ISSN, 0327-9332

INIDEP Documento Científico 5
Agosto 1999

REPRODUCTIVE HABITAT, BIOLOGY AND ACOUSTIC BIOMASS ESTIMATES OF THE SOUTHERN BLUE WHITING (*Micromesistius australis*) IN THE SEA OFF SOUTHERN PATAGONIA

Edited by Ramiro P. Sánchez

Secretaría de Agricultura, Ganadería, Pesca y Alimentación
Instituto Nacional de Investigación y Desarrollo Pesquero - INIDEP
Mar del Plata, R. ARGENTINA

República Argentina

Instituto Nacional de Investigación y Desarrollo Pesquero
INIDEP

REPRODUCTIVE HABITAT, BIOLOGY AND ACOUSTIC BIOMASS ESTIMATES OF THE SOUTHERN BLUE WHITING (*Micromesistius australis*) IN THE SEA OFF SOUTHERN PATAGONIA

Edited by Ramiro P. Sánchez

ISSN, 0327 - 9332

INIDEP Documento Científico 5
Agosto 1999
Mar del Plata, República Argentina

Primera impresión: 700 ejemplares

Diseño gráfico: D.C.V. Marisa Abinet. Av. J. J. Paso 2215. 7600 Mar del Plata.
Impresión: Offset Vega. Bolívar 3715. 7600 Mar del Plata.

Resumida/indizada en: Aquatic Sciences & Fisheries Abstracts (ASFA); Agrindex; INFOMARNAP; Marine, Oceanographic & Freshwater Resources; Wildlife Worldwide; Zoological Record.

COMENTARIO PRELIMINAR

Si bien en forma ocasional la plataforma patagónica austral había sido explorada por campañas de investigación oceanográfico-pesqueras durante de los sesenta, no fue sino hasta fines de la década siguiente, y como resultado de sendos programas de cooperación internacional con los gobiernos de la República Federal de Alemania y Japón, que pudo alcanzarse una cobertura completa del área, estacionalmente repetida. El valor de estos estudios sobre recursos que, a la sazón, podían considerarse vírgenes, adquirió significativa importancia, ante la desmedida intensificación de la actividad extractiva en los ochenta, la cual no fue lamentablemente acompañada por programas de investigación que permitieran monitorear la evolución de las poblaciones ante el incrementento del esfuerzo pesquero sobre ellas aplicado.

En el curso de los años recientes el INIDEP ha incrementado notablemente, la asignación de recursos económicos y humanos al estudio de dos de los recursos pesqueros más importantes de la región: la polaca (*Micromesistius australis*) y la merluza de cola (*Macruronus magellanicus*). En la actualidad, tres proyectos de la institución y un proyecto de cooperación técnica con Japón, tienen como objetivo el estudio de diferentes aspectos de la dinámica poblacional, evaluación y biología de esas especies. La creciente cantidad de información obtenida como resultado de la adecuada cobertura espacio-temporal del área de estudio, mediante buques de investigación y observadores a bordo de la flota comercial, nos ha permitido profundizar en nuestro conocimiento sobre el estado de estos recursos y comparar la situación actual con la que se observaba veinte años atrás.

Ha sido nuestra intención, al preparar este documento, reunir y sintetizar los conocimientos disponibles sobre la biología reproductiva de la polaca en la región austral del Mar Argentino. Se incluyen en el mismo tres trabajos en los que se hace referencia a las características ambientales que prevalecen en las áreas de puesta de la especie, un trabajo sobre su biología reproductiva y una caracterización acústica de la estructura de los cardúmenes y evaluación de las concentraciones reproductivas que corresponden a la región malvinense. Algunos de estos estudios se han iniciado recientemente en el INIDEP, otros tienen ya una cierta tradición institucional. En consecuencia, el alcance y profundidad del análisis difiere, en cada caso, según la disponibilidad de información actual y referencias históricas.

Los estudios oceanográficos se centraron en el análisis de las condiciones termo-halinas prevalecientes en invierno en la región sud-oriental de la plataforma continental y talud argentinos. Las masas de agua en el área derivan del estrato superior del Agua Intermedia Antártica, modificada por interacción con las aguas diluídas de plataforma. Se observaron variaciones interanuales en los campos térmicos. El invierno de 1995 fue el más frío en el

período analizado. Pudo definirse un intenso frente de talud en el borde oeste del canal situado entre la Isla de los Estados y el Banco Burdwood, el cual parece presentar un impacto biológicamente significativo sobre el comportamiento reproductivo de la especie.

Sabatini *et al.*describen en forma sinóptica la distribución de las biomasas zooplanctónicas durante el pico de desove invernal, a partir del análisis de dos campañas de investigación recientes, y comparan estos datos con informes previos de la abundancia zooplanctónica en la región malvinense durante el invierno y en la plataforma patagónica austral durante la primavera y el otoño. Los autores concluyen que, a pesar de ciertas diferencias, atribuíbles a los métodos de muestreo empleados en cada caso, no existen evidencias que permitan suponer la existencia de cambios de relevancia en la composición específica o en la abundancia del zooplancton durante los últimos veinte años.

Por el contrario, la distribución y composición del ictioplancton en la región, tal como se observan en la actualidad, contrastan marcadamente con las descriptas en trabajos previos. Se observa en particular una retracción del hábitat reproductivo de la polaca, y una ausencia total de formas embrionarias y larvales de *Salilota australis*, de ocurrencia frecuente en el pasado. La incorporación de nuevos sistemas de muestreo y el progreso alcanzado en el reconocimiento de los componentes del ictioplancton han permitido reseñar por primera vez, la presencia y distribución de larvas de varias especies de mictófidos, estudiar mediante análisis de clasificación jerárquica la existencia de asociaciones entre distintos niveles de la comunidad ictioplanctónica y su relación con las características del ambiente físico, y describir la estructura de tallas de las poblaciones de post-larvas y juveniles primarios de polaca y sardina fueguina.

Los estudios sobre la biología reproductiva de la especie, ponen de manifiesto que se trata de un desovante parcial, con fecundidad determinada. Se analiza asimismo la estacionalidad de la actividad de puesta y se propone una escala de madurez específica. Si bien los estimadores preliminares de la fecundidad caen dentro del rango de valores previamente calculados para la especie, la talla de primera madurez parece haber decrecido en relación con los valores calculados veinte años atrás.

Finalmente, el relevamiento acústico ha permitido describir la distribución en el plano geográfico y en la columna de agua y estimar las biomasas de las concentraciones reproductivas. El tema de la fuerza de blanco, una cuestión metodológica importante en este tipo de análisis, es tratado en detalle. Se discute también sobre la dificultad de obtener anualmente un estimador instantáneo de la población en puesta a partir de este tipo de metodología.

