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Title

Research plan for the Spanish exploratory longline fishery for *Dissostichus* spp. in Divisions 58.4.1 and 58.4.2: preliminary results of stage 1 (2012/13 season)

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Abstract

The Spanish vessel Tronio started the research plan in the 2012/13 season using the Spanish bottom longline system. One depletion experiments was completed in each of the SSRU surveyed (58.4.1H and 58.4.1G). Three prospecting-phase clusters of sets did not reach the established threshold to start the depletion.

A prospective estimation of the local biomass (B_{LOC}) of the two localized areas where the depletion experiments were performed is done as well as an estimation of the biomass of the SSRUs (B_{SSRU}), maximal and minimal, considering areas with high and low densities.

A summary of the activities and results from the survey is also presented related to the sampling scheme, collected samples and species involved.

Research plan for the Spanish exploratory longline fishery for *Dissostichus* spp. in Divisions 58.4.1 and 58.4.2: preliminary results of stage 1 (2012/13 season).

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INTRODUCTION

During the 2012/13 season Spain started the approved multi-year research survey in Divisions 58.4.1 and 58.4.2 in order to obtain information to better understand the population dynamics of both species of *Dissostichus* in areas off the Antarctic continent close to the Ross Sea and Banzare Bank, and to implement the use both local depletion and tag-recapture methods in areas described so as to estimate local abundance.

The research plan, as it was stated in the proposal, takes several years to be completed. It has started in the SSRUs closest to the Ross Sea, 58.4.1H and G, during the 2012/13 season. In order to fix the protocols and ascertain the viability and suitability of the study, it was establish the return to the same areas the two-three subsequent years along with the movement to new places and westwards to SSRUs 58.4.1D, C, B and 58.4.2E is expected.

The vessel Tronio has started the research plan after the exploratory fishing season in the Subarea 88.1, using the Spanish bottom longline system. A total of 42 research sets were performed within the SSRUs 58.4.1H and 58.4.1G. Two depletion experiments were completed and three prospecting-phase clusters of sets did not reach the established threshold to start the depletion.

A prospective estimation of the local biomass (B_{LOC}) of the two localized areas where the depletion experiments were performed is done and regarding the maximal and minimal biomass for the SSRUs (B_{SSRU}) considering areas with high and low densities.

This study will be reviewed and completed the upcoming years with the new data obtained revisiting the same areas as well as with the tag-recapture data in order to estimate the local abundance using two different approaches, depletion and tag-recapture methods.

A summary of the activities and results from the survey is also presented related to the sampling scheme, collected samples and species.

METHODS AND RESULTS

The vessel TRONIO arrived to the SSRU 58.4.1H on 26th January 2013 once the fishing season in the subarea 88.1 were over and finished the stage 1 of the research plan in the SSRU 58.4.1G on 22th February 2013.

The experiment was lead by Juan Agulló, the Spanish scientific observer on board along with Sergii Rebik, the international scientific observer from the YugNIRO, Ukraine. The experience was closely supervised by the research team of the IEO in Spain.

The survey protocol agreed with the recommendations from the 2012 WG-SAM,WG-FSA, SC-CCAMLR (paragraphs 3.143 y 3.145, SC-CCAMLR-XXXI) and following the research plan described in Sarralde *et al*. (2012) and the Spanish proposal (2012).
The phase of prospection was performed by clusters of 3-5 standardized sets. When the mean CPUE of the cluster was higher than 0.3 kg/hook (CV ≤ 30%), a minimum of 10 sets were carried out sequentially within a circle of approximately 10 nautical miles diameter, until partial depletion of the local population of *Dissostichus* spp. is observed i.e. until the catch and effort index has dropped (at least 0.2 kg/hook from the first set) significantly ($\alpha = 0.05$).

Fishing activities in these SSRUs were limited by the presence of ice during this period. The planned research was aimed to prospect the maximal fishing ground within each Division, but the ice condition prevented to do that and the vessel couldn't perform any research neither further east of 141E in the 58.4.1H SSRU nor easternmost of 133.5E in the 58.4.1G SSRU (Figure 1).

