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***Research Article***

# Reproductive aspects of the Patagonian toothfish (*Dissostichus eleginoides*) off southern Chile

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**ABSTRACT.** We present the results for the reproductive biology of Patagonian toothfish (*Dissostichus eleginoides*) caught off southern Chile from January to March and June to November 2006. A total of 10,896 specimens were measured (55-220 cm total length, TL) and sexed (7,049 males, 64.7%; and 3,847 females, 35.3%). Macroscopic observations showed that gonad maturation begins at 60 cm TL in both sexes, with an average maturation size of 81 cm TL in males and 89 cm TL in females. This species appears to have an ample spawning period that occurs only off the far southern region of Chile. To date, no evidence indicates that this resource reproduces in any other areas of the Pacific Ocean off the coasts of South America, where no specimens were observed with mature gonads, percentages of atresia were high, and juvenile fish were not caught in trawl fishing operations targeting other commercial species.

**Keywords:** size structure, reproduction, size at first maturity, Patagonian toothfish, *Dissostichus eleginoides*, Chile.

# Aspectos reproductivos del bacalao de profundidad (*Dissostichus eleginoides*) en el extremo austral de Chile

**RESUMEN.** Se dan a conocer resultados sobre la biología reproductiva del bacalao de profundidad (*Dissostichus eleginoides*) capturado en el extremo sur-austral de Chile, entre enero y marzo y de junio a noviembre de 2006. En dicho período se midió y determinó el sexo a 10.896 ejemplares, comprendidos entre 55 y 220 cm de longitud total (LT), de los cuales 7.049 correspondieron a machos (64,7%) y 3.847 a hembras (35,3%). Mediante la observación macroscópica de las gónadas se determinó que en machos y hembras se observa el comienzo de la maduración gonádica a partir de 60 cm de LT, con una talla media de maduración ($TMS_{50\%}$) en machos a 81 cm y en hembras a 89 cm. Se sugiere que esta especie presenta un período amplio de desove y que este proceso se efectuaría únicamente en la región austral de Chile, destacándose que hasta ahora no se cuenta con evidencias que este recurso se reproduzca en otra zona del océano Pacífico frente a la costa de Sudamérica en atención a la ausencia de ejemplares maduros en las capturas, altos porcentajes de atresia y ausencia de peces juveniles en faenas de pesca de arrastre dirigidas a otras especies comerciales.

**Palabras clave:** estructura de tallas, reproducción, talla de primera madurez sexual, bacalao de profundidad, *Dissostichus eleginoides*, Chile.

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## INTRODUCTION

The Patagonian toothfish (*Dissostichus eleginoides* Smith, 1898) is a demersal species distributed in the southern hemisphere, mainly between 40º and 60ºS and at depths of 500 to 2000 m. Most catches of this resource occur on the continental shelf off the southern cone of South America and around numerous islands and oceanic elevations in the southern sectors of the Atlantic, Pacific, and Indian oceans (Gon & Heemstra, 1990). The high fishery yields and the elevated price that Patagonian toothfish brings on international markets have awoken greater interest in extracting and commercializing its meat.

In Chile, *D. eleginoides* is an important resource for industrial and artisanal fishing. Thus, it has been subjected to intense exploitation over a long period of time. This situation is worrisome, especially since this is a slow-growing species. In order to adapt the management measures intended to conserve this resource, we must understand its reproductive cycle and particularly its size at first sexual maturity. Previous studies have shown that this fish is a synchronous spawner (also known as a total or isochronal spawner), with two groups of different sized ovocytes; the larger diameter group is released during the first spawning (Young *et al.,* 1999). *D. eleginoides* spawns in the southern part of the country in winter, mainly between July and August, presenting low fecundity in relation to its body weight (10-24 eggs per gram of weight) (Young *et al.,* 1995). This agrees with that indicated by Agnew *et al.* (1999) for South Georgia Island. These authors observed massive spawning in July/August and suggested that a second, less intense spawning period occurs in April/May. Arana & Bustos (2006) detected a high percentage of specimens in an advanced state of maturity during experimental fishing operations for *D. eleginoides* off far-southern Chile in the second half of September and first half of October 2005.

Given the uncertainty as to the spawning zones and periods of the Patagonian toothfish south of 50°S and the importance of understanding this species' reproductive aspects for its adequate management, the present investigation set out to define the stock composition, reproductive period, and size at first sexual maturity for these fish, especially including the months in which this species is under a reproductive ban.

## MATERIALS AND METHODS

The information analyzed was gathered on board a longline factory vessel during two commercial fishing campaigns: one from 01 January to 25 March 2006 and another from 17 June to 10 November 2006, totaling 130 days of operation. The extractive operations were carried out of far-southern Chile, between 49°49'S and 59°39'S (Fig. 1). From a bathymetric point of view, the hauls were done between 600 and 2,393 m depth.

The extractive operations were done with Spanish-type or "quebrado" longlines and size 9 hooks, those commonly used by the industrial fleet (Guerrero & Arana, 2009). The South American pilchard or "sardina" (*Sardinops sagax*) was used as bait.

For each fishing haul, random measurements were made of a certain number of Patagonian toothfish according to their arrival on the processing deck. The total length (TL) of each individual was measured with an ichthyometer (± 1 cm) and the total weight using a scale precise to ±10 g. At the same time, we determined the sex and state of maturity of the specimens through a visual, macroscopic examination of the gonads according to the scale proposed by Kock & Kellerman (1991) for Antarctic fishes (Table 1).

