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Patagonian toothfish population analysis with data from two Spanish vessels fishing in the South of the Indian Ocean (SIOFA CA) between 2017 and 2018

Relates to agenda item: 4.3 Working paper ☐ Info paper ☒

Delegation of EU

Abstract

Spanish longline fisheries targeting mainly Patagonian toothfish (Dissostichus eleginoides) have been operating in the South of the SIOFA convention area on a non-regular basis. Little information is available about these fisheries in the area. This document provides a preliminary analysis of the Patagonian toothfish population with data obtained by the scientific observers onboard the two Spanish vessels during commercial surveys between 2017 and 2018, in international waters of the South Indian Ocean within the FAO areas 51.7 and 57.4 managed by SIOFA, which are adjacent to the Commission for the Conservation of Antarctic Marine Resources (CCAMLR) convention area.

Patagonian toothfish population analysis with data from two Spanish vessels fishing in the South of the Indian Ocean (SIOFA CA) between 2017 and 2018

R. Sarralde and S. Barreiro

Centro Oceanográfico de Canarias
Instituto Español de Oceanografía
Santa Cruz de Tenerife, España

Introduction

Spanish longline fisheries targeting mainly Patagonian toothfish (*Dissostichus eleginoides*) have been operating in the South of the SIOFA convention area on a non-regular basis. Little information is available about these fisheries in the area. This document provides a preliminary analysis of the Patagonian toothfish population with data obtained by the scientific observers onboard the two Spanish vessels during commercial surveys between 2017 and 2018, in international waters of the South Indian Ocean within the FAO areas 51.7 and 57.4 managed by SIOFA, which are adjacent to the Commission for the Conservation of Antarctic Marine Resources (CCAMLR) convention area.

A metapopulation of *D. eleginoides* with genetic homogeneity in the Indian Ocean sector of the Southern Ocean is suggested (Appleyard et al., 2002 and 2004, Williams et al., 2002; Welsford et al., 2011; Sarralde et Barreiro, 2018), although the rate of exchange between the different areas/divisions has not been determined until recently within the Kerguelen plateau (Burch et al, 2017). The population of "EL Cano" ridge in the FAO area 51.7 could be the outer edge of the main Patagonian toothfish population ground (López Abellán, 2005) and probably the fished area in FAO area 57.4 would be the outer edge for the Patagonian toothfish population close the Kerguelen plateau.

Different approaches have been made to define the Patagonian toothfish populations taking into account the depth, latitude, sex and area of fishing. Some differences between the two study areas have been found but the different temporal distribution of the two surveys could have influenced the results.

Methods

The activity of the vessels have been in two very distant locations in "El Cano" ridge to the Northeast of the Prince Edward/Marion Islands and Northwest of Crozet Island (area 51.7), and in the East of the Kerguelen plateau (area 57.4), exceeding 4000 km of distance between them. Therefore, two independent working areas have been considered for the purpose of this document (Figure 1), both outside EEZs and within the SIOFA convention area.

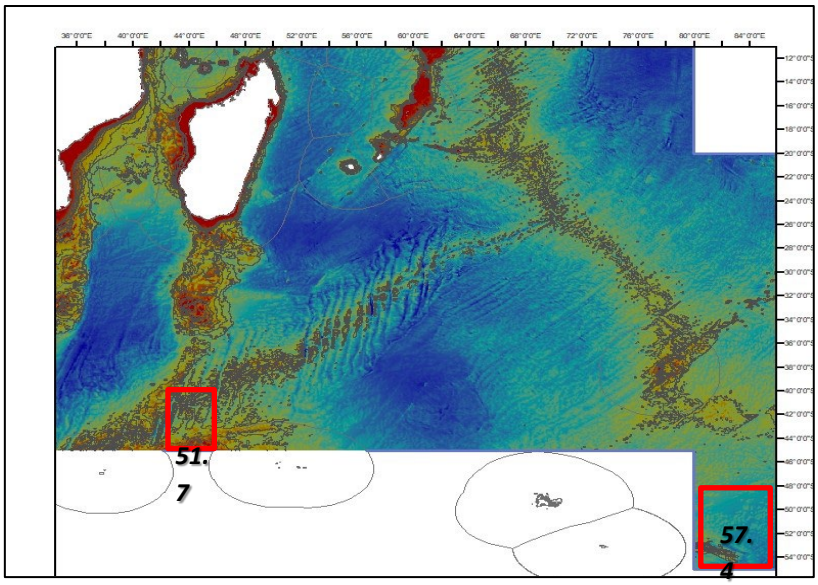

Figure 1: SIOFA convention area. Fishing areas in red.

