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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. (1976) 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. (1976)
14	hydrography, plankton, benthos some fishery biology	Nov. 1974	Legasto et al. (1976)
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).

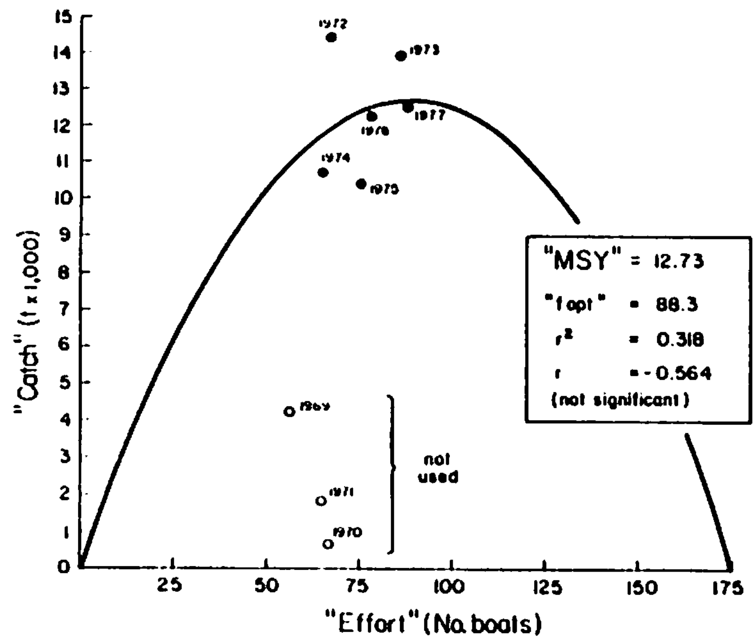

Fig. 1. Yield curve derived by Simpson (1978) and leading to his assessment that optimum effort level was reached in 1977/78 (see text)

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	6	*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. Ramn 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

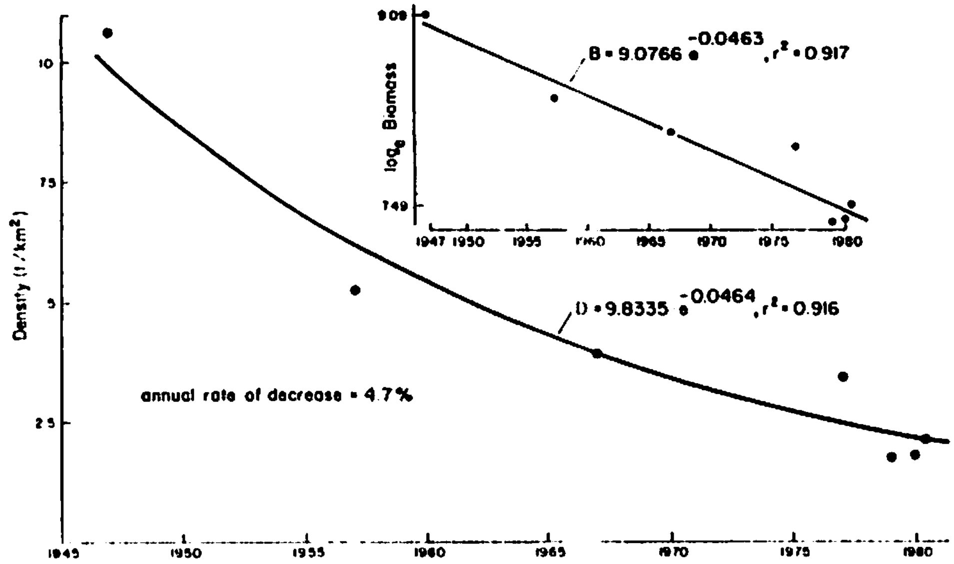

Fig. 2. Decline of the trawlable biomass of San Miguel Bay, 1947 to 1980. Note that data of Table 3, although obtained from different sources, suggest a steady decline corresponding to a linear trend in a semilogarithmic plot (inset).

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).

