Results of the longline survey on the seamounts in the southeast Atlantic and in the CCAMLR Subarea 48.6 (Atlantic Ocean) and Division 58.4.4 (Indian Ocean)

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RESULTS OF A LONGLINE SURVEY ON SEAMOUNTS IN THE SOUTHEAST ATLANTIC AND IN CCAMLR SUBAREA 48.6 (ATLANTIC OCEAN) AND DIVISION 58.4.4 (INDIAN OCEAN)

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Abstract

A bottom longline survey took place between 22 October and 1 December 1997, and several seamounts were surveyed to the south of Africa: close to the Antarctic Polar Front (Meteor Bank) and in the CCAMLR region (Shona and Spiess seamounts, the western slope of Bouvet Island, Ob and Lena Banks). Samples were collected from longlines set perpendicularly to the isobaths and in depths down to 1 500–2 000 m. Numerically, catches were dominated by Patagonian toothfish (*Dissostichus eleginoides*), with 2 822 individuals caught (83% of total catch). Grenadiers of the genus *Macrourus* were the second most abundant taxon (248 individuals). The total catch by weight was 21.430 tonnes, of which *D. eleginoides* comprised 20.502 tonnes (96%). The seamounts differed substantially in relation to seabed topography, species composition of catches, and relative abundance and size structure of *D. eleginoides* caught. Lengths of individual *D. eleginoides* generally increased with depth although this trend may be confounded by the presence of local seabed features, and juvenile fish in nearby shallow water. The sex ratio of immature *D. eleginoides* less than 90 cm total length did not significantly vary from 1:1. Females accounted for 70% of individuals of more than 90 cm in total length. The stratum with the highest catch (weight) per unit effort was 600 to 800 m, although absolute values varied between areas. Catch per unit effort ranged from a maximum value of 359 kg/1 000 hooks on Ob and Lena Banks to a minimum of 185 kg/1 000 hooks on Meteor Bank.

Résumé

Lors d'une campagne d'évaluation à la palangre de fond qui s'est déroulée du 22 octobre au 1er décembre 1997, plusieurs hauts-fonds ont été étudiés au sud de l'Afrique : à proximité du Front polaire antarctique (banc Meteor) et dans la région de la CCAMLR (bancs Shona et Spiess, pente occidentale de l'île Bouvet, bancs Ob et Lena). Des échantillons ont été prélevés sur les palangres posées perpendiculairement aux isobathes, jusqu'à 1 500 à 2 000 m de profondeur. Dans les captures, la légine australe (*Dissostichus eleginoides*) dominait, en nombre, avec 2 822 individus capturés (soit 83% de la capture totale), suivie par les grenadiers du genre *Macrourus* (248 individus). La capture totale s'élevait à 21,430 tonnes dont 20,502 tonnes de *D. eleginoides* (soit 96%). Les hauts-fonds se distinguent par la topographie du fond marin, la composition spécifique des captures et l'abondance relative et la structure de tailles de *D. eleginoides*. La longueur des individus de cette espèce augmente en général en fonction de la profondeur, cette tendance pouvant toutefois être influencée par certaines caractéristiques locales du fond marin et par la présence de poissons juvéniles dans les eaux peu profondes des alentours. Le sex-ratio des immatures de *D. eleginoides* de moins de 90 cm de longueur totale est toujours proche de 1:1. Les femelles représentent 70% des individus de plus de 90 cm de longueur totale. La strate où l'on a réalisé la plus grande capture (en poids) par unité d'effort est celle des 600 à 800 m, bien que les valeurs absolues varient selon les régions. La capture par unité d'effort varie d'un maximum de 359 kg/1 000 hameçons sur les bancs Ob et Lena à un minimum de 185 kg/1 000 hameçons sur le banc Meteor.

Резюме

С 22 октября по 1 декабря 1997 г. к югу от Африки проводилась донная ярусная съемка, в ходе которой было обследовано несколько подводных возвышенностей – около Антарктического полярного фронта (банка Метеор) и в зоне действия Конвенции АНТКОМ (банки Шона, Шпис, Обь и Лена и западный склон о-ва Буве). Сбор образцов рыб велся с ярусов, выставлявшихся

перпендикулярно изобатам на глубинах от 1500 до 2000 м. Наиболее массовым видом в уловах был патагонский клыкач (*Dissostichus eleginoides*): было выловлено 2822 особи этого вида, что составляет 83% от общего вылова. Вторым по частоте встречаемости таксоном являлись макрурусовые (248 особей). Общий вес вылова составил 21,430 т, из чего 20,502 т (96%) пришлось на *D. eleginoides*. Банки сильно различались по топографии морского дна, видовому составу уловов, а также относительной численности и размерной структуре пойманных особей *D. eleginoides*. Как правило, длина особей *D. eleginoides* увеличивалась с глубиной, однако на этих результатах могли сказаться локальные особенности морского дна и наличие молоди рыб на мелководье. Соотношение полов неполовозрелых особей *D. eleginoides* общей длиной менее 90 см колебалось около 1:1. Самки составили 70% особей длиной более 90 см. Наиболее (по весу) крупный улов на единицу усилия был получен в глубинном слое 600–800 м, хотя абсолютные величины варьировали от района к району. Максимальный улов на единицу усилия составил 359 кг/1000 крючков на банках Обь и Лена, а минимальный – 185 кг/1000 крючков на банке Метеор.

Resumen

Entre el 22 de octubre y el 1 de diciembre de 1997 se realizó un crucero de investigación con palangre de fondo. Durante el mismo se prospectaron diversas montañas submarinas al sur del continente africano, en las proximidades del frente polar antártico (banco de Meteor) y en la región de la CCRVMA (montañas submarinas de Shona, Spiess, talud occidental de la isla de Bouvet y bancos de Ob y Lena). El método de muestreo consistió en pescas con palangre utilizando radiales perpendiculares a las isóbatas hasta profundidades de 1 500 a 2 000 m. Las capturas en número fueron dominadas generalmente por *Dissostichus eleginoides* con 2 822 ejemplares (83%), siendo las especies del género *Macrourus* el segundo grupo más abundante (248 ejemplares). La captura total en peso fue de 21,430 toneladas, de las cuales 20,502 toneladas (96%) fueron de *D. eleginoides*. Las montañas submarinas mostraron diferencias sustanciales en relación con la topografía, la composición en especies de la captura, y la abundancia relativa y la estructura de tallas de *D. eleginoides*, encontradas en cada una de ellas. Las tallas de los ejemplares de *D. eleginoides* en general aumentaron en función de la profundidad aunque es posible que esta tendencia sea enmascarada por las características locales del lecho marino y la presencia de peces juveniles en aguas someras cercanas. La proporción de machos y hembras de *D. eleginoides* de talla menor a 90 cm no varió significativamente de 1:1. El 70% de los ejemplares mayores de 90 cm de longitud total fueron hembras. El estrato con la mayor captura por unidad de esfuerzo en peso fue el de 600–800 m, aunque los valores variaron entre las distintas áreas. La captura por unidad de esfuerzo total fue también diferente de una región a otra, variando su valor desde un máximo de 359 kg/1 000 anzuelos en los bancos de Ob y Lena a un mínimo de 185 kg/1 000 anzuelos en el banco Meteor.

Keywords: bottom longline survey, *Dissostichus eleginoides*, by-catch, seamounts, Subarea 48.6, Division 58.4.4, CCAMLR

INTRODUCTION

A bottom longline survey was carried out between 22 October and 1 December 1997 in waters of the southeast Atlantic close to the Antarctic Polar Front and within Subarea 48.6 and Division 58.4.4. During this expedition several seamounts were surveyed to the south of Africa: close to the Antarctic Polar Front (Meteor Bank) and in the CCAMLR region (Shona and Spiess seamounts, the western slope of Bouvet Island, Ob and Lena Banks). The overall objective of the cruise was to study fish populations inhabiting these seamounts, in particular those of Patagonian toothfish (*Dissostichus eleginoides*). The study used direct observation methods in order to improve knowledge on *D. eleginoides* and associated species and focused on a region in which the presence of *D. eleginoides* was uncertain (Moreno et al., 1997). The survey followed the recommendations of the CCAMLR Workshop on Methods for the Assessment of *D. eleginoides* (SC-CAMLR, 1995).