Based on the information recorded, we determined the global sexual proportion and estimated the average and median sizes, variance, and standard deviations. In order to establish the composition of the catches for each sex, the size records were grouped by trimesters and the corresponding size frequency distributions were constructed. Likewise, we determined the sexual proportion by size based on the number of males caught as compared to all the specimens (males+females) in each length range.

The size at first sexual maturity ($TMS_{50\%}$) was determined separately for males and females according to the percentage of specimens that presented mature sexual organs with respect to the total of specimens analyzed. The records were grouped every two centimeters in order to increase the number of observations in each length range. Individuals were considered to be mature at maturity stage 3 or higher (Everson & Murray, 1999; Young *et al.*, 1999).

The fit of the percentages of mature specimens *vs.* the size of the specimens was done using two procedures. In the first, the model parameters were estimated using the linearization of the logistic function:

$$\% \hat{M}ad_{LT} = \frac{1}{1 + exp^{(-a-b\ LT)}}$$

through which it is possible to estimate

$$TMS_{50\%} = -a/b$$

$$s(TMS_{50\%}) = 1/b$$

where:

$\%Mad_{TL}$ : proportion of mature specimens at length TL (cm)

a, b : model parameters

TL : total length (cm)

$TMS_{50\%}$ : size at first sexual maturity of 50%

$s(TMS_{50\%})$ : standard deviation of the $TMS_{50\%}$

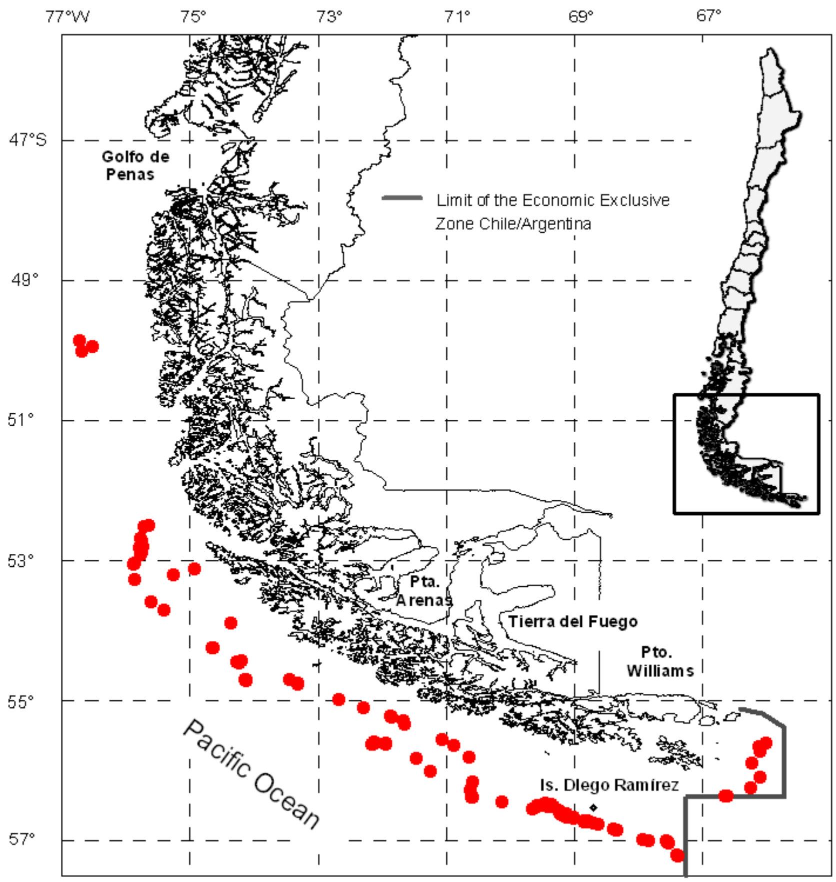


**Figure 1.** Area of *Dissostichus eleginoides* extraction operations.

**Figura 1**. Lugares de captura de los ejemplares analizados de *Dissostichus eleginoides*.

**Table 1.** Maturity scales based on ovarian and testis cycles in *Notothenia coriiceps*, *Champsocephalus gunnari*, *Chaenocephalus aceratus* and *Pseudochaenichthys georgianus* (from Kock & Kellerman, 1991).

**Tabla 1.** Escala de madurez basada en ciclos de ovarios y testículos de *Notothenia coriiceps, Champsocephalus gunnari, Chaenocephalus aceratus* y *Pseudochaenichthys georgianus* (Kock & Kellerman, 1991).

| Female | Maturity Stage | Males |
|---|---|---|
| Ovary small, firm, no eggs visible to the naked eye | 1 Inmature | Testis small, translucent, whitish, long, thin strips lying close to the vertebral column |
| Ovary more extended, firm, small oocytes visible, giving ovary a grainy appearance | 2 Developing or resting | Testis white, flat, convoluted, easily visible to the naked eye, about 1/4 length of the body cavity |
| Ovary large, starting to swell the body cavity, colour varies according to species, contains oocytes of two sizes | 3 Developed | Testis large, white and onvoluted, no milt produced when pressed or cut |
| Ovary large, filling or swelling the body cavity, when opened large ova spill out | 4 Ripe | Testis large, opalescent white, drops of milt produced when pressed or cut |
| Ovary shrunken, flaccid, contains a few residual eggs and many small ova | 5 Shrunk | Testis shrunk, flabby, dirty white in colour |

In the second procedure, the fit was made using the non-linear least squares routine, considering the Gauss-Newton method. The model was coded in MatLab language (v6.5) and solved using the function *nlinfit.m*, which, along with the resolved parameters, provided the vector of residuals and the "Jacobian" matrix of first-order partial derivatives, that is:

$$J=\left(\frac{\partial\%Mad_{LT}(a,b,LT)}{\partial a},\frac{\partial\%Mad_{LT}f(a,b,LT)}{\partial b}\right)$$

where $Mad_{LT}$ corresponds to the logistic models of sexual maturity at size TL.

