this report) present data which suggest that San Miguel Bay is in fact an estuary, i.e., the "Bicol River Estuary." According to Pritchard (1967) an estuary is a semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage.

Thus, to define the environmental conditions of a certain semi-enclosed coastal habitat as "estuarine", it is generally sufficient to demonstrate that mixing of sea and freshwater takes place (see Mines et al., this report).

Another approach to define the prevailing environmental conditions of a given habitat is to identify the various members of its fauna and to infer from what is known (elsewhere!) of their requirements and/or habits on the character of their habitat. In this context it should be noted that the list of fishes presented here shows a large amount of overlap with the lists of fishes reported from Indian brackishwaters by Pillay (1967) and by Whitfield et al. (1981) from South African estuaries. The estuarine character of the San Miguel Bay fish fauna can be demonstrated directly, however. The list of fish compiled here has been complemented with notes on the salinity tolerated by the various species. As might be seen from the list, 91 (48%) of the species recorded from San Miguel Bay are euryhaline marine species, i.e., species, which tolerate fresh- and/or brackishwater.

The asymmetry between the numbers of marine and freshwater species in San Miguel Bay can be easily explained in terms of what is generally known of the tolerance of freshwater and marine animals to increased and decreased salinities, respectively. Fig. 2A, redrawn from Remane (1971) is a graph of species diversity against salinity, based on a large number of studies conducted in and around large temperate brackishwater bodies (e.g., Zuidersee, Baltic and Black Seas). As the graph shows, true freshwater species tolerate only small increases of salinity, whereas marine species can generally tolerate great reductions of salinity. This explains the preponderance of marine species in estuaries.

However, due to the relative isolation of the Philippine Islands, there are only a few true freshwater species (predominantly Cyprinidae) (Herre 1928a). This has allowed a number of marine fishes to become secondarily adapted to freshwater (e.g., *Arius dispar* and *A. manilensis*, several gobiid species); these fishes are still capable, however, of tolerating salt- or brackishwaters better than true freshwater fishes. Also, it seems that it is altogether easier for tropical than for temperate marine fishes to adjust to freshwater, with the result that there are many more holoeuryhaline (marine fishes capable of living in freshwater) fishes in the Philippines than is suggested by Fig. 2A. For these reasons, I have attempted, based mainly on Herre (1928a, 1953 and 1958), to adapt Remane's graph to the peculiarities of the Philippine fish fauna; the result is given in Fig. 2B. The large number of holoeuryhaline marine fishes, will be noted together with the very small number of true freshwater species (see also Fig. 3A). Also worth noting is the category "secondary freshwater fishes", which replaces the brackishwater species in Remane's graph; this category may include a few truly brackishwater fishes, i.e., fishes which spawn in brackishwater (e.g., the white goby, *Glossogobius giurus).*

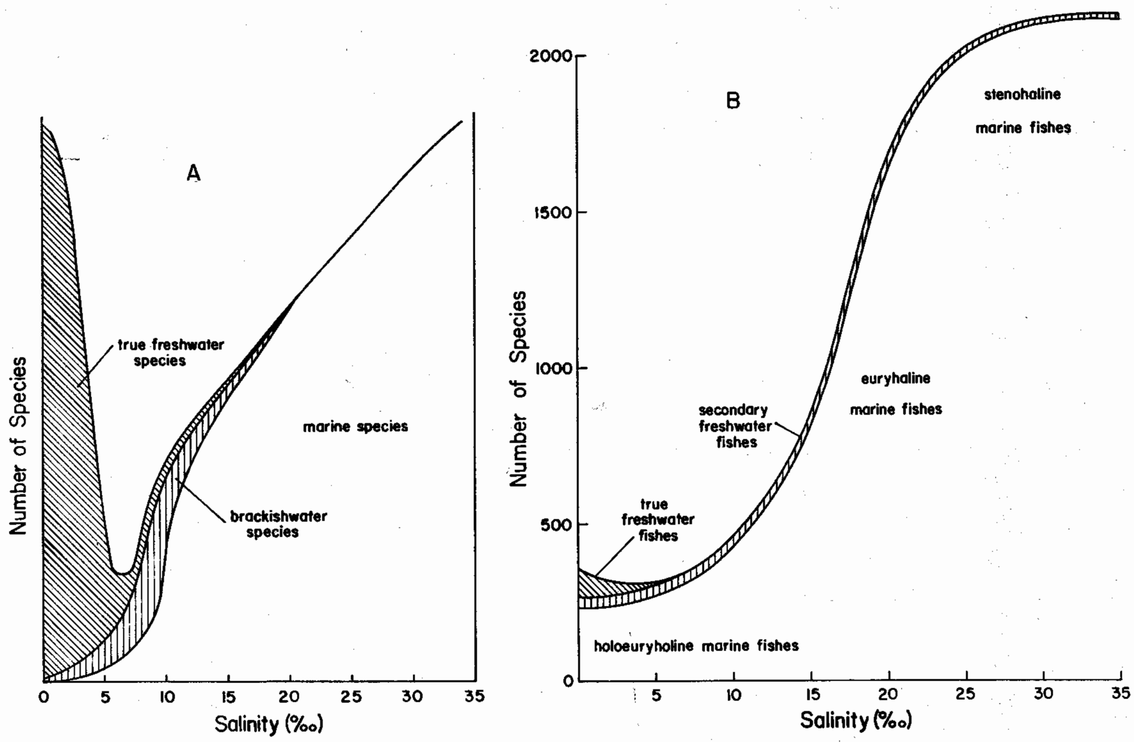

Fig. 2. A. General relationship between salinity and number of species, as suggested by Remane (1971) (based mainly on temperate forms). B. Relationship between salinity and number of fish species in the Philippines (see text).

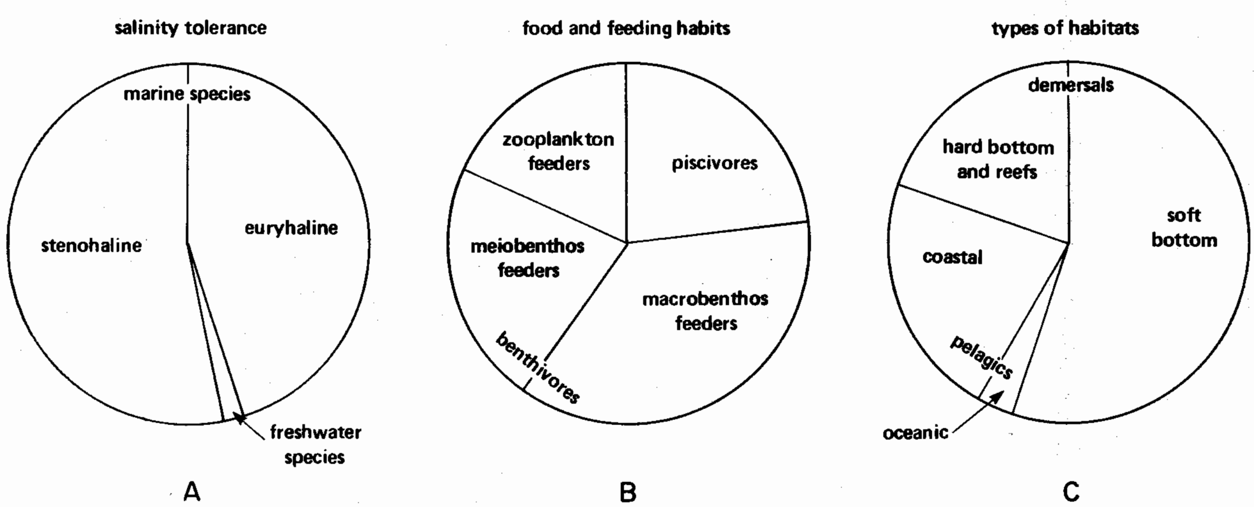

Fig. 3. Occurrence of San Miguel Bay fish species in terms of A) salinity tolerance, B) food and feeding habits, and C) type of habitats. See text.

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Food and Feeding Habits of San Miguel Bay Fishes

The species of fishes reported from San Miguel Bay have been grouped, on the basis of a thorough scanning of the literature on the feeding habits of tropical fishes, into the following four broad categories:

a) piscivores
b) zooplankton feeders
c) meiobenthos (small invertebrates, ≥1 mm, and algae) feeders
d) macrobenthos (large invertebrates) feeders

The results are given in Fig. 3B. As might be seen, most fish species in San Miguel Bay are macrobenthos feeders (37%), followed by piscivores (23%), meiobenthos feeders (22%) and zooplankton feeders (18%).

It must be realized, however, that these figures relate to species numbers, not to the relative biomasses (and catches) of these species. Thus, for example, meiobenthos feeders, which contribute relatively little in terms of species numbers, include leiognathid species which in the unexploited stock contributed more than 60% of the (trawlable) biomass (see Pauly, this report). On the other hand, many of the piscivorous species (e.g., the tuna and other oceanic fishes) are only occasional visitors to the Bay. Their biomass at any given time should generally be low.

Types of Habitats Offered by San Miguel Bay

On the basis of published information on their biology, the fishes have been grouped in Appendix I into four habitat types:

– coastal pelagics (e.g., anchovies)
– oceanic pelagics (e.g., tuna)
– soft-bottom demersals (e.g., most slipmouths)
– hard-bottom/reef demersals (e.g., groupers)

As is the case for the grouping into "food and feeding habits" groups (see above), these are broad categories, with a large overlap and involving essentially subjective decisions.

Nevertheless, an interpretable pattern emerged (Fig. 3C); predominant (55%) in the Bay are (not surprisingly in view of its shallowness and mud-covered bottom) soft-bottom demersal fish. The next group (22%) is the (small) "coastal pelagics", which, along with most soft-bottom demersals, are the fishes which use the Bay as a nursery area. The next category (20%) includes hard-bottom/reef fishes; the specimens belonging to these species were most probably recruited from the rocky outcrops and reefs at the mouth of the Bay (Fig. 1). The least important group is the (large) "oceanic pelagics", which enter the Bay as occasional visitors, and whose young do not use it as a nursery area.

San Miguel Bay as a Nursery Area

Several surveys were conducted in the 1970s which aimed at assessing the role of Philippine bays and estuaries as nursery grounds for marine fishes (Castillo and Barenguel 1975; Del Mundo et al. 1980; Legasto et al. 1975a; Legasto et al. 1975b; Ordoñez et al. 1974; Ordoñez et al. 1975). Although these surveys were generally of very short duration (Legasto et al. 1975b, for example, covered San Miguel Bay in a few days, in November 1974), data were gathered which, when put into an appropriate conceptual framework, clearly indicate a "nursery" role for most of these bays. This is demonstrated here for San Miguel Bay with data collected by Legasto et al. (1975b):

– all fish sampled within the Bay (8 species) were immature

Table 1. Largest observed sizes of fishes caught by trawlers inside and outside of San Miguel Bay.[a]

Species	Largest size observed (in cm) Inside	Outside[b]	# of samples Inside	Outside
Dussumieria acuta	15.5	19.5	1	4
Sardinella gibbosa	15.25	18.25	3	3
Stolephorus commersonii	8.75	11.25	3	4
Atule mate	23.5	25.5	3	4
Alepes djeddaba	17.75	(13.25)	5	1
Leiognathus bindus	7.75	11.25	1	10
Leiognathus splendens	10.8	12.6	7	7
Secutor insidiator	11.1	12.4	6	7
Secutor ruconius	6.75	9.25	2	4
Otolithes ruber	28.5	(24.5)	8	8
Johniops aneus	14.75	21.25	8	8
Johnius belangerii	17.5	22.5	4	6

[a]Based on length-frequency samples collected by J.M. Vakily (pers. comm.) on board large trawlers, except for the data for *Leiognathus splendens* and *Secutor insidiator* which stem from Tiews and Caces-Borja (1965).

[b]Note that maximum observed size is larger outside than inside in 10 out of 12 cases, and that one of the two (bracketed) cases in which this is reversed is a case where sampling outside was much less than inside.

- only 6 fish larvae and 2 (!) fish eggs were sampled from 30 plankton hauls, although sampling occurred during the northeast monsoon, i.e., during the period of the year when most Philippine marine fishes may be expected to spawn (see Weber 1976).

Another important bit of evidence for a nursery role for San Miguel Bay is that, within a given marine species, the largest fish occur at the mouth of, or outside the Bay, rather than inside the Bay (Table 1). These various items, combined with what is known elsewhere of the reproductive migrations of tropical neritic species suggest a reproductive cycle as put forward in Fig. 4. From this figure emerges a clear distinction between *spawning* and *nursery* grounds; the figure also explains

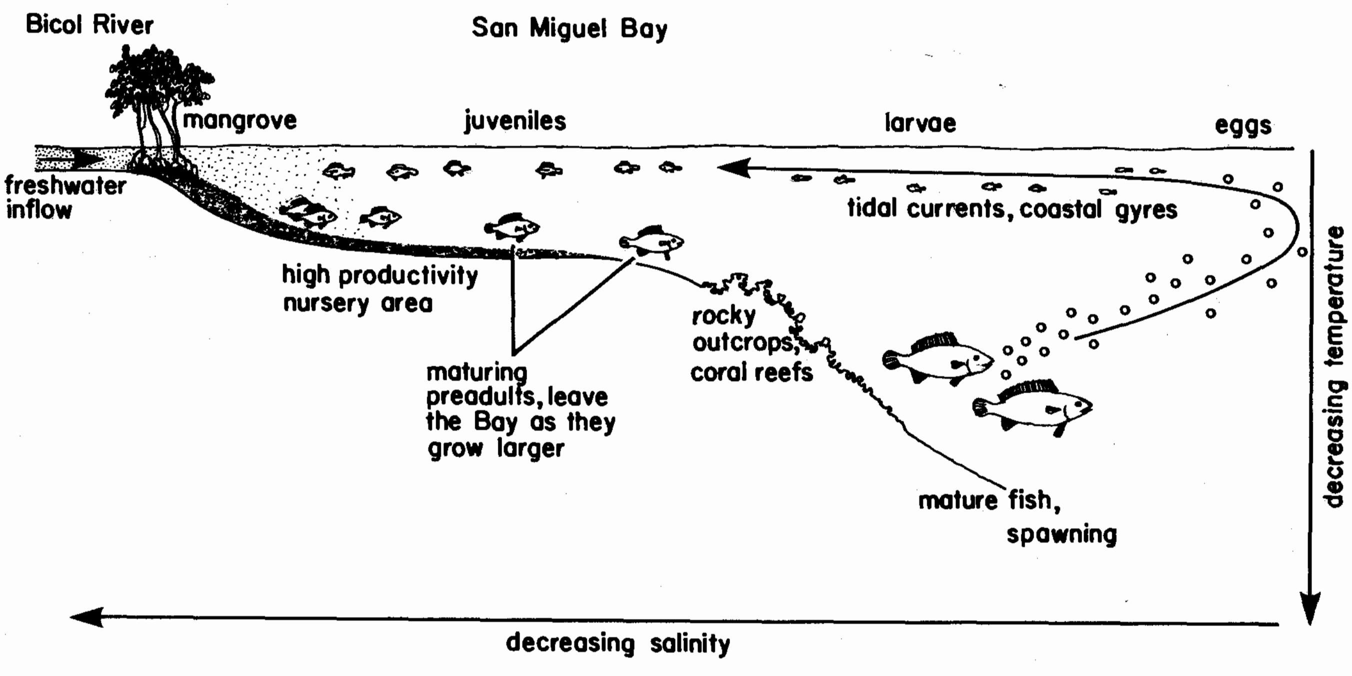

Fig. 4. Schematic representation of the role of San Miguel Bay as a nursery ground for marine fishes hatched further offshore. Generalized from Gunter (1967), Pauly (1976), Johannes (1978) and Buri (1980).

the low numbers of eggs and larvae found by Legasto et al. (1975b), as well as the absence of mature fish from their samples.

A similar graph could be constructed to illustrate the role of this Bay as a nursery ground for catadromous freshwater fishes, e.g., those freshwater gobies which return to the sea to spawn. This is not attempted here, as these migrations have been described by Herre (1927, 1958), whose papers should be consulted for further details on the migrations and relationship with salinity of Philippine fishes.

Allen (1978) wrote with regard to San Miguel Bay:

> one thing presently occurring that will surely diminish the productivity of the Bay, and adjacent coastal waters unless it is stopped, is the loss of mangrove and other types of wetland bordering the Bay. I believe that there is a good chance that the Bay productivity lost from a hectare of mangroves displaced by a fishpond may be as great or greater than the harvest from the pond.

While the mangrove and related ecological literature abounds with categorical statements of this kind (see Nixon 1980), hard data usable for the quantification of the role of mangroves in fisheries-related food chains are extremely scarce, particularly in the Indo-Pacific (Walsh et al. 1975; PCARR 1978).

The basic problem with all attempts to assess the impact of mangrove clearing in the Philippines and elsewhere is that the result, at best, is a time series of e.g., catch of fishes or shrimps which use mangrove/estuaries as nursery areas. Such time series are extremely difficult to interpret since fishing effort—which it should be remembered is a major cause of death among fishes—generally will have increased during the investigation period. Also, while it could be that there is, for example, in the San Miguel Bay area a direct, causal link between mangrove litterfall and fish yield, it could also be that the loss of nutrients to the Bay due to mangrove cutting is compensated or even over-compensated for by increased silt and organic wastes deposited into the Bay by the Bicol River (see Mines et al., this report). Clearly, empirical studies are needed on this topic. Gomez (1980) gives a recent review of the Philippine literature on mangroves.

Another related aspect is the maintenance—in spite of the diversion of water from the Bicol river for irrigation purposes—of an adequate supply of freshwater to the Bay.

Allen (1978) observed:

> a further safeguard for keeping the Bay healthy is insuring the availability of sufficient fresh water inflow from the streams entering the Bay. The exact amount of freshwater needed is not known, but I suggest the present dry season volume be maintained.

While more water than before is being used for irrigation purposes, and thus lost through evaporation, rampant upland deforestation will—other things being equal—actually *increase* overall freshwater inflow into the Bay.

At present, it seems extremely difficult to assess, even qualitatively, the impact, present and future, of these factors on the San Miguel Bay fishes.

Discussion

In spite of the scanty material available, it has been possible to derive here a generalization concerning the relationship of species diversity of Philippine fishes in relationship to salinity (Fig. 2B), as well as to consolidate evidence on the role of Philippine bays and estuaries into a single pattern (Fig. 4) suggested here to apply throughout the country.

Other generalizations pertaining to Philippine estuaries are:

- annual fish and invertebrate yields (excluding sergestid shrimps) can be very high, reaching up to 17 t/km^2 (see Pauly, this report);
- such production is maintained largely by a limited number of meiobenthos-feeding species of fish and shrimps;

- contrary to events in reef ecosystems, the production of such estuarine systems may not be affected negatively by siltation due to erosion; indeed, terrigenous material is a major contribution to estuarine productivity; and
- *non-toxic* organic wastes (from urban areas, from farms and certain factories) may increase the productivity of estuarine systems, given that their application does not fluctuate too rapidly (Soule and Soule 1981)

These generalizations might provide (testable) hypotheses around which to formulate future studies of Philippine estuaries.

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Appendix 1. List of fishes recorded from San Miguel Bay, 1868-1981.

Scientific names	English/Bicol names	First record	Remarks
	SCYLLIORHINIDAE (catsharks/–)		
Chiloscyllium punctatum	–/–	Herre (1925)	–––––
	CARCHARIIDAE (gray shark/pating; young sharks also called "iho")		
Carcharias melanopterus	black-tipped shark/lodlod, tutongan	Umali (1937)	–––––
Carcharias menisorrah	–/–	IFDR/ICLARM Project	–––––
Scoliodon palasorrah	sharp-nosed shark/bungalonon, balanohan, balatihan, balanakon	Umali (1937)	–––––
	SPHYRNIDAE (hammer-head shark/awal)		
Sphyrna zygaena	smooth hammerhead shark/awal, krusan, tampugan, ros	Umali (1937)	–––––
	PRISTIDAE (sawfish/sorodan)		
Pristis microdon	sawfish/surodan, barasan, pakangan	Herre (1953)	Herre's record is from the Bicol River. One specimen caught in July 1947 in San Miguel Bay weighed 480 lb (Warfel and Manacop 1950); reported from the mouth of the Ganges river (see Herre 1953)
Pristis cuspidatus	sawfish/surodan	NMP collection	entering freshwaters (Herre 1958)
	RHINOBATIDAE (rays/pagi)		
Rhinchobatus djiddensis	spotted guitar-fish/arado, rubarob, sudsud, sudsodan	Umali (1937)	one specimen caught in July 1947 in San Miguel Bay weighed 180 lb (Warfel and Manacop 1950)
	TORPEDINIDAE (electric rays, torpedoes/–)		
Narcine timlei	–/–	IFDR/ICLARM Project	–––––
	DASYATIDAE (stingrays/pagi)		
Dasyatis kuhlii	blue spotted stingray/daragon, dahunan, kuyampao	Umali (1937)	"bay and inlets, sandy or muddy coasts, enter river mouths" (Herre 1953)
Dasyatis uarnak	marbled stingray, whip ray/ bitoonan, kilkigan, pangladan, pilisan, paging dahunan	IFDR/ICLARM Project	"sometimes entering fresh water [. . ;] reach a meter and half broad and very bulky" (Herre 1953); reported from at least one river (see Herre 1953)
Dasyatis bleekeri	–/–	NMP collection	–––––
	MYLIOBATIDAE (eagle rays/pagi manok)		
Aetobatus narinari	spotted eagle ray/banugon, kaligmanok, bagtaw, bagtan	Umali (1937)	–––––
	RHINOPTERIDAE (cow-nosed rays/ogaog)		
Rhinoptera javanica	cow-nosed ray/ogaog, paging bungi, pasa-pasa	Umali (1937)	–––––
	MOBULIDAE (devil rays, mantas/salanga)		
Mobula diabolus	devil ray, manta/sarangan, pasa-pasa, saiag, salanga	Herre (1953)	reported as *M. ereregoodoo-tenke*, a synonym

Appendix 1 (continued)

	CLUPEIDAE (sardines, herring/tamban; clupeid fry are referred to as "piyak", or "tabyos")		
Anadontostoma chacunda	gizzard shad/kabasi	Roxas (1934)	"marine, frequenting estuaries and tidal streams" (Herre 1953)
Nematalosa nasus	Bloch's gizzard shad/suwagan, kabasi	Umali (1937)	euryhaline, listed in Herre (1958)
Pellona ditchela	big-eyed herring/bas-an, muang, matang-baka	NMP collection	record refers to *Ilisha hoeveni;* a synonym
Dussumieria acuta	rainbow sardine/kabasi, kanasi	Roxas (1934)	some early records are to *D. hasselti,* a synonym
Herklotsichthys punctatus	spotted herring/kabasi	Legasto et al. (1975b)	size sampled 75 to 95 mm; 75% were "immature"
Clupeiodes lile	transparent herring/bolinao	Umali (1937)	———
Sardinella fimbriata	fringescale sardinella/laolao, turay, lawlaw	Umali (1937)	"marine and entering river mouths" (Herre 1953)
Sardinella gibbosa	goldstripe sardinella/—	IFDR/ICLARM Project	reported from inside the Bay by J.M. Vakily (pers. comm.)
Sardinella albella	white sardinella/tamban kabasi-on, alubaybay	Roxas (1934)	early records are to *S. perforata,* a synonym
Sardinella longiceps	Indian sardine/tulay, turay, tamban	IFDR/ICLARM Project	"marine and entering river mouths" (Herre 1953)
	ENGRAULIDAE (anchovies/dilis, bulinao)		
Stolephorus commersonii	Commerson's anchovy/dilis, bulinao	Umali (1937)	most abundant engraulid in San Miguel Bay "marine and entering rivers" (Herre 1953)
Stolephorus zollingeri	—/dilis, bulinao	NMP collection	———
Stolephorus indicus	Indian anchovy/matalos	ICLARM/IFDR Project	euryhaline, listed in Herre (1958)
Stolephorus buccaneeri	buccaneer anchovy/dilis, bulinao	Tiews et al. (1972)	reported from stomachs of *Saurida tumbil*
Stolephorus heterolobus	shorthead anchovy/dilis	Tiews et al. (1972)	reported from stomachs of *S. tumbil*
Thryssa hamiltonii	Hamilton's thryssa/tigi	Legasto et al. (1975b)	"in the sea and estuaries" (Herre 1953). Specimens examined (in Nov. 1974) were "all mature" and ranged from 78 to 89 mm
Thryssa mystax	moustached thryssa/dilis, bulinao	Roxas (1934)	"marine and entering river mouths" (Herre 1953)
Thryssa setirostris	longjaw thryssa/dilis, bulinao	NMP collection	"marine entering estuaries" (Herre 1953)
	MEGALOPIDAE (tarpons/bulan-bulan)		
Megalops cyprinoides	ox-eyed tarpon/bulan-bulan, buan-buan, buwan, mulan-bulan	Umali (1937)	"marine, but occurs in lake and rivers" (Roxas 1934)
	CHIROCENTRIDAE (wolf herrings/balila)		
Chirocentrus dorab	wolf herring/balila, barira	Roxas (1934)	"marine, entering brackish waters" (Herre 1953, with ref. to the genus *Chirocentrus)*
	ANGUILLIDAE (eels/kasili)		
Anguilla marmorata	eel/kasili, barirauin	Herre (1953)	reported from Bicol river
Anguilla pacifica	eel/kasili, birirauin	Conlu (1978)	reported from Lake Bato, and thus had to swim through San Miguel Bay
	MURAENESOCIDAE (pike-eels/obud)		
Muraenesox cinereus	pike-eel/obud, obod, oldok, panapa, pindanga	Umali (1937)	euryhaline, listed in Herre (1958)
	MURAENIDAE (morays/buriwaran)		
Gymnothorax sp.	moray/buriwaran, indong, labung, payangitan, barason	IFDR/ICLARM Project	———

Appendix 1 (continued)

	CONGRIDAE (–/–)		
Conger sp.	–/–	IFDR/ICLARM Project	——————
	SYNODONTIDAE (lizardfish/–)		
Saurida tumbil	greater lizardfish/–	Tiews et al. (1972)	Tiews et al. (1972) give an account of the biology of this fish, based on San Miguel Bay samples
Saurida undosquamis	–/–	IFDR/ICLARM Project	——————
Trachinocephalus myops	–/–	IFDR/ICLARM Project	——————
	ARIIDAE (sea catfish/punicon, dupit, tabangko, also called "laudon" when large)		
Arius leiotocephalus	smooth-headed catfish/pohicon, bunguan, tabanko, tabangongo	Herre (1953)	"marine and estuarine" (Herre 1953)
Arius thalassinus	giant sea catfish/ponicon, bunguan, tabanko, tabangongo	NMP collection	"the commonest Philippine ariid catfish" (Herre 1953). Euryhaline, listed in Herre (1958)
	PLOTOSIDAE (stinging catfish/i-ito)		
Plotosus anguillaris	striped catfish/i-ito, nito	Herre (1926)	"marine but entering rivers" (Herre 1953)
	EXOCOETIDAE (flying fishes and halfbeaks/ilin & kutnog)		
Cypserulus sp.	flying fish/iliu, siliu, siliw	Umali (1937)	——————
Hemirhamphus far	spotted halfbeak/kutnog, buroy, sigwil	Umali (1937)	——————
Hemirhamphus sp.	halfbeak/bugin, sigwit, bagin, balamban, bangdaw	Umali (1937)	species not identified, but different from *H. far*
	BELONIDAE (garfish/balo, patlay, dual, do-al)		
Tysolurus strongylurus	light colored garfish/hamalit	Herre (1928b)	——————
	FISTULARIIDAE (cornetfishes/–)		
Fistularia villosa	cornet fish/–	NMP collection	"juveniles in shallow bays and estuaries, adults moving to deeper water" (Munro 1967)
Fistularia serrata	flutefish/–	Conlu (1978)	——————
	CENTRISCIDAE (shrimpfishes, razorfishes/–)		
Centriscus scutatus	razorfish/–	Conlu (1977)	"shallow coastal waters and estuaries" (Munro 1967)
	SCORPAENIDAE (lionfishes/–)		
Pterois russelli	Russel's lionfish/–	NMP collection	——————
	PLATYCEPHALIDAE (flatheads/sunog)		
Platycephalus isacanthus	flathead/sunog, itong, itang, lubalob	NMP collection	——————
	PEGASIDAE (sea months, sea dragons/–)		
Pegasus volitans	sea dragon/–	Conlu (1979b)	——————
	CENTROPOMIDAE (sea bass/bolgan)		
Lates calcarifer	giant sea bass/bulgan, apahap, mangagat	Umali (1937)	"shallow coasts and river mouths" (Herre 1953)
Ambassis gymnocephalus	–/–	De Beaufort (1932)	also reported from Lake Bombon

Appendix 1 (continued)

	SERRANIDAE (groupers/lapo-lapo, lapu-lapu, kugtong, pugapo, baraka, sigapo, kitking, inid)		
Epinephelus sp.	honey-comb grouper/lapo-lapo	IFDR/ICLARM Project	———
	THERAPONIDAE (grunts/bagaong, milipili, abo)		
Therapon quadrilineatus	four-lined grunt/gung-gong, kanigit, kuron, malipili, pagotpot, abo	IFDR/ICLARM Project	"marine, and in brackish and fresh waters" (Herre 1953)
Therapon puta	—/—	IFDR/ICLARM Project	———
Therapon jarbua	—/bugaong	IFDR/ICLARM Project	"marine and entering rivers" (Herre 1953)
Therapon theraps	—/—	NMP collection	———
	PRIACANTHIDAE (bigeyes/—)		
Priacanthus tayenus	purple-spotted bigeye/—	NMP collection	———
Priacanthus macracanthus	red bigeye/—	NMP collection	———
	APOGONIDAE (cardinal fishes/bagsang)		
Apogon quadrifasciatus	cardinal fish/bagaang	NMP collection	an "*Apogon* sp." was also reported from the stomach of *Saurida tumbil* by Tiews et al. (1972)
	SILLAGINIDAE (sandborers, whitings/osoos, tayotos)		
Sillago maculata	spotted whiting/osoos	IFDR/ICLARM Project	"shallow coastal waters and estuaries" (Munro 1967)
Sillago sihama	whiting/asohos, asuos, tayotos	Martin and Montelban (1934)	"marine and in estuaries and river mouths" (Herre 1953)
	LACTARIIDAE (false trevally/algodon, damos)		
Lactarius lactarius	false trevally/algodon, bas-an, damos	Umali (1937)	———
	RACHYCENTRIDAE (cobias, sergeantfishes/balisukan)		
Rachycentron canadus	sergeantfish/salakan-itang, balisukan, pandauan	Umali (1937)	———
	CARANGIDAE (jacks, horse mackerels/talakitok, malapondo, dalupani, marapini, mamsa)		
Alectis ciliaris	cobblerfish/—	NMP collection	———
Alectis indicus	Indian threadfish/bankungen, buhukan, lawihan	IFDR/ICLARM Project	"marine, but sometimes entering fresh waters (Herre 1953)
Alepes melanoptera	—/—	IFDR/ICLARM Project	———
Alepes djeddaba	Djeddaba crevalle/salay-salay	IFDR/ICLARM Project	"harbours and river mouths" (Munro 1967)
Alepes kalla	—/salay-salay	Umali (1937)	"coastal waters around river mouths" (Munro 1967)
Atule malam	—/—	NMP collection	———
Atule mate	—/—	NMP collection	"protected bays, harbours and river mouths" (Munro 1967)
Caranx sexfasciatus	dusky jack/lison	Roxas and Agco (1941)	"marine, and entering rivers and lakes" (Herre 1953)
Caranx malabaricus	Malabar jack/salay-salay	NMP collection	———
Caranx ignobilis	—/—	IFDR/ICLARM Project	euryhaline (Whitfield et al. 1981)
Caranx armatus	longfinned cavalla/lawayan, samin-samin palatikat, mamsa, mansa	NMP collection	"marine, entering rivers and lakes" (Herre 1953)
Carangoides ciliarius	longfinned cavalla/talakitok	Conlu (1978)	———
Gnathodon speciosus	golden toothless trevally/ badlon, malapandong, dilau	NMP collection	———

Appendix 1 (continued)

Scomberoides lysan	yellow leatherjacket/lapis, talang-talang	Umali (1937)	euryhaline (Whitfield et al. 1981)
Scomberoides tala	—/lapis	Umali (1937)	————
Scomberoides tol	—/lapis	Umali (1937)	"marine, and entering river mouths" (Herre 1953)
Megalaspis cordyla	hardtail scad/pakan	Roxas and Agco (1941)	"marine, sometimes in rivers and lakes" (Herre 1953)
Selar boops	eye of the sea/—	Conlu (1977)	————
Selar crumenophthalmus	big-eyed scad/atulay, matang baka, tingin	Umali (1937)	————
Decapterus macrosoma	roundscad/sibubog, tilus	IFDR/ICLARM Project	*D. layang* occurs near the mouth of the Bay (Vakily, pers. comm.)
Selaroides leptolepis	yellowstripe crevalle/ tabaroyan, salay-salay	Conlu (1978)	————
Seriola nigrofasciata	black-barred amberjack/lapis	Roxas and Agco (1941)	reported from Bicol River
	FORMIONIDAE (butterfishes, pomfrets/pampano)		
Formio niger	black butterfish, black pomfret/pampano	Umali (1937)	————
	MENIDAE (moonfishes/bilong-bilong)		
Mene maculata	spotted moonfish/bilong-bilong, tabas	IFDR/ICLARM Project	"rarely entering estuaries" (Munro 1967)
	LEIOGNATHIDAE (slipmouth, ponyfish, silverbellies/sapsap, dalupani, tambong)		
Gazza minuta	toothed ponyfish/—	Herre (1953)	reported from brackishwaters (refs. in Pauly and Wade-Pauly 1981)
Gazza achlamys	toothed ponyfish/sapsap	Tiews and Caces-Borja (1965)	reported from brackishwaters (refs. in Pauly and Wade-Pauly 1981)
Leiognathus bindus	orangefin ponyfish/dalupani	Tiews and Caces-Borja (1965)	————
Leiognathus daura	black-finned slipmouth, gold stripe pony fish/daguldulan, dalupani, tambung	Conlu (1980a)	reported from brackishwaters (refs. in Pauly and Wade-Pauly 1981)
Leiognathus elongatus	elongated slipmouth/dalupani	Conlu (1978)	————
Leiognathus blochi	—/—	Tiews and Caces-Borja (1965)	reported from brackishwaters (refs. in Pauly and Wade-Pauly 1981)
Leiognathus dussumieri	—/—	Tiews and Caces-Borja (1965)	"marine, and entering rivers and lakes" (Herre 1953)
Leiognathus equulus	common ponyfish/barorog, barusog	Umali (1937)	"in the sea, brackishwaters and entering rivers" (Herre 1953)
Leiognathus fasciatus	banded slipmouth/mutamot, striped ponyfish, tabiros	Umali (1937)	reported from brackishwaters by Pillay (1967)
Leiognathus smithursti	Smithurst's ponyfish/dalupani	Umali (1937)	reaches 20 cm
Leiognathus leuciscus	whipfin ponyfish/—	Tiews and Caces-Borja (1965)	————
Leiognathus splendens	splendid ponyfish/mutamot	Umali (1937)	reported from brackishwaters (Herre 1953)
Leiognathus elongatus	elongated ponyfish/—	IFDR/ICLARM Project	————
Secutor insidiator	wily slipmouth, pugnose pony-fish/bilong-bilong, damul-damul, sakmo	Umali (1937)	"marine, and entering rivers" (Herre 1953)
Secutor ruconius	spotted slipmouth, deep pugnose ponyfish/pirak-pirak, tabiros	Umali (1937)	"marine and entering rivers" (Herre 1953)
	LUTIANIDAE (snappers/—)		
Lutjanus argentimaculatus	mangrove red snapper/aliso, batangal, kisang, managagat, pargo	Umali (1937)	"marine, entering rivers and lakes" (Herre 1950)
Lutjanus malabaricus	Malabar red snapper/langit, pulahan, talutoon, dapak	Umali (1937)	euryhaline, included in Herre (1958)
Lutjanus fulvus	flame colored snapper/ tingarog	Umali (1937)	————

Appendix 1 (continued)

		EPHIPPIDAE (—/riring)	
Drepane punctata	spotted sicklefish/riring,	Herre and Montalban (1927)	reported from the Bicol River "reaches half a meter in length" (Herre 1953)
Drepane longimana	—/—	NMP collection	———
Platax orbicularis	leaf fish/bayang, dalapugan, kulyong, paras	Herre and Montalban (1927)	"marine but entering river mouths" (Herre 1953)
		SCATOPHAGIDAE (—/—)	
Scatophagus argus	—/bayang, kikiro, kitang	Herre and Montalban (1927)	"in the sea and in rivers and lakes" (Herre 1953)
		CHAETODONTIDAE (butterflyfishes/—)	
Chaetodon adiergastos	—/—	Herre and Montalban (1927)	———
Chaetodon octofasciatus	eight banded butterflyfish/—	Conlu (1980a)	———
		POMACENTRIDAE	
Abudefduf bengalensis	—/—	Montalban (1928)	"marine and entering river mouths" (Herre 1953)
Abudefduf coelestinus	—/—	Montalban (1928)	"in the sea and brackish waters" (Herre 1953)
		MUGILIDAE (mullets/araran, tabudyos, banak, balanak; large mullets (spawners) are called "aguas saranao, or agwas"; mullet fry is referred to as "gisao", or "ararang")	
Liza subviridis	greenback grey mullet/—	Conlu (1977)	*Mugil dussumieri* is a synonym; euryhaline, included in Herre (1958)
		SPHYRAENIDAE (barracudas/teako, rompe (when large), batig titso, or buleos (when small), dugso batog)	
Sphyraena jello	banded barracuda/batog, dugso, rompe kandado, manabang (large)	IFDR/ICLARM Project	euryhaline (Whitfield et al. (1981)
Sphyraena obtusata	obtuse barracuda/batog, dugso, rompe	IFDR/ICLARM Project	euryhaline (Whitfield et al. (1981)
		POLYNEMIDAE (threadfins/baka-dulce)	
Eleutheronema tetradactylum	fourfinger threadfin/hugao	Herre (1953)	"entering estuaries and rivers" (Herre 1953)
Polynemus microstomus	black spot threadfin/akin-akin, kuwa-kuwa	Umali (1937)	"entering estuaries and rivers" (Herre 1953)
		ELEOTRIDAE (sleepers/—)	
Ophiocara porocephala	—/palu	Herre (1927)	"in fresh and salt water" (Herre 1953)
		GOBIIDAE (gobies/—)	
Ctenogobius caninus	—/—	Herre (1927)	"in bays and estuaries and entering freshwater rivers" (Herre 1953)
Glossogobius giurus	white goby/bakla, batug, mulog, oro-on, sugunayon	Herre (1927)	reported from Lake Buhi, Bicol River and San Miguel Bay by Herre (1953)
Glossogobius giurus var *obscuripinnis*	golden goby/—	Peters (1868)	reported from Bicol River and Lake Bato
Gobius sp.	—/—	Tiews et al. (1972)	reported from the stomachs of *Saurida tumbil*
Oxyurichthys ophthalmonema	—/—	NMP collection	"in the sea and brackish and fresh-water" (Herre 1953)

Appendix 1 (continued)

	NEMIPTERIDAE (threadfin breams/bisugo)		
Nemipterus japonicus	Japanese threadfin bream/ kanasi	Conlu (1977)	———
Nemipterus nematophorus	—/kanasi	IFDR/ICLARM Project	———
Scolopsis taeniopterus	monocle bream/buroha	Conlu (1978)	———
Scolopsis vosmeri	whitecheek monocle bream/	Conlu (1978)	———
	GERRIDAE (mojarras/—)		
Gerres filamentosus	whipfin, or spotted mojarra/ latab, malagapas, sakalan	Montilla (1935)	"in the sea and rivers and lakes" (Herre 1953)
Pentaprion longimanus	longfinned mojarra/—	Conlu (1978)	"marine and in brackishwaters" (Herre 1953)
	POMADASYDAE (grunts/—)		
Pomadasys hasta	silver grunt/aguot; balay, ulibalay, kiskisan	Umali (1937)	euryhaline, included in Herre (1958)
Pomadasys argyreus	—/—	NMP collection	"entering bays and rivers" (Munro 1967)
Pomadasys maculatus	blotched grunt/tabal-tabal	IFDR/ICLARM Project	———
Pristipomoides microdon	—/taloto-on	Herre (1953)	Umali's "deep-bodied pristipomid"
	LETHRINIDAE (emperors/—)		
Lethrinus nebulosus	pearl spotted porgy/bakawel	IFDR/ICLARM Project	euryhaline, included in Herre (1958)
	PENTAPODIDAE (—/—)		
Pentapodus setosus	paradisefish/—	Conlu (1978)	———
	SPARIDAE (porgies, pargos/abo)		
Mylio berda	picnic seabream/bakoko	Umali (1937)	"marine and entering rivers" (Herre 1953)
	SCIAENIDAE (croakers/arakaak)		
Otolithes ruber	tigertooth croaker/abo	Umali (1937)	*O. argenteus* is a synonym. "Marine and entering river mouths" (Herre 1953)
Otolithoides biauritus	—/—	NMP collection	———
Johnieops aneus	—/arakaak	Umali (1937)	"marine and entering rivers" (Herre 1953)
Dendrophysa russelli	goatee croaker/pagotpot	NMP collection	"in the sea and entering rivers" (Herre 1953)
Johnius belengerii	Belanger's croaker/—	NMP collection	"marine, and entering rivers" (Herre 1953)
Johnius dussumieri	bearded croaker/—	NMP collection	———
Pennahia macrophthalmus	bigeye croaker/—	Conlu (1978)	———
	MULLIDAE (goatfishes/agingoy, amarilis, saramulyete; large specimen also called "timbungan.")		
Parupeneus bifasciatus	doublebar goatfish/—	Herre and Montalban (1928b)	reported from near a river mouth by Herre (1953)
Upeneus sulphureus	yellow goatfish/saminayon	Herre and Montalban (1928b)	reported from a river by Herre (1953)
Upeneus sundaicus	ochreband goatfish/—	NMP collection	"marine and in river mouths" (Herre 1953)
Upeneus moluccensis	goldband goatfish/agingoy	Conlu (1978)	———
	PEMPHERIDAE (sweepers/—)		
Pempheris moluca	Moluccan sweeper/—	Conlu (1978)	———

Appendix 1 (continued)

	TRYPAUCHENIDAE (–/–)		
Trypauchenichthys typus	–/–	Conlu (1980a)	a rare marine fish
	ACANTHURIDAE (doctorfishes, surgeonfishes/kalditan, salinkupao, uwakon, yaput, indangan)		
Acanthurus matoides	–/–	Herre (1927)	———
	SIGANIDAE (rabbitfishes/baliwis, mublad, bataway, turos, toros, dangit, kuyog, batawayi; siganid fry is referred to as "kuing" or "kuyog")		
Siganus fuscescens	–/–	Herre and Montalban (1928a)	"marine, but entering rivers and lakes" (Herre 1953)
Siganus hexagonata	–/–	Herre and Montalban (1928a)	———
Siganus javus	streaked spinefoot/–	Herre and Montalban (1928a)	"marine and entering rivers and lakes" (Herre 1953)
Siganus oramin	–/–	Herre and Montalban (1928a)	"marine, but entering rivers" (Herre 1953)
Siganus virgatus	blue-line spinefoot/batawayi, mublad, bataway, toros	Herre and Montalban (1928a)	euryhaline, included in Herre (1958)
Siganus canaliculatus	pearly spinefoot/toros, turos, dangit	Conlu (1978)	———
	TRICHIURIDAE (cutlassfishes, hairtails/langkay, liwit, sikwan, lankoy)		
Trichiurus lepturus	cutlassfish/lankoy, langkoy	Umali (1937)	*T. haumela* is a synonym
	SCOMBRIDAE (mackerels, tunas/turingan (subfamily Thunninae)		
Rastrelliger brachysoma	short-bodied mackerel/aguma-a, kabalyas, abobongon, amang	Umali (1937)	———
Rastrelliger kanagurta	striped mackerel/bulau, barao	Umali (1937)	reported as *R. chrysozonus,* a synonym
Scomberomorus commerson	spanish mackerel/tangigi, malaudiyong	Conlu (1978)	———
Auxis sp.	frigate, or bullet mackerel/rayado	Umali (1937)	———
at least one species of tuna	tuna/turingan	Umali (1937)	Umali's "Thunnidae"
	PSETTODIDAE (–/–)		
Psettodes erumei	–/–	IFDR/ICLARM Project	———
	BOTHIDAE (flounders, brills/palad)		
Pseudorhombus arsius	largetooth flounder/palad	NMP collection	"in seas, bays and estuaries" (Herre 1953)
Psettina profunda	–/palad	NMP collection	———
Arnoglossus aspilos	–/palad	NMP collection	———
	SOLEIDAE (solas/palad)		
Microbuglossus ovatus	–/–	NMP collection	———
Pardachirus pavoninus	peacock sole/palad-palad	NMP collection	———
Solea ovata	–/palad-palad	NMP collection	recorded as *S. humilis,* a synonym
Synaptura cornuta	horned sole/palad-palad	Conlu (1979a)	———
Synaptura mulleri	–/palad-palad	Conlu (1979a)	in "sea and rivers" (Conlu 1979a)
	CYNOGLOSSIDAE (tonguesoles/palad)		
Cynoglossus bilineatus	four lined tonguesole/palad	NMP collection	"coastal and brackish waters" (Munro 1967)

Appendix 1 (continued)

Cynoglossus puncticeps	speckled tonguesole/palad	NMP collection	"in salt, brackish and fresh waters" (Herre 1953)
		TRIACANTHIDAE (hornfishes/—)	
Triacanthus blochi	—/—	Herre (1924)	—————
Triacanthus biaculeatus	blackfinned triplespine/—	Conlu (1978)	"sandy bays and estuaries"
		BALISTIDAE (triggerfishes/—)	
Abalistes stellaris	starry filefish/—	Conlu (1979a)	—————
Balistapus verrucosus	—/—	Herre (1924)	—————
Osbeckia scripta	—/—	Herre (1924)	—————
Psilocephalus barbatus	barbeled leatherjacket/—	Conlu (1979a)	—————
		TETRAODONTIDAE (pufferfishes/—)	
Chelanodon patoca	pufferfish/—	Herre (1924)	"a species of salt and brackish, rarely of fresh water" (Herre 1953)
Sphoerodon lunaris	pufferfish/botin, tikong, tamburauan	Herre (1924)	—————

Length-Weight Relationships of Fishes

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Abstract

The length-weight relationships of 26 species of fish from San Miguel Bay, Philippines, have been investigated. Given are the values of the parameters a and b for relationships of the form $W = a \cdot L^b$. Condition factors have been calculated for each species. The mean value of b for all 26 species studied was 3.03, suggesting that the "cube law" (b = 3) can be used, as an approximation, for the length-weight relationship of most San Miguel Bay fishes.