The development and consolidation of fisheries for *D. eleginoides* on existing grounds, and recent expansions into new areas, have created a need for the acquisition of information that provides

greater knowledge on the biology and population dynamics of this species, as well as differences that may exist between oceanic regions. Thus, the specific objectives of the study were to analyse variations in the faunistic structure along latitudinal and longitudinal gradients within the geographical and bathymetric distributional range of *D. eleginoides* in the area surveyed.

MATERIAL AND METHODS

Spanish-style bottom longlines (López Abellán and González, 1998) of 2 775 to 13 875 m in length, and each with 1 500 to 7 500 hooks, were used throughout the survey. Straight and holed 31 mm hooks were used.

The study areas, identified *a priori*, were located in three rectangular areas covering (Figure 1):

(i) Zulu (47°45'S, 10°00'E) and Meteor Banks (48°00'S, 8°30'E) outside waters regulated by CCAMLR;

(ii) Shona Seamount (51°00'S, 2°45'E), Spiess Seamount (54°40'S, 0°15'E) and the slope of Bouvet Island (Subarea 48.6); and

(iii) Ob Bank (52°30'S, 41°30'E) and Lena Bank (53°00'S, 44°15'E) (Division 58.4.4).

A total of 21 longline sets (transects) were made, eight in region (i), five in region (ii) and eight in region (iii).

The longlines were set perpendicularly to the isobaths and in depths down to 1 500–2 000 m. The number of longline sets at each seamount was determined by seabed topography, and at least two sections of the slope around each seamount were sampled. Longlines were set at night, and soak times ranged from 7 to 10 hours, depending on the time of setting and the local time of twilight.

The aim of this sampling regime was to obtain as many samples as possible from each study area and depth stratum, and to sample continuously across the different depth strata within each longline set. This method required continuous sampling by four scientific observers during hauling of the longlines in order to assign catches to each stratum. Catch and effort were calculated by depth strata and by area for all species caught.

Differences in length frequencies of *D. eleginoides* with depth were examined using a two-tailed Kolmogorov–Smirnov test for large samples. The critical values were obtained at the 0.05 level of significance using the method of Siegel and Castellar (1988). Length-frequency distributions were standardised by sampling effort in each depth stratum, and summed to produce the overall length-frequency distribution. Lengths for *D. eleginoides* were measured as total length (TL).

The sex ratio of *D. eleginoides* by size and depth was obtained from biological samples, and the analysis of goodness of fit to the expected ratio 1:1 was carried out using the Chi-square method (t_0 = 0.05) (Zar, 1984). A *t*-test was also used to compare the allometry coefficients in the length–weight relationship.

RESULTS AND DISCUSSION

Fishing Operation and Bottom Topography

Details of the fishing operation are shown in Table 1, including date, depth, position and starting and finishing time of setting and hauling.

In the Meteor Bank region, the surveyed depth ranged from 630 to 2 300 m. The bottom was rocky but not excessively abrupt. Generally, seamounts in this area had small, relatively smooth, plateaus. In Subarea 48.6, seamounts were irregular with extensive slope areas and no plateaus (note that the Bouvet Island shelf was not surveyed). The Shona Seamount was difficult to survey because of its irregular topography above 900 m and strong currents. At Spiess Seamount, the surveyed depth ranged between 670 and 1 400 m; below this depth, the slope fell away sharply making sampling impractical. Only one set was made between 700 and 1 200 m on the abrupt slope of the Bouvet Island area. Ob and Lena Banks had a smoother topography similar to that found in the Meteor Bank area. Each of these banks had an extensive plateau which, in some cases, fell abruptly to great depths. Fishing took place at depths ranging between 280 and 1 800 m, and with fewer operational difficulties than in the other areas.

Species Composition and Size Distribution of Catches

Overall, the species diversity was low, with a total of 10 species caught, eight fish (including 6 teleosts, 1 channichthys and 1 Rajidae) and two

Table 1: Fishing operations by sector: setting date, time and position, hauling date and time, number of hooks by set.

Sector	Haul No.	Setting								Hauling			No. Hooks
		Date	Time		Depth		Latitude S		Longitude E		Date	Time		
			Start	End	Start	End	Start	End	Start	End		Start	End	
Meteor	1	27/10/97	1833	1924	810	1 935	48°11.894′	47°12.183′	9°38.250′	9°47.717′	28/10/97	0400	1410	7 500
	2	28/10/97	1901	1929	1 679	738	47°10.738′	47°12.802′	9°35.126′	9°38.332′	29/10/97	0420	1000	3 750
	3	30/10/97	0038	0104	727	1 084	48°10.982′	48°11.012′	8°19.527′	8°23.948′	30/10/97	0740	1205	3 750
	4	30/10/97	1833	1901	1 825	950	48°06.348′	48°07.557′	8°06.432′	8°10.687′	31/10/97	0553	0955	3 750
	5	31/10/97	1846	1912	1 718	1 007	48°34.743′	48°33.188′	7°44.267′	7°48.488′	1/11/97	0535	1125	3 750
	6	1/11/97	1848	1915	642	829	48°24.438′	48°22.220′	7°56.341′	7°59.549′	2/11/97	0535	0955	3 750
	7	2/11/97	1906	1931	888	704	48°25.818′	48°22.566′	7°39.576′	7°42.902′	3/11/97	0525	0945	3 750
	8	3/11/97	1917	1941	889	1 296	48°25.140′	48°27.670′	7°39.706′	7°37.404′	4/11/97	0538	0930	3 750
Shona	9	5/11/97	2225	2254	1 519	917	51°15.843′	51°15.920′	0°30.363′	0°36.371′	6/11/97	0622	1100	3 750
	10	6/11/97	1946	2007	1 583	2 062	51°12.943′	51°14.997′	0°41.201′	0°43.841′	7/11/97	0605	1150	3 750
Spiess	11	8/11/97	2025	2053	674	682	54°41.846′	54°42.713′	0°07.212′	0°13.243′	9/11/97	0530	1015	3 750
	12	9/11/97	2031	2100	785	1 405	54°42.172′	54°43.166′	0°15.219′	0°21.089′	10/11/97	0615	1130	3 750
Bouvet	13	10/11/97	2346	0016	1 156	714	54°32.887′	54°35.314′	2°50.295′	2°55.166′	11/11/97	0700	1207	3 750
Ob	14	17/11/97	1817	1912	955	521	52°23.455′	52°18.281′	41°03.810′	40°55.053′	18/11/97	0440	1330	7 500
	15	18/11/97	1837	1904	887	1 375	52°22.229′	52°25.957′	41°02.617′	41°02.465′	19/11/97	0508	1000	3 750
	16	19/11/97	1843	1909	359	294	52°17.914′	52°17.760′	40°54.137′	41°00.352′	20/11/97	0420	0818	3 750
Lena	17	20/11/97	2110	2200	773	500	52°49.503′	52°49.480′	43°30.055′	43°44.343′	21/11/97	0535	1353	7 500
Ob	18	22/11/97	0040	0107	1 500	1 789	52°28.346′	52°26.916′	41°45.104′	41°50.064′	22/11/97	1130	1420	3 750
	19	22/11/97	1814	1903	269	1 551	52°25.840′	52°27.311′	41°34.602′	41°46.846′	23/11/97	0510	1345	7 500
	20	23/11/97	1917	1944	267	374	52°14.343′	52°15.831′	41°15.136′	41°20.486′	24/11/97	0441	0850	3 750
	21	24/11/97	1832	1844	286	280	52°19.653′	52°18.525′	41°12.869′	41°11.196′	25/11/97	0602	0720	1 500

Table 2: Caught species (number, weight and percentage) by surveyed region and total.

