NOT TO BE CITED WITHOUT PERMISSION OF AUTHOR

CAFSAC Research Document 80/30

Species and Stocks of Redfish in NAFO Divisions 4VWX

T.J. Kenchington
Dept. of Biology
Dalhousie University
Halifax, N.S.

and

Marine Fish Division
Bedford Institute of Oceanography
Dartmouth, N.S.

Abstract

Three "species" of redfish (Sebastes) and the blackbelly rosefish (Helicolenus dactylopterus) are now recognised from the northwest Atlantic. The occurrence of these in 4VWX, and the existence of stocks in this area, were examined using 25 characters (mostly meristic or morphometric) on 550 fish.

Helicolenus can be readily identified (a key to these genera is included). They were only found in small numbers along the continental slope from Georges Basin to Western Bank.

Sebastes marinus was not found. S. mentella could only be distinguished from S. fasciatus by a discriminant function. There appeared to be some intermediates between these two "species". S. mentella were only taken at one station, and may be vagrants from further north. S. fasciatus are the typical redfish of the Scotian Shelf.

No conclusive evidence of separate stocks of S. fasciatus within 4VWX was found, but the data strongly suggest that these do occur.

Résumé

On reconnaît à l'heure actuelle trois «espèces» de sébastes (Sebastes marinus) et la présence de la chèvre impériale (Helicolenus dactylopterus) dans l'Atlantique nordouest. Vingt-cinq caractères (numériques et morphométriques pour la plupart) examinés sur 550 poissons ont servi à vérifier la présence de ces poissons dans 4VWX et l'existence de stocks dans cette région.

Helicolenus peut être facilement identifié (le présent article contient une clé des genres). On ne le trouve qu'en petit nombre le long du talus continental, depuis le bassin Georges jusqu'au banc Western.

Sebastes marinus n'a pas été trouvé. S. mentella ne peut être distingué de S. fasciatus que par une fonction discriminante. Il semble y avoir des intermédiaires entre ces deux «espèces» . S. mentella n'a été capturé qu'à une station, et il se peut qu'il s'agisse de vagabonds venus du nord. S. fasciatus est le sébaste typique du plateau Scotian.

Nous n'avons pas de preuves concluantes de la présence de stocks séparés de S. fasciatus dans 4VWX, mais les données suggèrent fortement qu'il en existe.

Introduction

In recent years it has become generally accepted that 3 species of redfish (*Sebastes*) occur in the northwest Atlantic: *S. marinus* (L.), *S. mentella* Travin and *S. fasciatus* Storer. No detailed study of Scotian Shelf redfish has been made since "*S. marinus*" was divided, to determine which types occur there, although Templeman (1973) has suggested that only *S. fasciatus* does so.

In addition to the redfish, the blackbelly rosefish (*Helicolenus dactylopterus*) is found on the Scotian Shelf. Although too small to be taken commercially, it appears that this species is sometimes confused with juvenile *Sebastes* in research vessel catches.

Thus, the primary purpose of the work reported here was to determine which species of redfish occur in Divisions 4VWX, and to devise reliable and practical keys for distinguishing them.

Present fisheries management plans treat all the 4VWX redfish as one stock. However, parasitological evidence suggests that the Gulf of Maine redfish are distinct from those further east, and indeed that there is little mixing of fish between Roseway and Western Banks on the Scotian Shelf (Templeman and Squires, 1960; Sinderman, 1961). An alternative stock separation between those redfish in the Shelf basins and those along the continental slope has been

---

Footnote:

Throughout this paper I have referred to *S. marinus, S. mentella* and *S. fasciatus* as though they are species. This is for convenience only and is not intended to imply that their specific status is, or is not, justified.

suggested by Martin (1953), Templeman (1959) and Kohler (1968). The last specified the dividing line as Scatarie, Western Bank, La Have Bank, Browns Bank. As pointed out by Clay (1979), separate management for redfish stocks in this area is needed, since the area of greatest fishing does not coincide with that of maximum abundance of fish.

The second object of this research was, therefore, to attempt to identify intraspecific stocks for whichever redfish species were found to occur.

Methods

Samples of redfish (and blackbelly rosefish) from most parts of 4VWX were collected during regular groundfish survey cruises, or special cruises using the same fishing methods, by technicians aboard the "Lady Hammond" and "A.T. Cameron" (see figures 1 and 2 and table 1). The intention was to collect all sizes and types of redfish from wherever they occur. These samples were frozen whole and returned to the laboratory for further study.

Four fish were collected (during a pollock study) from a fisherman who had caught them by gill net in St. Margarets Bay, N. S. (maximum depth 43 fm).

A considerable number of characters have been suggested for identification of these genera and species (tables 2 and 3), but specific identification of *Sebastes* still requires the examination of several characters, and is complicated by the presence of 'intermediates' (Templeman and Sandeman, 1959; Templeman, 1976). Thus 25 morphometric measurements and meristic and other characters were chosen (see table 4) with a view to their practicality with large samples, from those listed in tables 2 and 3, and from those thought to show inter-stock variability in earlier studies (Kelly, Barker and Clarke, 1961; Templeman and Pitt, 1961). These characters were then examined on 550 fish (although not every one could be recorded for every fish). Measurements were taken to millimetre accuracy. Most meristic characters were counted on the frozen or thawed fish (as the measurements were taken), but the vertebral counts are from X-ray plates.

Peritoneal colour was subjectively graded on a scale from black to silver. It appears to be linked to size (larger fish have lighter colour) and thus was little used in the analysis. Pre-opercular spine angles were also subjective, and often uncertain due to the complex shape of some spines.

All morphometric measurements were regressed against standard length (and, when appropriate, head length and orbit width). All relationships were found to be linear (see figures 3 to 20) except for the length of the longest dorsal spine which was either curvilinear, or composed of two different linear relationships. Standardized values were then calculated, by adjusting the measured values to those for a constant standard length (250 mm) using the gradient of the appropriate regression line. (Measurements standarized by head length used 100 mm as standard; those by orbit width used 25 mm). All subsequent use of morphometric values used these standardized ones.

The genera (*Helicolenus* and *Sebastes*) could be distinguished by vertebral count (when this was available). A key was devised which allowed separation of almost all the fish into appropriate genera. Known *Helicolenus* and fish of uncertain genus were excluded from subsequent analysis.

Univariate (Chi-square and t tests) and discriminant function analysis were then used to separate the species of *Sebastes*, and to examine the more common one (*S. fasciatus)* for possible stock separations.

Results and Discussion

The recorded values for the various characters are shown in figures 3 to 28.

Helicolenus and Generic Identification

H. dactylopterus were included in the samples from 5 sets (LH020/57, 58 and 63, LH021/74 and LH027/54). These were on the southern edge of Western Bank, southeast of LaHave Bank and in Georges Basin. None were included in samples from the Scotian Shelf basins. This is a considerable range extension from that previously reported (Leim and Scott, 1966; Musick, 1966), but their presence on the Scotian Shelf has long been known, and there is no reason to assume an actual change in range. The largest *Helicolenus* in the samples was under 180 mm fork length.

One character often used to separate this genus from *Sebastes*, the black peritoneum, was found to be unreliable since many small *Sebastes* share this feature. The most reliable character is, undoubtedly, vertebral number. When this is not available dorsal spine and anal soft ray counts will separate most individuals, as will a careful examination of the lower pectoral rays. Those who are experienced with these fish may be able to identify them by body shape, colouration or other characters, but these have not been checked in this study. The generic key to Scotian Shelf redfish is given in table 11.

Species of *Sebastes*

Most of the *Sebastes* examined were clearly *S. fasciatus*, while those from one set (cruise LH021, set 75) had the vertebral and anal soft ray counts usually considered to characterise *S. mentella*. None of the fish resembled *S. marinus*. Since all the identifying characters overlap, it is not possible (usually) to identify individuals on the basis of a single character. Thus the *Sebastes* were divided into *S. fasciatus* and *S. mentella*, by sets, on the basis of their anal soft ray and vertebral counts. Sets with intermediate values of either character were not classified at this stage. The assumption of one species only in a set is probably acceptable, for those sets which were classified.

The results of univariate comparisons (Chi-square and t-tests) between those fish considered to be *S. fasciatus* and those considered to be *S. mentella* are shown in table 5. Three discriminant functions were calculated for these groups. The first involved all available variables (only meristics standardized by standard length were used), the second excluded those used to select the groups (vertebral count and anal soft ray count) and the third involved only the best 8 discriminating variables. The second of these identified 98.2% of the fish to their assumed species. Thus, these groups appear to have some biological reality. The first function "correctly" identified all by 3 fish, which were, therefore, excluded from further analysis. The third function identified 98.7% of the fish "correctly" and thus appears to be adequate for future identifications. Details of these functions are given in table 6, and plots of the scores in figure 29.

Those fish which had not previosly been allocated to a species were divided on the basis of the first discriminant function. Each group thus formed was tested for differences from the remainder of its "species". The results are given in tables 7 and 8. From these, it seems that two species do not adequately explain these data; those fish not originally classified do not fit well into either species. Whether there is an additional species or subspecies, as Litvinenko (1979; abstract only, paper not yet available in English) suggests; a group of hybrids with intermediate characters, as has been suggested for other North Atlantic *Sebastes* (Altukhov and Nefyodov, 1968); or whether each "species" is really a sub-specific "type" (c.f. Kotthaus, 1960, 1961 a, b), can not be said at present.

No really adequate, routine, method is available for separating *S, fasciatus* and *S. mentella*. Apart from the discriminant functions (table 6) some characters which may be useful are given in table 12. Further study of this problem is needed.

All the *S. mentella* which were taken were in one set, at 540 m depth. All were large (fork length 335 mm to 434 mm). It is therefore likely that these fish originated further north and had migrated along the continental slope. Due to the lack of samples from these depths, the abundance of *S. mentella* in 4VWX is unknown.

S. fasciatus is widespread at middle and greater depths (range of sample depths 93 m to 622 m) in this area. The two samples from 4Vn were both of 'intermediate' fish, thus *S. fasciatus* may not occur there.