Introduction

The opportunity was taken, in the course of the IFDR-ICLARM Multidisciplinary Project on the Fisheries of San Miguel Bay to sample, measure and weigh fishes, and to use these measurements to establish the length-weight relationships of a number of species caught within San Miguel Bay. This paper presents an analysis of these measurements.

Materials and Methods

All sampling was done at landings of the inner part of San Miguel Bay (Sabang, Calabanga and Cabusao), from May 1980 to April 1981. Although many more fish were weighed and measured than those presented here, uncertainties concerning the identification of certain fishes that were measured prevented the inclusion of more than the data summarized in Table 1. Thus, this paper reports on 26 species, grouped in 22 genera and 14 families. The length-weight relationship of the croaker, *Otolithes ruber*, one of the most abundant fishes of San Miguel Bay is not investigated here (but see Navaluna, this report).

Each of the 758 fish reported upon here was measured to the nearest millimeter in terms of total length, i.e., from the tip of the snout to the end of the longest caudal ray; the weights were determined for each fish separately to the nearest gram by means of a triple beam balance. All measurements and weighings were made on land.

Table 1. Details on samples used for the determination of the length-weight relationships of San Miguel Bay fishes.

No.	Family	Species	n	Smallest	Largest
1	Clupeidae	*Sardinella albella*	118	9	15
2	Clupeidae	*Dussumeria acuta*	7	11.5	14
3	Engraulidae	*Stolephorus commersonii*	6	7.5	9
4	Engraulidae	*Stolephorus indicus*	53	6.5	10
5	Engraulidae	*Thryssa hamiltoni*	12	11.5	17
6	Synodontidae	*Saurida tumbil*	10	14	20.5
7	Sphyraenidae	*Sphyraena jello*	12	10.5	22
8	Polynemidae	*Polynemus microstomus*	3	12	14
9	Scombridae	*Rastrelliger brachysoma*	5	17	18.5
10	Scombridae	*Scomberomorus commerson*	12	13	22
11	Trichiuridae	*Trichiurus lepturus*	8	15.5	30.5
12	Carangidae	*Alepes djeddaba*	12	9.5	19.5
13	Carangidae	*Alepes kalla*	173	8	19
14	Carangidae	*Caranx malabaricus*	15	11	19.5
15	Carangidae	*Megalaspis cordyla*	18	12	19.5
16	Carangidae	*Scomberoides lysan*	31	17.5	20.5
17	Leiognathidae	*Gazza minuta*	5	7	9.5
18	Leiognathidae	*Secutor insidiator*	7	7.5	9.5
19	Leiognathidae	*Secutor ruconius*	30	3	7
20	Nemipteridae	*Scolopsis taeniopterus*	8	8.5	12
21	Pomadasydae	*Pomadasys hasta*	33	10	16
22	Mullidae	*Upeneus sulphureus*	9	9	12
23	Sciaenidae	*Dendrophysa russelli*	53	7	14.5
24	Sciaenidae	*Pennahia macrophthalmus*	64	7.5	17
25	Sillaginidae	*Sillago maculata*	17	11.5	15
26	Sillaginidae	*Sillago sihama*	37	10	21

Total: 14 families, 22 genera, 26 species and 758 fish measured.

Table 2. Length-weight relationships of San Miguel Bay fishes, with results of tests for the value of b.

No.	Species	r^2	a	b	$\overline{\text{c. f.}}$	t	df
1	*Sardinella albella*	0.982	0.0236	2.621	0.912	11.189**	116
2	*Dussumeria acuta*	0.927	0.0059	3.062	0.695	0.161	5
3	*Stolephorus commersonii*	0.971	0.0141	2.720	0.784	1.199	4
4	*Stolephorus indicus*	0.979	0.0041	3.325	0.811	5.241**	51
5	*Thryssa hamiltoni*	0.975	0.0246	2.610	0.873	2.926*	10
6	*Saurida tumbil*	0.998	0.0047	3.143	0.707	1.141	8
7	*Sphyraena jello*	0.982	0.0025	3.245	0.494	1.773	10
8	*Polynemus microstomus*	1.000	0.0056	3.229	1.002	62.9**	1
9	*Rastrelliger brachysoma*	0.969	0.0150	2.896	1.111	0.347	3
10	*Scomberomorus commerson*	0.986	0.0084	2.914	0.657	0.776	10
11	*Trichiurus lepturus*	0.968	0.00015	3.427	0.057	1.672	6
12	*Alepes djeddaba*	0.918	0.0169	2.761	0.905	0.913	10
13	*Alepes kalla*	0.989	0.0068	3.145	0.989	5.600**	171
14	*Carangoides malabaricus*	0.963	0.0047	3.384	1.282	2.100	13
15	*Megalaspis cordyla*	0.979	0.0070	3.084	0.882	0.736	16
16	*Scomberoides lysan*	0.995	0.0017	3.435	0.604	9.309**	29
17	*Gazza minuta*	0.987	0.0120	3.122	1.553	0.589	3
18	*Secutor insidiator*	0.970	0.0245	2.715	1.327	1.344	5
19	*Secutor ruconius*	0.983	0.0140	3.093	1.623	1.193	28
20	*Scolopsis taeniopterus*	0.961	0.0074	3.226	1.253	0.849	6
21	*Pomadasys hasta*	0.999	0.0180	2.927	1.497	3.879**	31
22	*Upeneus sulphureus*	0.773	0.082	3.214	1.355	0.325	7
23	*Dendrophysa russelli*	0.990	0.0071	3.201	1.136	4.490**	51
24	*Pennahia macrophthalmus*	0.993	0.0130	3.000	1.296	0.001	62
25	*Sillago maculata*	0.976	0.0322	2.288	0.504	7.692**	15
26	*Sillago sihama*	0.968	0.0092	2.937	0.775	0.717	35

*b is significantly different from 3 (P = 0.05)
**b is significantly different from 3 (P = 0.01)

The data were tabulated and the weight measurements grouped and averaged by length class. Then, the parameters a and b of the relationship

$$W = a \cdot L^b \qquad \ldots \quad 1)$$

were estimated for each species, using a linearized version of expression (1) of the form

$$\log_{10} W = \log_{10} a + b \log_{10} L \qquad \ldots \quad 2)$$

which can be fitted using standard linear regression techniques (Poole 1974). Fitting was done here using a HP97 programmable calculator and a program provided by D. Pauly, ICLARM (pers. comm.) which allows for weighting the data by sample size, which was done throughout.

Mean condition factors (c. f.), defined as

$$\overline{\text{c. f.}} = \frac{\Sigma(W \cdot 100/L^3)}{n} \qquad \ldots \quad 3)$$

where computed for each species (the multiplication by 100 in this expression ensures that the resulting condition factors range, in fishes with "normal" shapes, between 0.5 and 1.5). It will be noted that, by definition c.f./100 = a in equation (1) when b = 3; t - tests were performed to test whether the estimated b values in expression (2) differed significantly from a value of 3. The standard errors (S.E.) of the b values were estimated from

$$\text{S.E. (b)} = \frac{S^2_{y-x}}{\Sigma x^2}^{1/2} \qquad \ldots \quad 4)$$

where S^2_{y-x} is the variance in Y (= $\log_{10}$ W), given that the variance attributable to X (= $\log_{10}$ L) has been removed by the regression (Poole 1974) while Σx^2 is the sum of the squared x values. Then the t-values were estimated for each species from

$$t = \frac{|b-3|}{\text{S.E. (b)}} \qquad \ldots \quad 5)$$

and compared with tabled values of the t-distribution (d.f. = n - 2) (Vanichkul and Hongskul 1966; Poole 1974). The results are summarized in Table 2. Fig. 1 gives a frequency distribution of the estimated b values. The mean value of b is 3.028, with s.d. = 0.281.

Discussion

Although the number of fish per species involved in this study is rather small, the material was sufficient to help confirm the results of Carlander (1969), who, based on a much larger sample, found that the values of b of fishes are normally distributed about a mean equal to 3. Moreover, it was found that all but one of the values of b that differed *significantly* from 3 were actually rather close to 3 (i.e., larger than 2.5 and smaller than 3.5). The latter point suggests that, as Carlander (1969) suspected, values of b > 3.5 or < 2.5 are Indeed misleading values, based on too few fish a range of fish lengths that is too small.

Also, it must be realized that irrespective of the "significance" of any departure from a value of 3, values of b (and a) can be used for length/weight conversion only if they are based on a large

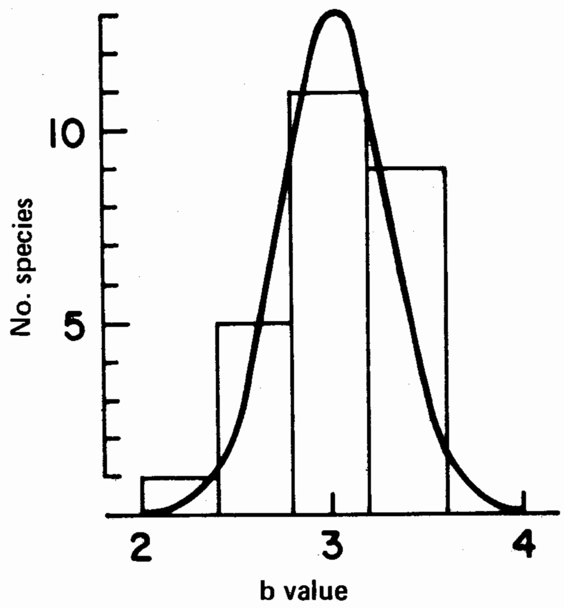

Fig. 1. Frequency distribution of values of the exponent (b) of the length-weight relationships of San Miguel Bay fishes, with superimposed normal curve ($\bar{x}$ = 3.028, s.d. = 0.281, n = 26).

number of fish and cover a wide range of sizes. In all other cases—i.e., in most cases represented in Table 2—it will be more appropriate to use for length-weight conversion the condition factors given in Table 2, along with a value of b = 3.

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Morphometrics, Biology and Population Dynamics of the Croaker Fish, *Otolithes ruber*

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Abstract

Morphometric data on the San Miguel Bay, Philippines, population of the demersal fish *O. ruber* are presented and discussed.

Length-frequency data referring to the periods 1958-61 and 1980-81 were analyzed in detail, using a computer-based method. The results suggest that in the last 20 years the growth of *O. ruber* has not changed much but that total mortality has increased markedly.

Total standing stock and spawning stock were estimated, based on present catch data and estimated fishing mortality. Annual egg production and egg-to-recruit mortality were estimated, based on calculated fecundity and available information on spawning periodicity.

A yield-per-recruit analysis was performed, which suggests that the *O. ruber* stock in San Miguel Bay is overfished.

Introduction

Otolithes ruber (Fig. 1) belongs to the family Sciaenidae, commonly called "croakers", marine and estuarine fishes occurring along most tropical and subtropical shores. They are carnivorous and abound in sandy and muddy grounds, but do not inhabit rocky areas.

Of the several species of croakers in San Miguel Bay (see Pauly, this report), *Otolithes ruber*, a slender, moderately-sized species locally known as "abo", was chosen for detailed investigation because it is the most abundant croaker and one of the major fish species of the Bay, where it is a first-class fish (locally termed "hoya") and commands a comparatively high price in the market.

It was the purpose of this study to contribute to the knowledge of the biology and the fishery of *Otolithes ruber*, particularly in San Miguel Bay. The study had the following specific objectives:

1. To provide a detailed description of the *Otolithes ruber* population in the San Miguel Bay area, including morphometrics,
2. To determine the growth and the length-weight relationship of the stock,

3. To estimate the total, natural and fishing mortalities of *Otolithes ruber* in San Miguel Bay,
4. To identify selection and recruitment patterns from the length-frequency samples,
5. To determine the present (1980-1981) catch of *Otolithes ruber* from San Miguel Bay,
6. To determine the present population size of *O. ruber* in San Miguel Bay,
7. To estimate recruitment of young *O. ruber* into the usable stock.

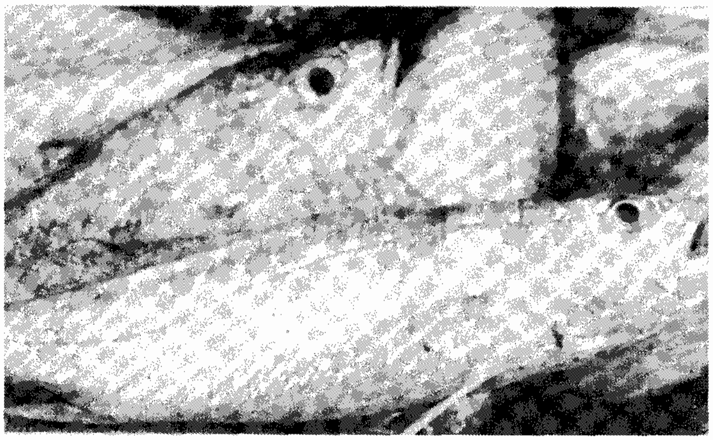

Fig. 1. The tiger-toothed croaker (*Otolithes ruber*, Sciaenidae).

Material and Methods

MORPHOMETRICS OF *OTOLITHES RUBER*

Morphometric and meristic characters were obtained from a sample of 86 specimens of *O. ruber*; 32 were used for the determination of the relationship between body length and gut length, while the remaining 54 fish were used for the other characters. Meristic characters were assessed which others, notably Fischer and Whitehead (1974) and Lowe-McConnell (1978) have used for this and similar species. Table 1 lists the meristic characters studied here.

Morphometric characters (Table 2) are reported as ratios, e.g., of head length to body length, with range, mean and standard deviation given for each ratio. Also, all linear measurements were plotted against standard length and fitted with linear regressions of the form

$$y = a + bx \qquad \ldots \quad 1)$$

where y is a linear measurement and x is the standard length.

The length-weight relationship of *O. ruber* in San Miguel Bay was established using the length and weight measurement of 105 fish. The fitted equation has the form

$$W = a \cdot L^b \qquad \ldots \quad 2)$$

where W is the weight of the fish and L their length. Fitting was done using the method also used by Cinco (this report).

FECUNDITY OF *O. RUBER*

The fecundity of ten mature female specimens of *O. ruber* was determined. For each specimen, the weight of the fish and of its ovary were recorded, and a sample of the ovary was taken which was preserved in formalin, and later in modified Gilson's fluid. The ovary samples were then sub-sampled and counted, using the method described in Bagenal and Braum (1978).

Table 1. Meristic characters of *Otolithes ruber.*

	Original data[1] Range	Mean	s.d.	Other source[2] Counts	Similar species[2] Counts
1. Dorsal spine:					
anterior part	10 – 10	10	0	9 – 10	
posterior part	1 – 1	1	0	1	
total	11 – 11	11	0	10 – 11	
2. Dorsal ray	27 – 30	28	0.55	27 – 30	
3. Anal spine	2 – 2	2	0	2	
4. Anal ray	7 – 7	7	0	7	10-11 in *Pterolithus maculatus*
5. Pectoral fin ray	15 – 16	16	0.33	16[3] – 19[3]	
6. Pelvic fin spine	1 – 1	1	0	1[3]	
7. Pelvic fin ray	5 – 5	5	0	5[3]	
8. Gill rakers: lower limb	9 – 11	10	0.57	8 – 11	12-14 in *O. cuvieri*
9. Swim bladder appendages:					
left side	32 – 38	36	1.28		
right side	32 – 39	36	1.47	32 – 36,	28 in *O. cuvieri*
total	64 – 76	71	2.35	in adults	
10. Canine teeth:					
upper jaw	3 – 5	4	0.42	2 – 4	
lower jaw	1 – 3	2	0.57	2	
total	4 – 8	6	0.70	4 – 6	

[1] n = 50.
[2] Fischer and Whitehead (1974).
[3] For Sciaenidae in general.

Table 2. Morphometric characters of *Otolithes ruber.*[a]

	Range	Mean	s.d.
1. Standard length/body depth	3.63 – 4.38	4.04	0.165
2. Snout/eye diameter	1.10 – 1.58	1.24	0.098
3. Head length/eye diameter	4.11 – 5.50	4.79	0.282
		as % of standard length	
4. Length of caudal peduncle	5.69 – 11.3	7.91	0.946
5. Head length	30.8 – 33.6	31.9	0.789
6. Postorbital	14.4 – 19.8	17.4	0.972
7. Dorsal fin base	57.2 – 62.6	59.6	1.18
8. Anal fin base	7.20 – 10.0	8.12	0.481
9. Length of pectoral fin	20.3 – 24.5	22.4	0.888
10. Length of pelvic fin	16.3 – 20.0	18.3	0.720
11. Body depth	22.8 – 27.6	24.8	1.00
12. Girth	63.9 – 83.2	70.2	3.56
13. Gut length	52.6 – 87.7	68.7	10.0
		as % of head length	
14. Lower jaw	50.8 – 57.1	53.2	1.48
15. Upper jaw	37.8 – 42.8	40.6	1.18
16. Snout length	23.1 – 30.2	26.0	1.36
17. Eye diameter	18.2 – 24.3	20.9	1.23

[a] n = 54 for all characters, except gut length for which n = 32.

ESTIMATION OF GROWTH PARAMETERS FROM LENGTH-FREQUENCY DATA

Length-frequency data were gathered one or more times each month on board trawling vessels operating in San Miguel Bay, from May 1980 to April 1981.

Samples of *Otolithes ruber* were taken after each haul. The total length (LT) of each specimen was measured in centimeters using a fish-measuring board.

The data were then grouped in 1-cm class intervals for each month. The date of collection of each month was noted. Since there were several sampling dates for some months, the monthly assigned dates were averages of two or more dates.

The length-frequency data were then converted into percentages before they were drawn in the form of histograms, arranged in such a way that the distances between them are proportional to the time elapsed between the sampling dates (Fig. 2).

Analysis of the length-frequency data for growth was done using the computer program ELEFAN I (Pauly and David 1981) which provides estimates of the parameters L_∞ and K of the von Bertalanffy Growth Formula (VBGF) of the form

$$L_t = L_\infty \left(1 - e^{K(t-t_o)}\right) \quad \ldots \quad 3)$$

where L_∞ and K are the asymptotic length and a growth constant, respectively (t_o is not estimated by ELEFAN I).

ELEFAN I, through a series of steps, restructures the samples entered. The restructured length-frequency samples are given points, positive points for peaks and negative points for troughs.

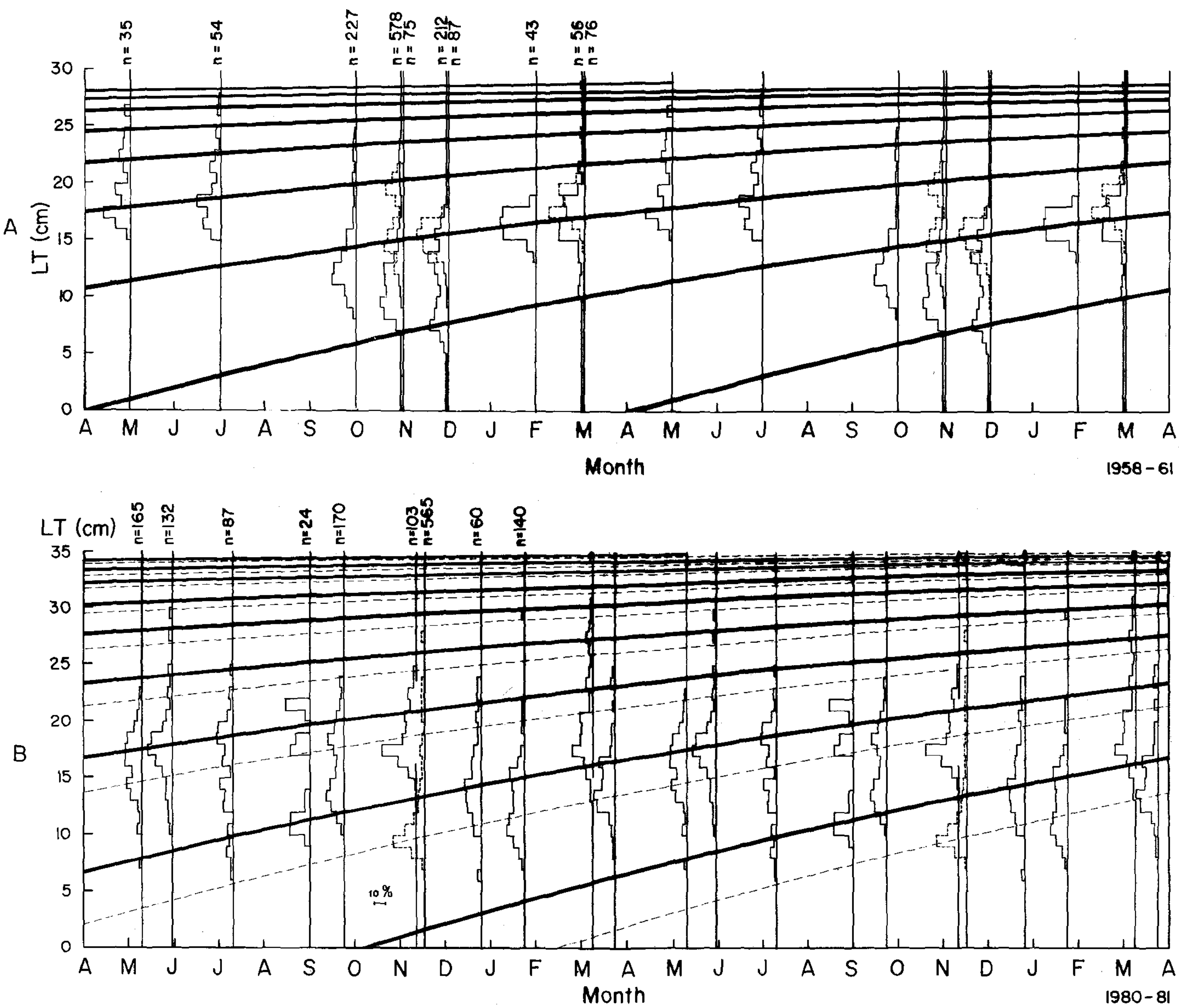

Fig. 2. Length-frequency data of *Otolithes ruber* in San Miguel Bay, with superimposed growth curves as estimated by ELEFAN I. A) data for 1958-61 (courtesy of the Research Division, Bureau of Fisheries and Aquatic Resources); B) data collected in 1980-81.

Using these points, the program searches for the growth curve which passes through most of the peaks and avoids most of the troughs, thus, scoring the highest (optimum) number of points. The goodness of fit of the growth curve traced by ELEFAN I is expressed by the ratio ESP/ASP, where ESP (Explained Sum of Points) is the number of points accumulated by a given growth curve while ASP (Available Sum of Points) is the highest number of points that the best possible growth curve can accumulate for a given set of length-frequency samples. A detailed discussion of the method is given in Pauly et al. (1980).

ESTIMATION OF TOTAL MORTALITY FROM LENGTH-FREQUENCY SAMPLES

The available length-frequency samples were put to another use, the estimation of the total mortality, Z. This was done by adding up all length-frequency data, then converting them into a catch curve (Ricker 1975) using the relationship

$$\log_e (N/\Delta t) = a + bt' \qquad \ldots \quad 4)$$

where N is the number of fishes in a given length class, Δt is the time needed to grow through that length class, and t' is the relative age (Pauly 1980a).

The equations for computing Δt and t' are

$$\Delta t = \frac{\log_e\left(\frac{L_\infty - L_1}{L_\infty - L_2}\right)}{K} \qquad \ldots \quad 5)$$

and

$$t' = \frac{-\log_e \left(1 - \frac{\underset{\sim}{L}}{L_\infty}\right)}{K} \qquad \ldots \quad 6)$$

where L_∞ and K are parameters of the VBGF, L_1 and L_2 the lower and upper limit of a given length class, respectively, and where $\underset{\sim}{L}$ is the mid-length of a same length class.

Equation (4) has the form of a linear regression where the slope b, with sign changed, represents the total mortality, Z. To convert the length-frequency data into a catch curve, the L_∞ and K values derived from ELEFAN I are used, with $t_o = 0$ (hence, "relative" age, see above).

The catch curve is then plotted with $\log_e (N/\Delta t)$ as ordinate and the relative age t' as abscissa. This facilitates the selection of points to be included in the computation of the total mortality. Only fully selected fishes, represented by the descending part of the catch, curve are included. Also, those fishes within 5% of L_∞ are discarded because their relative age may have been overestimated. Once the points are selected, Equation (4) can be used to estimate Z.

A second method to estimate total mortality from length-frequency samples is the use of the equation

$$Z = \frac{K}{\log_e \left\{ \frac{L_\infty - L'}{L_\infty - \bar{L}} \right\}} \qquad \ldots \quad 7)$$

where L_∞ and K are defined as above, L' is the lower limit of the first length class fully represented in the catch sample, and $\bar{L}$ the mean length of the sampled fish, computed from L' upward (see Pauly 1980a). L' is here taken as the lower limit of the first length class in the descending part of a catch curve.

ESTIMATION OF NATURAL MORTALITY

The natural mortality of fishes is notoriously difficult to estimate, particularly in stocks for which time series of catch composition and effort data are not available. For this reason, first estimates of natural mortality (M) were obtained from Pauly's (1980b) empirical relationship

$$\log_{10} M = -0.0066 - 0.279 \log_{10} L_\infty + 0.6543 \log_{10} K + 0.4634 \log_{10} T \qquad \ldots \quad 8)$$

where L_∞ is expressed in cm (total length) and where T is the mean environmental temperature in °C (here 28°C, see Mines et al., this report).

Relatively high values of M were obtained (M/K > 2), for which reason another set of assumed values of M were generated, using a value of M/K = 1, which represents the lower limit of the range of M/K values reported in the literature (Beverton and Holt 1959; Pauly 1980b).

ESTIMATION OF FISHING MORTALITY AND EXPLOITATION RATE

With total and natural mortality known, fishing mortality can be estimated from

$$Z = M + F \qquad \ldots \quad 9)$$

while the exploitation rate (E) is estimated from

$$E = F/Z \qquad \ldots \quad 10)$$

where

$$Z = M/(1-E) \qquad \ldots \quad 11)$$

DERIVATION OF SELECTION PATTERN

"Selection patterns" are constructed by projecting backward the straight, descending part of a catch curve. A series of ratios is then obtained by dividing the sampled number by the expected number (as computed from the backward projection of the descending portion of the catch curve), for each length class of the ascending part of the catch curve. When the ratios (converted into percentage) are plotted against their corresponding length, this results in a "selection pattern" which resembles a selection curve but is actually a "resultant curve" (Gulland 1969; Pauly et al. 1981).

From a selection pattern, values of L_c' (corresponding to L_c in a selection curve) were estimated graphically (Fig. 6). L_c' serves here as an index of the mean size at first capture ($L_c' \approx L_c$) (Pauly et al., in press).

RECRUITMENT PATTERN

Recruitment patterns are obtained by projecting the available length-frequency data onto the time axis using a set of growth parameters. The peaks and troughs of the length-frequency samples reflect the seasonality of recruitment and thus can be used to show the number of recruitment seasons (≈ spawning seasons) per year (see Pauly et al. 1981 and in press for details on the derivation of recruitment patterns).

The methods for the computation of the mortalities, selection patterns and recruitment patterns from length-frequency data are packaged in a computer program called ELEFAN II. Detailed description of the principles and methods are incorporated in Pauly et al. (1981).

DETERMINATION OF THE PRESENT CATCH OF *O. RUBER*

The determination of the present catch of *O. ruber* in San Miguel Bay was part of an effort to estimate the whole catch from the Bay (Pauly, this report). The monthly catch per effort (kg/trip) was determined for all boats/gears which catch *O. ruber.* This was achieved by monitoring fish landings for gill-netters and riding on trawlers, as well as through the collection and standardization of secondary data from the Philippine Fish Marketing Authority (PFMA) (Pauly et al., this report; Vakily, this report). To complement the catch-per-effort data, the amount of effort (number of boats and annual number of trips) was estimated from survey data obtained by the field staff of the IFDR/ICLARM project and from PFMA data. Total catch was determined by multiplying catch per effort by effort.

DETERMINATION OF STANDING STOCK SIZE

The average biomass ($\overline{B}$) of *O. ruber* in San Miguel Bay was determined using two methods, the swept area method (see Vakily, this report) and a relationship between yield (Y) and fishing mortality of the form

$$\overline{B} = Y/F \qquad \ldots \; 12)$$

The figure used for the mean annual catch per effort of *O. ruber* was 2.22 kg/hr; this figure was used in conjunction with a trawling speed of two knots and a headrope length of 17 m (Vakily, this report).

YIELD-PER-RECRUIT ANALYSIS

Yield per recruit was computed for 3 different sizes at first capture (t_c) using the equation

$$Y/R = F/K \cdot e^{Zr_1} \cdot e^{-Mr_2} \cdot W_\infty \, \{\beta[X, P, Q]\} \qquad \ldots \; 13)$$

where β is the symbol of the incomplete beta function, $X = e^{-Kr_1}$, $P = Z/K$, $Q = b + 1$ (where b is the exponent of the length-weight relationship used to convert L_∞ to W_∞), and $r_1 = t_c - t_o$, $r_2 = t_c - t_r$, with t_r = age at recruitment (Jones 1957; Ricker 1975). The value of t_o was estimated by first assuming that in *O. ruber*, which is a rather slow-growing fish, the ratio L_m/L_∞ should be low, of the order of 0.5 (see Beverton and Holt 1959 and Mitani 1970 for a discussion of the ratio between the length at first maturity (L_m) and the asymptotic length of fish). By assuming further that *O. ruber* reaches maturity at one year, t_o can be obtained by solving the VBGF for the estimated L_m values and t_m = 1 year, i.e.,

$$t_o = \frac{\log_e [1 - (L_m/L_\infty)]}{K} + 1 \qquad \ldots \; 14)$$

The computations of yield per recruit were performed with an HP calculator program provided by Dr. D. Pauly, ICLARM.

ESTIMATION OF PRERECRUITMENT MORTALITY

To estimate mortality from the egg to recruitment stage (i.e., from $t = 0$ to t_r), both the number of recruits produced and the number of eggs produced by the investigated population must be known.

The number of eggs produced annually was estimated by multiplying the number of eggs produced per spawning season (≈ the number of eggs present in the ovary of mature female) times the number of spawning seasons per year (= two). The number of eggs in the ovary of all mature females was determined by multiplying the relative fecundity (no. eggs per gram of female body weight) by 0.5 times the weight of the parent stock, the latter being estimated from

$$B_p = \overline{B} \cdot k \qquad \ldots\ 15)$$

where B_p is the parent stock, i.e., the biomass of all fish at or above L_m and t_m, and $\overline{B}$ is the total standing stock. The value of k, which is a function of fishing mortality, was estimated from

$$k = \frac{e^{-Zr_3}\left(\frac{1}{Z} - \frac{3e^{-Kr_2}}{Z+K} + \frac{3e^{-2Kr_2}}{Z+2K} - \frac{e^{-3Kr_2}}{Z+3K}\right)}{\left(\frac{1}{Z} - \frac{3e^{-Kr_1}}{Z+K} + \frac{3e^{-2Kr_1}}{Z+2K} - \frac{e^{-3Kr_1}}{Z+3K}\right)} \qquad \ldots\ 16)$$

where $r_1 = (t_c - t_o)$,
$r_2 = (t_m - t_o)$,
and $r_3 = (t_m - t_c)$.

The number of recruits of *O. ruber* produced annually by the San Miguel Bay stock was computed under the assumption of approximately steady state conditions from

$$R \approx Y/(Y/R_c) \qquad \ldots\ 17)$$

where Y/R_c is the yield per recruit for recruit of age t_c, estimated for the present level of F; Y is the total annual catch of *O. ruber* from San Miguel Bay.

The natural mortality (of prerecruits) on a daily basis (M_d) was then computed by using the relationship

$$M_d = \frac{\log_e\left(\frac{\text{recruits}}{\text{eggs produced}}\right)}{-t_c} \qquad \ldots\ 18)$$

where t_c is the age in days at first capture and recruitment. Finally, an estimate of the percentage of prerecruits dying per day was obtained from the equation

$$\%\ \text{dying per day} = (1 - e^{-M_d}) \cdot 100 \qquad \ldots\ 19)$$

(Pauly 1980c).

Results

MORPHOMETRICS

Tables 1 and 2 summarize the results obtained from the study of morphometric and meristic characters of *O. ruber* in San Miguel Bay. The meristic characters are in good agreement with those given in Fischer and Whitehead (1974) and sharply distinguish *O. ruber* from related species.

The regressions relating the morphometric characters that were plotted against standard length show that the different parts of the body grow at different rates (Table 3, Fig. 3). These relationships may be used later, along with the values in Tables 1 and 2 to distinguish the San Miguel Bay stock from other stocks of *O. ruber*.

The gut of *O. ruber* is shorter than its standard length (70% of SL), confirming what is known of the carnivorous habits of this species.

Table 3. Relationships between standard length (SL) and other characters.[1]

Character (y)	a	b	r^2
Total length	13.42	1.196	0.994
Gut length	−32.71	0.9103	0.805
Snout length	0.1804	0.0816	0.876
Body depth	−0.9187	0.2552	0.891
Dorsal fin	−0.6805	0.6009	0.987
Anterior dorsal fin	−0.0891	0.2031	0.940
Posterior dorsal fin	−1.371	0.4085	0.975
Anal fin	0.7517	0.0760	0.889
Caudal peduncle	1.517	0.0686	0.607
Head length	1.198	0.3106	0.977
Postorbital	−4.816	0.2074	0.957
Eye diameter	2.127	0.0521	0.869
Pectoral fin	−0.2098	0.2260	0.944
Pelvic fin	2.518	0.1659	0.945
Upper jaw	1.067	0.1220	0.942
Lower jaw	1.401	0.1597	0.949
Girth	−11.63	0.7819	0.921

[1]The relationships were fitted by linear regression with the equation $y = a + b(SL)$; all lengths in mm.

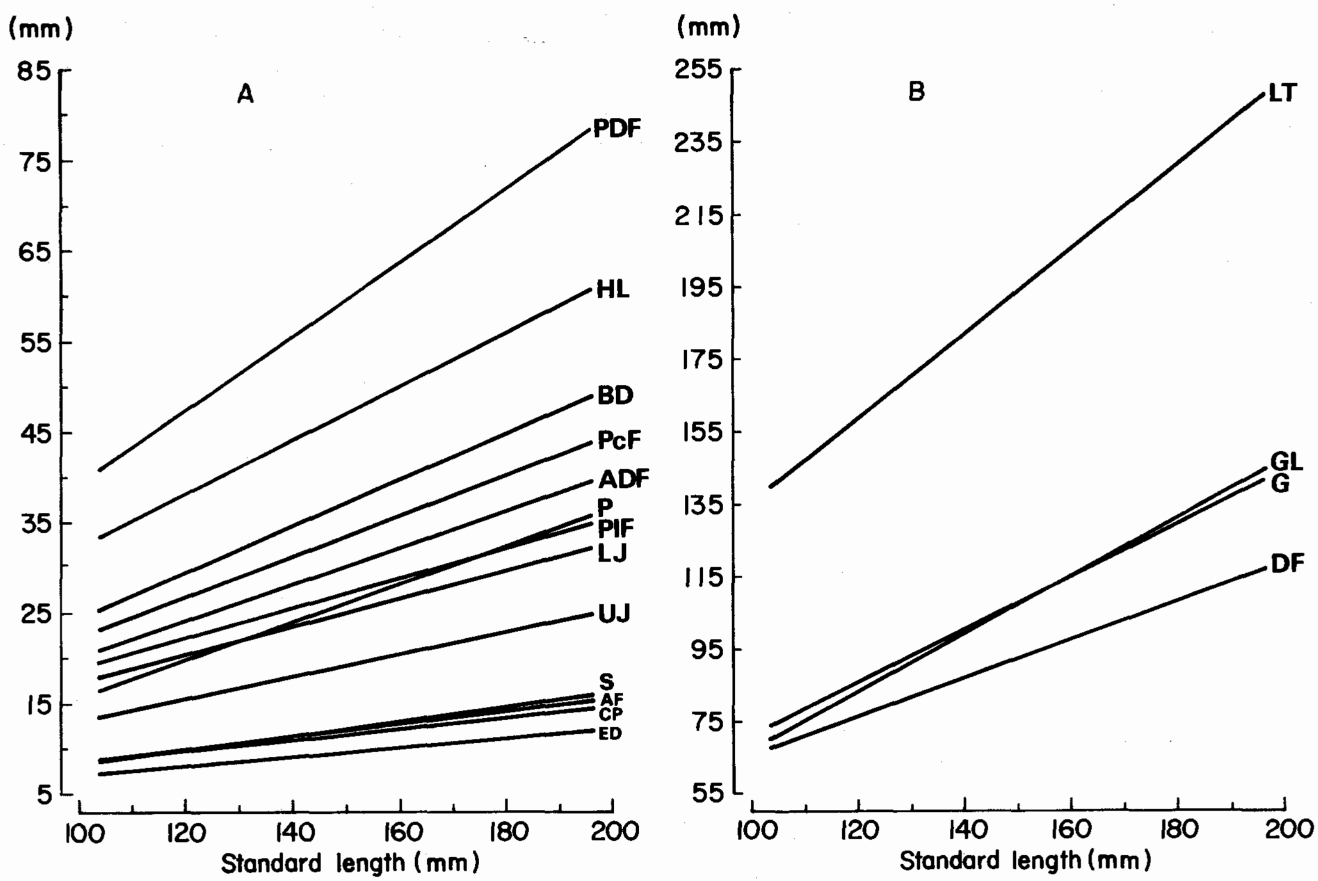

Fig. 3A. Relationship between standard length and other characters (PDF = posterior dorsal fin; HL = head length; BD = body depth; PcF = pectoral fin; ADF = anterior dorsal fin; P = postorbital; PIF = pelvic fin; LJ = lower jaw; UJ = upper jaw; S = snout length; AF = anal fin; CP = caudal peduncle; ED = eye diameter) of *Otolithes ruber.* 3B. Relationship between standard length (SL) and other characters (LT = total length; GL = gut length; G = girth; DF = dorsal fin) of *Otolithes ruber.*

LENGTH-WEIGHT RELATIONSHIP

The length-weight relationship for a combined sample of 105 male and female *O. ruber* is

$$W = 0.00474\ L^{3.24} \qquad \ldots\ 20)$$

or in logarithmic form

$$\log W = -2.324 + 3.24 \log L \qquad \ldots\ 21)$$

with a coefficient of determination $r^2 = 0.995$ (Fig. 4). The exponent of Equation (20) is significantly > 3 ($P = 0.01$), as assessed using the method given in Cinco (this report).

FECUNDITY

Table 4 presents the results of the fecundity study, from which a relative fecundity of about 600 eggs/g of female body weight was established.

