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Spanish discards of Small-spotted catshark (*Scyliorhinus canicula*) and Blackmouth catshark (*Galeus melastomus*)

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Abstract

Discard estimations of Small-spotted catshark (*Scyliorhinus canicula*) and Blackmouth catshark (*Galeus melastomus*) for the Spanish bottom otter trawl, bottom pair trawl and set gill nets fleets operating in the Northeast Atlantic ICES Subareas VI, VII, VIII and IX are presented. Information has been obtained from the "Spanish Discard Sampling Programme" carried out by IEO. Time series provide information on discarded catch in weight and length distributions since 2011 to 2016. A description of the sampling design and the discard estimation process is also provided. Low market value is the main factor that forces the fleet to discard these species.

Keywords: Discards, elasmobranches, Trawl, Celtic Sea, Iberian Waters.

1. Introduction

The IEO "*Spanish Discards Sampling Programme*" started in 1988, focused on the Spanish trawl fleets operating in the "*Celtic Seas*" (ICES Subareas VI and VII) and the "*Bay of Biscay and the Iberian coast*" (ICES Subareas VIII and IX) Ecoregions. However, at first it was funded by individual scientific projects, so that it did not have annual continuity until 2003, after the Data Collection Regulation (DCR) implementation. Since 2008, the set gillnets fleets operating in the North-western Iberian waters were also included for sampling.

Estimations of Spanish discards of elasmobranches were presented for first time at the WGEF in 2010 (Santos *et al*., 2010; ICES, 2010), although without technical (*métier*) or geographical disaggregation. Therefore, the objective of the present work is to complete the discards time series of Small-spotted catshark (*Scyliorhinus canicula*) and Blackmouth catshark (*Galeus melastomus*) under the geographical requirements of the WEGF 2017 Data Call, *i.e*. disaggregated by ICES Division, which can only be completed for the 2011-2016 time series.

2. Material and methods

2.1 Sampling strategy

The sampling strategy and the estimation methodology used in the IEO's "*Spanish Discards Sampling Programme*" are quite similar since the beginning (1988), although since 2003 it has been updated to meet the "*Workshop on Discard Sampling Methodology and Raising Procedures*" guidelines (ICES, 2003). Since 2016, the trip selection protocol was improved introducing a random selection of the vessel from the official census, with record of refusals.

The observers-on-board programme is based on a stratified random sampling design, where the métier is the sampling stratum, while trips and hauls are the Primary Sampling Unit (PSU) and Secondary Sampling Unit (SSU), respectively. The trips are randomly or quasi-randomly selected for sampling within métiers. Whenever possible, all hauls of the same trip are sampled. However, this is especially complicated in trips of Celtic Seas métiers, since their duration (between one and two weeks) do not allow the total coverage for operational issues.

The 2002 Data Collection Regulation (DCR) asked for annual estimates and, hence, sampling was organised so as to obtain annual results (time series 2003-2008). Since the Data Collection Framework (DCF) implementation in 2008, time stratification was introduced, so that the discard could start to be estimated quarterly from 2009 onwards.

2.2 Fleets stratification

Fishing area, gear and target species are the auxiliary covariates used to stratify fleets into métiers. Two DCF metiers are sampled by IEO within the Spanish trawl fleets operating in the Celtic Sea Ecoregion (ICES Subareas VI and VII):

1. Bottom otter trawl targeting megrim and monk (OTB-DEF_70_99_0_0).
2. Bottom otter trawl targeting hake and Nephrops (OTB-DEF_100_119_0_0).

In the North-western Iberian waters (ICES Divisions VIIIc and IXa-North), the following six DCF metiers are sampled:

1. Bottom otter trawl targeting demersal fish (hake, megrims and anglerfishes) (OTB_DEF _>=55_0_0).
2. Bottom otter trawl targeting a mixed of pelagic (horse mackerel and mackerel) accompanied by demersal fish (OTB_MPD_>=55_0_0).
3. Bottom pair trawl targeting a mixed of pelagic (blue whiting) and demersal fish (hake) (PTB_DEF_>=55_0_0).
4. Set gillnet targeting mixed of demersal species (GNS_DEF_60-79_0_0).
5. Set gillnet targeting hake (GNS_DEF_70-99_0_0).
6. Set gillnet targeting white anglerfish (GNS_DEF_>=100_0_0).