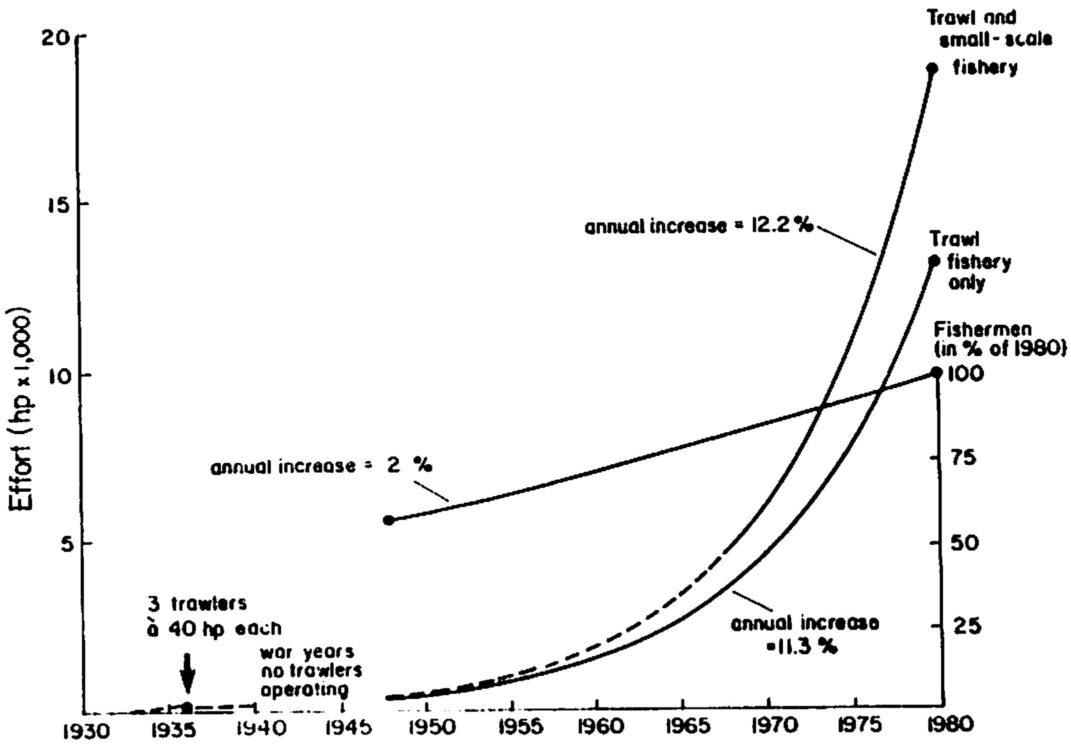

Fig. 3. Trajectories of effort from pre- and early post-war years to the present, assuming geometric increase from early to present figures (see text).

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	Small-scale fishery	% caught by: Trawl fishery	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

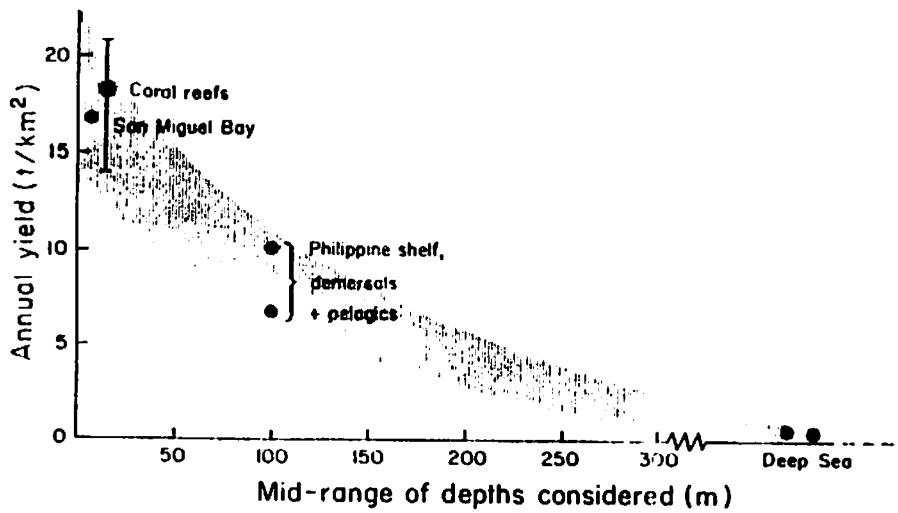

Fig. 4. Fish yields per area from Philippine waters, in relation to depth. Coral reef data from Alcala (1981 and pers. comm.); shelf and deep sea figures from Smith et al. (1980). (Shaded area is a subjective assessment of possible ranges, not a confidence belt.)