The variance-covariance matrix for the parameters was obtained with the equation:

$$v=(J'J)^{-1}\frac{\sum_{LT=1}^{n}(\%\hat{M}ad_{LT}-\%Mad_{LT})^{2}}{n-p}$$

where n is the number of observations and p is the number of parameters. The standard error of each parameter was obtained by taking the square root of the elements that make up the diagonal of this matrix. In this case, we determined the standard error and the confidence range (95%) for the average value.

## RESULTS

During the investigation, we analyzed a total of 10,896 individuals: 7,049 males and 3,847 females. The males presented total lengths between 55 and 202 cm and the females between 55 and 220 cm (Fig. 2). The average sizes of the specimens were similar in January and July, when males averaged 104 to 113 mm TL and females 110 to 122.5 cm TL. In August, however, the values decreased noticeably, remaining more or less constant until November, with average-sizes of 88.5 to 98.4 mm TL for the males and 88.6 to 98.6 cm TL for the females.

The sexual proportion, except in August and November, was predominated by males (62.3-71.4%) (Table 2). In terms of sexual proportion at size, in the three trimesters examined, the males were predominant in number up to approximately 120 cm TL, after which the proportion of females was greater (Fig. 3).

Between June and November (2006), we recorded the gonad maturity stage of 6,160 individuals: 3,950 males and 2,210 females. In the period analyzed, a high percentage of the specimens – both males and females – showed developing gonads in June and July; mature gonads from July to September, and spent gonads from August to October (Fig. 4).

Our observation of the maturity stage of the gonads revealed that maturation began as of 60 cm TL in both males and females. The percentages of mature individuals based on size (stages ≥ 3) showed the usual sigmoid form; the fit of these values was adequate with both procedures used (Fig. 5). The linear and non-linear fits (Table 3) showed an average size of maturity ($TMS_{50\%}$) of 81 cm in males and 89 cm TL in females.

Likewise, the maturity ogives show that not all the fish over the $TMS_{50\%}$ spawned. Only 90% of the males measuring 95 cm TL or more reproduced. Although this situation was not as notorious for females, nonetheless, not all specimens over 110 cm TL spawned.

## DISCUSSION

Fish reproduction studies that determine size at first sexual maturity and the place, period, and duration of spawning make a necessary contribution, both from a scientific point of view and to fishery management especially for exploited species. In the particular case of the Patagonian toothfish, both aspects are relevant given the high longevity and slow growth of the species, plus the heavy fishing pressure to which it has been subjected, indicating that this resource is highly vulnerable to extreme situations.

The high percentage females in maturity stage 3 and of both sexes in this and higher maturity stages in June and July indicate that the Patagonian toothfish spawns in these months (Fig. 4). Nonetheless, the high percentages of specimens in the post-spawning stage in the other months considered herein indicate that this species has a broad reproductive period. Despite this, the lack of information from the months prior to and following the analyzed periods impedes a more precise determination of the lapse in which the maximum release of sexual products occurs.

As for size at first sexual maturity, the $TMS_{50\%}$ values for males (81 cm TL) and females (89 cm TL) fall within the general range estimated by other authors (Table 4). The results for the females are similar to those presented by Moreno (1998), Prenski & Almeida (2000), Laptikhovsky & Brickle (2005), and Shust & Kozlov (2006); whereas the males' results resemble the $TMS_{50\%}$ values presented by CCRVMA (1997), Everson & Murray (1999), Prenski & Almeida (2000), and Laptikhovsky & Brickle (2005). In all cases, the larger mature size of the females is evident. According to the age estimates done by Oyarzún *et al*. (2003), males mature at around nine years and the females at around 11 years of age.

The lack of spawning in some fish larger than the $TMS_{50\%}$ is a phenomenon known for teleosts. A simi-

