

IPTP/87/GEN/13

REPORT OF WORKSHOP ON SMALL TUNA, SEERFISH AND BILLFISH
IN THE INDIAN OCEAN
Colombo, Sri Lanka
December, 9 - 11, 1987

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- 4.1 Current Production and potential yields of small tunas in the Indo-Pacific region - M. Yesaki
- 4.2 Preliminary studies of Scomberomorus commerson and Thunnus tonggol in Omani waters - R. Dudley
- 4.3 A simple method of determining exploitation levels of neritic tuna stocks - Yesaki
- 4.4 Description and identification of longtail tuna, Thunnus tonggol (Bleeker), in the Gulf of Thailand - R. Chayakul and C. Chamchang
- 4.5 Distribution of longtail tuna (Thunnus tonggol, Bleeker), kawakawa (Euthynnus affinis, Cantor) and frigate tuna (Auxis thazard, Lacepede) in the western coast of the Gulf of Thailand - C. Chamchang and R. Chayakul
- 4.6 Small tuna fishing gears in the Indo-Pacific region - M. Yesaki
- 4.7 Tuna sampling programme conducted by IPTP in Sri Lanka - R. Forster
- 4.8 Preliminary studies of billfish in Sri Lanka - R. Forster
- 4.9 Stock structure of blue marlin, Makaira nigricans, populations - G. Sakagawa
- 4.10 Tuna and tuna-like species in Bangladesh - Md. H. Rashid

Report of Workshop on Small Tuna, Seerfish and Billfish in the Indian Ocean
9-11 December 1987
Colombo, Sri Lanka

1. Opening of the Meeting

1.1 Opening address

Dr. G.C.N. Jayasuriya, Director-General of the National Aquatic Resources Agency (NARA), Sri Lanka opened the meeting with the welcoming address. He briefly described the history of this organization and its principal research activities, one of which is the tuna research programme. The tuna group of NARA has been monitoring the tuna fisheries since 1982 and has recently initiated regular sampling at selected sites along the south coast with technical assistance from the Indo-Pacific Tuna Programme (IPTP). Dr. Jayasuriya stressed the importance of tuna fisheries to the total fisheries production in Sri Lanka.

1.2 Welcoming address

Mr. T. Sakurai, Programme Leader, welcomed the participants on behalf of the staff of IPTP. He stated the principal objective of IPTP was to establish an international data center for tuna, seerfish and billfish in the Indian Ocean and Southeast Asian regions. The present workshop was to focus on the species groups that have been neglected in the past, namely small tuna, seerfish and billfish. The objectives of the workshop were to review the available information on these groups and to identify future research requirements and areas for cooperative effort within the region.

Mr. Sakurai emphasized that this was an informal meeting and called for free and frank discussions on technical matters to ensure a productive workshop.

He asked Mr. Yesaki, outposted Fisheries Resources Officer under the Regular Programme of FAO headquarters, who has been concerned with small tunas during the past 18 months to take a leading role during this meeting.

1.3 Appointment of chairman

Mr. Rashid al Barwani, Director of Fisheries Statistics, Sultanate of Oman was elected to chair the meeting. Mr Robert Forster (IPTP) was appointed rapporteur.

1.4 Adoption of agenda

The tentative agenda was adopted after modifications necessitated by the non-attendance of several participants. The agenda is attached as Appendix 2.

2. Status Reports

2.1 Indian Ocean and Southeast Asian countries

An Interim Report on 1986 tuna catch statistics in the Indian Ocean and Southeast Asian regions was presented by IPTP and explained by the Programme Leader as follows:

The total reported catch of tuna, seerfish and billfish in the Indian Ocean and Southeast Asian regions increased by 100% between 1974 and 1986 and currently stands at around 1.2 million tonnes. Small tuna, seerfish and billfish account for 36.0, 12.8 and 1.7 per cent of this catch, respectively.

The catch of small tunas in the Southeast Asian region is more than treble that of the Indian Ocean with the Auxis spp. complex being the most important. The composition of the unidentified tuna category is likely made up primarily of kawakawa and Auxis spp. along with the juveniles of the other commercially important species. Seventeen percent of the tuna catch still remains unidentified. Major fisheries for small tunas exist in the Gulf of Thailand, around the Philippines and in the Northwestern Arabian Sea area. A big increase in the landings of Auxis spp. and a slight increase for kawakawa was reported from the Southeast Asian region in the last 13 years.

Seerfish landings have risen in both regions, with Scomberomorus commerson being the most important species, followed by S. guttatus.

Billfish landings continue to show a gradual decrease in the Southeast Asian region and a slight increase in the Indian Ocean. Much of the catch from the Indian Ocean still remains unidentified (17%). Japan has started to separate black and blue marlins in its statistics.

2.2 Oman

The most important fishery is the drift gill-net fishery for narrow-barred king mackerel (Scomberomorus commerson), the landings from which stand at around 17,000 tonnes. It is mostly caught in the Sharkiya region of Oman. A strong upwelling in southwest Oman and resulting high productivity may explain the large seerfish landings from this region as well as the fast growth rates and large modal size of narrow-barred king mackerel.

The tuna fishery is concentrated in the Sharkiya region with longtail tuna and yellowfin being the main target species. Combined catch estimates of 11,000 tonnes are reported. The drift gill-net is the most important gear employed, but hand-lining is also used for catching large yellowfin which commonly reach 30 kg. Incidental catches of sailfish is reported to be quite high in this fishery, but owing to its low market price, statistics on total catch are not available.

2.3 U.A.E.

The most important species by weight is narrow-barred king mackerel followed by longtail, kawakawa, and then frigate tuna. Fishing for these species is primarily with drift gill-nets and secondarily by trolling. The highest landings of seerfish, occur immediately before the SW monsoon in April, while longtail tuna catches peak a month or so later in May-June, and again in October.

The catches of longtail, kawakawa and frigate tunas and the narrow-barred king mackerel all showed decreases between 1982 and 1985 despite an increase in the number of registered vessels. This is attributed to departure of experienced fishermen to other more lucrative employment and their replacement by less-experienced fishermen on fixed wages. Productivity thus is believed to have decreased despite the increase in fleet size. Secondly, not all registered vessels are engaged solely in fishing but are also involved in other maritime activity. Finally, statistical coverage was better in 1982.

2.4 Pakistan

Drift gill-nets are responsible for the bulk of the 15,700 tonnes of tuna, seerfish and billfish caught off Pakistan. Small tuna, seerfish and billfish comprise approximately 29%, 48% and 10% of this figure.

The gill-net fleet alternates between demersal and pelagic operations depending on season. Catches of tuna, seerfish and allied species are severely affected by the SW monsoon, especially from May to July. For billfish, there are only records of swordfish catch, which was estimated at 1,236 tonnes for 1985.

Waters off Baluchistan contribute 70% of the total tuna production. Gillnetters fish on the Pakistani continental shelf and in offshore waters.

2.5 Sri Lanka

Catches of tuna have again decreased slightly on account of the continued restriction of fishing operations to the west and south coasts. The amount of fishing effort actually directed at the small tunas and seerfish is small, although trolling for kawakawa and Auxis is important in the south and SW of the island. In some areas, hand-lining for seerfish is quite common. Billfish is caught principally in the drifting gill-net fishery which targets on yellowfin and skipjack tunas, but the catches are substantial and exceeded 3,000 tonnes for 1986.

Out of the total scombrid catch of tuna, seerfish and billfish of 25,200 tonnes observed in the study area in 1986, small tunas accounted for 11%, seerfish for 1.9%, and billfish for 13%.

2.6 Maldives

Pole-and-lining, trolling and some hand-lining are the main fishing methods employed in the Maldives. Most of the effort is pole-and-line for skipjack. Second in importance is trolling within and immediately outside atoll areas. The catch of small tunas is dominated by frigate tuna, followed by kawakawa and some dog-tooth tuna. Catches of these amounted to some 2,900 tonnes in 1986. Wahoo catches are roughly estimated at 400 tonnes (\pm 100 tonnes). Sailfish is caught by trolling but catches are small.

Since 1985, catches of yellowfin, frigate tuna and kawakawa have fallen substantially, whereas skipjack has increased. Catches of the same species showed the opposite trends in 1973 and 1983.

2.7 Australia

Longtail, kawakawa and frigate tunas occur throughout the shelf-waters of northern Australia. Longtail dominates the small tuna group. Since restrictions were imposed on the Taiwanese gill-net fishery, landings have fallen from around 2,500 tonnes to virtually zero.

Small amounts of longtail have been caught by pole-and-line fishing in the Gulf of Carpentaria, but schools tend to be small and scattered. Incidental catches of longtail and kawakawa are made by trollers targetting on narrow-barred king mackerel. About 300 tonnes of king mackerel were landed in 1986.

No information on billfish was offered, though there is a sport-fishery for this group off the east coast.

3. Current production and potential yields

3.1 Small tuna resources

Data for individual fish stock assessments are not available for most of the neritic tuna stocks in the Indo-Pacific region. Therefore, a simplistic comparative approach was tried. The method uses figures of production per unit area from areas where such observations are available as estimates for similar areas where they are not available.

The criticisms raised about the method included:

- neritic tunas are not the only large pelagics in the continental shelf and these should also be included in determining densities;
- confidence limits on a density estimate would probably be quite high;
- fish communities are in a state of flux so that the species composition can radically change from one year to the next.

Some felt this approach should only be used with extreme caution to prevent gross misstatement of yield potential. Others felt this was a pragmatic approach to be used where data for traditional assessment methods is not available. All felt that refining of the technique should be continued.

4. Investigations on small tuna, seerfish and billfish

Papers presented in this section are included in Appendix 4.

5. Mapping of tuna resources in the Indian Ocean

5.1 Atlas of industrial longline and purse-seine fisheries in the Indian Ocean

This is a part of on-going tuna resources mapping in the Indian Ocean. However, sample analyses were reviewed. "Thematic maps" depicting the distribution of the billfish densities for the period 1975-82 provided an overview of relative magnitudes, gradients, spatial/time-series patterns, movements and other distributional relationships at a glance. Maps are being planned for 5 species of billfishes (blue marlin, black marlin, striped marlin, sailfish and swordfish) caught by the industrial long-line fisheries of Japan, Taiwan and Korea (1962-85) in the Indian Ocean and the southeast Asian waters..

5.2 Atlas of tuna fisheries in the Indo-Pacific region

An IPTP project of preparing an atlas of the tuna resources of the Indo-Pacific region was outlined. The atlas will include a brief description of each fisheries and country maps. Information given in the country maps include:

- pie diagram showing total catch and percent composition by species (shade coded by species)
- bar graph showing numbers of vessels by gear type (color coded by fishing gear);
- bar graph showing percentage of vessels by size class (color coded);
- fishing grounds by gear type (color coded);
- pie diagram showing species catch and percentage contribution by gear type (color coded)
- length frequency distributions (color coded)

6. Recommendations

The workshop made the following recommendations for future activities to be undertaken.

- (1) Unclassified tunas still account for the highest percentage of the small tuna catch. Also, small tuna catches are frequently not specified by gear type. It is recommended that countries give greater emphasis to discriminating catches by species and gear type for small tuna, seerfish and billfish.

- (2) Sampling programmes for catch, effort and size frequency distributions are important sources for data to assess the condition of the exploited stocks. It is important that countries in the region continue to support sampling programmes and emphasize quality in sampling, i.e. unbiased length frequency sampling. IPTP should continue its technical assistance to countries concerned in improving their sampling programmes.
- (3) The longtail tuna and kawakawa stocks in the Gulf of Thailand are presently being heavily exploited. An assessment of these stocks should be initiated by Thailand and Malaysia with the assistance of IPTP in the near future to provide management options for the concerned governments.
- (4) The longtail tuna and kawakawa landings in the Gulf of Oman and adjacent areas are considered high, despite the lack of complete landing statistics for that region. It is possible that the stocks are quite heavily exploited at present, but this is uncertain because of the lack of complete fishery statistics and good biological information. Biological sampling programmes have been initiated in Oman during February 1987 and in Pakistan during March 1986, and these should be continued. It is also recommended that U.A.E. improve its present statistical collection system and IPTP provide technical assistance.
- (5) It is recommended that IPTP pursue organizing a workshop in one of the Arabian peninsular countries for December 1988 to review in detail the available information for an assessment of the neritic tuna stocks in the north Arabian sea.

7. Adoption of the final report

It was agreed that drafting and approval of the final report of the meeting will be by correspondence. The workshop was adjourned on 10 December 1987.

APPENDIX 1.

LIST OF PARTICIPANTS

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APPENDIX 2.

IPTP Workshop on Small Tunas, Seerfish and Billfish
 in the Indian Ocean
 9 - 11 December 1987, Colombo, Sri Lanka

A G E N D A

1. OPENING FORMALITIES

- 1.1 Opening Address - Jayasuriya
- 1.2 Welcoming address - Programme Leader - Sakurai
- 1.3 Election of chairman
- 1.4 Adoption of agenda

2. STATUS REPORTS

- 2.1 Indian Ocean and Southeast Asia - Sakurai
- 2.2 Oman - Barwani
- 2.3 U.A.E. - Dahmash
- 2.4 Pakistan - Imad
- 2.5 Sri Lanka - Moyiadeen
- 2.6 Maldives - Anderson
- 2.7 Australia -

3. Current production and potential yields

- 3.1 Small tuna resources - Yesaki

4. Investigations on small tuna, seerfish and billfish

- 4.1 Preliminary studies of Scomberomorus commerson and Thunnus tonggol in Omani waters - Dudley
- 4.2 A simple method of determining exploitation levels of neritic tuna stocks - Yesaki
- 4.3 Description and identification of longtail tuna, Thunnus tonggol (Bleeker) in the Gulf of Thailand - Chayakul and Chamchang
- 4.4 Distribution of longtail tuna (Thunnus tonggol, Bleeker), kawakawa (Euthynnus affinis, Cantor) and frigate tuna (Auxis thazard, Lacepede) in the western coast of the Gulf of Thailand - Chamchang and Chayakul
- 4.5 Small tuna fishing gears in the Indo-Pacific region - Yesaki
- 4.6 Tuna sampling programme conducted by IPTP in Sri Lanka - Forster
- 4.7 Preliminary studies of billfish in Sri Lanka - Forster
- 4.8 Stock structure of blue marlin, Makaira nigricans, populations - Sakagawa

5. Mapping of tuna resources in the Indo-Pacific region

- 5.1 Atlas of longline and purse-seine tuna fisheries in the Indian Ocean - Nishida
- 5.2 Atlas of tuna fisheries in the Indo-Pacific region - Yesaki

6. Recommendations

7. Adoption of final report

APPENDIX 3. Status Reports

3.1 Sultanate of Oman

3.2 United Arab Emirates

3.3 Pakistan

3.4 Sri Lanka

3.5 Maldives

3.6 Australia

STATUS REPORT
OF OMANBy
KASHID AL BAWANI

The landings of large pelagic species include the narrow-barred king mackerel, longtail tuna and yellowfin tuna. Tuna species are increasing in importance in the landings.

King mackerel comprised the bulk of the large pelagic species landed by the artisanal fleet at just under 17% of the total catch. Approximately 14,000 mt was landed in 1986. The industrial trawl fleet reported incidental catches of 46 mt, which was less than 1% of the total king mackerel landings.

Fishing gears used by artisanal fishermen to capture king mackerel include drift gillnets, troll lines and handlines with live-bait. The catch is sold fresh or whole frozen.

Tuna landings in 1986 was 11,800 mt which was approximately 1% of the total landing by the artisanal fleet. The industrial trawl fleet reported catches of 8 mt from their trawling operations.

Artisanal fishermen use drift gillnets, set gillnets, handlines and troll lines to capture tuna. Large yellowfin are caught principally with handlines during the period from September to March. The length range of longtail tuna is 50-80 cm and the weight range of yellowfin tuna is 20-30 kg.

There are no purse-seiners in Oman at present, but there is private sector interest in the feasibility of a purse-seine fishery for tuna.

Landings of Kingfish, 1985 – 1986

(*Scomberomorus commerson*)

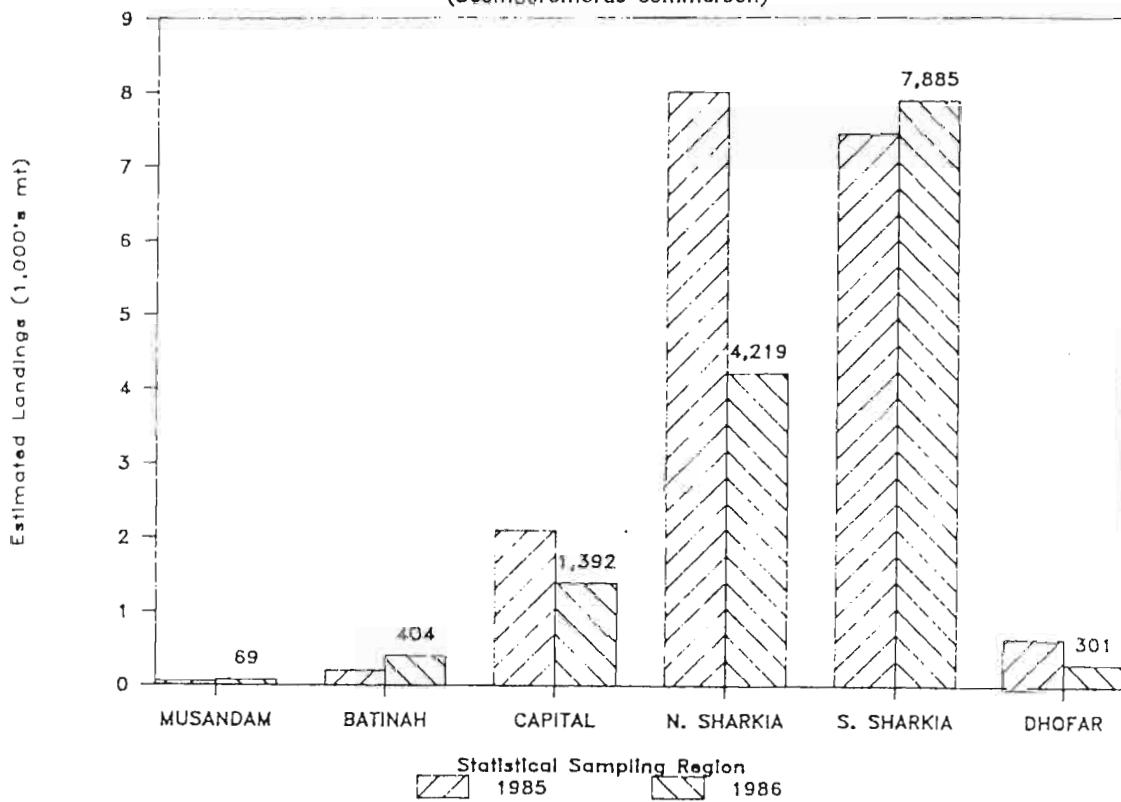
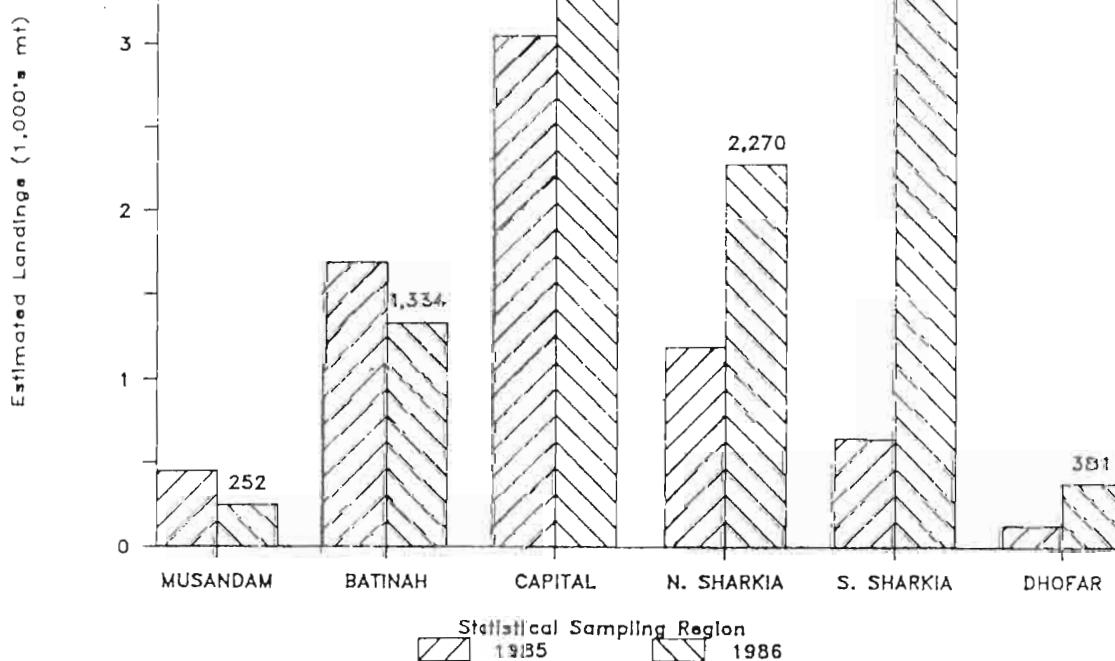


Figure 7. Total estimated artisanal landings of kingfish, (*Scomberomorus commerson*) during the calendar year 1986. The relative landings for 1985 are also presented, for reference. Of particular note is the increased landings of kingfish realized in the Southern Sharkia, and the much larger decrease in landings of kingfish in the Northern Sharkia. Data for the Musandam was supplied by the Musandam Development Council.

Landings of Tuna, 1985 – 1986

(other Scombridae)



Total estimated artisanal landings of tunas (*Thunnus tonggol*, *T. albacares*, *Euthynnus affinis*, *E. pelagicus*, *Auxis thazard*, and other species of the family Scombridae), during the calendar year 1986. The relative landings for 1985 are presented, for comparison. Of particular note is the increased landings of tunas in the Capital, Northern & Southern Sharkia, and Dhofar regions. Data for the Musandam was supplied by the Musandam Development Council.

INTRODUCTION

The marine areas which belong to the UAE are the main source of fish production in the country. The traditional fishing is dominate and the modern commercial fishing is prohibited.

The total fish production ranged between 64,68,70,73,72,2,79,5 metric tons for the years 1979,1980,1982,1983,1985 and 1986 respectively.

TUNA STATUS IN U.A.E.1. TUNA SPECIES

Longtail Tuna	(<i>Thunnus tonggol</i>)
Kawakawa	(<i>Euthynnus affinis</i>)
Frigate	(<i>Auxis thazard</i>)
Seerfish	(<i>Scomberomorus commerson</i>)

2. TUNA AND SEERFISH PRODUCTION

Species	1982	1985
Longtail Tuna	4000 mt	2830 mt
Kawakawa	2000 mt	980 mt
Frigate	1000 mt	470 mt
Seerfish	6580 mt	5000 mt

3. FISHING VESSELS

There are two basic types of mechanized fishing vessels in UAE, smaller outboard and larger inboard-powered vessels. The former is either wood-planked or fiberglass and the latter is wood-planked hulls.

The fiberglass vessels length range between 14-22 feet and between 18-30 feet for the outboard wooden vessels. Outboard motors used in UAE range in size from 25-120 H.P., many of these vessels have two motors.

The inboard vessels range in length from 30-50 feet and from 50-80 feet, also their motors range in size from 33-240 H.P.

The total number of vessels have increased by 49% since 1982 with a higher increase in the numbers of outboard-powered vessels (Table 1.)

4. FISHING GEARS

The most important fishing gear for tuna in UAE is the gillnet which is fished primarily with the outboard-powered vessels. Gillnets are used for drift netting at night and circle-setting surface schools during the day. These nets are 1000 m to 1700 m long and approximately 42 m deep. Gillnets of 1000 m length and 22 m deep are also used for beach-seining surface schools with 1 or 2 boats. Mesh size usually range from 10 cm to 14 cm stretch-mesh for tuna and King Mackerel.

A secondary fishing gear for tuna and seerfish is trawl lines which are generally used by inboard and outboard vessels while steaming to and from the fishing grounds.

5. TUNA FISHING SEASONS

Tables 2 and 3 show the monthly landings of seerfish and Tuna at Khorfakkan* for two periods from Nov. 1976 to Oct. 1977.

* Khorfakkan is a small town overlooking a natural bay on the Gulf of Oman having about 160 metric tons yearly landings.

Four species were discriminated during the latter survey of the site. In terms of weight, the most important species was Narrow-barred Mackerel, followed by Longtail Tuna, Frigate Tuna and Kawakawa.

The highest landings of Narrow-barred King Mackerel are made from February to June. There appears to be two peaks of abundance for Longtail from April to July and from September to November. Landings of Kawakawa were highest in September-October during one sampling period and in February-May during the other period. Frigate Tuna was most abundant in March-April and November.

6. SIZE COMPOSITION

Length frequency samples of Longtail and Kawakawa were taken from April through September 1987, except during May (Ramadan period) at Ras Al Khaimah Fish Market which is considered to be one of the ten major Fish Markets in the UAE. The number of samples taken each month ranged from 9 to 12 for Longtail and 3 to 4 for Kawakawa.

Fish counts at Ras Al Khaimah Fish Market show numbers of Longtail Tuna peaked in August and of Kawakawa in June; the number of Frigate Tuna was not recorded. The ratio of total counts of these two species for the sampling period was approximately 10 Longtail to 1 Kawakawa, 15% of the Longtail and 2% of the Kawakawa were less than 50 cm, small Longtail ranged from 27 to 49 cm and large ones from 65 cm to 85 cm, the smallest Longtail of 27 cm was found in September and the largest in June.

Length frequency distributions of Longtail Tuna taken in 1982, mostly at the Dubai Fish Market, which is considered to be the biggest in the country, also showed two size classes, one in the 40 to 54 cm interval and the other in the 60 to 79 cm interval.

Kawakawa were measured in April, June and July 1982, small fish recorded in April/June and large fish (70-84 cm) in July. The measured Kawakawa ranged from 30 to 89 cm with highest proportion in the 40-59 cm interval.

King Fish of 25 cm are usually found in September and 50 to 70 cm during Jan/Feb. Large King Fish of 100-150 cm are usually found during March, April and May every year.

7. COMMERCIAL VALUE

Tuna and Seerfish have a very important value in the local fish markets. The selling prices vary according to the freshness and the quantities displayed in the fish markets. In general the highest and lowest retail prices usually range between \$ 2.8-0.5 for one Kilo. The highest price usually record with the beginning of the season.

TABLE 1.
NUMBER OF VESSELS ENGAGED IN FISHING ACTIVITIES IN
THE A.E. ACCORDING TO DISTRICT DURING 1982 AND
1986

Year	Type of Vessels	1982		1986		Changing Rate
		Petrol	Diesel	Petrol	Diesel	
Western District	185	40	574	294	3,64	3.27
Central District	638	345	609	195	0.95	0.56
Northern District	216	98	570	157	2,63	1.60
Eastern District	372	105	413	138	1,11	1.31
TOTAL						
By type of vessels	1411	638	2266	784	1,61	1.23
For all vessels	2049	3050			1.49	
Total	29,445	9,040	1,631	40,116		

Source: Ministry of Agriculture and Fisheries

of Fisheries - Technical Report No. 3.

TABLE 2.
MONTHLY LANDINGS (KG.) OF SCOMBROID SPECIES AT
KHORFAKKAN DURING NOVEMBER 1976 TO OCTOBER 1977

Month	Species	S. Commerson		T. Tonggol		E. Afrinisi		Total
		1976	1977	1976	1977	1976	1977	
November		479	487	1	1	1	1	966
December	"	136	24	1	1	1	1	160
January	1977	75	131	1	1	6	1	212
February	"	186	70	1	1	14	1	270
March	"	5,100	328	1	1	21	1	5,459
April	"	18,760	2,340	1	10	1	1	21,110
May	"	787	2,274	1	35	1	1	3,096
June	"	3,565	1,152	1	1	1	1	4,717
July	"	26	865	1	1	1	1	891
August	"	26	83	1	1	1	1	109
September	"	105	570	1	1	1	1	1,329
October	"	-	622	1	975	1	1	1,597
Total		29,445	9,040	1	1,631	1	1	40,116

SOME OBSERVATIONS ON THE TUNA FISHERYFISHING GEAR.

Prior to 1953, only cotton twine nets were in vogue, but now all fishing nets used in marine fisheries are being fabricated from synthetic material, i.e., nylon twine.

"Rach" is the most common type of gillnet used throughout the coast of Pakistan. It is employed by all gillnetters mainly based at the Karachi and Korangi areas on Sind coast, and Gawader and Sonmiani on Baluchistan coast. Its technical description is as follows:

- | | |
|---|----------------------------|
| 1. Stretched mesh | 150 mm |
| 2. Hanging ratio | 0.5 |
| 3. Length of head rope | 2400.0 m |
| 4. Length of bottom rope | 2400.0 m |
| 5. Depth of net | 80 meshes |
| 6. Material dimensions and quantity of floats | 1454 P.V.C./ 115 L = 130 m |
| 7. Material, mesh and quantity of sinkers. | Stone, 4 to 7 kg each |

Construction details. The net is made from Nylon PAR 607 tex (Twine No.24). It is usually 32000 mesh long, 80 mesh in depth, and the stretched mesh size is 150 mm. The float line is made from polypropylene 2400 meters in length, and 20 mm in diameter. Fishermen use stones as sinkers which weigh approximately 4 to 7 kg each. The distance between the two stone sinkers and weight of sinkers depends on the layer of sea water, where the net is set. When the net is set on bottom, 7 kg sinkers are used at a distance of 5 meters, while the 4 kg sinkers are used at a distance of 10 meters, if the net is to be set above the bottom and on the surface as given below:

Net set at the bottom	:	Net set at the surface
Bouyancy of float : Mass of sinker	:	Bouyancy of float : Mass of sinker

Net set at the bottom	:	Net set at the surface
1599 kg	:	2640 kg

PISHING AREAS.

In 1947, i.e., at the time of creation of Pakistan the entire fishing fleet was sail driven and dependent at the mercy of winds. The process of mechanisation with inboard marine diesel engines was initiated in 1956. At present, the number of mechanised boats in actual operation in marine fisheries is around 1500, comprised of about 1200 trawlers and 300 gillnetters.

The fishing craft mainly engaged in tuna fishery are gillnetters, which are usually 15 to 20 meters of keel length, 20 to 25 meters in over all length, 5 to 7 meters of beam and are fitted with 88 to 135 H.P. engines. Their gross registered tonnage varies between 35 to 45. The gillnet used by these vessels also vary in size each ranging from 750 kg to 1500 kg, catching preferably demersal fish, but in case demersal fish is not available in abundance, they divert their fishing activities towards big pelagics like tuna and billfish. The area-wise distribution of gillnetters is given on Table II.

During fishing, either by trawler or by gillnetter, about 12 to 18 persons accompany the fishing vessel. In Sind, a fishing trip is 12 to 15 days duration, whereas in Baluchistan the duration of the trip varies between 15 to 25 days.

As far as the tuna fishery is concerned, the fishing area on Sind coast is the Great Kori Bank area along the swatch. On the Baluchistan coast, waters off Gawader, Jiwani, and Ormara are the most common fishing grounds. Pasni and Gaddani waters are reported as low catch areas. Tuna fishing in deep waters of Baluchistan coast is undertaken only after the monsoon season when the conditions are favourable. Observations reveal that some gillnetters undertake fishing as far as Muscat, Oman, i.e., 400 n.miles away from our coast for catching tuna and sharks.

DISPOSITION OF CATCH.

The gillnetters engaged in surface gillnetting often carry out fishing in offshore waters aiming for shark, tuna, and billfish. Since these boats are unable to carry sufficient ice for their long trips, there is no option except to bring salted dry products not favourable to Pakistani tastes. Hence, it is exported to Sri Lanka at comparatively low price. Seerfish are generally caught by pelagic and demersal gillnetters and preserved in ice, but sometime they are preserved with salt. Seerfish are consumed generally in local market, and sometime exported in fresh condition to Middle East countries.

FISHING SEASON.

It has been noticed that tuna catch vary with the season, though coastal tuna i.e., longtail tuna (*Thunnus tongol*), Kawakawa (*Euthynnus affinis*) and frigate tuna (*Auxis thazard*) are more or less available through out the year. Yellowfin tuna (*Thunnus albacares*) and skipjack (*Katsuwonus pelamis*) are recorded from September to March. There is a peak landing season of tuna from September to April. Catches are very low during the monsoon season. Seerfish are also available throughout the year with a lean period from May to July. This is not only for seerfish but holds good for other fishes as well.

CATCH STATISTICS.

Out of the total marine catch of 333,316 metric tons during the year 1985, 15,751 metric tons was seerfish, billfish and tuna or only 5% of the total fish production of Pakistan. Area-wise landings of tuna and allied species during the year 1985 is given in Table III which indicate that Baluchistan contributed 70% and Sind 30% of the total production.

There is no species-wise statistics, but the available statistics have been segregated on the basis of observations made during the tuna sampling programme and is given in Table III.

After the introduction of the tuna sampling programme various important aspects of tuna landings have emerged. For example, two commercially important oceanic tuna species yellowfin tuna (*Thunnus albacares*) and skipjack (*Katsuwonus pelamis*) are available in good quantity in waters facing Ormara, Gwadar, and Jiwani off the Baluchistan coast. The statistics compiled during the recent tuna sampling programme gives an indication of increasing production of tuna. In view of it, it can be said that there are good stocks for exploitation and development of the tuna fishery in Pakistan.

I have no hesitation in saying that for one reason of the other tuna fishery in Pakistan has not been given the due importance it deserved, as we all know that during recent years tuna fishery has attained importance on global basis and most of the coastal states are trying their best to harvest these resources but unfortunately Pakistan is lagging behind in this field. It is only in the recent years after initiation of the tuna sampling programme, that the importance of the tuna resources is being realized. It is hoped that this programme will help in determining the tuna potential and Pakistan will also make its contributions in the development, exploitation, and management of the tuna resources in the north Arabian Sea.

I would like to avail this opportunity to thanks I.P.M.P. for rendering valuable technical assistance which enabled Pakistan to start a tuna sampling programme and it is hoped that this assistance will further increase so that Pakistan can contribute much more in this behalf and develop its tuna fishery on scientific lines.

ACKNOWLEDGEMENT

I am grateful to Mr. Mohammad Yunus Khan, Director General, Marine Fisheries Department for encouragement and guidance in the preparation of this paper. My thanks are also due to Mr. Jameel Ahmed, Principal Research Officer, and to Mr. Marnhoob Ahmed Siddiqui, Deputy Director for reviewing the manuscript and giving valuable suggestions.

TUNA SAMPLING PROGRAMME

A tuna sampling programme, was initiated at Karachi Fisheries Harbour in May 1986. Under this programme regular visits to the Harbour were made twice a week. The following informations from the skippers / tindais of the incoming gillnetters were collected and compiled on a proforma.

1. Name / Registration number of boat.
2. Date of departure and arrival.
3. Number of fishing days.
4. Type of fishing gear.
5. Fishing area.
6. Number of species caught.
7. Name and quantity of each species.
8. Total catch.

TUNA CATCH IN PAKISTAN
1985

Table I. Statistics of tuna, seerfish and billfish from 1980 to 1985.

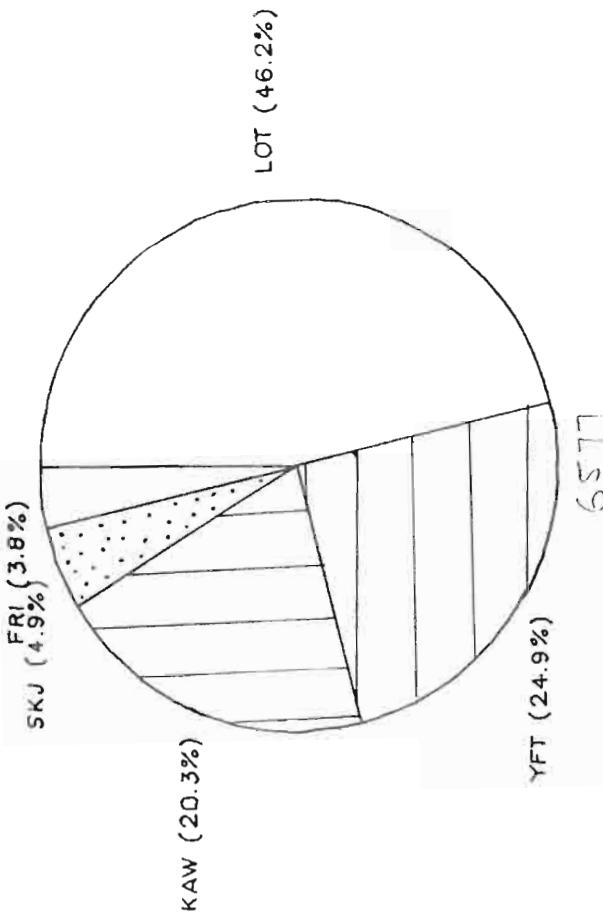
S. No. : YEAR		TOTAL MARINE: SEERFISH LANDINGS:			TUNA LANDINGS: BILLFISH LANDINGS:		
		LANDINGS : S	B	EM	LANDINGS : TOTAL S	B	TOTAL : S B
: 1	1980	232,943	N.R.	N.R.	1,963	N.R.	5,637 N.R.
: 2	1981	261,539	650	6,640	N.R.	7,90 5,445	3,212 8,558 N.R.
: 3	1982	278,149	1,012	6,512	11	7,535 5,086	5,747 10,833 N.R.
: 4	1983	268,043	1,353	6,843	72	8,243 800	2,841 3,641 N.R.
: 5	1984	308,050	1,373	5,704	68	7,148 700	3,172 3,942 N.R.
: 6	1985	333,316	2,041	5,197	44	7,582 1,801	4,776 6,577 896 340 1,236:

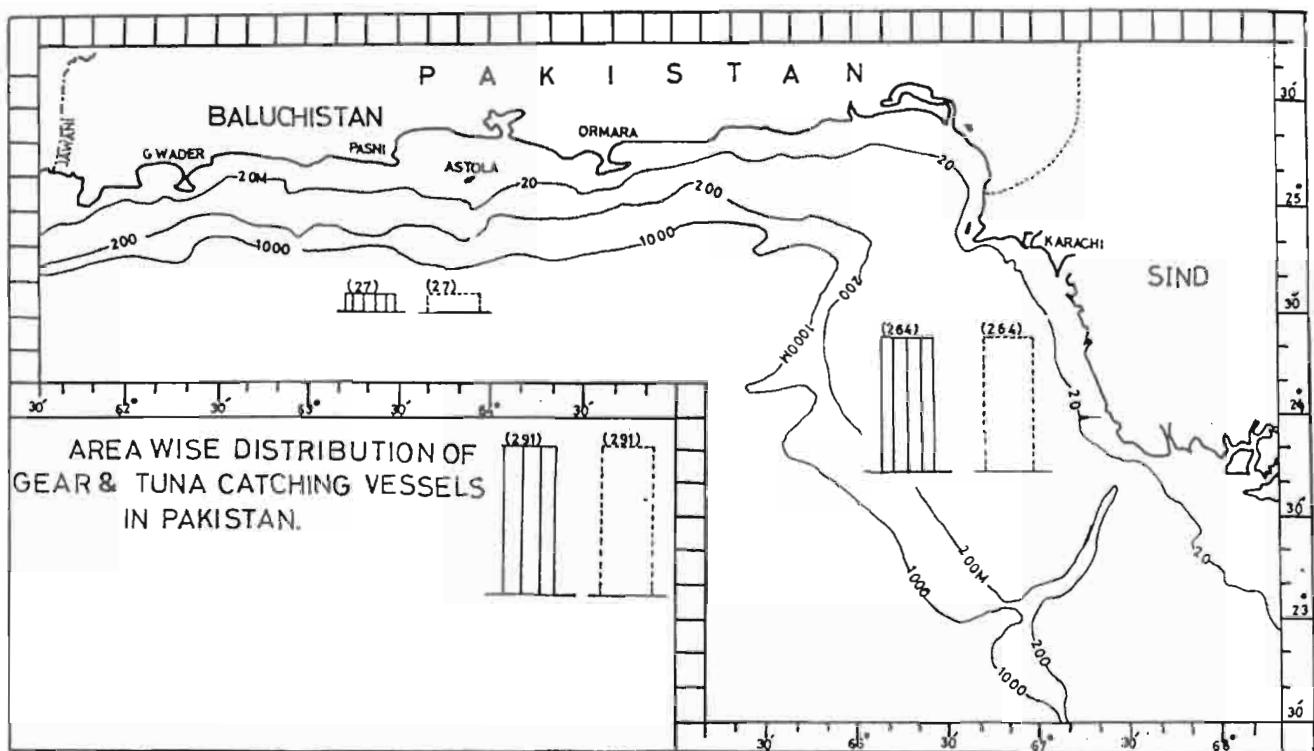
Table II. Area wise figures of marine fishing craft gears in Pakistan in 1985.

ITEM :		SINDH	BALUCHISTAN	ORKARA PASNI GAWADER JIANNI : TOTAL
: KARACHI : KORANGI :		SONHTANI	ORMARA	JINANI :
: TOTAL VESSELS :	1,983 :	2,372 :	522	467 616 176 6,488:
: Gillnetters :	204 :	60 :	9	— 3 11 4 : 291:
: FISHING GEARS :	:	:	:	:
: Gillnet (Rach):	198	283	166	22 287 278 1,386:
:	:	:	:	:

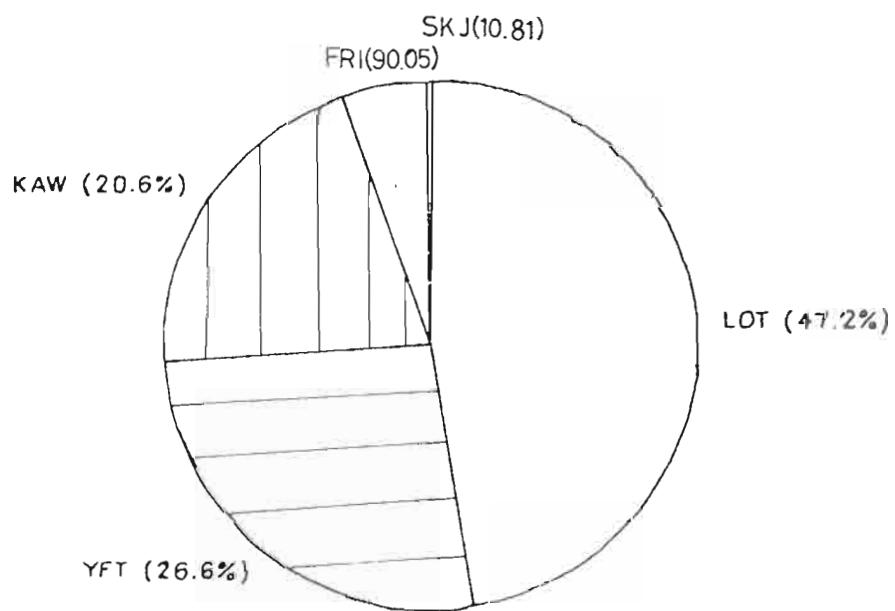
Table III. Species composition determined on the basis of observation made during the TUNA SAMPLING PROGRAMME started in May 1986.

