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*Research Article*

# Fishing yields and size structures of Patagonian toothfish (*Dissostichus eleginoides*) caught with pots and long-lines off far southern Chile

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**ABSTRACT.** Herein, we compare information taken from the Patagonian toothfish (*Dissostichus eleginoides*) fishery operations carried out off the far southern coast of Chile (47°00'S-57°00'S) using pots (pots) and long-lines. In January 2006 and from June to October 2006, 167 fishing hauls were done, 119 using long-lines and 48 using pots. The total Patagonian toothfish catch was 60.9 tons, of which 81.2% were caught with long-lines and 18.8% with pots. On average, 5,395 hooks and 147 pots were set per haul, with average yields of 0.08 kg hook$^{-1}$ and 1.43 kg pot$^{-1}$. The average depth for setting the gear was 1,581 m (long-lines) and 1,318 m (pots). Significant differences were found between these two types of gear, as well as between the time of setting and the time of retrieval. Greater fishing yields were obtained from the long-line fishery operations, with significant differences between the gear types in terms of the catch per haul (kg haul$^{-1}$) and the catch per length of the specimens retained (kg 1000 m$^{-1}$). On average, the individuals caught with pots (110.8 cm total length) were larger than those caught with long-lines (105.1 cm total length). Nonetheless, no significant differences were recorded for the size structures. In terms of interactions with birds, during setting, no birds were observed at the trapping operations, whereas a few specimens (≤ 10 birds) were seen during only 2.5% of the long-line operations. During retrieval, birds were observed during 34.9% of the hauls with pots and 62.8% of the long-line operations. The presence of mammals around the fishery operations during setting and retrieval was similar for both types of gear.

**Keywords:** yields, pot, long-line, Patagonian toothfish, *Dissostichus eleginoides*, Chile.

# Rendimientos de pesca y estructuras de tallas de bacalao de profundidad (*Dissostichus eleginoides*) capturados con trampas y espineles en el extremo sur de Chile

**RESUMEN.** Se compara información proveniente de operaciones de pesca de bacalao de profundidad (*Dissostichus eleginoides*) efectuadas mediante trampas y espineles en enero de 2006 y entre junio y octubre de 2006, frente a la costa sur-austral de Chile (47°00'S-57°00'S). Se realizaron 167 lances de pesca, 119 correspondieron a operaciones de pesca con espinel y 48 con trampas, registrándose una captura total de bacalao de profundidad de 60,9 ton, de las cuales 81,2% fue extraída con espinel y 18,8% con trampas. Se calaron en promedio 5.395 anzuelos/lance y 147 trampas/lance, obteniéndose un rendimiento promedio de 0,08 kg anzuelo$^{-1}$ y 1,43 kg trampa$^{-1}$. La profundidad media de calado fue 1.581 m con espineles y 1.318 m con trampas, encontrándose diferencias significativas entre ambos aparejos, al igual que en el tiempo de calado y de virado. En las operaciones de pesca con espinel se obtuvo rendimientos de pesca superiores, siendo estas diferencias significativas entre los aparejos en términos de la captura por lance (kg lance$^{-1}$) y la captura por longitud de retenida (kg 1000 m$^{-1}$). Respecto del tamaño de los ejemplares capturados, aquellos pescados con trampas exhibieron talla promedio superior a los extraídos con espineles, registrándose valores medios de 110,8 y 105,1 cm de longitud total, respectivamente; sin embargo, la estructura de talla no registró diferencias significativas. En relación a la interacción con aves, durante el calado con trampas no se observó presencia de ellas, mientras que con espineles sólo en el 2,5% de los lances se detectaron algunos ejemplares (≤ 10 aves). En la etapa de virado, las aves se observaron en el 34,9% de los lances con trampas y en el 62,8% en las faenas con espineles.

La presencia de mamíferos en las operaciones de pesca con ambos aparejos tanto en el calado como el virado fue similar.

**Palabras clave:** rendimientos, trampa, espinel, bacalao de profundidad, *Dissostichus eleginoides,* Chile.

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## INTRODUCTION

The Patagonian toothfish (*Dissostichus eleginoides* Smitt, 1898) is a demersal species found widely in the southern realms of the Atlantic, Pacific, and Indian oceans, especially between 40º and 60º S. This species is found all along the continental coast of South America, from northern Peru to far southern Chile. Its bathymetry covers 70 to 2,800 m and, in Chilean waters, specimens have been caught at up to 2,500 m depth (Young *et al.*, 1998). Most Patagonian toothfish fisheries are between 1,000 and 1,500 m (Young *et al*., 1996).

Given its wide Antarctic circumpolar distribution, *D. eleginoides* is caught mainly around the southern cone of America, the Falkland/Malvinas islands, South Georgia Island, and numerous other islands and oceanic elevations (Gon & Heemstra, 1990). A large part of the distribution of this resource is located in the Sub Antarctic and the Antarctic and its exploitation therein is regulated by the standards adopted by the Convention for the Conservation of Live Antarctic Marine Resources (CCRVMA).