Confiamos que el material aquí presentado pueda servir como base para futuras investigaciones. Nuestra intención al presentar este documento ha sido poner de relieve los aportes de algunas líneas de investigación que merecen continuarse e intensificarse. Recién entonces estaremos en condiciones de encarar cuestiones fundamentales que nos lleven a comprender cuáles son los mecanismos biológicos que pueden permitir a la polaca equilibrar las pérdidas causadas por la actividad extractiva y de qué modo el ambiente es capaz de condicionar la distribución, abundancia y fluctuaciones de la especie.

EL EDITOR

FOREWORD

Although occasional oceanographic and fisheries surveys of the sea off southern Patagonia began in Argentina during the 60's, the first seasonal coverage of the complete area was attained only by the end of the 70's, as a result of joint international scientific programmes with the Federal Republic of Germany and Japan. The value of these studies on resources that were at the time unexploited was enhanced in view of the uncontrolled rise of fishing during the following decade, that was unfortunately not supported by research programmes aiming at monitoring the response of the stocks under increasing fishing effort.

In the course of recent years INIDEP remarkably increased the allocation of economic and human means to the study of the major finfish of the region: the southern blue whiting (*Micromesistius australis*) and the hoki (*Macruronus magellanicus*). Three INIDEP's projects, and one technical co-operation programme with Japan target on different aspects of the population dynamics, assessment and biology of these species. The large amount of information derived from the enhanced time-space coverage of the area has widened the scope of our understanding of these resources, and allows comparison of recent results with those of the late 70´s.

Our primary aim in preparing this document was to bring together and summarize what is known about the spawning activity of the southern blue whiting in the southern region of the Argentine Sea. It comprises three scientific contributions referring to environmental characteristics which prevail in the spawning habitat of the species, a paper on its reproductive biology, and an acoustical description and assessment of spawning concentrations of the southern blue whiting around Malvinas Islands. Some of these studies have been recently undertaken, others have a certain tradition in INIDEP. Consequently the scope and extent of each analysis differ in relation to the availability of previous and present information.

Oceanographic studies were focused on the analysis of winter thermo-haline conditions in the SE region of the Argentine continental shelf and slope. Water masses in the area are derived from the lighter upper stratum of the Antarctic Intermediate Water, after being modified by interaction with shelf diluted waters. Inter-annual variations were observed in the temperature fields. Winter 1995 was the coldest over the period analysed. A sharp shelf break front was defined at the west border of the channel between Staten Island and Burdwood Bank, which has a significant biological impact on the reproductive behaviour of the species.

Sabatini *et al.* report on the synoptic distribution of zooplankton biomass during the winter spawning peak based on the analysis of two recent surveys, and compare these data with previous reports on zooplankton abundance around the Islands in winter, and on the southern Patagonian shelf in autumn and spring. The authors conclude that in spite of some differences which may be attributed to sampling methods, there is no evidence to suspect major changes in specific composition or abundance of zooplankton in the last 20 years.

Conversely, the regional icthyoplankton distribution and composition presents some striking con-

trasts with those of previous reports, particularly in relation with a contraction of the spawning grounds of the southern blue whiting and the total absence of *Salilota australis*, commonly observed in the past. The incorporation of new sampling devices and the progress in the identification of the main ichthyoplankton components allowed to report for the first time on the occurrence and distribution of larvaeof several myctophiid species, describe through hierarchical classification the relationship between larval group and physical characteristics, and present length frequency distributions of post-larvae and early juveniles of sprat and blue whiting.

Results on the reproductive biology reveal that the species is a partial spawner with a determinate fecundity. Based on histological and macroscopical analysis the seasonality of spawning activity is discussed, and a maturity scale is proposed. A preliminary fecundity estimate fell in the range of values previously reported. On the other hand the size at first maturity seems to have decrease as compared to that reported for the late 70's.

Finally, the paper on acoustic focuses on the geographical occurrence, spatial distribution and biomass estimates of spawning concentrations. Target strength, an important methodological issue to this type of analysis, is addressed in detail. The difficulty of obtaining accurate point estimates of spawning biomass through a single acoustic survey is discussed.

We hope that the material discussed herein may serve as a basis for future scientific activities. Our intention in presenting this document was to point out some fields of research that deserve to be continued and intensified. We may then be in a position to address such fundamental questions as the biological mechanisms that may allow the southern blue whiting stocks to compensate for losses due to fishing and the possible linkages between the environmental forces that control the species distribution, abundance and fluctuations.

The Editor

CONTENTS

CONTENIDO

ACOUSTIC SURVEYS ON THE SOUTHERN BLUE WHITING (*Micromesistius australis*)*

by

ADRIAN MADIROLAS [1]

[1] National Insitute for Fisheries Research and Development (INIDEP). P.O. Box 175, 7600 - Mar del Plata, Argentina.

RESUMEN

Investigaciones acústicas sobre la polaca (*Micromesistius australis*). Durante la primavera de 1994 y 1995 se llevaron a cabo dos cruceros acústicos conjuntos Argentino-Británicos para el estudio de la polaca (*Micromesistius australis*). Los cruceros confirmaron la existencia de una concentración reproductiva de polaca localizada hacia el sur del Estrecho de San Carlos. Las estimaciones puntuales de abundancia correspondientes a ambos cruceros fueron 84801 t y 140953 t, para 1994 y 1995 respectivamente. Los cruceros aportaron además información sobre la estructura y comportamiento de los cardúmenes de polaca como así también algunas pautas acerca del complejo patrón migratorio de la especie.

SUMMARY

Two joint Argentine-British acoustic surveys specifically targeted on the southern blue whiting (*Micromesistius australis*) were carried out during September 1994 and 1995. The surveys confirmed the existence of a spawning concentration area located south from San Carlos Strait. The obtained point estimates of blue whiting abundance were 84801 t for the 1994 survey and 140953 t for the 1995 survey. The surveys also provided information on the school structure and behavior as well as some clues about the complex migration pattern of the species.

Key words: *Micromesistius australis*, acoustic surveys.
Palabras claves: *Micromesistius australis*, cruceros acústicos.

* INIDEP Contribution Nº 1086.

INTRODUCTION

Since 1992 INIDEP has carried out several acoustic surveys aimed at gathering information on abundance and geographic distribution of the southern blue whiting. Two joint Argentine-British acoustic surveys specifically targeted on blue whiting were carried out during September 1994 and 1995 and most of the information presented here corresponds to them.

