FURTHER NOTES ON THE BIOLOGY OF EAST AFRICAN PELAGIC FISHES OF THE FAMILIES CARANGIDAE AND SPHYRAENIDAE

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In a previous paper (Williams, 1956) reporting on the 1951-1954 preliminary survey of the pelagic fishes of the area, the biology of these fishes was but briefly discussed. For various reasons detailed biological work on those species of economic importance did not take place. However, from 1954 to 1960, further routine observations were made on all catches of pelagic fishes taken during cruises of R.V. *Research* and later R.V. *Manihine*. Even after nine years' work the number of specimens of even the commonest species, was still very small and only limited information on the biology of the species was forthcoming.

Additional biological notes on certain Scombridae were given in Williams (1962) whilst those for the genus *Caranx* (Pisces, Carangidae) and the genus *Sphyræna* (Pisces, Sphyrænidae) are given in this paper. It is intended that these notes will amplify those of Williams (1956) and act as a base line for any detailed biological investigations on these important pelagic fishes which may be required in the future. Too often in the past such limited data have not been presented but filed away and lost.

It is indeed unfortunate that in this relatively unexploited and under-developed area of the Indian Ocean reliable fisheries statistics for even the commonest and most commercially valuable species, be they pelagic or demersal, are negligible.

For the purpose of this paper it has been considered that in the coastal waters between latitude 1° S. and 10° S. there is only one stock of each of the species of the genera *Caranx* and *Sphyræna* discussed in these notes. Reasons leading to this assumption are as follows: first, there appear to be no morphometric signs of subspeciation or racial differences in the specimens of the species examined from all parts of the area. Secondly, from the physico-chemical uniformity of the surface water mass—the East

African Coastal Current—present in the area at any one time of the year (Newell, 1957; 1959). In addition, pelagic fishes taken by E.A.M.F.R.O. research vessels have been considered representative samples, being caught by much the same gear and methods, and in roughly the same distributional and frequency patterns, as commercial catches made by local fishermen in the same areas in the years in question (personal observations).

Gonad Maturity States

The descriptions of the gonad maturity states used in the field for the genera *Caranx* and *Sphyræna* are as follows:—

MALES		
STAGE		
I	IMMATURE	Testes small, threadlike no sperm.
II	MATURE UNRIPE	Testes moderate, sperm extruded on cutting and squeezing.
III	MATURE RIPE	Testes enlarged, lobate, sperm extruded on cutting.
IV	MATURE RIPE RUNNING	As III above, but sperm extruded with or without pressure to flanks.
V	MATURE SPENT	Testes crinkled and shrunk, little sperm; some residual blood clots.
FEMALES		
STAGE		
I	IMMATURE	Ovaries very small, thread-like translucent.
II	MATURE UNRIPE (or VIRGIN MATURING)	Ovaries small to moderate; eggs microscopic, usually translucent.
III	MATURE RIPENING	Ovaries moderate; eggs visible to naked eye, opaque.
IV	MATURE NEARLY RIPE	Ovaries enlarged and distended; eggs clearly visible, opaque.
V	MATURE RIPE	Ovaries enlarged, distended tunica bursts easily; most eggs transparent.
VI	MATURE RIPE RUNNING	As V above, but nearly all eggs transparent; eggs extruded with or without pressure to flanks.
VII	MATURE SPENT	Ovaries flaccid and shrunk; some residual eggs and many residual blood clots.

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FAMILY CARANGIDAE

The taxonomy of the family was fully discussed in Williams (1958) and notes were also given on distribution and ecology.

Genus *Caranx*, Lacepede

Caranx ignobilis (Forsk.)

Karambesi, Kambesi (Kiswahili).

Occurrence

Between December 1951 and December 1959 some 344 specimens were taken of *C. ignobilis*, the largest of the Indo-Pacific carangids. This species is the most important of the horse mackerels to the native fishermen of East Africa because of its size (grows to 100 lb.) and valuable flesh. Surface trolling is the commonest fishing method used for the species and accounted for the majority of the pelagic fish taken on E.A.M.F.R.O. vessels. Other methods of capture included handlines, gill nets, and underwater spearfishing. Break-down of the catch was as follows:—

Trolling	..	..	322	} Total 344
Handlines	..	..	17	
Gill nets	..	..	2	
Spearfishing	..	..	3	

Small specimens of *C. ignobilis* for taxonomic studies were obtained from beach seine hauls, and also marine fish ponds (at the upper tidal limit of mangrove swamps) on Zanzibar Island. Fig. 1 shows the combined monthly catch rates for the period under review, as well as the average surface temperatures. As reported earlier (Williams 1956) highest catches are made during the N.E. monsoon when the species appears to be more abundant, the sea surface temperature is highest and the weather more suitable for trolling close to the fringing reefs. More than 75 per cent of the catch was taken during the months of November to March.

Length and Weight Distributions; Means and Variances

The normality of the distribution was tested by a χ^2 test on a normal distribution fitted to the grouped data. This showed that the natural data are not normally distributed, whereas the logarithmic data are so distributed. The logarithmic data have therefore been used in the calculations. Means and variance tests on the logarithmic data show the results given in Table I.

TABLE I.—MEANS AND VARIANCE TESTS ON LOGARITHMIC DATA

Difference between Sexes				Significance Level	
				Length	Weight
Mean (t)	..	..	..	N.S.	N.S.
Variance (F)	..	..	..	N.S.	N.S.

There are no significant differences between the sex means.

Length Frequency

In Fig. 2, 2 cm. length frequency groups are plotted for the combined data, a distinction being made between mature and immature fish. A smoothed curve (3 figure moving average) has been applied to the mature population; there is a considerable extension of the right-hand side of the smoothed curve caused by older fish. Modal length of the mature population is 74/75 cm.; however, the combined data show an additional mode at about 54/55 cm. composed of mature and immature fish. There were insufficient numbers of fish to analyse 2 cm. length frequencies on a monthly basis, but an attempt using 5 cm. groups showed that the difference between the two modes shown in Fig. 2 (54/55 cm. and 74/75 cm. almost certainly represents the amount of growth in one year. For the months in which many *C. ignobilis* were taken, modal lengths are as follows:—

January	..	..	75/79 cm.
February	..	..	80/84 cm.
March	..	..	75/79 cm.
November	..	..	70/74 cm.
December	..	..	75/79 cm.

Weight Frequency

An examination of weight frequencies (1 lb. groups) was carried out for the combined data and is shown in Fig. 3. From the smoothed curve two modes are visible at 8/9 lb. and 19/20 lb. The former is composed of immature and mature fish, the latter only of mature fish. These modes correspond with the results of the length frequency data (Fig. 2).

