Short Notes

DISTRIBUTION AND ABUNDANCE OF *MACROURUS CARINATUS* ON BANZARE BANK IN THE SOUTHERN INDIAN OCEAN

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Abstract

This paper provides an assessment of the distribution and abundance of *Macrourus carinatus* on BANZARE Bank in the southern Indian Ocean (Divisions 58.4.1 and 58.4.3) based on results from a trawl survey in 1999. This is the first quantitative assessment of *M. carinatus* in this region. *M. carinatus* was the most common species caught in each haul, comprising on average 52 ± 4% of the total biomass. The mean density of *M. carinatus* on BANZARE Bank was 176 ± 14 kg/km^2, while the biomass was estimated to be 16 658 ± 1 325 tonnes. *M. carinatus* appeared to be uniformly distributed over the bank.

Résumé

L'auteur a effectué une évaluation de la répartition et de l'abondance de *Macrourus carinatus* sur le banc BANZARE dans le secteur Indien de l'océan Austral (divisions 58.4.1 et 58.4.3) à partir des résultats d'une campagne d'évaluation par chalutages menée en 1999. Il s'agit de la première évaluation quantitative de *M. carinatus* dans cette région. *M. carinatus* était l'espèce le plus souvent capturée par chalut, représentant en moyenne 52 ± 4% de la biomasse totale. La densité moyenne de *M. carinatus* sur le banc BANZARE était de 176 ± 14 kg/km^2, alors que la biomasse est estimée à 16 658 ± 1 325 tonnes. *M. carinatus* semblait être réparti uniformément sur le banc.

Резюме

В статье дается оценка распределения и численности *Macrourus carinatus* на банке БАНЗАРЕ (юг Индийского океана, участки 58.4.1 и 58.4.3), основанная на результатах траловой съемки в 1999 г. Это – первая количественная оценка для *M. carinatus* в этом регионе. *M. carinatus* являлся наиболее массовым видом в каждом улове, составляя в среднем 52 ± 4% от общей биомассы. Средняя плотность *M. carinatus* на банке БАНЗАРЕ была 176 ± 14 кг/км^2, а биомасса составила 16 658 ± 1 325 т. Распределение *M. carinatus* по всей банке было равномерным.

Resumen

Este documento presenta una evaluación de la distribución y abundancia de *Macrourus carinatus* en el banco de BANZARE en el sector índico del océano Austral (Divisiones 58.4.1 y 58.4.3), basada en los resultados de una prospección de arrastre efectuada en 1999. Esta es la primera evaluación cuantitativa de *M. carinatus* en esta región. *M. carinatus* fue la especie predominante en la captura de cada lance, abarcando en promedio el 52 ± 4% de la biomasa total. La densidad promedio de *M. carinatus* en el banco de BANZARE fue de 176 ± 14 kg/km^2, mientras que la biomasa se estimó en 16 658 ± 1 325 toneladas. La distribución de *M. carinatus* en el banco parece ser uniforme.

Keywords: by-catch, trawl fishery, *Macrourus carinatus*, abundance, biomass, density, BANZARE Bank, CCAMLR

INTRODUCTION

Fish of the family Macrouridae (rat tails and grenadiers) have become common by-catch species in recent years due to the increase in longline fisheries for toothfish (*Dissostichus* spp.) in the Southern Ocean (SC-CAMLR, 1998). Reports from the Ross Sea indicate that macrourids can comprise up to 17% of the total catch in these fisheries (SC-CAMLR, 1998). Similarly, Duhamel et al. (1997) found that macrourids comprised 23% of experimental longline catches around the Kerguelen Islands. Due to the scarcity of data on the population abundance of *Macrourus* spp. it is unclear whether these catch rates are sustainable. CCAMLR aims to set catch controls for by-catch species that minimise the risk of depleting local populations and overexploiting the population generally. Its approach is to set nominally low catch limits for these species until sufficient information is available to assess long-term sustainable yields according to CCAMLR's decision rules.

This paper provides a brief review of available information on *Macrourus carinatus* along with the first quantitative assessment of the abundance of this species on BANZARE Bank. This assessment is the first step towards developing an estimate of long-term sustainable yield for this species.

OVERVIEW OF AVAILABLE INFORMATION

The family Macrouridae is the largest in the order Gadiformes, comprising over 300 species within 34 genera (Cohen et al., 1990). The genus Macrourus consists of four species: *Macrourus berglax* found in the northern hemisphere, and *M. carinatus, M. holotrachys* and *M. whitsoni* found in the southern hemisphere.

