To be completed by the Secretariat:

	Document No.:	WG-FSA-14/35
	Date submitted:	20 September 2014
	Original Language:	English

To be completed by the author:

	Meeting:	WG-FSA-14
	Agenda Item No(s):	5.2

Title **Results of the Spanish exploratory longline fishery for *Dissostichus* spp. in Divisions 58.4.1 and 58.4.2 in the two previous seasons**

Author(s) R. Sarralde, L.J. López-Abellán and S. Barreiro

Address(s) Instituto Español de Oceanografía, Centro Oceanográfico de Canarias, Vía Espaldón Dársena Pesquera PCL8, 38180 SC de Tenerife. Spain

Name and email address of person submitting paper: Roberto Sarralde Vizuete
roberto.sarralde@ca.ieo.es

Published or accepted for publication elsewhere? Yes [ ] No [x]

If published or in press, give details:

To be considered for publication in *CCAMLR Science*?[1] Yes [ ] No [x]

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Abstract

We addressed the revisions requested by the WG-SAM-14 regarding the results of the second year of Spanish research experience and ongoing research plan presented in WG-SAM- 14/12 and WG-SAM-14/09.

A summary of the results of the Spanish research that took place in the 58.4.1 division during the last two fishing seasons is presented.

A prospective estimation of the local biomass (B_{LOC}) of three SSRUs visited using the local depletion method, together with the extrapolation to the total Biomass in the entire SSRUs, as well as an estimation of the Biomass in SSRU 58.4.1H using the mark-recapture Petersen model is made.

Results of the Spanish exploratory longline fishery for *Dissostichus* spp. in divisions 58.4.1 and 58.4.2 in the two previous seasons

R. Sarralde, L.J López-Abellán and S. Barreiro

Instituto Español de Oceanografía, Centro Oceanográfico de Canarias, Vía Espaldón Dársena Pesquera PCL8, 38180 SC de Tenerife. Spain

INTRODUCTION

Regarding the results of the second Spanish research fishing and ongoing research plan presented in WG-SAM-14/12 and WG-SAM-14/09, several requests have been made by the WG-SAM for the authors to revise and submit to the WG-FSA for discussion.

i. The Working Group requested that the CV of the de Lury estimates of local biomass be provided to WG-FSA to be used to consider appropriate catch levels in the experiment and the value of such experiments relative to other methods for estimating biomass for use in stock assessments.
ii. It also recommended the survey area be stratified in areas of high and low catch rates and biomass be calculated accordingly.
iii. The Working Group noted that there is a need to identify the area to which the biomass estimate would be applied and recommended that this be considered by WG-FSA. It noted that one possible method might be to use areal attraction and effective area, which could be calculated using an approach similar to that used to assess lithodid crab densities in Subarea 48.3 (Collins et al., 2002).
iv. The Working Group noted that tags had been recaptured and recommended Petersen estimates be calculated where suitable.
v. And finally, it also noted that the biomass calculation extrapolated to the scale of entire SSRUs assumed all areas had a high catch rate as observed in the location of the depletion experiment, when actually some exploratory locations had catch rates too low to run a depletion experiment.

The Working Group recommended that a full review of all the results be considered by WG-SAM-15 before a decision is made to extend the survey.

We attempt to address all those points summarizing the results of the two Spanish research conducted in Division 58.4.1 during the last two fishing seasons.

Up to now, seven documents have been presented to the WG-FSA and WG-SAM in 2012, 2013 and 2014 namely WG-SAM-14/09, WG-SAM-14/12, WG-SAM-13/12, WG-SAM-13/30, WG-FSA-13/15, WG-FSA-12/69 and WG-SAM-12/13, describing the proposal and results considering the advice of previous Working Groups, Scientific Committee and our own adaptation to new befallen situations.

During the second year of the multi-year research survey in Divisions 58.4.1 and 58.4.2, the F/V *Tronio* has returned to the same places visited in the 2012/13 season and expanded the experience westwards to the 58.4.1D and 58.4.1C SSRUs. The same Spanish bottom longline system was used by the vessel *Tronio* and ten rectangles were visited during the experience. Five depletion experiments were attempted, three of which were successful and the two remaining incomplete.

at the three localized areas where the depletion occurred a prospective estimation of the local biomass (B_{LOC}) is made, together with the estimation of the total Biomass in the entire SSRUs, where the depletion experiment has succeeded.

Three individuals of Antarctic toothfish (TOA) tagged by the Tronio the previous year in the SSRU 58.4.1H were recaptured; one recapture of a TOA tagged in 2011 by another vessel; and two same-season recaptures in the SSRU 58.4.1C.

Being a multi-year proposal, this analysis will be reviewed, reanalyzed and completed with the new data obtained the upcoming years.

SUMMARY OF THE RESEARCH

The research was led by Juan Agulló (Spanish scientific observer on board), along with Zaytsev Oleksandr (International scientific observer from the YugNIRO, Ukraine). The experience was closely supervised by the research team from the *Centro Oceanográfico de Canarias* of the IEO in Spain, in real-time.

The survey protocol agreed with the recommendations proposed in the 2013 WG-SAM, WG-FSA and SC-CCAMLR (paragraph 2.29, SC-CCAMLR-XXXII) which updated the research plan described in Sarralde *et al*., 2013(a) and (b) and the Spanish proposal for a scientific survey (Spain, 2013). The highest priority has been to return to the previously visited locations, to evaluate CPUE variability between years and to recapture tagged fish.

A new prospection scheme has been made in order to conduct the survey across the whole range of depth, to inform improved area-based estimation of biomass within fishable depths at the SSRU scale (Figure 1). Rectangles in red show places where the depletion has been conducted, in yellow are highlighted those already prospected and in blue the rectangles not prospected. It was previewed to conduct at least one cluster of sets in the areas over shallower depths (550-800m). The minimum numbers of sets in these three priority areas were 5, when the established catch threshold is not reached.

The survey was planned to start within the first available rectangle starting from the H1. During the 2013/14 season, this plan had to be inverted due to the ice condition in this SSRU, but with the commitment to return to this locations later in the research when the ice cover would have decreased.