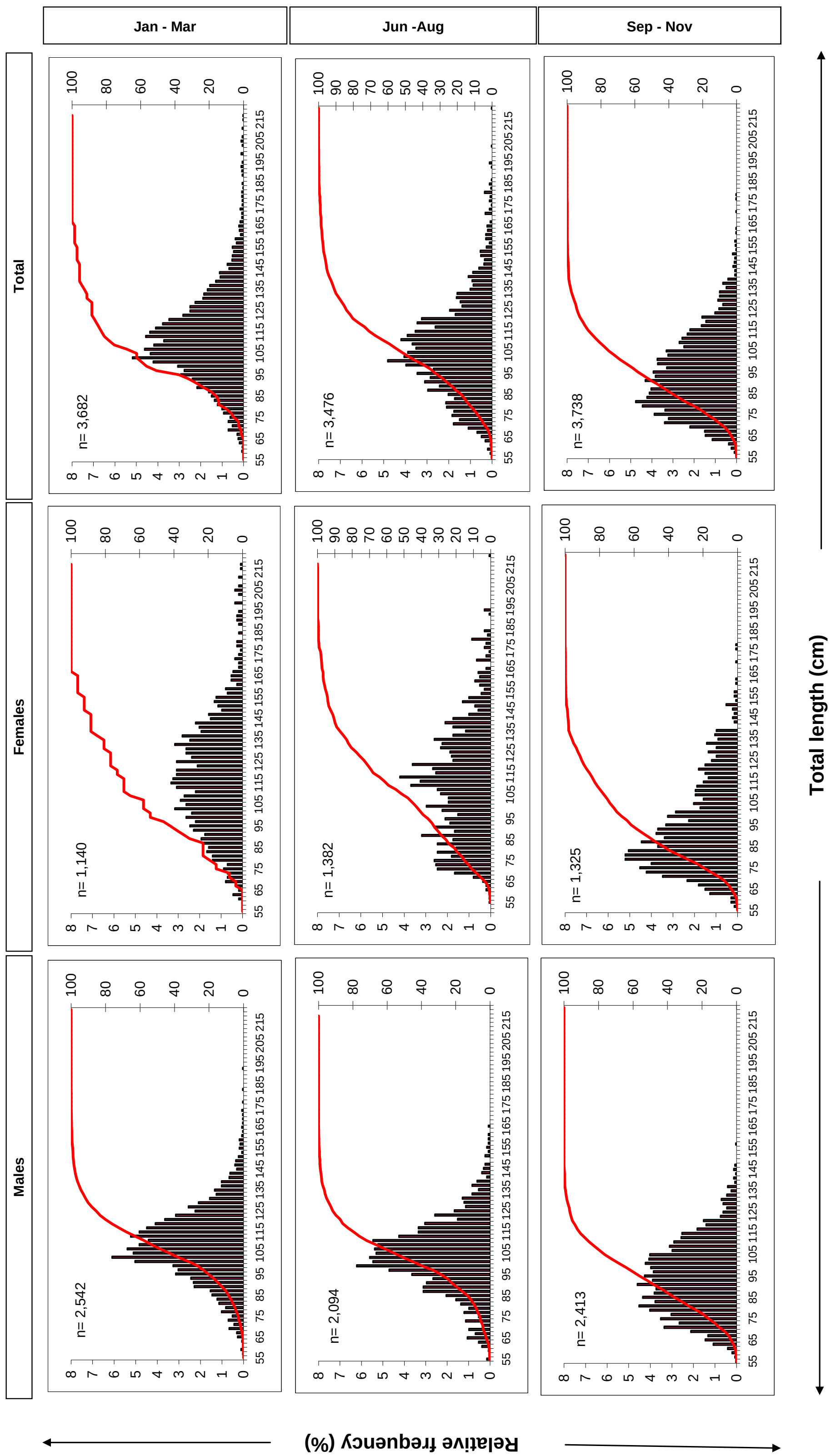


**Figure 2.** Trimester size frequency and accumulated frequency distributions in Patagonian toothfish (*Dissostichus eleginoides*).
**Figura 2.** Distribuciones de frecuencias de tallas y frecuencia acumuladas trimestrales en bacalao de profundidad (*Dissostichus eleginoides*).

**Table 2.** Monthly sexual proportion, mean size, median size, and standard deviation in Patagonian toothfish caught off the far southern tip of Chile.
**Tabla 2.** Proporción sexual mensual, talla media, talla mediana y desviación estándar en bacalao de profundidad capturado en la región sur-austral de Chile.

| | | Month | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | January | February | March | June | July | August | September | October | November |
| Monthly sexual proportion | Males | 62.3 | 68.6 | 71.4 | 67.6 | 59.6 | 41.2 | 68.5 | 59.4 | 49.4 |
| | Females | 37.7 | 31.4 | 28.6 | 32.4 | 40.4 | 58.5 | 31.5 | 40.6 | 50.6 |
| Range (cm) | Males | 80 - 138 | 57 - 169 | 59 - 192 | 58 - 202 | 57 - 159 | 58 - 152 | 55 - 156 | 56 - 144 | 59 - 132 |
| | Females | 71 - 170 | 61 - 216 | 63 - 210 | 55 - 220 | 61 - 195 | 60 - 161 | 56 - 177 | 57 - 178 | 59 - 146 |
| | Total | 71 - 170 | 57- 216 | 59 - 210 | 55 - 220 | 57 - 195 | 58 - 161 | 55 - 177 | 56 - 178 | 59 - 146 |
| Mean size (cm) | Males | 104.2 | 107.6 | 110.6 | 106.9 | 113.7 | 88.9 | 92.3 | 98.4 | 88.5 |
| | Females | 109.9 | 118.1 | 119.4 | 122.5 | 110.1 | 94.5 | 92.5 | 98.9 | 88.8 |
| | Total | 106-4 | 111.0 | 113.1 | 111.9 | 114.7 | 92.2 | 92.4 | 98.6 | 88.6 |
| Median size (cm) | Males | 101.0 | 107.0 | 109.0 | 105.0 | 112.9 | 90.0 | 90.0 | 99.0 | 86.0 |
| | Females | 102.5 | 117.0 | 117.0 | 120.0 | 109.2 | 89.5 | 87.0 | 96.0 | 86.0 |
| | Total | 101.0 | 110.0 | 110.0 | 109.0 | 113.2 | 90.0 | 90.0 | 99.0 | 86.0 |
| Standard deviation (cm) | Males | 12.6 | 16.8 | 17.4 | 16.8 | 20.3 | 17.2 | 16.6 | 16.8 | 14.2 |
| | Females | 26.8 | 26.5 | 27.5 | 26.6 | 26.5 | 23.3 | 20.5 | 22.2 | 16.1 |
| | Total | 19.5 | 21.0 | 21.2 | 21.8 | 23.6 | 21.2 | 17.9 | 19.2 | 15.2 |