Sex and Maturity

Sex was discernible in 323 fishes, male numbered 216 and females 107, a sex ratio of males to females 2.01:1. This is a highly significant difference, if the normal 1:1 sex ratio is assumed. Hence, as the sampling is

FIGURE 1

Fig. 1—Monthly catches of *Caranx ignobilis* expressed as a percentage of the total catch, December 1951 to December 1959; together with the monthly average sea surface temperature

FIGURE 2

Fig. 2—Length-frequency distribution (2 cm. groups) of the catch of *Caranx ignobilis* December 1951 to December 1959 (smoothed curve from a three figure moving average—immatures excluded)

FIGURE 3

Fig. 3—Weight-frequency distribution (2 lb. groups) of the catch of *Caranx ignobilis* December 1951 to December 1959 (smoothed curve from a three figure moving average—immatures excluded)

considered random, the probable conclusion is that the normal sex ratio for the species is not 1:1, at least for part of the year. This is shown to be correct in a later paragraph, which records shoaling by sexes in the immediate pre-spawning season.

Fig. 2 and 3 show that maturity is reached between 54-61 cm. fork length and 7-11 lb. weight.

TABLE IIIA.—MONTHLY GONAD MATURITY STATES IN *C. ignobilis*

MALES												
Stage	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
I	—	1	4	—	—	—	—	2	1	—	1	3
II	6	1	10	1	1	—	5	2	4	3	3	13
III	23	14	12	—	—	—	4	—	4	4	10	28
IV	33	6	7	—	—	2	—	—	—	—	2	2
V	1	1	—	—	—	—	—	—	1	—	—	1

FEMALES												
Stage	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
I	2	1	2	—	1	—	—	2	—	—	1	2
II	2	2	2	7	—	2	1	—	2	2	—	7
III	8	1	—	1	1	—	2	—	1	2	1	3
IV	5	—	5	—	2	—	1	—	1	4	2	4
V	8	—	4	—	—	—	—	—	1	—	—	2
VI	1	—	—	—	—	—	—	—	—	—	—	1
VII	1	—	4	—	—	—	1	—	—	—	1	1

TABLE IIIB.—MONTHLY NUMBERS OF BREEDING AND SPENT *C. ignobilis*

	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
Total Number of Fish	90	27	50	9	5	4	14	6	15	15	21	67
Ripe and Ripe Running	65	20	23	0	0	2	4	0	5	4	12	23
Spent	2	1	4	0	0	0	1	0	1	0	1	2

Table IIIA records the monthly gonad maturity states whilst IIIB records the monthly number of breeding and spent fish (♂♂ stage III, IV, V and ♀♀ V, VI, VII). These tables show that spawning takes place from July to March with a peak during the N.E. monsoon months, November to March. The lack of ripe and ripe running fish from April to June suggests a definite break in spawning activity during the year. However, further work over a still longer period of time may show this statement to be incorrect, as certainly in several demersal fish species in East Africa spawning can take place at any

time during the year, although there are one or more peaks (Talbot, 1960, Morgans—personal communication).

Testes of *C. ignobilis* were often found in a shrivelled and diseased state but ovaries very rarely so.

Talbot and Williams (1956) reported on a sexual colour difference discovered in mature *C. ignobilis*. Since then sex prediction tests have been carried out on a further 40 fish, over 70 cm. standard length, with almost 100 per cent accuracy.

What were thought to be spawning shoals of *C. ignobilis* were seen at Latham Island (35 miles SE. of Zanzibar Island) on several occasions during the NE. monsoon. These shoals were first encountered whilst trolling at the time of the full moon on 9th January 1955. Thirty-eight fish were taken in the space of a few minutes and the sexual breakdown of the specimens was as follows:—

♂♂	30	Stage III—4	Stage IV—25	Stage V—1
♀♀	8	Stage IV—3	Stage V—3	Stage VI—1

Many of the fish shed large quantities of milt and transparent eggs on deck immediately on landing. Unfortunately for various reasons no attempts were made to effect an artificial fertilization. A further cruise was made at the full moon period 1st-7th March 1955 but few fish were taken trolling although shoals of the species were seen at the surface. The fish caught were all female Stage VI and VII except for one Stage III. Further trolling was undertaken at the full moon period in February and March 1957 but again few fish were caught, those that were all being males, Stage III in February and Stage II in March. On both these cruises large frenzied shoals of the species were again seen at the surface. On these latter cruises in 1955 and 1957 preparations were made to enable artificial fertilization to be carried out but the ripe running fish were all of one sex. Trolling, and indeed any other fishing operations at night in the Latham Island area, are only possible at or near the full moon (except with the use of radar). The finding of shoals of *C. ignobilis* composed almost entirely of one sex suggests segregation in the immediate pre-spawning period.

Food

Of the 322 stomachs of *C. ignobilis* examined, 202 (63 per cent) were empty and 120 (37 per cent) had contents which were subjected to qualitative analysis, the results of which are given in Table IV.

TABLE IV.—QUALITATIVE ANALYSIS OF STOMACH CONTENTS OF 120 *C. ignobilis*

Item	Stomachs in which occurred	% frequency of occurrence
Pisces	(95)	(79.0)
Sauridae	1	0.8
<i>Plotosus anguillaris</i>	1	0.8
<i>Tylosurus</i> sp.	1	0.8
<i>Leiognathus</i> sp.	1	0.8
Carangidae	3	2.5
Callyodontidae	3	2.5
<i>Atherina</i> sp.	1	0.8
<i>Sphyræna</i> sp.	1	0.8
<i>Siganus</i> sp.	1	0.8
Monacanthidae	1	0.8
Tetraodontidae	1	0.8
Unidentified fish remains	80	66.8
Crustacea	(14)	(11.6)
Stomatopod remains	7	5.8
Unidentified crustacean remains	7	5.8
Mollusca—		
Unidentified cephalopod remains	3	2.5
Coral Mush	1	0.8
Weed	1	0.8
Unidentifiable material	6	5

From the analysis it is obvious that the species is primarily a fish eater (either pelagic or demersal), but does take smaller quantities of crustaceans and cephalopods. Some evidence of feeding near the bottom is also shown by the presence of coral mush and weed. The high percentage of empty stomachs is probably due to regurgitation of food at the moment of capture.

Parasites

Three specimens of *C. ignobilis* had nematode parasites in the stomach; five fish had unidentified cysts in the membranes of the body cavity. No external parasites were observed on the species.

Miscellaneous

On four occasions fish or fish remains were found in a dried condition in the membranes of the body cavity surrounded by large quantities of fatty tissue. In one case the "dried" fish was an eel with very sharp teeth. No sign of a scar was visible on the stomach wall nor was the body cavity damaged in any way. Some displacement of organs was noted due to the bulky nature of the "obstruction" and the surrounding fatty tissues.

Caranx elacate (Jordan and Evermann)

Kole-kole (Kiswahili).

Occurrence

One hundred and fourteen specimens of *C. elacate* were taken by E.A.M.F.R.O. vessels between March 1952 and January 1959: 73

were caught on hand lines, 37 by trolling and 4 in gill or trammel nets. The majority of those fish taken by hand lines were caught at night from the anchored research vessel in 10 fm. in the North Mafia area. Shoals of *C. elacate* seemed to be attracted by the mass of small fish, squid, etc., collected under over-side lights. Freshly netted *Atherina* sp. and *Hemirhamphus* sp. on floating nylon lines brought rapid catches of *C. elacate*.