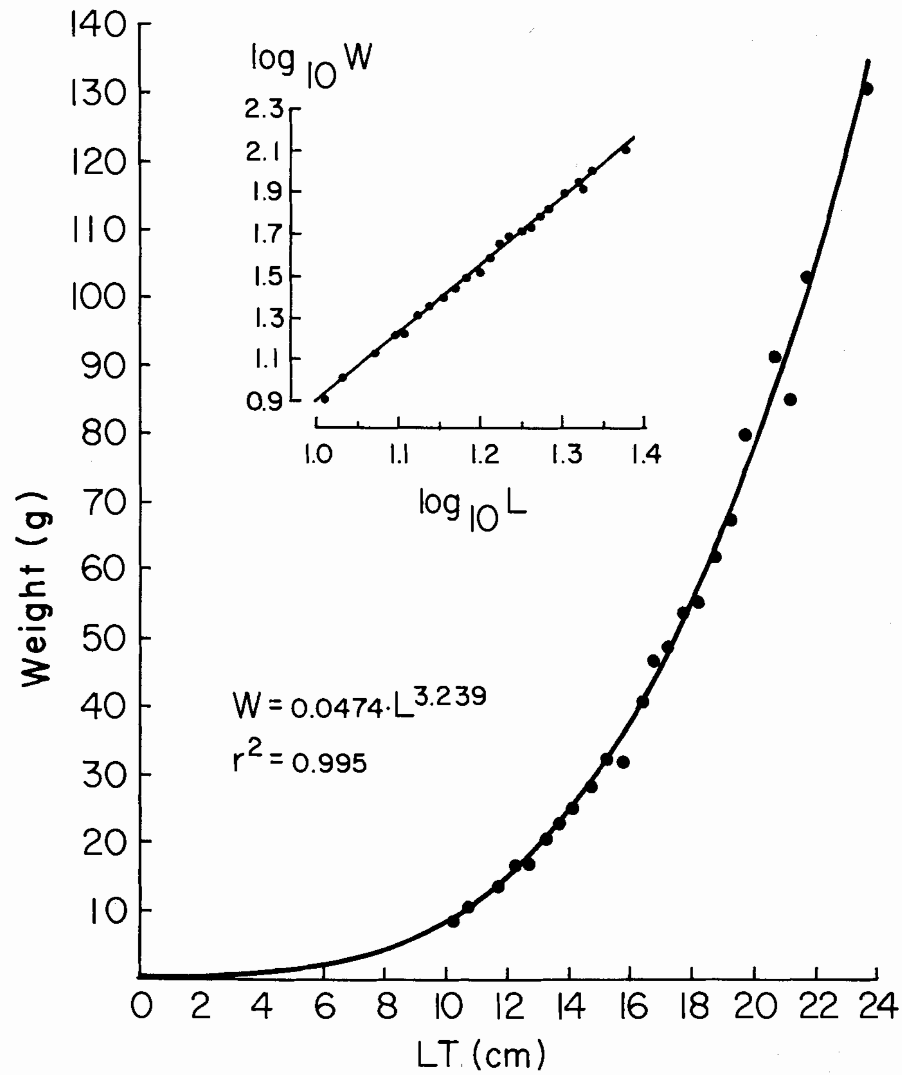

Fig. 4. Length-weight relationship of *Otolithes ruber* in San Miguel Bay, 1980-1981.

Table 4. Apparent fecundity of *Otolithes ruber.*

No.	Wt. fish (g)	Wt. ovary (g)	Total no. eggs*	No. eggs per g adult female
1	114.7	3.9	78,300	683
2	108.9	3.1	74,917	688
3	185.2	5.2	119,080	643
4	94.8	3.1	40,777	430
5	101.5	5.4	67,358	664
6	103.9	3.3	50,325	484
7	97.7	2.7	31,480	322
8	126.7	4.0	82,800	654
9	101.2	3.9	76,500	756
10	141.0	5.3	88,705	629
			mean	≈ 600

*Based on counting egg numbers in ovary samples of about 1/3 of total ovary (see text).

GROWTH

Table 5 gives the results of the growth studies. As might be seen, the growth parameters extracted from the length-frequency data in Fig. 2 for the periods 1958-61 and 1980-1981 do not differ much from each other. However, the data suggest the presence of only one cohort of fish in 1958-61 as opposed to two cohorts for the present data. The estimates of longevity obtained from ELEFAN I range between nine to ten years; the fit (ESP/ASP values), although it cannot be tested rigorously, seems by comparison with data derived from similar data sets (Ingles and Pauly 1982) high enough to make the growth estimates appear reliable.

Table 5. Estimated growth parameters of *Otolithes ruber* from length-frequency data by ELEFAN I.

Parameter estimated	1958-1961 single cohort	1980-1981 1st cohort	1980-1981 2nd cohort
L_∞ (cm)	29.5	35.5	35.6
K (per year)	0.455	0.43	0.43
Longevity (yr)	9.0	9.9	9.5
ESP	11.9	10.1	7.1
ASP	19.8	27.0	27.0
ESP/ASP	0.60	0.37	0.26

MORTALITIES AND EXPLOITATION RATIO

Table 6 summarizes the estimates of total mortality obtained from the catch curves (Fig. 5) and from the mean length in the catch as well as the estimates of natural and fishing mortalities. As might be seen, the various methods used, although differing slightly in their specific values, all suggest an increase in total mortality from 1958-61 to 1980-81, attributable to an increased fishing mortality. This becomes even clearer when the estimated range of values for each parameter is given, irrespective of the method used for estimation (Table 7).

SELECTION AND RECRUITMENT PATTERNS

The selection patterns for 1958-61 and 1980-81 (Fig. 6) suggest that 1958-61 length-frequency samples used for this analysis were collected with a mesh size similar to that used for the 1980-81 samples.

Table 6. Summary of mortalities and exploitation rate obtained by ELEFAN II.

	1958-1961	1980-1981
M_1 (empirical formula)	1.07	0.98
M_2 (M/K = 1)	0.46	0.43
Z_1 (catch curve)	1.45	1.89
Z_2 (mean length)*	1.96	2.67
F_1 ($Z_1 - M_1$)	0.38	0.91
F_2 ($Z_1 - M_2$)	1.00	1.46
F_3 ($Z_2 - M_1$)	0.89	1.69
F_4 ($Z_2 - M_2$)	1.51	2.24
E_1 ($F_1 - Z_1$)	0.26	0.48
E_2 (F_2/Z_1)	0.69	0.77
E_3 (F_3/Z_2)	0.45	0.63
E_4 (F_4/Z_2)	0.77	0.84

*For the 1958-1961 data, the values used for computation are: L_∞ = 29.5 cm, K = 0.455, $\bar{L}$ = 18.8 cm and L' = 16. For 1980-1981 the values are L_∞ = 35.5 cm, K = 0.43, $\bar{L}$ = 20.6 cm and L' = 18.

Table 7. Ranges of mortalities and exploitation rate.

	1958-1961	1980-1981
M	0.46 – 1.07	0.43 – 0.98
F	0.38 – 1.51	0.91 – 2.24
Z	1.45 – 1.96	1.89 – 2.67
E	0.26 – 0.77	0.48 – 0.84

The recruitment patterns, on the other hand (Fig. 7), differ considerably, with the recruitment pattern for 1958-61 suggesting a single, long spawning/recruitment season, while the recruitment pattern for 1980-81 suggests two spawning/recruitment seasons in one year. Whether this difference is due to the low quality of the samples, or reflects a real difference in the breeding habits of *O. ruber* in San Miguel Bay cannot be assessed.

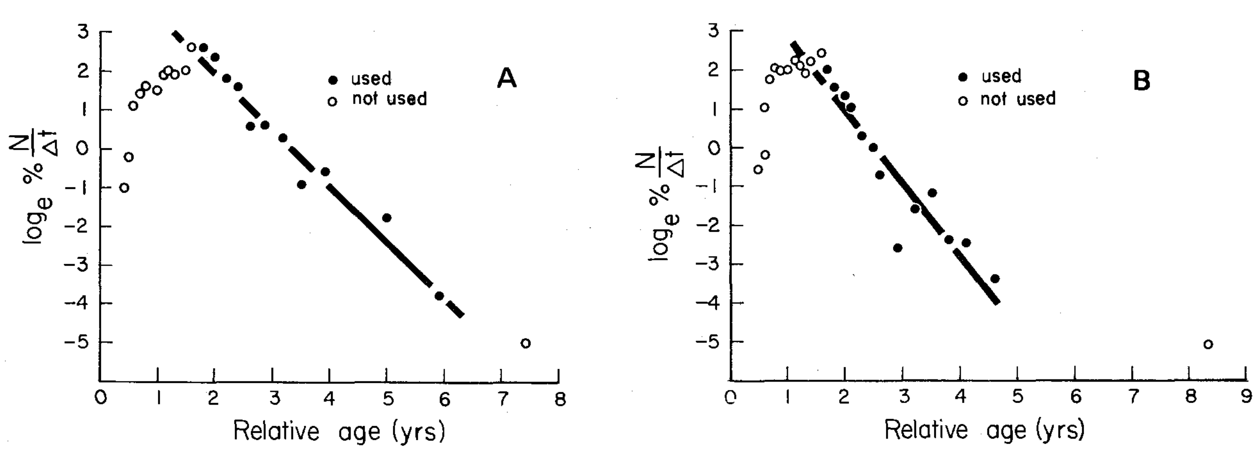

Fig. 5. Length-converted catch curve for *Otolithes ruber* in San Miguel Bay (A = 1958-61, B = 1980-81). Note increase in steepness of catch curve, indicating increased total mortality (see text).

Table 8. Catch (in kg) of *Otolithes ruber* in San Miguel Bay by gear type and month (1980-1981).

Gear type	F	M	A	M	J	J	A	S	O	N	D	J	Σ
Trawlers (medium and small)	66,489	48,751	34,739	27,445	37,644	28,071	35,590	23,245	28,828	5,691	11,536	39,644	387,673
Trawlers (large)	–	–	–	–	–	–	–	8,815	10,932	2,158	–	–	21,905
Gill-net (panke)	112,898	113,483	200,058	200,642	103,538	102,369	127,522	98,859	88,914	143,316	198,888	79,555	1,570,042
Gill-net (palataw)	–	–	–	–	–	–	5,381	6,404	–	–	–	12,108	23,893
Total	179,387	162,234	234,797	228,087	141,182	130,440	168,493	137,323	128,674	151,165	210,424	131,307	2,003,513
% of annual catch	9.0	8.1	11.7	11.4	7.0	6.5	8.4	6.9	6.4	7.5	10.5	6.6	100

PRESENT CATCHES OF *O. RUBER* IN SAN MIGUEL BAY

Table 8 summarizes the catch data for *O. ruber* in San Miguel Bay, for the period 1980-1981, by month and gear type. As might be seen, *O. ruber* contributes about 2,000 t or 14% of the catch from the Bay.

Fig. 8 shows how the catch of *O. ruber* by trawlers oscillates seasonally. However, as might be seen from Table 8, these oscillations are somehow dampened by the more steady catch of the gill-netters, to the effect that as a whole, the supply of *O. ruber* in San Miguel Bay oscillates less than that of any other major group caught in San Miguel Bay.

STANDING STOCK SIZE

The computation of the mean biomass of *O. ruber* in San Miguel Bay, using the "swept area method" results in an area swept in one hour of 0.0315 km^2 and a biomass of

$$\bar{B} = \frac{0.00222 \cdot 840}{0.0315 \cdot 0.5} = 118 \text{ t}$$

for the whole of San Miguel Bay, or 141 kg/km^2. This biomass represents the fish accessible at any given time, and to trawlers only.

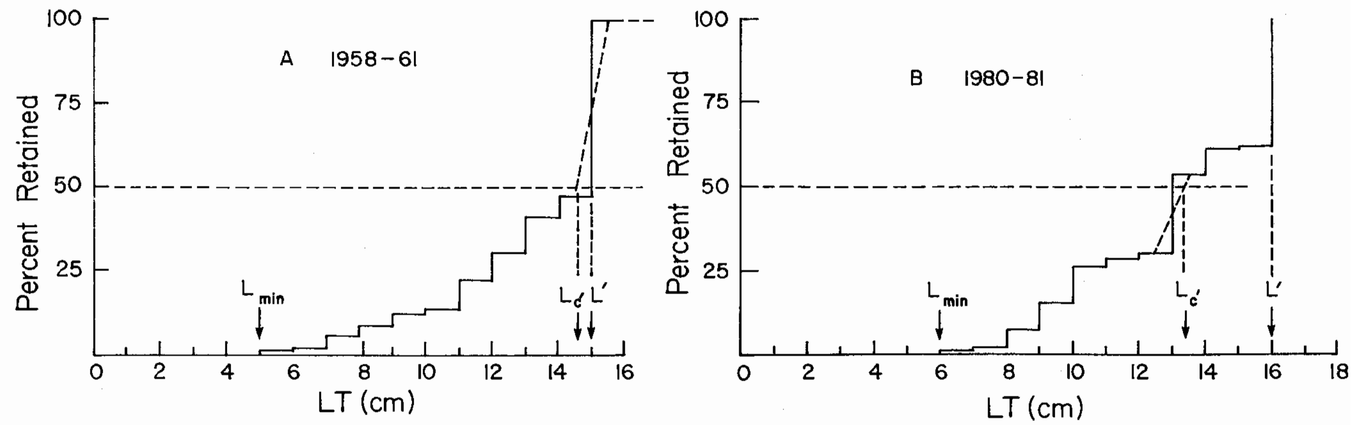

Fig. 6. Selection patterns for *Otolithes ruber* in San Miguel Bay (A = 1958-61; B = 1980-81).

Table 9. Data for the estimation of prerecruit mortality in *Otolithes ruber.*

Number of recruits (x 10^6)	72
♀ spawning stock (tonnes)[a]	189 – 656
Eggs produced per season (x 10^8)[b]	1,134 – 3,936
Eggs produced per year (x 10^8)[b]	2,268 – 7,872
Mortality (per day)[c]	0.048 – 0.055
% dying (per day)[d]	4.78 – 5.54

[a]50% of parent stock.
[b]With 600 eggs per g adult female and two recruitment periods per year. [See recruitment pattern for 1980-1981 (Fig. 7b).]
[c]From Equation (14).
[d]From Equation (15).

The biomass estimated using the relationship between the fishing mortality, the catch and the biomass (Equation 12) gave, using a yield of 2,004 t and a fishing mortality ranging from 0.91 to 2.24 (see Table 7), a range of standing stock of 895 to 2,202 t for the whole of San Miguel Bay, or 1.07 to 2.62 t/km^2.

YIELD PER RECRUIT, ABSOLUTE RECRUITMENT AND PRERECRUIT MORTALITY

Fig. 9 shows graphs of yield per recruit against fishing mortality for three selected values of age at first capture (t_c) hence, of three different mesh sizes. As might be seen, a value of t_c = 0.632 yr, which is higher than the present value of t_c = 0.447 yr results in higher yields per recruit, suggesting that yield per recruit could be increased by increasing the mesh size used by the trawler fleet.

The range of yield-per-recruit values obtained for F = 0.91 to F = 2.24 is 27.5 to 28.5 g/recruit of age t_c = 0.447 (i.e., using the present mesh size) (Fig. 10). Divided into an annual yield of 2,004 t, 28 g/recruit results in an estimate of 72 million recruits produced annually by the San Miguel Bay stock of *O. ruber.*

PRERECRUIT MORTALITY

Using Equation (16), with t_c = 0.447, t_o = –0.645, t_m = 1 year, K = 0.43, two values of k, k_1 = 0.596 and k_2 = 0.422, were computed, corresponding to the range of total mortalities Z_1 = 1.89 and Z_2 = 2.67, respectively.

With a range of total biomass of 895 to 2,202 t and using the two k values, a range of parent biomass B_p of 378 to 1,312 was derived using Equation (15).

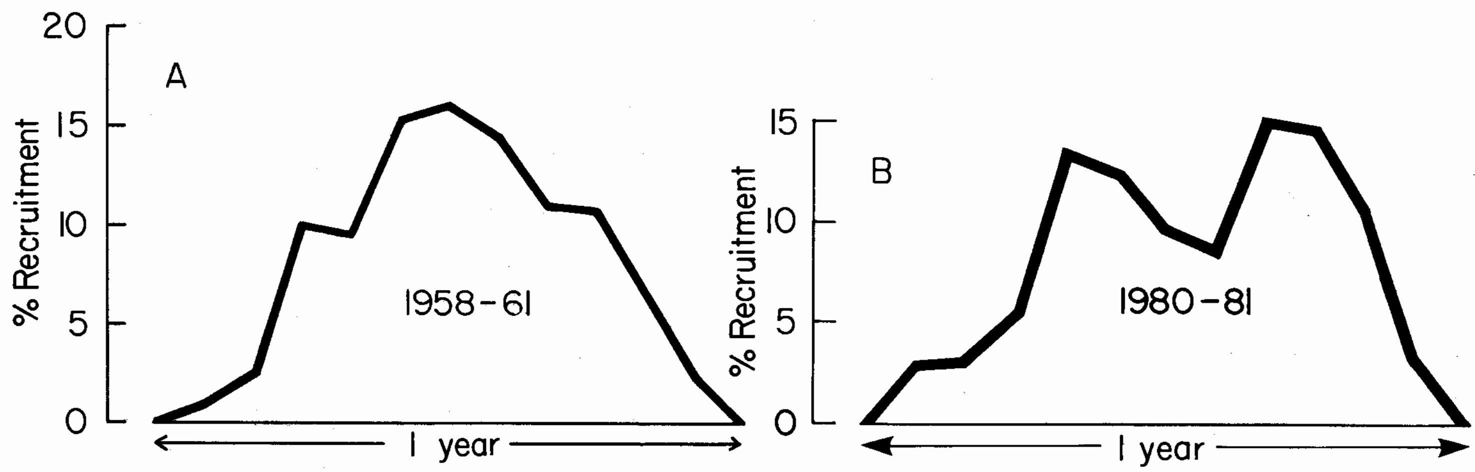

Fig. 7. Recruitment patterns for *Otolithes ruber* in San Miguel Bay (A = 1958-61; B = 1980-81). Note apparent transition from bimodality to unimodality of recruitment (but see text).

The female spawning stock (50% of the parent stock), together with a production of 600 eggs per gram of adult female (Table 4) give the number of eggs produced per season. The computed mortality from egg to prerecruit stage (per day) ranges from 4.78 to 5.54% (Table 9). On the average, an egg has a chance of 1 in 7,042 of turning into a recruited fish, or, put differently, 99.98% of the eggs, larvae and prerecruits die (of natural causes) before reaching a size at which they become liable to capture by the fishery.

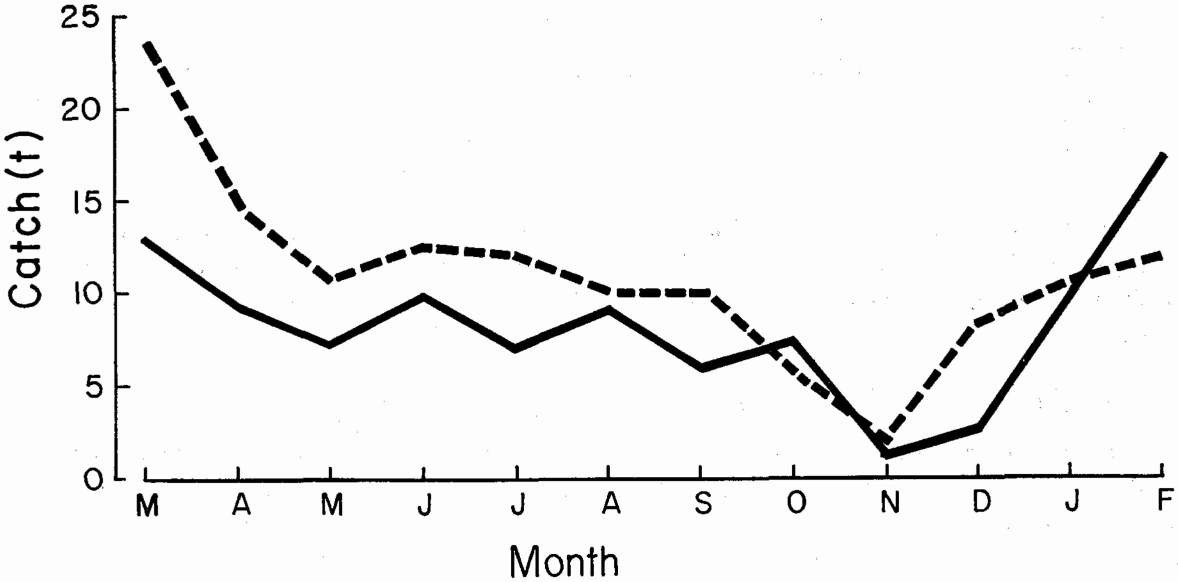

Fig. 8. *Otolithes ruber* catch by small and medium trawlers in Sabang, Calabanga, 1979-1980 (dotted line) and 1980-1981 (solid line). Based on adjusted PFMA data.

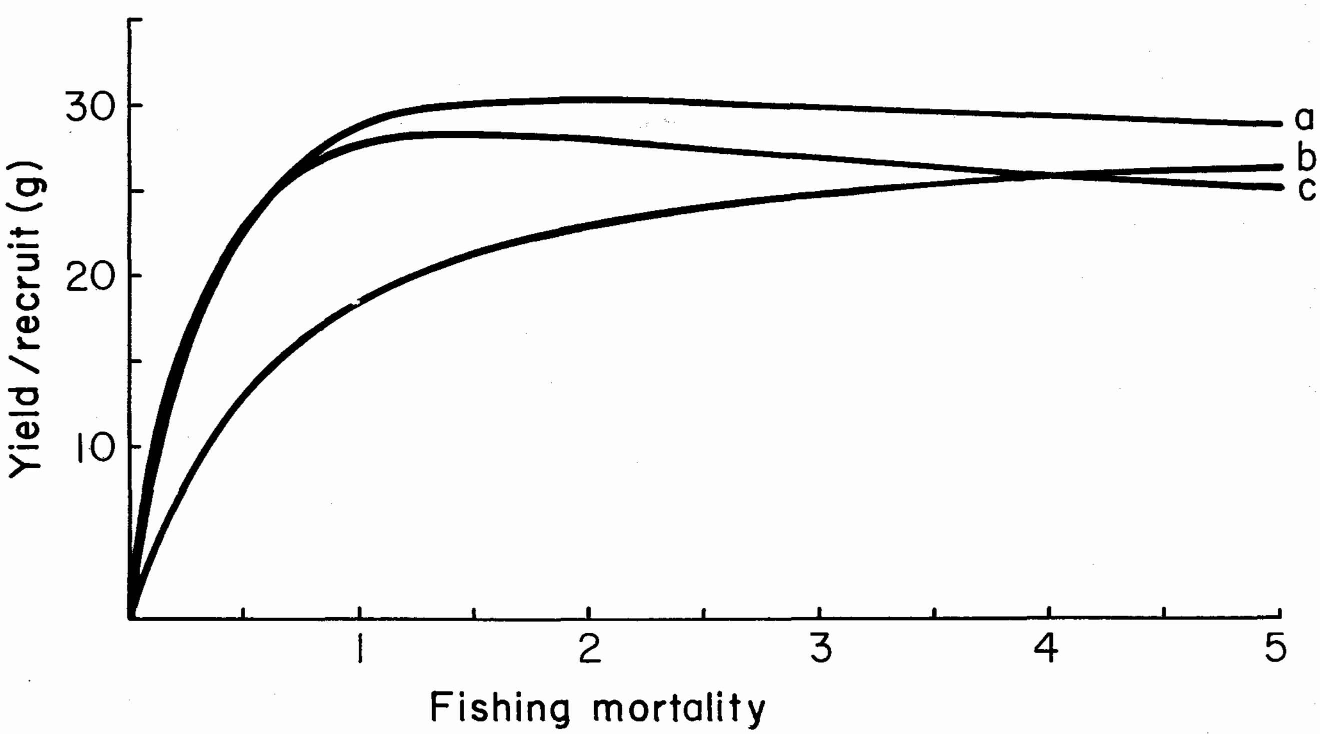

Fig. 9. Yield per recruit in grams of *Otolithes ruber* for three values of age at first capture a) $t_c = 0.632$; b) $t_c = 2.19$; c) $t_c = 0.447$.

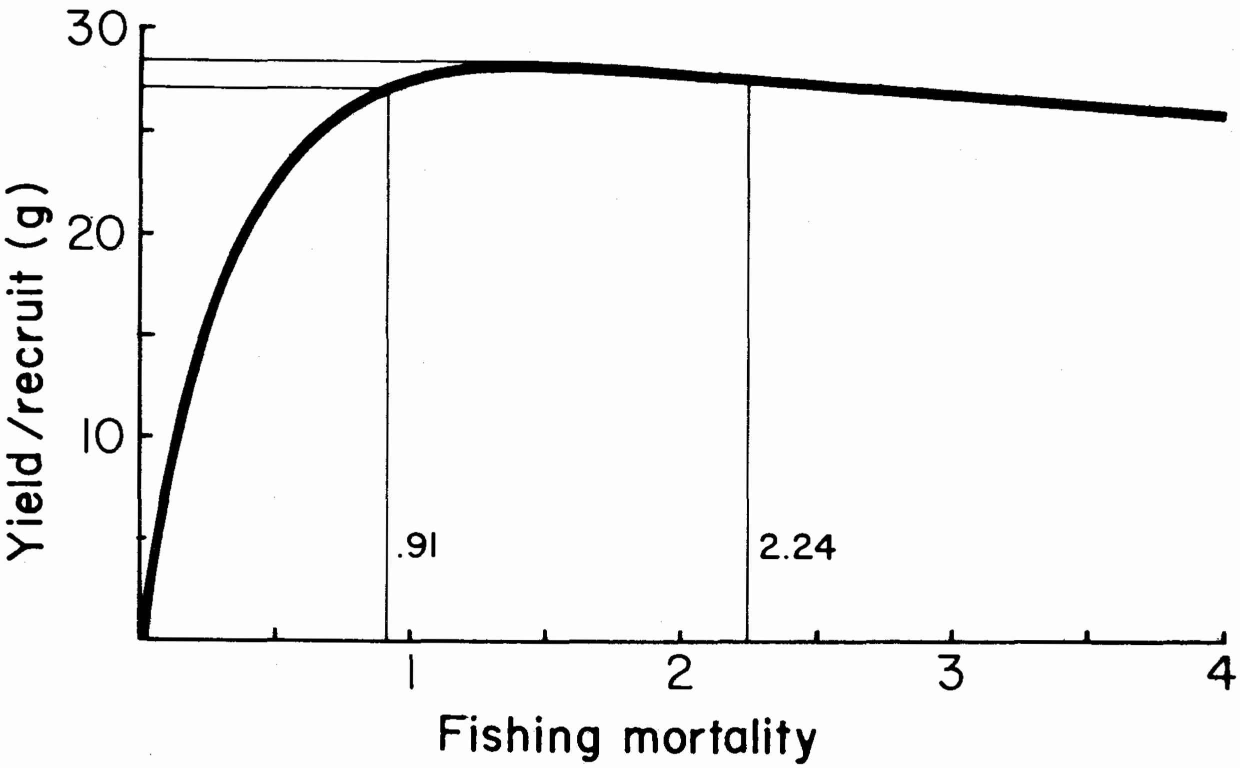

Fig. 10. Yield function of *Otolithes ruber* used for the estimation of about 28 g as yield per recruit of age $t_c = 0.447$ years for the range of fishing mortality likely to occur in 1980-81 (0.91-2.24).

Discussion

The study presented here of the dynamics of *O. ruber* in San Miguel Bay confirms the general trend established for the Bay as a whole that fishing effort is excessive. This is supported both by the estimated exploitation rate of *O. ruber*, which most probably considerably exceeds 0.5, and by the yield-per-recruit analyses which suggest that for the estimated fishing mortality for *O. ruber*, yield per recruit could be markedly increased by increasing mesh size.

The validity of the results presented here, however, is heavily tied to a set of assumptions, some of which may be viewed as questionable. This applies particularly to assumptions regarding the representativeness of the length-frequency data that were utilized.

On the other hand, the rather good match between the growth parameters and the recruitment patterns estimated from the 1958-1961 and the 1980-1981 data suggests the possibility that the length-frequency samples may indeed be representative of the population investigated. Also, the relatively slow growth of *O. ruber* estimated by the ELEFAN I method corresponds to the growth patterns established for other croaker species using more conventional methods (Pauly 1978). This suggests that the marked increase in total mortality apparent in those samples did really occur, resulting in a total mortality well above that needed to optimize yield.

As opposed to the convergence of results obtained in the analysis of the length-frequency data, the estimation of the standing stock of *O. ruber* by two different methods resulted in widely diverging estimates (118 t and a range of 895 to 2,202 t). One way to resolve this contradiction is by reference to the fact that as pointed out in Pauly (this report), the fish caught within San Miguel Bay are predominantly juveniles, with a significant part of the adult stock being outside of the Bay.

This should result, in the case of *O. ruber*, in an underestimate (when using the swept-area method) of the biomass which contributes to the catch, whereas the relationship between fishing mortality, yield and standing stock, which provided the range of biomass values should be unaffected by this feature.

Clearly, the fact that it was not possible to investigate the interrelationships between the parts of the stock inside and outside the Bay may reduce the reliability of the assessment presented here. There was no option but to use the available data to the furthest extent possible.

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Catch and Effort in the Small-Scale Fisheries*

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Abstract

The gears used by the small-scale fishermen of San Miguel Bay, Philippines, are presented and classified. Numbers around the Bay and catch per effort of the various gears are estimated, along with their annual fishing effort.

San Miguel Bay catches by gear type and species groups are presented. The estimated total annual catch of fish and crustaceans from the San Miguel Bay small-scale fishery (excluding all types of trawlers) is 7,760 t, or 9.2 t/km^2.

Introduction

Although they reportedly contribute more than half of the total marine fish catch of the country, the small-scale fisheries of the Philippines have been very little studied. There are many reasons for this, some of which are difficulties in obtaining catch data (not to speak of *reliable* catch data), inaccessibility of certain fishing communities, and lack of communications between the small-scale fishery sector and the fishery research institutions.

However, obtaining reliable catch statistics is an essential condition of any scheme aiming at managing a fishery (Gulland 1980), and nobody denies that the fisheries of the Philippines are in sore need of management (Smith et al. 1980).

In the Philippines, small-scale fisheries are termed "municipal fisheries", a term derived from the fact that fishing within a distance of 3 nautical miles or 5.5 km offshore is under the jurisdiction of the municipalities. These fisheries contrast with the "commercial fisheries" (all vessels above 3

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*ICLARM Contribution No. 95.

gross tons) which are placed under the authority of the Bureau of Fisheries and Aquatic Resources (BFAR).

We use here the term "small-scale" fishery, which corresponds to what elsewhere is also called "artisanal" or "traditional" fishery. The latter term, we think, is inappropriate because small-scale fishermen, in the Philippines as elsewhere, have displayed and continue to display considerable ingenuity in adapting new, non-traditional gears to their need. The term "artisanal", on the other hand, is synonymous with our use of the term small-scale. We do not use the term "municipal", finally, because, as discussed elsewhere in this volume, the current legal definition of the "municipal" fisheries, which include trawlers of just below 3 t, lumps together radically different type of gears (low cost, low-energy and low-catch gears are lumped with such expensive, high-energy and efficient gears as "baby" trawlers) and different types of fishermen (basically poor fishermen with little access to capital are lumped with well-to-do entrepreneurs capable of investing large sums into new gears) (see Thomson 1980).

Thus, our definition of small-scale fisheries, as used here, is equivalent to municipal fisheries *minus* the "municipal baby trawlers", which we call "small trawlers" (see Vakily, this report).

Materials and Methods

Umali (1950) gives a comprehensive, if slightly dated, review of small-scale and other fishing gears in the Philippines (see also Smith et al. 1980). The small-scale gears used in San Miguel Bay differ little from those used throughout the country. Thus, to define the gears that will be discussed here, we have completed a Table (1) which lists the small-scale gears used in the Bay, their Bikol* names, and the English and Tagalog* names given in Umali (1950). Fig. 1 shows a major gear, a gill-netter, while Fig. 2 shows a variety of small-scale gears used in the Bay.

Detailed catch-per-effort data were obtained for the following gears: drift gill-nets (all three types), crab gill-nets, bottom-set gill-nets, liftnets, filter nets, fish corrals and mini trawls, by recording their catch after each trip, mainly at Cabusao, a major fishing port.

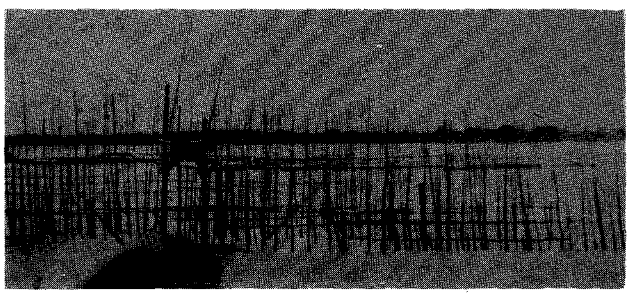
*Bikol and Tagalog are languages of the Malay family of languages, spoken in the San Miguel Bay area and in the central part of the Philippines, respectively.

Fig. 1. A gill-netter, San Miguel Bay. Photo by J.M. Vakily.

Table 1. Small-scale gears used in the San Miguel Bay, with their English, Tagalog and Bikol names.[a]

Gear type	English name in Umali (1950)	Tagalog name	Name in San Miguel Bay area
Non-textile devices:			
Spear gun	spears, harpoon	salapang, panibat	antipara
Fish trap	fish pots	bubo	bubo
Fish weir	barricade	pangharang	sabay
Stationary tidal weir			ambak
Fish corral	fish corral	baklad	baklad, also sagkad
Textile devices:			
Lines			
Pole and line	dropline	kawil	banwit
Longline	longline	kitang	kitang
Nets			
Liftnets	liftnet	panadiyok	bukatot
Scissor net	push net	sakag	sakag
Crab liftnet	crab liftnet	bintol	bintol
Filter net	filter net	dayakus	biakus
Beach seine	beach seine	pukot	sinsoro
Mini trawl	–	–	itik-itik, panquerna
Drift gill-net	drift nets	panti, paanod	panke
Drift gill-net			palataw
Drift gill-net			pamating
Crab gill-net	–	–	pangasag
Bottom-set gill-net	set gill-nets	palagiang-paningahan	palubog

[a]The gear classification is largely based on Umali (1950).


Stationery liftnet


Scissor net


Gill-net


Trap and multiple longline


Motorized gill-net

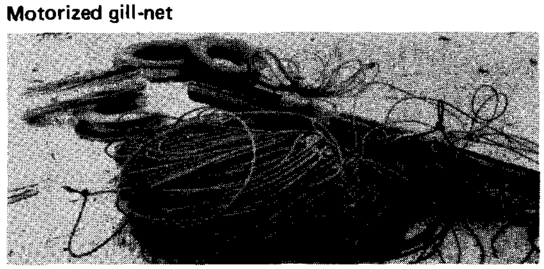

Multiple longline

Fig. 2. Examples of the gears used by San Miguel Bay fishermen.

Table 2. Estimated catch and effort by gill-netters in San Miguel Bay, 1980-81 (total annual catch: 4,854 t).

Type of banca / Gear used	Motorized bancas				Non-motorized bancas	
	No. of units	Catch per trip (kg)	No. of trips per year	Annual catch (t)	No. of units	Annual catch (t)
Panke (drift gill-net)	300	46	234	3,229	–	–
Other gill-nets	50	–	–	812.5	150	812.5[a]

[a]Assuming that the 150 non-motorized bancas, each manned by an average of 1.5 fishermen have the same total annual catch as the 50 motorized bancas that are manned by about 3 fishermen each.

Estimating catch per trip was performed by multiplying the number of baskets landed by 5 (kg), the mean weight of fish contained in the baskets (the woven baskets used by San Miguel Bay fishermen, called *baka-baka* are all of the same size).

The following groups of invertebrate and fish were distinguished (local names in italics): squids *(pusit)*, crabs *(kasag)*, penaeid shrimps *(pasayan)*, sergestid shrimps *(balao)*, sharks and rays *(pating* and *pagi)*, anchovies *(dilis)*, sardines *(tamban)*, sea catfish *(dupit)*, mullets *(banak)*, *Otolithes ruber (abo)*, other sciaenids *(pagotpot/arakaak)*, carangids *(salay-salay/talakitok)*, pomadasyds *(kiskisan)*, Spanish mackerels *(tangigi)*, slipmouths *(sapsap)*, cutlassfish *(lankoy)*, and miscellaneous species. Pauly (this report) gives a list of the species included in these various groups.

The total catch per trip per boat was computed, as was monthly average catch per trip of several boats per gear and species group. This sampling was conducted in conjunction with the collection of fish-price data by research assistants over a period of almost 2 years (1979-1981). The details of the collection of these data are given in several contributions in the economics module report of this project (Smith and Mines 1982).Two additional figures estimated to obtain the total effort, by gear type, applied in the Bay were: the number of trips per gear type in the course of a year, and the total number of gears of a given type used within the Bay. Number of trips was obtained, in the case of the motorized gill-netters, from observation of representative gill-netters at Cabusao, where many of the Bay's gill-netters land their catch. The annual number of trips for all other gears was based on a large number of interviews conducted during a sociological survey of the Bay's fishermen households (see contributions in the sociology module report of this project (Bailey 1982)).

The numbers of gears of various types used in the Bay were extrapolated from the household survey mentioned above, part of which consisted of a detailed inventory of assets (including gears). Gears were also counted in the villages and landing places surrounding the Bay to complement the interviews. Table 2 shows how the annual catch by gill-nets was split up between motorized and non-motorized bancas.

Results

Table 3 summarizes the catch-per-effort, effort and catch data obtained. Also, the total catch by gear was split up into major species groups to show target species (see Appendix Tables). Fig. 3 shows the seasonal fluctuations in the catch per effort of various gears.

Discussion

The approach used here of independently estimating, for each gear type, the catch per trip, annual number of trips and total number of units deployed in the Bay leads to a very high estimate of the annual catch of the small-scale fishery in San Miguel Bay of 7,760 t (excluding balao). This figure is slightly higher than the catch of the trawler fishery in the Bay (about 6,500 t/year, see Vakily, this report).

Table 3. Estimated annual catch and effort by small-scale gears in San Miguel Bay, 1980-1981.

Gear	Total no.	Annual no. of trips of each gear	Annual no. of trips of all gear	Catch per trip (kg)	Total annual catch (t)	Major groups caught (%)
Panke	300	234	70,200	46	3,229	*Otolithes ruber* (48.6), Sciaenidae (29), misc. spp. (8.73)
Palataw	470	115	54,050	11.4	616	Mugilidae (52.9), Sciaenidae (22.5), misc. spp. (15.3)
Pamating	30	94	2,820	4.95	14	Sharks and rays (48.7), misc. spp. (38.1), *Arius thalassinus* (8.11)
Pangasag	257	174	44,718	5.78	258	Crabs (85.8), misc. spp. (12.1), Sciaenidae (1.70)
Palubog	288	162	46,656	15.8	737	Mugilidae (65.2), *Sardinella* spp. (34.4), Crabs (0.234)
Liftnet (bukatot)	171	53	9,063	68.8	624	*Stolephorus* spp. (79.8), misc. spp. (9.07), *Sardinella* spp. (7.65)
Filter net (biakus)[a]	60	225	13,500	21.85	(295)[a]	*Stolephorus* spp. (45.5), Leiognathidae (19.8), misc. spp. (15.0)
Filter net (biakus)[b]	60	225	13,500	19.4	262[b]	*Stolephorus* spp. (51.3), Leiognathidae (22.3), misc. spp. (16.9)
Fish corral (baklad)	89	209	18,601	28.5	530	Misc. spp. (41.8), Crabs (18.0), Sciaenidae (13.5)
Mini trawl (itik-itik)[a]	188	191	35,908	133.1	(4,779)[a]	Balao (88.5), misc. spp. (6.49), shrimps (4.69)
Mini trawl (itik-itik)[b]	188	191	35,908	16.1	578[b]	Misc. spp. (56.4), shrimps (40.7), crabs (2.78)
Scissor net (sakag)[a]	634	150	95,100	5	(476)[a]	Balao (50), shrimps (50)
Scissor net (sakag)[b]	634	150	95,100	2.5	238[b]	Shrimps (100)
Longline (kitang)[c]	103	120	12,360	2	25	Carangidae (20), Pomadasydae (20), misc. spp. (60)
Hook and line (banwit)[c]	424	120	50,880	4	204	Misc. spp. (100)
Crab liftnet (bintol)[c]	71	132	9,372	3	28	Crabs (100)
Fish trap (bubo)[c]	106	120	12,720	4	51	Misc. spp. (100)
Spear gun (antipara)[c]	51	156	7,956	4	32	Pomadasydae (25), misc. spp. (75)
Fish weir (sabay)[c]	5	168	840	72	60	Shrimps (50), misc. spp. (50)
Stationary tidal weir (ambak)[c]	2	144	288	7	2	Mugilidae (33), misc. spp. (67)
Beachseine (sinsoro)[c]	11	308	3,388	80	271	Carangidae (34), *Sardinella* spp. (33), *Stolephorus* spp. (33)
				Total	7,759	(excluding balao)
				Total	4,472	(balao only)

[a]Total catch, including balao.
[b]Total catch, excluding balao.
[c]Based on information provided by A.E. Esporlas.

A shortcoming of this method was that it was not possible to use seasonally oscillating estimates of effort since such data were unavailable for most gears. Rather, the seasonally oscillating estimates of catch per effort (e.g., catch per trip) were multiplied with an effort figure (number of trips) that was assumed to be evenly distributed throughout the year. Given that fishermen may tend to increase their effort in times when catch per effort is high and reduce it when catch per effort is low, the method used here may result in an underestimation of catches during the peak fishing season, and an overestimation of catches during the off-season, hence an underestimation of seasonal catch fluctuations.

On the other hand, the procedure adopted (to which there was no real alternative, given the nature of the available data) will be unbiased with regard to annual catch estimates if the under- and overestimates compensate each other.

The status of the small-scale fisheries is discussed in the context of the overall San Miguel Bay fishery by Pauly (this report).