The joint surveys were designed to obtain estimates of the biomass of blue whiting during the spawning season, assuming that during September-October most of the adult components of the stock concentrate in the western side of Malvinas Channel. This assumption is based on scientific data collected during previous surveys carried out in the seventies and early eighties (Perrotta, 1982; Sánchez and Ciechomski, 1995).

MATERIALS AND METHODS

Acoustic instrumentation

The survey platform was R/V Cap. Oca Balda, a 66 m length stern trawler run by the INIDEP. The acoustic instrumentation consisted of a SIMRAD EK-500. In 1994 the echo sounder was interfaced to a 486 based PC computer for dataloging through an asynchronic port. In 1995 the EK-500 echo sounder was interfaced to a risk processor based Graphical Work Station via an Ethernet port and the SIMRAD BI500 software for dataloging and post processing (Foote et. al., 1991). The operating frequency was 38 KHz for both surveys and the processing method was echointegration.

The echointegration method (Forbes and Nakken, 1974) is based on measurements of the sound volume scattering caused by the targets that are insonified during the pass of a ship equipped with a calibrated echo sounder. The ship trackline is decided in advance and a given sampling strategy is chosen according to the characteristics of the area and the expected distribution of the species (Simmonds *et al.*, 1991; MacLennan and Simmonds, 1992).

For each survey the scientific sounder was calibrated according to ICES recommendations for calibration with standard targets (Foote *et al.*, 1987). Sounder calibration was accomplished during the survey in 1994 and just before the survey in 1995. Calibration reports and other related information are included in the corresponding survey activities reports.

Definition of the physical parameters involved in the biomass density calculation follow the definitions given in Clay and Medwin (1977). Equivalencies with definitions from other sources are given in Bodholt (1990) and in Foote (1991). The formulae utilized for conversion from sound scattering measurements to fish density values are as follows:

$$\sigma_{bs} = 10^{(TS/10)} \; ; \; \sigma_{bs} = \sigma / (4\pi) \; ; \; \sigma_{bs\text{-}kg} = \sigma_{bs} / W$$

$$s_a = 4\pi \cdot (1852^2) \cdot s_V \cdot \Delta R$$

$$\rho = s_a \cdot (1/10^3) \cdot (1/4\pi) \cdot (\sigma_{bs\text{-}kg})^{-1}$$

where:

s_a: column or area scattering coefficient normalized per squared nautical mile (Clay and Medwin, 1977), in units of m^2/nm^2 and as calculated internally by the SIMRAD EK-500 (Bodholt, 1990).

s_V: volume scattering coefficient, in units of m^2/m^3.

ΔR: depth interval, in units of m.

TS: fish acoustic target strength (Clay and Medwin, 1977), in units of dB.

σ_{bs} : fish equivalent back scattering cross sec-

tion, in units of m^2.

σ : fish equivalent scattering cross section, in units of m^2.

W : individual fish mean weight, in units of Kg.

ρ : fish biomass density, in units of t/nm2.

Target strength of the southern blue whiting

A target strength (TS) vs. fish length relationship for the particular species, is a key factor in the process of biomass estimation from sound scattering measurements. Different methods have been established to obtain this relationship (Foote, 1991), being the *in situ* measurements of single fish echoes or direct method generally recognized as the best approach to a solution for this problem. However, conditions suited to obtain reliable in situ TS measurements are rather uncommon in practice. For the present case, deep and high density blue whiting schools constitute serious limitations for the application of the direct method.

Before a TS relationship for the southern blue whiting can be obtained, models for other species has to be utilized. Fish target strength is a rather complex parameter and is determined by both, physiological and behavioral factors. As a first approach, given that southern blue whiting is a physoclist fish, the following general model for physoclist fish (Foote, 1987) can be considered:

$$TS = 20 \log (L) - 67.4 \text{ dB}$$

where L is the fish mean length, in units of cm.

In the 1994 survey very few TS data could be collected using split beam transducers and the general target strength model developed for physoclist fish was employed to obtain a biomass estimate. The acoustic instrumentation in the 1995 survey was significantly improved by the inclusion of a graphical work station, allowing further post-processing of acoustic data. The analysis of TS data collected in 1995 showed lower TS values than those obtained in the previous survey, indicating that due to the mentioned constraints, the obtained frequency distributions of blue whiting target strength may be affected by multiple echoes. Consequently it is believed that the general model for physoclist fish, employed for the 1994 survey, could represent an overestimation of the target strength of the southern blue whiting.

Data employed in the physoclist model corresponded to gadoid fish, mainly cod and haddock, for which the model has shown good agreement with *in situ* measurements. Nakken and Olsen (1977) performed a series of experiments to compare maximum dorsal aspect target strength of several fish species, including the northern blue whiting and showed that this species exhibits a lower TS in the dorsal aspect compared to other gadoids as cod.

Acoustic surveys on the northern blue whiting (*Micromesistius poutassou*) have been carried out inside the ICES programs for several years and the following TS/fish length relationship (Anon., 1985) is currently applied for biomass estimation:

$$TS = 21.8 \log (L) - 72.7 \text{ dB}$$

where L is the fish mean length, in units of cm.

The last target strength model agree with the lower TS compared to gadoids shown in the Nakken and Olsen experiments. Considering that both species, northern and southern blue whiting, are very similar in their physiology and school behavior and that the 1995 *in situ* measurements supports the validity of lower TS values than those of other gadoid fish, it is recommended that the TS relationship developed for the northern blue whiting (*Micromesistius poutassou*) be adopted also for the biomass estimates of southern blue whiting (*Micromesistius australis*), until a specific TS rela-