In Chile, Patagonian toothfish fisheries began in 1955, but it was not until the 1970s that an artisanal fleet in the central sector of the country began commercial exploitation of the species. Later, this same group expanded operations northward and then southward, where fishing yields improved (Oyarzún *et al.*, 2003a, 2003b). At present, the fishery is divided into two zones. The north zone, between Chile's northern limit (18º21'S) and parallel 47º'S, is reserved exclusively for artisanal fishing whereas, in the south zone (47ºS to 57º'S), the resource is exploited through industrial fishing activities.

Technologically, given the resource's bathymetric distribution, any fishing gear used to catch Patagonian toothfish must meet strength standards that allow hauling aboard heavy, large-sized specimens, generally from depths over 1,000 m. At the end of the 1960s, Pavez *et al.* (1968) designed a special long-line to be used at such depths. This long-line was adopted by the artisanal fishers that first exploited this resource. Later attempts to use gills nets and large, heavy rectangular traps were not very effective and, thus, the long-line was determined to be the most efficient fishing technique (Zuleta *et al.,* 1996).

The worldwide Patagonian toothfish fishery relies largely on bottom-set long-lines. In Chile, the rapid expansion of the fishery as of the 1990s resulted in the introduction of new fishing techniques, consolidating the design of a new fishing gear, the Spanish long-line, also known as "quebrado" or "retenida". This new design was successful in allowing fishing under any sea conditions and at greater depths (Cascorbi, 2004). In Chilean waters, the gear used to catch *D. eleginoides* is regulated, and the use of any fishing gear or technique other than the long-line is prohibited.

Nonetheless, the use of long-lines for Patagonian toothfish fishing operations has also had side effects such as sea bird mortalities, principally albatross (*Diomedea* spp.) and petrels (*Macronectes giganteus*) (Ashford *et al.*, 1994, 1995, 1996; Barea *et al.*, 1994; Moreno *et al*., 2003, among others). Likewise, interactions occur between fishery's activities and whales, mostly sperm whales (*Physeter macrocephalus*) and orcas (*Orcinus orca*) (Salas *et al*., 1987; Ashford *et al.*, 1996; Moreno *et al.*, 2003). In these cases, the mammals feed on the specimens caught on the long-lines when they are brought on deck, resulting in lost catches. The interaction is also dangerous for the whales, who could be harmed or killed when becoming tangled in the gear or when driven off by the fishers (Angliss & DeMaster, 1997).

Thus, the evaluation of other fishing techniques for catching Patagonian toothfish became pertinent for both the institutions whose objective it is to safeguard the ecosystem's conservation and for the users of the Patagonian toothfish fishery. One of the options being considered for the exploitation of this species is the use of pots or traps. In terms of the principle used for catching the resource, this method does not differ from the long-line: both are passive, use bait, and require a certain resting or soak period to attract the prey. No experiments have been done to evaluate this fishing alternative in Chilean waters. However, internationally, a study was done by the United Kingdom in waters off South Georgia Island (Subarea 48.3) in which pots were used for experimental fishing of Patagonian

toothfish from March to May 2000 (Agnew *et al.*, 2001).

Therefore, participants in this fishery, with the consent of the Chilean fishing authority, promoted a research fishing campaign in order to evaluate the feasibility and convenience of using pots for the industrial fishing of Patagonian toothfish. The objective of this study was to compare fishing operations using this gear with those using long-lines, considering fishing yields as well as the main associated operational aspects. We also analyzed the respective size structures of the catches obtained with each type of gear and interactions with birds and mammals.

## MATERIALS AND METHODS

This study analyzes information on Patagonian toothfish fishing operations using pots (traps) and long-lines along the southern coast of Chile (47°S-57°S) and from 630 to 2,269 m depth. The extractive activities were carried out in two periods: in January and from June to October 2006. The fishing operations were performed with the long-line factory vessel "Tierra del Fuego" (53.6 m long), which is normally used for commercial fishing of this species. The vessel was rigged to permit trap deployment without interfering with the equipment or the maneuvers required for long-line fishing. The main modifications were the implementation of a telescopic crane (Fig. 1a, 1b), the construction of a trap retrieval collar (Fig. 1c), and a rail (Fig. 1d) for moving the traps from the retrieval platform to the setting position (stern).

A Spanish or "quebrado" type long-line was used. This gear is used frequently by the industrial fleet for commercial catches of Patagonian toothfish off far southern Chile. This gear usually consists of a mother line (PA ø3.5 mm), leaders (PA ø1.2 mm), and hooks (No. 9). The traps used were troncoconical in design;