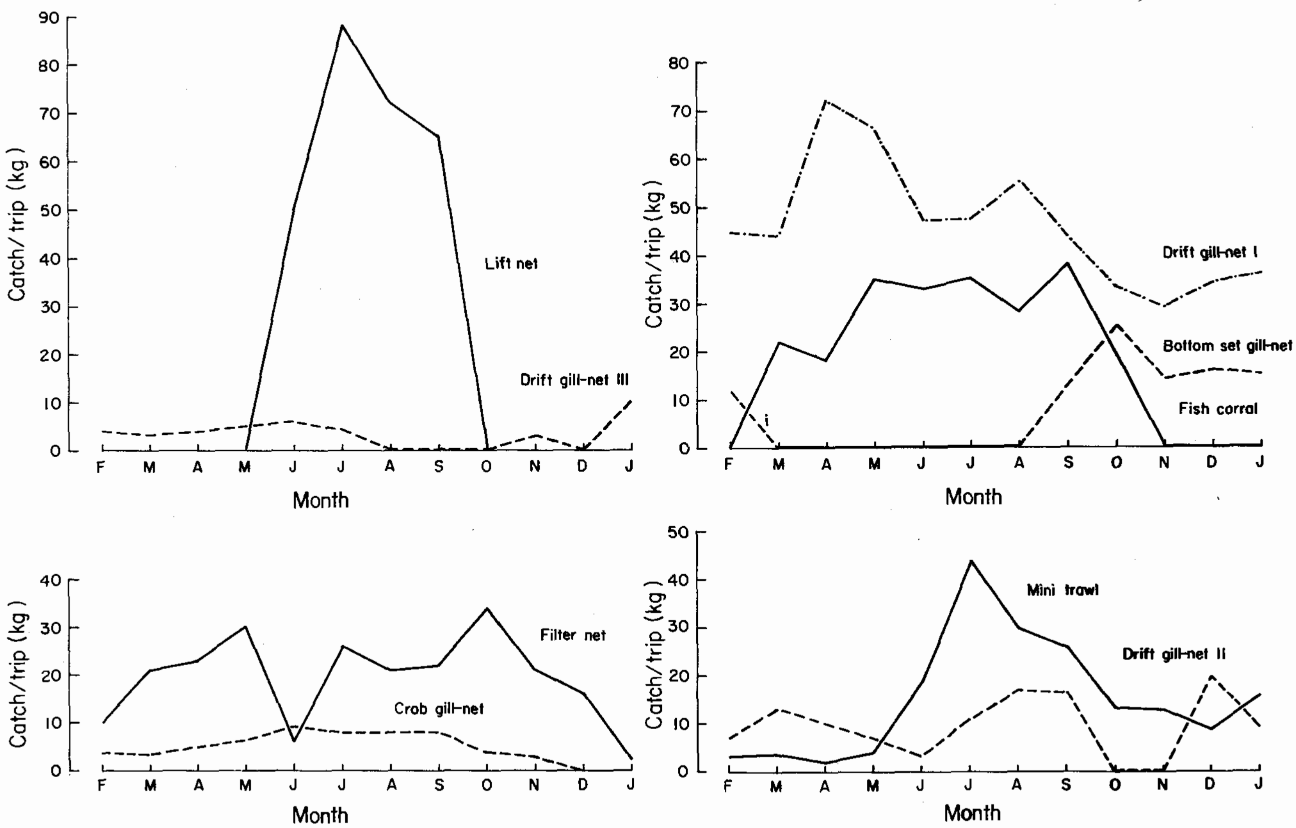


Fig. 3. Seasonal fluctuation in the catch per effort of some selected small-scale gears, San Miguel Bay, 1980-1981.

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Appendix Table Ia. Catch per trip (kg) of fish corral (sagkad) (total annual catch: 530 t).[a]

Taxonomic group	F	M	A	M	J	J	A	S	O	N	D	J	Σ	$\bar{x}$
Sharks and rays	–	–	–	–	–	0.409	–	–	–	–	–	–	0.409	0.051
Stolephorus spp. (Dilis)	–	–	–	–	3.15	0.731	–	–	–	–	–	–	3.88	0.485
Sardinella spp. (Tamban)	–	–	–	8.10	0.630	0.719	0.697	1.24	3.73	–	–	–	15.1	1.89
Arius thalassinus (Dupit)	–	0.154	0.174	–	–	0.983	0.233	2.08	–	–	–	–	3.62	0.452
Mugilidae (Banak)	–	–	–	–	–	0.467	–	0.799	–	–	–	–	1.27	0.159
Sciaenidae (Pagotpot/Alakaak)	–	4.36	3.57	–	4.16	4.13	0.619	9.84	4.15	–	–	–	30.8	3.85
Carangidae (Salay-salay/Talakitok)	–	–	–	–	5.17	5.73	8.14	1.20	0.828	–	–	–	21.1	2.64
Leiognathidae (Sapsap)	–	–	–	–	0.630	1.60	1.55	–	–	–	–	–	3.78	0.472
Trichiuridae (Lankoy)	–	–	–	–	–	0.427	–	–	–	–	–	–	0.427	0.053
Scomberomorus commersonii (Tangigi)	–	–	–	–	–	0.192	–	–	–	–	–	–	0.192	0.024
Misc. spp.	–	15.5	12.7	19.9	13.4	9.05	11.7	11.6	1.65	–	–	–	95.5	11.9
Squids	–	–	–	–	0.126	–	0.038	–	–	–	–	–	0.164	0.020
Crabs	–	1.29	1.05	4.32	5.42	9.35	4.69	10.5	4.35	–	–	–	41.0	5.12
Penaeid shrimps	–	0.803	0.657	2.70	0.250	1.25	0.312	0.785	4.25	–	–	–	11.0	1.38
Total catch	–	22.1	18.1	35.0	32.9	35.0	27.9	38.1	19.0	–	–	–	228	28.5

[a]Dashes here and in subsequent tables mean zero catch.

Appendix Table Ib. Catch per trip (kg) of liftnet (bukatot) (total annual catch: 624 t).

Taxonomic group	F	M	A	M	J	J	A	S	O	N	D	J	Σ	$\bar{x}$
Stolephorus spp. (Dilis)	–	–	–	–	47.5	60.2	61.4	50.4	–	–	–	–	219	55.0
Sardinella spp. (Tamban)	–	–	–	–	–	17.9	3.20	–	–	–	–	–	21.1	5.27
Sciaenidae (Pagotpot/Alakaak)	–	–	–	–	–	–	0.038	–	–	–	–	–	0.038	0.010
Leiognathidae (sapsap)	–	–	–	–	1.26	1.74	–	–	–	–	–	–	3.00	0.750
Misc. spp.	–	–	–	–	–	4.30	6.60	14.1	–	–	–	–	25.0	6.25
Squids	–	–	–	–	1.26	3.84	0.796	0.577	–	–	–	–	6.47	1.62
Crabs	–	–	–	–	–	–	0.076	–	–	–	–	–	0.076	0.019
Total catch	–	–	–	–	50.0	88.0	72.1	65.1	–	–	–	–	275	68.8

Appendix Table Ic. Catch per trip (kg) of filter net (biakus) (total annual catch: 262 t).

Taxonomic group	F	M	A	M	J	J	A	S	O	N	D	J	Σ	$\bar{x}$
Stolephorus spp. (Dilis)	4.00	21.0	10.3	13.4	–	–	–	19.3	29.8	21.0	–	0.096	119	9.92
Sardinella spp. (Tamban)	–	–	–	–	5.33	–	–	–	–	–	–	–	5.33	0.444
Mugilidae (Banak)	–	–	–	–	–	–	–	–	–	–	2.53	1.99	4.52	0.377
Sciaenidae (Pagotpot/Alakaak)	1.78	–	–	–	–	–	–	–	–	–	–	–	1.78	0.148
Leiognathidae (Sapsap)	–	–	12.3	16.1	–	13.0	10.5	–	–	–	–	–	51.9	4.32
Trichiuridae (Lankoy)	0.444	–	–	–	–	–	–	–	–	–	–	–	0.444	0.037
Misc. spp.	3.78	–	–	–	–	13.0	10.5	–	–	–	11.8	0.256	39.3	3.28
Penaeid shrimps	–	–	0.343	0.447	0.889	–	–	2.68	4.14	–	1.68	0.128	10.3	0.859
Balao	–	–	–	–	17.8	–	–	–	–	–	–	11.6	29.4	2.45
Total catch (excl. Balao)	10.0	21.0	22.9	29.9	6.20	26.0	21.0	22.0	33.9	21.0	16.0	2.40	232	19.4

Appendix Table Id. Catch per trip (kg) of mini trawl (itik-itik) (total annual catch, excl. balao: 578 t).

Taxonomic group	F	M	A	M	J	J	A	S	O	N	D	J	Σ	$\bar{x}$
Sciaenidae (Pagotpot/Alakaak)	–	–	–	–	–	–	0.078	–	–	–	–	–	0.078	0.006
Misc. spp.	–	–	–	–	13.3	31.6	15.1	12.1	3.88	8.93	5.71	12.6	103	8.60
Squids	–	–	–	–	–	–	0.078	–	–	–	–	–	0.078	0.006
Crabs	–	–	–	–	–	0.528	1.33	2.94	0.268	–	–	–	5.07	0.422
Penaeid shrimps	2.97	3.30	2.00	3.98	5.40	11.9	13.4	10.9	9.37	4.24	3.48	3.51	74.4	6.20
Balao	193	173	109	87.0	65.5	–	–	16.1	92.7	203	189	275	1,403	117
Total catch (excl. Balao)	2.97	3.30	2.00	3.98	18.7	44.0	30.0	25.9	13.5	13.2	9.19	16.1	1.83	15.2

Appendix Table Ie. Catch per trip (kg) of panke (total annual catch: 3,229 t).

Taxonomic group	F	M	A	M	J	J	A	S	O	N	D	J	Σ	$\bar{x}$
Sardinella spp. (Tamban)	6.12	3.21	1.57	0.920	1.77	0.850	2.18	1.50	1.78	–	–	3.91	23.8	1.98
Arius thalassinus (Dupit)	0.510	0.606	0.484	–	0.606	0.724	0.868	0.757	–	–	–	–	4.56	0.380
Mugilidae (Banak)	0.528	–	0.489	0.608	–	1.38	0.868	0.747	1.28	–	–	1.71	7.61	0.634
Otolithes ruber (Abo)	19.3	19.4	34.2	34.3	17.7	17.5	21.8	16.9	15.2	24.5	34.0	13.6	268	22.3
Sciaenidae (Pagotpot/Alakaak)	8.10	13.6	22.9	19.6	20.8	18.8	16.4	15.4	8.25	4.50	–	11.9	160	13.3
Carangidae (Salay-salay/Talakitok)	0.869	1.25	1.74	2.38	0.769	0.708	0.770	1.04	–	–	–	0.547	10.1	0.842
Trichiuridae (Lankoy)	2.86	1.61	3.10	2.59	–	0.505	–	–	–	–	–	0.828	11.5	0.958
Scomberomorus commersonii (Tangigi)	0.431	–	0.601	0.525	0.801	1.15	1.81	0.543	0.928	–	–	1.10	7.89	0.658
Misc. spp.	5.70	4.38	5.76	3.02	3.37	4.99	8.82	6.24	4.27	–	–	1.66	48.2	4.02
Crabs	–	–	–	–	0.551	0.716	0.955	0.614	–	–	–	–	2.84	0.237
Penaeid shrimps	0.178	–	0.718	1.88	0.930	–	0.718	0.507	1.57	–	–	0.580	7.09	0.591
Total catch	44.6	44.0	71.6	65.8	47.3	47.3	55.2	44.2	33.3	29.0	34.0	35.8	552	46.0

Appendix Table If. Catch per trip (kg) of palataw (total annual catch: 616 t).

Taxonomic group	F	M	A	M	J	J	A	S	O	N	D	J	Σ	$\bar{x}$
Sardinella spp. (Tamban)	–	–	0.160	–	–	–	–	4.00	–	–	–	–	4.16	0.416
Arius thalassinus (Dupit)	–	–	–	–	–	–	–	0.471	–	–	–	–	0.471	0.047
Mugilidae (Banak)	6.50	7.11	2.56	0.600	3.50	5.09	8.33	9.71	–	–	10.0	7.25	60.6	6.06
Otolithes ruber (Abo)	–	–	–	–	–	–	1.00	1.19	–	–	–	2.25	4.44	0.444
Sciaenidae (Pagotpot/Alakaak)	0.500	2.44	3.00	6.40	–	2.73	–	0.714	–	–	10.0	–	25.8	0.258
Carangidae (Salay-salay/Talakitok)	–	–	0.280	–	–	0.454	–	0.471	–	–	–	–	1.20	0.120
Trichiuridae (Lankoy)	–	–	0.160	–	–	–	–	–	–	–	–	–	0.160	0.016
Misc. spp.	–	3.33	3.42	–	–	2.73	8.00	–	–	–	–	–	17.5	0.175
Crabs	–	–	0.140	–	–	–	–	–	–	–	–	–	0.140	0.014
Total catch	7.00	12.9	9.72	7.00	3.50	11.0	17.3	16.6	–	–	20.0	9.50	114	11.4

Appendix Table Ig. Catch per trip (kg) of pamating (total annual catch: 14 t).

Taxonomic group	F	M	A	M	J	J	A	S	O	N	D	J	Σ	$\bar{x}$
Sharks and rays	1.59	1.88	2.17	0.950	6.00	4.50	–	–	–	2.17	–	–	19.3	2.41
Arius thalassinus (Dupit)	–	0.792	1.67	0.750	–	–	–	–	–	–	–	–	3.21	0.401
Mugilidae (Banak)	0.227	0.058	–	–	–	–	–	–	–	0.667	–	–	0.952	0.119
Sciaenidae (Pagotpot/Alakaak)	–	–	–	0.750	–	–	–	–	–	–	–	–	0.750	0.094
Misc. spp.	2.65	0.917	–	1.88	–	–	–	–	–	–	–	9.67	15.1	1.89
Crabs	–	–	–	0.325	–	–	–	–	–	–	–	–	0.325	0.041
Total catch	4.47	3.65	3.84	4.66	6.00	4.50	–	–	–	2.84	–	9.67	39.6	4.95

Appendix Table Ih. Catch per trip (kg) of pangasag (total annual catch: 258 t).

Taxonomic group	F	M	A	M	J	J	A	S	O	N	D	J	Σ	$\bar{x}$
Sharks and rays	–	0.231	–	0.037	–	–	–	–	–	–	–	–	0.268	0.027
Sciaenidae (Pagotpot/Alakaak)	0.143	0.385	0.232	0.222	–	–	–	–	–	–	–	–	0.982	0.098
Misc. spp.	2.95	1.35	1.83	0.216	0.140	0.044	–	–	0.468	–	–	–	7.00	0.700
Crabs	0.607	0.738	2.72	6.05	8.77	7.96	7.22	8.25	3.82	3.45	–	–	49.6	4.96
Total catch	3.70	2.71	4.78	6.52	8.91	8.00	7.22	8.25	4.29	3.45	–	–	57.8	5.78

Appendix Table Ii. Catch per trip (kg) of palubog (total annual catch: 737 t).

Taxonomic group	F	M	A	M	J	J	A	S	O	N	D	J	Σ	$\bar{x}$
Sardinella spp. (Tamban)	6.00	–	–	–	–	–	–	6.67	4.33	5.17	5.41	5.00	32.6	5.43
Mugilidae (Banak)	6.00	–	–	–	–	–	–	6.33	20.1	9.17	10.2	10.0	61.8	10.3
Misc. spp.	–	–	–	–	–	–	–	–	0.222	–	–	–	0.222	0.037
Crabs	–	–	–	–	–	–	–	–	0.222	–	–	–	0.222	0.037
Total catch	12.0	–	–	–	–	–	–	13.0	24.9	14.3	15.6	15.0	94.8	15.8

Catch and Effort in the Trawl Fishery

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Abstract

The trawl fishery of San Miguel Bay, Philippines, consists of 30 large trawlers operating occasionally in the Bay and 20 medium (3 to 6 t) and 75 small trawlers (2.5 to 2.9 t) whose total annual catch amounts to about 6,500 t, or 7.7 t/km^2. Using the swept-area method, a fishing mortality of 3.55 (per year) was estimated to be applied by trawlers on the fish stocks of the Bay, which suggests overfishing. This finding is corroborated by comparison with the data from a trawl survey conducted in the Bay in July 1948 which indicates that the portion of the stock accessible to trawlers now represents less than 20% of the 1948 standing stock.

Introduction

San Miguel Bay was found to yield the highest catch rates of 24 sites trawled in an exploratory survey of Philippine waters in 1948 (Warfel and Manacop 1950). The authors assumed that "four to five trawlers probably could be maintained without endangering these resources."

Legasto et al. (1975) reported the existence of thirteen commercial fishing boats in San Miguel Bay by 1975 and in 1977 the official number of commercial trawlers operating in- and outside the Bay was 88 (Simpson 1978). Both figures ignored the large number of small or "municipal" trawlers (see below) operating inside the Bay.

There are two main landing areas for trawlers. One of them, Camaligan, is an inland "harbor". Located on the Bicol River, about 16 km upstream, it benefits from the immediate vicinity of Naga City, the commercial center of the Bicol region. Catches landed there originate only from large commercial trawlers. The other is Sabang (Calabanga), where the bulk of the catches is landed by small trawlers. Both ports are accessible by relatively good roads.

Most fishing activities take place during the southwest monsoon, from April to September, during which the Bay offers well-protected waters. Some fishing activity is continued throughout the northeast monsoon (October-March), mainly in the shelter of mountains to the east. A number of small islands near the traditional fishing grounds also offer shelter to larger vessels in rough seas, such that they are forced to return to port only when a typhoon passes directly over the Bay.

The landed catches reflect the wide variety of tropical fish species. Croakers, small anchovies, sardines and mullets make up the bulk of commercially important species. The catches also include grunts, carangids and catfishes. "Trash fish" consists mainly of undersized slipmouth and goatfishes.

Economically, shrimps are the most important factor in the Bay's fishery. In 1977, a Workshop on the Fishery Resources of the Pacific Coast of the Philippines estimated the annual catch of shrimps originating from San Miguel Bay and the neighboring fishing grounds to be at least 12,000 t. It was assumed that the potential annual yield might even be higher (Simpson 1978).

Fishery Regulations

There are no specific fishery regulations for San Miguel Bay.[1] However, those regulations generally in force in the Philippines are to be respected. Hence, commercial fishing vessels (3 gross tons and more) are not permitted to trawl in waters less than 7 fathoms (12.8 m) deep. For the so-called "municipal" trawlers (below 3 t), as for trawling in general, the depth limit is 4 fm (7.3 m).[2] The areas shallower than 4 fm are reserved for the small-scale fishery.

The minimum legal mesh size for commercial trawlers is 25 mm. Trawlers below 3 t as well as traditional gear are not subject to special regulations concerning mesh sizes. They should not, however, be less than 20 mm, the general lower legal limit for mesh sizes in the Philippines. Exceptions to this rule are permitted when fishing for species which are small even when mature (Jones 1976).

Jones (1976) stated that in the Philippines the fishery regulations are not "adequately enforced due to the relatively small number of enforcement officers and possibly also due to the quality of enforcement". This is also likely to apply to the San Miguel Bay fishery.

Fishing Gears

Fishermen in San Miguel Bay use a broad range of traditional gears, such as traps, beach seines, hook and line, which are common alongside trawlers and gill-netters.

Trawlers operating in San Miguel Bay are quite variable in size, ranging from less than one GT up to 117 t. Rather arbitrarily, the limit of 3 t is used, as elsewhere in the Philippines, to differentiate "commercial" trawlers (3 t and more) from the smaller "municipal" trawlers.

In view of their different fishing activities, this distinction requires further division. Local names, such as "baby trawl" and *itik-itik* vary from village to village. Therefore, all trawlers were grouped into four classes—"Mini", "Small", "Medium", or "Large", depending on their size or mode of operation. The characteristics of these trawler types are as follows:

LARGE TRAWLERS

Generally known as "otter" trawlers, their size in San Miguel Bay ranges from 27 t to 117 t and their length from 19 to 25 m. They are propelled by engines varying from 275 hp to 555 hp. Most of the vessels are equipped with radar and echo-sounder.

All gear is sternset. On older vessels, hauling the net takes up much time. The opening of the cod end is attached to a wooden frame reaching past the stern and then the catch is brailed directly from the net. However, newer vessels are equipped with A-frames and double-drum winches for lifting the net over the stern, shortening the hauling time by nearly one hour.

The catch is dumped on the afterdeck, sorted by groups of species and/or size, and then stored in fish holds underdeck. The fish containers are covered with crushed ice.

Two types of net are in use. One, the so-called "Norwegian", is a medium-sized net with a head-rope length of about 20 m. It is used mainly to catch shrimps during the "shrimp-season", from

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[1] Since this was written a Fisheries Administrative Order has been issued banning commercial trawlers from San Miguel Bay for a period of 5 years. This issue will be discussed elsewhere in detail—Editors.

[2] Section 17 of the Presidential Decree No. 704 ("Fisheries Decree of 1975").

September to January. The other type, called "German" is used throughout the year and allows better catches of fish. Its head-rope measures about 43 m. The mesh size in the cod end is 28 mm for both types[3] (see Table 1).

All the large trawlers are stationed and land their catches upriver in Camaligan near Naga City. Local authorities record 30 such vessels operating at present in the area (see Table 2).

Large trawlers spend about 6 days on the fishing grounds each trip, and an additional day steaming to and from port. Average trawling time per trip is 113 hours.[4]

Their area of operation is usually outside the Bay up to 150 km from port. Only in rough weather, mainly from September to December, do they fish inside the Bay. Catches at these times are poor, and only a small part of the Bay is open to them. Fig. 1 depicts a typical large trawler.

MEDIUM TRAWLERS

These vessels form a continuum in size and appearance with small trawlers and are here distinguished because their size, 3 to 6 t, classifies them as commercial rather than municipal craft. Thus they are theoretically restricted in their area of operation.

Medium trawlers are around 18-m long, equipped with 200-hp engines. Like some large trawlers they use the German otter trawl with 28-mm mesh, but the net is smaller, the head-rope measures 18-20 m, and the cod end is often covered with a second one of 8-mm mesh, especially when fishing for anchovies.

The medium trawlers are based in Sabang, Calabanga. They leave generally early in the morning and come back the next day late in the afternoon. The total trawling time during these two days is estimated to be 15 hours.

A total of 17 trawlers of this class is registered in Sabang. Some, however, seem to have left the Bay. The landing statistics (see Appendix Table I) show an average arrival of only three medium trawlers per day.

SMALL TRAWLERS

These boats, generally called "baby trawl", play an important role in the San Miguel Bay fishery. A summary of technical details for this type of trawler, which is depicted in Fig. 2, is given in Table 1. Like the medium trawlers, they stay at sea for two days, during which time there are generally five 3-hr hauls. The net is hauled by hand. The catch is sorted into "shrimps", "first-class fish", other "good fish" and "trash fish", covered with ice and stored in a fish hold underdeck.

Sabang landing statistics, collected by the Philippine Fish Marketing Authority (PFMA), Naga City Office, show an average of 8.4 small trawlers arriving per day over one year. This is probably an underestimate. The small and medium trawlers at Sabang cannot land their catches directly on shore—the water is too shallow. The catches are ferried ashore by smaller boats, such that for the numerous small trawlers, it is nearly impossible to identify the origin of each catch. Again, while most of the catch is offered to buyers at distinct places, some is sold at other points and probably not recorded.

MINI TRAWLERS

The smallest trawlers operating in the Bay are about five meters in length with engines varying from 10 to 16 hp. Their fishing activity is concentrated on one resource only: *balao*, which

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[3]In the Philippines, the mesh size is usually not given in mm, but in knots. By using the formula $304.8/(K - 1)$, where K is the number of knots, they can be converted to internal mesh size in mm (Jones 1976).

[4]The calculation is based on the evaluation of 86 log sheets, each of them representing one trip (see Appendix Table II).

Table 1. Summary of data on trawlers stationed in San Miguel Bay; 1979/80.

		Boat characteristics						Net characteristics		Mode of operation			Regulations		
Type of fishing vessel	Common local names	Length (m)	Tonnage (gross tons) Mean	Min	Max	Engine (hp)	Crew	Length of headrope (m)	Mesh size in codend (mm)	Estimated trawling speed (kt)	Days per trip	Trawling hours per trip	Operation limit (f)	Small mesh size (mm)	Power factor[d]
Large trawler	Commercial trawl	19-25	54	27	117	275-555	10	20[a] or 43[b]	28	3	7	115	7	25	1
Medium trawler	Commercial baby trawl	~18	4.13	3.12	6.30	~200	7	18-22	28 or 8[c]	2.5[e]	2	15	7	25	1.5
Small trawler	Municipal baby trawl	~12	2.53	1.64	2.99	68-160	5	16-18	22 or 8[c]	2	2	15	4	–	2
Mini trawler	Itik-itik	~5	–	–	–	10-16	2	~6	8	1	1	5	4	–	–

[a]"Norwegian" trawl net
[b]"German" trawl net
[c]Double codend
[d]Estimated by comparing the boat and gear statistics (length, tonnage, length of head rope, trawling speed of the three types of boats; the ratio 1:1.5 between small and medium trawlers was subsequently confirmed by comparing the catch rates of medium and small trawlers directly (N. Navaluna, pers. comm.).
[e]As computed by N. Navaluna and E. El Cinco (pers. comm.) on board such boats.

Table 2. Summary of fishing vessel numbers in San Miguel Bay, in early 1980, by villages.

Village	Trawlers Large	Medium	Small	Mini	Source of information
Bagacay (Tinambac)	–	–	–	–	personal observation[a]
Barceloneta (Cabusao)	–	–	–	15	personal observation[a]
Camaligan	30	–	–	–	PFMA
Castillo (Cabusao)	–	–	–	88	personal observation[a]
Sabang (Calabanga)	–	17	53	23	PFMA
Sibobo (Calabanga)	–	–	–	–	personal observation[a]
Tinambac	–	–	19	–	personal observation[a]
Total	30	17	72	≈ 150[b]	

[a]A personal counting of boats was conducted at the landing areas on a Good Friday 1980 assuming that on this holiday no boats would leave the shore for fishing.

[b]Assuming about 20% of mini trawlers were overlooked.

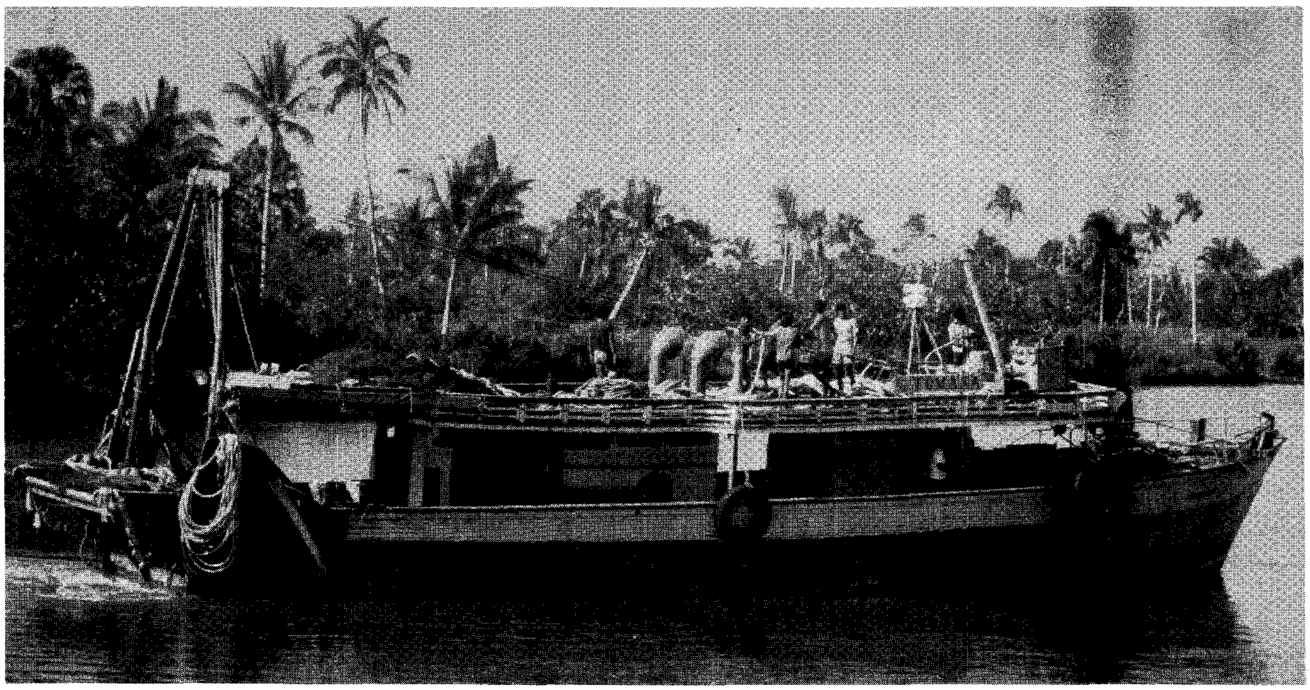

Fig. 1. A large trawler, San Miguel Bay, 1980.

consists of sergestid shrimp (see Pauly, this report) and which is the basis of numerous processed products much appreciated by the consumers, especially fish paste or *bagaoong.*

The fishery is highly selective. Due to the very slow trawling speed, fish are rarely caught.

The catch is landed in the evening and sold to local processors, who mix it with salt, pack it in plastic bags and then load it on trucks bound mainly for Manila (Yater et al. 1982).

A total of 126 mini trawlers was counted by the author during a survey along the shore. Taking into consideration the probable existence of more boats at those places around the Bay not accessible by road, the total was probably about 150 boats.[5]

Fishing for *balao* is undertaken mainly during December to May. Interviews with fishermen did not clearly reveal how these mini trawlers operate the rest of the year (but see Tulay and Smith

[5]Since this first estimate was obtained (in early 1980), the number of mini trawlers in and around San Miguel Bay has increased, up to the figure of 188 units used in the other parts of this report—Editors.

1982). At least some of them seem to be converted to outriggers and then used for setting gill nets. Because of the imprecise and unreliable information, no attempt was made to estimate the number of mini trawlers operating each day in the Bay. [The *balao* fishery of San Miguel Bay is dealt with in more detail in Tulay and Smith (1982).]

Catch and Effort Statistics

Detailed catch statistics of the San Miguel Bay fishery do not exist. However, miscellaneous data from different sources are available for the landings of trawlers.

The data used here originate from the Philippine Fish Marketing Authority (now Fisheries Development Authority), Naga City Office and from a private operator. Data were also compiled from unpublished statistical reports of the Bureau of Fisheries and Aquatic Resources (BFAR), Naga City Office.

PHILIPPINE FISH MARKETING AUTHORITY DATA

Enumerators of the PFMA started collecting data on the landings of small and medium trawlers in Sabang and of large trawlers in Camaligan in March 1979. Daily information is gathered on the number of boats arriving, their catch and catch composition, and the total commercial value of the landings. The recorded data are summarized in unpublished monthly reports.

For the computation of the total annual catch, the period of March 1979 to February 1980 was chosen. Details of the data collected by PFMA are given in Appendix Table I.

The PFMA data, however, represent only a sample of the total catch; data collection is irregular, covering between 8 and 28 days/month. It could not be determined from these data alone whether missing days represented no landings or no records made.

Two private operators provided additional records and only when all three sources showed no landings was it assumed there was no fishing on that day. The PFMA data were then adjusted by multiplying total fishing days by their average catch/day (Table 3).

The records of landings of large trawlers in Camaligan can be assumed to be of better quality than those of Sabang due to the concentration of their activities there. These data (which have not been adjusted) are, however, very different from those given by BFAR for the total catch landed in Camaligan (see Table 4). These differences cannot be explained. The PFMA gives data both on the landings of the small and medium trawlers as well as on the numbers of daily small and medium trawlers arrivals. The subdivision of the total landing figures into those parts attributable to the small and medium trawlers (see Appendix Table I) was done by means of the power factors discussed further below and a program developed for this purpose and implemented on a HP 67 programmable calculator (see p. 81-84 for program listing and description).

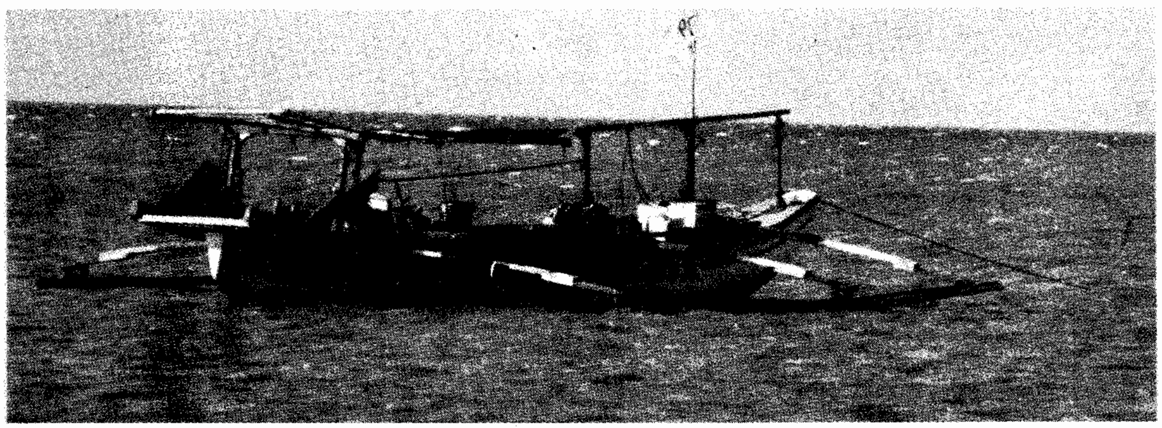

Fig. 2. A small trawler, San Miguel Bay, 1980.

Table 3. Computed total catch landed in Sabang, Calabanga by small and medium trawlers (all weights in tonnes).[a]

	March	April	May	June	July	August	September
1979-1980							
Days recorded/fishing days	28/31	20/27	28/31	14/27	8/28	23/31	16/28
Fish	195.64	174.16	187.78	160.86	191.66	164.55	119.61
Invertebrates	13.00	10.30	7.94	13.52	12.68	9.34	15.51
Total	208.64	184.46	195.72	174.38	204.34	173.89	135.12
1980-1981							
Days recorded/fishing days	22/31	17/27	20/31	17/27	20/28	22/31	19/28
Fish	203.22	157.97	83.49	84.94	113.59	144.16	124.20
Invertebrates	6.57	9.40	7.50	12.26	16.64	15.06	17.72
Total	209.79	167.37	90.99	97.20	130.23	159.22	141.92

Table 3 (continued)

	October	November	December	January	February	Total for one year
1979-1980						
Days recorded/fishing days	21/29	14/26	17/28	10/28	17/27	216/341
Fish	60.06	36.21	75.20	96.44	127.34	1,589.51
Invertebrates	9.78	8.84	25.44	17.31	8.38	152.04
Total	69.84	45.05	100.64	113.75	135.72	1,741.55
1980-1981						
Days recorded/fishing days	25/29	19/26	20/28	23/28	23/27	247/341
Fish	145.47	74.28	105.65	88.24	162.83	1,488.04
Invertebrates	28.03	19.33	29.14	22.86	15.92	200.43
Total	173.50	93.61	134.79	111.10	178.75	1,688.47

[a]Adjusted from PFMA data in Appendix Table I (a to x).

PRIVATE OPERATOR

A private operator/owner of several large trawlers supplied the author with the logbooks of three large trawlers, from which information on their catch and catch-per-hour within San Miguel Bay could be extracted. These data, which will be referred to in the text, are documented in Appendix Table II.

THE ESTIMATION OF FISHING EFFORT

Table 2 gives the number of trawlers of different types operating in the Bay as based on the numbers registered in Sabang, and on personal counts in the various fishing villages around the Bay. This survey was conducted in early 1980.

Records from a private operator, owner of many large trawlers based in the San Miguel Bay area, suggest that only a relatively small volume of fish is caught *inside* the Bay by large trawlers (see Table 5); the numbers involved there thus will not have a great impact on the total catch estimates, even if in error by as much as 50%, which is unlikely.

The situation is similar with the medium trawlers. At the time the survey was conducted, 17 of them were recorded in Sabang, and there were indications that some of them were about to leave, or had left the Bay. In early 1981, however, there were indications that some medium trawlers were actually added to the fleet. In this paper, a value of 20 medium trawlers was used in all computations covering the period from March 1979 to April 1981; it is expected that the impact on the total catch of an error in this estimate should be small.

The situation is different with the small trawlers, however, because their relatively large numbers have a strong impact on the total catch of the trawl fishery. Fifty-three small trawlers were registered in Sabang in early 1980, while 19 were operating from Tinambac (see Table 2). Also, two new small trawlers based in Castillo had been operating since mid-1980. Finally, a few very small trawlers based in Mercedes, i.e., outside the Bay, were reported to be operating inside the Bay. Throughout this paper, a figure of 75 small trawlers will be used for all effort computations.

Estimating the number of trips made annually by the various types of trawlers is impossible on the basis of the PFMA data alone, because as mentioned above, the landings of a large number of boats operating within the Bay are not considered by the PFMA.

In the course of the cost and return analysis of Sabang-based medium and small trawlers, however, it emerged that, on the average 128 trips per year are undertaken by these two types of boats.[6] Combined with estimated numbers of medium and small trawlers and considering the power factor of medium trawlers (see Table 1), it is possible to estimate the number of small-boat trips per year (see Table 6).

Table 4. Comparison of data on catches landed in Camaligan, collected by BFAR and PFMA in 1979.

Month	Recorded catch (in metric tons) BFAR[a]	PFMA[b]
January	295.3	–[c]
February	232.7	–[c]
March	221.9	550.9
April	247.9	312.3
May	278.6	419.7
June	251.5	601.7
July	179.5	414.6
August	191.0	683.1
September	251.5	330.5
October	152.2	201.8
November	121.0	301.7
December	103.5	287.7
Σ (March-December)	1,998.6	4,104.0

[a]Summarized from monthly internal reports of BFAR, Naga City.
[b]Summarized from monthly internal reports of PFMA, Naga City.
[c]PFMA first started data collection in March 1979.

Table 5. Computation of total catch (t) originating from San Miguel Bay and landed by large trawlers from September to November 1979.

	Sept	Oct	Nov	Total
Total catch recorded by PFMA	331	202	302	835
Number of days recorded	15	16	18	–
Fishing days[a]	30	31	30	–
Adjusted total catch	662	391	503	1,557
Proportion of the landed catch originating from San Miguel Bay[b]	10%	80%	40%	–
Total catch from San Miguel Bay	66	313	201	580

[a]It was assumed that all days of the month were fishing days.
[b]This proportion was calculated from log sheets.

[6]Since this study was conducted, this figure was modified slightly (see Navaluna and Tulay 1982); the effects of this improved estimate are minor, however—Editors.

Table 6. Summary of data on the effort by small and medium trawlers in San Miguel Bay.

	Medium trawlers	Small trawlers	Small trawler units
No. of units	20	75	105[b]
Mean annual catch per trip (kg)[a]	600/705	400/470	400/470
Mean annual no. of trips	128	128	128
No. of trawling hours per trip	13	13	13

[a]There were two periods, 1979/80 and 1980/81, respectively.
[b]Computed from (20 • 1.5) + 75 = 105, with 1.5 being the power factor linking up small and medium trawlers.

Table 7. Catch of small and medium trawlers in San Miguel Bay by species group.

	March 1979 to February 1980			March 1980 to February 1981		
	kg/hr	Total catch (t)	%	kg/hr	Total catch (t)	%
Sharks and rays	0.22	38.4	0.7	0.19	32.3	0.5
Stolephorus spp.	5.99	1,046.0	19.5	7.84	1,369.3	21.7
Sardinella spp.	1.34	234.6	4.4	1.09	190.0	3.0
Arius thalassinus	0.20	35.8	0.7	0.03	5.1	0.1
Mugilidae	2.18	380.9	7.1	1.68	294.0	4.7
Otolithes ruber	2.32	406.2	7.6	2.22	387.7	6.1
Sciaenidae[a]	1.41	246.7	4.6	1.69	294.8	4.7
Pomadasydae	0.22	37.8	0.7	0.12	20.8	0.3
Carangidae	0.84	146.1	2.7	0.32	55.6	0.9
Leiognathidae	0.52	91.6	1.7	0.19	33.2	0.5
Trichiuridae	0.66	114.9	2.1	1.42	247.5	3.9
Scomberomorus commerson	0.11	19.1	0.4	0.15	26.8	0.4
Misc. spp.	12.07	2,108.4	39.1	15.07	2,633.3	41.7
Squids	0.86	149.7	2.8	1.20	209.7	3.3
Crabs	1.83	319.7	5.9	0.56	98.1	1.6
Penaeid shrimps				2.40	418.7	6.6
Total	30.77	5,375.9	100.0	36.17	6,316.9	100.0

[a]"Sciaenidae" includes all species of this family, except for *Otolithes ruber.*

THE TOTAL ANNUAL CATCH FROM THE TRAWL FISHERY

Using the effort and catch per effort estimated in Table 6 and the adjusted catch from the PFMA data (Appendix Table I), it is rather straightforward to estimate for each year the total catch by medium and small trawlers within San Miguel Bay as the mean catch-per-effort of one small trawl unit times the mean annual number of trips times the total number of small trawl units operating in San Miguel Bay (see Tables 6 and 7).

To these results must be added the catch of the large trawlers made within San Miguel Bay (taken from Table 5). The results are given in Table 8. Altogether, they suggest that trawlers take annually 6 to 7 thousand tonnes of fish and invertebrates from the Bay, or 7.7 t/km^2.

THE ESTIMATION OF FISHING MORTALITY DUE TO TRAWLERS

The relations between catch, effort and stock density can be expressed mathematically in the following way.[7]

[7]The mathematical basis presented here is derived from Gulland (1969).

On the premise that the fish are evenly distributed in a given area, the catch per operation (e.g., in a trawl fishery) is proportional to the stock density. Thus:

$$\Delta C = q \cdot \Delta f \cdot N/A \qquad \ldots\ldots (1)$$

where ΔC = catch of one operation
q = catchability coefficient
Δf = fishing effort exerted by unit operation
N = mean stock abundance
A = area inhabited by the stock

The catch is related to the number of deaths (mortality) due to fishing, as expressed by

$$\Delta C = F \cdot N \cdot \Delta t \qquad \ldots\ldots (2)$$

where F = coefficient of fishing mortality
Δt = duration of a unit operation

Rearranged and combined, equations 1 and 2 give

$$F = q \cdot f/A \cdot t \qquad \ldots\ldots (3)$$

with f = total fishing effort during the period t

If $t = 1$ year, equation (3) simplifies to

$$F = q \cdot f/A \qquad \ldots\ldots (4)$$

which means that fishing mortality is proportional to fishing intensity (i.e., to the effort per unit area).

If the fishing effort is expressed in the same units as the area 'A', the value for F can be obtained directly by the "swept-area method", which applies mainly to fisheries where an important share of the landings is caught by trawlers. Fishing effort is expressed in terms of the total area swept by trawls. Hence, fishing mortality is proportional to the relationship between the area swept within one year and the total surface area of a fishing ground.

The swept-area method of calculating stock parameters makes the following assumptions:

1. *Even or random distribution of fish in the area.* This assumption may not apply under natural conditions, as factors such as water depth and food availability influence the distribution of fish.

Table 8. Total catch by trawlers in San Miguel Bay, March 1979 to February 1981.

	1979/80	1980/81	Per km^2 (mean of both years)
Annual catch by small and medium trawlers	5,376	6,317	7
Overall catch by large trawlers in the Bay[a]	580	(580)[b]	0.7
Total trawl fishery	5,956	6,897	7.7

[a]During the height of the northeast monsoon.
[b]Assuming the same value as in the previous year.