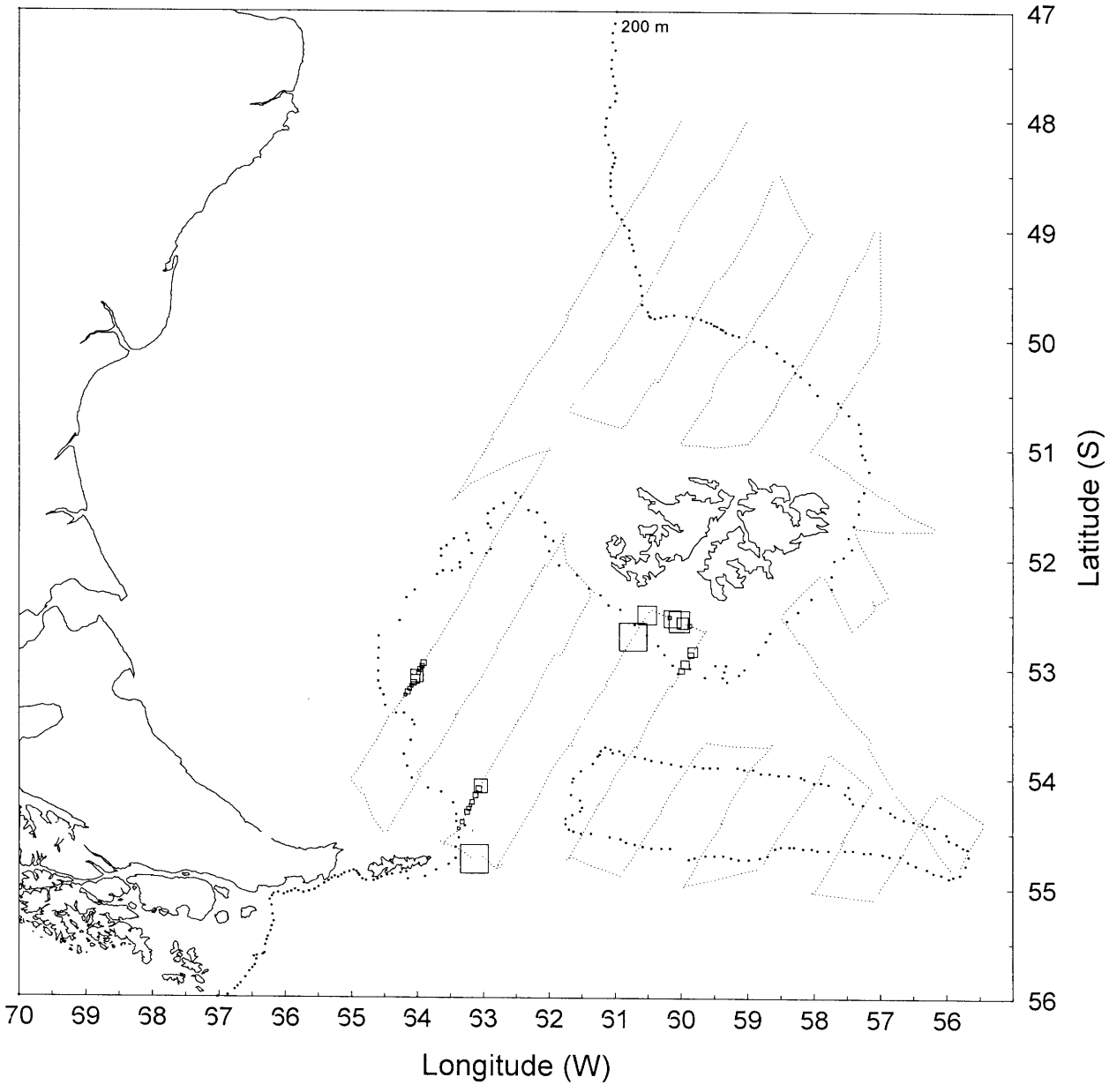

Figure 1 (A). Geographical distribution of blue whiting biomass density (OB-07/94). (Size of square symbols are proportional to square root of biomass density).

Figura 1 (A). Distribución geográfica de la densidad de biomasa de la polaca en la campaña OB-07/94. (tamaño de los símbolos proporcional a la raíz cuadrada de la densidad de biomasa)

Figure 1. (cont.)

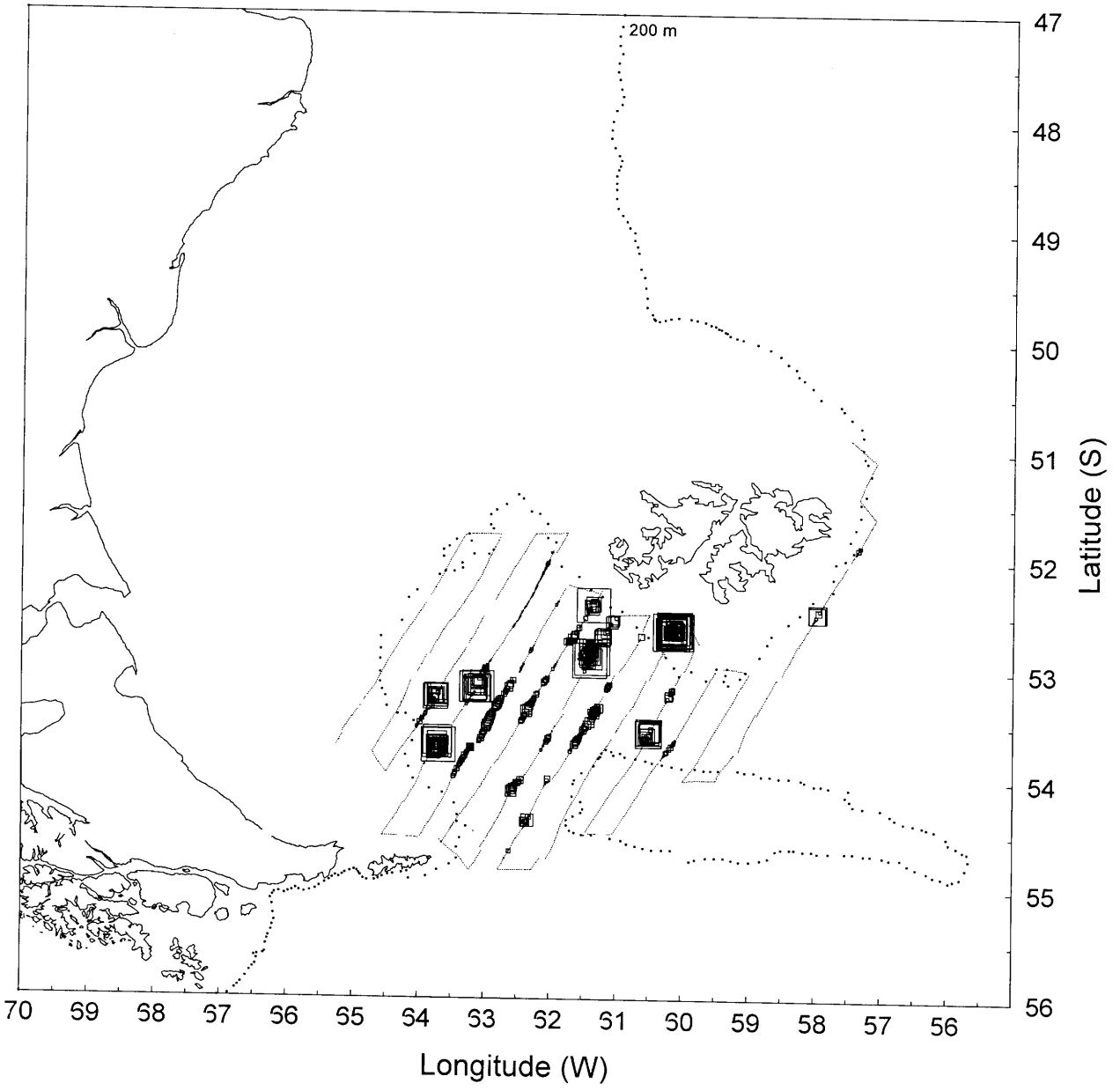

Figure 1 (B). Geographical distribution of blue whiting biomass density (OB-10/95). (Size of square symbols are proportiona to square root of biomass density).