Stocks of *Sebastes fasciatus*

The data for known *S. fasciatus* were tested for differences between two hypothetical stock arrangements; firstly that suggested by former studies:

1. Slope: southeast of a line Scatarie-Western-LaHave-Browns banks.
2. Basin: Northwest of that line
3. Inshore: St. Margaret's Bay sample
4. Gulf of Maine: West of Browns Bank-Cape Sable line.

The second arrangement was to divide the fish by their Divisions (4Vs, W, X, 5Y), since this might be the most practical arrangement for management.

For each pair of units in each arrangement, all characters were tested (Chi-square or t-test, as appropriate). The results are shown in tables 9 and 10. It should be noted that with the small samples available for some units, the morphometric data may deviate from normality sufficiently to give spurious significance with t-tests.

Every pair has at least two characters significantly different (at the 1% level), and all seem to be approximately equally divergent. Because of the doubt concerning normality of the standardized morphometric data, these results do not prove stock divisions within 4VWX, but they do strongly indicate them.

With respect to the stocks suggested by Martin (1953), Templeman (1959) and Kohler (1968) it should be noted that they did not distinguish *S. faciatus* from *S. mentella*. Thus the mixture of these, with intermediates, would comprise a "slope" group different from the pure *S. fasciatus* of the basins.

Conclusions

Helicolenus dactylopterus occurs in 4WX, along the continental slope, at least as far east as Western Bank. It has been poorly distinguished from *Sebastes* in the past, and the characters in table 11 are suggested for future use.

Sebastes fasciatus is the common redfish of 4VWX and is found over a wide depth range in Divisions 4VsWX. No record of it is available from 4Vn. *S. mentella* are also found on the continental slope. They may be rare vagrants, but the abundant large redfish found at this depth in 1978 (D. Clay, pers. comm.) may have been this species. Other *Sebastes* which appear to be intermediate between these types occur along the continental shelf from 4Vn to 4W (one such fish was from the Emerald Basin).

No characters, that are practical for routine use, have been found to reliably identify these species. Those which may be of some use are shown in table 12.

Conclusive proof of distinct stocks within 4VWX is not available, but this is strongly indicated.

Since neither *Helicolenus* nor *S. mentella* are currently subject to a commercial fishery (they are, respectively, too small and too deep), no separate management for them is required. Both samples from 4Vn were "intermediates", while those from the other subdivisions were primarily *S. fasciatus*, possibly of more than one stock. Thus, separate management of Vn, Vs, W and X redfish is biologically very desirable. Management by division appears to be as suitable as any other arrangement.

Acknowledgements

I would like to thank the captains, crews and scientific staffs of the "Lady Hammond" and "A. T. Cameron" for collecting my samples. Dianne Beanlands, Odelia Maessen and Maryanne Frame assisted with measuring the specimens. Bill Dougherty took the X-rays, which were kindly developed by Mr. Joe Arab and his staff at the Halifax Dockyard. Douglas Clay read my manuscript and provided a great deal of assistance throughout the work.

APPENDIX

External sexing of redfish

All the fish discussed in this paper were sexed by direct inspection of their gonads. The external method that is sometimes used (intromittent organ visible in male, none in female) did not appear to work with these (frozen) fish. Thus, on a recent cruise (LH030), I examined a total of 270 redfish (chosen without prior selection), and sexed them both externally and internally. Only 3 of the external sexings were incorrect, and these could have been avoided by more experience or working more slowly.

External sexing of redfish is therefore adequate, if there is a need to avoid cutting the fish. The only point to beware of is that the anus may be slightly everted and can be confused with an intromittent organ at first glance.

References

Altukhov, J.P. and G.N. Nefyodov. 1968. A study of blood serum protein composition by agar-gel electrophoresis in types of redfish (genus *Sebastes*). ICNAF Res. Bull.: 5, 86-90.

Barsukov, V.V. 1968. The systematic relationship of redfish of the genus *Sebastes* of the Northwest Atlantic Ocean. Doklady Biol. Sci. 183: 734-737.

Clay, D. 1979. Atlantic redfish *(Sebastes mentella)* in ICNAF Divisions 4VWX: A stock assessment and an estimate of the total allowable catch (TAC) for 1980. CAFSAC Res. Doc. 79/41

Hallacher, L.E. 1974. The comparative morphology of extrinsic gasbladder masculature in the scorpionfish genus *Sebastes* (Pisces: Scorpaenidae). Proc. Calif. Acad. Sci. 40: 59-92.

Kelly, G.F., A.M. Barker and G.M. Clarke. 1961. Racial comparisons of redfish from the Western North Atlantic and the Barents Sea. ICNAF Sp. Pub.: 3, 28-41.

Kohler, A.C. 1968. Fish stocks of the Nova Scotia Banks and Gulf of St. Lawrence. Fish. Res. Bd. Canada Tech. Rep. 80.

Kotthaus, A. 1960. Zum Rassenproblem beim Rotbarsch. Rotbarschformen aus dem zentralen Nordatlantik (zwischen den faroen und Gronland-West). Ber. dtsch. wiss. Komm. Meeresforsch.: N.F., 16, 18-50.

1961a. Contributions to the race problem in redfish. ICNAF Sp. Pub.: 3, 42-44.

1961b. Preliminary remarks about redfish otoliths. ICNAF Sp. Pub.: 3, 45-50.

Leim, A.H. and W.B. Scott. 1966. Fishes of the Atlantic coast of Canada. Bull. Fish. Res. Bd. Canada, 155.

Litvinenko, N.N. 1974. Colour and other morphological characteristics distinguishing the young of *Sebastes fasciatus* Stores, 1856 from the young of *Sebastes mentella* Travin, 1951 *(Scorpaenidae)*. J. Ichth. 14: 591-595.

Litvinenko, N.I. 1979. [*Sebastes fasciatus kellyi* Litvinenko, 1974 (Scorpaenidae) from the coastal water of Eastport (Maine, U.S.A.).] Vopr. Ikhtiol.: 19, 387-401. (In Russian).

Martin, W.R. 1953. Identification of the major groundfish stocks in subarea 4 of the Northwest Atlantic Convention area. ICNAF Ann. Proc.: 3, 57-61.

Musick, J.A. 1966. The distribution of *Helicolenus dactylopterus* in the Gulf of Maine. Copeia 1966: 877.

Templeman, W. 1959. Redfish distribution in the North Atlantic. Bull. Fish. Res. Bd. Canada, 120.

1973. First records of the gymnoblastic hydroid, *Ichthyocodium sarcotretis*, on the copepod, *Sphyrion lumpi*, from redfish of the northwest Atlantic. J. Fish. Res. Bd. Canada: 30, 1655-1660.

1976. Biological and oceanographic background of Flemish Cap as an area for research on the reasons for year-class success and failure in cod and redfish. ICNAF Res. Bull.: 12, 91-117.

Templeman, W. and T. K. Pitt. 1961. Vertebral numbers of redfish, *Sebastes marinus* (L.), in the north-west Atlantic, 1947-1954. ICNAF Sp. Pub.: 3, 56-89.

Templeman, W. and E. J. Sandeman. 1959. Variations and caudal pigmentation in late-stage pre-extrusion larvae from *marinus* - and *mentella* type female redfish from the Newfoundland area. J. Fish. Res. Bd. Canada.: 16, 763-781.

Templeman, W. and H. J. Squires. 1960. Incidence and distribution of infestation by *Sphyrion lumpi* (Kroyer) on the redfish *Sebastes marinus* (L.) of the western North Atlantic. J. Fish. Res. Bd. Canada: 17, 9-31.

Sinderman, C. J. 1961. Parasitological tags for redfish of the western North Atlantic. ICNAF Sp. Pub.: 3, 111-117.

Table 1. List of samples.

CRUISE	SET	DATE	NUMBER OF FISH EXAMINED
LH014	16	?	20
LH020	2	July 1979	25
	3	"	11
	4	"	8
	5	"	12
	6	"	7
	57	"	62
	58	"	10
	61*	"	20
	63	"	6
LH021	64	"	2
	65	"	1
	66	"	30
	68	"	1
	72	"	5
	74	"	29
	75	"	27
AT292	82	"	34
LH026	12	Sept/Oct 1979	20
	15	"	20
	26	"	24
	41	"	26
	55	"	20
	57	"	20
	59	"	20
LH027	54	"	19
	58**	"	11
	61	"	16
	64	"	20
	78	"	20
St. Margaret's Bay	-	Nov. 1979	4

* This sample was mis-labelled; it may have been LH014/61 rather than LH020/61. The former set was in the northeast of Emerald Basin.

** The position of this station was unknown when the analysis was being done. It was excluded from stock analysis.

Table 2. List of characters suggested in the literature for separating *Helicolenus* and *Sebastes*.

	Helicolenus	Sebastes	Authority
Dorsal spines	12	14-15	1, 2
Anal soft rays	5 - 6	7	1
Vertebrae	24 - 25	31	1
Body depth	slightly less than head length	-	1
Interorbital	less than 50% eye diameter	about 66-75% eye diameter	1
Scales	relatively large	relatively small	1
Caudal fin	relatively large	relatively small	1
Pectoral fin	blunt end	pointed end	1
Interorbital	concave	flat	1
Lower pectoral rays	free of membrane	not free	1
Peritoneal colour	black	-	1
Body colour	upper part of sides marked with "dusky vemiculations"	-	1

[1] Bigelow and Schroeder, 1953

[2] Leim and Scott, 1966

Table 3. List of some characters suggested in the literature for separating the northwest Atlantic species of *Sebastes*

	Marinus	*Mentella*	*Fasciatus*	Authority
Vertebrae	-	30 (29-31)	29	4
Vertebrae	-	30-31 (28-31)	29 (28-30)	5
Anal soft rays	8 (7-9)	8-9 (7-10)	7 (7-8)	4
Anal soft rays	-	Mean 9 (7-11)	Mean 7 (6-9)	5
Dorsal soft rays	-	Mean 14.6 (12-16)	Mean 13.6 (12-16)	5
Scale rows	-	-	more than others	1
Eye diameter	usually less than 26% head length	usually more than 26% head length	(included with *mentella*)	1
longest dorsal spine	-	Mean 11.9% standard length	Mean 15.1% standard length	5
Body depth	-	Mean 21.7% standard length	Mean 30.4% standard length	5
Schnabel shape	blunt	sharp	similar to *mentella*	1
Contour of head	-	concave	straight, convex	4
Highest point on back	-	under dorsal fin spine 3, 4 or 5	Under 1st dorsal fin spine	2, 4
Angle of lowest pre-opercular spine	directed back and down	straight down or rather forward	similar to *mentella*	1

page 1 of 2 ...