2. *Legitimacy of substituting "fishing ground" for "area of distribution of a given stock".* If a fishing ground is not enclosed entirely by land, there will always be fluctuations in the availability of fish due to their migrations. In reality the area of distribution can be larger than the fishing ground. The importance of this point will be discussed later in connection with conditions in San Miguel Bay.

3. *Constant catchability coefficient.* This coefficient expresses the availability of the fish, which is closely related to the behavior of the individual species. Factors like spawning season, diurnal movements, escape behavior, age, etc., influence their vulnerability to capture. In a multispecies fishery, the individual catchability coefficients are likely to differ to a large extent between the various species.

More general criticisms include (i) the dependence of the method on the reliability of statistical data employed, and (ii) the existence of very different fishing gears in the same area, the modes of operation of which are generally not comparable.

A common unit of effort is needed to express all fishing activities. For San Miguel Bay, the trawling hours of a small trawler were chosen as a unit. To convert the various forms of fishing effort into this unit, the combined total catch of all trawlers was divided by the average catch per hour of a small trawler. This gives the total number of trawling hours an average "unit trawler" would need, if the total catch of the Bay were landed only by small trawlers.

In conformity with equation 4, the formula to calculate F by means of the swept-area method is

$$F = X_1 \cdot a/A \qquad \ldots\ldots (5)$$

where A represents the surface area of the fishing ground in km^2, X_1 the "escapement factor", and a the swept area, which is defined as follows:

$$a = H \cdot X_2 \cdot kt \cdot c \cdot f \qquad \ldots\ldots (6)$$

with H = average length of the head-rope (in km) of the net used on a "unit trawler"
X_2 = correction factor for the actual opening of the net
kt = average trawling speed (in knots) of small trawlers
c = factor to convert knots to km/hr
f = total effort, trawling hours of "unit trawler"

To apply the swept-area method, the total catch was converted into units of effort of small trawlers as follows:

Average catch per trip of a small trawler	0.435	t[8]
Average trawling time per trip of a small trawler (Table 6) . . .	13	hr
Average catch per hour of a small trawler	0.0335	t
Trawling time for a small trawler to catch 6,426 mt[8]	191,821	hr

The area swept by a small trawler in one hour is

$$0.017 \text{ km (H)} \cdot 2 \text{ (kt)} \cdot 0.5\ (X_2) \cdot 1.83 \text{ (c)} = 0.0311 \text{ km}^2$$

---

[8]The value of 0.435 t/trip and the total catch estimate of 6,426 t are mean values obtained by averaging the two annual values in Table 7.

Thus, the area swept is 191,821 · 0.0311 = 5,966 km^2

In this calculation, the correction factor (X_2) for the net opening is the mid-range (i.e., 0.5) of values generally used in Southeast Asian waters (0.4 to 0.6).

To estimate the fishing mortality, the relation "swept area" to "area of the fishing ground" was multiplied by an escapement factor (X_1). Values of this factor lie between 0 (no fish caught) and 1 (all fish within the swept area caught). Values from 0.4 to 0.6 are commonly used in Southeast Asian waters (Isarankura 1971; SCS 1978). For this paper, escapement was assumed to be 50%, i.e., X_1 was set at 0.5 (Pauly 1980).

Thus, using equation 5, where

	X_1,	the escapement factor	= 0.5
	a,	the swept area	= 5,966 km^2
and	A,	area of the Bay	= 840 km^2

fishing mortality (F) in the Bay = 3.55

Seasonal Variations

The average daily catches per trip of small and medium trawlers each month in San Miguel Bay are given in Fig. 3. The figure shows the marked decline in landings during the northeast monsoon, especially in October to December.

In Figs. 4 to 7, seasonal variations in catch of the more important species groups in San Miguel Bay are shown, based on landing data of small and medium trawlers in Sabang (see also Appendix Table III). Strong seasonality is evident in anchovy and sardine catches, while mullets are caught more evenly throughout the year. The winter maximum in crustacean landings reflects the lucrative shrimp fishery at that time. Possibly, this fishery compensates for the reduction in total catch per effort during this period of the year.

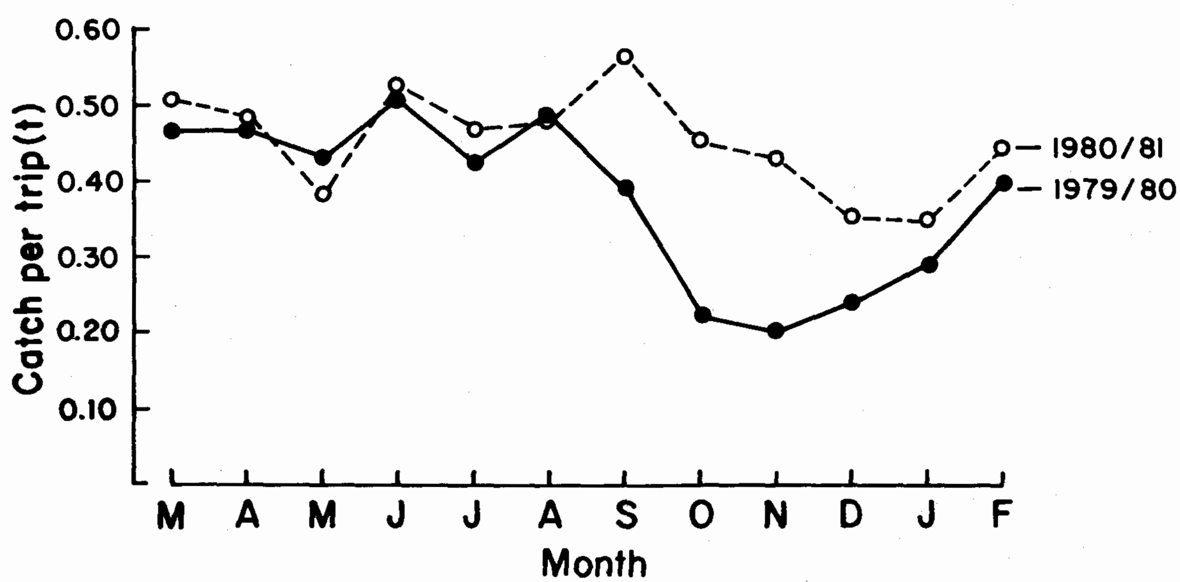

Fig. 3. Catch per two-day trip of small and medium trawlers in San Miguel Bay, March 1979 to February 1981.

Discussion

One of the major aims of this paper has been to determine the fishing mortality of fish stocks in San Miguel Bay. From this figure, one can assess the state of the stocks.

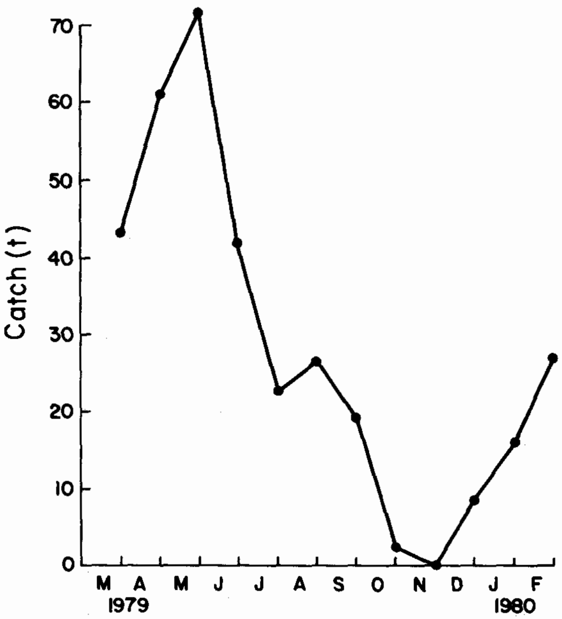

Fig. 4. Long-jawed anchovy *(Stolephorus commersonii)* catch landed by small and medium trawlers in Sabang, Calabanga, 1979/80 (adjusted PFMA data).

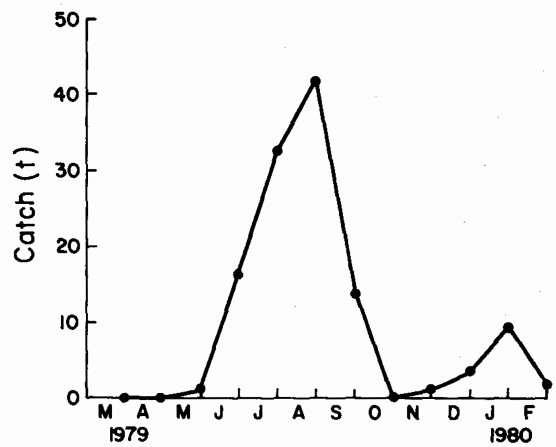

Fig. 5. Sardine *(Sardinella* spp.) catch landed by small and medium trawlers in Sabang, Calabanga, 1979/80 (adjusted PFMA data).

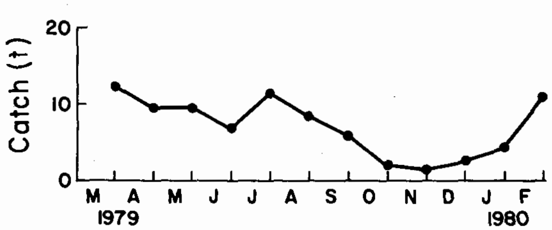

Fig. 6. Mullet (Mugilidae) catch landed by small and medium trawlers in Sabang, Calabanga, 1979/80 (adjusted PFMA data).

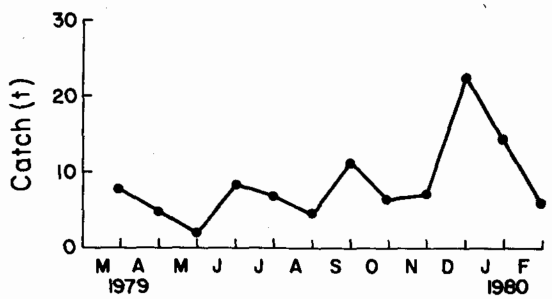

Fig. 7. Crustacean catch by small and medium trawlers in Sabang, Calabanga, 1979/80 (adjusted PFMA data).

The calculated value for fishing mortality, F = 3.55, from this study is subject to four major potential sources of error.

1. *The catch and effort figures might be erroneous.* The reliability of the figures used here is difficult to assess. It is encouraging, however, that the catch-per-effort data obtained during two subsequent years by different researchers are similar. They were gathered by this author in the first year, and by project research assistants in the second year (N. Navaluna and E. Cinco).

2. *The area of distribution of the stock ("A" in Equation 5) is underestimated.* As mentioned earlier, in using the swept-area method, the assumption was made that the defined area of San Miguel Bay was also the exclusive area of distribution of the fish caught there. This assumption certainly does not hold. It is more likely that exchange with the fish stocks of the open Pacific occurs.

One could meet this migration problem by considering a larger area and including the waters adjacent to San Miguel Bay in computing F. The catches of large trawlers operating in this area would have to be included. The fishing mortality outside the bay, however, is probably lower than inside, due to the spread of effort over a greater area. The resulting average value of F would probably be an overestimate for the fishery outside the Bay, and an underestimate for the fishery inside the Bay.

Moreover, the problem of migration is not then solved; it is only shifted to another level; migration of fish into the extended area would still occur. However, the influence on the final result would diminish in comparison with the influence migration has on relatively small areas like San Miguel Bay.

3. *The trawling speed may be incorrectly estimated.* Due to the equations used, the value for the trawling speed has a crucial impact on the result. If, for example, the speed of 2 kt employed for the present computations had been 25% less, the result would also have decreased by 25%.

4. *The values of X_1 and X_2 are erroneous.* As might be seen from the computations presented above, the estimate of F is directly proportional to the value of X_1 and X_2 used. Unfortunately, direct estimates of these values are not available in Southeast Asian waters, although Pauly (1980), using an indirect method, suggested them to be compatible with available information on F obtained by means other than the swept-area method. Also, many authors have used these values throughout Southeast Asia, thus ensuring that the result obtained here will at least be comparable with results obtained elsewhere in Southeast Asia. There are, of course, various other sources of error. In general, however, their influence on the final result is less obvious.

Values of F are generally used in connection with growth parameters of fish and data on their natural mortality to perform stock assessments on a per-species basis (see Navaluna, this report; Pauly, this report).

Here, an assessment is made of the state of the Bay's fishery by comparison with another area, the Gulf of Thailand, for which the demersal trawl fishery is relatively well documented (see Pauly 1979). This fishery started in the early 1960s and was considered overexploited in the late 1960s when F was still below 2.0. Since then, the value of F has steadily increased, while catch per effort declined to about 15% of its original value (Pauly 1979). A value of F = 3.55 would thus imply overfishing even if the San Miguel Bay stocks were more resilient than the Gulf of Thailand stocks.

Another approach to assessing the Bay's stocks is by comparison with the July 1948 survey data (Warfel and Manacop 1950). Five hauls were made in San Miguel Bay, the results of which may be summarized as follows:

Average catch per hour	0.289 t
Area swept per hour	0.081 km^2

In July 1979 and 1980, catch per trip of small trawlers was 0.43 and 0.47 t, respectively, corresponding to an average catch per hour of 0.0355 t, while the surface area swept in one hour of fishing is 0.0311 km^2. Since catch per effort is assumed proportional to standing stock, the relationship between present and past standing stock can be estimated from

$$\frac{0.0355 \times 0.081}{0.289 \times 0.0311} = 0.320, \text{ or } 32\%$$

However, the earlier survey used larger meshes ($\approx$ 6 cm), for which reason the value of 32% is an overestimate. Thus, for example Boonyubol and Hongskul (1978) reported of trawl experiments conducted in the Gulf of Thailand in which meshes of 2 cm caught 60% more than 4-cm meshes. Assuming the same relationship holds between 2- and 6-cm meshes results in the value of 0.289, in the above equation, being replaced by 0.289 x 1.6 = 0.461, in which case present stock size would be 20% of the stock size in 1948. This value, although still an overestimate (because 6-cm mesh sizes catch less than 4-cm meshes) comes close to the 15% value reported from the Gulf of Thailand, which is known to be overfished.

In connection with the reduction of the size of the Bay's fish stocks, a peculiar phenomenon may be noted. Slipmouths (Leiognathidae) were once dominant in the catches from San Miguel Bay

(Tiews and Caces-Borja 1965). Nowadays, larger species, especially *Leiognathus equulus* and *L. splendens*, have virtually disappeared from the landings of the trawlers. Only some of the small-sized species, such as *L. bindus*, *Secutor ruconius* and *S. insidiator* are still present in the catches. The same phenomenon occurred in the Gulf of Thailand, where the marked reduction of the species of the Leiognathidae family was considered a consequence of overfishing (Pauly 1979).

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Program Description

Program Title Weighted catch per gear
Name Jan Michael Vakily
Address German Society for Technical Cooperation (GTZ)
D-6236 Eschborn, Dag-Hammarskjöld-Weg 1
Federal Republic of Germany

Compatibility

In its present form, this program can be implemented on HP 67/97, as well as on HP 41C and HP 41CV.*

Program Description, Equations, Variables, etc.

The program calculates the fish catch per gear for different types of gears, given the total catch landed by all gears, the number of gears of each type and the power factor of the various gears.

One program version can be used with up to 3 different gears (A); the other with up to 9 types of gears (B).

Operating Limits and Warnings

The two methods (A, B) cannot be used concurrently.

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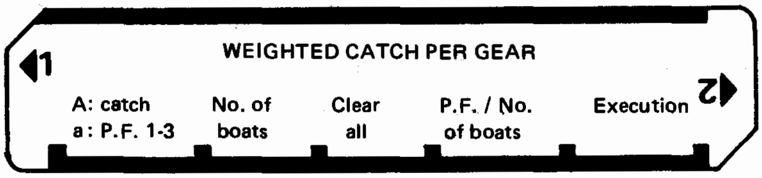
*Mention of trade names does not imply endorsement of commercial products.

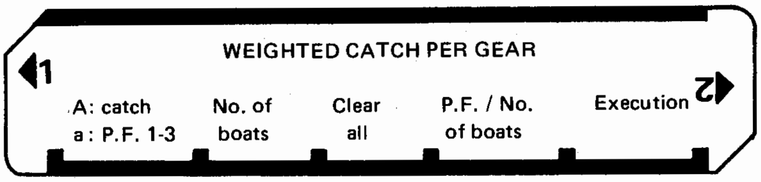
User Instructions (A)



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
	Method for computing the catch per gear of, at the most, three different types of gears:			
1	Read side 1 and 2 of card			
2	Initialize	C		0.00
3	Enter power factor for gear of type 1	P.F.	↑	P.F.
4	Enter power factor for gear of type 2	P.F.	↑	P.F.
5	Enter power factor for gear of type 3*	P.F.	f a	0.00
6	Enter total catch	catch	A	0.00
7	Enter no. of gear of type 1 contributing to the total catch (t.c.) landed	No.	↑	No.
8	Enter no. of gear of type 2 contr. to the t.c.	No.	↑	No.
9	Enter no. of gear of type 3 contr. to the t.c.	No.	B	c/g 1 c/g 2 c/g 3
	Note: The catch per gear (c/g) 1 to 3 can also be recalled from store 1 to 3!		RCL 1-3	
10	For new set of landing data start at step 6			
11	For gears with other power factors go to step 2			

*One always has to enter three power factors. If only two different types of gears are included in the computation, one has to enter "0" for the power factor of type 3. In the following, however, it is not necessary to enter a "0" for the no. of boats of type 3. "B" can be pressed immediately after entering the no. of gears of type 2.

User Instructions (B)



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
	Method for computing the catch per gear of more than three different types of gears (Maximum: 9 types of vessels!):			
1	Read side 1 and 2 of card			
2	Initialize		C	0.00
3	Enter total catch	catch	A	0.00
4	Enter power factor for gear of type 1	P.F.	↑	P.F.
5	Enter no. of gears of type 1 contributing to the total catch landed	No.	D	0.00
6	Repeat step 4 and 5 for each type of gear contributing to the total catch landed*			
7	Calculate catch per gear (c/g)		E	c/g 1 c/g 2
	Note: The catch per gear of type 1 to 9 can also be recalled from store 1 to 9!		RCL 1-9	
8	For new set of landing data start at step 3			

*If more than 9 types of gears are included in the computation, an "Error" message will appear.

Program Listing

Step	Key Entry	Key Code	Step	Key Entry	Key Code	Step	Key Entry	Key Code
001	*LBLA	21 11	051	0	00	101	CLX	– 51
002	RCLA	36 11	052	X = Y?	16 – 33	102	F2?	16 23 02
003	RCLB	36 12	053	GTO0	22 00	103	GTOE	22 15
004	RCLC	36 13	054	CLX	– 51	104	RTN	24
005	CLRG	16 – 53	055	R↓	– 31	105	*LBLE	21 15
006	STOC	35 13	056	CLX	– 51	106	RCLE	36 15
007	R↓	– 31	057	R↓	– 31	107	RCL0	36 00
008	STOB	35 12	058	STOi	35 45	108	÷	– 24
009	R↓	– 31	059	x	– 35	109	RCLi	36 45
010	STOA	35 11	060	ST + 0	35 – 55 00	110	x	– 35
011	R↓	– 31	061	CLX	– 51	111	STOi	35 45
012	STOE	35 15	062	RTN	24	112	DSZI	16 25 46
013	0	00	063	*LBL3	21 03	113	GTOE	22 15
014	STOI	35 46	064	X = 0?	16 – 43	114	F0?	16 23 00
015	CLX	– 51	065	GTOd	22 16 14	115	GTO6	22 06
016	RTN	24	066	RCLC	36 13	116	F1?	16 23 01
017	*LBLa	21 16 11	067	STO3	35 03	117	GTO9	22 09
018	2	02	068	x	– 35	118	GSBc	23 16 13
019	2	02	069	ST + 0	35 – 55 00	119	*LBL6	21 06
020	STOI	35 46	070	R↓	– 31	120	PSE	16 51
021	R↓	– 31	071	GTO4	22 04	121	PSE	16 51
022	X ≠ 0?	16 – 42	072	*LBLd	21 16 14	122	R↓	– 31
023	GTO1	22 01	073	R↓	– 31	123	*LBL9	21 09
024	SF1	16 21 01	074	X = 0?	16 – 43	124	PSE	16 51
025	*LBL2	21 02	075	GTO5	22 05	125	PSE	16 51
026	R↓	– 31	076	*LBL4	21 04	126	R↓	– 31
027	DSZI	16 25 46	077	X = 0?	16 – 43	127	RTN	24
028	STOi	35 45	078	GTOe	22 16 15	128	*LBLc	21 16 13
029	R↓	– 31	079	RCLB	36 12	129	1	01
030	DSZI	16 23 46	080	STO2	35 02	130	STOI	35 46
031	STOi	35 45	081	x	– 35	131	*LBL7	21 07
032	0	00	082	ST + 0	35 – 55 00	132	RCLi	36 45
033	STOI	35 46	083	R↓	– 31	133	X = 0?	16 – 43
034	CLX	– 51	084	X = 0?	16 – 43	134	RTN	24
035	RTN	24	085	GTO6	22 06	135	PSE	16 51
036	*LBL1	21 01	086	GTO5	22 05	136	PSE	16 51
037	SF0	16 21 00	087	*LBLe	21 16 15	137	ISZI	16 26 46
038	STOi	35 45	088	R↓	– 31	138	GTO7	22 07
039	GTO2	22 02	089	X = 0?	16 – 43	139	*LBL0	21 00
040	*LBLB	21 12	090	GTO6	22 06	140	0	00
041	SF2	16 21 02	091	*LBL5	16 – 43	141	÷	– 24
042	*LBLD	21 14	092	X = 0?	16 – 43	142	RTN	24
043	F0?	16 23 00	093	R↓	– 31	143	*LBLC	21 13
044	GTO3	22 03	094	RCLA	36 11	144	CLRG	16 – 53
045	F1?	16 23 01	095	STO1	35 01	145	CF0	16 22 00
046	GTO4	22 04	096	x	– 35	146	CF1	16 22 01
047	X ⇋ Y	– 41	097	ST + 0	35 – 55 00	147	CF2	16 22 02
048	ISZI	16 26 46	098	*LBL6	21 06	148	CLX	– 51
049	RCLI	36 46	099	3	03	149	RTN	24
050	1	01	100	STOI	35 46			

REGISTERS

0	1	2	3	4	5	6	7	8	9
used	used	used	used	used	used	used	used	used	used

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I
P.F. 1	P.F. 2	P.F. 3	used	used	used

LABELS

A	B	C	D	E
used	used	used	used	used

a	b	c	d	e
used			used	used

0	1	2	3	4
used	used	used	used	used

5	6	7	8	9
used	used	used		used

FLAGS

0	1	2	3
used	used	used	

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☒	☒	DEG	☒	FIX	☒
1	☒	☒	GRAD	☐	SCI	☐
2	☒	☒	RAD	☐	ENG	☐
3	☐	☒			n = 3	

Appendix Tables

Appendix Table Ia. Summary of PFMA catch and effort data from the San Miguel Bay trawl fishery, March 1979 (31 fishing days).

Date	Recorded catch (t)	No. trawlers Medium	No. trawlers Small	Catch per trip[a] (t) Medium	Catch per trip[a] (t) Small
01	–	–	–	–	–
02	–	–	–	–	–
03	–	–	–	–	–
04	0.84	2	0	0.42	–
05	3.64	2	8	0.50	0.33
06	1.43	3	0	0.48	–
07	3.00	5	8	0.29	0.19
08	3.88	5	2	0.61	0.41
09	4.15	2	8	0.57	0.38
10	5.06	6	5	0.54	0.36
11	2.86	1	4	0.78	0.52
12	7.53	2	10	0.87	0.58
13	12.88	9	13	0.73	0.49
14	8.10	4	10	0.76	0.51
15	11.53	7	14	0.71	0.47
16	7.71	3	11	0.75	0.50
17	10.82	5	17	0.66	0.44
18	5.32	1	13	0.55	0.37
19	2.65	2	3	0.66	0.44
20	11.72	5	16	0.75	0.50
21	8.51	6	7	0.80	0.53
22	9.33	3	7	1.22	0.81
23	8.39	1	13	0.87	0.58
24	7.63	5	10	0.65	0.44
25	8.96	2	11	0.96	0.64
26	1.98	1	2	0.85	0.57
27	9.64	3	18	0.64	0.43
28	4.58	1	9	0.65	0.44
29	10.01	6	15	0.63	0.42
30	5.01	3	6	0.72	0.48
31	11.27	4	16	0.77	0.51
Σ :	188.42	99	256	19.39	12.34
x :	6.73	3.5	9.1	0.69	0.47
s :	3.51	–	–	0.18	0.11

[a]The computation and the following 23 tables consider the different power factors of medium and small trawlers.

Appendix Table Ib. Summary of PFMA catch and effort data from the San Miguel Bay trawl fishery, April 1979 (27 fishing days).

Date	Recorded catch (t)	No. trawlers Medium	No. trawlers Small	Catch per trip (t) Medium	Catch per trip (t) Small
01	7.03	3	5	1.11	0.74
02	6.69	3	5	1.06	0.70
03	15.91	5	19	0.90	0.60
04	7.08	4	7	0.82	0.54
05	–	–	–	–	–
06	6.17	2	6	1.03	0.69
07	11.37	5	18	0.67	0.45
08	3.36	1	6	0.67	0.45
09	4.30	2	9	0.54	0.36
10	9.09	4	18	0.57	0.38
11	6.06	6	11	0.45	0.30
12	–	–	–	–	–
13	–	–	–	–	–
14	–	–	–	–	–
15	–	–	–	–	–
16	–	–	–	–	–
17	–	–	–	–	–
18	–	–	–	–	–
19	–	–	–	–	–
20	–	–	–	–	–
21	5.71	3	9	0.63	0.42
22	4.77	5	5	0.57	0.38
23	7.03	2	8	0.96	0.64
24	7.77	7	10	0.57	0.38
25	6.05	3	12	0.55	0.37
26	6.74	3	9	0.75	0.50
27	6.40	4	9	0.64	0.43
28	9.07	5	18	0.53	0.36
29	4.55	2	8	0.62	0.41
30	1.42	0	5	0.0	0.28
Σ :	136.57	69	197	13.64	9.38
x :	6.83	3.5	9.9	0.72	0.47
s :	3.03	–	–	0.20	0.14

Appendix Table Ic. Summary of PFMA catch and effort data from the San Miguel Bay trawl fishery, May 1979 (31 fishing days).

Date	Recorded catch (t)	No. trawlers Medium	No. trawlers Small	Catch per trip (t) Medium	Catch per trip (t) Small
01	7.67	2	15	0.64	0.43
02	3.87	2	8	0.53	0.35
03	7.37	3	10	0.76	0.51
04	12.53	5	8	1.21	0.81
05	9.17	6	12	0.66	0.44
06	5.27	1	8	1.05	0.70
07	3.46	0	6	0.0	0.58
08	9.84	4	12	0.80	0.54
09	6.40	2	9	0.80	0.53
10	9.42	6	11	0.71	0.47
11	5.67	2	10	0.65	0.44
12	0.64	4	14	0.72	0.48
13	–	–	–	–	–
14	5.19	1	7	0.92	0.61
15	10.83	5	11	0.88	0.59
16	5.11	1	9	0.73	0.49
17	3.86	5	10	0.33	0.22
18	2.75	0	9	0.0	0.31
19	5.03	4	10	0.47	0.31
20	2.00	1	5	0.46	0.31
21	2.87	1	6	0.57	0.38
22	6.66	4	11	0.59	0.39
23	4.88	1	10	0.64	0.42
24	–	–	–	–	–
25	7.01	4	17	0.46	0.30
26	6.28	2	15	0.52	0.35
27	5.02	1	13	0.52	0.35
28	5.79	5	13	0.42	0.28
29	6.22	3	18	0.41	0.28
30	6.96	3	18	0.46	0.31
31	–	–	–	–	–
Σ :	176.57	78	303	16.93	12.17
x :	6.31	2.8	10.8	0.65	0.43
s :	2.55	–	–	0.21	0.14

Appendix Table Id. Summary of PFMA catch and effort data from the San Miguel Bay trawl fishery, June 1979 (27 fishing days).

Date	Recorded catch (t)	No. trawlers Medium	No. trawlers Small	Catch per trip (t) Medium	Catch per trip (t) Small
01	7.41	5	15	0.49	0.33
02	5.06	3	11	0.49	0.33
03	–	–	–	–	–
04	–	–	–	–	–
05	7.31	3	11	0.71	0.47
06	9.12	2	10	1.05	0.70
07	4.45	1	6	0.89	0.59
08	–	–	–	–	–
09	9.20	4	14	0.69	0.46
10	–	–	–	–	–
11	8.53	4	17	0.56	0.37
12	2.80	2	2	0.84	0.56
13	4.89	0	5	0.0	0.98
14	7.11	3	13	0.61	0.41
15	4.85	2	10	0.56	0.37
16	–	–	–	–	–
17	–	–	–	–	–
18	4.49	3	4	0.79	0.53
19	–	–	–	–	–
20	11.2	3	10	1.19	0.79
21	–	–	–	–	–
22	–	–	–	–	–
23	3.65	3	9	0.41	0.27
24	–	–	–	–	–
25	–	–	–	–	–
26	–	–	–	–	–
27	–	–	–	–	–
28	–	–	–	–	–
29	–	–	–	–	–
30	–	–	–	–	–
Σ :	90.39	38	137	9.28	7.16
x :	6.46	2.7	9.8	0.71	0.51
s :	2.52	–	–	0.23	0.20

Appendix Table I (continued)

Appendix Table Ie. Summary of PFMA catch and effort data from the San Miguel Bay trawl fishery, July 1979 (28 fishing days).

Date	Recorded catch (t)	No. trawlers		Catch per trip (t)	
		Medium	Small	Medium	Small
01	–	–	–	–	–
02	–	–	–	–	–
03	–	–	–	–	–
04	–	–	–	–	–
05	–	–	–	–	–
06	–	–	–	–	–
07	–	–	–	–	–
08	–	–	–	–	–
09	–	–	–	–	–
10	–	–	–	–	–
11	–	–	–	–	–
12	–	–	–	–	–
13	–	–	–	–	–
14	–	–	–	–	–
15	–	–	–	–	–
16	–	–	–	–	–
17	–	–	–	–	–
18	–	–	–	–	–
19	–	–	–	–	–
20	–	–	–	–	–
21	–	–	–	–	–
22	–	–	–	–	–
23	–	–	–	–	–
24	7.05	5	12	0.54	0.36
25	2.88	0	8	0.0	0.36
26	8.87	5	11	0.72	0.48
27	5.90	4	11	0.52	0.35
28	6.27	5	10	0.54	0.36
29	10.32	4	14	0.77	0.52
30	8.80	5	10	0.75	0.50
31	8.29	3	12	0.75	0.50
Σ :	58.38	31	88	4.60	3.43
x :	7.30	3.9	11.0	0.66	0.43
s :	2.31	–	–	0.12	0.08

Appendix Table If. Summary of PFMA catch and effort data from the San Miguel Bay trawl fishery, August 1979 (31 fishing days).

Date	Recorded catch (t)	No. trawlers		Catch per trip (t)	
		Medium	Small	Medium	Small
01	4.25	3	5	0.67	0.45
02	–	–	–	–	–
03	4.41	2	6	0.74	0.49
04	–	–	–	–	–
05	1.61	0	3	0.0	0.54
06	–	–	–	–	–
07	4.64	5	5	0.56	0.37
08	6.75	4	12	0.56	0.38
09	7.44	3	9	0.72	0.48
10	5.53	1	8	0.87	0.58
11	6.44	3	9	0.72	0.48
12	–	–	–	–	–
13	5.96	2	10	0.69	0.46
14	5.02	4	8	0.54	0.36
15	4.83	5	9	0.44	0.29
16	6.82	3	8	0.82	0.55
17	7.89	4	10	0.74	0.49
18	6.55	1	10	0.85	0.57
19	6.35	4	7	0.73	0.49
20	3.29	0	6	0.0	0.55
21	9.66	5	12	0.74	0.50
22	5.66	1	8	0.89	0.60
23	–	–	–	–	–
24	–	–	–	–	–
25	–	–	–	–	–
26	–	–	–	–	–
27	4.57	2	6	0.76	0.51
28	5.64	2	11	0.60	0.40
29	2.09	0	5	0.0	0.42
30	8.71	3	9	0.97	0.65
31	4.91	2	6	0.82	0.55
Σ :	129.02	59	182	14.54	11.20
x :	5.61	2.6	7.9	0.73	0.49
s :	1.91	–	–	0.13	0.09

Appendix Table Ig. Summary of PFMA catch and effort data from the San Miguel Bay trawl fishery, September 1979 (28 fishing days).

Date	Recorded catch (t)	No. trawlers		Catch per trip (t)	
		Medium	Small	Medium	Small
01	13.73	6	15	0.86	0.57
02	2.77	0	5	0.0	0.55
03	6.51	3	9	0.72	0.48
04	8.32	5	10	0.71	0.48
05	3.59	0	6	0.0	0.60
06	–	–	–	–	–
07	–	–	–	–	–
08	–	–	–	–	–
09	2.22	0	6	0.0	0.37
10	–	–	–	–	–
11	–	–	–	–	–
12	4.88	4	9	0.49	0.33
13	3.58	2	9	0.45	0.30
14	2.58	2	7	0.39	0.26
15	–	–	–	–	–
16	–	–	–	–	–
17	–	–	–	–	–
18	–	–	–	–	–
19	–	–	–	–	–
20	–	–	–	–	–
21	–	–	–	–	–
22	–	–	–	–	–
23	–	–	–	–	–
24	3.94	3	7	0.51	0.34
25	4.68	3	10	0.48	0.3[illegible]
26	3.20	2	8	0.44	0.29
27	4.74	4	8	0.51	0.34
28	3.39	1	8	0.54	0.36
29	7.08	6	13	0.48	0.32
30	2.00	0	5	0.0	0.40
Σ :	77.21	41	135	6.58	6.31
x :	4.83	2.6	8.4	0.55	0.39
s :	2.97	–	–	0.27	0.11

Appendix Table Ih. Summary of PFMA catch and effort data from the San Miguel Bay trawl fishery, October 1979 (29 fishing days).

Date	Recorded catch (t)	No. trawlers		Catch per trip (t)	
		Medium	Small	Medium	Small
01	–	–	–	–	–
02	3.42	3	6	0.49	0.33
03	4.96	2	10	0.57	0.38
04	5.83	4	12	0.49	0.32
05	2.44	1	5	0.56	0.38
06	–	–	–	–	–
07	–	–	–	–	–
08	2.10	5	6	0.23	0.16
09	1.57	2	4	0.34	0.22
10	2.18	2	7	0.33	0.22
11	2.79	3	10	0.29	0.19
12	1.18	1	5	0.27	0.18
13	2.71	3	10	0.28	0.19
14	–	–	–	–	–
15	–	–	–	–	–
16	–	–	–	–	–
17	1.06	0	6	0.0	0.18
18	0.72	2	2	0.22	0.14
19	1.88	3	8	0.23	0.15
20	2.83	3	10	0.27	0.18
21	–	–	–	–	–
22	1.41	3	3	0.28	0.19
23	3.50	2	12	0.35	0.23
24	1.65	0	6	0.0	0.28
25	2.81	2	8	0.38	0.26
26	1.41	3	3	0.28	0.19
27	3.08	3	11	0.30	0.20
28	–	–	–	–	–
29	1.25	0	6	0.0	0.21
30	–	–	–	–	–
31	–	–	–	–	–
Σ :	50.58	47	150	6.16	4.76
x :	2.41	2.2	7.1	0.34	0.23
s :	1.28	–	–	0.11	0.07

Appendix Table I (continued)

Appendix Table Ii. Summary of PFMA catch and effort data from the San Miguel Bay trawl fishery, November 1979 (26 fishing days).

Date	Recorded catch (t)	No. trawlers		Catch per trip (t)	
		Medium	Small	Medium	Small
01	–	–	–	–	–
02	–	–	–	–	–
03	–	–	–	–	–
04	–	–	–	–	–
05	–	–	–	–	–
06	–	–	–	–	–
07	–	–	–	–	–
08	0.82	1	3	0.27	0.18
09	0.87	1	3	0.29	0.19
10	1.21	2	4	0.26	0.17
11	–	–	–	–	–
12	1.74	5	6	0.19	0.13
13	2.27	3	9	0.25	0.17
14	–	–	–	–	–
15	2.09	3	8	0.25	0.17
16	2.74	4	8	0.29	0.20
17	1.25	0	6	0.0	0.21
18	0.99	2	3	0.25	0.17
19	–	–	–	–	–
20	2.23	4	7	0.26	0.17
21	–	–	–	–	–
22	–	–	–	–	–
23	–	–	–	–	–
24	–	–	–	–	–
25	–	–	–	–	–
26	–	–	–	–	–
27	4.14	2	8	0.56	0.38
28	1.60	1	4	0.44	0.29
29	1.86	1	7	0.33	0.22
30	0.44	1	1	0.26	0.18
Σ :	24.25	30	77	3.91	2.82
x :	1.73	2.1	5.5	0.30	0.20
s :	0.95	–	–	0.10	0.06

Appendix Table Ij. Summary of PFMA catch and effort data from the San Miguel Bay trawl fishery, December 1979 (31 fishing days).

Date	Recorded catch (t)	No. trawlers		Catch per trip (t)	
		Medium	Small	Medium	Small
01	–	–	–	–	–
02	–	–	–	–	–
03	–	–	–	–	–
04	2.03	1	2	0.68	0.45
05	1.41	1	2	0.60	0.40
06	3.71	4	9	0.37	0.25
07	2.18	1	7	0.38	0.26
08	–	–	–	–	–
09	1.50	2	2	0.45	0.30
10	2.19	2	4	0.47	0.31
11	–	–	–	–	–
12	–	–	–	–	–
13	0.90	1	2	0.39	0.26
14	0.46	1	1	0.28	0.18
15	–	–	–	–	–
16	–	–	–	–	–
17	1.18	3	1	0.32	0.21
18	6.34	1	13	0.66	0.44
19	3.13	3	6	0.45	0.30
20	6.48	3	11	0.63	0.42
21	3.20	2	8	0.44	0.29
22	7.65	6	12	0.55	0.36
23	8.32	2	15	0.69	0.46
24	–	–	–	–	–
25	–	–	–	–	–
26	–	–	–	–	–
27	–	–	–	–	–
28	3.22	2	4	0.69	0.46
29	7.21	3	12	0.66	0.44
30	–	–	–	–	–
31	–	–	–	–	–
Σ :	61.11	38	112	8.69	5.79
x :	3.59	2.2	6.6	0.51	0.34
s :	2.58	–	–	0.14	0.09

Appendix Table Ik. Summary of PFMA catch and effort data from the San Miguel Bay trawl fishery, January 1980 (28 fishing days).

Date	Recorded catch (t)	No. trawlers		Catch per trip (t)	
		Medium	Small	Medium	Small
01	–	–	–	–	–
02	–	–	–	–	–
03	–	–	–	–	–
04	–	–	–	–	–
05	6.81	3	8	0.82	0.54
06	–	–	–	–	–
07	1.30	1	2	0.56	0.37
08	3.13	2	7	0.47	0.31
09	–	–	–	–	–
10	–	–	–	–	–
11	3.77	2	6	0.63	0.42
12	–	–	–	–	–
13	–	–	–	–	–
14	–	–	–	–	–
15	3.30	1	7	0.58	0.39
16	3.33	2	6	0.56	0.37
17	5.52	4	10	0.52	0.35
18	5.02	4	7	0.58	0.39
19	5.86	2	12	0.59	0.39
20	–	–	–	–	–
21	–	–	–	–	–
22	2.58	1	5	0.60	0.40
23	–	–	–	–	–
24	–	–	–	–	–
25	–	–	–	–	–
26	–	–	–	–	–
27	–	–	–	–	–
28	–	–	–	–	–
29	–	–	–	–	–
30	–	–	–	–	–
31	–	–	–	–	–
Σ :	40.62	22	70	5.89	3.93
x :	4.06	2.2	7.0	0.59	0.39
s :	1.69	–	–	0.09	0.06

Appendix Table Il. Summary of PFMA catch and effort data from the San Miguel Bay trawl fishery, February 1980 (27 fishing days).

Date	Recorded catch (t)	No. trawlers		Catch per trip (t)	
		Medium	Small	Medium	Small
01	–	–	–	–	–
02	–	–	–	–	–
03	–	–	–	–	–
04	–	–	–	–	–
05	9.01	4	10	0.84	0.56
06	7.02	2	7	1.05	0.70
07	2.89	3	5	0.46	0.30
08	2.34	3	4	0.41	0.28
09	–	–	–	–	–
10	–	–	–	–	–
11	–	–	–	–	–
12	–	–	–	–	–
13	–	–	–	–	–
14	–	–	–	–	–
15	3.87	6	5	0.41	0.28
16	7.05	4	14	0.53	0.35
17	–	–	–	–	–
18	2.58	2	6	0.43	0.29
19	3.69	3	10	0.38	0.25
20	7.27	6	14	0.47	0.32
21	2.21	2	4	0.47	0.32
22	2.84	3	4	0.50	0.33
23	9.84	7	16	0.56	0.37
24	3.11	3	4	0.55	0.37
25	1.07	0	3	0.0	0.36
26	–	–	–	–	–
27	8.69	3	15	0.67	0.45
28	10.08	4	8	1.08	0.72
29	8.13	3	9	0.90	0.60
Σ :	91.69	58	138	9.73	6.84
x :	5.39	3.4	8.1	0.81	0.40
s :	3.08	–	–	0.23	0.15

Appendix Table I (continued)

Appendix Table Im. Summary of PFMA catch and effort data from the San Miguel Bay trawl fishery, March 1980 (31 fishing days).

Date	Recorded catch (t)	No. trawlers		Catch per trip (t)	
		Medium	Small	Medium	Small
1	3.4	0	5	–	0.68
2	–	–	–	–	–
3	–	–	–	–	–
4	11.0	6	16	0.66	0.44
5	10.8	6	9	0.90	0.60
6	9.0	2	10	1.04	0.69
7	3.0	1	4	0.82	0.55
8	10.3	5	13	0.75	0.50
9	7.0	2	9	0.88	0.58
10	12.5	7	16	0.71	0.47
11	7.2	2	13	0.68	0.45
12	10.1	8	10	0.69	0.46
13	6.1	0	9		0.68
14	9.3	3	11	0.90	0.60
15	11.0	5	13	0.80	0.54
16	5.5	2	2	0.83	0.55
17	7.2	2	9	0.90	0.60
18	6.2	4	13	0.49	0.33
19	2.9	1	5	0.67	0.45
20	5.0	2	7	0.75	0.50
21	–	–	–	–	–
22	–	–	–	–	–
23	–	–	–	–	–
24	–	–	–	–	–
25	–	–	–	–	–
26	–	–	–	–	–
27	1.8	2	3	0.4	0.3
28	4.0	3	6	0.6	0.4
29	3.4	1	5	0.8	0.5
30	–	–	–	–	–
31	3.3	3	6	0.5	0.3
Σ :	150.0	67.0	199.0	*4.74	10.50
$\bar{x}$:	6.8	3.0	9.0	0.70	0.51
s :	3.2	–	–	0.22	0.11

Appendix Table In. Summary of PFMA catch and effort data from the San Miguel Bay trawl fishery, April 1980 (27 fishing days).

