6.8 Seasonal Abundance, Morphometrics and Hook Selectivity of Yellowfin *(Thunnus albacares)* off Darigayos Cove, La Union, Philippines*

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Abstract

Daily samples of yellowfin tuna were collected from a handline fishery at Darigayos Cove, northern Philippines, between May and November, 1981. Measurements of body length, weight, head length and eye diameter were used to determine different morphometric relationships. A modified Baranov/Holt selection model was used to determine the effects of hook selectivity. The estimated optimum capture length (L_{opt}) increased with hook size, as did the selection range. Overall, selection was found to be highly asymmetrical, with yellowfin n cm below L_{opt} having, for any hook size, a much lower probability of capture than large yellowfin n cm above L_{opt}.

Introduction

Recent landings (1980-1985) of yellowfin tuna *(Thunnus albacares)* in the Philippines have ranged between 48,000 and 64,000 tonnes, accounting for 4.5% of total marine landings (Table 1). Small fish are consumed fresh or canned, whilst fish larger than 1 m are greatly esteemed for sashimi or raw fish. These large tunas are particularly abundant in the northern waters of the Celebes Sea and a large handline fishery was established along the southeastern coast of Mindanao (Ganaden and Ali 1983).

In this paper, we present some observations on the seasonality, morphometrics and hook selectivity of yellowfin tuna caught around payaos by a seasonal handline fishery of the northeastern coast of Luzon. A recent analysis by Ralston (1982) of a handline fishery in Hawaii for percoid fishes, suggests that selectivity is strongest against smaller fish. We present data which suggests that this may also be the case for yellowfin tuna caught by handline.

Table 1. Annual landings of yellowfin tuna in the Philippines and contribution to the total marine landings.

Year	Yellowfin landings	Percent of total marine landings
1980	48023	4.23
1981	56176	4.66
1982	51922	4.21
1983	62036	4.81
1984	58924	4.52
1985	64293	4.49

Materials and Methods

A detailed description of the Darigayos Cove (Fig. 1) handline fishery and the methods of data collection is given in Cortez-Zaragoza (1983). All handline fishermen

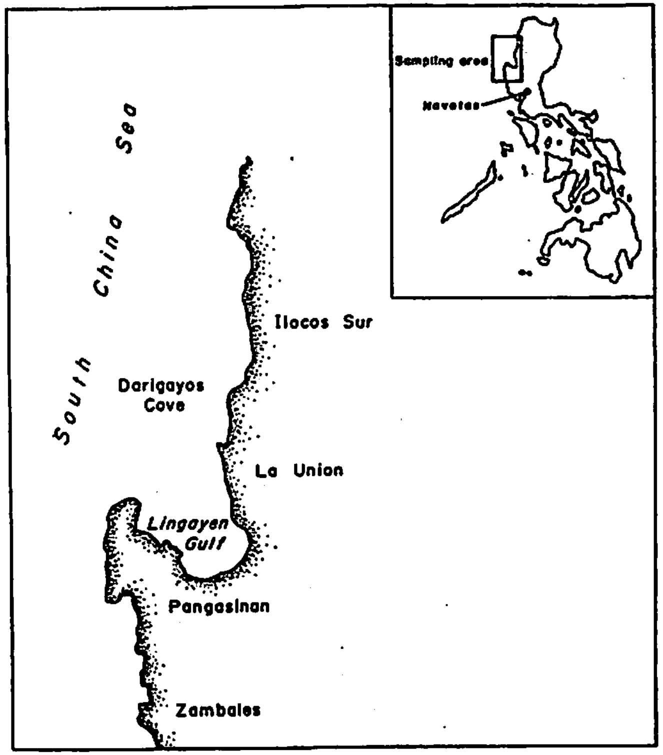

Fig. 1. Map of sampling area.

operate from small boats or bancas with an average length of 10 m, an average gross tonnage (GT) of 0.3 which are powered by 16 hp Briggs and Stratton gasoline engines. Observations on catch, fishing effort, fork length and weight of catch were made between May and November 1981. Fishing effort was expressed as the number of line days per month or the product of number of days at sea and the number of handlines per vessel. The hook sizes used in the fishery were 1.2, 1.3, 1.4, 1.5, 1.6, 2.4, 2.7 and 2.9 cm. Hook size refers specifically to the gap between hook point and shank (Fig. 2).

The length distribution of each yellowfin catch was recorded by hook size and standardized per unit of effort. The whole weight of individual fish in the catch was recorded where possible. Yellowfin larger than 90 cm were landed already gilled and gutted. A comparison of the weights of gutted and ungutted fish less than 90 cm was used to compute ungutted weights for larger yellowfins. In addition to fork length, measurements of head length and eye diameter were made on 30 specimens of yellowfin tuna.

Gulland (1983) suggested that the selection effects of different hook size in fish catches can be compared by a modification of the Baranov/Holt model for gill net

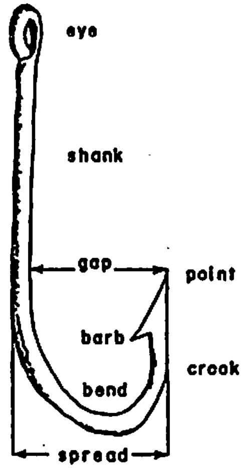

Fig. 2. Parts of a hook; "size" as defined here is the gap.

selection (Baranov 1914; Holt 1963), whose properties and fitting are explained in detail in Pauly (1984). Selection curves of handline catches were estimated by comparing the length-frequency distributions of yellowfin caught by two adjacent hook sizes after standardization for fishing effort.

Given the smaller hook size A and the larger hook size B, it is possible to convert the catch data into a linear equation of the form (y = a + bx), where:

$$Y = \log_e \frac{C_B}{C_A} \qquad \text{... 1)}$$

where C_A is catch by length class for hook size A and C_B is the corresponding for hook size B, and where

$$X = L_i \text{ (class midlength)} \qquad \text{... 2)}$$

The intercept (a) and slope (b) of this regression are used to estimate optimum length for hook size A from:

$$L_A = \frac{-2a\ A}{b\,(A+B)} \qquad \text{... 3)}$$

and

$$L_B = \frac{-2a\ B}{b\,(A+B)} \qquad \text{... 3b)}$$

The standard deviation of either selection curve ($S_A = S_B = S$) is given by:

$$SD = \sqrt{\frac{2a\,(A - B)}{b^2\,(A + B)}} \qquad \text{... 4)}$$

When L_A, L_B and S have been estimated the probability of capture (P) at a given length (L_i) is given for a hook size A by:

$$P_A = \exp\left(-\frac{(L_i - L_A)^2}{2S^2}\right) \qquad \text{... 5)}$$

and for hook size B by:

$$P_B = \exp\left(-\frac{(L_i - L_B)^2}{2S^2}\right) \qquad \text{... 6)}$$

In its original form, this selection model yields symmetrical curves about the optimum capture length. However, asymmetrical curves, where selection is less intense at larger sizes can be fitted by replacing length by $\log_e$ (length) in the above equations.

Results

Seasonal Abundance

The monthly catch and effort data for handline caught yellowfin at Darigayos Cove between May to November are summarized in Table 2. Over this period, twenty tonnes of yellowfin were caught that comprised 55.3.% of the total catch of this fishery.

Table 2. Fishing Effort, Catch and Catch Rate of Hook and Line
Line Fishermen at Darigayos Cove, La Union, May-November, 1981.

Months	May	June	July	August	September	October	November
No. of line-days	704	508	128	336	508	584	336
Catch, total (kg)	20745	3499	52	491	3431	6070	1928
Yellowfin	11548	1094	-	95	2627	3615	1052
Total catch/line-day	29.47	6.89	0.41	1.46	6.75	10.39	5.74
Yellowfin catch/ line-day	16.4	2.15	-	0.28	5.17	6.2	3.13

Although the data for Darigayos Cove are rather sparse, the seasonal pattern of yellowfin catches appears to be similar to that of the Philippines as a whole. The monthly landings of various fish species at Navotas Fish Port Complex (NFPC) in Manila are kept on file by the Philippine Fisheries Development Authority. The monthly landings of yellowfin at the NFPC between 1980 and 1986 were kindly made available to the authors. From these, the mean monthly catches of this species were estimated for 1980-1986. Landings of yellowfin at the NFPC account for about 10% of the total catch and come from all over the Philippines. Both the NFPC yellowfin landings data and the landings data for Darigayos Cove show very similar trends between May to November (Fig. 3).

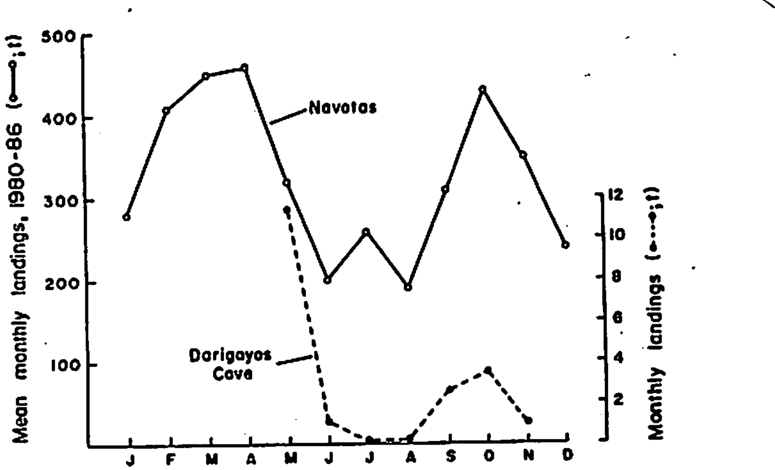

Fig. 3. Mean monthly landings of yellowfin tuna at Navotas, Manila, 1980-1986 (o) and monthly landings of yellowfin tuna at Darigayos Cove, May to November 1981, Philippines.

Morphometric Relationships

Length-weight and other morphometric relationships for yellowfin tuna are shown in Fig. 3. The ratio between gutted and ungutted weight was established as 0.82:1.

Hook Selectivity

Plots of the logarithms of catch ratios versus the logarithms of the corresponding midlengths for the different hook size combination are shown in Fig. 4, based on the data in Table 1. Apart from one instance the data were well described by linear functions. The exception was the comparison of 1.4 and 1.5 cm hooks, which could not be performed. The optimum capture lengths estimated from each pair of hook sizes are given in Table 4.

A non-linear relationship was fitted to the scatter of optimum lengths versus hook size. A straight line was forced through the mean and the origin for the scatter of the selection range (defined here as one standard deviation on either side of the optimum length) versus optimum length.

