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Distribution of Roughhead and Roundnose Grenadiers in the Northwest Atlantic

by

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### Introduction

Over 300 species of macrourid fish have been identified throughout the oceans of the world and of these, more than 90% occupy the continental slopes between depths of about 200 and 2000 m (Marshall 1965). At least seven species have been found off the coast of eastern Canada (Liem and Scott 1966). The two largest of these are the roundnose grenadier (*Coryphaenoides rupestris* Gunnerus 1765) and the roughhead grenadier (*Macrourus berglax* Lacépède 1802), both of which are fairly widely distributed along the continental slope (Parsons 1976). Of these, the roundnose grenadiers are present in the greatest quantities and are exploited commercially under quota regulation imposed through the Northwest Atlantic Fisheries Organization (NAFO).

Parsons (1976) described the distribution and relative abundance of these two species off the east coast of Canada based on the results of Canadian research surveys conducted in the area from 1958-1973. This paper presents an update of this work based on the results of Canadian research surveys conducted from 1974-1986.

### Materials and Methods

Data concerning the distribution of the two species of grenadier were obtained from bottom trawl research surveys conducted by various vessels operating out of the Newfoundland Region of the Department of Fisheries and Oceans from 1974 to 1986. Trawling was carried out using either a No. 41-5 Yankee otter trawl, a No. 36 Yankee shrimp trawl, a Sputnik shrimp trawl or an Engels High Lift otter trawl. All nets contained a 60 mm liner in the codend and towing was normally at 3.5 knots for 30 min. No adjustments were made for any possible differences in catchability between the different gears. Fishing was carried out in depths of less than 200 m to depths greater than 1250 m and set allocation was not made on the basis of grenadier distribution. Distribution of successful sets by units of 1/2 degree latitude by 1 degree longitude are shown in Figure 1.

The data were first analysed by species for distribution of average catches (kg) by units of 1/2 degree latitude by 1 degree longitude. In addition, the average catches (kg), the mean weight of individual fish (kg) and the mean bottom temperatures were calculated for 100 m depth intervals by NAFO Subarea and Division. Finally, the sex ratios of the two species were examined by depth range and NAFO Subarea and Division.

### Results

#### Roundnose Grenadier

This species was primarily taken along the continental slope from about 66° N to the southern tip of the Grand Banks and west towards the Gulf of St. Lawrence (Figure 2). The largest catches were found off West Greenland (SA 1), and off Labrador (Div. 2GHJ). Slightly smaller quantities were found off northern and central Newfoundland (Div. 3K and northeastern Div. 3L). A few specimens were taken around the edge of

Flemish Cap and the Grand Banks as well as along the Laurentian Channel outside the Gulf of St. Lawrence. Only one was caught in the gulf itself, and this was taken in the southeastern part.

Roundnose grenadier were not found in significant amounts in depths of less than about 500 m (Table 1 and Figure 3). In the areas of the largest mean catches (SA 1, Div. 2GHJ), the greatest weights were usually taken in about 500-1000 m (largest being 1674 kg per standard tow in 801-900 m in Div. 2H) with catches decreasing beyond these depths. Mean bottom temperatures in these depths ranged from about 2.0-4.5°C. In the area of the greatest commercial effort (Div. 3K), catches were fairly stable from about 500 m to the greatest depths fished (largest being 137 kg per standard tow in 901-1000 m), in mean bottom temperatures of 3.4-3.9°C. In the more southerly areas of SA 3, the largest catches were generally taken between 601-700 m (largest being 22 kg per standard tow in Div. 3O) corresponding to bottom temperatures of 3.5-3.9°C. In divisions 3P and 4RST, where catches were the smallest (<1 kg per standard tow), bottom temperatures were above 5.0°C. Throughout the entire area, some roundnose grenadier were taken in bottom temperatures as low as 1.5°C and as high as 6.1°C.

Average fish weights ranged from 0.03-0.93 kg in the area surveyed (Table 2 and Figure 4). Generally, in depths of the greatest concentrations (>500 m), there was a gradual increase in size of the grenadier with depth in the more northern areas (eg. 0.56-0.86 kg in Div. 2J) down to about Div. 3K. Further south, fish size with depth was quite variable. The mean fish weights were lower in subareas 0 and 1 (particularly SA 1) (about 0.2-0.3 kg) than those in SA 2 (about 0.55 kg) and Div. 3M (about 0.4 kg). Fish in SA 3 were also somewhat smaller (0.2-0.4 kg) than those in SA 2. A few large fish were taken in depths of 201-300 m in divisions 3L and 3N (0.9 kg) and some very small fish (0.03 kg) were taken in Div. 3N.

The sex ratios (Table 3 and Figure 5) do not indicate any trends with depth or geographic area. Overall the ratio is about 60% males and 40% females.

#### Roughhead Grenadier

The largest catches of roughhead grenadiers were generally less than those of roundnose grenadier but the roughheads appear to be more widely distributed. They were caught from the western and southern Grand Banks in the south to as far north as about 69° N between Baffin Island and Greenland (Figure 6). The best average catches were off the north and east slopes of the Grand Bank (Div. 3LN) (10-26 kg per standard tow). Good catches were also obtained in SA 0 and 1 between Baffin Island and Greenland (8-12 kg per standard tow). Off central Labrador, catches were intermediate (6-10 kg) between those in the more northern and southern areas. Only small catches were taken along the west slope of the Grand Bank and in Div. 3P as far west as off the eastern part of St. Pierre Bank. None were taken in the Gulf of St. Lawrence.

There were no significant catches of roughhead grenadiers made in depths of less than 200 m, but they were taken from 200 m to the greatest depths fished (Table 4 and Figure 7). In the more northern areas there is an apparent trend in average catches with depth with catches peaking at about 701-900 m (at maximum levels of 10-15 kg per standard tow) then decreasing at greater depths. Bottom temperatures at these depths ranged between about 2.5-4.5°C. Further south (divisions 3L and 3N), significant catches were made in somewhat shallower waters (301-500 m) as well as at the greatest depths fished (9-19 kg per standard tow). Temperatures averaged about 1.0-4.2°C in this area. Only few roughheads were taken in divisions 3O and 3P (generally <5 kg per standard tow) and bottom temperatures were above 5.0°C.

The fish ranged in weight from 0.25-1.22 kg throughout the surveyed area but generally were between about 0.5-0.9 kg. Overall, there does not appear to be any definite trend with regard to fish size and depth (Table 5 and Figure 8) but it can be seen that in many instances larger fish were taken in the shallowest depths (even though the overall amounts caught were small). In some areas (eg Div. 2G and 2J) the data may be interpreted to suggest a slight increase in weight with depth to about 800 m followed by a gradual decline on moving deeper. Fish weights in subareas 0 and 1 appear to be lower, on average (0.38-0.48 kg), than those from the more southern areas where weights ranged from about 0.6-1.19 kg. Fish weights increase somewhat moving from north to south.

An examination of sex ratios (Table 6 and Figure 9) does not indicate any clear trend with depth but it may be argued that the percentage of females increases from north to south, going from about 50-55% in subareas 0 and 1 to about 89% in Div. 3P.

## Discussion

### Roundnose Grenadier

Roundnose grenadier have previously been reported to dwell along the continental slopes as far north as about 66°N in both the northwest Atlantic (Marshall and Iwamoto 1973) and the northeast Atlantic (Eliassen MS 1983a). The results of the Canadian surveys in the north, to about 70°N, confirm a northern limit of the range in Davis Strait to about 66°N. A total of 4 specimens (0.15 kg) were taken at 66° 28.5'N but none were captured north of this. In the northeast Atlantic, this species has been found further north along the coast and in the fjords of Norway (Eliassen MS 1983b) however, there are no reports of similar findings in the more northern coastal waters of West Greenland.

Parsons (1976) reported that based on research data collected between 1958 and 1973, catches were greatest off Funk Island Bank (Div. 3K), Hamilton Bank (Div. 2J) and the northern third of Labrador (Div. 2GH). More recent data indicate that the largest concentrations reside off West Greenland (SA 1) (an area not included to a large extent in Parsons' (1976) database) and in NAFO divisions 2GHJ. The present study, however, indicated somewhat smaller catches of roundnose grenadier in Div. 3K. It has been hypothesized (Chumakov and Savvatimsky MS 1983) that the cooling of the water masses in the northwest Atlantic in the 1975-1983 period resulted in a dispersal of roundnose grenadier along with movement into deeper, warmer waters since the species forms the densest concentrations when temperatures are above 4°C. Using their argument, any cooling should have resulted in a drop in the catches of roundnose in all areas, not just in Div. 3K. Comparison of the two data sets however, would suggest a disproportionate drop in Div. 3K. A comparison of mean temperatures at depth between Parsons' (1976) study and this paper does not indicate any major shift in bottom temperatures in the two time periods between about 500-1000 m. The average temperatures (about 3.4-4.0°C), while below those suggested by Chumakov and Savvatimsky (MS 1983) as being preferred, do not appear to be at the limits of the species' tolerance (cf. Eliassen MS 1983b, Magnússon MS 1977). Eliassen (MS 1983b) does suggest that roundnose grenadier adapt to quite different temperatures in different regions of the continental slopes of the north Atlantic.

Since its inception in 1967, the commercial fishery has primarily been prosecuted in Div. 3K. Savvatimsky and Shafran (MS 1981) noted that from 1967-1970 this fishery, conducted over a limited area of the continental slope in Div. 3K, appeared to adversely affect the stock here. They also state that after 1971 the fishing grounds in Div. 3K expanded and the stock in this area appeared to recover based on mean fish lengths. Parsons' (1976) research data from 1958 to 1973 only encompassed 7 years of the commercial fishery when landings from Div. 3K averaged about 17,500 t and standardized catch rates remained quite high (Atkinson and Power MS 1987). Since 1973 annual landings from Div. 3K have averaged only about 8000 t and standardized catch rates have declined considerably (from about 2 t/hr in 1973 to less than 1 t/hr in 1981-1985) (Atkinson and Power MS 1987). The apparent change in abundance in Div. 3K from the earlier period may thus be a reflection of the commercial fishery.

The results of this study confirm previous work (eg. Parsons 1976, Savvatimsky 1972) that in the northwest Atlantic relatively few roundnose grenadier are found south of Div. 3K. Very few were taken in the depths fished in Div. 3L and south between 1974 and 1986. In Div. 3P and the Gulf of St. Lawrence bottom temperatures were higher on average than those of other areas, usually being above 5.0°C. The species is known to range as far south as Cape Hatteras (Liem and Scott 1966).

Very few roundnose grenadier are present in depths less than 500 m. Parsons (1976) reported that in the northwest Atlantic overall, only small numbers of roundnose grenadier were caught at depths less than about 366 m. Examination of his data indicates that except for some large catches in Div. 2G (1046 kg based on 2 sets in 367-410 m) very few were taken in depths less than 276 fathoms (505 m). It has been reported (Forest *et al* MS 1978) that in SA 0 there were no catches in depths less than about 200 fathoms (366 m) and very few between 200-300 fathoms (366-549 m). The largest catches were taken in two strata with a combined depth range of 300-700 fathoms (449-1280 m). Berth and Vaske (MS 1980) reported that in divisions 2GHJ combined, very few were caught shallower than 500 m in 1979. Catches were greatest between about 525 and 925 m in bottom temperatures of about 3.7-3.9°C.

Savvatimsky (MS 1983) also reported that in SA 0 and divisions 2GHJ combined, very few roundnose grenadier were taken in less than 500 m in 1983 and 1984. In addition, he indicated that the mean weight of roundnose grenadier caught per tow increased with increasing depth down to the maximum fished (1300 m in 1983 and 1500 m in 1984). The Canadian data, however, suggest that the amounts decrease beyond about 1000 m. This may be attributed to possible changes in distribution with season, or, more likely, to a decrease in the efficiency of the fishing trawls used by Canada beyond depths of about 750-1000 m. Roundnose grenadier have been caught as deep as 1750-2600 m in Div. 3K and as deep as 1000-1200 m in Div. 3M (Konstantinov MS 1980).