Two vessels using different longline gear, namely F/V IBSA QUINTO fishing with autoline with integrated weighting line and F/V TRONIO with a Spanish system longline operated in these areas.

Scientific observations were conducted by Spanish scientific observers and monitored by the IEO (*Instituto Español de Oceanografía*). The observer coverage on the commercial surveys has been 100% on board the F/V TRONIO and nearly 72% on board the F/V IBSA QUINTO.

A chronogram of the period of the study is presented in Figure 2. Both vessels have fished in the area 51.7 however there is no temporary overlap. The area 57.4 have been fished only by the F/V TRONIO.

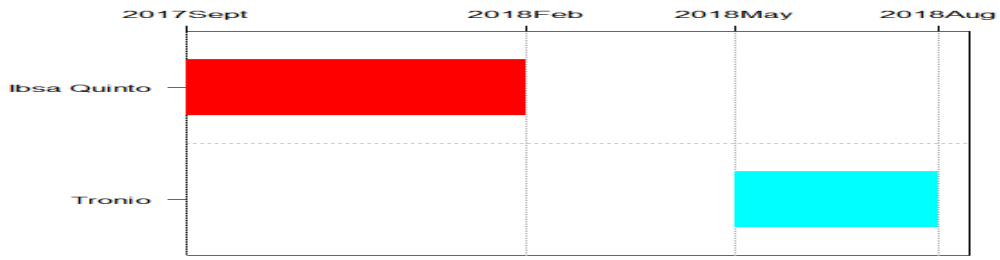

Figure 2: Chronogram of the fishing activities.

Catch data from the vessels and biological data sampled by scientific observers have been used. Biological data collection includes representative samples of length, weight, sex and maturity stage, as well as collection of otoliths for age and growth studies.

In order to analyze the data taking into account the depth distribution we have considered three strata considering the initial depth of the setting:

- ✓ *strata 1* between 600 and 1000m
- ✓ *strata2* between 1000 and 1500m
- ✓ *strata 3* between 1500 and2000m.

To classify the maturity stages of caught Patagonian toothfish, the observers have used the same macroscopic key for gonads that the International Scientific Observation (SISO) of CCAMLR:

Stage	***Female***	***Male***
1	Immature	Immature
2	Maturing virgin or resting	Developing or resting
3	Developing	Developed
4	Gravid	Ripe
5	Spent	Spent

Results

Catches by depth and latitude

The fishing depths were between 635 m and 2000 m. with a mean value of 1350 m (Table 1). The depth strata 2 (1000-1500m) has been the more sampled strata in both areas, around 61% of the total sets.

Table 1: Number of sets by depth strata, vessel and area.

	Area			
	51.7		*57.4*	
Depth strata	IBSA QUINTO	TRONIO	TRONIO	***Total***
strata 1	6	3	21	30
strata 2	133	39	40	212
strata 3	56	19	32	107

The deepest set (2000 m) has been performed in the area 51.7 and the shallowest (635 m) in area 57.4. (Figure 3).

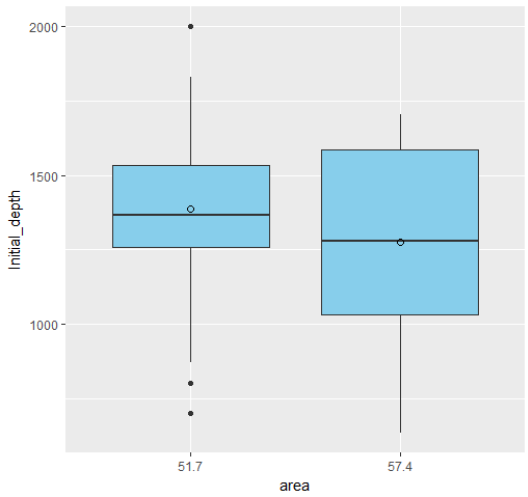

Figure 3: Fishing depth sampled by area. The circle on the boxplot is the mean depth value.

The mean CPUE in the area 57.4 has been 376 kg/1000 hooks, much higher than the 98 kg/1000 hooks obtained from area 51.7.