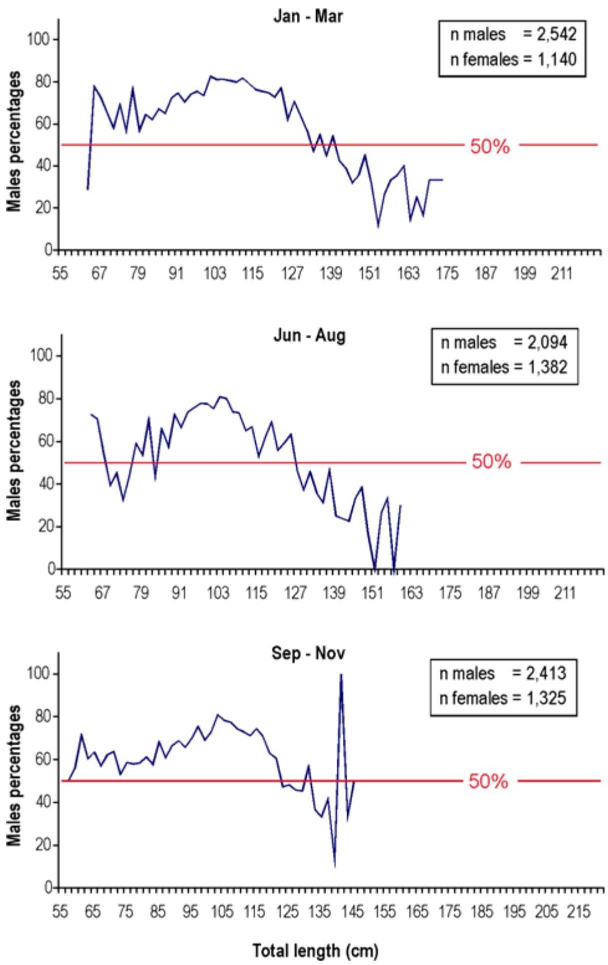


**Figure 3.** Sexual proportion at size in Patagonian toothfish .

**Figura 3.** Proporción sexual a la talla en bacalao de profundidad.

lar situation was described by Everson & Murray (1999) for this same species around South Georgia Island, where up to 43% of the sampled females did not spawn. It is reasonable to expect a certain percentage of atresia in large-sized females. Moreover, this situation can be found in species with extended reproductive periods, so that, at any given moment, it is possible to find spawning and spent individuals.

During the spawning period, females have been reported to emerge to shallower waters (400 a 500 m), making it hard to find them in the commercial fishery operations carried out at greater depths (Chikov & Melnikov, 1990; Kock & Kellerman, 1991; Young *et al.*, 1999). This fact explains, at least partially, the predominance of males in the catches in most of the months analyzed, although the low proportion of females could also indicate an actual different proportion between the sexes or that the females are less attracted to the bait used in the fishing gear.

This study allowed us to gather information on the reproductive process during the period of the reproductive ban decreed by the fishery authority for this resource between 53°S and 57°S, recognizing the occurrence of this process in the region. Nevertheless, the specimens caught in this period presented evidence of a progressive development of gonad maturity that spanned practically the entire lapse analyzed. This evidence indicates that the reproductive period of Patagonian toothfish is broader than that considered so far, with a certain number of mature specimens even in the second half of the year (June to November 2006). In the samples analyzed in October-November from far-southern Chile, when handling the specimens for purposes of registering their total length and sex, it was possible to induce ejaculation in males by palpating or placing slight pressure on the abdomen; the same occurred with females, which released massive amounts of eggs when slight pressure was applied to their abdomens (Figs. 6 to 8).

Our results confirm that the Patagonian toothfish reproduces in the southern region of Chile and that the spawning period extends, partially or totally, to the last trimester of the year. Likewise, these results show the need to use the sizes determined herein as the $TMS_{50\%}$ rather than those values that attribute sexual maturity to much larger sizes. This possible overestimation of lengths could be due to the analysis of small samples in periods of scant reproductive activity or the omission of small-sized specimens from the study.

According to the available evidence, this resource does not reproduce off Chilean coasts north of 50°S, despite being present in the deep waters of this oceanic sector. Several studies done off north and central Chile verify this, mentioning the presence of specimens considered to be "maturing". Thus, for example, the microscopic analyses and gonadosomatic indexes determined by Oliva *et al.* (1999) for the fish caught in the far north of the country during an annual cycle did not reveal a seasonal pattern; thus, these authors could not identify a possible spawning period. The same was found first by Martínez (1975) and then by Young *et al.* (1999), who noted no mature individuals in the north and central-south zones; rather, 95.6% and 99.7% of the males in these areas had "immature" testicles. Moreover, an important percentage of the females presented folicular atresia: on average, 82.0% in the north and 54.3% in the south (Young *et al.*, 1999). More recently, Oyarzún *et al.* (2003) analyzed the monthly variation of the gonadosomatic index (GSI) calculated for samples of specimens landed at Lebu (37°35`S) and Corral (39°53`S), reporting no reproductive activity.