Figura 1. (B). Distribución geográfica de la densidad de biomasa de la polaca en la campaña OB-10/95. (tamaño de los símbolos proporcional a la raíz cuadrada de la densidad de biomasa).

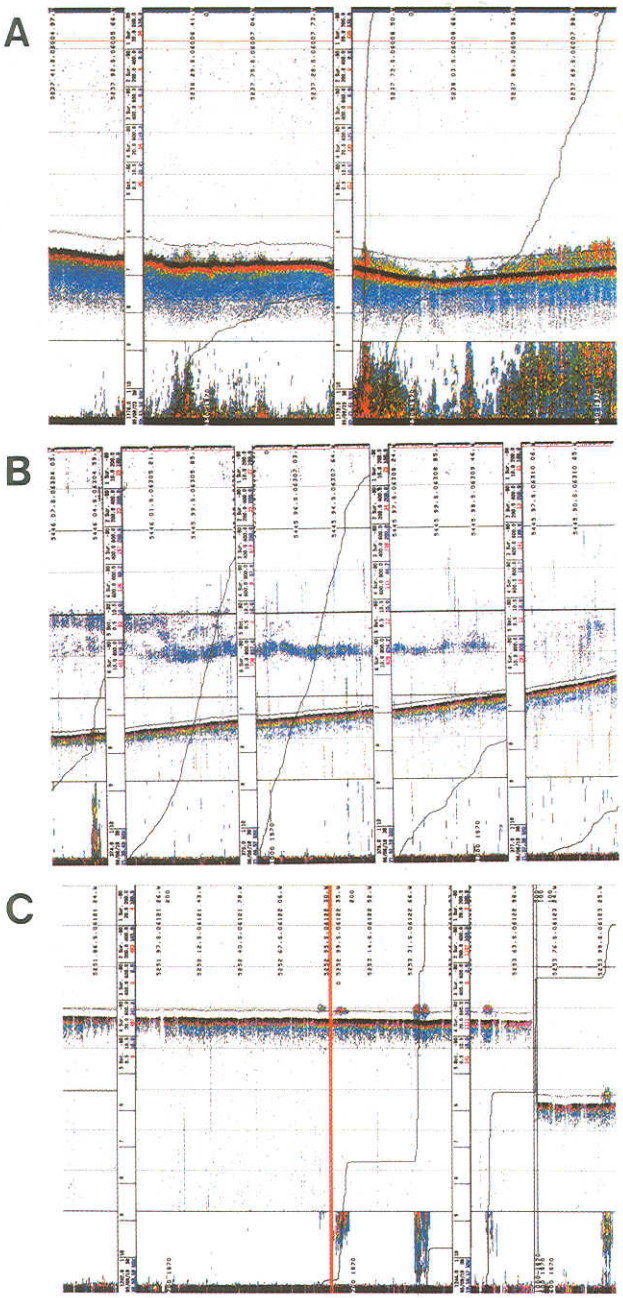

Figure 2 (A). Examples of echorecordings of southern blue whiting. Spawning fish concentration located south of San Carlos Strait. (05:00 GMT ; bot. Depth 170 m) *Ejemplos de registro ecoico de polaca. Concentración reproductiva de peces localizada al sur del Estrecho San Carlos. (05:00 GMT ; prof. fondo 170 m).* (B). Examples of echorecordings of southern blue whiting. School of adult fish located near Isla de los Estados. (22:00 GMT ; bot. Depth 600 m)

Figura 2 (A). *Ejemplos de registro ecoico de polaca.Cardumen de peces adultos ubicado cerca de la Isla de Los Estados. (22:00 GMT ; prof. fondo 600 m)* (C). Examples of echorecordings of southern blue whiting. Juvenile fish schools located south-west from Malvinas Islands. (19:00 GMT ; bot. Depth 370 m) *Ejemplos de registro ecoico de polaca. Cardúmenes de peces juveniles localizados hacia el sud-oeste de las Islas Malvinas. (19:00 GMT ; prof. fondo 370 m)*