Date	Recorded catch (t)	No. trawlers		Catch per trip (t)	
		Medium	Small	Medium	Small
1	–	–	–	–	–
2	–	–	–	–	–
3	–	–	–	–	–
4	–	–	–	–	–
5	–	–	–	–	–
6	–	–	–	–	–
7	–	–	–	–	–
8	–	–	–	–	–
9	4.6	3	6	0.7	0.4
10	7.5	5	7	0.8	0.5
11	4.9	3	8	0.6	0.4
12	4.2	1	5	1.0	0.6
13	–	–	–	–	–
14	6.7	6	8	0.6	0.4
15	10.6	6	12	0.8	0.5
16	4.7	3	6	0.7	0.4
17	3.0	1	6	0.6	0.4
18	8.7	7	12	0.6	0.4
19	–	–	–	–	–
20	–	–	–	–	–
21	3.2	3	4	0.6	0.4
22	8.7	5	9	0.8	0.5
23	8.1	3	8	1.0	0.6
24	7.2	4	8	0.8	0.5
25	5.6	1	8	0.9	0.6
26	8.5	2	9	1.1	0.7
27	–	–	–	–	–
28	–	–	–	–	–
29	6.0	4	8	0.6	0.4
30	3.2	1	5	0.7	0.5
Σ :	105.4	58.0	129.0	12.9	8.2
$\bar{x}$:	6.2	3.4	7.6	0.8	0.48
s :	2.3	–	–	0.2	0.1

Appendix Table Io. Summary of PFMA catch and effort data from the San Miguel Bay trawl fishery, May 1980 (31 fishing days).

Date	Recorded catch (t)	No. trawlers		Catch per trip (t)	
		Medium	Small	Medium	Small
1	6.1	4	3	1.0	0.7
2	3.1	2	4	0.7	0.4
3	–	–	–	–	–
4	–	–	–	–	–
5	4.2	2	5	0.8	0.5
6	4.3	4	6	0.5	0.4
7	1.7	2	2	0.5	0.3
8	2.3	1	3	0.8	0.5
9	2.9	2	7	0.4	0.3
10	4.0	0	10	–	0.4
11	–	–	–	–	–
12	1.3	1	3	0.4	0.3
13	–	–	–	–	–
14	–	–	–	–	–
15	0.2	0	2	–	0.1
16	1.9	0	6	–	0.3
17	2.1	1	5	0.5	0.3
18	–	–	–	–	–
19	2.9	4	7	0.3	0.2
20	2.5	1	7	0.4	0.3
21	2.1	2	4	0.5	0.3
22	–	–	–	–	–
23	4.1	2	6	0.7	0.5
24	4.6	3	5	0.7	0.5
25	–	–	–	–	–
26	–	–	–	–	–
27	–	–	–	–	–
28	3.3	3	3	0.7	0.4
29	2.4	2	3	0.6	0.4
30	2.7	2	4	0.6	0.4
31	–	–	–	–	–
Σ :	58.7	38.0	95.0	10.1	7.5
$\bar{x}$:	2.9	1.9	4.8	0.6	0.38
s :	1.3	–	–	0.2	0.1

Appendix Table Ip. Summary of PFMA catch and effort data from the San Miguel Bay trawl fishery, June 1980 (27 fishing days).

Date	Recorded catch (t)	No. trawlers		Catch per trip (t)	
		Medium	Small	Medium	Small
1	2.1	1	2	0.9	0.6
2	3.1	1	3	1.0	0.7
3	1.3	1	3	0.4	0.3
4	–	–	–	–	–
5	–	–	–	–	–
6	–	–	–	–	–
7	3.1	2	2	0.9	0.6
8	–	–	–	–	–
9	4.3	3	7	0.6	0.4
10	3.4	1	5	0.8	0.5
11	2.5	7	0	0.4	–
12	3.2	1	4	0.9	0.6
13	2.0	2	6	0.3	0.2
14	3.9	1	4	1.1	0.7
15	–	–	–	–	–
16	–	–	–	–	–
17	3.9	1	7	0.7	0.5
18	3.2	2	3	0.8	0.5
19	–	–	–	–	–
20	2.6	1	5	0.6	0.4
21	4.6	3	8	0.6	0.4
22	–	–	–	–	–
23	–	–	–	–	–
24	–	–	–	–	–
25	–	–	–	–	–
26	2.1	2	1	0.8	0.5
27	9.3	3	10	1.0	0.6
28	6.6	3	3	1.3	0.9
29	–	–	–	–	–
30	–	–	–	–	–
Σ :	61.2	35.0	73.0	13.1	8.4
$\bar{x}$:	3.6	2.1	4.3	0.8	0.52
s :	1.9	–	–	0.3	0.2

Appendix Table I (continued)

Appendix Table Iq. Summary of PFMA catch and effort data from the San Miguel Bay trawl fishery, July 1980 (28 fishing days).

Date	Recorded catch (t)	No. trawlers Medium	No. trawlers Small	Catch per trip (t) Medium	Catch per trip (t) Small
1	6.20	3	7	0.8	0.5
2	1.00	0	2	–	0.5
3	3.82	3	3	0.8	0.5
4	6.02	4	6	0.8	0.5
5	–	–	–	–	–
6	–	–	–	–	–
7	3.38	2	3	0.9	0.6
8	3.08	1	6	0.6	0.4
9	8.99	7	13	0.6	0.4
10	–	–	–	–	–
11	1.83	0	6	–	0.3
12	–	–	–	–	–
13	3.21	3	7	0.4	0.3
14	1.79	3	2	0.4	0.3
15	3.71	5	4	0.5	0.3
16	3.94	3	4	0.7	0.5
17	2.22	2	2	0.7	0.4
18	6.27	8	8	0.5	0.3
19	5.20	4	7	0.6	0.4
20	–	–	–	–	–
21	–	–	–	–	–
22	–	–	–	–	–
23	6.97	6	5	0.8	0.5
24	–	–	–	–	–
25	–	–	–	–	–
26	–	–	–	–	–
27	–	–	–	–	–
28	3.38	1	4	0.9	0.6
29	7.00	3	6	1.0	0.7
30	8.18	4	6	1.0	0.7
31	6.86	3	6	1.0	0.7
Σ :	93.1	65.0	107.0	13.0	9.4
$\bar{x}$:	4.7	3.3	5.4	0.7	0.47
s :	2.3	–	–	0.2	0.1

Appendix Table Ir. Summary of PFMA catch and effort data from the San Miguel Bay trawl fishery, August 1980 (31 fishing days).

Date	Recorded catch (t)	No. trawlers Medium	No. trawlers Small	Catch per trip (t) Medium	Catch per trip (t) Small
1	2.38	2	5	0.5	0.3
2	1.00	0	2	–	0.5
3	3.96	2	4	0.9	0.6
4	6.07	4	6	0.8	0.5
5	3.97	5	1	0.7	0.5
6	–	–	–	–	–
7	3.38	2	3	0.9	0.6
8	–	–	–	–	–
9	9.02	5	15	0.6	0.4
10	–	–	–	–	–
11	–	–	–	–	–
12	5.36	1	8	0.9	0.6
13	–	–	–	–	–
14	4.38	4	2	0.8	0.6
15	8.70	3	18	0.6	0.4
16	–	–	–	–	–
17	–	–	–	–	–
18	3.62	4	4	0.5	0.4
19	11.59	4	21	0.6	0.4
20	3.77	2	4	0.8	0.5
21	3.10	3	2	0.7	0.5
22	8.04	2	14	0.7	0.5
23	6.39	6	8	0.6	0.4
24	0.96	1	2	0.4	0.3
25	0.53	1	0	0.5	–
26	4.16	3	3	0.8	0.6
27	6.94	4	13	0.6	0.4
28	–	–	–	–	–
29	7.44	6	5	0.8	0.5
30	8.24	6	6	0.8	0.5
31	–	–	–	–	–
Σ :	113.2	70.0	146.0	14.5	10.0
$\bar{x}$:	5.1	3.2	6.6	0.7	0.48
s :	2.9	–	–	0.1	0.1

Appendix Table Is. Summary of PFMA catch and affort data from the San Miguel Bay trawl fishery, September 1980 (28 fishing days).

Date	Recorded catch (t)	No. trawlers Medium	No. trawlers Small	Catch per trip (t) Medium	Catch per trip (t) Small
1	5.46	3	6	0.8	0.5
2	10.24	4	14	0.8	0.5
3	6.17	3	4	1.1	0.7
4	–	–	–	–	–
5	5.19	5	3	0.7	0.5
6	5.62	1	4	1.5	1.0
7	–	–	–	–	–
8	0.76	1	0	–	–
9	5.10	1	10	0.7	0.4
10	–	–	–	–	–
11	4.77	2	6	0.8	0.5
12	5.65	4	9	0.6	0.4
13	–	–	–	–	–
14	–	–	–	–	–
15	2.40	1	3	1.2	0.8
16	5.97	3	3	1.2	0.8
17	3.83	0	5	–	0.8
18	6.16	9	2	0.6	0.4
19	–	–	–	–	–
20	–	–	–	–	–
21	–	–	–	–	–
22	–	–	–	–	–
23	5.43	5	5	0.6	0.4
24	3.46	4	2	0.6	0.4
25	5.35	2	4	1.2	0.8
26	2.43	1	3	0.8	0.5
27	6.71	6	6	0.6	0.4
28	–	–	–	–	–
29	–	–	–	–	–
30	5.86	4	4	0.9	0.6
Σ :	96.3	59.0	93.0	14.3	10.1
$\bar{x}$:	5.1	3.1	4.9	0.8	0.6
s :	2.0	–	–	0.3	0.2

Appendix Table It. Summery of PFMA catch and affort data from the San Miguel Bay trawl fishery, October 1980 (29 fishing days).

Date	Recorded catch (t)	No. trawlers Medium	No. trawlers Small	Catch per trip (t) Medium	Catch per trip (t) Small
1	5.98	4	8	0.6	0.4
2	8.58	7	9	0.7	0.4
3	7.59	6	8	0.7	0.4
4	2.66	1	4	0.7	0.5
5	–	–	–	–	–
6	3.19	2	4	0.7	0.5
7	5.49	5	5	0.7	0.4
8	3.45	5	1	0.6	0.4
9	10.08	9	8	0.7	0.5
10		–	–	–	–
11	2.36	1	3	0.8	0.5
12		–	–	–	–
13	2.78	3	2	0.6	0.4
14	9.65	6	14	0.6	0.4
15	4.11	2	6	0.7	0.5
16	5.15	3	5	0.8	0.5
17	5.61	4	8	0.6	0.4
18	10.74	7	9	0.8	0.5
19	–	–	–	–	–
20	4.87	4	4	0.7	0.5
21	5.34	5	3	0.8	0.5
22	7.61	5	14	0.5	0.4
23		–	–	–	–
24	9.55	5	8	0.9	0.6
25	8.64	8	4	0.8	0.5
26	–	–	–	–	–
27	6.29	5	3	0.9	0.6
28	3.13	2	8	0.4	0.3
29	4.15	4	7	0.5	0.3
30	4.53	3	5	0.7	0.5
31	8.02	7	9	0.6	0.4
Σ :	149.5	113.0	159.0	17.1	11.3
$\bar{x}$:	6.0	4.5	6.4	0.7	0.5
s :	2.5	–	–	0.1	0.1

Appendix Table I (continued)

Appendix Table Iu. Summary of PFMA catch end effort date from tha San Miguel Bay trawl fishery, November 1980 (26 fishing days).

Date	Recorded catch (t)	No. trawlers Medium	No. trawlers Small	Catch per trip (t) Medium	Catch per trip (t) Small
1	–	–	–	–	–
2	–	–	–	–	–
3	–	–	–	–	–
4	–	–	–	–	–
5	–	–	–	–	–
6	–	–	–	–	–
7	4.46	2	6	0.8	0.5
8	5.04	5	4	0.7	0.4
9	–	–	–	–	–
10	5.61	2	12	0.6	0.4
11	3.92	3	9	0.5	0.3
12	0.76	1	1	0.5	0.3
13	3.19	2	3	0.8	0.6
14	4.53	3	4	0.8	0.5
15	1.40	0	2	–	0.7
16	–	–	–	–	–
17	–	–	–	–	–
18	3.94	2	5	0.7	0.5
19	2.23	3	3	0.6	0.4
20	4.78	3	5	0.6	0.5
21	–	–	–	–	–
22	2.34	2	2	0.7	0.5
23	–	–	–	–	–
24	1.96	1	3	0.7	0.4
25	4.93	3	8	0.5	0.4
26	5.97	5	12	0.5	0.3
27	5.79	4	8	0.6	0.4
28	2.45	1	5	0.6	0.4
29	2.71	3	4	0.5	0.3
30	1.92	0	5	–	0.4
Σ :	66.3	45.0	100.0	10.9	8.1
$\bar{x}$:	3.6	2.4	5.3	0.6	0.43
s :	1.5	–	–	0.1	0.1

Appendix Table Iv. Summary of PFMA catch and effort data from the San Miguel Bay trawl fishery, December 1980 (31 fishing days).

Date	Recorded catch (t)	No. trawlers Medium	No. trawlers Small	Catch per trip (t) Medium	Catch per trip (t) Small
1	–	–	–	–	–
2	5.28	5	5	0.6	0.4
3	8.47	6	8	0.8	0.5
4	1.81	1	3	0.6	0.4
5	5.27	3	7	0.7	0.5
6	7.19	4	8	0.8	0.5
7	–	–	–	–	–
8	4.44	4	4	0.7	0.4
9	6.08	3	16	0.4	0.3
10	3.52	2	4	0.8	0.5
11	6.78	7	10	0.6	0.4
12	4.49	4	6	0.6	0.4
13	2.36	2	4	0.5	0.3
14		–	–	–	–
15	6.40	5	9	0.6	0.4
16	6.24	4	16	0.4	0.3
17	–	–	–	–	–
18	–	–	–	–	–
19	–	–	–	–	–
20	–	–	–	–	–
21	–	–	–	–	–
22	–	–	–	–	–
23	1.34	2	1	0.5	0.3
24	1.36	1	3	0.5	0.3
25		–	–	–	–
26	2.04	3	2	0.5	0.3
27	2.30	2	7	0.3	0.2
28	0.57	1	1	0.4	0.2
29	5.15	2	17	0.3	0.2
30	3.88	6	6	0.4	0.3
31		–	–	–	–
Σ :	87.1	72.0	137.0	11.0	7.1
$\bar{x}$:	4.4	3.6	6.9	0.6	0.36
s :	2.4	–	–	0.2	0.1

Appendix Table Iw. Summary of PFMA catch and effort data from the San Miguel Bay trawl fishery, January 1981 (28 fishing days).

Date	Recorded catch (t)	No. trawlers Medium	No. trawlers Small	Catch per trip (t) Medium	Catch per trip (t) Small
1	–	–	–	–	–
2	1.45	1	1	0.8	0.6
3	2.34	2	4	0.5	0.3
4		–	–	–	–
5	2.66	5	5	0.3	0.2
6	5.46	4	11	0.5	0.3
7	4.03	5	9	0.4	0.2
8		–	–	–	–
9		–	–	–	–
10	3.37	3	9	0.4	0.3
11		–	–	–	–
12		–	–	–	–
13	0.46	2	0	0.2	-
14	2.31	3	6	0.3	0.2
15	3.61	7	5	0.3	0.2
16	4.38	5	8	0.4	0.3
17	4.82	4	6	0.5	0.3
18		–	–	–	–
19	3.08	3	4	0.5	0.4
20	4.49	3	11	0.4	0.3
21	7.92	4	11	0.7	0.5
22	7.53	6	8	0.7	0.4
23	4.78	1	8	0.8	0.5
24	7.68	6	6	0.8	0.5
25		–	–	–	–
26	2.36	2	3	0.6	0.4
27	4.64	7	3	0.5	0.3
28	0.52	0	1	-	0.5
29	3.31	3	7	0.4	0.3
30	4.92	6	8	0.4	0.3
31	5.12	4	6	0.6	0.4
Σ :	91.0	86.0	142.0	11.0	7.7
$\bar{x}$:	4.0	3.7	6.2	0.5	0.4
s :	2.0	–	–	0.2	0.1

Appendix Table Ix. Summary of PFMA catch and effort data from the San Miguel Bay trawl fishery, February 1981 (27 fishing days).

Date	Recorded catch (t)	No. trawlers Medium	No. trawlers Small	Catch per trip (t) Medium	Catch per trip (t) Small
1	–	–	–	–	–
2	9.52	5	13	0.7	0.5
3	6.22	6	12	0.6	0.4
4	5.49	4	7	0.6	0.4
5	4.50	3	4	0.8	0.5
6	5.94	6	5	0.6	0.4
7	9.36	8	6	0.7	0.5
8		–	–	–	–
9	1.26	1	2	0.6	0.4
10	6.71	3	12	0.6	0.4
11	2.88	2	8	0.4	0.3
12	4.18	1	6	0.8	0.6
13	6.93	6	12	0.5	0.3
14	6.70	5	9	0.6	0.4
15		–	–	–	–
16	4.89	2	8	0.7	0.4
17	9.30	5	13	0.7	0.5
18	6.85	5	9	0.6	0.4
19	9.76	8	8	0.7	0.5
20	5.06	2	7	0.8	0.5
21	–	–	–	–	–
22	–	–	–	–	–
23	3.72	4	5	0.5	0.3
24	7.94	7	6	0.7	0.5
25	10.71	10	7	0.7	0.5
26	6.35	2	10	0.7	0.5
27	7.68	8	8	0.6	0.4
28	8.33	4	14	0.6	0.4
Σ :	152.2	107.0	193.0	14.6	9.9
$\bar{x}$:	6.6	4.7	8.4	0.6	0.44
s :	2.5	–	–	0.1	0.1

Appendix Table IIa. Summary of catch and effort data on representative large trawlers operating from Camaligan[a] (1979/80).

Vessel No. 1 (85.83 GT, 365 HP)

Date of operation				Total		Within San Miguel Bay			
Day	Month	Fishing days	Hauls	Trawling hours	Catch[b] (t)	Hauls	Trawling hours	Catch[b] (t)	Catch in % of total
04-08	Jan	5	21	104.8	9.9	0	0	0	–
09-14	Jan	6	21	100.9	8.7	1	4.0	0.3	3
05-10	Feb	6	15	69.4	4.8	0	0	0	–
12-16	Feb	5	20	96.6	7.1	0	0	0	–
01-06	Mar	6	23	109.7	6.1	11	44.3	2.5	41
15-20	Mar	6	22	110.2	6.2	0	0	0	–
21-25	Mar	5	18	86.8	4.2	0	0	0	–
30-03	Mar/Apr	4	13	63.4	6.0	0	0	0	–
04-10	May	7	23	107.1	6.1	0	0	0	–
11-17	May	7	26	129.3	7.8	0	0	0	–
09-16	Jun	8	28	142.8	10.7	0	0	0	–
12-19	Jul	8	29	144.9	11.8	0	0	0	–
21-26	Jul	6	25	127.6	8.4	0	0	0	–
27-03	Jul/Aug	8	29	149.7	9.8	0	0	0	–
07-12	Aug	6	24	121.4	11.6	0	0	0	–
13-19	Aug	7	26	135.3	11.1	0	0	0	–
27-03	Sep/Oct	7	30	135.0	7.2	3	12.9	0.7	10
05-11	Oct	7	25	126.1	6.0	20	100.1	4.3	72
14-21	Oct	8	33	153.0	6.2	30	137.8	5.7	92
22-29	Oct	8	27	133.8	4.9	27	133.8	4.9	100
06-13	Nov	8	27	130.8	5.5	27	130.8	5.5	100
13-18	Nov	6	19	83.8	5.0	4	14.8	0.5	10
25-30	Nov	6	23	105.9	4.3	6	25.7	0.8	19
02-08	Dec	7	23	103.9	5.7	4	16.0	0.6	11
09-15	Dec	7	27	126.1	4.5	27	126.1	4.5	100
04-10	Feb	7	27	126.5	7.8	0	0	0	–
20-27	Feb	8	26	131.8	11.3	0	0	0	–
n = 27	Σ :	179	650	3,156.6	198.7	160	746.3	30.3	
	x :	6.6	24.1	116.9	7.4				
	s :	1.1	4.5	23.3	2.4				

[a]Adapted from log sheets supplied by a private operator.
[b]The weight is converted from "Salok" units (1 Salok ≈ 100 kg).

Appendix Table IIb. Summary of catch and effort data on representative large trawlers operating from Camaligan[a] (1979/80).

Vessel No. 2 (79.83 GT, 440 HP)

Date of operation				Total		Within San Miguel Bay			
		Fishing		Trawling	Catch[b]		Trawling	Catch[b]	Catch in
Day	Month	days	Hauls	hours	(t)	Hauls	hours	(t)	% of total
25-30	Aug	6	23	98.5	6.6	0	0	0	–
02-07	Sep	6	22	94.0	10.4	1	4.0	0.2	2
09-15	Sep	7	28	130.5	8.2	0	0	0	–
19-25	Sep	6	23	102.5	6.4	5	22.0	0.6	9
27-04	Sep/Oct	8	30	140.0	6.1	17	78.0	3.3	54
06-11	Oct	6	23	112.0	4.2	15	71.0	2.6	62
12-18	Oct	7	26	129.0	4.9	19	97.0	3.7	76
20-26	Oct	7	27	136.0	5.1	27	136.0	5.1	100
27-02	Oct/Nov	6	22	100.5	3.8	16	78.0	2.7	71
03-11	Nov	6	23	103.0	8.9	0	0	0	–
13-18	Nov	6	22	108.0	5.6	3	14.0	0.2	4
20-26	Nov	6	19	91.0	3.9	2	8.0	0.2	5
26 Nov-29 Dec					No operation because of engine trouble				
29-04	Dec/Jan	7	23	115.0	7.6	0	0	0	–
06-08	Jan	2	5	24.0	1.6	0	0	0	–
10-16	Jan	7	24	116.5	8.0	0	0	0	–
18-24	Jan	6	21	106.5	5.1	0	0	0	–
26-29	Jan	4	14	70.0	4.1	0	0	0	–
02-07	Feb	6	23	120.0	5.4	0	0	0	–
09-13	Feb	5	12	56.6	3.4	0	0	0	–
15-19	Feb	4	13	65.2	3.2	0	0	0	–
23-01	Feb/Mar	7	27	135.8	6.9	0	0	0	–
02-11	Mar	7	23	11.5	6.1	0	0	0	–
13-19	Mar	6	22	109.0	5.4	0	0	0	–
21-27	Mar	6	20	91.9	4.0	0	0	0	–
29-02	Mar/Apr	4	15	71.5	5.0	0	0	0	–
06-14	Apr	8	25	114.2	6.1	0	0	0	–
n = 26	Σ :	156	555	2,652.7	145.0	105	508	18.6	
	x :	6.0	21.3	102.0	5.6				
	s :	1.3	5.6	27.0	2.0				

[a]Adapted from log sheets supplied by a private operator.
[b]The weight is converted from "Salok" units (1 Salok ≈ 100 kg).

Appendix Table IIc. Summary of catch and effort data on representative large trawlers operating from Camaligan[a] (1979/80).

Vessel No. 3 (34.17 GT, 275 HP)

Date of operation				Total		Within San Miguel Bay			
		Fishing		Trawling	Catch[b]		Trawling	Catch[b]	Catch in
Day	Month	days	Hauls	hours	(t)	Hauls	hours	(t)	% of total
20-25	Jan	6	25	126.5	6.9	0	0	0	–
02-08	Feb	7	27	132.5	7.1	0	0	0	–
11-16	Feb	6	26	120.3	9.3	0	0	0	–
18-23	Feb	6	26	122.0	7.3	0	0	0	–
25-02	Feb/Mar	6	24	119.0	6.6	0	0	0	–
04-09	Mar	6	24	117.5	6.6	0	0	0	–
17-23	Mar	6	25	124.8	8.0	0	0	0	–
14-21	Apr	8	22	108.2	5.3	0	0	0	–
24-29	Apr	6	26	130.5	5.8	0	0	0	–
01-06	May	6	25	128.5	5.6	0	0	0	–
07-13	May	7	24	106.9	4.7	0	0	0	–
31-05	May/Jun	6	24	115.5	6.5	0	0	0	–
09-15	Jun	7	28	140.0	10.2	0	0	0	–
16-22	Jun	7	25	125.5	5.9	0	0	0	–
23-28	Jun	6	23	107.5	5.2	0	0	0	–
30-07	Jun/Jul	7	24	118.0	6.8	10	48.0	2.5	37
08-14	Jul	7	28	128.5	6.9	0	0	0	–
08-13	Aug	6	24	119.0	9.0	0	0	0	–
22-27	Aug	6	24	119.0	8.1	0	0	0	–
30-04	Aug/Sep	6	21	90.7	7.7	0	0	0	–
05-11	Sep	7	25	112.0	8.6	0	0	0	–
13-17	Sep	5	16	78.0	3.9	2	10.0	0.4	10
27-03	Sep/Oct	7	31	146.5	6.7	0	0	0	–
04-10	Oct	7	26	130.0	4.3	0	0	0	–
12-18	Oct	7	29	142.0	5.8	29	142.0	5.8	100
19-25	Oct	7	28	138.0	5.4	28	138.0	5.4	100
26-27	Oct	2	8	38.0	1.6	8	38.0	1.6	100
31-05	Oct/Nov	6	20	95.0	3.7	20	95.0	3.7	100
07-14	Nov	8	29	139.0	4.3	29	139.0	4.3	100
15-21	Nov	7	27	125.7	3.8	11	59.7	1.6	42
03-09	Jan	7	28	135.7	7.7	11	53.5	2.6	34
12-19	Feb	8	29	141.3	4.8	11	55.0	1.6	33
01-07	Mar	7	27	129.3	8.6	0	0	0	–
n = 33	Σ :	213	818	3,950.9	208.7	160	778.2	29.5	
	x :	6.5	24.8	119.7	6.3				
	s :	1.1	4.2	21.1	1.9				

[a]Adapted from log sheets supplied by a private operator.

[b]The weight is converted from "Salok" (1 Salok ≈ 100 kg).

Appendix Table IIIa. Monthly catch by species (groups) landed in Sabang, Calabanga by small and medium trawlers, March 1979-February 1980 (all weights in kg) (based on adjusted[a] PFMA data).

Taxonomic group	March 1979	April 1979	May 1979	June 1979	July 1979	August 1979	September 1979	October 1979	November 1979	December 1979	January 1980	February 1980	Annual total
Sharks and rays	1,048.5	1,635.5	1,488.0	1,182.2	1,410.5	1,091.7	922.3	962.5	611.0	808.7	358.4	922.8	12,442.1
Stolephorus spp.	42,855.8	60,493.0	71,809.3	41,560.7	22,347.5	26,612.8	19,314.8	2,536.8	–	8,581.2	15,582.0	27,166.8	338,860.7
Sardinella spp.	12,330.8	9,570.8	9,697.5	6,869.4	11,536.0	8,343.0	5,944.8	2,075.6	1,504.3	2,669.9	4,370.8	1,099.0	76,011.9
Arius thalassinus	448.4	–	8,304.7	347.1	–	1,195.5	1,081.5	–	–	–	42.0	166.8	11,586.0
Mugilidae	49.0	–	1,150.0	16,879.8	34,405.0	41,843.3	13,938.8	–	724.3	3,257.9	9,436.0	1,702.6	123,386.7
Otolithes ruber	23,417.2	14,492.9	10,720.2	12,480.8	12,036.5	9,909.2	10,123.8	5,562.5	1,926.6	8,325.9	10,525.2	12,074.6	131,595.4
Sciaenidae[b]	18,406.3	11,596.5	6,181.2	6,721.1	8,298.5	5,465.4	6,137.3	2,324.1	1,483.9	3,518.1	4,289.6	5,503.2	79,925.2
Pomadasydae	1,324.7	1,699.4	1,959.1	744.0	2,541.0	1,140.3	1,118.3	183.7	–	–	–	1,546.9	12,257.4
Carangidae	8,565.1	10,388.9	4,977.2	9,622.6	5,124.0	1,985.3	288.8	2,067.3	315.7	1,151.3	156.8	2,698.4	47,341.4
Leiognathidae	7,895.6	6,682.5	3,283.7	9,083.6	–	–	–	1,103.4	–	–	–	1,635.9	29,684.7
Trichiuridae	8,998.3	5,366.3	1,284.3	462.9	525.0	–	–	–	–	1,704.7	6,305.6	12,567.7	37,214.8
Scomberomorus commerson	499.9	620.3	626.1	5.8	1,718.5	1,399.0	1,085.0	179.5	–	–	–	63.5	6,197.6
Misc. spp.	69,795.8	51,610.5	66,302.7	54,897.8	91,717.5	65,567.7	59,659.3	43,063.6	29,645.6	45,183.8	45,374.0	60,189.4	683,007.7
Squids	5,199.0	5,330.7	5,841.3	4,922.5	5,662.7	4,728.2	3,941.0	3,136.1	1,820.4	2,757.2	2,514.4	2,629.2	48,482.7
Penaeid shrimps and crabs	7,798.7	4,970.3	2,095.0	8,600.1	7,021.4	4,616.3	11,572.8	6,647.9	7,023.9	22,681.5	14,793.8	5,747.2	103,568.9
Total weight per month	208,633.1	184,457.6	195,720.3	174,380.4	204,344.1	173,897.7	135,128.5	69,843.0	45,055.7	100,640.2	113,748.6	135,714.0	1,741,563.2

[a]Adjustment based on landings recorded by PFMA multiplied by the ratio of fishing days to recorded days (see Appendix Table I).
[b]"Sciaenidae" includes all species of this family, except for *Otolithes ruber.*

Appendix Table IIIb. Monthly catch by species (groups) landed in Sabang, Calabanga by small and medium trawlers, March 1980-February 1981 (all weights in kg) (based on adjusted[a] PFMA data).

Taxonomic group	March 1980	April 1980	May 1980	June 1980	July 1980	August 1980	September 1980	October 1980	November 1980	December 1980	January 1981	February 1981	Annual total
Sharks and rays	1,045.5	986.3	652.6	480.6	403.2	821.5	1,355.0	850.3	119.1	215.5	683.0	995.5	8,608.1
Stolephorus spp.	51,988.4	61,814.1	21,366.8	16,632.0	14,112.0	21,784.5	31,296.9	43,102.1	18,665.3	22,847.0	15,957.6	44,931.5	364,498.2
Sardinella spp.	11,829.3	4,124.6	3,834.7	6,002.7	2,017.4	3,486.1	2,107.6	4,195.7	1,758.4	1,824.4	893.6	8,503.8	50,578.3
Arius thalassinus	–	473.3	35.7	–	–	176.1	300.4	133.4	82.1	–	–	144.4	1,345.4
Mugilidae	1,450.0	1,851.9	883.5	6,476.5	14,770.0	16,034.0	14,705.9	5,935.7	4,236.6	3,200.8	4,964.5	3,741.3	78,250.7
Otolithes ruber	12,976.3	9,246.7	7,305.2	10,020.0	7,471.8	9,473.3	6,187.2	7,673.4	1,514.8	3,070.6	10,552.3	17,697.9	103,189.5
Sciaenidae[a]	8,091.0	11,845.1	6,184.5	6,478.2	6,728.4	10,276.5	5,499.4	3,938.2	3,655.1	6,409.3	2,123.1	7,229.0	78,457.8
Pomadasydae	2,437.7	1,110.2	469.7	172.7	380.8	465.0	–	–	–	–	–	486.0	5,522.1
Carangidae	5,074.1	2,960.4	1,252.4	940.9	511.0	569.2	642.1	443.1	41.0	31.0	32.9	2,297.4	14,795.5
Leiognathidae	3,073.2	1,334.1	93.0	51.3	84.0	380.5	1,926.4	1,229.6	123.2	–	–	540.0	8,835.3
Trichiuridae	27,508.3	5,082.4	1,917.4	–	63.0	–	–	1,902.4	2,976.3	3,727.8	5,120.3	17,572.3	65,870.2
Scomberomorus commerson	–	42.9	10.9	73.5	2,207.8	2,971.8	983.8	128.8	–	–	–	722.0	7,141.5
Misc. spp.	77,751.8	57,097.1	39,481.6	37,615.5	64,838.2	77,722.6	59,194.6	75,935.9	41,106.0	64,325.0	47,909.2	57,967.8	700,945.3
Squids	3,789.0	4,855.2	2,772.9	4,928.7	7,747.6	5,361.6	6,833.8	6,643.3	4,051.9	3,982.0	1,628.9	3,234.1	55,829.0
Crabs	848.3	752.6	1,167.2	914.9	767.5	1,975.6	6,081.1	6,666.5	2,694.4	2,855.1	1,104.2	295.3	26,122.7
Penaeid shrimps	1,933.3	3,273.3	3,561.9	6,413.2	8,128.1	7,720.4	4,761.6	13,918.8	11,496.1	21,273.8	16,825.6	12,140.9	111,447.0
Total weight per month	209,796.2	166,850.2	90,990.0	97,200.7	130,230.8	159,218.7	141,875.8	172,697.2	92,520.3	133,762.3	107,795.2	178,499.2	1,681,436.6

[a]Adjustment based on landings recorded by PFMA multiplied by the ratio of fishing days to recorded days (see Appendix Table I).
[b]"Sciaenidae" includas all species of this family, except for *Otolithes ruber.*

History and Status of the San Miguel Bay Fisheries*

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PAULY, D. 1982. History and status of the San Miguel Bay fisheries, p. 95-124. *In* D. Pauly and A.N. Mines (eds.) Small-scale fisheries of San Miguel Bay, Philippines: biology and stock assessment. ICLARM Technical Reports 7, 124 p. Institute of Fisheries Development and Research, College of Fisheries, University of the Philippines in the Visayas, Quezon City, Philippines; International Center for Living Aquatic Resources Management, Manila, Philippines; and the United Nations University, Tokyo, Japan.

Abstract

This paper reviews the available data on San Miguel Bay fisheries and their history, and contrasts "small-scale" and "trawl" fisheries, each of which land about half of the Bay's total catch of 15,000 t/year. On the basis of historical trawl data, it is shown that the trawlable biomass in the Bay declined in the period from 1947 to 1980/81 to less than 20% of its original value, while total effort by the motorized fleet increased by more than 150 times from 120 horsepower in 1936 to the present value of 18,800 hp. The catch data and other relevant information are reviewed by taxonomic group and by gear type.

The available evidence suggests that the Bay is overfished in the sense that an increase in effort by either the trawl or the small-scale fishery would not result in an increased catch from the San Miguel Bay fisheries as a whole, but rather exacerbate the present allocation problems between the small-scale and trawl fisheries.

Introduction

San Miguel Bay is one of the most productive fishing grounds of the Philippines. Indeed, if one disregards coral reef-based fisheries, it is possibly, on a per area basis, the most productive fishing ground in the country.

The first investigation on the Bay's resources and fishery was that of Umali (1937) who presented a thorough review of the gears used, their mode of operation and a partial list of the fish supporting the fishery.

Umali (1937) was also concerned about the lack of management:

> Because of injudicious exploitation of these valuable resources, the fishermen being interested merely in gathering all they can without giving the least thought to the prevention of depletion, it is imperative that regulatory measures based on intensive researches be formulated and enforced, not only by control on the part of the municipal authorities concerned, but also through the more desirable medium of education. The inhabitants should be acquainted with the necessity for such precautions in order that the richness of these grounds may yet be handed to posterity.

Later, Warfel and Manacop (1950) reported the results of a trawl survey conducted in San Miguel Bay, in July 1947, where the highest fish densities of the whole Philippine archipelago were obtained. At that time, the few trawlers that had been operating when Umali surveyed the Bay (in

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1936) had not been replaced, and there was no trawling, and presumably, no motorized fishing in the Bay.

Warfel and Manacop (1950), on the basis of the high catch rates they obtained, suggested that "four or five trawlers could be maintained without endangering these resources." Later investigations, most of them conducted in the late fifties under the leadership of Dr. K. Tiews (then with FAO), led to a number of publications on the biology of various fish and shrimps inhabiting the Bay (see Table 1).

Twenty years then passed until the publication by Legasto et al. (1975) of an account of their work in and around San Miguel Bay. However, their sampling of biological data and of data on the fishery was limited to a few days only, and no conclusive evidence emerged as to the status of the fishery.

Simpson (1978) included San Miguel Bay in his review of the fisheries of the Pacific coast of the Philippines. His report represents the first attempt to assess the status of the San Miguel Bay fishery, and his main findings are worth citing in full:

> ..... commercial trawlers catch about 20% of the demersal fish landed from within the bay, and 30% of the catch landed from outside the bay. Baby trawls, however, are very important in the bay, landing 40% of the demersal fish; outside the bay, they land only 10% of the catch, 40% being landed by municipal hook and line boats.
>
> Catch and effort data were only available for commercial trawlers and these were taken as a sampling of the total stock. As the commercial trawlers caught some 25% of the total catch of bottom

Table 1. Scientific work conducted in or related to San Miguel Bay 1907 to 1981.

#	Type of work	When conducted	Reported in
1	bathymetry	1907	Philippine Coast and Geodetic Survey, Map PC&GS 4223, San Miguel and Lamit Bays
2	collection of fish specimen	Dec. 1918	Roxas (1934)
3	collection of fish specimen	1924	Roxas and Agco (1941)
4	investigation of fishery, the gears and the resource base	1936	Umali (1937)
5	description of Bay and gears	?	Anon. (1944)
6	trawl survey	July 1947	Warfel and Manacop (1950)
7	description of trawls	1954	Estanislao (1954)
8	food and feeding habits of shrimps	1956-1958	Tiews et al. (1972a)
9	food and feeding habits of slipmouth	1956-1958	Tiews et al. (1972b)
10	biology of lizardfish	1956-1958	Tiews et al. (1972c)
11	benthos studies	1956-1958	Tiews et al. (1972d)
12	primary productivity (C_{14} method) samples sent to Dr. Maxwell Doty, Hawaii	1958	Sampling reported in Ronquillo (1959); results not published, nor available as raw data
13	"socioeconomics"	April-May 1974	Legasto et al. (1975)
14	hydrography, plankton, benthos some fishery biology	Nov. 1974	Legasto et al. (1975)
15	assessment of stocks, San Miguel Bay and adjacent waters	data used pertained mainly to the seventies	Simpson (1978)
16	fish marketing/economics (whole province of Camarines Sur)	February 1979	Piansay et al. (1979)
17	stock assessment	1979-1981	This report
18	economics of fishery	1979-1981	Smith and Mines (1982)
19	sociology of fishermen	1979-1981	Bailey (1982a, 1982b)

Table 2. Data used by Simpson (1978, Table 2) for the assessment of the San Miguel Bay and outside fisheries. (See also Fig. 2.)

	Commercial catch (trawl) (tonnes)		Number of boats	Catch (t) per boat	Catch (t) municipal fishing
1969	4,255	not used for computation	57	75	–
1970	702	not used for computation	67	10	–
1971	1,881	not used for computation	65	29	–
1972	14,418		67	215	–
1973	13,942		86	162	–
1974	10,696		65	165*	–
1975	10,427		75	139	–
1976	12,274		78	157*	11,622
1977	12,519		88	142	–

*These figures were corrected from the original table for the sake of consistency.

fish, the catch and effort data were considered worth examining, recognizing their limitations. These data are given in Table [2]. It was considered that the catch data from 1969 to 1971 was incomplete and not comparable with the catch data for later years.

The number of trawlers are the numbers licensed and are considered to be reliable. It is seen that the number of trawlers has been steadily increasing, and it was stated that over the period since 1972, there has also been a steady improvement in fishing methods, both in the municipal and the commercial fishing.

The yield curve is shown in Fig. [1]. The position of the yield curve cannot be drawn with much certainty due to the scatter of the points, but using the more definite curve of catch per boat[1] to calculate the annual catch, it would appear that the curve is reaching the MSY at about the total effort being used in 1977 or 1978.

It was stated that the fish species caught by trawlers within the bay were similar to those caught outside, but this requires verification.

It would appear that this stock on soft grounds inside and outside San Miguel Bay is reaching full exploitation and that the total amount of fishing in this stock should not be much increased.

While this conclusion should lead to caution in plans to further develop this fishery, much more information about the stock and the fishing is required in order to check the position. In particular, it would be informative to obtain data on the areas fished by baby trawls, commercial trawls and hook and line vessels and to determine the size composition of the main species caught by them. Attention should be paid to the measurement of fishing effort by the hook and line vessels so that assessments can also be made using them as the standard unit of effort.

Studies should also be made on the inter-relation between the fishing for shrimp, fish and anchovy, and the extent to which the very small meshed nets used are destroying the juveniles of valuable demersal species. It is possible that an increase in the minimum size of the meshes of the commercial trawls to at least 30 mm would increase the value and weight of the total catch of the commercial trawls, however, the effect on the catch of shrimps would need to be determined.

Simpson's main conclusion is that "MSY" was reached at about the total effort used in 1977/78. Fig. 1 represents the "yield curve" used in reaching this conclusion.

Major reasons why Simpson's assessment may be questionable are:

- he relied heavily on catch and effort data supplied to him, and had no possibility of checking the reliability of these data; and
- the data used, which refer to catches made inside *and* outside the Bay, do not pertain to the same stocks, or to the same fishery.

[1]This curve (a plot of catch per boat on number of boats) is not reproduced here because it was most probably drawn by eye, gives an extremely bad fit (see also Fig. 1) and, being curvilinear, is in fact inconsistent with the Schaefer type model used by Simpson (1978).

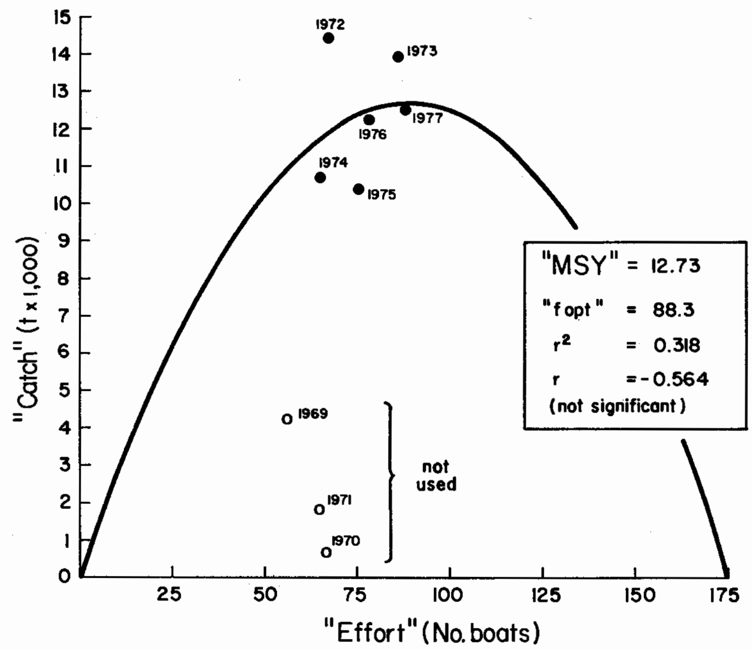

Fig. 1. Yield curve derived by Simpson (1978) and leeding to his assessment that optimum effort level was reached in 1977/78 (see text)

However, the recommendations that detailed studies be conducted on the various aspects of the fishery were certainly appropriate, and the present paper might, in a sense, be seen as following up on these recommendations.