Combined monthly catch rates of *C. elacate* were as follows:—

Month	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
Number	45	3	28	5	1	0	1	3	0	2	24	3

This distribution shows little other than a trend towards higher catches during the NE. monsoon, when the species is also seen in the Zanzibar fish market in small numbers.

Six small specimens of 120-265 mm. standard length were obtained for taxonomic studies from beach seine hauls on Zanzibar Island in April (2), May (2) and October (2).

Length and Weight Distribution, Means and Variances

A Chi² test on a normal distribution fitted to the grouped data, showed that the natural data are not normally distributed, whereas the logarithmic data are so distributed. Means and variance tests on the logarithmic data show the results given in Table V.

TABLE V.—MEANS AND VARIANCES TESTS ON LOGARITHMIC DATA

Difference between Sexes	Significance Level	
	Length	Weight
Means (t)	N.S.	N.S.
Variance (F)	2%	0.7%

There is no significant difference between the average length and weight of the males and females, which are as follows:—

	Average Length	Average Weight
Males	59.7 cm.	7.1 lb.
Females	58.8 cm.	7.2 lb.

However, there is a significant difference between the variances of the lengths of the different sexes, and an indication that a similar difference exists between the weights.

FIGURE 4

Fig. 4—Length-frequency distribution (2 cm. groups) of the catch of *Caranx elacate* March 1952 to January 1959 (smoothed curve from a three figure moving average—immatures excluded)

Length Frequency

Fig. 4 shows the length frequency distribution in 2 cm. groups for the combined data, with mature specimens differentiated from immature ones. The smoothed curve is considerably skewed (to the right) and the modal length 64-65 cm. is very close to the maximum known length of the species which is about 70 cm. This is probably due to the heavy catch of fish from a shoal of like size (55-69 cm.) during one night's fishing in early 1959.

Weight Frequency

Weight frequency distributions show the modal weight to be 8 lb.; the maximum known weight of the species being 12 lb.

Length/Weight Relationship

Length/Weight relationship has been calculated in the usual manner of the regression equation $W=aL^b$ expressed as its logarithmic transformation $\log W=\log a+b \log L$ where W =weight in pounds and L =standard length in centimetres.

The regression equations for males, females and combined data are as follows:—

Males: $\log W=2.3632 \log L-3.3451$

Females: $\log W=2.3755 \log L-3.3578$

Combined: $\log W=2.3721 \log L-3.3557$

There is no significant difference between the regression equations for males and females and thus there is no significant difference in weight of the two sexes at a given length.

FIGURE 5

Fig. 5—Length-weight relationship in *Caranx elacate*. Growth curve fitted from the regression equation (sexes combined) $W = 4.4090 \times 10^{-4} L^{3.3721}$; outer lines indicate the expected range of variation (95 per cent confidence limits)

In Fig. 5 length is plotted against weight for the observed data and the growth curve and 95 per cent confidence limits are drawn in from the natural form of the regression equation for the combined data— $W=4.4090 \times 10^{-4} L^{2.3721}$. The same equation has been used for estimations of weight at given length which are given in Table VI.

TABLE VI.—ESTIMATED WEIGHT OF *C. elacate* AT GIVEN LENGTH

Length in cm.	Weight in lb.	95% Confidence Limits	
		Min. Weight	Max. Weight
35	2.0	1.8	2.3
40	2.8	2.3	3.3
45	3.7	3.0	4.5
50	4.7	3.7	6.0
55	5.9	4.6	7.7
60	7.3	5.5	9.6
65	8.8	6.6	11.8
70	10.5	7.7	14.3

Sex and Maturity

Sex was discernible in 104 specimens; 46 were males and 58 females, a sex ratio of males to females 1:1.24. This is not a significant departure from the expected 1:1 sex ratio—the probability of having 46 males out of 103 fish being 14 per cent.

A sexual colour difference has been observed in *C. elacate* of 54.5–70 cm. standard length. On one cruise in late 1958 and one in early 1959, 44 specimens were taken in the Mafia area. Examination of the fish as a whole showed two distinct colour groups—although the basic colour pattern was that described in Williams (1958). One group appeared to be much darker (more heavily pigmented) on the head and upper body regions than the other. Having due regard to the discovery of a sexual colour difference in *C. ignobilis* (Talbot and Williams, 1956), sex prediction tests were made on the 44 specimens. The tests proved 82 per cent correct, 3 females and 5 males being incorrectly sexed. As with *C. ignobilis* the differences in colour are comparative and prediction on a single specimen is most difficult.

Maturity in *C. elacate* appears to be reached between 40–50 cm. (Fig. 5) at 3–4 lb.

Table VII records monthly gonad maturity states, but little can be deduced from the scattered data. It is interesting to note that except for one male, no ripe, ripe running or spent fish have been taken.

TABLE VII.—MONTHLY GONAD MATURITY STATES IN *C. elacate*

MALES											
Stage	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N. D.
I	—	—	—	—	—	—	—	—	—	—	—
II	—	1	1	—	1	—	1	2	—	4	—
III	24	—	6	—	—	—	—	—	—	5	—
IV	—	—	1	—	—	—	—	—	—	—	—
V	—	—	—	—	—	—	—	—	—	—	—
FEMALES											
Stage	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N. D.
I	1*	—	6*	—	—	—	—	—	—	—	—
II	—	—	1	5	—	—	—	—	—	—	—
III	14	—	5	—	—	—	—	1	—	1	5
IV	5	1	5	—	—	—	—	—	—	10	1
V, VI, VII	—	—	—	—	—	—	—	—	—	—	—

*Sex indeterminate.

Food

The stomachs of all specimens were examined; 50 (44 per cent) were empty and 64 (56 per cent) had contents which were subjected to qualitative analysis with the results given in Table VIII.

TABLE VIII.—QUALITATIVE ANALYSIS OF STOMACH CONTENTS OF 64 *C. elacate*

Item	Stomachs in which occurred	% frequency of occurrence
Pisces	(49)	(76.7)
<i>Holocentrus</i> sp.	1	1.6
<i>Gerres</i> sp.	1	1.6
Chromidae	2	3.1
Atherinidae	1	1.6
<i>Sphyræna</i> sp.	1	1.6
Tetraodontidae	1	1.6
Unidentifiable fish remains	42	65.6
Mollusca—Cephalopoda	(6)	(9.3)
Decapoda	4	6.2
Octopoda	2	3.1
Crustacea	(11)	(17.2)
Penaeidae	6	9.4
Stomatopoda	1	1.6
Pagurid remains	4	6.2
Plankton	1	1.6

C. elacate is predominantly a fish eater (pelagic or coral reef fishes) but also takes cephalopods and crustaceans in fair quantities.

Caranx melampygus (C.V.).

Kole-kole (Kiswahili).