Species	Meteor Bank				Subarea 48.6				Ob and Lena Banks				Total			
	No.	%	Weight (kg)	%	No.	%	Weight (kg)	%	No.	%	Weight (kg)	%	No.	%	Weight (kg)	%
Dissostichus eleginoides	401	68.20	6 128.64	92.78	79	42.02	494.41	77.02	2 342	89.59	13 879.26	97.73	2 822	83.24	20 502.31	95.58
Macrourus spp.	146	24.83	422.41	6.39	89	47.34	124.76	19.44	13	0.50	54.95	0.39	248	7.32	602.10	2.81
Lepidonotothen squamifrons									176	6.73	95.71	0.67	176	5.19	95.71	0.45
Antimora rostrata	34	5.78	49.91	0.76	17	9.04	20.43	3.18	15	0.57	17.18	0.12	66	1.95	87.52	0.41
Muraenolepis microps	1	0.17	0.57	0.01	1	0.53	1.24	0.19	7	0.27	3.64	0.03	9	0.27	5.44	0.03
Lepidonotothen larsenii									2	0.08	0.06	0.00	2	0.06	0.06	0.00
Raja taaf									44	1.68	142.01	1.00	44	1.30	142.01	0.66
Lithodidae	6	1.02	4.34	0.07	2	1.06	1.06	0.16	15	0.57	9.28	0.07	23	0.68	14.67	0.07

crustaceans (Lithodidae) (Table 2). Numerically, the dominant species was *D. eleginoides* (n = 2 822, 83% of total catch), and grenadiers of the genus *Macrourus* ranked second (248 individuals). In all, 3 376 individuals were caught weighing 21.430 tonnes, of which *D. eleginoides* comprised 20.502 tonnes (96%).

Five species of fish were caught on Meteor Bank. The highest diversity was recorded on Ob and Lena Banks and species included grey rockcod (*Lepidonotothen squamifrons*), painted rockcod (*Lepidonotothen larsenii*) and skate (*Raja taaf*) (Gon and Heemstra, 1990). Samples here were taken over the largest bathymetric range sampled during the survey. Comparison with results obtained from nearby areas indicated that the number of by-catch species was lower during the survey than, for example, the diversity reported from the Kerguelen Islands (Duhamel et al., 1997), although the dominance in the by-catch of the widespread genus *Macrourus* was common to both areas.

The relative numerical abundance of the species in catches taken in the regions studied is shown in Figure 2. *D. eleginoides* represented 68% of the catch on Meteor Bank, 42% in Subarea 48.6 and 90% on Ob and Lena Banks. Species of the genus *Macrourus* were the second most abundant in catches from the first two regions, representing a similar percentage to that of *D. eleginoides* in Subarea 48.6. In the region of Ob and Lena Banks *Macrourus* spp. was replaced by *L. squamifrons*, although with a lower percentage (7%). This substitution resulted from the incorporation of shallow areas (above 400 m) in that region. From the results obtained it can be concluded that there was an inverse relationship between the abundance of *D. eleginoides* and *Macrourus* spp. in the catch. *Dissostichus mawsoni* was not recorded in any of the sets.

The continuous sampling regime provided information on the relative position along the longline of each individual caught, and the size of the individuals in relation to topography (Figure 3). Comparing set 1 in the Meteor Bank area and sets 14 and 19 on Ob Bank, the differences already noted were clearly shown in relation to the species composition of catches and the inverse relationship between the catches of *D. eleginoides* and *Macrourus* spp. At the same time, differences were observed in the density of catches of *D. eleginoides* that could not be explained by interspecific competition for bait, but rather by the density of this species in the area surveyed.

Figure 3 illustrates differences in the sizes of *D. eleginoides* from the two regions. Fish were larger in set 1 (Meteor Bank) and there was a tendency for sizes to increase with depth, a trend in bottom-dwelling species which has been described by other authors (Duhamel, 1987; Moreno et al., 1997). In addition, changes in topography, such as at the shelf break, produced changes in size and, therefore, in the size structure at these locations (set 19). In addition, changes in size were noted at specific locations within longline sets due to schools of fish which appeared associated with elevations, depressions, walls etc. on the seafloor (set 14). The results also corroborate the tendency of *D. eleginoides* to form aggregations, as Duhamel (1987) has described, although some of these aggregations consisted of fish of widely ranging sizes within a small spatio-temporal scale.

Dissostichus eleginoides

Length-frequency Distributions of Catches

There were marked differences in sizes of specimens caught on Meteor Bank and those caught on Ob and Lena Banks (Figure 4), and these may reflect differences between the number of shallow strata surveyed in the two regions (Figure 5). A greater percentage of large individuals was present on Meteor Bank compared with Ob and Lena Banks. Thus the mean sizes of individuals on Meteor Bank was 105.24 cm (SD = 21.5) – larger than that of specimens from Ob and Lena Banks (77.04 cm, SD = 16.21) and in Subarea 48.6 (75.38 cm, SD = 21.12). However, in this latter area only 79 individuals were caught and several strata could not be surveyed. The overall mean length of specimens was 81 cm (SD = 19.83) and the mean weight was 7.27 kg (SD = 6.47).

Length-frequency Distributions by Depth

Statistical analysis of the length distributions per 100 m depth strata using the Kolmogorov–Smirnov test indicated that there were five depth strata in relation to size: 200–300 m, 300–600 m, 600–800 m, 800–1 500 m and 1 500–1 900 m. Although this stratification was generally applicable to the areas of Meteor Bank and Ob and Lena Banks, regional differences were seen between the population size structures of *D. eleginoides* (Figure 6). In the depth strata where individuals from different regions overlapped, the

relative length-frequency distributions were different, and the mean size of specimens from Meteor Bank was larger than that from the other regions.

The differences observed may have been due to the presence on Ob and Lena Banks of young individuals that inhabited depths between 200 and 600 m. We concluded that the presence of juveniles affected the length structure in nearby deeper strata through the contribution of small individuals, and produced the unimodal structure observed in the shallower strata. The progression of this mode with depth indicated an ontogenetic migration to deeper water, as described by Duhamel (1987), when he considered factors affecting the migration of this species. Thus, the mode of 65 cm at depths of 300 to 600 m moved to 70 cm at the next deepest stratum, then 75 cm at the 800 to 1 500 m stratum. However, the shallowest stratum (200–300 m) was more affected by the presence of both small and large individuals than the 300 to 600 m stratum.

Sex Ratio

Of the 662 individuals of *D. eleginoides* used in this analysis, 463 were females and 199 males. Females reached larger sizes than males (females = 168 cm TL, males = 136 cm TL), and the proportion of males in the catch decreased with increasing body size (Figure 7). The goodness-of-fit analysis of the expected ratio 1:1 indicated that, up to 90 cm TL, the ratio of sexes was not significantly different from 1:1.

Comparing these results with those obtained by Konforkin and Kozlov (1992), in which they reported that males reached sexual maturity at 72 to 90 cm in length, we can confirm that there is a correlation between the length at which sexual maturity of males is reached and the size at which the abrupt shift in the sex ratio (male:female) occurs, changing from 1:1.30 to 1:3.38.

A global interpretation of the situation is that the decrease in the presence of males is linked to length at maturity. Thus, large, mature, males had either migrated out of the survey areas, or became inaccessible to the bottom longline, or had disappeared through natural mortality, with the result that males represented only 30% of the total individuals analysed. However, we did not determine whether the sex ratio fluctuated over a 12-month period. Moreno et al. (1996) showed that, in spite of a tendency for the proportion of females in the catch to be higher than that of males, the sex ratio fluctuated over time, possibly due to a migration of males to other geographical areas, or vertically within the water column. It is evident that males migrate to greater depths at a small size (72–90 cm) than females, which first reach maturity at 90 to 100 cm (Konforkin and Kozlov, 1992). Thus, the migration of males to deeper water increased their proportion at the 600 to 800 m (32%) and 800 to 1 500 m strata (34%), but did not explain the marked change in the sex ratio when males reached 95 cm TL.