Table 3. Catch by Length of Different Hook Sizes to Estimate their Selectivity for Thunnus albacares, off Darigayos Cove, La Union

Midlength of size group in cm	Hook size							
	1.2	1.3	1.4	1.5	1.6	2.4	2.7	2.9
22	124	10	-	-	-	-	-	-
26	145	17	-	-	-	-	-	-
30	170	82	8	96	7	-	-	-
34	60	91	20	160	29	-	-	-
38	50	143	67	125	88	-	-	-
42	15	60	91	190	455	-	-	-
46	1	8	24	45	160	-	-	-
50	1	6	23	3	25	-	-	-
54	-	1	8	5	25	-	-	-
58	-	1	5	4	15	-	-	-
62	-	-	1	-	1	-	-	-
126	-	-	-	-	-	26	3	-
130	-	-	-	-	-	53	11	-
134	-	-	-	-	-	31	18	2
138	-	-	-	-	-	5	8	3
142	-	-	-	-	-	3	7	4
146	-	-	-	-	-	2	10	15
150	-	-	-	-	-	1	7	25
154	-	-	-	-	-	-	4	17
158	-	-	-	-	-	-	1	6
162	-	-	-	-	-	-	1	4
166	-	-	-	-	-	-	-	-

Discussion

The results presented here document the selective effects of different hook sizes on yellowfin tuna. Similar observations of hook selectivity on skipjack were made by Tandog et al. (1987). Larger hooks catch larger fish but the standard deviations of the selection curves increase as the hook size increases, suggesting that bigger hooks capture a wider range of lengths. Ralston (1982) suggested that hook selection conformed to a flat-topped sigmoidal curve similar to that observed for trawls (Fig. 7A). In Ralston's analysis, the largest hook used was 71% greater than the smallest whilst in this study, the difference was 240%. Koiki et al. (1968) and Kanda et al. (1978) used series of hooks in which the largest sizes were 215% and 115%, respectively, larger than the smallest of sizes. Both studies reported shifts in the size composition of the catch. Saetersdal(1963) reported a change in the selective characteristics of fishing hooks which differed in size by 76%.

Table 4. Hook size and predicted optimum length of yellowfin tuna.

Hook size (cm)	Optimum capture length (cm)[a]
1.2	29.4
1.3	37.6
1.4	47.6
1.5	36.5
1.6	46.4
2.4	102.6
2.7	152.7
2.9	173.8

[a] Where there was more than one optimum length for a hook size, means are given.

The schematic forms of different proposed selection curves are shown in Fig. 7. Curves A and B correspond to the Baranov/Holt model and the flat-topped sigmoidal curve, respectively. The latter may include, as suggested by S. Ralston (pers. comm.), a descending limb, albeit at very large sizes (dotted in Fig. 7B). Curve C is a suggested possible compromise between the two models; it has a slowly declining right hand limb beyond the optimum capture length.

An appreciation of hook selectivity (or lack of it) is important for two reasons. First, where length data are used for stock assessment purposes in a fishery employing a wide range of hook sizes, adjustments to the data based on probabilities of capture may be necessary. Simply pooling all data in the hope that selectivity effects may be negligible or will cancel, out may introduce biases into estimates of growth and mortality parameters. Secondly, hook size may be used to regulate minimum capture sizes from a fishery, in the same way that minimum mesh sizes are employed in net fisheries. We suggest that further investigation of this type should be undertaken, especially on the large handline fisheries for tunas around the southern coast of Mindanao.

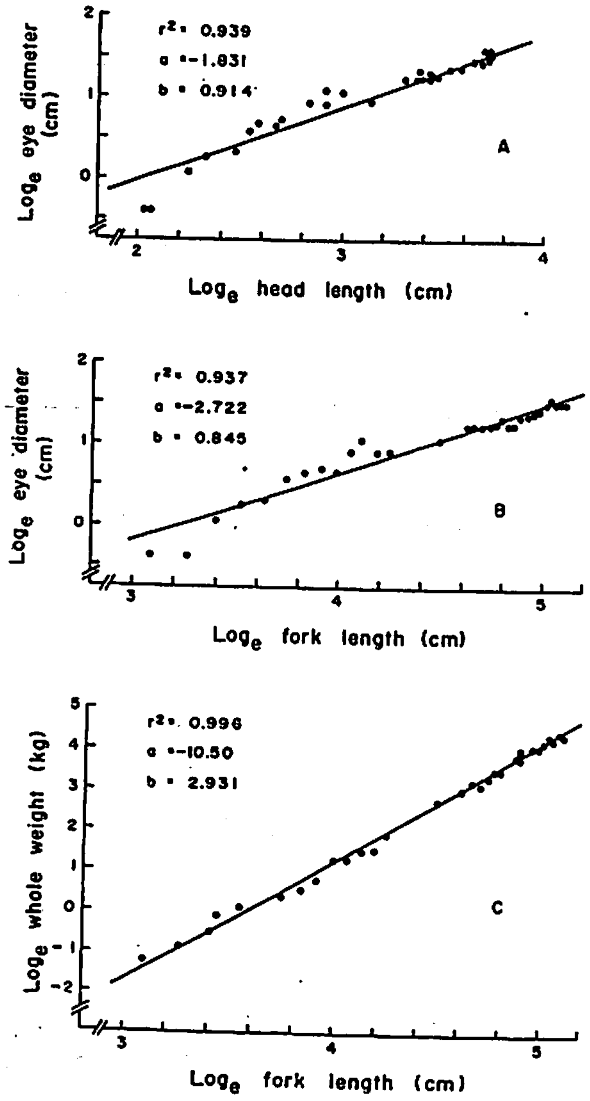

Fig. 4. Morphometric relationships for yellowfin tuna.

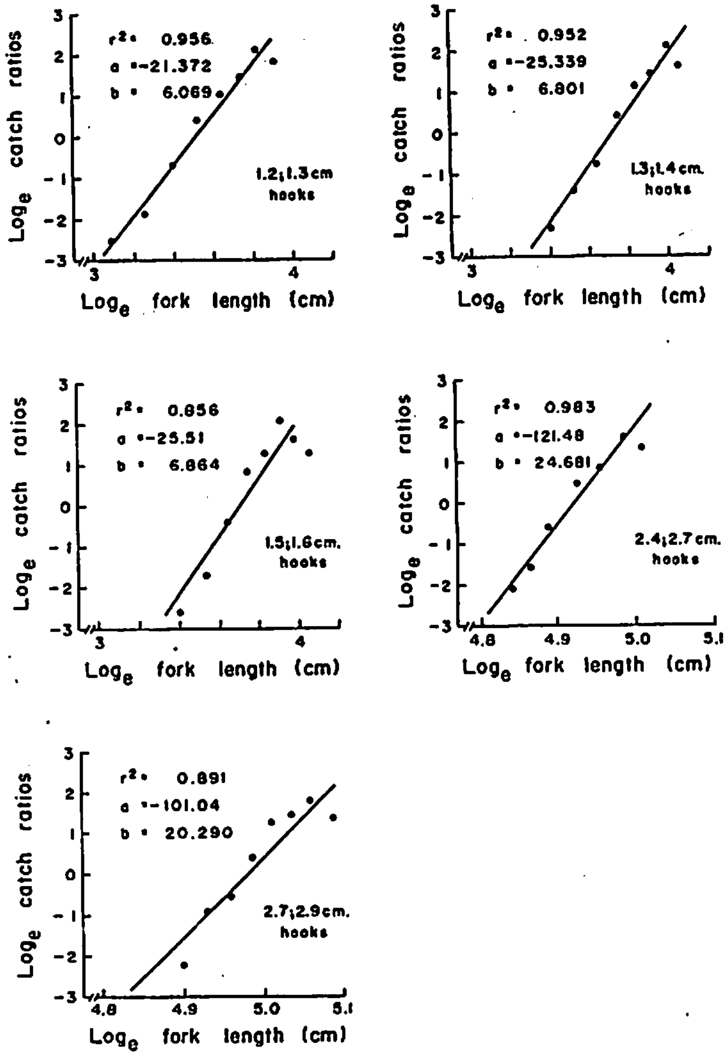

Fig. 5. Log$_e$ catch ratio vs. log$_e$ fork length for catches of yellowfin tuna for different hook size combinations.

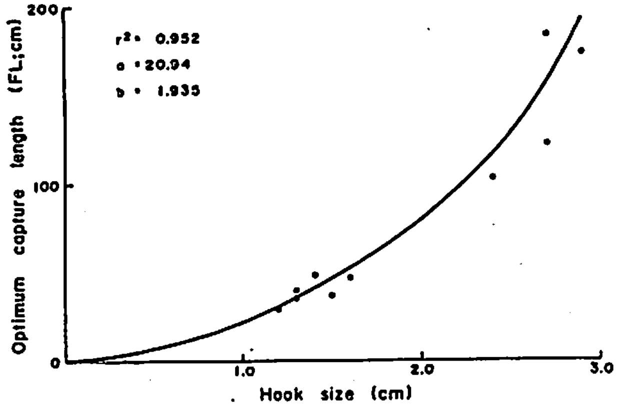

Fig. 6. Optimum capture length vs. hook size for yellowfin tuna.

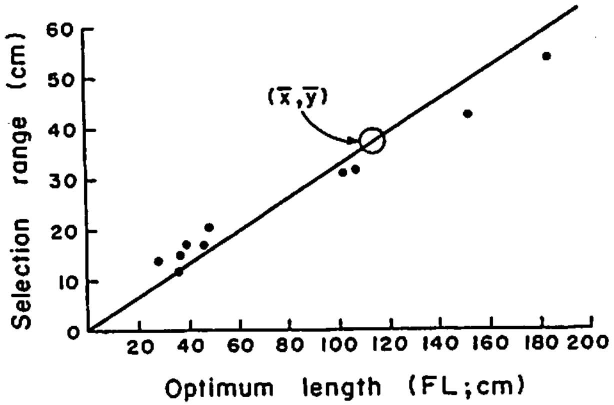

Fig. 7. Selection range vs. optimum length for yellowfin tuna.

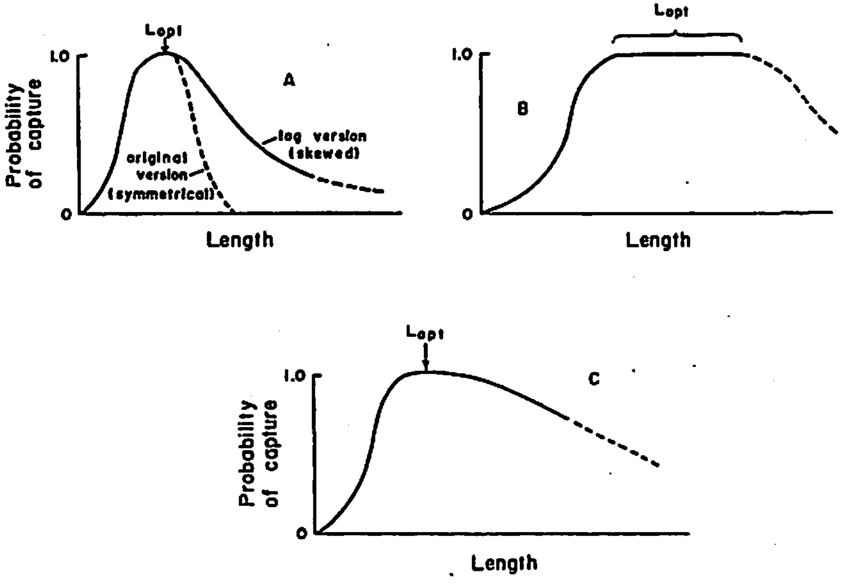

Fig. 8. Different types of possible selection curves for fish hooks. Type A is the Baranov/Holt model, Type B was proposed by Ralston (1982) and Type C is a suggested compromise between A and B (see text).