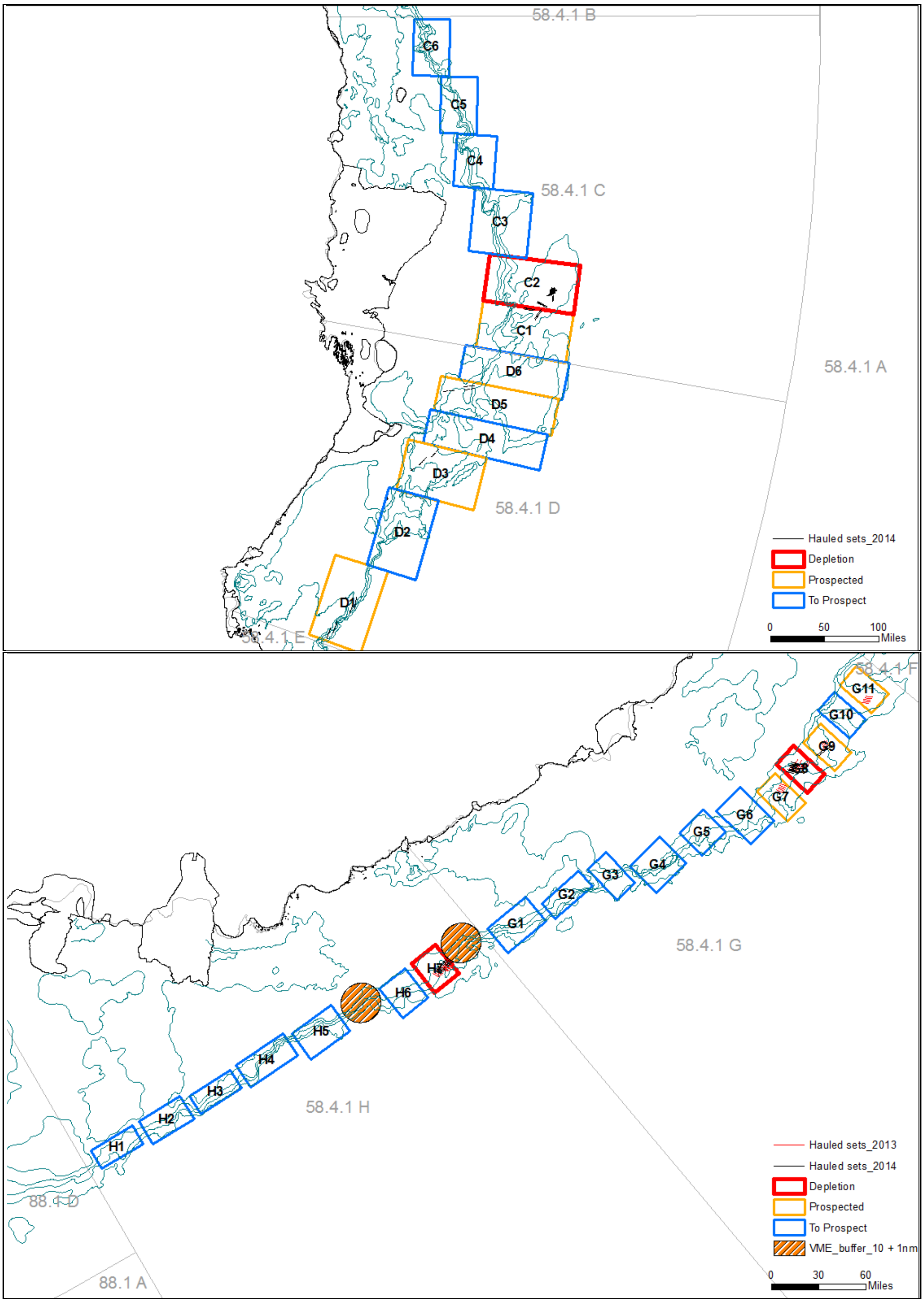


Figure 1. Research fishing in SSRUs 58.4.1C and D (above) and 58.4.1G and H (below) during the 2012/13 and 2013/14 seasons.

During the 2014 survey in Division 58.4.1 the minimum depth was 566 m and 1788 m the maximum (Table 1), this last consistent with the 1800 m as deeper limit calculate by the Secretariat.

Table 1. Fishing depths by SSRU in the Spanish surveys in Division 58.4.1.

SSRU	Min Fishing depth (m)	Max Fishing depth (m)
58.4.1C	1555	1788
58.4.1D	566	1779
58.4.1G	953	1648
58.4.1H	1053	1450

The phase of prospection was performed in clusters of 4, 5 or 6 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, until the catch and effort index has dropped (at least 0.2 kg/hook from the first set) significantly ($\alpha = 0.05$).

In the 2013/14 season, the established catch limit in the SSRU 58.4.1C was 257t, including 42t for the Spanish depletion experiment (CM 41-11, 2013). The CPUE in this SSRU has been higher than other precedent places so it was necessary to increase slightly the catch allocated for the Spanish experiment, in order to achieve a significant reduction in the CPUE. CCAMLR secretariat and Japan (the only country allowed to do research fishing in this SSRU) were consulted regarding the situation, asking for an exceptional leave to exceed the 42 t in detriment of the Japanese catch limit. Finally a small amount of extra catch has been used (12t) that allow us to conduct the preliminary estimation of abundance using the De Lury depletion method.

In the other visited SSRUs (58.4.1D, H, and G) the vessel did not reached the maximum catch limit assigned to Spain to perform the depletion experiment (42t). Bearing in mind that in areas with higher density of toothfish the limit of 42 t could be insufficient to accomplish a single depletion experiment, we think that the first proposal of 50t by SSRU (Sarralde *et al.*, 2012), based on the analysis of historical catches in the region, seems to be more realistic.

Because the tagged toothfish were only measured, the weight of tagged fish was derived from the length-weight equation by species obtained from the samples on these four SSRUs in order to obtain the total hauled catch (tagged-released and retained):

TOP: $y = 2E\text{-}06x^{3.4383}$ $R^2 = 0.9686$

TOA: $y = 5E\text{-}06x^{3.1761}$ $R^2 = 0.9349$

The total toothfish catch during the experience, including the two seasons, were 165.76 t, mainly *D. mawsoni* (TOA) (Table 2).

Table 2. Number of sets completed by cluster, along with total *Dissostichus* spp. hauled catch (estimated), CPUE (kg /1000 baited hooks), mean soak time and mean weight of fish (Clusters where the depletion occurred are highlighted in grey).

	Season	Number of sets	SSRU	Clusters	Total catch	mean CPUE	mean soak time (h)	mean weight (kg)
PROSPECTION	2012/13	5	G	G7	5411	225.4	25.8	39.7
	2012/13	5		G9	3474	144.7		
	2012/13	5		G11	4332	180.5		
	2013/14	4		G9	6257	314.3		
DEPLETION	2012/13	11	G	G8	13008	246.4		
	2013/14	15	G	G8	22232	297.8		
	2012/13	16	H	H7	23700	308.6	33.5	34.2
	2013/14	12	H	H7	18357	307.4		
	2013/14	19	C	C2	54004	571.1	30.8	40.4
PROSPECTION	2013/14	4	C	C-1.1	2432	122.2		
	2013/14	4		C-1.2	2217	111.4		
	2013/14	4		C2-1	2906	146.0		
	2013/14	2		C2-2_no	1350	135.6		
	2013/14	8	D	D1	2694	67.6	21.5	21.8
	2013/14	5		D3	1600	64.3		
	2013/14	6		D5	1784	59.7		

A daily monitoring of the sea-ice concentration was made based on the website AMSR-E/ASI Sea Ice Concentration Data hosted in the Bremen University (http://iup.physik.uni-bremen.de:8084/amsredata/asi_daygrid_swath/l1a/s6250/).