Members of the Macrouridae family include some of the most widespread and abundant species of deep-water fish. They are typically benthopelagic and are found predominantly along continental slopes between depths of 200 and 2 000 m (Massutí et al., 1995). Many studies on the biology, ecology and distribution of Macrouridae have been conducted in the northern hemisphere, mainly in the northeast Atlantic (Merrett, 1978; Mauchline and Gordon, 1984; Middleton and Musick, 1986; Atkinson, 1991; Gordon and Swan, 1996; Merrett and Barnes, 1996; D'Onghia et al., 1996; Kelly et al., 1996, 1997; Marques and Almeida, 1998) and the western Mediterranean (MacPherson, 1979; Stefanescu et al., 1992, 1993; Massutí et al., 1995). Despite these studies, published information on the biology, distribution and abundance of *Macrourus* spp. (and in particular *M. carinatus*) in the southern hemisphere is scarce. What little information is available is derived mainly from taxonomic works (Trunov and Konstantinov, 1986; Cohen et al., 1990; Iwamoto, 1990) and a small number of other studies, including Revina and Pinskaya, 1975; Lisovenko, 1980; Alekseyeva et al., 1993 and Duhamel et al., 1997.

Macrourus carinatus and *M. holotrachys* were first recorded during the HMS *Challenger* voyages (Günther, 1878). From the time of their discovery till the mid-1980s there was considerable confusion in the literature about how to distinguish the two species. Trunov and Konstantinov (1986) provided a means of separating them based on a number of characteristics: the extent of squamation on the underside of the head; lunate areas behind the snout; the number of pelvic fin rays; pyloric caeca; and the relative positions of the origins of the second dorsal and anal fins. Consequently, information prior to this publication may not be attributed to the respective species correctly. This occurred in publications by Revina and Pinskaya (1975) and Lisovenko (1980), which provided detailed information on the reproductive biology of *M. carinatus*, although this species was referred to in these papers as *M. holotrachys* (Alekseyeva et al., 1993). The reproductive biology (fecundity and spawning season) and corresponding distribution of various life stages of *M. carinatus* off the Patagonian–Falkland/Malvinas shelf was studied by Alekseyeva et al. (1993). They found that juveniles and adults were segregated in this region, with immature fish located in the north, and spawning and spent fish in the south. Duhamel et al. (1997) reported the bathymetric and geographical distribution of *M. carinatus* caught as by-catch in an experimental longline fishery off the Kerguelen Islands. *M. carinatus* comprised the highest proportion of the by-catch and was most abundant in the northwestern sector of the study area.

The global distribution of *M. carinatus* includes waters along both sides of South America, Falkland/Malvinas Islands, Discovery and Meteor seamounts, South Africa, Crozet and Prince Edward Islands, Macquarie Island and off the coast of New Zealand (Trunov and Konstantinov, 1986; Iwamoto, 1990). Many of these records of distribution are derived from a single capture, and no quantitative information on density or biomass at these locations is available in the literature. Further, this species has since been recorded as by-catch in fisheries on the Kerguelen Plateau and in the Ross Sea (CCAMLR, 2000). In the Indian

Ocean sector, *M. carinatus* is a common by-catch species in the trawl fishery around Macquarie Island in the Southern Ocean. It also occurs around Heard Island but is less common in catches there due to the preference of the commercial fishery for shallow-water trawls.

Nakamura (1986) describes *M. carinatus* (under the synonym of *Coryphaenoides holotrachys*) as occurring between depths of 300 and 1 200 m in both Chilean and Argentine Patagonian waters, however it is most commonly taken at depths between 500 and 800 m (Trunov and Konstantinov, 1986). At Macquarie Island, *M. carinatus* is caught in depths ranging from 300 to 1 300 m, although it is most abundant in deeper water (>800 m) (Australian Antarctic Division, unpublished data). Around Heard Island it occurs in depths of 250 to 1 550 m (Australian Antarctic Division, unpublished data). Data from Southern Ocean longline fisheries in the Ross Sea (Subarea 88.1) show that *M. carinatus* is most commonly found in deeper waters (800–1 100 m) in this area (CCAMLR unpublished data, collected by the New Zealand Ministry of Fisheries). Similarly, Duhamel et al. (1997) found that *M. carinatus* was more abundant between 800 and 1 500 m in waters around the Kerguelen Islands. The Australian, New Zealand and French data suggest that *M. carinatus* is more commonly caught in waters deeper than 800 m, contrary to the situation in Chilean and Argentine Patagonian waters. It is not clear if these data represent the centre of biomass distribution for the species, or whether they simply reflect the preferred operating depths of the commercial fisheries which may be specific to each area. This will be an interesting question to address once more data become available.