When comparing CPUEs within the only area where both vessels have spatially overlapped their activities (area 51.7) the CPUE obtained in the F/V using the Spanish LL is lower than the CPUE of the F/V using autoline system, 64 and 109 kg/1000 hooks respectively (Figure 4). This variability between vessels may reflect differences in the gear but also the temporal distribution of fishing among other potential factors.

When comparing the CPUE between depth strata we noticed that the CPUE of the 3rd depth strata (>1500m) is higher that the CPUE in the two more superficial strata in the area 57.4, with an ascending trend as the activities go deeper. In area 51.7 the trend is similar for the F/V IBSA QUINTO unlike the pattern in the F/V TRONIO where a steady decrease on the CPUE is observed as the vessel activities go deeper.

Results suggest a difference in the CPUE depending of the gear used or the period of fishing, for instance the soak time between both gears are completely different (Figure 5). Up to now, only few data from both vessels overlapping the fishing area are available. Approaches to consolidate effort between different gear types for CPUE evaluations will be made as soon as more data are incorporated into the study.

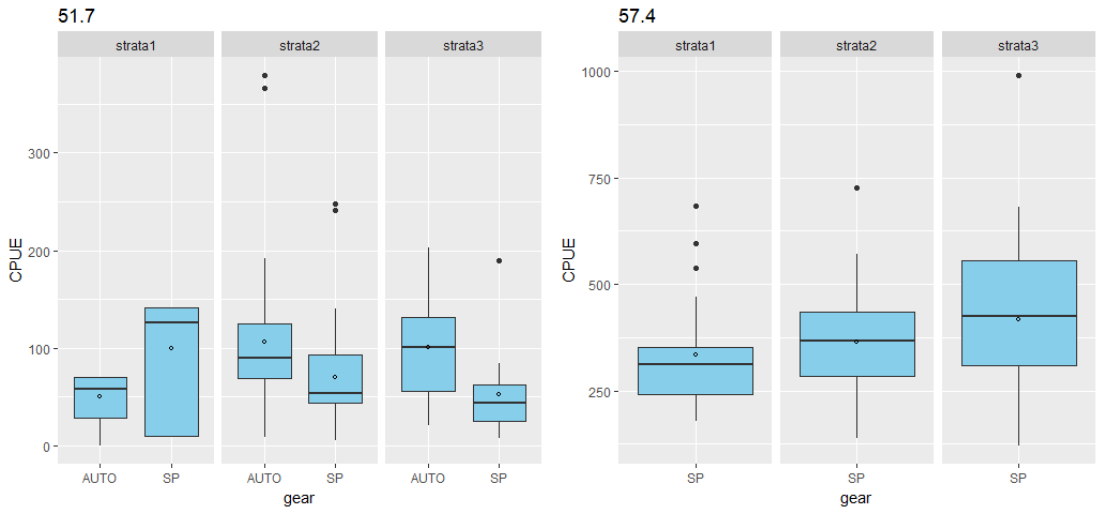

Figure 4: CPUE (kg/1000hooks) by gear, depth strata and area. The circle on the boxplot is the mean CPUE value.

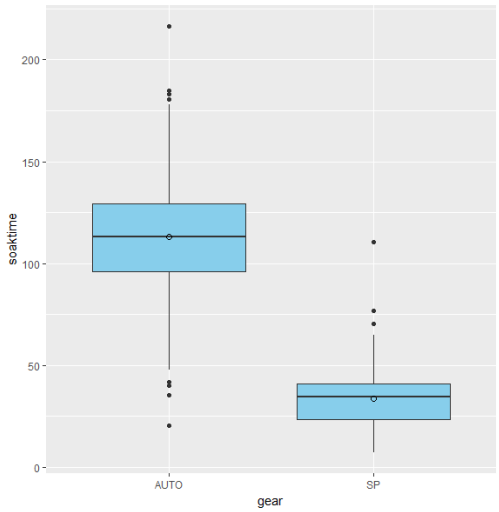

Figure 5: Soaktime (hours) by gear. The circle on the boxplot is the mean soaktime value.

Length frequencies

Different approaches have been made to analyse the length frequency data, firstly by sex and area, secondly by sex and depth strata and finally by sex and latitude of the catch.