The ice cover made it impossible to prospect the SSRUs 58.4.1H and G at the start of the survey in mid-January. On the last week the ice extent was thinner and allowed to work but not in shallower depths.

Local depletion

Five depletion experiments have been performed during the last two seasons, two in each SSRU 58.4.1H and G, and one in the SSRU 58.4.1C. In the SSRU 58.4.1D never were reached the threshold to start the depletion, the low density in this SSRU could be related to the presence of IUU fishing in the area.

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

$$I = c + mC \qquad \textit{eq.1}$$

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:

$$B_{LOC} = -c/m \qquad \textit{eq.2}$$

In the SSRU 58.4.1C, 19 sets were deployed inside the depletion 10 nm ø circle. The results of the regression between the CPUE and the cumulative catch is showed in Figure 2, where two different analysis have been made, the first one taking into account the last set when the catch threshold for this SRRU was reached (42t), showing that the regression is not significant (p-value=0.265), not reaching our objectives, and the second analysis where all sets were taken into account (adding the 12 extra tons necessary to finish the depletion with a significant p-value). The fit of the regression and their CV are calculated as well. Note that the first consecutive exploratory sets have been grouped in order to obtain a better fit of the regression, so graphs start from their cumulative catch and mean CPUE.

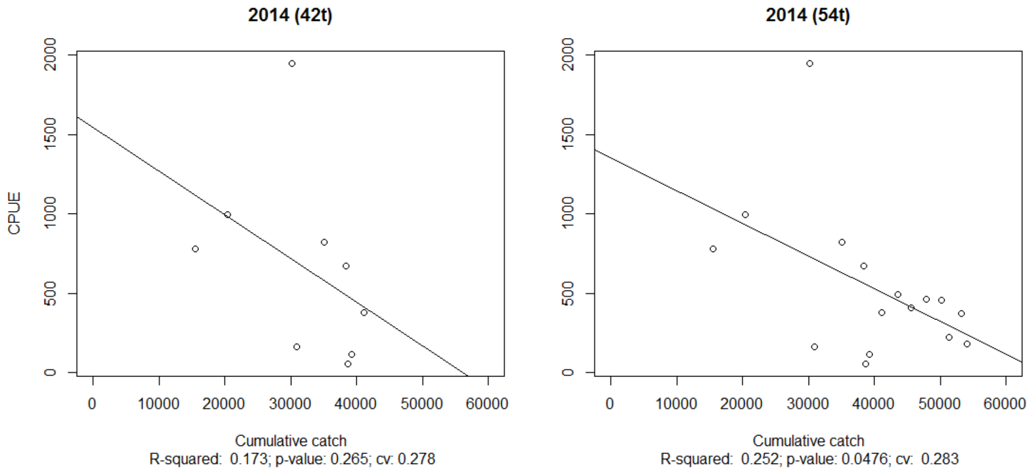


Figure 2. CPUE (kg/1000 hooks) against the cumulative catch (kg) in SSRU 58.4.1C in 2014. To the left, regresion at 42t (catch allocated for the experiment) and at the end of the complete depletion (right side).

The SSRU 58.4.1G and 58.4.1H have been visited in both seasons, according to the commitment on revisiting the areas where the depletion has been performed. Unfortunately, the deferment due to the ice cover at the beginning of the survey together with the ice persistence (but to a lesser extent) at the end of the experience, left the vessel with a limited time due to a fuel constrictions and the two depletion experiment made in these SSRU in the 2013/14 season were unsuccessful. The linear regression of CPUE against cumulative catch in these two SSRUs has a positive slope (Annex1). Anyway in these SSRUs two depletion experiments have been performed in the 2012/13 season, one in each prospected SSRU. The coefficient of determination, p-value and the CV of the regression are shown in Figure 3.

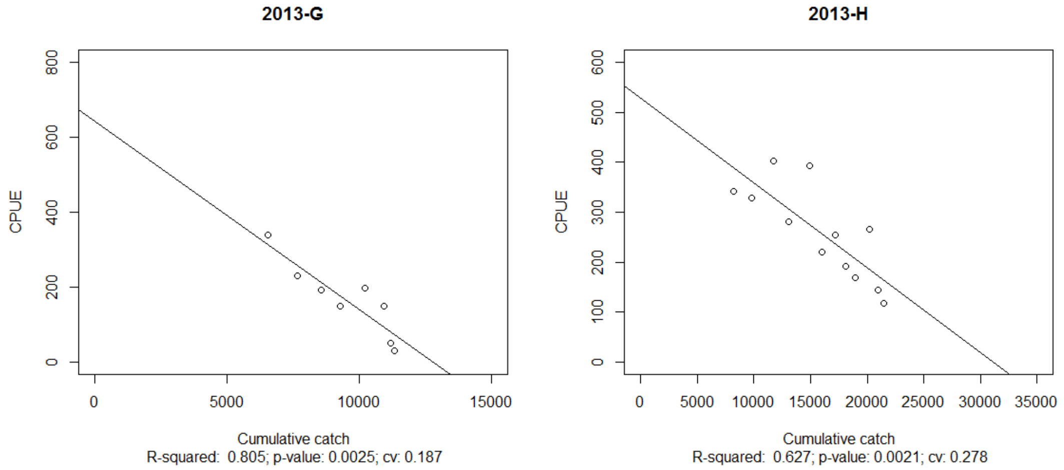


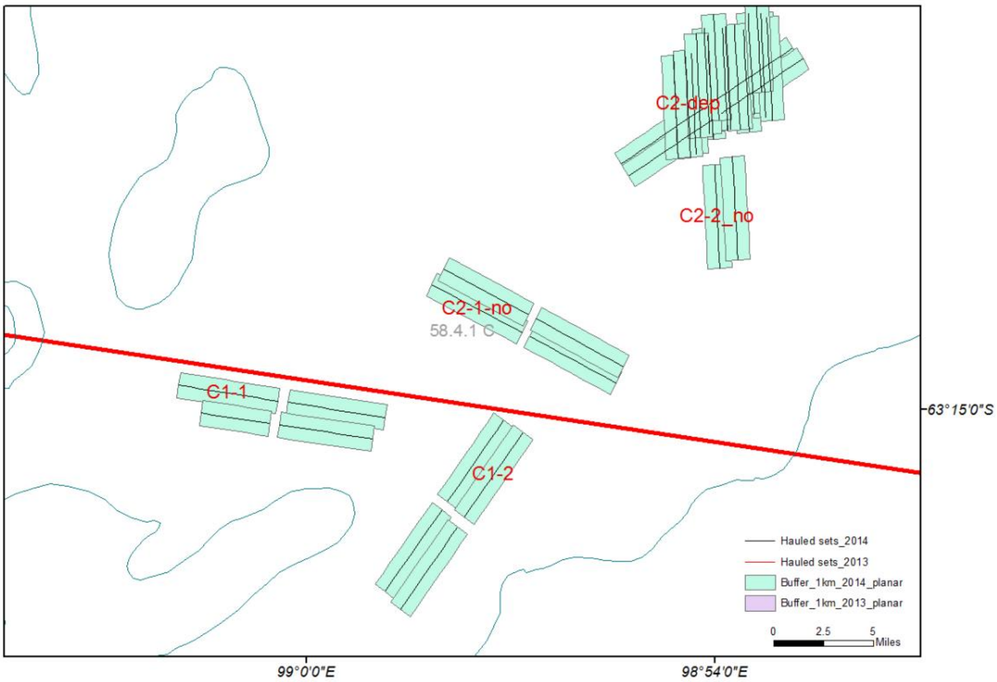
Figure 3. CPUE (kg/1000 hooks) against the cumulative catch (kg) in SSRU 58.4.1G and H in 2013.