At present, there are few estimates of biomass or density of *M. carinatus* in the Southern Ocean available in the literature. This paper provides the first quantitative assessment of this species at BANZARE Bank in the southern Indian Ocean.

MATERIALS AND METHODS

In 1999 an exploratory trawl fishery for *Dissostichus* spp. was undertaken at BANZARE Bank. As part of this exploration, a comprehensive research survey of the bank assessed the distribution and abundance of commercially important species. In addition to this, data were collected on the abundance and biomass of by-catch species. The research survey was conducted by a commercial fishing vessel, *Southern Champion*, from 25 April to 3 May 1999.

BANZARE Bank is part of the Kerguelen Plateau located in the southern Indian Ocean on the border of Divisions 58.4.1 and 58.4.3 (Figure 1a). At 2 300 km long, the Kerguelen Plateau is one of the largest submarine plateaus in the world (Schlich and Wise, 1992). The only exposed parts of the plateau are the Kerguelen, Heard and MacDonald Islands, all located to the northwest of BANZARE Bank (Figure 1b).

BANZARE Bank was surveyed to a depth of 1 500 m. The area of the bank contained within the 1 500 m depth contour comprises 94 646 km^2, calculated using bathymetry data obtained from GEBCO (General Bathymetric Chart of the Oceans). The survey area was subdivided into a grid of 40 squares (each 25 x 25 n miles). Within each square, a single haul was conducted at one of five random locations. Alternative locations were provided in the event that ground too rough for trawling was encountered. The survey design was modified slightly, with seven of the original squares abandoned, due to either rough ground or inaccurate bathymetry. The GEBCO data proved to be unrealistic in some areas with several squares located outside the 1 500 m depth contour. Five new squares, in less than 1 500 m of water, were selected by the vessel's master. Trawl locations were chosen haphazardly within each new square.

A demersal trawl net with a head-line height of 7 m and wing width of 19 m was used to conduct a total of 38 valid hauls. The codend liner had a mesh size of 60 mm and the net was fished hard against the bottom for the duration of all trawls. The depth range fished was between 670 and 1 540 m. The average tow speed was 3 knots and standard haul duration was 30 minutes fishing time. However, owing to the rough nature of the ground, hauls where the net fished on the bottom for at least 15 minutes without ripping or coming fast were counted as valid.

Two scientific observers were present on the vessel to monitor catches and collect biological data. Information on the abundance and total biomass of *M. carinatus* was recorded for each haul during the survey. Catch weights of *M. carinatus* per haul were standardised to the area swept by the trawl to give a density in kg/km^2.

The standard method used in CCAMLR for estimating biomass from trawl surveys is the TRAWLCI program (de la Mare, 1994). This program is used when many hauls have zero abundance of the species of interest in the catch. An important assumption in the method is that non-zero hauls are approximately lognormally

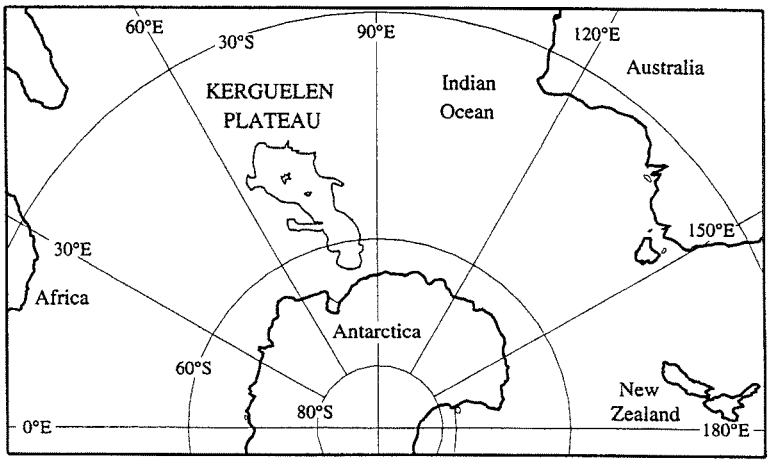

Figure 1a: Map denoting the position of the Kerguelen Plateau in the southern Indian Ocean.