S. NO	GROUP/SCIENTIFIC NAME	SINDH	CATCH STATISTICS BALUCHISTAN	ESTIMATED: TOTAL	SPECIES
: 1	: SEERFISH	: 2,041	5,497	7,538	—
	: <u>Scomberomorus guttatus</u>		—	—	3,015
	: <u>Scomberomorus commerson</u>	—	—	—	4,523
: 2	: TUNA	—	—	—	—
	: <u>Thunnus tongol</u>	492	4,776	6,577	—
	: <u>Thunnus albacares</u>	—	—	5,268	3,035
	: <u>Euthynnus affinis</u>	1,309	—	—	1,634
	: <u>Katsuwonus pelamis</u>	—	—	1,309	1,335
	: <u>Auxix thazard</u>	—	—	—	395
				—	178
: 3	: BILLFISH	400	—	400	—
	: <u>Istiophorus platypterus</u>	—	—	—	N.R.
	: <u>Xiphias gladius</u>	340	896	1,236	1,236

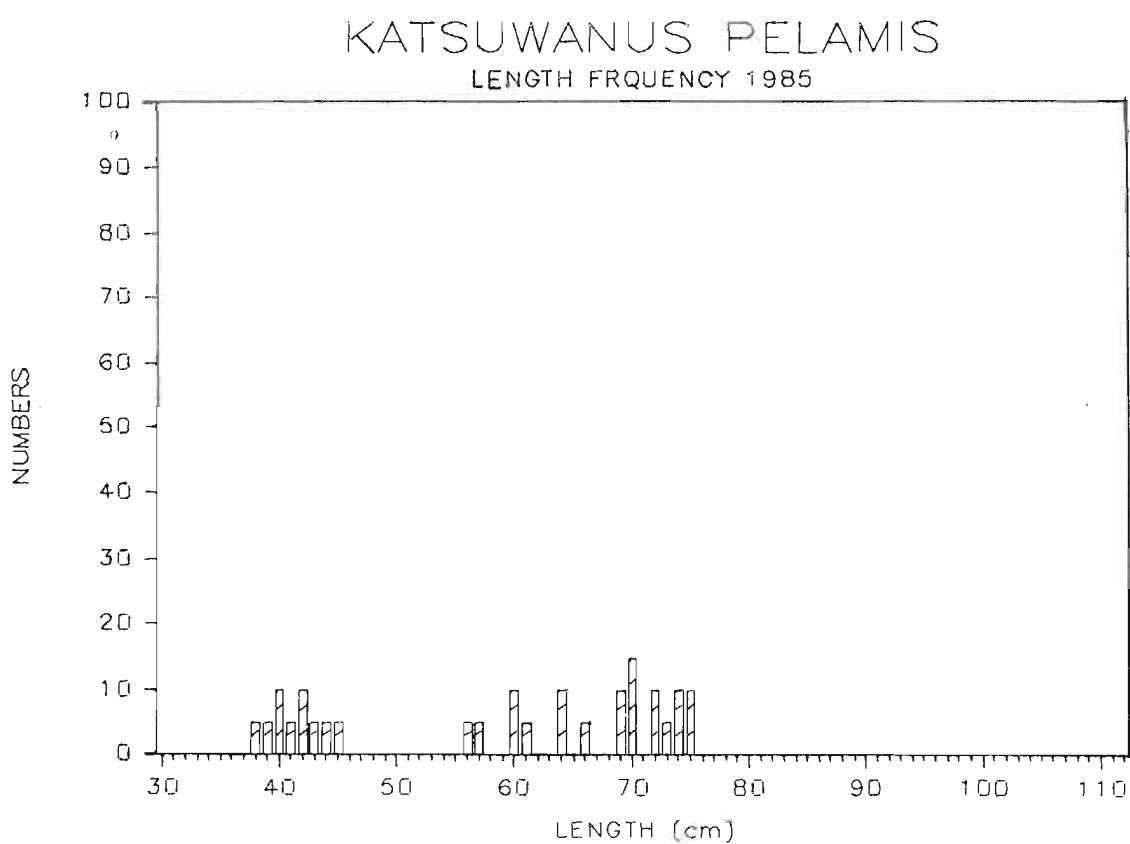
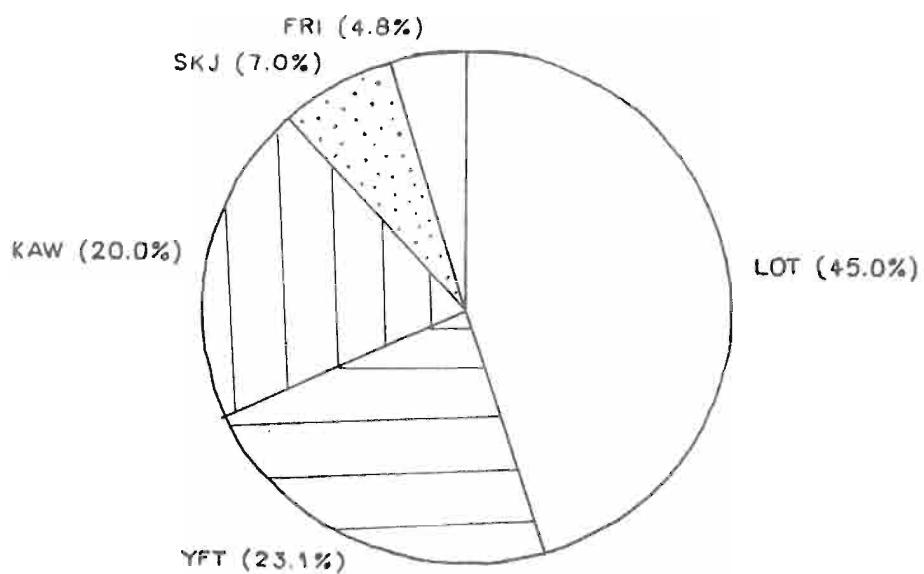




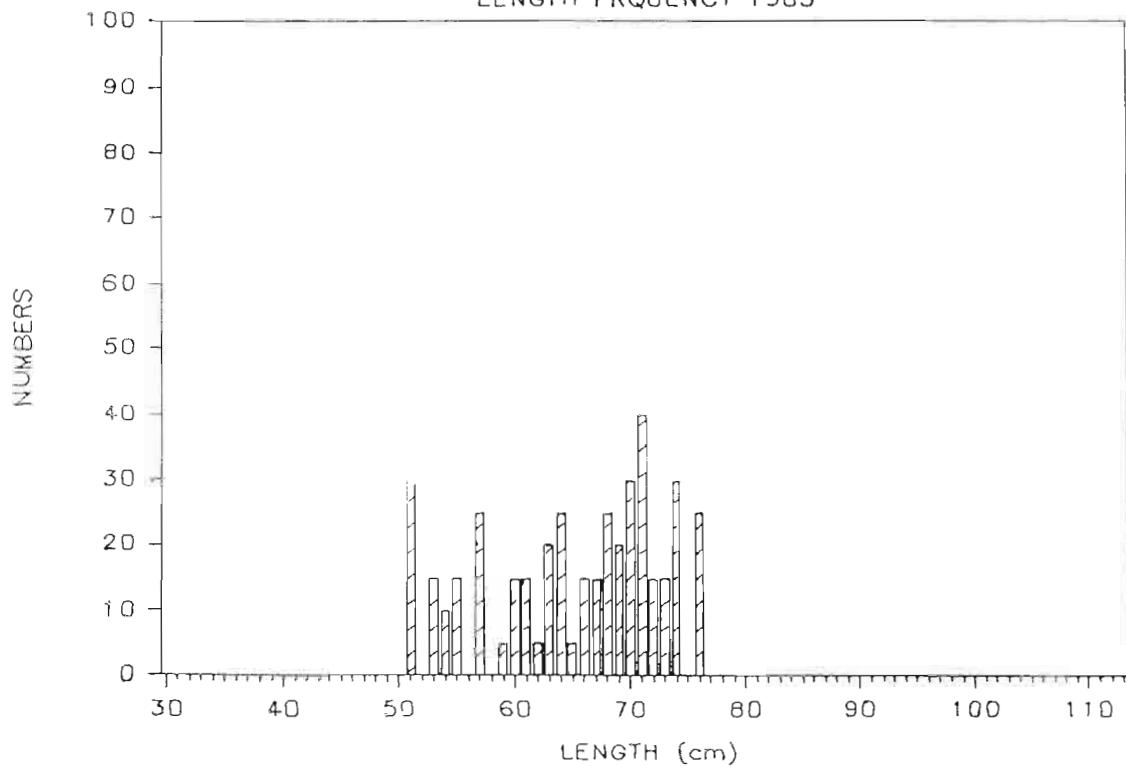
TUNA CATCH IN SIND 1985



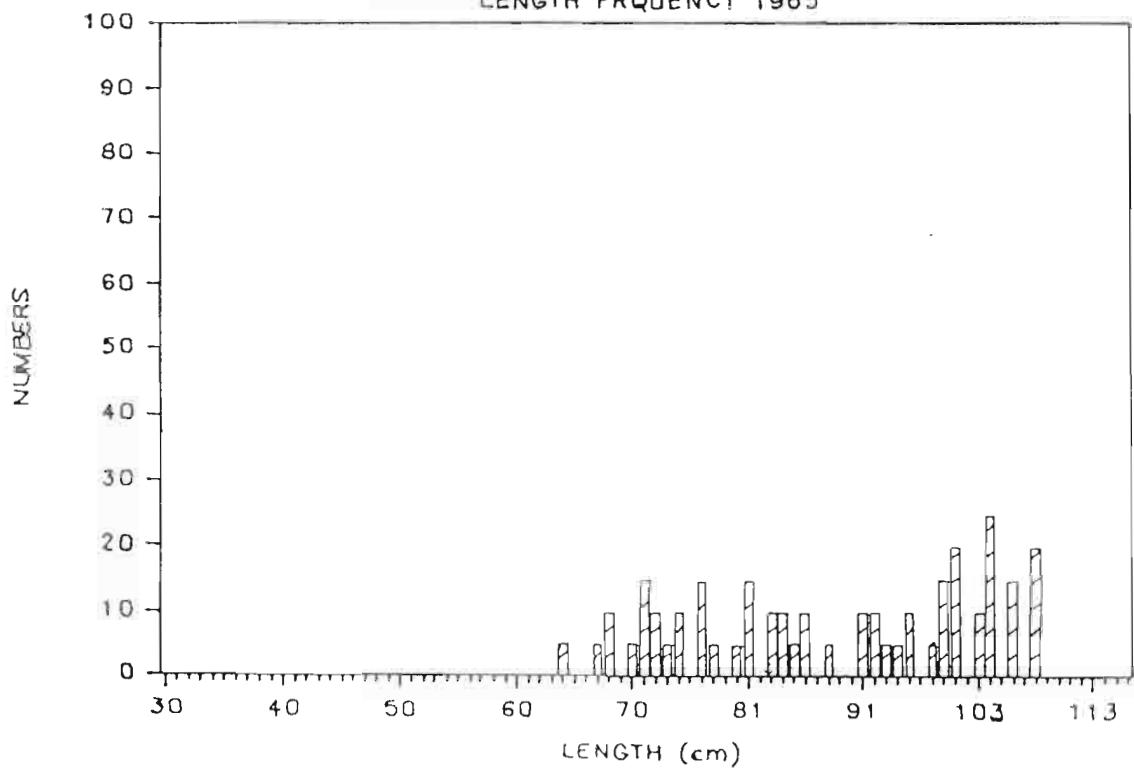
TUNA CATCH IN B ALUCHISTAN
1985



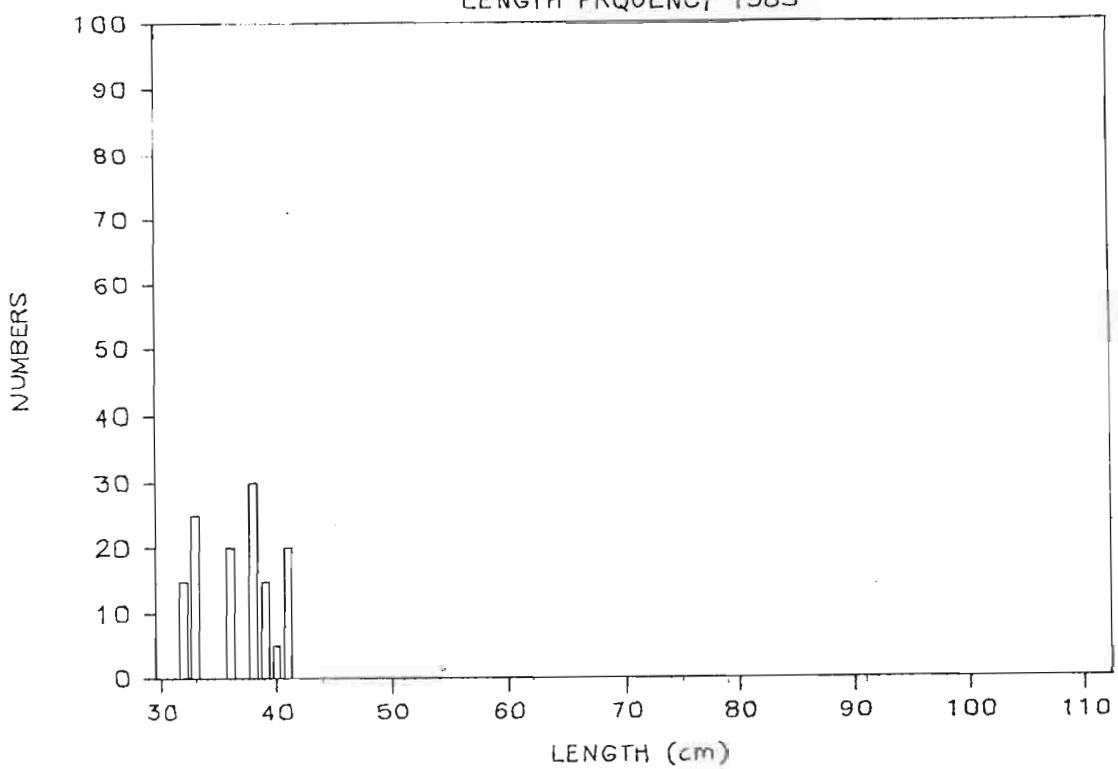
EUTHYNUS AFFINIS
LENGTH FRQUENCY 1985



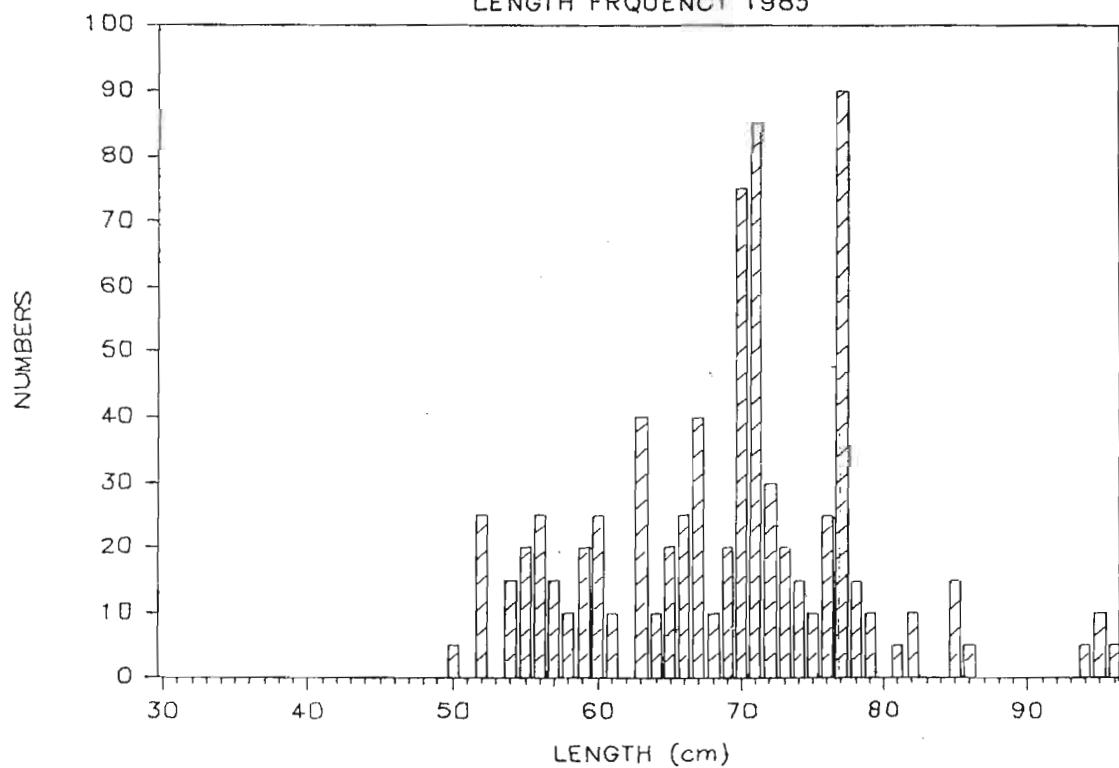
THUNNUS ALBACARES
LENGTH FRQUENCY 1985



AUXIS THAZARD
LENGTH FRQUENCY 1985



THUNNUS TONGGOL
LENGTH FRQUENCY 1985



Introduction :

Coastal fisheries in Sri Lanka are well documented for large tuna species over the past three decades. Considerable information is available on the status of the resource, fishery and biology of tuna, mainly skipjack tuna (Katsuwonus pelamis) and yellowfin tuna (Thunnus albacares). In the case of other major fish species, the information available is not adequate for a proper understanding of the status of resource, fishery and biology. Among these the smaller tuna species, billfish and swordfish contribute over 9 percent of the total marine production according to Ministry of Fisheries Statistics. Though these species are such important the information available from past publications are very limited for future developmental work.

By

R. Maledeniyâ,
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The studies on small tuna species started in late nineteen sixties and were mainly based on fishery, distribution and the abundance of these species. Sivasubramaniam (1966) has studied the distribution and the length - weight relationship of Kawakawa (Euthynnus affinis) frigate tuna (Auxis thazard) bullet tuna (A. rochei) and oriental bonito (Sarda orientalis). Some informations on biology such as recruitment, season, age and size range for different fishing methods used for capture Kawakawa were given by Sivasubramaniam (1970). The relative abundance of Auxis sp. using the catch rates for different fishing gear has been reported by Sivasubramaniam (1973). Joseph and Noiyadeen (1985/86) have reported the level of contribution of small tuna species to total production for different gear and crafts. Joseph et al. (1986) have reported on the estimation of growth parameters of Kawakawa and frigate tuna. Due to low catches the information available on oriental bonito was on their distribution only.

Billfish, being a non targeting fish group in any fishing method it has not been studied in depth and therefore available information too is very few. De Bruin (1970) discussed the distribution of some large pelagic fish species within and beyond the continental shelf. Billfish were included in the results of experimental gillnet fishing carried out during 1966 to 1968. Jiradase (1985) has reported on the species composition, size range and abundance of sailfish and marlins caught in the waters off Negombo. The percentage compositions of billfish in the tuna gillnet fishery has been reported by Joseph et al (1985) and Joseph and Noiyadeen (1986). The major seasonal contribution of

billfish by different gears for the fishery in south and west coast of the Island were reported by Joseph and Amarasiri (1986). Only one published paper is available on seer fishery by Jindalas (1984), reporting species composition, the age structure, maturity and size range of Scomberomorus commersoni in the catches North of Negombo (west). Joseph et al. (1985) estimated the percentage composition of seer fish in tuna gillnet fishery.

This paper reviews some different aspects related to small tuna species, billfish and seerfish including resource and methods of exploitation, production, seasons, biology, distribution of main species and research and development activities.

Fishing gear and crafts

Neither the small tuna species, billfish nor seerfish are target species for any local fishery except in troll with multiple hooks for tunas (Joseph and Amarasiri, 1985). However these species are caught as incidental catches in many fisheries. Gillnet is the dominant gear in the study area while troll, and pole and line are important only in south-west and south, and are the main gears for capture of small tuna species. In addition to these beach-seine and purse-seine fishery also contribute a certain amount but in small quantities.

The bulk of the billfish catch comes from gillnet, troll with large hooks (Joseph and Amarasiri, 1985) and longline which is mainly carried out in west, south-west and south. The contribution from trolling is small compared to others. Seer fish production for any fishing method is relatively low but main production comes from gillnets and handlines. Small quantities of smaller varieties of seerfish such as Scomberomorus guttatus, S. leniolutus are caught by beach-seine.

The fishing fleet involved in different fisheries in Sri Lanka consist different kinds of crafts. Gillnetting conducted mainly by 32 feet (11 meter) boats and 9 meter (3.5 CT) class boats. These gillnetters usually carry 20 - 25 pieces of net onboard with mesh sizes ranging from 4" - 6". The 5 - 6 meters TRP boats with out-board engines and mechanised traditional crafts carry 5 - 10 pieces of net with 14" - 30" mesh size range. These crafts aim at small varieties such as makarels and

small tuna species. In addition 11 meter class "boat and 9 meter class" boats operating in west coast carry 20 - 30 hundred of longline combination with gillnet. Troll and pole and line are mainly conducted by 9 meter boats, but a few mechanised traditional crafts are also engaged.

According to statistics of ministry of fisheries, 57% of the small tuna species classified under "other blood fish" were landed by 9 meter class of boats and 11 meter boats during 1983. Nine percent is recorded from crafts with out board engines and 4% recorded from non mechanised traditional crafts.

Billfish categorised under sailfish, are recorded as boatwork caught up to 73.1% from craft with inboard engines and 17.3% and 9.5% respectively from crafts with outboard engines and non mechanised crafts. Statistics for production by crafts for seer fish were not available, but the production mainly comes from in-board engine boats. Total number of registered boats in 1985/86 consisted of 2717, 9 meter boats and 80, 11 meter boats. Due to considerable effort from 9 meter class⁴ boats which contribute the major portion of production of these three major fish groups, this study is directed on 9 meter class boats.

Study area and sampling strategy

The study area is restricted to north - west to south coast of Sri Lanka. This area covers Fisheries Administrative Areas (District Fisheries Secretariat offices), Pottalam, Chilaw, Negombo, Colombo, Kalutara, Galle, Matara and Tarkalle. The 14% were within the study area (Joseph and Moyadren, 1986). After 1983 due to disturbance in North and East Coasts, most of the boats keep on coming to west coast. An average of two days coverage per fortnight sampling visits were made on selected 14 major landing sites. The three major sites covering north-west, west and South-West were covered every other day for detailed catch and effort data.

Results

1. Effort and catch per unit effort

Effort conducted through varied gears such as gillnet, troll, pole and line and longline and handline is considered in terms of boat days for 9 meter class of boats, irrespective of which of the above gear is used. Each fishing trip lasts less than 24 hours. Monthly effort was separately

calculated for each fishing method, considering that each boat operated 22 days per month, except in pole and line fishery. Due to unavailability of bait, pole and line boats on an average operate only 15 days per month. The relative importance of each gear and the catch of these three major fish on the basis of fishing effort for the study area during the period 1984 - 1986 is given in Table 1.

The gillnet is dominated in all sub-areas while troll, pole and line, longline and handline are more popular in south and south-west areas. The combined gillnet and longline gear is mainly used in west. The longline are generally set to catch particularly large yellowfin, bigeye inhabiting sub-surface waters. The method of hand line is not contributing much to catches of small tuna species and billfish but it is apparently important for seer fish production.

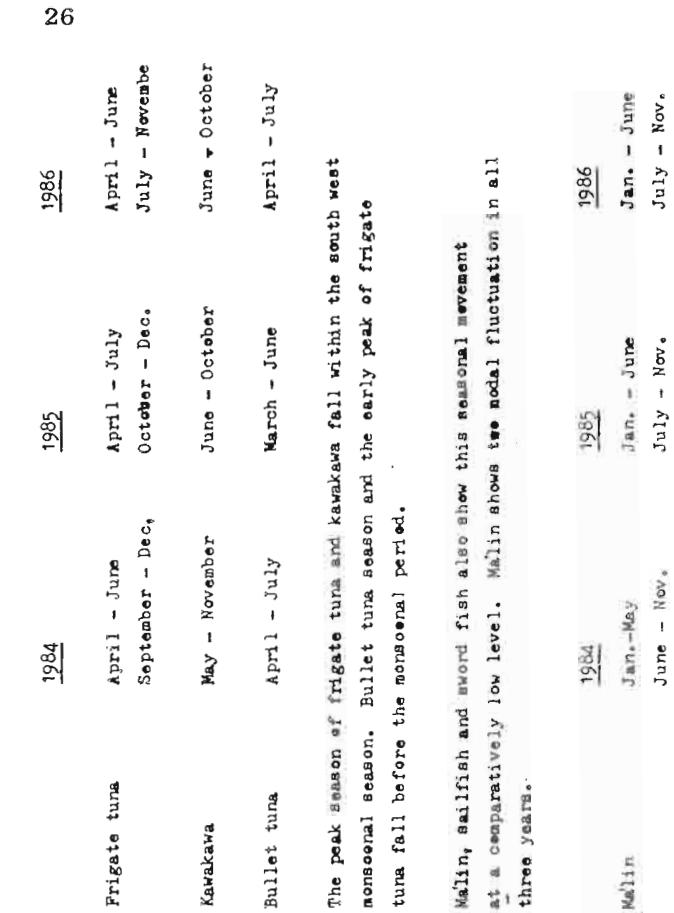
A seasonal variation in the relative importance of different gears, gillnet, troll, pole and line, longline and handline are observed mainly in south-west and south areas. The monthly variation of fishing effort by these gears in south - west and south for 1984 to 1986 is given in Fig. 2.

Gillnet and trolling operate through out the year, but during south-west monsoonal period, (May to October), the activity of gillnetting dominate others, trolling being conducted intensively during non-monsoonal months. Pole and line, longline and hand-line fishery are highly seasonal. The season falling within the non monsoonal months from November to March/April. The efficiency of each fishery on small tuna, billfish and seer-fish were estimated using average catch rates (Table 2,a,b,c). High catch rates for small tuna were observed by troll and pole and line because these are mainly directed towards pure schools of these species. Trolling with multiple hook is the target for small tuna species. Gillnet show moderate efficiency due to the fact that most of the nets being 5" to 6 3/4" mesh range (Joseph et al., 1985), which are generally aimed for large species such as skipjack and yellowfin.

Gill net, combined gillnet/longline and longline are the most effective methods for billfish catches because these methods are aimed at surface or sub-surface scattered large offshore species. Seer-fish show relatively low catch rate for all fisheries, but production mainly comes by gillnet and handline. The contribution by other gears are not significant.

The mean monthly CPUE estimated for all fisheries within the study area for different species of small tuna and billfish and seer-fish are given in Fig. 2, 3 and 4.

All three fish groups seems to be following a seasonal pattern with nodes around regular intervals. Two distinct nodes of high CPUE values for frigate tuna have been observed in all three years. The latter nodes was more dominant in 1985 and 86. Kawakawa and bullet tuna show only one clear node in a year.



The seasonal node of high CPUE values for marlin fall at the beginning of the year during non monsoonal period. Seer fish also show clear seasonal pattern of catch rate distribution and consists of two nodes January - March/April and July - October. The node around the end of the year is more dominant than the former.

2. Catch and species composition

Total production of small tuna, billfish and seerfish by the 3.5 GT class of boats has been estimated utilising the monthly mean catch per unit effort values and the monthly total effort estimated for each sub area. Estimates of total production was made separately for different types of gears. (Table 3, a, b, c). Though catch rates of small tuna species in pole and line fishing is higher than gillnet, the proportion of production from gillnet and trolling is higher than any other fishing method. Table 3(b) and 3(c) show similar characteristics in distribution. Table 3(a) differs from these distributions basically because of high production on troll. The higher percentage of troll has reduced the higher gillnet percentage. The high incident of troll in small tuna species is due to the fact that troll is used as a directed fishing method for small tuna where as other fishing methods produce only incidental catches. (Table 2).

The catches of billfish and seerfish is mainly from gillnet and is higher than that from any other fishing method. Estimates of total production made separately for small tuna billfish and seerfish in different sub areas for the year 1984 to 1986 are given in Table 4a, b, c.

The bulk of the production of small tuna species, billfish and seer fish comes from south and south west areas.

Small tuna species occur in mixed schools, restricted to waters over and immediately continuous to the continental shelf. Among this multipelagic group, kawakawa (*Bathyurus affinis*) Frigate and Bullet tuna (*Auxis thazard* and *A. rochei*) dominate in the small tuna catches made around Sri Lanka. Oriental bonito (*Sarda orientalis*) and longtail tuna (*Thunnus tonggol*) contribute in small quantities, but dogtooth tuna, (*Gymnogeards unicolor*) are occasionally reported in commercial catches.

Billfish catches are also multispecies in composition. Six species have been identified in local commercial catches. They are sailfish (*Istiophorus platypterus*), Sword fish (*Xiphias gladius*) and three species of marlins, Black marlin (*Makaira indica*), Blue marlin (*M. nigricans*) and striped marlin (*Tetrapturus audax*). In addition rare sighting of short bill spearfish (*I. angustirostris*) also have been reported.

The group of fish commonly called as seer fish consist of four species, and the fishery take place in the coastal area, and in the fringes of the offshores range.

King mackerel (*Scomberoides commersoni*) and wahoo (*Acanthocybium solandri*) are the dominant species in the landings, but (*S. guttatus* and *S. lineatus*) are also found in small quantities.

3. Production

The estimated total fish production in 3.5 GT class boats in the study area in 1984, 85 and 86 was 15227.8c, 21871.2t and 59446.7t. Small tuna species, billfish and seerfish, in total contribute 39.8, 26.0, 11.0 percent to the total fish production respectively in 1984, 85 and 86.

Production percentages of different species of small tuna, and different categories of billfish and seerfish are given in Table 5. A marked increase is shown in small tuna catches from 84 to 85 and quite a drop in billfish catches in the same period. The changes in percentage composition is mainly attributable to the drop in marlin production. The indications are that except for the marlin production, the other varieties show a growing production potential.

The seer fish production show increasing tendency, but it is relatively low. There is also a noted decrease in the bullet tuna harvest.

The detail species break down in marlins and seer fish summarised for the period of August 1986 - July 1987, are listed below.

Number of individuals caught					
	Kandakuliya	Negombo	Beruwala	No.	Percentag
Blue marlin	201	51.3	602	51.9	1969
Black marlin	176	44.9	496	42.7	1310
Striped marlin	15	3.8	63	5.4	101
Total	392		1161		3380
<i>Scomberesox commersoni</i>	1133	83.6	7884	91.6	7354
<i>S. guttatus</i>	-	-	300	3.5	57
<i>S. lineatus</i>	142	10.5	3	0.03	34
<i>Acanthocybium solandri</i>	81	6.0	421	4.9	1617
Total	1356		8608		4067

The individual fish count for marlins indicates the three landing sites to have a similar distribution. This similarity is somewhat dististed in the seerfish distribution. In case of distribution of marlin, it is quite possible that all the three landing sites collect their harvest from one same stock of marlins. The extra-ordinary low count for striped marline would be either the striped marlins are generally rare in the waters around Sri Lanka or that the fishing gear used is not very effective on them.

In the distribution of seer-fish individual counts, it is very clear that *S. commersoni* is the dominant species caught and the contribution of the other species are very low.

Seer-fish distribution could be evaluated on the basis of the dominant species, *S. commersoni*, as contribution from other species are relatively very low.

Small tuna and billfish production estimated for 1984 to 1986 have been pooled and used to calculate the percentage composition of different varieties of small tuna and billfish for different gears. The results are presented in Table 6, a and b.

Small tuna catches in gill net and pole and line consist mainly of frigate tuna while kawakawa is dominant in the catches of trolling and hand line. Bullet tuna shows high catches in combined gillnet/longline, and moderate catches in gillnet, marlin catches mainly occur in gillnet, troll and longline and moderate catches in gillnet. Marlin catches mainly occur in gillnet, troll and longline, where as sailfish shows high percentage of catches in handline and moderate catches in troll. Presence of sword fish in the combined gillnet/longline, fishery is high but moderate catches are shown in gillnet and longlines.

Discussion

Small tuna species contributed 12.3, 15.8, 6.1 percent to the total tuna production in the study area during 1984, 85 and 86 respectively. Due to high catch-rates and being valuable to most fishing gears such as gillnet, troll, pole and line, handline, purse-seine and beach-seine they are an important place in the marine fishery. The island's production of small tuna in 1983 was 9383 (t) and 1985 6298 (t) (source - Ministry of Fisheries). This reduction was mainly due to low fishing effort in the East Coast, where civil disturbances took place. The catch rates realised in the gill net fishery for small tuna are low in the study area compared to those realised in the troll and pole and line fishery, but the production mainly comes from gillnet and trolling. The effort applied for troll fishery is lower than gillnet, trolling is targeted for malli tuna which gives a high production rate than gillnet, which is aimed at larger species.

The estimated production for different areas show decrease towards north (Table 4). High productions are recorded from south and south-west because the effort applied for small tuna fishery is high.

Sivasubramaniam (1970) has observed two peak seasons for Kawakawa in the troll fishery off south-west. January to March and July to September; but in the present study, one peak season is observed during June - Oct. (Fig. 2). For Auxis sp. high catch rates in the gillnet fishery have been recorded within the south west monsoonal period, from May - Oct. This observation falls in line with the two peak seasons observed for frigate tuna in Fig. 2. The most dominant season is more toward the tail end of the south west monsoon. Bullet tuna show a peak season at the beginning of the south west monsoon.

Sivasubramaniam (1973) estimated that Auxis sp. contributed 15% by weight to the total annual tuna landings in the country with frigate tuna and bullet tuna contributing 92% and 6% respectively. In the present study, within the study area Auxis sp. contributed 6.7, 8.5 and 6.1 percent to the total tuna production during 1984, 85 and 96 period, respectively. The overall ratio of frigate tuna and bullet tuna in the catches has been approximately 8:1. This is due to increased popularity of 1.5 GT class of boats particularly from 1970 onwards and there has been an increased exploitation of large tuna species.

The relative importance of different fisheries for the production of small tuna varieties show gillnet and pole and line are effective for frigate tuna catches. Troll and handline fishery are important for Kawakawa production while bullet tuna is more prominent in combined gillnet/longline fishery. This indicates some pattern of distribution of these species.

Kawakawa is more vulnerable to gears which operate within inshore waters and frigate and bullet tuna are more common in the gears operating in the offshore areas.

According to Sivasubramaniam (1970), major recruitment of Kawakawa to the exploited stock in south-west, is during the months of June and July and to a small degree during the period November to February. In the case of frigate tuna, the major recruitment in south and south-west coasts occurs between March and August (Sivasubramaniam, 1973). But Joseph et al. (1986) observed small Kawakawa in both gillnet/troll fisheries from May to August and in November/December.

The information on age and growth of Kawakawa and frigate tuna for different fishes has been estimated by Joseph et al. (1986). The ELEFFN I program (Brey and Fauly, 1986) was applied to the length data of Kawakawa and frigate tuna separately. The values obtained for Kawakawa were $L_{\infty} = 59.5$ cm and $K = 0.63$ and $L_{\infty} = 63$ cm and $K = 0.6$ cm respectively for troll fishery and gillnet fishery.

The values for Frigate tuna were $L_{\infty} = 59$ cm, $K = 0.51$ cm for gillnet and pole and line fishery and $L_{\infty} = 58$ cm $K = 0.54$ cm for troll fishery.

The available information on age and growth of Kawakawa and frigate tuna is sketchy and fragmentary. The maximum size and longevity of Kawakawa are not well defined. Yoshida (1979) refers to instances where specimens of over 100 cm length have been reported from Japanese waters, and a specimen of 87 cm length off Mauritius/Seychelles area. Yoshida (1979) has reviewed available information on age and growth of Kawakawa, mainly from Seychelles, Aden and Red Sea areas. The length at age values are 25 - 34.5, 45, 50 - 65, 55 - 65 and 65 - 80 for one, two, three and four and five year old fish respectively. Joseph et al. (1986) has reported length at age of Kawakawa, 28.2 - 38.8, 42.8 - 44.4, 50.6 - 52.9, 54.8 - 57.5 for one, two, three and four year old fish respectively. Silas et al. (1985) obtained values of 0.37 and 81.0 cm for K and L_{∞} for Kawakawa and 0.49 and 63 for K and L_{∞} for Frigate tuna. The available information is not conclusive enough to establish accurate and reliable values for growth parameters of these small tunas and a more directed study would be needed to complete the understanding on these fish.

De Bruin (1970) has recorded the distribution of some major pelagic fish species from continental shelf to offshore waters in Sri Lanka. In the case of billfish, he has observed more of sailfish, shortbill spearfish, striped marlin and black marlin in the gillnet catches made within the shelf and zero of sword fish being caught beyond the shelf. These observations seem to have some relationship with the values in Table 6(b). Marlin dominate the catches of gillnet, troll and longline. Sword fish is relatively high in gillnet/longline combined operations. High catches of sailfish are observed in handline and troll and the contribution from gillnet, longline and gillnet/longline is relatively low. This gives some idea of distribution of these three species. Gillnet/longline combined gear operates in more distant waters than in other.

LONGLINE IS most commonly in operation in south and south west areas and is set for large yellows in inhabiting at the surface waters during non monsoonal periods. The activity of troll and handline are common in the areas within the continental shelf. The high catches of sailfish for these methods indicate sailfish are more inhabiting in the insular waters. Jinadasa (1985) has observed a high percentage of striped marlin composition of marlins and billfish from the catches of combined gillnet/ longline fishery. These are 52.5, 37.8, 5.8 and 3.7 percent for Black marlin, blue marlin, striped marlin and short bill spearfish respectively. Present study shows percentage species composition of 56.2, 40.2 and 3.6 for blue marlin, black marlin and striped marlin respectively. The species composition observed by Korean longliners operated during 1980 - 1983 in the Indian Ocean had high catches of blue marlin than striped and black marlin. Two seasons of high CPUE values in gillnet fishery were observed, in both years 1984 and 85 with seasons falling in February - May and September - December (Joseph and Amarasiri, 1986).

The same pattern of distribution was also observed in the present study with more prominent season being at the beginning of the year than at the tail end.

Jinadasa (1985) has observed that small sailfish of 125 to 150 cm size range are caught in the gillnet fishery off Negombo (west) mostly during the south west monsoon period of May to September. About thirty juvenile sailfish of 36 cm length has been caught in the gillnet fishery on the west coast in November 1985. This seem to fit in with the smallest size range vulnerable to the gillnet fishery during the south west monsoon. The presence of juvenile sail fish in beach seine catches also indicate that spawning takes place in nearby waters, or that there is a movement of this species as reported, to show a strong tendency to approach continental reefs islands and reefs (Nakamura 1985). It is quite probable that spawning occurs in waters close to the Sri Lankan coast.

Spearfish fetch high prices in the local market and therefore it is economically advantageous to concentrate on spearfish though its contribution to production is low compared to other varieties.

Joseph et al. (1986) reported the percentage composition of spear fish in tuna gillnet fishery for different sub areas for the period of April - November 1984 in North-west, West, South-West and south to be 1.9, 6.1, 1.0 and 3.9 respectively. The estimates made in the present study for gillnet fishery is 0.6, 2.4, 2.0 and 1.1 for north-west, west, south-west and south respectively. De Bruin (1970) has reported using the observations of experimental gillnet fishery conducted by 11 tonner boats, that Acanthocybium solandri inhabits the waters beyond the continental shelf while S. commersoni is distributed within the shelf. Due to low catches of A. solandri there exists only a low possibility to expand spearfish production by expanding the range of fishing.

Jinadasa (1984) reported the production of spearfish in west was about 300 (+) but the present study estimates this to be 41, 54.7 and 78.9 (+) during the years 1984, 85 and 86 in west by 3.5 GT class boats. Seasonal distribution of spearfish show two clear peaks (Fig. 4) but the main season is during the south west monsoon from July to October.

Biological and fishery aspect of spearfish had been discussed by Jinadasa (1984). The growth characters of S. commersoni are $L_{\infty} = 178$ cm, $K = 0.2774$ and $W = 12$ kg. The asymptotic weight for S. commersoni is relatively low. Larger fish have been observed mainly in south inshore line fishery during non monsoonal season.

Among the spearfish S. commersoni dominate the catch and consist over 80% of the total catch. A. solandri is the second most common species in the waters around Sri Lanka. Estimates for the island production for small tuna, billfish and spearfish was not attempted because of the incompleteness of data, especially the number of boats operated along the east coast not being well known. Due to recent civil disturbance it appears that most of the boats has migrated to West coast from the east.

The 11 meter class boats introduced from 1982 has increased in number up to 80 in 1987. Though the skippers of these boats are expected to provide information on fishing operations in their returns, such information is almost always incomplete. Therefore it is very difficult to get adequate and accurate informations for the estimation of production.

Due to lack of personnel, the contribution of onboard mechanised craft, mechanised traditional crafts and non mechanised traditional crafts alike were not sampled.

The values for island production was obtained from the estimated values from the Statistical Division of Ministry of Fisheries. According to production in 1984 was small tuna species 7922 (t) billfish 1180 (t) and seabird 3332 (t).

The production of all three fish groups show some reduction from 1983 probably due to the civil disturbances which effected certain fish producing areas.

Table I : Percentage effort on total effort in each fishing gear operate in each sub-area

	Fishing gear					Total
	Trolling	Gill net	Gill net/longline	Longline	Pole & line	Hand line
<u>1984</u>						
North-west	-	100	-	-	-	-
West	-	76.4	23.6	-	-	-
South-west	19.4	74.5	-	-	0.5	5.4
South	35.6	57.2	-	0.9	4.5	1.7
<u>1985</u>						
North-west	-	100	-	-	-	-
West	-	78.0	22.0	-	-	-
South-west	28.6	65.2	-	-	2.8	3.4
South	33.4	56.6	-	0.1	9.9	-
<u>1986</u>						
North-west	-	100	-	-	-	-
West	-	74.0	24.1	-	-	-
South-west	17.7	73.7	-	7.0	1.1	0.4
South	34.3	53.2	-	6.7	5.1	0.7

Table 2 (a) : Average catch per unit effort of small tuna species for different years compared with total catch per unit effort

Gear	Total CPUE	Total small tuna CPUE	Total small tuna	Total CPUE	Total small tuna	84	85	86
Gill net	107.7	5.7	136.0	9.3	191.3	9.3		
Gill net/ Long line	203.3	3.5	172.7	0.3	166.4	1.3		
Long line								
Long line	30.6	-	4.4	-	76.5	-		
Trolling	37.7	18.9	36.0	23.5	72.8	32.8		
Pole and line	45.3	10.0	220.8	22.6	84.6	10.1		
Hand line	25.8	0.7	29.2	0.1	41.5	0.5		

2 (b) : Average catch per unit effort of Bill fish for different years

Gear	84	85	86
Gill net	12.9	10.5	17.8
Gill net/Long line	18.8	22.1	26.0
Long line	20.5	3.2	18.9
Trolling	1.3	3.5	12.3
Hand line	-	4.2	2.0

3 (b) : Relative importance (%) of different gear in production of billfish

Gear	84	85	86
Gill net			
Gill net/Long line			
Long line			
Trolling			
Hand line			
Quantity	1394.9 (t)	2589.8 (t)	2778.5 (t)

2 (c) : Average catch per unit effort of seerfish for different gears

Gear	84	85	86
Gill net	2.8	2.7	2.9
Gill net/Long line	0.2	0.1	0.4
Long line	-	-	0.3
Trolling	0.4	0.5	1.1
Pole and line	-	0.1	-
Hand line	1.1	0.6	21.4

3 (c) : Relative importance (%) of different gear in production of seerfish

Gear	84	85	86
Gill net			
Gill net/Long line			
Long line			
Trolling			
Hand line			
Pole and line			
Total	100	100	100
Quantity	340.5 (t)	387.8 (t)	477.2 (t)

Table 5 : Species wise production percentage of small tuna, billfish and seerfish in the study area during 1984 to 1986

Table 4 (a) : Area wise estimated production percentage of small tuna species by 3.5 GT class boats in different sub areas of Sri Lanka - 1984 to 1986

Sub area	84	85	86
North-west	2.1	1.8	1.8
West	5.0	2.3	6.2
South-west	5.3	28.3	46.9
South	5.5	67.6	45.2
Total	1394.9 (t)	2589.8 (t)	2778.5 (t)
Total	1394.9 (t)	2589.8 (t)	2778.5 (t)
Total tuna production	11336.4 (t)	16378.7 (t)	25202.6 (t)

4 (b) : Area wise production percentage of billfish by 3.5 GT class boats in different sub areas of Sri Lanka 1984 to 1986

Sub area	84	85	86
North-west	1.9	5.4	6.9
West	7.9	15.7	12.0
South-west	19.0	44.8	35.5
South	71.1	34.2	45.7
Total	4187.8 (t)	2714.8 (t)	3259.6 (t)

4 (c) : Area wise estimated production percentage of seerfish species by 3.5 GT class boats in different sub areas of Sri Lanka 1984 to 1986

Sub area	84	85	86
North-west	3.9	6.2	2.0
West	12.1	14.1	16.5
South-west	47.0	17.1	33.5
South	37.0	62.4	47.2
Total	240.5 (t)	387.8 (t)	477.2 (t)

Table 6 (a) : Relative importance (%) of small tuna species in different fisheries
1984 to 1986

	Gill net	Gill net/Long line	Trolling	Longline	Handline
Frigate Tuna	50.7	26.8	40.1	79.8	-
Kawakawa	40.1	9.9	57.1	20.2	100.0
Bullet Tuna	8.5	62.4	2.8	-	-
Other	0.7	0.9	0.02	-	-

Table 6 (b) : Relative importance (%) of billfish varieties in different fisheries
1984 - 1986

	Gill net/ long line	Trolling	Longline	Handline
Mahi	74.7	51.1	66.5	72.4
Bail Fish	17.4	13.5	32.3	17.0
Sword Fish	7.9	35.4	1.2	10.5

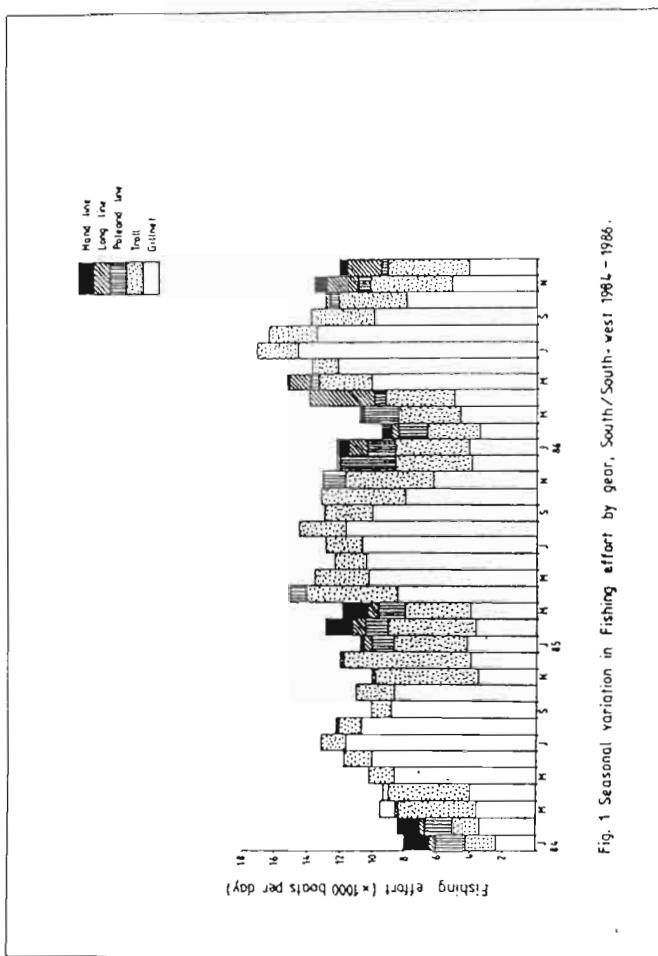


Fig. 1 Seasonal variation in Fishing effort by gear, South/South-west 1984 - 1986.

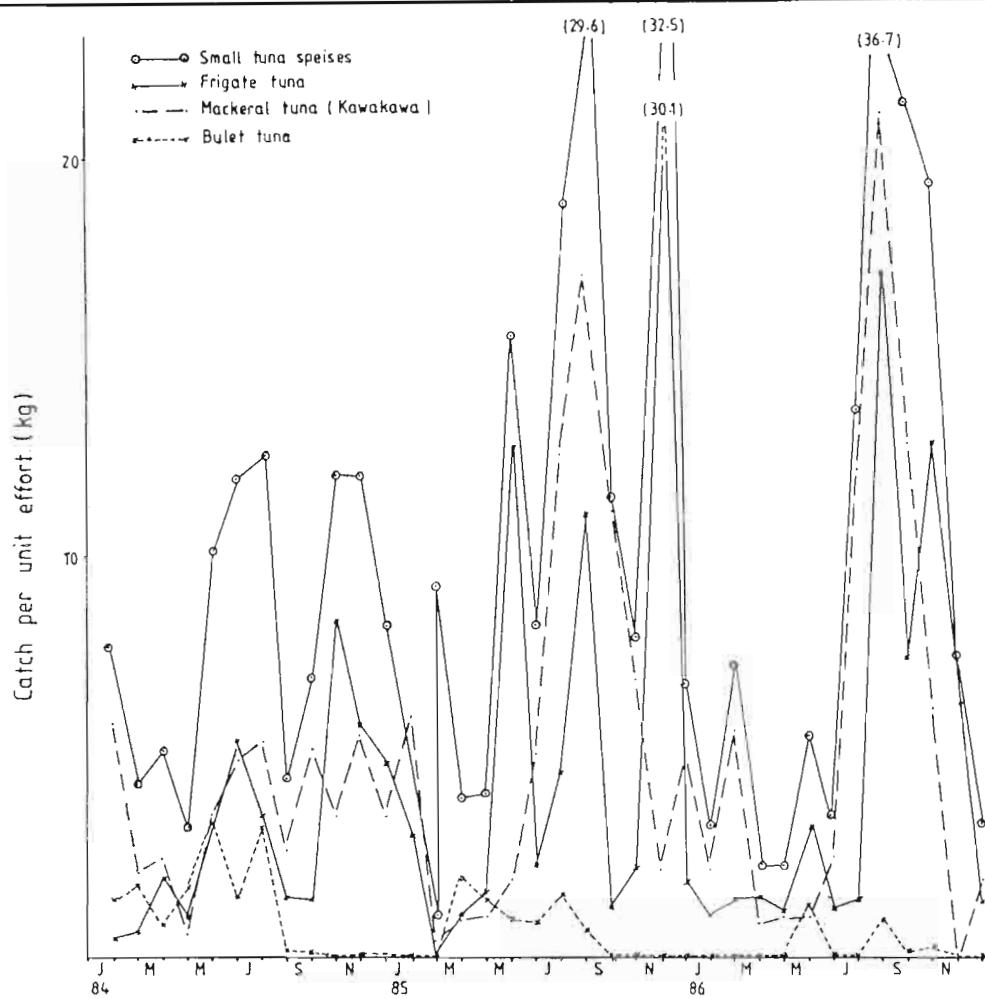


Fig. 2 Seasonal variation of Catch per unit effort of Small tuna speises 1984 - 1986

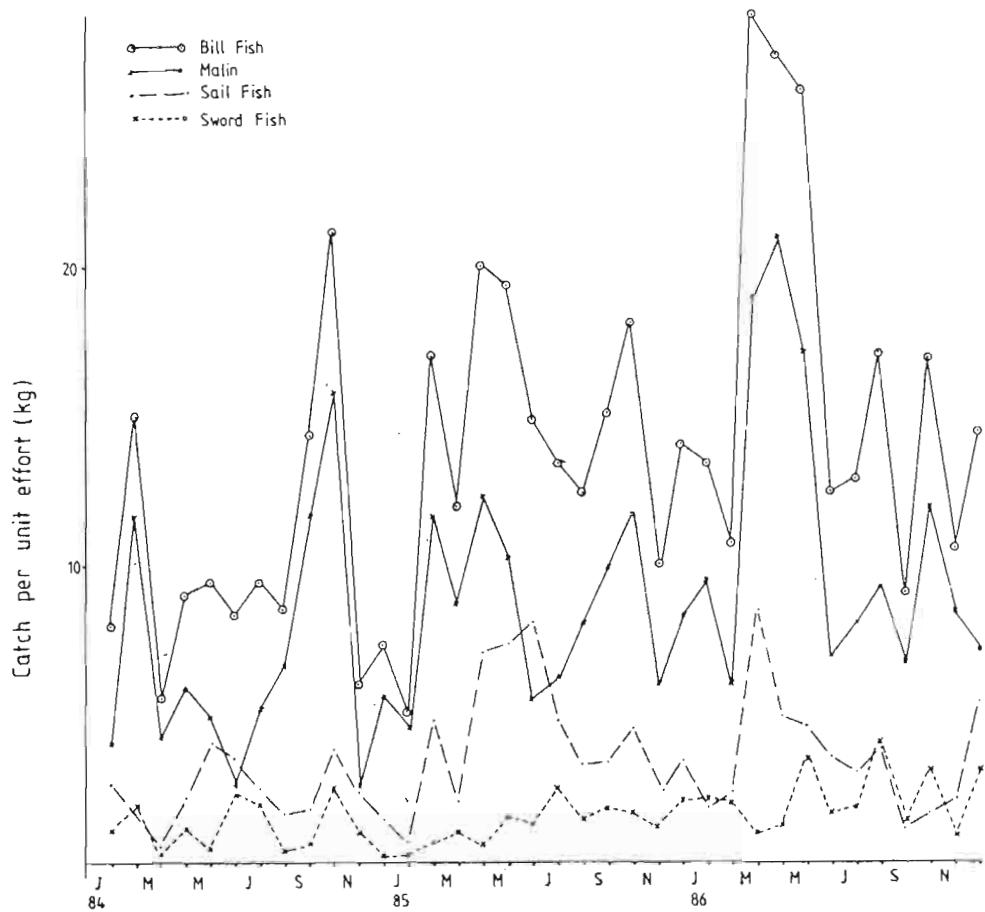
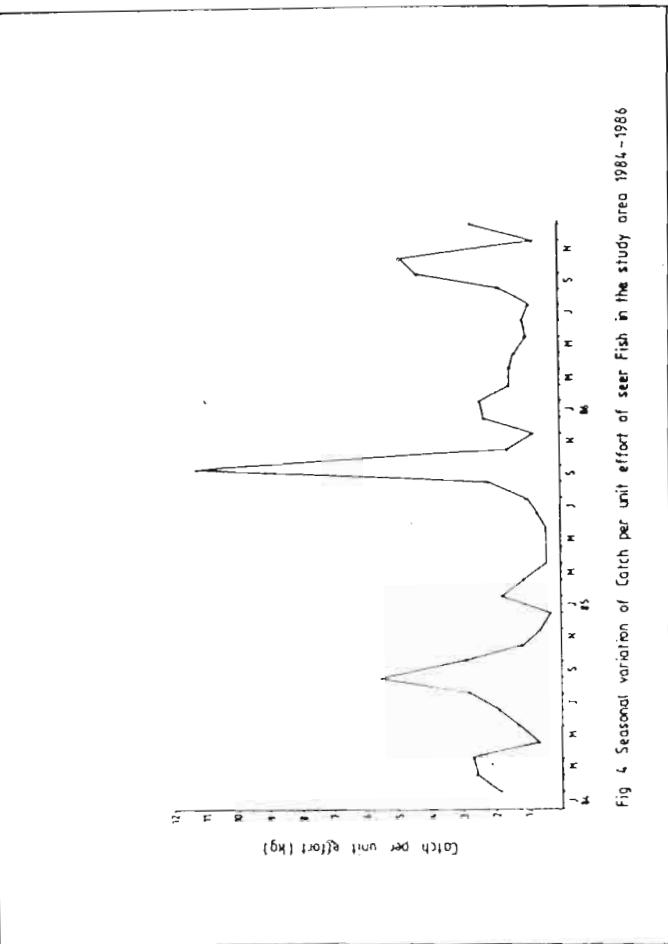


Fig. 3 Seasonal variation of Catch per unit effort of Bill Fish in the study area 1984-1986.