Table 3. List of some characters suggested in the literature for separating the northwest Atlantic species of *Sebastes*.

	Marinus	*Mentella*	*Fasciatus*	Authority
Gas bladder muscles pass between ribs	2,3	2,3	3,4	6
Colour	yellow, orange-red, greenish	bright red	bright red	1
		(Juveniles have different colour patterns)		5
Depth range	usually above 375 m	usually below 275 m	-	3
Depth range	usually above 300 m	usually below 300 m	-	1
	-	174-658 m	82-439 m	4

1. Templeman, 1959
2. Kotthaus, 1961 b.
3. Templeman, 1976
4. Barsukov, 1968
5. Litvinenko, 1974
6. Eschmeyer, in Hallacher, 1974

Among other characters claimed to distinguish these species are: retinal characters (Hanyu and Ali, 1962), head spination (Litvinenko, 1974; and otolith characters (Kotthaus, 1961 b; Trout, 1961). Many other morphometric and meristic characters differ but not sufficiently to permit identification of individuals.

page 2 of 2.

Table 4. Characters recorded for each fish.

Total Length:	As Kelly *et al.*, 1961, Measurement 2.
Fork Length:	Greatest dimension between most anterior part of head (with mouth closed) and tip of shortest caudal fin ray.
Standard Length:	As Kelly *et al*, 1961, Measurement 1. Posterior end of measurement taken to be tip of most posterior scale.
Snout to Ventral Fin Origin:	As Kelly *et al*, 1961, Measurement 26.
Snout to Anal Fin Origin:	As Kelly *et al*, 1961, Measurement 24.
Body Depth:	As Kelly *et al*, 1961, Measurement 5.
Caudal Peduncle Depth:	As Kelly *et al*, 1961, Measurement 7
Head Length:	From most anterior part of head (with mouth closed) to most posterior tip of operculum or opercular spine.
Snout Length:	From slot in mid-line of upper jaw to most anterior part of orbit.
Schnabel Length:	As Kelly *et al.*, 1961, Measurement 20.
Orbit Width:	As Kelly *et al*., 1961, Measurement 12.
Orbit Height:	As Kelly *et al*., 1961, Measurement 13.
Interorbital:	As Kelly *et al*., 1961, Measurement 14.
Length of Longest Dorsal Spine:	As Kelly *et al*., 1961, Measurement 37 (excludes last spine which is in 2nd dorsal fin)
Vertebral Count:	Excluding basioccipital and hypural
Dorsal spine	count
Dorsal soft ray:	count
Anal soft ray:	count
Pectoral ray:	count

page 1 of 2 ...

Table 4. Characters recorded for each fish. (page 2 of 2)

Presence or absence of free pectoral rays

Sex

Peritoneal Colour

Angles of upper, middle and bottom pre-opercular spines: Measured from vertically upward through posterior, downward to anterior, in 10° units.

All morphometrics were standardized by standard length. Snout and schnabel lengths, orbit width and height and interorbital were also standardized by head length, and these last two also by orbit width.

Table 5. Statistical comparison of *S. fasciatus* and *S. mentella*

t-tests	*S. fasciatus* mean	*S. mentella* mean	P
snout-ventral (SL)	97.23	94.20	0.6%
snout-anal (SL)	169.51	169.38	*
body depth (SL)	89.84	80.53	<0.1%
peduncle depth (SL)	22.13	19.21	<0.1%
head length (SL)	88.16	88.60	*
snout length (SL)	21.27	21.52	*
snout length (HL)	23.80	24.03	*
schnabel length (SL)	9.68	9.56	*
schnabel length (HL)	11.23	11.07	*
orbit width (SL)	28.11	31.68	<0.1%
orbit width (HL)	31.74	35.12	<0.1%
orbit height (SL)	27.09	30.59	<0.1%
orbit height (HL)	30.64	33.97	<0.1%
orbit height (OW)	24.07	24.33	*
interorbital (SL)	17.80	16.54	0.1%
interorbital (HL)	20.13	18.91	0.2%
interorbital (OW)	15.83	13.23	<0.1%
longest dorsal spine (SL)	30.77	24.83	<0.1%

SL = standardized by standard length
HL = standardized by head length
OW = standardized by orbit width
* = not significant at 1% level

page 1 of 2 ...

Table 5. Statistical comparison of *S. fasciatus* and *S. mentella* page 2 of 2.

Chi-Square Tests	RANGES *S. fasciatus*	*S. mentella*	P
Dorsal spines	13-18	14-16	*
Dorsal soft rays	11-17	14-18	<0.01%
Anal soft rays	6- 8	8-10	<0.01%
Pectoral rays	17-20	18-20	<0.01%
Vertebrae	28-30	30-31	<0.01%
Upper pre O. spine	40-120	50-100	*
Middle pre O. spine	70-170	90-170	*
Lower pre O. spine	120-230	140-220	*

* Not significant at 1% level

Table 6. Discriminant functions for species identification.

Function 1 Variable	Unstandardized Coefficient
Dorsal soft rays	0.380348
Anal soft rays	1.36631
Pectoral rays	0.527547
Vertebrae	2.35858
Lower Pre O. spine angle	0.611488×10^{-2}
Middle Pre O. spine angle	-0.520032×10^{-2}
Upper Pre O. spine angle	-0.116139×10^{-1}
Peritoneal colour	0.200551
Snout-ventral	0.171332×10^{-1}
Snout-anal	0.176482×10^{-1}
Body depth	-0.157765×10^{-1}
Peduncle depth	-0.146126
Head length	-0.598082×10^{-1}
Snout length	0.297471
Schnabël length	-0.848966×10^{-1}
Orbit width	0.969939×10^{-1}
Orbit height	0.204826
Interorbital	-0.368463×10^{-1}
Longest dorsal spine	-0.128964
Constant	-98.0272

Scores of less than 3.5 represent *S. fasciatus*

Scores of more than this represent *S. mentella*

Function 3 Variable	Unstandardized Coefficient
Dorsal soft rays	-0.269212
Anal soft rays	-1.29203
Pectoral rays	-0.425753
Vertebrae	-2.51685
Body depth	0.594997×10^{-1}
Snout length	-0.263132
Orbit height	-0.237971
Longest dorsal spine	0.132478
Constant	97.2208

Scores of more than -3.3 represent *S. fasciatus*

Scores of less than this represent *S. mentella*

Table 7. Statistical comparison of *S. fasciatus* with fish allocated to this species by discriminant function .

t-tests	*S. fasciatus* mean	Others mean	p
Snout-ventral (SL)	97.2	95.9	*
Snout-anal (SL)	169.5	167.5	0.2%
Body depth (SL)	89.8	87.5	<0.1%
Peduncle depth (SL)	22.1	20.8	<0.1%
Head length (SL)	88.1	86.5	<0.1%
Snout length (SL)	21.3	20.2	<0.1%
Snout length (HL)	23.8	23.1	<0.1%
Schnabel length (SL)	9.7	9.1	<0.1%
Schnabel length (HL)	11.2	10.8	<0.1%
Orbit width (SL)	28.1	27.4	*
Orbit width (HL)	31.7	31.5	*
Orbit height (SL)	27.1	26.5	*
Orbit height (HL)	30.6	30.5	*
Orbit height (OW)	24.1	24.1	*
Interorbital (SL)	17.8	17.8	*
Interorbital (HL)	20.1	20.4	*
Interorbital (OW)	15.8	16.1	*
Longest dorsal spine (SL)	30.8	29.6	<0.1%

* Not significant at 1% level.

HL = Standardized by head length

SL = Standardized by standard length

OW = Standardized by orbit width

Chi-square tests	RANGES		p
	S. fasciatus	Others	
Dorsal spines	13- 18	14- 16	*
Dorsal soft rays	11- 17	13- 16	*
Anal soft rays	6- 8	6- 9	0.95%
Pectoral rays	17- 20	17- 20	*
Vertebrae	28- 30	29- 30	<0.01%
Upper Pre O. spine angles	40-120	40-120	<0.01%
Middle Pre O. spine angles	70-170	80-160	*
Lower Pre O. spine angles	120-230	120-220	0.98%

* not significant at 1% level

Table 8. Statistical comparison of *S. mentella* with fish allocated to this species by discriminant function 1.

t-tests	*S. mentella* mean	Others mean	p
Snout-ventral (SL)	94.2	100.0	<0.1%
Snout-anal (SL)	169.4	168.2	*
Body depth (SL)	80.5	82.9	*
Peduncle depth (SL)	19.2	20.5	0.1%
Head length (SL)	88.6	90.9	*
Snout length (SL)	21.5	21.9	*
Snout length (HL)	24.0	23.9	*
Schnabel length (SL)	9.6	9.6	*
Schnabel length (HL)	11.1	10.8	*
Orbit width (SL)	31.7	30.8	*
Orbit width (HL)	35.1	33.5	*
Orbit height (SL)	30.6	29.5	*
Orbit height (HL)	34.0	32.2	0.7%
Orbit height (OW)	24.3	24.0	*
Interorbital (SL)	16.5	17.9	0.2%
Interorbital (HL)	18.9	19.8	*
Interorbital (OW)	13.2	14.8	*
Longest dorsal spine (SC)	24.8	28.5	0.1%

* not significant at 1% level

SL = standardized by standard length

HL = standardized by head length

OW = standardized by orbit width

Chi-square tests	RANGES		p
	S. mentella	Others	
Dorsal spines	14- 16	12- 16	*
Dorsal soft rays	14- 18	14- 17	*
Anal soft rays	8- 10	7- 10	0.18%
Pectoral rays	18- 20	18- 20	*
Vertebrae	30- 31	30- 31	*
Upper Pre O. spine angles	50-100	40-100	*
Middle Pre O. spine angles	90-170	100-170	*
Lower Pre O. spine angles	140-220	160-220	*

* not significant at 1% level.