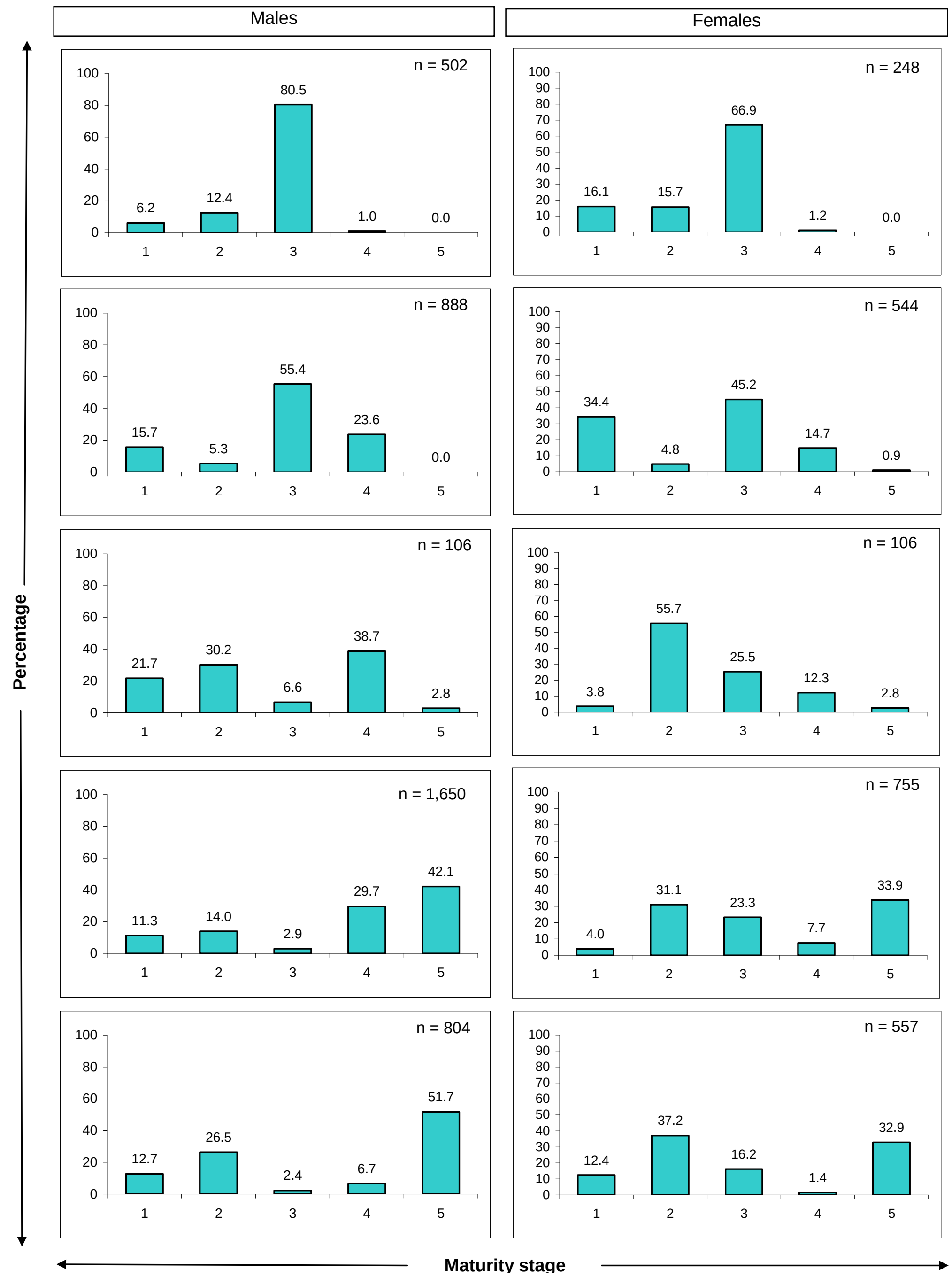


**Figure 4.** Maturity stage by sex and month in Patagonian toothfish (*Dissostichus eleginoides*).

**Figura 4.** Estados de madurez, por sexo y mes en bacalao de profundidad (*Dissostichus eleginoides*).

However, those individuals landed at Quellón (43°S), but caught farther south, showed high GSI values.

Our results, and those of earlier studies, allow us to conclude that *D. eleginoides* reproduces massively in the far south of Chile. No similar situation has been shown in other parts of the country, suggesting that this resource does not reproduce off north and central Chile. The Patagonian toothfish is known to be stratified by size according to depth, with juveniles found in shallower strata than the adults; this is a defense mechanism that allows the former to avoid being preyed on by individuals of their own species. Despite this, trawlers operating in diverse Chilean fisheries on the continental shelf and upper slope to at least 500 m depth have not reported catches of *D. eleginoides* juveniles, strengthening the hypothesis that only adults, displaced from rearing zones in far southern Chile or from Atlantic sectors, are present in these waters.

The size range and average sizes determined for Patagonian toothfish are generally found within the margins determined previously for the region where the present study was performed. Likewise, the average sizes reported herein agree with those established for specimens extracted with longlines from the waters around the Falkland/Malvinas Islands (Laptikhovsky *et al*., 2006). Nevertheless, the change in the average sizes found in the study area during the different months is striking, possibly indicating differences in the behavior of the resource or geographic or bathymetric displacements that reveal the arrival of large-sized specimens in the first month of the year; in the second semester, the average size declines, reflecting a process of recruitment of smaller sizes or the displacement of larger sizes to areas where they are not fished.

