Field document 2

EXPLORATORY FISHING FOR LARGE PELAGIC SPECIES IN THE MALDIVES

Biological Report

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1. BIOLOGICAL SAMPLING PROCEDURES

Length and weight of each fish. Small fish were measured on a 1 m measuring board, larger ones with a tape. Tunas were measured to fork length, billfish to lower bill-fork length, and sharks to total length. All measurements were to the nearest centimetre below. It was not always easy to weigh fish on the rocking vessel, and overestimation of weights may have been common. So, length-weight relationships for skipjack and yellowfin, which are already well documented, are not presented. Most large sharks were weighed at the point of sale.

In general, this recording programme went well, with about 9.5% of all fish caught being measured. Further biological sampling was carried out only when a fisheries biologist was on board as observer. This was the case in over half of all stations (30 out of 49). The following information was recorded.

1.1 Sex of fish where it could be determined (i.e. not immature fish or some billfishes). Sex ratios are presented here in the form p males : q females (where $p = 1 - q$) so that approximations of 95% confidence limits can be estimated as follows :

$$\text{C.I. of } p \text{ and } q = 1.96\sqrt{p.q/N}$$

1.2 Gonad maturity stages for tunas, maturity stages of sharks and billfishes were not readily identifiable. It did not prove feasible to weigh gonads on board. The maturity of tuna gonads was recorded according to an approximate six point scale :

I -immature	IV -mature
II -early maturing	V -ripe
III -late maturing	VI -spent

1.3 Stomach contents : Skipjacks and yellowfins of all sizes were inspected but only small sharks were cut open because of the great loss in value if large sharks were opened. It did not prove feasible to weigh stomach contents, and these were roughly quantified by eye.

1.4 Information on any other non-commercial species.

I.5 Anything else of note, for example weather conditions, presence of fish schools and water temperature (only during the latter part of the project).

2. BIOLOGY OF SPICES CAUGHT

2.1 Skipjack

2.1. I Length frequency distribution

Length frequency distribution of skipjack caught in gillnets of three different mesh sizes during the northeast and southwest monsoons are given in Figures la and lb respectively. Fig.3 summarizes this data, and also presents data from the Maldivian pole and line fishery, for comparison. The following points are of note :

The northeast season catch had a distinctly bimodal length frequency distribution with modes at about 48 cm FL and 63 cm FL (Fig.1). The southeast season catch appeared to have a trimodal length frequency distribution, with modes at about 49 cm, 57 cm and 66 cm FL (Fig.2).

The gillnet catch by ***Marha*** Hari shows remarkable similarities in its length frequency distribution to that of the pole and line catch landed at Male (Fig.3-the only comparative skipjack data available from the Maldives). The same modes (plus or minus a couple of centimetres) can be identified in both data sets. The major difference is in the relative importance of these modes. The gillnet used would appear to slightly underestimate the abundance of small skipjack, while **the pale** and line technique appears to seriously underestimate the abundance of large skipjack. Maldivian fishermen do in fact say that large skipjack are much more difficult to land by pole and line than small skipjack.

The bimodal length frequency observed from December 1987 to April 1988 appears **to be a regular** feature of skipjack catches off the east coast of Maldives in the northeast monsoon season (Anderson and Hafiz, 1986, Hafiz and Anderson, 1988). The southwest monsoon season length frequency distributions were more variable but also appear to show some modes that are stationary **for** several months and are repeated year after year. For the skipjack catch as a whole (Fig.3, bottom) there is a relative scarcity of fish of 50-60 cm FL. Amarasiri and Joseph (1988) show that a **substantial** proportion of the Sri Lankan gillnet catch of skipjack is within this size range. These **observations** suggest that skipjack off the east coast of Maldives undertake constant large scale migrations.

2.1.2 Sex ratio and Gonad Maturity

A total of 419 skipjack was sexed-269 were male, 143 female and 7 were immature and of indeterminate sex. The estimated sex ratio for skipjack is :

0.65 + 0.05 males: 0.35 + 0.05 females.

There is a significant excess of males. This was' the case in both seasons, all three fishing zones, **and all size classes. A** preponderance of males in skipjack catches has been reported previously for both the Maldives and Sri Lanka (Hafiz, 1988; Amarasiri and Joseph, 1988). However, an excess of females has been reported for the Laccadives (Mohan and Kunhikoya, 1985). Whether this is indicative of latitudinal segregation is yet to be confirmed.

Gonad maturity data are summarised in Table 1. For convenience of presentation, **immature fish**

Table 1: Skipjack sexual maturity

(a) Males and immature fish

Fork length (cm)	*Gonad maturity stage* I	II	III	IV	V	VI	*Total*
< 34	2	-	-	-	-	-	2
35-39	3	1	-	1	-	-	5
40-44	2	8	8	7	-	-	25
45-49	-	3	14	32	1	-	50
50-54	-	1	8	16	2	-	27
55-59		—	3	17	7	-	27
60-64	-	-	-	63	28	-	91
65-69	-	-	-	30	9	2	41
70-74	-	-	-	7	1	-	8
Total	7	13	33	173	48	2	276

(b) Females

Fork length (cm)	*Gonad maturity stage* I	II	III	IV	V	VI	*Total*
40-44	-	10	7	1	-	1	18
45-49	-	5	8	20	-	-	33
50-54	-	-	3	14	1	-	18
55-59	-	-	3	9	2	-	14
60-64	-	-	-	34	5	-	39
65-69	-	-	-	9	10	1	20
70-74	-	-	-	1	-		1
Total	**0**	**15**	**21**	**88**	**18**	**1**	**143**

are arbitrarily combined with males. Data from both seasons and all three fishing zones are combined because there were no apparent differences between them. Ripe fish were observed in all months during which samples were taken, which suggests that spawning occurs year round. These data are presented also in Fig. 4, from which the lengths by which 50% of skipjack reach maturity are estimated to be within the following ranges:

Males	44 - 47 cm
Females	45 - 49 cm

The categorization of maturity stages is somewhat subjective so these estimates must be considered as rough only.

2.1.3 Stomach Contents

A summary of stomach contents from 423 skipjack is given in Table 2.77% of the skipjack examined had empty stomachs. For the remainder, raising the frequency of occurrence of food items by stomach fulness gives the following measures of importance of each major food category to the total diet:

Fish	70.7%
Squid	19.0%
Crustaceans	5.4%
Unidentified	4.9%

It was normally possible to identify fish remains because of their advanced stage of digestion, But, of the wide variety of prey species that were sometimes identifiable, flying fish (Exocetidae) were particularly common, and anchovies (Engraulidae), myctophids (Myctophidae) and file fishes (Monacanthidae) were noticeably abundant on a few occasions. The crustacean component was composed almost entirely of planktonic shrimps, notably euphausiids.

Table 2: Summary of tuna stomach contents

(a) Skipjack

Stomach fullness	*Number of stomachs containing* *Fish*	*Squids*	*Crustaceans*	*Unidentified*	*Total*
0	-				325
1/8	9.5	11.5	4	1	26
1/4	17	8	1	-	26
112	13.5	2	2.5	2	20
3/4	7	0.5	0.5	-	8
Full	13.5	3.5	-	1	18
Total					423
Percent contribution	70.7%	19.0%	5.4%.	4.9%	100%

(b) Yellowfin

Stomach fullness	*Number of stomachs containing* *Fish*	*Squids*	*Crustaceans*	*Unidentified*	*Total*
0			-	-	34
1/8	2	3	1	-	6
1/4	2.5	5	1.5		9
1/2	3.3	4.83	0.83		9
3/4	4	1	-		5
Full	1	1			2
Total					65
Percent contribution	49.4%	43.7%	6.9%	0.0%	100%

2.2 Yellowfin Tuna

2.2.1 Length frequency distribution

Length frequency data are summarized in Fig. 5. The catch rate for yellowfin hy tuna longline was about half that achieved by Far Eastern longliners operating in the Indian Ocean in recent years (Suzuki, 1988). This may be due to chance, regional differences or the inadequate bait used during the survey. The gillnet and trolling lines tended to catch smaller surface swimming fish (average weight = 4.5 kg) while the longline caught larger deep swimming fish (average weight = 36.4 kg). The mean lengths of yellowfin caught by the different gears were :

Trolling line	50.3 cm	(SD = 2.5. n = 8)
Gillnet	58.2 cm	(SD = 15.1, n = 97)
Longline	127.5 cm	(SD = 22.8, n = 6)

2.2.2 Gonad maturity

Gonad sampling was done but almost all the yellowfin opened were immature.

2.2.3 Stomach Contents

A summary of stomach contents from 65 yellowfin is given in Table 2. Three major food categories contributed to the diet in the following proportions' :

Fish	49.4%
Squid	43.7%
'Shrimps'	6.9%

Fish remains were not normally identifiable, but in addition to flying fish, small tunas appeared to be a significant component of the diet. Squid formed a much more important component of the diet of yellowfin than skipjack (44% v. 19%). 52% of yellowfin sampled had empty stomachs, compared with 77% of skipjack. perhaps indicating more nocturnal feeding or slower gastric evacuation rates.