Table 9. Statistical comparisons between Divisions 4Vs, 4W, 4X and 5Y

t-tests	VsW	VsX	VsY	WX	WY	XY
Snout-ventral (SL)	*	*	0.1%	*	*	*
Snout-anal (SL)	*	*	*	<0.1%	*	*
Body depth (SL)	*	<0.1%	<0.1%	<0.1%	0.4%	*
Peduncle depth (SL)	<0.1%	<0.1%	<0.1%	*	*	*
Head length (SL)	<0.1%	<0.1%	<0.1%	*	*	*
Snout length (SL)	<0.1%	<0.1%	*	*	*	*
Snout length (HL)	0.2%	*	*	*	0.4%	*
Schnabel length (SL)	*	*	*	*	0.3%	*
Schnabel length (HL)	*	*	*	*	<0.1%	0.7%
Orbit width (SL)	<0.1%	<0.1%	*	*	0.1%	0.2%
Orbit width (HL)	0.3%	*	*	*	<0.1%	0.1%
Orbit height (SL)	<0.1%	<0.1%	*	*	<0.1%	<0.1%
Orbit height (HL)	<0.1%	*	*	*	<0.1%	<0.1%
Orbit height (OW)	*	*	*	*	*	*
Interorbital (SL)	*	*	*	*	*	*
Interorbital (HL)	*	*	*	*	*	*
Interorbital (OW)	*	*	*	*	0.7%	0.9%
Longest dorsal spine (SL)	*	*	0.7%	*	*	*

* = not significant at 1% level — HL = standardized by head length

SL = standardized by standard length — OW = standardized by orbit width

Chi-square tests	VsW	VsX	VsY	WX	WY	XY
Dorsal spines	*	*	*	*	*	*
Dorsal soft rays	*	*	*	*	*	*
Anal soft rays	*	*	*	*	*	*
Pectoral rays	*	*	*	*	*	*
Vertebrae	-	-	-	*	*	*
Upper Pre O. spine angle	0.02%	0.24%	*	*	*	*
Middle Pre O. spine angle	*	*	*	*	*	*
Lower Pre O. spine angle	0.7%	0.55%	0.12%	*	*	*

* not significant at 1% level

\- not enough data for test

Table 10. Statistical comparisons between suggested stocks.

	Slope Basin	Slope Inshore	Slope Gulf of Maine	Basin Inshore	Basin Gulf of Maine	Inshore Gulf of Maine
t-tests						
Snout-ventral (SL)	*	*	*	*	*	*
Snout-anal (SL)	*	*	*	*	*	*
Body depth (SL)	*	0.2%	0.8%	*	<0.1%	0.3%
Peduncle depth (SL)	*	0.1%	*	0.1%	*	<0.1%
Head length (SL)	*	0.6%	0.9%	0.7%	<0.1%	<0.1%
Snout length (SL)	*	*	<0.1%	*	<0.1%	*
Snout length (HL)	*	*	<0.1%	*	<0.1%	*
Schnabel length (SL)	*	*	*	*	*	*
Schnabel length (HL)	*	*	0.4%	*	*	*
Orbit width (SL)	0.5%	*	*	*	*	*
Orbit width (HL)	<0.1%	*	*	*	0.3%	*
Orbit height (SL)	*	*	*	*	*	*
Orbit height (HL)	0.5%	*	*	*	0.3%	*
Orbit height (OW)	*	*	*	*	*	*
Interorbital (SL)	*	*	*	*	*	*
Interorbital (HL)	*	*	*	*	*	*
Interorbital (OW)	*	*	*	*	*	*
Longest dorsal spine (SL)	<0.1%	*	*	-	-	*

\- not enough data for test

* not significant at 1% level

SL - standardized by standard length
HL - standardized by head length
OW - standardized by orbit width

	Slope Basin	Slope Inshore	Slope Gulf of Maine	Basin Inshore	Basin Gulf of Maine	Inshore Gulf of Maine
Chi-square tests						
Dorsal spines	*	*	*	*	*	*
Dorsal soft rays	*	*	*	*	*	*
Anal soft rays	0.36%	*	*	*	*	*
Pectoral rays	*	*	*	*	*	*
Vertebrae	*	*	*	*	*	*
Upper Pre O. spine angle	*	*	*	0.4%	*	*
Middle Pre O. spine angle	*	*	*	*	*	*
Lower Pre O. spine angle	*	*	*	*	*	*

* not significant at 1% level

Table 11. Characters suggested for use in distinguishing *Helicolenus* and *Sebastes* for research vessel technicians, observers and port samplers.

	Helicolenus	*Sebastes*
Vertebral number	23, 24	28-31
Anal soft rays	3 - 5	6 - 10
Dorsal spines	11 - 13	12 - 18
	(*Sebastes* with 12 spines are very rare. Most fish in my samples with 13 spines were *Sebastes*)	
Lower pectoral rays	free of fin membrane	attached
Peritoneal colour	always black	black, grey, silver
Length	Usually less than 20 cm (individuals over 30 cm have been reported[1])	can be much larger

Some specimens outside the ranges given above can be expected. The freedom of pectoral rays should be used cautiously., since they can appear to be free in *Sebastes* if the membrane is torn.

[1] Leim and Scott, 1966

Table 12. Characters for routine identification of 4VWX *Sebastes*.

	S. fasciatus	*S. mentella*
Anal soft rays	6-7 (sometimes 8)	8 - 10
Vertebrae	28-30	30 - 31

An assumption of one species per set appears to be acceptable, thus average values for the fish caught can be used.

Anal soft rays	<8	>8
Vertebrae	<29.3	>29.9

FIGURE 1 : STATIONS, SHOWING CRUISE AND SET NUMBERS
CRUISES LH014,20,21 AND AT292 PLAIN
CRUISES LH026,27 CIRCLED

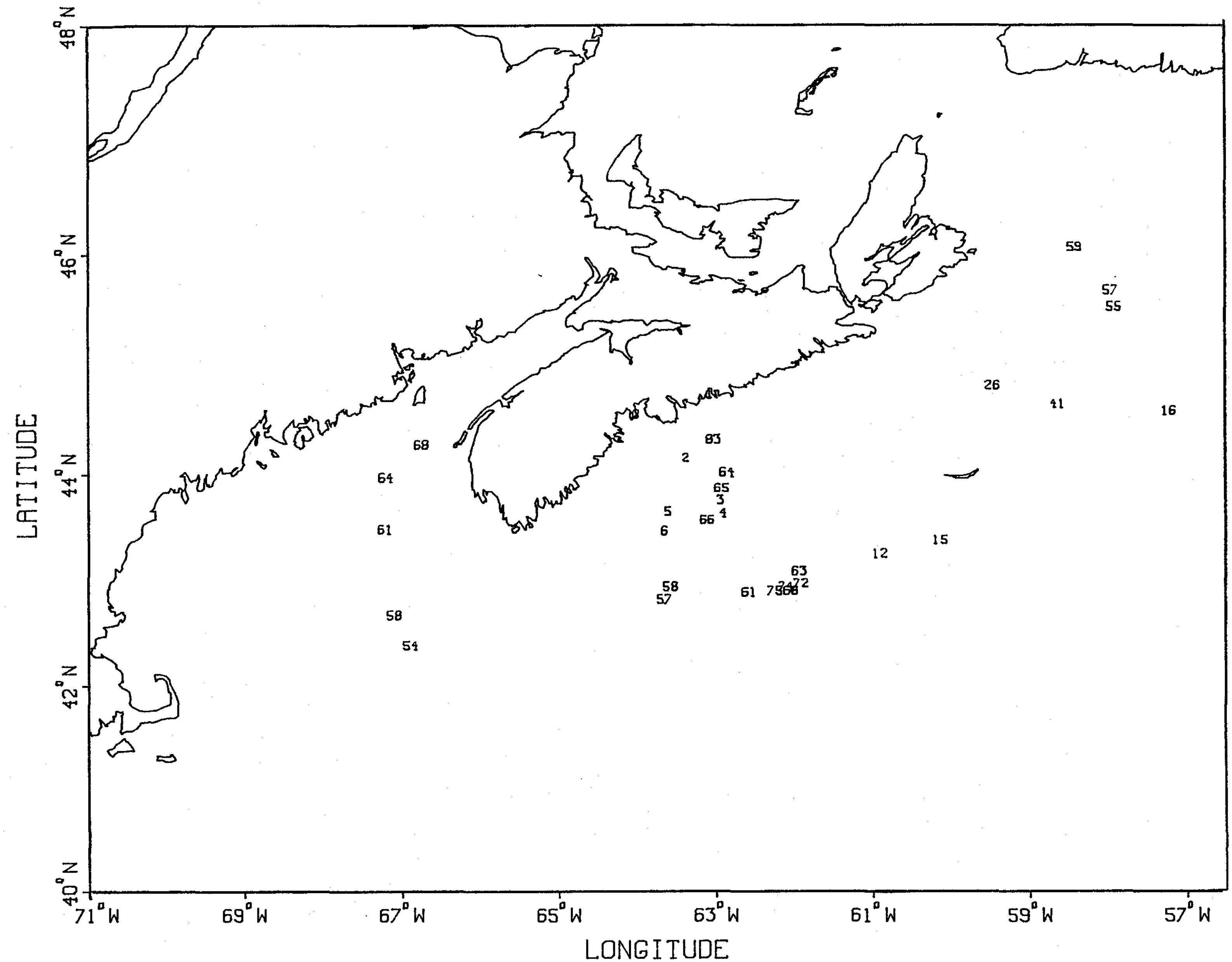
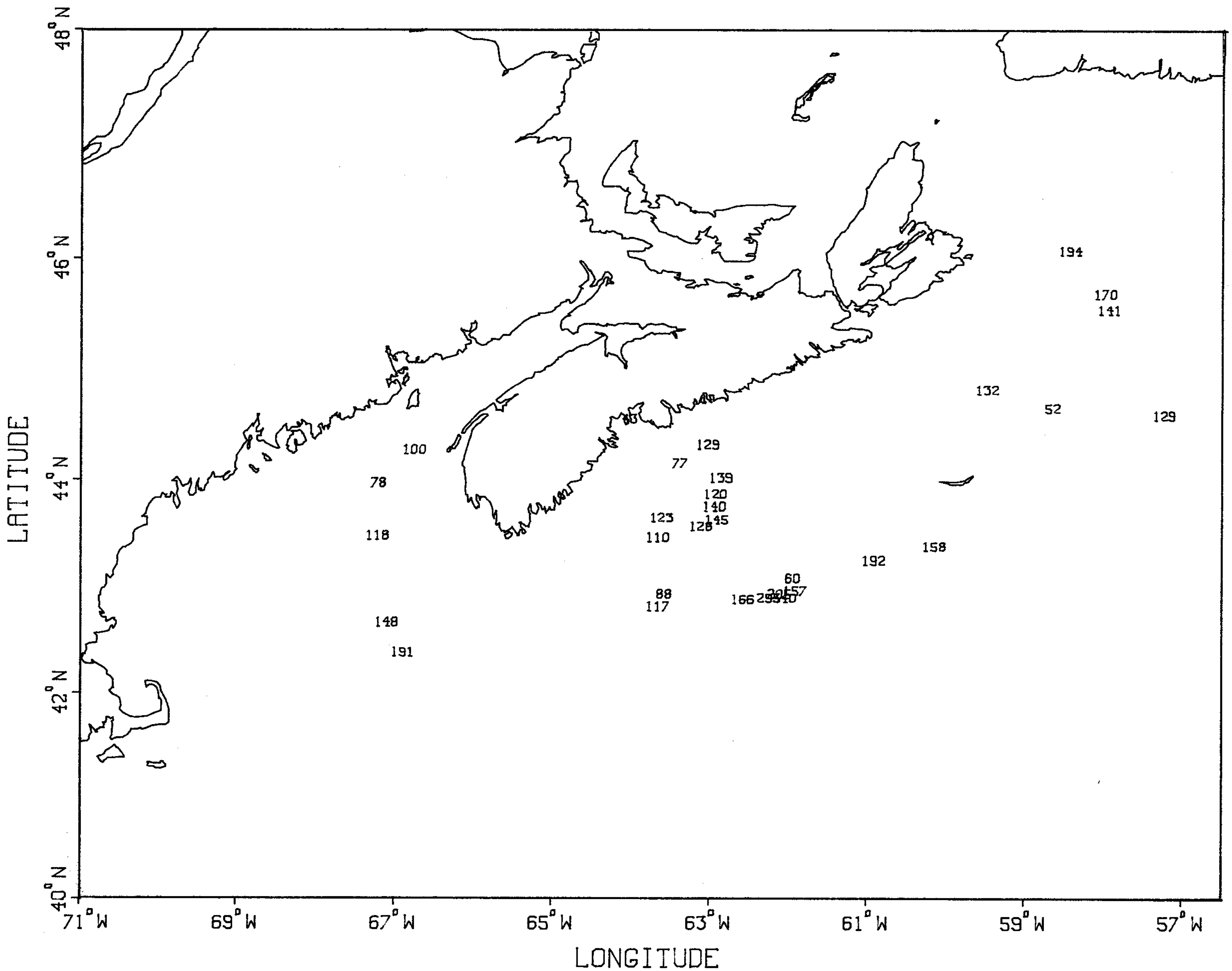