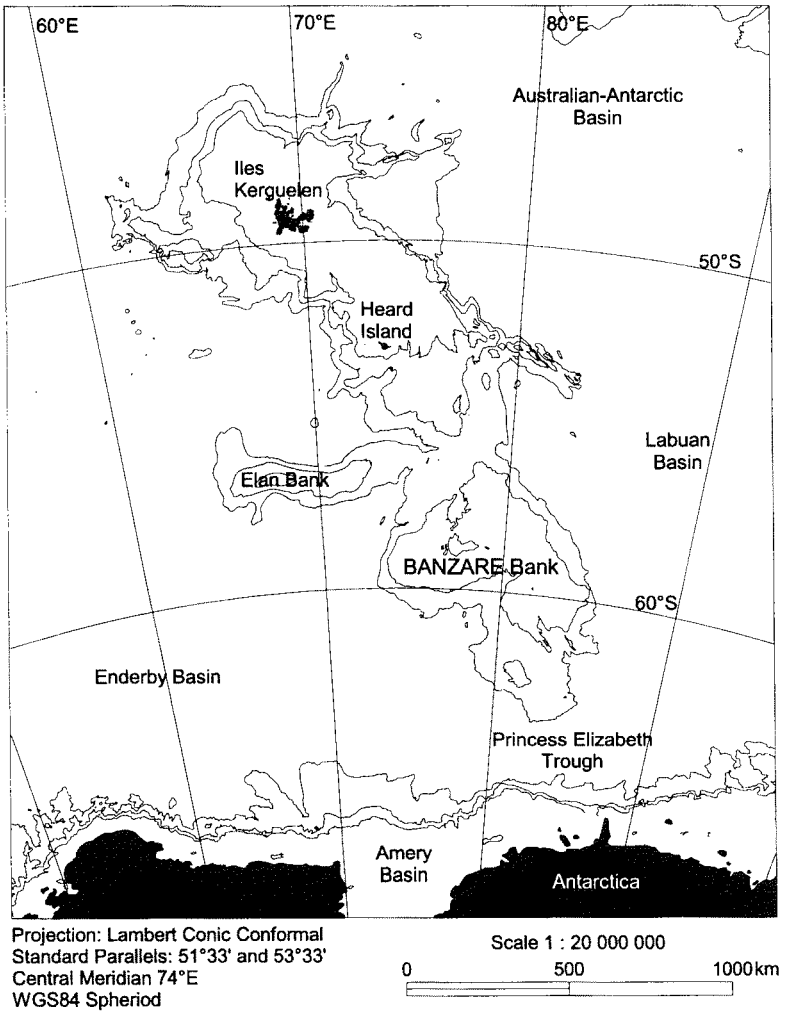

Figure 1b: Enlargement of the Kerguelen Plateau detailing the relative positions of the Kerguelen Islands, Heard Island, BANZARE Bank and surrounding features. The bathymetric contours are at 1 000 m intervals.