2.3 Bigeye Tuna

A single bigeye tuna, *Thunnus obesus,* was caught by shark longline in December 1987. It was a maturing (Stage II) male of 115 cm FL, weighing 29.0 kg. During the course of gut and gonad sampling during the SW season a note was made of liver morphology in order to distinguish juvenile yellowfin and bigeye. After some initial confusion over the pyloric caecae. all the fish sampled (n = 22) proved to be yellowfin.

2.4 Silky sharks

Nearly 70% of the sharks caught (by number) were silky sharks, *Carcharhinus falciformis.* The length frequency distribution of silky shark catches, by fishing gear and sex, is given in Fig.6. A distinctly bimodal distribution is apparent, with a relative scarcity of silky sharks of about 130-l 70cm TL. Since silky sharks weie caught fairly efficiently by both gillnet and longline it seems unlikely that this is due to gear selection. Size segregation as a result of differential migration may be involved.

In all size classes below 160cm TL more silky sharks were caught by gillnet than longline; for sizes larger than 160cm TL the opposite is true. The mean length of silky sharks caught by gillnet was 142cm TL and by longline 191cm TL. The mean length of silky sharks caught at different depths are listed below :

2-14.5m	(Gillnet)	142cm TL (n = 119)
23-30 m	(Shark longline Hooks l&S)	181cm TL (n = 46)
33-48 m	(Shark longline Hooks 2&4)	190cm TL (n = 37)
38-54 m	(Shark longline Hook 3)	212cm TL (n = 20)

There appears to be a clear increase in size with depth, but there is considerable variability associated with these mean length estimates. Because the length frequency distribution of the catch is not normal, it is difficult to quantify this variability ; it is, however, large. Only four silky sharks were recorded as being caught by tuna longline. The overall catch rate by shark longline is estimated at

2.9 silky sharks per 100 hooks, while that by tuna longline is only 0.3 per 100 hooks. This may be due as much to differences in the bait used as to the vertical distribution of silky sharks (thcrc are no significant differences in catch rates between hooks at different depths on the shark longline). The mean catch rate for the gillnet is estimated at 3.6 silky sharks per complete set.

The three smallest silky sharks (a 56 cm male, a 57 cm female and a 59 cm male) were all caught by gillnet in December 1987, 30 miles east of Male (Cruise 4). This is smaller than the sizes at birth quoted by most authorities, i.e. 70-87 cm (Compagno 1984; Randall 1986). It is possible that data on this one cruise were recorded incorrectly. However, the next smallest individual measured, a female of 63cm TL taken by gillnet in November 1988 30 miles cast of Lh.Atoll (Cruise 24). was definitely measured accurately.

From this limited data it appears that size at birth in this ocean may be smaller than in others, and that there may be a peak in November to December. More small silky sharks were caught during the NE monsoon (69% of silkys were less than 160 cm) than during the SW monsoon (19% less than 160 cm), and this is reflected in higher catch rates by gillnets in the NE season. The mean length of silky sharks caught during the NE season was 133 cm TL. while during the SW season it was 193 cm TL. There is no evidence of significant differences in the sizes of silky sharks caught in different areas. Catch rates were over three time's higher off the northern and central parts of the Maldives compared to the southern fishing area. This is a highly significant departure from random expectations (catch number chi squared = 26.9; df = 1; $p < 0.01$). Despite the low catch estimates achieved while fishing in the southern zone during the southwest season, the catch rate for the southwest season as a whole was actually marginally greater than that of the northeast season (5.3 silkies per day v.4.5). The reason for this was that the catch rate in the northern and central regions was higher. in the southwest season than the northeast (7.7 silkies per day v.4.5). This difference is significant (catch number chi square = 15.9; df = 1; $p < 0.01$). Note that these tests for significance in differences in catches between strata depend on an assumption that the silky sharks are distributed randomly within strata. This may not be true. During fishing operations it was sometimes observed that silky sharks catches tended to be clumped, three or four sharks being landed from a relatively short stretch of longline or gillnet.

The overall sex ratio of silky sharks caught by Matha Hari was 0.42 females: 0.58 ± 0.06 males (n = 234). This pattern was observed in both the NE and SW monsoon seasons. Sivasubramaniam (1969) also noted an excess of males in longline catches of C. falciformis for the north-central Indian Ocean.

A length weight relationship for silky sharks is illustrated in Fig.7. A total of 208 length-weight measurements were available but 5 were excluded from the analysis as outliers, leaving a total of 203 measurements for which the following relationship is estimated :

$$W = 8.174 * 10^{-6} L^{2.914} \quad (r^2 = 0.98)$$

There may be a slight bias in this relationship, as a result of a tendency to overestimate the weight of small sharks (those of less than 10 kg were weighed on board the frequently rocking vessel) and to overestimate the length of big sharks (those over 1 metre in length were measured by tape, not board). Nevertheless it is probably a reasonable working relationship. A notable feature is that 'fat' silky sharks are commonly as much as 40% heavier than 'thin' silky sharks of the same length.

20 silky sharks were examined for stomach contents. Most were empty or contained only bait. The major components were the remains of fish and squid. Some pelagic crabs and Spirula shells were also recorded.

2.5 Oceanic white-tip sharks

The oceanic white-tip, Carcharhinus longimanus, was the second most common shark species caught, after the silky shark. Oceanic white-tips accounted for some 23% of shark catches by number. Most were taken by longline. This is in contrast to the silky sharks, an equal number of which was caught by longline and gillnet. Possible explanations for this difference include the following : oceanic white-tip sharks may be more readily attracted to baits than silky sharks; with their more leisurely swimming style oceanic white-tips may be less likely to blunder into gillnets than silkies; there may be differences in depth distribution between the two species. Far more oceanic white-tips were taken by handline than any other species; individuals would quite frequently approach and slowly circle the vessel while it was drifting, by day or night, and they were then not too difficult to catch if good bait was available. In this respect they seem much more curious or loss cautious than the more common silky sharks.

Length frequency distributions by fishing gear and sex are presented in Fig.8. The length frequency distribution is roughly normal, with the modal length of about 160cm TL. The smallest individual measured was a 74 cm male, the largest a 263 cm female. Although all size classes are represented in both gillnet and longline catches there is some indication of vertical size segregation.

The mean lengths of oceanic white-tips caught by different gears are listed below in order of increasing mean depth of operation :

0-10m	(Handline)	149 cm TL (S.D. 27. n = Y)
2-14.5m	(Gillnet)	152 cm TL (S.D. 57, n = 13)
23-54m	(Shark longline)	165 cm TL (S.D. 47, n = 47)
65-101m	(Tuna longline)	186 cm TL (S.D. 46, n = 8)

While there is considerable variability in the data, there is a clear suggestion that larger sharks tend to be found deeper than small ones, on average. This possibility is further suggested by data from shark longline catches. Sharks caught on deeper hooks tend to be larger:

Hooks nos. 1 & 5	(depth 23-30m)	. 151 cm TL (S.D.28, n = 18)
Hooks nos.2 & 4	(depth 33-48m)	155 cm TL (S.D.52, n = 18)
Hooks no.3	(depth 38-54m)	204 cm TL (S.D.47, n = 11)

The overall sex ratio was 0.42 ± 0.11 males: 0.58 ± 0.11 females (n = 74). The excess of females was most noticeable within the length range 110-179 cm TL. Within this range the sex ratio was 0.29 ± 0.14 males: 0.71 ± 0.14 females, a signficant departure from 0.5 : 0.5

Available length and weight data are summarised in Fig.7. From this data (n = 65) the following length-weight relationship is estimated:

$$W = 1.822 * 10^{-5} L^{2.780} \quad (r^2 = 0.98)$$

2.6 Blue Sharks

The blue shark, *Prionace glauca*, was the third most abundant species, constituting nearly 5% of the total shark catch by numbers. A total of 17 blue sharks was caught, of which 16 were males - a clear indication of sexual segregation. Compagno (1984) noted that in the Atlantic, female blue sharks are more abundant than males at higher latitudes. Blue sharks are the most widespread of all sharks, being found from cool temperate to equatorial waters. But they are less abundant in the equatorial than other areas of their range. Sivasubramaniam (1969) noted that the blue shark formed only about 10% of the total shark catch in the Indian Ocean between 10º N-10º S but over 50% of the catch south of 20º S. Compagno (1984) suggests that blue sharks prefer relatively cool waters, and exhibit tropical submergence to avoid high surface temperatures. No blue sharks were caught by the relatively shallow gillnet. However, more (8 out of 17) were taken by the shallowest hooks of the longline than the deeper ones. The fact that the only female caught was taken by a deep hook (tuna longline hook 3, depth about 86-101m) suggests the possibility that sexual segregation could have vertical as well as horizontal components.