Konstantinov (MS 1980) notes that this species forms commercial concentrations in shallower waters in the north (600-800 m in SA 0) than in the south (1000-1300 m in Div. 3K) and suggests a geographic cline with depth distribution. In the area around Iceland, they were most abundant in 600-1000 m (Magnússon MS 1977) at bottom temperatures of 3.2-6.8°C and along the continental slopes off the Hebrides and Rockall the largest catches were taken in 600-900 m at temperatures ranging from 7.6-11.5°C (Eliassen MS 1983b). In the coastal waters and fjords of Norway (north of about 66°N), the species was taken in 350-707 m of water. In this area, bottom temperatures were quite warm, being about 6.0-6.7°C.

Although taken demersally, roundnose grenadier have also been caught pelagically. Haedrich (1974) reported a modal distance off bottom of 480 m in the Denmark Straits, and Savvatimsky (1969) noted that in the northwest Atlantic, concentrations can be found to 300-500 m up from the bottom. More recently, Eliassen (MS 1983b) reported catches up to 100 m off the bottom along the coast and in the fjords of Norway, but the largest pelagic concentrations were found only about 25 m off bottom.

Savvatimsky (1969) concluded that the largest roundnose grenadier live off Iceland and are, on average, about 20 cm (total length) longer than those off northeastern Newfoundland (Div. 3K). In the northwest Atlantic, he, as well as Podrazhanskaya (MS 1976) found a gradual decline in size of these fish from north to south contrary to our results which show smaller fish in subareas 0 and 1. Berth *et al* (MS 1979) also found that the roundnose grenadier in SA 0 were smaller than those in SA 2. Fish caught in Div. 3K were intermediate in size between the two subareas, similar to the results of our analyses. Our data also show a north-south decline in fish size in subareas 2 and 3.

Savvatimsky (1969) stated that the length of the fish may increase gradually with depth but never decreases. Our data suggest more variability than this although in the more northern areas there is an increasing trend in fish size with depth. In water shallower than 500 m, large fish were often encountered although present in relatively few numbers. Parsons (1976) also found that the largest fish were occasionally found in relatively shallow water (eg. Div. 3K).

Our study indicated that in the northwest Atlantic, the sex ratio was fairly constant over the entire area during 1974-1986, there being about 40% females and 60% males. Savvatimsky (1969) also reported that the sex ratio was quite constant along the whole of the continental slope regardless of season or depth being about 65% males from 1965-1968. This same researcher (Savvatimsky 1972) noted that the fishery in a small area of Div. 3K from 1967 to 1969 had an apparent effect on the sex ratio which changed from 39.3% to 30.8% females over this period. Geistdoerfer (1979) found 69.1% of the roundnose grenadier caught to be males during experimental fishing on the continental slope of Newfoundland and Labrador in 1975. More recently, Savvatimsky (1982) reported that the sex ratio is subject to seasonal as well as year-to-year fluctuations and is dependent on water temperatures.

In the northeast Atlantic the sex ratio is quite different. Savvatimsky (1969) found that only about 30% of the roundnose grenadier caught off Iceland were males. Magnússon (MS 1977) noted that in some areas off Iceland the percentage females was as high as 91%. The difference in the sex ratios between the northeast and northwest Atlantic, along with the fact that larger fish are found off Iceland, led Zakharov and Mokanu (MS 1970) to suggest that the spawning area for roundnose grenadier in the north Atlantic is off Iceland. They hypothesized that the eggs and larvae were carried passively to West Greenland and off Baffin Island and eventually to the continental slope of Canada. Larger, maturing fish migrate back to Iceland to spawn. This hypothesis was supported by Podrazhanskaya (MS 1971) but refuted by Grigorev (1972) and Savvatimsky (1972). They argued that because of the shape of these fish, they were probably not capable of the long migrations back from Canadian waters to Iceland. Grigorev noted that juveniles (about 8 cm) were found along all of the Canadian coast as well as along West Greenland and even in southwest Iceland waters and suggested that this observation would be unlikely if there was localized spawning off Iceland only. Savvatimsky noted that sexually mature individuals were caught in depths of 1400-1500 m in the northwest Atlantic and that the percentage of mature individuals increased with depth. He also concluded that the difference in the weight-at-length of the fish off Iceland and those in the northwest Atlantic was indicative of different stocks. These two authors proposed that spawning takes place in the northwest Atlantic in waters deeper than those generally fished (>1000 m). Geistdoerfer (1979) has confirmed the presence of sexually mature individuals in the northwest Atlantic and concluded that spawning takes place in spring. He agrees with the observations of Grigorev and Savvatimsky above.

#### Roughhead Grenadier

Similar to the roundnose, roughhead grenadier are found in both the northeast and northwest Atlantic. They have been caught along the continental slope of North America

from Davis Strait to as far south as Georges Bank, off West and southern Greenland, Spitzbergen and northern Norway (Liem and Scott 1966). They are also found as far north as 82° 10'N along the western boundary of the Barents Sea (Savvatimsky MS 1983). The results of this study, along with those of Parsons (1976) indicate that they are more widely distributed in the northwest Atlantic than roundnose grenadier but in fewer numbers. Overall, the distribution of roughhead grenadier in the northwest Atlantic from 1974-1986 was very similar to that reported by Parsons (1976) for the period 1958-1973. The areas of the largest concentrations as reported here, divisions 3L and 3N, correspond to the areas where Parsons (1976) found the largest concentrations. The concentrations reported here in subareas 0 and 1 are in areas largely not included in Parsons' (1976) database.

Roughhead grenadier are found in shallower depths than are roundnose (Savvatimsky 1969). In the northwest Atlantic only a few were caught shallower than about 200 m (Parsons 1976 and this study). Our results indicated that bottom trawl catches peaked deeper than 300 m then decreased again beyond about 700-900 m. Parsons (1976) concluded that in the northwest Atlantic the largest concentrations were found between about 300-500 m although his data do in fact, indicate sizable concentrations between 500 and about 775 m (deepest fished) in many areas. Savvatimsky (MS 1983) found that when fishing longlines in divisions 3LMNO, although roughheads were caught over the entire range fished (300-1000 m), the largest numbers of specimens per thousand hooks were taken in depths of 400-500 m (about 65 fish). Beyond this range, catches again decreased. Results of USSR bottom trawlings in SA 0 and divisions 2GHJ combined in 1983 and 1984 however, indicate that the highest catch rates were achieved in depths of about 600-1000 m (Savvatimsky MS 1986). Forest *et al* (MS 1978) found that in SA 0 the highest catch rates were achieved between about 100 and 200 fathoms (183-366 m) and these decreased in deeper water. In the northwest Atlantic, roughhead grenadier were found in temperatures ranging from about -0.5 to 5.4°C with the largest concentrations in bottom temperatures of <4.0°C. Overall, they appear to be more tolerant of cooler water than the roundnose as noted by Parsons (1976).

Around Iceland, this species has been mainly found in 350-800 m and temperatures of 3.0-5.0°C (Magnússon MS 1977). Along the continental slope of Norway, catch rates were greatest in about 600-700 m (Bakken *et al* MS 1975, Eliassen MS 1983a) although the fish were found from 500-910 m. Bottom temperatures in the areas of highest concentration were between 1.0 and 4.0°C but the fish were caught in water as cold as -0.5°C and as warm as 5.5°C (Eliassen MS 1983a). Thus it appears that the distribution of roughhead grenadier by depth and temperature is more similar in the northeast and northwest Atlantic than that of the roundnose. Eliassen (MS 1983a) does point out that the salinity levels at equivalent temperatures in the northwest Atlantic are somewhat lower than in the northeast Atlantic.

Our finding, that roughhead grenadier appear to be smaller in subareas 0 and 1 than further south, can also be concluded from an examination of Parsons' (1976) data. There is also an indication of smaller fish in SA 0 from the results of a research cruise conducted in the northwest Atlantic by the German Democratic Republic in 1978 (Berth *et al* MS 1979). Savvatimsky (MS 1983) reported that roughhead grenadier in divisions 3N and 3O were somewhat larger than those in more northern areas and our results support this finding.

Savvatimsky (MS 1983) noted that the mean weight of roughhead grenadier was about the same from 300-700 m then increased in deeper waters. We found, as did Parsons (1976), that the largest fish were often found in the shallowest waters (<200 m) although the abundance in this depth range is very low. Eliassen (MS 1983a) found a slight increase in fish size with depth along the continental slope of Norway with the larger fish in the deeper cooler water. He pointed out that if there is a difference in temperature preference with fish size, then the differences in the temperature profiles between the northeast and northwest Atlantic would explain the differences in the size distribution, as described by himself and Parsons (1976), in the two areas. This may serve as a partial explanation for the observed differences, but the subsequent increase in fish size again in the deeper waters in some areas of the northwest Atlantic (Parsons 1976 and this study) tend to suggest a more complex situation.

This study and the results of Geistdoerfer (1979) indicate that the sex ratio is variable but shows no trend with depth in Div. 3K and northward. Savvatimsky (MS 1983) found that in divisions 3LMNO almost all of the roughhead grenadier caught below 700 m were female. Our data suggest an increase in the percentage of females with depth in these same divisions as well as an overall increasing trend in the percentage of females with decreasing latitude south of subareas 0 and 1. Geistdoerfer (1979) found that the sex ratio varied sharply from one division to another (he examined data from divisions 2J, 3K and 3L) rather than any trend with latitude. He also noted that the ratio was different depending on the season, there being a higher percentage of males in the winter in divisions 2J and 3K. Magnússon (MS 1978) also found differences in the sex ratio at

different times of the year. Off Iceland the percentage males was 53.7% in March but it dropped to 40% in May. Eliassen and Jobling (1985) also documented changes in the sex ratio at different times of the year in catches of roughheads made in about 700 m off the coast of northern Norway. The results of our analyses may be complicated by the fact that fishing in the different areas is usually conducted at different times of the year and the apparent geographic cline in sex ratios may be an artifact of this. Alternately, it is possible that observed differences in sex ratio are a result of the relatively low sample sizes resulting from the low densities of this species.

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Table 1: Average catch (kg) of roundnose grenadier per 30 min. trawl by depth range (m) in NAFO subareas/divisions and corresponding average temperatures (°C) during research surveys conducted from 1974-1986 (numbers in parentheses are numbers of successful sets).