Length distributions show that the size of females in the catch is longer in area 57.4 with a mean of 99 cm TL compared to 89 cm TL in the area 51.7 (Figure 6). Mean length distribution of males in 57.4 is also longer (88 cm) in area 57.4 than the mean TL in area 51.7 (79 cm).

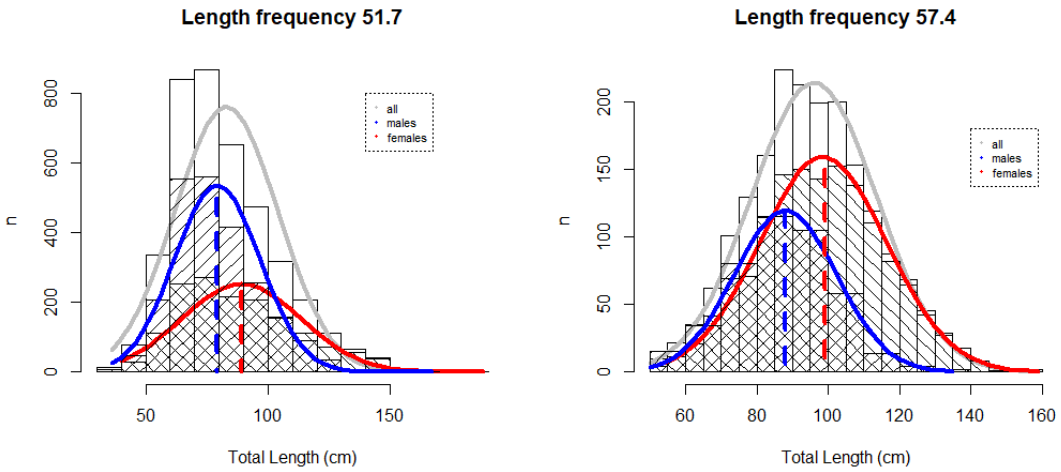

Figure 6. Length frequency distributions of Patagonian toothfish by sex and area.

Length size of females and males sampled at the three depth strata in area 57.4 are similar (Figure 7), as well as the male length distribution in area 51.7, with no depth distribution pattern, whereas sampled females in the area 51.7 are slightly bigger in the deepest strata.

D. eleginoides has an ontogenetic habitat shift toward deeper waters as fish grow older (Near et al. 2003, Welsford 2011), andat depths deeper than 1 000 m catches of older larger fish occurs. This trend could be observed in the area 51.7 but not in the area 57.4.

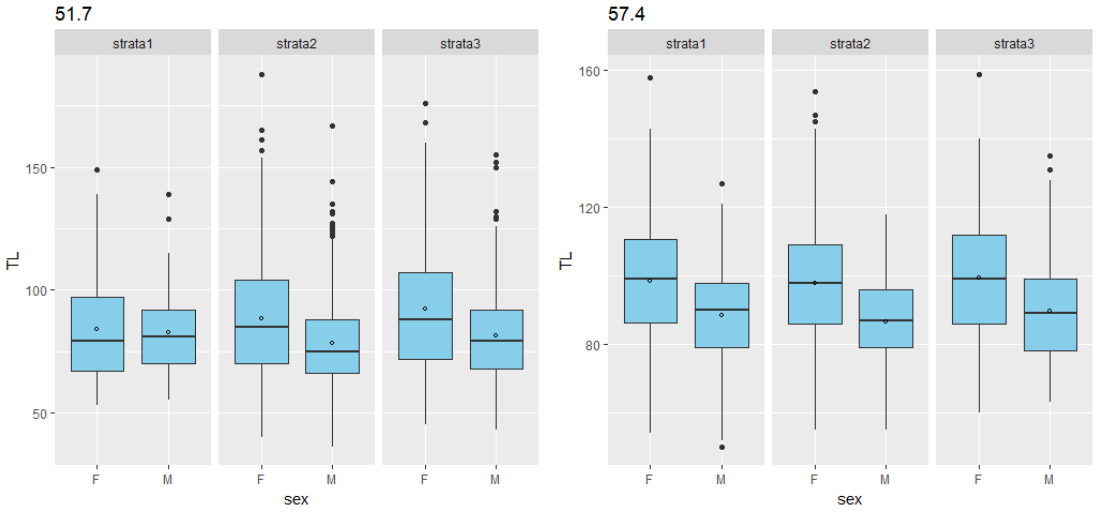

Figure 7: TOP total length (cm) by depth strata and sex. On the left side females and males on the right side. The circle on the boxplot is the mean TL value.