All the blue sharks caught were relatively large. The length frequency distribution is summarised in Fig.5. Of 17 specimens the mean total length was 244 cm (range 219-273 cm). Of 9 specimens weighed the mean weight was 46 kg (range 31 kg at 220 cm (female) to 56 kg at 273 cm).

There was no difference in catch rates between seasons, and differences in catches between areas are too small to warrant discussion.

2.7 Other sharks

Silvertip sharks, *Carcharhinus albimarginatus*, were only caught during the northeast monsoon season. There was some confusion in the recording of catches of this species since one of its local names (ainu miyaru means schooling shark) is shared with the silky shark. However, it seems that six specimens were caught, mainly by longline. All were large, between 205 cm and 233 cm in total length.

Four tiger sharks *Galeocerdo cuvier* were caught, all by longline in the northern fishing area. One of these was taken on cruise 11 in March 1988, during which biological data were not properly recorded and most sharks were not identified to species; it is therefore not recorded. They were a male of 300 cm TL. two females of 210 cm and 287 cm TLm and one of unknown sex and size. Three were taken in the northeast season. the other in the southwest season.

A single shortfin mako, *Isurus oxyrinchus*, was caught. It was a 150 cm TL female weighing 22 kg. It was caught by longline in the northern fishing area during the northeast monsoon.

In addition to these species taken during offshore fishing operations, juveniles of three other sharks were taken by night handlining while *Matha Hari* was moored inside the atolls between trips. These were the grey reef shark, *Carcharhinus amblyrhynchos*, the spottail shark, *Carcharhinus sorrah* , and the scalloped hammerhead, *Sphyrna lewini*.

2.8 Swordfish

Roughly 80% of the billfish caught was swordfish (Table 3). A total of 52 swordfish was recorded. Four were no more than heads, left after being eaten by sharks. These are not included in estimates of catch or catch rates. There were four billfish not recorded to species (Table 3). These were almost certainly swordfish and are included as such in the following estimates of catch rates.

The mean catch rate by gillnet was 0.29 swordfish per complete set (n = 12). For shark longline the mean catch rate was 0.64 swordfish per 100 hooks (n = 30) and for tuna longline it was 0.72 per 100 hooks (n = 9). There were some differences in estimates of catch rates in different seasons and areas, but these are not significant. The annual average catch rate was 1.14 swordfish per night.

The length frequency distribution of the swordfish catch is illustrated in Fig.9. All billfish were measured from the tip of the lower bill to the fork, a measurement known as body length (BL). The smallest individual measured was 45 cm BL, the largest 201 cm BL. There was a large proportion of juvenile swordfish in the catch. The median length was only 97 cm BL. There was no obvious pattern to the occurrence of juveniles, with small swordfish being caught in both seasons and all three fishing areas. The estimated mean lengths and weights of swordfish caught by different gears were :

Gillnet (n = 9) Mean BL 12Ocm (SD = 39) Mean W = 24.8kg (SD = 25.2)
Shark (n = 26) Mean BL = 97cm (SD = 21) Mean W = 10.8kg (SD = 8.5) longline
Tuna (n = 8) Mean BL = 87cm (SD = 21) Mean W = 7.7 kg (SD = 4.1) longline
All (n = 37) Mean BL = 96cm (SD = 23) Mean W = 10.8kg (SD = 9.0) longline
All (n = 47) Mean BL = 100cm (SD = 28) Mean W = 13.3kg (SD = 14.8) gear

Although there appears to be a tendency for larger swordfish to be caught on shallower gears, these differences are not signficiant. Indeed further analysis of shark longline catches shows that larger swordfish tended to be caught on deeper hooks; the differences are again not significant. It is concluded that there is no evidence of vertical size segregation within the depth range fished.

Table 3: Summary of billfish catches

	Gillner	*Longline*	*Handline*	*Total*
Swordfish	10	41	1	52
Sailfish	4	1		5
Black Marlin	-	1	-	1
Blue Marlin	4	-	-	4
Unknown Marlin	1		-	1
Unknown Billfish	3	1	-	4
Total	22	44	1	67

Note: These records are of total billfish catches and include four swordfish (one taken by gillnet and 3 by longline) of which only the heads were left following attacks by sharks. There is therefore a difference between the total in this Table and Table 4, which records only catches of useable fish.

Available length and weight data (n = 33) arc summarized in Fig.9. The following length-weight relationship for swordfish within the range 50-130cm BL is estimated.

$W = 5.316 * 10^{-6} L^{3.138}$

In all 16 swordfish were cut open for stomach content and gonad analyxis. Nine (56%) were empty or contained only longline bait. The rest contained an estimated 70% fish, 26% squid and 4% 'shrimp'. It was not possible to reliably sex or stage the gonads of the majority of the swordfish examined.

2.9 Sailfish

The five sailfish caught did not vary much in size - from 195-217 cm BL (mean = 210 cm BL) and 3232 kg in weight (mean = 37 kg). This is within the size range of sailfish normally landed at Male market by inshore fishermen (Anderson and Hafiz, 1986). Sailfish is considered to be more coastal in habitat than other billfishes (Nakamura. 1985). The relatively small contribution of sailfish to the total billfish catch (about 7%. see Table 16) during the offshore fishing survey compared to their contribution to inshore billfish catches landed at Male market (over 90%; Anderson and Hafiz, 1986) support this view.

Sailfish were represented in catches by gillnet and longline, from northern and southern fishing zones. and at 'inshore' and 'offshore' fishing stations.

3.0 Marlins

A total of six marlins were caught. One was a black marlin of 226 cm BL, four were blue marlins of 193-207cm BL (mean = 200cm) and 63-73 kg in weight (mean = 67kg). One marlin of 230 cm BL was not identified to species. The blue marlins were all caught by gillnet at two consecutive fishing stations (16/4 and 71/l) east of Laamu Atoll, in mid-August.

3.1 Other Species

The size range of the undamaged 13 individuals of rainbow runners was 43-93 cm FL (mean = 71 cm, SD = 16). Using data from these fishes plus additional data from Male, the following length-weight relationship for rainbow runner within the range 30-95 cm FL is estimated :

$$W = 3.714 * 10^{5} L^{2.691} \quad (r^2 = 0.99;\ n = 57)$$

Fourteen dolphinfish were caught. These were taken by the widest variety of gears of any species: trolling line, handline, longline and gillnet. Two individuals caught by longline were bitten by sharks leaving just the heads. The length range of the remaining 12 was 38-121 cm FL (mean = 84 cm, SD = 25). Using additional data from Male the following length-weight relationship for dolphinfish within the range 38-140 cm FL is estimated :

$$W = 4.992 * 10^{-6} L^{3.077} \quad (r^2 = 0.94;\ n = 18)$$

Eight little tunas of size range 36-51 cm FL were caught by trolling line and gillnet. All were taken during the SW monsoon season. Eight frigate tunas of 1742 cm FL were caught by trolling line and gillnet. Two had been damaged by other fish. A single dogtooth tuna of 77 cm FL was caught by trolling line. This fish, as well as most of the others taken by trolling line, was caught close to an atoll, not out in the open ocean.

The fishes of no commercial value caught during offshore fishing operations were:

Pilotfish	*Naucrates ductor*	(F.Carangidae)
Little dolphin fish	*Coryphaena* equiselis	(F.Coryphaenidae)
Driftfish	Psenes cyanophrys	(F.Nomeidae)
Manta ray	*Manta hirostris*	(F.Mobulidae)
Manta ray	*Mobula diaholus*	(F.Mobulidae)
Snake mackerel	Gempylus *serpens*	(F.Gempylidae)
Escolar	Lepidocybium flavobrunneum	(F.Gempylidae)
Oilfish	Ruvettus *pretiosus*	(F.Gempylidae)
Tripletail	*Lobotes surinamensis*	(F.Lobotidae)
Ocean trigger	*Canthidermis* maculatus	(F.Balistidae)
Snipe eel	Nemichthys sp.	(F.Nemichthyidae)

Relatively large numbers of pilotfish and little dolphinfish were caught by gillnet. Length frequency distributions are summarized in Fig. 10.

A total of six-manta rays were caught, all by gillnet. Three were identified as *Manta birostris* (1.5-4m across) and one as *Mobula diabolus* (195 cm across). As there is no local market for mantas all were discarded, and are therefore not included in the catch summary.

Two Olive Ridley turtles *Lepidochelys olivacea* (35cm and 55cm carapace length) and one leather-back turtle *Dermochelys coriacea* (120 cm carapace length) were caught and put back in the sea. A single dolphin (species unknown) was entangled in the gillnet and used for longline bait.