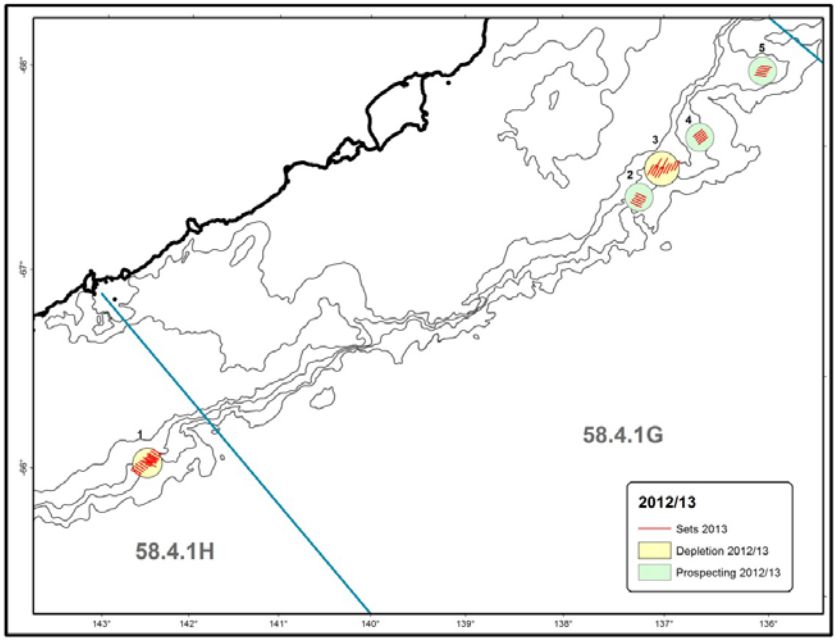


Figure 1: Research sets performed within the SSRUs 58.4.1H and 58.4.1G.

The Spanish longline system was the only gear used during the whole cruise. The configuration of the gear can be obtained from the "Preliminary risk assessment of the proposed bottom fishing activities in relation to potential severe damage of vulnerable marine ecosystems during the 2012-13 season" presented by Spain (CCAMLR-XXXI/14 Rev. 1). The main line of the set was standardized to a length of 8887m and 4800 hooks.

The 42 research sets within these two SSRUs have been performed in five clusters (1 to 5). Two of them include a depletion experiment (clusters 1 and 3) and the three remaining cluster of sets did not reach the threshold to start (clusters 2, 4 and 5).

In no case was reached the 42t catch limit for each SSRU (58.41H and 58.4.1G) assigned to Spain to perform the depletion experiment (CM 41-11, 2012). The total catch hauled in both SSRUs has been 49.925t mainly of *D. mawsoni* (TOA), only 14 individuals were *D. eleginoides* (TOP) from a total number hauled of 1 403 individuals (Table 1).

Table 1. Number of stations completed by cluster, along with total *Dissostichus* spp. hauled catch, retained catch, observed catch rates (kg /1000 baited hooks), coefficient of variation(CV), mean soak time and mean fish weight.

Cluster	SSRU	n sets	Total hauled catch (kg)	Retained catch(kg)	Mean CPUE/1000 hooks	CPUE CV	Mean soak time	Mean weight
1	58.4.1H	16	23700	21480	308,6	0,35	29,68	36,9
2	58.4.1G	5	5411	4827	225,4	0,43	24,10	43,9
3	58.4.1G	11	13008	11315	246,4	0,57	29,58	36,3
4	58.4.1G	5	3474	3228	144,7	0,80	24,18	39,6
5	58.4.1G	5	4332	3905	180,5	0,29	25,12	42,1

To obtain the total hauled catch (tagged and retained) estimation of the total weight of the tagged fishes was derived from the length-weight equation estimated from the samples made on these two SSRUs, n=956 (Figure 2).

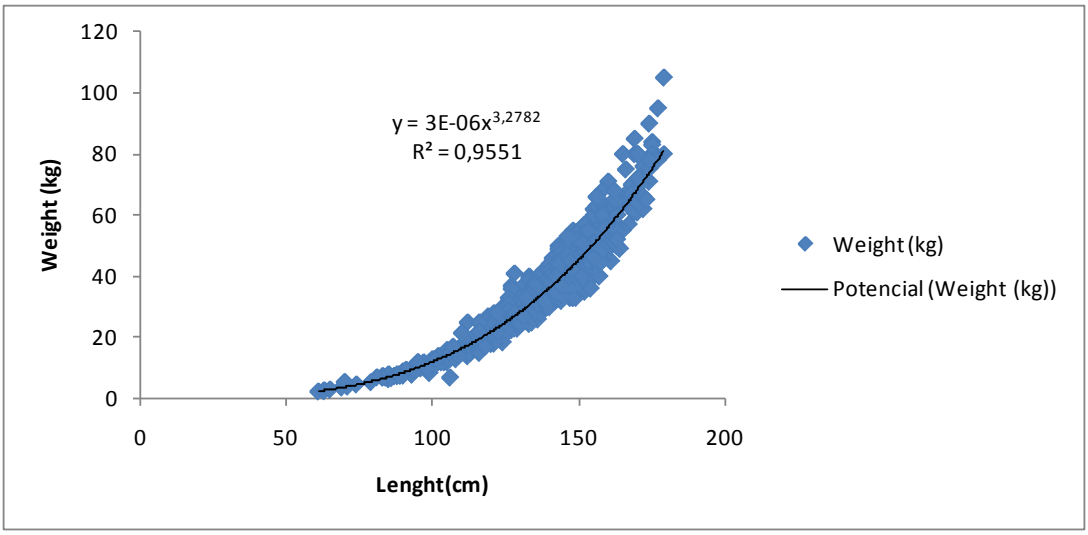


Figure 2: Length-weight curve and ecuation derived from *Dissostichus mawsoni* sampled during the cruise in the SSRUs 58.4.1H and 58.4.1G.