In the following, the evidence available on the status of the Bay's fisheries is reviewed, first in terms of the whole multispecies stock, then in more detail by taxonomic groups.

The Trawlable Biomass, 1947 to Present

Since the first trawling survey was conducted in July 1947, by the *Theodore N. Gill* (Warfel and Manacop 1950), various research vessels have worked in the Bay; also, the catches of fishing vessels have been monitored by various agencies. This has resulted in a fair amount of catch data being available on a per-haul basis (Table 3).

Table 3. Estimates of trawlable biomass in San Miguel Bay, 1947-1981.[a]

#	Year	Month	Apparent density (t/km^2)	Trawlable biomass (t)	Number of hauls	Vessels used	Source of data
1	1947	July	10.6[b]	8,900	5	*Theodore N. Gill*	Warfel and Manacop (1950)
2	1957/58	8 months	5.20	4,370	> 100	*Arca I, Arca II*	daily reports of a private operator to BFAR Research Division
3	1967	July	3.91	3,280	2	*R/V Maya Maya*	logbook of *R/V Maya Maya* (BFAR Res. Div.)
4	1977	September	3.49	2,930	6	"a baby trawl"	Manuscript, BFAR Res. Div.
5	1979	July	1.84	1,560	3	*F/B Gemma*	Manuscript, BFAR Res. Div.
6	1980	February	1.89	1,590	25	*F/B Sandeman*	Manuscript, BFAR Res. Div.
7	1980/81	year-round	2.13	1,790	whole fishery	average small trawler	Vakily (this report)

[a]Compiled with the assistance of Mr. Ranin Regalado, BFAR Research Division, Quezon City.

[b]This value was obtained by multiplying with 1.5 the density estimates obtained from the data in Warfel and Manacop (1950), to adjust for the very large meshes used by the *Theodore N. Gill.* This correction factor produces conservative (= low) estimate of density (see Vakily, this report).

Density estimates (= biomass per area) have been computed from these data, using the swept-area method (Gulland 1969; Vakily, this report) for all data sets for which the net and boat characteristics were known. The results are given in Table 3. The density estimates for 1947, it should be noted, are conservative (= low) estimates, because a factor of 1.5 only was used to adjust for the fact that the *Theodore N. Gill* used very large meshes (Vakily, this report).

As shown in Fig. 2, trawlable biomass declined from 1947 to 1980 at a rate of about 5% per year, to less than 20% of the 1947 value. The commonly used Schaefer model (e.g., as used by Simpson 1978, see above) assumes that MSY and optimum effort (f_{opt}) occur when the virgin stock is reduced to half (50%) of its original value.

Thus, in terms of the Schaefer model, it can be concluded that the trawlable fish of San Miguel Bay became overexploited in the early sixties, and not in the late seventies as implied by Simpson (1978).

The density data used here are viewed as reliable because they give, in spite of the differences in the vessels used, a consistent trend over time (as opposed to the data in Table 2). Also, the trend in Fig. 2 would still express a decline in abundance even if the conversion factors used in computing densities were erroneous, because the catch rates in the Bay *did* decline.

The Evolution of Fishing Effort, 1936 to Present

Although the fisheries of the Bay have been studied repeatedly, virtually no attempts have been made earlier to follow the evolution of fishing effort in the Bay.

Scanty data on two measures of effort are available, however, and these refer to total horsepower of the Bay's fleet and relative numbers of fishermen.

TOTAL HORSEPOWER APPLIED IN THE BAY

Umali (1937) described the San Miguel Bay fishery based on data gathered in 1936. At that time, there were three Japanese beam trawlers of 40 hp each operating in the Bay; in his earlier (1932) paper on trawling in the Philippines, he reports no trawl vessel from San Miguel Bay. Hence, trawling–and motorized fishing–started somewhere between 1932 and 1936, with an effort of 120 hp.

Using average hp per type of craft, and its estimated number in the Bay, a total of 18,800 hp in the Bay can be estimated for 1980, 13,200 of which refer to small and medium trawlers and to

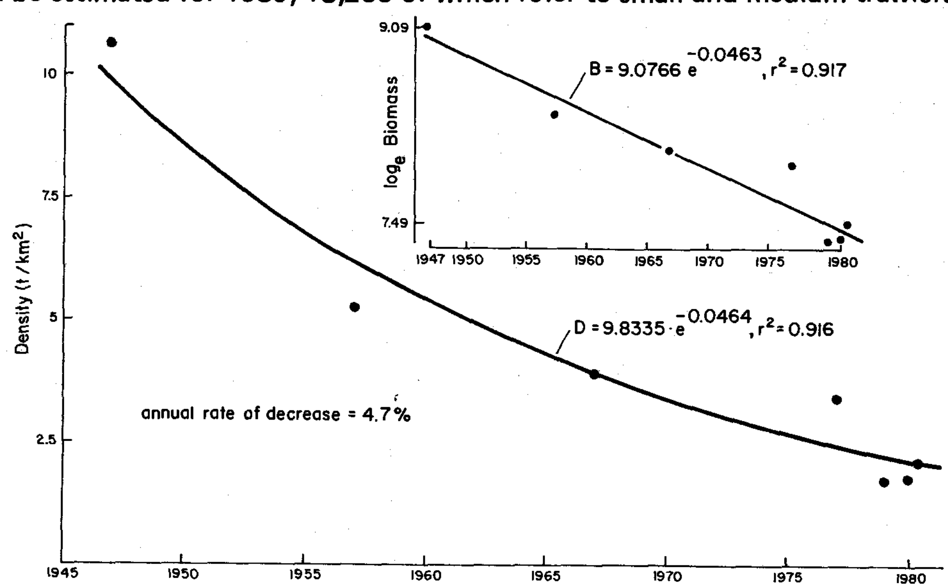

Fig. 2. Decline of the trawlable biomass of San Miguel Bay, 1947 to 1980. Note that data of Table 3, although obtained from different sources, suggest a steady decline corresponding to a linear trend in a semilogarithmic plot (inset).

that fraction of large trawler effort that is applied inside the Bay (Vakily, this report), while the residual 5,600 hp pertain to mini trawlers used for catching "balao" and to motorized gill-netters (Pauly et al., this report).

Various vessel counts given in earlier papers (e.g., Legasto et al. 1975; Simpson 1978) are here considered unreliable especially because of the absence of details as to how the counts were made. This leaves only two values, the one for 1936 and that for 1980; the missing years can be interpolated, assuming a geometric increase of effort (i.e., assuming that effort increased by a constant percentage every year), and discounting the fact that motorization went back to zero during the second world war (Fig. 3).

While 1936 to 1980 is a very long time to interpolate, it might well be that the rate of increase obtained here (about 12% per year) is in fact an underestimate of the true rate of increase, because motorization restarted at zero after the war (reading Warfel and Manacop (1950) suggests that there was no motorized fishing at least until July 1947).

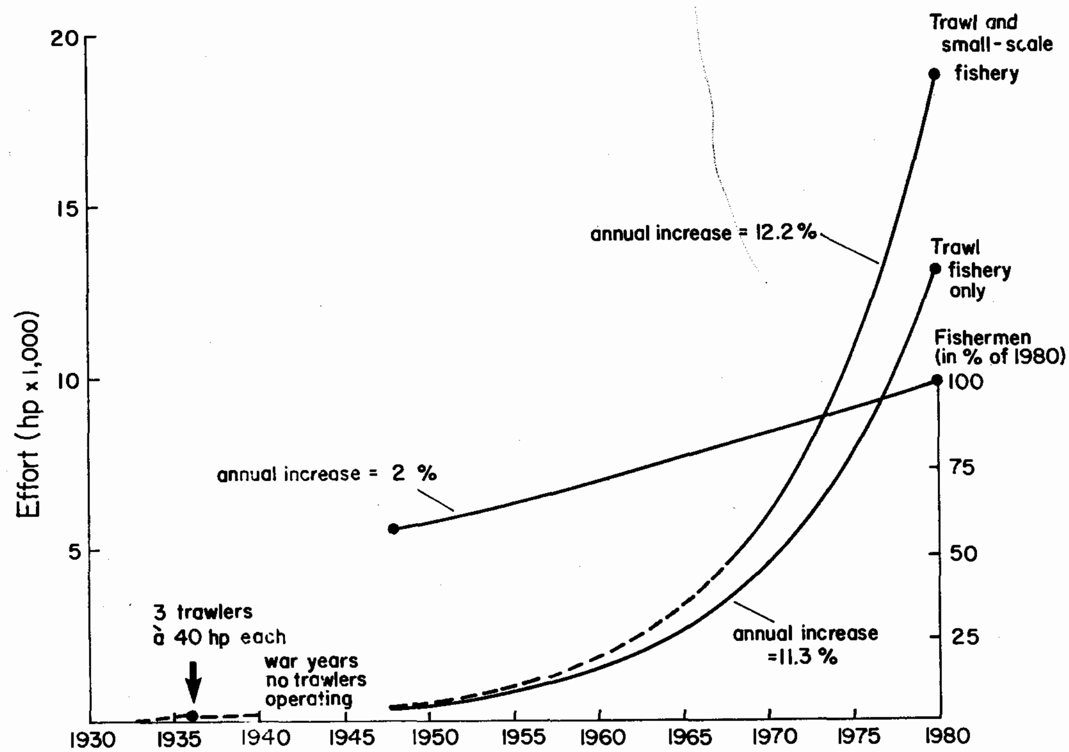

Fig. 3. Trajectories of effort from pre- and early post-war years to the present, assuming geometric increase from early to present figures (see text).

RELATIVE NUMBER OF FISHERMEN

Census data collected by Bailey (1982a) for the period 1948-1980 suggest a rate of increase of about 2% per year for the population of fishermen around San Miguel Bay (Fig. 3).

Unfortunately, due to the motorization of many small-scale vessels, it is not possible to convert "fishermen" as a unit of effort into horsepower units (or vice versa). Thus, the trends of effective effort by the small-scale fishery cannot be computed, even roughly.

Present Catches by the Small-Scale and Trawl Fisheries

Table 4 presents the catch by species group of the trawl and small-scale fisheries of San Miguel Bay. The total estimated catch is 14,660 t/year (excluding the balao which contributes another

Table 4. Total annual catch by groups for the trawl and small-scale fisheries of San Miguel Bay (1980-1981).[a]

Taxonomic group	Total annual catch (t)	Catch (t) by: Trawl fishery	Catch (t) by: Small-scale fishery	% caught by: Trawl fishery	% caught by: Small-scale fishery
Sharks and rays	45	36	9	*79.9*	20.1
Stolephorus spp.	2,100	1,369	731	65.2	34.8
Sardinella spp.	795	201	594	25.3	*74.7*
Arius thalissinus	44	6	38	13.0	*87.0*
Mugilidae	1,190	330	860	27.7	*72.3*
Otolithes ruber	2,004	409	1,595	20.4	*79.6*
Sciaenidae (excl. *O. ruber*)	1,468	313	1,155	21.3	*78.7*
Pomadasydae	34	21	13	61.5	38.5
Carangidae	269	57	212	21.3	*78.7*
Leiognathidae	112	38	74	33.8	66.2
Trichiuridae	324	254	70	*78.5*	21.5
Scomberomorus commerson	75	28	47	37.9	62.1
Misc. spp.	4,406	3,018	1,388	*68.5*	31.5
Squids	250	235	15	*93.9*	6.1
Crabs	500	120	380	24.0	*76.0*
Penaeid shrimps	1,044	461	583	44.2	55.8
Balao	4,473	0	4,473	0	*100*
Total catch (excl. balao)	14,660	6,896	7,764	47.1	52.9

[a]Groups contributing more than 2/3 of their total to either of the two fisheries are in italics for identification as "target groups".

4,500 t), which is extremely high given that this figure refers only to the 840 km^2 that comprise the Bay proper (see Fig. 1 in Mines et al., this report). This figure corresponds to the value estimated by Simpson (1978) as "MSY" for the San Miguel Bay *and surrounding waters* (see Fig. 1). This correspondence is coincidental, resulting as it does from lower catches from a larger area (Simpson 1978).

This correspondence, as will be shown below, also occurs when catches by species groups are considered (e.g., squids), but should not detract from the fact that the present figures are on a per area basis, two to four times higher than had been previously estimated from San Miguel Bay proper (see also Table 4 in Vakily, this report). The estimation of a yield per area of 17.5 t/km^2, although very high, fits neatly into the plot of yield per area in Fig. 4. [Including balao in the yield estimate would increase the previous value to 22.8 t/km^2, but this would render comparisons with other areas and depth ranges difficult, considering the fact that balao is essentially zooplankton, ecologically located one trophic level below most commercial fishes and invertebrates.] Sustainable yields from San Miguel Bay probably cannot be substantially increased (Fig. 4) because this yield is only

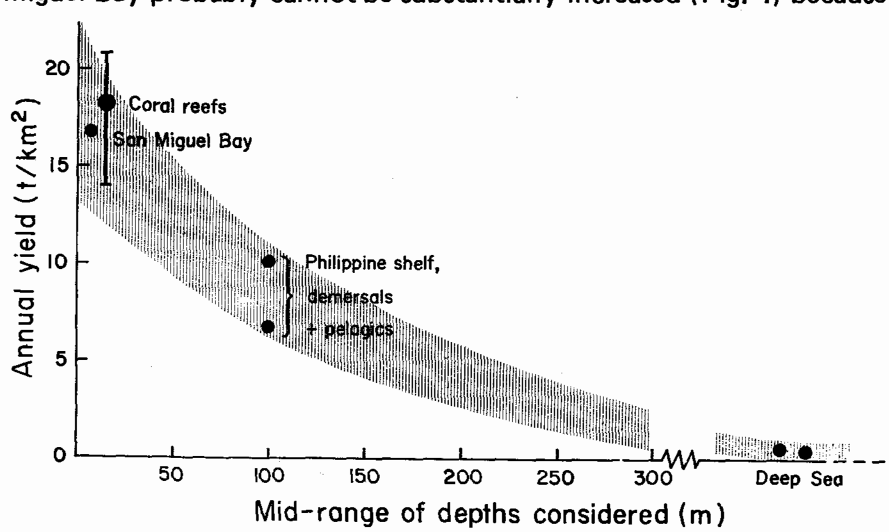

Fig. 4. Fish yields per area from Philippine waters, in relation to depth. Coral reef data from Alcala (1981 and pers. comm.); shelf and deep sea figures from Smith et al. (1980). (Shaded area is a subjective assessment of possible ranges, not a confidence belt.)

slightly below the very high values reported from Philippine coral reefs by Alcala (pers. comm. to N. Marshall and 1981), whose figures were until recently contested because they appeared to be too high (Marshall 1980).

Of the 17 different groups of fish and invertebrates distinguished in the catch, four occur predominantly in the trawl catch: sharks and rays, Trichiuridae, squids, and (not surprisingly) "miscellaneous species" (Table 4). On the other hand, Table 4 shows that 8 groups of fish and invertebrates are selected positively by the artisanal fishery: clupeids, ariid catfish, mullets, *Otolithes ruber*, other croakers, carangids, crabs and balao. This results from the use by the small-scale fishermen of gears that are far more selective than trawls, e.g., crab gill-nets, 86% of whose catch is crabs, or mini trawls, whose catch consists of 76% balao (Table 5). Among the gears that are used by the small-scale fishery, only one, the fish corral, has a catch predominantly of "miscellaneous species" (Table 5), i.e., a catch similar to that of the trawl fishery.

It is a well-known feature of trawl fisheries that they tend to be unselective and the San Miguel Bay trawl fishery is no exception. An implication of this feature, however, is the extreme difficulty of reducing relative effort on those species that are overexploited. (Pope (1979) gives a mathematical treatment of this problem and shows that in fact, due to "technological interactions", a trawl, or any other type of unselective fishery simply cannot exploit a multispecies stock optimally.) The small-scale fishery, on the other hand, because of its use of a multitude of gears, all of them with different selective properties and target species can—in principle at least—better utilize a multispecies stock because effort can be redirected toward any group that is abundant, away from a group with falling catch rates.

Munro (1980) describes this feature as follows:

> Additionally, artisanal and subsistence fishermen often have a fund of knowledge of fish behavior, migrations, and general ecology which enables them to switch their attention from one habitat to the next in order to capture the most readily available species. This will result in the sudden absence of a species from the landings—not because the species is unavailable but because a different species is more readily available.

Table 5. San Miguel Bay catch and major species groups in catch by gear type, 1980-1981.

Gear type	Total catch (t)	Major groups caught, in %
Trawlers (medium and small)	6,317	misc. spp. (41.7), anchovies (21.7),
Trawlers (large)	580	shrimps (6.63)
Drift gill-net (panke)	3,229	*Otolithes ruber* (48.6), Sciaenidae (29.0), misc. spp. (8.73)
Drift gill-net (palataw)	616	Mugilidae (52.9), Sciaenidae (22.5), misc. spp. (15.3)
Drift gill-net (pamating or pandarakul)	14	sharks and rays (48.7), misc. spp. (38.1), Ariidae (8.11)
Crab gill-net (pangasag)	258	crabs (85.8), misc. spp. (12.1), Sciaenidae (1.70)
Bottom-set gill-net (palubog)	737	Mugilidae (65.2), *Sardinella* spp. (34.4), crabs (0.234)
Liftnet (bukatot)	624	anchovies (79.8), misc. spp. (9.07), *Sardinella* spp. (7.65)
Filter net (biakus) (excl. balao)	262	anchovies (45.6), Leiognathidae (19.8),
balao	(33)	misc. spp. (15.0)
Fish corral (baklad or sagkad)	530	misc. spp. (41.8), crabs (18.0), Sciaenidae (13.5)
Mini trawl (itik-itik) (excl. balao)	578	balao (76.5), misc. spp. (6.9),
balao	(4,201)	shrimps (5.0)
Misc. artisanal gears (excl. balao)	911	misc. spp. (28.3), shrimps (23.3),
balao	(238)	Carangidae (8.5)
Total (excl. balao)	14,656	

In other situations, fishing might cease entirely, despite favorable conditions, because abundant supplies of some terrestrial crop have become available and rendered fishing uneconomical. Alternatively, fishing might simply cease because the fisherman's labor is required elsewhere.

This shifting behavior, which is also documented for San Miguel Bay fishermen in several papers in Bailey (1982b) and Smith and Mines (1982) can occur both within and between years and it might be speculated that by acting as if they were generalized predators which shift to the most abundant prey (Jones 1979), the small-scale fishermen, unless they resort to destructive fishing practices, probably stabilize the stocks upon which they depend, and maintain their diversity.

Trends in Total Catch from the San Miguel Bay Fishery

Although a considerable amount of work has been conducted in San Miguel Bay (Table 1), this report is the first to document an estimate of total catch from the Bay.

Catch estimates are crucial to fisheries management (Gulland 1980) and the lack of a *time series* of such figures considerably limits the ability to make a reliable assessment of the status of the San Miguel Bay stocks. The catch of the trawl fishery can be roughly approximated, however, by multiplying, for the period 1947 to 1980, the trawlable biomass values (Fig. 2) by the estimated horsepower of the trawl fishery (Fig. 3), then multiplying by the ratio 6,500/13,200, i.e., by the present ratio between catch and effort.

The result is a gradual increase in trawl catches (Fig. 5). Clearly this trend is not the only possible representation of the evolution of the trawl catches; it probably reflects the basic trend, however, since the present value of 6,500 t/year had to be reached, from low values in the fifties through some more or less steady increase, up to the present high value.

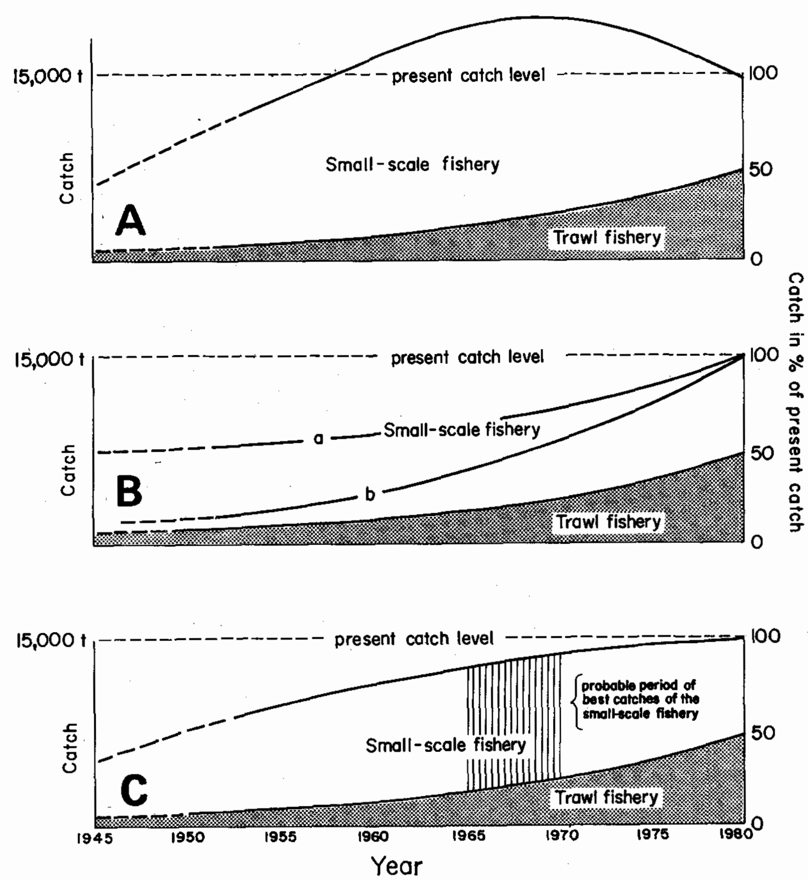

Fig. 5. The probable trajectory of the trawler catch in San Miguel Bay, 1945 to 1980, with three hypothetical situations for the evolution of the total catch (= trawler + small-scale fishery). See text for interpretation.

Not even crude assumptions can be made in the case of the trend in catch of the small-scale fishery, mainly because we are not able to assess the relative impact (and the changes in the ratio) of motorized *vs* non-motorized fishermen.

So, instead of drawing a single curve for the evolution of the total catch from the Bay, three hypothetical ones have been drawn, each illustrating a different trajectory for the total small-scale fisheries catch, and a certain type of interactions between the trawl and the small-scale fisheries (Fig. 5). The alternatives that one might consider thus are:

A) Total catch from the Bay went through a maximum—higher than present catches—in earlier years, with the small-scale fishermen catching substantially more than they do now (Fig. 5A).

B) Both small-scale and trawl catches have increased continuously and are still increasing, with higher catches being possible at higher effort levels of both trawl and small-scale fishery (Fig. 5B). This option allows for an increase of small-scale catches that is less, or more rapid than the increase in trawl catches, as illustrated by lines a and b, respectively.

C) Total catches in the Bay have leveled off in the last years and the increased catch of the trawl fishery has resulted in lowered catch for the small-scale fishery; the latter may have made its best catch earlier, possibly in the late sixties (Fig. 5C).

I believe it is the last of these 3 scenarios which is the most plausible. To be really different from option C, option A implies past catch levels that are substantially higher than those made now, which are already very high. Such higher catch levels are difficult to conceive, and have not been documented anywhere from tropical estuaries. Option B similarly implies future catch significantly higher than those made presently to which the same reservation as in option A applies. Option C, on the other hand, is obviously possible, and would provide an explanation for the series of complaints regarding poorer catches from the small-scale fishermen (see Smith and Mines 1982; Bailey 1982a, 1982b).

Also, the yield curve in option C corresponds to the very flat-topped yield curve suggested by a number of authors to be characteristic of several multispecies stocks, whose total yield appears to change little at increasingly high levels of effort (discussion in Larkin 1982). This purely empirical yield model, it must be stressed, does not preclude the decline or even disappearance of single species, but stresses that total physical yield may not abruptly decline with increasing effort as long as habitat degradation does not occur. Economic considerations with regard to overfishing, however, are similar with this model to those developed in conjunction with a parabolic Schaefer model (see Smith and Mines 1982).

Catch and Status of Various Groups Caught in San Miguel Bay

The following is a discussion by species group of biological and catch data of the exploited resources of San Miguel Bay. Included are four groups of invertebrates (sergestid and penaeid shrimps, crabs and squids), sharks and rays, and the 10 families of teleostean fishes for which catch data are available.

This discussion is also intended as a brief review of knowledge available on these groups, in San Miguel Bay and elsewhere in the Philippines. Thus, gaps identified here suggest where fruitful research could be conducted in the future.

SERGESTID SHRIMPS (BALAO)

Balao consist of very small shrimps—essentially zooplankton—of the family Sergestidae (Table 6). The largest species known from this group is *Acetes indicus* whose size range (♀) is from 23 to 40 mm (Holthuis 1980).

In Philippine waters, 7,230 t of balao are reportedly caught annually, of which 1,199 t stem from Camarines Sur (Region V) i.e., from San Miguel Bay (Anon. 1979). However, the present

Table 6. Decapod crustaceans reported from San Miguel Bay.[a]

Family	Species	Remarks
(Suborder Macrura)		
Palaemonidae	*Palaemon* sp.	Reported by Tiews et al. (1972c) from stomachs of *Saurida tumbil.*
Penaeidae	*Penaeus monodon* Fabricius	Reported by Blanco and Arriola (1937), Villaluz and Arriola (1938) and in NMP collection. Also reported from stomach of *Saurida tumbil* by Tiews et al. (1972c). Villaluz and Arriola (1938) distinguish a variety: *P. monodon* var. *manillensis.*
	Penaeus semisulcatus de Haan	NMP collection. The food of this shrimp in San Miguel Bay is discussed in Tiews et al. (1972a)
	Penaeus merguensis de Man	Reported by Tiews et al. (1972a) who also discuss its food in San Miguel Bay.
	Penaeus incisipes Bate	Reported by Blanco and Arriola (1937).
	Penaeus anchoralis Bate	Reported by Blanco and Arriola (1937).
	Penaeus latisulcatus Kishinouye	NMP collection.
	Penaeus japonicus Bate	Reported by Villaluz and Arriola (1938) as *P. canaliculatus* var. *japonicus* Bate. Tiews et al. (1972a) discuss the food of this shrimp in San Miguel Bay.
	Penaeus indicus Milne-Edwards	Reported by Villaluz and Arriola (1938) as *P. indicus* var. *longirostris* de Man; Blanco and Arriola (1937) list only *P. indicus*, however.
	Penaeus rectaculus Bate	NMP collection.
	Metapenaeus monoceros (Fabricius)	NMP collection; also reported from stomachs of *Saurida tumbil* by Tiews et al. (1972c). Tiews et al. (1972a) discuss the food of *M. monoceros* in San Miguel Bay.
	Metapenaeus ensis (de Haan)	NMP collection.
	Metapenaeopsis affinis (Milne-Edwards)	NMP collection.
	Metapenaeopsis novae-guinae (Haswell)	NMP collection.
	Parapenaeopsis cornuta (Kishinouye)	NMP collection; a *Parapenaeopsis* sp. is reported from stomachs of *Saurida tumbil* by Tiews et al. (1972a)
	Trachypenaeus curvirostris (Stimpson)	NMP collection, listed as *T. asper*, a synonym.
Sergestidae	not identified	"Balao" consists of a mixture of sergestid and luciferid species, consisting of the genera *Acetes, Sergestes* and *Lucifer*. The species composition of Philippine balao is unknown.
(Suborder Brachyura)		
Paguridae	*Pagurus asper* de Haan	NMP collection.
Portunidae	*Scylla serrata* (Forskål)	Reported by Estampador (1959) from Calabanga. He also states that "these crabs grow to considerable size and constitute the most valuable edible species. They are widely distributed, but abound especially in places where there are extensive mangrove swamps."
	Charybdis ornata	NMP collection, but labelled *C. truncata,* a synonym.
	Portunus pelagicus de Haan	Reported by Umali (1937).
	Portunus sanguinolentus (Herbst)	Reported by Estampador (1959) from Lake Buhi, Camarines Sur; the nearest marine waters are those of San Miguel Bay.
Grapsidae	*Sesarma bidens* (de Haan)	Reported by Estampador (1959) from Calabanga.
Xenophthalmidae	*Xenophthalmus pinnetheroides* White	Reported by Legasto et al. (1975).
Parthenopidae	*Parthenope ornatus* (Flipa)	NMP collection.

[a]Compiled with the kind assistance of Mr. R. Garcia, National Museum of the Philippines (NMP). The FAO Species Catalogue compiled by L.B. Holthuis (1980) was used for establishing the synonymy of the penaeid species.

estimate of balao catch from San Miguel Bay is about 4 times higher (Table 7). In the Bay, balao forms a very large proportion of the total catch (23%), although its high water content and low price diminish its economic importance, e.g., *vis-à-vis* other shrimps or croakers.

The bibliographies of Gomez (1980) and Vicente (1980) suggest no biological work has ever been published on balao in the Philippines. In India, the major exploited species of sergestid shrimps is *Acetes indicus* and its development has been reported upon by Pillai (1973). Other references on sergestid shrimps are Omori (1969, 1975, 1977), Walter (1976), Donaldson (1975), and Le Reste (1970). The present state of knowledge of this resource makes it impossible to assess the status of the balao stock of San Miguel Bay.

PENAEID SHRIMPS

There is a fair amount of literature on Philippine penaeid shrimps, which can be accessed via Gomez (1980) or Vicente (1980). However, little of this work contains information on catches, growth and mortality, such as used in stock assessment and population dynamics (Garcia and Le Reste 1981).

Table 6 gives a list of the penaeid species reported from San Miguel Bay, while Table 8 gives the estimate of shrimp catch for 1980/1981. Pauly et al. (in press), based on length-frequency data published by Mohamed (1967) in India, calculated growth parameters and natural mortality of *Metapenaeopsis affinis*, a species which also occurs in San Miguel Bay. They obtained the parameter values $W_\infty = 49$ g, $K = 1.2$, and $M = 2.3$, which were used here to perform a yield-per-recruit analysis (Beverton and Holt 1957; Ricker 1975), using two likely values of age at first capture (t_c).

Table 7. Catch (in kg) of "balao" in San Miguel Bay by gear type and month (1980-1981).

Gear type	F	M	A	M	J	J	A	S	O	N	D	J	Σ
Filter net	–	–	–	–	19,980	–	–	–	–	–	–	13,020	33,000
Mini trawl	577,900	518,014	326,378	260,504	196,126	–	–	48,208	277,571	607,842	565,922	823,432	4,201,897
Subtotal	577,900	518,014	326,378	260,504	216,106	–	–	48,208	277,571	607,842	565,922	836,452	4,234,897
Other gear	32,478	29,112	18,342	14,640	12,145	–	–	2,709	15,599	34,160	31,805	47,010	238,000
Grand total	610,378	547,126	344,720	275,144	228,251	–	–	50,917	293,170	642,002	597,727	883,462	4,472,897
% of annual catch	13.6	12.2	7.7	6.2	5.1	0	0	1.1	6.6	14.3	13.4	19.8	100

Table 8. Catch (in kg) of penaeid shrimps in San Miguel Bay, by gear type and month (1980-1981).

Gear type	F	M	A	M	J	J	A	S	O	N	D	J	Σ
Trawlers (medium and small)	45,612	7,263	12,297	13,382	24,094	30,536	29,005	17,889	52,292	43,190	79,924	63,212	418,696
Trawlers (large)	–	–	–	–	–	–	–	6,784	19,830	16,379	–	–	42,993
Panke	1,041	–	4,258	10,997	5,440	–	4,200	2,966	9,184	–	–	3,393	41,479
Filter net	–	–	387	505	1,004	–	–	3,026	4,675	–	1,897	144	11,638
Fish corral	–	1,867	1,527	6,276	581	2,906	725	1,825	9,879	–	–	–	25,586
Mini trawl	9,381	10,423	6,317	12,571	17,056	37,586	42,323	34,427	29,595	13,392	10,991	11,086	235,148
Subtotal	56,034	19,553	24,786	43,731	48,175	71,028	76,253	66,917	125,455	72,961	92,812	77,835	775,540
Other gears	19,363	6,757	8,565	15,112	16,647	24,545	26,351	23,124	43,353	25,213	32,073	26,897	268,000
Grand total	75,397	26,310	33,351	58,843	64,822	95,573	102,604	90,041	168,808	98,174	124,885	104,732	1,043,540
% of annual catch	7.2	2.5	3.2	5.6	6.2	9.2	9.8	8.6	16.3	9.4	12.0	10.0	100

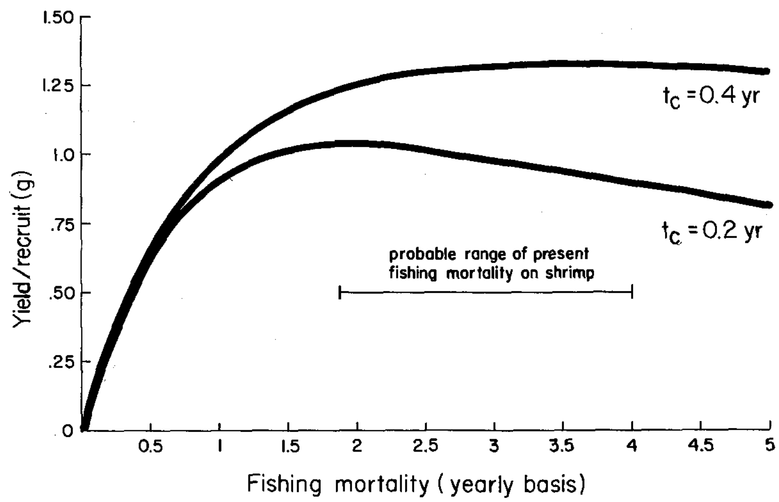

Fig. 6. Yield-per-recruit analysis for *Metapenaeus ensis* in San Miguel Bay using W_∞ = 43 g; K = 1.2; M = 2.3; t_0 = t_r = 0; and equation (10.21) of Ricker (1975). Likely present values of age at first capture (t_c) were used.

As might be seen from Fig. 6, yield per recruit cannot be further increased by increasing fishing mortality; in fact, any further increase in F will depress yield per recruit. To turn yield per recruit into an assessment of a real fishery, knowledge is needed of, or at least some assumptions about the shape of the stock-recruitment curve, i.e., on the impact of a given F on future recruitment. Fishermen are not interested in an imaginary yield per recruit, but in a physical yield, i.e., in the product of yield per recruit multiplied by the number of recruits entering the fishery.

Shrimp compete with and are predated upon by a variety of fish; in San Miguel Bay, the lizard fish *Saurida tumbil* is known to be a major shrimp predator (Tiews et al. 1972c, and see Table 6), and several of the other fishes listed in Pauly (this report) are known to relish shrimps.

Because of the unselective nature of most shrimp fisheries, and of the trawl fishery in San Miguel Bay, fishing for shrimps implies also fishing for shrimp predators. Pauly (1982) has shown that the removal of shrimp predators in the Gulf of Thailand has helped in maintaining a high recruitment of shrimps from a very reduced parent stock of shrimps. This feature might explain the recent apparent surge of shrimp catches reported by Simpson (1978) from the San Miguel Bay area, which may have taken place concurrently with an increased effort and increased removal of fish (Table 9).

The same considerations apply also to a lesser extent to the removal of shrimp competitors. Slipmouths, i.e., fishes of the family Leiognathidae, occur in large numbers in the Indo-Pacific

Table 9. "Commercial" catch of shrimps, San Miguel Bay area, 1969-1977.[a]

Year	Trawl catch (t)	# boats	C/f (t/boat)
1969	688	38	18
1970	267	42	6
1971	425	41	10
1972	1,915	47	41
1973	1,819	40	45
1974	2,433	–	–
1975	1,767	36	49
1976	3,272	45	73
1977	4,898	56	87

[a]Adapted from Table 6 in Simpson (1978). These data pertain only to large and medium trawlers but were taken from an area much larger than San Miguel Bay proper.

wherever penaeid shrimp occur, and at least in one publication slipmouths are referred to as "prawn indicators" (Rapson and McIntosh 1972). More important here is the fact, however, that slipmouths, which in 1947 formed a very large part of the trawlable biomass of San Miguel Bay, and which have a very broad food overlap with shrimps (see Tiews et al. 1972a, 1972b) have now declined to a small fraction of their previous standing stock sizes (see also Vakily, this report), leaving the field to their shrimp competitors.

CRABS

Umali (1937) gives the name *Neptunus pelagicus* (= *Portunus pelagicus*, or "alimasag") to the crabs caught in San Miguel Bay, although a number of other crab species are reported from the Bay (Table 6).

Table 10 gives the computed catch of crabs from San Miguel Bay. Major gears used to catch crabs are crab gill-nets, trawlers and fish corrals.

The available data do not allow explaining or even confirming the claim by San Miguel Bay fishermen that crab catches have been declining recently. About 48% of the crabs caught in the Bay are caught by relatively large-meshed nets, which tend to catch the crabs at adult sizes. However, berried (pregnant) females that are caught are not thrown back into the sea. It is difficult to state whether the present catch levels are likely to have a significant effect on recruitment; also, the various gears used to catch balao might also catch a large amount of crab larvae. Clearly, investigations on the fishery biology of this resource are needed.

SQUIDS

Table 11 gives a list of mollusc species reported from San Miguel Bay; of these, squids ("pusit") are the most important. The squid resources of the Philippines have been recently reviewed by Hernando and Flores (1981), who cite the relevant Philippine literature. They report, based on BFAR data, a total Philippine catch of squids of 10,560 t (in 1976), of which 229 t (2%) stemmed from San Miguel Bay.

The figure estimated here for the annual squid catch for the period 1980-1981 is 250 t (Table 12). However, as explained above with regard to the total catch from the Bay, this agreement is coincidental, being based in the case of the BFAR data on a larger area (San Miguel Bay *plus* adjacent waters).

Table 10. Catch (in kg) of crabs in San Miguel Bay, by gear type and month (1980-81).

Gear type	F	M	A	M	J	J	A	S	O	N	D	J	Σ
Trawlers (medium and small)	1,109	3,187	2,827	4,385	3,437	2,883	7,422	22,846	25,045	10,123	10,726	4,148	98,138
Trawlers (large)	–	–	–	–	–	–	–	8,664	9,498	3,839	–	–	22,001
Panke	–	–	–	–	3,223	4,188	5,586	3,592	–	–	–	–	16,589
Palataw	–	–	753	–	–	–	–	–	–	–	–	–	753
Pangasag	2,709	3,294	12,141	27,005	39,146	35,531	32,228	36,825	17,051	15,400	–	–	221,330
Palubog	–	–	–	–	–	–	–	–	1,726	–	–	–	1,726
Pamating	–	–	–	115	–	–	–	–	–	–	–	–	115
Liftnet	–	–	–	–	–	–	172	–	–	–	–	–	172
Fish corral	–	2,999	2,441	10,042	12,599	21,735	10,902	24,408	10,112	–	–	–	95,238
Mini trawl	–	–	–	–	–	1,668	4,201	9,286	846	–	–	–	16,001
Subtotal	3,818	9,480	18,162	41,547	58,405	66,005	60,511	105,621	64,278	29,362	10,726	4,148	472,063
Other gears	226	562	1,077	2,464	3,464	3,915	3,589	6,266	3,813	1,742	636	246	28,000
Grand total	4,044	10,042	19,243	44,011	61,869	69,920	64,100	111,886	68,091	31,104	11,362	4,394	500,066
% of annual catch	0.81	2.0	3.9	8.8	12.4	14.0	12.8	22.4	13.6	6.2	2.3	0.88	100

Table 11. Molluscs reported from San Miguel Bay.[a]

Group		Remarks
"Veliger larvae"		reported from the stomachs of shrimps and slipmouths
"Gastropods"		reported by various authors from the San Miguel Bay benthos and the stomachs of shrimps and slipmouths
	Turritela terebra	reported by Legasto et al. (1975)
Bivalvia		reported as "pelecypods" from the benthos by Tiews et al. (1972d)
	Chiones sp. *Siliqua* sp. *Macoma incongrua*	reported by Legasto et al. (1975)
	"young *Pecten*"	reported from the stomachs of shrimps by Tiews et al. (1972a)
	Placuna placenta	(window pane oyster, or capiz shell) reported by Umali (1937) from Sibobo, "a very rich collecting ground for window shells"
Cephalopods		
	"*Loligo* sp."	reported from stomachs of *Saurida tumbil* by Tiews. et al. (1972c)

[a]No sampling for molluscs specifically has been conducted in San Miguel Bay, as evidenced by the absence of specimens from the Bay in the Collections of the National Museum of the Philippines.

An important feature of squids in Southeast Asia and elsewhere is that their abundance seems to increase tremendously after stocks of demersal fishes have been depleted. This might be readily explained by the fact that most squids have demersal (benthic) eggs, which undoubtedly represent prime food for demersal fishes. Thus, the massive reductions of fish biomass which occurred in San Miguel Bay presumably resulted in increased squid recruitment, as occurred also off west Africa (Caddy 1981), or in the Gulf of Thailand (Pope 1979; Pauly 1979a).

In San Miguel Bay, squids are caught at present almost exclusively by trawlers; indeed, the trawling speed of small trawlers in San Miguel Bay (2 knots) corresponds precisely to the speed of Japanese squid trawlers off west Africa (Caddy 1981).

The development of a technique which would allow small-scale fishermen in the Philippines to also catch squids seems a worthwhile task. Methods for the management of squid stocks are discussed in Lange and Sissenwine (1980) and Caddy (1981).

Table 12. Catch (in kg) of squids in San Miguel Bay, by gear typa and month (1980-1981).

Gear type	F	M	A	M	J	J	A	S	O	N	D	J	Σ
Trawlers (medium and small)	12,150	14,235	18,240	10,418	18,517	29,107	20,143	25,674	24,958	15,223	14,960	6,120	209,745
Trawlers (large)	–	–	–	–	–	–	–	9,736	9,465	5,773	–	–	24,974
Liftnet	–	–	–	–	2,859	8,713	1,806	1,309	–	–	–	–	14,687
Fish corral	–	–	–	–	293	–	88	–	–	–	–	–	381
Mini-trawl	–	–	–	–	–	–	246	–	–	–	–	–	246
Total	12,150	14,235	18,240	10,418	21,669	37,820	22,283	36,719	34,423	20,996	14,960	6,120	250,033
% of annual catch	4.8	5.7	7.3	4.2	8.7	15.1	8.9	14.7	13.8	8.4	6.0	2.4	100

SHARKS AND RAYS

Pauly (this report) gives a list of the sharks and rays reported from San Miguel Bay, and their present catch is given in Table 13. In 1947, elasmobranchs represented 22% of the trawlable biomass of the Bay (Warfel and Manacop 1950, Table 26), or about 2.3 t/km^2. At present, this figure is 0.6%, or about 0.013 t/km^2 (see Vakily, this report), i.e., the elasmobranch stock—or at least its exploitable part—was reduced to 1/177 of its previous value. Also, most of the present elasmobranch catch consists of small sharks, whereas in 1947 rays were the main group taken.

