

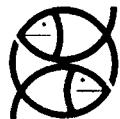
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**REPRODUCTIVE HABITAT, BIOLOGY AND ACOUSTIC BIOMASS ESTIMATES  
OF THE SOUTHERN BLUE WHITING (*Micromesistius australis*)  
IN THE SEA OFF SOUTHERN PATAGONIA**

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

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## **COMENTARIO PRELIMINAR**

Si bien en forma ocasional la plataforma patagónica austral había sido explorada por campañas de investigación oceanográfico-pesqueras durante 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 incremento 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 diluidas 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, atribuibles 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 ichthyoplankton 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 larvae of 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

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## FEATURES OF THE REPRODUCTIVE BIOLOGY OF THE SOUTHERN BLUE WHITING (*Micromesistius australis*)\*

by

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### RESUMEN

**Aspectos de la biología reproductiva de la polaca (*Micromesistius australis*).** Se analizan distintos aspectos de la reproducción de la polaca (*Micromesistius australis*), que incluyen la determinación de la época de puesta, tipo de desove de la especie, estimación de la talla de primera madurez y de la fecundidad. Se trabajó con muestras obtenidas en aguas adyacentes a las Islas Malvinas entre marzo y noviembre de 1995, provenientes de campañas de investigación y del "Programa Nacional de Observadores en Buques Comerciales". Se observó actividad reproductiva de la polaca entre fines de julio y setiembre, al sudoeste de las Islas Malvinas. El análisis microscópico de los ovarios y la distribución de diámetros ovocitarios, permitió establecer que la polaca es un desovante parcial con fecundidad determinada. Esta característica permite estimar la fecundidad anual de la especie mediante el conteo de ovocitos vitelados en aquellas hembras que se encuentran en estadio de madurez avanzada. Este parámetro fue cercano a los 478.000 ovocitos para una talla media de 51 cm Lt. La talla de primera maduración para las hembras de esta especie fue cercana a los 31 cm Lt.

### SUMMARY

Different features of the reproductive biology of the southern blue whiting (*Micromesistius australis*) are analyzed. Samples were obtained from research cruises and from commercial catches carried out between March-November 1995, in waters near Malvinas Islands. Reproductive activity of *M. australis* was observed between the end of July and September, southwest of Malvinas Islands. Oocyte diameter distribution of gravid females and the histological observations show that this species is a batch spawner with determinate annual fecundity. Preliminary estimate of the potential annual fecundity was about 478,000 oocytes for a 51-cm mean total length. Size at first maturity for this species was about 31 cm total length.

\* INIDEP Contribution N° 1085.

**Key words:** *Micromesistius australis*, southern blue whiting, Southwest Atlantic, reproduction.

**Palabras claves:** *Micromesistius australis*, polaca, Atlántico Sudoccidental, reproducción.

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## INTRODUCTION

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*Micromesistius australis* is a mesopelagic species typical of the Cold Malvinas Current. From 38°S to 47°S it inhabits waters near to the continental shelf at depths ranging from 100 to 700 m; from 47°S to 55°S, it distributes over a wider area around the Malvinas Islands, reaching 800 m depths (Otero, 1976; Madirolas, 1996). Southern blue whiting is one of the most important resource species in the south Patagonian fisheries. Up to 1982, a significant number of studies on this species were carried out by Argentine researchers, dealing with biological aspects such as spawning areas and seasons, egg and larval morphology and distribution, seasonal sexual stages analysis, and length at maturity (Weiss, 1974; Ciechomski *et al.*, 1981; Ciechomski and Booman, 1981; Perrotta, 1982). However, papers dealing with specific aspects on the reproductive biology of this species are scarce: in this sense, only a paper by Lisovenko *et al.* (1982), where a preliminary fecundity estimation is made and another by Sánchez *et al.* (1986) describing the type of spawning, potential fecundity, length at maturity and a preliminary estimation of spawning stock can be cited. The goal of the present work is to update the existing information on reproductive aspects of this species concerning type of spawning, and reproductive season and area. Moreover, a preliminary estimation of total fecundity was carried out.

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## MATERIAL AND METHODS

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Samples of *M. australis* were collected during three research cruises of the INIDEP (Instituto Nacional de Investigación y Desarrollo Pesquero)

and from commercial catches (Argentina's National Scientific Fisheries Observer Programme), carried out between March-November 1995 (Table 1).

The main working area was located southwest of Malvinas Islands, but during September other samples were analyzed, including one taken off the Malvinas zone, at 47° 20'S - 60° 50'W (Fig. 1).

Total length (cm) and macroscopical maturity stages were recorder from 1240 females. For this, a maturity scale of five stages designed for biological studies was employed: 1) immature, 2) developing, 3) gravid and running, 4) spent and 5) resting (Macchi and Diaz Astarloa, 1996). This classification was used for the temporal analysis of the relative composition of maturity stages.

For the histological analysis 77 paired ovaries in different maturity stages were selected and fixed in 10% formalin. At the laboratory, tissue samples were dehydrated, embedded in paraffin wax and sectioned at 5 µm thickness. The sections were stained with Mayer's haematoxilin and eosin. A microscopical maturity scale was established, based on the histological analysis of the ovaries.