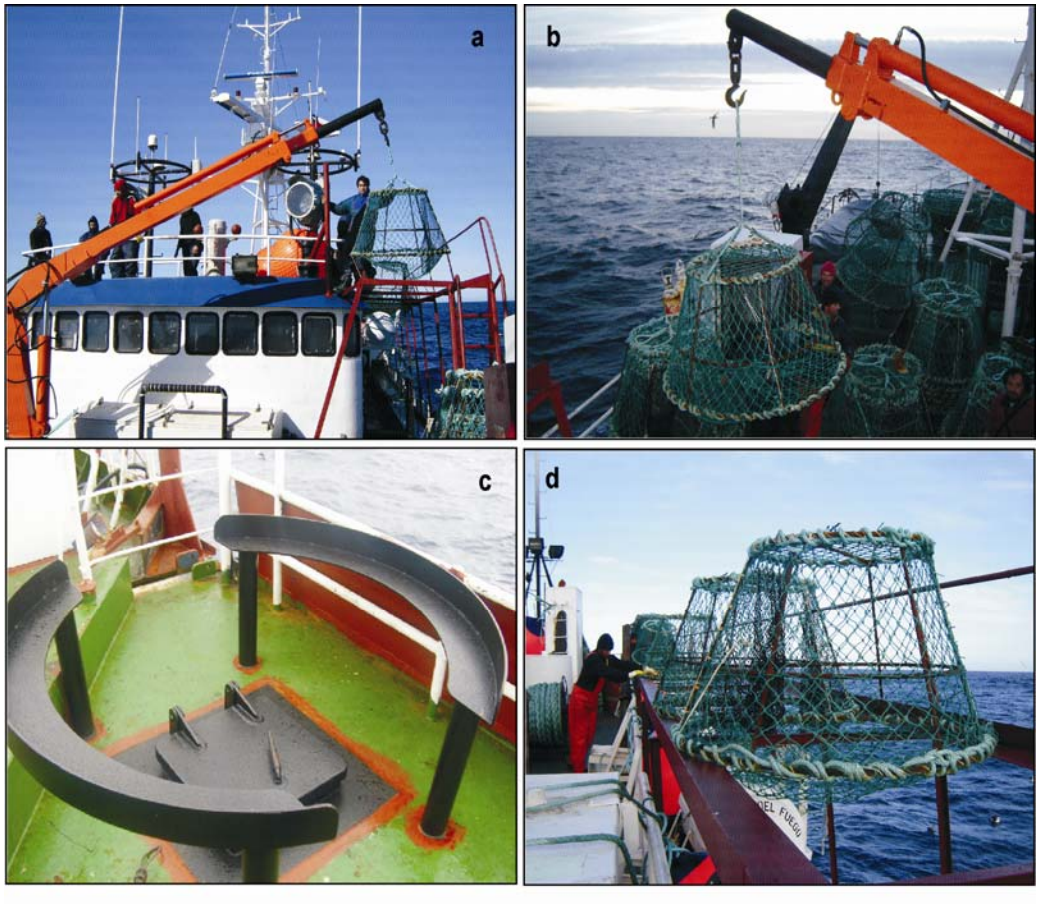


**Figure 1.** Rigging the vessel to operate with a) pots, b) telescopic crane, c) pot retrieval collar, and d) rail for moving the pots.

**Figura 1.** Acondicionamiento de la nave para operar con a) trampas, b) grúa telescópica, c) anillo de recepción de trampas y d) riel para desplazamiento de trampas.

with a circular base of 150 cm, an upper part of 86 cm; they were 90 cm high and made of FE (ø17 mm) and mesh panels (120 mm for the body and 38 mm for the mouth). These pots were operated using bait, specifically South American pilchard (*Sardinops sagax*), the same species used for long-line fishing.

The pot fishing was done in the fishery grounds where the fleet typically operates and was randomly interspersed with long-line fishing. For each haul, the geographical position, date, depth, setting and retrieval time, gear soak time, and corresponding catch were noted, as were the characteristics of the gear used (mother line length, number of hooks/pots set).

The main test statistics used to compare the pot and long-line fishing operations were the depth of setting and the setting, retrieval, and soak times; the corresponding average values were determined. A *t*-test (95% confidence interval and $n_1+n_2$ -2 g.l.) was used to compare the operational variables for the two types of fishing gear.

In terms of fishing yields from long-line and trap operations, the catch per haul (kg haul$^{-1}$), catch per hook set (kg hook$^{-1}$), and catch per trap set (kg trap$^{-1}$) were determined. It should be noted that the comparison of yields for different types of fishing gear is not a trivial matter, requiring a common unit of effort for both types of gear. Herein, the soak time (h) for each gear type and length of the mother line (m) were taken as the nominal unit of effort. These were used to determine the two indicators – catch per hour the gear was soaked (kg h$^{-1}$) and catch per 1,000 m of mother line (kg 1,000 m$^{-1}$) – used for the comparative analysis.

To analyze the catches obtained per fishing gear, Patagonian toothfish specimens were measured at random according to their arrival on the processing deck. Each individual was sexed and total length (TL) was determined with an ichthyometer (± 1 cm). These records were used to determine the sexual proportion (% males) of the catches. Furthermore, the respective size frequency distributions were elucidated and individual measurements of total length were grouped in 2-cm intervals, thereby allowing us to compare the size structures of the Patagonian toothfish specimens caught with both types of fishing gear. In each case, we estimated the mean and median sizes, the variance, and the standard deviation. For purposes of comparison, in order to establish the differences in the size structures of the catches, the Kolmogorov-Smirnov test was used.