Depth (m)	Subarea 0		Subarea 1		Div. 2G		Div. 2H		Div. 2J	
	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C
<200	0 (2)	-1.0	0 (6)	2.3	0 (71)	0.5	0 (81)	0.3	0 (349)	0.5
201-300	0 (31)	0.7	0 (31)	2.9	+ (62)	1.5	0 (78)	1.4	+ (586)	1.6
301-400	0 (44)	1.7	0 (25)	3.5	+ (29)	3.0	0 (114)	3.0	+ (421)	2.5
401-500	0 (36)	2.2	+ (16)	3.9	4 (24)	3.7	5 (98)	3.3	1 (395)	3.0
501-600	+ (30)	2.5	+ (3)	4.0	208 (20)	3.9	33 (61)	3.5	11 (219)	3.2
601-700	1 (18)	2.8	2 (13)	3.2	141 (3)	4.1	2 (14)	3.4	64 (25)	3.9
701-800	3 (8)	2.7	61 (9)	3.6	33 (1)	3.6	99 (3)	4.4	58 (27)	3.8
801-900	33 (7)	2.6	99 (4)	3.2			1674 (3)	3.9	66 (21)	3.8
901-1000	19 (10)	3.0	589 (2)	4.1					70 (4)	3.7
1001-1250	23 (9)	3.2	168 (4)	4.0	68 (1)	-	293 (2)	4.1	146 (10)	3.5
>1250					3 (1)	3.6	51 (1)	3.6	26 (3)	3.4

Depth (m)	Div. 3K		Div. 3L		Div. 3M		Div. 3N		Div. 3O	
	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C
<200	0 (42)	-0.5	0(2399)	-0.5	0 (163)	3.8	0(1072)	1.0	0(1122)	2.1
201-300	0 (580)	1.6	+ (629)	1.1	0 (418)	4.0	+ (172)	2.5	+ (189)	6.1
301-400	+ (572)	2.8	+ (379)	2.6	0 (195)	3.9	+ (85)	3.1	+ (95)	5.4
401-500	1 (249)	3.1	+ (73)	3.4	+ (122)	3.8	0 (14)	3.2	0 (17)	5.0
501-600	57 (24)	3.9	1 (47)	3.5	+ (87)	3.7	+ (16)	3.5	9 (10)	4.2
601-700	70 (19)	3.7	11 (45)	3.7	+ (57)	3.7	3 (11)	3.5	22 (3)	3.9
701-800	113 (22)	3.7	1 (5)	3.6	0 (4)	3.6				
801-900	46 (22)	3.6								
901-1000	137 (6)	3.5								
1001-1250	60 (6)	3.4								
>1250	96 (6)	3.4								

Depth (m)	Div. 3P		Div. 4RST	
	Catch	°C	Catch	°C
<200	0(1038)	1.3	0 (473)	2.9
201-300	+ (564)	5.7	0(1010)	5.4
301-400	+ (326)	5.4	0 (263)	5.6
401-500	+ (205)	5.2	+ (40)	5.3
501-600	+ (10)	5.1	0 (2)	5.2
601-700	+ (10)	4.8		
701-800				
801-900				
901-1000				
1001-1250				
>1250				



Table 2: Mean fish weight (kg) of roundnose grenadier caught by depth range (m) in NAFO subareas/divisions during research surveys conducted from 1974-1986 (numbers in parentheses are numbers of fish).

Depth (m)	Subarea 0		Subarea 1		Div. 2G		Div. 2H		Div. 2J	
	Weight		Weight		Weight		Weight		Weight	
<200										
201-300					0.40	(1)			0.59	(8)
301-400					0.82	(1)			0.57	(28)
401-500			0.27	(13)	0.57	(132)	0.69	(674)	0.64	(861)
501-600	0.52	(3)	0.13	(3)	0.54	(7763)	0.57	(3343)	0.56	(4420)
601-700	0.20	(63)	0.16	(131)	0.47	(908)	0.39	(56)	0.39	(4184)
701-800	0.16	(190)	0.18	(3082)	0.39	(89)	0.60	(497)	0.43	(3646)
801-900	0.21	(1112)	0.20	(1968)			0.51	(9918)	0.46	(3022)
901-1000	0.36	(345)	0.23	(4976)					0.33	(839)
1001-1250	0.61	(340)	0.29	(2280)	0.51	(133)	0.76	(769)	0.77	(1908)
>1250					0.23	(11)	0.94	(54)	0.86	(92)
Overall	0.30		0.22		0.53		0.55		0.50	

Depth (m)	Div. 3K		Div. 3L		Div. 3M		Div. 3N		Div. 3O	
	Weight		Weight		Weight		Weight		Weight	
<200										
201-300			0.91	(5)			0.93	(53)	0.12	(17)
301-400	0.67	(7)	0.20	(1)			0.35	(63)	0.19	(5)
401-500	0.23	(791)	0.30	(1)	0.40	(1)				
501-600	0.27	(5139)	0.21	(212)	0.48	(8)	0.03	(48)	0.28	(315)
601-700	0.31	(4328)	0.21	(2378)	0.30	(2)	0.25	(150)	0.24	(275)
701-800	0.37	(6720)	0.14	(42)						
801-900	0.28	(3628)								
901-1000	0.28	(2890)								
1001-1250	0.28	(1293)								
>1250	0.49	(1173)								
Overall	0.31		0.21		0.44		0.35		0.26	

Depth (m)	Div. 3P		Div. 4RST	
	Weight		Weight	
<200				
201-300	0.22	(32)		
301-400	0.16	(10)		
401-500	0.20	(17)	0.18	(1)
501-600	0.14	(3)		
601-700	0.19	(15)		
701-800				
801-900				
901-1000				
1001-1250				
>1250				
Overall	0.20		0.18	

Table 3: Proportion of male roundnose grenadier caught by depth range (m) in NAFO subareas/divisions during research surveys conducted from 1974-1986 (numbers in parentheses are total numbers of fish sexed).

Depth (m)	Subarea 0		Subarea 1		Div. 20		Div. 2H		Div. 2J	
	Proportion		Proportion		Proportion		Proportion		Proportion	
<200										
201-300					1.00	(1)				
301-400									0.57	(28)
401-500			0.46	(13)	0.57	(7)	0.58	(170)	0.69	(622)
501-600	1.00	(1)	0.33	(3)	0.59	(4243)	0.62	(3239)	0.62	(2593)
601-700	0.59	(44)	0.51	(131)	0.58	(490)	0.66	(56)	0.58	(558)
701-800	0.65	(176)	0.65	(3082)			0.58	(377)	0.63	(2015)
801-900	0.61	(106)	0.66	(1968)			0.53	(372)	0.55	(1774)
901-1000	0.69	(345)	0.64	(4976)					0.68	(764)
1001-1250	0.54	(340)	0.63	(2280)					0.47	(19)
>1250										
Overall	0.63		0.64		0.59		0.60		0.62	

Depth (m)	Div. 3K		Div. 3L		Div. 3M		Div. 3N		Div. 3O	
	Proportion		Proportion		Proportion		Proportion		Proportion	
<200										
201-300										
301-400	1.00	(7)	0.00	(1)						(1)
401-500	0.60	(791)	1.00	(1)	0.00	(1)				
501-600	0.61	(4581)	0.42	(48)	0.63	(8)		(1)	0.54	(296)
601-700	0.61	(3112)	0.58	(2086)	1.00	(2)	0.57	(21)	0.81	(32)
701-800	0.64	(4913)	0.52	(42)						
801-900	0.62	(3158)								
901-1000	0.65	(2853)								
1001-1250	0.61	(71)								
>1250	0.60	(5)								
Overall	0.62		0.58		0.64		0.55		0.57	

Depth (m)	Div. 3P		Div. 4RST	
	Proportion		Proportion	
<200				
201-300				
301-400	0.00	(1)		
401-500	0.50	(2)		
501-600	0.00	(1)		
601-700	0.00	(6)		
701-800				
801-900				
901-1000				
1001-1250				
>1250				
Overall	0.10			

Table 4: Average catch (kg) of roughhead grenadier per 30 min. trawl by depth range (m) in NAFO subareas/divisions and corresponding average temperatures (°C) during research surveys conducted from 1974-1986 (numbers in parentheses are numbers of successful sets).

Depth (m)	Subarea 0		Subarea 1		Div. 20		Div. 2H		Div. 2J	
	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C
<200	0 (2)	-1.0	0 (6)	2.3	+ (71)	0.5	+ (81)	0.3	+ (349)	0.5
201-300	1 (31)	0.7	+ (31)	2.9	4 (62)	1.5	3 (78)	1.4	3 (386)	1.6
301-400	1 (44)	1.7	+ (25)	3.5	5 (29)	3.0	3 (114)	3.0	5 (421)	2.5
401-500	3 (36)	2.2	+ (16)	3.9	7 (24)	3.7	5 (98)	3.3	4 (395)	3.0
501-600	2 (30)	2.5	2 (3)	4.0	6 (20)	3.9	4 (61)	3.5	5 (219)	3.2
601-700	2 (18)	2.8	3 (13)	3.2	5 (3)	4.1	5 (14)	3.4	8 (25)	3.9
701-800	2 (8)	2.7	6 (9)	3.6	9 (1)	3.6	6 (3)	4.4	10 (27)	3.8
801-900	6 (7)	2.6	2 (4)	3.2			16 (3)	3.9	10 (21)	3.8
901-1000	2 (10)	3.0	6 (2)	4.1					4 (4)	3.7
1001-1250	1 (9)	3.2	5 (4)	4.0	2 (1)	-	13 (2)	4.1	5 (10)	3.5
>1250					0 (1)	3.6	2 (1)	3.6	+ (3)	3.4

Depth (m)	Div. 3K		Div. 3L		Div. 3M		Div. 3N		Div. 3O	
	Catch	°C	Catch	°C	Catch	°C	Catch	°C	Catch	°C
<200	0 (42)	-0.5	+ (2399)	-0.5	+ (163)	3.8	+ (1072)	1.0	+ (1122)	2.1
201-300	2 (380)	1.6	6 (629)	1.1	+ (418)	4.0	8 (172)	2.5	+ (189)	6.1
301-400	3 (572)	2.8	9 (379)	2.6	+ (195)	3.9	12 (85)	3.1	+ (95)	5.4
401-500	4 (249)	3.1	19 (73)	3.4	3 (122)	3.8	11 (14)	3.2	1 (17)	5.0
501-600	8 (24)	3.9	15 (47)	3.5	7 (87)	3.7	16 (16)	3.5	5 (10)	4.2
601-700	7 (19)	3.7	15 (45)	3.7	10 (57)	3.7	14 (11)	3.5	4 (3)	3.9
701-800	15 (22)	3.7	16 (5)	3.6	15 (4)	3.6				
801-900	10 (22)	3.6								
901-1000	7 (6)	3.5								
1001-1250	6 (6)	3.4								
>1250	4 (6)	3.4								

Depth (m)	Div. 3P		Div. 4RST	
	Catch	°C	Catch	°C
<200	0 (1038)	1.3	0 (473)	2.9
201-300	0 (564)	5.7	0 (1010)	5.4
301-400	+ (326)	5.4	0 (263)	5.6
401-500	+ (205)	5.2	0 (40)	5.3
501-600	1 (10)	5.1	0 (2)	5.2
601-700	1 (10)	4.8		
701-800				
801-900				
901-1000				
1001-1250				
>1250				

Table 5: Mean fish weight (kg) of roughhead grenadier caught by depth range (m) in NAFO subareas/divisions during research surveys conducted from 1974-1986 (numbers in parentheses are numbers of fish).

Depth (m)	Subarea 0		Subarea 1		Div. 2G		Div. 2H		Div. 2J	
	Weight		Weight		Weight		Weight		Weight	
<200					1.06	(5)	1.10	(5)	1.18	(64)
201-300	0.93	(20)	0.70	(1)	0.70	(386)	0.67	(326)	0.76	(2094)
301-400	0.37	(109)	0.54	(3)	0.64	(247)	0.68	(549)	0.88	(2557)
401-500	0.59	(209)	0.25	(27)	0.63	(258)	0.90	(547)	0.85	(2043)
501-600	0.36	(164)	0.86	(7)	0.81	(156)	0.73	(376)	0.81	(1247)
601-700	0.33	(110)	0.33	(113)	1.01	(14)	0.82	(78)	1.08	(173)
701-800	0.42	(46)	0.34	(146)	0.98	(9)	0.55	(33)	1.09	(245)
801-900	0.58	(75)	0.47	(19)			1.14	(42)	0.88	(229)
901-1000	0.63	(25)	0.63	(19)					0.58	(27)
1001-1250	0.64	(21)	0.46	(44)	0.61	(4)	0.67	(38)	0.65	(78)
>1250							0.32	(7)	0.56	(2)
Overall	0.48		0.38		0.69		0.76		0.84	

Depth (m)	Div. 3K		Div. 3L		Div. 3M		Div. 3N		Div. 3O	
	Weight		Weight		Weight		Weight		Weight	
<200			1.00	(159)	0.60	(1)	1.16	(312)	0.60	(1)
201-300	0.85	(1265)	0.84	(4322)	0.63	(12)	0.94	(1540)	0.66	(7)
301-400	0.86	(2311)	0.78	(4583)	0.66	(77)	0.87	(1136)	0.54	(34)
401-500	0.72	(1300)	0.76	(1842)	0.59	(599)	0.78	(198)	0.84	(14)
501-600	0.77	(256)	0.69	(1048)	0.74	(798)	0.98	(255)	0.91	(60)
601-700	0.58	(222)	0.86	(803)	0.72	(784)	0.86	(176)	0.99	(13)
701-800	0.66	(492)	0.70	(117)	0.66	(90)				
801-900	0.56	(374)								
901-1000	0.53	(83)								
1001-1250	0.65	(52)								
>1250	0.85	(28)								
Overall	0.78		0.80		0.69		0.93		0.80	

Depth (m)	Div. 3P		Div. 4RST	
	Weight		Weight	
<200				
201-300				
301-400	0.82	(3)		
401-500	0.47	(5)		
501-600	0.68	(9)		
601-700	1.22	(6)		
701-800				
801-900				
901-1000				
1001-1250				
>1250				
Overall	0.79			

Table 6: Proportion of male roughhead grenadier caught by depth range (m) in NAFO subareas/divisions during research surveys conducted from 1974-1986 (numbers in parentheses are total numbers of fish sexed).