Local depletion experiments

During the survey, two depletion experiments have been performed, one in each prospected SSRU (clusters 1 and 3).

A linear regression of CPUE against cumulative catch were calculated by fishing season on every cluster of sets where the depletion experiment reached a mean threshold of 0.3kg/hook in the first 5 sets (CV $\leq$ 30%). The regression coefficients and standard errors as well as the significance of the regression are presented in Annex 1. Both analyses have been significant (p-value < 0.05) with a negative slope.

Scrutinizing clusters 2, 4 and 5 it seems as expected, areas with low CPUEs are not useful to detect depletion.

The calculation process has been similar to that used in Agnew *et al.*, 2009. The regression takes the form:

$$I = c+mC$$

where I is the unstandardised CPUE in kg/1000 hooks, *c* is the intercept, m is the slope and C the cumulative catch in tonnes. If m < 0, then the biomass for the local area being fished (B_{LOC}) is given by:

$$B_{LOC} = -c/m$$

Using an estimate of the local area fished during that season (A_{LOC} representing the fished area of the depletion cluster) and the assumed area occupied by the vulnerable population within SSRU (A_{SSRU}), it is possible to estimate the biomass for the SSRUs under investigation:

$$B_{SSRU} = B_{LOC} * A_{SSRU}/A_{LOC}$$

To obtain an estimate of uncertainty, 2 000 bootstrap samples were taken from every depletion experience, allowing confidence intervals to be derived from the resultant distribution of coefficients.

Results from the bootstrap analysis are presented in Annex 1.

This is a theoretical approach to be applied once are established all premises regarding the representativeness of the study area (fished area) in relation to the SSRU whole area, fishes may not be present in similar densities across an SSRU and this would be a source of error.

Estimation of areas

The area that would be potentially fished (fish distribution) in each SSRU (A_{SSRU}) would be the interval from 550 to 2000 m depth, that has been extracted from the bathymetric data of Smith & Sandwell (1997) and calculated using the spatial analyst tool in ArcMap (v.10.1) (Datum: D_WGS_1984; Spatial Reference: South Pole Lambert Azimuthal Equal Area)

- Fishing area of SSRU 58.4.1.H: 29 155 km^2
- Fishing area of SSRU 58.4.1.G: 29 493 km^2

A polygon was created in ArcMap covering the extent of sets in each depletion experiment to obtain the estimation of the area of every polygon (A_{LOC}), using the geometry calculator in ArcMap (Figure 3).

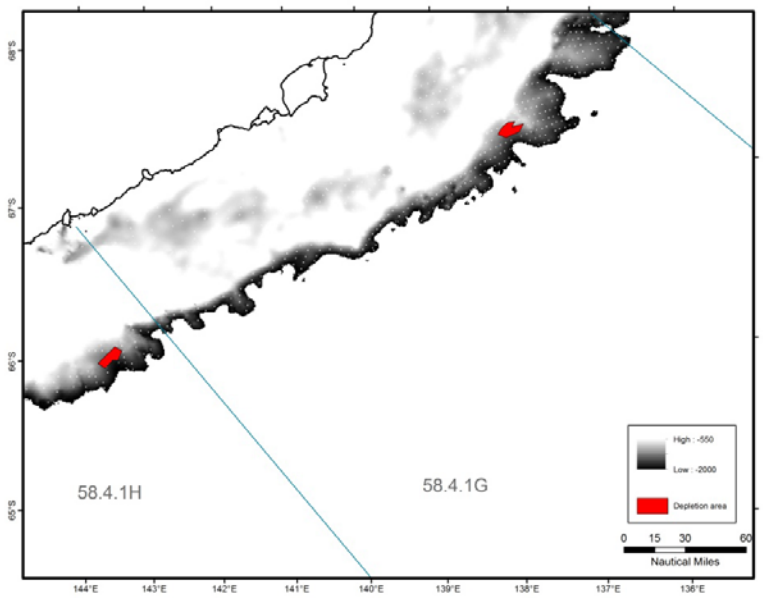


Figure 3: **Polygons used to calculate the local area where depletion experiment occurred.**

From the depletion and bootstrap analysis we estimate the B_{LOC} with the confidence intervals in both depletion areas. These are the areas where the maximum density of *Dissostichus* spp. has been found.