Finally, in order to quantify the interaction of the gear with marine birds and mammals, we recorded the presence of these animals during setting and retrieval operations. These interactions were categorized as either many (> 10), few (≤ 10), or none (0). Later, we determined the percentage of hauls in which we recorded the presence/absence of these animals with the different types of fishing gear. Likewise, we noted the by-catch of birds, indicating the number of birds caught (live or dead) for each haul.

## RESULTS

During the study, 167 fishing hauls were carried out from 1 to 28 January 2006 and from 17 June to 31 October 2006, spread over the entire study area (Fig. 2). Long-line fishing was done on 119 of the hauls and trap fishing on the remaining 48. The total catch of Patagonian toothfish was 60.9 ton, 81.2% from the long-lines and 18.8% from the pots.

During the two fishing periods, 642,024 hooks were used, ranging from 2,704 to 10,296 hooks/haul ($\bar{x}$ = 5.395 hooks haul$^{-1}$), and 7,052 pots were used, ranging from 60 to 238 pots haul$^{-1}$ ($\bar{x}$ =147 pots haul$^{-1}$). The average yield obtained by each gear was 0.08 kg hook$^{-1}$ and 1.43 kg pot$^{-1}$.

The fishing hauls were done at average depths of 810 to 2,269 m (long-lines) and 630 to 2,020 m (pots). The average setting depth differed significantly by type of gear, averaging 1,581 m for long-lines and 1,318 m for pots (Fig. 3).

The setting of the long-lines required 0.8 h for an average of 5,395 hooks haul$^{-1}$, whereas setting the pots required 0.9 h for 147 pots haul$^{-1}$. The average retrieval time was 5.2 h (long-lines) and 4.2 h (pots). Both setting and retrieval times differed significantly. The average soak time for the long-lines was 17.9 h and for the pots 19.1 h; this difference was not significant (Fig. 3).

The fishing yields for the long-line operations were higher than those obtained with traps. The catch per haul with the traditional gear was 462.1 kg haul$^{-1}$ whereas, with the pots, it was 253.6 kg haul$^{-1}$. Likewise, when basing these values on the soak time and length of the mother line, they were 28.9 ton h$^{-1}$ and 48.1 kg 1000 m$^{-1}$ for long-lines and 17.3 kg h$^{-1}$ and 28.6 kg 1000 m$^{-1}$ for traps. Although the three indicators revealed clear differences between the types of gear, these were only statistically significant in terms of the catch per haul (kg haul$^{-1}$) and the catch per length of mother line (kg 1000 m$^{-1}$) (Fig. 4).

During the study period, we sampled 2,058 specimens from long-lines and 663 from pots (Table 1). The global sexual proportion of the catches obtained with the two types of gear varied slightly, with more

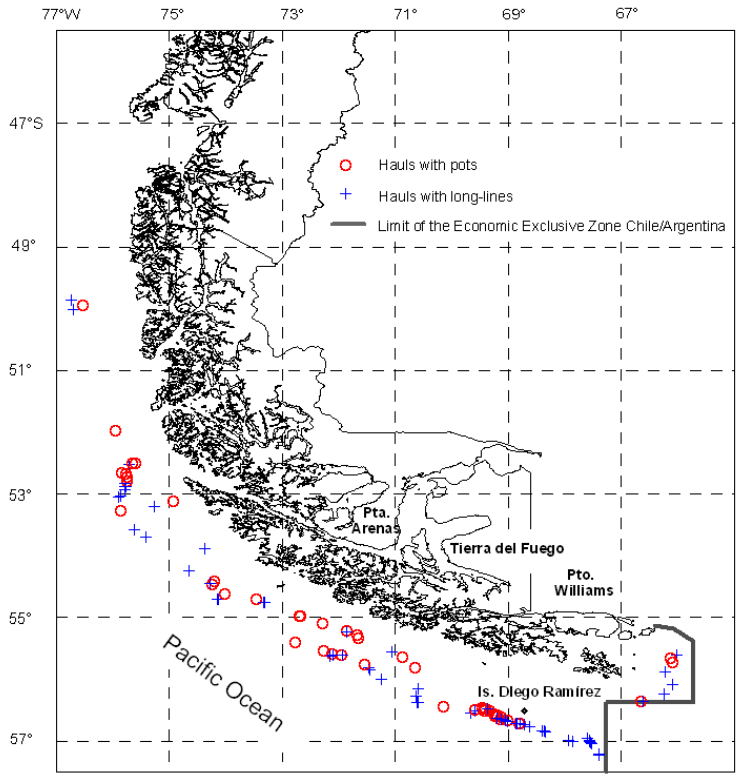


**Figure 2.** Locations of the fishing hauls done with long-lines and pots during the study period.
**Figura 2.** Posicionamiento de los lances de pesca con espinel y trampas efectuadas durante el período de estudio.