FIGURE 2 : STATIONS, SHOWING DEPTH IN FATHOMS



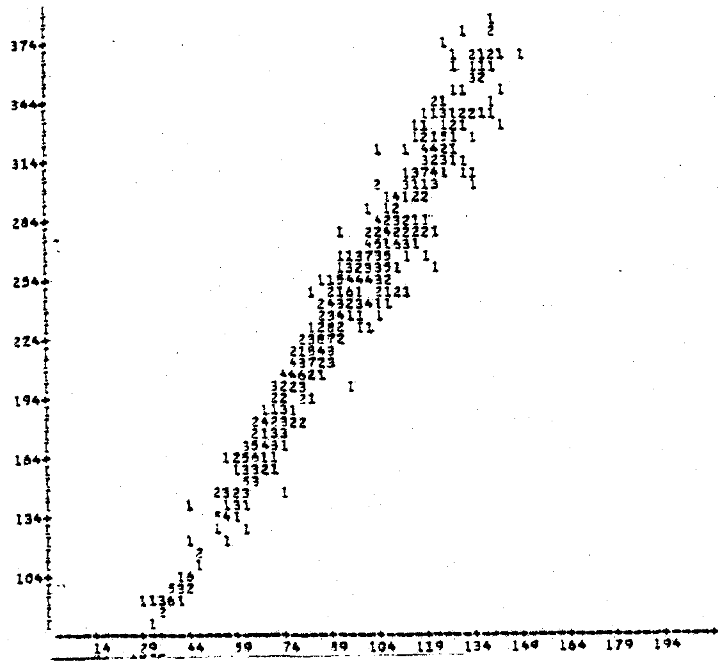


Figure 3: standard length vs. snout-ventral fin

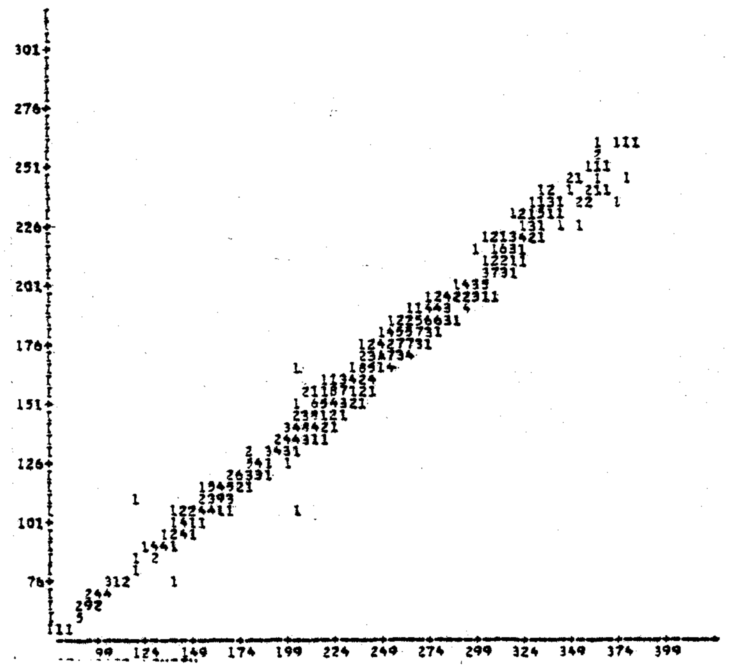


Figure 4: Snout-Anal fin vs. standard length

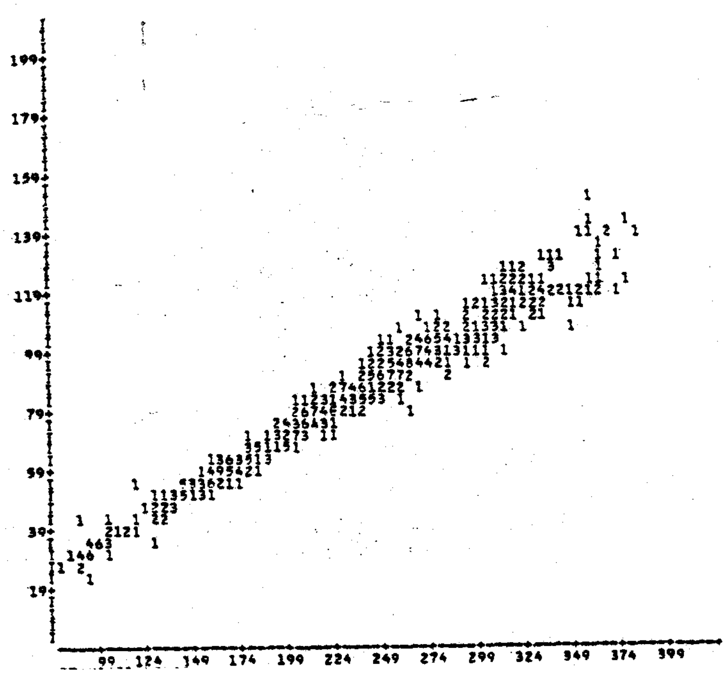


Figure 5: body depth vs. standard length

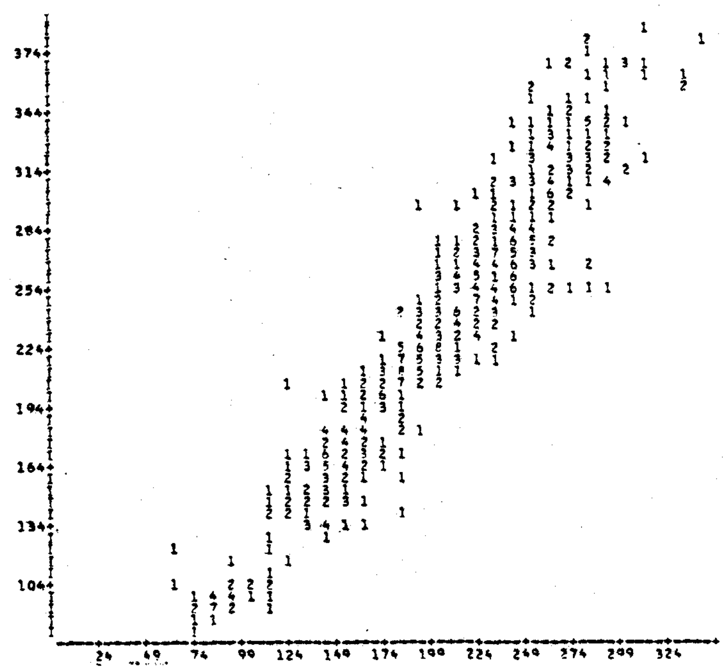


Figure 6: Standard length vs. peduncle depth (x 10)