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6.9

An analysis of stomach contents of yellowfin tuna captured by handlines under payaos in the north Celebes Sea

by Noel C. Barut

ABSTRACT

Stomach of 620 yellowfin were collected from November 1983 to October 1984 and examined for prey composition and volume. The average weight of the 403 males and 217 females was 52 and 40 kg, respectively. Twenty-four families, 20 genera and 11 species of prey organisms were identified. Total stomach contents (chum + prey organisms) averaged 8.1 g/kg for males and 10.0 g/kg for females, which was not statistically significant. The most important item, in terms of weight, in the stomachs was chum followed by digested food. The Index of Relative Importance (IRI) showed the principal prey organisms were skipjack (504), yellowfin (434), Loliginidae (256), Balistidae (129) and <u>Pseudobalistes</u> <u>fuscus</u> (34).

THE AUXIS SPP. FISHERIES OF BATANGAS, PHILIPPINES

by

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ABSTRACT

The paper presents the result of monitored landings of small tunas caught by bagnets and ringnets of Batangas from April 1983 to December 1984.

The species composition, relative abundance and seasonality of the small tunas, locally called "tulingan" and some biological features of the dominant species, Auxis rochei, is presented.

I. Introduction

The frigate tuna forms about 30% of the total landed catch of tuna from 1982 to 1984 (BFAR Statistics) which show that this group is one of the important marine resources of the country. In the province of Batangas alone, this resources locally termed "tulingan" is considered important and served as the mainstay of most fishermen especially during the season. It is not a delicacy but is a common fish on the tables of both rich and poor Batangueños.

Inspite of its importance, very little attention has been given to this group as compared to the larger and more expensive ones - the yellowfin the big-eye and the skipjack. For years, studies have been concentrated on these larger groups.

In the Philippines, studies conducted on these species were on the taxonomic differentiation of the adult and juvenile forms of the genus Auxis (Wade, 1984), on the description, distribution and abundance of larval forms and their spawning areas (Wade, 1951) and on the distribution and relative abundance of larval Auxis in Sulu Sea (Baguilat, 1987). Except for the recorded catches of frigate tuna reported yearly in the Fisheries Statistics of the Philippines, no other study on his fishery including their biological characteristics, has been made.

The landings of bagnets were monitored at Wawa Fish Landings, Batangas City during the dark phase of the moon from April 1983 to October 1984 and those of ringnets at Sambal, Lemery from April 1983 to December 1984. The sampling methods adopted are those of the Tuna Research Project with modification on the sampling frequency.

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[1] Paper presented to the 2nd IPTP Tuna Research Groups Meeting held at the U.P. PCED Hostel, Quezon City, Philippines from August 25-28, 1987.

Fishing Gear

It is reported that there are various gears catching the frigate tuna in Batangas but the most commonly used are the bagnet, locally known as "basnig" and the ringnet or "pukat".

The bagnet is of the lift net type which uses out riggered banca and lights to attract or concentrated fish. The tonnage of the vessels ranged from 7 to 30 G.T. The ringnet uses bancas with or without riggers and catches fish by surrounding them. It either operates in conjunction with "bobo" (fish aggregating device made of bamboo and coconut fronds) or catches the free schooling fish. The method of fishing operation of both gear is described by de Jesus, 1982.

Fishing Grounds

The traditional fishing grounds of bagnets are the waters of Batangas Bay, between Mindoro and Batangas, around Maricaban Island, off Lobo, up to the Anilao side of Balayan Bay. The ringnets based in sambal fish regularly in Balayan Bay off Lemery and sometimes off Anilao (Figure 1).

Species Composition, Relative Abundance and Seasonality

The "tulingan" catch being landed in Batangas is usually composed of three species, namely: the bullet tuna (*Auxis rochei*), the frigate tuna (*A. thazard*) and the eastern little tuna (*Euthynnus affinis*). The bullet tuna is the dominant species landed followed by the frigate tuna. The eastern little tuna is seldom landed,particularly if the catch is less than a bañera, as they are the ones given away to labor and crew as wage in kind.

The bagnet catch is predominantly *Auxis rochei* throughout the year with big landings from April to September and peak in August of 1983 and in May and June of 1984. *A. thazard* were landed in several months of the year with peak landings in September 1983 and March 1984. *Euthynnus affinis* were landed in large quantities in June 1983 but were not found in 1984.

Small *Auxis* spp. below 15 cm. FL were landed from August, 1983 and from July to October of 1984. This probably indicate that they have been spawned in March to June.

The ringnet catch is a mixture of both species throughout the year. The peak season for *A. rochei* in February and May. *A. thazard* were landed in July and August when most of the fishing activity were done in conjunction with "bobo" or "payao". *E. affinis*. as well as the small *T. albacares* and *K. pelamis* were landed occasionally.

Size Composition

The sizes of *A. rochei* caught by both gear do not differ considerably. There is also not much variation in the monthly size composition except for the appearance of the smallest-sized group with a fork length of 9.5 cm in the ringnet catch in December 1984 and 10.0 cm. FL in the bagnet catch in September 1984. However, since the external characteristics differentiating *A. rochei* from *A. thazard* is not yet prominent, these size groups could be a mixture of bobh species. At sizes below 15 cm, the only means by which the two species can be separated is through the gill raker counts; 39-43 in *A. thazard* (Wade, 1950) and 44 to 48 in *A. rochei* (Wade, 1949).

Gonadal Condition, Spawning Season and Size at Sexual Maturity

In Batangas Bay and approaches juvenile of *A. rochei* were recorded from March to May and from July to September with peaks in October of 1983 and September to October in 1984. Maturing ovaries were found in fish measuring 20 cm. FL in March, June, July, November and December which indicate that the spawning period could be protracted.

In Balayan Bay, juvenile fish appeared in May and mature ones were observed in March, July, September and December.

The size at first maturity was estimated at about 18.8 cm FL (Fig. 1).

Length-Weight Relationship

The length-weight conversion values for *A. rochei* caught by both gear were computed to be:

For the bagnet catch:

♂ = $W = 0.004527\ L^{3.36}$

♀ = $W = 0.005337\ L^{3.303}$

Both sexes = $W = 0.004375\ L^{3.367}$

For the ringnet catch:

♂ = $W = 0.002033\ L^{3.616}$

♀ = $W = 0.001486\ L$

Both sexes = $W = 0.0016625\ L^{3.676}$

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OCCURENCE AND DESCRIPTION OF TUNA AND TUNA-LIKE LARVAE IN THE SULU SEA

By

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ABSTRACT

A total of 248 tuna larvae was sorted from the ichthyoplankton samples collected on board the RV SARDINELLA in the Sulu Sea during the October-November, 1982 and February-March, 1983 cruises.

Six genera and 6 species were identified. These are: *Thunnus albacares* (yellowfin), *Katsuwonus pelamis* (skipjack), *Gymnosarda unicolor* (dogtooth tuna) *Acanthocybium solandri* (wahoo) *Auxis thazard* (*frigate tuna*) one unidentified species of the genus *Buthynnus* and four unidentified species of the genus *Auxis*.

During the October-November, 1982 cruise, *T. albacares* and *K. pelamis* were the most abundant with *T. albacares* larvae more widely distributed. *Auxis* species predominated during the February-March, 1983 cruise. In general, tuna larvae were found to be abundant during the February-March, 1983 cruise and more concentrated in southern Sulu Sea. The abundance of tuna larvae during the said period coincided with the prominent peak of spawning as reported in the literature.

Small Tuna Fisheries in the Philippines

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August 1987

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Small Tuna Fisheries in the Philippines

1. Introduction

Marine fish production in the Philippines totalled 1,867,701 mt in 1985, a slight decrease from the previous 2 years. Tuna production, on the other hand, increased 15% over 1984 and 8% over 1983 to 261,607 mt. Small tunas, specificially frigate/bullet and kawakawa, accounted for 52% of this total.

Recent studies on tuna in the Philippines have concentrated on the larger species, skipjack and yellowfin tuna (White, 1982; Yesaki, 1983; Ganaden and Stequert, 1987). These species are targeted for export, either canned or fresh, to generate foreign exchange. Small tunas are fished for the food economy of the country and are important in providing cheap protein to the populus.

The present paper investigates the fisheries for small tunas in the Philippines. Small tuna landings are described by fishing area, fisheries sector and fishing gear. Landings are correlated to wind stress patterns and yields per unit area derived for selected areas. Potential for future increases of frigate/bullet tunas and kawakawa are discussed.

2. Tuna landings

The present fishery statistics collection scheme was implemented in 1976. This scheme categorizes scombrid landings into Indo-Pacific and Indian mackerels, spanish mackerel, mackerel, frigate, eastern little, yellowfin and skipjack tunas. The following species are included in the 4 tuna categories:

frigate - frigate tuna (*Auxis thazard*)
- bullet tuna (*Auxis rochei*)
eastern little - kawakawa (*Euthynnus affinis*)
yellowfin - yellowfin tuna (*Thunnus albacares*)
- bigeye tuna (*Thunnus obesus*)
- longtail tuna (*Thunnus tonggol*)
skipjack - skipjack tuna (*Katsuwonus pelamis*)

Tuna landings in the Philippines have increased 2.1 times in the 10 year period since 1976 (Fig. 1). Of the 4 tuna categories, frigate landings increased the most (3.4 times) and yellowfin landings the least (1.5 times). Frigate landings prior to 1980 were over-estimated with the inclusion of juvenile skipjack and yellowfin. White and Yesaki (1982) calculated the frigate figure for 1980 was over-estimated by at least 8,000 t. However, the frigate landing was high during this year and was surpassed only in 1985. Kawakawa landings peaked in 1977, decreased to a low level in 1979, then steadily increased to 1982. Landings have since stabilized at about the 40,000 t level.

3. Tuna landings by fishing areas

Distribution of frigate and kawakawa landings by statistical fishing areas are shown in Figures 2 and 3, respectively. Highest landings of frigate are made in the large, deep, exposed seas (Moro Gulf, Sulu Sea, Bohol Sea). Kawakawa landings, on the other hand, are highest in the small, shallow archipelagic seas (Ragay Gulf, Cuyo Pass, Guimaras Strait).

Statistical fishing areas were grouped either as shallow-water or deep-water, depending on whether the extent of the continental shelf was more than or less than half the entire area, respectively. The neritic zone accounts for 61% of the total area of the 6 shallow-water fishing areas (Table 1) and only 18% of the total area of the 7 deep-water fishing areas (Table 2). The shallow-water fishing areas encompasses 18% of the total area of the 13 fishing areas.

Kawakawa is a neritic species usually associated with the continental shelf. Sixty-three percent of total kawakawa landings are taken from the shallow-water fishing areas, versus 32% from the deep-water fishing areas. Frigate, yellowfin, skipjack and to a lesser extent, frigate are oceanic species. Approximately 73% of total landings of these categories are made in the deep-water fishing areas.

A very high percentage of the Philippine tuna production is captured in association with payaos or FADs (fish aggregating devices). Payaos are deployed almost exclusively in the shallow and deep-water fishing areas. These areas are all relatively small bodies of water bounded by numerous islands. Winds in these areas rarely exceed Beaufort force 3, whereas winds frequently exceeds force 4 in the Pacific Ocean and South China Sea fishing areas (Fig. 4). Wave action would be minimal in the shallow and deep-water fishing areas because of low wind stress and protection from the numerous islands. This is a principal reason for the success of payaos in the Philippines. The shallow and deep-water fishing areas account for 89% of the Philippine tuna production.