Although not taken directly by any gear, flying fish and small squid appear to be very abundant in the study area. Not only did they occur regularly in tuna and shark stomach contents, but they were also attracted in substantial numbers by the lights of the boat while it was drifting at night. While they may be of little direct commercial interest (except perhaps as bait) they undoubtedly form a major component of the near-surface oceanic food web.

4. SEA SURFACE TEMPERATURES

The temperature of the surface water was recorded at 10 stations in the southern zone in August (mean = 29.5” C,. SD = 0.33) and 13 stations in the northern zone in October and November (mean = 30.2” C, SD = 0.79). For all 23 stations the mean sea surface temperature was 29.9” C (SD = 0.71).

5. REFERENCES

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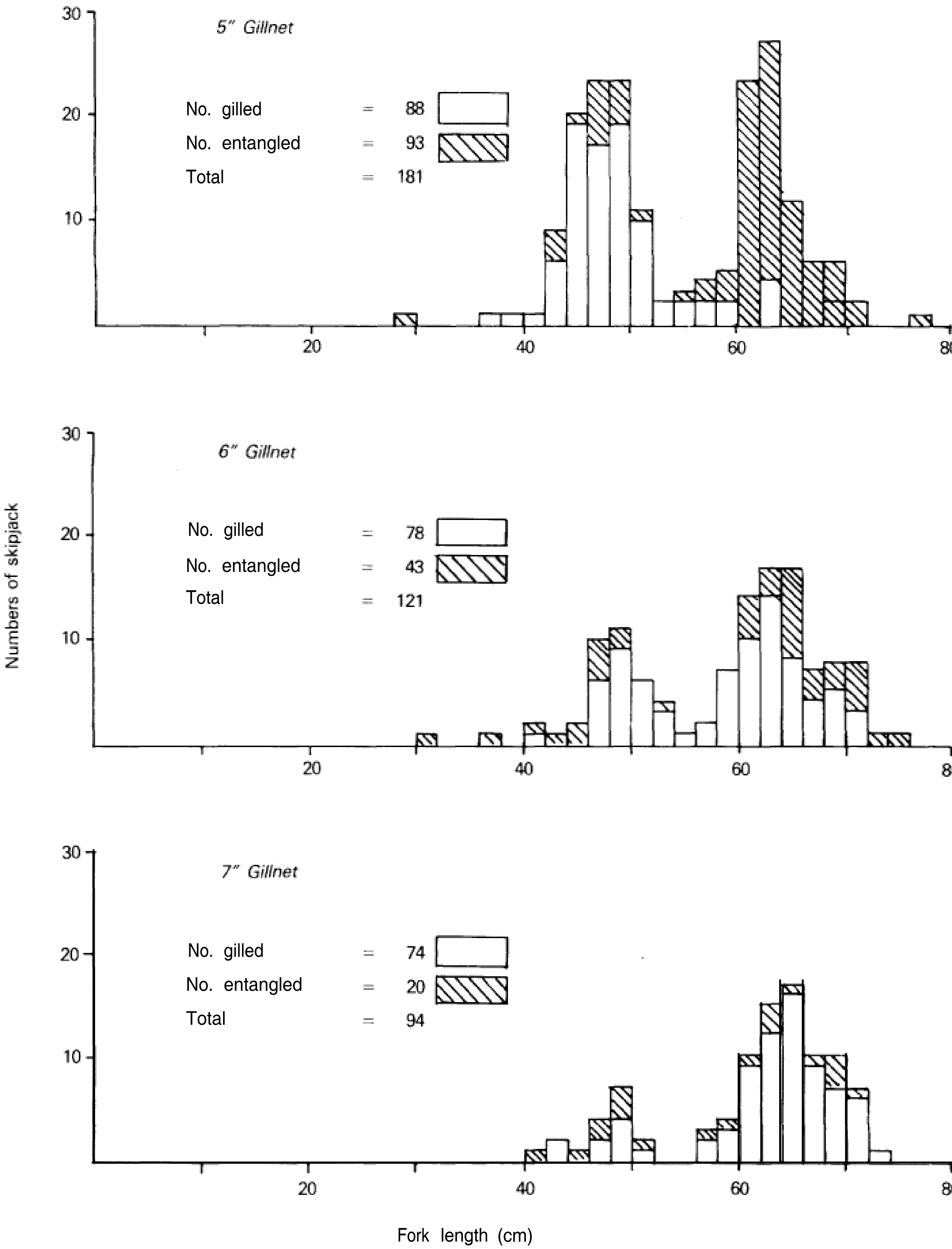


Fig. **1(a)** **Length frequency distributions of skipjack caught by gilinets of different mesh sizes, Dec. '87 to April '88**

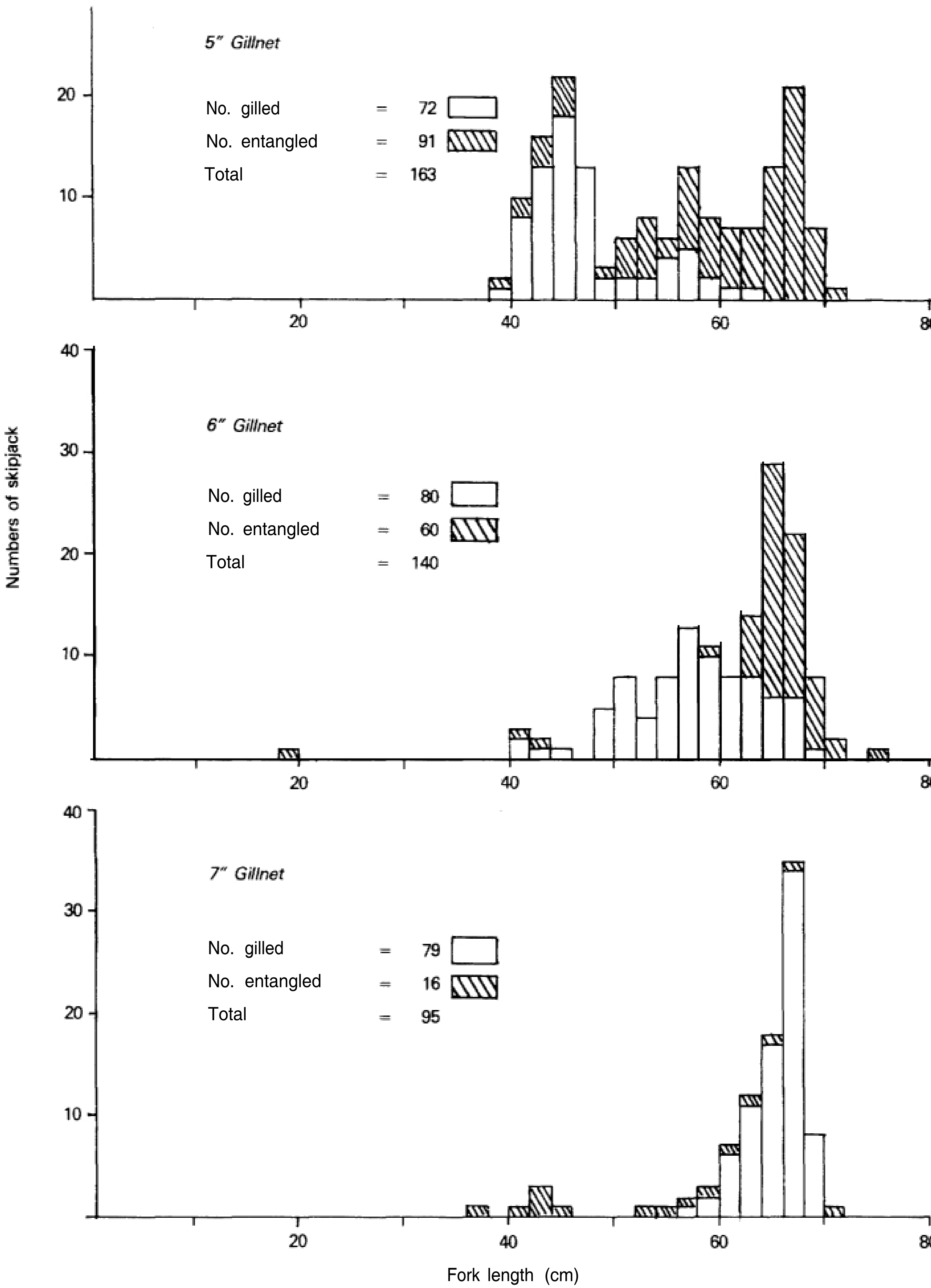


Fig. 1(b) Length frequency distributions of skipjack caught by gilinets of different mesh sizes, July - Nov. 1988