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. (16.0)
Fish corral (baklad or sagkad)	530	misc. spp. (41.8), crabs (18.0), Sciaenidae (13.6)
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.

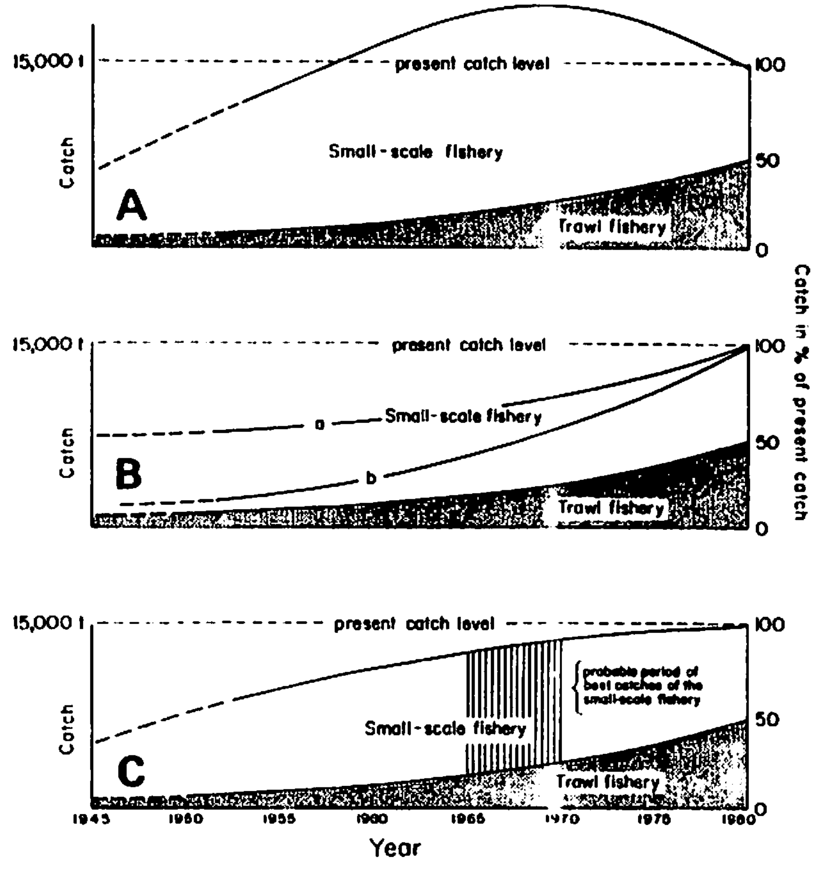

Fig. 5. The probable trajectory of the trawler catch in San Miguel Bay, 1945 to 1980, with three hypothetical situations for the evolution of the total catch (= trawler + small-scale fishery). See text for interpretation.

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-guineae (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_∞ = 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	677,900	618,014	326,378	260,604	196,126	–	–	48,208	277,671	607,842	666,922	823,432	4,201,897
Subtotal	677,900	618,014	326,378	260,604	216,106	–	–	48,208	277,671	607,842	666,922	836,452	4,234,897
Other gear	32,478	29,112	18,342	14,640	12,146	–	-	2,709	15,699	34,160	31,806	47,010	238,000
Grand total	610,378	647,126	344,720	276,144	228,261	--	-	50,917	293,170	642,002	697,727	883,462	4,472,897
% of annual catch	13.6	12.2	7.7	6.2	6.1	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)	46,612	7,263	12,297	13,382	24,094	30,536	29,006	17,889	62,292	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	4,676	–	1,897	144	11,638
Fish corral	--	1,867	1,527	6,276	681	2,906	725	1,825	9,879	–	–	–	25,686
Mini trawl	9,381	10,423	6,317	12,671	17,066	37,586	42,323	34,427	29,686	13,392	10,991	11,086	235,148
Subtotal	56,034	19,563	24,786	43,731	48,175	71,028	76,263	66,917	125,455	72,961	92,812	77,836	776,640
Other gears	19,363	6,757	8,665	15,112	16,647	24,645	26,361	23,124	43,353	25,213	32,073	26,897	268,000
Grand total	75,397	26,310	33,351	58,843	64,822	95,673	102,604	90,041	168,808	98,174	124,885	104,732	1,043,640
% 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