Maturity

Most individuals in the three regions sampled were at stages 1 (immature) and 2 (maturing virgin or resting). On Meteor Bank, 23% of the females and 3% of males were at stage 5 (spent), and only a single male at stage 4 (ripe) was found. On Ob and Lena Banks, five females (2%) were at stage 5 and one at stage 3 (developing).

These results indicated that spawning had already occurred, and that this took place on Ob and Lena Banks earlier than on Meteor Bank. According to the synopsis reported by Moreno et al. (1997) from diverse authors and areas, the results obtained did not contradict previous findings that *D. eleginoides* spawned in winter. In areas close to those in this study (Crozet and Kerguelen), spawning is known to take place from June to August/September (Duhamel, 1987). This coincided with our observations which were carried out during November.

Length–Weight Relationship

Values of the constants a and b of the length–weight equation, the correlation coefficient, the interval of sizes used, the number of individual males and females, and the totals for both sexes are presented in Table 3. Note that from 136 cm TL, only females were present. The t-test applied to the allometry coefficients showed that there were no significant differences ($p < 0.05$) between sexes.

Catches, Effort and Catch per Unit Effort (CPUE)

The CPUE (kg/hook) by depth stratum followed a similar trend in all regions (Figure 8). The stratum with largest yields in weight was

Table 3: *Dissostichus eleginoides* length–weight relationship. Values of *a* and *b* constants, correlation coefficient, size interval and number of individuals, for males, females and total.

$W = a \times LT^b$	Males	Females	Total
a	8.804E-06	7.974E-06	8.128E-06
b	3.0557	3.0795	3.0749
Min. length	45	43.8	43.8
Max. length	136	168	168
n	199	463	662
r	0.9948	0.9925	0.9935

600 to 800 m, although maxima were different for Ob and Lena Banks (413.06 kg/1 000 hooks), Meteor Bank (225.10 kg/1 000 hooks) and Subarea 48.6 (58.16 kg/1 000 hooks).

However, CPUE (fish/hook) (Figure 9) indicated that the stratum where *D. eleginoides* was abundant (82 specimens/1 000 hooks) was 300 to 600 m (Ob and Lena Banks), where recruitment mainly occurred. From this stratum, CPUE (fish/hook) decreased in both shallower and deeper waters.

Changes in the mean size by stratum (Figure 8) and CPUE (Figures 8 and 9) indicated that decreases in CPUE (fish/hook) between strata 300–600 m and 600–800 m were compensated by increases in CPUE (kg/hook), although this effect disappeared at deeper strata. The mean sizes of fish on Meteor Bank were larger than those of the other areas, but the smallest number of individuals in the catches there contributed to low CPUE in weight.

Estimates of yield by region confirmed that the CPUE on Ob and Lena Banks (359 kg/1 000 hooks) was double the value for Meteor Bank (185 kg/1 000 hooks). In Subarea 48.6, the highest yield was 43 kg/1 000 hooks. The estimated CPUE for the total of the three regions was 246 kg/1 000 hooks.

CONCLUSIONS

D. eleginoides was the most abundant species within the area surveyed. The diversity of the by-catch varied in relation to depth.

The surveyed seamounts showed substantial differences in topography, in the number and abundance of species, and in the catches and size structures of the *D. eleginoides* population. Thus it is inadvisable to extrapolate results from one geographical area to another without further information on the characterisation of the populations inhabiting the different regions.

The sizes of the individuals of *D. eleginoides* that inhabit the shallower stratum in the seamounts were reflected in the size structure of the deepest strata. Likewise, *D. eleginoides* had a tendency to increase in size with depth. This general tendency showed some local variation which may have been related to changes in topography.

The overall length-frequency distribution by depth indicated that the proportion of the population that inhabits Meteor Bank may consist primarily of adults dispersing from other areas through migration, with few juveniles, which would generate a polymodal structure such as the one observed in the 600 to 800 m stratum, in which the largest individuals were dominant.

The success of recruitment may be dependent on the depth of the bottom. Thus, the absence of substrate shallower than 300 m at seamounts may lead to poor recruitment in these regions.

The sex ratio of *D. eleginoides* less than 90 cm TL was not significantly different from 1:1. At sizes above 90 cm TL, the sex ratio (male:female) increased with length from 1:1.30 to 1:3.38 in the 140 cm interval. The size at which the sex ratio ceased to be 1:1 coincided with the size at which males reached sexual maturity, which in turn coincided with some natural process that reduced their presence, probably spawning mortality. Thus, the shortage of large males meant that females represented 70% of the total individuals analysed.

The spawning season of *D. eleginoides* in the area surveyed took place in winter, i.e. in the months prior to this study. The timing of this season was similar to that reported in waters adjacent to the Crozet and Kerguelen Islands.

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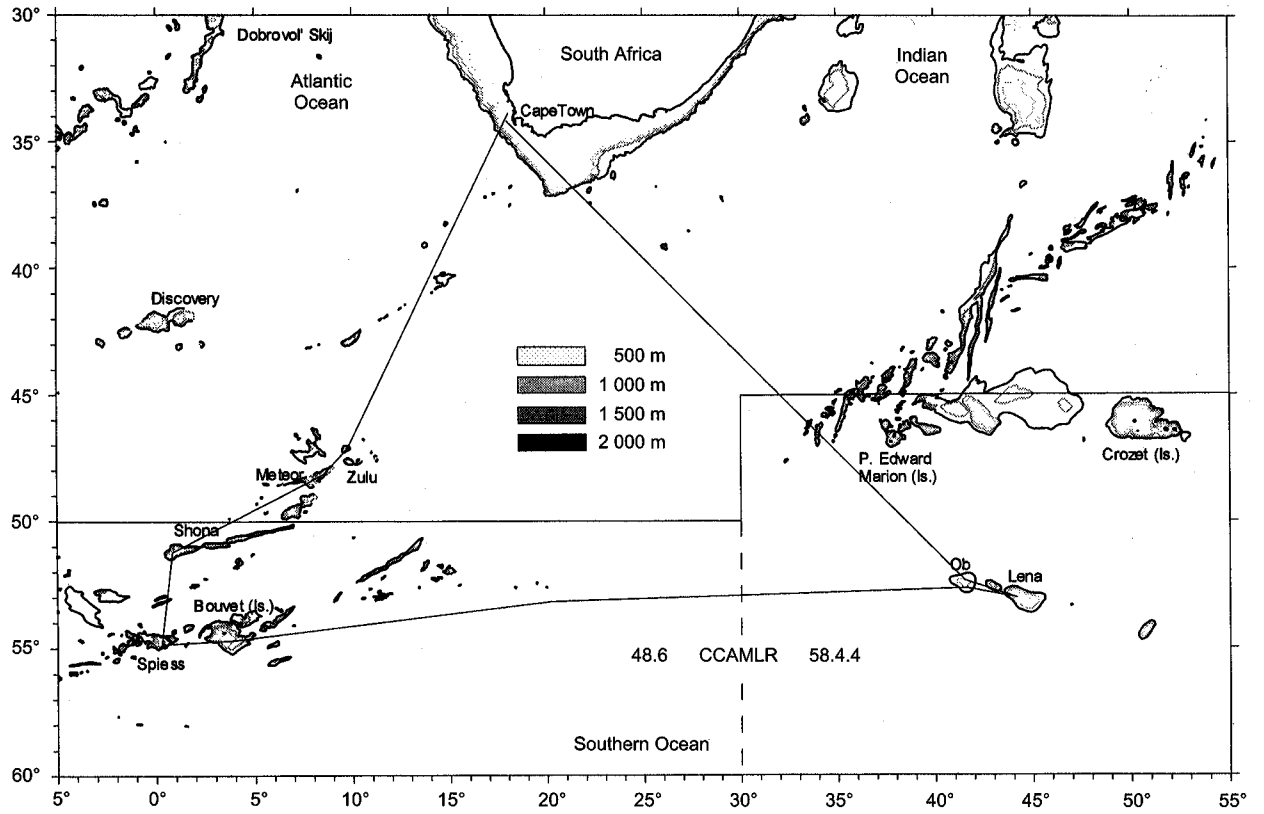


Figure 1: Cruise track and areas surveyed. Coastline and the 500, 1 000, 1 500 and 2 000 m depth contours are shown.