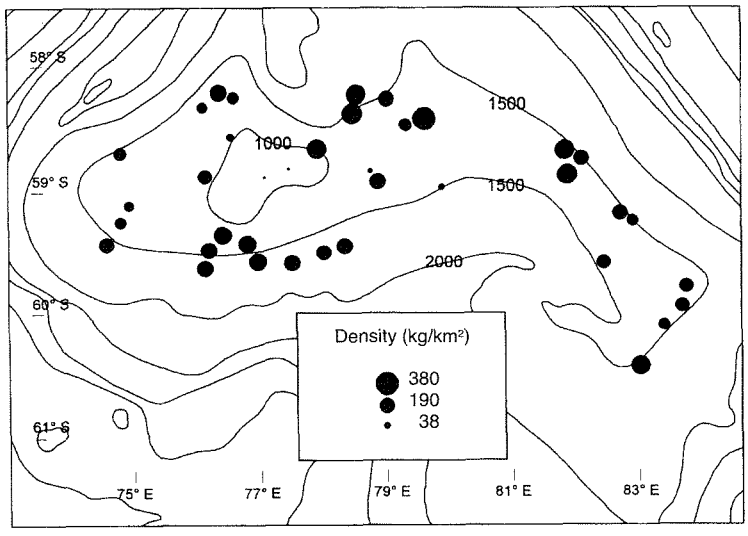

Figure 2: The density distribution of *Macrourus carinatus* on BANZARE Bank in kg/km² determined from a research trawl survey conducted in April–May 1999. The solid black lines denote the depth contours in intervals of 500 m. Note: the bathymetric data obtained from GEBCO proved to be inaccurate in some areas. Thus the location of some hauls outside the 1 500 m depth contour is an artefact of the bathymetry data used for plotting, and in reality all hauls were conducted in depths of 1 500 m or less.

distributed. This was tested using a Cramer von Mises goodness-of-fit test. For the survey results described here, this test showed that the non-zero observations did not approximate a lognormal distribution ($W2 = 0.3592$, $p < 0.05$, $n = 37$). Thus, the TRAWLCI method proved to be inappropriate in this case, and a biomass estimate for the region was calculated by multiplying the mean density of *M. carinatus* by the area of the bank.

RESULTS AND DISCUSSION

Catch Composition

M. carinatus was almost ubiquitous on BANZARE Bank, occurring in all but one of the 38 hauls. Where *M. carinatus* was present, its biomass ranged from 3 to 90% of the total biomass in each haul. The average biomass (± standard error) of *M. carinatus* as a proportion of the total catch in each haul was 52 ± 4%. On average, the rest of the catch comprised (by weight): invertebrates (35%), cephalopods (4%), *Antimora rostrata* (3%), *Bathylagus* spp. (2%), *Raja georgiana* (1%), crustaceans (1%) and other fish (2%). The 'other fish' category includes fish that were present in very low concentrations (<0.5%) and which were only found in a few of the hauls, e.g. *Aethotaxis mitopteryx*, *Paraliparis* spp., *Lepidonotothen squamifrons*, *Paradiplospinus gracilis* and *Alepocephalus* spp. If only the biomass of fish is considered, then *M. carinatus* comprised on average 85 ± 2% of the total caught per trawl. Clearly, *M. carinatus* is the dominant species of fish caught in benthic trawls on BANZARE Bank. Other studies have also found that macrourids are the dominant species in deep-water fish communities. Mauchline and Gordon (1984) found that macrourids were the most abundant species in the Rockall Trough (northeast Atlantic), comprising 41% of the total number of fish caught. Similarly, Middleton and Musick (1986) found that the four species of dominant macrourids in the Norfolk Canyon area contributed an average of 31% to the total catch. In the Denmark Strait and Irminger Sea, macrourids comprised on average 48.3% of the fishes captured in a depth range of 763 to 1 503 m (Haedrich and Krefft, 1978).

Density and Biomass Estimates

The densities (kg/km²) of *M. carinatus* on BANZARE Bank observed at each station are shown in Figure 2.

The cumulative probability of densities observed in the survey, along with a fit to a normal distribution is shown in Figure 3. A Kolmogorov–Smirnov goodness-of-fit test showed that the data were normally distributed ($Dn = 0.0629$, $p < 0.05$, $n = 38$). The mean density (± standard error) of *M. carinatus* derived from the data was

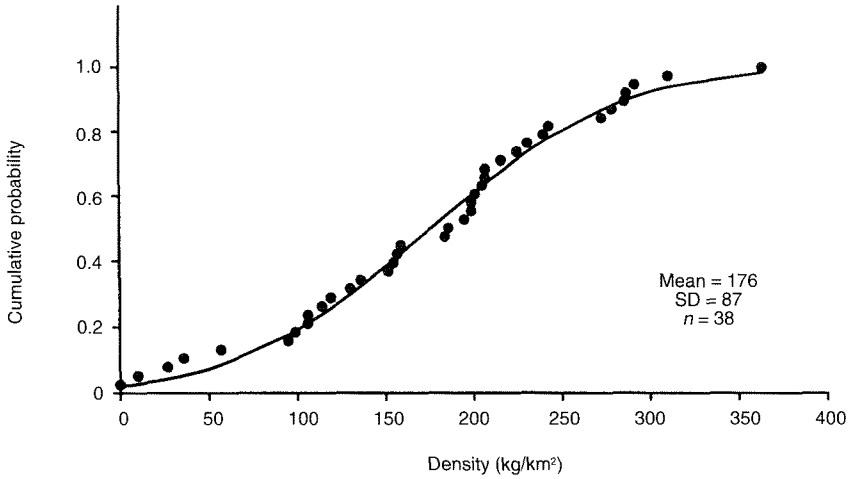

Figure 3: A cumulative probability plot of the density of *Macrourus carinatus* on BANZARE Bank (solid circles). The normal cumulative distribution fitted using a least-squares method is denoted by the solid line.