To obtain an estimate of uncertainty, 2000 bootstrap samples were taken from every depletion experience; allowing 90, 95 and 99% confidence intervals to be derived from the resultant distribution of coefficients (Annex 1) and a summary of the results are shown in Table 3.

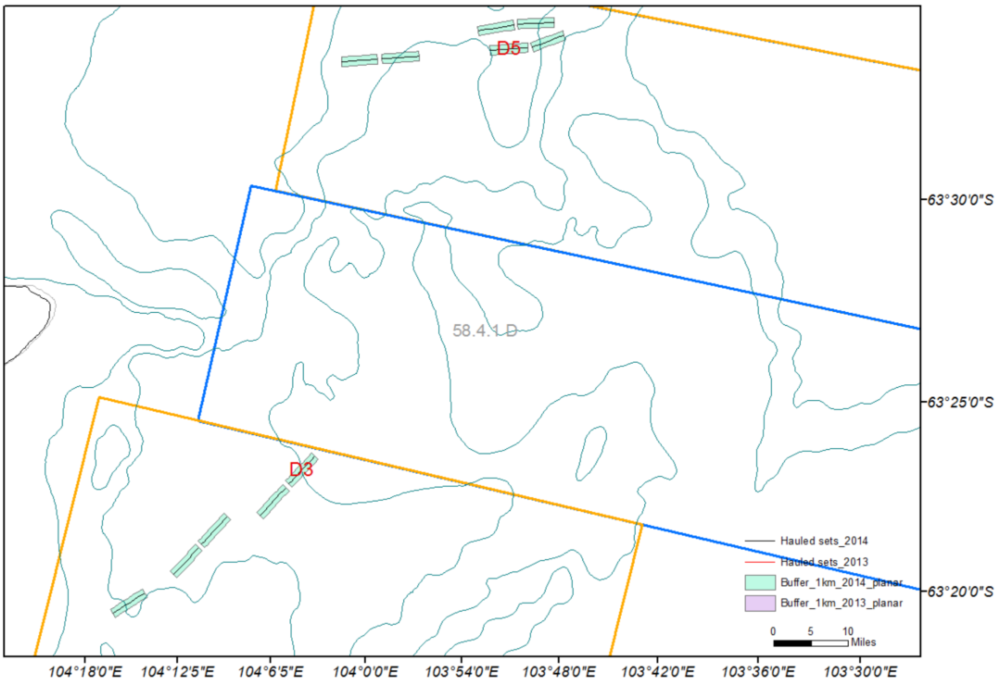
Table 3. B_{LOC} (k) and confidence intervals obtained by bootstrap analysis by SSRU.

	Year	B_{LOC}	95% confidence interval bootstrap
58.4.1C	2014	65433	(53196 , 112341)
58.4.1G	2013	12777	(11728, 15966)
58.4.1H	2013	31174	(26744, 46686)

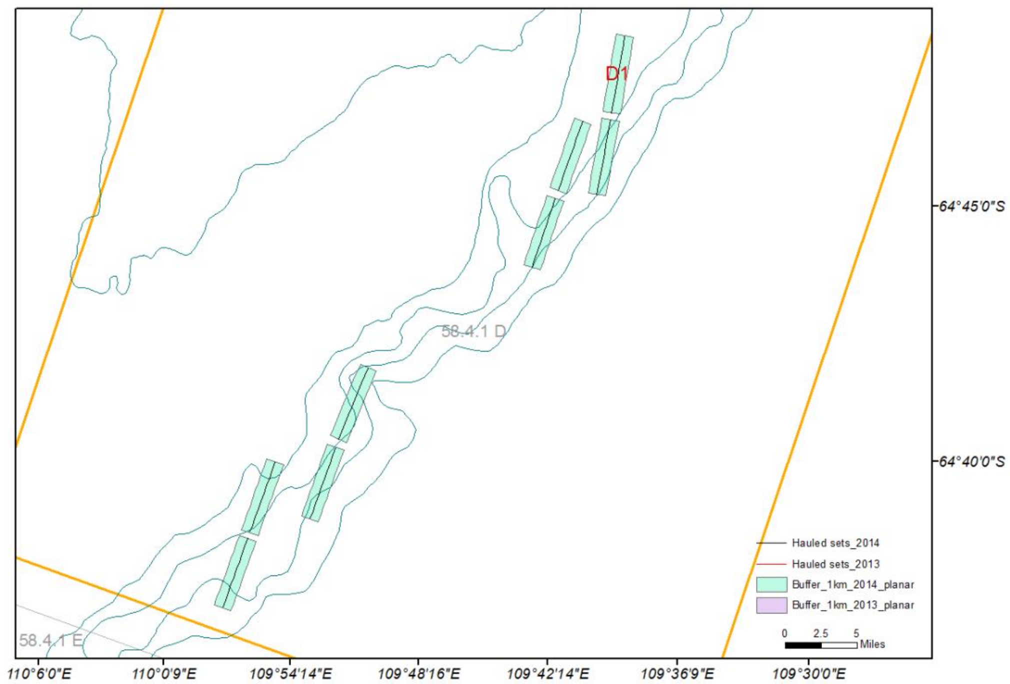
To estimate the surface of the bottom covered by the longline, a buffer of 1 km from the line between points at the beginning and the end of the set hauling. This is thought to be the minimum distance in which there is no risk of overlapping between neighboring sets and potentially the minimum distance in which there is no interaction between the toothfish individuals (mean of 2 km of distance between sets). The buffer was created with the Analysis tools/Proximity in ArcMap. Resultant polygons are aggregated (Data management tools/Generalization/Dissolve) by clusters and the cluster areas are calculated using the Geometry calculator. In Figure 4 is shown the detailed sequence and buffer used by each cluster and SSRU.