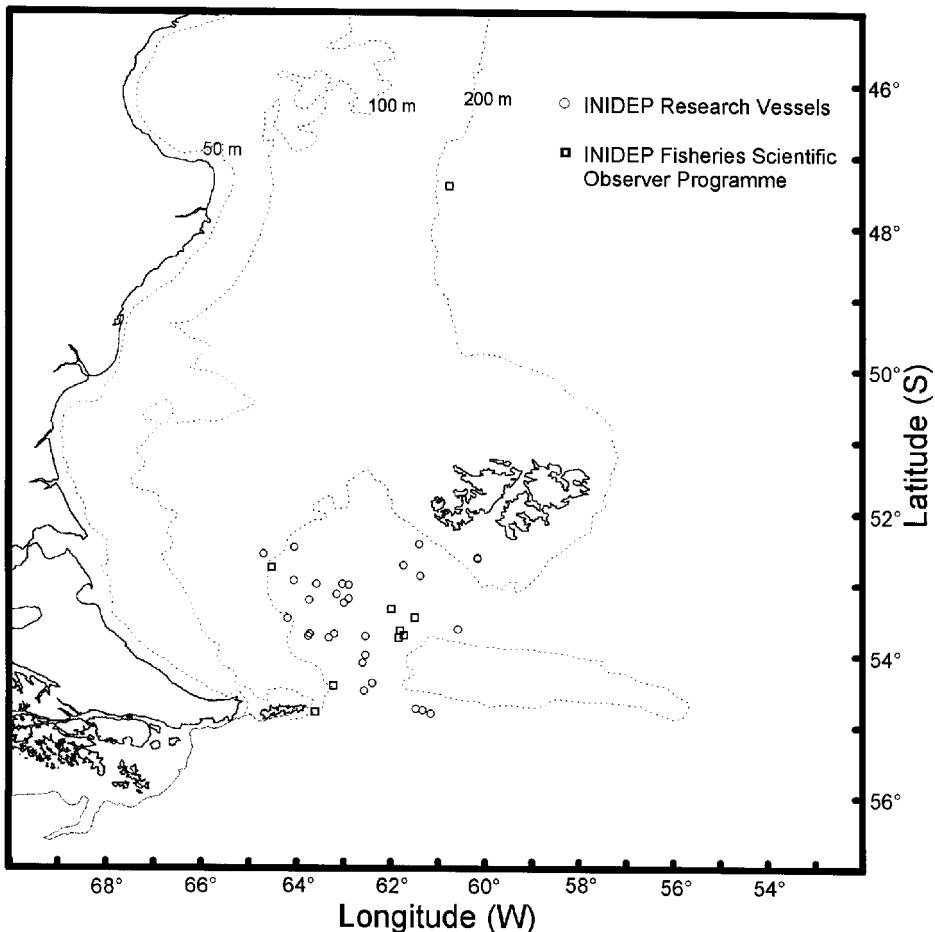
To estimate mean length at first maturity ( $L_{50}$ ) for females, the fraction of mature fish per 1,0 cm length intervals was fit to the logistic function.  $L_{50}$  was defined as the length in which 50 % of the individuals were mature. Females were considered sexually mature if they were in gonad stage 2 (macroscopical scale) or higher.

A preliminary total fecundity estimation was carried out using the gravimetric method (Hunter *et al.*, 1982). For this estimation, 7 ovaries with advanced yolked oocytes were selected. These gonads were weighed and three tissue samples of each paired ovaries were removed from anterior, mid-, and posterior regions. In order to obtain 100-300 yolked oocytes, tissue samples of 40-100 mg (weighed to the nearest 0.01 mg) were placed on a slide, and yolked oocytes counted (Hunter, 1985).

Table 1. Basic data.

Tabla 1. Datos básicos.

Source	Ship	Origin	Month	Nº of trawls	n
OB-04/95	“Capitán Oca Balda”	Research vessel	March	3	178
CENTURION	“Centurión del Atlántico”	Commercial fleet	July - August	4	412
ROKKO MARU	“Rokko Maru”	Commercial fleet	September	1	25
OB-10/95	“Capitán Oca Balda”	Research vessel	September	14	263
OB-13/95	“Capitán Oca Balda”	Research vessel	November	12	253
YAMATO	“Yamato”	Commercial fleet	November	4	109

Figure 1. Map of the study area showing the total sampling stations with occurrence of southern blue whiting.  
Figura 1. Mapa con la distribución de estaciones en las cuales se obtuvieron muestras de polaca.

Total fecundity for each female was calculated from the product of the number of yolked oocytes per unit weight in the tissue sample and the ovary weight.

## RESULTS

### Ovarian maturation (histological analysis)

The morphological changes observed in the different oocytic growth phases were similar to those established for other species, and the terminology used was adapted from Forberg (1982) (Table 2).

The main histological changes in the ovary were

Table 2. Morphological changes observed in the different oocytic growth phases. Adapted from Forberg (1982).

*Tabla 2. Cambios morfológicos observados en las diferentes fases de crecimiento ovocitario. Adaptado de Forberg (1982).*

Oocytic growth stages	Description
First growth phase	Previtellogenetic oocytes with diameter smaller than 200 µm. Cytoplasm is basophilic and the nucleus shows a number of nucleoli situated peripherally.
Cromatin nucleolus stage	Follicular cells are flattened and become visible on the outer surface of oocyte.
Early nucleolus stage	
Late nucleolus stage	
Second growth phase	Diameter ranged between 200-350 µm. Citoplasm is basophilic and shows small vacuoles optically empty (yolk vesicles). Granulosa and follicular theca are distinguished and the zona radiata become visible around the periphery of oocyte.
Yolk vesicle stage	
Primary yolk stage	Diameter ranged between 350-500 µm. Numerous eosinophilic yolk globules appear between the yolk vesicles. These yolk globules are composed mainly of proteins. The zona radiata and the follicle epithelium are more prominent.
Secondary yolk stage	Diameter between 500-800 µm. The yolk globules have multiplied and increased in size, occupying all the cytoplasm. The nucleus exhibits an irregular shape, and the zona radiata increased in thickness.
Tertiary yolk stage	Oocytic diameter ranged between 800-1100 µm. In the first instance, the nucleus is displaced to the animal pole (migratory nucleus stage). The nuclear membrane desintegrates and the yolk globules tend to coalesce. In the section, these oocytes appear with a cytoplasm weakly eosinophilic and an irregular shape.

classified in a maturity scale of eight stages:

1 - **Immature.** This stage is not described because the small virginal individuals (< 15 cm TL) were not present in the samples.