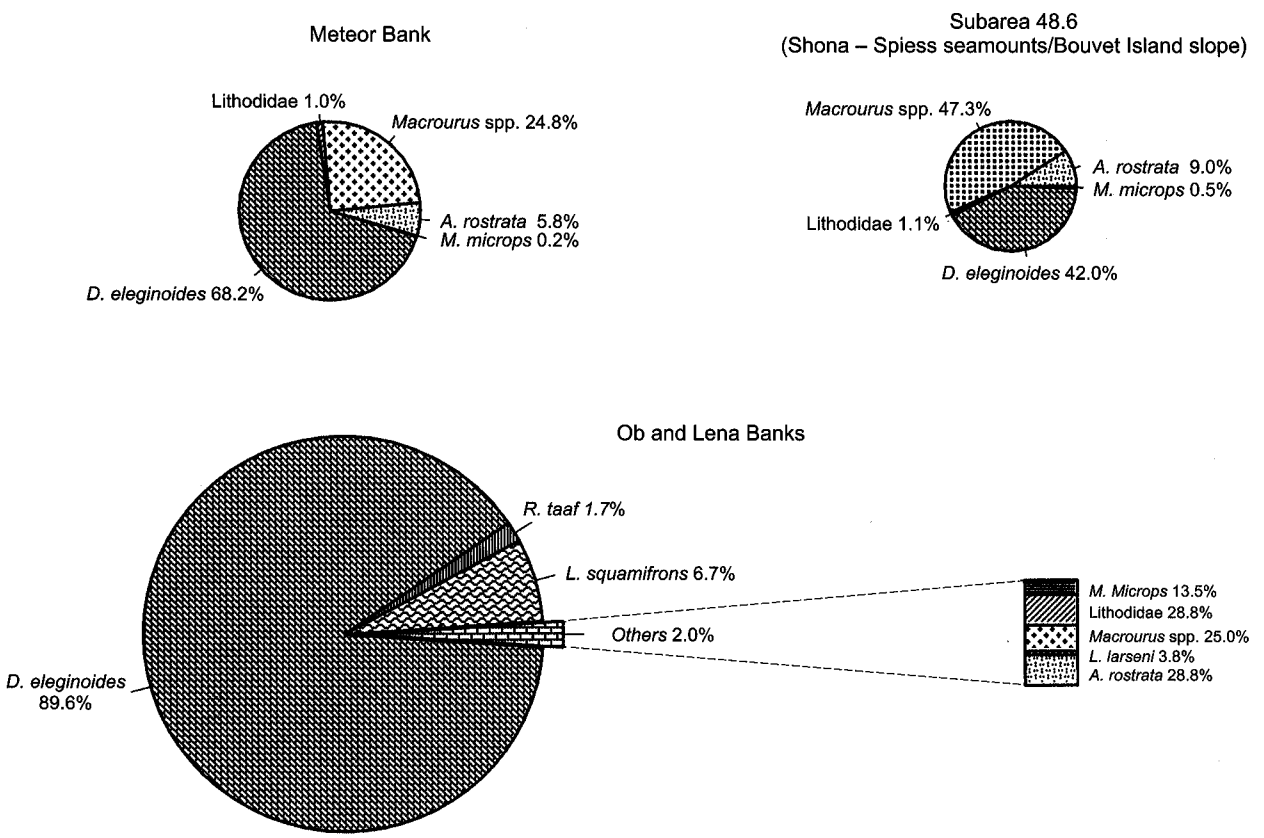
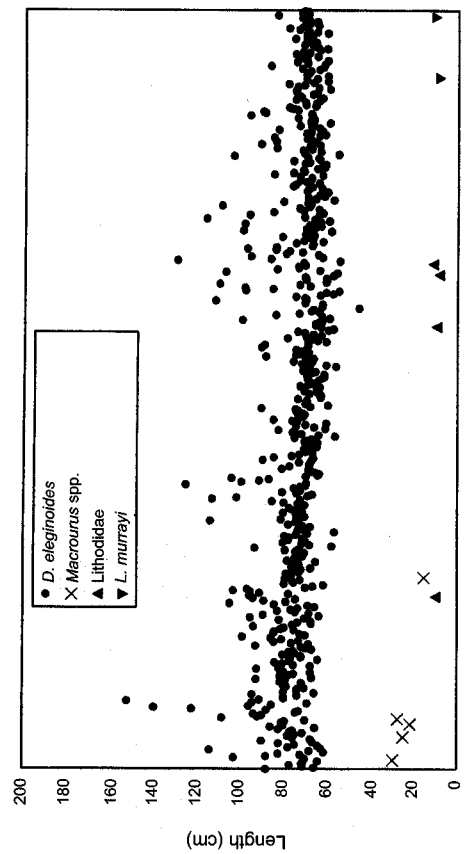
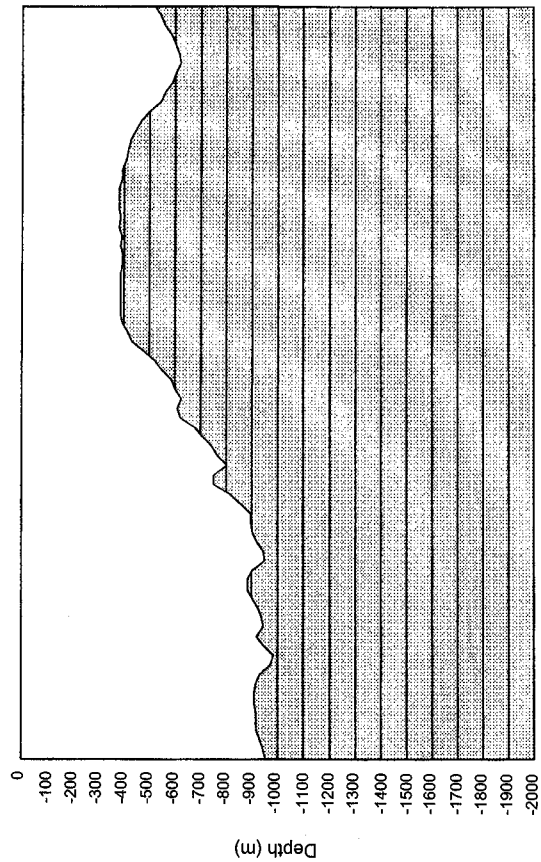
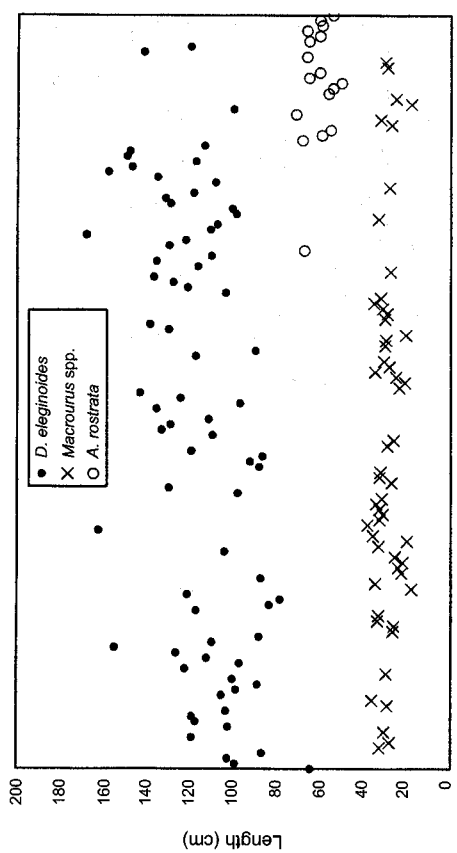