Depth (m)	Subarea 0		Subarea 1		Div. 20		Div. 2H		Div. 2J	
	Proportion		Proportion		Proportion		Proportion		Proportion	
<200					0.60	(5)	0.00	(3)	0.35	(60)
201-300	0.31	(13)		(1)	0.53	(292)	0.60	(320)	0.51	(1308)
301-400	0.46	(28)	0.50	(2)	0.39	(110)	0.47	(326)	0.36	(1354)
401-500	0.32	(66)	0.56	(27)	0.31	(107)	0.36	(371)	0.31	(953)
501-600	0.50	(102)	0.00	(7)	0.40	(89)	0.43	(228)	0.40	(579)
601-700	0.45	(56)	0.43	(110)	0.00	(4)	0.56	(52)	0.27	(100)
701-800	0.34	(41)	0.53	(146)			0.47	(32)	0.44	(110)
801-900	0.58	(19)	0.63	(19)			0.38	(42)	0.45	(142)
901-1000	0.39	(23)	0.58	(19)					0.44	(27)
1001-1250	0.65	(20)	0.73	(44)	1.00	(4)	0.33	(9)	0.54	(13)
>1250							0.57	(7)	0.00	(1)
Overall		0.44		0.52		0.45		0.46		0.40

Depth (m)	Div. 2K		Div. 2L		Div. 3M		Div. 3N		Div. 3O	
	Proportion		Proportion		Proportion		Proportion		Proportion	
<200			0.46	(122)	0.00	(1)	0.39	(93)		
201-300	0.50	(1078)	0.43	(3505)	0.56	(9)	0.37	(879)	0.00	(2)
301-400	0.37	(1877)	0.34	(3680)	0.54	(67)	0.34	(643)	0.21	(14)
401-500	0.40	(937)	0.32	(1616)	0.51	(572)	0.25	(126)	0.20	(5)
501-600	0.28	(114)	0.33	(888)	0.41	(784)	0.20	(162)	0.37	(49)
601-700	0.47	(156)	0.27	(768)	0.43	(688)	0.23	(136)	0.08	(13)
701-800	0.48	(304)	0.42	(117)	0.40	(90)				
801-900	0.56	(370)								
901-1000	0.46	(56)								
1001-1250	0.71	(14)								
>1250	0.46	(13)								
Overall		0.43		0.37		0.45		0.33		0.28

Depth (m)	Div. 3P		Div. 4RST	
	Proportion		Proportion	
<200				
201-300				
301-400	0.00	(2)		
401-500	0.25	(4)		
501-600	0.00	(7)		
601-700	0.17	(6)		
701-800				
801-900				
901-1000				
1001-1250				
>1250				
Overall		0.11		

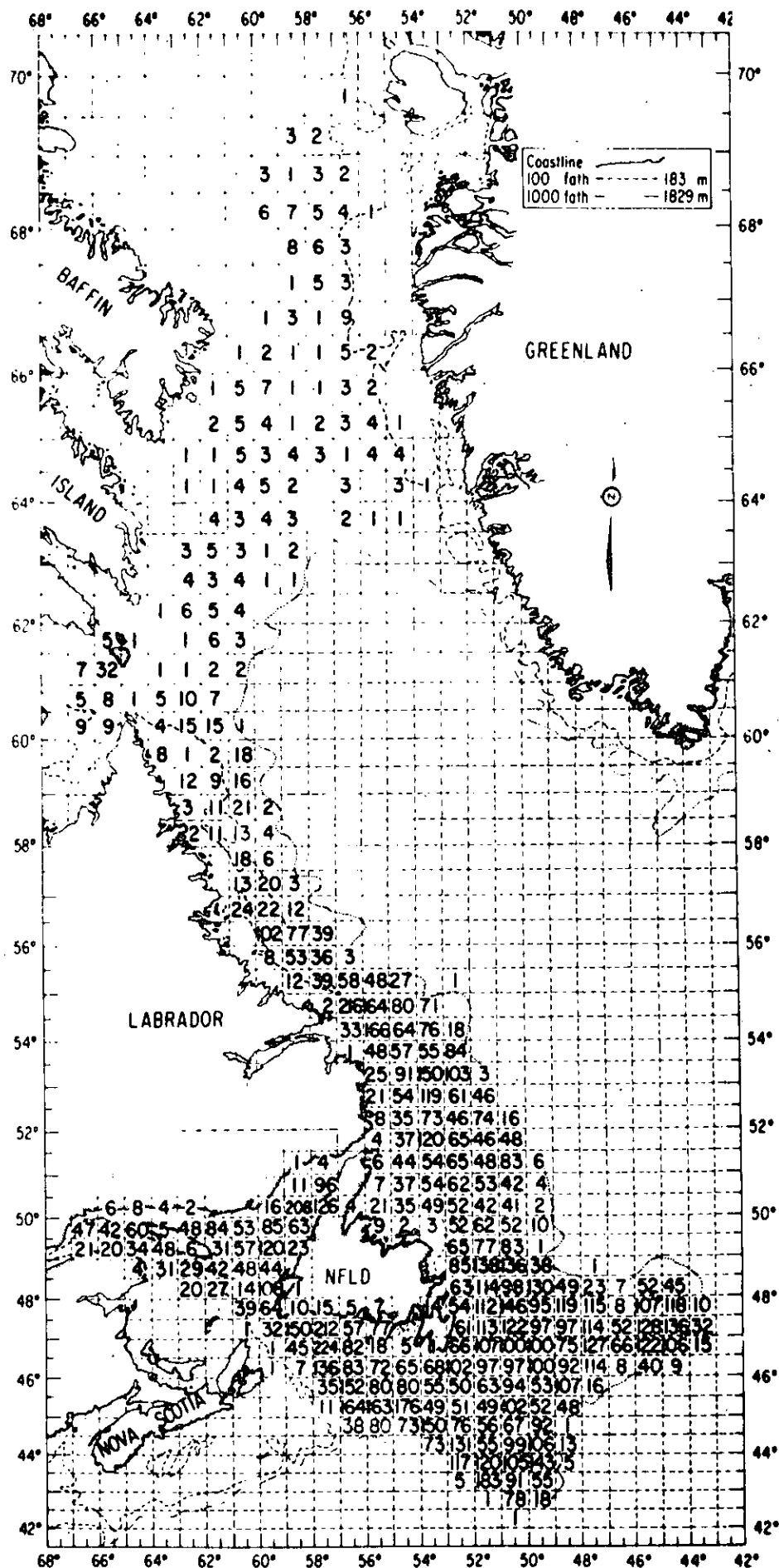


Figure 1: Distribution of successful 30 min. tows in the northwest Atlantic made by Canadian research vessels working out of the Newfoundland Region of the Department of Fisheries and Oceans during 1974-1986.

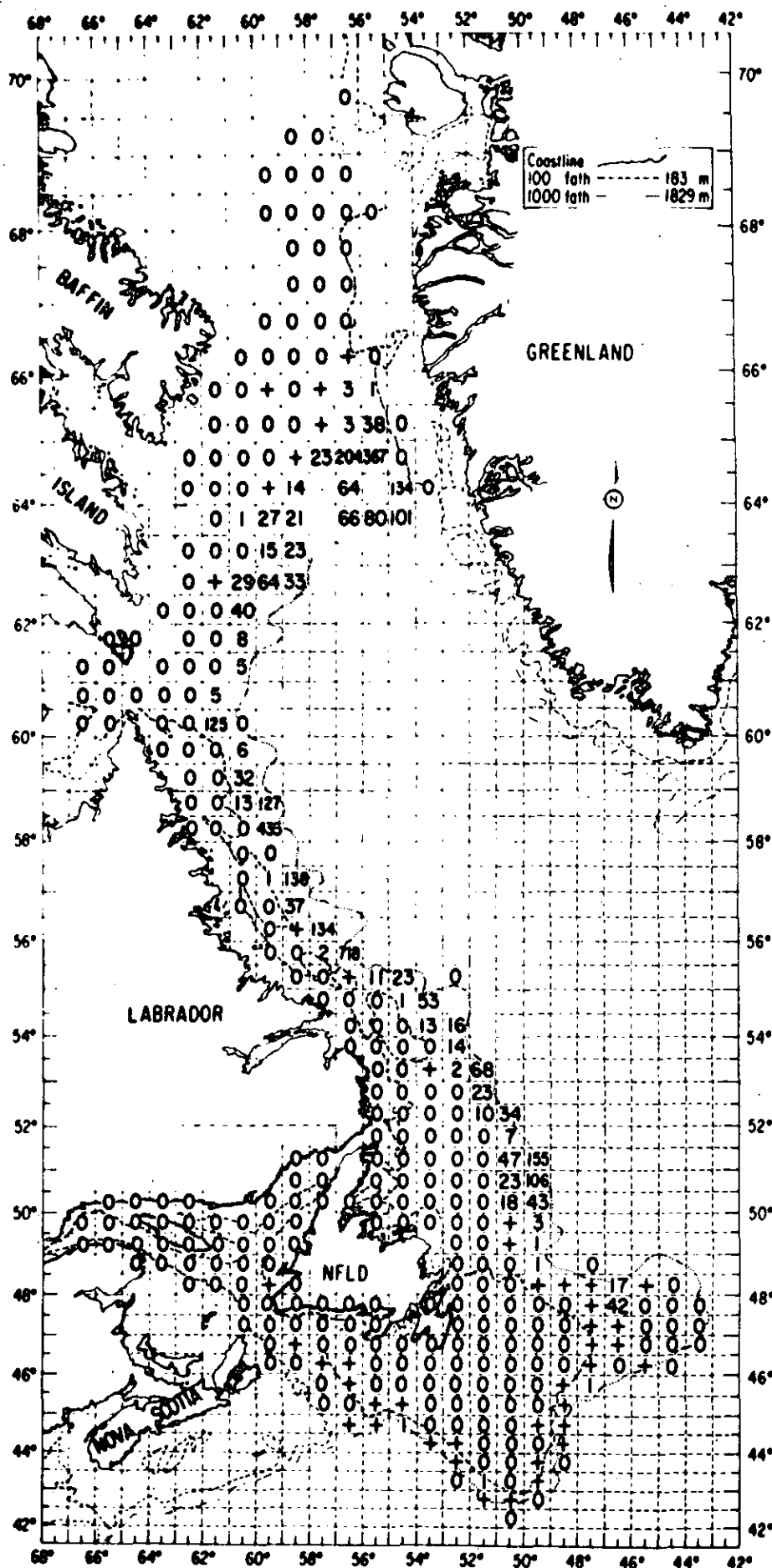


Figure 2: Distribution of average catches (kg) of roundnose grenadier in the north-west Atlantic by Canadian research vessels from the Nfld. Region of the Department of Fisheries and Oceans during 1974-1986.