2 - **Developing (virgin).** The microscopical image shows compact ovigerous lamellae, a characteristic that persists until spawning, and the tunica albuginea is very thin (10-20 µm). Only basophilic oocytes in first growth phase are observed (Fig. 2 A).

3 - **Developing (early).** A number of oocytes have started the secondary growth phase, and shows yolk vesicles in the cytoplasm (yolk vesicle stage) (Fig. 2 B). The larger oocytes, moreover, have yolk globules between the vesicles (primary yolk stage). The remaining oocytes stayed in "resting stage"

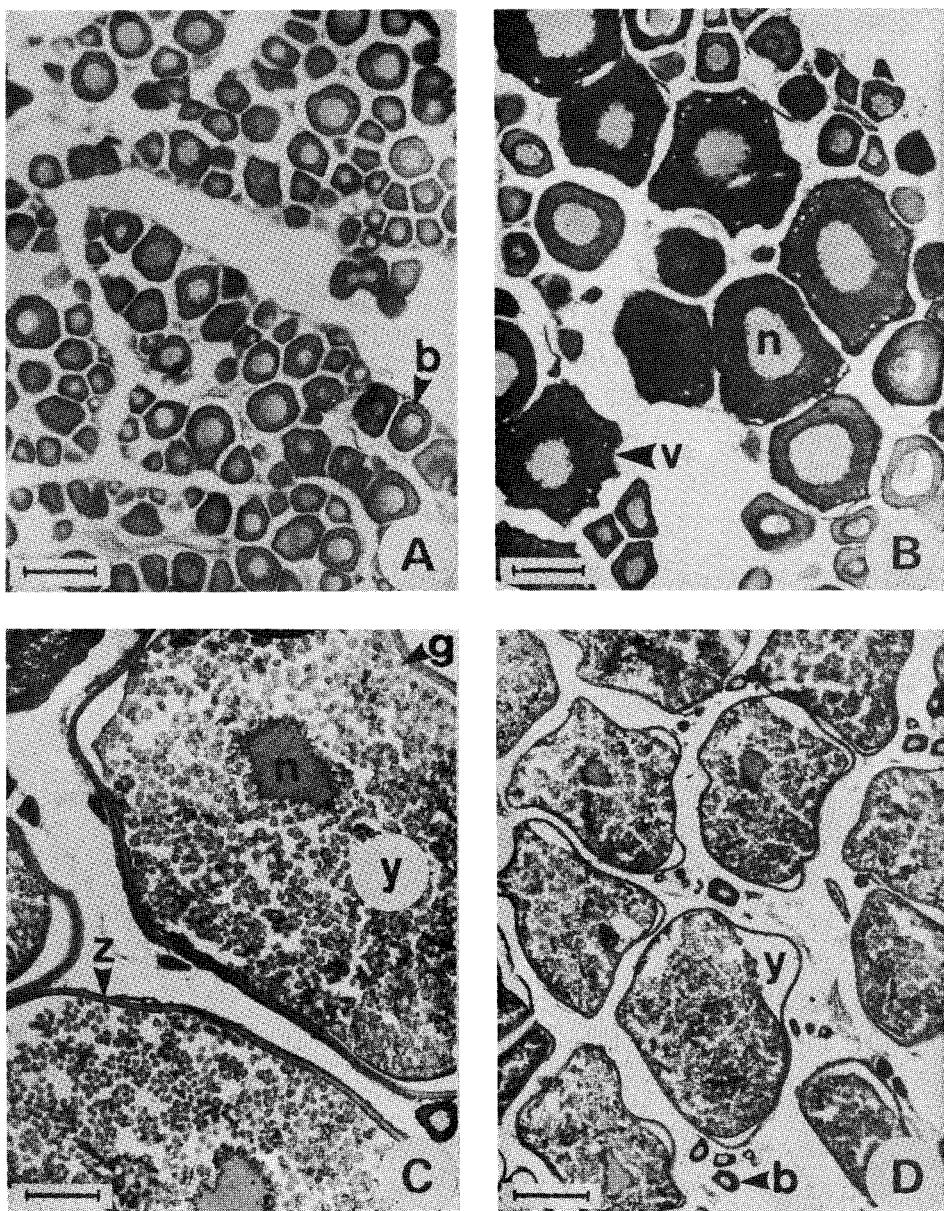


Figure 2. Ovaries of *M. australis* at different maturity stages: A) developing (virgin); B) developing (early); C) and D) developing (late). b: previtellogenic oocytes; g: yolk globule; v: yolk vesicle stage; y: yolk globules stage; n: nucleus; z: zona radiata. A), B) and C): bar = 100  $\mu\text{m}$ ; D): bar = 250  $\mu\text{m}$ .

Figura 2. Ovarios de *M. australis* en diferentes estadios de madurez: A) juvenil; B) maduración temprana; C) y D) maduración avanzada. b: ovocitos previtelogénicos; g: glóbulos de vitelo; v: estadio de vitelo vesicular; y: estadio de vitelo globular; n: núcleo; z: zona radiata. A), B) y C): segmento = 100  $\mu\text{m}$ ; D): segmento = 250  $\mu\text{m}$ .

(previtellogenesis).