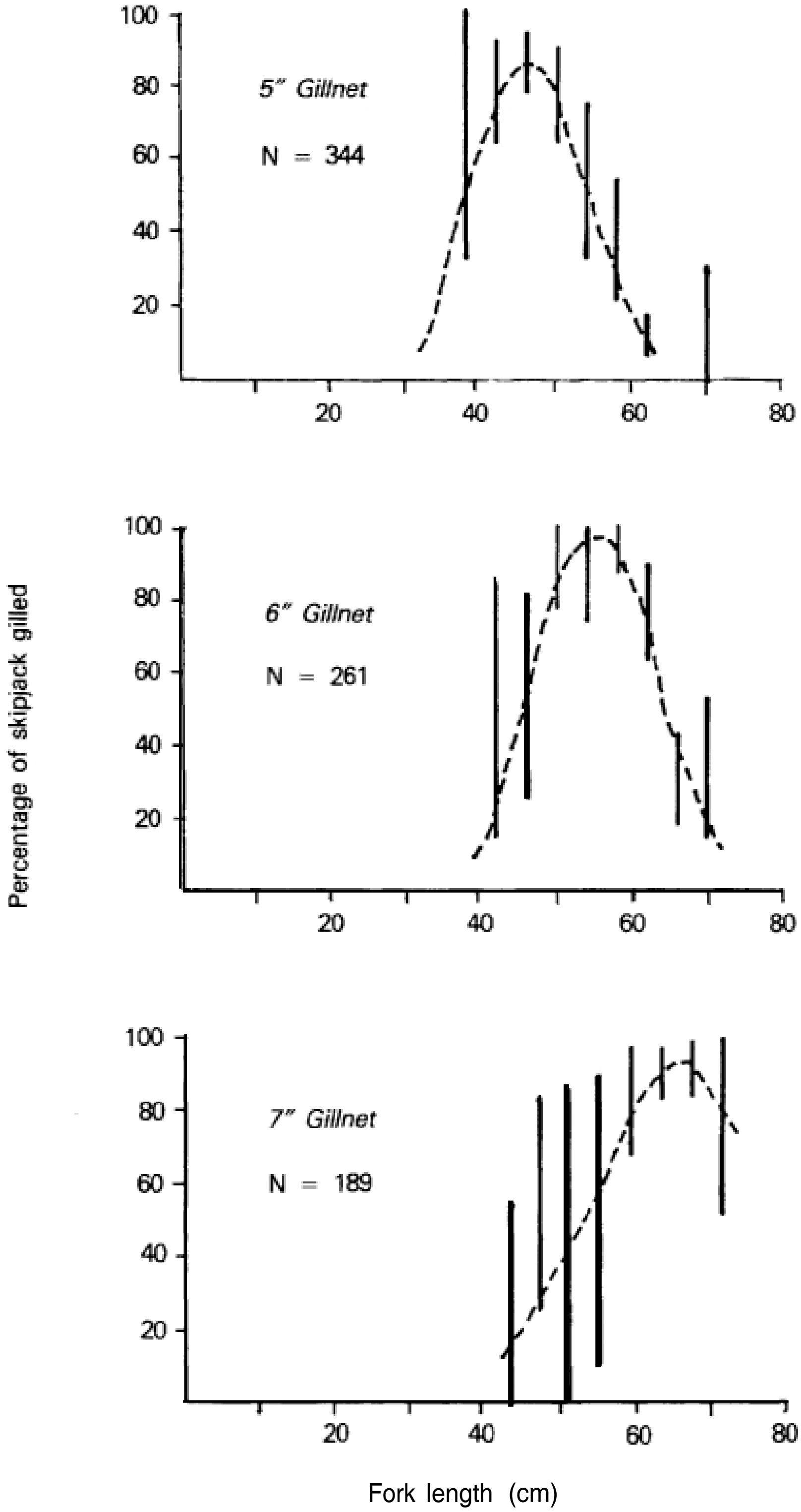


Fig. 2 Proportions of different sizes of skipjack gilled by gilinets of three different mesh sizes

Vertical bars represent approximate 95% confidence intervals

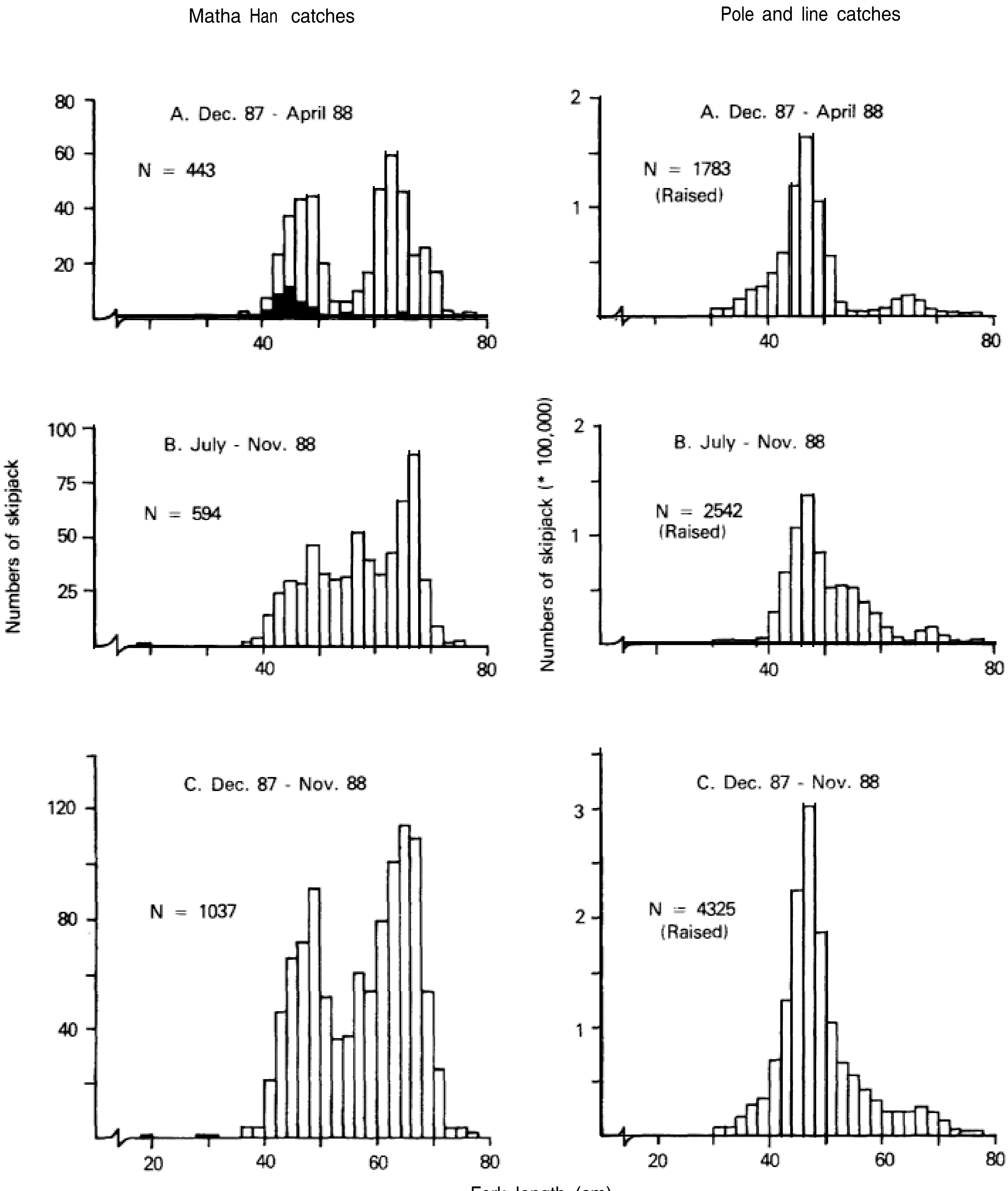


Fig. 3 Comparisons of length frequency distributions of skipjack catches by

'Matha Hari and pole and line vessels landing at Male.