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Introduction

Fisheries and tourism are the only two income generating activities of major significance in the Maldives. Fishing is especially important because it offers the only source of employment on most of the 202 inhabited islands and because it provides the preferred source of protein for the population. The catch is dominated by tunas and tuna-like species. While skipjack and yellowfin are the most important species, small tunas, seerfishes and billfishes also make significant contributions. The species concerned include frigate tuna (*Auxis thazard*) eastern little tuna or kawakawa (*Euthynnus affinis*), dogtooth tuna (*Gymnosarda unicolor*), wahoo (*Acanthocybium solandri*) and sailfish (*Istiophorus platypterus*). The fisheries for these species have previously been reviewed by Anderson and Hafiz (1986, 1987.)

Virtually all fishing is conducted from locally built wooden craft of which there are three main types: masdhonis, vadhu dhonis and bokkura. Mas dhonis are sleek vessels of 8 - 12 m length from which live bait pole and line fishing for oceanic tunas is conducted. They were traditionally sail powered, most being lateen rigged (vessels from some southern islands are square rigged.) Since 1974 - 1975 the major part of the masdhoni fleet has been mechanized (using inboard diesel engines, most frequently of 30 HP) Vadhu dhonis are smaller versions of masdhonis, being about 5 - 7 m in length. Traditionally sail powered, increasing numbers are now being mechanized with small inboard engines. Vadhu dhonis are mainly used for trolling within or close to the atolls. Bokkuras are rowing boats, usually about 2 - 4 m in length. Mechanization of these vessels is just starting: bokkuras based in Male' are now powered by small (1 - 4 HP) outboard engines. Fishermen use bokkuras for drop-lining, ^{WEAK TACKLE} and angling for scads (*Carangidae*) in lagoons. Fishing vessels statistics are presented in Table 1.

The statistical collection system

There is a well developed system for the collection of catch and effort statistics in the Maldives. On each inhabited island

daily records are kept of the number of vessels that go fishing and the number of fish caught by each. Major tuna species are recorded individually but most other species are lumped together as "reef fish." Despite some problems this system is felt to give reasonable results, at least for the main tuna species. Because catches are recorded in numbers of fish, conversion factors are needed to estimate weight of catches. There is room for substantial errors here. Since 1976 a conversion factor of 0.95 kg per fish has been used for both frigate and little tuna. Market sampling in 1986 suggests that the weight of catches of frigate tuna may have been over estimated, while those of little tuna may have been under estimated, since conversion factors of 0.6 kg and 1.4 kg per fish have been utilized (Anderson et al., 1987). Similarly a conversion factor of 2 kg per fish has been used for dogtooth tuna, while one of about 6 kg per fish might be more appropriate. (Note, however, that these figures are based on sampling at Male' only.) Catch estimates for 1986 presented here are official figures based on the old conversion factors.

Frigate tuna

Frigate tuna (Auxis thazard) is known in the Maldives by the local name "ragodi." It is the third most important species landed, after skipjack and yellowfin tuna. Its accounts for an average of nearly 10% of the total recorded catch. Catches by vessel type for the years 1970 - 1986 are presented in Table 2 and Fig. 1. Annual reported catches have varied quite markedly about a mean of roughly 3000 MT. The highest reported catch was 6626 MT in 1973, the lowest was 1595 MT in 1980. There is no immediate explanation for this variation. There is no evidence that variation in catch is a direct reflection of variation in fishing effort. It might therefore be supposed that catch variation is a result of variation in frigate tuna abundance or catchability. Since high catches of frigate, little and yellowfin tuna (but not skipjack) were all obtained in 1973 and in 1983, some oceanographic agency (possibly related in some way to the El Nino phenomenon) might be involved.

Catches of frigate tuna have been measured on a regular basis at Male' market since September 1985. The data collected are summarized in Fig. 2. Most fish measured were within the range 26 - 44 cm FL. The largest individual measured was 49 cm FL. There is a complex pattern of modal movements from one month to the next: there are periods of modal progression, modal regression and modal stasis. While modal patterns may to a limited extent be influenced by sampling efficiency, there is clearly a very complex process not only of recruitment and growth, but also of the fish (and their extended spawning). The little tuna data presented

migration going on within the sampled population. While this may not be resolvable by length frequency sampling alone, it will certainly not be resolved by sampling at a single point. For this reason, attempts have been made to initiate length frequency sampling of tuna catches in six outlying atolls.

Bullet tuna

The bullet tuna (Auxis rochei) is very rare in Maldivian tuna catches. Approximately weekly observations at Male' market over a four year period have revealed this species on only two occasions. A single specimen was seen in June 1984, and about a dozen were seen during June - July 1987. All specimens were of the order of 30 - 35 cm FL, and were present among catches of similar sized frigate tuna. Maldivian fishermen do not recognise bullet tuna as a separate species from frigate tuna.

Little tuna

Eastern little tuna or kawakawa (Euthynus affinis) is known in the Maldives by the local name 'latti.' It is the fourth most important fish species landed, accounting for an average of about 3% of the total recorded catch. Annual catches by vessel type for 1970 - 1986 are presented in Table 3 and Figure 1. There seems to have been a general trend towards increasing catches, reaching around 2000 MT during 1982 - 1985. In the cases of skipjack, yellowfin and frigate tunas, pole and line masdhonis account for the bulk of the catch. However, this is not the case with little tuna, for which trolling vadhu dhonis account for an average of just over 60% of the catch. Little tuna is more atlantic associated than the other species, which are more truly oceanic. This might suggest that the little tuna around the Maldives could be considered as a single unit of stock for management purposes. Surplus production model analysis has been carried out on available little tuna catch and effort data. No meaningful results were obtained, in part atleast due to an inability to resolve relevant components of fishing effort.

Monthly length frequency distributions of samples of Male' landings of little tuna for a two year period are presented in Fig. 3. Most little tuna sampled are within the range 27 - 39 cm FL; the largest individual measured was 74 cm FL. As mentioned above in the section on frigate tuna, tuna length frequency data collected at one location will usually be of little or no use in estimating growth rates by analysis of progressing modes (Petersen's method) because of the migratory nature of the fish (and their extended spawning). The little tuna data presented

In Fig. 3 show clear signs of modal progression, but the problem of interpretation remains. For example, between May and December 1986 two separate sets of modes may be followed. One starts at about 29 cm and the other at about 41 cm, but both converge on 49 cm. Growth estimates from both modal sets cannot be correct. One atleast must represent the result of migration as well as growth. While experience may lead one to favour one estimate over the other there is no a priori justification for distinguishing between them. Further more, given that one growth estimate must be biased as a result of migration, there is no way of knowing that the other is not also biased. In other words, the fact that one estimate is wrong does not make another estimate correct.

Dogtooth tuna

Dogtooth tuna (Symnodon aunicolor) is known in the Maldives as 'woshimas'. It is a reef associated species, and is caught in relatively small numbers throughout the Maldives, mainly by droplines and trolling. Separate catch statistics for this species have only been recorded since the beginning of 1984. Recorded catches by vessel type, in numbers of fish were:

	1984	1985	1986
Mechanized masdhoni	48,691	16,632	12,704
Sailing masdhoni	998	2,220	817
Vadhu dhoni	12,593	11,434	8,987
Rowing boat	424	21	114
Total	<u>62,706</u>	<u>30,307</u>	<u>22,622</u>

Given the uncertainties of reporting catches of 'minor species' these data are unlikely to be too precise, nevertheless they do give rough estimates of catches. To date an estimated conversion factor of 2 kg per fish has been used by the Ministry of Fisheries to convert catch numbers to weight. This gives 'official' landings of about 125 MT, 60 MT and 45 MT for 1984, 1985 and 1986 respectively. However, measurements of dogtooth tuna landed at Male' fish market during 1986 suggest that a conversion factor of about 6 kg per fish would be more appropriate (Anderson et al. 1987.)

Length frequency sampling of dogtooth tuna landings at Male' market commenced in October 1985. Data are presented in a summarized form for two 12-month periods in Fig. 4. Most dogtooth tuna landed are within the range 45 - 100 cm FL. A limited quantity of length ..

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weight data have been collected at Male' market, and are also presented in Fig. 4.

Catches of dogtooth tuna displayed for sale at Male' market are nearly always of single specimens, although larger numbers (up to a dozen on one occasion) are sometimes seen together. Underwater observations of this species adjacent to reefs show that it most frequently occurs singly. Of 29 recorded observations of this species, 24 were of single fish, 3 were of pairs, 1 was of 3 fish together, and 1 of 4 fish together. These data contradict an earlier statement (Anderson and Hafiz, 1986) which, on the basis of subjective assessment of observations, suggested that dogtooth tuna were more frequently seen in pairs around Maldivian reefs. Silas (1963) summarizes early observations.

Longtail tuna

There are no records of catches of longtail tuna (Thunnus tonno) in the Maldives. There are reports from fishermen in the northern atolls of unusual varieties of yellowfin tuna which may relate to this species, but no specimens have been seen by qualified fisheries personnel.

Seerfishes

Landings of seerfishes are not separately recorded so accurate catch statistics are not available. Anderson and Hafiz (1986) suggested that as a rough estimate something of the order of 400 MT (+ 100 MT) was landed annually. Observations of landings at Male' fish market demonstrate that catches are composed almost entirely of wahoo, Acanthocybium solandri, with only very occasional specimens of narrow-banded Spanish mackerel, Scomberomorus commerson, being landed. Wahoo is known locally as 'kurumas' (literally, short fish.) Most wahoo are caught by trolling, and find a ready market on tourist resorts and to the expatriate population in Male'.

Length frequency of seerfish landings at Male' market (i.e. essentially only A. solandri) are summarized for 12-month periods in Fig. 5. Most wahoo measured were within the range 90 - 130 cm FL. The largest individual measured was 139 cm FL.

billfishes

Landings of billfishes are not separately recorded so accurate catch statistics are not available. The greatest billfish catch is that of Sailfish, Istiophorus platypterus. These are usually taken within or just outside the atolls by various trolling with

lures, or by towing boats using droplines with live fish bait. Lengths of sailfish landed at Male' market over two 12-month periods are summarized in Fig. 5. Most sailfish are within the range 180 - 230 cm FL; the longest individual measured was 265 cm FL.

Much smaller numbers of other billfish are sometimes caught outside the atolls by mardhoni towing trolling lines. The species involved include the swordfish (Xiphias gladius) and marlins (Kajikia mazara, M. indica, and Tetrapturus audax). Klawe (1980) estimated that Mr. Eastern longliners operating in what is now the Maldives EEZ during 1977 - 1978 took an annual average of 106 MT of billfish. Of this 37% was S. audax, 19% X. gladius, 19% T. audax, and 7% M. indica.

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FAO Fisheries Biology Synopsis No. 75.

TABLE 1. NUMBER OF FISHING VESSELS AND ANNUAL FISHING EFFORT
NUMBER OF DAYS FISHED

YEAR	NUMBER OF FISHING VESSELS			TOTAL FLEET	SAILING MASDHONI	MECH. MASDHONI	TOTAL MASDHONI	VADHU DHONI	MECH. MASDHONI	TOTAL MASDHONI	VADHU DHONI
	SAILING MASDHONI	MECH. MASDHONI	VADHU DHONI								
1970	1929	-	1929	4718	191,421	-	191,421	-	191,421	104,482	
1971	2011	-	2011	2898	4909	169,237	-	169,237	67,378		
1972	2089	-	2089	2986	5075	158,544	-	158,544	76,136		
1973	2146	-	2146	3012	5158	215,278	-	215,278	90,461		
1974	2131	1	2132	3056	5188	203,362	-	203,362	93,504		
1975	2040	42	2082	3156	5236	171,808*	4,200*	176,008	90,100		
1976	1940	218	2158	3284	5442	153,539*	21,800*	175,339	135,031		
1977	1801	413	2214	3385	5599	104,943*	41,300*	146,243	157,949		
1978	1631	548	2179	3390	5569	53,739*	54,800*	108,539	176,878		
1979	1485	767	2222	3386	5638	24,615	74,904	99,519	132,903		
1980	1255	805	2060	3416	5476	16,877	83,134	100,011	136,934		
1981	1061	970	2031	3364	5395	13,852	83,731	97,582	130,362		
1982	952	1166	2118	3428	5346	10,036	97,085	107,121	132,342		
1983	811	1231	2042	3448	5490	6,339	117,172	123,511	118,639		
1984	651	1296	1947	3021	4368	6,220	153,460	159,681	108,314		
1985	561	1202	1763	3115	4878	4,681	162,430	167,111	110,061		
1986	507	1358	1865	3278	5143	3,354	161,910	165,264	79,139		

* Estimated

Anderson R. C., A. Hafiz, S. Mohamed and M. Faiz (1987). The average weights of tuna species landed at Male' Market in 1986.
13 pp. Ministry of Fisheries, Male'.

Klawe W. L. (1980). Longline catches of tunas within the 200-mile economic zones of the Indian and Western Pacific Oceans.

Rev. Rep. Indian Ocean Programme (48) : 83p.

Silas E. G. (1963). Synopsis of biological data on dogtooth tuna

Gymnuridae unicolor (Ruppell) 1838 (Indo-Pacific).

FAO Fisheries Biology Synopsis No. 75.

Fisheries Biology Synopsis No. 75.

TABLE 2. FRIGATE TUNA CATCHES IN THE MALDIVES BY VESSEL TYPE, 1970 - 1986 (MT)

YEAR	VADHU DHONI	SAILING MASDHONI	MECHANIZED MASDHONI	TOTAL MASDHONI	TOTAL
1970	248	2775	-	2775	3203
1971	166	2849	-	2849	3015
1972	182	3004	-	3004	3186
1973	186	6440	-	6440	6626
1974	202	5804	-	5804	6006
1975	163	3713*	181*	3894	4057
1976	289	1971*	448*	2419	2707
1977	264	1863*	953*	2816	3080
1978	206	720*	735*	1455	1661
1979	272	435	994	1429	1701
1980	304	207	1084	1291	1595
1981	309	141	1156	1297	1606
1982	231	80	1750	1830	2061
1983	351	141	3048	3189	3540
1984	338**	66	2701	2767	3105
1985	683**	70	2071	2141	2824
1986	339**	130	1309	1439	1778

* Estimated

** Includes catches by rowing boats

TABLE 3. LITTLE TUNA CATCHES IN THE MALDIVES BY VESSEL TYPE, 1970 - 1986 (MT)

YEAR	VADHU DHONI	SAILING MASDHONI	MECHANIZED MASDHONI	TOTAL MASDHONI	TOTAL
1970	402	242	-	242	644
1971	253	220	-	220	473
1972	343	253	-	253	596
1973	514	574	-	574	1088
1974	433	397	-	397	830
1975	268	140*	7*	147	415
1976	762	157*	34 *	191	953
1977	767	112*	48 *	160	927
1978	634	78*	55*	133	768
1979	543	94	79	173	721
1980	768	104	191	295	1063
1981	871	119	284	403	1274
1982	1044	172	671	843	1887
1983	1094	98	895	993	2087
1984	1019**	49	646	695	1714
1985	1267**	99	811	910	2177
1986	572**	23	476	499	1071

* Estimated

** Includes catches by rowing boats.

FIG.1 ANNUAL PRODUCTION OF LITTLE AND FRIGATE TUNAS IN THE REPUBLIC OF MALDIVES, BY VESSEL TYPE

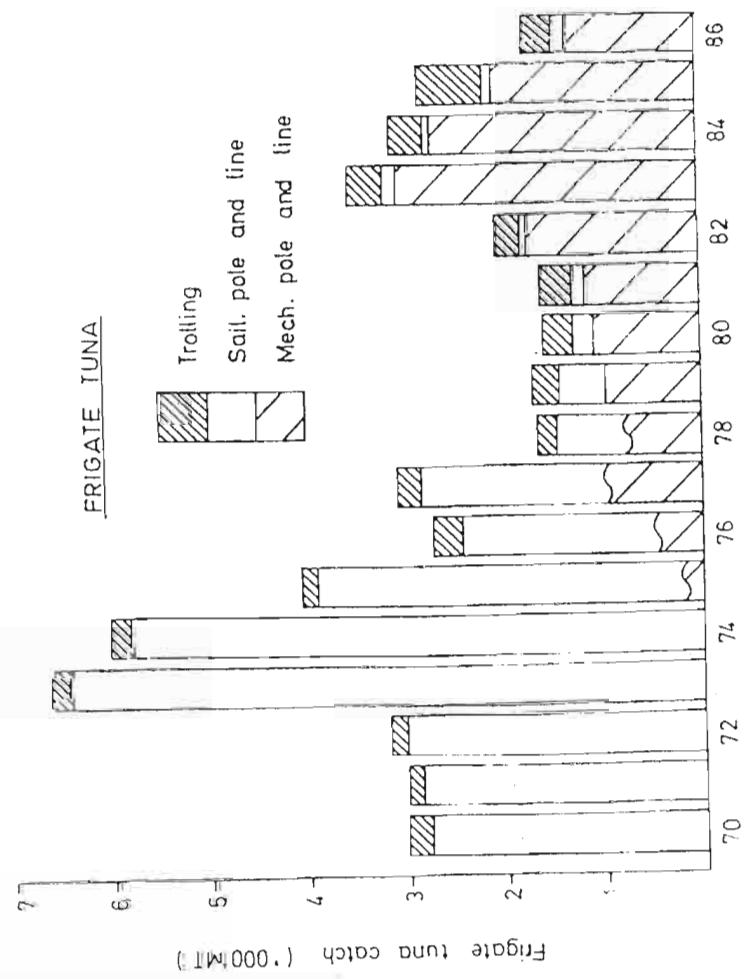


FIG.2 Frigate tuna — length freq. distributions of Malé landings

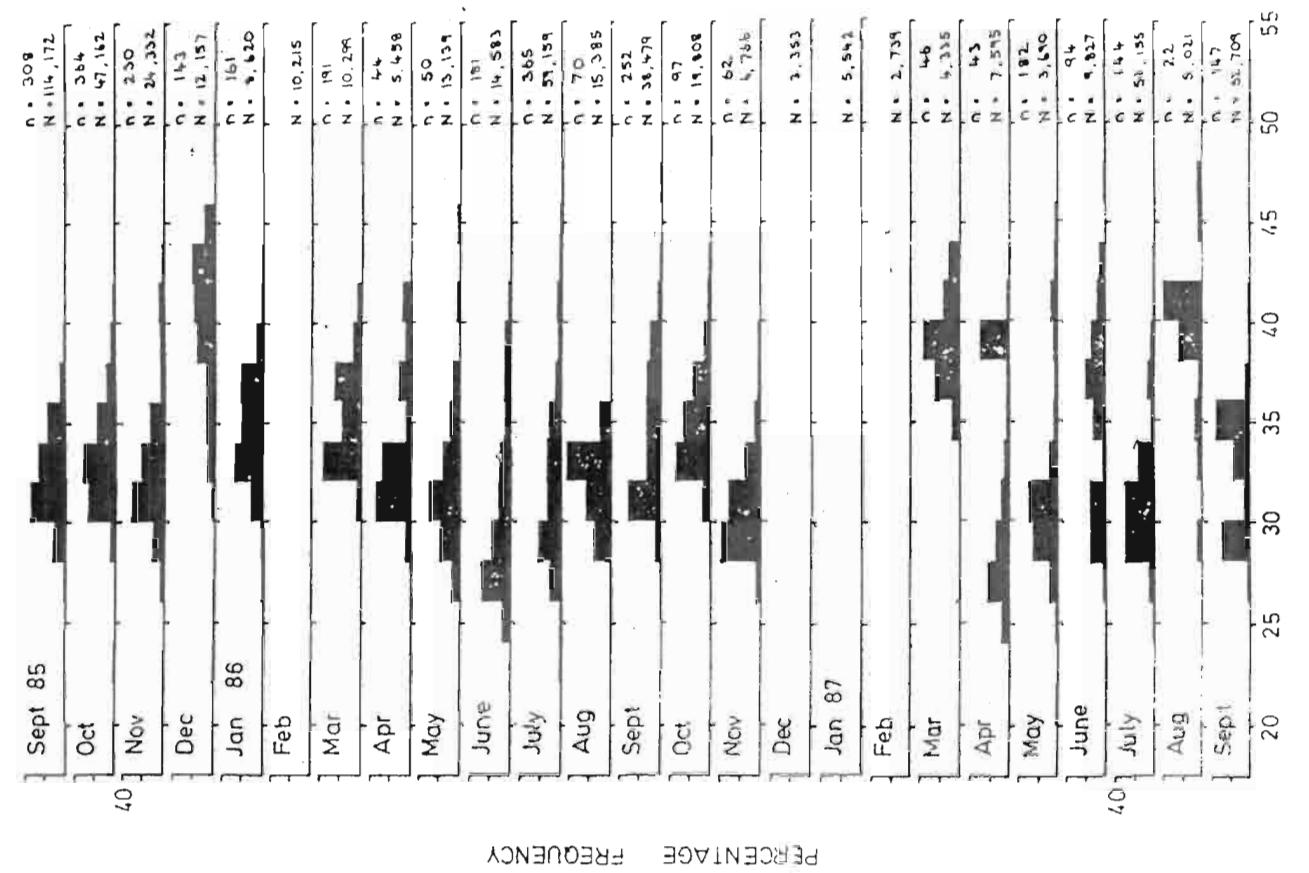


FIG. 3 Little tuna — length freq distributions of Malé landings

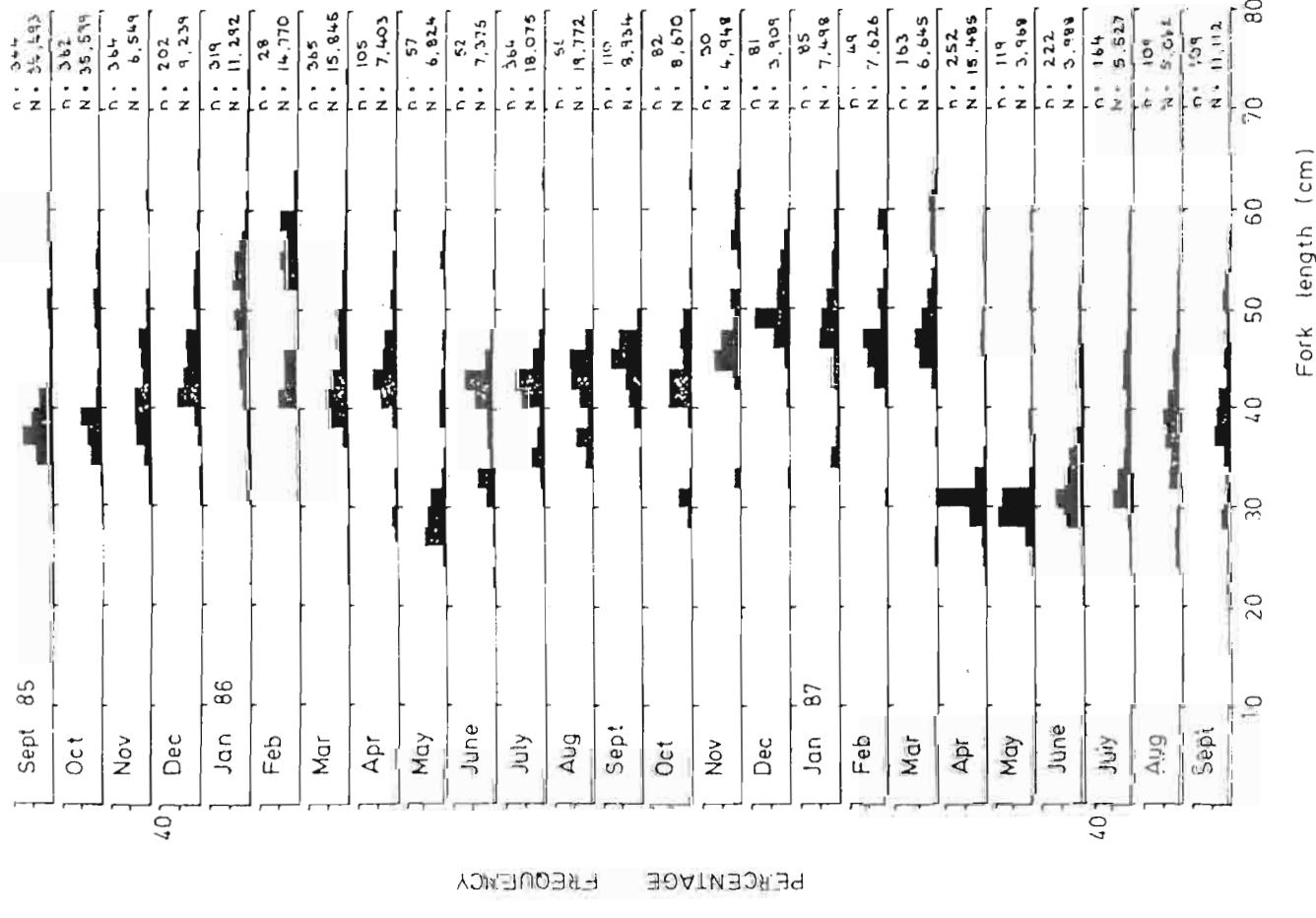


FIG. 4 Dogtooth tuna — length frequency and length-weight summaries

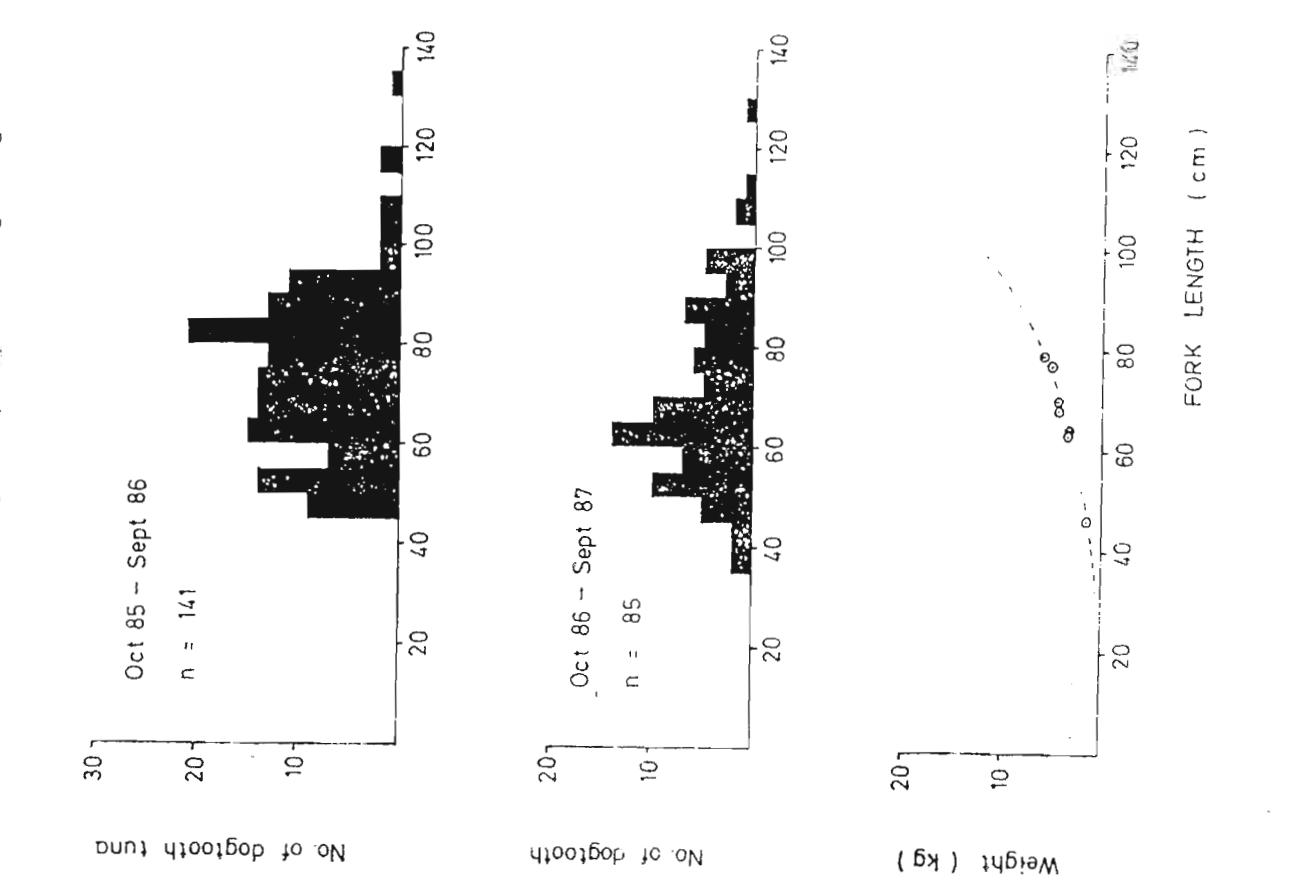
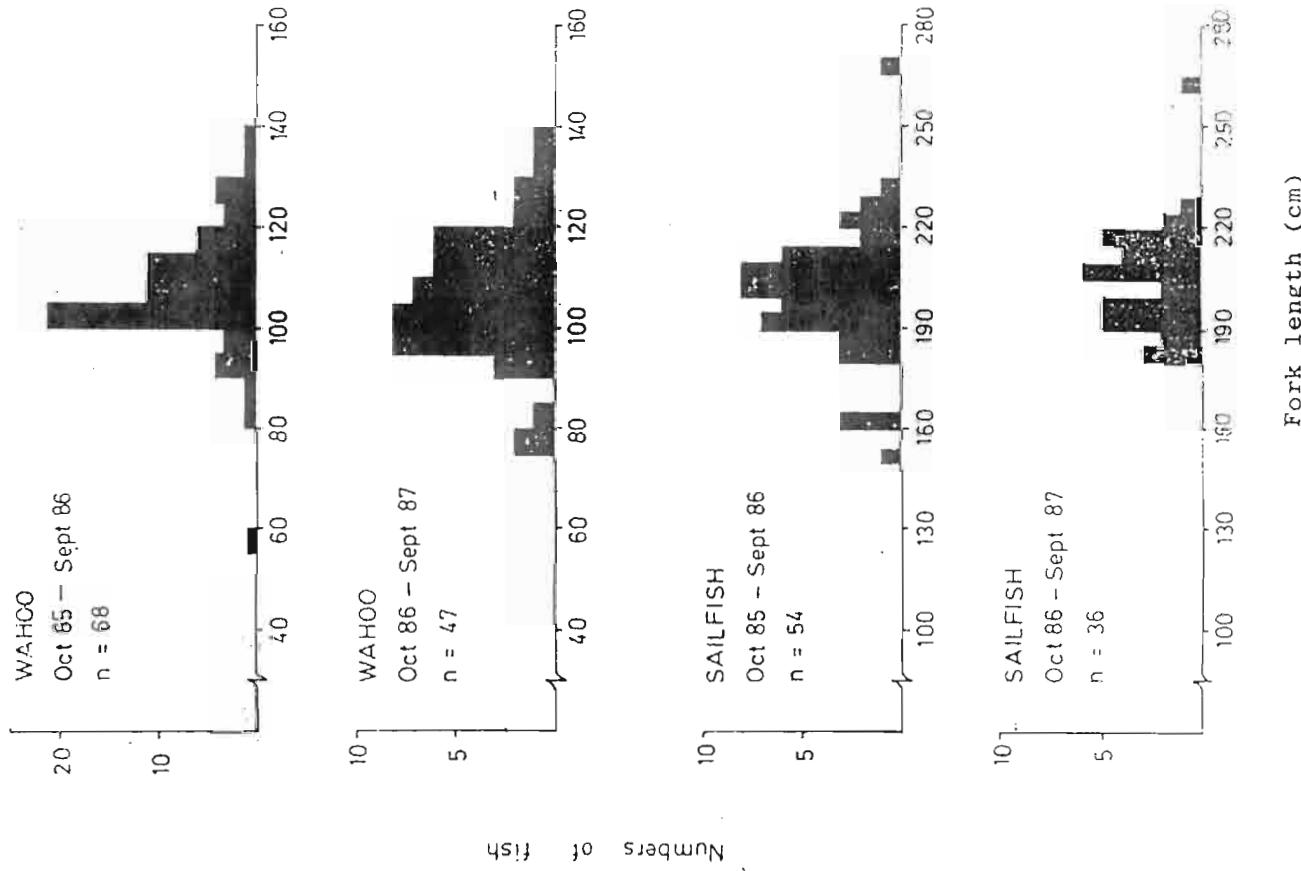


FIG. 5 Length freq. of wahoo and sailfish landed at Molé



common between 4 and 7 kg off Western Australia (Robins 1975) and around 7 kg off north eastern Queensland. Frigate tuna grow to at least 43 cm fork length (1.6 kg) off northern Australia.

Surface schools of longtail tuna and kawakawa are a common sight in northern waters. This has led to speculation about the potential of a fishery based on these species. An aerial survey of surface schooling tunas off northern Australia indicated that most schools are small, probably less than 2 tonnes in size, and are often widely scattered (Lyle and Read 1985). These factors are seen as constraints to the development of a fishery targeted on tuna. West and Wilson (unpublished) noted that longtail tuna schools of Papua New Guinea are also relatively small, ranging between 1 and 10 tonnes and averaging about 4 tonnes. Large longtail tuna do not appear to form large surface aggregations but may form sub-surface schools (Wilson 1981a).

At various localities around Western Australia and Queensland, prawn fishermen report opportunistic catches of longtail tuna. Tuna are attracted to the trawlers by fish discarded from trawl catches and are caught on lines baited with small fish. There has been some limited poling for longtail tuna in the Gulf of Carpentaria and off the east coast of Australia. Although successful in catching small quantities, poling has tended to be undertaken as an adjunct to another fishery. Incidental catches of longtail tuna (sometimes in excess of 1 tonne per set) are taken in pelagic gillnets fishing for shark and mackerel in the coastal waters of the Northern Territory and Queensland. In New South Wales the species is caught by beach seine as schools move in close to shore to feed (Serventy 1942, 1956). Trolling accounts for small catches of longtail tuna, they are caught incidentally in the narrow-barred Spanish mackerel (Scomberomorus commerson) fishery or as the target species. Incidental catches of kawakawa are made by Australian fishermen using a variety of fishing methods but they are invariably discarded or used for bait.

Longtail tuna represented most if not all of the retained tuna catch taken by Taiwanese gillnetters operating off northern Australia. The Taiwanese Probably caught significant quantities of kawakawa but as the species was usually discarded no catch records are available (details of this fishery are presented below). Canning trials reported by Serventy (1942) and more recently those conducted on behalf of the Northern Territory Fisheries Division have indicated that longtail tuna produce a highly acceptable canned product. In some parts of the world kawakawa are highly esteemed as a food fish and are eaten fresh or salted and sun-dried. The flesh is graded as 'dark meat' and is strongly flavoured. When canned the flesh is dark and coarse and thus is not acceptable for canning in Australia (Williams 1963; Wilson 1961b). Roughley (1966) has noted that while frigate tuna are common in some situations in Australian waters, they are unlikely to be of value as a canning fish because of their small size.

1. Introduction

The Australian tuna fishing industry has traditionally been based on southern bluefin tuna (Thunnus maccoyii) with fishing operations concentrated off southern Australia. In recent years there has been development alternative fisheries including a fishery for yellowfin tuna (T. albacares) off the east coast.

In 1984/85 a national catch quota for southern bluefin tuna was introduced. This coupled with the development of potentially lucrative sashimi markets created short-falls of tuna for canning in Australia. In order to maintain canning operations, imports of frozen whole tuna have been necessary. There has also been interest in finding alternative supplies of tuna from within Australia. Longtail tunas (T. tongol) have been identified as suitable for canning and markets are currently available for this species.

2. Species Accounts and Interest to Fisheries

Longtail tuna, kawakawa (Euthynnus affinis) and frigate tuna (Auxis thazard) occur throughout the shelf waters of northern Australia and into the sub-tropical waters off Western Australia, Queensland and New South Wales. Apart from work by Serventy (1942, 1956) and Wilson (1981c) on longtail tuna, virtually nothing is known about the biology of these tunas in Australia. The lack of such basic information is related to the fact that they have little or no commercial value.

Longtail tuna are characteristically small off the Northern Territory, common between 50 and 65 cm fork length (2 to 4.5 kg) and rare above 75 cm fork length. Individuals of approximately 5 to 8 kg appear to be common in the southern Gulf of Carpentaria while in the waters off eastern Queensland, New South Wales and Western Australia fish of above 90 cm and larger (10 kg plus) are prevalent (Serventy 1956). Kawakawa (locally known as mackerel tuna) rarely exceed 65 cm fork length and are common between 50 and 60 cm (2 to 4 kg) in the Timor and Arafura Seas. The species is

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3. Taiwanese Gillnet Fishery

Taiwanese gillnetters operated in the Timor and Arafura Seas from 1974 to mid 1986 and their catches were comprised primarily of shark, tuna and mackerel. Tuna catches for the period 1974 to 1978 are reported to have ranged between 410 tonnes (1975) and about 4770 tonnes (1977). During this period, however, the region fished included areas within the Australian Fishing Zone (AFZ) that are currently closed to foreign fishing as well as areas now in the Indonesian 200 mile zone (Walter 1981).

With the implementation of the AFZ in November 1979, Australia assumed management responsibility for the fish resources within the zone. Under Australian jurisdiction, Taiwanese fishing operations were restricted to specified offshore areas and a catch quota of 7000 tonnes was imposed (Branford 1984). This quota was reduced to 6000 tonnes in 1985 because of concern over declining catch rates, for shark in particular. In July 1986 the Australian Commonwealth Government passed legislation that limited pelagic gillnets and drift nets to a maximum of 2.5 kilometres in length. This measure was intended to reduce the accidental kill of dolphins in gillnets but also forced the withdrawal of the Taiwanese gillnetters from the AFZ. Taiwanese gillnetters had been using up to 20 kilometres of net prior to the introduction of this measure. The restriction rendered their operations uneconomical.

As part of licencing conditions, foreign operators are required to keep logbooks (in which set and catch information are recorded) and to provide six day catch summaries by radio. Radio reports include catch and effort details for shark, mackerel and total catch. The remainder of the catch, a figure that is derived by subtracting the shark and mackerel components from the total catch, is categorised as 'other'. Monitoring of commercial catches revealed that tuna comprise between 82 and 97% (average of 92%) of the 'other' component (Anderson and Read 1984). For the purposes of this report, the 'other' category has been assumed to refer exclusively to tuna.

3.1 Areas of Operation

The area within the AFZ authorised for foreign gillnet vessels has strict boundaries that are designed to avoid competition or conflict with Australian fishing operations. The authorised zone covers an area between outer limit of the AFZ with inner limits which vary from 12 nautical miles off the coast to lines of closure such as the Gulf of Carpentaria (Figure 1). The southern boundary is latitude 18°S and the eastern boundary is longitude 141°E. In practice, Taiwanese gillnetters restricted their operations to the area between longitudes 125° and 140°E. Fishing outside of this area was rare.

3.2 Gear and Methods

The Taiwanese gillnet fleet comprised two vessel classes: smaller, converted longline vessels (26 - 36 m in length) and larger vessels which included converted pair trawlers and modern purpose-built gillnet vessels (up to 40 m in

Gillnets were made of multifilament nylon with mesh sizes of between 15 and 17 cm. They were between 14 and 20 m in depth and ranged between about 10 and 20 km in length. Over the period 1980 to 1986 the average length of net deployed increased but catch per set remained fairly stable. Up until mid-1984, nets were buoyed using polystyrene floats attached to the headline by 2 - 3 m long float-lines. By 1985 the float-line system had been replaced with polystyrene floats attached directly to the headline. The reasons for this change are not certain but it seems that the Taiwanese had anticipated better catch rates for tuna and mackerel by surface setting.

The nets were set at dusk and allowed to drift free of the vessel for about 6 - 8 hours. Haul duration was dependent on the size of the catch and gear complications.

3.3 Fishing Strategy

While there did not appear to be an obvious pattern in the overall movement of the gillnet fleet throughout the year, localised movements appeared to be determined by fishing success. Vessels fished over a wide area until one achieved good catch results. This information was relayed to other vessels which would converge on the productive ground. As catches dropped off, vessels dispersed and searched for new areas.

It had been initially assumed by Australian authorities that when shark catches were poor the Taiwanese would target on tuna (by shortening float-lines or surface setting). It seems more likely now that target fishing was primarily in response to market pressures, that is the comparative prices of shark, mackerel and tuna in Taiwan tended to determine the preferred species.

3.4 Tuna Catch

Longtail tuna represented the bulk of tuna caught and most if not all of the tuna retained by the Taiwanese. Length-frequency distribution for longtail tuna is strongly unimodal and presumably reflects the influence of mesh selectivity on the size composition of the catch (Figure 2). Most individuals ranged between 50 and 65 cm fork length and the average weight for the species was 3.2 kg. In general the caudal fin lobes were severed (primarily for ease of storage) and the tuna frozen whole. Little information is available from Taiwan as to how the product was utilised but presumably most was canned.

Kawakawa were also commonly caught but apart from some larger specimens which tended to be retained for consumption by the crew, they were almost invariably discarded. Kawakawa are generally smaller than longtail tuna and were common between 47 and 56 cm fork length (Figure 2). Individuals over about 60 cm were rare. Anderson and Read (1984) recorded that kawakawa comprised between 64 and 95% of the discarded fish component in the catches and that the ratio of longtail tuna to kawakawa was about 5:1 by weight. It was noted, however, that the quantity of kawakawa caught was probably underestimated because of difficulties in recording all discarded fish. Frigate tuna were less frequently caught though on occasions large numbers were taken. They were not retained.

While the stocks of small tunas off northern Australia are undoubtedly under-exploited, Australian fishermen continue to show little interest in fishing for these species. Prior to any substantial development of a fishery it will be necessary to evaluate appropriate fishing methods and determine whether such a fishery could be economically viable. Any future fishery development by Australians will clearly require a significant commitment from both the fishing industry and government.

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- There is only limited fishing targeted on longtail tuna in Australia, most of the catch of small tunas tends to be taken incidentally or on an opportunistic basis. The reported catch is doubtlessly underestimated, small tunas are either not recorded by fishermen or are grouped together with other species in catch returns.
- Reported landings of small tunas for the Northern Territory and Western Australia are presented in Table 1. Landing statistics for Queensland and New South Wales do not distinguish longtail tuna so it is not possible to accurately estimate catches in these States. New South Wales is undertaking a review of their catch return forms and will be coding longtail tuna separately in the future.
- Northern Territory figures refer to longtail tuna (kawakawa are not considered commercial) that are taken by pelagic gillnets along with shark (*Carcharhinus spp.*) and mackerel (*Scomberomorus spp.*). Longtail tuna command a comparatively poor price and as a consequence fishermen have been reluctant to retain them. This has resulted in only small quantities being landed (about 10 tonnes maximum). The actual catch of longtail tuna is likely to be in the order of 20 - 40 tonnes per annum (based on the operation of 5 gillnetters).
- Catches in Western Australia peaked at around 130 tonnes in 1983/84 but have usually been in the range 50 - 70 tonnes (Table 1). Except for a small quantity of kawakawa (1.9 tonnes) that was landed in 1982/83, these catches refer to longtail tuna. Over 90% of this State's catch is taken from Shark Bay with small quantities taken in Exmouth Gulf and from the Abrolhos Islands region. The main fishing method is handlining from prawn trawlers.
- Longtail tuna are caught by handlines from trawlers in the Gulf of Carpentaria, Princess Charlotte Bay and Moreton Bay off Queensland. Small quantities are also caught in pelagic gill nets, by poling and by trolling. At least some of longtail tuna caught in Moreton Bay are believed to be sold as pet food and probably do not appear on any catch returns. Longtail tuna are caught by beach seine off northern New South Wales during the summer months. Retained catches of longtail tuna are probably in the order of 50 tonnes for the east coast of Australia and 30 tonnes for the Gulf of Carpentaria. Wilson (1981a) estimated that the total commercial catch of longtail tuna taken by Australians may be about 250 tonnes per annum. Given under-reporting and coding problems with catch returns it seems that Wilson's estimate is reasonable.

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TABLE 1: Annual catches (tonnes) of small tunas for the Australian region.

Source	Fiscal year						
	80/81	81/82	82/83	83/84	84/85	85/86	86/87
Taiwanese gillnet ^a (Timor & Arafura Seas)	1084	962	2397	2673	1840	683	-
Northern Territory ^b	0	0	0	0	11	10	.3
Western Australia ^c	52	66	48	131	48	58	N/A

^a Based on radio reports

^b Live weight

^c Landed weight

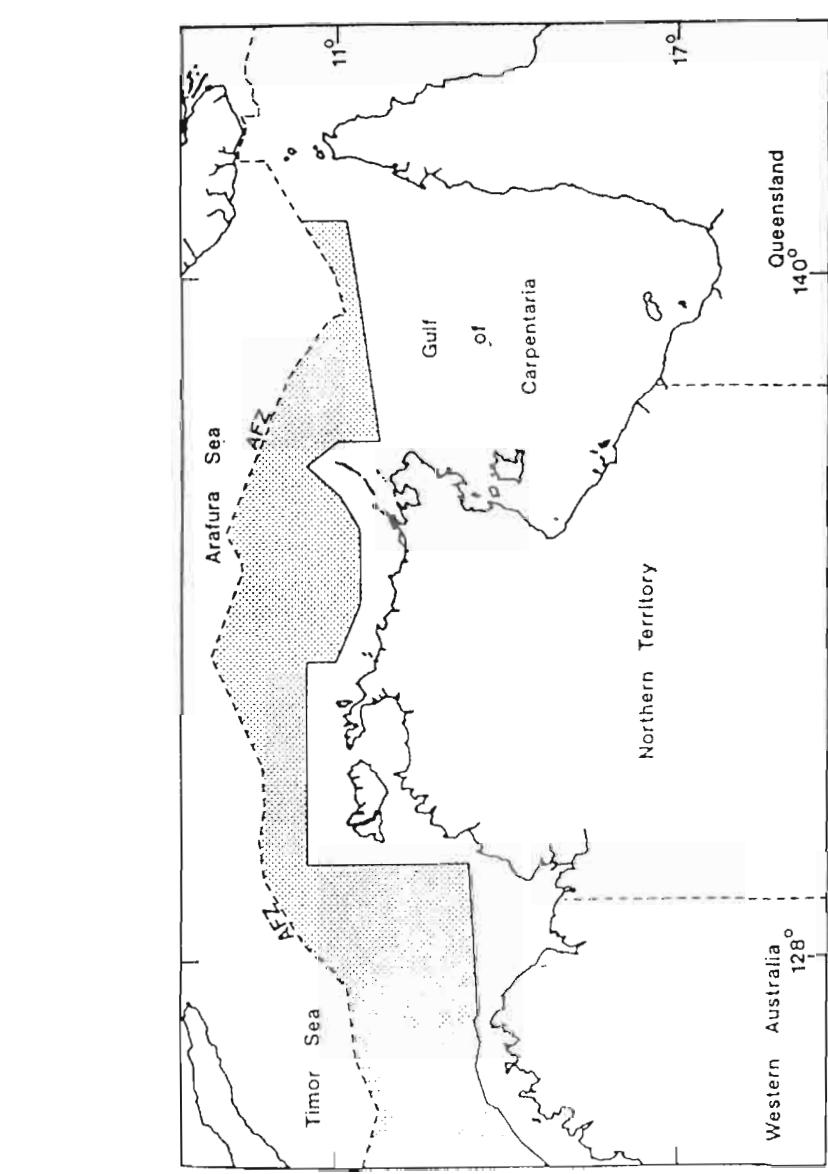


Figure 1.
Authorised foreign fishing area (shaded) off northern Australia.

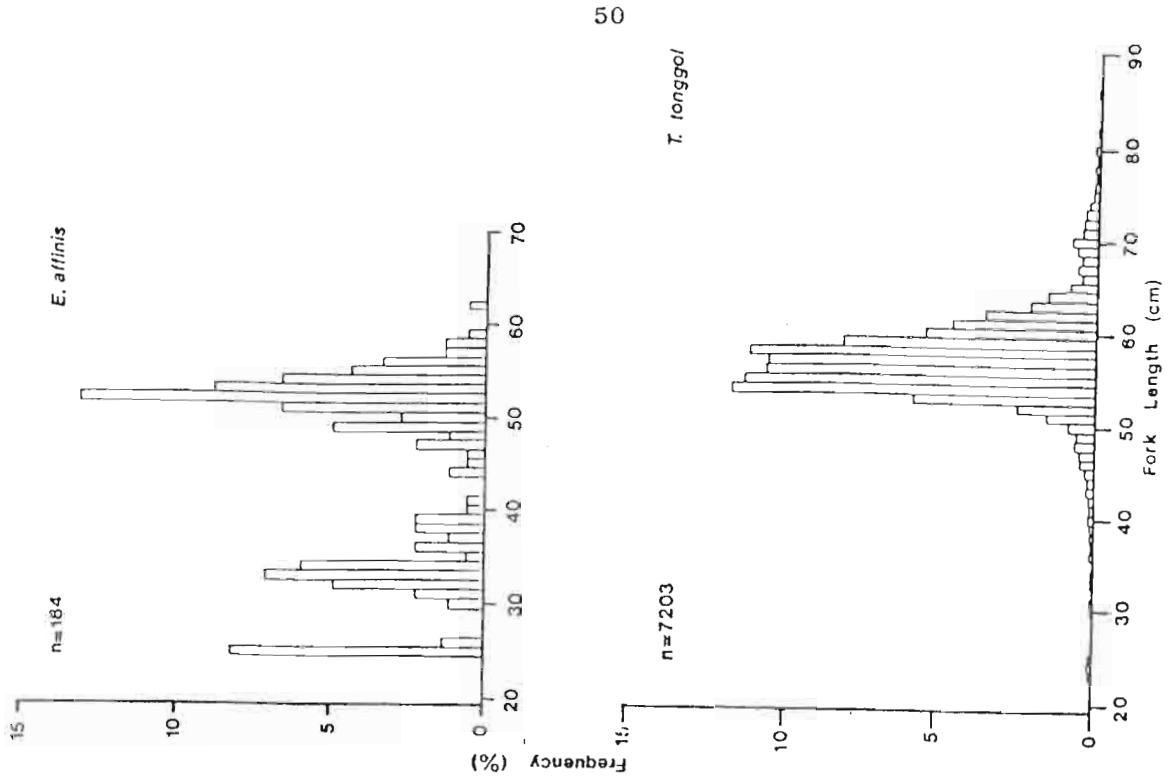


Figure 2.
Length — frequency distribution of longtail tuna (*T. tonggoi*) and mackerel tuna (*E. affinis*) from Taiwanese gillnet catches.