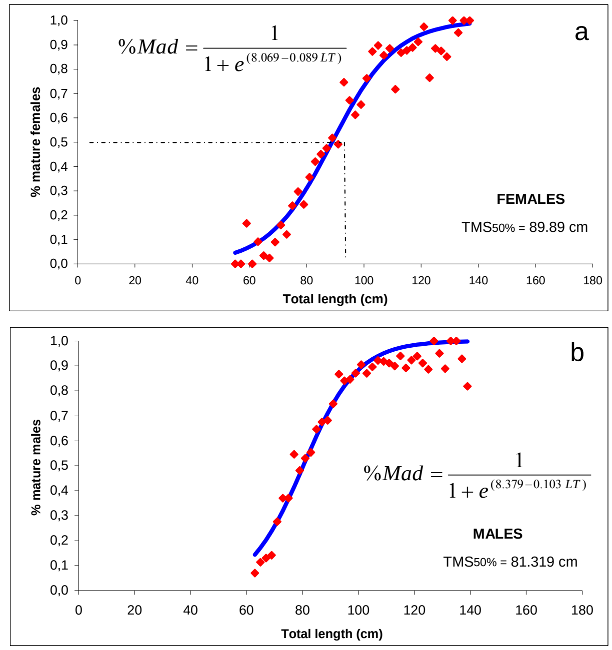


**Figure 5.** Sexual maturity ogive in Patagonian toothfish off southern region of Chile.

**Figura 5.** Ojiva de madurez sexual en bacalao de profundidad en la región sur-austral de Chile.

**Table 3.** Logistic function results of the fit the data of maturity.

**Tabla 3.** Resultado del ajuste de la función logística con los datos de madurez a la talla.

| Fit | Sex | Parameter | | $TMS_{50\%}$ | $TMS_{50\%}$ limits | |
|---|---|---|---|---|---|---|
| | | a | b | | lower | upper |
| Linear | Females | 8.069 | 0.089 | 89.89 | 86.4 | 93.4 |
| | Males | 0.379 | 0.103 | 81.31 | 78.4 | 84.4 |
| Non-linear | Females | 7.864 | 0.089 | 88.84 | 87.15 | 90.54 |
| | Males | 8.277 | 0.103 | 80.31 | 78.93 | 81.69 |

The rapid change in average sizes determined in the three analyzed trimesters highlights the lower sizes towards the end of the year and the corresponding increment in the proportion of specimens that are caught under the $TMS_{50\%}$ (Table 5). This situation is especially evident in the last trimester, when 47.5% of the females caught were smaller than those at maturity. This situation is worrisome since the decreasing sizes are due to extraction, which puts the conservation of the stock at risk.

An alternative explanation could be that the females are not attracted to the bait during certain periods or that they move away from the fishing areas normally used by the fleet. Another option is that, in the second semester, Patagonian toothfish come from the Atlantic sector, possibly juveniles that are recruited to the Pacific population. This would produce a progressive increment in the smaller size fraction and, therefore, the reduction of the quantity of specimens over the $TMS_{50\%}$ (Fig. 2, Table 5). The fishermen know to expect a sudden increment in yields in the second half of September due to the apparent arrival of specimens from the Atlantic sector. Thus, they prefer to postpone the onset of fishing for this species,

**Table 4.** Size at first sexual maturity ($TMS_{50\%}$) determined in Patagonian toothfish.

**Tabla 4.** Tallas de primera madurez sexual ($TMS_{50\%}$) determinadas en el bacalao de profundidad.

| Geographic area | Total length (cm) | | | Author |
|---|---|---|---|---|
| | Males | Females | Both sexes | |
| South Georgia Island (Subarea 48.3) | 75.7 | 110.4 | - | CCRVMA (1997) |
| | 67 | 86 | - | Moreno (1998) |
| | 78.5 | 98.2 | - | Everson & Murray (1999) |
| | 75 | 101 | - | Agnew *et al*. (1999) |
| Head and MacDonald Islands | - | - | 100 | Constable *et al*. (1999) |
| Kerguelen Islands | 65 | 80 | - | Duhamel (1991) |
| | 63 | 85 | | Lord *et al*. (2006) |
| Falkland/Malvinas Islands | 86 | 96 | - | Laptikhovsky & Bricckle (2005) |
| Argentina | 76.3 | 87.1 | - | Prenski & Almeyda (2000) |
| Chile | 105 | 117 | - | Moreno *et al*. (1997) |
| | - | 128.7 | - | Young *et al*. (1999) |
| | 78-94 | 113-117 | - | Oyarzún *et al*. (2003) |
| | 81 | 89 | - | Present study |