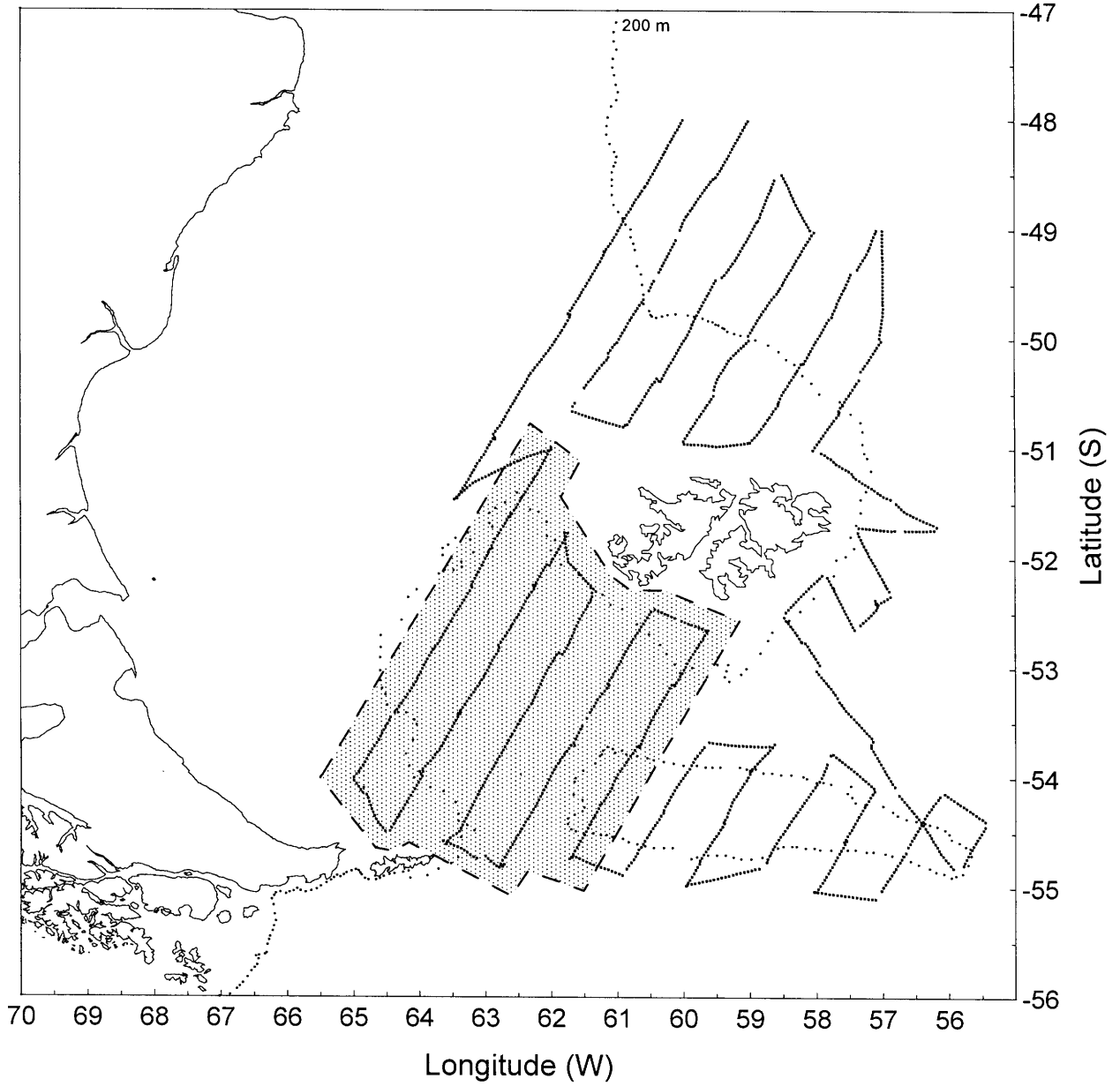

Figure 3 (A). Definition of the area for the biomass estimations (OB-07/94).
Figura 3 (A). Definición del área para la estimación de la biomasa (OB-07/94).

Figure 3. (cont.)

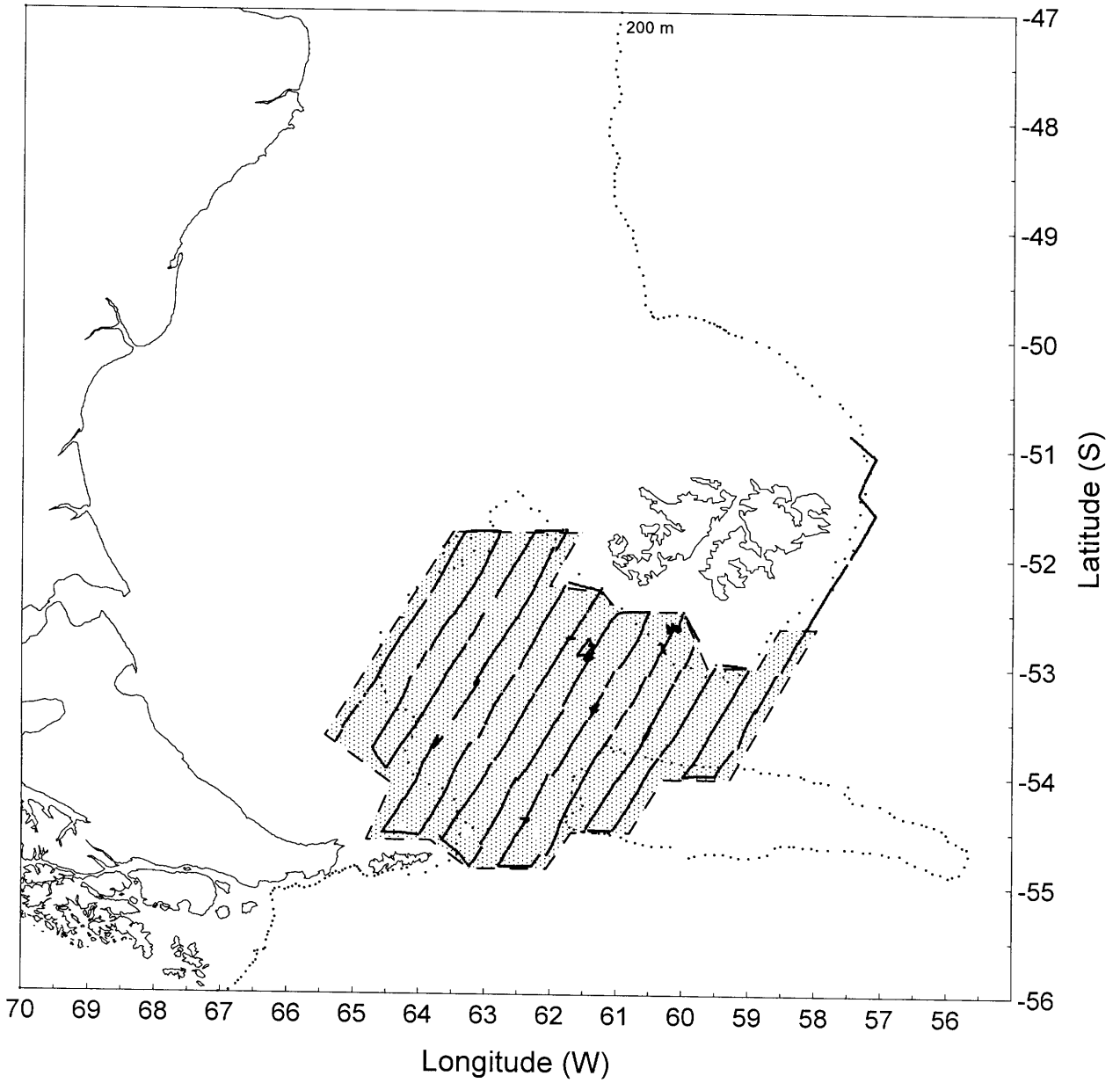

Figure 3 (B). Definition of the area for the biomass estimations (OB-10/95).
Figura 3 (B). Definición del área para la estimación de la biomasa (OB-10/95).

tionship could be developed and in order to maintain consistency between successive survey results.

Survey design

A scheme of parallel equally spaced transect was chosen as the sampling design for both surveys. The area established for the 1994 survey was based on historical catch data and ichthyoplankton samples, resulting in an extended area around Malvinas Islands. The survey design for 1995 was based on catch data only from recent years and consequently the survey area was restricted to the southern sector of the area covered in 1994. This allowed a better survey design with closer transects an thus an increased sampling effort compared to 1994. The sailed acoustic trackline were 3342 nm and 2380 nm for 1994 and 1995 surveys respectively.