As a preliminary prospecting analysis it was calculated the mean CPUE from the 5 first sets in each area in order to identify the area with a minimum density (cluster 4: Table 2). A conversion factor has been calculated to estimate the minimum extrapolated B_{SSRU} within the SSRU 58.4.1G. In the SSRU 58.4.1H this approach is not possible because the only cluster of sets performed has derived in a depletion experiment. Values obtained from this exercises are merely indicatives in this early stage of the research. New approaches should be developed to compile all information proportionally to obtain as accurate as possible estimates.

Table 2. Mean CPUE by SSRU and cluster from the first five sets and the ratio from the maximum CPUE by SSRU.

Cluster	SSRU	mean CPUE (5 sets)	ratio from the maximum
1	58.4.1H	366,6	100
2	58.4.1G	225	62,6
3	58.4.1G	359,4	100
4	58.4.1G	144,4	40,18
5	58.4.1G	180,2	50,14

Results are summarized in Table 3.

Table 3. Estimation of the A_{LOC}, A_{SSRU}, B_{LOC} and confidence intervals, and maximum and minimum "extrapolated" biomass (B_{SSRU}) by SSRU.

SSRU	58.4.1H	58.4.1G
Cluster	1	3
$A_{LOC}(km^2)$	182,22	188,56
A_{SSRU} $(km^{2)}$	29493	29155
% prospected area	0,618	0,647
$B_{LOC}(t)$	51.056	17.373
Confidence intervals	(33.640,129.799)	(14.552,25.271)
$B_{SSRU}(t)$ máx.	*8264*	*2686*
$B_{SSRU}(t)$ min.	*Not available*	*1079*

Tagging

The tagging rate was five fish per ton caught. All fish tagged selected randomly were in good condition. A total of 231 toothfish were tagged (227=TOA, 4=TOP) with 84% of length tag overlap statistics. In Figure 4 is represented the release position by species.

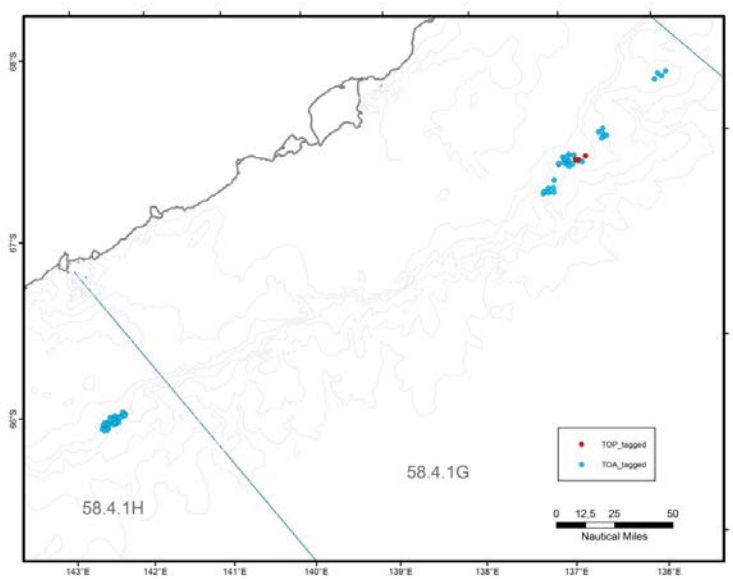


Figure 4: Location where tagged toothfish individuals were released.

Length frequency distribution and maturity stage

Records of length measurements were obtained from 1115 antarctic toothfish (96% of the retained catch). The overall length distribution for females showed a principal mode of about 145-150 cm in the SSRU 58.4.1H and about150-155 cm in the SSRU 58.4.1G. Mode in males is about 135-140 cm in both SSRUs (Figure 5).