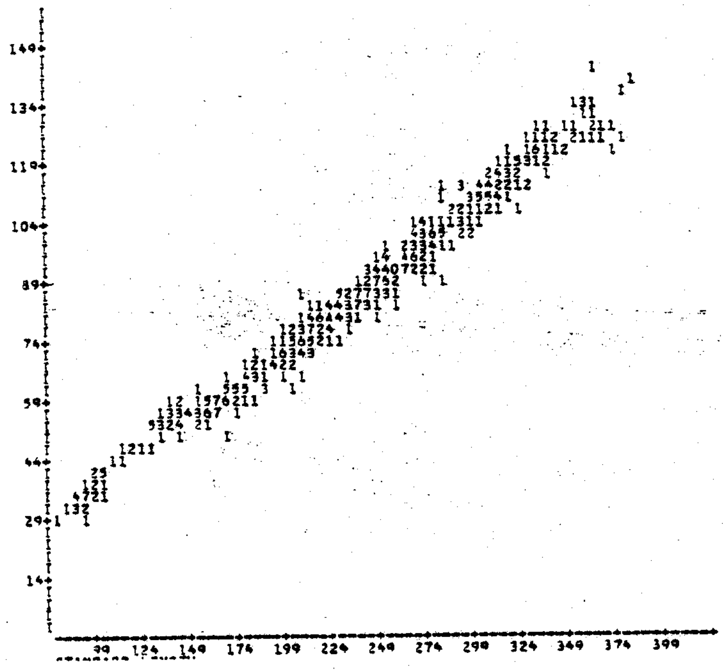


Figure 7: Head length vs. standard length

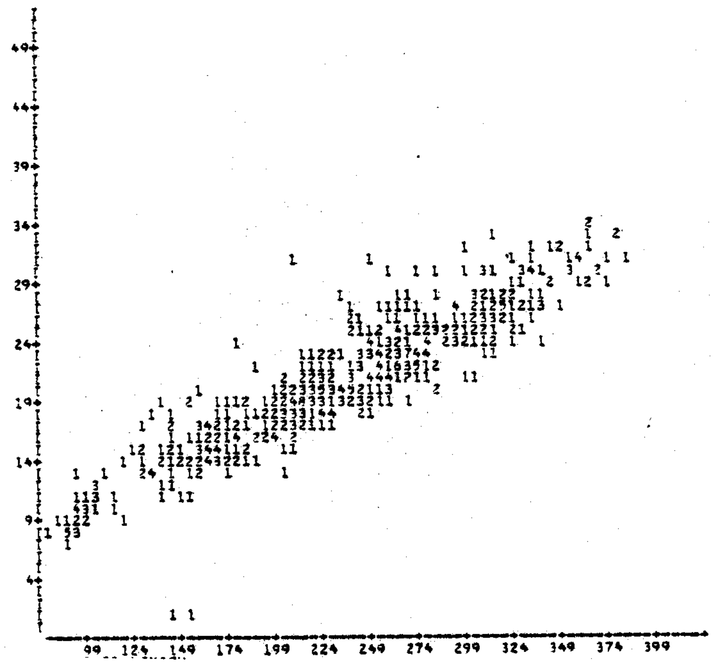


Figure 8. Snout length vs. standard length

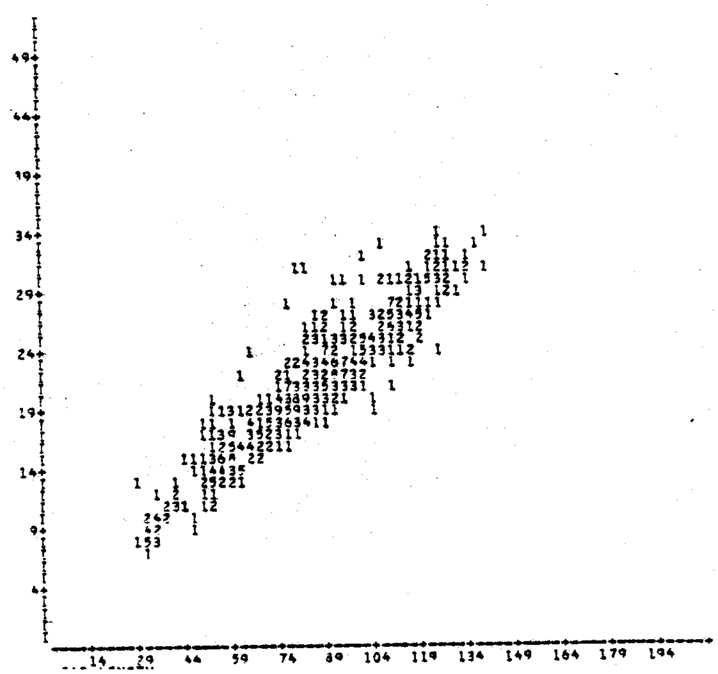


Figure 9: Snout length vs. head length

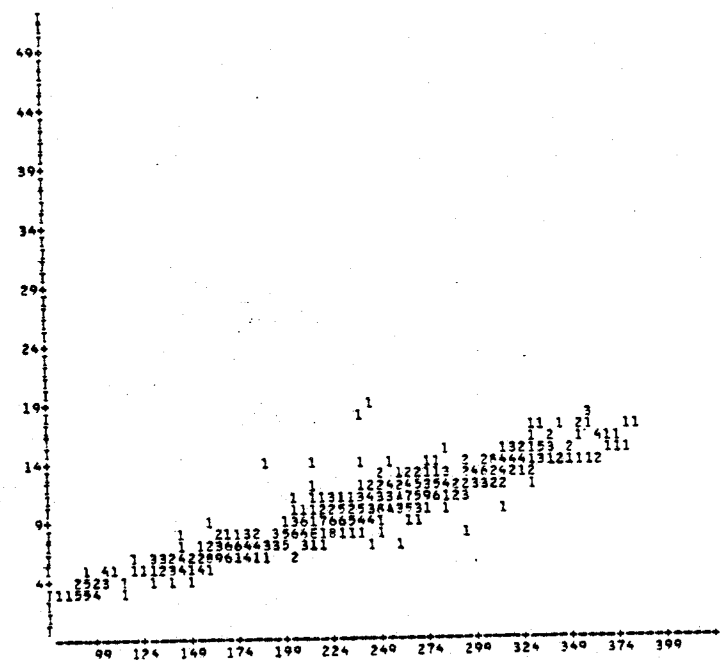


Figure 10: Schnabel length vs. standard length

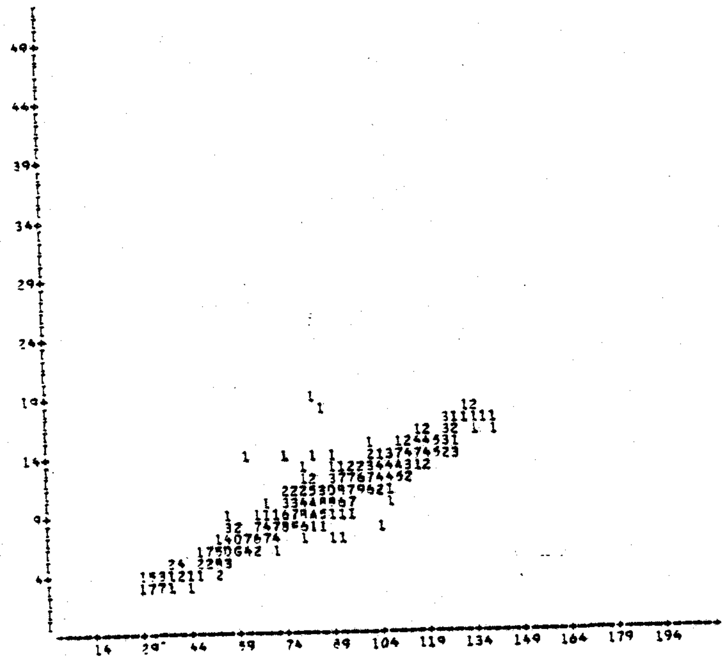


Figure 11: Schabel length vs. head length

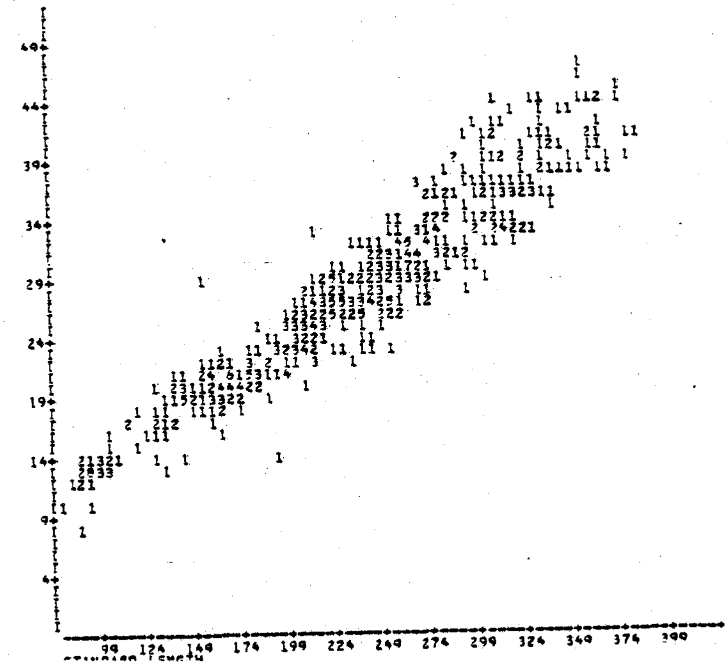


Figure 12: Orbit width vs. standard length

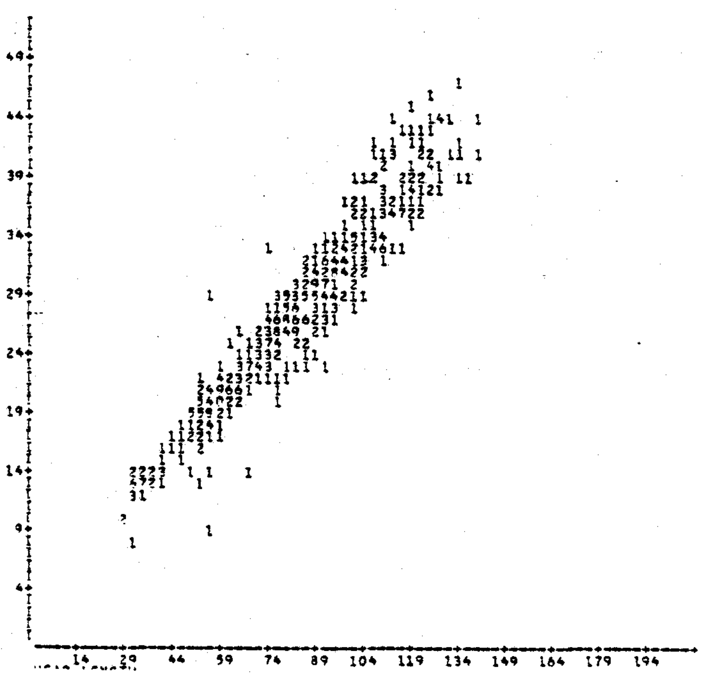


Figure 13: Orbit width vs. head length

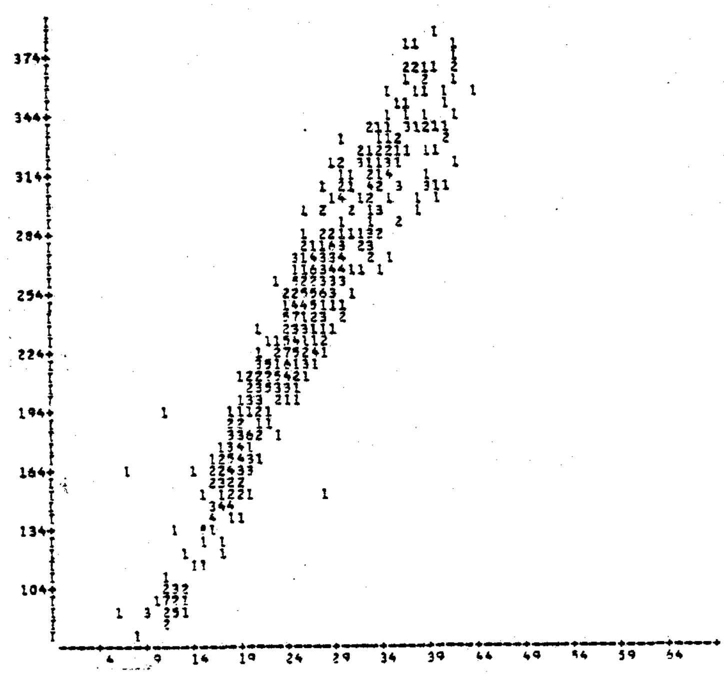