Shaded areas denote catches by 'Matha Hari by gears other than gillnet

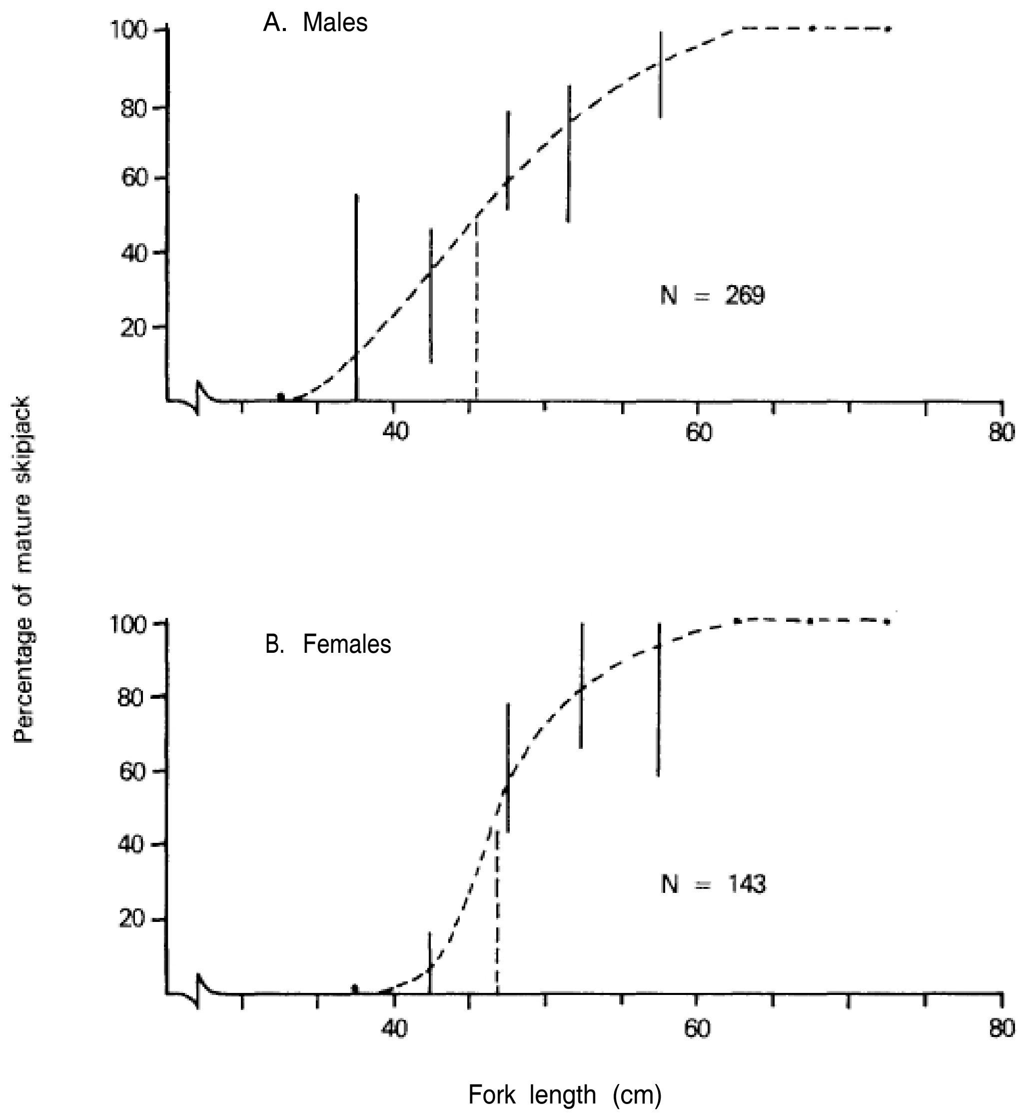
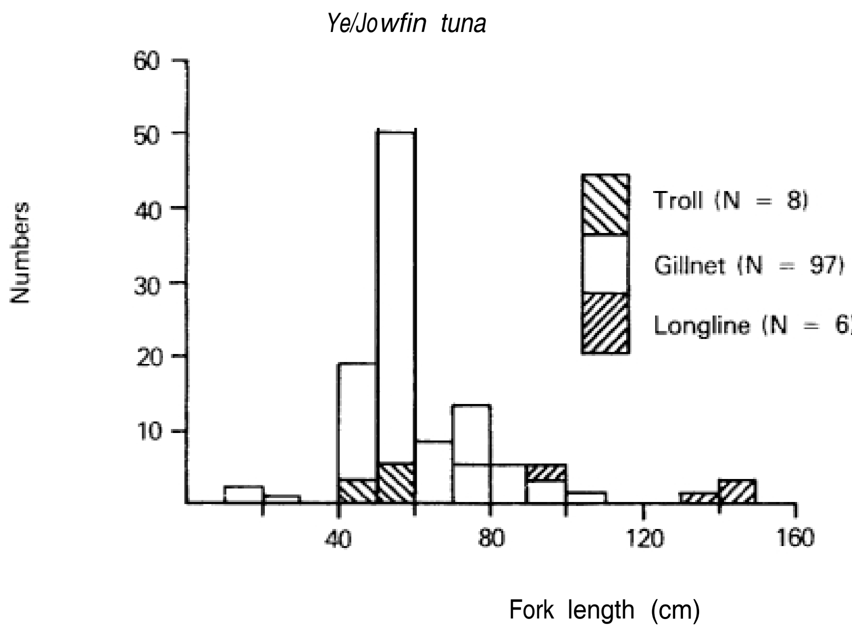


Fig. 4 Proportions of skipjack catch of different length classes that had reached maturity