Occurrence

From December 1951 to March 1959, 78 specimens of this species were taken; 53 by trolling, 8 on handlines and 17 by underwater spearfishing. Monthly catches (combined data) are as follows:—

Month	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
Number	22	5	14	3	3	0	2	1	10	2	6	6

Numbers are small but the species appears to be more abundant and more easily caught during the months of the NE. monsoon. The species is never frequent in the Zanzibar fish market and is rarely seen outside this period of the year. The fish taken by the fishing methods mentioned previously were all mature except for one fish caught by trolling. Five juveniles of 136-222 mm. were taken in January (1), April (3), May (1) and June (1) from beach seine hauls and the marine fish ponds on Zanzibar Island and were used in taxonomic investigations.

Length and Weight Distributions: Means and Variances

The number of fish under consideration is so small that there is no evidence to suggest that the natural data is not normal, nor is there any evidence to indicate the log transformation, used for subsequent analysis, "improves" the distribution.

Means and variance tests on the logarithmic data show the results given in Table IX.

TABLE IX.—MEANS AND VARIANCE TESTS ON LOGARITHMIC DATA

Difference between Sexes	Significance Level	
	Length	Weight
Means (t)	0.1%	0.1%
Variances (F)	N.S.	5%

The results show a great probability that there is a real difference between the sexes. The averages are as follows:—

<i>Sex</i>	<i>Average Length</i>	<i>Average Weight</i>
	<i>cm.</i>	<i>lb.</i>
Male	58.3	9.93
Female	50.8	6.65

There is also a strong probability that males were not only bigger on average but that they were more variable in weight than females (though not in length).

Length Frequency

Length frequency distribution in 5 cm. groups for the combined data is shown in Fig. 6, but even with such coarse groups, the 78 specimens yield little information. The modal length is 55/59 cm. whilst the maximum size of the species is thought to be about 70 cm.

FIGURE 6

Fig. 6—Length-frequency distribution (5 cm. groups) of the catch of *Caranx melampygus* December 1951 to March 1959 (smoothed curve from a three figure moving average—immatures excluded)

Weight Frequency

The modal weight of *C. melampygus* was 10 lb.

Length/Weight Relationship

No significant difference was found between the regression equations calculated for the sexes separately. The equation for the combined data is as follows:—

$$\log W = 3.0659 \log L - 4.4393$$

In Fig. 7 weight is plotted against length for the observed data and the growth curve and 95 per cent confidence limits are drawn in from the natural form of the regression equation for the combined data, $W = 3.6366 \times$

distribution differs from the males, then estimation of weight at given length for each sex has the different confidence limits shown in Table XI.

TABLE X.—ESTIMATED WEIGHT OF *C. melampygus* AT GIVEN LENGTH—SEX UNKNOWN

Length cm.	Weight in lb.	95% Confidence Limits	
		Min. Weight	Max. Weight
35	2	1.4	2.9
40	3	2.1	4.3
45	4.3	3.1	6.0
50	5.9	4.3	8.1
55	7.9	5.9	10.6
60	10.3	7.5	14.1
65	13.2	9.5	18.2
70	16.5	11.8	23.2
75	20.4	14.4	29.0

FIG. 7.—Length-weight relationship in *Caranx melampygus*. Growth curve fitted from the regression equation (sexes combined) $W = 3.6366 \times 10^{-5} L^{3.0659}$; outer lines indicate the expected range of variation (95 per cent confidence limits)

$10^{-5} L^{3.0659}$. Estimated weights at given length, together with 95 per cent confidence limits, are given in Table X. However, this table is useful only if the sex of the fish is not known or if one assumes that the differences between males and females (see pp. 15 and 16) is due to a non-random sample (i.e. that the population of *C. melampygus* conforms to a bivariate distribution).

If one accepts, however, that the sampling was random and hence that the female size

TABLE XI.—95% CONFIDENCE LIMITS OF ESTIMATED WEIGHT OF *C. melampygus* AT GIVEN LENGTH—GIVEN SEX

Length cm.	Weight in lb.	95% Confidence Limits			
		Males		Females	
		Min. Weight	Max. Weight	Min. Weight	Max. Weight
35	2	1.4	2.7	1.2	3.2
40	3	2.2	4	1.9	4.7
45	4.3	3.3	5.5	2.7	6.6
50	5.9	4.7	7.5	3.8	9.0
55	7.9	6.4	9.7	5.1	12.3
60	10.3	8.4	12.6	6.5	16.2
65	13.2	10.5	16.5	8.3	20.9
70	16.5	12.9	21.1	10.3	26.6
75	20.4	15.7	26.5	12.6	33.1

Although the females are less variable in weight than the males the confidence limits are much wider than for the males. The reason for this is the appreciably smaller sample of females which gives a large value of *t* for females and less weight to the pooled regression equation thus satisfying the male data better than the female.

Sex and Maturity

Of the 78 fish in which sex was discernible, 47 were males and 28 females, a sex ratio of 1.68:1 males to females. This is a significant departure from the normal 1:1 sex ratio and the probability of obtaining such a high proportion of males, if the sample was random, is about 3/1000 (see below).

It is thought the transition from the immaculate to the maculate form of the species (see Williams, 1956; 1958) takes place at the onset of first maturity which is at about 30-40 cm.

Monthly gonad maturity states are given in Table XII but once again little can be deduced from the scattered data. No sign of pre-spawning segregation by sexes has been observed nor has any other information on spawning activity been obtained.

TABLE XII.—MONTHLY GONAD MATURITY STATES IN *C. melampyus*

MALES											
Stage	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N. D.
I	—	—	—	—	—	—	—	—	—	—	—
II	4	2	4	1	3	—	—	—	—	—	1
III	6	3	1	—	—	—	1	—	9	1	4
IV	—	—	2	—	—	—	—	—	—	—	2
V	—	—	—	—	—	—	—	—	—	—	—

FEMALES											
Stage	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N. D.
I	—	—	—	—	—	—	—	—	—	—	—
II	2	—	3	2	—	—	1	1	—	—	—
III	4	—	1	—	—	—	—	—	—	—	1
IV	5	—	1	—	—	—	—	—	1	—	1
V	1	—	1	—	—	—	—	—	—	1	—
VII	—	—	—	—	—	—	—	—	—	—	—
VIII	—	—	1	—	—	—	—	—	—	—	—

Food

Of the 75 stomachs examined, 16 (19 per cent) were empty whilst 59 (81 per cent) had contents which were subjected to qualitative analysis with the results given in Table XIII.

TABLE XIII.—QUALITATIVE ANALYSIS OF STOMACH CONTENTS OF 59 *C. melampyus*

Item	Stomachs in which occurred	% frequency of occurrence
Pisces	(57)	(96.6)
<i>Caesio</i> sp.	1	1.7
<i>Naso</i> sp.	1	1.7
Lutjanidae	1	1.7
Callyodontidae	3	5.1
Labridae	1	1.7
Mullidae	1	1.7
Scorpaenidae	1	1.7
Unidentified fish remains	48	81.4
Crustacea-Stomatopoda—		
Unidentified remains ..	1	1.7
Coral mush	1	1.7

As has been shown previously (Williams, 1956) *C. melampyus* is almost exclusively a fish eater, with the majority of its diet obtained in the close vicinity of the coral reef. This is certainly confirmed by underwater observation on the species.