2.3 Sampling scheme and raising procedures

Taken, as indicated above, that the métier is the sampling stratum, and trips and hauls are the Primary Sampling Unit (PSU) and Secondary Sampling Unit (SSU), let h_{ij} be the $j-th(j = 1 \ldots., J)$ sampled haul in sampled trip $i(i = 1, \ldots., t)$. Let d_{ij}^{s} be a randow sample drawn from the total discards d_{ij} ocurred in h_{ij}. Therefore the ratio of the sampled weight to the total weight of discards is:

$$r_{ij} = \frac{d_{ij}}{d_{ij}^{s}} \qquad (1)$$

For a given species, let f_{ijlk} be the k-th (k = 1,…,n) fish of size l sampled in d_{ij}^{s}. The total individuals of size l in d_{ij}^{s} is denoted as $F_{ijl} = \sum_{k=1}^{n} f_{ijlk}$. Alternatively, biomass by size can be obtained using the species weight-length relationship available:

$$w_{ijl} = \sum_{k=1}^{n} f_{ijl} \times a \times b^{l} \qquad (2)$$

Further steps will be expressed in terms of numbers.

2.3.1 **Trip level**

Let $$y_{ijl} = F_{ijl} \times r_{ijl} \qquad (3)$$

Be the estimated numbers of individuals of size l discarded in haul j and,

$$y_{ijl}^{w} = w_{ijl} \times r_{ij} \qquad (4)$$

The estimated discards in terms of biomass. The mean discards for size l in trip i can be calculated as follows,

$$\bar{y}_{il} = \frac{1}{J} \sum_{j=1}^{J} y_{ijl} \qquad (5)$$

With variance

$$Var(\bar{y}_{il}) = \frac{1}{J-1} \sum_{j=1}^{J} \left(y_{ijl} - \bar{y}_{il}\right)^{2} \qquad (6)$$

If J is the total number of hauls carried out in trip i, the estimated total discards in numbers by size is:

$$Y_{i} = \sum_{j=1}^{J} y_{ijl} \qquad (7)$$

Else,

$$Y_{i} = \bar{y}_{il} \times H_{i} \qquad (8)$$

With H_i being the total number of hauls (sampled + unsampled). The variance associated to (8) is

$$Var\,(Y_{i} = \left(1 - \frac{J}{H}\right) \times H^{2} \times \frac{Var(\bar{y}_{il})}{J} \qquad (9)$$

2.3.2 **Strata level**

In order to obtain the estimation of the total discard by métier, the raising procedure is made by weighting to the total effort (number of trips) of all the vessels that have operated in each métier. Mean discarded by trip is estimated to be

$$\bar{Y} = \frac{1}{t} \sum_{i=1}^{t} \times Y_{i} \qquad (10)$$

With associated variance

$$Var(\bar{Y}) = \frac{1}{t-1}\sum_{i=1}^{t}(Y_i - Y)^2 \qquad (11)$$

(10) and (11) can be raised to the total fishing effort of the fleet (*T*), to obtain a estimation of total Discarded (*D*) of the fleet:

$$D = \bar{Y} \times T \qquad (12)$$

With variance

$$Var\,(D) = \left(1 - \frac{t}{T}\right) \times T^2 \times \frac{Var\,(\bar{Y})}{t} \qquad (13)$$

2.4 Sampling effort

The sampling effort (number of trips sampled) by fishing area, gear, year and ICES Division is presented in Table 1.

3. Results

The level values show stability in both Ecoregions for trawlers, but a steady increase, greater than 50%, has occurred in gillnets during the last two years (Table 2). The mean proportion of sampled hauls $\hat{p} = \frac{J_i}{H_i}$ within trip is ~ 0.5 in the Celtic Seas Ecoregion, while the Iberian métiers present higher ratios ($\hat{p}$ ~ 0.8). In both cases, the information is considered representative of the discard behavior of the whole fleets operating in the areas.

Estimations on biomass discarded for Small-spotted catshark (*Scyliorhinus canicula*) and Blackmouth catshark (*Galeus melastomus*) are presented in Tables 2-3 and Figures 1-3. Data are presented by métier, year and ICES Division, also included percentage of discards and variation coefficients.

$$(\,\%\,Discarded = \frac{Discarded\ Catch}{Total\ Catch})$$

Gill nets data show that these species discards are not significant in these métiers, although the percentage discard is mostly of the 100 % total volumes are not high.