This indicates that, as can be expected on theoretical grounds (Gulland 1976) and as also reported from various parts of the world, including the Gulf of Thailand (Pauly 1979a), large rays (and sawfish) dwindle rapidly upon exploitation. The same applies to sharks, possibly to a lesser extent (Holden 1977). This should be considered when discussing shark fishing potentialities, as in Warfel and Clague (1950), or Encina (1973).

Table 13. Catch (in kg) of sharks and rays in San Miguel Bay, by gear type and month (1980-1981).

Gear type	F	M	A	M	J	J	A	S	O	N	D	J	Σ
Trawlers (medium and small)	3,740	3,928	3,705	2,452	1,806	1,515	3,086	5,091	3,194	447	810	2,566	32,340
Trawlers (large)	–	–	–	–	–	–	–	1,930	1,211	170	–	–	3,311
Pangasag	–	1,031	–	165	–	–	–	–	–	–	–	–	1,196
Pamating	562	665	767	336	2,121	1,591	–	–	–	767	–	–	6,809
Fish corral	–	–	–	–	–	951	–	–	–	–	–	–	951
Total	4,302	5,624	4,472	2,953	3,927	4,057	3,086	7,021	4,405	1,384	810	2,566	44,607
% of annual catch	9.7	12.6	10.0	6.6	8.8	9.1	6.9	15.7	9.9	3.1	1.8	5.8	100

CLUPEIDAE

Pauly (this report) gives an annotated list of the clupeids reported from San Miguel Bay. The PFMA office in Naga City reports some of the Clupeidae catch from San Miguel Bay as "*Sardinella* spp.", the other Clupeidae being included in the "miscellaneous fishes" category. How well this separation is done in the field cannot be assessed here, but given the difficulty in distinguishing tropical clupeids without good reference material, I believe that the category "*Sardinella* spp." as used by the PFMA, and hence in Vakily (this report) probably includes at least some clupeids not belonging to the genus *Sardinella*. This also applies to the data collected (by our research assistants) from the landing places of the small-scale fishery. Thus, the category *Sardinella* spp. as used in Pauly et al. (this report) and in this paper should be labelled "*Sardinella* spp." (= *Sardinella* spp. with admixtures of other clupeids); Table 14 gives the catch data for "*Sardinella* spp." in San Miguel Bay.

Although there is a sizeable body of literature on Philippine clupeids (see Gomez 1980; Vicente 1980) little of it is directly usable for stock assessment purposes. Simpson (1978, Table 18) presented

Table 14. Catch (in kg) of sardines in San Miguel Bay, by gear type and month (1980-1981).

Gear type	F	M	A	M	J	J	A	S	O	N	D	J	Σ
Trawlers (medium and small)	31,948	44,442	15,496	14,407	22,552	7,579	13,097	7,918	15,763	6,606	6,854	3,357	190,019
Trawlers (large)	–	–	–	–	–	–	–	3,003	5,978	2,505	–	–	11,486
Panke	35,800	18,777	9,184	5,382	10,354	4,972	12,752	8,774	10,412	–	–	22,872	139,279
Palataw	–	–	861	–	–	–	–	21,525	–	–	–	–	22,386
Palubog	46,646	–	–	–	–	–	–	51,854	33,662	40,193	42,059	38,871	253,285
Liftnet	–	–	–	–	–	40,617	7,261	–	–	–	–	–	47,878
Filter net	–	–	–	–	6,019	–	–	–	–	–	–	–	6,019
Fish corral	–	–	–	18,829	1,464	1,671	1,620	2,882	8,671	–	–	–	35,137
Subtotal	114,394	63,219	25,541	38,618	40,389	54,839	34,730	95,956	74,486	49,304	48,913	65,100	705,489
Other gears	14,501	8,014	3,238	4,895	5,120	6,952	4,402	12,164	9,442	6,250	6,200	8,252	89,430
Grand total	128,895	71,233	28,779	43,513	45,509	61,791	39,132	108,120	83,928	55,554	55,113	73,352	794,919
% of annual catch	16.2	9.0	3.6	5.5	5.7	7.8	4.9	13.6	10.6	7.0	6.9	9.2	100

1976 catch data for "sardines" by gear types; these data (for Region V) aggregate San Miguel and Lamon Bay catches, however, and cannot be compared with the present results. Useful references pertaining to the assessment of tropical clupeids are given in Ritterbush (1975) and Troadec et al. (1980).

ENGRAULIDAE

The problems reported above with the identification of Clupeidae also appeared with the anchovies, and for reasons analogous to those given above, the estimated catch of "*Stolephorus* spp." (Table 15) in fact pertains to *Stolephorus* spp. plus admixtures of other anchovies. Pauly (this report) lists the species of anchovies reported from San Miguel Bay.

In San Miguel Bay, anchovies are caught predominantly by trawlers; Simpson (1978) writes on this:

> it was reported .... that when fishing for anchovies a number of commercial trawlers attached a fine anchovy net which enclosed the whole cod end and reach almost half way up the net. Such fine covers were legal when anchovies were being caught and resulted in an almost pure catch in the cover as few larger fish escaped through the inner 20 mm nets. These nets must capture everything that enters the net and reach the 20 mm netting.

The mesh size of the fine "anchovy net" is generally of about 8 mm in San Miguel Bay (Fig. 7), although even smaller sizes ($\geqslant$ 3 mm) have been reported by Jones (1976) from "baby trawls" of other fishing grounds in the Philippines.

Table 15. Catch (in kg) of anchovies in San Miguel Bay, by gear type and month (1980-1981).

Gear type	F	M	A	M	J	J	A	S	O	N	D	J	Σ
Trawlers (medium and small)	168,803	195,316	232,230	80,273	62,485	53,017	81,842	117,580	161,930	70,124	85,834	59,951	1,369,385
Liftnet	–	–	–	–	107,782	136,599	139,322	114,362	–	–	–	–	498,065
Filter net	4,517	23,716	11,632	15,133	–	–	–	21,796	33,653	23,716	–	108	134,271
Fish corral	–	–	–	–	7,322	1,699	–	–	–	–	–	–	9,021
Subtotal	173,320	219,032	243,862	95,406	177,589	191,315	221,164	253,738	195,583	93,840	85,834	60,059	2,010,742
Other gears	7,232	9,139	10,175	3,981	7,410	7,982	9,228	12,448	10,723	5,025	3,581	2,506	89,430
Grand total	180,552	228,171	254,037	99,387	184,999	199,297	230,392	266,186	206,306	98,865	89,415	62,565	2,100,172
% of annual catch	8.6	10.9	12.1	4.7	8.9	9.5	11.0	12.6	9.7	4.7	4.3	3.0	100

A yield-per-recruit analysis was performed for three species of anchovies occurring in the Bay, namely, *Stolephorus heterolobus, S. indicus* and *S. commersonii* (see Table 16). The results (Fig. 8) suggest that yield-per-recruit for values of $E > 0.5$, i.e., at high levels of fishing mortality would increase considerably if mesh sizes were *increased* to 2 cm.

Simpson (1978, Table 21) presented a time series of catch and effort data (Table 17) on anchovies from San Miguel and Lamon Bays. The correlation between catch per effort and effort is $r = -0.371$ which, with 4 degrees of freedom is not significant ($P = 0.05$). Thus, it may be stated, based on the data of Table 17, that there is at present no relationship between anchovy abundance and fishing effort on anchovies, i.e., that there is at the present levels of effort, no direct relationship between fishing effort and recruitment. This suggests that the previous yield-per-recruit analysis can be extended to the yield itself, which leads to the conclusion that the anchovy yield of San Miguel Bay could be increased if mesh sizes were *increased.*

The present legal situation with regard to minimum mesh sizes is that sizes of 2 cm are the rule, with qualified exceptions, i.e.,

> *Fishing with Fine-Mesh Nets.*—It shall be unlawful for any person to fish with nets with mesh smaller than that which may be fixed by rules and regulations promulgated conformably with the

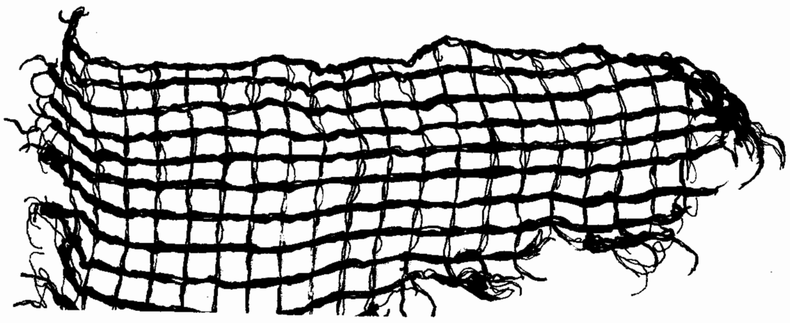

Fig. 7. Actual size of material used in the San Miguel Bay area to line the cod end of trawlers during the anchovy season. The mesh size depicted here corresponds to about 8 mm stretched, and generates sizes at first capture of 2-3 cm (see text).

Table 16. Parameter values used for the yield per recruit analyses of three species of anchovies.

Species	L_∞[a] (cm)	M/K[a]	SF[b]	Mean length at first capture (cm) for 8-mm and 20-mm meshes	
Stolephorus heterolobus	11.05	1.94	2.8	2.25	5.6
Stolephorus indicus	11.25	2.06	2.7	2.16	5.4
Stolephorus commersonii	11.2	2.38	2.6	2.08	5.2

[a]Estimated from Philippine stocks by Ingles and Pauly (1982).
[b]The selection factors were estimated from the nomogram in Pauly (1980, Fig. 12).

provisions of Section 7 hereof: *Provided,* That this prohibition in the use of fine-mesh nets shall not apply to the gathering of fry, glass eels and elvers and such species which by their very nature are small but already mature.[2]

"Section 7" refers to implementation rules; the implementation rule pertaining to "small meshes" reads as follows:

Prohibition.—It shall be unlawful for any person, association or corporation to fish in any fishing area of the Philippines, with the use of fine-meshed nets and/or sinamay cloth at the bunt or bag, of any fishing gear except when catching ipon, padas, bañgus fry, glass eels and elvers, banak fry and such species which by their nature are small but already mature such as alamang, tabios, sinarapan, dilis, dulong, hipon tagunton and snails.

"Fine-meshed nets", for the purpose of this Order, shall include all nets, used in fishing or intended for fishing purposes, with less than two centimeters when stretched.[3]

The species for which small meshes are legal are generally very small; thus alamang (= balao) reaches 1.4 cm at most (see above), tabios (= *Pandaka pygmaea,* the smallest vertebrate on earth, incidentally) reaches at most 1.1 cm when adult, while sinarapan (= *Mistichthys luzonensis*) and dulong (= *Microgobius lacustris*) reach 1.2 and 1.9 cm, respectively (Herre 1927). "Hipon tagunton", finally refers to a very small freshwater shrimp, while the small "snails" meant here are presumably *Vivipara angularis* ("papan"), a freshwater species which reach 2-3 cm at most.

[2]Presidential Decree No. 704 "Revising and consolidating all laws affecting fishing and fisheries" (1975).

[3]Fisheries Administrative Order No. 40-4, Fish. Gazette, March 26, 1973. This implementation rule stands unmodified by Presidential Decree No. 704.

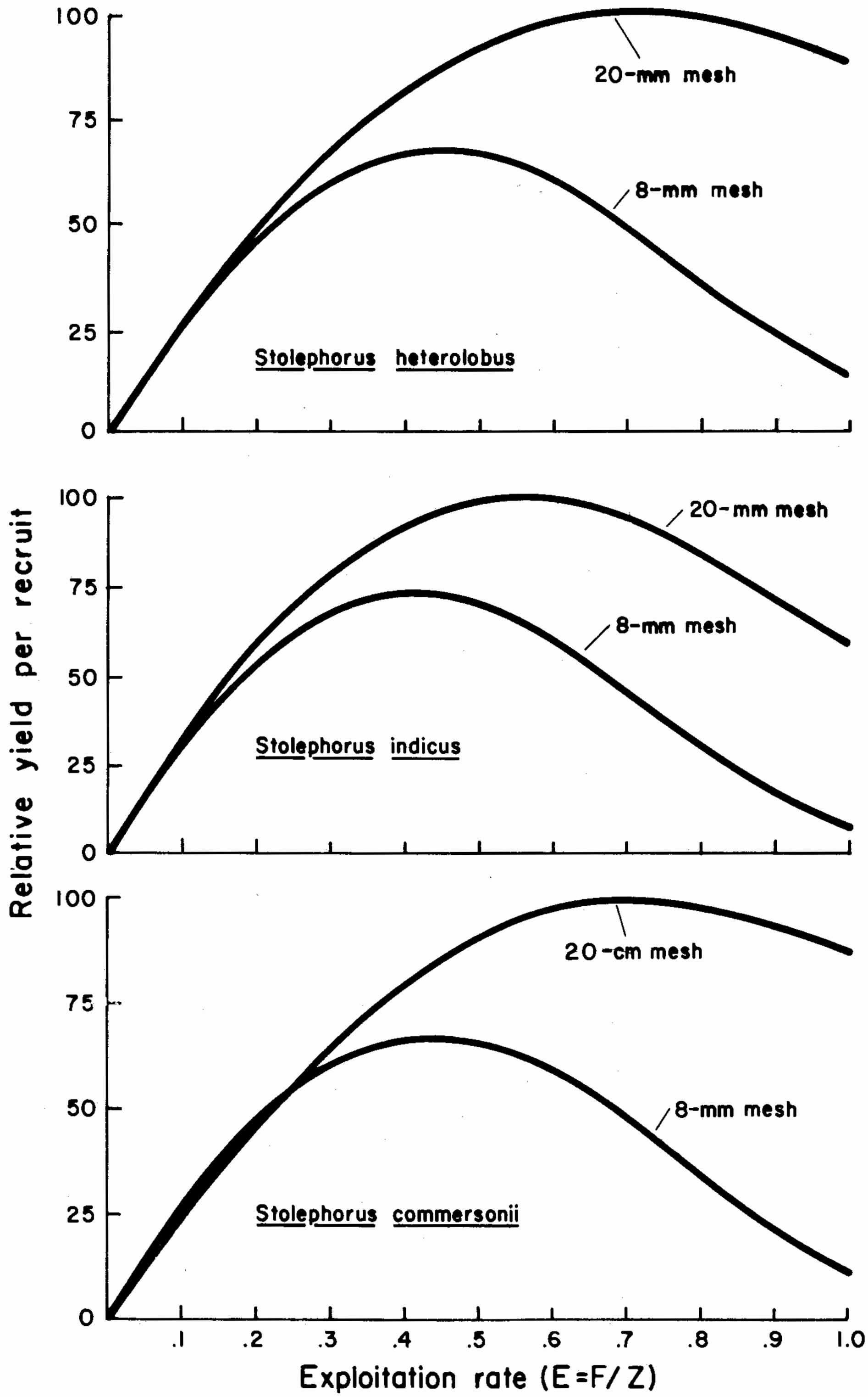

Fig. 8. Yield per recruit (after Beverton and Holt 1966) for San Miguel Bay anchovies. Note higher yield per recruit for larger mesh sizes.

In contrast to this, it may be recalled that "dilis" (anchovies) reach 10 cm and more when adult, and do not mature at sizes below 6-7 cm (Tiews et al. 1971). Since anchovies of 2-3 cm are not "small but already mature" (see above), the small meshes used to catch these fishes in San Miguel Bay do not seem to be covered by the existing regulations.

Moreover, the impact of meshes such as depicted in Fig. 7 on the non-anchovy resources of San Miguel Bay cannot be but very deleterious, and skew the size and age distribution of fish caught in San Miguel Bay toward smaller and younger forms to the detriment of the small-scale fishery, of the offshore fishery, and ultimately of the San Miguel Bay trawl fishery itself.

ARIIDAE

Since at least two species of ariid catfish occur in San Miguel Bay (Pauly, this report), the *"Arius thalassinus"* used by the various agencies monitoring the landings in San Miguel Bay is too restrictive (see also comments above on clupeids). Table 18 gives the estimate of the *"Arius thalassinus"* catch in San Miguel Bay. Ariid catfish can reach considerable sizes, i.e., up to 150 cm for the giant catfish *Arius thalassinus*, and should be, on grounds of their propensity to feed on fish, one of the major predators in San Miguel Bay.

No published data on growth, mortality or stock abundances in relationship to effort are available on ariid catfish in the Philippines (Gomez 1980; Vicente 1980). This also applies to the next 7 teleost families, but will not be restated.

Table 18. Catch (in kg) of *Arius thalassinus* in San Miguel Bay, by gear type and month (1980-1981).

Gear type	F	M	A	M	J	J	A	S	O	N	D	J	Σ
Trawlers (medium and small)	542	–	1,778	134	–	–	662	1,128	501	308	–	–	5,053
Trawlers (large)	–	–	–	–	–	–	–	428	190	117	–	–	735
Panke	2,983	3,545	2,831	–	3,545	4,235	5,077	4,428	–	–	–	–	26,644
Palataw	–	–	–	–	–	–	–	2,535	–	–	–	–	2,535
Pamating	–	280	590	265	–	–	–	–	–	–	–	–	1,135
Fish corral	–	358	404	–	–	2,285	542	4,835	–	–	–	–	8,424
Total	3,525	4,183	5,603	399	3,545	6,520	6,281	13,354	691	425	–	–	44,526
% of annual catch	7.9	9.4	12.6	0.90	8.0	14.6	14.1	30.0	1.5	1.0	–	–	100

MUGILIDAE

Table 19 presents the catch of mullets in San Miguel Bay. As will be noted, most (72.3%) of the estimated annual catch of 1,190 t is made by the small-scale fishermen, at rather large sizes with nets that are highly selective (the "palataw" and "palubog" type gill-nets). It is possible that the mugilid catch from San Miguel Bay consists of one single species, *Liza subviridis* (= *Mugil dussumieri*) (Pauly, this report).

SCIAENIDAE

Sciaenids are very important constituents of tropical and subtropical inshore communities particularly in estuaries (Longhurst 1969). In San Miguel Bay, the Sciaenidae are represented by seven species of which *Otolithes ruber* is the most important. Navaluna (this report) gives an account of the biology and population dynamics of *O. ruber* in San Miguel Bay.

Growth parameters were calculated, using length-frequency data collected in the Project, for two other species of sciaenids. The results, which were obtained using the ELEFAN I method of Pauly and David (1981) (see Navaluna, this report) are for *Dendrophysa russelli:* $L_\infty = 17.5$ cm, $K = 0.95$ (yearly basis), and for *Pennahia macrophthalmus* $L_\infty = 20$ cm, $K = 0.6$ (Ingles and Pauly 1982). Further details will be given in Ingles and Pauly (in prep.).

Table 19. Catch (in kg) of Mugilidae, in San Miguel Bay, by gear type and month (1980-1981).

Gear type	F	M	A	M	J	J	A	S	O	N	D	J	Σ
Trawlers (medium and small)	14,056	5,448	6,957	3,319	24,332	55,490	60,238	55,249	22,300	15,916	12,025	18,651	293,981
Trawlers (large)	–	–	–	–	–	–	–	20,952	8,457	6,036	–	–	35,445
Panke	3,089	–	2,860	3,556	–	8,072	5,077	4,370	7,488	–	–	10,003	44,515
Palataw	34,978	38,261	13,776	3,229	18,835	27,391	44,826	52,253	–	–	53,813	39,014	326,376
Palubog	46,646	–	–	–	–	–	–	49,211	156,263	71,290	79,297	77,743	480,450
Pamating	80	20	–	–	–	–	–	–	–	236	–	–	336
Filter net	–	–	–	–	–	–	–	–	–	–	2,857	2,247	5,104
Fish corral	–	–	–	–	–	1,086	–	1,857	–	–	–	–	2,943
Subtotal	98,849	43,729	23,593	10,104	43,167	92,039	110,141	183,892	194,508	93,478	147,992	147,658	1,189,150
Other gears	55	24	13	6	24	51	61	102	108	52	82	82	660
Grand total	98,904	43,753	23,606	10,110	43,191	92,090	110,202	183,994	194,616	93,530	148,074	147,740	1,189,810
% of annual catch	8.3	3.7	2.0	0.90	3.6	7.7	9.3	15.5	16.3	7.9	12.4	12.4	100

Table 20 summarizes the catch data for Sciaenidae (excluding *O. ruber).* As might be seen from this table, the croakers are an important target group of the small-scale fishery, which obtains about 80% of the total sciaenid catch from the Bay. Sciaenidae probably increased their relative biomass in the Bay since 1947, as suggested by a proportion of 0.9% in the catch of the *Theodore N. Gill*, compared with their present proportion of 9.2% of the trawler catch.

POMADASYDAE

Table 21 gives the catch of *Pomadasys hasta* in San Miguel Bay. The pomadasyds, of which several species occur in San Miguel Bay (Pauly, this report), are caught in small quantities mainly by the trawl fishery (see Table 4).

CARANGIDAE

A large number of carangid species are reported from San Miguel Bay, with the group, as a whole, contributing 270 t to the total catch; of these 78% are taken by the small-scale fishery. The carangids may thus be considered a target group of that fishery (see Table 4).

Simpson (1978) gave a preliminary assessment of the roundscad fishery off the Pacific coast of the Philippines; roundscads (*Decapterus* spp.) do not seem to occur in the Bay and so are not discussed here.

The carangid species reported from San Miguel Bay range from small fishes (≈ 20 cm) which often occur in estuaries, to large, oceanic species, so that a discussion of the fishery of the group as a whole is not warranted. The catch of carangids is given in Table 22.

LEIOGNATHIDAE

In 1947, when a trawl survey was conducted in San Miguel Bay, slipmouths formed a large proportion (60%) of the fish catch (Warfel and Manacop 1950), and this value is an underestimate of true relative abundance because the *Theodore N. Gill* was using large meshes which do not retain the smallest leiognathids (e.g., those of the genus *Secutor*). The present catch of Leiognathidae that is reported as such contributes only 0.6% of the trawler catch but this proportion increases to 22% if the reasonable assumption is made that half of the miscellaneous species category consists of small-sized Leiognathidae. Thus, slipmouths have diminished in the Bay both in absolute and relative abundance, as also noted by Vakily (this report).

The ecological niche of leiognathids is similar to that of shrimps (see above) and to that of sciaenids (Longhurst 1969), two groups which, as shown above, have increased—at least in relative terms—since intensive exploitation of the Bay's demersal resources began. This suggests competitive interactions between these various groups; these interactions and their possible effects on yields will be discussed further below.

Table 20. Catch (in kg) of croakers (excl. *O. ruber*) in San Miguel Bay, by gear type and month (1980-1981).

Gear type	F	M	A	M	J	J	A	S	O	N	D	J	Σ
Trawlers (medium and small)	27,159	30,397	44,501	23,234	24,338	25,278	38,608	20,661	14,795	13,732	24,079	7,976	294,758
Trawlers (large)	–	–	–	–	–	–	–	7,835	5,611	5,208	–	–	18,654
Panke	47,382	79,555	133,957	114,653	121,672	109,973	95,934	90,084	48,260	26,323	-	69,611	937,404
Palataw	2,691	13,130	16,144	34,440	–	14,691	–	3,842	–	–	53,813	–	138,751
Pangasag	638	1,718	1,036	991	–	–	–	–	–	–	–	–	4,383
Pamating	–	–	–	265	–	–	–	–	–	–	–	–	265
Liftnet	–	–	–	–	–	–	86	–	–	–	–	–	86
Filter net	2,010	–	–	–	–	–	–	–	–	–	–	–	2,010
Fish corral	–	10,135	8,299	–	9,670	9,600	1,439	22,874	9,647	–	–	–	71,664
Mini trawl	–	–	–	–	–	–	246	–	–	–	–	–	246
Total	79,880	134,935	203,937	173,583	155,680	159,542	136,313	145,296	78,313	45,263	77,892	77,587	1,468,221
% of annual catch	5.4	9.2	13.9	11.8	10.6	10.9	9.3	9.9	5.3	3.1	5.3	5.3	100

Table 21. Catch (in kg) of *"Pomadasys hasta"* in San Miguel Bay, by gear type and month (1980-1981).

Gear type	F	M	A	M	J	J	A	S	O	N	D	J	Σ
Trawlers (medium and small)	1,826	9,158	4,171	1,765	649	1,431	1,747	–	–	–	–	–	20,747
Other gears	1,144	5,738	2,613	1,106	407	897	1,095	–	–	–	–	–	13,000
Total	2,970	14,896	6,784	2,871	1,056	2,328	2,842	–	–	–	–	–	33,747
% of annual catch	8.8	44.2	20.1	8.5	3.1	6.9	8.4	0	0	0	0	0	100

Table 22. Catch (in kg) of Carangidae in San Miguel Bay, by gear type and month (1980-1981).

Gear type	F	M	A	M	J	J	A	S	O	N	D	J	Σ
Trawlers (medium and small)	8,632	19,063	11,122	4,705	3,535	1,920	2,138	2,412	1,665	154	116	124	55,586
Trawlers (large)	–	–	–	–	–	–	–	915	631	58	–	–	1,604
Panke	5,083	7,312	10,178	13,922	4,498	4,142	4,504	6,084	–	–	–	3,200	58,923
Palataw	–	–	1,507	–	–	2,443	–	2,535	–	–	–	–	6,485
Fish corral	–	–	–	–	12,018	13,320	18,922	2,789	1,925	–	–	–	48,974
Subtotal	13,715	26,375	22,807	18,627	20,051	21,825	25,564	14,735	4,221	212	116	3,324	171,572
Other gears	7,765	14,932	12,913	10,546	11,352	12,357	14,474	8,343	2,390	120	66	1,882	97,140
Grand total	21,480	41,307	35,720	29,173	31,403	34,182	40,038	23,078	6,611	332	182	5,206	268,712
% of annual catch	8.0	15.4	13.3	10.9	11.7	12.7	14.9	8.6	2.5	0.12	0.07	1.9	100

The Leiognathidae are a group that has been relatively well investigated in the Philippines in general, and in San Miguel Bay in particular (Tiews and Caces-Borja 1965; Tiews et al. 1972b, and see further references in Pauly and Wade-Pauly 1981).

Growth parameters were estimated, using the ELEFAN I method (see above) in the toothed ponyfish *Gazza minuta* from San Miguel Bay, with results L_∞ = 14 cm and K = 1.1. These results are tentative, however, as the goodness of fit obtained was well below average (Ingles and Pauly, unpublished data).

Table 23 summarizes the catch data on Leiognathidae from San Miguel Bay. It must be realized, however, that these figures are minimum estimates—particularly for the trawl fishery—because, as discussed above, a large amount of slipmouths is also included in the "miscellaneous fishes" category.

TRICHIURIDAE

This family seems to be represented in San Miguel Bay by one species only, *Trichiurus lepturus*, the catch of which is given in Table 24. Cutlass fishes are predominantly piscivorous (James 1967).

SCOMBRIDAE

The spanish mackerel *Scomberomorus commerson* is a highly valued fish in the San Miguel Bay area (and elsewhere) and catch data are available for that species alone (Table 25) while the other Scombridae caught in the Bay are included under the "miscellaneous fishes". This makes it difficult to comment on the biology or exploitation of any of the scombrid species except that most of the larger forms reported from the Bay (notably the tunas) can be considered to be occasional visitors (see Pauly, this report). This would make the abundance of these fishes virtually independent of

Table 23. Catch (in kg) of Leiognathidae in San Miguel Bay, by gear type and month (1980-1981).

Gear type	F	M	A	M	J	J	A	S	O	N	D	J	Σ
Trawlers (medium and small)	2,029	11,546	5,012	349	193	316	1,430	7,237	4,619	463	–	–	33,194
Trawlers (large)	–	–	–	–	–	–	–	2,745	1,752	176	–	–	4,673
Liftnet	–	–	–	–	2,859	3,948	–	–	–	–	–	–	6,807
Filter net	–	–	13,890	18,182	–	14,681	11,858	–	–	–	–	–	58,611
Fish corral	–	–	–	–	1,464	3,719	3,603	–	–	–	–	–	8,786
Total	2,029	11,546	18,902	18,531	4,516	22,664	16,891	9,982	6,371	639	–	–	112,071
% of annual catch	1.8	10.3	16.9	16.5	4.0	20.2	15.1	8.9	5.7	0.60	–	–	100

Table 24. Catch (in kg) of Trichiuridae in San Miguel Bay, by gear type and month (1980-1981).

Gear type	F	M	A	M	J	J	A	S	O	N	D	J	Σ
Trawlers (medium and small)	66,017	103,346	19,094	7,203	–	237	–	–	7,147	11,182	14,005	19,236	247,467
Trawlers (large)	–	–	–	–	–	–	–	–	2,710	4,240	–	–	6,950
Panke	16,730	9,418	18,134	15,150	–	2,954	–	–	–	–	–	4,844	67,230
Palataw	–	–	861	–	–	–	–	–	–	–	–	–	861
Filter net	501	–	–	–	–	–	–	–	–	–	–	–	501
Fish corral	–	–	–	–	–	992	–	–	–	–	–	–	992
Total	83,248	112,764	38,089	22,353	–	4,183	–	–	9,857	15,422	14,005	24,080	324,001
% of annual catch	25.7	34.8	11.8	6.9	–	1.3	–	–	3.0	4.8	4.3	7.4	100

fishing activities in the Bay and suggests that these fishes are in no need of management, at least not as part of the San Miguel Bay fisheries.

MISCELLANEOUS SPECIES

Miscellaneous species, unfortunately, represent the largest category (Table 26), and include unsorted fishes from the groups discussed above as well as fishes belonging to other taxa.

As expected, it is the trawler fishery which lands most unsorted fish, which are one of the trawl fishery's few "target groups" (see Table 4). This large amount of unsorted fish in the statistics, which the IFDR/ICLARM project had no means of breaking into more specific categories, renders species-by-species assessments of the Bay's resources virtually impossible. Attempts should be made in future projects of this kind to obtain more detailed catch data on a per-species basis, at least as far as important groups are concerned.

Trophic Interrelationships Between the Stocks of San Miguel Bay

Various components of the San Miguel Bay ecosystem have been studied at different times, notably the fish stocks, the benthos and the plankton (Table 1). On the basis of the relevant publica-

Table 25. Catch (in kg) of Spanish mackerels in San Miguel Bay, by gear type and month (1980-1981).

Gear type	F	M	A	M	J	J	A	S	O	N	D	J	Σ
Trawlers (medium and small)	2,712	–	161	41	276	8,294	11,165	3,696	484	–	–	–	26,829
Trawlers (large)	–	–	–	–	–	–	–	1,402	184	–	–	–	1,586
Panke	2,521	–	3,516	3,071	4,686	6,727	10,588	3,176	5,428	–	–	6,435	46,148
Fish corral	–	–	–	–	–	446	–	–	–	–	–	–	446
Total	5,233	–	3,677	3,112	4,962	15,467	21,753	8,274	6,096	–	–	6,435	75,009
% of annual catch	7.0	0	4.9	4.2	6.6	20.6	29.0	11.0	8.1	0	0	8.6	100

Table 26. Catch (in kg) of "miscellaneous fishes" in San Miguel Bay, by gear type and month (1980-1981).

Gear type	F	M	A	M	J	J	A	S	O	N	D	J	Σ
Trawlers (medium and small)	217,780	292,106	214,508	148,329	141,318	243,591	291,996	222,388	285,284	154,431	241,663	179,990	2,633,384
Trawlers (large)	–	–	–	–	–	–	–	128,927	169,597	85,158	–	–	383,682
Panke	33,343	25,621	33,694	17,666	19,713	29,190	51,594	36,502	24,978	–	–	9,710	282,011
Palataw	–	17,919	18,404	–	–	14,691	43,050	–	–	–	–	–	94,064
Pangasag	13,168	6,026	8,168	964	625	196	–	–	2,089	–	–	–	31,236
Palubog	–	–	–	–	–	–	–	–	1,726	–	–	–	1,726
Pamating	937	324	–	665	–	–	–	–	–	–	–	3,419	5,345
Liftnet	–	–	–	–	–	9,757	14,976	31,944	–	–	–	–	56,727
Filter net	4,269	–	–	–	–	14,681	11,858	–	–	–	13,326	289	44,423
Fish corral	–	36,031	29,522	46,259	31,149	21,037	27,197	26,965	3,836	–	–	–	221,996
Mini trawl	–	–	–	–	42,007	99,808	47,693	38,217	12,255	28,205	18,035	39,797	326,017
Subtotal	269,497	378,027	304,296	213,883	234,812	432,951	488,364	484,993	499,765	267,794	273,024	233,205	4,080,611
Other gears	21,487	30,139	24,261	17,053	18,721	34,518	38,937	38,668	39,845	21,350	21,768	18,593	325,340
Grand total	290,984	408,166	328,557	230,936	253,533	467,469	527,301	523,661	539,610	289,144	294,792	251,798	4,405,951
% of annual catch	6.6	9.3	7.4	5.2	5.8	10.6	12.0	11.9	12.2	6.6	6.7	5.7	100

tions, and of other papers relating to the feeding habits of the groups concerned, it is possible to construct a simplified "box model" (Pauly 1981) of San Miguel Bay, in which the trophic inter-relationships of various groups are emphasized (Fig. 9).

Also, an attempt was made to attribute the catch to the various "boxes" that were identified, as well as to indicate, based on the data discussed previously, which groups increased their share to the total biomass (since 1947) and which groups declined.

As might be seen from Fig. 9, the case can be made that the demise of the Leiognathidae is related to the increases of both the shrimps and croakers, with whom the slipmouths compete for zoobenthos. Also, the increase of the squids can be explained, as suggested above, by a reduction of overall predation on their eggs which are benthic. The croakers and the other medium-sized demersal fishes should also have benefited from the demise of the large zoobenthos feeders (i.e., the rays).

As discussed by Daan (1980), changes within multispecies communities are generally difficult to predict and even more difficult to control. Some of the changes that occurred in the San Miguel Bay multispecies stock were predictable, especially the replacement of the rays by smaller-sized zoobenthos feeders (Pauly 1979a).

The decline of the Leiognathidae is surprising, however. Both Kvaran (1971) and James (1973) suggested that, on account of their small size and short life-span, they should be virtually immune to overfishing. Possibly, these fishes might indeed be specialists ("K-selected") and not tolerant of massive changes in their habitats, such as brought about by fishing (Pauly 1979a).

Discussion

The present catch from San Miguel Bay, although very high on a per-area basis, can be accommodated in the plot of yields as tonnes/km^2 on depth derived from Philippine data (Fig. 4). This high value, however, along with various circumstantial evidence, suggests not only that total yields from the Bay cannot be substantially increased, but also that additional increases of effort, especially by the trawl fishery would only exacerbate present problems of allocations of catch between the small-scale and the trawl fisheries.

As opposed to all assessments conducted previously in Philippine waters, this assessment of the San Miguel Bay fisheries did not subdivide the fishery into a "municipal" and a "commercial" sector, but rather lumped the "municipal baby trawlers" (= small trawlers) with the "commercial baby trawlers" (= medium trawlers) and the few large trawlers operating sporadically in the Bay into a single "trawl fishery", which is differentiated from the other, "small-scale" fishery by its investment level, profitability, energy consumption, and catch and income per fisherman (Thomson 1981).

This procedure considerably increased the homogeneity of the fisheries described both biologically (see Vakily, this report; Pauly et al., this report) and from an economic perspective (Smith and Mines 1982).

A search was made for research results upon which the 3-t demarcation which is presently used in the Philippines to distinguish between "commercial" and "municipal" fisheries may have been based. Such research does not seem to have been conducted. Rather, the 3-t limit which was codified as early as 1932[4] was purely arbitrary and had its only purpose in defining "commercial fishing" for taxation and licensing.

The 3-t limit, formulated into law in colonial times has been restated in Presidential Decree No. 704. However, I believe that this 3-t limit does not provide a useful demarcation between

[4] Commonwealth Act No. 4003 "An act to amend and compile the laws relating to fish and other aquatic resources of the Philippine Islands and for other purposes." Manila, December 5, 1932.

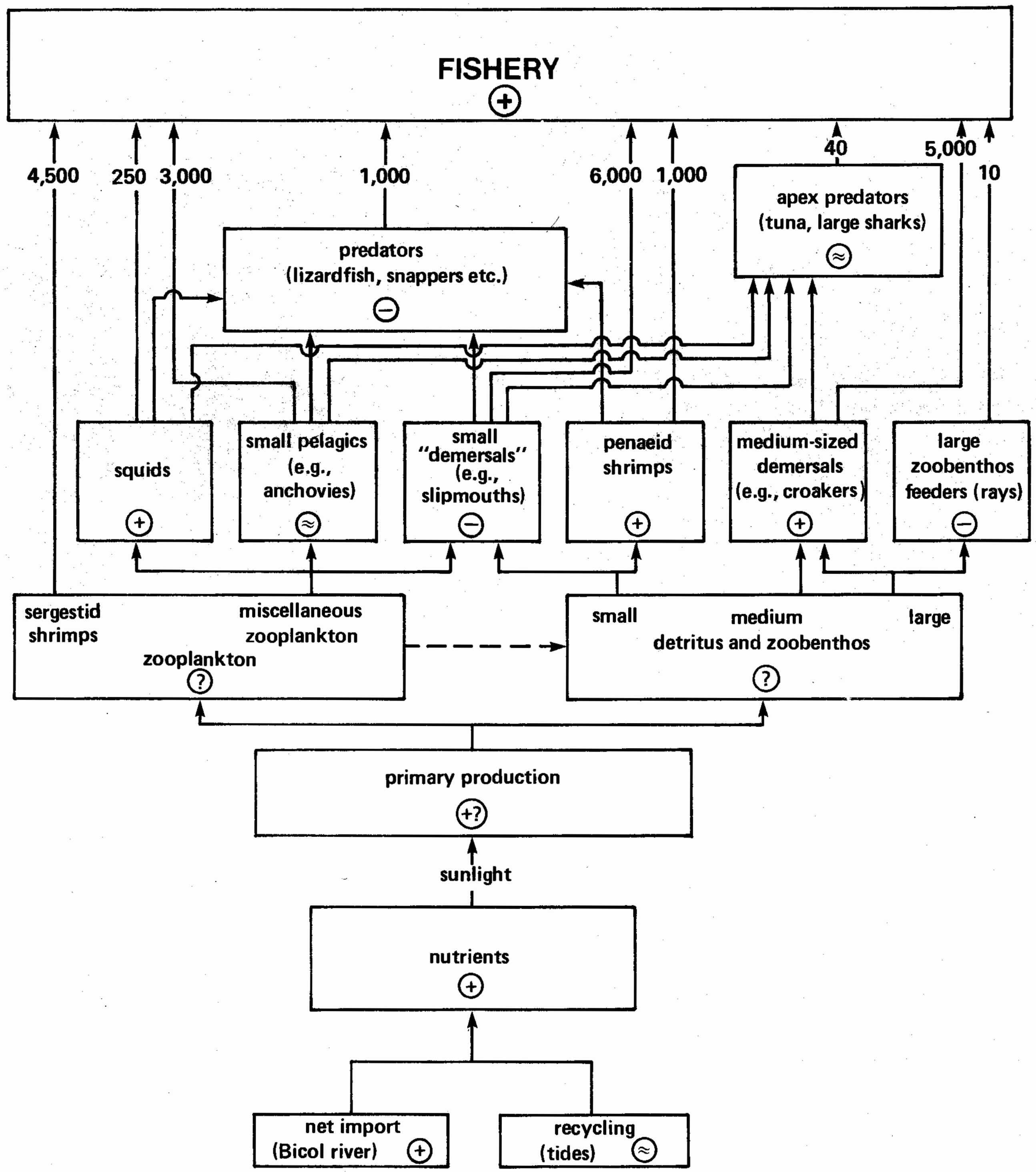

Fig. 9. Trophic interrelationships in San Miguel Bay in relation to the fishery. Numbers under fishery "box" are present catches in tonnes per year. The signs (+, –, ≈ or ?) are used to illustrate increases (+), decreases (–), relative constancy (≈) and no inference possible (?) all with regard to situation in 1947.

small-scale ("municipal") and large-scale ("commercial") fisheries. The limit would have to be set considerably lower to separate the truly artisanal gears from scaled-down commercial gears, possibly below one tonne.

Some problems which could not be investigated sufficiently here are those represented by the interactions between the fisheries inside and outside the Bay. To a very large extent, the stocks exploited by these two fisheries are *shared* stocks, the link between the two fisheries being the offshore migration of maturing fishes (see Pauly, this report). Clearly, this is a major shortcoming of the present study. However, expanding the study area, while allowing for an inclusion of adult and mature substocks of many species, would have brought in a large number of hard bottom/reef species generally not occurring inside the Bay. Possibly, the dividing line used here for defining San Miguel Bay proper was best to isolate a relatively homogenous stock of predominantly estuarine fishes (see Fig. 1 in Pauly, this report).

The multispecies nature of the San Miguel Bay stocks and the predator-prey, and competitive interactions between these stocks make single-species assessments difficult. Still, it appears that some resources would benefit (i.e., yield larger catches) by being exploited at lesser effort levels, or with larger meshes or both. These measures, however, may not increase total catch.

Overfishing in multispecies stocks is hard to define and certainly cannot be defined in terms of "growth overfishing" or "recruitment overfishing" (Cushing 1975) which are concepts pertaining to single-species stocks.

"Ecosystem overfishing" has been defined by Pauly (1979b) "as what takes place in a mixed fishery when the decline (through fishing) of the originally abundant stocks is not fully matched by the contemporary or subsequent increase of the biomass of other exploitable animals".

The species that were once abundant components of the San Miguel Bay ecosystem (e.g., rays, slipmouths) have been to a large extent replaced by croakers, squids and shrimps, all of which, although they may have smaller biomass than the group they replaced, undoubtedly generate a more valuable catch.

The Bay may not be overfished ecologically if the definition given above is used. This leaves us with the concept of economic overfishing (Smith 1981). Most probably, a catch similar to the one made now could be generated with a markedly reduced effort and cost (see Fig. 5). This would define the Bay fishery as "overcapitalized", or economically overfished (see Smith and Mines 1982).

In a sense, throughout this investigation, a full circle has been completed: the data presented here—notably the effort data—would not have been available had not this project been interdisciplinary, i.e., also concerned with socioeconomic issues such as the extent of fishermen's assets. Now, a biological assessment of the fishery has been performed, and it is found that the fishery—the real fishery that involves real people living around a real San Miguel Bay—cannot be understood without considering socioeconomic issues. The reader is thus referred to Smith and Mines (1982) and Bailey (1982a, 1982b).

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