When comparing the length composition in relation to the latitude (Figure 8) results show differences between both areas. In area 57.4 there is a decreasing trend for both sexes in the length composition southwards, while the trend is not so clear in the area 51.7. Although in the southernmost sector of this area the smaller fishes are found.

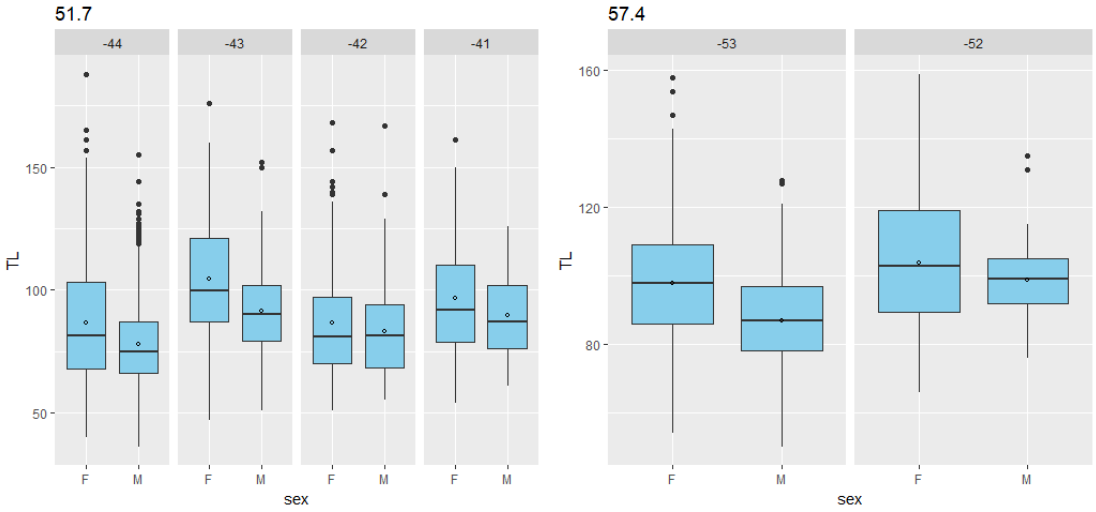

Figure 8: PATAGONIAN TOOTHFISH total length (cm) by latitude and sex. The circle on the boxplot is the mean TL value.

Length-weight relationship

The length-weight relationship calculated from a total of 2954 females and 2772 males is similar for both areas (Figure 9). The weight of *D. eleginoides* caught was modeled in relation to the length as a non-linear function and predicted for both sexes and areas combined by the following formula:

$Weight = 2*10^{-6} Length^{3,3384}$; $R^2 = 0.9802$.

Figure 9. Length-weight relationship of *D. eleginoides*. Green and red lines are the non-linear regression of length-weight relationship by sex.

Sex ratio and maturity

5792 individuals were sampled and used for a sex ratio analysis. Significant differences have been found between areas. 60% of the sampled individuals in area 51.7 are males and those are predominant at small sizes. The ratio 1:1 is reached at the 110-120 cm TL interval when the female proportion increases steadily (Figure 10). In area 57.4 the ratio of females is much bigger than males, 77% of females and predominant at all sizes.

The size at which males reached sexual maturity could be related to the abrupt shift (male:female) in the sex ratio (López-Abellán and González-Jiménez, 1999). This hypothesis could explain the sex ratio in the area 51.7 but the larger presence of females at all sizes in area 57.4 needs further research to understand the high sexual segregation found. It is common in many fish species on spawning grounds, with males typically arriving earlier and remaining for longer periods resulting in a higher proportion of males on spawning grounds (Péron et al. 2016), but according to the length distribution and maturity stage these areas are inhabited by subadult fish with a low proportion of mature individuals.