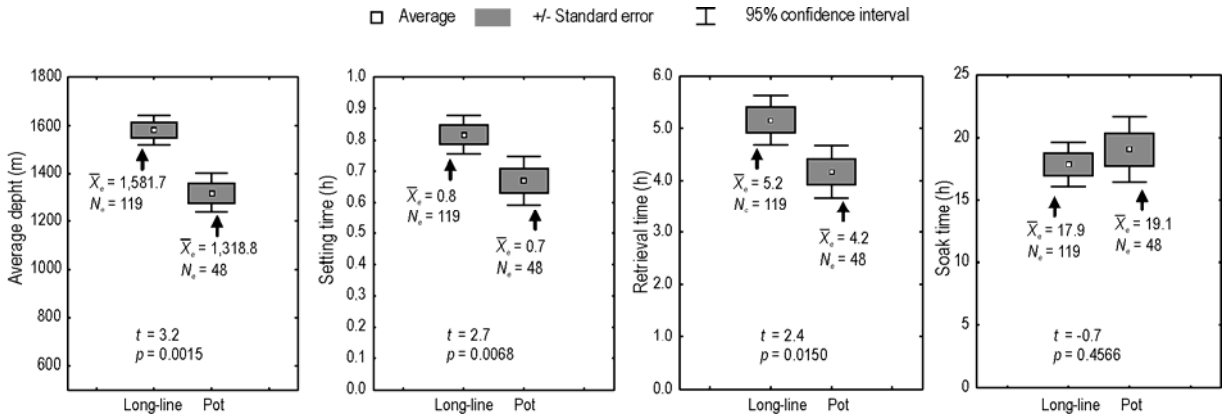


**Figure 3.** Box plot of operational variables recorded with long-lines (e) and pots (t).
**Figura 3.** Box plot de variables operacionales registradas con espinel (e) y trampas (t).

males caught on long-lines than in pots (65.3% *vs* 49.6%). Nevertheless, males between 85 and 115 cm total length predominated the size structures of the catches from both types of gear (Fig. 5).

On average, the trapped specimens were larger than those caught on long-lines (110.8 *vs* 105.1 cm TL) (Table 1). The size frequency distributions revealed, in both cases, a greater breadth of range in length for the females. The males showed an important mode of 101 cm TL (Fig. 6). The total size structures of the catches from both types of gear were similar. In fact, the results of the Kolmogorov-

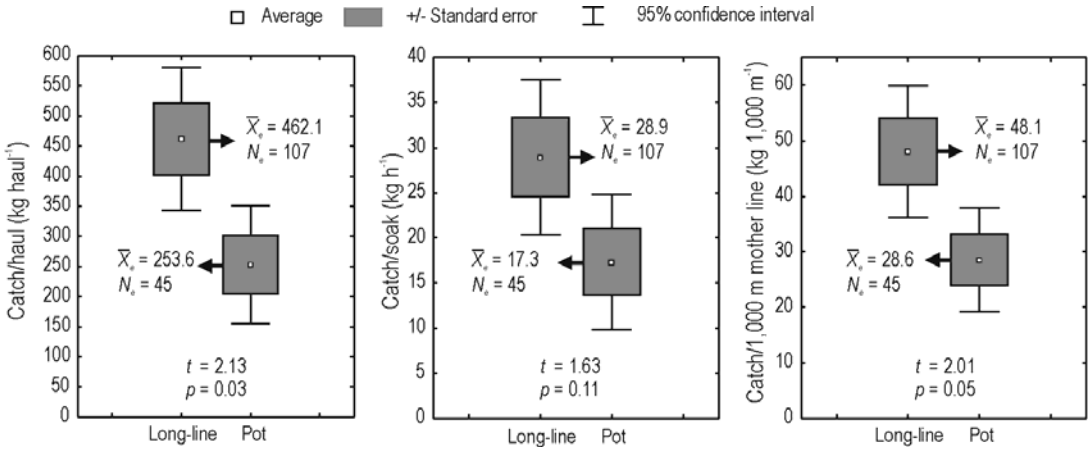


**Figure 4.** Box plot of yields obtained with long-lines (e) and pots (t).

**Figura 4.** Box plot de los rendimientos obtenidos con espinel (e) y trampas (t).

Smirnov test confirmed that no significant differences exist between the size frequency distributions for long-lines and pots (Fig. 7, Table 1).

Regarding the matter of bird interactions, no birds were observed during trap setting and only a few (≤ 10 birds) were seen during 2.5% of the long-line settings. More birds were observed during retrieval, again with lower numbers for traps than long-lines. Birds were present, considering both observations of "few" and "many", at only 34.9% of the trapping and 62.8% of the long-line operations (Table 2). During this study, bird mortality was 0.0031 birds 1000 hooks$^{-1}$ and only occurred during long-line fishing.

The presence of mammals around trapping and long-line fishing operations, both during setting and retrieval, was similar. In fact, with long-lines, mammals were observed in 80.7% of the setting and 99.1% of the retrieval operations whereas, with the pots, mammals were observed in 97.8% of the setting and 100% of the retrieval operations (Table 2). The personnel onboard reported that the trapped catch showed no evidence of attack by mammals.