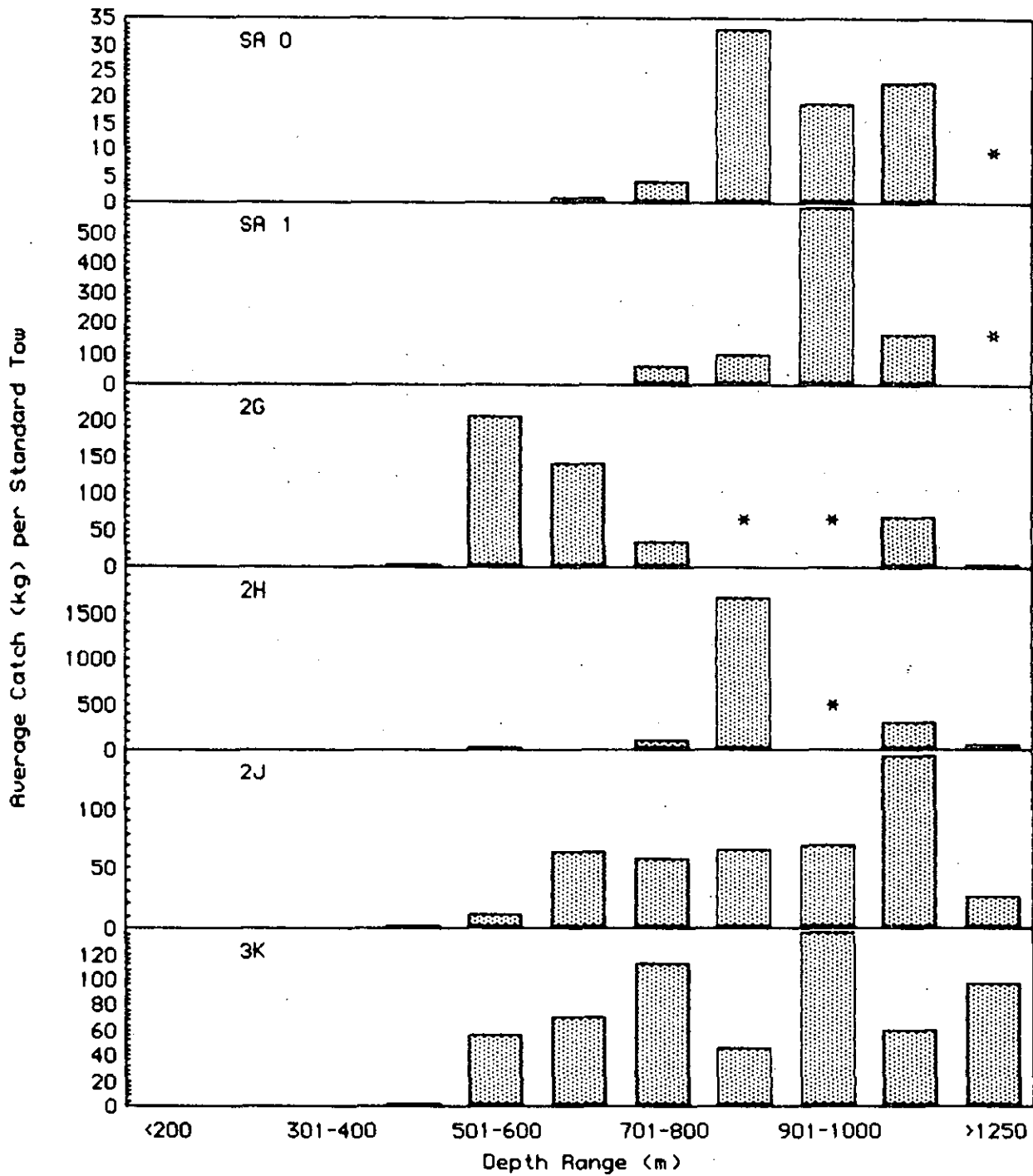


Figure 3: Average catch (kg) of roundnose grenadier per standard tow by depth range and NAFO Subarea/Division during Canadian research cruises from 1974-1986 (\* indicates no fishing sets).



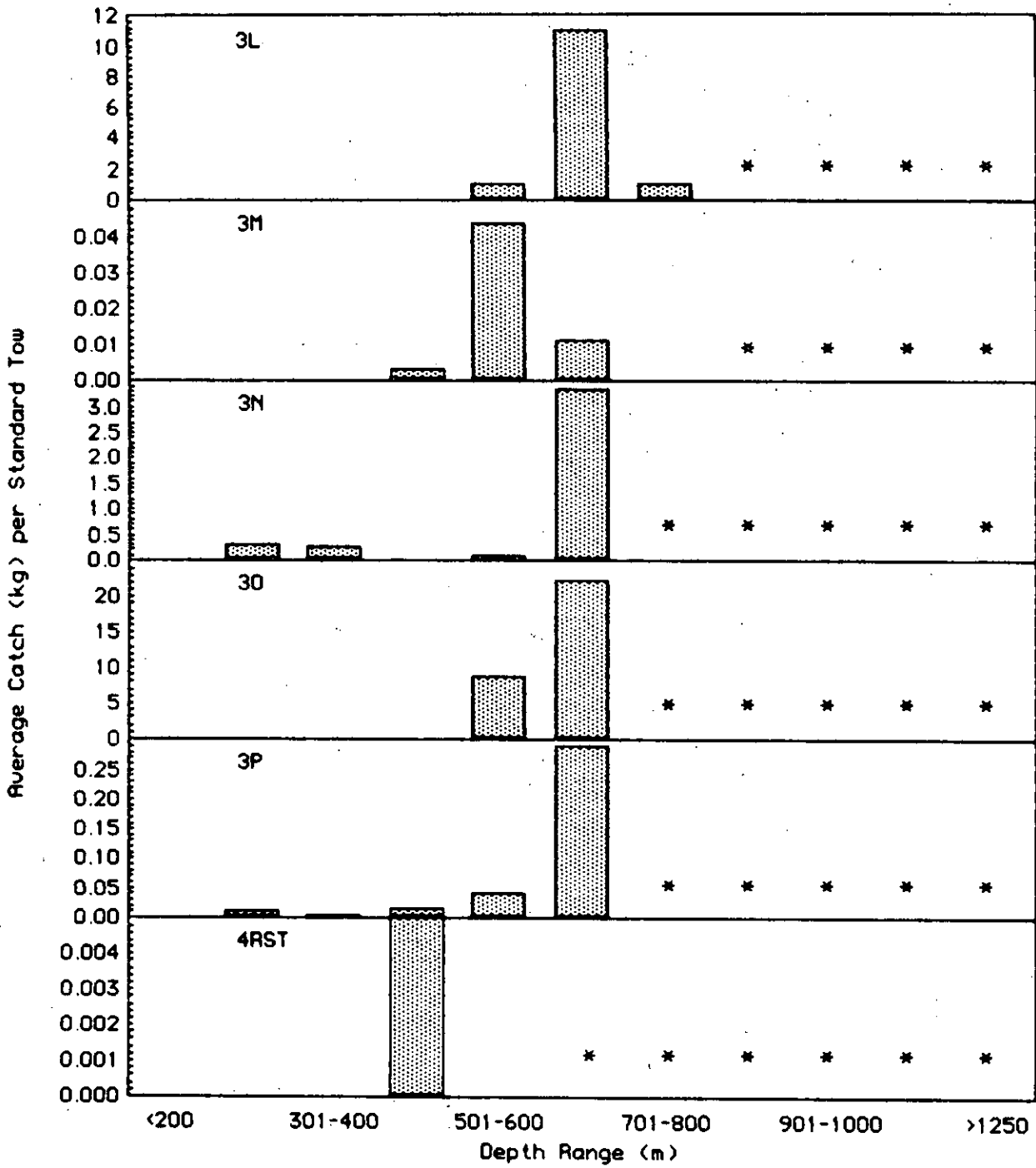


Figure 3: Continued.

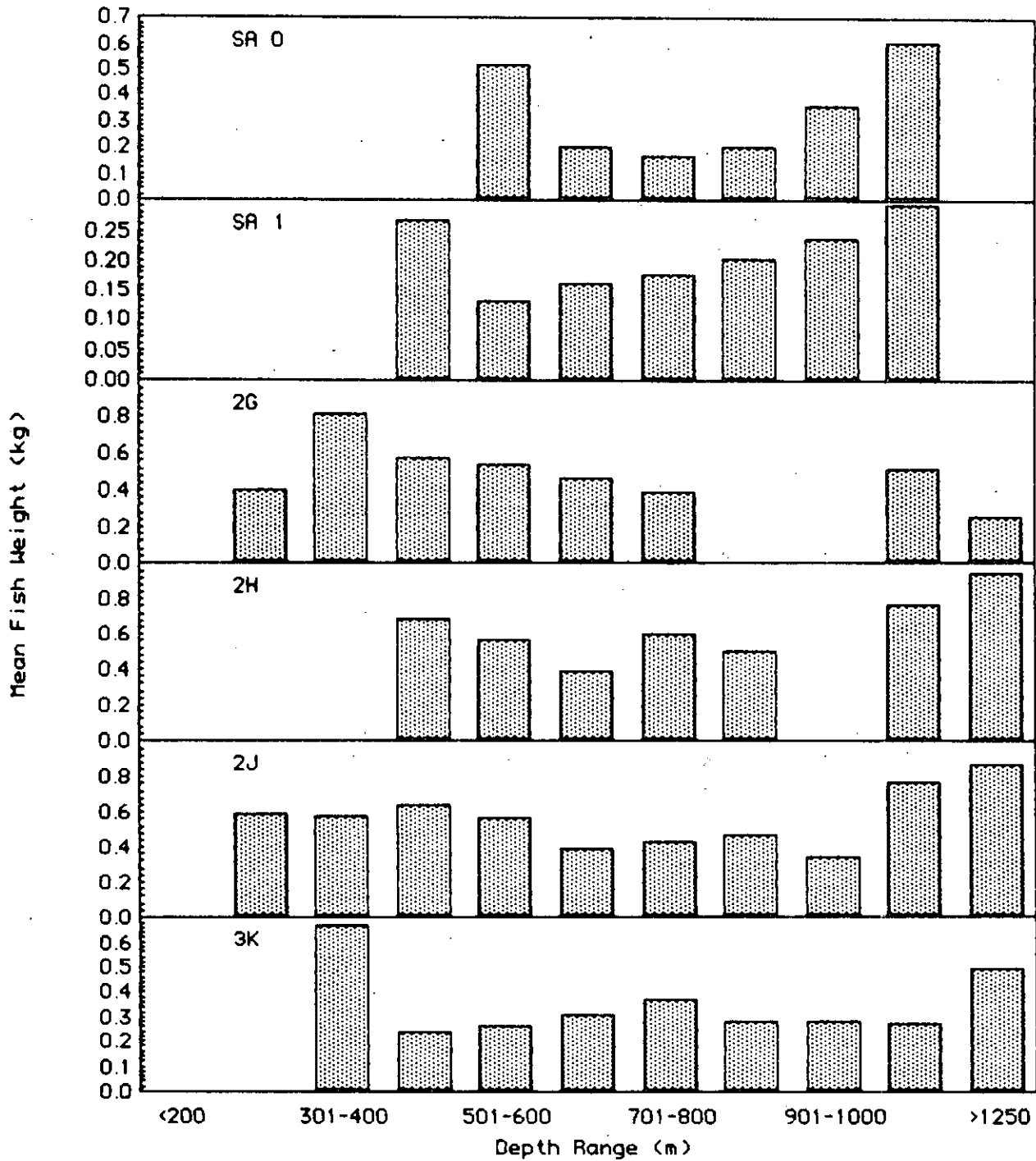


Figure 4: Mean fish weight (kg) of roundnose grenadier caught by depth range and NAFO Subarea/Division during Canadian research cruises from 1974-1986.