3.1 Yield per unit area

Tuna yields averaged 0.58 mt/km^2 for the shallow and 0.33 mt/km^2 for the deep-water fishing areas. Yields of kawakawa decreased almost 10-fold from the shallow (0.28 mt/km^2) to the deep-water 0.03 mt/km^2) fishing areas, whereas yields of frigate, yellowfin and skipjack were identical for these fishing areas. Kawakawa accounted for 48% and frigate for 43% of the total yields for the shallow and deep-water fishing areas, respectively.

4. Small tuna landings by fishing gear

Philippine statistics discriminate landings by commercial and municipal fisheries. Vessels larger than 3 gross tonnes are considered in the former and smaller vessels in the latter.

4.1 Commercial fisheries

The commercial fishery accounts for 59% of the frigate (Table 3) and 45% of the kawakawa landings (Table 4). Essentially the entire commercial landings of frigate and kawakawa are made by ringnet/purse-seine and bagnet. Kawakawa is more susceptible to capture with bagnet than frigate. Percent landings by fishing gear of frigate and kawakawa differed markedly, between shallow and deep-water fishing areas (Fig. 5). Ringnet/purse-seine and bagnet each accounted for approximately half the landings of frigate and kawakawa in the shallow-water fishing areas. In contrast, ringnet/purse-seine accounted for almost the entire landings of these 2 species in the deep-water fishing areas. Vessels lie at anchor when fishing bagnets thereby restricting use of this fishing gear to grounds with relatively shallow depths and weak currents (de Jesus, 1982).

4.2 Municipal fisheries

A greater variety of fishing gears are employed by the municipal sector to capture frigate and kawakawa (Table 3 and 4). The most important fishing gear for both species is the hook and line. The second most important gear for frigate is the gillnet, followed by ringnet/purse-seine. Ringnet/purse-seine, bagnet and gillnet are equally important fishing gears for kawakawa after hook and line.

The highest percentage of frigate landings by the municipal sector is taken by gillnets in the shallow-water areas and by hook and line in the deep-water areas. Hook and line accounts for the highest proportion of kawakawa landings in both the shallow and deep-water fishing areas (Fig. 5).

5. Methods of capture

Ringnets and purse-seines are usually fished in conjunction with payaos. Table 5 shows percent of frigate and kawakawa captured under payaos and as free-schools by these gears at 6 landing sites. Free schools of pelagic fish are fished by ringnetters at only 3 of the landing sites. Purse-seiners operated out of 3 of these sites and fished exclusively on fish aggregated under payaos. An estimated 80% of the frigate and kawakawa are captured by ringnetters/purse-seiners after aggregating under payaos (Table 6).

5.1 Species composition

The composition of tuna catches by ringnets under payaos is given in Figure 6 and as free-schools in Figure 8. Kawakawa accounts for a significant proportion of the tuna landings at Labuan, where ringnet fishing is targeted on free-schools. This species is an insignificant component of ringnet catches under payaos by purse-seiners at Labuan (Fig. 7). These low catches could result from either non-attraction to payaos or deployment of payaos in offshore areas outside the normal range of the species.

The proportion of frigate was slightly higher in ringnet catches made on free-schools than those made under payaos. Frigate is the smallest of the tunas and may not be able to swim out of an encircling gear as readily as the larger tuna species. Yellowfin constituted a significant portion of the ringnet catches under payaos at Opol, but was negligible in catches made as free-schools. This species was also insignificant in the ringnet catches on free-schools in Labuan (Fig. 8).

Frigate and bullet were lumped in the frigate category during the initial years of the biological sampling programme. These species were identified and recorded separately from 1982. The relative abundance of these species appears to fluctuate annually with strong year class for bullet in 1983 and for frigate in 1984 (Fig. 9).

The proportion of oceanic species is higher in catches made under payaos by purse-seines (Fig. 7) than by ringnets (Fig. 6). This higher proportion results primarily from higher catches of yellowfin. Skipjack and yellowfin are distributed lower in the water column and consequently more vulnerable to capture with the deeper sinking purse-seines.

5.2 Size composition

Size composition of all tuna species captured under payaos by ringnets and purse-seiners were very similar, except for yellowfin tuna (Fig. 10). Small numbers of larger yellowfin (40-70 cm) were captured by purse-seines, but not by ringnets. This catch of larger fish results from purse-seines fishing deeper than ringnets.

Maximum size of frigate, kawakawa, skipjack and yellowfin is approximately 55, 100, 105 and 200 cm, respectively. However, almost the entire catch of all species captured under payaos was less than 30 cm (Fig. 30). In contrast, significant proportions of the catches of frigate, kawakawa and skipjack captured as free-schools by ringnet were larger than 30 cm. These pronounced differences in size composition indicate tuna species less than 30 cm have a greater affinity for fish aggregating devices than fish larger than this size.

6. Discussion

There does not appear to be further scope for expansion of areas for deploying payaos in the EEZ of the Philippines. An estimated 5,000 payaos are currently deployed in the Philippines, principally in the shallow and deep-water fishing areas (Ganaden and Stequert, 1987). Payaos are also deployed off the west coast of Luzon Island during the northeast monsoon, when seas are relatively calm. The next phase in the development of Philippine tuna fisheries will have to be expansion into the Western Pacific Ocean and fishing on either free-swimming schools or schools aggregated by drifting FADs.

Landings of kawakawa peaked at 49,000 mt in 1982 and have since decreased to about 41,000 mt. The reported landing of 55,000 mt in 1977 is discounted because figures for the initial 2 years of the present statistical collection system are suspect. Kawakawa in the shallow and deep-water fishing areas is probably being fully exploited at present. Therefore, further increases in kawakawa landings are probably possible only with expansion of fishing effort into the Pacific Ocean and South China Sea fishing areas with extensive continental shelves. These include the West Palawan, Leyte Gulf and Lamon Bay fishing areas (Munro, 1986).

The shallow-water fishing areas are relatively small bodies of water so that the oceanic zones are restricted and in close proximity to land. It is not unreasonable in the context of large pelagic species, therefore, to consider the entire extent of these fishing areas as continental shelf.

Yields per unit area of continental shelf have been used to define densities of demersal species. This method has generally not been applied for pelagic species because of their greater mobility, low affinity to the substrate and their three-dimensional life-styles. Nevertheless, the habits of kawakawa permit the use of this method for deriving first estimates of density. This species spends its entire life cycle within the neritic regime (Yoshida, 1979).

Yield of kawakawa per square kilometer of shallow-water fishing area averaged 0.28 mt. This is probably about the maximum potential yield per square kilometer of continental shelf of a neritic tuna species.

Kawakawa are restricted to the neritic regime of continents and islands, whereas *Auxis* species are more widely distributed in the neritic regime and contiguous zone. Nishikawa, et al (1985) found kawakawa larvae near land masses and *Auxis* larvae from near land to the open ocean. However, *Auxis* larvae were associated more with land masses in the Western Pacific, but were distributed throughout the oceanic regime in the Eastern Pacific.

Landings of *Auxis* species peaked at 95,000 mt in 1985. There is scope for further increase in landings as the distributional range of *Auxis* species is probably not yet fully exploited. Yields of *Auxis* species in the deep-water fishing areas averaged 0.14 mt/km^2. This compares with estimate of 0.12 mt/km^2 of *Auxis* species consumed by yellowfin each year in the Commission Yellowfin Regulatory Area (CYRA) of I-ATTC (Yesaki, 1983).

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Table 1. Area of shallow-water fishing grounds, tuna landings 1/ and yields per unit area

Fishing ground	Tayabas Bay	Cuyo Pass	Visayan Sea	Guimaras Strait	Ragay Gulf	Samar Sea	km^2	Total %
Area, neritic zone 2/	2,500	29,100	11,500	4,400	3,100	7,200	57,800	61
oceanic zone 2,3/	1,300	24,300	4,000	2,800	1,900	2,800	37,100	39
total	3,800	53,400	15,500	7,200	5,000	10,000	94,900	100
							mt	% of total
Species, frigate	3,094	2,614	4,251	522	1,011	1,434	12,956	16
yellowfin	246	3,814	1,660	2,006	154	849	8,729	15
kawakawa	328	7,149	3,561	6,366	8,784	343	26,531	63
skipjack	485	4,307	176	19	888	452	6,327	15
total	4,153	17,884	9,648	8,943	10,837	3,078	54,543	24
							mt/km^2	%
Yield/area, frigate	0.81	0.05	0.27	0.08	0.20	0.14	0.14	27
yellowfin	0.06	0.07	0.11	0.29	0.03	0.08	0.09	16
kawakawa	0.09	0.13	0.22	0.88	1.76	0.03	0.28	48
skipjack	0.13	0.08	0.01	0.00	0.18	0.05	0.07	12
total	1.09	0.33	0.61	1.25	2.17	0.30	0.58	100

1/ - 1984 landing statistics
2/ - Munro, 1986
3/ - Yesaki, 1983

Table 2. Area of deep-water fishing grounds, tuna landings 1/ and yields per unit area

Fishing grounds	Batangas coast	Sulu1/ Sea	Moro Gulf	Davao Gulf	Bohol Sea	Comotes Sea	Sibuyan Sea	Total km2	%
Area, neritic zone2/	300	50,400	12,400	3,100	500	5,300	7,000	79,000	18
oceanic zone2/,3/	3,000	188,900	101,600	3,900	28,500	7,600	23,500	357,000	82
total	3,300	239,300	114,000	7,000	29,000	12,900	30,500	436,000	100
								mt	% total
Species, frigate	4,989	12,926	22,960	2,212	11,643	3,454	2,057	60,241	75
yellowfin	688	13,842	21,742	2,840	1,604	159	430	41,305	70
kawakawa	6	6,386	4,505	-	1,820	16	799	13,532	32
skipjack	863	13,880	10,562	1,551	3,050	91	621	30,618	73
total	6,546	47,034	59,769	6,603	18,117	3,720	3,907	145,696	65
								mt/km2	%
Yield/area, frigate	1.51	0.05	0.20	0.32	0.40	0.27	0.07	0.14	43
yellowfin	0.21	0.06	0.19	0.41	0.06	0.01	0.01	0.09	27
kawakawa	0.00	0.03	0.04	-	0.06	0.00	0.03	0.03	9
skipjack	0.26	0.06	0.09	0.22	0.11	0.01	0.02	0.07	21
total	1.98	0.20	0.52	0.95	0.63	0.29	0.13	0.33	10

1/ - includes East, South and West Sulu Sea fishing grounds
2/ - Munro, 1986
3/ - Yesaki, 1983

Table 3. Landings of frigate by fisheries sector and fishing gears

Fishing gear	Commercial		Municipal		Total	
	mt	%	mt	%	mt	%
Ringnet/purse-seine	41,067	87	4,839	15	45,906	57
Bagnet	5,781	12	2,281	7	8,062	10
Gillnet	-	-	9,521	29	9,521	12
Hook and line	117	0	11,919	36	12,036	15
Longline	357	1	1,358	4	1,715	2
Troll line	-	-	1,987	6	1,987	3
Beach seine	14	0	562	2	576	1
Trawl	15	0	25	0	40	0
Others	9	0	182	1	191	0
	47,360	100	32,674	100	80,034	100

Table 4. Landings of kawakawa by fisheries sector and fishing gear

Fishing gear	Commercial		Municipal		Total	
	mt	%	mt	%	mt	%
Ringnet/purse-seine	12,549	67	3,758	16	16,307	39
Bagnet	6,240	33	3,761	16	10,001	24
Gillnet	-	-	3,267	14	3,267	8
Hook and line	.11	0	11,122	48	11,133	27
Longline	4	0	165	1	169	0
Troll line	-	-	10	-	10	0
Pole and line	-	-	195	1	195	0
Trawl	28	0	698	3	726	2
Others	-	-	167	1	167	0
	18,832	100	23,143	100	41,975	100

Table 5. Percent frigate and kawakawa captured under payaos and as free-schools at 6 landing sites on Mindanao Island.