**4 - Developing (late).** As growth proceeds, the diameter of the larger oocytes increases and the cytoplasm becomes acidophilic, due to an accumulation of yolk globules (secondary yolk stage). Some vesicles tend to coalesce and to form the oil droplet (Fig. 2 C). Moreover, this phase shows previtellogenic and yolk vesicle stage elements. Oocytes at primary yolk stage are not observed (Fig. 2 D), which indicates that no immature elements are incorporated into the cohort of yolked oocytes. This observation was confirmed when the oocyte diameter distribution was analyzed (Fig. 3), where only two batches (unyolked and yolked oocytes) are observed.

**5 - Gravid and running.** In the final phase of maturation, some yolked oocytes rapidly increases in volume due to hydration (Fig. 4 A). These elements have an irregular shape caused by the loss of fluid during histological processing. The rest of the yolked oocytes will begin the hydration afterwards, conforming new egg batches during the reproductive season. For this reason, the number of yolked

oocytes diminish with the number of spawnings (Fig. 4 B).

**6 - Partially spent.** When the fully hydrated oocytes are released, the postovulatory follicles (granulosa and thecal cells) remains in the ovary. The presence of yolked oocytes together with the postovulatory follicles (POF), suggest that although *M. australis* shows a main mature oocyte group before spawning (Fig. 3), partial expulsion of those eggs is to be expected (Fig. 4 C).

**7 - Spent.** This phase indicates the end of spawning, and involves the degeneration and absorption of residual ripe oocytes. Together with the atretic follicles, previtellogenic oocytes are observed (Fig. 4 D).

**8 - Resting.** This stage is similar to the developing (virgin) phase. Microscopically, only previtellogenic oocytes are observed. The tunica albuginea remains thick during this phase, which allows the differentiation with the juvenile individuals.

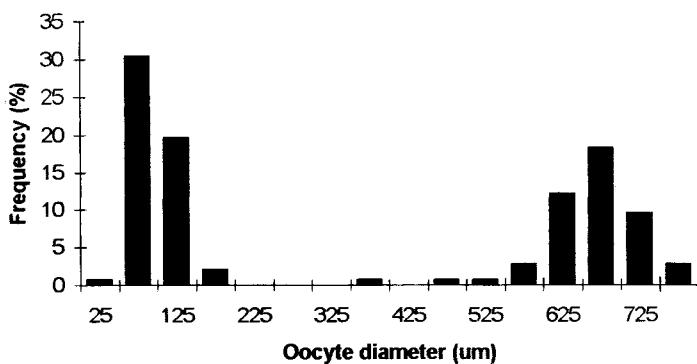


Figure 3. Frequency distribution of oocyte diameter in developing (late) ovaries of *M. australis*.

Figura 3. Distribución de frecuencias de diámetros ovocitarios en ovarios en maduración avanzada de *M. australis*.