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4.2 Preliminary studies of <u>Scomberomorus commerson</u> and <u>Thunnus tonggol</u> in Omani waters - R. Dudley	62
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4.4 Description and identification of longtail tuna, <u>Thunnus tonggol</u> (Bleeker) in the Gulf of Thailand - R. Chayakul and C. Chamchang	71
4.5 Distribution of longtail tuna (<u>Thunnus tonggol</u> , Bleeker), kawakawa (<u>Euthynnus affinis</u> , Cantor) and frigate tuna (<u>Auxis thazard</u> , Lacepede) in the western coast of the Gulf of Thailand - C. Chamchang and R. Chayakul	80
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Current Production and Potential Yields of Small Tuna in the Indo-Pacific Region

1. Introduction

The world nominal catches of small tuna in 1985 was 590,000 mt. Of this total, 74% was taken in the Indo-Pacific region and 13% each from the Pacific and Atlantic Oceans (Table 1). Two species, longtail tuna *Thunnus tongol* and kawakawa *Euthynus affinis*, and a species complex (frigate tuna *Auxis thazard* and bullet tuna *A. rochei*) account for almost the entire small tuna catch of 437,000 mt from the Indo-Pacific region. In comparison, the catch of all tuna species (10 species and 1 species complex) in the Atlantic Ocean was 536,000 mt during 1985 (FAO, 1987).

Mitsuo Yesaki
Tuna Biologist

Small-scale fisheries account for much of the small tuna catch in the Indo-Pacific region. The exceptions are the purse-seine/ringnet and bagnet fisheries in the Philippines and the purse-seine fishery in Thailand. Only the small tuna catches of Thailand and Pakistan are canned and salted, respectively, for export. Therefore, almost the entire production of small tunas in the region enters into the food economy of the countries of capture. Small tunas have been virtually ignored to present because there is no international demand to generate foreign exchange. However, small tunas are important in the producing countries in providing relatively cheap, high quality protein to the populace.

Production of small tunas has increased 2.6 times from 1973 to 1985 (Fig. 1). The highest increase (101.0X) has been in longtail tuna landings, but this is probably in part due to inclusion as kawakawa in the earlier years. Kawakawa landings was about 60,000 mt in the first half of the 1970's, declined to a low of 36,000 mt in 1975 and has since increased to 88,000 mt. *Auxis* species and unclassified tunas increased 3.3 and 2.0 times, respectively, during the 13 year interval. These increases resulted in part from better collecting and reporting systems, but primarily from increased catches. Increases in small tuna production has been especially dramatic in the decade from 1976 to 1985 and will most probably continue to expand geometrically in the immediate future.

There are well developed fisheries for small tuna in only a few countries in the region, notably the Philippines, Thailand and Iran where the stocks are being heavily exploited. Small tuna fisheries in other countries are not as well developed so the stocks are either lightly exploited or as yet untouched. Therefore, there is still considerable potential for increasing production of small tunas from this region. The present study attempts to delineate the areas of highest potential for increasing production and to assess the magnitude of small tuna resources. This was accomplished by examining in detail the current productions of small tuna by countries in the region. Yield per unit area estimates for countries with high landings of neritic tunas are compared to define limits of carrying capacity of the continental shelf. Lower and upper limits of carrying capacity, in turn, were used to estimate potential yields of neritic tunas in the region.

2. Method of Analysis

An accepted method of estimating densities of commercial species is the use of landing statistics to determine yields per unit area. This method is especially appropriate for demersal fish and other benthic organisms because of their close association with the sea bottom. Their two-dimensional habits facilitate demarcation of distributional limits by depth and/or bottom type. This method is less frequently used for

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Figure 1

determining densities of pelagic species because of the difficulty in defining distributional limits of species affected principally by environmental factors in a three-dimensional habitat. Nevertheless, this method was used in the present analysis to estimate densities of longtail tuna, kawakawa and little tunny (*Euthynnus alletteratus*) as the distributions of these 3 species are confined essentially to the continental shelf.

Longtail tuna is the most strongly associated to the continental shelf of all tuna species. Larvae of this species have only been reported from the neritic zone. This species is generally abundant in areas with extensive continental shelves (Gulf of Thailand, Arfura-Timor Seas) and rare in areas with restricted shelves (Sri Lanka). There are no confirmed reports from off-shore islands and island groups such as the Lakshadweep and Maldives Islands (Yesaki, 1987).

Kawakawa is more widely distributed than longtail tuna and occurs off continents and all islands in the Indian and western central Pacific Oceans. Larvae of this species occurs only near continents and islands (Nishikawa, et al., 1985). The entire life cycle of this species is completed within the neritic zone (Yoshida, 1979).

Postlarvae and juveniles of little tunny have been captured 3.2 to 160 km off the coasts of Ivory Coast and Ghana, but no adults were found beyond the continental shelf (Yoshida, 1979).

The distribution of frigate and bullet tunas range from the continental shelf out into the contiguous oceanic zone. Larvae of *Auxis* species generally occur near land masses and are the most abundant of all tuna species in the Sulu Sea (Beguiat, 1987) and off the southwest coast of India (George, 1979). The distributional pattern of *Auxis* larvae suggest these species are not as abundant as the large tunas in the oceanic zone, except in the eastern Pacific Ocean, where they have been captured to 140° W. longitude (Nishikawa, et al., 1985). The abundance of frigate tuna in this area has been confirmed by a study of stomach contents of yellowfin tuna (Olson, 1982).

Yields of longtail tuna and kawakawa per unit area of continental shelf were derived for various areas in the Indo-Pacific region with high landings of these 2 species. Yields per unit area of little tunny were also derived for West African countries with high landings. These yields were compared to estimate the carrying capacity of continental shelves for neritic tunas.

3. Source of Information

3.1 Landing statistics

Statistics of small tuna landings in Indo-Pacific countries were obtained from ITPP Data Summary Number 6, 7 and the ITPP data bank. Statistics of little tunny landings by West African countries were obtained from the Yearbook of Fishery Statistics Volume 60 (FAO, 1987).

3.2 Area of continental shelf

Area of continental shelf off various countries in the Indo-Pacific region and West African countries were obtained from the literature. For countries and/or areas for which there were no information, the extent of the continental shelf was calculated with the aid of a polar planimeter from nautical charts published by the Hydrographer of the Navy, U.K. and Kepala Jawatan Hidro-Oceanografi, Indonesia.

4. Current Production

The 1985 production of small tunas from the Indo-Pacific region was 460,000 mt (Table 2). Of this total, unclassified tuna accounted for 38%, followed by *Auxis* species (24%), kawakawa (19%) and longtail tuna (19%). Indonesian statistics do not differentiate small tuna species, so the bulk of the unclassified tuna landings was reported by this country. The Indonesian landings is probably comprised in large part by *Auxis* species with lesser amounts of kawakawa and longtail tuna. The second highest landing of unclassified tuna reported by Thailand is principally kawakawa with small amounts of *Auxis* species. Only 7 countries reported landings of *Auxis* species and almost the entire landings of this species was made by the Philippines. The highest landings of kawakawa are made by the Philippines, India and Taiwan. Sixty percent of the longtail tuna landings was made by Thailand. The second highest landing was made by Malaysia, followed by Iran.

5. Yield per Unit Area

Current yields per unit area of small tunas (longtail tuna, kawakawa and unclassified tunas) for the countries in the Indo-Pacific region are given in Table 3. For countries reporting only unclassified tunas, high yields are currently being taken in Sri Lanka (0.25 mt/km²), several districts in Indonesia (0.21 - 0.53 mt/km²) and Reunion/Mayotte (0.26 mt/km²). *Auxis* species contributions significantly to the unclassified tuna landings of the first 2 countries and most probably oceanic tunas are included in the landings of the latter countries.

High yields for countries with landings of longtail tuna, kawakawa and unclassified tunas ranged from 0.18 to 1.60 mt/km². The latter is obtained from Comoro Islands and comprised of principally kawakawa and a small amount of unclassified tunas. If these high kawakawa landings are confirmed, the yield of neritic tuna is considerably higher than that of any other country. High yields of neritic tunas are currently being taken in the Gulf of Thailand, (0.27 mt/km²), Gulf area (0.19 mt/km²) and Philippines (0.18 mt/km²).

5.1 Neritic tunas from the continental shelf.

The nominal catches of the Philippines, Sri Lanka, Thailand, Ghana and Senegal were considered to assess the carrying capacity of the continental shelf. For the Philippines, only the catches in the heavily-exploited shallow and deep-water fishing areas (Yesaki, 1987) in the central and southern regions of the country were considered.

The catch of Thailand was assumed to originate entirely from the Gulf of Thailand which was defined by the land masses of Thailand, Kampuchea, Vietnam and a line from Point Cambodia to the Malaysian border (SSCP, 1978). The extent of the continental shelves and nominal catches for these countries for the years 1980 to 1986 are given in Table 4. Catches of all countries have increased since 1980, ranging from 1.4 times for Sri Lanka and Ghana to 6.4 times for Thailand.

Maximum yields/ km^2 varied from 0.21 mt for Senegal to 0.33 mt for Philippines (Fig. 2). The range of maximum yields is surprisingly close considering the potential for further increases in some countries and the extent of the continental shelf which ranges from archipelagic (Philippines) to narrow (Sri Lanka, Ghana, Senegal) to expansive (Thailand).

Philippine yields peaked in 1982-1983 and subsequently stabilized between 0.28 and 0.30 mt/ km^2 . Thailand yields reached a maximum in 1983 and have since fluctuated between 0.23 and 0.27 mt/ km^2 . The kawakawa stock in the shallow and deep-water fishing areas of the Philippines and the longtail tuna - kawakawa stocks in the Gulf of Thailand are probably being exploited at maximum levels. The upper carrying capacity of the continental shelf for neritic tunas is taken to be 0.30 mt/ km^2 .

The little tunny yields in Senegal increased annually from 1981 to 1984 and the figure for the latter year was given as the provisional yield for 1985. Sri Lankan yields declined after 1982 which most probably reflects reduced effort resulting from racial disturbances rather than over-exploitation of the kawakawa stock. There appears to be potential for further increases in yields in both these countries. However, for the present analysis, 0.21 mt/ km^2 of continental shelf was taken as the lower carrying capacity for neritic tunas.

5.2 Auxis species from the neritic zone

Auxis species range from the neritic to the contiguous oceanic zone, so their distributional limits are difficult to define. The catches of Sri Lanka are taken by small-scale fisheries and therefore assumed to be principally from the neritic zone. This was also assumed to be the case for Ghana. The entire small tuna catch of Thailand is made in the neritic zone.

The yield of Auxis species was lowest from Thailand with its extensive continental shelf and great distance from the oceanic zone (Table 5). Yields were 0.18 mt and 0.27 mt for Ghana and Sri Lanka, respectively, where the continental shelves are narrow and contiguous to the oceanic zone.

5.3 Auxis and tuna species from the oceanic zone

Yield estimates of Auxis and tuna species for various oceanic areas are given in Table 6. Yields of Auxis species determined from Philippine landings and consumption estimates in the eastern Pacific Ocean are very similar at 0.12 and 0.14 mt/ km^2 , respectively. Yields of tuna species ranged from 0.04 to 0.07 mt/ km^2 for the most productive 5 - degree squares in the major oceans to 0.50 mt/ km^2 for the Maldives.

6. Potential yields

6.1 Neritic tunas

Potential yields of neritic tunas for countries and areas in the Indo-Pacific region are given in Table 3. The potential for the entire region is estimated to range between 1.3 and 1.9 million metric tonnes, which is 3.7 to 5.5 times the 1985 production of neritic tunas. The area of greatest potential yield is Irian Jaya-Australia where current landings are essentially nil. The projected yield for this area is 360,000 - 515,000 mt. The South China Sea area has the second highest potential of 326,000 - 465,000 mt. Current landings are 23 - 33 percent of potential yields. The area with the fourth greatest potential yield is the Indian sub-continent with 163,000 - 233,000 mt. Current landings are only 15 - 22 percent of potential yields and the greatest increase in landings will be off India/Pakistan and Burma/Bangladesh. The Indonesian area has the third highest potential for neritic tunas of between 191,000 - 273,000 mt. If Auxis species accounts for a third of the small tuna catch, then the current production of neritic tunas in this area is 16-23 percent of potential.

Species composition of the areal yields was estimated from distributional patterns, fishing surveys and proportion in present landings (Table 7). Kawakawa will comprise slightly more than 50% of total potential yield because of its distribution throughout the region. This species will account for the entire yields off East Africa, Island states, Philippines and most districts of Indonesia. Areas of highest kawakawa potential are Irian Jaya-Australia, Indonesia and South China Sea. The yield of longtail tuna is only slightly less than kawakawa because of its high potential in 2 areas. Potential yields from Irian Jaya-Australia and South China Sea will account for approximately 70 percent of the total for this species.

7. Discussion

There are few estimates of potential yields of neritic tunas in the Indo-Pacific region. An exploratory fishing survey, including trolling, of the Seychelles was conducted by the Seychelloise/German Fisheries project from February to December 1981 (Steinberg, et al., 1982). Trolling explorations were conducted principally over the edges of the continental shelf. Mean trolling catch rates and areas of continental shelf were used to estimate biomasses and maximum sustainable yields of large pelagic fish. The estimates for kawakawa were 1,071.7 mt of biomass and 431 mt for maximum sustainable yield. The present study projects the potential kawakawa yield of 10,100 - 14,500 mt for the Seychelles.

Two aerial surveys for tuna were conducted by the Department of Fisheries and Wildlife off the coast of Western Australia; the first from December 1966 to February 1968 and the second from August 1973 to September 1974 (Robins, 1975). The surveys were confined primarily to the neritic zone and generally conducted by 2 sporters during most months of the survey period. A conservative standing stock figure of approximately 130,000 mt was derived for both the 1966/67 and 1973/74 surveys. Potential neritic tuna yield of between 74,000 and 110,000 mt is projected for Western Australia in the present study.

The Pole and Line fishing in Southern Thailand project conducted exploratory fishing off the west coast of Thailand from May 1979 to May 1981. Almost all the exploratory and simulated commercial fishing operations were conducted in the neritic zone. An attempt was made to estimate standing stocks of neritic tunas from sighting rates and area surveyed, but the results were too low. The method used in the present analysis, that is, densities derived for various countries, was subsequently resorted to for estimating potential yield of neritic tunas for the west coast of Thailand (Yesaki, 1982). I further expanded this study to encompass the Indo-Pacific region and derived potential yields for all areas. My estimates of potential coastal tuna yields for the Gulf of Thailand ranged from 64,000 to 106,700 mt. This study was completed in early 1981, when the catch in the Gulf of Thailand was 12,900 mt and the available statistics on hand were even lower.

Estimates of potential yield of Auxis species were not attempted, but there is evidence to suggest very high potential in the Indo-Pacific region, perhaps the highest of all tuna species. Larvae studies show Auxis species to be widely distributed throughout the Indian Ocean. Japanese investigations have collected Auxis larvae along all coasts (except the West coast of Australia), off the Andaman, Nicobar and Seychelles Islands, as well as to a limited extent in the oceanic zone. Areas of high captures include south of the Sunda Islands (Indonesia), Gulf of Aden, Gulf of Oman and Bay of Bengal (Nishikawa, et al., 1985). Auxis species was the second most abundant larvae, after Stolephorus species, collected during an extensive survey off the southwest coast of India (George, 1979). Auxis larvae and juveniles have been detected under night-lights in the Gulf of Aden (Løsset, 1987). Baguilat (1987) reports Auxis species was the most numerous of all tuna species in the Sulu Sea. The catch of Auxis species exceeds that of any other tuna species and accounts for 37% of the Philippine tuna landings.

Stomach content analyses indicate Auxis species to be an important forage organism for large tunas and billfishes. Watanabe (1962) found Auxis species in stomachs of predators captured in the Banda-Sawu Seas, off Queensland, Australia and southern Japan. Ten specimens from Queensland and 34 specimens from Banda Sea were identified as Auxis rochei versus 6 specimens from the Banda Sea as A. thazard. Based on these numbers, Watanabe suspected the bullet tuna to be more abundant than the frigate tuna. Auxis species is the most common forage organism in the stomachs of yellowfin tuna captured off Sri Lanka (Rekha Maldeniya, pers. comm.). Olson (1982) determined daily ratios of yellowfin tuna from stomach contents and gastric evacuation rates. From daily consumption of frigate tuna by yellowfin tuna, he extrapolated the annual consumption of frigate tuna to be 2,000,000 mt.

Frigate tuna is captured incidentally by tuna purse-seiners operating in the western Indian Ocean. Tuna purse-seiners try to avoid catching this species because of low market value and problem of gilling in the meshes. Frigate tuna is also captured with pole and line and troll line by the traditional small-scale fisheries in the Maldives. These captures indicate adult frigate tuna occurs throughout the western central Indian Ocean.

There are virtually no records of visual sightings of Auxis species. Løsset (1975) describes 2 such sightings, "in March 1981, very large schools of Auxis like fish, about 14-25 cm in length, were observed in lat. 14°N. long. 49°E. and lat. 15°N. long. 51°E. These schools were in loose formation (not compacted) moving slowly and forming a "scatter" on the surface of the sea as far as the eye could discern. These records suggest that large unexploited stocks exist, which could be of considerable potential commercial importance".

Neritic tuna stocks in the Philippines (shallow and deepwater fishing areas), Gulf of Thailand and the Gulf are presently being heavily exploited. However, further assessment of the kawakawa stock in the Philippines is not advisable because of its relative unimportance and complexity of the fisheries. Small-scale fisheries account for 55% and the industrial fisheries for 45% of the kawakawa catch. This species is reported in catches of 14 small-scale gears and 5 industrial gears. Kawakawa is captured incidentally in all industrial fisheries and in most of the small-scale fisheries. The only targeted fishery for this species is the hook and line and possibly gillnet in aggregate accounts for approximately 38% of the total catch. Monitoring catches of small-scale hook and line and gillnet fisheries throughout the central and southern Philippines would be extremely costly of manpower and finances.

Assessments of the longtail tuna kawakawa stocks in the Gulf of Thailand and Gulf are necessary and feasible as the fisheries are targeted for tuna and are relatively simple. Almost the entire tuna catch in the Gulf of Thailand and contiguous South China Sea is taken by tuna purse-seine, luring purse-seine, gillnet and troll line. Historic catch and effort data is available and a sampling programme for tunas was initiated in Thailand during April 1987 and in Malaysia during February 1987. A preliminary assessment of this stock should be possible in the not too distant future.

Gillnet is the principal gear used to capture longtail tuna-kawakawa in Iran, Pakistan, United Arab Emirates and Oman, though the length of the nets varies markedly within and between countries. The only historical records available in the area are sales receipts of national fishing company purchasing stations in Iran. A statistics collection system was initiated in Oman during July 1984. A biological sampling programme for seerfish and tuna was initiated in Oman during February 1987 and in Karachi during September 1987. Similar programmes are necessary in Iran and U.A.E. for a global assessment of the neritic tuna stocks in this area.

8. Summary

1. The 1985 nominal catches of small tunas in the Indo-Pacific region was 460,000 mt, of which unclassified tuna accounted for 38%, Auxis species 24%, kawakawa 19% and longtail 19%.
2. Yields per unit area were determined for 5 countries with high landings of neritic tunas. Maximum yields ranged from 0.21 mt/km² for Senegal to 0.33 mt/km² for the Philippines. Lower and upper carrying capacities of the continental shelf for neritic tunas were taken to be 0.21 and 0.30 mt/km², respectively.

3. Potential yields of between 1.3 and 1.9 million metric tonnes of neritic tunas were projected for the Indo-Pacific region. Areas of highest potential include Irian Jaya-Australia, South China Sea, Indian sub-continent and Indonesia.

4. Estimates of potential yields of *Auxis* species were not attempted, but evidence from larvae studies, stomach contents, captures in oceanic fisheries and visual sightings indicate the potential yield to be considerably higher than that of neritic tunas.

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Table 1. Nominal catches of small tunas in the 3 major oceans of the world ^{1/}

Species	Atlantic	Indian ^{2/}	Pacific ^{3/}	Total
<u>Sarda sarda</u>	24,715	-	-	24,715
<u>Sarda chilensis</u>	-	-	12,930	12,930
<u>Orcynopsis unicolor</u>	41	-	-	41
<u>Auxis</u> sp.	18,057	100,823	24,471	143,351
<u>Euthynnus alletteratus</u>	17,996	-	-	17,996
<u>E. lineatus</u>	-	-	0	0
<u>E. affinis</u>	-	89,875	3,763	93,638
<u>Thunnus tongol</u>	-	16,146	-	16,146
<u>T. alalatus</u>	1,445	-	-	1,445
<u>Tuna nei</u>	277	-	-	277
<u>Tuna-like nei</u>	12,910	230,547	35,664	279,121
Total	75,441	437,391	76,828	589,660

^{1/} - FAO, 1987
^{2/} - includes FAO fishing area 51, 57 and 71
^{3/} - excludes FAO fishing area 71

Table 3. Extent of continental shelves, landings, densities and potential yields of bericid tunas in the Indo-Pacific region

Country	Species			Unclassified	Total
	Longtail	Kawakawa	Auxis sp.		
Australia ^{1/}	138	-	-	20	158
Bangladesh ^{1/}	-	-	-	95	95
China (Taiwan) ^{2/}	2,621,344 ^{1/}	10,299	7,384	-	20,304
Comoros ^{1/}	-	1,310	-	140	1,450
Djibouti ^{1/}	-	-	-	34	34
Egypt ^{1/}	-	-	-	300	300
India ^{1/}	5,540	16,529	3,083	2,762	27,914
Israel	-	-	-	50	50
Indonesia ^{3/}	11,848	1,707	-	111,630	111,630
Iran ^{1/}	-	2,177	2,824	59	5,060
Maldives ^{1/}	-	6,789	-	-	22,630
Malaysia	15,841	-	-	285	285
Mozambique ^{1/}	-	-	-	10,410	10,410
Oman ^{1/}	-	-	-	-	5,268
Pakistan ^{1/}	-	5,268	-	-	5,268
Philippines ^{3/}	-	41,060	95,718	-	136,778
Qatar ^{1/}	-	-	-	35	35
Reunion ^{1/}	-	-	-	180	180
Saudi Arabia ^{1/}	-	-	-	1,341	1,341
Seychelles ^{1/}	-	326	-	-	326
South Africa ^{1/}	-	-	-	27	27
St. Lanka ^{1/}	-	-	-	6,298	6,298
Tanzania ^{1/}	-	-	-	1,060	1,060
Thailand ^{3/}	48,000	-	86,881	38,881	86,881
United Arab Emirates ^{1/}	2,830	980	470	-	4,280
Yemen, A.R. ^{1/}	640	378	-	-	1,218
Yemen, P.D.R. ^{1/}	87	1,272	24	-	1,383
total	87,745	88,095	109,503	173,607	458,950

^{1/} - IPTP, 1987^{2/} - SEAFDEC, 1986^{3/} - IPTP data bank^{4/} - 1985 landings from the Atarafura - Timor Seas

Area, Country	Continental shelf, km ²	Landing ^{a,b,c,d} , t	Density, kg/km ²	Potential yield ^{e,f,g,h,i,j} , t/1000 km ²
East Africa, sub-totals	186,400	1,373	0.01	39.2
South Africa ^{1/}	24,600	27*	-	0.00
Kenya ^{1/}	71,200	285*	0.00	-
Tanzania ^{1/}	18,500	1,040*	0.06	-
Maldives ^{1/}	13,200	-	-	-
India ^{1/} , sub-totals	55,100	-	-	-
Nagasaki ^{1/}	281,700	4,192	0.01	59.2
Seychelles ^{1/}	111,600	-	-	-
Maldives, and offshore banks ^{1/}	48,800	11,716	0.01	-
Maldives, Rayong ^{1/}	11,700	-	-	-
Comoros ^{1/}	1,600	-	-	-
Réunion ^{1/}	900	-	-	-
Red Sea ^{1/} , sub-totals	19,000	2,336	0.01	66.4
Eritrea ^{1/} , sub-totals	221,000	2,943	0.01	66.5
Sudan ^{1/} , sub-totals	60,300	-	-	-
Egypt ^{1/} + Israel ^{1/}	23,100	-	-	-
Saudi Arabia ^{1/}	20,200	150*	0.02	-
Armenia, A.R. ^{1/}	88,400	1,341*	0.02	-
Arabian Peninsula and Gulf, sub-totals	311,100	17,267*	0.04	-
Tunisia, P.D.R. ^{1/}	25,200	1,359	0.05	-
Italy ^{1/}	53,500	10,410*	0.19	-
United Arab Emirates	25,200	13,555*	-	-
Qatar ^{1/}	8*	3,810	-	-
Indian sub continent, sub-totals	67,900	35*	0.19	-
Pakistan ^{1/}	277,400	36,492	0.05	163.2
India ^{1/} , west coast	281,300	5,268	0.10	-
India ^{1/} , east coast	11,200	24,811	0.08	-
Lakshadweep	4,200	-	-	-
Andaman	15,200	-	-	-
Sri Lanka ^{1/}	25,200	4,298*	0.25	-
Bangladesh ^{1/}	65,600	95*	0.06	-
Burma ^{1/}	217,500	-	-	-
Malacca Strait ^{1/} , sub-totals	178,200	33,412	0.19	53.5
Thailand ^{1/}	45,900	5,648	0.12	-
Malaysia ^{1/}	4,500	4,550	-	-
Indonesia ^{1/}	132,400	23,234*	0.21	-
South China Sea ^{1/} , sub-totals	1,551,700	139,612	0.07	-
Vietnam ^{1/}	191,900	-	-	-
Peninsular Malaysia ^{1/}	137,200	34,600	0.10	-
Sabah ^{1/}	33,200	8,800	0.01	-
Peninsular Thailand ^{1/}	9,400	-	-	-
Sabah ^{1/}	7	2,600	? ^k	-
Cost of Thailand ^{1/}	305,700	81,233	0.27	-
Vietnam to 9° N., 14° E. ^{1/}	296,300	-	-	-
Cost of Tongking (to 15° N., lat 10° E.) ^{1/}	200,000	-	-	-
Cost of China (to Formosa Straits) ^{1/}	280,000	10,299	0.04	-
Philippines ^{1/} , sub-totals	224,000	41,060	0.18	67.0
Indonesia, sub-totals	907,900	88,394	0.10	191.1
W. coast Southeast ^{1/}	98,200	9,682	0.10	-
W. coast, Maldives ^{1/}	29,800	7,944*	0.17	-
Java Sea ^{1/}	54,200	26,874*	0.05	-
Bali-Nusa Tenggara-Timor ^{1/}	24,400	12,890*	0.53	-
East coast, Sulawesi ^{1/}	72,200	3,567*	0.05	-
Celebes ^{1/}	61,100	19,452*	0.32	-
Moluccas - Irian Jaya ^{1/}	81,600	7,986*	-	-
Irian Jaya - Australia ^{1/} , sub-totals	1,118,700	2,115*	0.10	-
Australia - Tiwi Islands ^{1/}	88,500	-	-	-
Gulf of Carpentaria ^{1/}	471,600	2,779	0.00	-
W. Australia ^{1/}	356,600	-	-	-
Total	6,223,100	349,447	0.06	1,306.7

^a - 1979 - 1987 landings for 1985
^b - Includes longtail, skipjack and unclassified tunas
^c - Based on density of 0.21 m³/t/m²
^d - Based on density of 0.30 m³/ha²
^e - Calculated
^f - IOC, 1979
^g - Unclassified tunas
^h - Included in Gulf and Oman
ⁱ - Included in Gulf
^j - IOC-Gulf, 1974 & included only driftfish
^k - States less than 50 m²
^l - Jones and Bentz, 1973
^m - SC-SP, 1978
ⁿ - Not available
^o - Katsuv, et al.
^p - Niida and Saitoh, 1986
^q - Includes landings for diboutis tunas
^r - Seafdec, et al.
^s - WCO, 1986
^t - Seafdec, et al., 1976

Table 5. Yields of neritic tunas and Auxis species from continental shelves of various countries

Country	Continental shelf, km ²	1980	1981	1982	1983	1984	1985	1986
Philippines ^{1/}	136,800 ^{3/}	23,255	28,778	44,609	45,838	40,515	38,492	40,638
Sri Lanka ^{2/}	25,300 ^{5/}	3,813 ^{6/}	5,016 ^{6/}	5,507 ^{6/}	4,129 ^{6/}	3,040	2,771 ^{6/}	-
Thailand ^{7/8/}	305,700 ^{9/}	12,895	20,198	39,661	82,001	69,469	81,233	-
Chad ^{9/}	24,400 ^{12/}	4,134	3,287	2,141	5,009	5,966	6,000	-
Senegal ^{10,11/}	33,300 ^{12/}	2,716	2,285	3,384	5,905	6,929	6,929	-

^{1/} - BFAR, statistical reports and IPTP data bank

^{2/} - Kawakawa area of shallow and deep-water fishing areas

^{3/} - Yesaki, 1987

^{4/} - IPTP, 1987

^{5/} - Jones and Banerji, 1973

^{6/} - based on 1984 proportion, frigate tuna 56% and Kawakawa 44%

^{7/} - IPTP, 1986 and IPTP data bank

^{8/} - longtail tuna, Kawakawa and lesser amounts of Auxis species

^{9/} - SCSP, 1978

^{10/} - FAO, 1987

^{11/} - little tunny

^{12/} - CECAF, 1984

^{13/} - Ratio of Kawakawa and frigate tuna assumed to be identical to that of

^{14/} - Jones and Banerji, 1973

^{15/} - IPTP, 1987

^{16/} - Kawakawa

^{17/} - Ratio of Kawakawa and frigate tuna 1984

^{18/} - SCSP, 1978

^{19/} - IPTP data bank

^{20/} - includes longtail, Kawakawa and lesser amounts of frigate tuna

Table 6. Yields of frigate and other tunas from various oceanic areas

Table 7. Potential yields of longtail tuna and kawakawa by areas in the Indo-Pacific region

Species	Country and/or region	area, km ²	year	landings, mt	yield, mt/km ²
Auxis species	Philippines	436,000 ^{1/}	1984 ^{2/}	60,241	0.14
Auxis species	CYRA ^{3/}	16,920,000 ^{4/}	1970 ^{5/}	2,000,000	0.12
tuna species ^{6/}	Philippines ^a	436,000 ^{1/}	1984 ^{2/}	145,696	0.33
tuna species ^{7/}	Maldives	102,900 ^{8/}	1985 ^{9/}	51,551	0.50
tuna species ^{10/}	Atlantic Ocean ^{11/}	308,700 ^{12/}	1973-76	23,000	0.07
tuna species ^{10/}	E. Pacific Ocean ^{11/}	308,700 ^{12/}	1978-82	14,700	0.05
tuna species ^{10/}	Indian Ocean ^{11/}	308,700 ^{12/}	1984-85	12,100	0.04
^{1/}	Yesaki, 1987; area of deep-water fishing areas with 79,000 km ² of continental shelf				
^{2/}	BPAR, 1985				
^{3/}	IATTC, Commission Yellowfin Regulatory Area				
^{4/}	Sharp and Francis, 1976				
^{5/}	Olson, 1982; estimate of frigate tuna consumed by yellowfin in the CYRA during 1970				
^{6/}	includes frigate/bullet, kawakawa, skipjack and yellowfin tunas				
^{7/}	includes frigate, skipjack and yellowfin tunas				
^{8/}	fishing area 500 nm long by 30 nm wide along both coasts of the Maldivian Islands				
^{9/}	ITMP, 1987				
^{10/}	included skipjack, yellowfin, bigeye tunas				
^{11/}	Ganaden and Steegeit, 1987				
^{12/}	area of 50 lat. by 5° long				

^{1/} - 60% kawakawa, 40% longtail
^{2/} - 60% longtail tuna, 40% kawakawa
^a - includes frigate/bullet, kawakawa, skipjack and yellowfin tunas

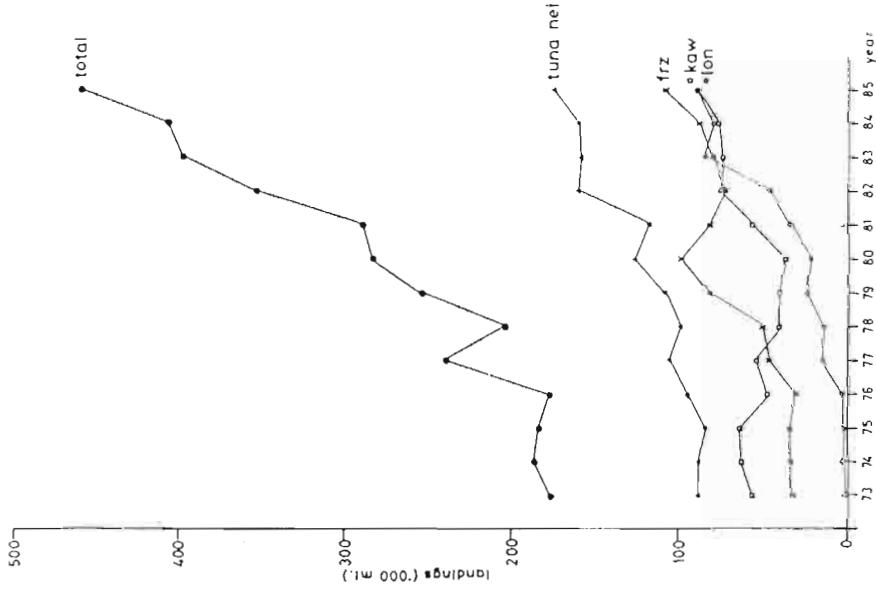


Fig. 1. Landings of small tunas in the Indo-Pacific region for 1973 to 1985.

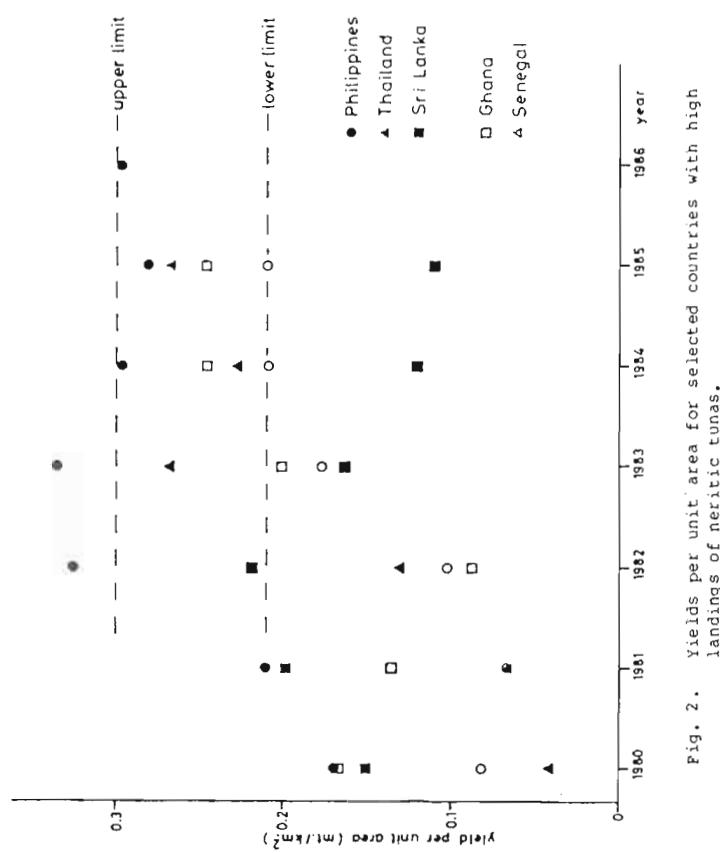


Fig. 2. Yields per unit area for selected countries with high landings of neritic tunas.

Preliminary Studies of *Scomberomorus commerson* and
Thunnus tonggol in Omani Waters

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Sultanate of Oman

December 1987

ABSTRACT

Monthly length frequency data and examination of otoliths of *Scomberomorus commerson* and *Thunnus tonggol* provided information about the size composition and growth of these species in Omani waters. *S. commerson* first enters the catch at 48 cm, probably at an age of one year. At two years they average 84 cm. Otoliths of *S. commerson* show marks which may be useful in determining age. Preliminary yield per recruit analysis indicates that *S. commerson* are being caught at sub-optimum size. *T. tonggol* first enter the fishery at 30 cm in October, but typical catches consist of fish between 50 and 80 cm. Length frequency analysis of *T. tonggol* from commercial catches is of less value than that for *S. commerson*. Otoliths of *T. tonggol* show potential for analysis using daily growth rings.

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INTRODUCTION

Scomberomorus commerson (Bennett) (tailed Spanish mackerel) and *Tetrapturus longirostris* (Linnaeus) (longtail tuna) comprise a substantial portion of the fish catch from Omani waters. Between 15,000 and 20,000 tons of *S. commerson* and about 6,000 to 10,000 tons of *T. longirostris* are landed in Oman annually (Rash and McClure 1986, McClure pers. com.). *S. commerson* is particularly important because of its high market value in Oman and in other countries of the region. Consequently Oman exports considerable amounts of this species to the United Arab Emirates, Saudi Arabia and Kuwait. *T. longirostris* is of growing importance in the northwestern Indian Ocean where catches are now in the neighborhood of 25,000 mt.

Because of the importance of these two species to Oman, they are priority species for research at Oman's new Marine Science and Fisheries Center which first opened in late 1986. This paper reports on a part of the activities of the Large Pelagics Section at the Center.

METHODS

Research with *S. commerson* and *T. longirostris* has made use of two approaches: work with length frequency data and work with otoliths.

Length frequency data was collected at the Muttrah fish market on a monthly basis starting in February 1987. On daily visits to the market during the first two weeks of each month the total fork length of a representative sample of each of the above species was measured to the nearest cm. If relatively few specimens were present then almost all were measured. If many specimens were present then a representative sample was measured.

Because these species are usually marketed whole, there was little opportunity to obtain sex specific length data. However, some such data was obtained through cooperation with fish processors.

Additional length frequency data was collected at other landing places as opportunity permitted. Heads of *S. commerson* and *T. longirostris* were collected for later extraction of otoliths. *S. commerson* are often sold to the consumer with the upper part of the head still attached making the collection of heads of this species more difficult. When only the discarded head was available, the length of the upper jaw was used as a predictor of fork length.

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Otoliths were extracted by cutting off the top of the head to include the otoliths and then cutting away the bone to plainly see the otoliths themselves. Otoliths were stored in xylene. Fig. 1 shows the examination.

Preliminary yield per recruit calculations for *S. commerson* were made based on the following: Sizes of one and two year old fish were estimated from the length frequency data. *L₀* was estimated at 200 cm, since fish of this size have been found only rarely in the catches. These two points were used to estimate the line describing the relationship between *L_t* and *L₀*, which in turn was used to estimate the growth coefficient *k* and *H*. Length weight data from Bouhlel (1985) was used to estimate *W_t*. The natural mortality rate *M* was calculated by the method described by Pauly (1980). Calculations were for both sexes combined. Calculations were done using Sluzczanowski's (1985) Lotus 123 template.

RESULTS AND DISCUSSION

Scomberomorus commerson

Length frequency data of *S. commerson* revealed a very distinct mode which progressed from 59 cm in February to 84 cm in October. In October a mode appeared at 48 cm (Fig. 1). Only indistinct modes are apparent at sizes above 95 cm.

S. commerson has a relatively elongate body, and because several mesh sizes are used in the fishery, it is unlikely that gillnet selectivity is a substantial confounding factor in length frequency analysis.

Limited examination of gonads indicates that spawning probably takes place in September and October. Of 45 female specimens examined in September, 18 were in ripe condition.

Examination of length frequency distributions reveals that *S. commerson* are about 48 cm long at the end of their first year and enter the fishery at about that time. They then grow at a rate of about 3 cm per month reaching about 84 cm by the end of their second year. This rate of growth is significantly greater than that reported for adjacent regions. Two year old fish were 62 cm long in Djibouti (Bouhlel 1985) and 73 cm in India (Devaraj 1981). Probable growth curves are given in Fig. 2.

Although it is known that females of some species of *Scomberomorus* grow faster and larger than males (e.g. Beaumarais 1973, Devaraj 1981, Johnson et al 1983), neither Devaraj (1981) nor Bouhlel (1985) reported this situation for *S. commerson*. In September we measured and determined the sex of 138 specimens ranging from 73 to 94 cm. The size distribution of the two sexes was virtually identical. However, sex dependent growth rates may not be apparent until the fish are larger.

Literature Cited

- Preliminary yield per recruit analysis indicates that current size at first capture (about 48 cm) is significantly below the size which would be considered optimal if maximizing the weight of harvested fish is a primary management goal (Fig. 3). While it is premature to make management recommendations, it would be wise to start examining the possibility of increasing the size at first capture of this species. The first step toward this goal would be to examine the usefulness of various mesh regulation strategies. Some items of concern here would be: The actual abundance of "undersized" fish in the catch, the relative monetary value of large and small fish, and the relationship between fecundity and fish size.
- Work with otoliths of *S. commerson* is still in progress. Otoliths of *S. commerson* which have been stored in xylene often have opaque white zones similar to those reported for *S. commerson* by Devraj (1981). However, these zones vary considerably among specimens. On some otoliths the zones are broad, pale, and indistinct, while on others they are narrow and very distinct.
- A cursory examination of *S. commerson* otoliths indicated that the number of marks corresponds with expected size at age for two and three year old fish. However, more marks are present on larger fish than would be expected if length frequency distributions are an accurate indicator of age (Fig. 4). We are still in the process of examining otoliths to determine their utility in determining the age of this species in Oman.
- Thunnus tonggol**
- Length frequency data of *T. tonggol* indicates that they first appear in the catches in October in small numbers, at a size of about 36 cm. These fish are caught incidentally to catches of *Auxis*. A corresponding mode (at 36 cm) was present in February (we have not yet sampled in December and January) and persisted until May (at 46 cm). Fish representing this mode were present in June and July, but in much smaller numbers. This mode does not appear in later months (Fig. 5). A similar mode was reported in May from Iranian waters of the Gulf of Oman (Yesaki 1987).
- Most larger *T. tonggol* are between 50 and 80 cm. A persistent mode at about 60 cm was apparent in February through July. Another mode at about 70 cm was also rather persistent. Only slight evidence of modal progression is apparent in the data. It is likely that billnet selectivity has contributed to the persistence of these modes. If this is so then the use of this data for analysis of growth must be done with caution. At present we have no billnet selectivity data for this species.

Table 1. Parameters used in yield per recruit calculations

Linf	200 cm
Winf	46.47 kg
Growth coefficient k	0.2744
Natural mortality rate	0.447

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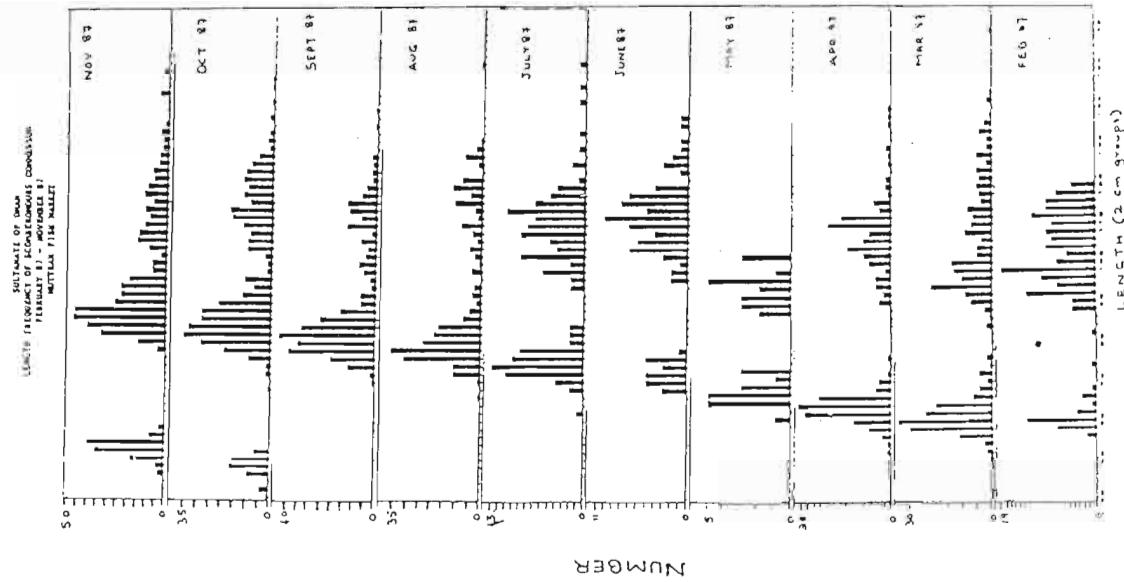


FIG. 1. Length frequency data for *Scoberella gracilis* collected during February through November of 1987.

Fig. 2a. Von Bertallany growth curve for *Scomberomorus* connexus based on preliminary data.

25. Van Bertalanffy growth curve for second year growth of S. commersoni. Also shown are the upper and lower lengths in the distribution corresponding to the smallest mode each month.

Fig. 3. Result of preliminary yield per recruit analysis. Significant increases in yield per recruit would be gained by increasing minimum size at capture.

3a. Yield versus length at first capture.
3b. Yield versus fish mortality.

3a. Yield versus length at first capture.
3b. Yield versus fish mortality.

Fig. 4. Number of marks found on otoliths of *Scomberomorus* commersoni of different sizes. Marks do not appear to correspond to sizes and ages as determined by length frequency analysis.

Fig. 5. Length-frequency data for *Ibundus tanggol* collected during February-May 1982.