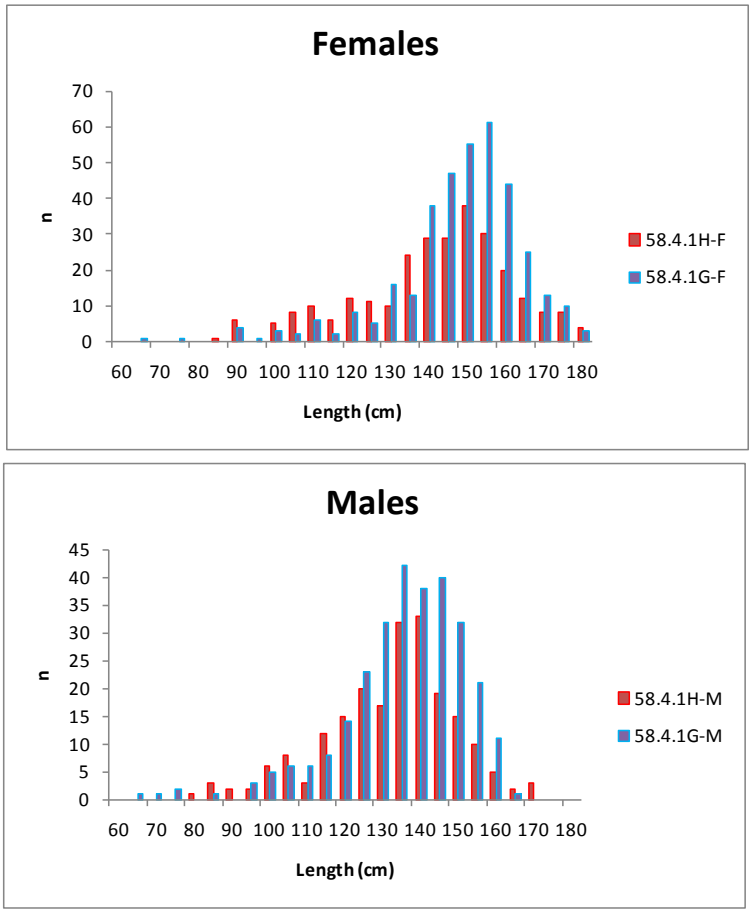


Figure 5: Length frequency distributions of Antarctic toothfish by sex and SSRU.

Gonad maturity stages were visually determined in 1111 individuals (96% of the retained catch). Most of the gonads were maturing virgin or resting (stage 2). Only one female was gravid (stage 4) or developing (stage3) (Table 4).

Table 4: Gonad maturity stages of *Dissostichs mawsoni* by SSRU

		Females						Males					
		1	2	3	4	5	Total females	1	2	3	4	5	Total males
58.4.1H	n	7	296	1	0	0	304	7	233	8	0	0	248
	%	2,3	97,4	0,3	0,0	0,0	100	2,8	94,0	3,2	0,0	0,0	100
58.4.1G	n	5	318	1	1	0	325	9	236	2	0	0	247
	%	1,6	97,8	0,3	0,3	0,0	100	3,7	95,5	0,8	0,0	0,0	100

Bycatch

The most common bycatch species were grenadiers (*Macrourus* spp.) comprising about 8.6% of the catch by weight but more than 71% of the catch by number (Table 5). The other bycatch especies are scarce amounting less than 0.1% of the catch by weight. In terms of numbers the crocodile icefish *Chionobathyscus dewitti* (CHW) and the small eye moray *Muraenolepis microps* (MOY) represent the 2.1 and 1.2% of the bycatch by number respectively.

Table 5. Total hauled catch/bycatch and numbers (including tagged fish), weight and number hauled and proportions of catch by weight and number by species*.

Species	Catch kg	Catch n	Hauled kg	Hauled n	Proportion w	Proportion n
TOA	44516	1162	49602	1389	90,7	24,4
GRV	4709	4059	4709	4059	8,6	71,4
CHW	56,2	121	56,2	121	0,1	2,1
MOY	51	66	51	66	0,1	1,2
TRL	6,95	23	6,95	23	0,0	0,4
RAJ	26	2	26	2	0,0	0,0
POG	4,9	9	4,9	9	0,0	0,2
TOP	160	10	202,9	14	0,4	0,2
NOK	4,6	4	4,6	4	0,0	0,1

*TOA: Dissostichus mawsoni; GRV: Macrourus spp.; CHW: Chionobathyscus dewitti; MOY: Muraenolepis microps; TRL: Trematomus eulepidotus RAJ: Raja spp.; POG: Pogonophryne spp.; TOP: Dissostichus eleginoides; NOK: Notothenia kempi

Vulnerable marine ecosystem taxa indicators

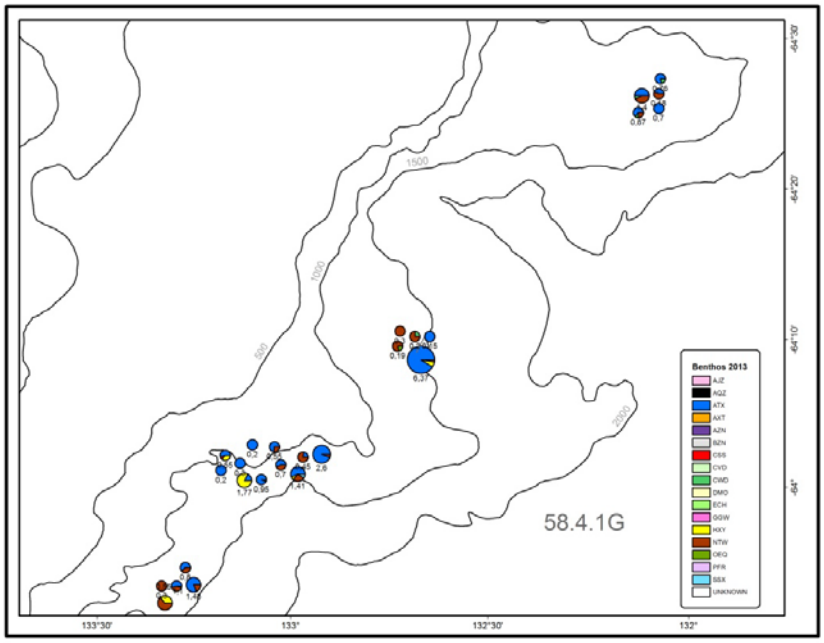
Monitoring on VME taxa by-catch according to CM 22-06 and 22-07 showed no segments exceeded the 5 kg reporting threshold. Differences in taxa found by SSRU indicates the prevalence of phylum Porifera (PFR+DMO+HXY) in the SSRU 58.4.1H (95% - kg) while this phylum amount only the 10% of the by-catch in kg in the SSRU 58.4.1G. The most abundant taxa in SSRU 58.4.1G are Cnidaria from the Order Actiniaria (ATX)- 68% and Pennatulacea (NTW)- 19% in kg (Table 6).