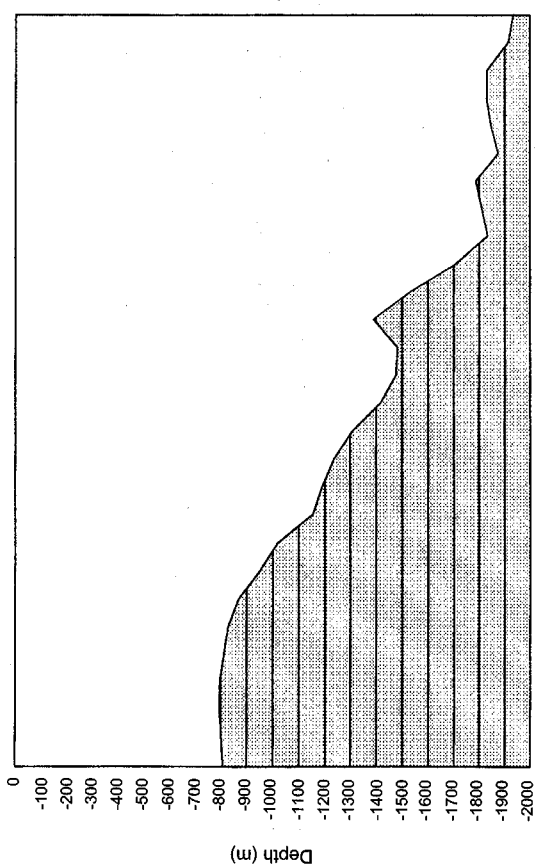
Figure 2: Relative abundance of species by region.


D. eleginoides
Macrourus spp.
Lithodidae
L. murrayi
Length (cm)
200
180
160
140
120
100
80
60
40
20
0


Depth (m)
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
-1100
-1200
-1300
-1400
-1500
-1600
-1700
-1800
-1900
-2000

Set 14


D. eleginoides
Macrourus spp.
A. rostrata
Length (cm)
200
180
160
140
120
100
80
60
40
20
0


Depth (m)
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
-1100
-1200
-1300
-1400
-1500
-1600
-1700
-1800
-1900
-2000

Set 1

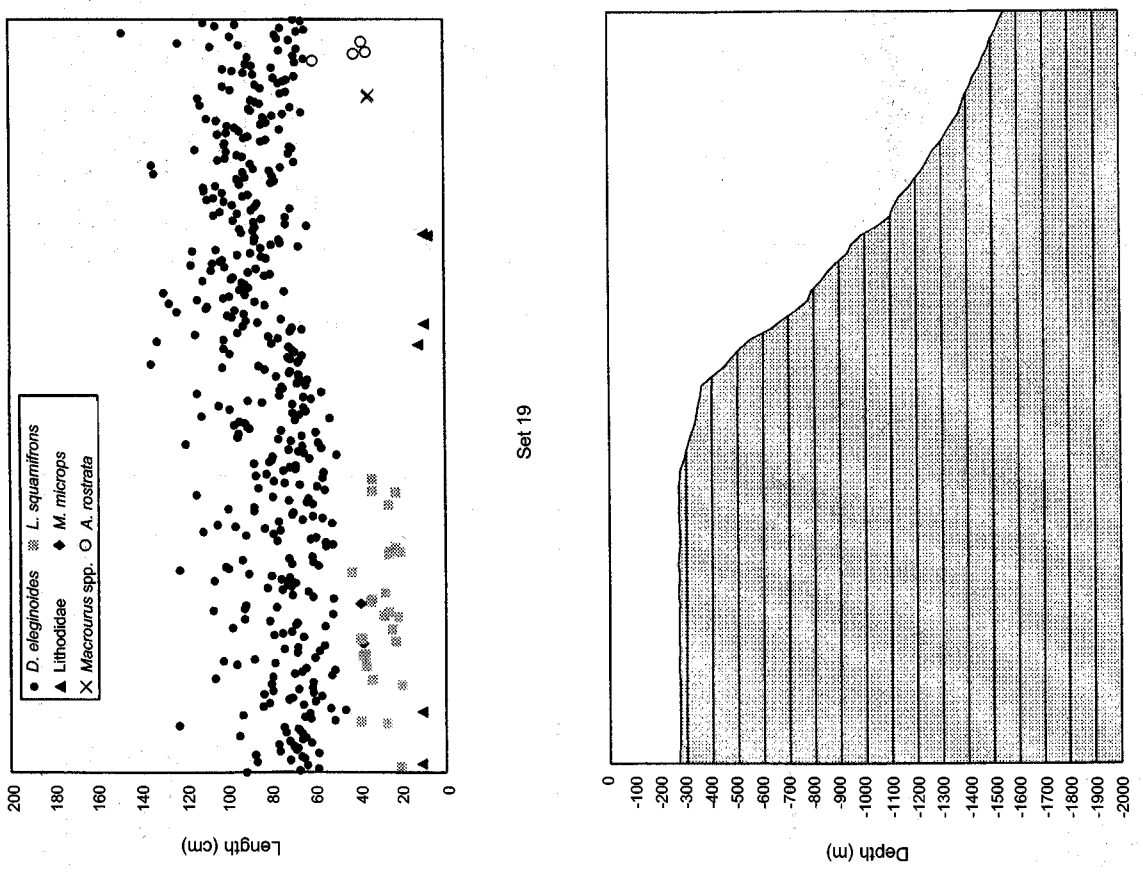


Figure 3: Depth profile, position and length of fish caught during set 1 on Meteor Bank and sets 14 and 19 on Ob Bank.

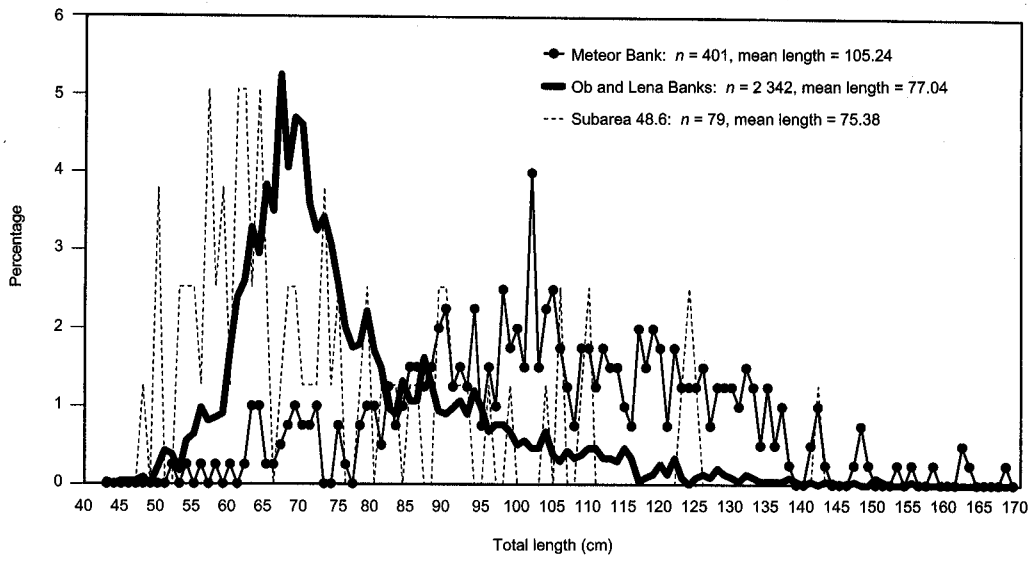


Figure 4: Length-frequency distributions of *Dissostichus eleginoides* in catches by area surveyed.