Miscellaneous

From the limited data it is impossible to deduce statistically whether there is really a difference between the size distribution of this species or whether the sample was biased. It would appear that only the smaller (younger) females were caught by the methods used—this might be due to difference in behaviour or location of larger (older) fish. If this were correct then it would account for (a) the apparent difference in sizes between the sexes; (b) the relatively greater weight distribution of the males and (c) the apparent greater percentage of males in the population. Evidence in support of this is that the coefficient of variation of male and female weights are very similar at 16.6 per cent and 15.8 per cent respectively. One factor not fitting this theory is the lack of small male fish. It is impossible due to lack of knowledge of the biology (behaviour, growth rates, ecology) at this stage, therefore, to determine the reasons for these anomalies.

Family SPHYRAENIDAE Barracudas, *Mzia* (Kiswahili)

The taxonomy of the family was fully described in Williams (1959) together with short notes on the ecology and distribution of each species. Biological notes are given here on five of the species mentioned in the above publication.

Genus *Sphyraena* (Klein)
Sphyraena barracuda (Walbaum)

Brief biological notes were made on this species in Williams (1956) under the name of *S. commersoni*.

Occurrence

Some 210 specimens of *S. barracuda*, the most important of the East African barracudas, were taken in the open sea between December 1951 and October 1959. In addition 34 small individuals (less than 80 mm. SL) were taken from seine nets in enclosed coastal waters, in mangrove swamps and in marine fish ponds on Zanzibar Island.

Catches of *S. barracuda* by each method were:—

Trolling ..	192	} 244
Handline ..	11	
Tuna longline ..	7	
Seine nets ..	34	

Surface trolling accounted for most of the specimens taken and all were mature; all fish taken in nets were immature.

Monthly catches of *S. barracuda* for the combined data are given in Fig. 8. Although not directly related to the effort put into the fishery, the figures show that the species is apparently more abundant during the NE. monsoon. This is borne out by the numbers of the species landed by native fishermen. Monthly breakdown of catches of juveniles in nets are as under:—

January ..	6	} Total 34
Feb./March ..	14	
April ..	2	
May ..	2	
June ..	2	

Length and Weight Distributions; Means and Variances

The natural data are not normally distributed whilst the logarithmic data are so distributed.

Means and variance tests on the logarithmic data are given in Table XIV.

TABLE XIV.—MEANS AND VARIANCE TESTS ON LOGARITHMIC DATA

Difference between Sexes	Significance Level	
	Length	Weight
Means (t)	0.8%	0.9%
Variances (F)	0.2%	1.0%

The results show a slightly significant difference between the average length and weight of the sexes; similarly there is a comparable difference between the variances of the sexes for weight and length.

Length Frequency

In Fig. 9, 2 cm. length frequency groups are plotted for 208 fish, a distinction being made between mature and immature fish (juvenile fish taken in nets are not included). The smoothed curve, for mature fish only, shows a distinct mode at 72/73 cm. SL., with a considerable extension to the right representing older and larger fish. The range of fish taken was considerable, 52 to 131 cm. A separation of the length frequencies by sex showed that the size range for males (52 to 114 cm.) was shorter than for females (54 to 134 cm.). In males there is a marked mode at 70/74 cm. whilst in females there are two modes at 65/69 and 85/89 cm. It may be that there is a differential growth between the sexes. This possibility is supported by the findings in the means and variances tests and the length/weight relationship.

Weight Frequency

The range of weight of the specimens was 2 to 36 lb. with the modal weight 7 lb. The maximum weight of the species in the area is thought to be in excess of 50 lb. There is a considerable variation in weight at a given length over 70 cm.

Length/Weight Relationship

The regression equations for the sexes separately and combined are as follows:—

Females: $\log W = 3.0515 \log L - 4.8725$

Males: $\log W = 3.3801 \log L - 5.4719$

Combined: $\log W = 3.1300 \log L - 5.0105$

There is a significant difference between the regression equation for the sexes (significant difference in weight of sexes at a given length). In Fig. 10 (a and b), length is plotted against weight for the two sexes separately and the growth curves are drawn in from the natural forms of the regression equations for each sex—

Females: $W = 1.3410 \times 10^{-5} L^{3.0515}$

Males: $W = 3.3740 \times 10^{-6} L^{3.3801}$

In view of the significant differences in the regression equations the estimated weights at given lengths have been calculated separately and are as given in Table XV.

FIGURE 8

Fig. 8—Monthly catches of *Sphyraena barracuda* expressed as a percentage of the total catch, December 1951 to October 1959; together with the monthly average sea surface temperature

FIGURE 9

Fig. 9—Length-frequency distribution (2 cm. groups) of the catch of *Sphyraena barracuda* December 1951 to October 1959 (smoothed curve from a three figure moving average—immatures excluded)

Sex and Maturity

Sex was clearly visible in specimens down to 30 cm. SL ($3\frac{1}{2}$ lb.). Two hundred and two specimens were sexed, 132 were males and 70 females, a sex ratio of 1.89:1 males to females. This is a highly significant departure from the expected 1:1 ratio; the probability of only 70 females in a sample of 202 being approximately 2/10,000. Calculations of the sex ratios on a quarterly basis also show similar significant departures from the normal. As the sampling is considered random it appears that the normal sex ratio for the species is not 1:1 for considerable parts of the year. There is, however, no biological data from the area showing the probability of shoaling by sexes at various times such as pre-spawning, etc.

Maturity is reached at 54-67 cm. SL at a weight of 3 to 5 lb.

The monthly gonad maturity states are shown in Table XVI. The uneven distribution of the data over the year (due to the larger catches of the NE. monsoon) and the low number of ripe, running and spent fish make it such that little can be deduced from the results. It seems probable that the species can spawn at any time of the year.

Few immature specimens of *S. barracuda* have been taken at sea by any method, whereas many at this stage have been taken in the mangrove swamps on Zanzibar Island. Those specimens taken in the E.A.M.F.R.O. marine fishponds on Zanzibar Island are known to have entered as fry at times of refilling and it is possible the use of data from these fish

FIGURE 10a

Fig. 10a—Length-weight relationship in *Sphyraena barracuda*. Growth curves fitted from the regression equation Males. $W = 3.3740 \times 10^{-6} L^{3.3801}$

FIGURE 10b

Fig. 10b—Females. $W = 1.3410 \times 10^{-5} L^{3.0515}$ outer lines indicate the expected range of variation (95 per cent confidence limits)

in length/weight regressions is not justified due to a possible difference of growth rate under fish pond conditions. The data have therefore been omitted from the calculated regressions.