Vertical bars represent approximate 95% confidence intervals



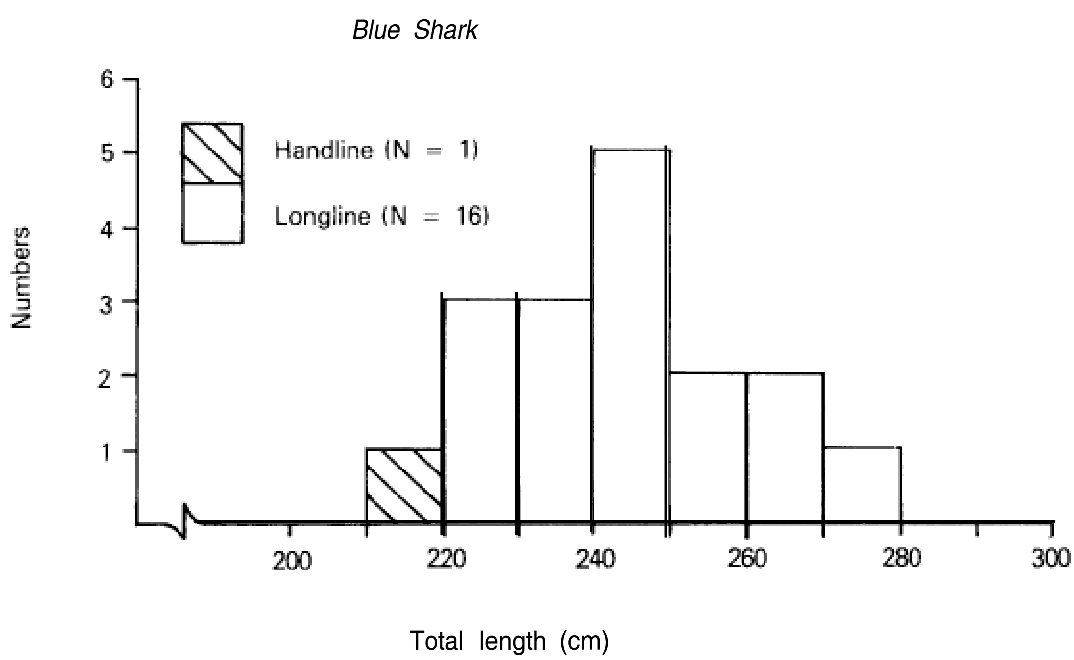


Fig. 5 Length frequency distributions of yellowfin tuna and blue shark catches

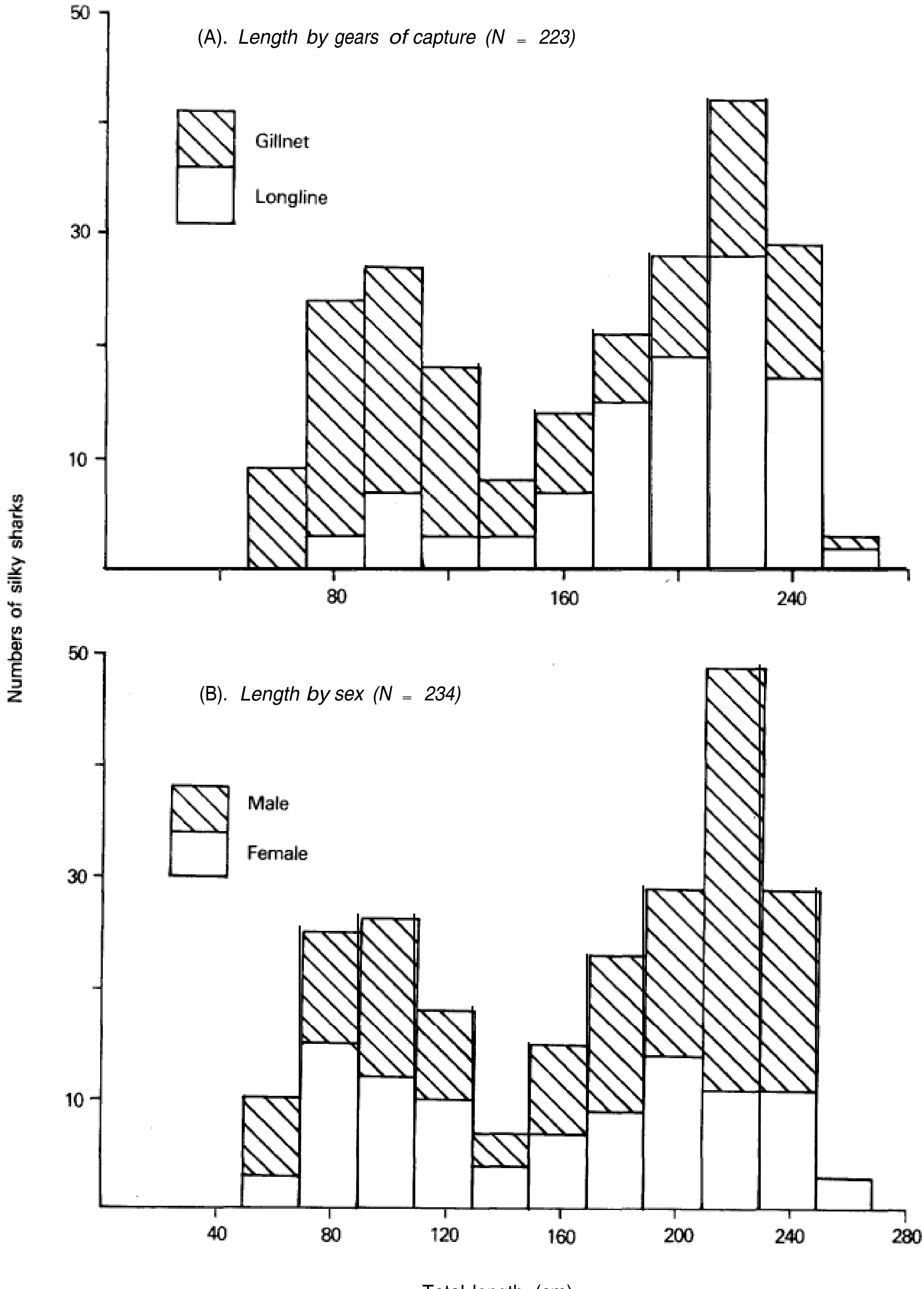


Fig. 6 Length frequency distribution of silky shark catches

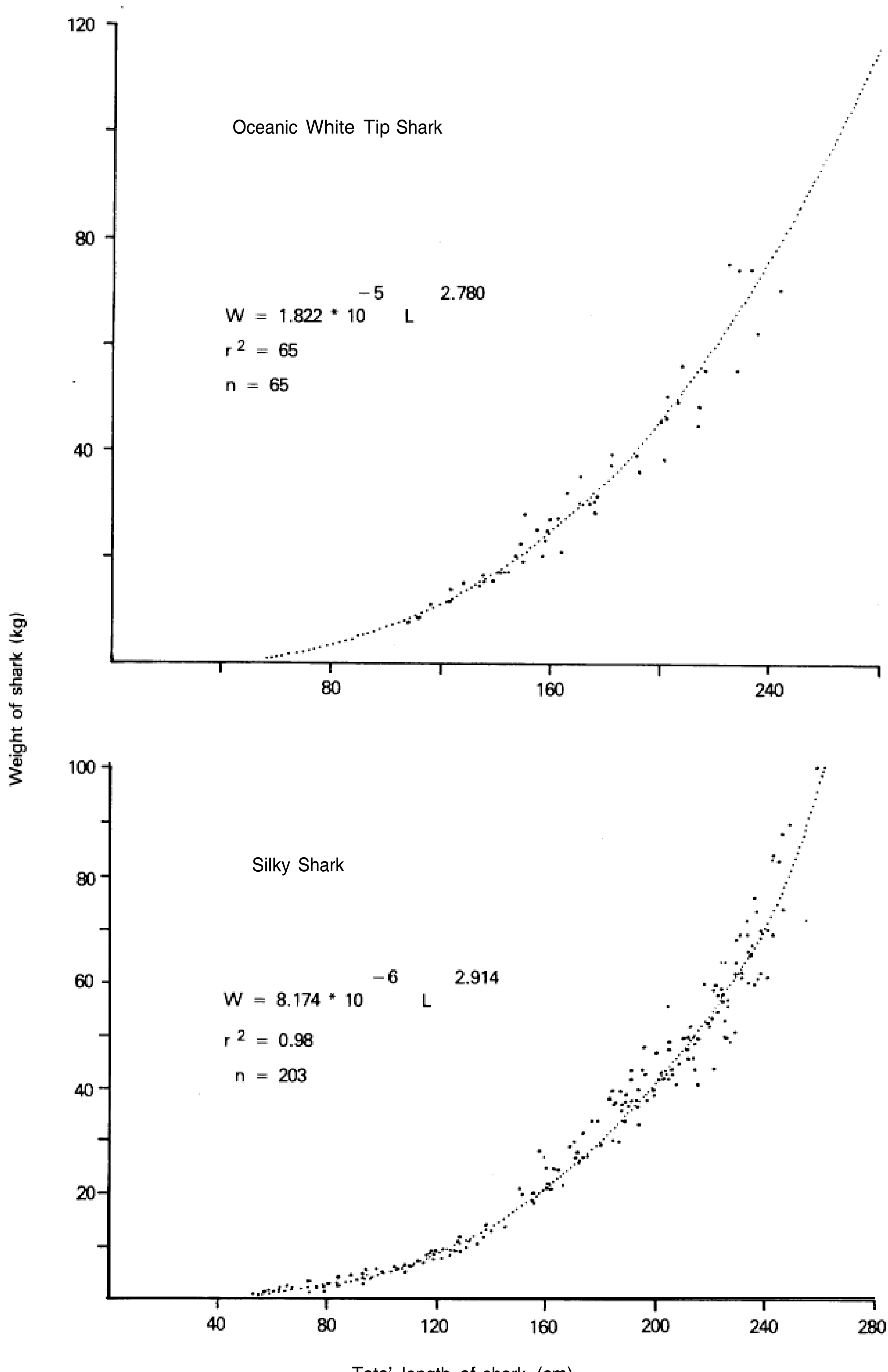


Fig. 7 Length-weight relationships for two shark species