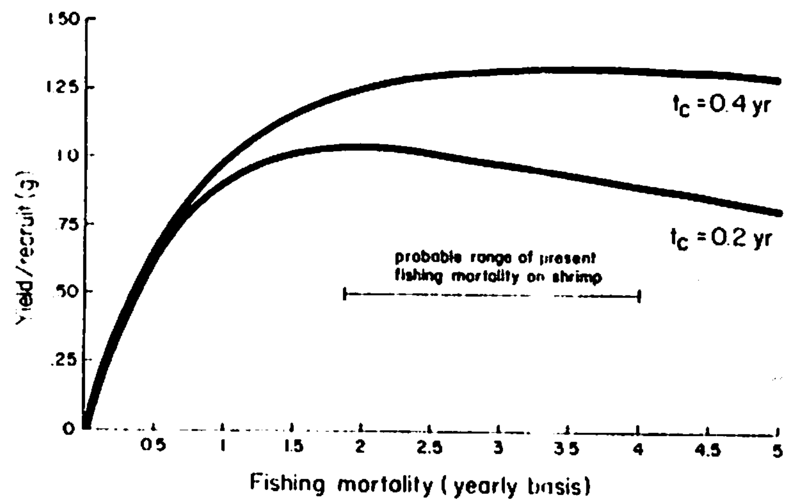

Fig. 6. Yield-per-recruit analysis for *Metapenaeus ensis* in San Miguel Bay using W_∞ = 43 g; K = 1.2; M = 2.3; t_o = t_r = 0; and equation (10.21) of Ricker (1975). Likely present values of age at first capture (t_c) were used.

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	6,686	3,592	–	–	–	–	16,689
Palataw			763			–	–	–	–	–	–	–	763
Pangasag	2,709	3,294	12,141	27,005	30,148	36,631	32,228	36,826	17,061	16,400	–		221,330
Patubog		–	–			–		–	1,726	–			1,726
Pamating				115									116
Liftnet							172			–			172
Fish corral		2,999	2,441	10,042	12,699	21,736	10,902	24,408	10,112			–	96,238
Mini trawl		–			–	1,668	4,201	9,286	846	–			16,001
Subtotal	3,818	9,480	18,162	41,647	68,406	66,006	60,611	106,621	64,278	30,362	10,726	4,148	472,083
Other gears	226	562	1,077	2,464	3,464	3,916	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	500,086
% of annual catch	0.81	2.0	3.9	8.3	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 type 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	209,746
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	3,706	2,462	1,806	1,616	3,086	6,091	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	16.7	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	6,864	3,367	190,019
Trawlers (large)	–	–		-	–	–	-	3,003	5,978	2,605	–	-	11,486
Panke	35,800	18,777	9,184	5,382	10,364	4,972	12,752	8,774	10,412	-	-	22,872	139,279
Palataw	–	-	861		–	–	–	21,525	–	–	-	–	22,386
Palubog	46,646	-	–	-	–	–	–	61,864	33,662	40,193	42,059	38,871	263,286
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	8,262	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	73,362	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 (≥ 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	62,486	53,017	81,842	117,680	161,930	70,124	85,834	59,961	1,369,385
Liftnet	–	–	–	–	107,782	136,699	139,322	114,362	–	–	–	–	498,085
Filter net	4,517	23,716	11,632	16,133	–	–	–	21,798	33,653	23,716	–	108	134,271
Fish corral	–	–	–	–	7,322	1,699	–	–	–	–	–	–	9,021
Subtotal	173,320	219,032	243,862	96,406	177,589	191,316	221,164	253,738	195,583	93,840	85,834	60,069	2,010,742
Other gears	7,232	9,139	10,175	3,981	7,410	7,982	9,228	12,448	10,723	6,026	3,581	2,506	89,430
Grand total	180,552	228,171	254,037	99,387	184,999	199,297	230,392	266,186	206,308	99,866	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