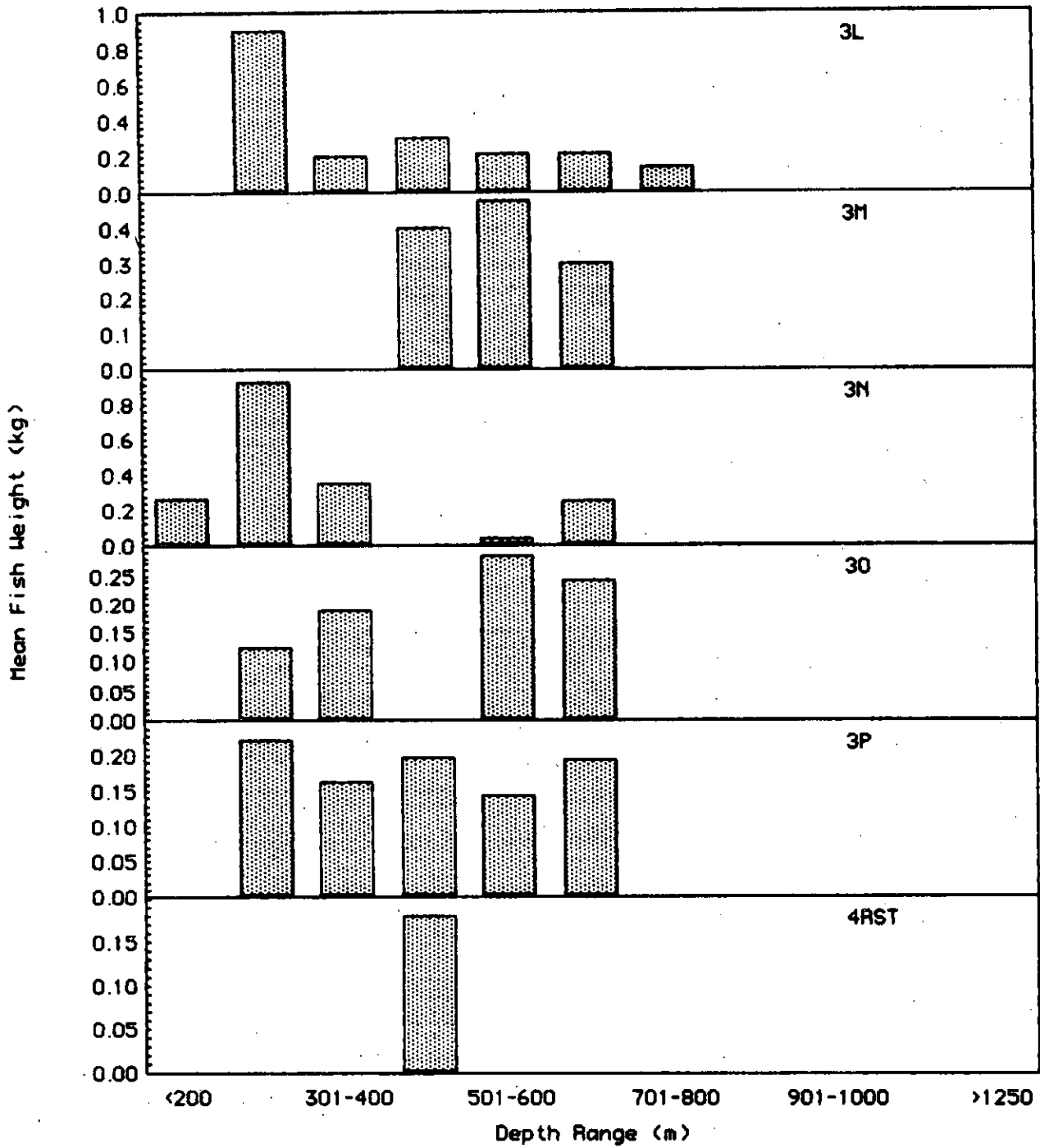


Figure 4: Continued.

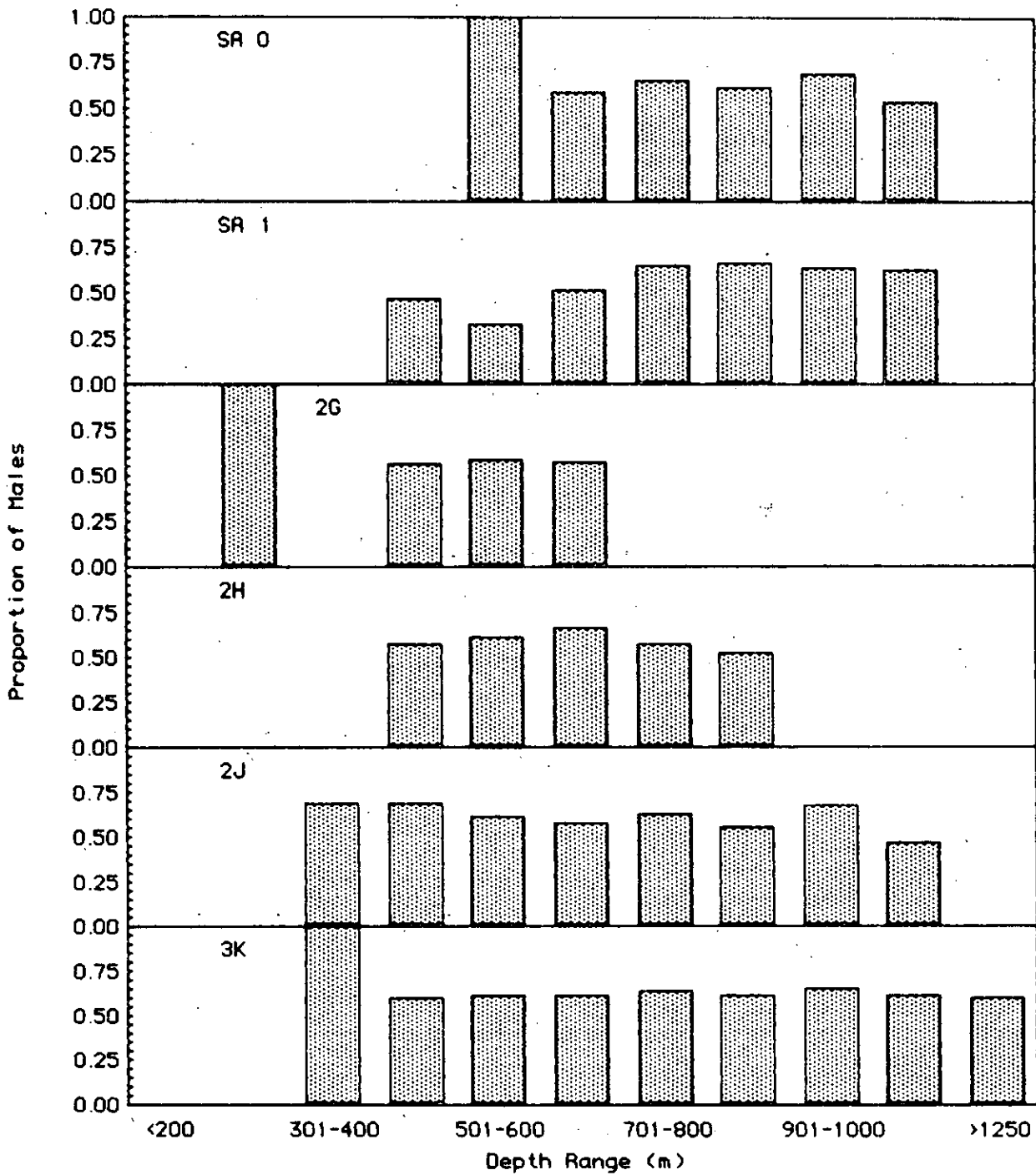


Figure 5: Proportion of males of roundnose grenadier caught by depth range and NAFO Subarea/Division during Canadian research cruises from 1974-1986.

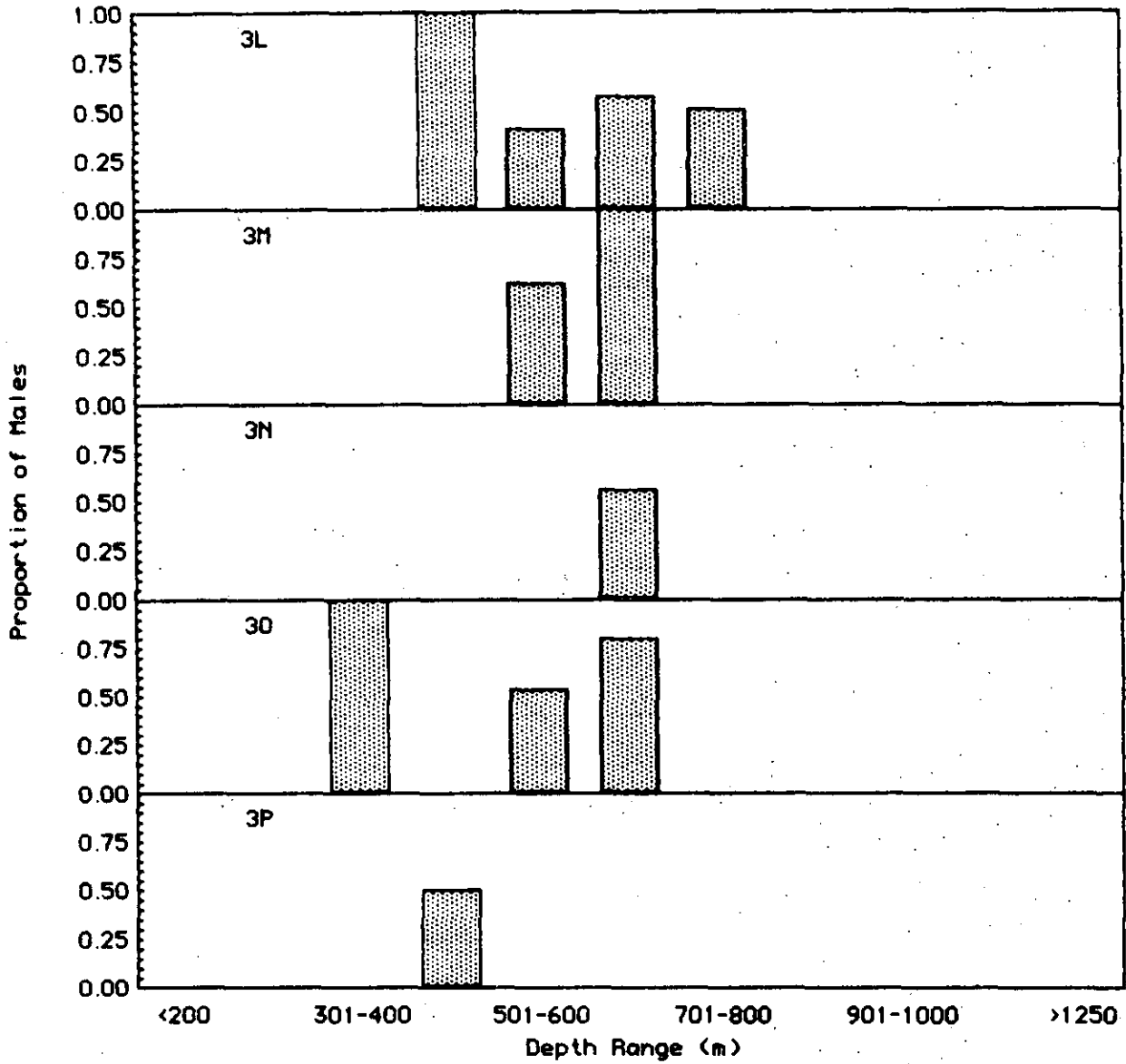


Figure 5: Continued.