In Celtic Seas Ecoregion, **Small-spotted catshark** presents the highest discards values in the bottom otter trawl métier targeting megrim and anglerfish (**OTB_DEF_70-99_0_0**), which present percentages around 100% all years. The maximum is observed in Division VIIj in 2012 (3544 t), while the minimum is in Division VIIk in 2016 (1 t). In Iberian waters, Small-spotted catshark presents the highest discards in the bottom otter trawl métier targeting demersal fish (**OTB_DEF_>=55_0_0**), with percentages between 72.4 and 85.4 %. The highest discard value occurred in 2014 in Division VIIIc (1446 t), while the lowest one is shown in 2012 Division IXa (234 t).

For **Blackmouth catshark** in the Celtic Seas Ecoregion, the highest values are also observed in the bottom trawl métier targeting hake (**OTB_DEF_100-119_0_0**), with percentages around 100% all years. The maximum in Division VIIj in 2011 (452 t) and the minimum in Division VIIc in 2016 (0.5 t). In Iberian waters, the highest Blackmouth catshark discards occur, as for Small-spotted catshark in the bottom otter trawl targeting demersal fish (**OTB_DEF_>=55_0_0**),

with percentages above 90 %. Maximum biomass discarded occurred in Division VIIIc in 2015 (1112 t), and minimum in Division IXa in 2016 (137 t).

Only discard length distributions from the most important métiers for each species are presented in the paper (Figures 4-7).

4. References

ICES 2003. Report of ICES Workshop on Discard Sampling Methodology and Raising Procedures. Charlottenlund, Denmark, 2-4 September 2003. 27 pp.

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Santos, J., Araújo, H., Salinas, I. and N. Pérez. 2010. Elasmobranches Results from Spanish Discard Sampling Programme. Working Document presented at WGEF 2010. 20 pp.

Fishing Area	Gear	Year	Division	Hauls Sampled
Divisions *VIIIc- IXa North*		2011	*VIIIc*	328
			IXa North	38
		2012	*VIIIc*	296
			IXa North	73
		2013	*VIIIc*	267
			IXa North	44
	Bottom trawls	2014	*VIIIc*	194
			IXa North	81
		2015	*VIIIc*	310
			IXa North	81
		2016	*VIIIc*	275
			IXa North	71
		2011	*VIIIc*	28
		2012	*VIIIc*	7
		2013	*VIIIc*	13
	Gill nets	2014	*VIIIc*	44
		2015	*VIIIc*	89
		2016	*VIIIc*	82
			IXa North	12
Subárea *VI- VII*		2011	*VIb*	11
			VIIc	34
			VIIh	29
			VIIj	207
			VIIk	12
		2012	*VIIc*	7
			VIIg	23
			VIIh	49
			VIIj	241
			VIIk	20
		2013	*VIIb*	10
			VIIc	23
			VIIg	5
			VIIh	73
			VIIj	196
			VIIk	2
	Bottom trawls	2014	*VIIb*	36
			VIIc	3
			VIIg	7
			VIIh	8
			VIIj	257
			VIIk	1
		2015	*VIIb*	9
			VIIc	25
			VIIg	11
			VIIh	29
			VIIj	205
		2016	*VIb*	15
			VIIb	6
			VIIc	87
			VIIg	1
			VIIh	94
			VIIj	170
			VIIk	2

Table 1. Sampling effort of the IEO's Spanish Discard Sampling Programme for years 2011-2016.