RESULTS

Spatial distribution

Figure 1 (A and B) shows the geographical distribution of the values of blue whiting biomass density recorded in the survey area. During the 1994 survey the presence of blue whiting concentrations was extremely rare while in 1995, if still scarce, blue whiting occurrence was much frequent. Blue whiting schools were recorded only south of Malvinas Islands, in the western side of Malvinas Channel (along the circular shaped slope) and in the west channel of Burdwood Bank. Schools depth ranged from 150 to 700 m. The shallowest schools (spawning blue whiting) were found on the Malvinas shelf, south from San Carlos Strait. Schools of juvenile fish were detected only in the 1995 survey near shore and south-west from Malvinas Islands.Figure 2 shows different examples of echorecordings of southern blue whiting concentrations. School size, density and position in the water column varied. Southern blue whiting aggregates forming deep pelagic schools which may occupy an area of several squared nautical miles and extend vertically several tenths of meters. These fish layers are generally found at depths ranging from 450 m to 600 m. Exceptionally, in deep waters blue whiting schools can be found as deep as 800 m. Schools si-tuate over the slopes and when a layer riches the bottom, at depths shallower than 450 m, fish form bottom layers that generally exceeds ten meters height. A rather moderate scattering of the schools is observed at night, as it is the vertical diurnal migrations. Juvenile fish were observed forming pelagic schools of relative small size, compared to adult fish, and scattering at night was more pronounced than in adult fish schools.

Spawning concentrations are characterized by a significantly higher fish density, modifying the appearance of the bottom layers by creating very dense and high bottom schools. Other, much less dense concentrations of blue whiting can be found on the bottom, at depths shallower than 400 m. This very low density concentrations mix with other bottom fish, as grenadiers, being difficult to discriminate between the different species in the echorecordings.

Biomass estimation

Since the area covered by the 1994 survey was much larger, the trackline was splitted into blocks of transects or strata for data processing. Four strata were defined, i.e. the Burdwood Bank, north, east and south Malvinas area. Only the stratum defined south of Malvinas Islands contained non zero values. The whole survey area for 1995 was in fact approximately limited to the southern strata of 1994. No stratification was applied to the 1995 survey data. Figure 3 (A and B) shows the definition of the area corresponding to the biomass estimations. As it

can be seen in Figure 3A (1994 survey), the inter-transects containing non zero values indicated a distribution area extending beyond the ends of the transects. Consequently the values recorded along the inter-transects were utilized to estimate the abundance in that survey, and the corresponding sampling area was extended. In 1995 no schools were observed along the inter-transects and hence the area considered for the estimation of the biomass was restricted to the ends of the transects (Figure 3B).

Equally spaced transects are considered to be a systematic sampling design, having the advantage of a good coverage of the area (better representation of the geographic distribution). However, selection of the best estimator for the variance of the estimated mean fish density, has been a well known object of controversy (Aglen, 1989; Jolly and Hampton, 1990; Foote and Stefansson, 1993). In the present work the simple random sampling estimator is utilized with the only aim to facilitate a comparison between surveys.

Table 1 contains the results of the biomass estimation corresponding to the 1994 and 1995 surveys. The estimates were obtained utilizing the TS model corresponding to *Micromesistius poutassou.*

DISCUSSION AND CONCLUSIONS

Very low biomass estimations resulted from both, 1994 and 1995 surveys. It is known that annual catches of blue whiting were comparable to these figures and hence obviously none of the survey estimates accounted for the total biomass of the stock. However, it is believed that the estimates produced by the surveys agree with the fraction of the biomass that was present in the spawning area. The major catches made by the commercial fleet at the time of the surveys corresponded to the same locations where the concentrations of blue whiting were detected. The ichtyoplankton samples also confirmed that there was no spawning activity in areas other than those where the concentrations were recorded.

Migration in the NE direction of large schools of blue whiting found near Isla de los Estados was observed during the surveys. This behavior was also reported by the INIDEP observers onboard the commercial fleet. The schools probably enter the spawning area through the west channel of Burdwood Bank and move along the slope, at depths from 300 to 600 m, towards Malvinas Islands where schools are found on shallower bottoms and major spawning activity was recorded.

This notably migratory behavior could be the explanation for the low biomass point estimates.

Table 1. Abundance estimates for the 1994 and 1995 surveys.
Tabla 1. Estimaciones de abundancia para los cruceros de 1994 y 1995.

Survey ---	TS model ---	Mean Biomass Density [t/mn^2]	C. V. [%]	Area [mn^2]	Biomass [t]
OB-07/94	*Micromesistius poutassou*	3.15	34	26884	84801
OB-10/95	*Micromesistius poutassou*	5.74	13	24551	140953