TABLE XV.—ESTIMATED WEIGHTS OF *S. barracuda* AT GIVEN LENGTHS

MALES				FEMALES			
Length cm.	Weight in lb.	95% Confidence Limits		Length cm.	Weight in lb.	95% Confidence Limits	
		Min. Weight	Max. Weight			Min. Weight	Max. Weight
50	1.9	1.5	2.3	50	2.1	1.5	2.8
55	2.6	2.1	3.2	55	2.7	2.0	3.8
60	3.5	2.7	4.4	60	3.6	2.5	5.0
65	4.5	3.5	5.8	65	4.6	3.2	6.5
70	5.8	4.5	7.5	70	5.7	4.0	8.2
75	7.4	5.6	9.6	75	7.1	4.9	10.1
80	9.1	6.7	12.0	80	8.6	6.0	12.4
85	11.2	8.5	14.8	85	10.4	7.2	15.0
90	13.6	10.2	18.1	90	12.5	8.5	17.9
95	16.3	12.2	21.9	95	14.5	10	21.2
100	19.4	14.4	26.2	100	17.0	11.6	24.9
105	22.9	16.9	31.1	105	19.7	13.4	29.0
110	26.8	19.7	36.5	110	22.7	15.4	33.6
115	31.2	22.8	42.7	115	26.0	17.6	38.6
120	36	26.2	49.5	120	29.7	20.0	44.1

TABLE XVI.—MONTHLY GONAD MATURITY STATES IN *S. barracuda*
MALES

Stage	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
I	—	—	1	—	—	—	—	—	—	—	—	—
II	25	9	13	4	1	4	3	3	—	11	4	15
III	17	5	4	—	—	—	—	—	—	—	4	6
IV	1	—	—	—	—	—	—	—	—	—	1	—
V	—	—	—	—	—	—	—	1	—	—	—	—

FEMALES

Stage	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
I	—	2	—	—	2	—	—	—	—	—	1	—
II	1	1	4	5	4	4	4	3	—	—	4	3
III	1	2	2	—	2	—	2	—	2	5	1	2
IV	—	—	—	1	—	—	—	—	2	—	1	2
V	—	—	1	—	—	—	—	—	1	—	1	—
VI	—	—	—	—	—	—	—	—	—	—	—	—
VII	—	—	3	—	1	—	—	—	2	—	—	2

Food

Stomachs of 204 fishes were examined, 150 (73.5 per cent) were empty and 54 (26.5 per cent) had contents which were subjected to qualitative analysis with the results given in Table XVII.

S. barracuda is primarily a fish eater, being predacious on those types of fish around the fringing coral reefs. Other animal groups are utilized but only squids and crustaceans appear to be of any importance. The high percentage of empty stomachs is probably due to the regurgitation of food at the moment of capture.

TABLE XVII.—QUALITATIVE ANALYSIS OF STOMACH CONTENTS OF 54 *S. barracuda*

Item	Stomachs in which occurred	% frequency of occurrence
Pisces	(46)	(85.1)
<i>Tylosurus</i> sp.	1	1.8
<i>Nemipterus</i> sp.	1	1.8
<i>Caesio</i> sp.	1	1.8
<i>Solar ucrumenophthalmus</i>	1	1.8
<i>Callyodontidae</i>	1	1.8
<i>Muraenidae</i>	4	7.5
<i>Scorpaenidae</i>	1	1.8
<i>Balistidae</i>	1	1.8
Unidentified fish remains	35	65
Mollusca-Cephalopoda		
Unidentified squid remains	5	9.3
Crustacea	(5)	(9.3)
Stomatopod remains	4	7.5
Penaeid remains	1	1.8
Polychaeta		
Unidentified remains	1	1.8
Algae	1	1.8

Parasites

Ten specimens showed parasitization of the gut and body cavity mesenteries by small cysts.

Miscellaneous

Several large fish were taken with a single specimen of the sucker fish (*Remora* sp.) attached. In two specimens small dried whole fish were found in the mesenteries of the body cavity. They had obviously bitten through the stomach wall, then died and had been preserved. The stomach had then healed without any visible scars. Similar observations were made in *Caranx ignobilis* (see above).

Sphyræna genie (Klunzinger)

Occurrence

Between January 1953 and February 1959 some 59 specimens were taken of this species of barracuda. Data on a further 22 fishes have been excluded as at the time of capture the identification of *S. genie* was in doubt. The species is solitary, inhabits the open ocean and is taken throughout the year (see Williams, 1959), mainly at night. Only one immature fish was caught.

Length and Weight Distributions; Means and Variances

The sample is small for a check on the distributions and the log data have been used in carrying out subsequent analyses.

The means and variances are given in Table XVIII. There is no significant difference between the average length and weight of the sexes, but the variances of the sexes for weight and length are significant.

TABLE XVIII.—MEANS AND VARIANCE TESTS ON LOGARITHMIC DATA

Difference between Sexes	Significance Level	
	Length	Weight
Means ($\bar{t}$)	N.S.	N.S.
Variances (F)	2.5%	5%

Length and Weight Frequency

Total number of fish are so small and the size range so large that length and weight frequency has not been attempted. The size range for each sex is 55-115 cm. at 2 to 24 lb.

Length/Weight Relationship

There is no significant difference between the length/weight regressions for the two sexes:—

Males: $\log W = 3.4131 \log L - 5.6453$;

Females: $\log W = 3.1067 \log L - 5.0672$.

For the combined data the regression equation is:— $\log W = 3.2109 \log L - 5.2606$. In Fig. 11, weight is plotted against length and the growth curve is drawn in from the natural form of the regression equation:—

$$W = L^{3.2109} 10^{-5.2606} = 5.4880.$$

Fig. 11—Length-weight relationship in *Sphyraena qenie*. Growth curve fitted from the regression equation (sexes combined) $W = 5.4880 \times 10^{-6} L^{3.2109}$; outer lines indicate the expected range of variation (95 per cent confidence limits)

Estimated weights at given lengths (for the range of the observed data), together with 95 per cent confidence levels, are given in Table XIX.

TABLE XIX.—ESTIMATED WEIGHT OF *S. qenie* AT GIVEN LENGTH

Length cm.	Weight lb.	95% Confidence Levels	
		Min. Weight	Max. Weight
55	2.1	1.9	2.4
60	2.8	2.4	3.2
65	3.6	3.1	4.3
70	4.6	3.9	5.5
75	5.8	4.8	6.9
80	7.1	5.8	8.6
85	8.6	7.0	10.5
90	10.3	8.4	13.7
95	12.3	9.9	15.3
100	14.5	11.6	18.1
105	17.0	13.5	21.4
110	19.7	15.5	24.9
115	22.7	17.8	28.9

Sex and Maturity

Sex was determined in 58 specimens, 28 were females and 30 males, a sex ratio of 1:1.07 females to males. This is not a significant departure from the normal 1:1 sex ratio.

Length at first maturity is not known, no juveniles having been seen in the area.

The monthly gonad maturity states are given as Table XX but the data are too scattered for any observations to be made on them.

TABLE XX.—MONTHLY GONAD MATURITY STATES IN *S. genie*

MALES											
Stage	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N. D.
I	—	1	—	—	—	—	—	—	—	—	—
II	—	4	—	3	1	—	—	—	—	—	—
III	3	3	2	1	1	—	—	—	—	6	1
IV	1	—	—	—	—	—	—	—	—	—	2
V	—	—	—	—	—	—	—	—	—	—	—

FEMALES											
Stage	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N. D.
I	—	—	—	—	—	—	—	—	—	—	—
II	—	—	2	—	1	—	2	—	1	1	1
III	1	3	2	—	—	—	—	—	—	—	—
IV	1	3	2	—	1	—	—	—	—	4	1
V	—	—	1	1	—	—	—	—	—	—	—
VI, VII	—	—	—	—	—	—	—	—	—	—	—

Food

Of the 58 stomachs examined, 45 (77.5 per cent) were empty, the remaining 13 (22.5 per cent) contained unidentifiable fish remains (11 occurrences) and fish and squid remains (2 occurrences).