Fig. 2a

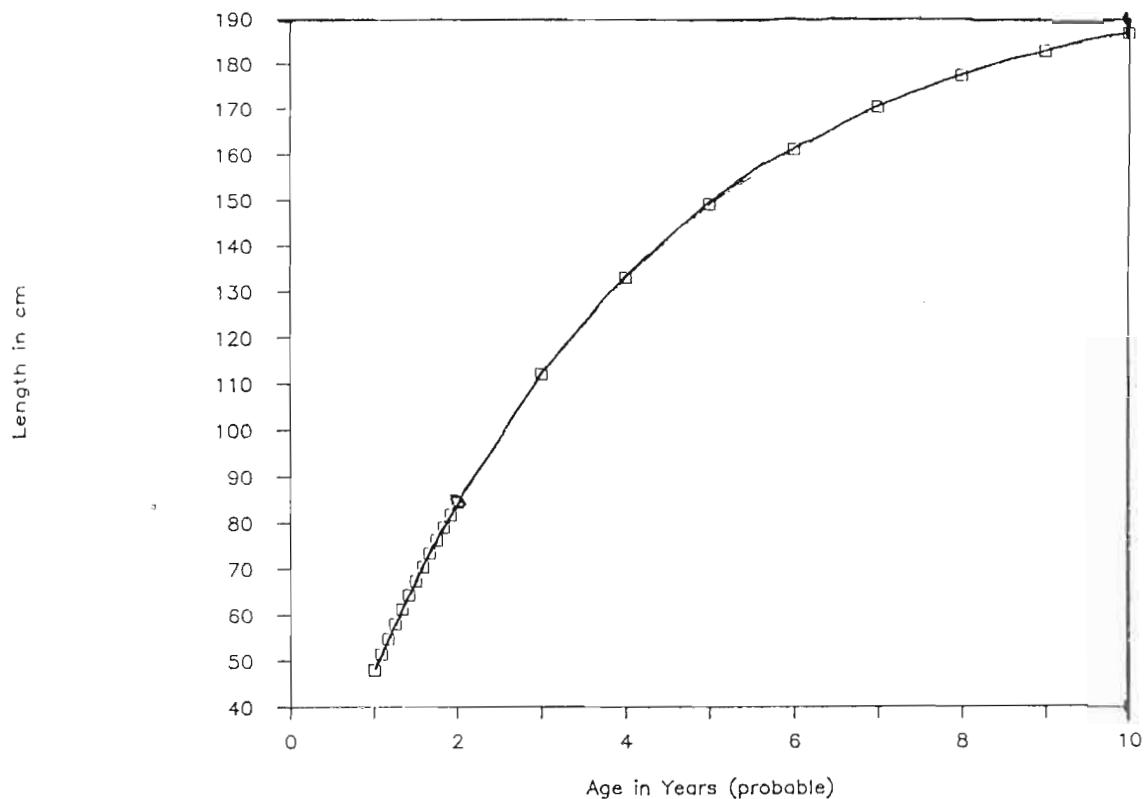
Growth of *S. commerson*

Fig. 2b

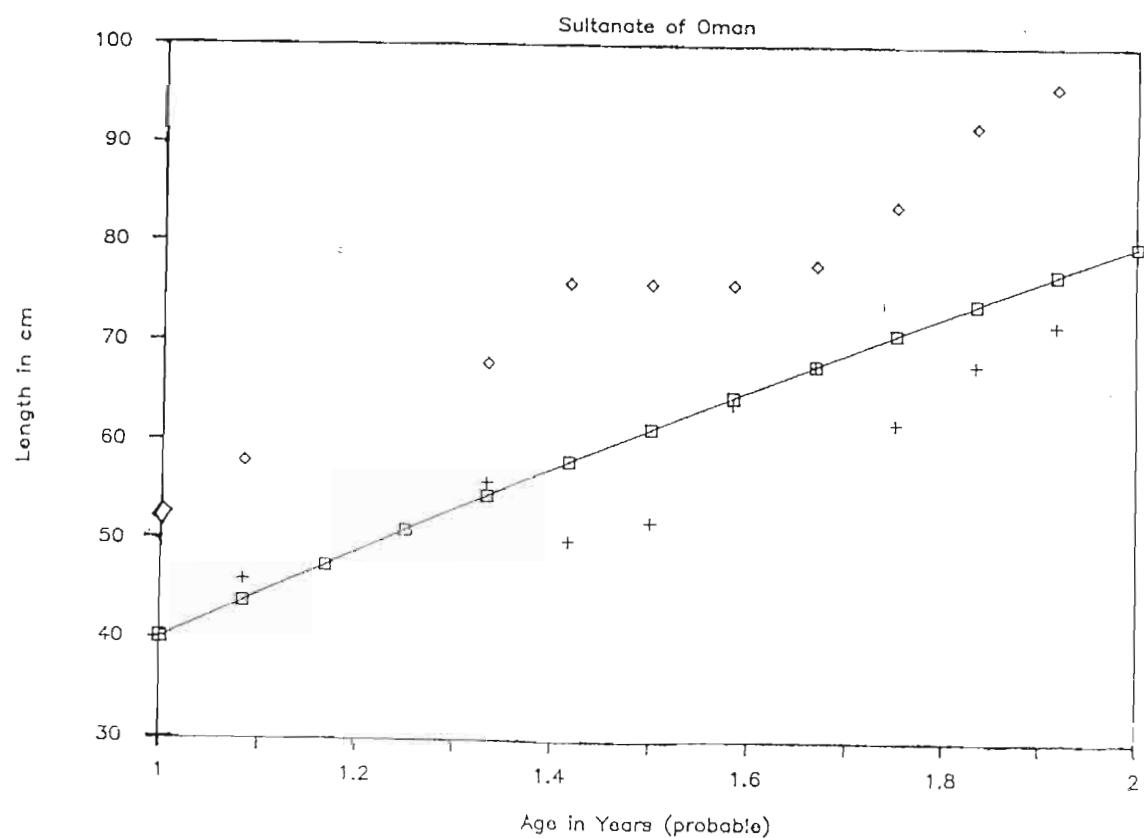
Growth of *S. commerson* (Year Two)

Fig. 3a

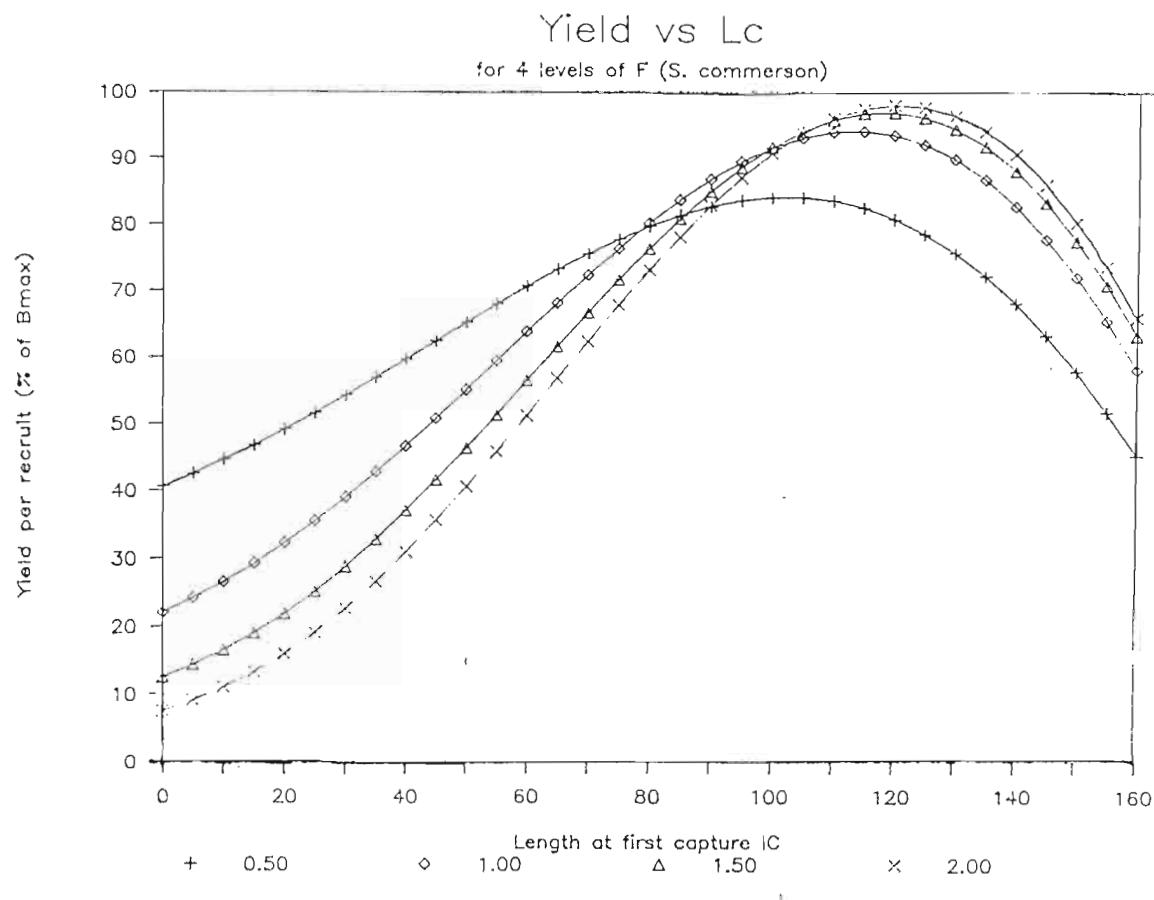
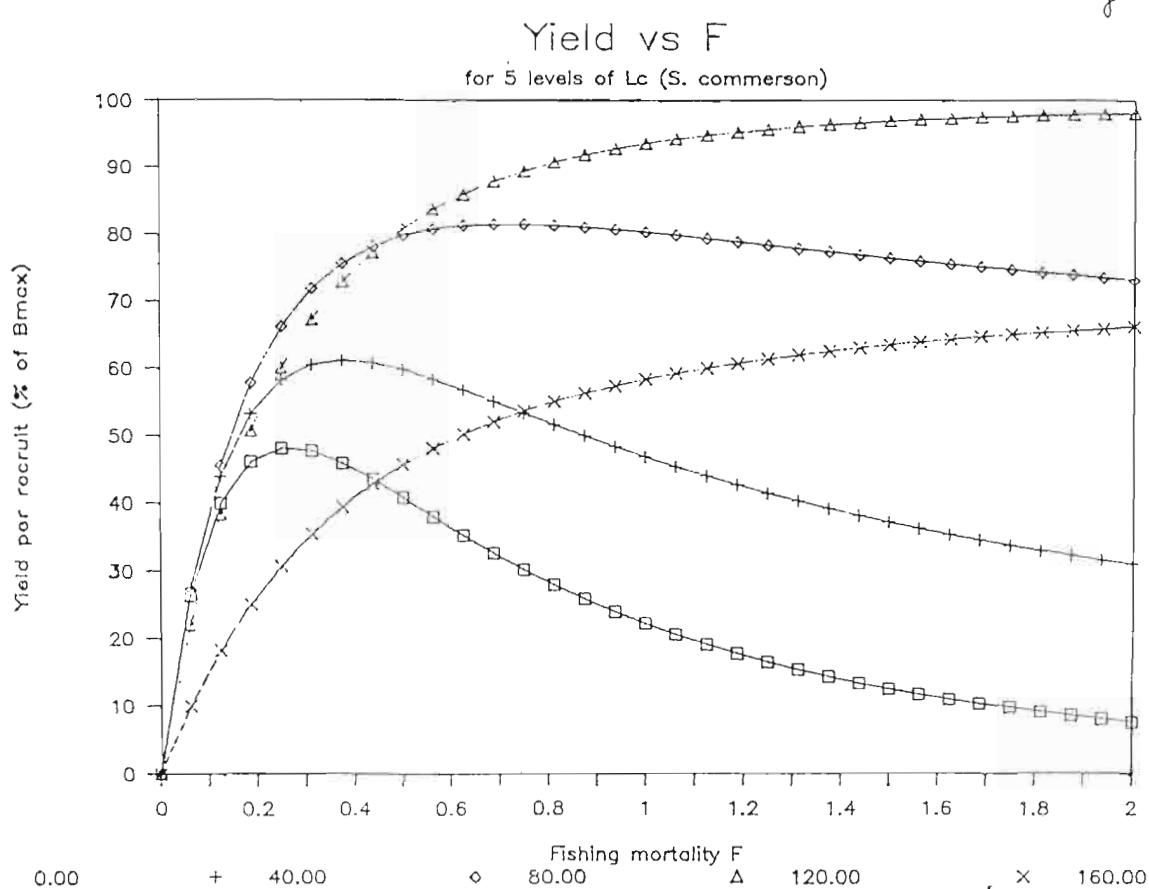
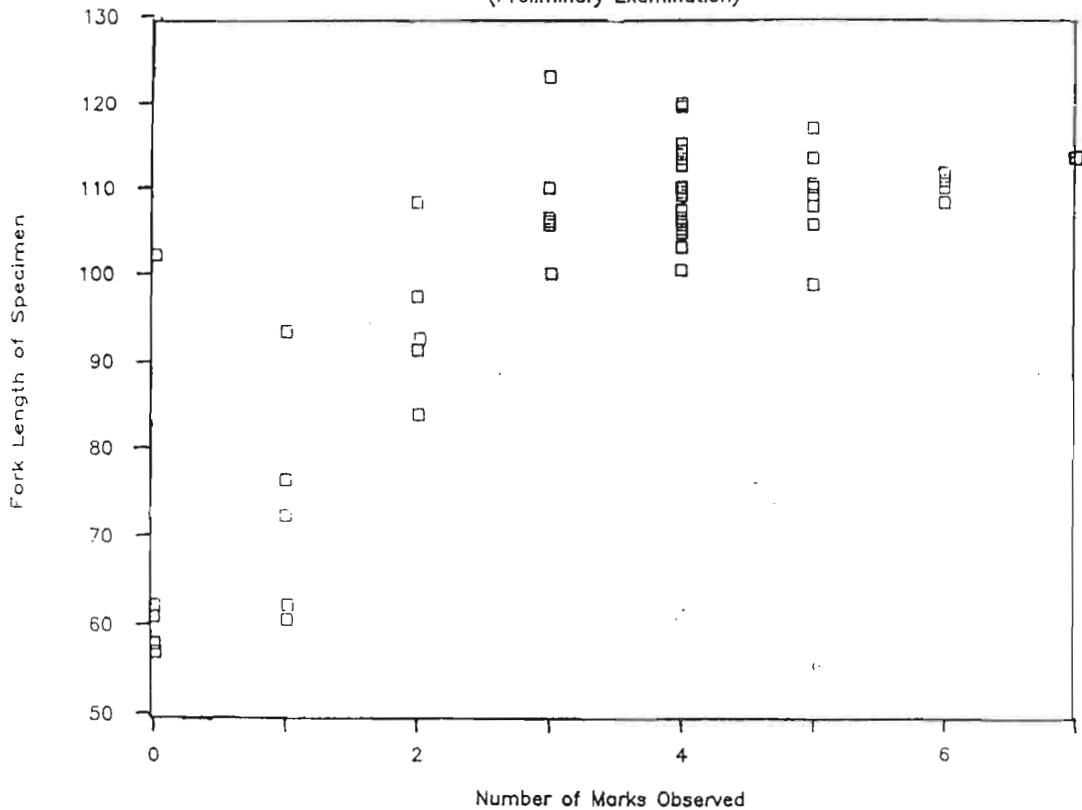


Fig. 3b

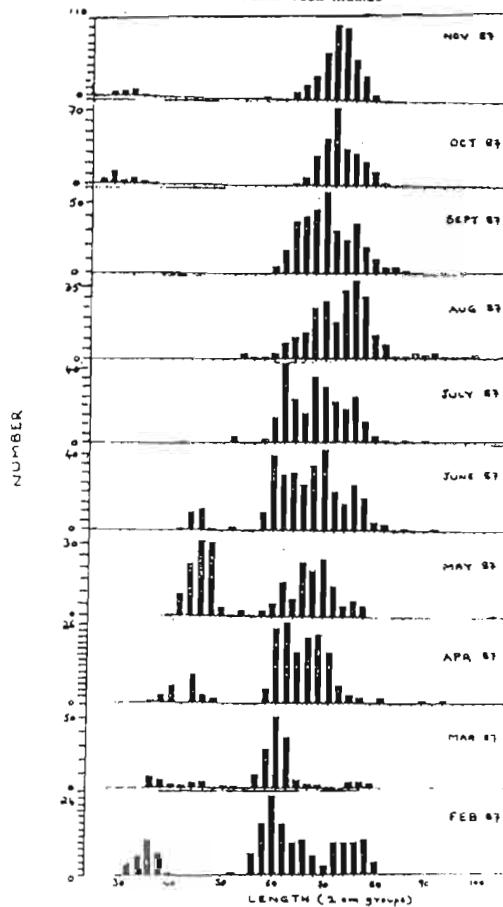


Marks on Otoliths of *S. commerson*

(Preliminary Examination)



SULTANATE OF OMAN
LENGTH FREQUENCY OF *THUNNUS TONGOL*
FEBRUARY-87 - NOVEMBER 87
MUTTRAH FISH MARKET



1. Introduction

Kawakawa (*Bathyynus affinis*) is a small tuna distributed over the continental shelves throughout the Indo-Pacific region. This species is the dominant neritic tuna off the east coast of Africa and in areas with relatively narrow continental shelves; for example, off Sri Lanka and the Philippines. Kawakawa is generally subordinate to the longtail tuna (*Thunnus tonggol*) in areas with broad continental shelves, such as the Gulf of Thailand and north coast of Australia. Kawakawa is one of the least preferred of tuna species because of its dark flesh and strong taste. Consequently, there are few directed fisheries for this species and most catches are taken incidentally in other fisheries targeting either for small or large pelagic species. As a result, kawakawa is generally captured by a variety of fishing gears. For example, a total of 5 industrial and 14 small-scale fishing gears are reported to capture this species in the shallow and deep-water fishing areas of the Philippines (Table 1). Kawakawa is captured incidentally in all industrial fishing gears or in 45% of the total catch from these areas. Of the small-scale fishing gears, hook and line and possibly the gillnet are targeted specifically for kawakawa. Therefore, a maximum 38% of total catch is captured in targeted fisheries.

The surplus production model for assessment of stocks compares catch with corresponding effort to ascertain the state of exploitation. This model is inappropriate for assessing the kawakawa stock of the Philippines because of the nature of the fisheries for this species. The industrial bagnet, purse-seine and ringnet fisheries catch kawakawa incidentally while targeting for other species. For such fisheries, there would be no relationship between kawakawa catches and effort, so a catch/effort plot is meaningless. On the other hand, statistics of gears and vessels in the small-scale fisheries sector are not available. Biological sampling programmes for catch and effort statistics would be prohibitively costly because of the distribution of kawakawa targeted small-scale fisheries throughout the shallow and deep-water fishing areas. Hook and line and gillnet catches of kawakawa are reported from 13 and 12, respectively, out of the 15 shallow and deep-water fishing areas. Munro (1986) given the length of coastline of these areas as 16,933 km. Furthermore, even if effort for small-scale fisheries targeting kawakawa are available and collectable, there still remains the problem of standardization of the remaining 62% of the catch.

2. "Density method" of assessing non-target species stocks

The Philippines is an extreme example of the complexity of kawakawa fisheries, but the problem of effort for incidental catches and small-scale fisheries are valid for kawakawa fisheries in other countries. The present method of stock assessment is based solely on annual catches translated into yields per unit area to circumvent the inherent problems of effort. This method is similar to the "relative response method" of Altagracia (1983), which is based on successive catches.

The 2 assumptions for the "density method" are:

1. Yields per unit area of a species or species group increases from inception of fisheries to highest density and then either stabilizes at this level or declines with continuing development of the fisheries;
2. maximum yields per unit area of a species or species group are equal for similar ecosystems within a zoogeographic province.

A Simple method of determining exploitation levels
of neritic tuna stocks

by

Mitsuo Yesaki
Tuna Biologist

Table of Contents:

1. Introduction
 2. "Density method" of assessing non-target species stocks
 3. References
- Table 1
Figure 1

Three stocks of neritic tunas in the Indo-Pacific region were examined to demonstrate the present method. These include the Kawakawa stocks of the Philippines and Sri Lanka and the longtail - Kawakawa stocks in the Gulf of Thailand (Fig. 1). The extent of the continental shelf was defined as the distributional limits for these stocks of neritic tunas.

Yields per unit area of Kawakawa for the shallow and deep-water fishing areas of the Philippines increased to highest density ($0.33 \text{ mt}/\text{km}^2$) in 1982-83 and thereafter fluctuated at slightly lower densities (0.28 - $0.30 \text{ mt}/\text{km}^2$). This stock is at present being fully exploited.

Longtail tuna-Kawakawa yields per unit area in the Gulf of Thailand increased geometrically from a very low density ($0.04 \text{ mt}/\text{km}^2$) in 1980 to high densities (0.23 - $0.27 \text{ mt}/\text{km}^2$) in 1983-85. These stocks are being fully exploited at present.

Yields per unit area of the Kawakawa stock of Sri Lanka increased gradually from 1980 ($0.15 \text{ mt}/\text{km}^2$) to a peak in 1982 ($0.22 \text{ mt}/\text{km}^2$) and subsequently declined to a low ($0.11 \text{ mt}/\text{km}^2$) in 1985. The fall in densities is attributed to the racial disturbances that have curtailed fishing operations in some parts of the country since 1983. The Kawakawa stock off this country is presently not being fully exploited.

The maximum carrying capacity of the continental shelf for neritic tunas in the Indo-Pacific region is estimated to be between 0.27 and $0.30 \text{ mt}/\text{km}^2$. Information for additional stocks will provide better estimates of maximum carrying capacity and confidence limits on the estimates. Assessment on the status of a stock are made from the trend of successive densities and relative position of the current density to the estimate of maximum carrying capacity. The assessments that can be made are the stock is either is not being fully exploited or is being fully exploited. This method does not permit discrimination of whether a stock is being fully exploited or is being over-exploited. However, this method is suggested for non-target species for which management advice regarding fleet or gear restrictions would be meaningless.

3. References

- Alagarija, K., Mathematical models in fish stock assessment. *J. Mar. biol.* Ass. India, 25(1 and 2): 142-157.
- Munro, J.L., Marine fishery resources in the Philippines: catches and potentials. In: D. Pauly, J. Saeger and G. Silvestre (eds.). *Resources, Management and Socioeconomics of Philippines Marine Fisheries*.

Fishing gear	Industrial		Small-scale		Total
	kg	%	kg	%	
bagnet	6,748	39	1,244	6	7,992
purse-seine	6,630	38	2,652	13	13,149
ringnet	3,867	22			34
trawl	156	1	78	0	234
hook and line	81	0	11,147	53	11,228
gillnet	-	-	3,342	16	3,342
longline	-	-	520	3	520
beach seine	-	-	266	1	266
troll line	-	-	94	0	94
spear	-	-	1	0	1
fish corral	-	-	1,489	7	1,489
fip	-	-	54	0	54
push-net	-	-	7	0	7
pole and line	-	-	6	0	6
Total	17,482	45	21,097	55	38,579
			100		

Table 1. Yields per unit area of Kawakawa by industrial and small-scale fishing gears in the shallow and deep-water fishing areas of the Philippines during 1985.

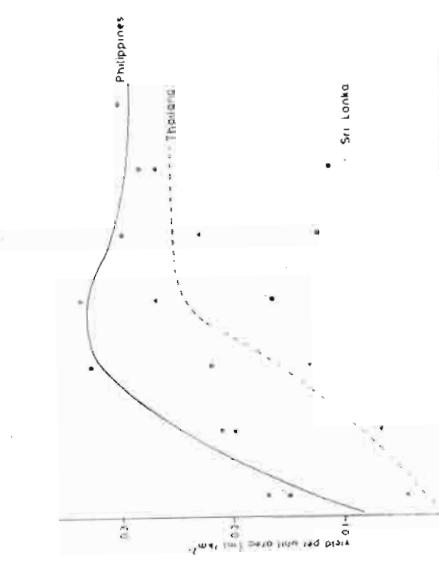


Fig. 1. Fields per unit area of neritic tunas for 4 countries in the Indo-Pacific region.

Description and Identification of Longtail
Tuna larvae, *Thunnus tonggol* (Bleeker) in the Gulf of Thailand
R. Chayakul and C. Chamchang

Abstract

Larvae of *T. tonggol* were obtained from the plankton sample collected in the Gulf of Thailand. A total of 28 postlarval specimens were identified as *T. tonggol* based on the meristic (morphological) characters, and the arrangement of pigments on the body and the locality of the sampling area. The pigmentation and growth stage development in postlarvae are described in detail.

Introduction

Recently, the small tunas are a group of important commercial pelagic fishes in Thailand. There are three species of small tuna that have been reported in the Gulf of Thailand, namely *Euthynnus affinis* (Cantor), *Auxis thazard* (Lacepede) and *Thunnus tonggol* (Bleeker) (Chullasorn and Martosubroto, 1986); the major type of gear used to catch them are drift gill net and luring purse seine. A total of 6,189 to 82,001 metric tons were caught during the period from 1979 to 1984 (Cheunpan, 1986).

Since the number of tuna canneries in Thailand in recent years has rapidly increased, consequently, the number of the fishing crafts and fishing techniques, especially for luring purse seine, have developed as well. Therefore, the total number of tuna landing in Thailand show a yearly increasing trend.

Among the three species of small tuna captured, Cheunpan (1986) stated that the tuna in the Gulf of Thailand are generally mixed schools, but the

percentage contribution of *T. tonggol* was higher than the others two species. This may be due to the fact that the longtail tuna is distributed more abundantly in the deep water, which is the main fishing ground for the luring purse seine.

As far as is known, the early life history of small tunas in this region especially for long tail tuna is virtually unknown. There is only the Cheunpan's studies on the sexual maturity, size at first maturity, and the spawning time (Cheunpan, 1984). Therefore the Marine Fisheries Division, Department of Fisheries, Thailand, during the period of January to June 1987 undertook to study the distribution and abundance of small tunas in this region.

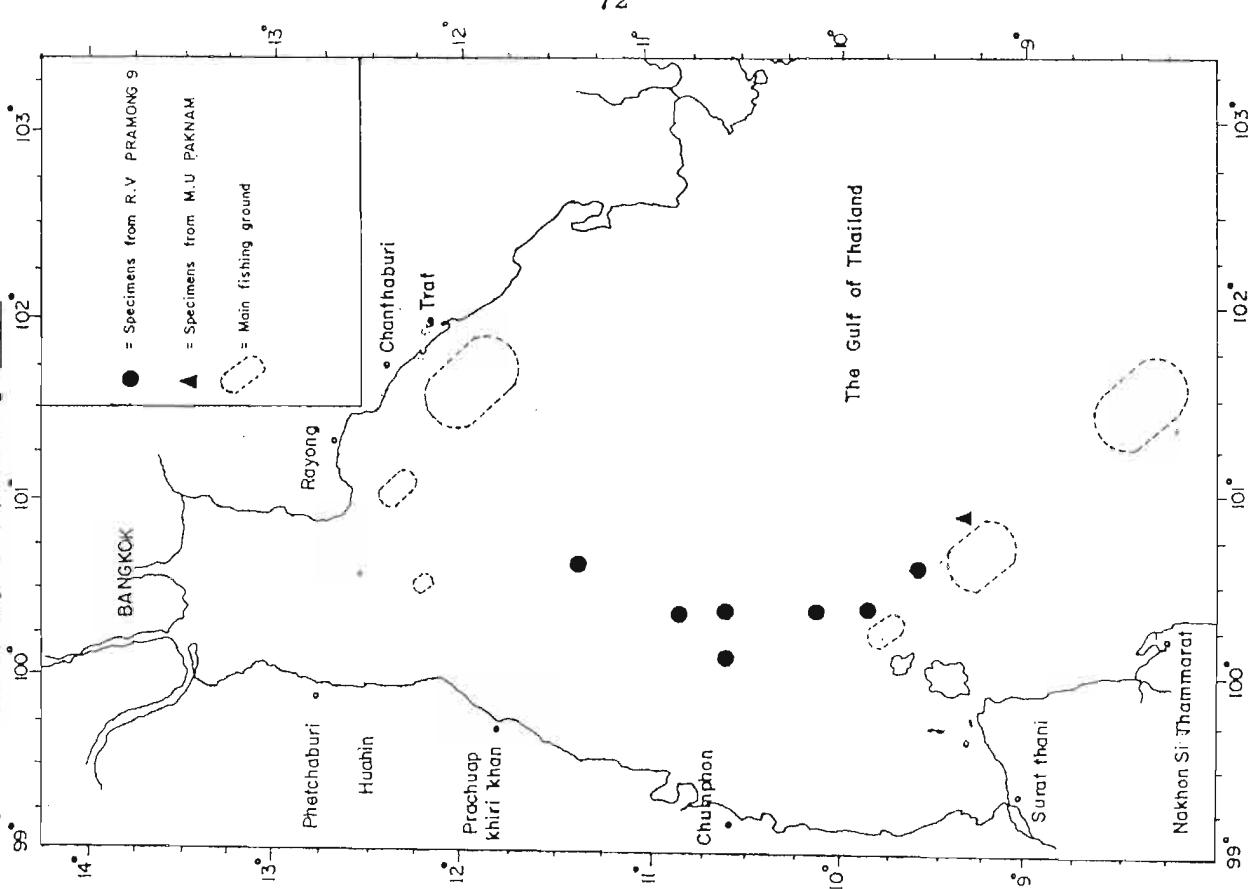
The purpose of the present study is to identify and describe the *T. tonggol* larvae in order to gain information on the locality, the spawning time and to compare larvae were found in this region with those of other regions.

Material and Methods

Fish larvae were collected by using a larva net 4.5 m in length with a mouth of 1.3 m in diameter. The net consists of two parts: the anterior part having a 3 m length with a 3 mm mesh size, and the posterior part having a 1.5 m length with a very fine mesh (GG.38). An iron ring was attached to the mouth of the net with a flowmeter fixed at its center.

The specimens used in this study were transferred from plankton samples collected from the Gulf of Thailand taken by two research vessels belonging to the Marine Fisheries Division (R.V. Pramong 9) in 1987 and South East Asian Development Center (M.V. Parknam) in 1984. The locations of the larvae collections are shown in Fig. 1.

Figure 1. The locality of capture of T. tonggol.



The towing methods of the two vessels were different. During the R.V. PRAMONG 9 cruises, the net was towed obliquely at the speed of 2-3 knots for 10 minutes, and in the other case it was towed at the surface layer for 20 minutes at the same speed.

Collections were preserved in 4-10% formalin solution on board. The samples were later sorted, identified, counted, and then measured at the Marine Fisheries Division.

Table 1. Capture records of the larval T. tonggol (Bleeker)

Date	Methods	Locality	Lat.	Long.	No. of Specimens	Size (TL) mm.
Sept. 22, 1984	surface	9° 21.5' N	100° 56.5' E		1	6.7
Jan. 14, 1987	oblique	10° 37.5' N	100° 7.5' E		1	4.6
Feb. 16, 1987	oblique	10° 37.5' N	100° 22.5' E		1	6.7
Apr. 13, 1987	oblique	11° 22.5' N	100° 37.5' E		4	4.0-5.9
May. 21, 1987	oblique	10° 7.5' N	100° 22.5' E		2	5.2, 6.0
May. 22, 1987	oblique	9° 37.5' N	100° 37.5' E		10	4.2-5.9
Jun. 9, 1987	oblique	10° 52.5' N	100° 22.5' E		1	4.3
Jun. 16, 1987	oblique	9° 37.5' N	100° 37.5' E		5	4.2-5.0
Jun. 17, 1987	oblique	10° 7.5' N	100° 22.5' E		2	4.3, 6.4
Jun. 17, 1987	oblique	9° 52.5' N	100° 22.5' E		1	4.5

R.V. PRAMONG 9 in 1987

M.U. PAKNAM 1 in 1984

Descriptions of early developmental stage

Measurement and counts of five specimens described and illustrated are presented in table 2.

Table 2. Data on the capture and measurements of five specimens described and illustrated.

Specimens No.	1	2	3	4	5
Date	87/4/13	87/5/22	87/5/21	87/6/17	84/9/22
Locality	Lat. 11° 22.5' N 9° 37.5' N	10° 7.5' N	10° 7.5' N	9° 21.5' N	
Long.	100° 37.5' E 100° 37.5' E	100° 22.5' E	100° 22.5' E	100° 56.5' E	
Measurement in mm.					
Total length	4.20	5.30	6.00	6.40	6.70
Standard length	4.10	5.00	5.20	5.80	6.10
Head length	1.30	1.70	1.80	2.20	2.50
Snout length	0.30	0.40	0.50	0.70	0.80
Diameter of eye	0.40	0.55	0.60	0.75	0.85
Diameter of orbit	0.60	0.70	0.80	0.90	0.95
Preanus distance	1.70	2.30	2.60	2.90	3.50
Snout to dorsal fin origin	1.60	1.90	2.20	2.30	2.80
Count :					
Dorsal fin	-	IV	VII	VII	IX
Anal fin	-	-	-	-	-
Pectoral fin	-	-	-	-	-
Pelvic fin	-	-	-	1,-	1,5
Caudal fin	-	-	-	15	17
Myomere	39	39	39	39	39

Specimen No. 1; 4.1 mm in SL (FIG. 2).

The body is evenly tapered caudally. The head is large, being 32% of standard length. In the dorsal profile of the head, anterior to the eye is slightly concaved, and gently arched posteriorly, terminating in the nape.

The snout is pointed, its length occupied 23% of head length. The nasal opening is an oval single pore, situated nearer the eye than the tip of the snout. The mouth is large and oblique, and its posterior tip extends to a point vertical of eye. The teeth are present on the both jaws, with 6 and 3 teeth on the upper and lower jaws, respectively.

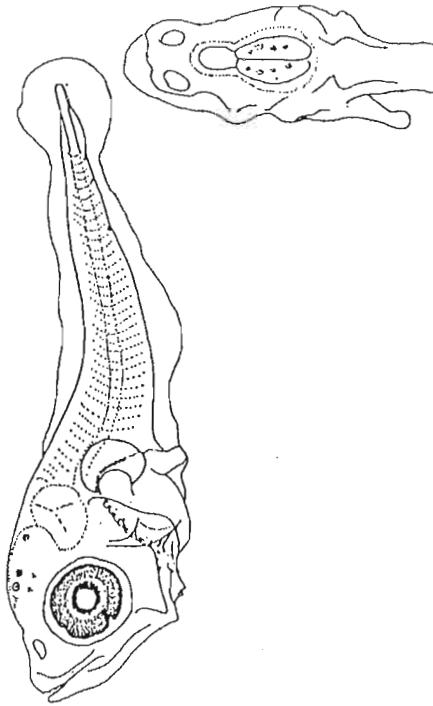


FIG. 2 Specimen No. 1

The eye is round and large, its diameter is 31% of head length, with a small fissure ventrally. The gill membrane is free from the isthmus. The abdominal sac is compact and triangular shape. The anus is located a little before the mid part of notochord length, representing 41% of standard length. The tip

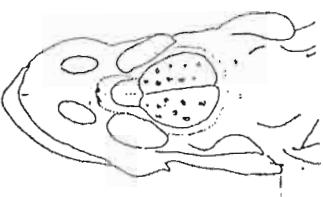
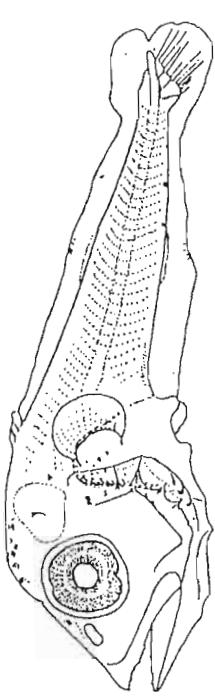


Fig. 3 Specimen No. 2

of notochord is straight and no trace of hypural bones are visible. There are 3 spines each on the both inner and outer edges of the preopercle. The spine at the angle of the outer edge is longer than that the others, being about one-fifth of the head length. The pectoral fins are fan-like shape, and quite evident although they are still rudimentary. The pelvic fin is absent. The unpaired fins are not developed, but are represented by the fold continuous from the anus to the dorsal fin through the caudal fin. The myomere count is 39.

On the head region, the pigment is feeble, with 7-8 stellated chromatophores on the mid brain. Several chromatophores are scattered on the dorsal surface and the anterior part of abdominal sac. There are 3 spots of chromatophores on the ventral surface of tail on the 29th, 34th and 38th myomeres. The anterior one is larger than that of the others. One spot of chromatophore is seen faintly in the caudal fin region, located ventrally on the expose of notochord tip. The rest of body is unpigmented.

Specimen No. 2; 5.0 mm in SL (Fig. 3).

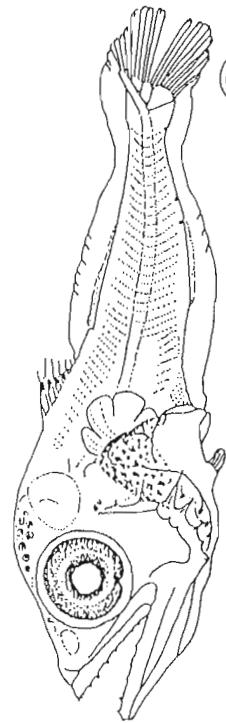
The development of the larva at this size is remarkably progressed, particularly in the first dorsal fin region. The body is fusiform in shape. The head is relatively larger than the preceding specimen, occupied 34% of standard length. The anus is located in advance of the anal fin, and close to the pelvic fin insertion. In the anterior portion of dorsal fin where the spines develops appeared 4 small spines, the first spine originates on the about 1st myomere. The number of spines at the preopercle are noticeably increased, there are 3 small spines and 6 spines in the inner and outer edges respectively. The mouth has 10 small teeth on the upper jaw and 8 similar teeth on the lower jaw. There is one small spine now appearing on the temporal region. The pectoral fins are still rudimentary. The pelvic fins are present

as fleshy bud. The dorsal and ventral fin folds are still continuous with the caudal fin. The distal pterygiophores of the dorsal and anal fins are visible, but are not clearly defined and no accurate count could be made.

The anal fin originates at the about half way of the tail. The tip of notochord is slightly turned upward, and the formation of hypural bones are noticeable. The caudal fin is developing, with a faint striation can be seen. The pigmentation of the head and abdominal sac are advanced. On the head region, there are about 15 stellated chromatophores on the mid brain, and a stripe of dark internal chromatophores is found on the hind brain. The dorsal end of preopercle bears 1 or 2 chromatophores, and a few internal chromatophores are seen feebly on the forebrain. The number of spots on the ventral surface of tail remain the same as the preceding specimen, but the positions of the pigment spot are slightly changed (on the 27th, 31th, and 36th myomeres). The middle one is larger than the others two.

Specimen No. 3; 5.2 mm in SL (Fig. 4).

The specimen of this size has the same general appearance of the foregoing specimen, but the head is shown some advance in development, representing 35% of standard length. The snout is slightly longer, and its front edge is farther square built in shape. The diameter of eye is equal to the diameter of preceding specimen.

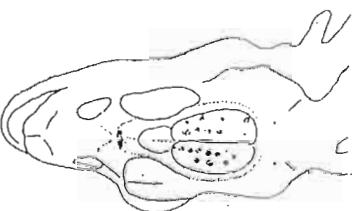


fins are developing, and about 13 distal pterygiophores of dorsal fin and 12 of anal fins are counted. The caudal fin is more developed, equipped with 15 rays.

In addition to the pigmentation previously mentioned, the new conspicuous chromatophores occur on the membrane of the first dorsal fin between the 1st and the 6th spines. Pigmentation is more extensive over the mid brain and over the abdominal sac. Two small chromatophores are present on the ventral surface of tail (on the 29th and 31th myomeres).

Specimen No. 4; 5.8 mm in SL (Fig. 5).

General shape of the body resembles with that of the previous one, but the head is more developed, being 38% of standard length.



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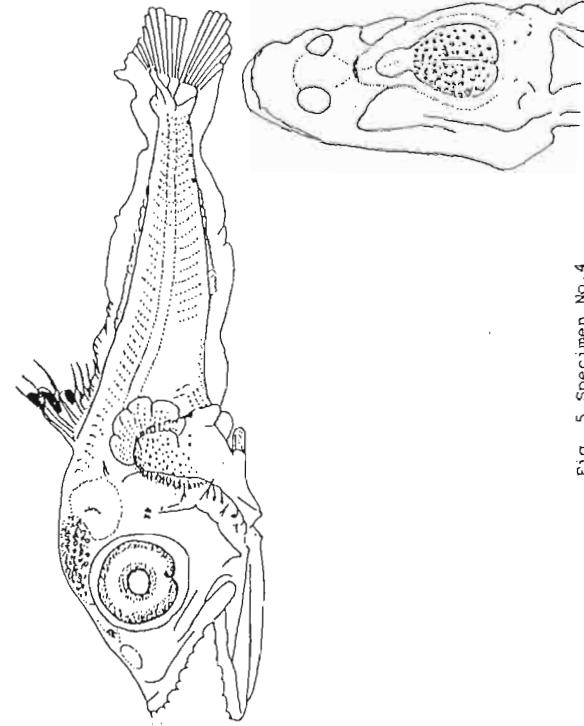


Fig. 4 Specimen No. 3

The eye fissure is still discernible. The mouth consists of 11 teeth on the upper jaw and 9 similar teeth on the lower jaw. The most noticeable developments is in the first dorsal fin, with 7 spines. The anterior 5 spines are strong, concurrently with 2 weak spines. The pectoral fins are still rudimentary. The pelvic fins are longer than the 5.0 mm SL specimen. The dorsal and anal

Fig. 5 Specimen No. 4

On the head region, dorsal profile of the head is concaved in the upper part of nasal opening. The eye fissure is still discernible. The pectoral fins are differentiation. The pelvic fins are more developed, with 1 spine and the soft rays appear only as striation. The dorsal and ventral finfolds are still persisting, but the development on the first dorsal fin is progressive, comprises of very strong 7 spines. The distal pterygiophores of the dorsal and anal fins have increased in number, about each 4-5 pterygiophores for the further finlets are noticeable on the both of the dorsal and anal fins. The caudal fin is differentiated, its posterior tip shows the sign of becoming forked, and about 17 rays are counted.

On the head region, the pigmentation of the mid brain is similar to the previous specimen, but it expands over almost the entire mid brain area.

The pigmentation of the forebrain is fairly developed. There are 3 spots of the pigment on the ventral surface of tail on the 32th, 34th and 38th myomeres, the anterior 2 of them are larger than the remaining one. The dorsal surface of the body is still free from the pigments. The count of the myomeres is 39.

Specimen No.5; 6.1 mm in SL (Fig. 6).

The head is still large, being 41% of standard length. The nasal opening is elongated and has a small constriction in the mid part. The mouth contains 12 teeth on the upper jaw and 10 teeth on the lower jaw. The spines on the first dorsal fin have increased to 11 spines with growth, the anterior 9 spines of them are strong, followed with 2 feeble spines. The fin fold are still visible in the preanal part along the ventral surface. The second dorsal and anal fins are beginning to form, but are not clearly defined and difficult to distinguish each ray. There are about 7 distal pterygiophores of the dorsal and anal finlets are noticeable. The pelvic fins are progressively

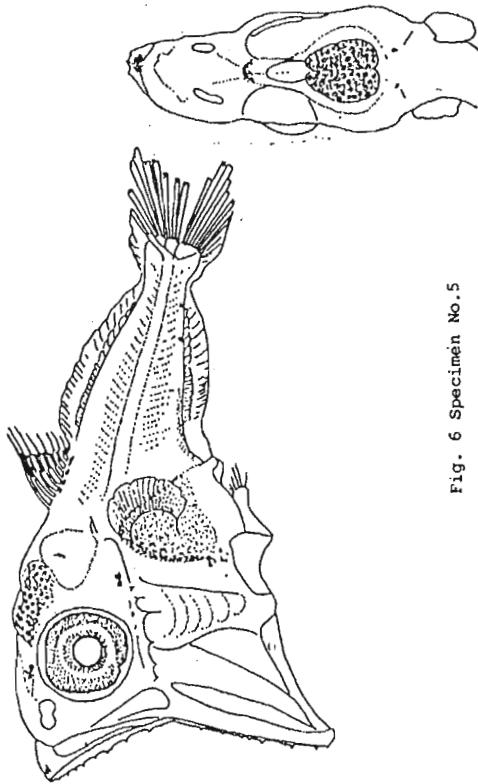


Fig. 6 Specimen No.5

developed, and well enough to permit the enumeration, with 1 spine and 5 soft rays are evident. The anus is moved posteriorly though still separated from the origin of anal fin base, which representing 57% of standard length. The notochord flexion is almost completed, and the hypural bones are in the terminal position. The caudal fin is more developed, with forked posteriorly.

Some striking changes are seen in the pigmentation of the head and the first dorsal fin area. On the head area, a few chromatophores now appear on the tip of the upper jaw and the pigments are more developed on the mid brain. The first dorsal fin has several chromatophores on the membrane between the 1st and 9th spines. A row of 4 pigment spots is present along the base of first dorsal fin, originating posterior to the 3rd spine. Two similar dots of chromatophores are present on the ventral surface of tail, situated in the region of future anal finlets.

Table 3. Summarized characters to separate the larvae of T. tonggol
from E. affinis and A. thazard

Characters	<u>T. tonggol</u>	<u>E. affinis</u>	<u>A. thazard</u>
Small larvae (3.7-6.7 mm TL)			
Black pigmentation:			
Upper jaw tip	Appear at about 6.7 mm TL	Appear at about 5.5 mm TL	Absent
Lower jaw tip	Absent	Appear at about 4.6 mm TL	Appear at about 3.7 mm TL
Mandible	Absent	1 spot and increasing with growth	Absent
Symmetry of pectoral girdle	Absent	1 spot	1 spot
Dorsal edge of trunk and tail	4 spots along the base of the first dorsal fin at 5.7 mm TL	Absent	2-3 spots on the caudal peduncle
Mid-lateral line	Absent	2-3 spots on the caudal peduncle	9-10 spots
Ventral edge of mouth	1-3 spots	3 or more	Ventral edge of trunk
Postorbital	Appear from 5.0 mm TL	3 spots	Absent

Table 4. Comparison of the larvae of the Genus Thunnus having black pigment cell on the trunk

Characters	<u>T. thynnus</u> (Atlantic)	<u>T. thynnus</u> (Pacific)	<u>T. tonggol</u> (Indo-Pacific)	<u>T. maccoyii</u>	<u>T. obesus</u>
Small larvae (3.0-6.1 mm)					
Number of pigment cell					
Upper jaw tip	No observation	Appear at above 6.0 mm SL	No observation	Appear at 6.1 mm SL	mm SL
Lower jaw tip	2 on inner edge	2 on inner edge	No observation	None	0-2 inner edge below 4 mm SL
Dorsal edge of trunk	1 or more between second dorsal and caudal fin	1 or more between second dorsal and caudal fin	1, 2 or more along the base of first dorsal and caudal fin	1 or more spots along the base of first dorsal and caudal fin	1 or more spots along the base of first dorsal and caudal fin
Ventral edge of trunk	1-4	2 or more	2 or more	1-3	1-3

Source : Matsumoto et al 1972

* * * : Obtained from present study

1 = Present study
2 and 3 from Matsumoto (1968, 1969)

Identification and Comparison

The above postlarval specimens in the present study can be characterized by the following: fusiform shape, large head and mouth, early formed spines at the preopercle, 39 myomeres, 1-3 spots of chromatophores on the ventral surface of tail, triangular pigmented abdominal sac.

Only three species of small/coastal tunas are found in the Gulf of Thailand namely Euthynnus affinis, Auxis thazard and Thunnus tonggol (Chullasarn and Martosubroto, 1986). Hence the larvae of small tunas which were collected in this area must also be identical to the adult populations previously identified.

Okuyama and Ueyanagi (1978) compared presumed phylogenetically important larval characters for 12 genera of the subfamily scombrinae to determine intergeneric relationships. Using their criteria, the present study's largest specimen was identified as genus Thunnus. The study then traced identifiable characteristics down from the largest to the smallest specimen collected. It was therefore, concluded that all specimens examined were of the genus Thunnus.

The identification becomes clearer by pigment character observations based on the size series of specimens 4.2-6.7 mm in total length. Matsumoto (1958, 1959) reported that, about the said length E. affinis and A. thazard possess a single chromatophore each at three parts of body, i.e. at the tip of the lower jaw, at the symphysis of the pectoral girdle and the ventral surface of the abdominal sac just anterior to the anus. Besides, A. thazard bears three rows of chromatophores in the region of the caudal peduncle, and the conspicuous chromatophores are present at the middle of mandible in E. affinis. However, the present specimens bear no such pigmentation. Moreover, E. affinis possess 3 or more chromatophores on the ventral surface

of the tail while the present specimens have only 1-3 chromatophores on the same region. (Table. 3)

Referring to the pigmentation character, the specimens in this study are all referable to T. tonggol based on the evidences stated above and the locality of sampling area.

In comparison, Matsumoto (1962) described the larvae of T. tonggol as having initial chromatophores at the anterior to the origin of the second dorsal fin, along the base of the first dorsal fin, but the succeeding ones may be found anywhere between the origin of the second dorsal fin and the caudal fin, and also have 2 or more chromatophores on the ventral surface of the tail. In contrast, the study specimens designated here as T. tonggol possess 1-3 spots of pigment on the ventral surface of the tail and lack pigments on the dorsal surface of the body, until a length of about 5.8 mm SL is attained (At 6.1 mm SL the base of the first dorsal fin is pigmented).

Table 4 summarizes pigment characters to compare larvae of Genus Thunnus having black pigments on the trunk using existing literature and the present study.

Taking into consideration the pigments on the ventral surface of tail, it is observed that the number of the black pigments on the said region of the specimens in this study vary from 1 to 3 and the position of each pigment also varies. A total of 28 specimens of larvae was checked; 5 had 1 spot of black pigment, 11 and 12 had 2 and 3 spots respectively.

Since the description and identification for T. tonggol as given here is based on the limited specimens of 28 larvae, therefore further detailed study is required.

Acknowledgements

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Distribution of Longtail tuna (*Thunnus tonggol*, Bleeker), Kawa kawa
 (*Euthynnus affinis*, Cantor) and Frigate tuna (*Auxis thazard*, Lacépède)
 in the Western Coast of the Gulf of Thailand

C. Chamchang and R. Chayakul

Abstract

The paper presents the abundance and distribution of the three species of tuna larvae namely longtail tuna, kawa kawa and frigate tuna in the western Gulf of Thailand collected monthly for a six-month period between January to June 1987. A total of 68.06 tuna larvae per $1,000 \text{ m}^3$ of strained water were collected. Tuna larvae were found most abundantly in June which longtail tuna was dominant.

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Tuna fishes are one of the commercially important fishes, which are commonly found in the South China Sea area and its adjacent waters, e.g. the west of the Gulf of Thailand and the east coast of Peninsular Malaysia. They have become the economically important species in Thailand since 1970 as the result of the rapid development of the pelagic fishery and of the fastgrowing business of the fish canning industry. The production of tuna were significantly increased, ranging from 6,500 to 82,000 tons during 1973-1984 (Table 1) with the average of 24,000 tons per annum. Three species of tuna, namely longtail tuna, Kawa kawa and frigate tuna are found to distribute in the Gulf of Thailand at the distance of between 30-60 miles offshore and exist more abundantly near islands at the depth of 20-45 meters. Klinimuang (1981) and Chenpun (1986) studied species composition of adult tunas in the Gulf of Thailand and both of them found that the percentage contribution of longtail tuna was higher than those of Kawa kawa and frigate tuna. This may be due to the fact that longtail tuna distributes more abundantly in the deeper water especially in the middle

region of the Gulf than kawa kawa and frigate tuna, and this area is known to be the main fishing grounds for tuna purse-seining.

The biological information of tunas in this region is rather limited. Studies dealing with the early life history of tuna in the South China Sea have been carried out by a small number of investigators, e.g. Vatanachai (1972)

Table 1 Annual catch of Tuna of Thailand and in the Gulf of Thailand 1973-1984

Year	Catch (MT)		% of total catch	increasing rate %
	Total	Gulf of Thailand		
1973	7,914	6,519	82.4	-
1974	9,925	8,715	87.8	33.7
1975	12,044	11,172	92.8	28.2
1976	9,719	8,890	91.5	-20.4
1977	12,932	11,296	87.3	27.1
1978	10,353	8,258	79.8	-26.9
1979	16,850	14,713	87.3	78.2
1980	13,683	12,895	94.2	-12.4
1981	22,273	20,198	90.7	56.6
1982	49,307	39,661	80.4	96.4
1983	85,820	82,001	95.5	106.8
1984	80,669	69,182	85.76	-15.6

(Source : Cheunpun, 1986)

Chen and Tan (1973) and Marquez (1975). Vatanachai (1975), Chayakul and Uttaraponge (1983 & 1983), Tungkasaeeranee (1980 & 1980) and Chamchang (1987) studied on the abundance of tuna larvae in the western coast of the Gulf of Thailand. Cheunpun (1984) studied on the spawning season of longtail tuna, kawa kawa and frigate tuna in the Gulf of Thailand and found the peaks of spawning period of longtail tuna were between March-May and between July-December, whereas of kawa kawa were between January-March and June-September and of frigate tuna were between April-June and August. Therefore the study of tuna larvae in the Gulf of Thailand is necessary. The purpose of this study was to describe the distribution of longtail tuna larvae (Thunnus tonggol, Bleeker), kawa kawa larvae (Euthynnus affinis, Cantor) and frigate tuna (Auxis thazard, Lacepede) found in the western Gulf of Thailand to gain information on location and time of spawning.