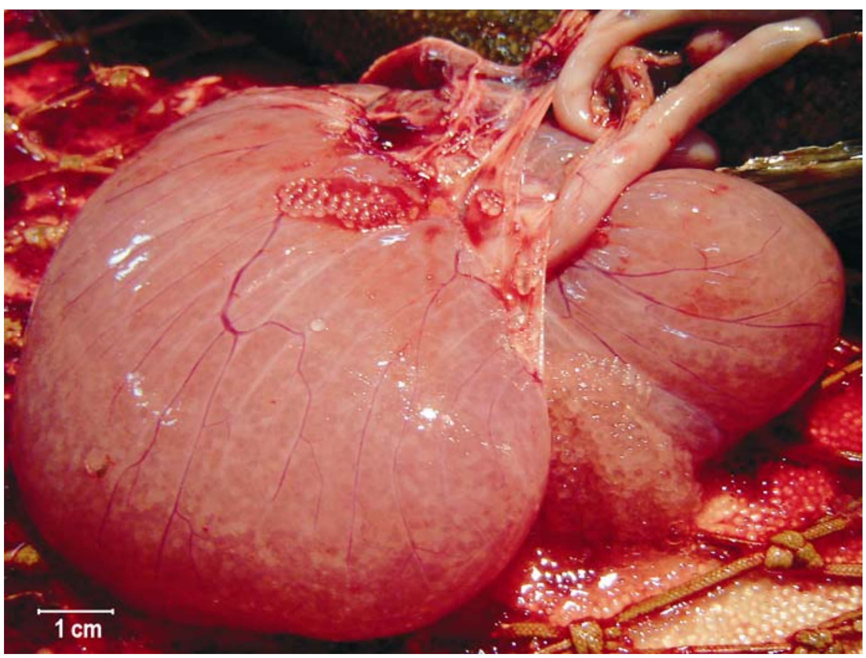


**Figure 6.** Female *Dissostichus eleginoides* gonad in an advanced stage of maturity.

**Figura 6.** Gónada de hembra de *Dissostichus eleginoides* en avanzado estado de madurez.

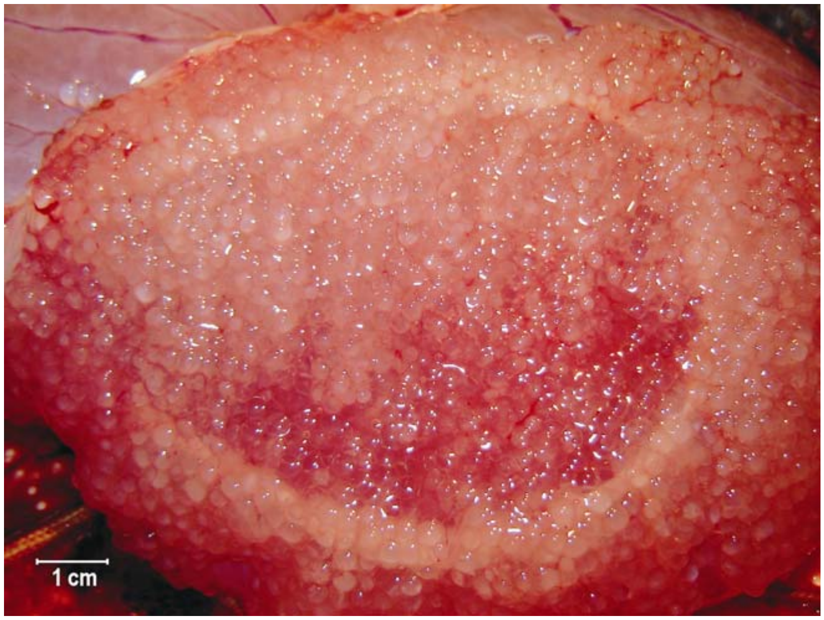


**Figure 7.** Ovas in a female *Dissostichus eleginoides* gonad.

**Figura 7.** Óvulos en gónada de hembra de *Dissostichus eleginoides.*

**Table 5.** Average size and weight of the specimens, and percentage of specimens under the size at first sexual maturity per period for each sex.

**Tabla 5.** Talla y peso media de los ejemplares, y porcentaje de ejemplares bajo la talla de primera madurez sexual por período en cada sexo.

| | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| Period | n | Mean size (cm) | Mean weight (kg) | % below $TMS_{50\%}$ | n | Mean size (cm) | Mean weight (kg) | % below $TMS_{50\%}$ |
| Jan - Mar | 2,542 | 109.0 | 8.3 | 6.1 | 1,140 | 118.5 | 17.7 | 14.6 |
| Jun - Aug | 2,094 | 103.1 | 7.1 | 12.3 | 1,382 | 111.2 | 15.0 | 25.9 |
| Sep - Nov | 2,413 | 93.7 | 5.4 | 27.8 | 1,325 | 94.2 | 8.0 | 47.5 |
| Total | 7,049 | | | | 3,847 | | | |

first filling quotas for other resources (*e.g.*, southern hake and pink cusk-eel).

The displacement of the Patagonian toothfish from the far south of Chile or even from the Atlantic sector towards lower latitudes, should be confirmed by tagging, a methodology that is being used successfully in other regions where this species is found (*e.g.,* Williams *et al*., 2002; Marlow *et al*., 2003; Agnew *et al*., 2006). Along with the scientific contribution of such a study in diverse biological aspects, it would allow us to determine whether the Patagonian toothfish effectively migrates northward along the western coast of the South American continent. This, in conjunction with the hypothesis (not yet proven with certainty) that *D. eleginoides* does not reproduces north of 47°S, would imply that these fish are only invaders, taking advantage of oceanographic conditions similar to those found in deeper waters. If this is so, it would also help explain the progressive decline in the yields off central and northern Chile, since the exploitation of these fish in the south would decrease the possibility of finding them farther north.

**Figure 8.** Gonad and ejaculation induced by pressure on the abdomen of *Dissostichus eleginoides* male.

**Figura 8.** Gónada y eyaculación inducida por presión del abdomen de machos de *Dissostichus eleginoides*

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