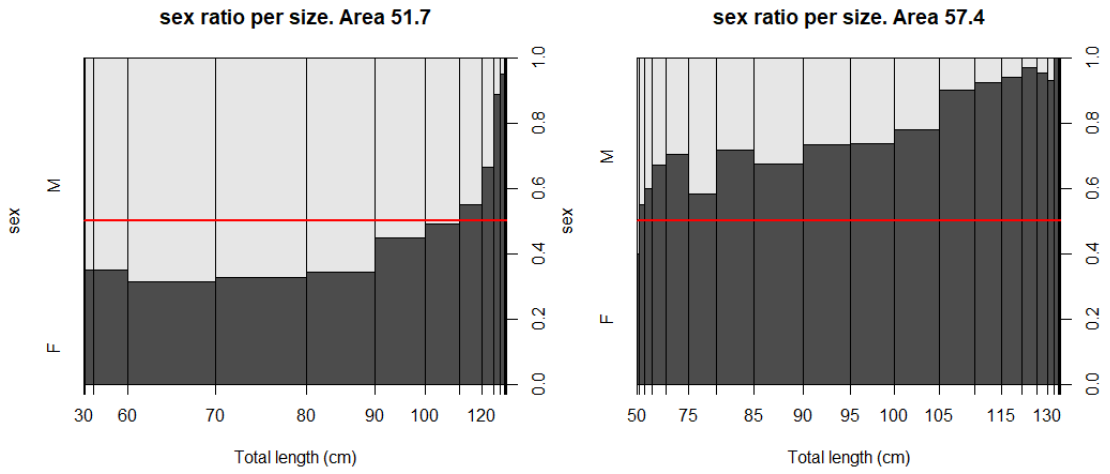

Figure 10. Sex ratio of *Dissostichus eleginoides* by size. The red line shows the 1:1 proportion.

In area 51.7, most of the females were immature with gonad stages 1 or 2 (87%), and also most of males were immature (76%) (Figure 11). Only 1.1% of all sampled females were in stage 4 (spawning) and 0.2% of males (ripe). In the area 57.4 female immature reached the 99% of the total catch and immature males the 96% and neither females nor males were in post-spawning stage (stage 5).

In the area 57.4, very few Patagonian toothfish were mature, it is mostly a subadult population that will move as they grow to different areas. A different view of the sexual maturity of *D. eleginoides* can be made looking at Yates et al. (2017) results. They considered all stages ≥ 2 as mature since a large proportion of fish that were macroscopically determined to be stage 2 were found to contain cells of higher stages when gonads were examined histologically.

The spatial variation in maturity stage and sex composition may also be influenced by months in which sampling took place. López-Abellán (2005) found that 50% of the TOP sampled for maturity were in stage 4 (gravid or ripe) or 5 (spent), in the area 51.7, but were sampled in a different time period than this study period.

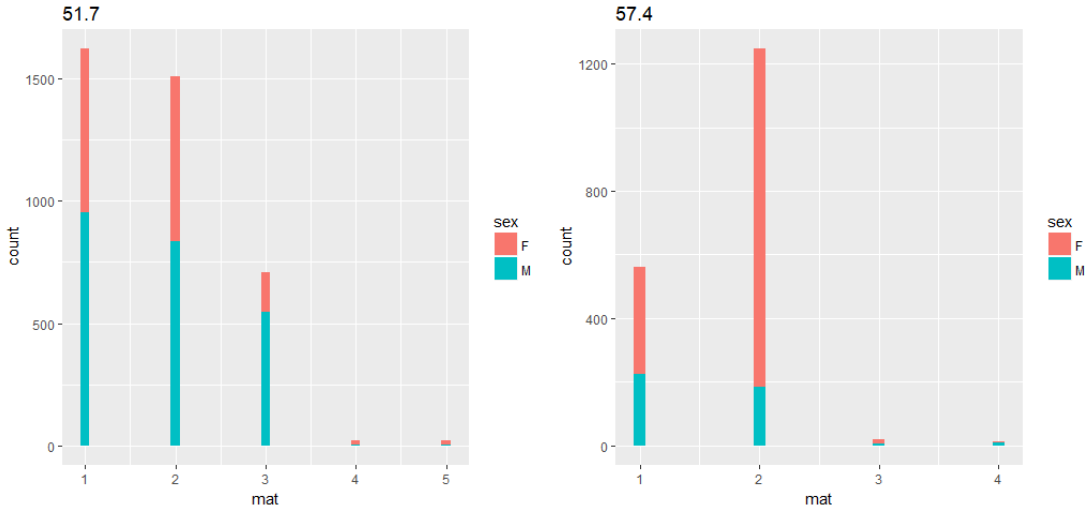

Figure 11. Maturity stages cumulative frequencies distribution of *Dissostichus eleginoides* by area and sex. left: area 51.7 and right: area 57.4.