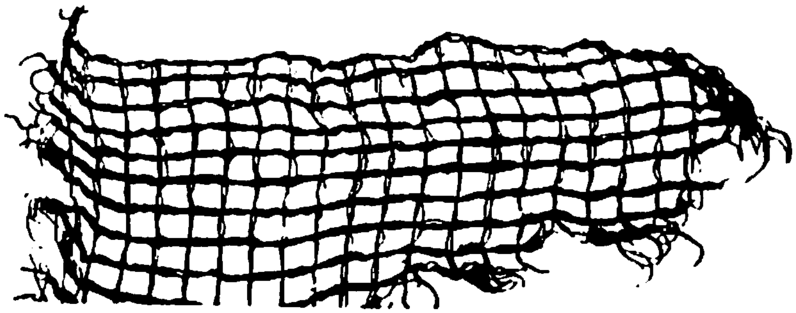

Fig. 7. Actual size of material used in the San Miguel Bay area to line the cod end of trawlers during the anchovy season. The mesh size depicted here corresponds to about 8 mm stretched, and generates sizes at first capture of 2-3 cm (see text).

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	2.26	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 lucustris*) 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.

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[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.

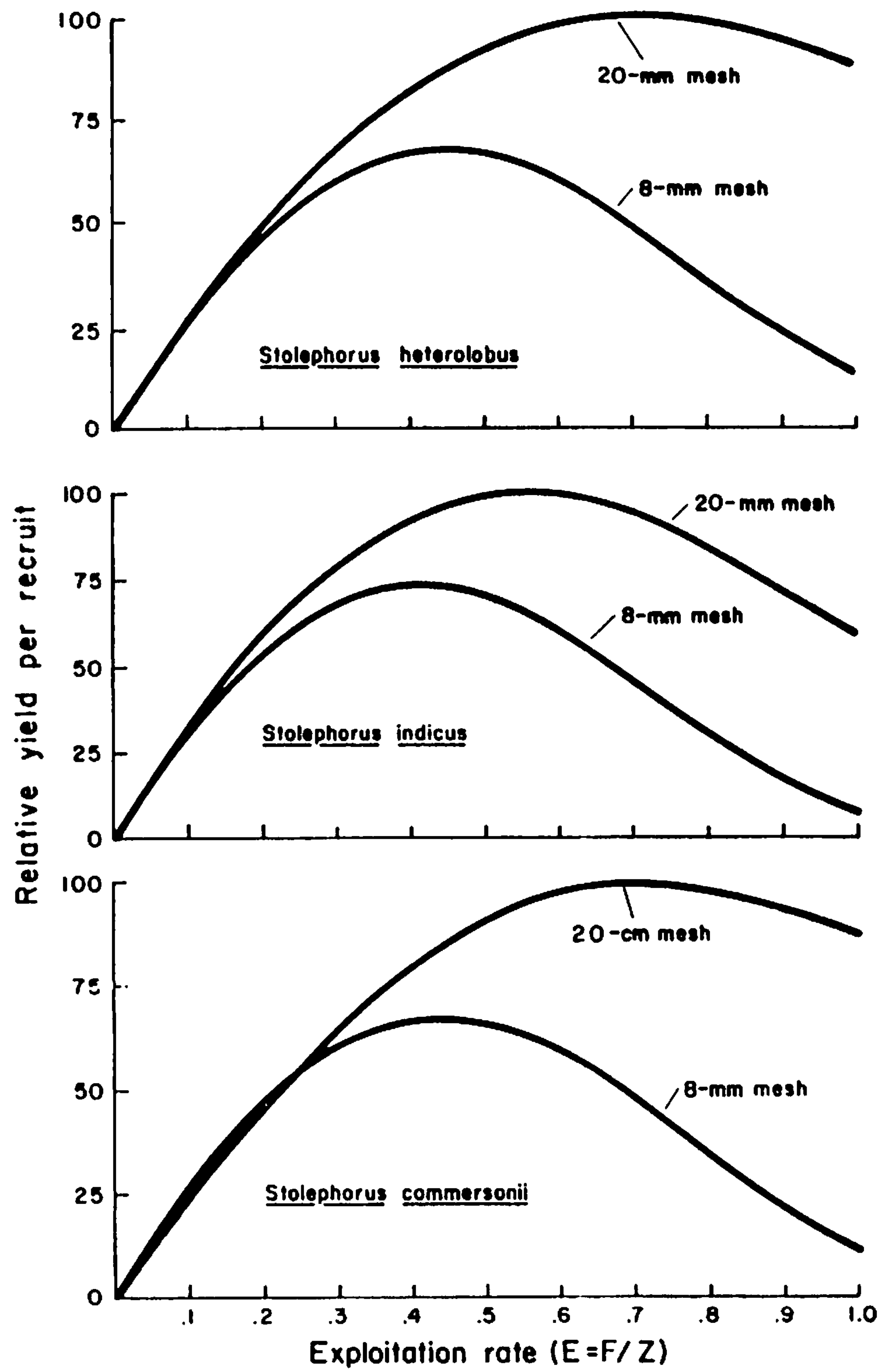

Fig. 8. Yield per recruit (after Beverton and Holt 1966) for San Miguel Bay anchovies. Note higher yield per recruit for larger mesh sizes.