Materials and method

Samples in this study were obtained from an area in the western Gulf of Thailand, extending from the latitude $9^{\circ}22.5'$ to $12^{\circ}7.5'$ N and the longitude $100^{\circ}7.5'$ to $100^{\circ}52.5'$ E. The study area is offshore between Prachuap Khirikhan to Surat Thani provinces.

Collections of samples of six cruises on board the research vessel Pramong 9 of the Marine Fisheries Division, Department of Fisheries were made between the period January to June 1987. There were 25 sampling stations as shown in figure 1.

Fish larvae were collected by the larvae net with a mouth opening of 1.3 meters in diameter and 4.5 meters in length. The net consists of two parts: the anterior part is 3 meters in length with a mesh size of 3 mm. whereas the posterior part (cod end) is of 1.5 meters in length with a very fine mesh (G.G.38).

The specimens were preserved in 5% neutral formalin solution. The fish larvae were sorted under a stereoscopic microscope at the Marine Fisheries Division and only the tuna fish larvae were picked out for study on species and their distribution.

Results

1. Abundance of tuna fish larvae

During this survey period, the average of 68.06 tuna larvae individuals per 1000 m³ of strained water were collected, consisting of longtail tuna, *Thunnus tonggol* of 34.73 individuals per 1000 m³, frigate tuna, *Auxis thazard* of 28.00 individuals per 1000 m³ and kawa kawa, *Euthynnus affinis* of 5.33 individuals per 1000 m³. Tuna larvae were found most abundantly in June in which longtail tuna larvae were predominant species. (Table 2 & Figure 2)

2. Distribution of tuna fish larvae

Range of distribution

Sampling sites of tuna larvae taken during the period January-June 1987 are shown in figures 3A-3E. Three types of symbols are used to represent the occurrence and the abundance of the tuna species. Larvae of longtail tuna, kawa kawa and frigate tuna were taken offshore as far north as 11° 52' N of Prachuap Khirikhan. And at the south of the western Gulf of Thailand at 9° 37' N in the eastern side of Samui Island. In an east-west direction, they were taken between 100° 37' S to 100° 52' S.

Figure 1. Locations of larvae net operations in the western Gulf of Thailand, 1987. The numbers in the grid indicate the station numbers.

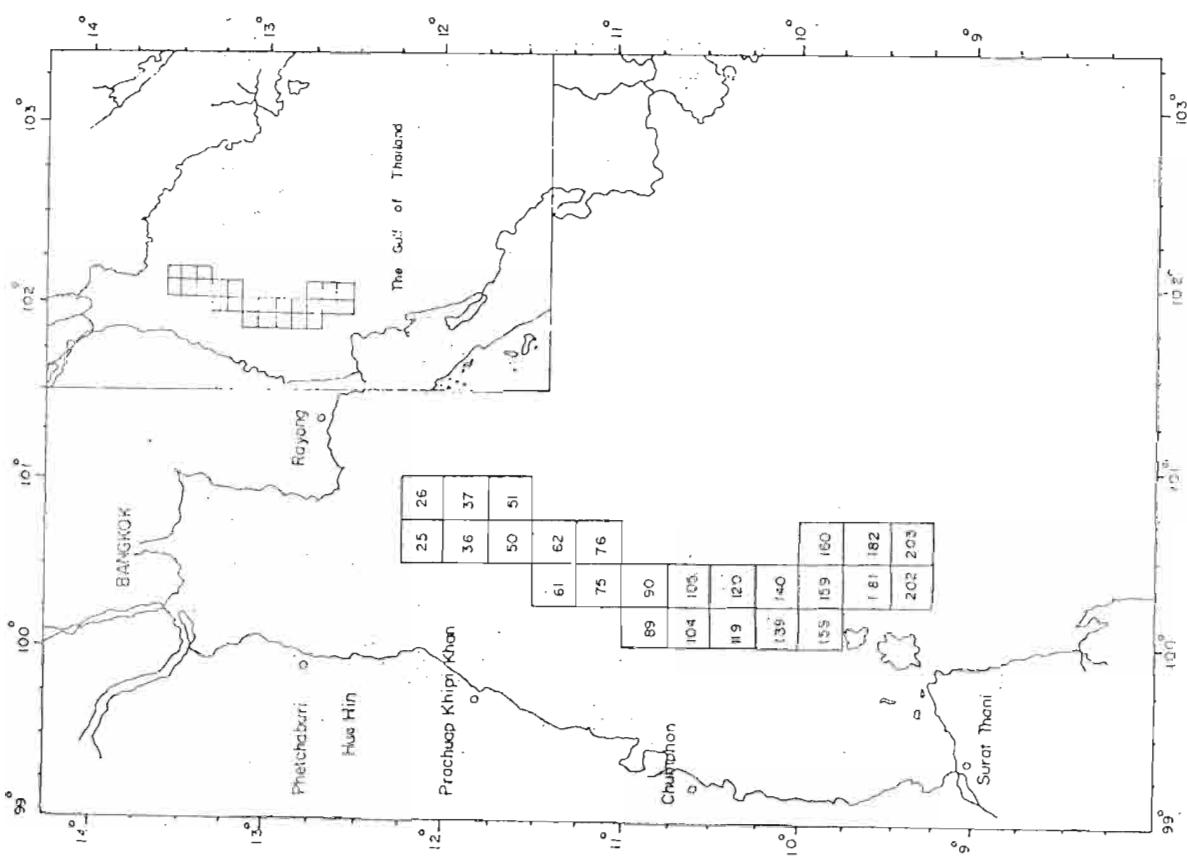


Table 2 Kind and abundance of Tuna fish larvae at the offshore of Prachuap Khirikhan to Surat Thani Provinces in 1987 (individual/1000 m³)

Month	Station	No. of fish larvae												* = No operation											
		25	26	27	50	51	61	62	75	76	80	90	104	105	119	120	129	140	158	159	160	181	182	202	203
Jan.	Lon. Sura	*	-	-	-	-	-	-	-	-	-	(1)	-	-	-	-	-	-	-	-	-	-	-	-	1.36
Jan.	Kao. Kao	-	-	-	-	-	-	-	-	-	-	1.36	-	-	-	-	-	-	-	-	-	-	-	-	-
Feb.	Frigate tuna	-	*	-	(2)	-	-	-	-	-	-	(2)	-	-	-	-	-	-	-	-	-	-	-	-	4.15
Mar.	Lat.	-	*	-	-	-	-	-	-	-	-	0.86	-	-	-	-	-	-	-	-	-	-	-	-	0.86
Mar.	Kao.	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mar.	Frig.	-	*	-	-	-	-	-	-	-	-	(1)	(1)	0.86	-	-	-	-	-	-	-	-	-	-	2.66
Apr.	Lat.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Apr.	Kao.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.05
Apr.	Frig.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.30
May.	Lat.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.85
May.	Kao.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15.50
May.	Frig.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.23
Jun.	Lat.	-	-	-	-	-	-	-	-	-	-	(1)	-	-	-	-	-	-	-	-	-	-	-	-	-
Jun.	Kao.	-	-	-	-	-	-	-	-	-	-	1.11	(1)	-	-	-	-	-	-	-	-	-	-	-	10.96
Jun.	Frig.	-	-	-	-	-	-	-	-	-	-	1.50	-	-	-	-	-	-	-	-	-	-	-	-	3.03

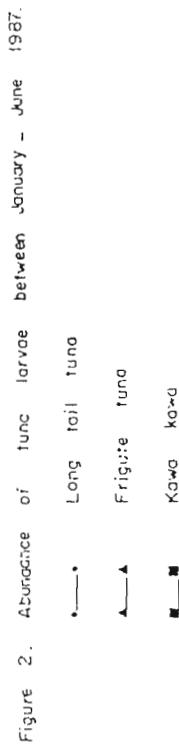


Figure 2. Abundance of Tuna larvae between January - June 1987.

Longtail tuna

The larvae of longtail tuna were collected from the latitude $9^{\circ}37'5''$ to $11^{\circ}22'5''$ N. They were slightly abundant in May at station 182, off Samui Island and Phuan Island at the water depth of 57 meters. Longtail tuna larvae distributed more abundantly in June than they were found in the other months.

They were found in an area far from the coast, especially in the deep water. (Figures 3A-3E)

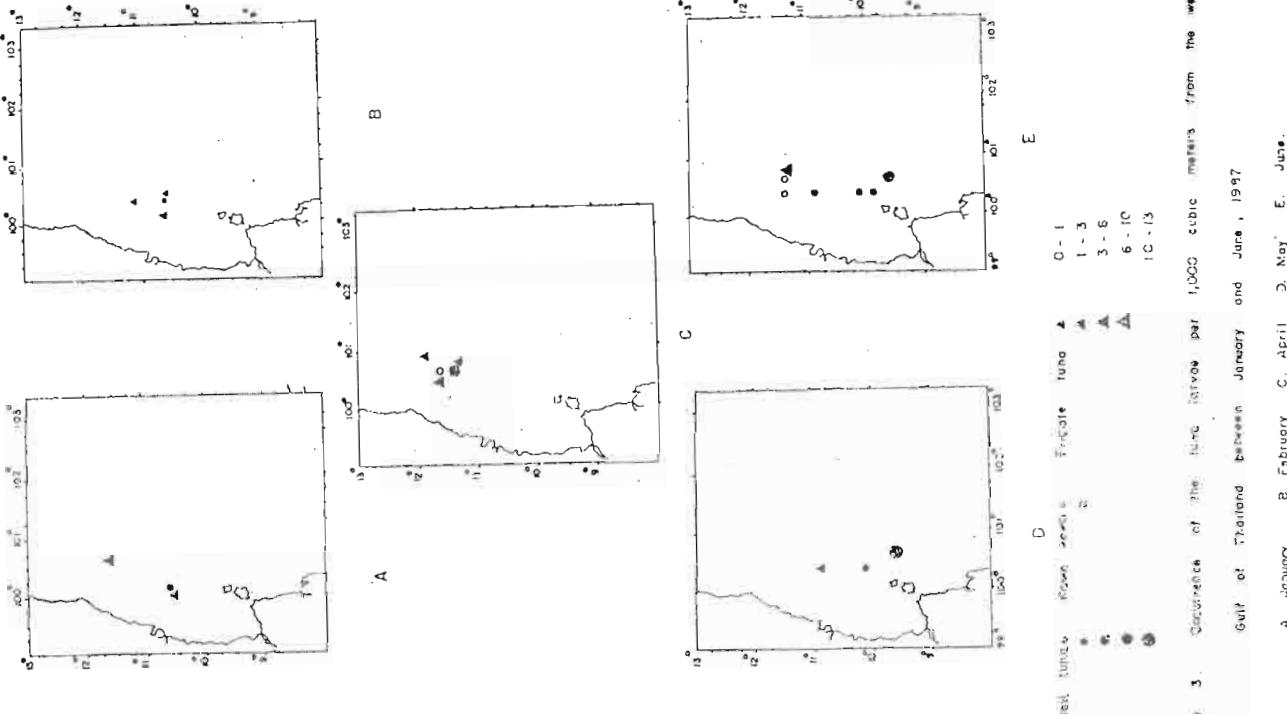
Frigate tuna

These larvae were found between $10^{\circ}37'5''$ to $11^{\circ}52'5''$ N. They were most abundantly in June at the latitude $11^{\circ}22'5''$ N and the longitude $100^{\circ}37'5''$ E off Prachirap Khirikhhan's coastline (station 62, at the water depth of 46 meters).

Frigate tuna larvae mostly distributed between $11^{\circ}22'5''$ to $11^{\circ}52'5''$ N of Prachirap Khirikhhan provinces's offshore. (Figures 3A-3E)

Kawa kawa

The kawa kawa larvae were found only in a small number i.e. on the average of 5.33 individuals per 1000 m^3 . They were found only in April at station 50 and in June at station 61 as well as 62 (Figures 3A & 3E). Kawa kawa larvae were collected in the deep water stations like longtail tuna and frigate tuna larvae were caught.



Discussion

There are many papers on distribution of many species of fish larvae in the Gulf of Thailand but very few paper on tuna species. There are some papers showing the occurrence and location of tunal larvae in the Gulf of Thailand. Figure 4 shows the occurrence of tunal larvae previously studied by many marine biologists and by the authors in this study.

Tuna fish larvae in this investigation were mostly found in the deep water stations which were similar to the studies of Vatanachai (1975), of Chayakul and Uttraponges (1983) and of Chamchang (1987) in the western Gulf of Thailand between Prachaup Khirikhan to Narathiwat provinces. All of them also found tunal fish larvae at the deep water stations. It is, therefore, possible that the adult tuna fish might go to spawn in deep water which is far from the coast. Kliamuang (1981) reported that ripe adult female longtail tuna had never been found nearshore or at low salinity area.

Longtail tuna larvae were found to be more abundant than kawa kawa and frigate tuna larvae in this study. This finding conforms to the study on species composition of adult tunas taken in the Gulf of Thailand by Kliamuang (1981). Cheunpun (1986) also reported that the percentage of longtail tuna was generally higher than those of kawa kawa and frigate tuna.

Longtail tuna larvae were collected most abundantly in May and June at $9^{\circ}37.5'N, 100^{\circ}37.5'E$ (station 182) where as some of them were collected rather sparsely at $11^{\circ}22.5'N, 100^{\circ}37.5'E$ (station 62) as well as at $10^{\circ}7.5'N, 100^{\circ}22.5'E$ (station 140) although these latter areas were adjacent to the former one. It might be probable that the former was an area spawning ground of longtail tuna. However, Cheunpun (1984) found that May and June were not quite the good months to collect longtail tuna larvae as found in this study. She studied the spawning

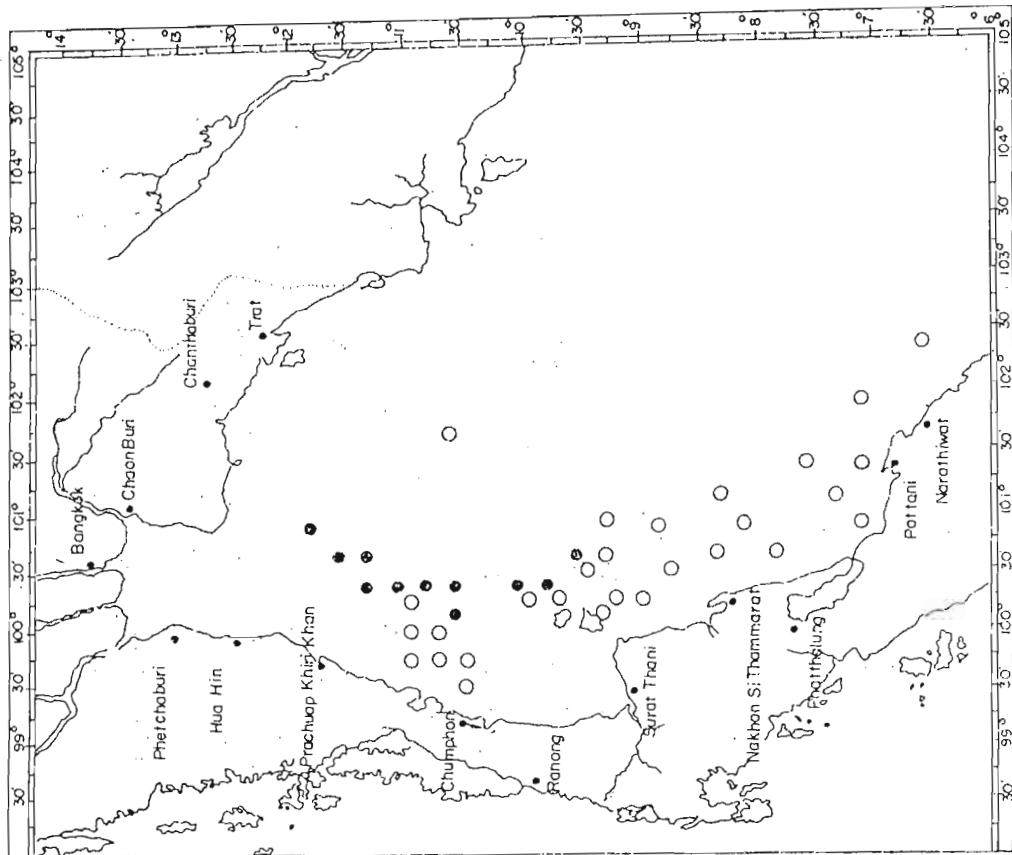


Figure 4. Locations of capture of tunal larvae in the Gulf of Thailand.
 ● Present specimens examined
 ○ Larval specimens in literature

season of longtail tuna by gonadal index method and found that they spawned every month, and the peaks of the first spawning period were between March to May.

Frigate tuna larvae distributed narrowly compared with the distribution of longtail tuna larvae. Cheunpun (1986) stated that longtail tuna distributed more abundantly in the deeper water especially in the middle Gulf than those of kawa kawa and frigate tuna, and this area was the main fishing grounds for tuna purse seine. In this study frigate tuna larvae were most abundant in June and April while Cheunpun (1984) reported that the peaks of the first spawning period were between April to June. Therefore, it could be confirmed that the peaks of the spawning season period of frigate tuna were between April to June.

Kawa kawa larvae were found less abundant than those of longtail tuna and frigate tuna larvae. They occurred only in April and June. Therefore, the spawning period of kawa kawa can not be concluded.

This study provides some background information on tuna larvae in the western Gulf of Thailand. Only six cruises were conducted in this area, therefore it is difficult to conclude the pattern of distribution of tuna larvae and location of spawning ground of tuna fishes. Further study is needed to investigate the spawning ground and spawning season of tunas.

Acknowledgements

The authors are deeply indebted to the crew of Pramong 9. Vessel and I would like to express my appreciation to the Senior Marine Biologist, Mr. Surapol Vatanakul for his helping to collect the specimens, Dr. Pongsak Rojanavipat for his helping to correct the manuscript. Thanks to Mrs. Vasana Sangnak for helping to sort the fish larvae from specimens.

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Appendix 1 Conditions of Larvae net operations on board M.V. Pranong 9 from January-June 1987.

Cruise No.	Station No.	Date	Locality		Volume of strained water (m ³)	Water Depth (m)	Time Start-finish
			Latitude	Longitude			
I 25	11/1/87	12° 7.5' N	100° 37.5' E	642.21	34	11.35-11.45	
37	11/1/87	11° 52.5' N	100° 52.5' E	723.18	46	15.10-15.20	
50	12/1/87	11° 37.5' N	100° 37.5' E	878.12	53	05.05-05.15	
61	13/1/87	11° 22.5' N	100° 22.5' E	694.14	44	08.35-08.45	
104	14/1/87	10° 32.5' N	100° 7.5' E	733.35	59	11.20-11.30	
181	22/1/87	9° 32.5' N	100° 22.5' E	522.46	42	05.05-05.15	
203	22/1/87	9° 22.5' N	100° 37.5' E	674.01	44	11.35-11.45	
II 25	11/2/87	12° 7.5' N	100° 37.5' E	1019.91	35	10.45-10.58	
26	11/2/87	12° 7.5' N	100° 52.5' E	1216.18	37	13.30-13.40	
37	11/2/87	11° 52.5' N	100° 52.5' E	786.34	52	16.30-16.37	
50	12/2/87	11° 37.5' N	100° 37.5' E	1275.95	52	08.15-08.25	
51	12/2/87	11° 37.5' N	100° 52.5' E	981.34	58	05.05-05.15	
61	13/2/87	11° 22.5' N	100° 22.5' E	2043.64	52	16.35-16.45	
75	14/2/87	11° 7.5' N	100° 22.5' E	1066.12	57	08.13-08.23	
76	14/2/87	11° 7.5' N	100° 37.5' E	1685.02	60	05.12-05.23	
89	14/2/87	10° 52.5' N	100° 37.5' E	1299.27	57	14.05-14.16	
90	14/2/87	10° 52.5' N	100° 22.5' E	1235.68	60	11.07-11.17	
104	16/2/87	10° 37.5' N	100° 7.5' E	1155.14	37	05.10-05.20	
105	16/2/87	10° 37.5' N	100° 22.5' E	1167.86	59	08.10-08.20	
119	17/2/87	10° 22.5' N	100° 7.5' E	1339.54	56	11.44-11.54	
120	17/2/87	10° 22.5' N	100° 22.5' E	1067.18	62	11.09-11.19	
139	17/2/87	10° 7.5' N	100° 7.5' E	1375.56	54	07.52-08.02	

Cruise	Station No.	Date	Locality		Volume of strained water (m³)	Water Depth (m)	Time	Locality		Volume of strained water (m³)	Water Depth (m)	Time			
			Latitude	Longitude				Latitude	Longitude						
IV	140	16/2/87	10° 7.5' N	100° 22.5' E	1074.60	61	13.41-13.51	90	17/5/87	10° 52.5' N	100° 22.5' E	750.31	60	05.07-05.17	
	158	17/2/87	9° 52.5' N	100° 7.5' E	1441.27	37	05.20-05.31	139	21/5/87	10° 2.5' N	100° 7.5' E	699.44	52	10.56-10.46	
	159	16/2/87	9° 52.5' N	100° 22.5' E	1093.67	59	16.38-16.48	140	21/5/87	10° 7.5' N	100° 22.5' E	754.55	60	13.23-13.33	
								158	21/5/87	9° 52.5' N	100° 7.5' E	699.44	38	07.43-07.53	
								159	21/5/87	9° 52.5' N	100° 22.5' E	690.96	58	16.15-16.25	
V	25	11/4/87	12° 7.5' N	100° 37.5' E	663.41	33	13.58-14.08	181	22/5/87	9° 37.5' N	100° 22.5' E	1032.21	41	05.08-05.18	
	26	11/4/87	12° 7.5' N	100° 52.5' E	712.16	34	08.46-08.56	182	22/5/87	9° 37.5' N	100° 37.5' E	777.86	57	07.55-08.05	
	37	11/4/87	11° 52.5' N	100° 52.5' E	629.20	42	10.33-10.43	202	22/5/87	9° 22.5' N	100° 22.5' E	869.00	34	13.49-13.59	
	50	13/4/87	11° 37.5' N	100° 37.5' E	369.00	47	05.03-05.13	203	22/5/87	9° 22.5' N	100° 37.5' E	841.45	43	10.52-11.02	
	61	13/4/87	11° 22.5' N	100° 22.5' E	784.22	52	10.38-10.48								
	62	13/4/87	11° 22.5' N	100° 37.5' E	661.29	49	07.54-07.64	VI	25	6/6/87	12° 2.5' N	100° 37.5' E	894.44	28	10.36-10.46
	90	14/4/87	10° 52.5' N	100° 22.5' E	949.54	52	15.01-15.11		26	6/6/87	12° 2.5' N	100° 37.5' E	705.80	30	13.27-13.37
	139	18/4/87	10° 7.5' N	100° 7.5' E	640.09	53	08.07-08.17		37	6/6/87	11° 52.5' N	100° 52.5' E	724.88	42	16.29-16.39
	140	18/4/87	10° 7.5' N	100° 22.5' E	680.37	60	11.58-12.06		50	7/6/87	11° 37.5' N	100° 52.5' E	705.80	42	05.11-05.21
	158	18/4/87	9° 52.5' N	100° 7.5' E	678.25	36	05.13-05.23		61	8/6/87	11° 22.5' N	100° 52.5' E	652.81	46	11.15-11.25
	159	18/4/87	9° 52.5' N	100° 22.5' E	985.58	58	13.53-14.03		62	8/6/87	11° 22.5' N	100° 37.5' E	665.52	46	13.50-14.00
	181	18/4/87	9° 37.5' N	100° 22.5' E	703.68	30	16.48-16.58		76	8/6/87	11° 7.5' N	100° 37.5' E	712.15	52	16.55-17.05
	182	19/4/87	9° 37.5' N	100° 37.5' E	911.39	57	05.11-05.21		90	9/6/87	10° 52.5' N	100° 22.5' E	663.41	54	05.10-05.20
	202	19/4/87	9° 22.5' N	100° 37.5' E	941.07	34	10.46-10.56		139	17/6/87	10° 7.5' N	100° 7.5' E	771.50	48	11.03-11.13
	203	19/4/87	9° 22.5' N	100° 37.5' E	1030.09	43	07.57-08.07		140	17/6/87	10° 7.5' N	100° 22.5' E	1057.64	53	07.49-07.59
								159	17/6/87	9° 52.5' N	100° 22.5' E	690.96	53	04.48-04.58	
	25	14/5/87	12° 7.5' N	100° 37.5' E	1089.43	31	11.15-11.25		181	16/6/87	9° 37.5' N	100° 22.5' E	657.05	43	14.17-14.27
	26	14/5/87	12° 7.5' N	100° 52.5' E	680.36	33	14.06-14.16		182	16/6/87	9° 37.5' N	100° 37.5' E	818.13	49	14.09-14.19
	50	15/5/87	11° 54.5' N	100° 37.5' E	769.39	48	05.07-05.17		202	16/6/87	9° 22.5' N	100° 22.5' E	784.22	32	07.59-08.09
	61	16/5/87	11° 22.5' N	100° 22.5' E	678.25	51	10.37-10.47		203	16/6/87	9° 22.5' N	100° 37.5' E	962.26	38	10.35-10.42
	62	16/5/87	11° 22.5' N	100° 52.5' E	869.00	46	13.22-13.32								

Small tuna fishing gears in the Indo-Pacific region

1. Introduction

An estimated 70 percent of the small tunas are captured by the small-scale fisheries and the remainder by the industrial fisheries. Small tunas are captured by a variety of fishing gears, especially by the small-scale fisheries sector. The dimensions of a particular gear generally vary markedly between industrial and small-scale fisheries, as well as within the small-scale fisheries.

by

Mitsuo Yesaki
Tuna Biologist

Longtail (*Thunnus tonggol*), Kawakawa (*Euthynnus affinis*) and Auxis species commonly occur together, but are rarely captured in equal proportions. Highest catches of each species are usually made in different areas. Highest catches of each species are also generally made by different fishing gears.

The present paper assesses the relative importance of the various fishing gears for each small tuna species and examines the general characteristics of the principal fishing gears used in various countries in the region. This is followed by several recommendations for future fishing trials in areas of suspected and as yet unexploited small tuna resources.

2. Description of fishing gears

There are 6 general types of fishing gears for tunas. These include gillnet, surroundings net (purse-seine, ringnet, payang), hook and line (troll line, handline), pole and line, lift net (bagnet) and longline. The most important gears for small tunas in the Indo-Pacific region, in terms of weight landed, are as follows: purse-seine 47%, gillnet 27%, troll line 16%, bagnet 8%, pole and line 1% and longline 0% (Tables 1-3). However, the use of gillnets is more widespread than other gears. Gillnet catches of small tunas are reported by 9 countries whereas purse-seine and troll line catches are reported by 4 and 3 countries, respectively. Gillnet are ubiquitous throughout the Indo-Pacific region with the exception of the Maldives. Troll lines are also used throughout this region, but is generally fished as a secondary gear when steaming to and from fishing grounds, so catches are minimal and overlooked in fisheries statistics.

The bagnet is an important gear for small tunas only in the Philippines. Pole and line and longline are of minor importance for small tunas.

2.1 Longtail tuna

The entire catch of longtail tuna is made by 3 fishing gears. The most important gear for this species is the purse-seine, which accounts for 53% of the global catch (Table 1). Almost the entire catch of longtail tuna is made in Thailand and Malaysia. Two types of purse-seine are used in these countries, luring purse-seine and tuna purse-seine (Table 4). The former is generally fished at night in conjunction with anchored fish aggregating devices (PADS) and night-lights. Tuna incidentally with small pelagic fish which are the target species. Tuna purse-seines are fished on schools detected visually or with sonar. These nets are lightly constructed with wings of gillnet webbing and the bunt near the middle of the net. The light construction of the net limits its effectiveness to areas of relatively shallow depth, soft bottom and weak currents. This net is set over the starboard side, pursed over the bow and hauled simultaneously by manpower over the port and starboard sides.

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 2. Description of fishing gears
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 - 2.2 Kawakawa
 - 2.3 Auxis species
 3. Future Developments and Recommendation
 4. References

Tables 1, 2, 3, 4, 5 and 6

Gillnet account for 37% of the global longtail tuna landings. Particulars of gillnets used to capture small tunas in the Indo-Pacific region are given in Table 5. The longest nets are used by the Taiwanese industrial fleet operating off the coast of Australia. These vessels are equipped with net haulers which have recently been improved, consequently resulting in substantial increases in the length of nets (Iyle, workshop paper). The longest gillnets that are hauled manually are the 6,000 m. nets used in Iran and Thailand. This is probably about the longest that can be fished without mechanical haulers. The nets used in Thailand are constructed of the thinnest twines, but the mesh sizes are smaller to capture seafish. These nets are also fished by smaller vessels than those of Iran.

Longtail tuna is captured on troll lines throughout its distributional range. However, there is only the troll fishery off the east coast of peninsular Malaysia targetting for this species.

2.2 Kawakawa

A greater number of fishing gears capture kawakawa because of its wider geographic distribution than longtail tuna. Gillnet is the most important fishing gear for this species accounting for 31% of the global catch. The relative contribution of this gear would be higher with inclusion of the landings of the United Arab Emirates, Arabic Republic of Yemen and People's Democratic Republic of Yemen. Approximately half the gillnet landings of kawakawa are made in India. Gillnets used in India are shorter than those used in neighbouring countries, especially to the north (Table 5).

Purse-seine is the second most important fishing gear for kawakawa and accounts for 25% of the global catch. Only 3 countries report landings with this gear, of which the Philippines contributes the highest proportion. Kawakawa is captured incidentally in purse-seines in all countries.

Hook and line contributes 20% to the global catch of kawakawa. This gear is the most important for kawakawa of all fishing gears in the Philippines. Troll line are used for this species in Malaysia and Maldives (Table 4).

The bagnet accounts for substantial catches of kawakawa only in the Philippines.

2.3 Auxis species

Only 5 countries report landings of Auxis species in the Indo-Pacific region. The principal reason for the low numbers of reporting countries is that Auxis species is generally included with kawakawa in fisheries statistics. Another reason is that Auxis species are concentrated in the outer neritic and contiguous oceanic zones, so are generally not susceptible to coastal fisheries. Almost the entire landing in the Indo-Pacific region is made in the Philippines where a wide variety of fishing gears are used to capture this species (Table 6.). Surrounding nets, principally purse-seine and ringnet, account for 40% of global catches. These gears are generally fished in conjunction with payaos (PFDs) and night-lights (White, 1982).

The second most important gear for Auxis species is the hook and line, which accounts for 19% of the global catch. Of the hook and line gears, the multiple lure troll line is the most effective for this species and is used in the Philippines, Sri Lanka and Indonesia (Bali). Multiple lure troll line fisheries in the latter 2 countries have declined after the oil shocks of the 1970's (White, 1984; K. Sivasubramanian, pers. comm.).

The bagnet and gillnet also contribute substantially to the landings of Auxis species.

3. Future Developments and Recommendation

The relative contributions of the various fishing gears to the small tuna landings is expected to remain as at present. The dominance of the purse-seine will be maintained with increase in catches of longtail tuna-kawakawa in the Irian Jaya - Australia, South China Sea, Indian sub-continent areas. Purse-seine catches of Auxis species will also increase with extension of fishing grounds to the outer neritic and contiguous oceanic zones. The gillnet will remain the second most important fishing gear with increases in small tuna catches from all areas, with the exception of the Philippines and Gulf of Thailand. This gear will most probably remain the dominant gear in the Arabian Peninsula, Red Sea, east Africa and Island states. The relative contribution of the troll line to small tuna landings will most probably decrease in the future.

The largest resource of longtail tuna is predicted for the north coast of Australia. Taiwanese gillnetters fished in this area under license to the Australian government during the first half of the 1980's (Iyle, workshop paper). Gillnetting is labour intensive and so probably unsuitable for Australia. Purse-seining is effective in areas of high concentrations of longtail tuna as demonstrated in the Gulf of Thailand. Drum purse-seining for longtail tuna - kawakawa is recommended for the north coast of Australia. This type of purse-seining is most appropriate as labour requirements are minimal. Drum purse-seiners fished in the west coast of Canada are frequently crewed by 5 men. Many more sets can be made in day with drum purse-seiner than by a purse-seiner equipped with a power block. This is especially important when the target species are concentrated in small schools. Longtail tuna are generally aggregated in 1-3 tonne schools (Yesaki, 1987). The South China Sea Programme chartered 2 power-block purse-seiners to survey the programme area during the late 1970's. Many schools of longtail tuna - kawakawa - frigate tuna were observed off both coasts of Thailand and Malaysia, but few sets were made as the schools were deemed too small to warrant a set (Simpson and Chikundi, 1978). Many more sets can be made by a drum purse-seiner as the entire net does not have to be let out in order to retrieve the net as in the case of a power-block purse-seiner. A small circle can be completed with a portion of the net on a compact school or a set can be terminated if the school escapes, and the net retrieved. Small catches do not have to be bailed on a drum purse-seiner, but can be hauled up over the stern rollers. The net is guided by hydraulic level-winders directly onto the drum, thereby eliminating the task of manually stacking the net, a time-consuming process.

The 3 1/2 and 11-tonne vessels in Sri Lanka are used primarily to fish gillnets for large pelagic species including oceanic tuna, shark and billfish. Gillnet are fished from the outboard-powered skiffs to catch small pelagic species including sardines, anchovies and mackerel. The current universal usage of gillnets at the present time by the mechanized fleet has resulted in relatively reduced landings of Auxis species with multiple line troll lines. Siwasubrahmanian (1971) reports almost the entire catch of Auxis species in the 1960's was made by multiple lure troll lines fished from the 3 1/2 - tonnes vessels. The popularity of this gear decreased after the oil shocks in the 1970's and with increasing success of gillnetting for large pelagic species. Multiple lure trolling with low fuel consumption vessels is recommended to ascertain the economic feasibility of again utilizing this method for exploiting the Auxis species resource off this country.

Experimental fishing with the Philippine ringnet and/or Thai purse-seine is also recommended in the outer neritic and contiguous oceanic zone of Sri Lanka. Auxis species is the principal prey organism of yellowfin tuna off this coast (Rekha Maldeniya, pers. comm.). Egg and larvae studies off the southwest coast of India have shown Auxis species to be the second most abundant species after Stolephorus species (George, 1979). Fish larvae studies in the Sulu Sea showed Auxis species to be the most abundant tuna species (Baguilat, 1981). The landings of Auxis species is the highest of any tuna species in the Philippines and was 96,000 mt in 1985. A 11-tonne vessel is suggested for these fishing trials to ascertain the feasibility of purse-seining in more off-shore areas. These fishing trials would also be interesting in providing information of the Decapterus resources off this coast. It is the author's opinion the the Auxis and Decapterus species resources offer the best opportunity for this country of attaining self sufficiency in marine fish protein from within its contiguous waters.

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Table 3. 1985 landings of *Auxis* species by country and fishing gear in the Indo-Pacific region.^{1/}

Country	gill	ps	trol	bb	bag	ll	unclass	total
Australia ^{2/}	-	-	-	-	-	-	-	138
China (Taiwan) ^{3/}	2,621	-	-	-	-	-	-	2,621
India ^{2/}	3,564	1,145	-	-	-	-	-	5,540
Iran ^{2/}	11,848	-	-	-	-	-	-	11,848
Malaysia ^{4/}	4,107	5,424	4,398	-	-	6	1,906	15,841
Thailand ^{2,4/}	7,758	40,188	-	-	-	-	54	48,000
United Arab Emirates ^{2/}	2,330	-	-	-	-	-	-	2,330
Yemen, A.R. ^{2/}	-	-	-	-	-	-	840	840
Yemen, P.D.R. ^{2/}	-	-	-	-	-	-	87	87
Total	32,728	46,757	4,398	-	6	-	3,856	87,745

^{1/} - includes PAO fishing areas 51, 57 and 71
^{2/} - IPTP, 1987
^{3/} - SEAPDEC, 1986
^{4/} - IPTP data bank

ps - includes purse-seine, ringnet and seine-net
trol - includes troll line, handline, hook and line

Table 1. 1985 landings of longtail tuna by country and fishing gear in the Indo-Pacific region.

Country	gill	ps	trol	bb	bag	ll	unclass	total
Australia ^{2/}	-	-	-	-	-	-	-	138
China (Taiwan) ^{3/}	2,621	-	-	-	-	-	-	2,621
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trol - includes troll line, handline, hook and line

Table 2. 1985 landings of kawakawa by country and fishing gear in the Indo-Pacific region.^{1/}

Country	gill	ps	trol	bb	bag	ll	unclass	total
Cambodia ^{2/}	-	-	-	-	-	-	-	1,310
India ^{2/}	12,066	2,479	-	83	-	-	1,901	16,529
Iran ^{2/}	1,707	-	-	-	-	-	1,707	1,707
Maldives ^{2/}	-	-	1,267	910	-	-	2,177	3,344
Malaysia ^{2/}	1,760	2,325	1,885	-	2	-	817	6,789
Pakistan ^{2/}	5,668	-	-	-	-	-	-	5,268
Philippines ^{3/}	3,545	14,309	12,259	197	6,311	535	1,904	41,060
Seychelles ^{2/}	4	-	-	-	-	-	322	326
United Arab Emirates ^{2/}	-	-	-	-	-	-	980	980
Yemen, A.R. ^{2/}	-	-	-	-	-	-	378	378
Yemen, P.D.R. ^{2/}	-	-	-	-	-	-	1,272	1,272
Total	24,350	19,113	15,411	1,190	8,313	535	8,884	77,796

^{1/} - includes PAO fishing areas 51, 57 and 71
^{2/} - IPTP, 1987
^{3/} - SEAPDEC, 1986
^{4/} - IPTP data bank

ps - includes purse-seine, ringnet and seine-net
trol - includes troll line, handline, hook and line

Table 3. Characteristics of surrounding nets capturing small tunas in various countries of the Indo-Pacific region.

Country	Type	Target species	Length (m)	Depth (m)	Bait weight (kg)	Mesh size (cm)
Indonesia	purse ^{1/}	small pelagics	360	7	center	30-0
India	purse-seine ^{2/}	small pelagics	600	ca.50	7	1.4
Malaysia	purse ^{3/}	tunas	1080	54	180	6.4
Philippines	ringnet ^{4/}	small pelagics	301	7	ca.133	2.3
Philippines	small pelagics	small pelagics	488	79	ca.127	4.4
Philippines	small pelagics	small pelagics	627	ca.57	ca.139	3.4
Thailand	purse ^{5/}	tunas	1082	ca.134	end	7.4
Thailand	small pelagics	small pelagics	420	20	ca.38	2.5
Thailand	purse ^{6/}	tunas	1729	50	ca.86	5.0

^{1/} - Majapitono and Nasution, 1985

^{2/} - Dhulikhel, et al., 1982

^{3/} - Fisheries Research Institute, Kuala Terengganu, Malaysia

^{4/} - de Jesus, 1982

^{5/} - Okamura, et al., 1986

Table 5. Characteristics of drift gillnets capturing small tunas in various countries of the Indo-Pacific region

Country	Target species	Length (m)	Depth	Hanging ratio	Mesh size (cm)	Materials	Twine sizes
China (Taiwan)	sharks, tunas ^{1/}	10,000-20,000	14-20m	?	15.0 - 17.0	multifilament	?
India	large, Pelagic ^{2/}	800-1,000	4-8 m	?	7.0 - 13.0	monofilament	6/8/22
	large, Pelagic ^{2/}	450-700	6-7 m	?	6.5 - 13.5	?	?
Iran	tunas ^{4/}	6,000	100 mesh	?	15.0	multifilament	210d/36
	tunas ^{5/}	4,000-5,000	?	?	13.3 - 14.6	multifilament	?
Pakistan	large Pelagic ^{6/}	2,400-3,200	80 meshes	0.5 - 0.6	10.2 - 15.2	multifilament	210d/24-66
Philippines	tunas ^{7/}	550-640	60 meshes	?	15.2	multifilament	210d/18-21
Sri Lanka	tunas ^{8/}	1,760	100 meshes	0.58	15.2	multifilament	210d/27
Thailand	threadfin, seerfish ^{9/}	1,225	100+15 meshes	0.64	5.7	monofilament	0.35
	seerfish ^{9/}	6,000	150+25 meshes	0.60	10.0	multifilament	210d/18

^{1/} - Lyle, workshop paper
^{2/} - Silas, et al, 1985
^{3/} - Muthiah, 1985
^{4/} - McNeilly, C., 1986, IRA/83/013 Travel report 1
^{5/} - White, T.P., 1986, IRA/83/013, Travel report
^{6/} - Crockett, J., FAO Masterfishermen pers. comm.
^{7/} - de Jesus, 1982
^{8/} - Kurata, K., 1987, manuscript report
^{9/} - Okawara, et al, 1986

Table 6. Characteristics of troll lines capturing small tunas in various countries of the Indo-Pacific

Country	Target species	Speed (knots)	Depth	No. lines	No. hooks/line	Hook size	Lure
Indonesia	frigate, bullet ^{1/}	?	surface	1	multiple	?	goat hair, coloured thread
Maldives	Kawakawa, frigate	?	surface	?	?	?	?
Malaysia	longnail, Kawakawa ^{2/}	4-6	surface	2-4	1-25	8	Polyethylene wrapping tape
Philippines	frigate, bullet ^{3/}	?	surface	1	10-100	117	Plastic tubing
Sri Lanka	skipjack, yellowfin ^{3/}	1.5	sub-surface	1	multiple	112	fish, artificial squid
	frigate, bullet ^{4/}	?	surface	3	30	19	colored synthetic fibers

^{1/} - White and Merta, 1983
^{2/} - Yesaki, M., 1986. Travel report
^{3/} - de Jesus, 1982
^{4/} - Sivasubramaniam, 1973

1. Introduction

The tuna fisheries of Sri Lanka have been monitored by fishery scientists on a periodic basis since the 1950's. As part of its regional programme, the Indo-Pacific Tuna Development and Management Programme (IPTP) encourages the fisheries departments of individual coastal states to undertake sampling programmes to monitor their tuna fisheries. Since 1982, the Marine Resources Group of the National Aquatic Resources Agency (NARA) of Sri Lanka has concentrated much of its effort on the study of tuna fishing operations in the NW, W, SW, and S districts of the island, and the biology of the four most important tuna species. These are the yellowfin tuna (*Thunnus albacares*), skipjack (*Katsuwonus pelamis*), kawakawa (*Euthynnus affinis*), and the small tunas of the genus *Auxis*.

With the development of industrial purse-seining for tuna in the Western Indian Ocean since 1982, and the increasing emphasis being put on exploiting tuna resources as a means of raising fish production in general, the need for monitoring the tuna fisheries both on an oceanic scale and on a national scale is becoming greater all the time.

Attempts to understand the interactions between different components of the fishery (industrial vs. artisanal, coastal vs. oceanic, surface vs. sub-surface, etc.) by tagging, for example, will require an increase in the coverage of landing sites around the Indian Ocean. It was therefore pertinent to launch a tuna sampling programme in Sri Lanka to support the existing survey and to look at ways of extracting information from landing centres already being monitored but under a different sampling strategy. A comparison of the results (in preparation) obtained from the two systems is useful not only as a statistical exercise, but also as a means of determining the most economical way of sampling. Most of the coastal states in the Indian Ocean and South-east Asian region are lesser-developed countries and locally established sampling programmes cannot generally maintain sufficient coverage or sampling intensity to generate the quantity of information needed to analyse any particular aspect of the fishery or the biology of any particular species. The logistic problems and financial burden of supporting sampling programmes in countries like the Maldives or Indonesia are considerable; so it is essential that efficient systems can be developed which are cost-effective.

With its own unique set of conditions, Sri Lanka was a useful starting point for investigating sampling systems for monitoring artisanal tuna fisheries. Sri Lanka has one of the highest figures for tuna production by a single nation in the Indian Ocean, currently between 30 and 35 thousand tonnes per annum. The fishery itself demands year-round observation due to the seasonal fluctuations and areal variations in overall abundance of tuna, the catch and size compositions, and the fishing methods employed.

The present paper reports on the form which IPTP sampling activities follows in Sri Lanka.

Contents

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2. Objectives
3. Description of the fishery and sampling conditions
4. Sampling strategy
5. Sampling forms
6. Monitoring of sampling activities
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8. Summary of data collected
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2. Objectives

- to establish sampling programmes at three landing sites on the west coast of Sri Lanka;
- to collect information on catch, effort, and size compositions by species and by vessel/gear combination; and detailed catch composition by vessel/gear combination;
- sampling frequency to be 12-14 times per month at each site;
- make comparisons between results obtained by this system and those obtained by the NARA system;
- make recommendations for future sampling activities in Sri Lanka and other countries in the Indo-Pacific region.

3. General description of the tuna fishery and sampling conditions

A general description of the tuna fishery conducted off the west and south coasts of Sri Lanka is given by Joseph (1984). The present paper deals only with the landings at three sites on the west coast - Kandakuliya, Negombo and Beruwela - where fishermen employ four methods for catching tuna and tuna-like species. In order of decreasing importance, these are drift gill-netting, trolling, hand-lining and pelagic long-lining. Most boats carry out gill-netting all year round, though some specialise in trolling and hand-lining at certain times of the year. On some fishing trips all four years might be used.

There are three types of vessels regularly engaged in tuna fishing. Most abundant, but of least importance to the production of tuna, are the 5.5m FRP boats powered by out-board engines. The most important vessel type is the E26 design which is 8.5-10.0m in length, has a beam of 2.7m, and a displacement of around 3.5 tonnes, and is driven by an inboard engine in the power range of 25-40hp. Finally, there are vessels of the "11-ton" category which are typically 11m in length with a beam of 3.7m. This last category was first to undertake trips of more than one night in duration to take ice. Nowadays, the 3.5-tonners often make trips of more than 1 night, especially in the slack season from October to April. A significant number of the 3.5-tonners now carry ice. Boats based in Kandakuliya are sometimes at sea for 10 days, but these vessels salt their catch.

The trend in pelagic fishing therefore, appears to be one of longer trips, not necessarily going further off shore, but to enable savings in time and fuel used steaming to and from port. This is complicating the collection of landings statistics slightly and is rendering some unobtainable.

Although the sampling programme monitors the catch of tunas and the activity of the vessels engaged in fishing, attempts at analysing the landings data for purposes of stock assessment and biological studies are complicated by the "multi-species" and "multi-gear" aspects of the fishery. The problems that have been encountered are listed as follows:

1. identifying the catch taken by specific gears, e.g., separating fish taken by long-line and hand-line;
2. apportioning effort by gear;
3. boats specialising in long-lining for pelagic sharks and large tunas quite often do not catch tuna, so the problem is whether to include those trips in samples.

Conditions at the landing sites and the market system have a great bearing on the outcome of any sampling programme. Access to the catch depends on co-operation from fishermen and middle-men, the amount of congestion at the point of sale and the speed with which the catch is sold and split up. At Kandakuliya, access is good because fish is sold by weight and there is no congestion at the point of sale; coverage of boats however, tends to be low because it is necessary to track the catch from the beach to one of the many "wadiyas" (sheds), and this is time-consuming. The owners of wadiyas will generally not allow the weight of individual fish to be taken. At Negombo and Beruwela, fish is sold by the piece and any form of activity which might be regarded as interference, such as weighing fish before they are auctioned, is not tolerated. Catches from individual boats are normally auctioned off in lots according to the number of species, approximate size groupings and quality. Sometimes the size range within a group is quite wide, and fishermen and salesmen are particularly anxious that buyers are not made aware of undersized fish. The presence of samplers at this stage therefore is undesirable and access to the fish is virtually nil unless market supply exceeds demand and the landing site is relatively uncongested.

Despite the mayhem at Beruwela and Negombo, it is an advantage to have all the catches laid out in a small area so that it is possible to obtain catch and effort data from a large proportion of boats. It is easy to identify the catch and the crew from each boat and information about the length of trip and the gear is readily obtainable.

4. Sampling strategy

Generalised sampling strategy is laid out in the IPFP Manual (IPFP, 1987).

4.1 Sampling frequency

The frequency of sampling visits is on average 13 times per month. The intention is to sample every second day regardless of week-ends or holidays, but it is unnecessary to stick rigidly to this regime, because certain public and religious occasions are observed fairly strictly. As a rule there are no landings on Sundays at either Kandakuliya or Negombo; at Beruwela, there are no landings on the day following full-moon.

At Kandakuliya, sampling at this intensity is unnecessary during the beginning of the SW monsoon season because most boats operate further south or switch to other forms of fishing, such as bottom long-lining for sharks. Catches in the NW region of Sri Lanka are poor at this time of year.

4.2 Daily landings

The means of obtaining the numbers of boats landing their catches differs at each of the three sites. At Kandakuliya, the tuna fleet is made up almost entirely of 3.5-tonners, with the occasional 5.5 m boat that makes an incidental catch. The total number of vessels operating and landing on a particular day is estimated by counting the number at anchor before the first boat arrives and again after the last boat has arrived. In the peak season (November - March) there are usually 125 boats landing daily.