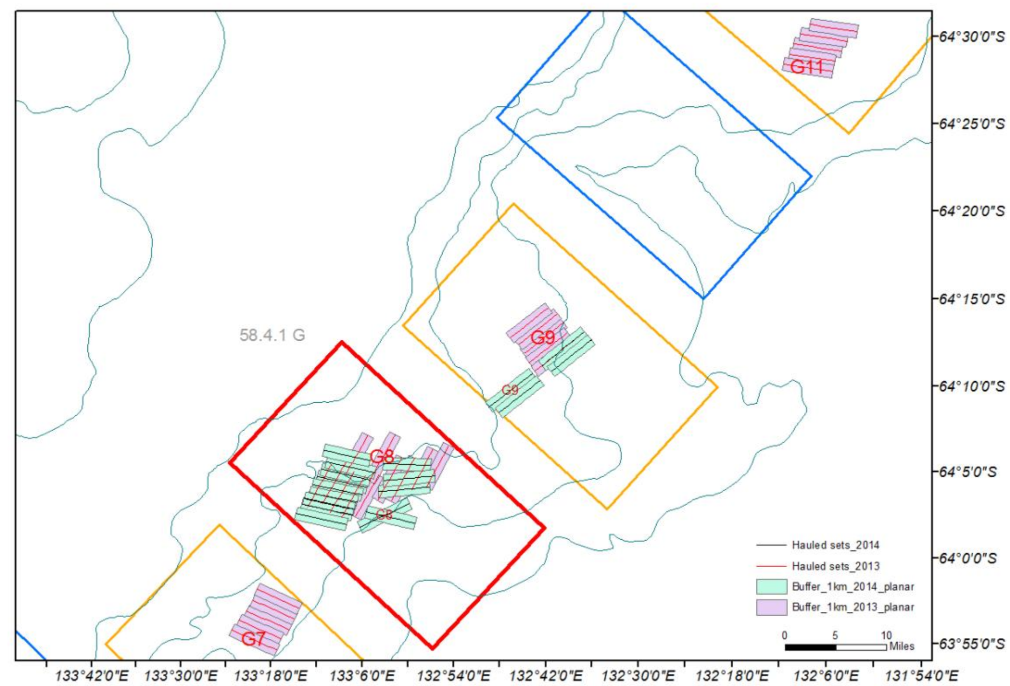
a/ SSRU 58.4.1C



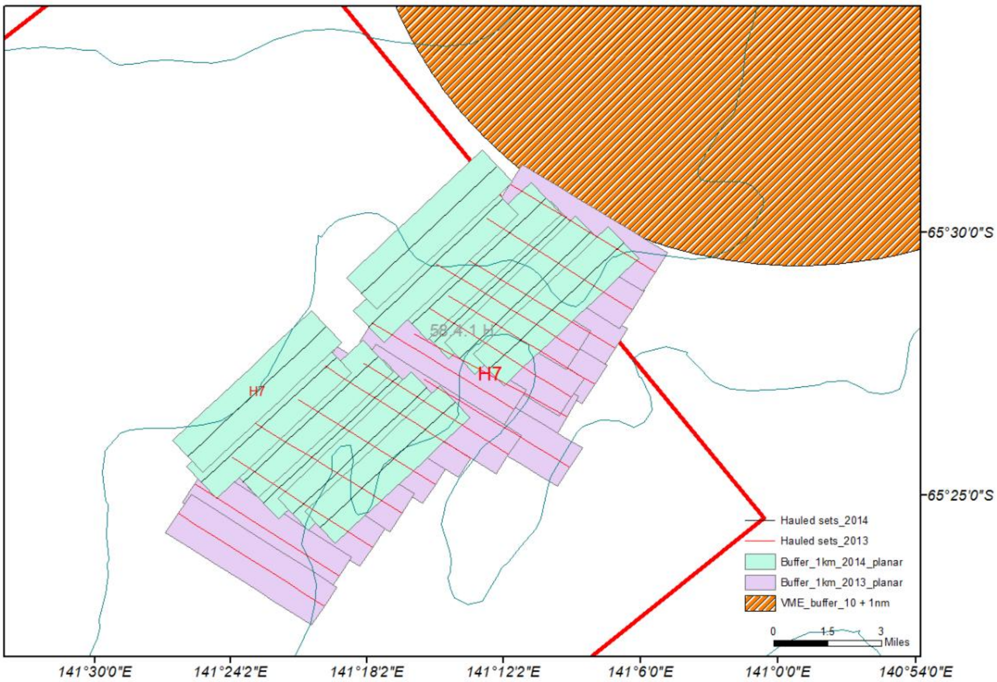
b/ SSRU 58.4.1D



c/ SSRU 58.4.1D



d/ SSRU 58.4.1G



e/ SSRU 58.4.1H

Figure 4. Detailed sequence of all sets hauled by SSRU (2013 and 2014) and the buffer area used to estimate the area covered by each rectangle.

In the process of using all this information to approach the status of *Dissostichus* spp. in each SSRU, the estimated local biomass (B_{LOC}) provides a value of the abundance in the area where the depletion took place, areas where the maximum densities of *Dissostichus* spp. were found. On the other hand, places with low densities of fish are included in the analysis as a proportion among places surveyed.

In Table 4 is presented a preliminary estimation of the Total Biomass (t) in the SSRU 58.4.1C and 58.4.1G by means of simple calculations. The objective is to relate the areas surveyed with the total SSRU area and their local CPUEs. Procedure would be as follows:

i. The percentage of the cluster´s area of the total SSRU is calculated. That is the % of the area prospected.
ii. The sum of these percentages is the percentage surveyed in the SSRU. We extrapolated the cluster's prospected area to the total surveyed.
iii. On the other hand, we do the proportion of the cluster CPUEs with respect to the maximum CPUE obtained (that is the depletion area).
iv. We divide the B_{LOC} obtained from the regression in the depletion area by the proportion of the cluster CPUEs.
v. Knowing the B_{LOC} of every polygon, the area prospected and the area it represents in the SSRU, to know the SSRU biomass partial that represents every cluster we simply apply:

$$B_{LOC} \text{*Extrapolated Area/ Prospected Area} \quad \textit{eq. 3}$$

vi. The total stock biomass in the SSRU will be the sum of the partial estimations of biomass in every SSRU.

Table 4. Estimation of the Biomass by SSRU. Clusters of the depleted areas are highlighted in grey.