Table 6. Number, weight (kg) and % of presence by set and SSRU of VME taxa*.

	58.4.1G			58.4.1H		
Taxa	number	Weight (kg)	% presence	number	Weight (kg)	% presence
AJZ	0	0	0,0	1	0,05	2,3
ATX	70	16,93	48,8	0	0	0,0
CSS	2	0,05	2,3	0	0	0,0
CVD	0	0	0,0	2	0,1	4,7
CWD	21	0,42	11,6	0	0	0,0
DMO	0	0	0,0	35	10,18	11,6
GGW	1	0,01	2,3	3	0,1	2,3
HQZ	0	0	0,0	1	0,01	2,3
HXY	9	2,57	11,6	77	10,45	30,2
NTW	36	4,8	39,5	5	0,85	9,3
OEQ	4	0,07	4,7	0	0	0,0
PFR	0	0	0,0	13	1,2	2,3
SSX	6	0,18	4,7	1	0,05	2,3

*AJZ: Alcyonacea; ATX: Actiniaria; CSS: Scleractinia, CVD: Cidaroida; CWD:Stalked crinoids; DMO: Demospongiae; GGW: Gorgonacea; HQZ: Hydroidolina; HXY: Hexactinellida; NTW: Pennatulacea; OEQ: Euryalida; PFR: Porifera; SSX: Ascidiacea

The spatial distribution of the VME taxa recovered is presented in Figure 6. The figure below (SSRU 58.4.1H) shows the buffer area protected by the CM 22-09 (Annex A). We can perceive certain trend that increases the amount in kilograms of VME taxa as we approach the buffer area.



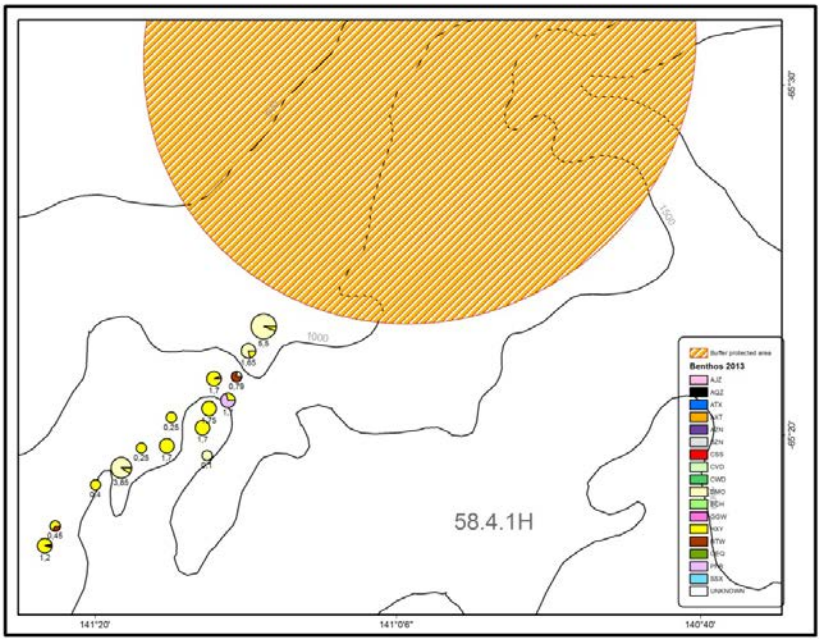


Figure 6: **VME taxa indicator distribution by SSRU.**

The maximum amount (kg) in a set was 5.5 kg in SSRU 58.4.1H (set number 3) and 6.37 kg in SSRU 58.4.1G (set number 36). When the by-catch of these two lines is split in segments we notice that the maximum catch in a segment in SSRU 58.4.1H was 3.3 kg and 2.8 kg in SSRU 58.4.1G (Table 7).

Table 7. Maximum catch sets by segment and VME taxa.