METIER	YEAR	*DIVISION*	% DISCARD	DISCARD (Tn)	CV
GNS_DEF_>=100_0_0	2011	*IXa-North*	100	0.026	42.23
		VIIIc	100	0.459	44.49
	2012	*IXa-North*	100	0.026	0.00
		VIIIc	100	0.991	0.00
	2013	*IXa-North*	0	0.000	0.00
		VIIIc	0	0.000	0.00
	2014	*IXa-North*	100	0.009	96.92
		VIIIc	100	0.332	99.92
	2015	*IXa-North*	0	0.000	0.00
		VIIIc	0	0.000	0.00
	2016	*IXa-North*	100	0.023	62.73
		VIIIc	100	0.475	65.92
GNS_DEF_60-79_0_0	2011	*IXa-North*	100	10.896	99.99
		VIIIc	100	9.593	99.99
	2012	*IXa-North*	na	na	na
		VIIIc	na	na	na
	2013	*IXa-North*	100	43.096	38.80
		VIIIc	100	43.182	38.80
	2014	*IXa-North*	0	0.000	0.00
		VIIIc	77.3	15.241	52.17
	2015	*IXa-North*	100	7.494	51.49
		VIIIc	100	5.213	51.49
	2016	*IXa-North*	0	0.000	0.00
		VIIIc	0	0.000	0.00
GNS_DEF_80-99_0_0	2011	*IXa-North*	100	10.896	99.99
		VIIIc	100	9.593	99.99
	2012	*IXa-North*	0	0.000	0.00
		VIIIc	0	0.000	0.00
	2013	*IXa-North*	100	43.096	38.80
		VIIIc	100	43.182	38.80
	2014	*IXa-North*	0	0.000	0.00
		VIIIc	77.3	15.241	52.17
	2015	*IXa-North*	0	0.000	0.00
		VIIIc	0	0.000	0.00
	2016	*IXa-North*	0	0.000	0.00
		VIIIc	0	0.000	0.00
OTB_DEF_>=55_0_0	2011	*IXa-North*	82.4	314.354	21.52
		VIIIc	82.4	655.295	21.76
	2012	*IXa-North*	78.4	233.820	25.73
		VIIIc	78.4	592.414	26.02
	2013	*IXa-North*	73.8	330.849	25.53
		VIIIc	73.8	799.070	25.74
	2014	*IXa-North*	83.3	436.704	32.90
		VIIIc	83.3	1446.525	33.26
	2015	*IXa-North*	85.4	507.880	20.71
		VIIIc	85.4	1262.763	20.99
	2016	*IXa-North*	72.4	362.343	20.66
		VIIIc	72.4	673.140	20.82
OTB_MPD_>=55_0_0	2011	*IXa-North*	74.2	6.735	50.62
		VIIIc	74.2	19.408	51.05
	2012	*IXa-North*	86.0	5.162	62.20
		VIIIc	86.0	11.362	62.62
	2013	*IXa-North*	69.3	9.054	41.89
		VIIIc	69.3	17.582	42.27
	2014	*IXa-North*	64.7	0.705	99.12
		VIIIc	64.7	1.231	99.38
	2015	*IXa-North*	85.2	24.371	73.99
		VIIIc	85.2	45.182	74.50
	2016	*IXa-North*	21.6	3.189	38.97
		VIIIc	21.6	3.780	39.01
PTB_MPD_>=55_0_0	2011	*IXa-North*	46.5	0.155	99.26
		VIIIc	46.5	0.280	99.56
	2012	*IXa-North*	0	0.000	0.00
		VIIIc	0	0.000	0.00
	2013	*IXa-North*	0	0.000	0.00
		VIIIc	0	0.000	0.00
	2014	*IXa-North*	100	1.287	98.64
		VIIIc	100	4.458	99.61
	2015	*IXa-North*	100	0.499	99.08
		VIIIc	100	1.153	99.60
	2016	*IXa-North*	98.6	1.556	66.72
		VIIIc	98.6	3.746	67.33