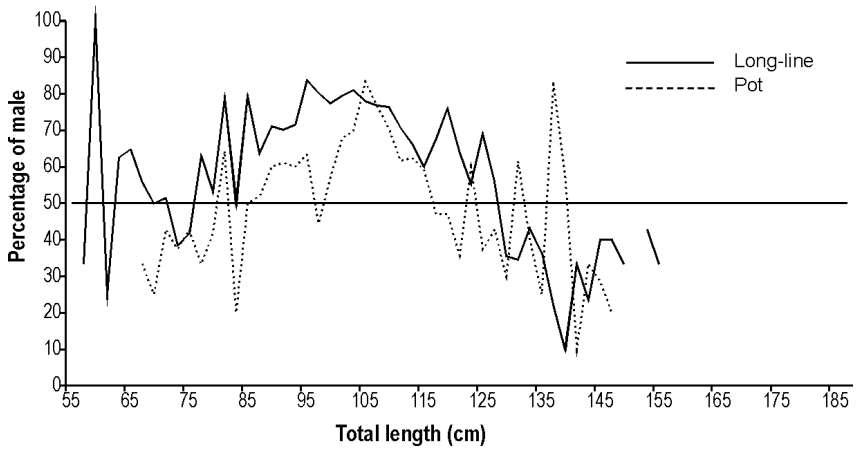


**Figure 5.** Sexual proportion of the size at catch of Patagonian toothfish obtained with long-lines and pots.

**Figura 5.** Proporción sexual a la talla de las capturas de bacalao de profundidad obtenidas con espinel y trampas.

**Table 1.** Main statistics for total length of Patagonian toothfish caught with long-lines and pots and the results of the comparison of the respective size frequency distributions.

**Tabla 1.** Principales estadígrafos de la longitud total en bacalao de profundidad capturado con espinel y trampas y resultados de la comparación de las respectivas distribuciones de frecuencias de tallas.

| | Long-lines | | | Pots | | |
|---|---|---|---|---|---|---|
| | Males | Females | Total | Males | Females | Total |
| Number of specimens | 1,331 | 727 | 2,058 | 325 | 338 | 663 |
| Range (cm) | 57 - 171 | 55 - 183 | 55 - 183 | 67 - 203 | 63 - 221 | 63 - 221 |
| Mean size (cm) | 103.1 | 108.8 | 105.1 | 104.9 | 116.4 | 110.8 |
| Median (cm) | 103.5 | 110.0 | 104.8 | 103.5 | 113.3 | 106.5 |
| Variance ($cm^2$) | 287.2 | 619.9 | 411.7 | 321.3 | 982.1 | 690.6 |
| Standard error (cm) | 0.5 | 0.9 | 0.5 | 1.0 | 1.7 | 1.0 |
| Coefficient of variation | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 | 0.2 |
| Kolmogorov-Smirnov test | | | Dn | 0.023 | | |
| | | | Dα=0.05 | 0.26 | | |