At Negombo, officials of the Negombo South Fisheries Co-operative keep records of the sales of each boat that lands, so the numbers of landings is accurate. Unfortunately, it is not possible to break this figure down according to vessel type, but the numbers of 11-tonners and 5.5 m boats landing per day are small and are relatively easily determined by direct count. During the main season (May-September) up to 200 boats can land in a day, but half this figure is more normal.

The numbers of boats landing at Beruwala is obtained from the youths ferrying catches from boats to the beach in outrigger canoes, called oruus. There are about 10 oruus operating regularly and each one generally services a fixed complement of boats. There are about one hundred and fifty 3.5-tonners which are more or less permanently based at Beruwala, with one or two 11-tonners that visit during the SW monsoon. The average number of 3.5 tonners landing per day during this season is around 75.

The coverage of 3.5-tonners for catch and effort information is about 15-20% and for 11-tonners and 5.5 m boats between 50 and 100%. During off-seasons the coverage of the 3.5-tonners may increase to 50% as landings fail.

4.3' Catch and effort

From previous knowledge of the numbers of boats landing per day, catch and effort information is obtained from a maximum of 20 boats per sampling day. During the peak season, this is equivalent to a coverage of 15%, during the off-season, coverage will be from 50-100%.

Owing to the multi-gear nature of the fishery, especially at Negombo and Beruwala, there may be two or three periods during the day when the landings are more concentrated. Drifting gill-netters generally return to shore between 0100 and 0500 hrs and they land as soon as the merchants have assembled; vessels operating a combination of drifting gill-nets and pelagic long-lines tend to return later, around noon; trawlers usually fish between 0500 hrs and 1000 hrs, returning between 1100 and 1400 hrs. With more boats making trips of more than 1 night in duration, adherence to this pattern is becoming less. There is no fail-safe way of predicting the landing patterns by different vessel types from one day to the next. The only way of optimising coverage of the whole day's landings and to avoid over-sampling is to maintain the frequency of visits so that a 'feel' for the site can be developed.

The catch of scombrids is estimated from the numbers of each species. Length-frequency data and length-weight relationships are used to estimate a mean weight for each species, and then numbers of each species caught are converted to total weight. Small tunas landed in baskets (*Auxis* spp. and Kawakawa) are generally counted as well; this is sometimes rather time-consuming, so numbers are often estimated from the numbers of baskets and an estimate (through experience) of the mean number of fish held in a basket. The weight of fish caught other than tuna and tuna-like species is estimated by taking into consideration the estimates of regular merchants and knowledge gained from periods when fish is occasionally weighed. The carcharhinid sharks are the most important non-tuna category and actual weight measurements are available quite frequently. The estimated weight of other categories, listed on the Catch and Effort Data Form and explained in Section 5, is not so accurate.

Indices of effort which are monitored are as follows:

- Duration of trip (number of days/nights)
- Quantity of gear fished (number of pieces of net, number of hooks on long-line, number of troll lines and hooks)

The number of days actually spent fishing is obtained from the lilton vessels and others making longer trips. As it is not always possible to guarantee the ingenuousness of the fisherman, it is not considered worthwhile trying to extract very detailed information about the quantity of gear used and the time for which each was deployed. For the same reason mentioned earlier (i.e. lack of detailed information about the deployment of gear used on a trip) it was decided that a fishing trip would be classified as a 'combination - trip', if more than one gear type was used. No attempt would be made to apportion a fraction of the total effort for a trip to each gear type. Instead, the objective is to determine the average catch rates for each type of trip, whether drifting gill-nets along or gill-nets and long-liners in combination are used. Then, perhaps, sufficient data can be amassed to enable the fishing effort of each trip type to be standardised, and analysed thus. For the initial 6 months information on the mesh sizes of netting and the numbers of pieces of net was obtained, but these did not seem to vary much, so latterly, this kind of information has been taken one day per month.

4.4 Size composition

The aim of length-frequency sampling is to collect up to 500 length measurements for each species from each type of gear at each landing site every month. This is generally only possible for yellowfin, skipjack, kawakawa and frigate tuna caught by gill-net. Translated into practical terms, size - sampling strategy is as follows:

- all billfish are measured (eye - fork length)
- samples of each species from a maximum of 10 boats (for common species, a minimum of 5 boats should be sampled);
- when the lengths of fish in the catch of one boat fall into a narrow range, sample size is 5;
- when the length range is wide, sample size is 10;
- when the length-frequency distribution appears to consist of two or more modal groups, sample size is 10, taking fish from each modal group in the same proportion as their relative frequencies,
- e.g., Catch consists of 200 small skipjack and 50 large; Sample should consist of 8 small and 2 large skipjack

For all tuna and tuna-like species, other than billfish, the length measurements taken is the fork length. Ideally, measuring-boards, calipers and tape measures should be used, but often it is only practical to use a tape measure. Auctioneers, merchants and fishermen are more likely to object to someone wielding a set of calipers or a measuring-board.

Our experiences have shown that, for fish in the size range 40-90 cm, calipers are the best tool for taking measurements. Firstly, it is not necessary to touch the fish as is the case with a measuring board. Secondly, straight-line measurements with a tape measure are not as accurate as those made with calipers owing to parallax errors encountered with length greater than 30 cm. For fish above this size range, the tape measure is the only practical choice, as an instrument more than 1 metre long is unwieldy in tight spaces. For small fish, a foldable measuring board (say, 20 cm long when folded) would be most convenient and allow percentage errors to be minimised.

5. Sampling forms

An example of each of the two sampling forms is given in the appendix.

One of each is sufficient for each sampling day.

A translation of the codes used for tuna and tuna-like species is available in the IPRP Manual. For non-tuna species (category numbers 20-27) the codes are translated as follows:

ALO - Alopias spp (thresher sharks)
R EQ - requiem or carcharhinid sharks
H AM - hammer-head or sphyrnid sharks
L AH - mackerel or lamnid sharks
E LA - other elasmobranchs, eg. skates, rays, guitar-fish, etc
P EL - assorted pelagics, eg. carangids, clupeids, dolphin-fish, barracuda, etc
D EM - assorted demersal, eg. snappers, croakers, rockcods, etc
M AM - mammals (dolphins, porpoises and small whales)

The catch of these categories is recorded as estimated weight in kilogrammes.

The use of serial numbers which are continuous for the month for observations of both catch and effort and size-frequency facilitates data entry and checking.

On the catch and effort data sheet, there are columns YFL and YFS which refer to yellowfin tuna larger and smaller than 80 cm. This is only to help samplers and in subsequent processing they are lumped together.

Monitoring of sampling activities

On the first working day of the month, all the samplers come to the office in Colombo to receive their salaries and to return the data sheets for the previous month. Any trends in catch rates, the number of landings, or the size of fish being landed, for example, can be reported. Any difficulties can be discussed and the samplers assist with data entry and checking.

For the first three months of the programme, landing sites at Negombo and Beruwala were visited once a week, and at Kandakulya, once a fortnight. Negombo and Kandakulya had been designated as sites to be sampled every even-numbered day, Beruwala, every odd-numbered day. It is therefore possible to make unannounced visits and to check that samplers are actually present when they are supposed to be.

There are several problems with having 'field' personnel obtaining information which is to be analysed by someone else. Lack of understanding of the information to be collected and how it is to be analysed, lack of incentive and the possible monotony for the sampler all suggest that information might be of suspect quality and that there will be a great temptation to fabricate data.

About the only way of overcoming these possibilities is to keep up the level of unannounced check visiting. As most of the samplers are pre-university grade students, it is worthwhile expanding the training element beyond the level sufficient for them to be able to identify different species and to understand the sampling method. Familiarisation with computer equipment and making literature available to satisfy their own interests are ways of doing this.

7. Data Processing

Owing to the non-availability of direct weight measurements, the process of generating statistics on catch rates and production in terms of weight is rather long-winded. The emphasis is put on collecting good length-frequency data that is raised in three stages to give a monthly summary for the site being sampled. Length-frequency distributions are then converted to weight-frequency distributions using the respective length-weight relationship and hence the total weight of each species landed in the month can be obtained by simple addition of the weights of each length class interval.

Each sample of length measurements, (referred to as distribution LP), is raised to the total catch (in number) of that species by the particular vessel, according to species. The first-stage raising factor is given by: (see L-P data sheet)

$$RP_1 = \frac{\text{No. of fish of species } j \text{ in total catch of vessel}}{\text{No. of fish of species } j \text{ in length-frequency sample}} = \frac{N}{n}$$

The resulting distribution is referred to as LP₁.

It is then decided whether or not to lump together the length-frequency distributions resulting from this first stage raising from different gear/vessel combinations. In many instances there is only one major gear/vessel combination and there is insufficient length-frequency data from the other minor combinations to allow any comparative analysis. It is probably best to ignore these latter few.

The second stage of raising is to sum the length-frequency distributions, according to species, obtained from all boats sampled which are to be considered in the same set, and to raise this sum, LP₁, to the production for the sampling day, which is effectively the total number of landings by the gear/vessel combination being considered. The resulting distribution is given by:

$$LP_2 = LP_1 \cdot RF_2,$$

where $RP_2 = \frac{\text{Total no. of vessels landing on the sampling day}}{\text{No. of vessels from which catch and effort data was taken}}$

The third and final stage of raisin, for our purposes, is to raise the LP₂ distribution to the total number of landings in the month, which is effectively given by:

$$LP_3 = LP_2 \cdot RP_3,$$

where $RP_3 = \frac{\text{Total no. of days in the month on which landings occurred}}{\text{No. of sampling days in the month}}$

The numerator of this expression is generally taken as 23 days, as there are usually 4 whole holidays per month, and on average, 2 days are lost due to weather and 2 are lost due to gear and/or boat repairs. Adjustments are made, however, as more detailed and accurate information becomes available.

The main disadvantage with this method is that any bias in length-frequency sampling will be amplified, by the raisin process, but under the circumstances, it is the only way of determining production in terms of weight. Estimates would be improved if, instead of raising to the total number of days in the month on which landings occurred, it was possible to obtain the total number of landings in that month. This would be possible at one site, where co-operative officials keep daily records, but elsewhere, there is no such diligent organization.

An alternative method would be to determine the mean length of pooled length measurements from each sampling day, convert to weight, and then multiply by an estimate, of the total number of fish of a particular species landed in the month. A comparison of the two methods is possible by considering the mean weight of skipjack and yellowfin tuna generated by each method. This is laid out in appendix 3.

8. Summary of data collected

The programme began in August 1986 and has run continuously since. A record of the data collected is presented in the following table:

MONTH	KANAKULIYA			NEGOMBO			BEROMALA		
	C-E	L-P	C-E	L-P	C-E	L-P	C-E	L-P	
AUG	186	186	79	257	379	386	385	385	
SEP	302	155	540	949	371	607			
OCT	373	198	344	416	234	430			
NOV	375	304	208	340	341	548			
DEC	280	190	140	192	274	421			
JAN	187	292	199	213	294	431			
FEB	276	177	228	291	237	380			
MAR	283	222	223	339	270	414			
APR	235	372	209	353	265	482			
MAY	201	304	207	329	292	558			
JUN	19	33	221	364	165	320			
JUL	202	219	238	480	264	614			
TOTAL	3042	2452	3028	4726	3388	5590			
AVERAGE	253.5	204.3	252.3	393.8	282.3	465.8			

NB. C-E: Total number of boats from which catch and effort data was obtained

L-P: Total number of length-frequency distributions obtained

Literature cited

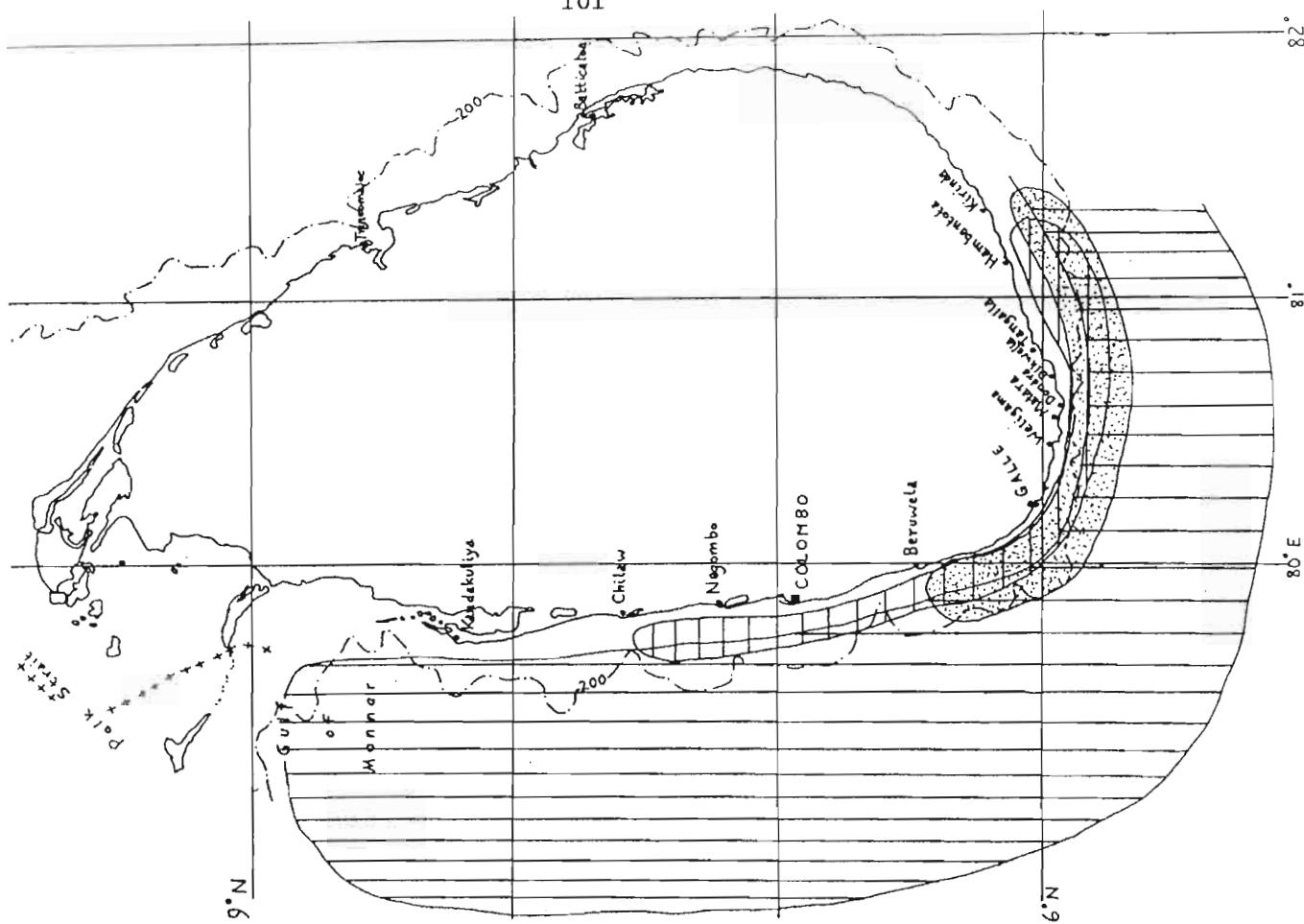
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APPENDIX 1. P-2 SAMPLING PROGRAMME - SRI LANKA CATCH AND EFFORT

APPENDIX 2. **IPTP SAMPLING PROGRAMME - SKII LANKA**
SIZE COMPOSITION

Location: _____ Date: _____

Map of Sri Lanka showing the approximate boundaries of fishing grounds worked by the principal gears in the south and west regions.



Appendix 3. Comparison of mean weight estimates by the "mean-of-pooled-lengths" method and the "raised-frequency" method.

Date	Source	No. of observations	Mean weight (kg) Pooled method, W_p	Mean weight (kg) Raised method, W_r	Percentage difference, $W_r - W_p \times 100$
Beruwala : June 1987	SKJ	309	6.28	6.22	1.0
Beruwala : July 1987	SKJ	322	5.05	4.99	1.2
Negombo : May 1987	SKJ	488	4.24	3.80	11.6
Negombo : May 1987	YFT	195	9.97	8.59	16.1
Negombo : June 1987	YFT	328	6.30	4.47	40.9

Points worth mentioning are as follows:

1. The raised method gives a lower estimate in every case, which is probably due to the fact that occasionally, large numbers of small fish are landed.
2. For yellowfin tuna, the percentage difference in estimates is as much as 41%. It is suggested that for species which show a large size range, the difference is significant at times.

In conclusion, the extra demands which would be made on computer soft and hard-ware by raising length-frequency observations to the vessel may not be worthwhile in terms of the accuracy of mean weight estimates that are produced, and subsequent estimates of production and catch per unit effort. However, for length-based determinants of population parameters where the identification of modal groups is fundamental, the raising process is a necessary part of producing a length-frequency summary.

A PRELIMINARY ANALYSIS OF THE BILLFISH LANDINGS
OBSERVED ON THE WEST COAST OF SRI LANKA

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- 2. Materials and methods
- 3. Fishing gear and effort
- 4. Catch and effort statistics
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IPTP Workshop on Small Tunas, Seerfish and Billfish in the Indian Ocean, 9-11 December 1987, Colombo Sri Lanka.

1. Introduction

The multi-species/multiple gear fishery that is conducted on the pelagic resource around Sri Lanka includes what appears to be an increasingly important billfish component. The present fishing regime on the South-west coast consists of heavy dependence on the drifting gill-net during the south-west monsoon, where the main target items are the tunas and an increasing dependence on shallow set drifting long-lines in the "slack" north-east monsoon for catching sharks. Although previous workers have indicated that commercial long-lining for sub-surface swimming tunas and billfishes may not be economically viable on the scale typical for far-eastern fishing nations, the improved capabilities of the 3.5 to 4 ton class of small-scale vessels operating from Sri Lanka raise the possibility of billfish landings being sustained at higher levels over an extended part of the year.

The in-depth monitoring of this fishery was required in about 1982 by the Marine Resources Group of the National Aquatic Resources Agency (NARA) covering a large number of landing sites from the north-west to the far south of Sri Lanka. The present move has been to choose a smaller number of sites which are monitored more frequently.

One of the aims of this paper is to make comparisons between the results obtained from this and previous sampling programmes, in the hope that a practical and economic method can be developed for collecting data necessary for assessment of small-scale fisheries. These are typically dispersed and therefore difficult to monitor. A programme based on more intensive determination of catch rates and species composition, may have implications throughout the Indian Ocean region.

2. MATERIALS AND METHODS

The current source of information on billfish landings is the sampling programme that is being conducted at three sites on the west coast of Sri Lanka. Between August 1986 and July 1987 landings at Kandakuliya (NW), Negombo (W) and Beruwala (SW) were visited on alternate days and information on the catch of 19 scombrid species (including the 6 billfish species) and 8 other catch categories was recorded. Details of this sampling programme can be found elsewhere (Forster, 1987).

The author also had access to data on the tuna fishery (catch/effort, length measurements, etc) in Sri Lanka between the years 1964 and 1977. These were records maintained on punch cards by the tuna researchers of the Fisheries Research Station of the Ministry of Fisheries and which are now kept by the National Aquatic Resources Agency. The bulk of the data available concerns the landings by the fleet of forty or so 11 ton boats operated by the Ceylon Fisheries Corporation during that period.

A private businessman operating five 3.5 ton vessels from Galle and Kalpitiya in the SW and NE monsoon seasons, respectively, provided data for 3 years. This included details of catch broken down into "tuna", "seerfish", "billfish", "shark" and "other" categories for every trip made by each boat. A comparison of catch rates sustained between these migratory units and those using one base throughout the year ought not to be made too closely.

3. FISHING GEAR AND EFFORT

Joseph and Amarasingri (1986) reported on the billfish component of the multi-species - multiple gear fishing around the South and West coasts of Sri Lanka for the years 1984 and 1985. Data from the present sampling programme indicate that the complement of fishing gear carried by the 11 ton and 3.5 ton classes of vessel is more or less the same as they reported.

The multi-species nature of the fishery has meant that it is impossible to estimate the total effort corresponding to the catch of billfish. The use of a number of gears in a variety of combinations has meant that it is difficult to determine the effort that has been applied through different fishing gears individually. For these, and other reasons, it was felt that a simplified analysis would be appropriate. Catch and effort data obtained from all gear combinations was pooled.

As the capability of the 3.5 ton class of vessel has been seen to match that of the 11 ton class more and more closely in terms of endurance and catch rates, no separate analysis by vessel type has been attempted in this study; data has been pooled.

Samplers are urged to obtain length measurements from every billfish that is landed. On the extended trips of 3-4 nights made by the 3.5 ton class vessels, billfish are usually butchered at sea for the purpose of storage. This has greatly reduced the amount of length-frequency data available and has made it virtually impossible to make positive identification to the species level on many occasions.

Fish is sold by weight at only one site, Kandakuliya, and this made it necessary to develop length-weight relationships in order that objective estimates of production could be made at the other two sites. It was decided that eye-length should be the standard measurement. Unfortunately, there are not many billfish landed at Kandakuliya, and very few weight measurements have been made at Negombo and Beruwala due to resistance from fish sellers.

Length-weight relationships in the literature are of limited value for two reasons. Firstly, many authors overlook to define the length and weight measurements that are being correlated; as weight of billfish at a given length can vary widely, precise length definition is critical.

Secondly, size ranges and the condition of fishes capable of such extensive migration are likely to vary from one part of the world ocean to another. It is, therefore, desirable to develop length-weight relationships based on local catches, and attention is drawn to this source of error in the production and catch rate figures.

Shortly after the present sampling programme began, samplers were asked to take the following length measurements whenever possible:

FORK LENGTH	:	tip of bill to the fork
BODY LENGTH	:	tip of lower jaw to the fork
BILL LENGTH	:	tip of bill to centre of the eye
EYE-FORK LENGTH	:	centre of the eye to the fork
MAX. BODY DEPTH	:	normally at insertion of pectoral fins
MAX. GIRTH	:	

In this way, a set of expressions correlating a number of variables to a standard measurement (E-FU) could enable total fresh weight to be estimated irrespective of how the fish was dressed or the head mutilated.

4. CATCH AND EFFORT STATISTICS

4.1 Catch rates

Overall catch rates for the present period of study range between 33.50 and 4.47 kg per boat-night with the highest rates being found in the South-west sector, decreasing northwards. Even when comparing rates in the peak season at each site, this trend holds true. Similar observations were made recently by Joseph and Amarasiri (1986). Fishermen in Beruwala (SW) show a preference for using no, or very little, weight on the foot rope when rigging their nets. It is believed by some that billfish are more vulnerable to entanglement with very light rig, but there has been no in-depth comparative study of billfish catch rates between differently rigged gill-nets in Sri Lanka. Omission of a foot rope renders the net far more prone to twisting and many trips have to be prematurely aborted in order that nets can be untwisted.

Billfish catch-rates at Beruwala and Negombo fell in December, whereas they reached a peak in the same month at Kandakuliya.

The catch-rate pattern is given in figure 1 and this follows the generalised pattern of the peak season in the SW and W sectors coinciding with the SW monsoon and that of the northern sectors occurring during the NE monsoon. Joseph and Amarasiri (1986) chose a level of 20% of the total catch rate to look at the impact of billfish on the drifting gill-net fishery which indicated that maximum relative abundance of billfish occurred during the periods January - May and September to December. These coincide approximately with the inter-monsoon and north-east monsoon, but, on first impressions, weather patterns on the west coast of Sri Lanka do not appear to conform to a regular sequence, and it may not be appropriate to designate certain months with a season label.

Considering Beruwala catch rates above 35 kg per boat-night in the present study the peak seasons occur from mid-August to November and from mid-December to mid-January. The peak seasons in Negombo appear to occur earlier in the year, August-September and March-April, considering a lower catch rate level of 20 kg per boat-night. The contribution of billfish to the total landings in Negombo is not as great, as shown in Table 1 and the peak seasons are not as prolonged.

The recent trends of catch rates over the past few years have shown an increase. For the west coast, Joseph and Amarasiri (1986) observed that catch rates exceeded 10 kg per boat-night for 4 months in 1984, and for 10 months in 1985. In the present study, the same catch rates was exceeded for 9 months, but the peaks observed have been higher. For the south-west sector, catch rates exceeded 30 kg per boat-night for 2 months in 1984, and 4 months in 1985. More recently at Beruwala, catch rates exceeded this level for 9 months. It should be noted that the study made by Joseph and Amarasiri (1986) included more than one site in each sector, and it may be misleading to make too close a comparison.

4.2 Catch composition

4. The catch composition of all fish landings information used in this study has been broken down into the broad categories "tuna", "seerfish", "billfish", "shark", and "Others". Recent data is presented in this fashion in table 1 along with data from earlier years.

The current centre for shark landings is at Negombo, where use of shallow pelagic long-lines is very popular and fishes at a maximum depth of 25-30 metres (G. Pajot pers. comm.) and baited with cut pieces of mackerel and dolphin flesh. This method of long-lining is ineffective for tunas and billfish, and application of hook rates sustained by oceanic long-liners to the local pelagic fishery to estimate potential yields should be avoided. Joseph and Amarasiri (1986) estimate that billfish constituted about 4% of the long-line catches in 1984-85.

It is not really possible to isolate the spatial differences in catch composition from the effects of slightly different fishing methods or combinations of gears being preferred in different coastal sectors. Unfortunately, the detail of the catch and effort data obtained so far does not allow an accurate gear-wise breakdown of the catch. It is interesting to note, however, that all three landing sites studied here show some broad similarities. The "others" category includes carangids, barracuda, rays, dolphin fish, remora, and mammals, and makes up 4.3 or 4.2% of the total catch consistently. Maybe a significant part of the differences in the importance of billfish to the pelagic catch composition in different sectors can be explained by differences in fishing behaviour and gears. Comparing with data from 11 ton operations in the period 1968 - 73, it appears that the billfish component of landings in the NW have fallen, and that in the SW and W sectors it has risen.

4.3 Species composition

Species composition data has been calculated both in terms of numbers and in terms of weight. It is very easy to obtain good information on the numbers caught, and will allow comparisons to be made between the relative abundance of different species caught here and in other parts of the Indian Ocean, typically by long-liners of Japanese, Taiwanese and Korean origin. Some sport fisheries exist in the Western Indian Ocean (Kenya and Mauritius) and some clubs have quite extensive catch records.

Data from this study on the production of billfish species is presented in Tables 2 and 3, and the percentage composition is included on the bottom line. What is immediately apparent is that at Beruwala and Negombo sailfish and swordfish, individually are both more abundant by number than all the marlins put together. At Kandakuliya the marlins make up the bulk of the billfish catch. The fishing in the NW is supported principally by 60-80 cm yellowfin tuna and possibly, the sail fish and sword fish are not attracted to this region as much because of inappropriately sized prey organisms. However, compared to the two more southerly sites, the number of marlins is lower as well.

Data obtained for the same season (November - February for the north-west, and June-October for the south-west) over three consecutive years, 1984-1986, also follow this upward trend.

Sailfish is most abundant from April to October when the overall catch rates from drifting gill-net fishery is highest. The peak season for swordfish is not as clear cut when comparing landing sites. January to July appears to be the best period for Beruwala and January to May and August to October best for Negombo. Swordfish only makes a short-lived appearance at Kandakuliyawa between November and February.

As is shown in table 6, the mean weight of the three marlin species do not vary much and it is equally convenient to compare relative abundance in terms of weight. The blue marlin is consistently more abundant than either the black or the striped marlin. Striped marlin is relatively uncommon in this fishery which is in stark contrast to data from the long-line fishery elsewhere in the Indian Ocean, and especially in the area $0^{\circ}10'N$, $75^{\circ}85'E$. Jinadasa (1985) observed 49% of the billfish landings to be striped marlin. The high anterior lobe of the dorsal fin of striped marlin and its more moderately elevated shape make it easy to distinguish from blue and black marlins. There are two possible explanations which could account for some of this disparity in species composition. Firstly, when a marlin is landed, it is frequently chopped up into sections, and the fins and head have been discarded, which makes it virtually impossible to identify the species. Secondly, the timing of this study ran from August to July and that of Jinadasa ran from January to December.

Information extracted from the set of punch-card records on the relative numbers of billfish species landed at six sites down the west coast (Negombo, Padadura, Kalutara, Beruwala, Balapitiya and Hikkaduwa) between 1964 and 1967 indicates that black, blue and striped marlin are all equally abundant at around 15-20% of all billfish.

It is possible that the striped marlin has been underestimated by the present sampling programme, but given the frequency of coverage and the number of sites monitored where data on species composition independently agrees, I feel it is unlikely that striped marlin is the dominant billfish landed in Sri Lanka.

Regarding the peak season for individual marlin species there does not appear to be any consistent pattern between sites. In August and September black marlin was more abundant than blue marlin at Negombo, but at Beruwala black marlin was more abundant in November, February and April.

A summary of the species composition by percentage weight is given below.

SITE	SAI	SWO	BUM	BLM	MHS	SSP
KANDAKULIYAWA	5.1	20.2	44.5	29.4	0.6	0.2
NEGOBO	21.3	26.5	26.8	23.1	2.2	0.2
BERUWALA	23.8	16.6	35.0	23.1	1.6	0
ALL SITES	21.5	19.7	33.3	23.7	1.7	
COMBINED						

Marlins accounted for 58.7% by weight of all billfish landings covered during this study which compares well with the estimate made by Joseph and Amarasinghe (1986) for 1985. Discrepancies in the percentage of sword fish and sailfish may have arisen due to incomplete overlap in the study area. Trolling is more common in the south and south-west sector and appreciable, albeit low, catch rates of marlin and sailfish are sustained.

5. SIZE COMPOSITION

Size frequency distributions have been produced for the more common species from Negombo and Beruwala for the whole year being considered. These are presented in Figures 2-10.

Modal eye-fork lengths (in Centimetres) are given below:

SITE	SAI	SWO	BUM	BLM	MHS	SSP
BERUWALA	172		182/204	196	188	116
NEGOMBO		180	212	-	116/132	

The only other size-frequency data that exists for the area was reported by Jinadasa (1985), but standard length was measured and no conversions exists to allow a comparison. There were insufficient observations in the present study to allow analysis of modal progression, and similarly, no large one-off length frequency sample was obtained which could have indicated the number of age components present.

Mean weights on a quarterly basis have been calculated for all sites, and these are given on Table 6. At Negombo, it is interesting to note that the mean weights of sailfish, blue marlin, black marlin and swordfish all reach a maximum in the third quarter, and fall off sharply in the fourth. There was no parallel trend found at either Beruwala or Kandakuliyawa.

6. CONCLUDING REMARKS

Over the study period in excess of 1000 sailfish and swordfish and over 500 blue and black marlin measurements were taken. Owing to the relative scarcity of billfish in some months it will be necessary to maintain the intensity of sampling for another year at least. More attention is needed in the gear-wise breakdown of billfish catches to gain a better understanding of the fishery, with first-hand observations at sea from time-to-time being desirable. It is hoped that within a further six months enough morphometric observations will have been accumulated for four out of the six species occurring around Sri Lanka to improve the accuracy of catch statistics from whole and gutted billfish.

The production of billfish for Sri Lanka for 1986 was reported by IPPTP to be around 2000 tonnes. Joseph and Amarasinghe (1986), used two approaches to estimate the national catch. Their first approach was based on the number of boats operating in the pelagic fishery and the typical catch rates observed in the study area.

They estimated that for the years 1984 and 1985, an average annual catch of 2414.3 tonnes of billfish was caught by 1207 boats of the 3.5 ton class. This is equivalent to 2 tonnes/boat/year, or, assuming each boat operated 22 days per month, 7.58 kg/boat/night. Catch rates observed in this study range from 33.5 kg/boat/night in Beruwala to 4.47 kg/boat/night in Kandakuliya taking the annual average for each site. Setting the national average catch rate at 15 kg/boat/night, as observed at Negombo, would offer potential national production of around 10,000 tonnes at the present levels of exploitation observed on the west coast.

Their second approach involves the determination of relative proportions of tuna and billfish in the catch composition, and dividing the national tuna catch of the year by the same factor. In 1984, an estimated 17,530 tonnes of tuna was landed in the study area by all craft and gear type; the billfish catch by 3.5 ton boats for the same area was 1969.6 tonnes. This yields a ratio of 8.9 tuna : 1 billfish. In the present study, the production of tuna is estimated at 6,042 tonnes for the three sites, and the corresponding production of billfish at 1254 tonnes. This gives a ration of 4.8 tuna : 1 billfish. Assuming the national production of tuna to be around 25,000 tonnes, a total production of 5,200 tonnes of billfish is obtained.

The presently restricted access to much of the coast-line of Sri Lanka will render estimates on national production rather speculative. The study of the biology of billfishes could quite easily proceed, however, and this would probably make a more valuable contribution to the understanding of the fishery in the Indian Ocean.

7. ACKNOWLEDGEMENTS

The author wishes to acknowledge the co-operation of the IPTP samplers and secretariat in collecting, entering and checking of the data. Thanks are also due to Mr. L. Joseph, (former head of the Marine Resources Group, NARA) and to Dr. K. Sivasubramaniam (Senior Fishery Biologist, FAO/Bay of Bengal Programme) for allowing access to the set of punch-card records amassed between 1964 and 1977.

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TABLE 1.

CATCH COMPOSITION REALISED BY FISHING OPERATIONS BASED IN
SRI LANKA CONDUCTED WITHIN ABOUT 50 MILES OF THE COAST

LOCATION GEAR AND VESSEL	YEAR	PERCENTAGE COMPOSITION (WEIGHT)				SOURCE
		TUNA	BILLFISH	SHARK	SEER	
BATTICALOA (E) DGN/LL 11 ton	1968 1969 1970	34.5 51.7 48.0	18.7 4.8 9.0	33.9 33.8 38.4	2.5 1.0 0	National Aquatic Resources Agency, Colombo
TANZALLE (S) DGN/LL 11 ton	1968 1969 1970 1971	60.4 20.5 27.7 74.9	3.1 1.4 1.4 8.6	31.4 25.7 15.2 11.7	0.2 0 2.8 1.2	" " " " " " " " "
GALLE (SW) DGN/LL 11 ton	1970 1971 1972	54.3 66.0 56.6	5.6 6.3 5.9	24.8 22.6 29.2	0 0 0.1	" " " " " " " "
COLombo (W) DGN/LL 11 ton	1958 1959 1970 1971 1972 1973	46.5 57.2 50.5 63.5 62.1 79.0	4.2 9.3 6.4 8.6 4.1 5.7	39.2 28.5 24.0 20.6 29.6 8.5	0 0 0 0 0 0	" " " " " " " "
KALPITIYA (SW) DGN/LL 11 ton (fishing only 1st and 4th quarters)	1968 1970 1971 1972 1973	38.5 48.2 57.8 54.3 52.1	6.2 15.1 15.6 7.5 8.9	45.6 15.1 28.8 21.5 33.4	2.1 1.2 0.3 0.1 0.2	" " " " " " " "
NW DGN/LL 11 ton	1934	67.4	3.1	10.6	17.8	Joseph and Moyadeen, 1956
SW DGN/LL 11 ton	1934	73.4	5.9	13.8	6.7	"
S DGN/LL 11 ton	1934	61.3	8.6	20.7	8.9	"
S DGN/LL 11 ton	1934	72.3	7.5	34.1	5.7	"

TABLE 2

ESTIMATED PRODUCTION (TONNES) OF BILLFISH FROM THE THREE
MAJOR LANDING SITES ON THE WEST COAST OF SRI LANKA

MONTH	SAI	BUM	BERUWALA			NECOMBO			KANDAKULIYA			TOTAL
			BLM	MLS	SWO	SSP	SAI	BUM	BLM	MLS	SWO	
AUG 86	16.09	13.14	8.45	0	3.04	0	15.84	1.89	19.96	0.96	34.77	-
SEP	14.35	17.18	12.86	1.03	5.89	0	15.65	2.56	26.65	4.27	6.63	0.59
OCT	11.01	11.45	12.98	1.59	6.12	0	11.28	7.21	7.85	-	9.66	0.13
NOV	14.12	13.80	18.69	1.85	12.03	0	1.16	7.26	7.15	-	2.06	0.03
DEC	3.14	5.78	4.33	0.20	3.27	0	2.75	0.71	0.85	-	1.94	-
JAN 87	12.78	31.64	13.16	0	13.68	0	2.65	6.91	2.32	0.33	12.96	-
FEB	4.98	6.96	19.70	3.02	9.08	0	0.88	6.21	5.85	-	8.66	0.24
MAR	12.10	16.10	13.45	1.19	16.75	0	3.07	16.64	9.92	-	10.22	-
APR	21.70	14.30	29.41	1.22	21.95	0	15.06	21.01	3.33	0.43	0.28	0.40
MAY	23.41	45.94	21.52	0.54	8.52	0	6.52	15.58	6.01	1.25	-	-
JUN	9.09	15.23	3.01	0	3.32	0	4.89	3.79	0.67	4.25	-	-
JUL	35.21	68.75	15.00	1.06	19.92	0	5.43	1.43	1.70	1.50	1.09	0.08
TOTAL	177.98	260.87	172.26	11.70	123.57	0	85.18	107.2	92.26	8.74	105.97	0.83
PERCENTAGE COMPOSITION	23.8	35.0	23.1	1.6	16.6	0	21.3	26.8	23.1	2.2	26.5	0.2

TABLE 3
ESTIMATED PRODUCTION (NUMBERS) OF BILLFISH FROM THE THREE MAJOR
LANDING SITES ON THE WEST COAST OF SRI LANKA

MONTH	SAI	BUM	BERUWALA			NECOMBO			KANDAKULIYA			TOTAL
			BLM	MLS	SWO	SSP	SAI	BUM	BLM	MLS	SWO	
AUG 86	526	167	116	0	157	0	445	12	226	12	501	0
SEP	402	144	144	16	211	0	504	25	272	59	316	35
OCT	290	134	165	21	186	0	469	114	105	0	356	6
NOV	419	183	255	26	386	0	73	107	87	0	138	2
DEC	137	110	49	4	217	0	73	13	10	0	190	5
JAN 87	333	352	158	0	465	0	96	112	32	6	515	0
FEB	148	133	255	41	348	0	21	126	60	0	340	0
MAR	236	202	162	17	431	0	125	230	129	0	448	0
APR	605	196	336	17	661	0	504	485	44	11	351	5
MAY	650	524	228	8	521	0	219	168	69	25	315	0
JUN	230	192	29	0	186	0	176	62	9	0	142	0
JUL	1418	840	138	6	1204	0	183	20	20	10	91	16
TOTAL	5494	3177	2035	156	4973	0	2868	1474	1063	133	3643	123
PERCENTAGE COMPOSITION	34.7	20.1	12.9	1.0	31.4	0	32.5	16.7	12.0	1.5	41.2	1.4

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PERCENTAGE
COMPOSITION
34.7
20.1
12.9
1.0
31.4
0
32.5
16.7
12.0
1.5
41.2
1.4
11.3
23.6
20.6
3.1
40.3
1.1

TABLE 4.

CATCH RATES OF BILLFISH (ALL SPECIES) FROM VARIOUS SECTORS
OF SRI LANKAN COASTAL WATERS EXTENDING OUT TO 100 MILES

* Figures may be misleading as data is only available for the peak season

SECTOR	GEAR AND VESSEL TYPE	YEAR	CATCH RATE (kg per boat-night)	SOURCE
NW KANDAKULIYA	DGN / 3.5 ton	1986-87	4.47	IPTP
	DGN / LL / 11 ton	1968	22.71	NARA
KALPITIYA	"	1970	39.62	"
	"	1971	21.29	"
KALPITIYA*	DGN / 3.5 ton	1984-85	14.31	Peter
	"	1986-87	21.97	"

W NECOMBO	DGN / LL 3.5 ton/LL ton	1986-87	15.54	IPTP
COLONBO	DGN/L/LL ton	1968	17.18	NARA
		1969	37.98	
		1970	41.16	
		1971	25.33	
		1972	13.94	
		1973	13.65	

SW SERUMALI	DGN / LL / HAN 3.5 ton	1986-87	33.56	IPTP
GALLE	DGN / LL 1 ton	1970	13.74	NARA
	"	1971	12.17	
GALLO*	DGN / 3.5 ton	1972	9.21	Peter
	"	1984	9.82	
	"	1985	15.07	
	"	1986	21.53	

S TANGALLE	DGN / LL 11 ton	1968	13.47	NARA
		1969	8.03	
		1970	4.05	
		1971	15.33	
TATTICALOA*	DGN / LL 11 ton	1946 1970	44.64 26.12	NARA

TABLE 5.
SPECIES COMPOSITION OF BILLFISHES TAKEN FROM WATERS
AROUND SRI LANKA EXTENDING TO 100 MILES OFFSHORE

LOCATION AND GEAR TYPE	PERCENTAGE COMPOSITION BY NUMBER					SOURCE
	SAI	EUM	BLH	MHS	SWO	
BERUWALA DGN/LL/HAN	34.7	20.1	12.9	1.0	31.4	0
NECOMBO DGN/LL	32.5	16.7	12.0	7.0	31.4	0
KANDAKULIYA DGN	11.3	23.6	20.6	3.1	40.3	1.1
"OFF-SHORE" LL	23.9*	10.4	21.3	28.0	12.2	- Sivasubramiam, 1971
PERCENTAGE COMPOSITION BY WEIGHT						
BERUWALA DGN/LL/HAN	23.8	35.0	23.1	1.5	16.6	0
NECOMBO DGN/LL	21.3	26.8	23.1	2.2	26.5	3.1
KANDAKULIYA DGN	5.1	44.5	29.4	0.6	1.2	0.2
NECOMBO DGN/LL/TROLL	31.0	16.0	49.0	1.0	2.2	Jinadasa, 1985
WEST AND SOUTH SECTORS OF SRI LANKA						
(DGN)	25.6		63.9	10.5		- Joseph Amarasiri, 1985
LL TROLL	3.0	48.2	69.6	48.6	2.2	-
TUTICORIN INDIA TROLL	58.3	44.2	16.7	8.3	0	12.5 Silas and Rajapalai, 1963?

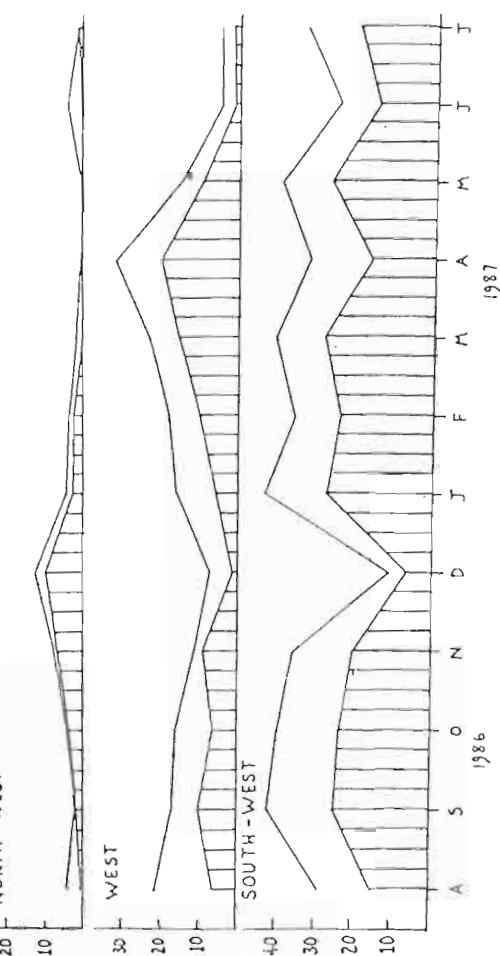
* includes SSP
+ "others" category

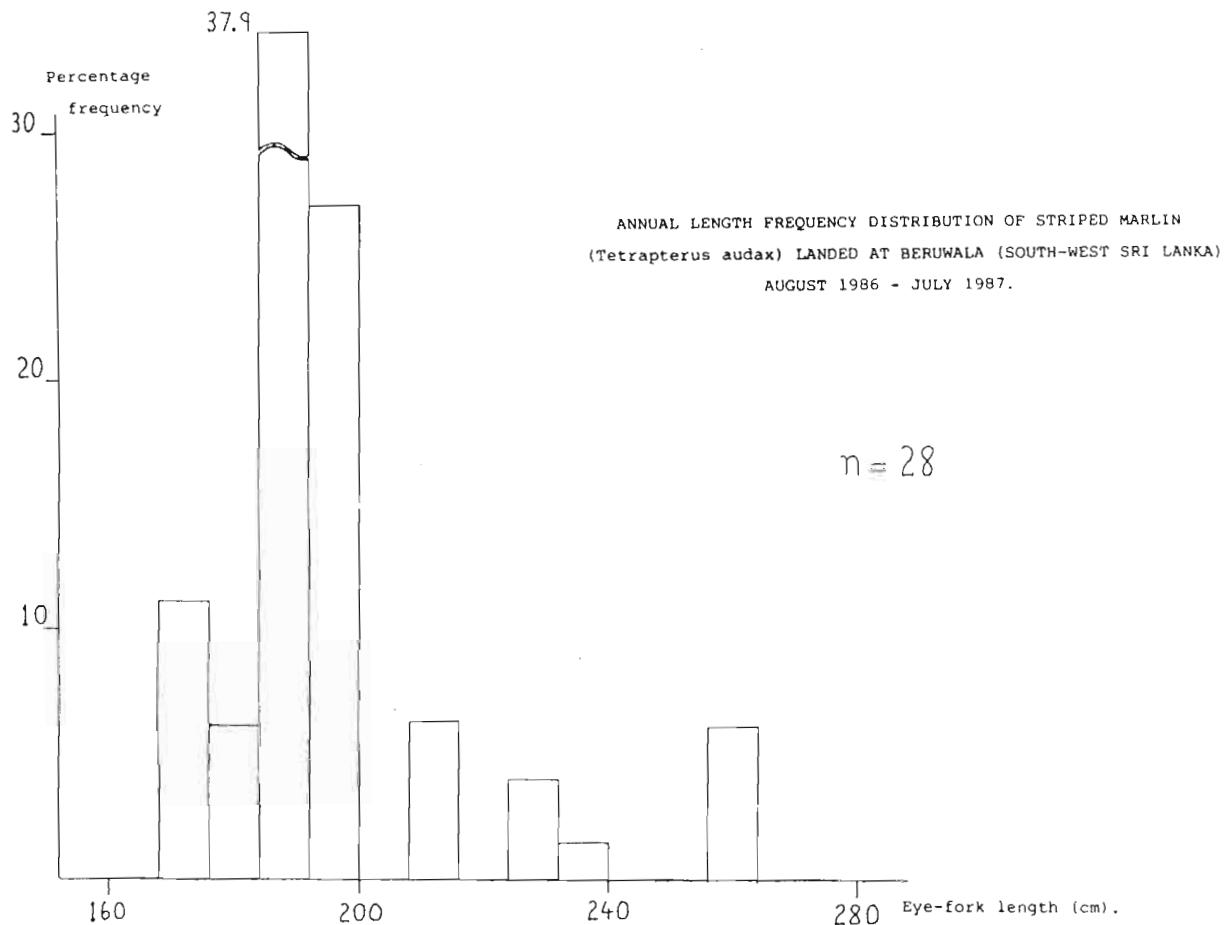
MEAN WEIGHTS OF BILLFISH LANDED ON THE WEST
COAST OF SRI LANKA, AUGUST 1986 - JULY 1987
(WEIGHT * kg)

SITE	QUARTER	SAI	BUM	BLM	MLS	SWO	SSP
KANDAKULIYA	I	20.0	97.7	101.9	-	16.2	23.3
	II	56.0	80.0	-	-	22.3	-
	III	23.8	51.7	42.5	5.4	23.5	-
	IV	31.7	127.6	105.4	16.4	29.5	10.0
	ANNUAL	26.4	110.9	84.0	10.9	22.0	10.5
NEGOMBO	I	27.3	63.6	81.9	35.0	24.4	-
	II	29.4	78.9	82.0	46.7	22.2	-
	III	32.6	103.2	93.3	74.0	46.8	5.1
	IV	25.5	64.9	78.5	-	21.9	20.0
	ANNUAL	29.7	72.7	86.8	65.7	29.1	6.7
BERUNALA	I	36.5	79.6	80.5	72.6	31.8	-
	II	36.5	83.4	91.0	70.4	24.2	-
	III	30.0	86.1	90.5	95.0	18.4	-
	IV	33.4	72.7	76.8	71.4	27.1	-
	ANNUAL	32.4	82.1	84.6	75.0	24.8	-
OVERALL		31.3	81.8	85.2	61.0	26.3	7.2

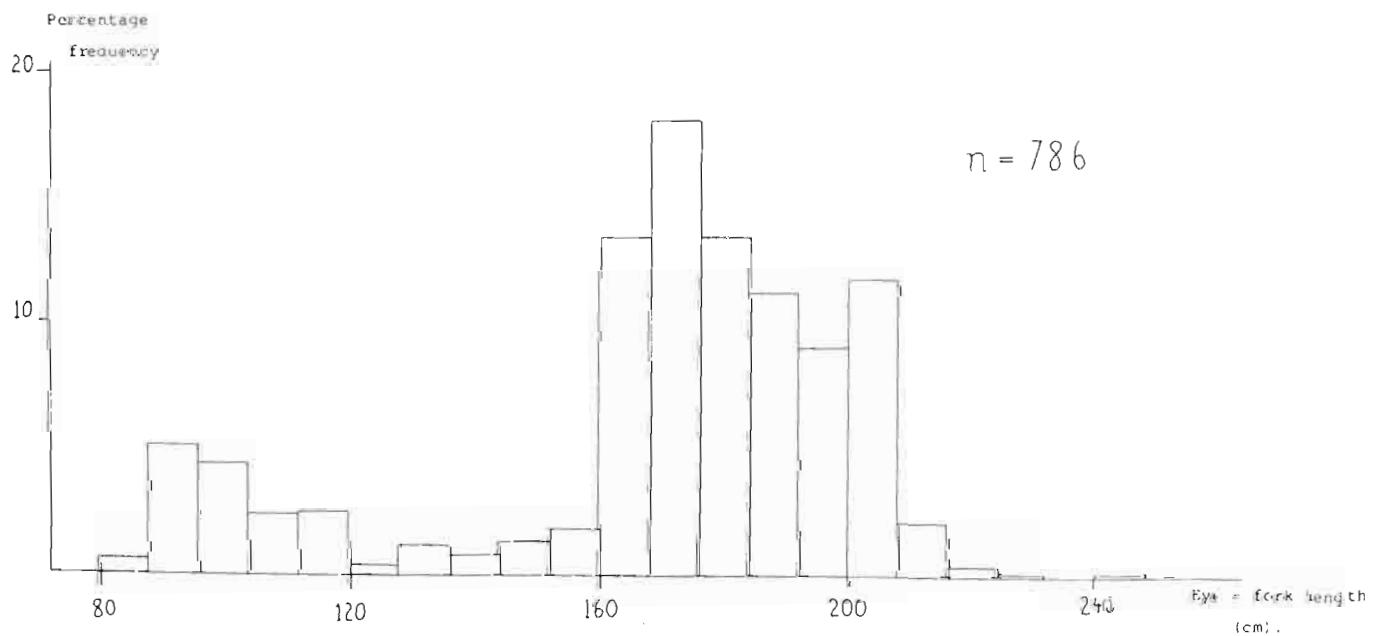
CATCH RATE

(kg per bat-night)

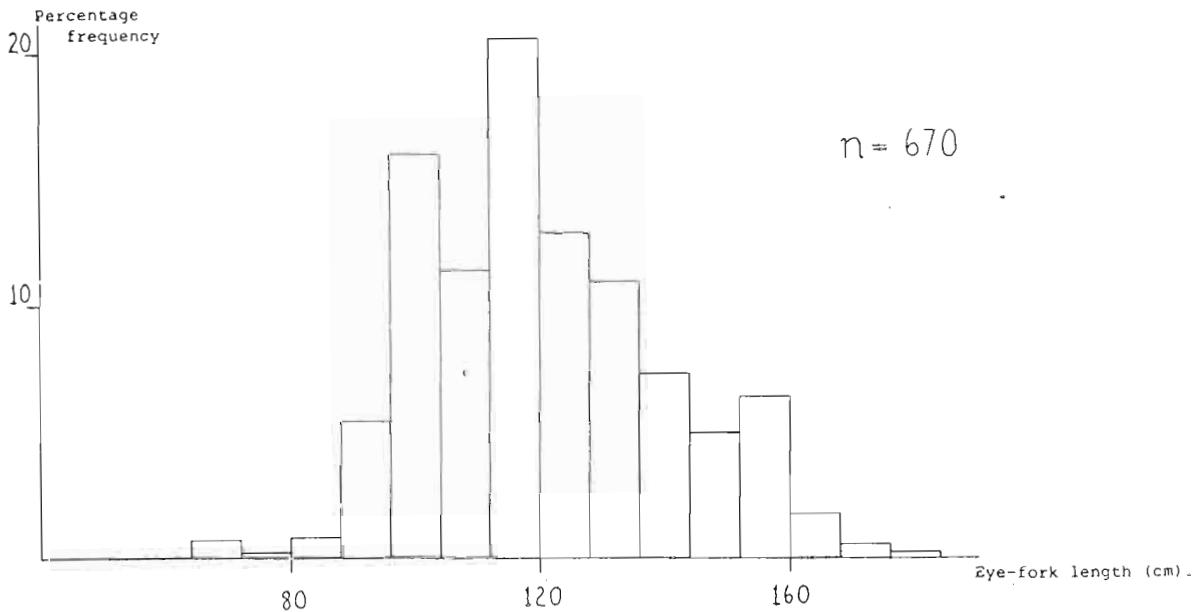




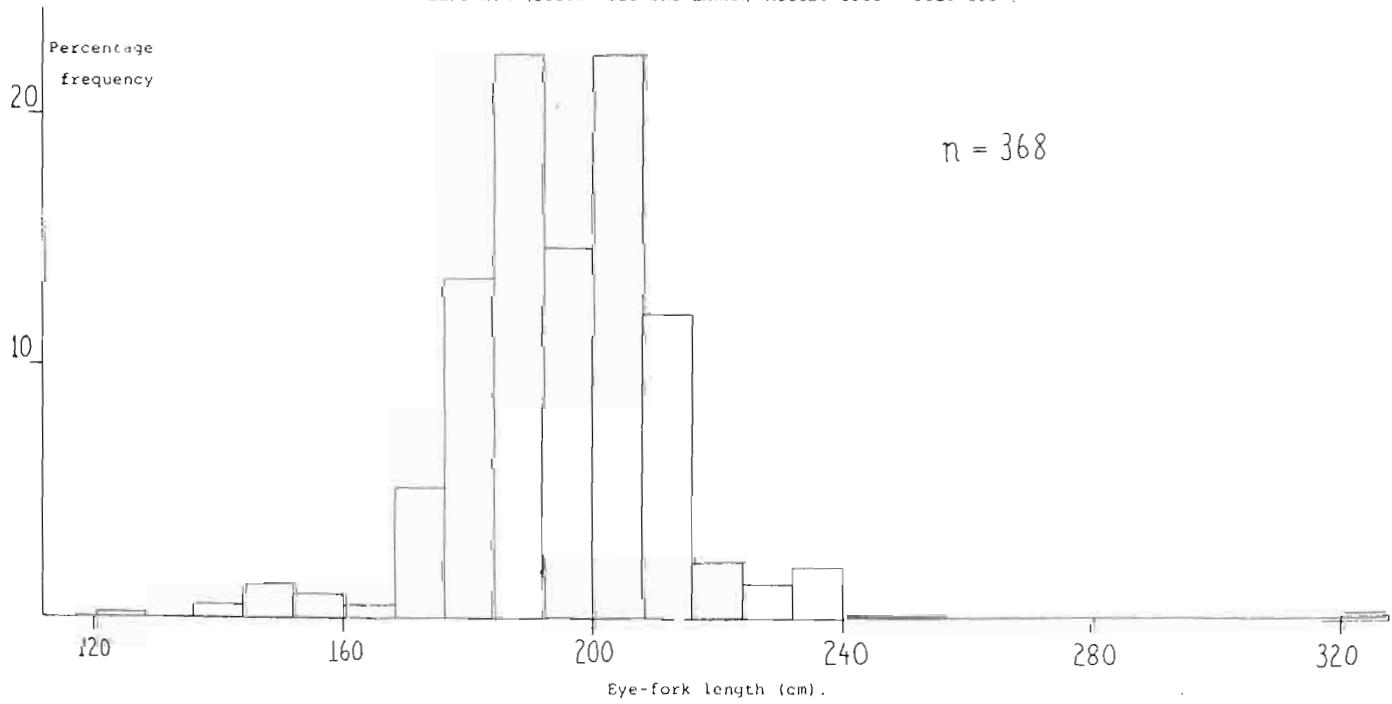
ANNUAL LENGTH FREQUENCY DISTRIBUTION OF SAILFISH (*Istiophorus platypterus*) LANDED AT
BERUWALA (SOUTH-WEST SRI LANKA) AUGUST 1986 - JULY 1987.