METIER	YEAR	*DIVISION*	% DISCARD	DISCARD (Tn)	CV
OTB_DEF_100-119_0_0	2011	*VIIj*	100	24.623	99.58
		VIIk	100	7.408	98.58
		VIIb	100	1.461	92.58
		VIIc	100	6.677	98.43
	2012	*VIIj*	0	0.000	0.00
		VIIk	0	0.000	0.00
		VIIb	0	0.000	0.00
		VIIc	0	0.000	0.00
	2014	*VIIj*	100	2.853	0.00
		VIIk	100	2.622	0.00
		VIIc	100	1.002	0.00
OTB_DEF_70-99_0_0	2011	*VIIj*	100	2820.655	37.76
		VIb	100	78.042	22.77
		VIIb	100	66.893	19.05
		VIIc	100	217.402	33.42
		VIIg	100	5.574	0.00
		VIIh	100	189.530	32.67
	2012	*VIIj*	99.0	3544.190	28.10
		VIb	99.0	33.835	0.00
		VIIb	99.0	118.422	16.98
		VIIc	99.0	380.641	25.41
		VIIh	99.0	499.063	26.15
	2013	*VIIj*	98.2	3277.049	22.62
		VIb	98.2	30.770	0.00
		VIIb	98.2	153.852	16.18
		VIIc	98.2	153.852	16.18
		VIIg	98.2	38.463	0.00
		VIIh	98.2	430.786	20.74
	2014	*VIIj*	98.5	1121.954	23.42
		VIb	98.5	4.171	0.00
		VIIb	98.5	116.783	18.12
		VIIc	98.5	183.517	20.44
		VIIg	98.5	20.854	0.00
		VIIh	98.5	133.467	18.95
	2015	*VIIj*	97.8	637.103	14.04
		VIIk	97.8	2.700	0.00
		VIb	97.8	21.597	0.00
		VIIb	97.8	70.189	11.58
		VIIc	97.8	153.876	13.14
		VIIh	97.8	78.288	11.89
	2016	*VIIj*	98.0	262.872	27.64
		VIIk	98.0	1.355	0.00
		VIb	98.0	2.710	0.00
		VIIb	98.0	44.715	22.27
		VIIc	98.0	81.301	25.32
		VIIg	98.0	2.710	0.00
		VIIh	98.0	27.100	16.93

Table 2. Discards estimates in weight (t), percentage of discard and associated CV of Small-spotted catshark.

METIER	YEAR	DIVISION	% DISCARD	DISCARD (Tn)	CV
GNS_DEF_>=100_0_0	2011	*IXa-North*	100	0.006	94.65
		VIIIc	100	0.103	99.71
	2012	*IXa-North*	100	0.008	0.00
		VIIIc	100	0.319	0.00
	2013	*IXa-North*	100	0.007	95.20
		VIIIc	100	0.247	99.87
	2015	*IXa-North*	100	0.273	49.74
		VIIIc	100	10.225	51.52
	2016	*IXa-North*	100	0.024	66.72
		VIIIc	100	0.506	70.11
GNS_DEF_60-79_0_0	2016	*IXa-North*	100	19.481	99.98
		VIIIc	100	11.969	99.96
GNS_DEF_80-99_0_0	2014	*IXa-North*	100	0.770	98.65
		VIIIc	100	6.691	99.85
	2015	*IXa-North*	76	1.829	46.39
		VIIIc	76	14.965	47.04
	2016	*IXa-North*	100	3.117	47.12
		VIIIc	100	25.439	47.73
OTB_DEF_>=55_0_0	2011	*IXa-North*	99.7	407.962	50.38
		VIIIc	99.7	850.429	50.93
	2012	*IXa-North*	99.2	426.755	37.26
		VIIIc	99.2	1081.242	37.68
	2013	*IXa-North*	96.1	234.344	26.45
		VIIIc	96.1	565.990	26.67
	2014	*IXa-North*	98.9	273.749	36.93
		VIIIc	98.9	906.757	37.33
	2015	*IXa-North*	96.7	447.303	26.87
		VIIIc	96.7	1112.148	27.23
	2016	*IXa-North*	93.8	137.422	44.15
		VIIIc	93.8	255.294	44.47
OTB_MPD_>=55_0_0	2011	*IXa-North*	100	0.465	73.10
		VIIIc	100	1.341	73.72
	2013	*IXa-North*	100	1.214	45.51
		VIIIc	100	2.357	45.92
	2015	*IXa-North*	97.8	5.649	64.05
		VIIIc	97.8	10.473	64.49
PTB_MPD_>=55_0_0	2011	*IXa-North*	63.5	7.902	85.06
		VIIIc	63.5	14.329	85.31
	2012	*IXa-North*	100	4.311	70.99
		VIIIc	100	8.660	71.27
	2013	*IXa-North*	100	0.187	99.21
		VIIIc	100	0.518	99.71
	2014	*IXa-North*	100	1.440	98.64
		VIIIc	100	4.986	99.61
	2015	*IXa-North*	100	12.000	62.54
		VIIIc	100	27.744	62.87
	2016	*IXa-North*	100	1.521	93.48
		VIIIc	100	3.660	94.33