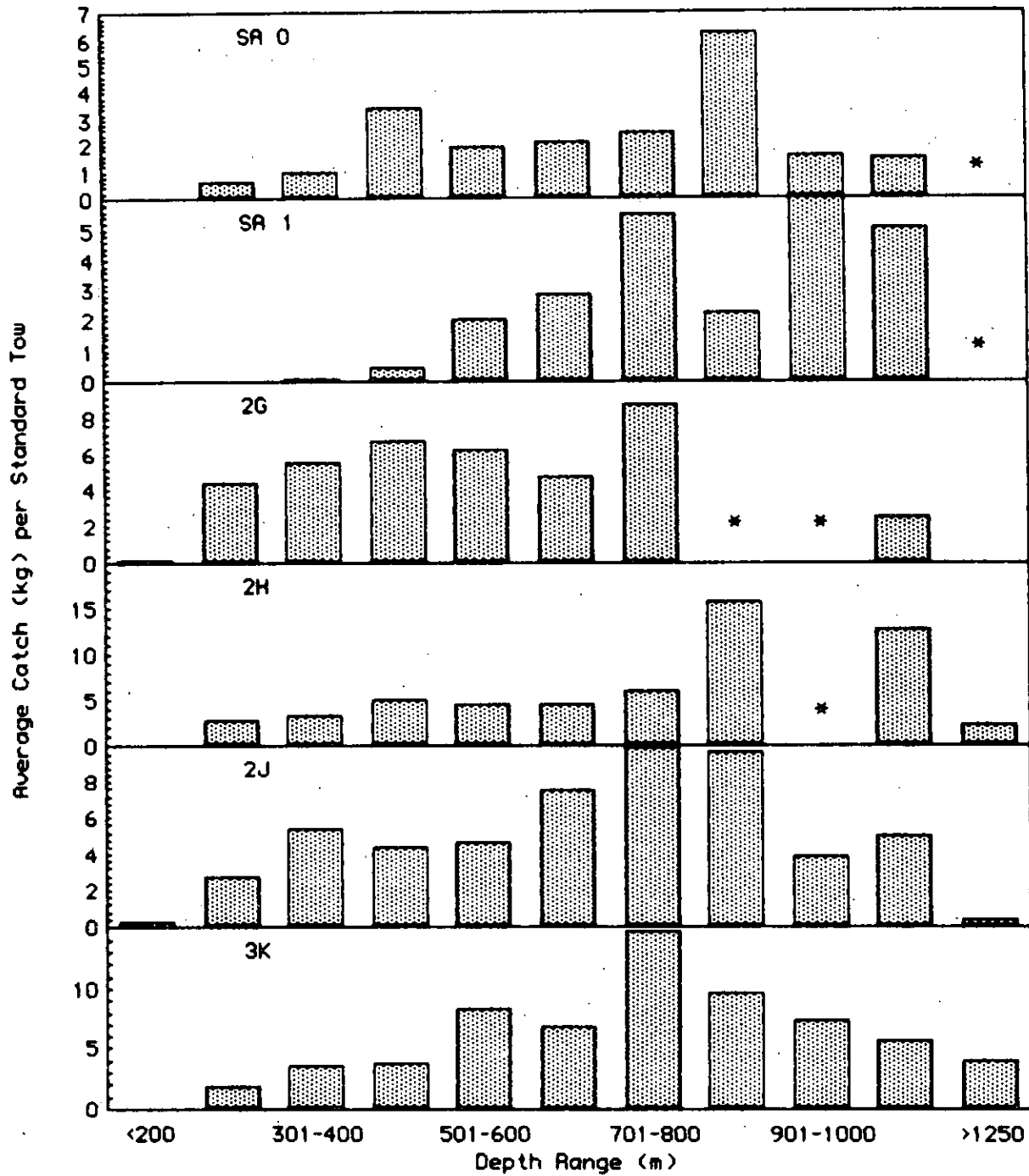


Figure 7: Average catch (kg) of roughhead grenadier per standard tow by depth range and NAFO Subarea/Division during Canadian research cruises from 1974-1986 (\* indicates no fishing sets).

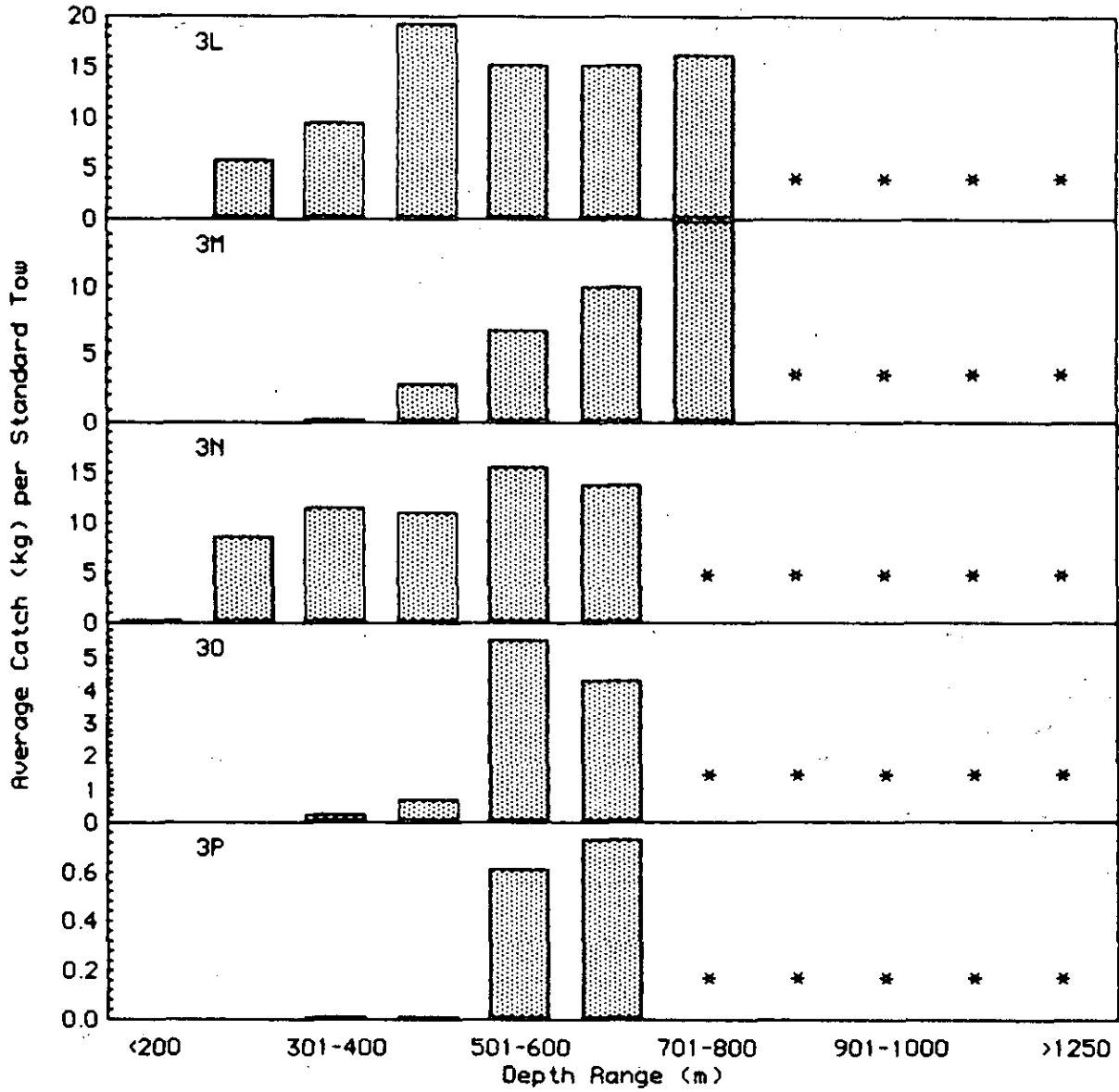


Figure 7: Continued.



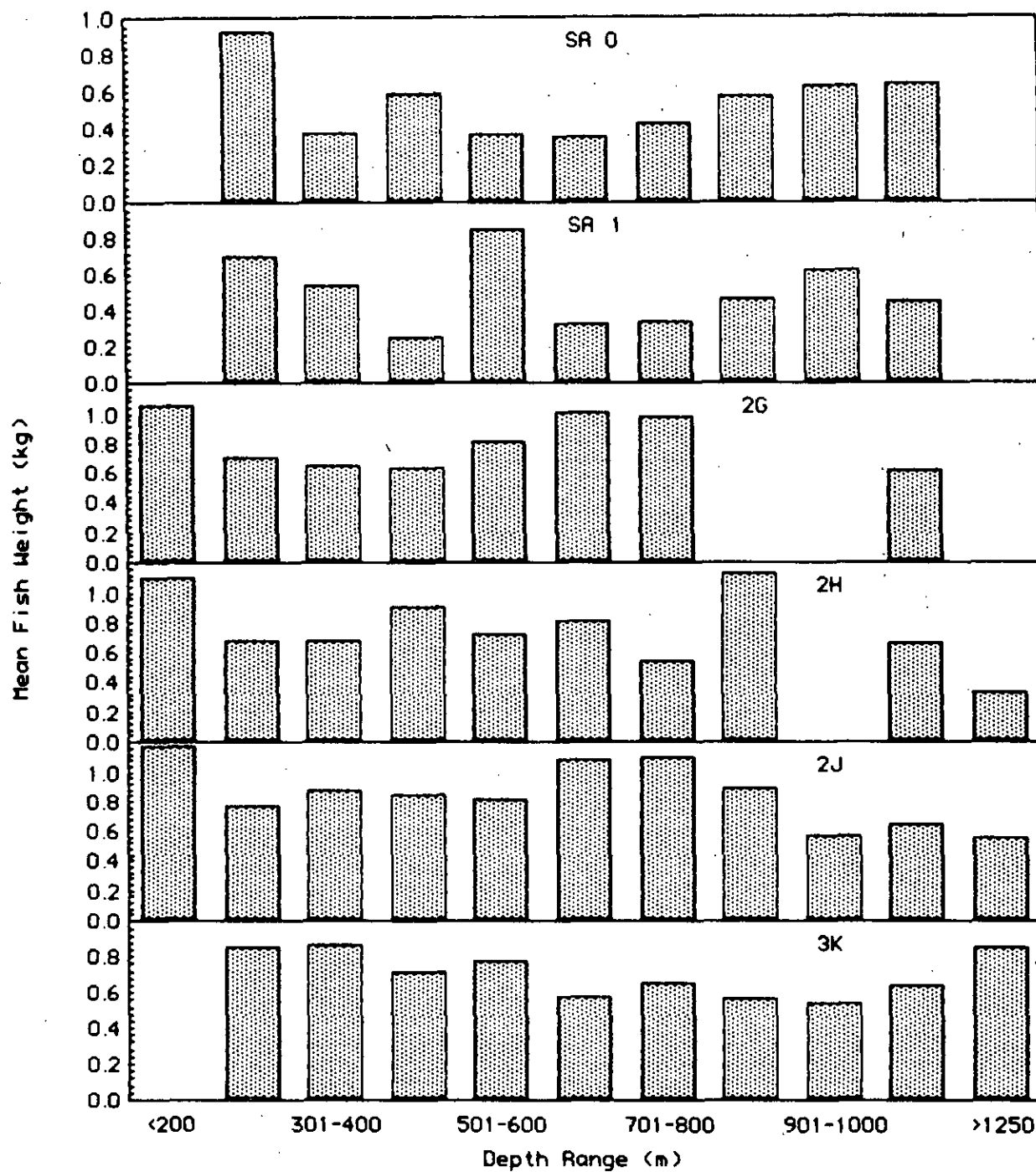


Figure 8: Mean fish weight (kg) of roughhead grenadier caught by depth range and NRFO Subarea/Division during Canadian research cruises from 1974-1986.