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	601	308	–	–	5,063
Trawlers (large)	–	–		–	–	–	–	428	190	117	–	–	736
Panke	2,983	3,545	2,831	–	3,546	4,236	5,077	4,428	–	–	–	–	26,644
Palataw	–	–		–	–	–	–	2,536	–	–	–	–	2,536
Pamating	–	280	590	265	–	–	–	–	–	–	–	–	1,136
Fish corral	–	358	404	–	–	2,285	542	4,835	–	–	–	–	8,424
Total	3,525	4,183	5,603	399	3,546	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_∞ = 17.5 cm, K = 0.95 (yearly basis), and for *Pennahia macrophthalmus* L_∞ = 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)	14,066	5,448	6,957	3,319	24,332	55,490	60,238	55,249	22,300	15,916	12,026	18,651	293,981
Trawlers (large)	–	-	–	.	-	-	–	20,952	8,457	6,038	–	–	35,445
Panke	3,069	–	2,860	3,566	–	8,072	6,077	4,370	7,488	–	–	10,003	44,616
Palatew	34,978	38,261	13,776	3,229	18,835	27,391	44,826	52,263	–	–	53,813	39,014	326,378
Palubog	46,646	–	–	–	–	–	–	49,211	156,283	71,290	79,297	77,743	480,450
Pamating	80	20	–	–	-	–	–	–	–	238	–	–	338
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)	27,169	30,397	44,601	23,234	24,338	26,278	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
Palatew	2,691	13,130	16,144	34,440	··	14,691	–	3,842	--	--	53,813	–	138,761
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	134,936	203,937	173,583	155,680	159,542	136,313	145,296	78,313	46,263	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	1,766	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	3,636	1,920	2,138	2,412	1,665	154	116	124	55,686
Trawlers (large)	--	·		·	--	–	-	915	631	58	--	-	1,604
Panke	6,083	7,312	10,178	13,922	4,498	4,142	4,504	6,084	–	–	–	3,200	58,923
Palatew	–	--	1,607	-	–	2,443	-	2,535	–	–	–	--	6,486
Fish corral	·	·			12,018	13,320	18,922	2,789	1,926	·	–	·	48,974
Subtotal	13,716	26,376	22,807	18,627	20,061	21,826	26,664	14,735	4,221	212	116	3,324	171,672
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		–	–	–	2,869	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	14,006	19,236	247,487
Trawlers (large)					–	–	–		2,710	4,240	–		6,950
Panke	16,730	9,418	18,134	15,150	–	2,954		–	–	–	–	4,844	67,230
Palatow			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	11,166	3,898	484	–	–	–	26,829
Trawlers (large)	–	–	–	–	–	–	–	1,402	184	–	–	–	1,586
Panke	2,621	–	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	2,833,384
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	36,602	24,978	–	–	9,710	282,011
Palataw	–	17,919	18,404	–	–	14,691	43,060	–	–	–	–	–	94,064
Pangasag	13,168	6,026	8,168	964	626	196	–	–	2,089	–	–	–	31,238
Palubog	–	–	–	–	–	–	–	–	1,726	–	–	–	1,726
Pamating	937	324	–	666	–	–	–	–	–	–	–	3,419	5,346
Liftnet	–	–	–	–	–	9,767	14,976	31,944	–	–	–	–	56,727
Filter net	4,269	–	–	–	–	14,681	11,868	–	–	–	13,326	289	44,423
Fish corral	–	38,031	29,622	46,269	31,148	21,037	27,197	26,966	3,838	–	–	–	221,998
Mini trawl	–	–	–	–	42,007	99,808	47,693	38,217	12,266	28,206	18,036	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	233,206	4,080,611
Other gears	21,487	30,139	24,261	17,053	18,721	34,518	38,937	38,668	39,846	21,350	21,768	18,593	326,340
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	4,406,951
% 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 interrelationships 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.