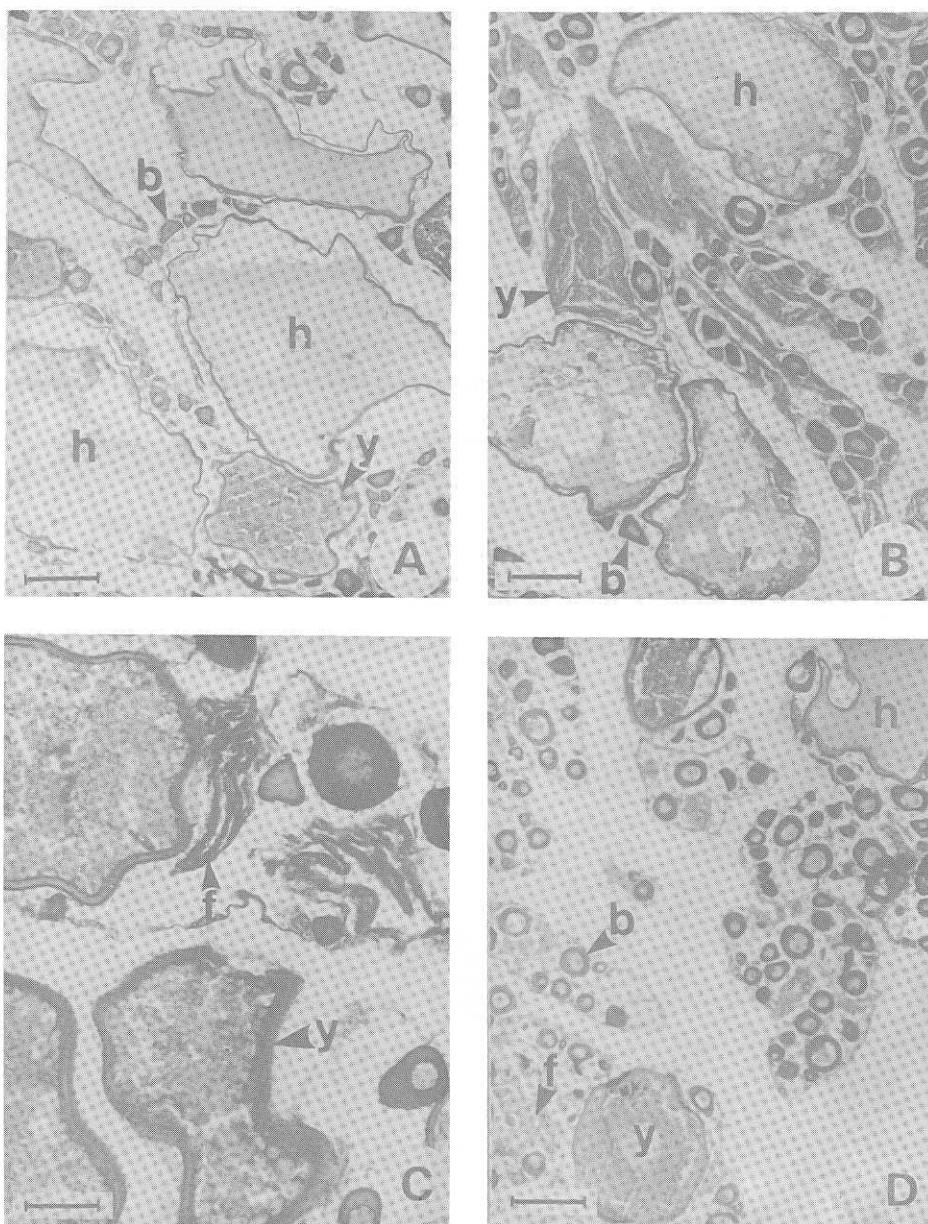


Figure 4. A) and B) Ovaries of *M. australis* in gravid and running stage. C) partially spent stage. D) spent stage. b: previtellogenic oocytes; y: yolked oocytes; h: hydrated oocytes; f: postovulatory follicles. A), B) and D): bar = 250  $\mu\text{m}$ ; C) bar = 100  $\mu\text{m}$ .

Figura 4. A) y B) ovarios de *M. australis* hidratados. C) estadio de puesta parcial. D) ovarios en postpuesta. b: ovocitos previtelogénicos; y: ovocitos vitelados; h: ovocitos hidratados; f: folículo postovulatorio. A), B) y D): segmento = 250  $\mu\text{m}$ ; C) segmento = 100  $\mu\text{m}$ .

### Temporal variation in the relative composition of maturity stage (Macroscopical scale)

In March, at the southwest of Malvinas, a high proportion of the resting stage was observed (60%), the rest of the sample consisted of immature individuals (Fig. 5). During July-August, the samples were obtained at the northwest of the Burdwood Bank, near the area sampled during March. In this case, a reproductive concentration with a high per-

centage of gravid females (85 %) was observed (Fig. 6). In September the sampled area was larger, and three zones with different composition of maturity stages were established (Fig. 7):

A) This is a large area between the southwest of Malvinas and the northeast of Isla de los Estados. In this zone most females were in developing stage (60%). The histological analysis indicates that these individuals were in early developing phase (stage 3, microscopical scale). The rest of the sample consisted of immature individuals.

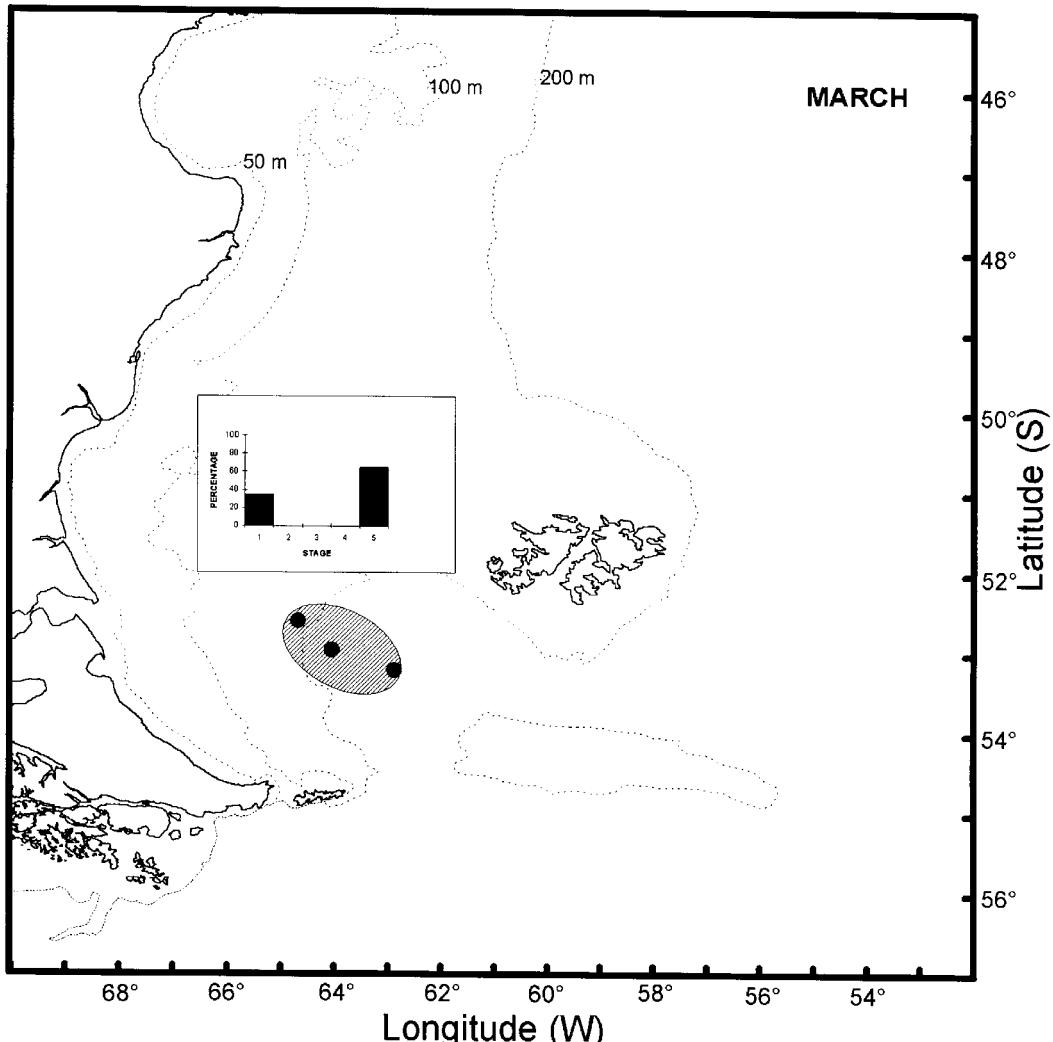


Figure 5. Map of the study area showing occurrence of southern blue whiting and macroscopical maturity stages during March.