METIER	YEAR	DIVISION	% DISCARD	DISCARD (Tn)	CV
OTB_DEF_100-119_0_0	2011	*VIIb*	100	26.816	49.09
		VIIc	100	122.587	52.19
		VIIj	100	452.038	52.80
		VIIk	100	135.995	52.27
	2012	*VIIb*	100	6.026	68.33
		VIIc	100	19.584	88.89
		VIIj	100	141.610	95.60
		VIIk	100	105.454	95.24
	2014	*VIIc*	100	0.544	0.00
		VIIj	100	1.550	0.00
		VIIk	100	1.424	0.00
OTB_DEF_70-99_0_0	2011	*VIb*	87.2	2.739	38.91
		VIIb	87.2	2.528	35.07
		VIIc	87.2	8.216	61.52
		VIIh	87.2	7.162	60.15
		VIIj	87.2	106.593	69.52
	2012	*VIb*	99.8	0.201	0.00
		VIIb	99.8	0.704	31.73
		VIIc	99.8	2.264	47.49
		VIIh	99.8	2.968	48.88
		VIIj	99.8	21.078	52.52
		VIIk	99.8	0.252	0.00
	2013	*VIb*	100	0.153	0.00
		VIIb	100	0.765	41.92
		VIIc	100	0.765	41.92
		VIIg	100	0.191	0.00
		VIIh	100	2.142	53.73
		VIIk	100	16.298	58.58
	2014	*VIIb*	100	0.306	63.02
		VIIc	100	0.481	71.09
		VIIg	100	0.055	0.00
		VIIh	100	0.350	65.90
		VIIj	100	2.938	81.48
	2015	*VIb*	100	0.127	0.00
		VIIb	100	0.412	62.02
		VIIc	100	0.904	70.39
		VIIh	100	0.460	63.70
		VIIj	100	3.743	75.23
		VIIk	100	0.016	0.00
	2016	*VIb*	95.2	0.266	0.00
		VIIb	95.2	4.393	52.76
		VIIc	95.2	7.987	59.98
		VIIg	95.2	0.266	0.00
		VIIh	95.2	2.662	40.09
		VIIj	95.2	25.825	65.46

Table 3. Discards estimates in weight (t), percentage of discard and associated CV of Blackmouth catshark.

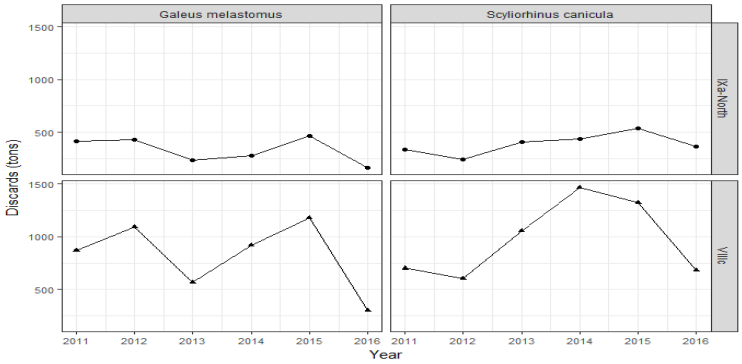

Figure 1. Biomass discarded (t) of Small-spotted catshark and Blackmouth catshark in Iberian waters by ICES Divisions (all métiers).

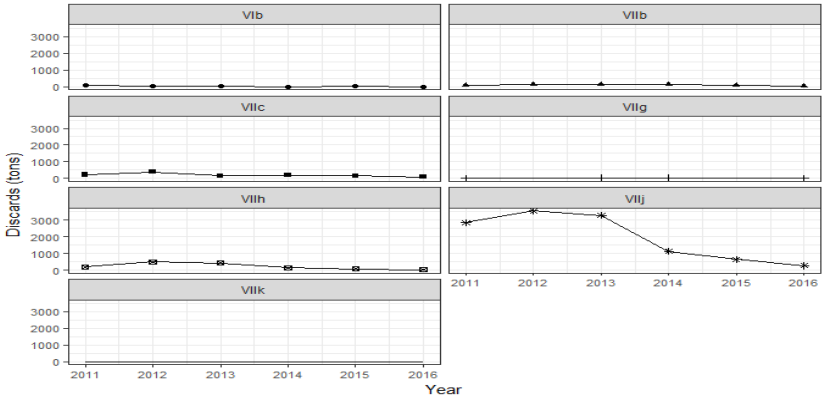

Figure 2.Biomass discarded (t) of Small-spotted catshark in the Celtic Seas Ecoregion by ICES Division (all métiers).