Landing site	Fish. gear	Year	Frigate		Kawakawa	
			payao	free-school	payao	free-school
General Santos	ringnet	1980-84	100	0	100	0
	purse-seine	1980-84	100	0	100	0
Opol	ringnet	1980-84 1/	48(?)	52(?)	100	0
Labuan	ringnet	1980-1985	0	100	0	100
	purse-seine	1980,1982-83	100	0	0	-
Santa Cruz	ringnet	1980-83	100	0	100	0
Recordo	ringnet	1980-83	86	14	-	0
	purse-seine	1983, 1985	100	0	-	0
Malita	ringnet	1984	100	0	100	0

1/ - 1983 data for free-schools missing

Table 6. Estimates of frigate and kawakawa landings made under payaos and as free-schools from fishing areas around Mindanao Island

Species	Frigate				Kawakawa			
Type of fishing	Payao		Free-school		Payaos		Free-school	
Fishing gear	Ringnet	Purse-seine	Ringnet	Purse-seine	Ringnet	Purse-seine	Ringnet	Purse-seine
Moro Gulf (General Santos)	12,083	7,281	0	0	1,529	1,015	0	0
Opol (Bohol Sea)	3,216	-	3,483	-	1,102	-	0	-
Labuan/Recordo (East Sulu Sea)	0	2,017	2,634	0	0	179	899	0
Santa Cruz/Malita (Davao Gulf)	1,766	-	0	-	0	-	0	-
Gear total	17,065	9,298	6,117	0	2,631	1,194	899	0
Fishing type totals	26,363		6,117		3,825		899	
Percent	81		19		81		19	