As only a low proportion of fishes were mature, no maturity latitudinal pattern can be observed within the current data.

Onboard the F/V TRONIO 3016 gonads were weighted. Figure 12 shows the length-gonad weight relationship. In the area 57.4 only few females and males were found matures. The mean gonad weight for spawning females is 2.87kg and 0.42 for ripe males (Figure 13). The maximum gonad weight of a spawning female is 8.3kg in area 51.7.

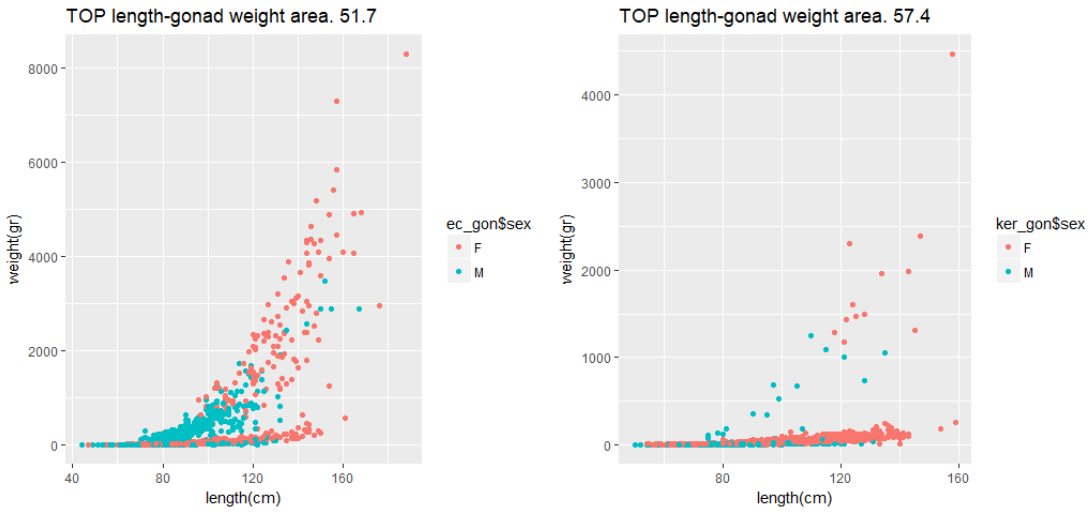

Figure 12: Gonad weight by TOP length and sex.

The mean weight of the gonad for maturity stage and sex is shown in Figure 13.

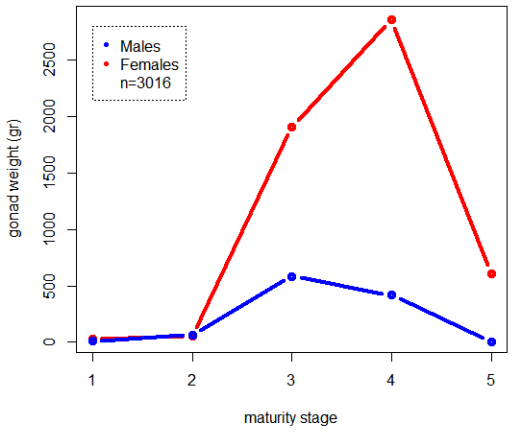

Figure 13: Mean gonad weight by maturity stage and sex

Recaptures of tagged TOP within the SIOFA area

In 2018, eleven *D. eleginoides* recaptures within the SIOFA management area have been reported by these two Spanish vessels at SIOFA and the CCAMLR Fish Stock Assessment Working Group meeting (Sarralde and Barreiro, 2018). These tagged fish were released in the CCAMLR management area in Divisions 58.5.2 and 58.5.1 and Area 58.6. The years at liberty were between 3 and 10 and 6 out of 10 fish travelled a very long distance exceeding 1000 km (Figure 11). All fish were subadults at release (between 75-93 cm) being the maximum increment in weight 5 kg and 26 cm in length.

The Working Group noted that most of the fish that travelled long distances were subadults, which was similar to findings from Area 48.3 (Soeffker et al, 2014) and that movement frequency, directions and distances were consistent with previous movement studies conducted in Areas 48.3 and 58.6 and Divisions 58.5.1 and 58.5.2.

As no tagging of *D.eleginoides* is made in the SIOFA area, it is difficult to know the residence time in these areas and the migration pattern from the SIOFA waters towards other grounds, likely within CCAMLR convention waters.