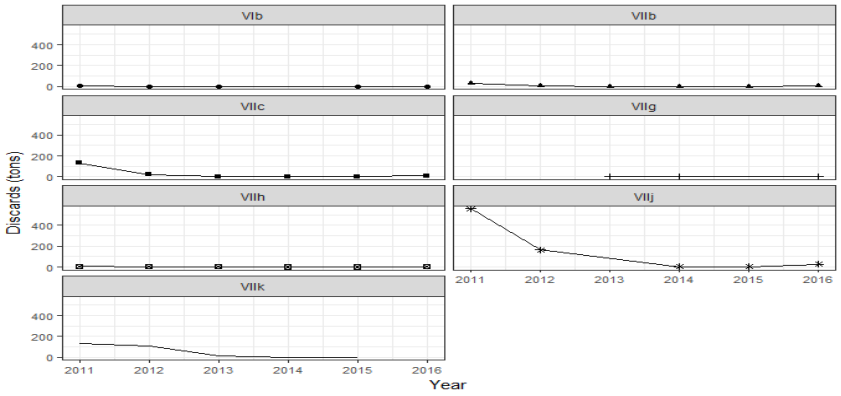

Figure 3. Biomass discarded (t) of Blackmouth catshark in the Celtic Seas Ecoregion by ICES Division *(a*ll métiers).

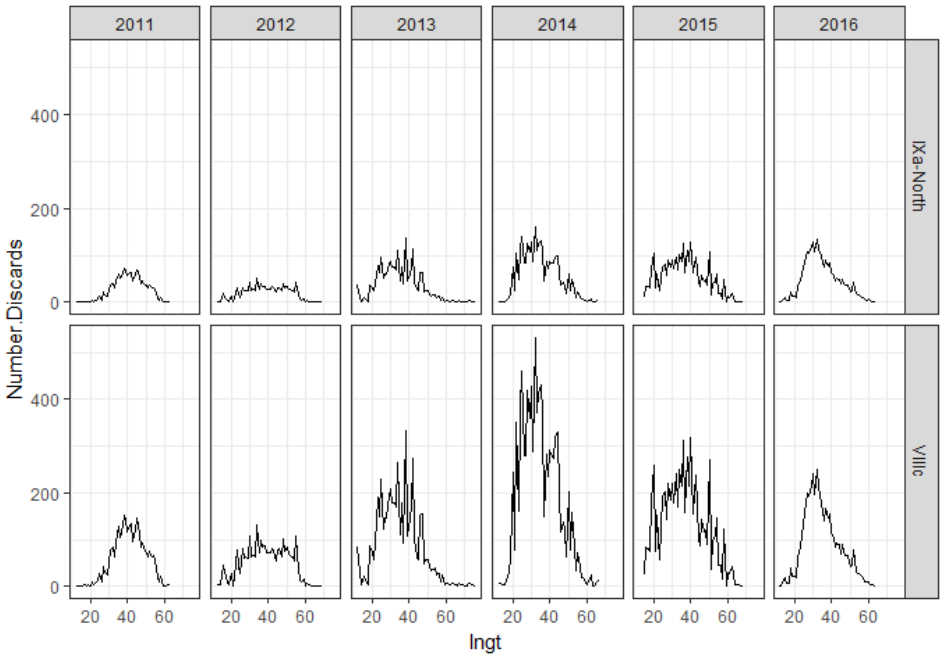

Figure 4. Annual length size distribution of Small-spotted catshark discarded in Iberian waters (in thousands of indivuals).