176 ± 14 kg/km². This translates into an estimate of biomass (± standard error) for the region of 16 658 ± 1 325 tonnes.

The density coefficient of variation was 0.50 and indicates that the distribution of *M. carinatus* over the bank is relatively uniform. The one exception to this occurred in the shallowest waters where hauls in less than 1 000 m resulted in relatively small catches of fish.

CONCLUSIONS

M. carinatus was the most common species caught in the survey of BANZARE Bank, comprising on average 52 ± 4% of the total biomass in each haul. The results of the survey indicate that this species is uniformly distributed on the bank with a mean density of 176 ± 14 kg/km². Such a uniform distribution may be characteristic of this ubiquitous deep-water species in the Southern Ocean, as similar reports of *M. carinatus* distribution exist for the Ross Sea (SC-CAMLR, 1998).

In order for CCAMLR to advance the estimation of catch limits for by-catch species in Southern Ocean fisheries beyond nominally low catch levels, information on abundance and demography of by-catch species is required. The estimate of density provided here is the first quantitative assessment of *M. carinatus* based on a research survey in the region. Further assessment of catch levels requires the estimation of demographic parameters such as natural mortality, growth rates and recruitment variation for this or closely related species. Until such estimates are obtained, CCAMLR will need to retain its precautionary approach to managing the by-catch of this species.

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Figure 1b: Agrandissement du plateau de Kerguelen détaillant la position relative des îles Kerguelen, de l'île Heard, du banc BANZARE et des caractéristiques adjacentes. Les isobathes sont à 1 000 m d'intervalle.

Figure 2: Répartition de la densité de *Macrourus carinatus* sur le banc BANZARE en kg/km^2 déterminée à partir d'une campagne de recherche par chalutages menée en avril-mai 1999. Les lignes continues noires indiquent les isobathes à 500 m d'intervalle. Notez : les données bathymétriques provenant de GEBCO se sont révélées inexactes en certains secteurs. Ainsi l'emplacement de certains chalutages en dehors de l'isobathe de 1 500 m a été déterminé à partir des données bathymétriques utilisées pour la représentation graphique. En réalité tous les chalutages ont été réalisés à des profondeurs inférieures ou égales à 1 500 m.

Figure 3: Graphique de probabilités cumulées de la densité de *Macrourus carinatus* sur le banc BANZARE (cercles pleins). La distribution normale cumulative ajustée au moyen de la méthode des moindres carrés est indiquée par la ligne continue.

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Рис. 3: Кривая кумулятивной верятности плотности *Macrourus carinatus* на банке БАНЗАРЕ (точки). Сплошной линией показано нормальное кумулятивное распределение, рассчитанное по методу наименьших квадратов.

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Figura 1a: Ubicación geográfica de la plataforma de Kerguelén en el sector índico del océano Austral.

Figura 1b: Ampliación de la plataforma de Kerguelén. Ubicación de las islas Kerguelén y Heard, el banco de BANZARE y alrededores. Los contornos batimétricos se presentan a intervalos de 1 000 m.

Figura 2: Distribución de la densidad de *Macrourus carinatus* en el banco de BANZARE expresada en kg/km^2, determinada de la prospección de investigación efectuada en abril-mayo de 1999. Las líneas negras muestran los contornos batimétricos a intervalos de 500 m. Nota: los datos batimétricos obtenidos de GEBCO demostraron ser inexactos para algunas áreas. Así, la ubicación de algunos lances fuera del contorno de profundidad de 1 500 m es un artefacto de los datos batimétricos utilizados para el trazado; de hecho, todos los lances fueron efectuados a profundidades iguales o menores de 1 500 m.

Figura 3: Gráfico de las probabilidades acumuladas de la densidad de *Macrourus carinatus* en el banco de BANZARE (•). La línea negra representa la distribución acumulada normal ajustada mediante el método de los mínimos cuadrados.