Season	n sets	Cluster	Cluster areas (km^2)	SSRU areas (km^2)	% prospected area	extrapolated area by SSRU	mean CPUE	CPUEdepletion /CPUEcluster	B_{LOC} (t)	SSRU biomass (t)
2013/14	19	C2	110.45	33959	0.33	35.0	571.1	1.0	65.43	7043
2013/14	4	C-1.1	57.90	33959	0.17	18.4	122.2	4.7	14.00	1507
2013/14	4	C-1.2*	61.55	33959	0.18	19.5	111.4	5.1	12.76	1374
2013/14	4	C2-1-no	56.71	33959	0.17	18.0	146.0	3.9	16.73	1800
2013/14	2	C2-2_no	28.89	33959	0.09	9.2	135.6	4.2	15.54	1672
					0.93	100.0				**13396**
2012/13	11	G8	156.13	23945	0.65	43.1	246.4	1.0	12.48	824
2012/13	5	G7	71.39	23945	0.30	19.7	225.4	1.1	11.42	754
2012/13	5	G9*	66.98	23945	0.28	18.5	144.7	1.7	7.33	484
2012/13	5	G11	68.04	23945	0.28	18.8	180.5	1.4	9.14	604
					1.51	100.0				**2666**

Although this is a preliminary approach, it could be effective at the end of the multiyear survey when most of the planned rectangles will be prospected, including all depth strata.

Tagging and recaptures

The toothfish tagging rate during the survey was five fish per ton caught. All fish tagged were selected randomly and in good condition. A total of 765 toothfish were tagged from which 749 were TOA and 16 TOP (15 from the 58.4.1G and 1 from the 58.4.1H SSRUs).

During the 2014 survey; six tagged TOA were recovered (Table 5); three of which occurred in SSRU 58.4.1C of which two were within-season recaptures and the other was a recapture from a tagged toothfish in 2011 by a different vessel; and the remaining three were recovered in 58.4.1H, from the same Spanish research conducted last season.

Table 5. Number of tags and recaptures of toothfish by year and SSRU.

SSRU	release year	number of tags	within-season recaptures	Between-season recaptures
58.4.1C	2014	281	2	1(other vessel)
58.4.1D	2014	29	0	0
58.4.1G	2013	120	0	0
	2014	139	0	0
58.4.1H	2013	111	0	0
	2014	85	0	3

The movements of the three TOA recovered in the SSRU 58.4.1H were lower than 2 nm.

As a preliminary approach, it is estimated the stock size (Table 6) for the SSRU 58.4.1H (the only with recaptures from the 2012/13 research survey) using a modified Lincoln-Petersen method (Seber, 1982; Hillary, 2009). The methodology is similar to that used by Japan in the SSRU 58.4.1C (Japan, 2013).

The stock size in weight base in CCAMLR year j (Wj) was estimated referring to the equation 4 below as follows:

$$W_j = (n_j + 1)(cw_j) / (m_j + 1) \qquad \text{eq.4}$$

where:

n_j = Total number of tagged fish available for recapture in CCAMLR yearj.
cw_j= Total weight of all fish caught including the tagged fish in CCAMLR yearj.
m_j= Total number of recaptured fish in CCAMLR year j.

and referring to Wakeford et al. (2011), the number of available tagged fish in the subsequent CCAMLR year ($n_{i,j}$) was calculated as follows:

$$n_{i,j} = n_i(1-t)\, e^{-(\lambda + M)(j-i)} - \sum_{K=i}^{j-1} m_{i,k}\ e^{-(\lambda + M)(j-i)} \qquad \text{eq.5}$$

where:

$n_{i,j}$ = Total number of tagged fish tagged and released in CCAMLR year i estimated to be available for recapture in CCAMLR yearj.
$m_{i,k}$ = Total number of fish tagged and released in CCAMLR year i that were recaptured in CCAMLR year k.
t = post-tagging mortality rate = 0.1 (WG-SAM-13 report, paragraph 2.18).
λ = annual tag loss rate approximation = 0.0084.
M = natural mortality = 0.13.

For single estimates, in order to know the low and high ranges of recaptures, we use a Poisson distribution, (Ricker, 1975), which values are replacing m_j in eq.4 to calculate the lower and upper 95 % confidence limits

Table 6. Stock size estimates from available tagged and released fish using modified Lincoln-Petersen method.

	release year	catch year	number of tags	years	number of available tags	catch(t)	number of recaptures (m)	estimated stock size (t)	Confidence limit -95	Confidence limit 95
58.4.1H	2013	2014	111	1	84.4	16.48	3	**352**	144	933
	2014	2014	85	0						

Comparison of both methods

When comparing the preliminary estimates of the SSRUs Biomass with the two methods used (local depletion and Petersen) in SSRU 58.4.1H, results vary greatly (Table 7), although it is expected that as soon as new data from future surveys are integrated better estimation from both methods be achieved. Note that the only estimation made in the SSRU 58.4.1H (in red) is obtained from the extrapolation of the local biomass obtained from the local depletion experiment to the total SSRU area. This is probably the area with higher toothfish density in the SSRU, so this result could be overestimated and more surveys in other rectangles of the SSRU are needed to detect areas with different abundances as well as revisiting the same area trying to increase the recapture of tagged toothfish.

There is also shown the results on previous estimates. Main differences are because of the areas considered for the calculations, as well as the changes in the current methodology that takes into account all sets unlike the previous estimates.

Table 7. SSRU Biomass estimates by SSRU with the two applied methods

Season	n sets	SSRU	B_{LOC} (k)	Previous estimates B_{SSRU} (t)	B SSRU 2014 (t)	Petersen
2013/14	12	H	NA			
2013/14	15	G	NA			
2013/14	19	C	65433	(SAM-14) 17053	13396	
2012/13	11	G	12478	(FSA-13) 1929	2666	
2012/13	16	H	31174	(FSA-13) 5046	4098	352

Otoliths interpretation and age estimation

A total of 1985 otoliths from the last two surveys in the 58.4.1 division are available at the IEO laboratory, 1089 females and 896 males. At present we are starting to determine the age of TOA using these otoliths and the methodology described in the Manual for age determination of Antarctic toothfish, *Dissostichus mawsoni* V2 (Sutton et al, 2012), summarized as follows:

1. The left otolith is selected, unless it is broken or damaged.
2. Mark the distal surface of each otholit throught the primordium with a pencil. These lines ensure that otholit primordial are readly aligned during embedding.
3. Marked otoliths are placed in a metallic tray and baked in a Selecta muffle furnace until dark colored (285ºC for 15 minutes).
4. Once baked and cooled, the otoliths are embedded in an insaturated, ortoftalic, preaccelerated polyester resine (Crystic 115) blocks. Each block comprises a layer of 20 otholiths.
5. Each block is extracted and cut in a high speed revolving saw with a diamond disk supplied by *Asahi diamond industrial Europe SAS* (Disque 1A1R Ø 152 T 0,9 E 0,6 H 13 W9, Ref 8502578A001).

6. The cut surfaces are polished with faceting machine using a 1200 µ diamond coated disc, to remove any blade marks which can inhibit clarity during otolith reading. Sections are conveniently labeled and stored.

Up to now all otoliths are processed (Figure 5) and we already start to implement the individual age estimation process. It is expected to input the resulting catch at age data into a future robust assessment.