Set_Number	Segment Number	ATX	CVD	CWD	DMO	HXY	NTW	SSX	TOTAL
3	1	0	0	0	2,1	0	0	0	2,1
	6	0	0	0	3	0,3	0	0	3,3
	7	0	0,05	0	0	0	0	0,05	0,1
36	4	1	0	0	0	0	0,15	0	1,15
	6	2,8	0	0	0	0	0	0	2,8
	7	2	0	0,02	0	0,4	0	0	2,42

DISCUSSION

Although local depletion methods have been widely used to estimate local biomass of fish stocks, both in CCAMLR and others areas, almost all assessments made in CCAMLR using depletion methods have been performed using commercial data. This is the only direct experience aimed to cause a localised reduction in fish abundance after the one described in Parkes et al. (1996) performed in a CCAMLR experiment during the 1993/94 season.

In this first approach we try to value the methodology and potential results aimed to fill the gap and to contribute to an assessment of the Antarctic toothfish in these two data-poor divisions. The survey was successful in completing the overall objectives even though a complete prospection of the whole area was prevented by the ice presence.

During this first step of the research, the two experiments of local depletion where high densities of toothfish were found together with the exploration of new areas with lower density is believed to have a high potential. Given that a revisit to the same areas is expected for at least the next two seasons, several objectives are planned for the upcoming years:

- ✓ likely a prospection could be conducted on the areas that the presence of the ice prevented the searching action the previous season.
- ✓ to study the toothfish movements in a yearly basis noting the potential recovery of the depleted areas.
- ✓ revisiting the same location to recapture tags in the years subsequent to the depletion experiment would enable comparison of local abundance estimates generated by two different methods.

Estimation of the local biomass is considered preliminary and revision of the methodology as well as updates is expected as soon as new data would be available during the next seasons. Bootstrap analysis might be compromised by the low number of data. To develop an understanding of the relative density of toothfish over the whole fishable area within an SSRU is expected.

Comparison between the preliminary results and the estimation of the toothfish biomass in SSRU 58.4.1G by Agnew et al. 2009, using the depletion methodology, shows great difference, and it appears to be due to the relatively large difference between the local area size (representing the spatial coverage of CPUE data points) and fished area. Results from this survey are about 10 times lower and is consistent with that estimated using the CPUE comparison method presented in the same document.

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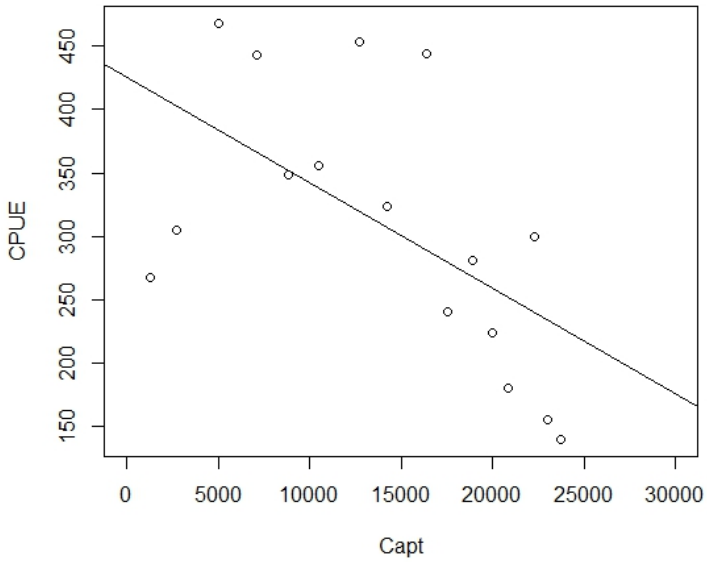
Annex 1

Linear regression coefficients.

Regression coefficients and standard errors using data from the Spanish research survey by cluster. Graphics represents the CPUE (kg/1000 hooks) against the cumulative catch (kg). The depletion experiment has been performed in two of the 5 prospected clusters (clusters 1 and 3).

CLUSTER 1- SSRU 58.4.1H



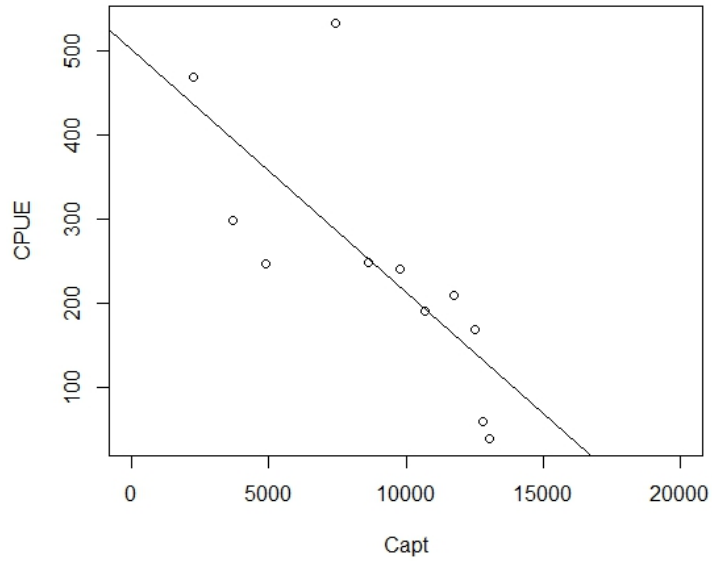
Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	425.477798	49.147912	8.657	5.4e-07	***
Capt	-0.008334	0.003112	-2.678	0.018	*