*Figura 5. Localización de las estaciones realizadas y composición de los estudios de madurez (escala macroscópica), durante marzo.*

B) This area ranges from South Malvinas to the Burdwood Bank, and is located to the east of the previously described area (Fig. 7). In this area, 40% of the sample were gravid females, while a high proportion of spent stage was observed (50%).

C) This is one sample far off the Malvinas area (Fig. 7). All individuals were in developing stage, and the microscopical analysis established that the oocytes were fully yolked, near to hydration (stage

4, microscopical scale).

During November the samples were obtained from a large zone between Malvinas, Isla de los Estados and the Burdwood Bank (Fig. 8). Most females were in resting stage (60%), which indicates the end of the reproductive season. However, a low percentage (15%) of spawners was observed.

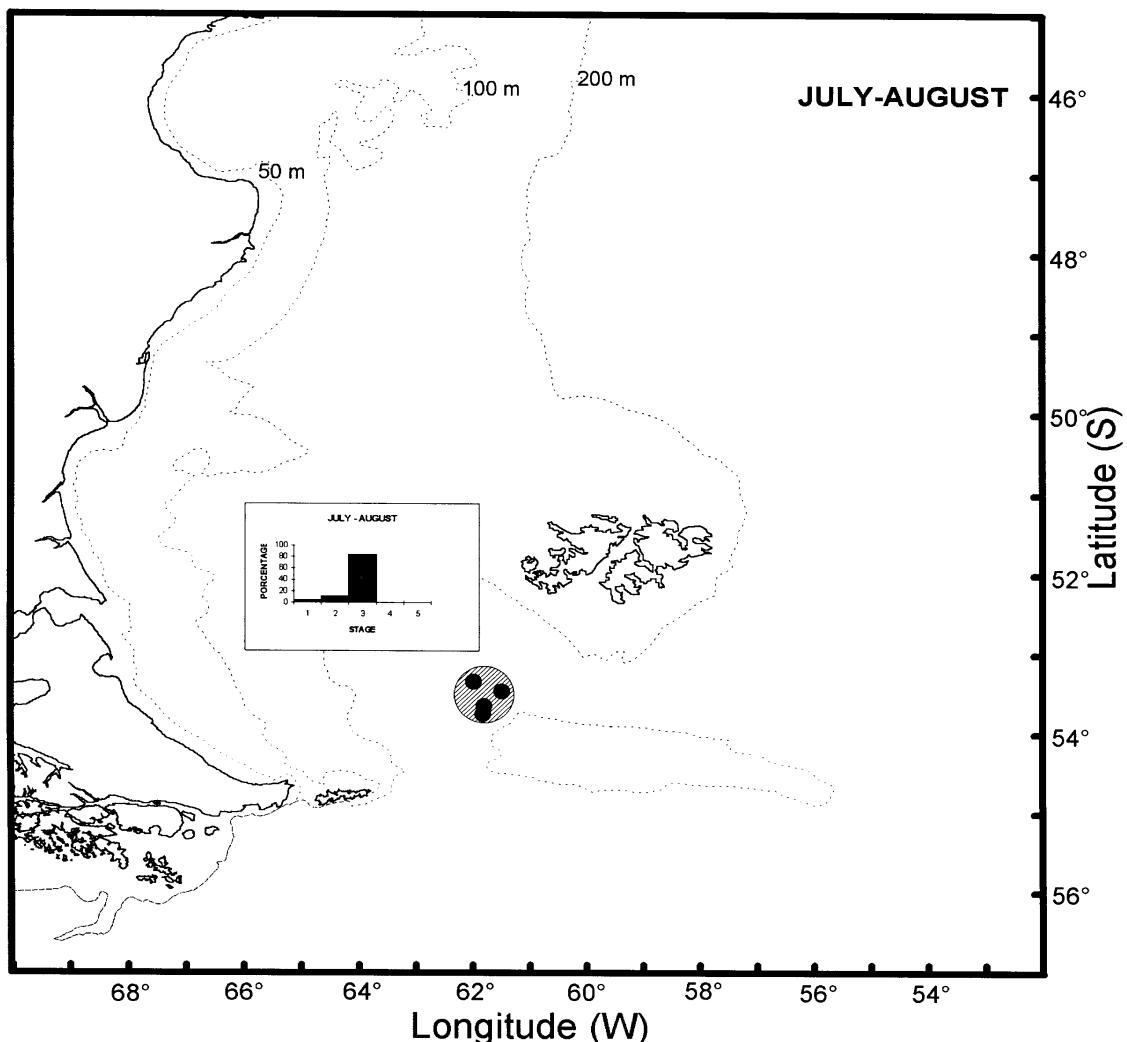


Figure 6. Map of the study area showing occurrence of southern blue whiting and macroscopical maturity stages during July-August.

*Figura 6. Localización de las estaciones realizadas y composición de estadios de madurez (escala macroscópica), durante julio - agosto.*

## Size at maturity

Figure 9 shows the percentages of mature females for each length class, between 18.0 - 51.0 cm TL. Estimated mean length at first maturity ( $L_{50}$ ) was 30.81 cm.