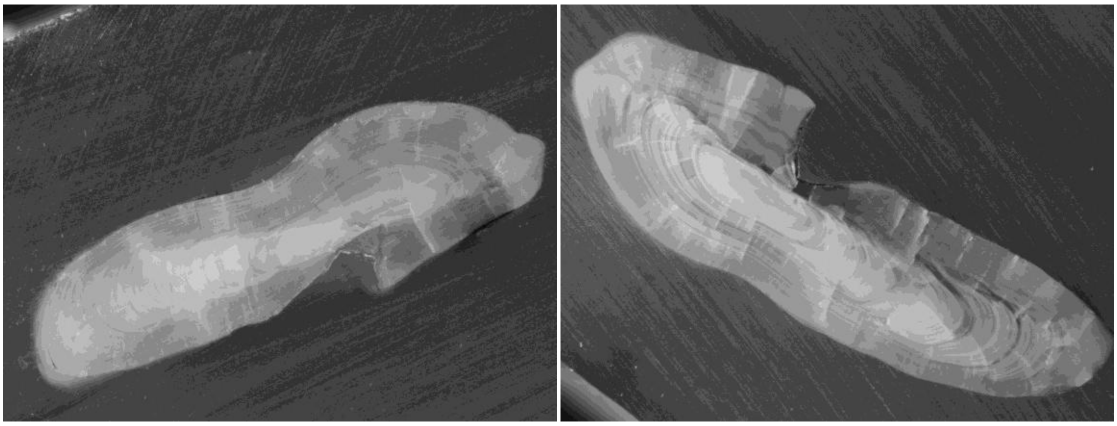


Figure 5. Transverse otolith sections from *Dissostichus mawsoni.*

TENTATIVE SCHEDULE

A tentative work schedule is proposed below. Depending on available data it is intended to start a robust stock assessment in 2017/18.

	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
Estimation of local abundance in SSRUs with Leslie's depletion method.						
58.4.1H	X	X	X			
58.4.1G	X	X	X			
58.4.1D		X	X	X		
58.4.1C		X	X	X		
58.4.1B				X	X	X
58.4.2E				X	X	X
Estimation of local abundance in SSRUs with Petersen's simple estimator (tag/recapture data)						
58.4.1H				X	X	X
58.4.1G				X	X	X
58.4.1D					X	X
58.4.1C					X	X
58.4.1B						X
58.4.2E						X

D.mawsoni age estimation of otoliths. Length-age keys						
58.4.1H				X		
58.4.1G				X		
58.4.1D				X		
58.4.1C				X		
58.4.1B						X
58.4.2E						X

FRAMEWORK FOR WHICH THE DATA COLLECTED CAN BE DEVELOPED INTO A STOCK ASSESSMENT

Up to now, estimates of local abundance are being calculated from the depletion experiment and also compared with local estimates from commercial fishing activity at different periods. At the second year of the experience three recaptures from the previous survey have been recovered, that allowed us to make a preliminary estimate of the local abundance using the simple Petersen method. From the prospecting phase of the experience we have derived areas with low, medium and high density, but more data are needed to progress in this issue. The best the prospection phase, covering the maximum of fishing depth strata, the better estimates of partial abundance and SSRU stock biomass.

There should be a balance between the need to concentrate fishing in areas to be depleted and succeed in the tag-recapture against the need of spread the areas to be studied and to integrate the areas with low fish density in the whole approach.

The Spanish proposal (CCAMLR, 2014) take account all these points, spreading the effort in the same area rectangles and revisiting the same areas surveyed during the depletion experiments from at least the two/three following years, so as far as the survey progress it is expected to improve the quality of biomass estimates.

Spain has started to read otoliths to determine age at length. It is expected to input the resulting catch at age data into an expected robust assessment at the end of the survey.

CONCLUSIONS

This experience is conceived as a multi-year proposal, so it is expected that every year new data will be available to better understand the toothfish dynamic in Divisions 58.4.1 (up to now) and 58.4.2. This has been the second year already implemented, and despite some difficulties as the ice-condition, results are highly promising.

The prospection pattern has been adapted year to year to the circumstances and to the WG-CCAMLR and SC-CCAMLR suggestions, but as usual "at-sea work", unpredictable situations happened that need a quick response. The IEO team and the observers on board have been in permanent contact during the surveys to try to solve these problems, mainly:

- ✓ The 42t of retained toothfish allowable by SSRU seem to be low and could jeopardize the experience in areas with higher densities.
- ✓ The presence of IUU fishing vessels in some areas.

- ✓ The sea ice concentration is highly variable from one season to other and movements of pack-ice due to strong winds are a handicap.
- ✓ As long as the prospection progress and more SSRUs are visited the fuel consumption could be a weak point at the end of the fishing season.

The IUU fishing is highly problematic. The extent of this fishing in the SSRU 58.4.1D is unknown but presumably high. This year the presence of the Spanish vessel forced a IUU vessel to flee from the area.

With respect to tag recaptures, there were only within-season recaptures in the SSRU 58.4.1C, that is the area with higher toothfish densities and where a bigger survey effort has been made. Also there were recaptures in the SSRU 58.4.1H but no one in the 58.4.1G, although it has been the most surveyed. Ice constraint could be one of the causes.

Local biomass has been estimated in the SSRUs 58.4.1C, G and H, using the depletion de Lury method, and an approach to model the toothfish distribution between areas with different densities. Progress in this approach is needed to develop a realistic picture of the relative density of toothfish over the whole fishable area within a SSRU.

Coordination with other members fishing in the same SSRUs is an important issue, but also the harmonization of scientific guidelines.

It has not been detected a decrease in the CPUE when revisiting the same areas that were depleted the previous season.

The effective area of longline work used to estimate the local biomass needs to be studied. The utility of baited camera systems to estimate the abundance of scavenging lithodid crabs in deep water (Collins et al, 2002) is interesting when working with crab populations, which may accumulate at bait over time. However, differences between fishing methods and species behavior, and also all the variables with instantaneous values that could intervene on movements of fish and the attraction process make difficult to define any reliable study.

What we propose in this revision is to establish a fix buffer around the longline based on fishermen experience. They set longlines in parallel with 2 km between them trying to avoid lines entanglements and the overlapping of fishing action.