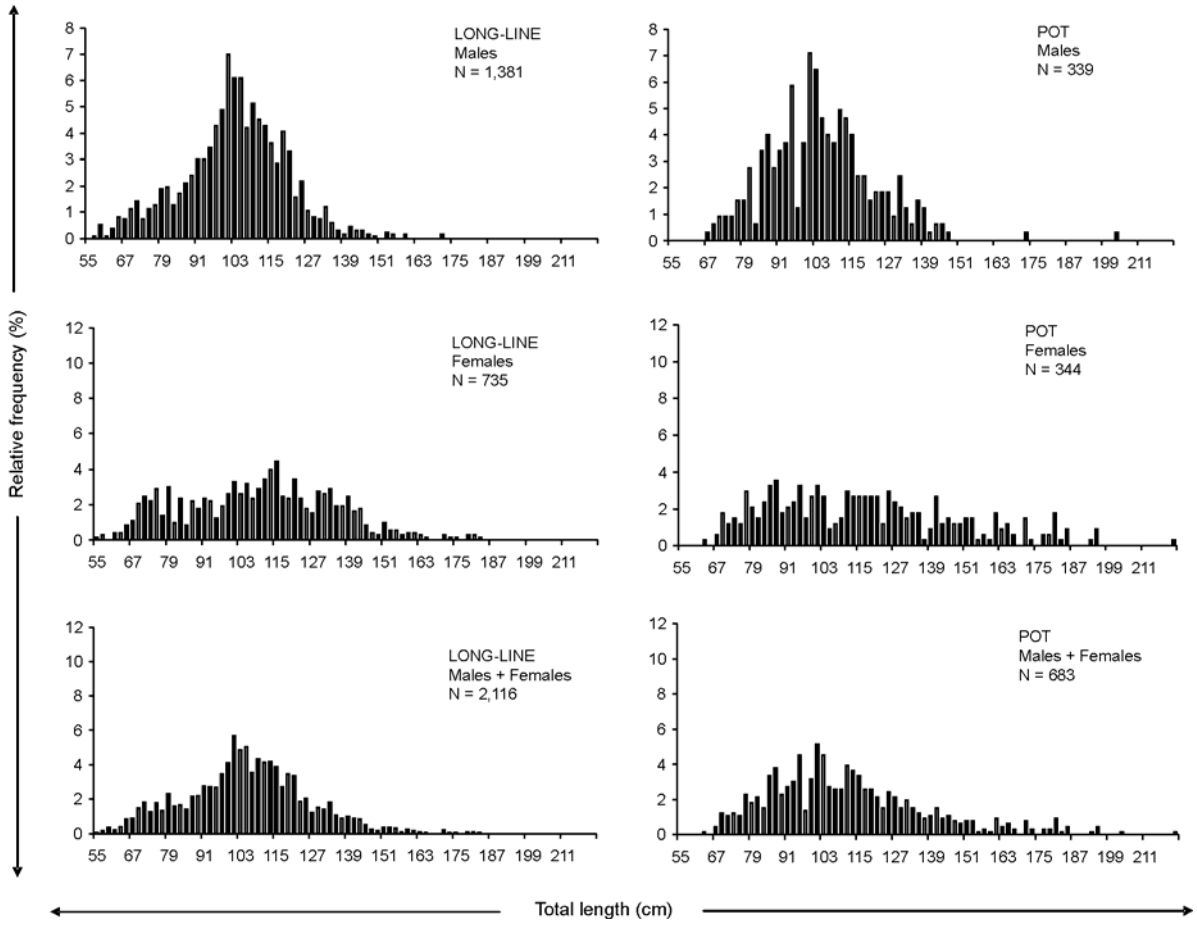


**Figure 6.** Distribution of size frequencies in Patagonian toothfish by sex and fishing gear.

**Figura 6.** Distribución de frecuencias de tallas en bacalao de profundidad por sexo y aparejo de pesca.

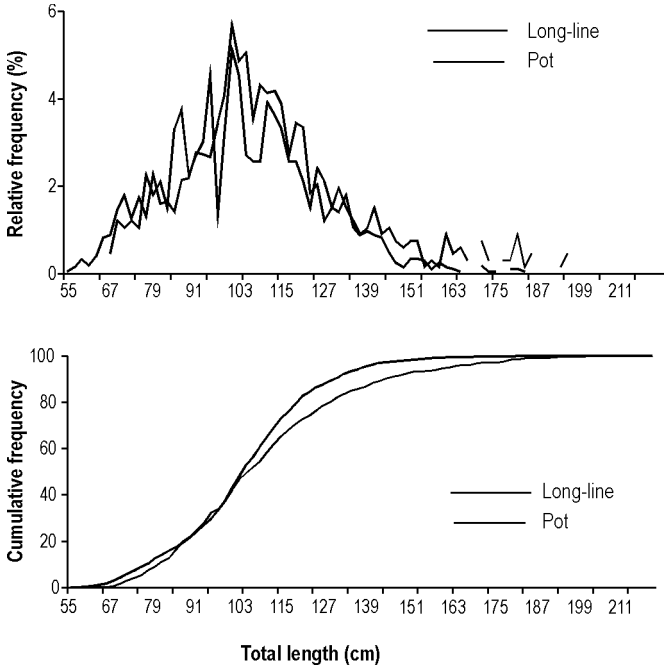


**Figure 7.** Distribution of relative and accumulated size frequencies in Patagonian toothfish caught with long-lines and pots.

**Figura 7.** Distribución de frecuencias de tallas relativas y acumuladas en bacalao de profundidad capturado con espinel y trampas.

**Table 2.** Presence of birds and mammals (%) during gear setting and retrieval operations (long-lines and pots).

**Tabla 2.** Presencia de aves y mamíferos (%) en las faenas de calado y virado de los aparejos (espinel y trampas).

| | Percentage of hauls (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Setting | | | Retrieval | | | |
| Number of individuals observed | N<br>None<br>(0 ind.) | P<br>Few<br>(≤ 10 ind.) | M<br>Many<br>(> 10 ind.) | N<br>None<br>(0 ind.) | P<br>Few<br>(≤ 10 ind.) | M<br>Many<br>(> 10 ind.) | |
| Presence of birds | 97.5 | 2.5 | 0.0 | 37.3 | 51.0 | 11.8 | Long-lines |
| Presence of mammals | 9.3 | 69.5 | 21.2 | 0.9 | 56.5 | 42.6 | |
| Presence of birds | 100.0 | 0,0 | 0.0 | 65.1 | 32.6 | 2.3 | Pots |
| Presence of mammals | 2.2 | 78.3 | 19.6 | 0.0 | 54.5 | 45.5 | |

## DISCUSSION

The fishing activity exercised on Patagonian toothfish has historically been the subject of studies and controversy. The intense exploitation to which the species has been subjected around the Antarctic continent and in the waters off southern Chile, as well as the implications of this for the ecosystem, have led to the constant evaluation of long-line fishing operations and discussions as to the possibility of using an alternative fishing gear that would allow efficient fishing without interfering with other marine populations. However, such a change requires more experiments to compare types of fishing gear.