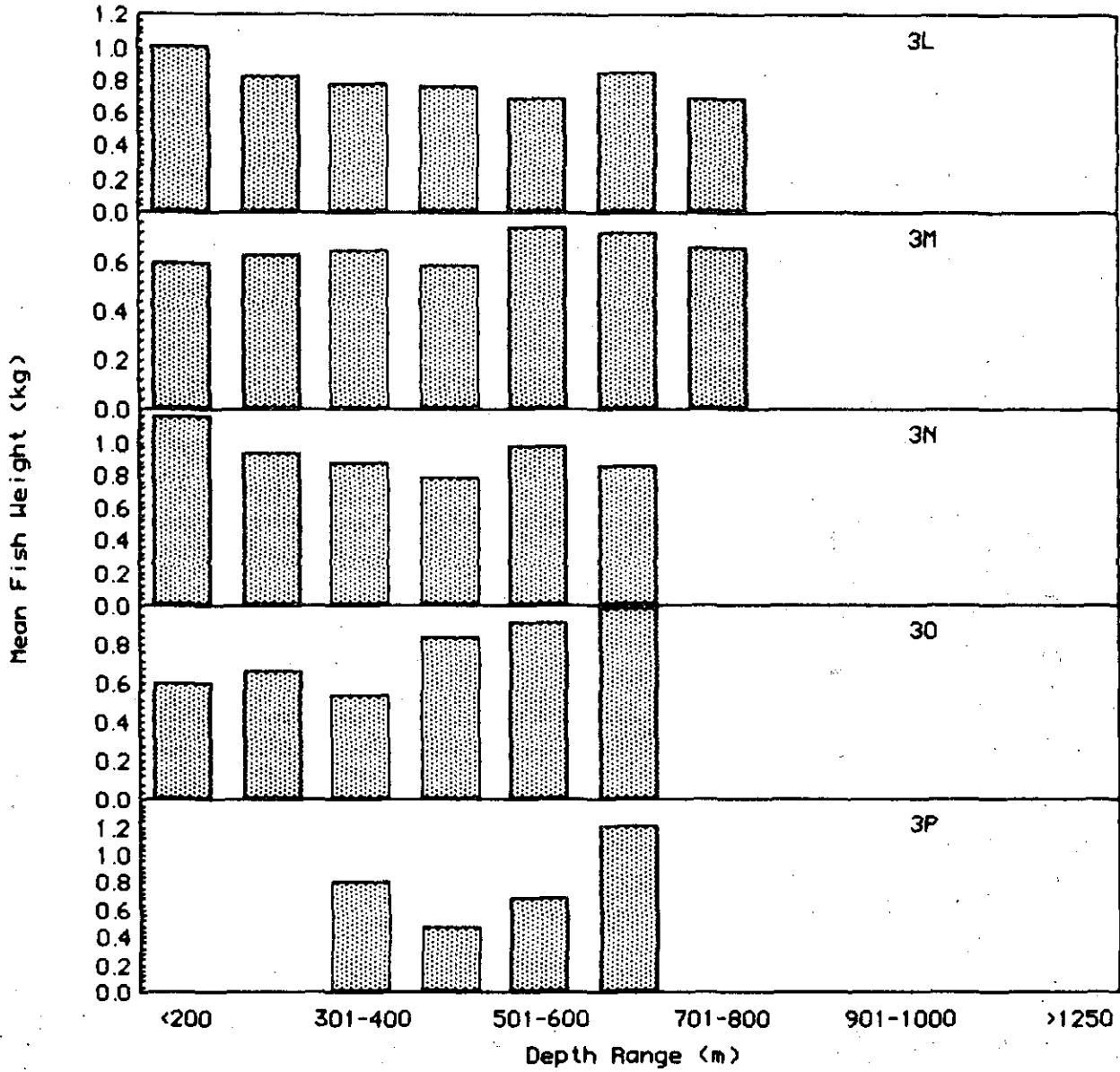


Figure 8: Continued.

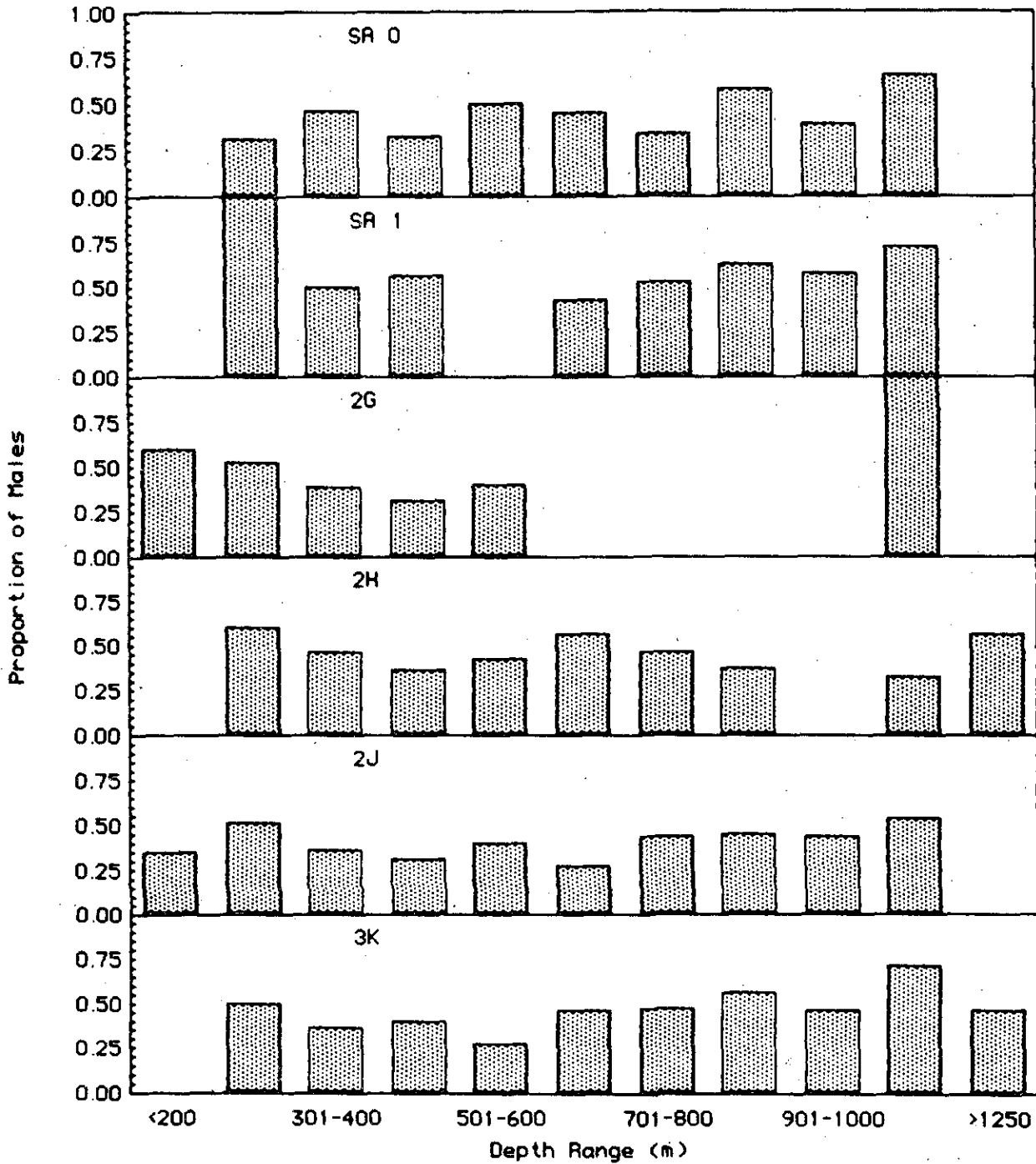


Figure 9: Proportion of males of roughhead grenadier caught by depth range and NAFO Subarea/Division during Canadian research cruises from 1974-1986.

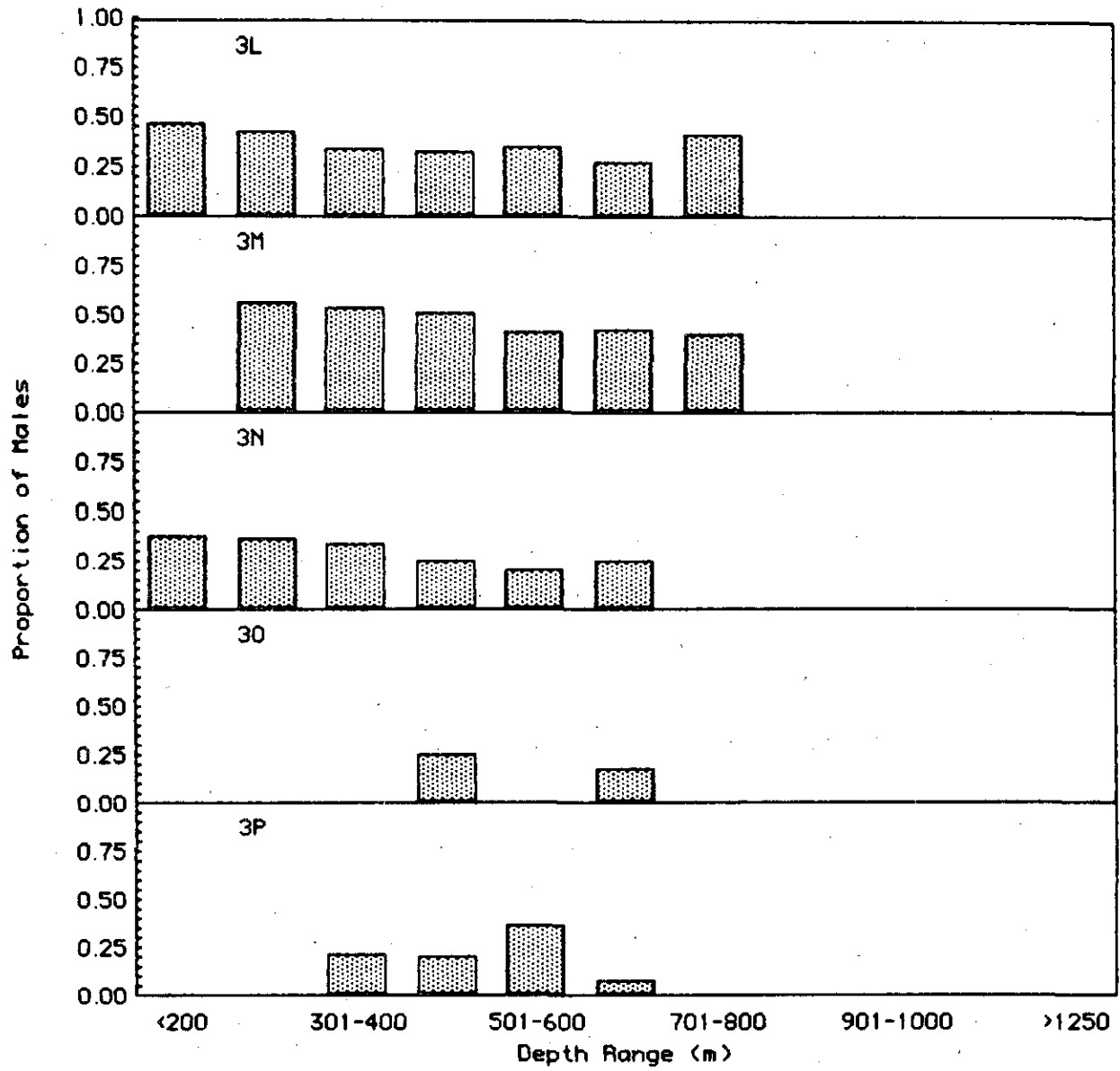


Figure 9: Continued.