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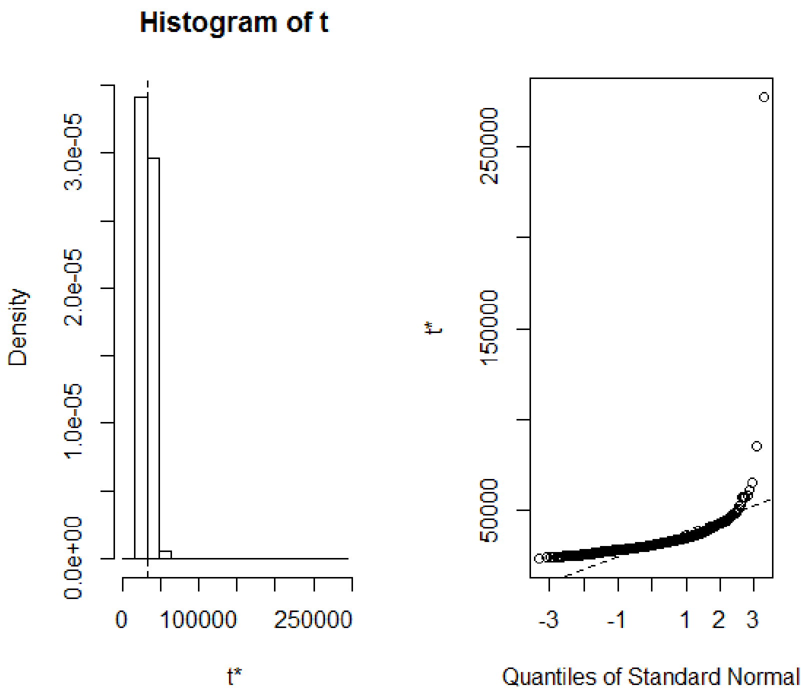
Annex 1

1. *Bootstrap results of the depletion experiments*
2. *Regression of the unfinished depletion experiments in SSRUs 58.4.1G and H in 2014*

1. Bootstrap results of the depletion experiments

58.4.1C- 2014



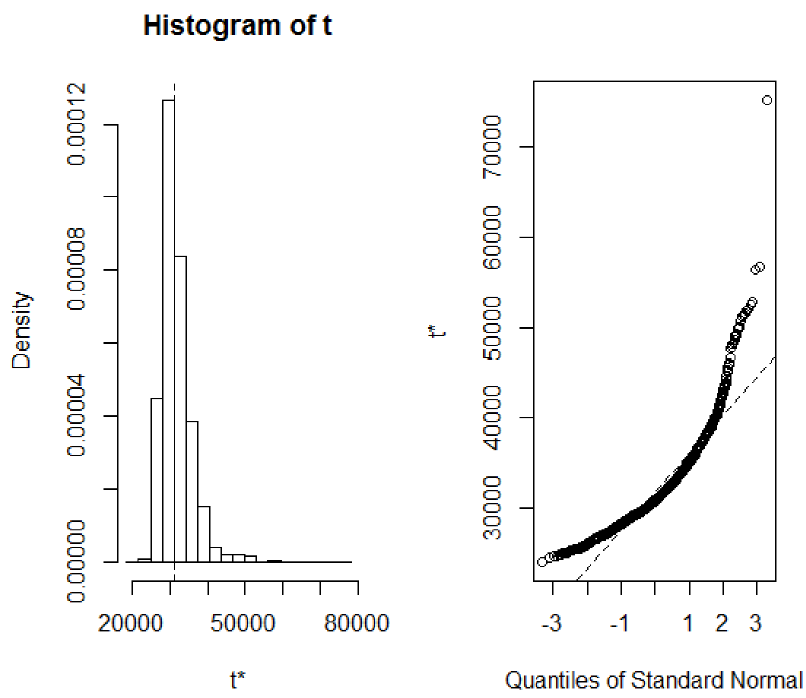

```
Bootstrap Statistics :
    original    bias    std. error
t1* 31173.96 625.7794    7027.377

BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
Based on 2000 bootstrap replicates

CALL :
boot.ci(boot.out = results, conf = c(0.9, 0.95, 0.99), type = c("perc",
    "bca"))

Intervals :
Level      Percentile            BCa
90%   (26654, 39305 )   (27172, 41484 )
95%   (25706, 42733 )   (26306, 44580 )
99%   (24765, 52793 )   (25049, 60366 )
```

58.4.1H- 2013

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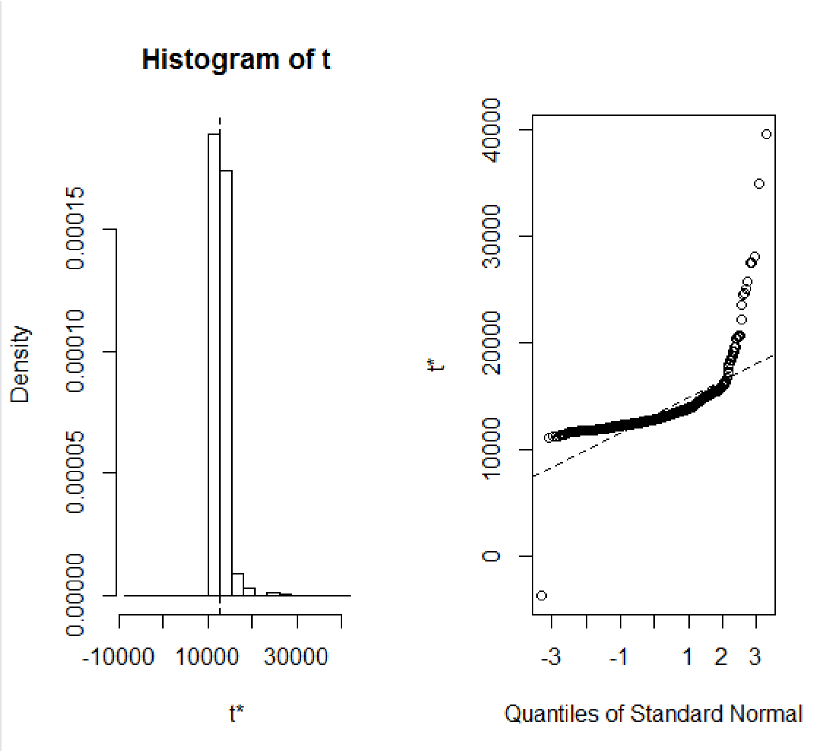
Bootstrap Statistics :
    original    bias    std. error
t1* 31173.96 536.7728    4249.866

BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
Based on 2000 bootstrap replicates

CALL :
boot.ci(boot.out = results, conf = c(0.9, 0.95, 0.99), type = c("perc",
    "bca"))

Intervals :
Level     Percentile            BCa
90%   (26794, 39012 )   (27287, 41915 )
95%   (26101, 42340 )   (26727, 48064 )
99%   (25071, 51333 )   (25512, 56113 )
```

58.4.1G- 2013




```
Bootstrap Statistics :
    original    bias    std. error
t1* 12777.34 320.9677    1614.393

/BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
Based on 2000 bootstrap replicates

CALL :
boot.ci(boot.out = results, conf = c(0.9, 0.95, 0.99), type = c("perc",
    "bca"))

Intervals :
Level      Percentile            BCa
90%   (11827, 15104 )   (11835, 15142 )
95%   (11725, 15715 )   (11741, 15928 )
99%   (11509, 23507 )   (11533, 24520 )
```

2. Regression of the unfinished depletion experiments in SSRUs 58.4.1G and H in 2014