Parasites

Three specimens had unidentified cysts in the body cavity mesenteries.

Sphyræna jello (C.V.)**Occurrence**

As with *S. genie* total numbers are small; only 56 specimens were caught between March 1953 and December 1956. All the fish except two (one in trammel net, one on handline) were taken by surface trolling. The species is known to be shoaling (Williams, 1959), $\pm$ 50 fish forming a tight group moving in unison, and is normally taken over shallow water banks or close to the fringing reefs. Underwater observations show the species to be much more numerous throughout the year than East African catches would suggest.

Length and Weight Distributions; Means and Variances

There is slight evidence suggesting that the natural data are not normally distributed but that the logarithmic data are so distributed. Means and variances are given in Table XXI and show that there are no significant differences between the average weights or lengths of the sexes.

FIGURE 12

Fig. 12—Length-frequency distribution (5 cm. groups) of the catch of *Sphyræna jello* March 1953 to December 1956 (smoothed curve from a three figure moving average)TABLE XXI.—MEANS AND VARIANCES OF LOGARITHMIC DATA IN *S. jello*

Difference between Sexes	Significance Level	
	Length	Weight
Means (t)	N.S.	N.S.
Variances (F)	0.1%	0.7%

There is, though, a slightly significant difference between the variances of the lengths and weights of the different sexes.

Length and Weight Frequency

Distribution of 5 cm. length groups (Fig. 12) shows a distinct mode at 85/89 cm. The modal weight of the species is 8 lb. The size range is 65-124 cm. at 3-22 lb. weight.

Length/Weight Relationship

There is no significant difference between the length/weight regression equations for the sexes separately. The equation for the combined data is:— $\log W = 2.8157 \log L - 4.5395$. In Fig. 13, weight is plotted against length and the growth curve is drawn in from the natural form of the regression equation:— $W = L^{2.8157} 10^{-5} 2.8840$.

There is a considerable variation in weight at a given length over 80 cm. In Table XXII estimated weight at given length within the limits of the observed data is shown, together with the 95 per cent confidence limits.

TABLE XXII.—ESTIMATED WEIGHT OF *S. jello* AT GIVEN LENGTH

Length cm.	Weight lb.	95% Confidence Limits	
		Min. Weight	Max. Weight
65	3.8	3.4	4.0
70	4.5	3.9	5.3
75	5.5	4.5	6.8
80	6.6	5.2	8.4
85	7.8	6	10.2
90	9.2	6.8	12.3
95	10.7	7.8	13.1
100	12.3	8.8	17.3
105	14.2	10	20.2
110	16.2	11.2	23.4
115	18.3	12.5	26.9
120	20.7	13.9	30.7
125	23.2	15.4	34.9

FIGURE 13

Fig. 13—Length-weight relationship in *Sphyræna jello*. Growth curve fitted from the regression equation (sexes combined) $W = 2.8840 \times 10^{-5} L^{2.8157}$; outer lines indicate the expected range of variation (95 per cent confidence limits)

Sex and Maturity

Sex was determined in 55 specimens, 27 were females and 29 males, a sex ratio of 1:1.11 males to females. This is not a significant departure from the expected 1:1 sex ratio. Only one immature fish (19 cm. and $\frac{1}{4}$ lb.) was taken in Zanzibar harbour on a handline, but already sex was discernible with the naked eye. There is no information on the size of *S. jello* at first maturity.

Table XXIII gives the monthly gonad maturity states but once again little can be gathered from the scattered data.

TABLE XXIII.—MONTHLY GONAD MATURITY STATES IN *S. jello*
MALES

Stage	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
I	—	—	—	—	—	—	—	—	—	—	—	—
II	—	—	—	1	—	—	1	1	—	—	—	—
III	11	1	—	—	—	—	—	—	2	2	2	2
IV	3	2	—	—	—	—	—	—	—	—	1	—
V	—	—	—	—	—	—	—	—	—	—	—	—

Stage	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
I	—	—	—	—	—	—	—	—	—	—	—	—
II	1	—	1	—	—	3	2	1	—	1	—	1
III	8	—	1	—	—	—	—	1	1	—	—	—
IV	2	—	—	—	—	—	—	—	—	—	1	—
V	—	—	—	—	—	—	—	—	—	—	—	—
VI	—	—	—	—	—	—	—	—	—	—	—	—
VII	—	—	1	—	—	—	—	—	—	1	1	—

Food

Fifty-seven stomachs were examined; 32 (56.1 per cent) were empty whilst 25 (43.9 per cent) had contents on which a qualitative analysis was carried out with the results given in Table XXIV.

TABLE XXIV.—QUALITATIVE ANALYSIS OF STOMACH CONTENTS OF 25 *S. jello*

Item	Stomachs in which occurred	% frequency of occurrence
Pisces	(25)	(100)
<i>Lutjanus gibbus</i>	1	4
Callyodontidae	1	4
Atherinidae	1	4
Unidentified fish remains ..	22	88
Crustacea—		
Unidentified stomatopod remains	1	4

Like the other species of barracuda, *S. jello* is primarily a fish eater.

Parasites

Few specimens of *S. jello* were parasitized; those that were had unidentified cysts in the mesenteries surrounding the gonads.

Sphyraena bleekeri (Williams, 1959)*Occurrence*

One hundred and eight specimens of this small shoaling barracuda were taken between April 1952 and February 1960, 100 by handlining and 8 by trolling. The species is normally taken at night on or near the bottom, but those caught by trolling were taken during the hours of daylight. Fishing for this species was spasmodic and although 60 out of 108 were caught in the month of October, it may be encountered during any months in the Zanzibar fish market.

Length and Weight Distributions; Means and Variances

Once again the sample is small and it is difficult to tell whether the log transformation improves the distribution.

Tests on logarithmic data give the means and variances shown in Table XXV.

TABLE XXV.—MEANS AND VARIANCES OF LOGARITHMIC DATA

Difference between Sexes				Significance Level	
				Length	Weight
Means (t)	..	..	..	N.S.	N.S.
Variances (F)	..	..	..	1%	0.1%

The average weights and lengths for the sexes are not significantly different, although there is a difference between the length and weight variances for the sexes.

Length and Weight Frequency

Fig. 14 gives length frequency distributions—2 cm. groups—for the combined data, distinguishing mature from immature fishes. There is a distinct mode at 44/45 cm. and a probable secondary one at 60/61 cm. As over 50 per cent of the fish were taken in October it is thought that these two peaks might represent two separate length groups in that month's catch. However, an examination of the October length frequencies showed only one mode at 42/43 cm. But if the combined data are examined according to sex, the males show a mode at 44/45 and the females, two at 44/45 and 60/61 cm.