## Estimation of total fecundity

Total fecundity was considered to be equivalent to the standing stock of yolked oocytes in advanced maturity, prespawning females. The mean value of

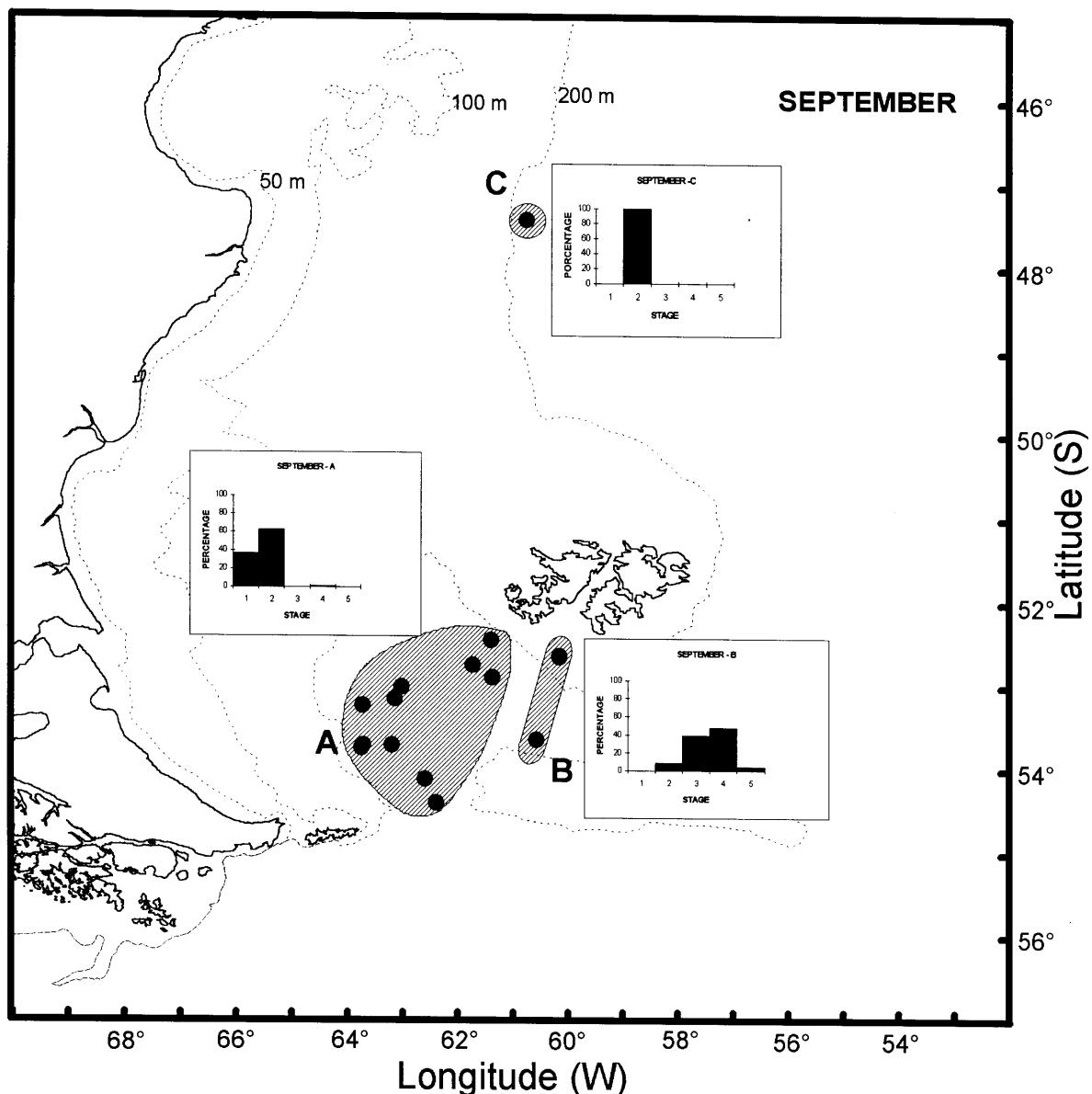


Figure 7. Map of the study area showing different regions (A, B and C) with occurrence of southern blue whiting and macroscopical maturity stages, during September.

*Figura 7. Localización de las estaciones realizadas en diferentes regiones (A, B y C) y composición de estadios de madurez*

total fecundity was 477,771 (206,783 s.d.) oocytes for a 51.1 cm (3.9 s.d.) mean total length fish. Relative fecundity was about 706 (258 s.d.) per gram ovary-free female weight.

## DISCUSSION AND CONCLUSIONS

An eight-stages microscopical ovarian maturity scale was established on the basis of oocyte development phases. The difference with the macroscopical