In this sense, the use of traps has been considered as an alternative to the long-line. However, a comparison of the two presents some difficulties since nominally the effort used for catching the resource with the

two types of gear are not equivalent. Therefore, although hooks and traps use a similar fishing technique, requiring bait to attract the fish and soak time for the catch process to take place, the traditional yield indicators used to contrast the results of fishing operations cannot be used herein.

In this case, one of the first aspects of the fishing operations to compare is whether both types of gear act on the same fraction of the stock from the point of view of its structure. According to the size frequency distributions, although the average specimens caught with pots were larger than those on the long-lines (110.8 *vs* 105.1 cm TL), the size structures revealed no significant differences. Thus, we can infer that the differences found are basically associated with factors related to the operation and effectiveness of the gear.

Our analysis showed significant differences in the operation of the gear. The long-lines were set at greater depths; the pots were set at shallower depths due to problems with the retrieval equipment onboard that impeded deploying the traps any deeper. Likewise, gear operation differed significantly during setting and retrieval, with the maneuvering time being longer for long-lines during both operational phases. The total difference generated in the haul was 1.1 h (66 min). This value is, in practical terms, irrelevant and can be attributed to the greater depth at which the long-lines were set.

The soak time recorded for the two types of gear differed, but not significantly. Gear soak time is defined *a priori* and usually does not exceed 24 h in order to prevent the catch being attacked by "mixines" or "pulguilla" predators (Anphipoda: Crustacea). Nonetheless, the soak time is subject to the weather conditions and, when these are adverse, can last up to three or more days.

The fishing yields also differed, with greater values found for the long-lines than for the pots. The catch per haul with long-lines was nearly double that with pots (462.1 kg haul$^{-1}$ *vs* 253.6 kg haul$^{-1}$). The same was true for the yield in function of the length of the mother line (long-lines: 48.1 kg 1000 m$^{-1}$ *vs* pots: 28.6 kg 1000 m$^{-1}$). In spite of the lack of clarity regarding the equivalence in the catchability of these two types of gear – no hook-trap relationship has been defined and between-gear comparisons are complex – the results show that the long-lines are more effective. Hence, from this point of view, the use of pots is not an option for the near future.

It should be noted that this experience of trapping Patagonian toothfish is unique in Chile. Only one similar experiment was found in the literature, a report by Agnew *et al.* (2001) of Shag Rocks and the waters to the northeast of South Shetland Island in the South Atlantic. These authors reported lower yields per pot than those found herein (1.28 kg trap$^{-1}$ *vs* 1.43 kg trap$^{-1}$). However, they operated under different conditions and in fishing zones with different abundances.

One of the main advantages of the pots was the lack of incidents with birds. Nevertheless, birds were present around the fishing operations. The use of traps eliminated bird mortality as well as bait consumption by birds, thereby reducing the real fishing effort by up to 26% of the line (Brothers & Foster, 1997). It should be mentioned that, according to the number of hooks set, the bird mortality rate recorded in the present study (0.003 birds 1000 hooks$^{-1}$) was significantly inferior to that obtained in 2001 by Moreno *et al*. (2003), who reported mortality of 0.36 birds 1000 hooks$^{-1}$.

Interactions with mammals were also altered. The trapping operation eliminated predatory attacks by mammals on the catch, with none of the caught specimens showing signs of having been attacked by these animals. This is an important factor for the fishery users, since such attacks reduce the effective catch on the long-line. Moreno *et al*. (2003) calculated a monetary loss of US$ 138 per haul caused by marine mammals and of US$ 92,684 for the entire fleet in the fishing season, due to the high value of this resource on the international markets.

The present research shows the feasibility of employing pots for catching Patagonian toothfish. However, this gear was not sufficiently favorable for the fishers. The main difficulties in using the pots were operational aspects due, by and large, to the considerable depth at which this resource is caught, the weight of the gear, and the complexity of its operation. Long-lines are clearly more efficient than pots. Here it is important to mention that, parallel to the execution of this project, the industrial fleet introduced "cachaloteras" (anti-predation devices) on their long-lines. This modification basically involves a net that wraps around the leaders and hooks during retrieval, impeding predation by sperm whales and orcas on the caught specimens, thereby incrementing the effectiveness of the long-lines.

The experience of fishing with pots can be repeated successfully with other resources, mainly those available at lesser depths and that are affected by birds and/or mammals. Nonetheless, the use of these traps requires technological changes in the fishing vessels that should be analyzed and evaluated for the target species, particularly regarding those aspects related directly to the capacity of the winches to raise the gear.

Finally, it is necessary to state that adopting the use of pots as a fishing method necessitates a study of the impact this change would produce on the exploited population. Such a study should include the "ghost fishing" that would arise due to the loss of pots, which continue to attract and trap specimens indefinitely, causing mortality that could become significant and that should be incorporated into the population evaluation models. An evaluation could be done of the use of biodegradable materials in some sections of the pot that would allow the organisms to escape after a certain time, thus minimizing or eliminating this additional source of mortality.

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