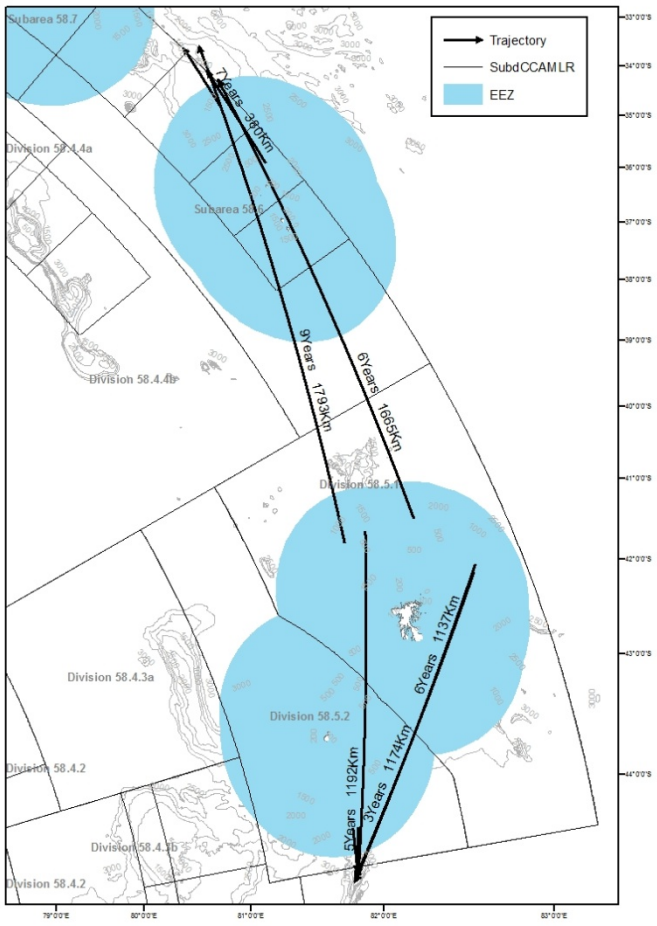

Figure 11. Trajectory showing the years at liberty and distance traveled (km). Figure extracted from Sarralde and Barreiro (2018).

Discussion

Dissostichus eleginoides are widespread across the Subantarctic islands of the Indian ocean sector and are known to move long distances associated with the different stages of the life cycle. On maturation they migrate to spawning locations in deep water around sub-Antarctic islands, including in the vicinity of Prince Edward Islands and Crozet Islands.

From the recaptures obtained in these two areas it seems that they are located towards the outer edge of the main grounds, but further research is needed to understand the ontogenetic movements of the Patagonian toothfish population as well as the movements associated with water masses that would affect the distribution area of *D. eleginoides*.

The vicinity area 58.6 (Crozet) and Divisions 58.5.2 (Heard and Mc Donald) and 58.5.1 (Kerguelen) within the CCAMLR Convention Area are all assessed fisheries, where models are based on tag recapture. The emigration of tagged fish out of the assessed area results in initial and current spawning biomass, as well as the stock status being potentially over-estimated if not accounted for (Burch et al, 2017). Integration of toothfish research and stock assessment between SIOFA and CCAMLR, taking into account the movement of Patagonian toothfish across

the CCAMLR Convention Area's northern boundary and SIOFA Management Area´s southern boundary could help to a better accuracy of these assessments.

On the other hand, the presence of two marine mammals, sperm whales (*Physeter macrocephalus*) and killer whales (*Orcinus orca*) that feed on Patagonian toothfish caught on longlines adds uncertainty to the total catch estimates. A high level of catch depredation is the main reason why fishers avoid fishing in CCAMLR area 58.6 where fishing effort concentrates on the Crozet shelf slope and on the eastern part of the del Cano Rise (Tixier et al., 2010).

Marine mammal removal of the vessel´s catch in Crozet and Kerguelen area have been preliminary estimated based in the presence or absence of odontocetes during the hauling of the catch (Gasco et al 2016), however a large series of data are needed to do these estimations. During the two Spanish commercial surveys, more than 50 interactions with sperm whales, the most frequently observed marine mammal species, and 12 with killer whales have been registered in area 51.7 and none from area 57.4. Marine mammal impact is likely lower in SIOFA waters than in the adjacent Crozet area due to the higher proportion of fishing vessels fishing in the latter area.

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