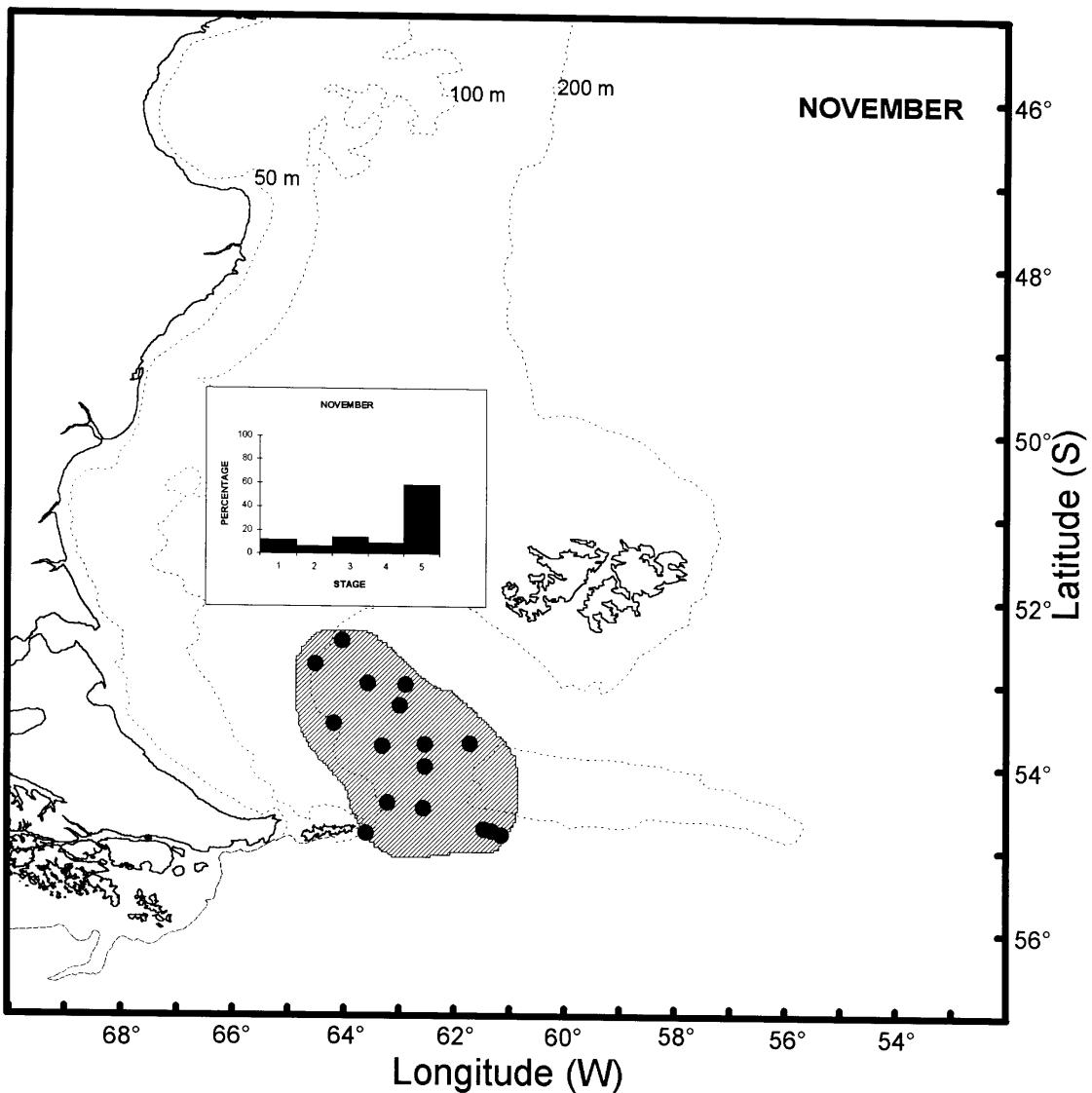


Figure 8. Map of the study area showing occurrence of southern blue whiting and macroscopical maturity stages during November.

*Figura 8. Localización de las estaciones realizadas y composición de estadios de madurez (escala macroscópica), durante noviembre.*

scale (five stages) employed, is the incorporation of three developing substages and the inclusion of the partially spent phase. The presence of maturing ovaries with postovulatory follicles, is evidence that after the expulsion of one batch of eggs, a new batch of oocytes will develop and be released. However, in mature ovaries (with yolked oocytes between 500 - 800  $\mu\text{m}$ ), a hiatus exist between the yolked elements and smaller, indicates that the recruitment of oocytes into the advanced stock of yolked elements cease during this phase. Moreover, the number of mature oocytes (yolked and hydrated) was lower in females having postovulatory follicles. These facts, support the assumption of partial spawning and determinate fecundity for *M. australis*. Hunter *et al.* (1992) define this term as: "Annual fecundity is determinate when the potential annual fecundity becomes fixed prior to the onset of spawning. In fishes with determinate fecundity, total fecundity decreases with each spawning because the standing stock of advanced yolked oocytes is not replaced during the spawning season".

The potential annual fecundity (or total fecundi-

ty) in these species, is equivalent to the standing stock of advanced yolked oocytes in fully developed, prespawning females. In fishes with determinate fecundity, a key question is to establish if atretic losses during a season constitute an important fraction of the potential annual fecundity. For this reason, it is necessary to estimate an index of the intensity of atresia in all females used for fecundity estimation (Hunter *et al.*, 1992).

Temporal variation of the composition of maturity stage during the months sampled (March, July-August, September and November) shows a reproductive concentration of *M. australis* between the end of July and September, at the southwest of Malvinas. These results are coincident with those presented by Ciechomski and Sánchez (1983) and Sánchez *et al.* (1986). In the same area where the gravid females of *M. australis* were detected, highest densities of eggs and larvae of this species were observed (Ehrlich *et al.*, in this volume).

Our estimates of length at 50% mature females (30.81 cm TL) were lower than other values previously reported. Perrotta (1982) established this para-

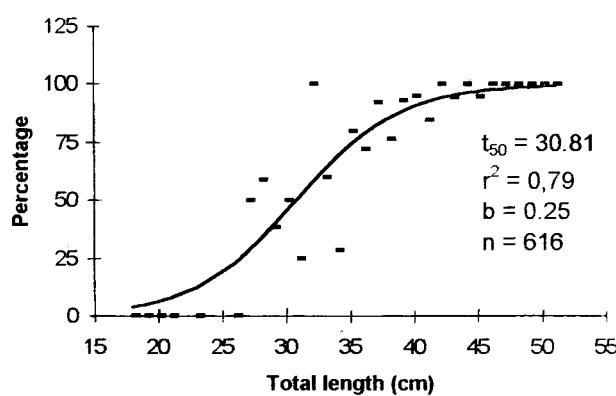


Fig. 9. Percentage of mature females for each length class, between 18-51 cm total length.  
Fig. 9. Porcentaje de hembras maduras por clase de tallas, entre 18-51 cm de longitud total.

meter at 34.69 cm TL and Sánchez *et al.* (1986) obtained a value of 38.0 cm TL.

Finally, the preliminary estimate of the mean total fecundity ranged within the values estimated by Sánchez *et al.* (1986).

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