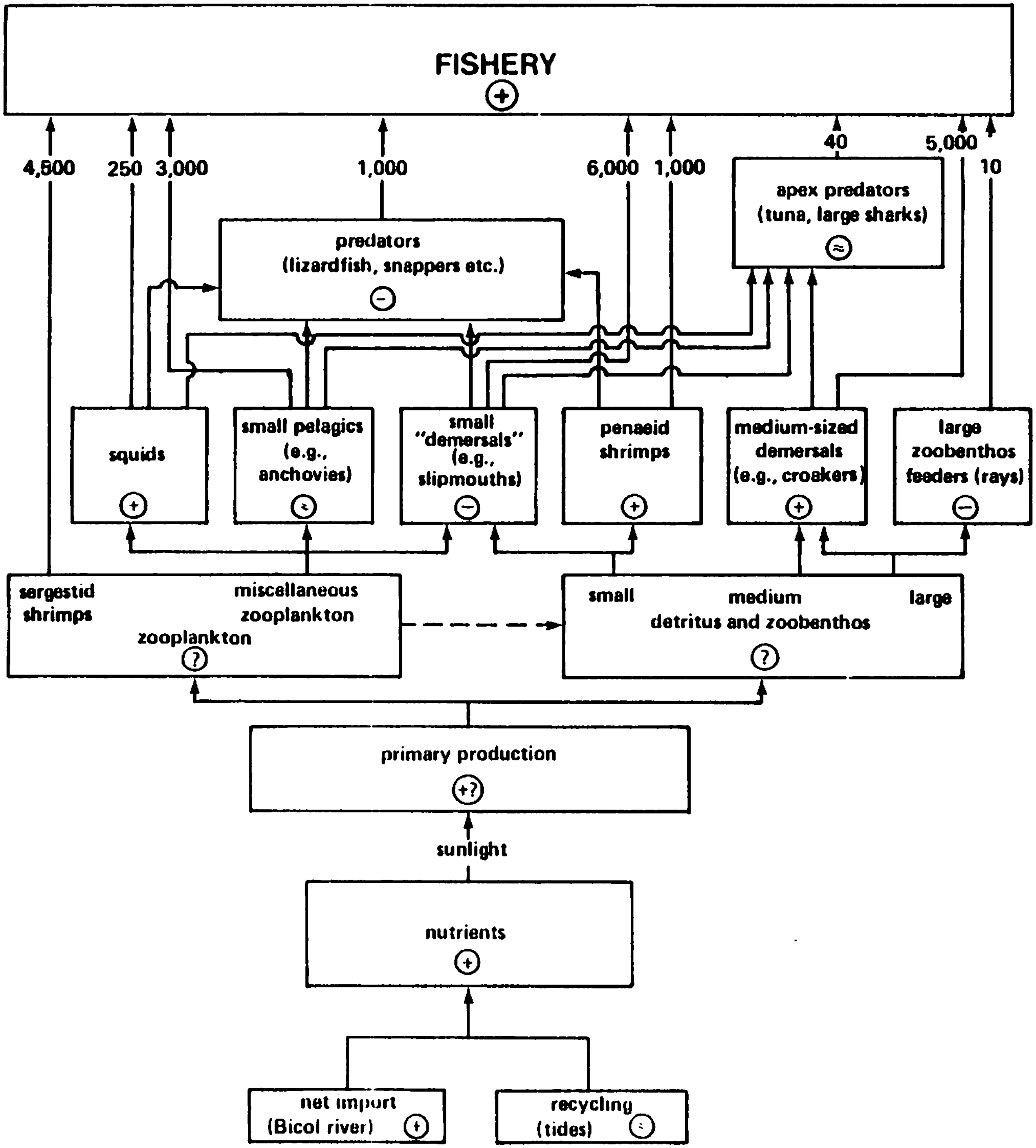

Fig. 9. Trophic interrelationships in San Miguel Bay in relation to the fishery. Numbers under fishery "box" are present catches in tonnes per year. The signs (+, −, ≈ or ?) are used to illustrate increases (+), decreases (−), relative constancy (≈) and no inference possible (?) all with regard to situation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