Figure 14: Standard length vs. orbit height

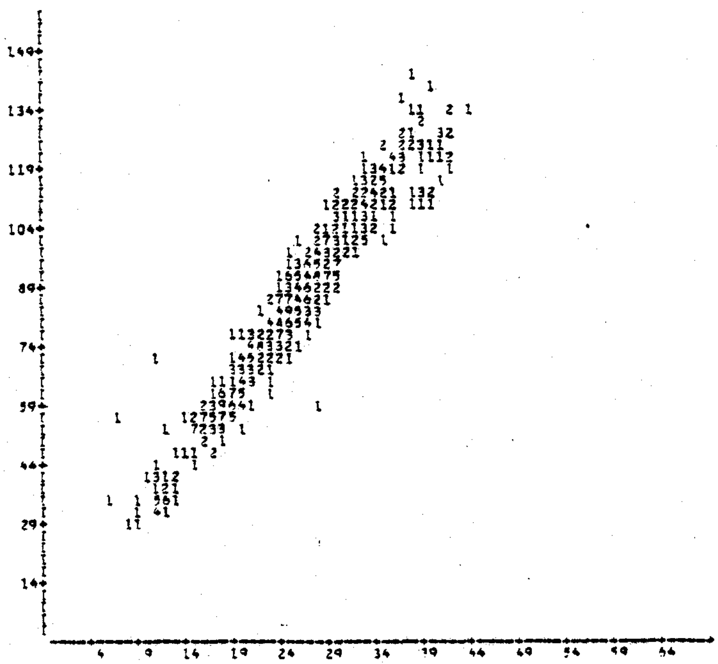


Figure 15: Head length vs. orbit height

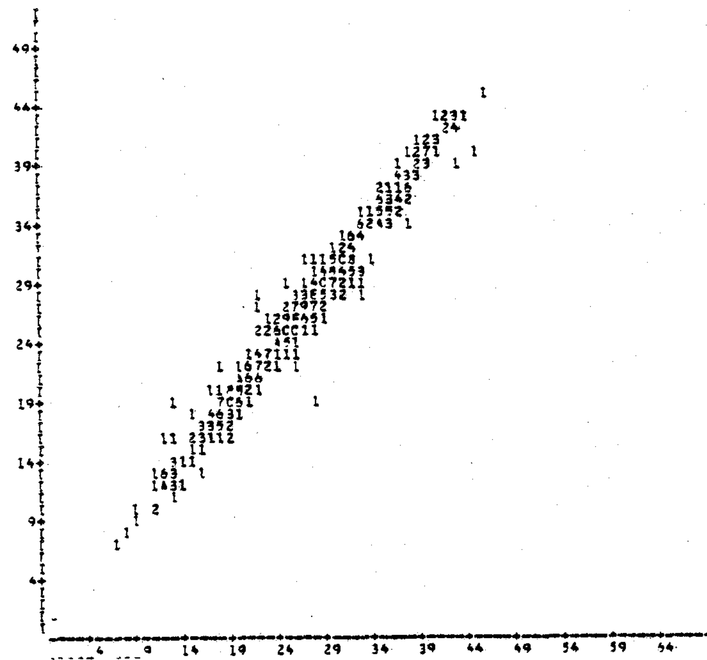


Figure 16: Orbit height vs. orbit width

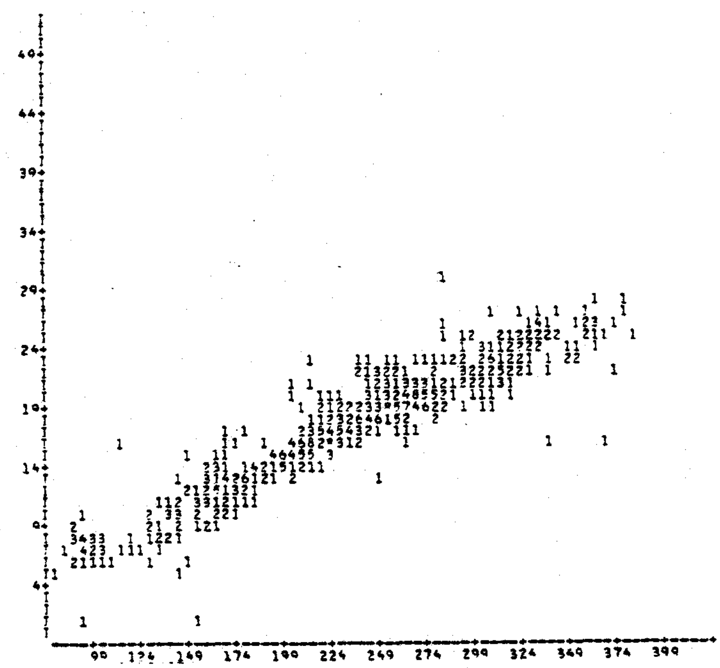


Figure 17: Interorbital distance vs. standard length

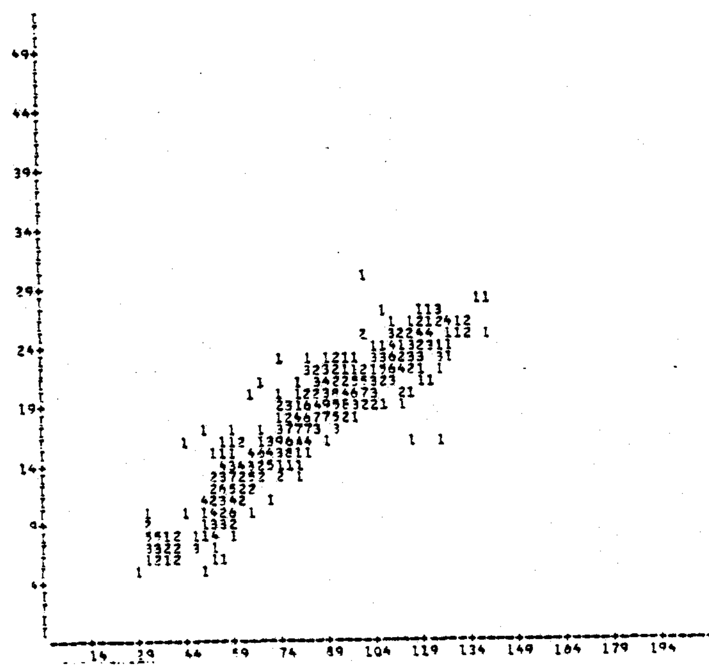


Figure 18: Interorbital distance vs. head length

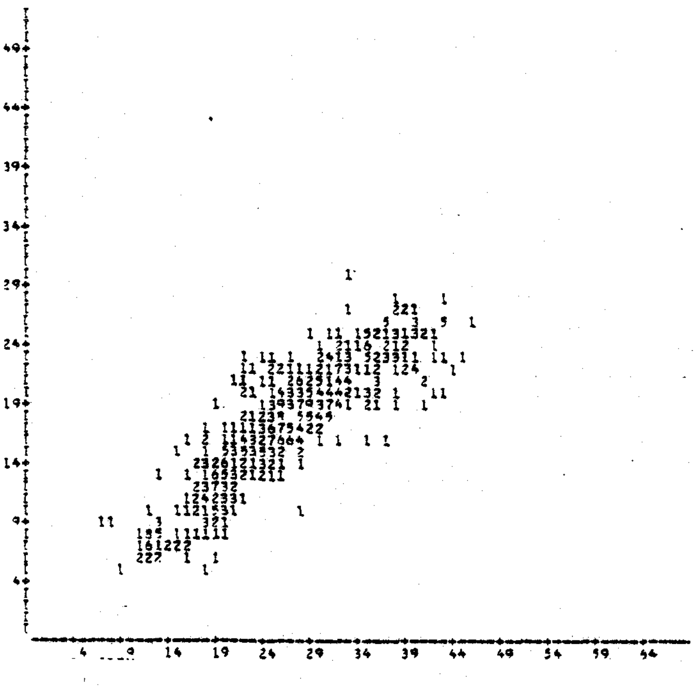


Figure 19: Interorbital fistance vs.
Orbit width

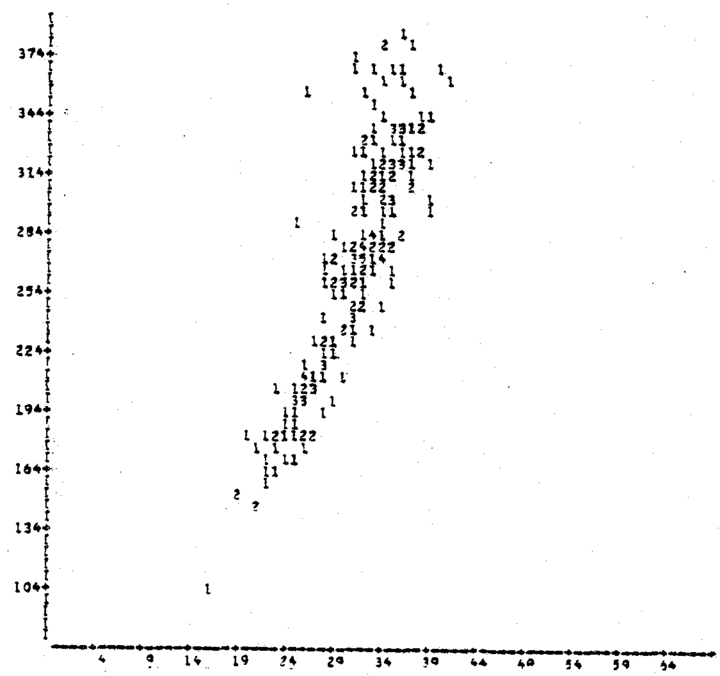


Figure 20: Standard length vs.
length longest dorsal spine

Figures 21 to 28: Meristics

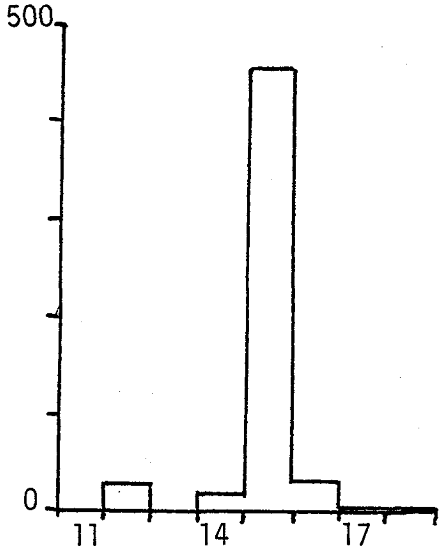