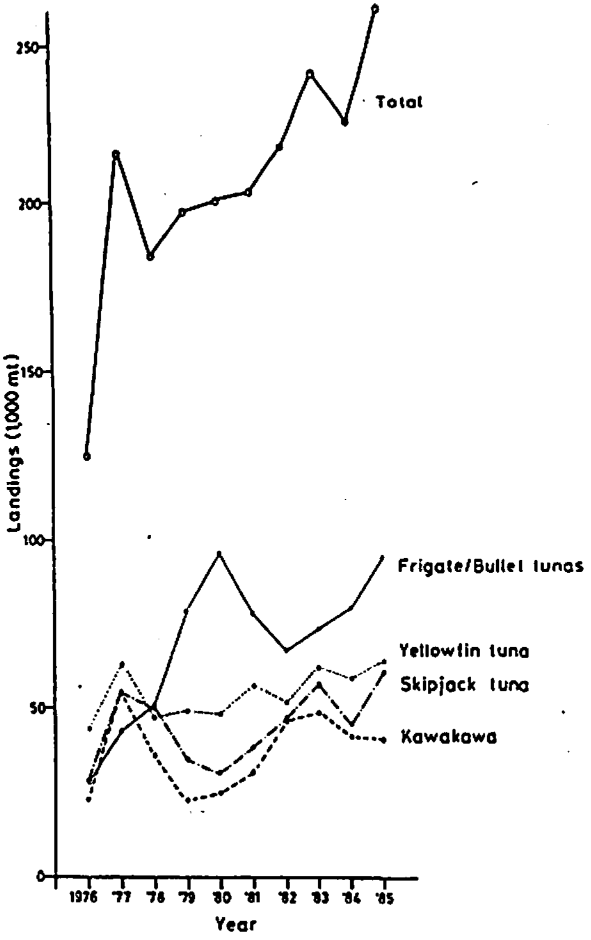

Fig. 1. Landings of tuna by species in the Philippines from 1976 to 1985

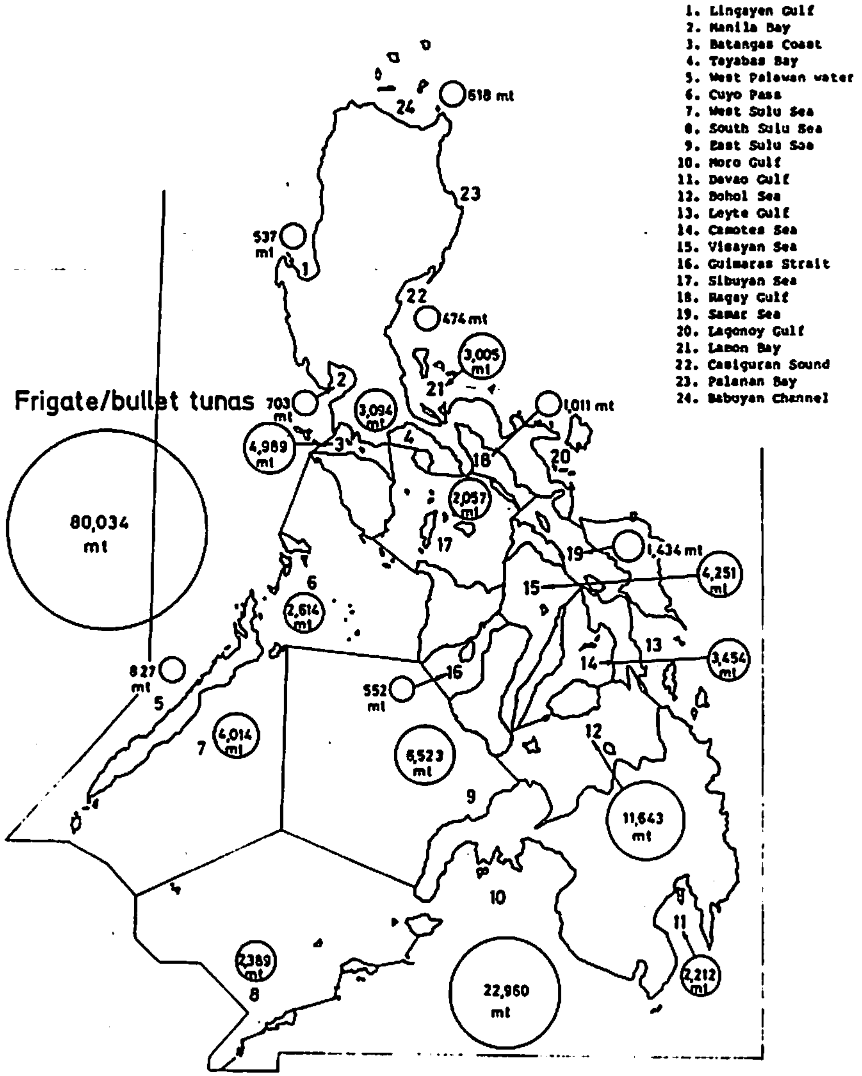

Fig. 2. Distribution of frigate/bullet tuna landings by fishing areas

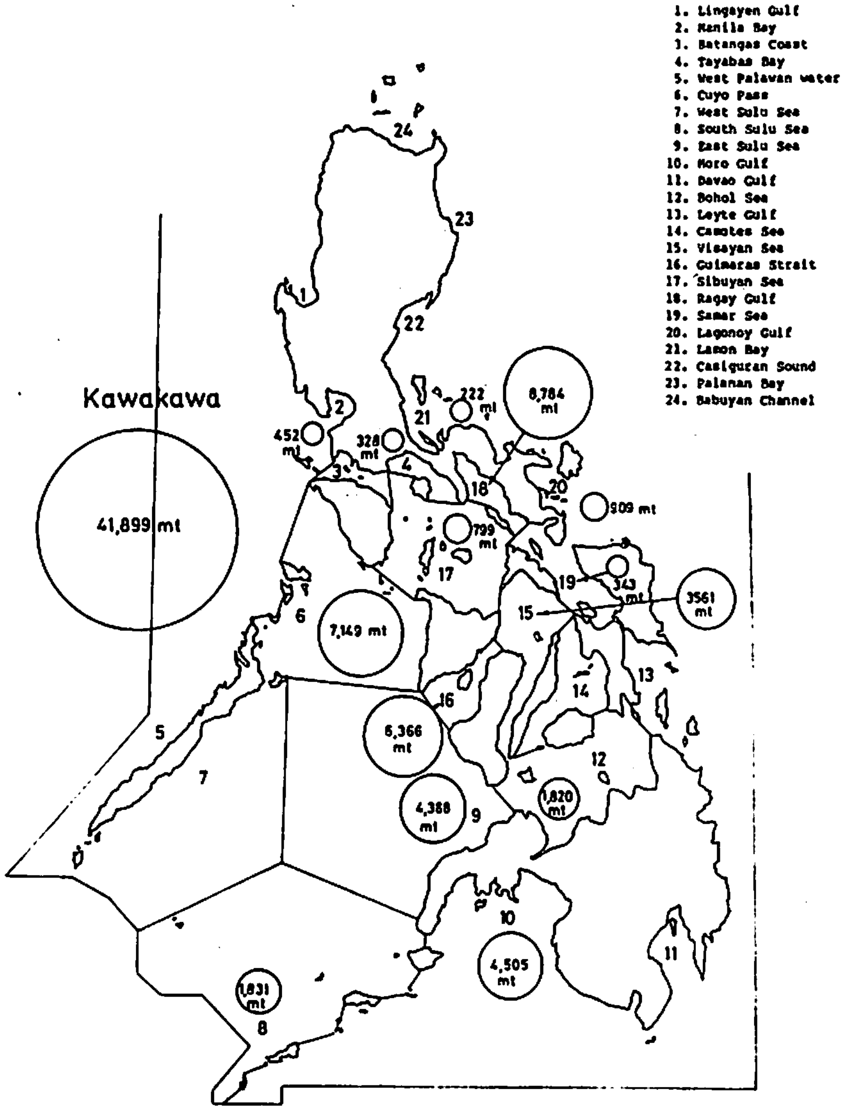

Fig. 3. Distribution of kawakawa landings by fishing areas

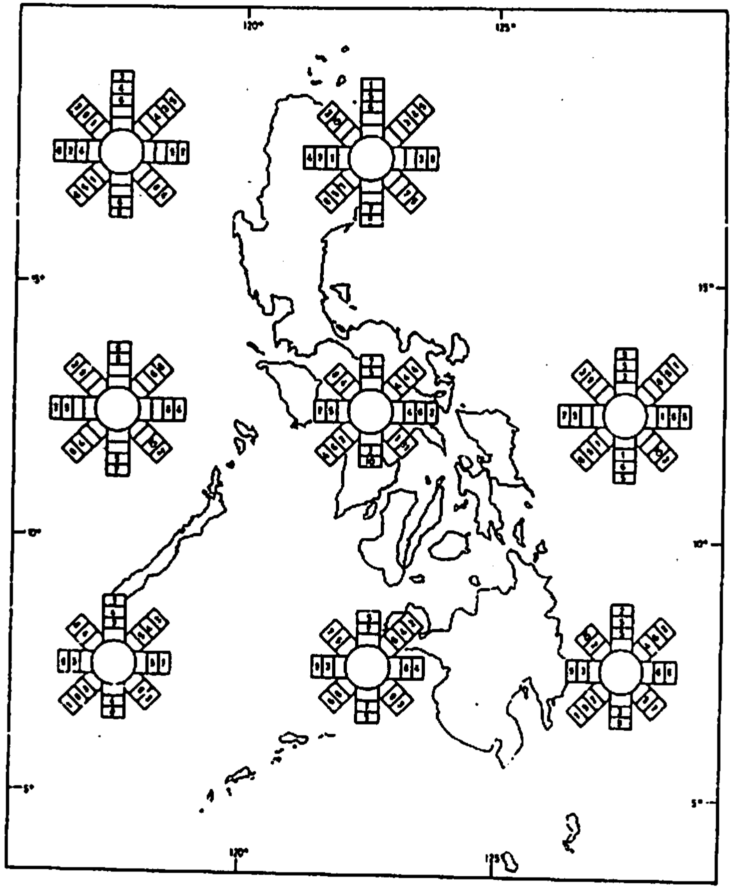

Fig. 4. Wind stress patterns in the EEZ of the Philippines. Wind direction represented by bars. Wind force represented by divisions of the bar beginning with Beaufort force 1 at the center and increasing outward. Numbers in the division represents number of months of the year (12 observation for each direction) (from U.S. Defence Mapping Agency, 1979)

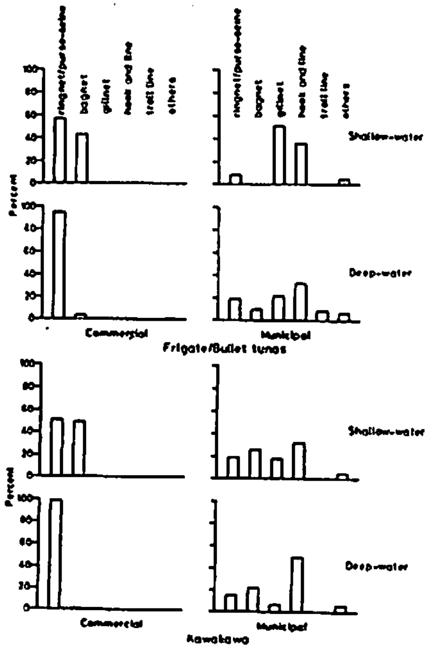

Fig. 5. Landings of frigate/bullet tunas and kawakawa by fisheries sector, gear type and fishing areas

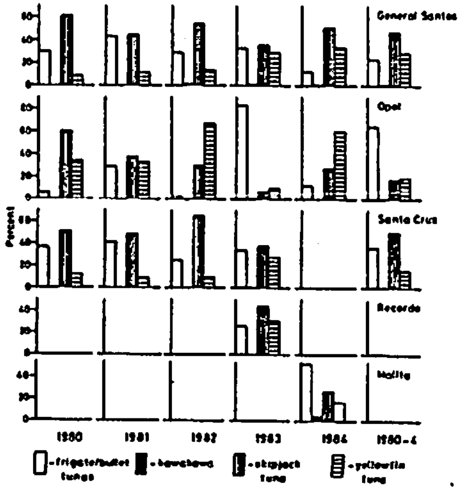

Fig. 6. Species composition of tuna landings by ringnetters fishing payao-associated schools at various landing centers for the years 1980-84

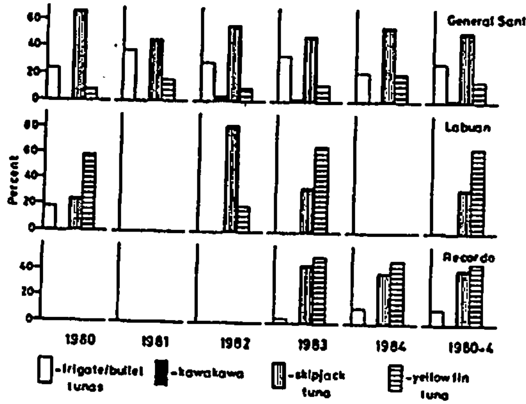

Fig. 7. Species composition of tuna landings by purse-seiners fishing payao-associated schools at various landing centers for the years 1980-84

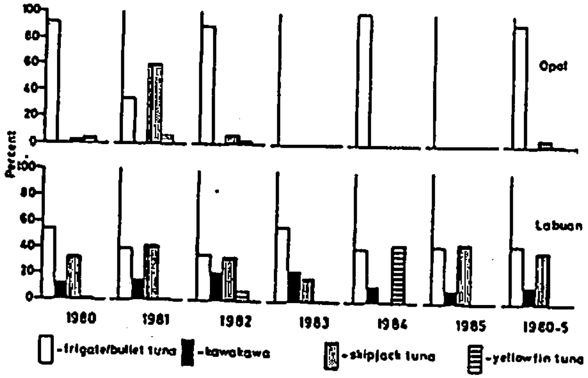

Fig. 8. Species composition of tuna landings by ringnetters fishing free-schools at 2 landing centers for the years 1980-85

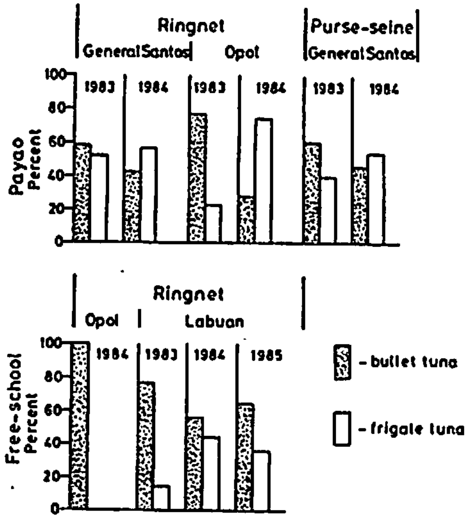

Fig. 9. Composition of *Auxis* landings by ringnetters and purse-seiners fishing payao-associated schools and free-schools

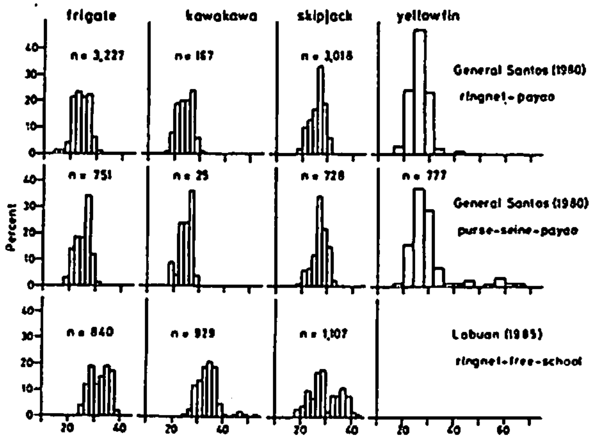

Fig. 10. Length frequency distributions of tuna species captured under payaos and as free-schools by ringnetters and purse-seiners

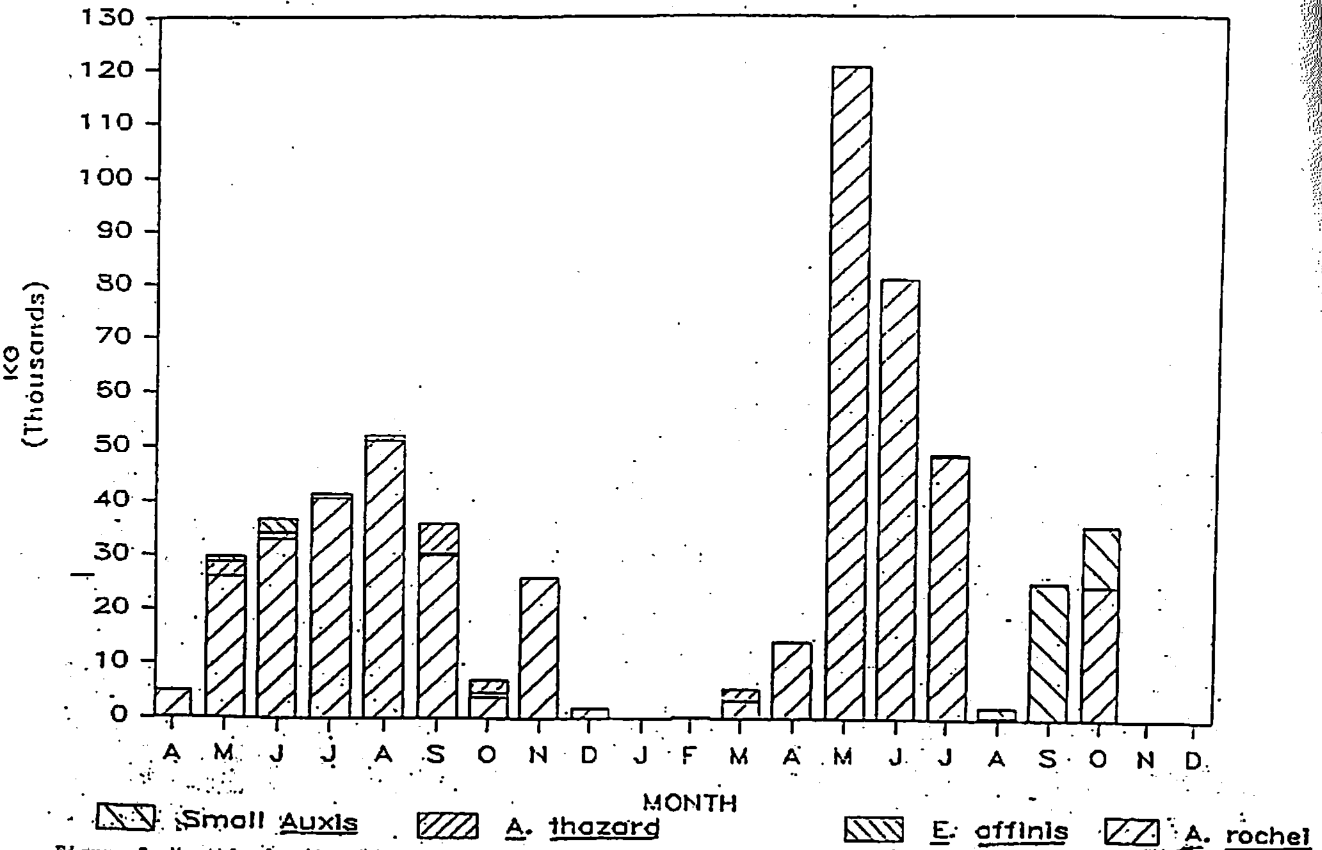

Figure 2. Monthly landings in 000 kgs of small tunas caught by bagnets in Batangas.