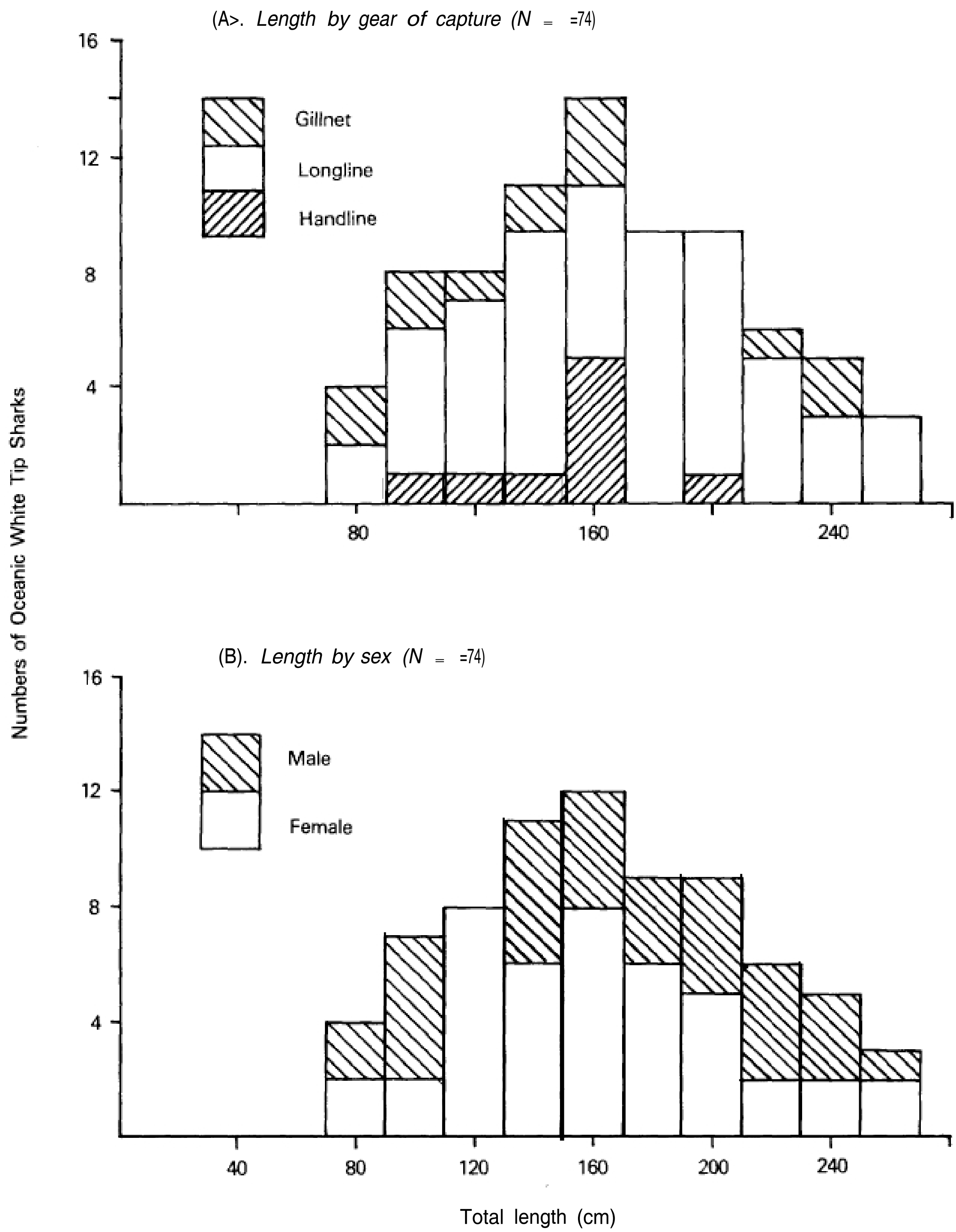


Fig. 8 Length frequency distribution of Oceanic White Tip Shark catches

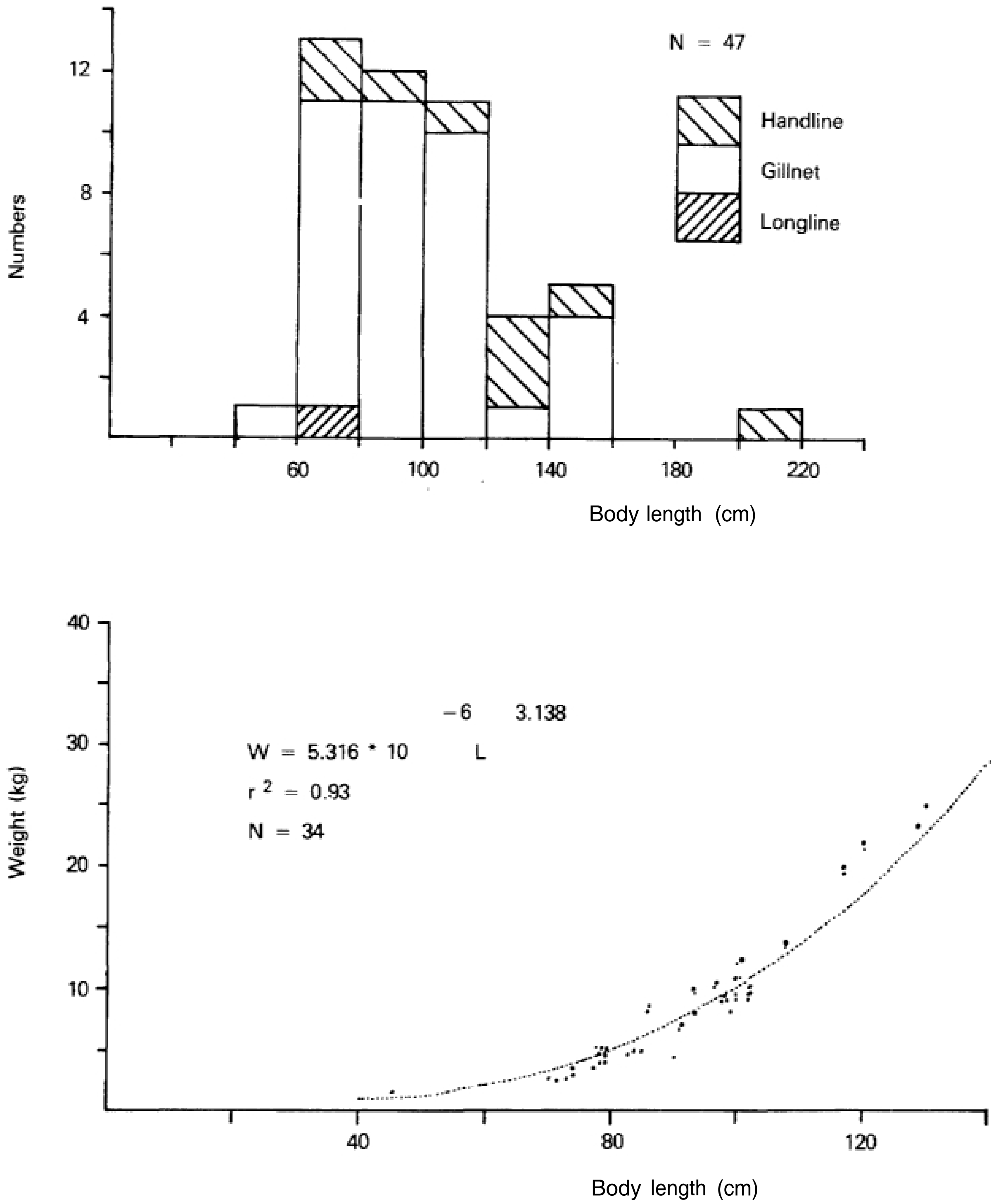


Fig. 9 Length-frequency distribution and length-weight relationship of swordfish catches.

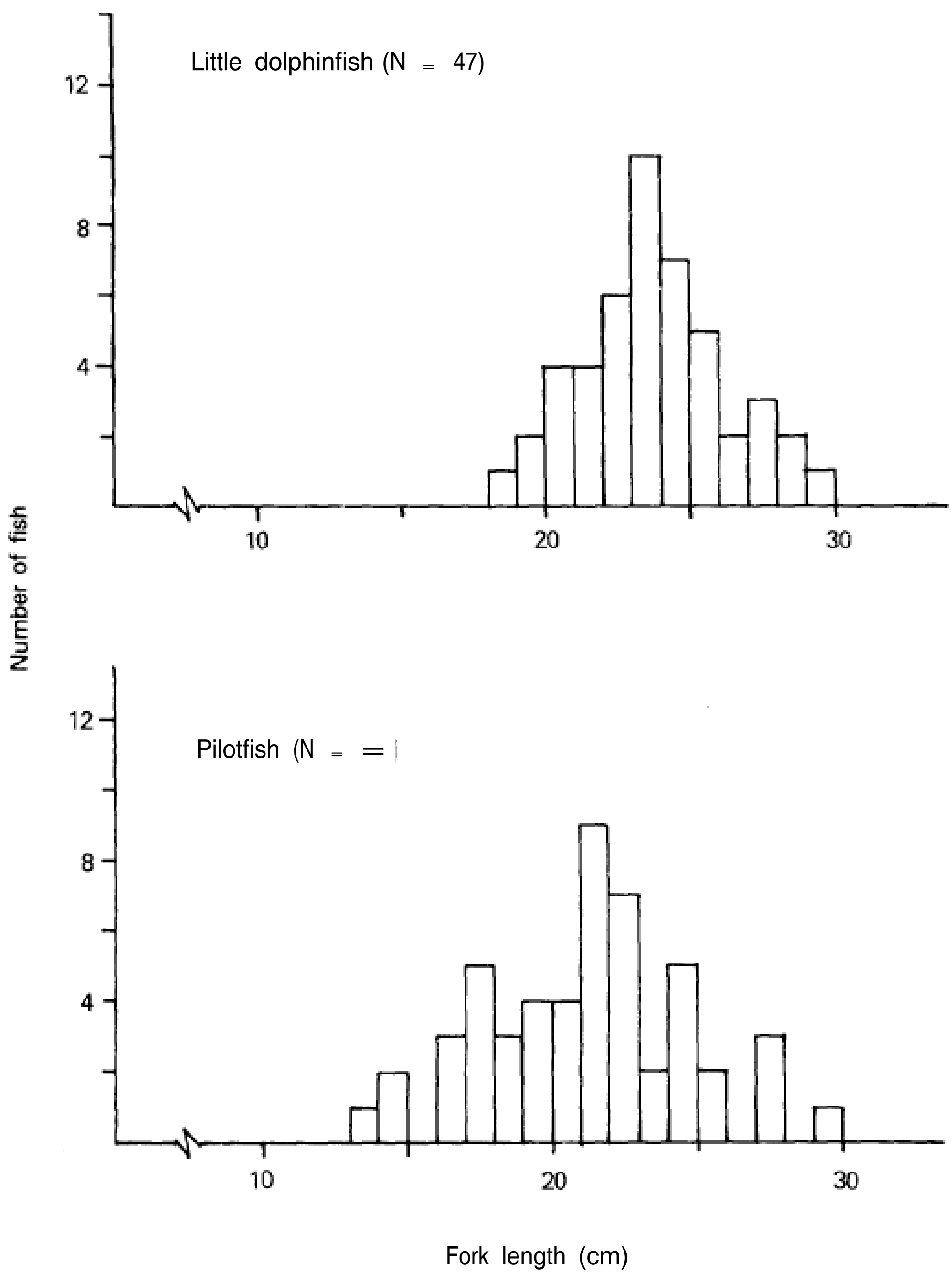


Fig. 10 Length frequency distributions of two species taken as 'by-catch' by the gilinet