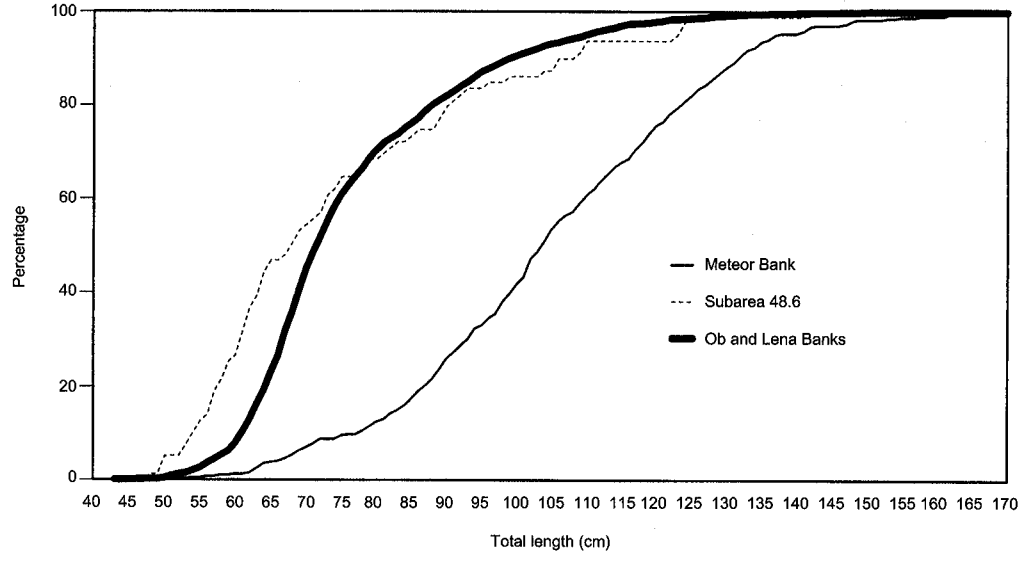


Figure 5: Cumulative length-frequency distributions of *Dissostichus eleginoides* in catches by area surveyed.

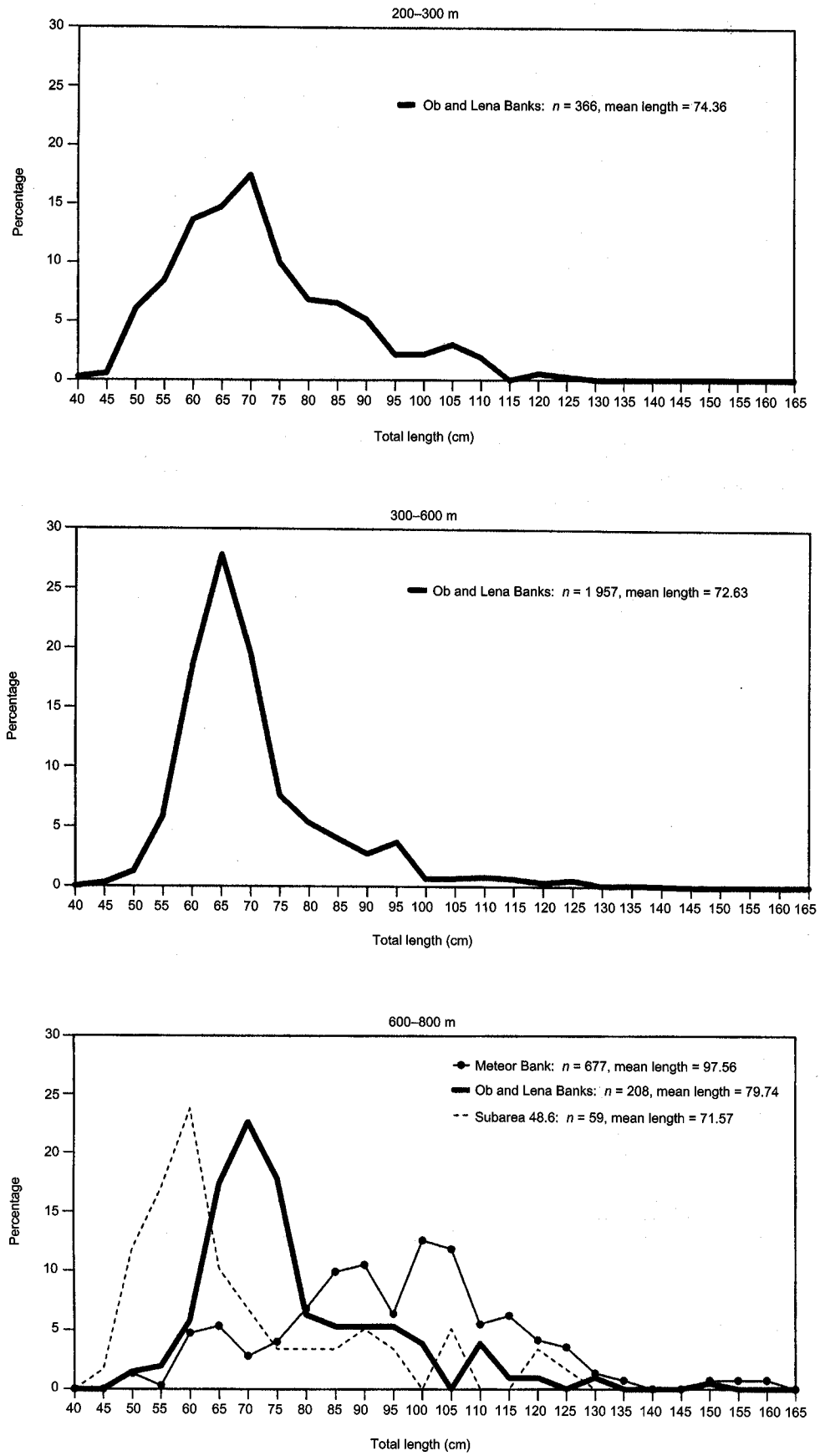
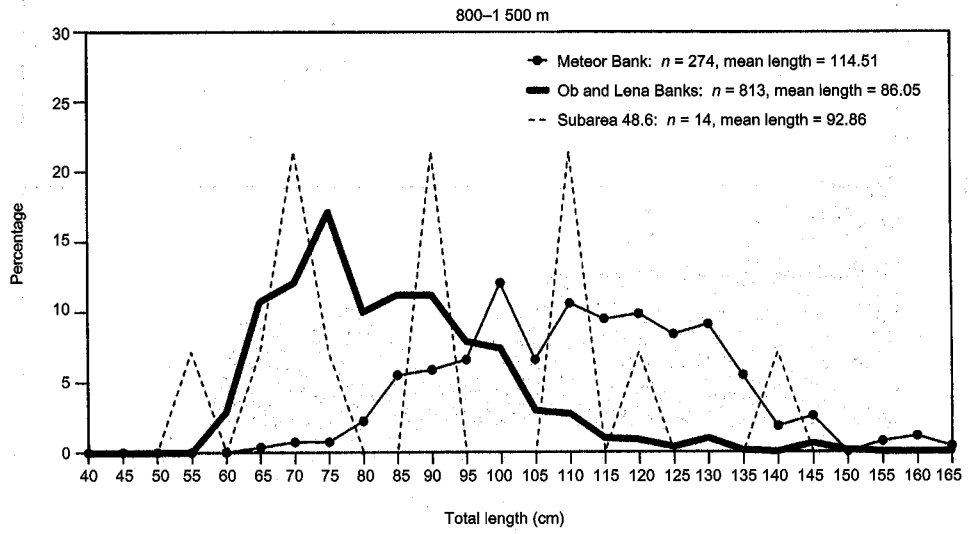
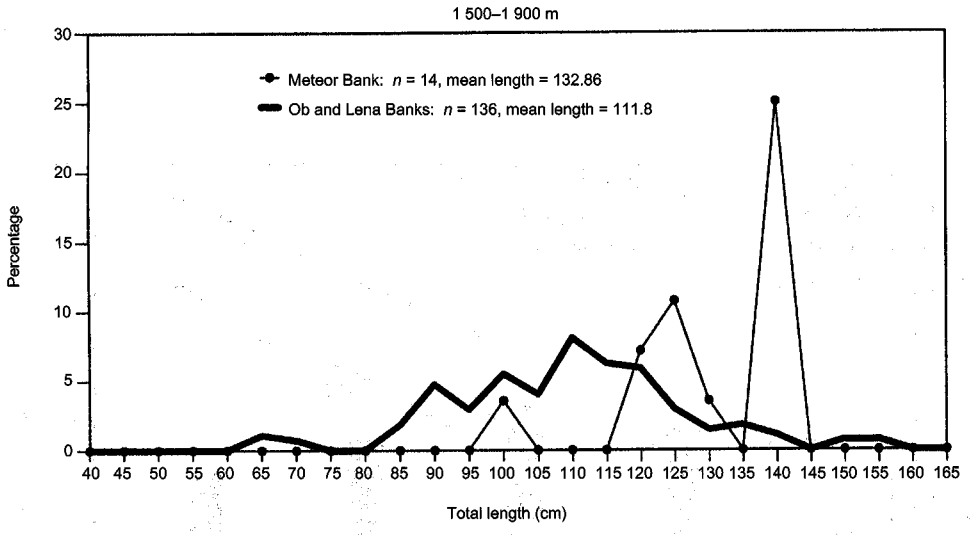