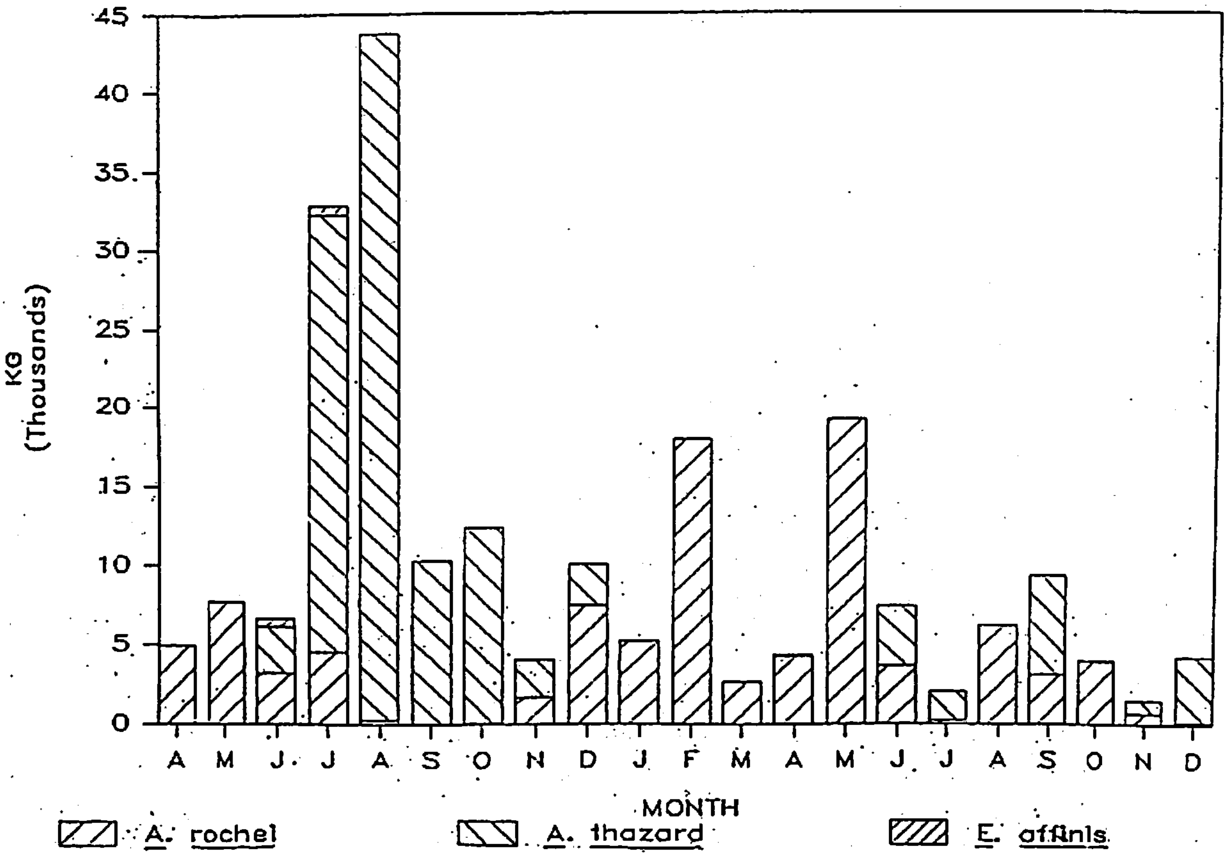

Figure 3. Monthly landings in 000 kgs of small tunas caught by ringnets in Batangas.

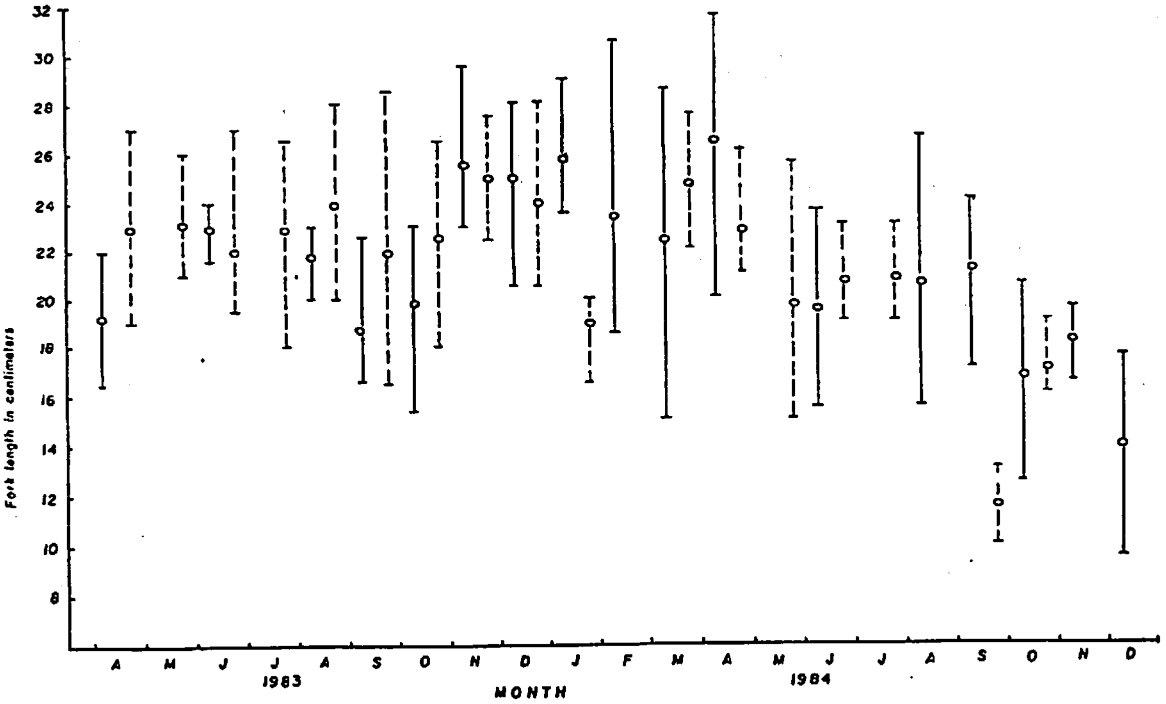

Fig. 4. Monthly mean and range of fork lengths of *Auxis rochei* caught by ringnets (—) and bagnets (---) in Batangas (April 1983 - December 1984).

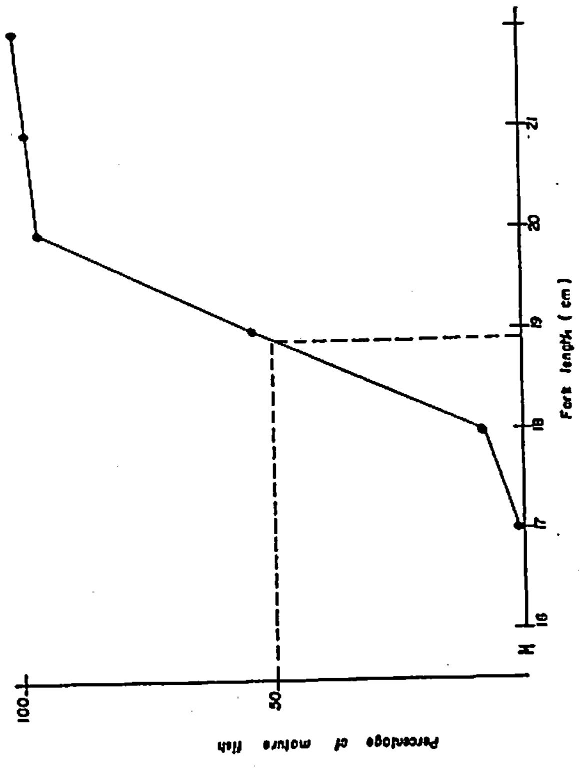

Figure 5. Length at first maturity for *Auxis rochei*, Batangas, Philippines.

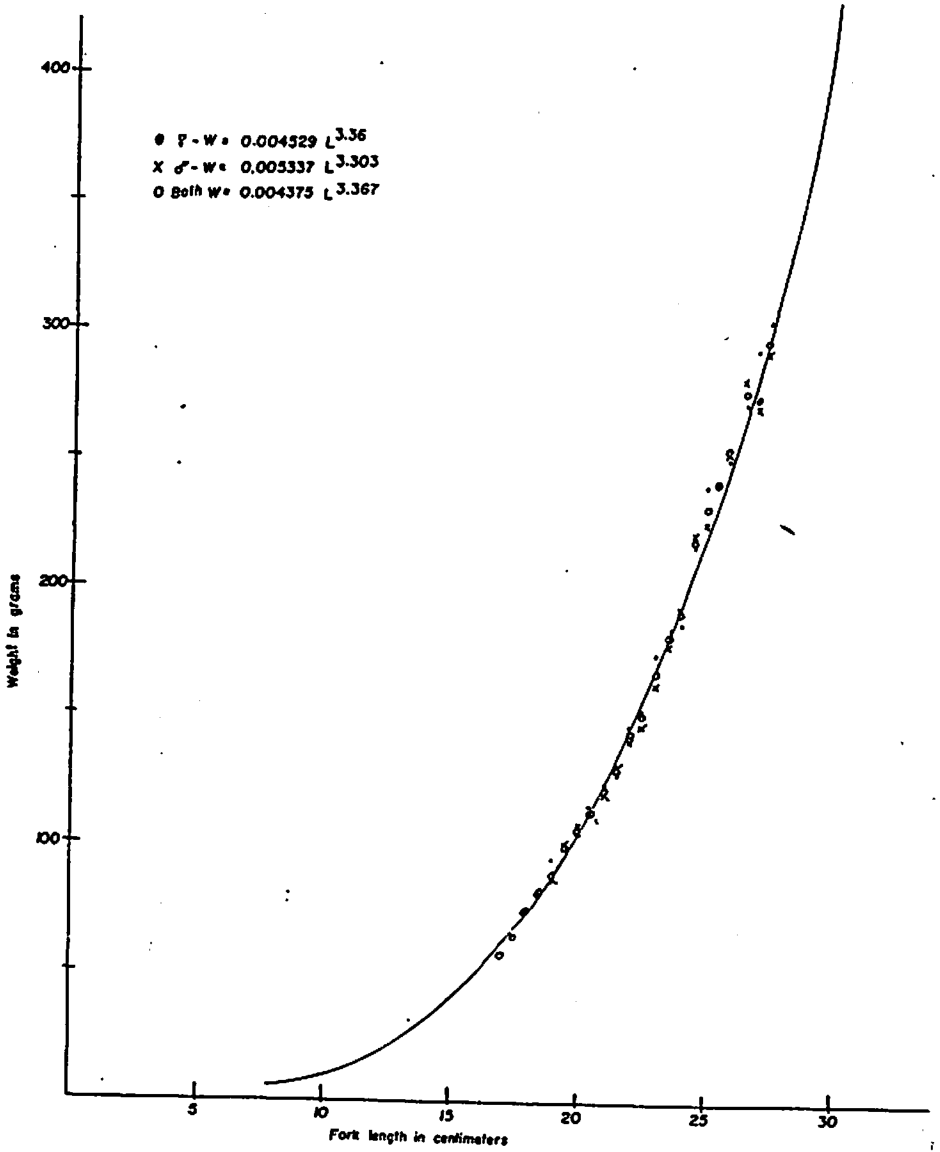

Fig. 6. Length-weight relationship of Auxis rochei caught by bagnets in Batangas.