Modal weight is 2 lb.

Size range of the species is 30 to 89 cm. at 1 to 8 lb.

FIGURE 14

Fig. 14—Length-frequency distribution (2 cm. groups) of the catch of *Spilopterygia bleekeri* April 1952 to February 1960 (smoothed curve from a three figure moving average—immatures excluded)

Length/Weight Relationship

There is no significant difference between the regression equations for the two sexes. The regression equation for the combined data is:—

$$\log W = 1.6687 \log L - 2.4917.$$

In Fig. 15, weight is plotted against length and the growth curve is drawn in from the natural form of the regression equation:—

$$W = L^{1.6687} \cdot 10^{-3} \cdot 3.223.$$

In Table XXVI estimated weight at given length within the limits of the observed data is given for the species, together with the 95 per cent confidence limits.

TABLE XXVI.—ESTIMATED WEIGHT OF *S. bleekeri* AT GIVEN LENGTH

Length cm.	Weight lb.	95% Confidence Limits	
		Min. Weight	Max. Weight
35	1.2	0.7	2.3
40	1.5	0.8	2.9
45	1.9	1	3.5
50	2.2	1.1	4.2
55	2.6	1.3	5.1
60	3	1.5	6
65	3.4	1.7	6.9
70	3.9	1.9	7.9
75	4.3	2.1	9
80	4.8	2.3	10.1

Fig. 15—Length-weight relationship in *Sphyraena bleekeri*. Growth curve fitted from the regression equation (sexes combined) $W = 3.223 \times 10^{-3} L^{1.6687}$; outer lines indicate the expected range of variation (95 per cent confidence limits)

Sex and Maturity

Of the 108 specimens sexed, 39 were males and 69 females, a sex ratio of 1:1.77 males to females. The probability of so few males in the sample, if it was random, is about 2/1,000. The departure from the normal 1:1 sex ratio is therefore most significant. The sex ratio for the month of October (60 specimens) is almost identical with that for the combined data.

Assuming that the sampling was random the indication is, therefore, that the sex ratio varies according to time of the year. However, it is possible that the majority of the sampling was not random if there was segregation of sexes at say the prespawning period, but no confirmatory evidence of this is forthcoming.

Fourteen of the 108 specimens were immature and all were taken by handlining. It would seem that first maturity is reached between 36 to 45 cm. at a weight of 1 to 3 lb.

Monthly gonad maturity states are shown in Table XXVII but numbers are too few except in October to give any information on the breeding cycle.

TABLE XXVII.—MONTHLY GONAD MATURITY STATES IN *S. bleekeri*

MALES												
Stage	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
I	—	—	—	—	1	—	—	—	—	2	1	—
II	—	2	—	—	2	—	—	—	1	15	1	—
III	—	—	1	—	1	—	—	—	—	1	1	—
IV, V	—	—	—	—	—	—	—	—	—	—	—	—

FEMALES												
Stage	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
I	—	—	—	—	1	—	1	—	—	7	1	—
II	—	—	—	1	—	—	—	3	1	9	—	—
III	—	—	—	1	—	—	—	—	—	14	9	—
IV	—	—	—	—	—	—	—	—	—	7	2	—
V	—	—	—	—	—	—	—	—	—	4	6	—
VI	—	—	—	—	—	—	—	—	—	—	—	—
VII	—	2	—	2	—	—	—	—	—	—	—	—

Food

One hundred stomachs of *S. bleekeri* were examined; 76 were empty whilst the remaining 24 had contents. The results of the qualitative analysis of these contents is given in Table XXVIII.

TABLE XXVIII.—QUALITATIVE ANALYSIS OF STOMACH CONTENTS OF 24 *S. bleekeri*

Item	Stomachs in which occurred	% frequency of occurrence
Pisces	(23)	(95.8)
Clupeidae	2	8.1
Caesio sp.	2	8.1
Chromidae	2	8.1
Unidentified fish remains	17	70.8
Crustacea—		
Unidentified Decapod remains	1	4.2

As with the other species of barracuda already discussed, the percentage of empty stomachs is high, but the inference from those with contents is that *S. bleekeri* is primarily a fish eater.

Sphyræna toxæuma (Fowler)*Occurrence*

S. toxæuma is normally only taken at night (Williams, 1959) and of the 74 specimens caught, 57 were taken by trolling and 17 by handlines fishing on or near the bottom. The period of capture was January 1955 to March 1959; prior to 1955 the species had not been identified from the East African area. Monthly catches for 1955-1959 were as follows:—

Month	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
Number	8	6	20	19	6	—	5	—	—	—	9	1

Length and Weight Frequency

Total numbers are few and 5 cm. length frequency groups show little other than a modal length of 50/54 cm. for the adult specimens. Modal weight is 2 lb. The size range for the species in East Africa is 20 to 64 cm. at $\frac{1}{2}$ to 4 lb.

Length/Weight Relationship

Fig. 16 shows the plot of weight on length for 71 specimens; the regression equation has not been calculated for this species and the growth curve indicated in Fig. 16 is approximate.

FIGURE 16

Fig. 16—Length-weight relationship in *Sphyræna toxseuma*—the growth curve is approximate and not fitted from a regression equation

Sex and Maturity

Sex was discernible in 66 specimens, 13 were males and 53 were females, a sex ratio of 1:4.07 males to females. The probability of so few males, if the sample was random and the sex ratio the expected 1:1, is about 3/1,000,000. The assumption therefore is that the sample was not random. It is highly likely that the species shoals by sex, possibly just before (or after) the spawning season. This is borne out by the fact that most catches were taken during the NE. monsoon period (November to April) which is also the probable breeding season.

First maturity appears to be reached at 40 cm. at 1 lb. weight. Table XXIX gives the monthly gonad maturity states for the combined data; once again virtually nothing can be deduced from them, except that spent females were taken from January to April so that spawning at least covers the NE. monsoon period.

TABLE XXIX.—MONTHLY GONAD MATURITY STATES IN *S. toxseuma*

MALES											
Stage	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N. D.
I	—	—	1*	—	—	6*	—	—	—	—	1*
II	1	—	—	4	—	—	1	—	—	—	—
III	1	1	3	2	—	—	—	—	—	—	—
IV, V	—	—	—	—	—	—	—	—	—	—	—

*Sex not determined.

FEMALES											
Stage	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N. D.
I	—	—	—	—	—	—	—	—	—	—	—
II	—	1	2	6	—	—	3	—	—	—	—
III	3	—	7	—	—	—	1	—	—	7	1
IV	2	—	6	—	—	—	—	—	—	—	—
V	—	—	—	—	—	—	—	—	—	—	—
VI	—	—	—	—	—	—	—	—	—	—	—
VII	1	1	3	7	—	—	—	—	—	—	—

Food

Of the 60 stomachs examined, 50 (85 per cent) were empty and only 9 (15 per cent) had any contents. These contents were mainly unidentifiable fish remains (6) penaeid prawns (2) and squid remains (1).

Parasites

One specimen had several small unidentified cysts in the body cavity mesenteries.

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