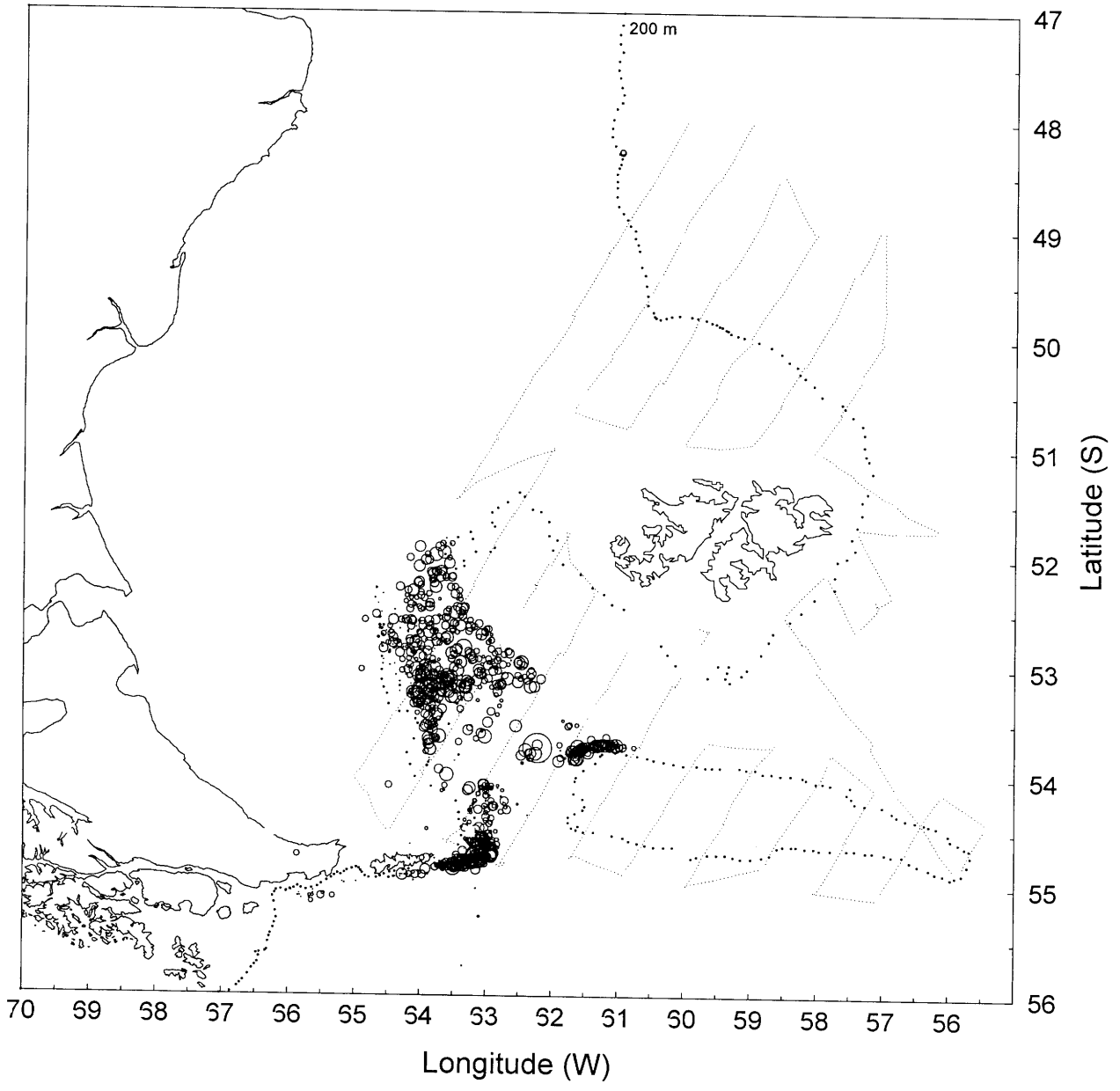

Figure 4. Positions and relative size of catches made by the commercial fleet in the period 1993 - 1996. (data from INIDEP Observers project)

Figura 4. Posiciones de las capturas de polaca realizadas por la flota comercial durante el período 1993 - 1996.

According to Macchi and Pajaro (in this volume) instead of a unique massive spawning concentration of the stock, the fish might aggregate forming different spawning concentrations. If this is the case, different schools could move in and out the spawning grounds at different times during a spawning season which continues for some months.

Methodology and equipment employed in the surveys seems to be adequate for sampling blue whiting biomass density. If a rather low sampling effort can be attained to the 1994 survey, the design for 1995 was substantially improved by limiting the area and reducing the distance between transects to approximately 22 nm, which stands for a more appropriate sampling effort. Also the survey area appears to be adequate as indicated by the operations of the commercial fleet in recent years. Data obtained from the INIDEP project *Observers on board the commercial fleet* are shown in Figure 4 for the period 1993 - 1996, where the positions and the relative size of the blue whiting catches are indicated by circles (circles made proportional to catches).

If the described behavior of the southern blue whiting is confirmed then, at least from a practical point of view, no point estimate of the total biomass of the stock would be possible from a survey alone. The validity of an annual point biomass estimate as an index and its contribution to other methods for determining the biomass of the stock (e.g. VPA) has to be analyzed.

LITERATURE CITED

AGLEN, A. 1989. Reliability of acoustic fish abundance estimates. Dr. Scient. Thesis, University of Bergen, Department of Fisheries Biology.

ANON, 1985. Acoustic surveys on blue whiting in the Norwegian, August/September 1985. ICES, C.M. 1985 (H:4), 1-24.

BODHOLT, H. 1990. Fish density derived from echo-integration and *in situ* target strength measurements. ICES C.M. 1990/B:11.

CLAY, C.L. & MEDWIN, H. 1977. Acoustical oceanography: principles and applications. J. Wiley & Sons, New York.

FOOTE, K. G. 1987. Fish target strengths for use in echo-integration surveys. J. Acoust. Soc. Am. 82 (3): 981-987.

FOOTE, K. G. 1991. Summary of methods for determining fish target strength at ultrasonic frequencies. ICES J. mar. Sci., 48: 211-217.

FOOTE, K. G., KNUDSEN, H.P., VESTNES, G., MACLENNAN, D.N. & SIMMONDS, E.J. 1987. Calibration of acoustic instruments for fish density estimation: a practical guide. ICES (International Council for the Exploration of the Sea) Cooperative Research Report N° 144.

FOOTE, K.G., PETTER KNUDSEN, H. & KORNELIUSSEN, R.J. 1991. Postprocessing system for echo sounder data. J. Acoust. Soc. Am. 90, 37-47.

FOOTE, K.G. & STEFANSSON, G. 1993. Definition of the problem of estimating fish abundance over an area from acoustic line-transect measurements of density. ICES J. mar. Sci., 50: 369-381.

FORBES, S. T. & NAKKEN, O. 1974. Manual de métodos para el estudio y la evaluación de los recursos pesqueros. Parte 2: Utilización de instrumentos acústicos para la localización de peces y la estimación de su abundancia. Manual de la FAO de Ciencias Pesqueras No. 5.

JOLLY, G.M. & HAMPTON, I. 1990. Some problems in the statistical design and analysis of acoustic surveys to assess fish biomass. In: Proceedings of the 1987 International Symposium on Fisheries Acoustics, Seattle, WA, USA.

MACCHI, G. J. & PAJARO, M. Aspects on the reproductive biology of the southern blue whiting (*Micromesistius australis*). This volume.

MACLENNAN, D. & SIMMONDS, E. 1992. Fisheries acoustics. Chapman & Hall, London, 325pp.

NAKKEN, O. & OLSEN, K. 1977. Target strength measurements of fish. Rapp. P.-v Réun. Cons. Int. Explor. Mer, 70: 52-69.

PERROTTA, R. 1982. Distribución y estructura poblacional de la polaca (*Micromesistius australis*). Rev. Inv. Des. Pes., 3: 35-52.

SANCHEZ, R.P. & CIECHOMSKI, J.D. 1995. Spawning and nursery grounds of pelagic fish species in the sea-shelf off Argentina and adjacent areas. Sci. Mar., 59 (3-4:455-478.

SIMMONDS, E. J., WILLIAMSON, N.J., GERLOTTO, F. & AGLEN A. (Mimeo). Survey design and analysis procedures: A comprehensive review of good practice. ICES C.M 1991/B:54, 132 pp.