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 89.41 on 14 degrees of freedom
Multiple R-squared: 0.3388, Adjusted R-squared: 0.2915
F-statistic: 7.173 on 1 and 14 DF, p-value: 0.01801

CLUSTER 3. SSRU 58.4.1G



Coefficients:
	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	501.94730	83.28169	6.027	0.000196	***
Capt	-0.02889	0.00869	-3.325	0.008871	**

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 105.4 on 9 degrees of freedom
Multiple R-squared: 0.5512, Adjusted R-squared: 0.5014
F-statistic: 11.05 on 1 and 9 DF, p-value: 0.008871

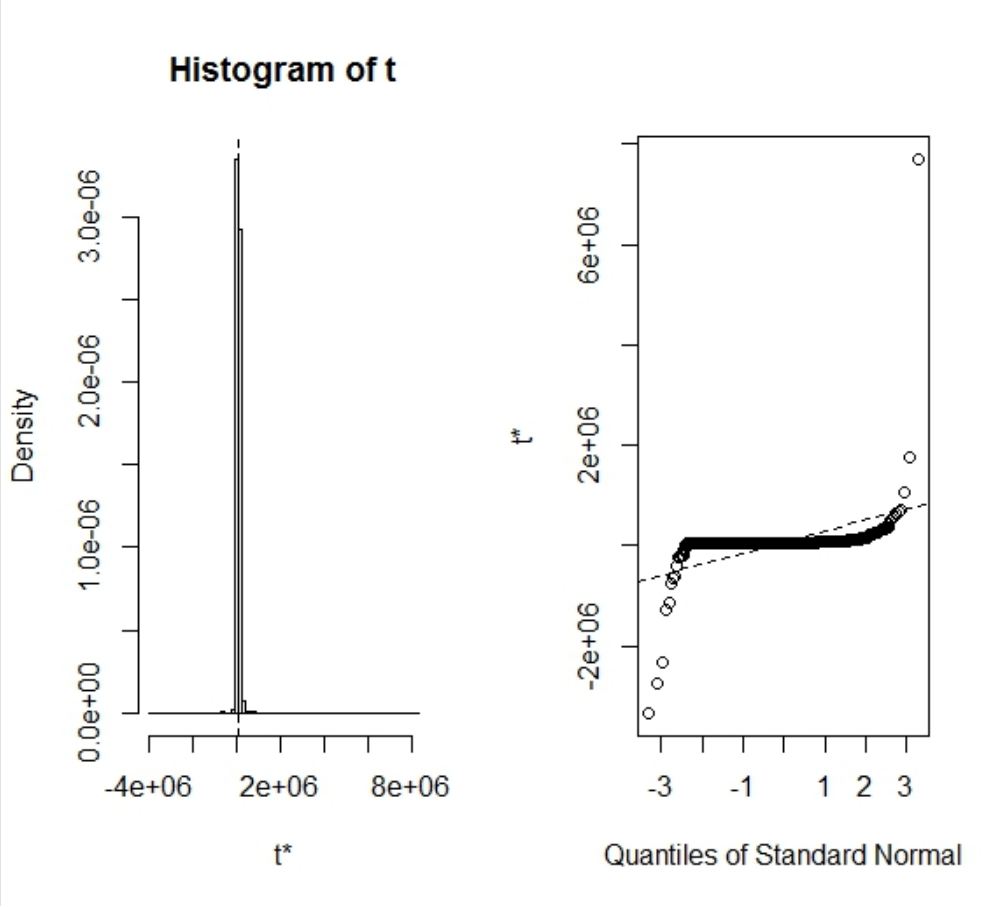
Bootstrap cluster 1

Bootstrap Statistics :
    original   bias   std. error
t1* 51056.12 6677.155   220144.4

BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
Based on 2000 bootstrap replicates

CALL :
boot.ci(boot.out = results, conf = 0.95, type = "perc")

Intervals :
Level   Percentile
95%   (33136, 149626)
Calculations and Intervals on Original Scale



Bootstrap cluster 3

Bootstrap Statistics :
    original   bias   std. error
t1* 17373.16 626.0595   4142.278

BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
Based on 2000 bootstrap replicates

CALL :
boot.ci(boot.out = results, conf = 0.95, type = "perc")

Intervals :
Level   Percentile
95%   (14452, 25271)
Calculations and Intervals on Original Scale