ANNUAL LENGTH FREQUENCY DISTRIBUTION OF SWORDFISH (*Xiphias gladius*)
BERUWALA (SOUTH-WEST SRI LANKA) AUGUST 1986 ~ JULY 1987.

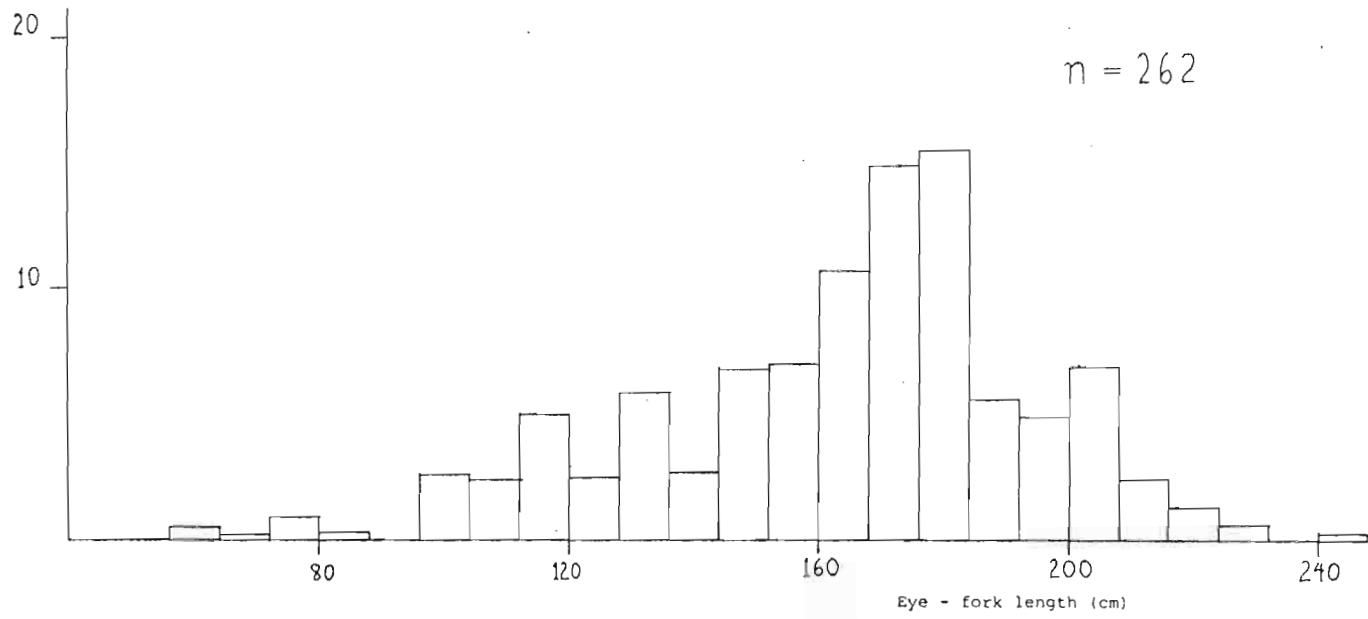


ANNUAL LENGTH FREQUENCY DISTRIBUTION OF BLUE MARLIN (*Makaira mazara*) LANDED AT
BERUWALA (SOUTH-WEST SRI LANKA) AUGUST 1986 ~ JULY 1987.



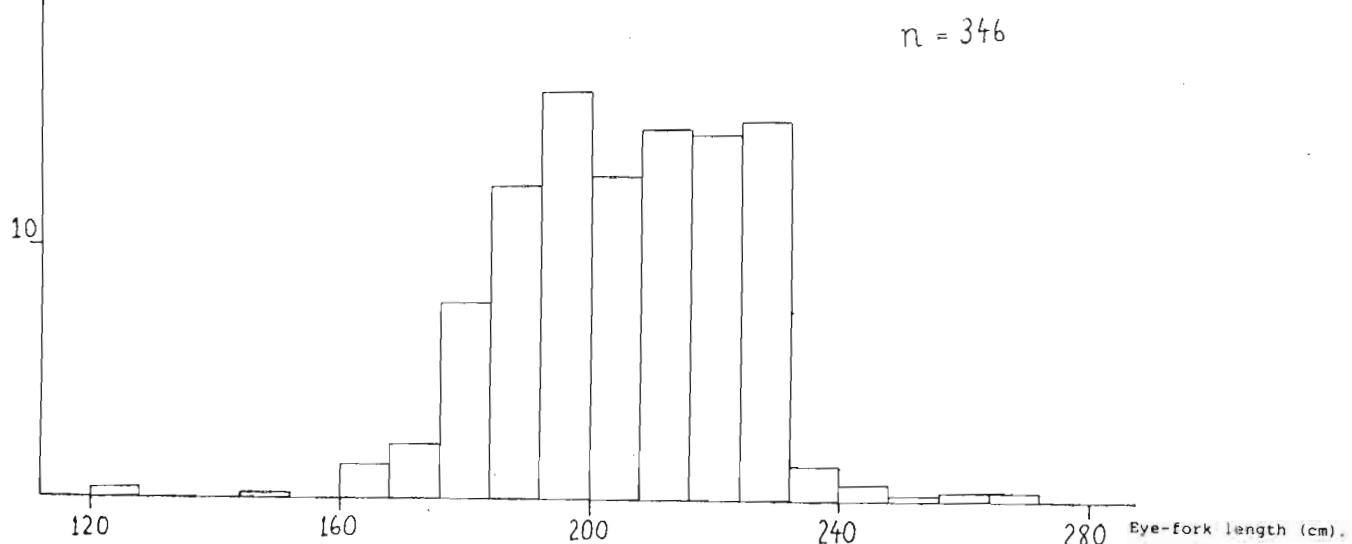
ANNUAL LENGTH-FREQUENCY DISTRIBUTION OF SAILFISH (*Istiophorus platypterus*)
LANDED AT NEGOMBO (WEST SRI LANKA) AUGUST 1986 - JULY 1987

Percentage
Frequency

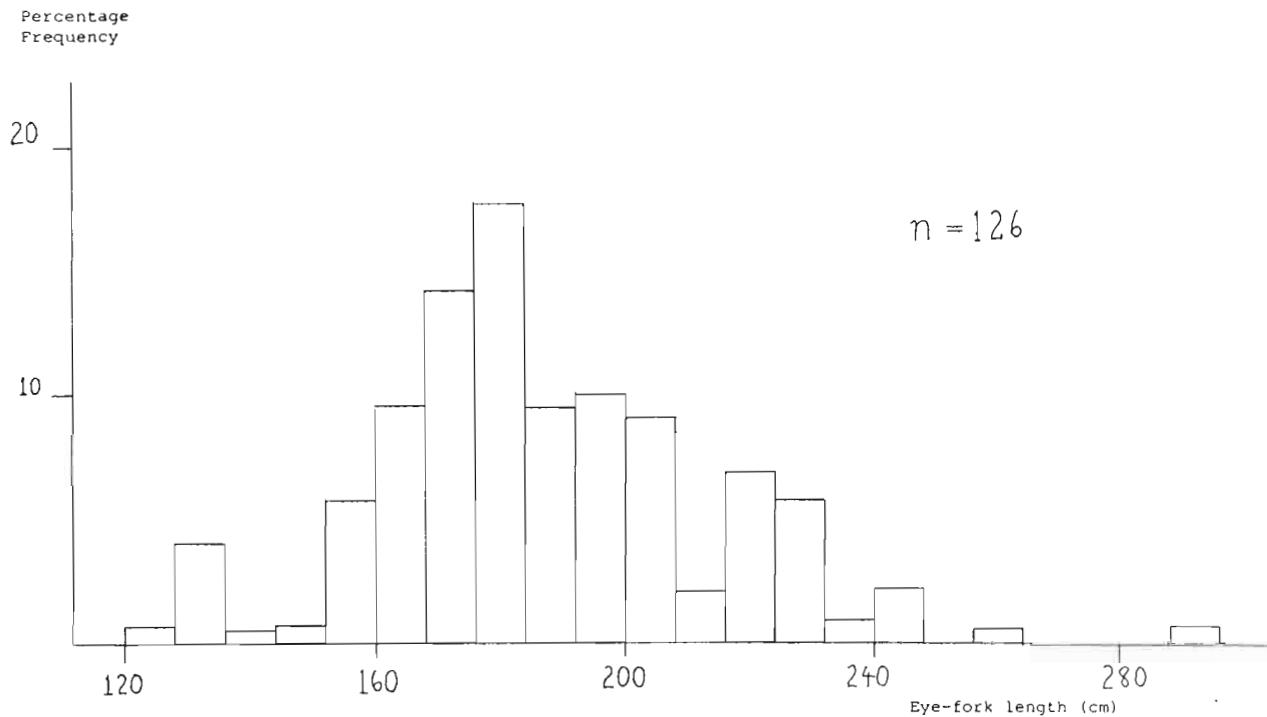


ANNUAL LENGTH FREQUENCY DISTRIBUTION OF BLACK MARLIN (*Makaira indica*) LANDED AT
BERUWALA (SOUTH-WEST SRI LANKA) AUGUST 1986 - JULY 1987.

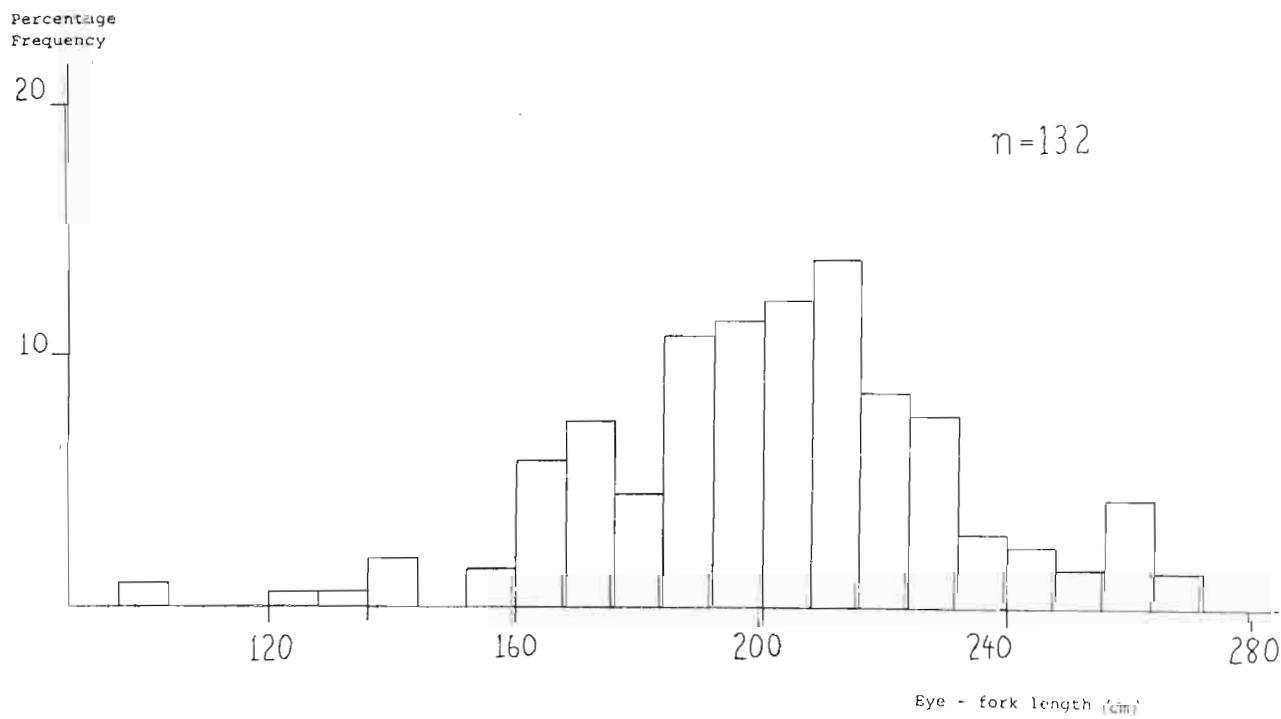
Percentage
frequency



ANNUAL LENGTH-FREQUENCY DISTRIBUTION OF BLUE MARLIN (*Makaira nigricans*)
LANDED AT NEGOMBO (WEST SRI LANKA) AUGUST 1986 - JULY 1987

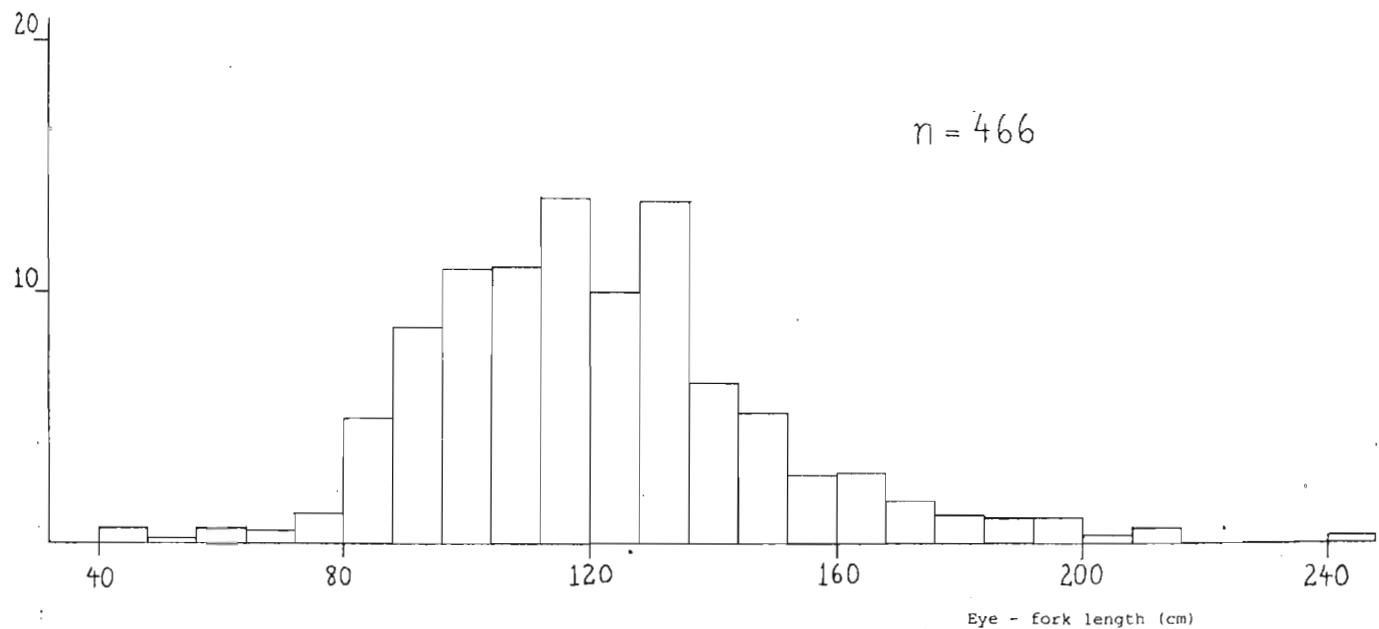


ANNUAL LENGTH-FREQUENCY DISTRIBUTION OF BLACK MARLIN (*Makaira indica*)
LANDED AT NEGOMBO (WEST SRI LANKA) AUGUST 1986 - JULY 1987



ANNUAL LENGTH-FREQUENCY DISTRIBUTION OF SWORDFISH (*Xiphias gladius*)
LANDED AT NEGOMBO (WEST SRI LANKA) AUGUST 1986.- JULY 1987

Percentage
Frequency



STOCK STRUCTURE OF BLUE MARLIN, MAKAIRA NIGRICANS, POPULATIONS

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Stock Structure Models

The blue marlin, Makaira nigricans, is a wide-ranging oceanic species. Among all the marlin species, it is the only one that is circumtropical in distribution, occurring in the Atlantic, Indian and Pacific Oceans and adjacent seas. The adults are found in waters warmer than 24°C on the high seas as well as in areas adjacent to land masses with narrow shelves that drop off abruptly, such as around volcanic islands and atolls (Nakamura 1985).

As with other wider-ranging species such as tunas, the stock structure of the blue marlin population is not well understood. However, as a necessary step in preparing stock assessments or for evaluating responses of the population to exploitation, models of the structure have been proposed. The models are predicated on both a genetic concept, i.e., members are genetically alike, isolated together and self-sustaining, and a fishery-management concept, i.e., members have identical vital rates and are exploited while mixed in the fishing areas. In practice, this latter concept has been more useful than the former for developing fishery management advice for the wide-ranging species.

The information base for constructing the models has been primarily catch records of adults obtained from Japanese tuna longline vessels and catch records of larvae obtained from research cruises. From this information, the stock structure of the global population of blue marlin has been postulated as follows: Separate, isolated populations exist in each ocean. Within each ocean, the population is further partitioned into stocks.

For the Atlantic population, ICCAT (1980) concluded that there is strong evidence for a separate north and south stock separated at the equator, but there is a likelihood of intermixing between them. For the Indian Ocean, experts consulted by FAO (1980) concluded that there is a single blue marlin stock in the Pacific Ocean (Yuen and Miyake 1980).

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How consistent are these stock structure models with the data and other information on blue marlin? This question is explored in the following sections of this report with a review of available data on longline catch rates, larval occurrences, and tag recoveries.

Distribution of Adults

The most comprehensive and longest series of data on catches of blue marlin and amount of fishing effort expended is Japanese tuna longline fleet (Yuen and Miyake 1980). Published records of this series extends from 1956 to 1980 and have been the foundation for most stock structure analyses of billfishes as well as of tunas. To understand the strength and limitation of this data series for stock structure analysis, a general understanding of the fishery and fishing characteristics of the gear is essential.

The Japanese developed the longline gear for fishing tunas off the coast of the Japanese archipelago. The fishery expanded rapidly beginning in the 1950s in response to a growing demand for tuna in both Japan and the United States. By 1953, the Japanese longline fleet was operating world-wide (Ueyanagi 1974). Tuna is the target species for this fishery although, at times, billfish is the target. For example, in the early 1960s striped marlin, Tetrapturus audax, and sailfish, Istiophorus platypterus, appeared to have been the target in the northeastern tropical Pacific Ocean, and in the 1950s to the mid-1960s sets were made at night to catch swordfish, Xiphias gladius, in the northwestern Pacific (Ueyanagi 1974). Billfish catches, however, are a small percentage (18% during 1968-70) of the total longline catch and are, for the most part, an incidental catch during fishing operations for tunas.

Before the early 1970s, standard longlining, which fishes at a depth of 100-150m, was common (Ueyanagi 1974). Since then, deep longlining, which targets on the deep swimming bigeye tuna, Thunnus obesus, and fishes at a maximum depth of 300m, has become widespread (Suzuki, Warashima and Kishida 1977). This switch to deep longlining resulted in improved catches of tuna that inhabit the region of the thermocline, but reduced catches of billfishes that prefer the shallower, mixed layer depths (within 200m of the surface for blue marlin (Yuen, Dizon and Uchiyama 1974)).

For stock structure analyses, the longline data are typically summarized, such as overall months and years, to reduce the volume. Nominal catch rates are computed for 5-degree squares and plotted on maps. Areas of concentrations or regions of contiguous high catch rates are then delineated. The number of such regions provides an indication of number of stocks (fishery-management units). Particularly if the regions are separated by oceanographic features that might serve as barriers to movements or serve to delineate preferred habitat boundaries.

A typical plot of the longline data for blue marlin is shown in Figure 1. The plot represents a summary of data for the years 1965-75, a period when fishing effort was principally of standard longlining and was distributed over the entire global range of the species. Regions of high catch rates separated by areas of low catch rates can be seen within each ocean. There appears to be a southern and a northern concentration separated by the equator, where the strong equatorial and counter currents could serve as barriers to cross movement.

If these data are summarized on a monthly scale and plotted, the pattern is quite different. The plots (Suzuki and Honma ms) show blue marlin present throughout most of its distributional range in all months and oceans, but tending to be denser in the western regions of the oceans. From January to about March, there is only one band of high concentration (>2.0 fish/1000 hooks) which is in the southern hemisphere of each ocean (southern locations as in Figure 1). During March and April, the concentration appears to disintegrate particularly in the Atlantic and Pacific. In May, a new region of high concentration begins to take shape, but this time it is only in the northern hemisphere (northern locations as in Figure 1). The northern concentration becomes quite prominent during the summer and persists until September in the Pacific and October in the Atlantic. It too begins to disintegrate; its center migrates southward towards the general location of the southern high density region. By January disintegration is complete and the cycle is ready to begin again with the southern concentration.

A similar finding was described by Anraku and Yabuta (1959) for the Pacific blue marlin. They, however, felt that fish of primarily 140-180cm long and only males participated in migration across the equator.

The apparent seasonal movement of the concentrations suggests that a single stock is involved; the stock is widespread throughout the year, but the center of high concentration moves between the northern and southern hemispheres within each ocean in response to seasonal changes. This explanation assumes that blue marlin are highly mobile, undeterred by oceanographic features at the equator, and that the efficiency of the longline gear is constant with adequate effort distributed over time and space (e.g., not affected by seasonal weather patterns).

The alternative explanation is that there are two stocks, north and south, in each ocean. Each stock alternates between states of being concentrated during one season and being dispersed during other seasons. The timing of these states is different for north and south stocks. This explanation assumes seasonal behavioral changes of the fish, changes in effectiveness of the longline gear, i.e. catchability is not constant, and oceanographic features at the equator serve as a barrier to north-south movement. Selecting the most plausible explanation of the two requires more information than available solely in the longline data series.

Distribution of Larvae

Various types of plankton nets have been used to collect blue marlin larvae and other pelagic fish larvae in order to study their taxonomy and development and to locate spawning areas. Collections have been made by research vessels mostly between 1956 and 1976 (e.g. Bartlett and Haedrich 1968; Eschmeyer and Bullis 1968; Matsumoto and Kazama 1974; Nishikawa, Kikawa, Honma and Ueyanagi 1978), and largely in a piecemeal fashion. The majority of collections are from Japanese sources. Sampling areas, seasons, times of day, types of net and depths of net tow have all varied to complicate the standardization of sampling effort and has not been done.

For stock structure analyses, typically all records of occurrences, rather than catch rates, are tabulated and plotted on maps. Regions of occurrences are delineated and are assumed to be spawning areas. I used this procedure with data from Bartlett and Haedrich (1968), Eschmeyer and Bullis (1968), Gehringer (1956), Matsumoto and Kazama (1974), Nishikawa et al. (1978), and Ueyanagi (1963).

The results (Figure 2) show one large spawning region for each of the Indian and Pacific Oceans, and two spawning regions in the Atlantic. Closer examination of the sampling effort (Figure 3) indicates that sampling coverage was generally spotty. Effort is particularly poor for the Atlantic and Indian Oceans, and for the central and eastern regions of the Pacific Ocean. Consequently, the pattern in Figure 2 may be an artifact. It is possible that with more thorough sampling coverage, both over space and time, the separate regions of spawning in the Atlantic might turn out to be not separated, but connected, or the single regions in the Indian and Pacific Oceans, might turn out to be a mosaic of concentrations that extends further eastward.

Typically, this type of analysis ignores the limitations of the data and concludes that single stocks (genetic units) occur in the Indian and Pacific Oceans and two stocks occur in the Atlantic Ocean (e.g. Mather, Jones and Beardsley 1972). Such interpretations are based on the assumption that larval distribution corresponds to the distribution of spawning and that spawners return to their "home" spawning areas. Since adult blue marlin are batch spawners, spawn throughout the year in the tropics and subtropics (Matsumoto and Kazama 1974), are highly mobile during a moderately long life span (maximum age of over 15 years (Skidmore and Yong 1976; De Silva 1974)), and are found in the tropics year round, there is high probability that they do not "home" to specific spawning areas, but spawn wherever and whenever conditions are favorable. The result would be a fairly homogeneous, panmictic stock within each ocean. A test of this hypothesis will require evidence that separate, distinct groups form year after year during spawning to produce genetically separate units.

Distribution of Tag Returns

There has not been a world-wide, intensive tagging effort for blue marlin. To date, most of the tagging has been organized by U.S. scientists, with assistance from primarily sport fishermen and limited to fish caught off the U.S. coast. Over the past 20 years, only about 1,500 blue marlin have been tagged and released world-wide. The majority of the releases has been in the Gulf of Mexico and Caribbean Sea (fewer than 1,000 (Mather et al. 1972; Mather, Mason and Clark 1974) and off Baja California, Mexico and Hawaii about 500 have been released. (J. Squire, pers. comm.).

A fraction of 1% of the releases has been recaptured and the tags returned to the scientists (Mather et al. 1974). This relatively low return rate, compared for example to 2.3% average return for black marlin, *Makaira indica* (Squire and Nielsen 1983), is probably caused by high tagging mortality, both tag drop-off and death from hooking soon after tagging, rather than a reflection of low exploitation rate of the stocks (Mather et al. 1972).

Between 1978 and 1987, 16 blue marlin recaptures in the Atlantic and six in the Pacific were reported to the U.S. National Marine Fisheries Service. Of these 22 recaptures, eight were from individuals recaptured within 50 nm of the release site. These were not used for my study.

I examined the remaining 14 recaptures, 10 in the Atlantic and four in the Pacific, as long-distance returns (>50 nm). The longest distance travelled between release and recapture locations was more than 3,000 nm in both the Atlantic and Pacific (Table 1), and estimated travel rates were as high as 700 to 800 nm/month.

Examination of the plot of each long-distance return (Figure 2) shows that most returns were within 1,000 nm of the release location and five were beyond 1,000 nm. Two long-distance returns crossed the equator and two in the Atlantic were transoceanic returns. One return in the Pacific was nearly transoceanic, tagged near the equator in the central Pacific and recaptured off Australia.

These data clearly show that blue marlin are wide ranging and capable of transoceanic movements. They also demonstrate that the equator is not a barrier to movement of adults from one hemisphere to another and adults can travel at a rapid rate. They support a conclusion that each ocean could have a single stock, or if there are multiple stocks, the rate of mixing could be rapid enough to warrant treating the population as a single stock for stock assessment purposes.

Concluding Remarks

For most wide-ranging oceanic species, there is little concrete information for objectively determining the stock structure of the populations. The bits and pieces of available information on blue marlin point to a single stock in each ocean, but the information is not comprehensive or precise enough to negate the notion that multiple stocks exist or that blue marlin might ever be roaming between oceans.

It will take large and expensive data-collection programs over a period of years to accumulate data to clarify this stock structure puzzle. I doubt, though, that more of the same types of data-collection programs to date will be sufficient. The fact that blue marlin is a solitary animal, that throughout most of its range it is only caught incidentally during tuna fishing, and that juveniles are not caught in any significant numbers by traditional sampling gears, points to a major sampling problem. However, if there is a breakthrough in methods of stock identification that is cheap, easy to use and decisive, it might be possible to work around this sampling problem and solve the puzzle.

Perhaps a more general question is whether a more precise stock structure model is needed at all given the level of precision of other population dynamics parameters required for stock assessments and for formulating management advice. Since most population parameters such as growth, natural mortality, abundance for blue marlin are just as imprecisely estimated as is stock structure, the imprecision of the stock structure parameter might not be critical to the final assessment.

For the near term, it appears that the crude stock structure models for blue marlin will continue to be used for stock assessments despite their limitations. Until a cheap, easy to use and decisive technique of stock identification is developed, there is little hope of significant improvement in precision of existing models with more of the same types of data collected to date. Perhaps the focus of research should be directed at studies to understand vital rates (e.g., growth, sex ratio) and behavior (e.g., territorial, feeding) of blue marlin to obtain a better understanding of movements and indirectly stock structure while new techniques of stock identification are being developed.

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TABLE 1. Tag return information for blue marlin recaptured
more than 50 nm from the tagging sites.

Ocean	Year Recapture	Estimated		Gear
		At Liberty (month)	Distance Traveled (nm)	
Atlantic	1979	16	240	Longline
	1980	18	60	Rod & Reel
	1980	13	1,080	Longline
	1983	2	480	Longline
	1984	5	4,080	Rod & Reel
	1984	10	1,080	Rod & Reel
	1985	10	750	Rod & Reel
	1985	14	2,400	Rod & Reel
	1986	7	540	Rod & Reel
	1986	4	300	Longline
Pacific	1974	4	110	Rod & Reel
	1982	5	465	Rod & Reel
	1985	27	690	Purse seine
	1986	5	3,400	Rod & Reel
				Unknown

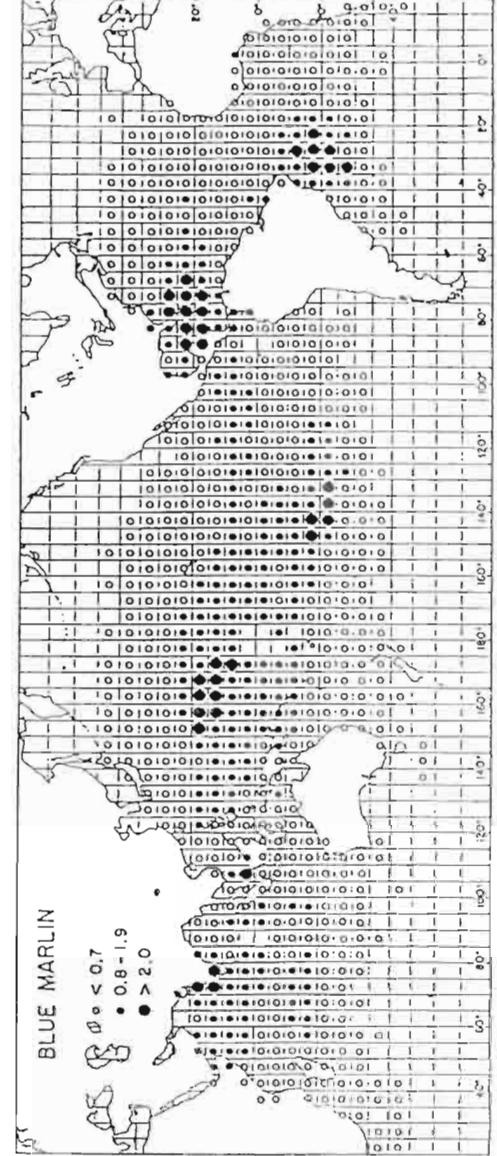


FIGURE 1. Distribution of longline catch rates for blue marlin. Catch rates (number of fish per 1,000 hooks), 1965-75, for 50 squares. (Source: Yuen and Miyake 1980).

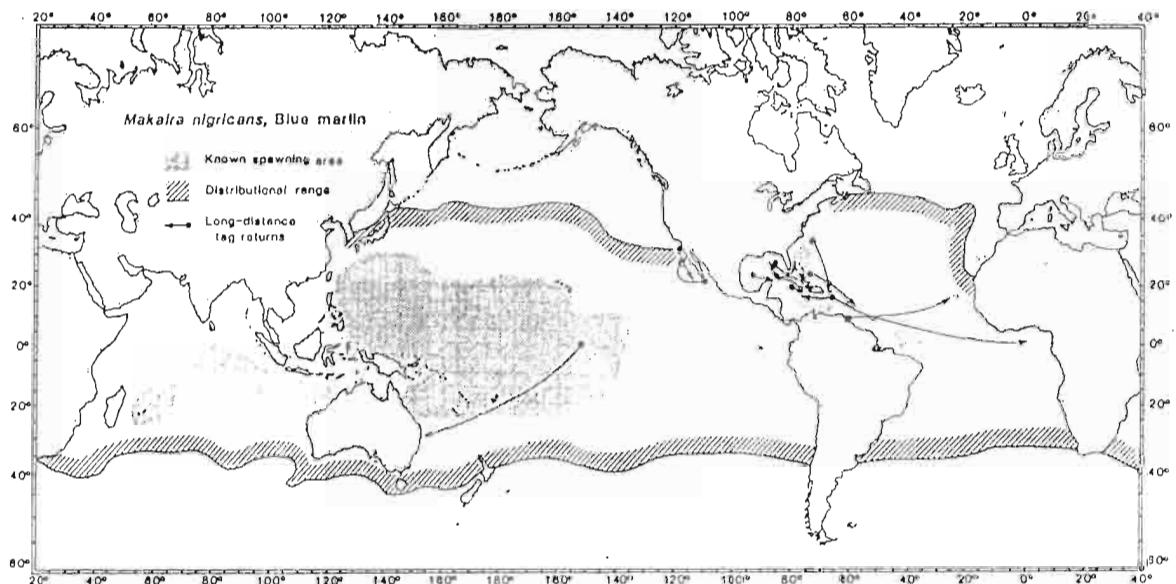


Figure 2: Distributional range, spawning areas and long-distance tag returns for blue marlin.

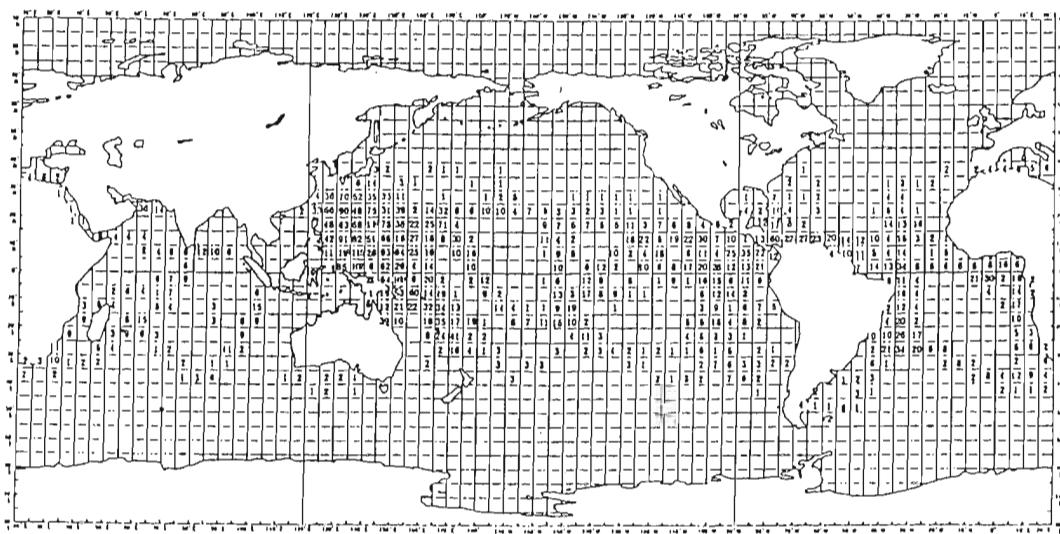


Figure 3: Number of plankton net tows by 5° square made by the R/V Shunyo Maru and Shoyo Maru during 1956-1976. (Source: Nishikawa et al. 1978)

TUNA & TUNA-LIKE FISHES IN BANGLADESH

This first two being more commonly observed than the others. Past survey records indicate the occurrence of *Thunnus tongol* (longtail tuna) also. The Spanish mackerel commonly caught are *Scomberomorus commerson* and *S. macratus*.

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ABSTRACT

EEZ of Bangladesh, extends 380 km towards the sea covering an area of 69,000 km² covering mostly the neritic zone and little of the oceanic province. There is continuous discharge of fresh water by the rivers and riverlets. Inspite of the large extent of estuarine waters, a few varieties of tuna and tuna-like fishes, which are generally oceanic are available as evident from past survey results and recent commercial landings by drift gillnet and hook and lines. This creates a scope for further investigation for determining commercial viability for a pelagic fishery in the offshore region.

1. Introduction

The existing marine fishery by artisanal crafts and trawlers is limited to the inshore waters of Bangladesh. Although the 380 km from the base line (EEZ of Bangladesh) extends towards the Bay, it is almost entirely covered by the continental shelf of 69,000 km². Present trawl and artisanal fishery fall within the neritic zone rather than the oceanic province. The availability of some tuna which are oceanic and tuna-like fishes while other tuna are neritic in their habitat, in the estuarine waters would normally be not expected. The area being a deltaic region subjected to continuous fresh water discharges by the rivers and riverlets causing change in the marine environmental factors such as salinity, oxygen content, pH values and transparency of the water. Inspite of the unfavourable environmental condition for tunas, the results of the surveys by R.V. Fishery Research No. 2 (1979) and R.V. Dr. Fridtjof Nansen (1979, 1980) indicate presence of some species of runa and tuna-like fishes in the EEZ of Bangladesh. Besides commercial landing of tuna and tuna-like fishes by drift gillnets and baited hook and line provides a scope for further investigation to determine the commercial viability of a pelagic fishery in the offshore range.

2. Tuna, tuna-like fish and billfish species

The following species have been observed in the landings by gillnetters at Cox's Bazar and Chittagong.

- Euthynnus affinis* – Eastern little tuna/kawakawa
- Auxis thazard* – Frigate tuna
- Thunnus albacares* – Yellowfin tuna
- Katsuwonus pelamis* – Skipjack tuna
- Sarda orientalis* – Oriental bonito
- Istiophorus platypterus* – Sailfish

3. Past survey fundings

Although as many as 10 (ten) fisheries surveys in the EEZ of Bangladesh have been conducted in the past, none of them covered the pelagic resources in the offshore region (oceanic province). Hence knowledge of the pelagic resources in the offshore region is completely lacking. However, evidence of the occurrence of tunas and related species from the surveys of R.V. Fishery Research, No. 2 (1979) and R.V. Dr. Fridtjof Nansen (1979, 1980) are highlighted below.

Table 1 reveals that as many as 4 (four) varieties of tunas are available in the marine water of Bangladesh. In the report it has been mentioned that the pelagic fish survey by drift gillnets close to the shore the fish available are Chinese herring and spanish mackerel, while far from the shore sharks, tunas and bonitos are found. Though *T. maccoyii* has been recorded during this survey, the occurrence of this species in the upper Bay of Bengal is doubted.

Table 1. Tuna and tuna-like fishes caught during the pelagic fish survey with drift gillnet, in the Bangladesh waters by R.V. Fishery Research No. 2 Cruise No. 1/1979, March 15-18, 1979.

Station	01	02	03
Depth (meter)	28-31	62-58	42-34
Lat N.	21-15-00	21-06-00	21-07-00
Long E.	90-22-00	90-47-00	91-04-00
Fish number/weight (kg)/catch rate (kg/km) Spotted spanish mackerel (<u><i>Scomberomorus guttatus</i></u>)	807/820/328.0	22/16/6.8	39/47/42.7
Narrow Barred king mackerel (<u><i>Scomberomorus commersoni</i></u>)	21/69/27.6	6/18/7.6	2/71/6.4
Bonito (<u><i>Auxis thazard</i></u>)	1266/1276/210.4	26/253/107.6	–
Bonito (<u><i>Euthynnus affinis</i></u>)	40/82/32.8	67/80.5/34.2	4/4/3.6
Bonito (<u><i>Thunnus tongol</i></u>)	275/556/222.4	132/242/103.0	2/1/12.7
Skipjack	–	6/9/3.8	–
Bluefin tuna (<u><i>Thunnus maccoyii</i></u>)	–	–	1/6.5/5.9

Source: Bangladesh – Thai Fisheries Expedition, 1979 (Modified form)

The survey made by the Norwegian research vessel 'Dr. Fridtjof Nansen' during the period 25 Nov. - 12 Dec. 1979 and 7-24 May 1980 included about 16 pelagic trawl hauls during the first survey period and about 7 in the second period along with some gillnetting and longlining. Catches of frigate tuna, billfishes and spanish mackerels are summarised below: (Table 2.)

Table 2.

Date	Gear type	bottom depth(m)	Portion North East	Species of Tuna & Tuna-like fishes present
29.11.79	Pelagic trawl	95	20°10'	91°19' Spanish mackerel (<i>Scomberomorus guttatus</i>)
30.11.79	Pelagic trawl	81	21°08'	90°03' Indian mackerel (<i>Rastrelliger kanagurta</i>)
2.12.79	Gillnet	20	21°28'	89°47' Spanish mackerel (<i>S. guttatus</i>)
4.12.79	Pelagic trawl	32	21°13'	90°13' Spanish mackerel (<i>S. guttatus</i>)
7.12.79	Longline	55	20°59'	91°14' 2 sailfish (<i>Istiophorus platypterus</i>) 206-218 cm
9.12.79	Pelagic trawl	43	20°41'	91°54' Spanish mackerel
8.5.80	Pelagic trawl	63	20°41'	91°44' Frigate tuna (<i>Auxis thazard</i>)
9.5.80	Gillnet	-	21°08'	91°50' Indian mackerel Spanish mackerel

Source: Saetre. (1981): Modified form

The area of survey by both the research vessels were confined to the neritic waters.

4. Present trend of commercial catch

It has also been observed at the fish landing centre in Chittagong (Bangladesh) that in 1984 about 197 t tuna and 482 t tuna-like fishes have been landed by the mechanized fishing boats (38', LOA) operating drift gillnetters (Table 3.) The fishing area, known from personal communication is located off Cox's Bazar and Teknaf area:

Table 3.

Year	Tuna fish	Tuna-like fish
1984	197 MT	482 MT
1985	70 MT	55 MT
1986	67 MT	47 MT

The mechanized fishing boats manned by a skipper, a cook and 10-12 crew member usually conduct 1-3 days trip from Cox's Bazar and Teknaf areas and 7-8 days trip from Chittagong. The mesh size of the drift gillnets for tuna fishing is usually 200 mm and the size of the net usually between 2,000 - 3,000 m length and 20 m depth.

From the records of export of catches made by a trawler based fishing company, it is found that a considerable amount of tuna and tuna-like fishes are being exported alongwith other fish (Table 4.).

Table 4.

Year	Tuna (tonnes)	Tuna-like fish (tonnes)
1984	-	42 t
1985	-	5 t
1986	-	4 t
1987	10 t	66 t

From Table 4 it appears that about 10 t of tuna fish have been exported by the company in 1987. By personal enquiry it was learnt that the trawlers engaged in bottom trawling in distant clear waters, frequently sight schools of tunas. Tunas are captured with baited hooks. This indicates that schools of tunas occur in the inshore waters of Bangladesh, when salinity, temperature and transparency of the water are favourable, particularly during winter months. During this season each drift gillnetter may land 30-60 kg tunas, excluding other fishes in each trip.

5. Conclusion

There is evidence of occurrence of tunas in Bangladesh waters. However, the abundance of their resources within the EEZ is unknown. Investigation must be conducted to explore the possibilities of establishing a commercial fishery and to gain information on the tuna resources in the EEZ of Bangladesh.

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