Fig 21: Dorsal spines

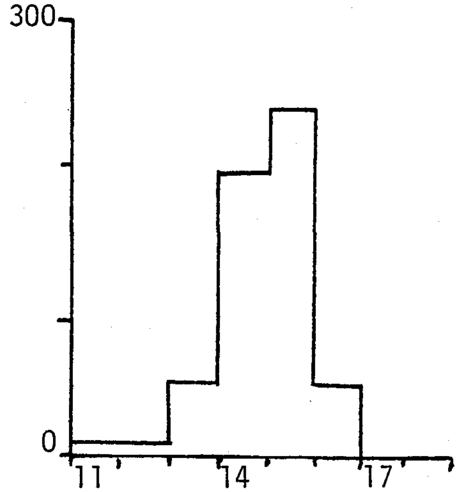


Fig 22: Dorsal soft rays

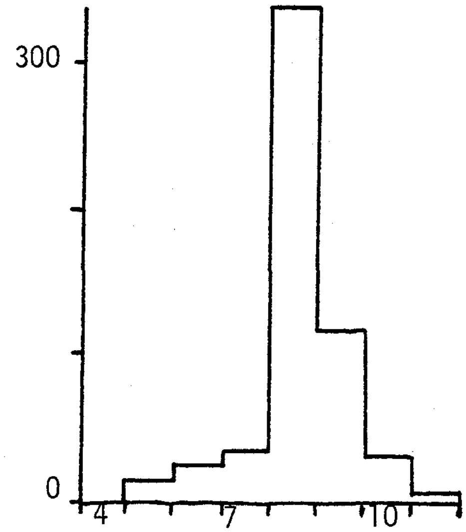


Fig 23: Anal soft rays

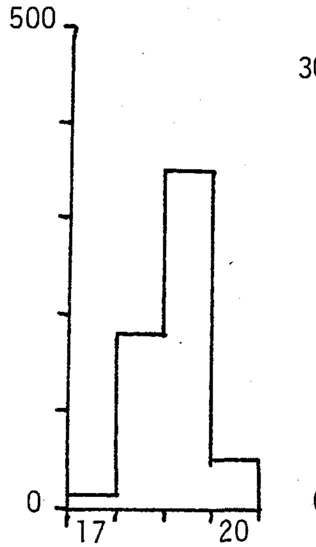


Fig 24: Pectoral rays

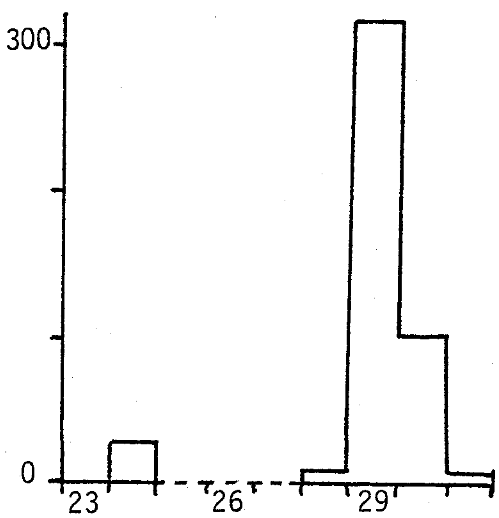


Fig 25: Vertebrae

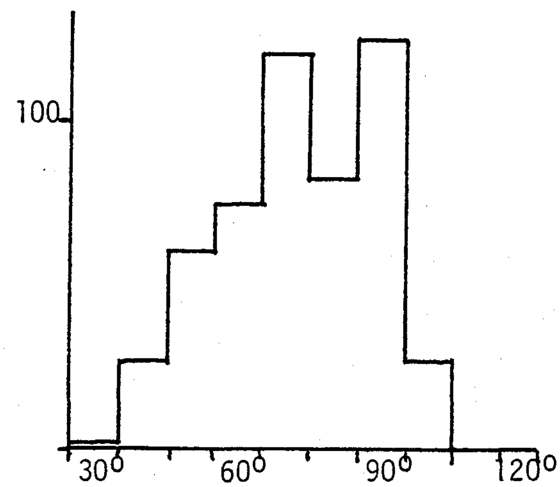


Fig 26: Upper pre-opercular spine

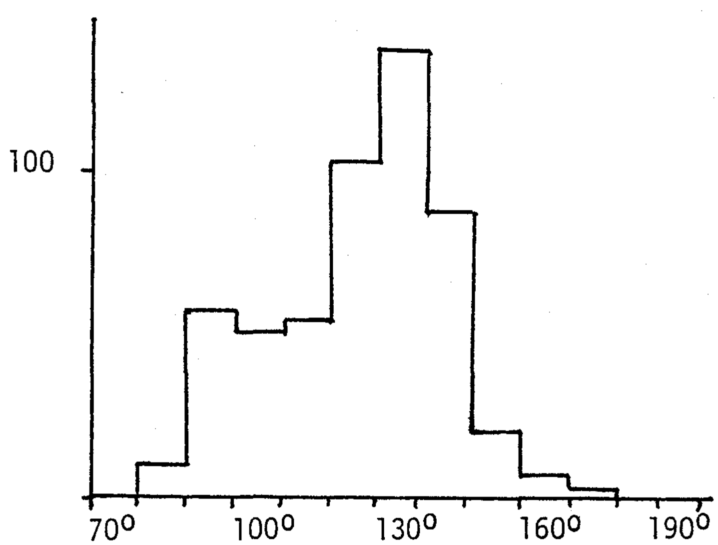


Fig 27: Middle pre-opercular spine

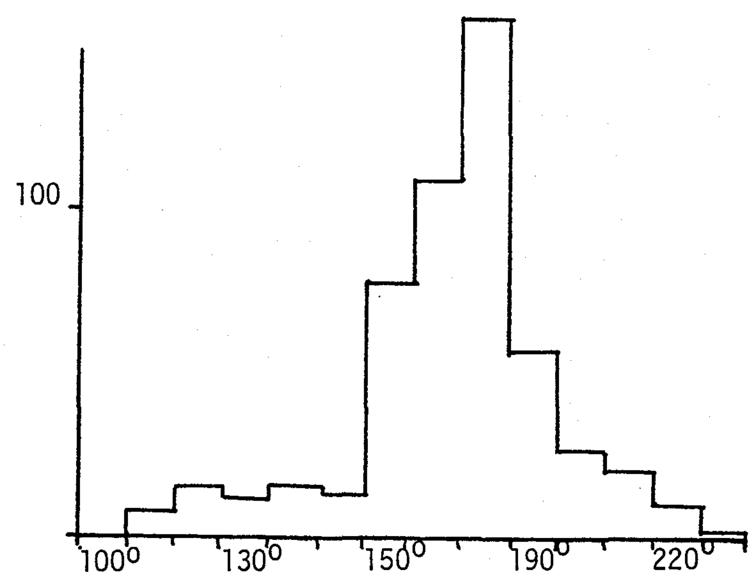


Fig 28: Lower pre-opercular spine

Figure 29: Peritoneal colour

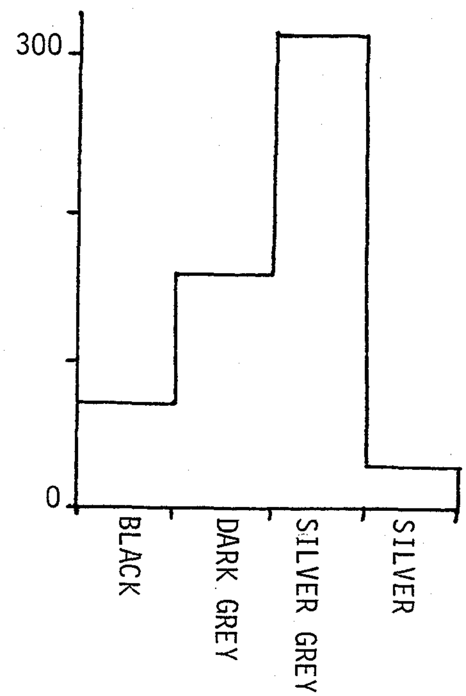


Figure 30: Discriminant function 1: histogram of scores