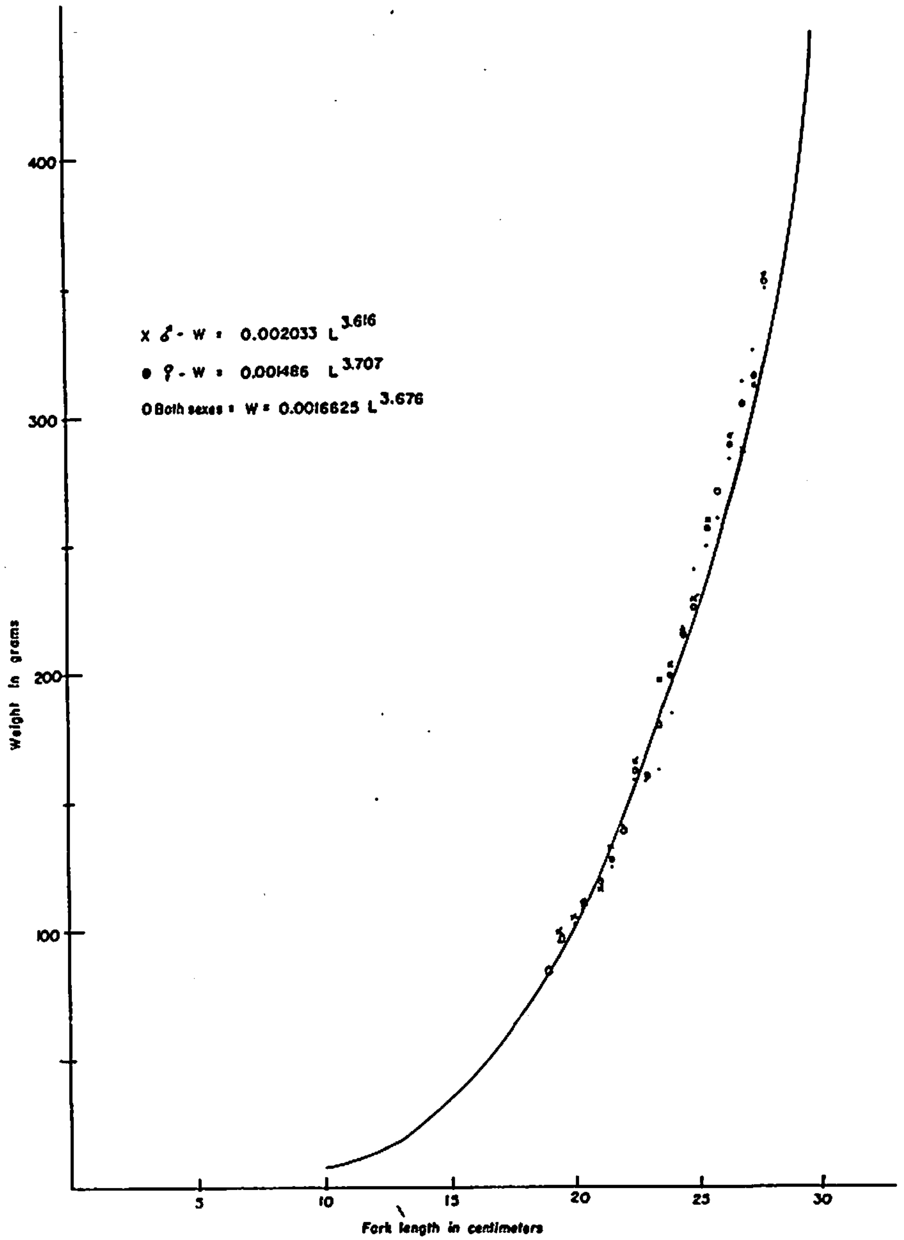

Fig. 7. Length-weight relationship of Auxis rochei caught by ringnets in Batangas.

Table 1. Monthly data on landed catch of bagnets at Wawa, Batangas City

Month	No. of Sampling Days	No. of Boats Landed	Total Landed Catch	Catch per Boat (kg)	Species Composition/Weight in Kilograms						
					A. rochei	A. thazard	E. affinis	T. albacares	Decapeterus spp	Other fish	Squid
April '83	7	40	11661	291	5020				6166	50	425
May	20	135	50148	371	26120	2840	880		11740	977	7760
June	25	178	45,493	256	33034	1240	2511		6684	1900	124
July	16	87	43010	494	40680		740		560	1030	
August	17	145	55310	381	51040	40* 880			2650	500	200
September	19	194	38307	197	30146	220* 5453	20		1720	688	60
October	17	147	9451	64	3800	838* 2280			620	1633	280
November	12	117	29760	254	25780				2120	1860	
December	4	17	2942	173	1858				995	89	
January '84	9	205	74312	362	86				34703	39218	305
February	6	123	18713	152	400	120			13685	4508	
March	8	209	23053	110	3185	2115			13306	4020	427
April	7	161	19315	120	13964	75			2756	1095	1425
May	10	204	133825	656	120405				11565	840	1015
June	8	141	82845	587	80815				1060	660	310
July	12	168	49848	297	48185	320*			760	243	280
August	3	41	5850	143	510	1640* 160					
September	10	173	46067	266	27	24934* 77		210	17800	1871	1148
October	10	170	45613	268	24440	10973*	80		8090	580	1450

* "tulingan" small <u>Auxis</u> below 15 cm.

Table 2. Monthly data on landed catch of ringnets at Sambal, Lemery, Batangas

Month	No. of Sampling Days	No. of Boats Landed	Total Catch Landed (kg)	Catch per Boat	Species Composition/Weight in Kilograms						
					A. rochei	A. thazard	E. affinis	K. pelamis	T. albacares	Decapterus spp	Others
April'83	7	206	6755	33	4955					1800	
May	31	793	105202	133	7805	13				97169	215
June	27	694	78304	113	3293	2914	570			70925	575
July	28	548	59083	108	4636	27653	560			24845	1390
August	24	530	48818	92	279	43434				5005	100
September	29	431	21093	49		10313				7640	3140
October	27	418	15870	38	117	12296			45	1692	1720
November	21	263	10118	39	1750	2328		180			5860
December	28	572	11988	21	7565	2573		90			1760
January '84	30	607	7305	12	5250				135	320	1600
February	26	749	20250	27	17960					1080	1210
March	15	184	3525	19	2678	88					760
April	12	120	4509	38	4235	95	59				120
May	15	194	26250	135	19250					5760	1240
June	11	195	15990	82	3675	3835				7980	500
July	15	182	11195	62	200	1855				8560	580
August	15	110	7745	70	6265					1040	440
September	17	293	17775	61	3156	565* 6287			200	4168	3400
October	15	150	6685	45	3970	15				1160	1540
November	15	225	10765	48	735	770				5320	3940
December	8	216	6935	32	140	4095					2700

* small <u>Auxis</u>

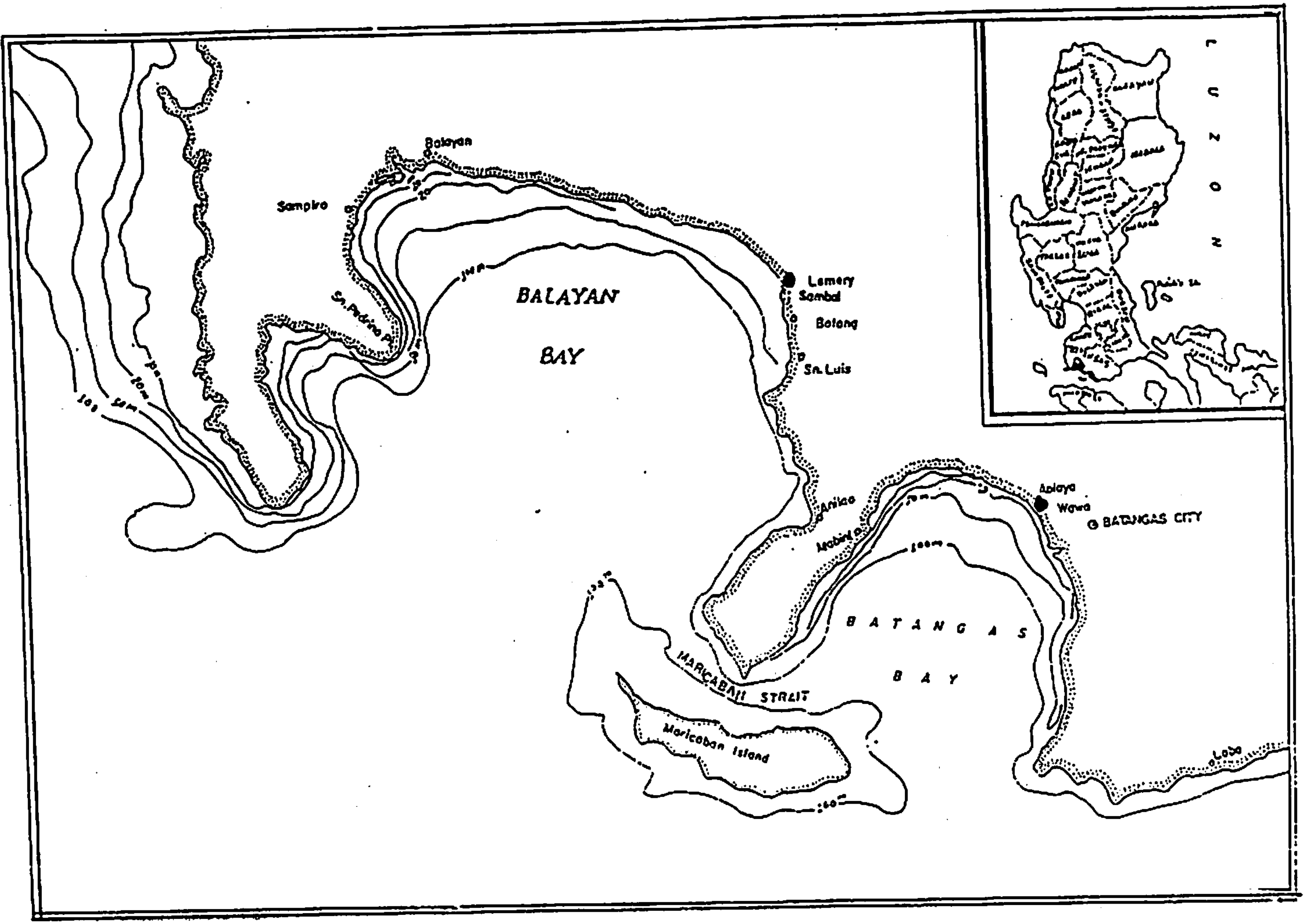

Figure 1. Fishing areas for Auxissspp and monitoring stations Sambal, Lemery for the ringnets and Wawa, Batangas City for bagnets.

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