Figure 6: Length-frequency distributions of *Dissostichus eleginoides* by depth stratum in each area surveyed.

(Figure 6 continued next page)





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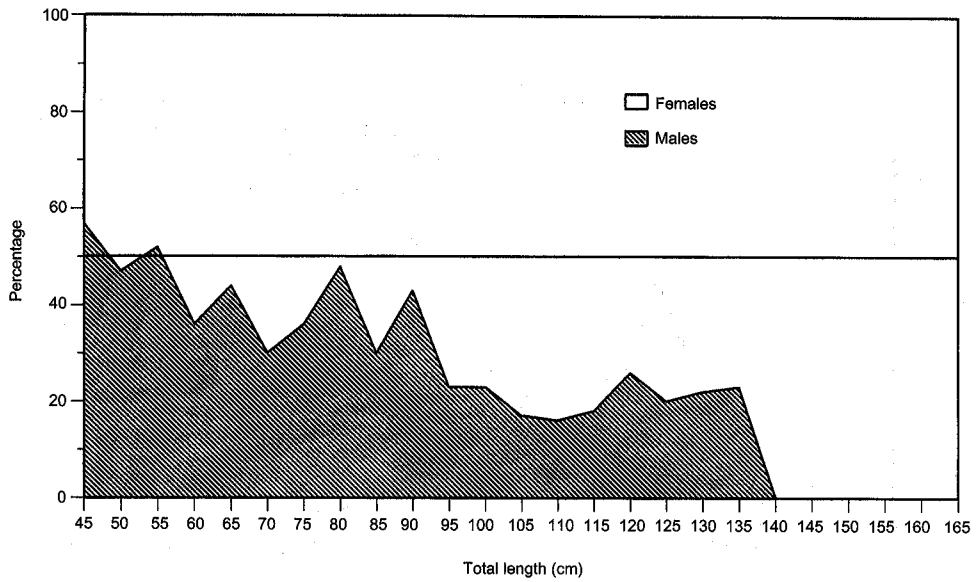


Figure 7: Sex ratio of *Dissostichus eleginoides* by size.

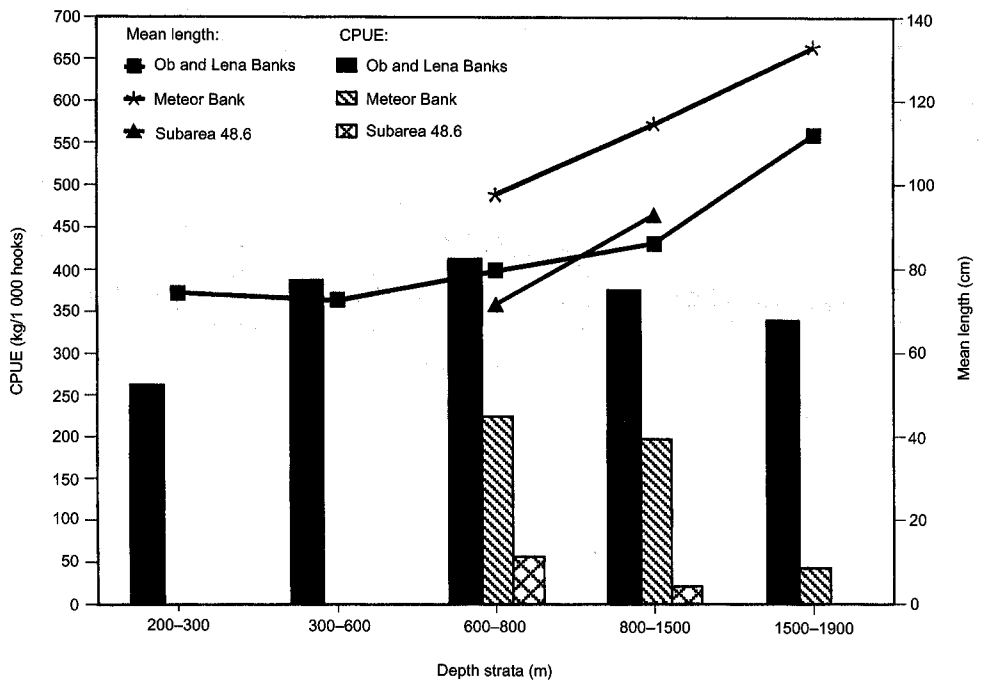
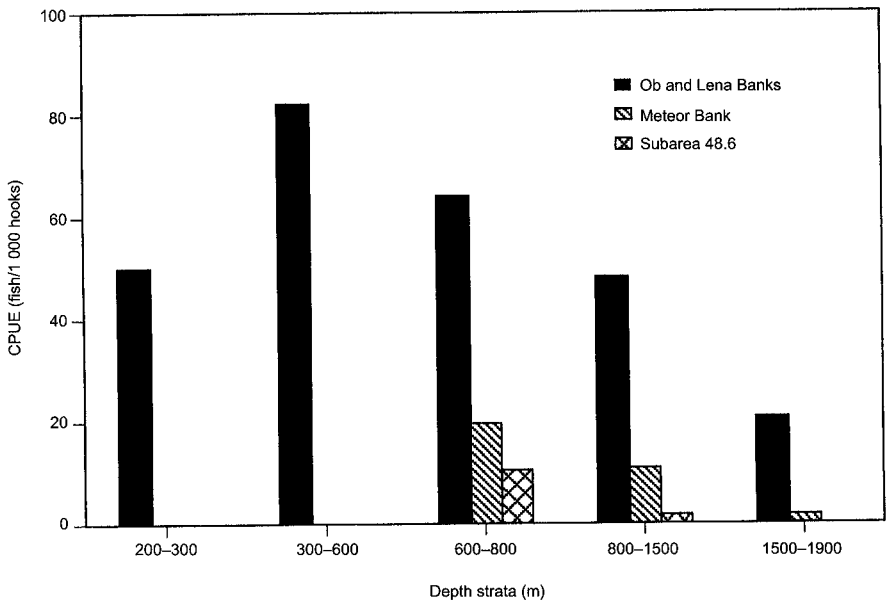


Figure 8: CPUE (kg/1 000 hooks) of *Dissostichus eleginoides* and mean length by depth stratum and area surveyed.



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