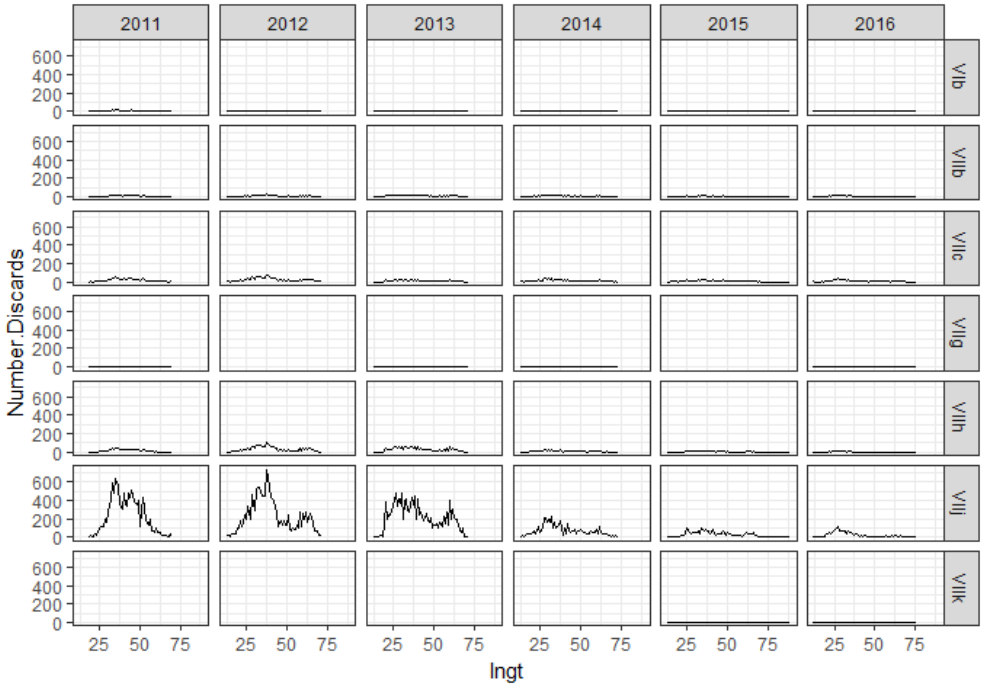

Figure 5. Annual length size distribution of Small-spotted catshark discarded in Celtic Sea (in thousands of indivuals).

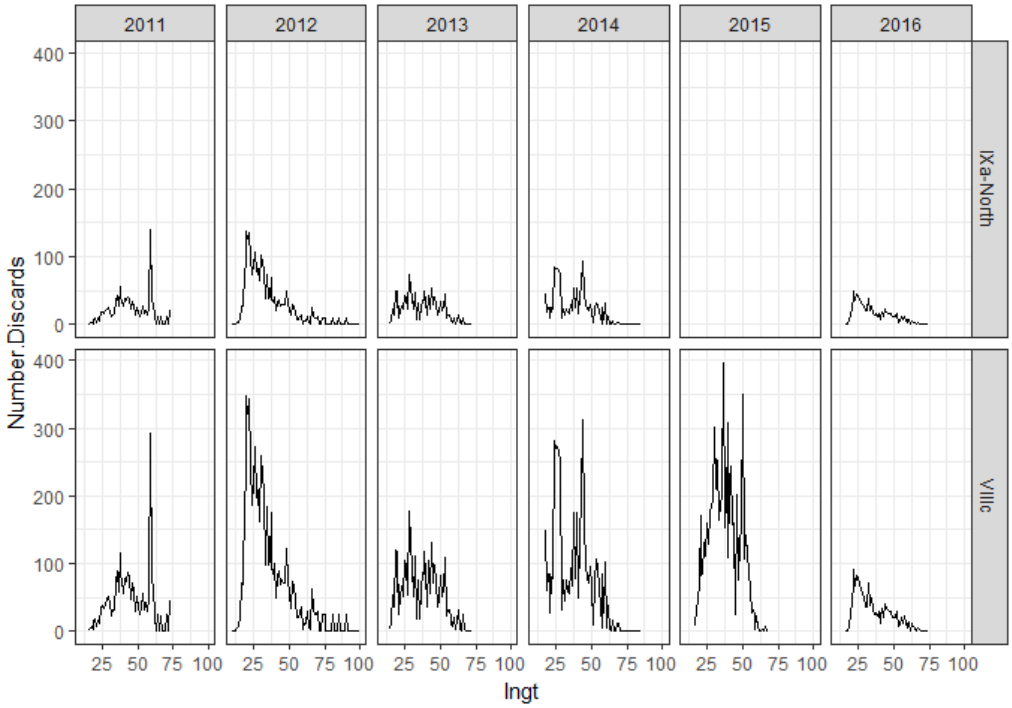

Figure 6. Annual length size distribution of Blackmouth catshark discarded in Iberian waters (in thousands of indivuals).

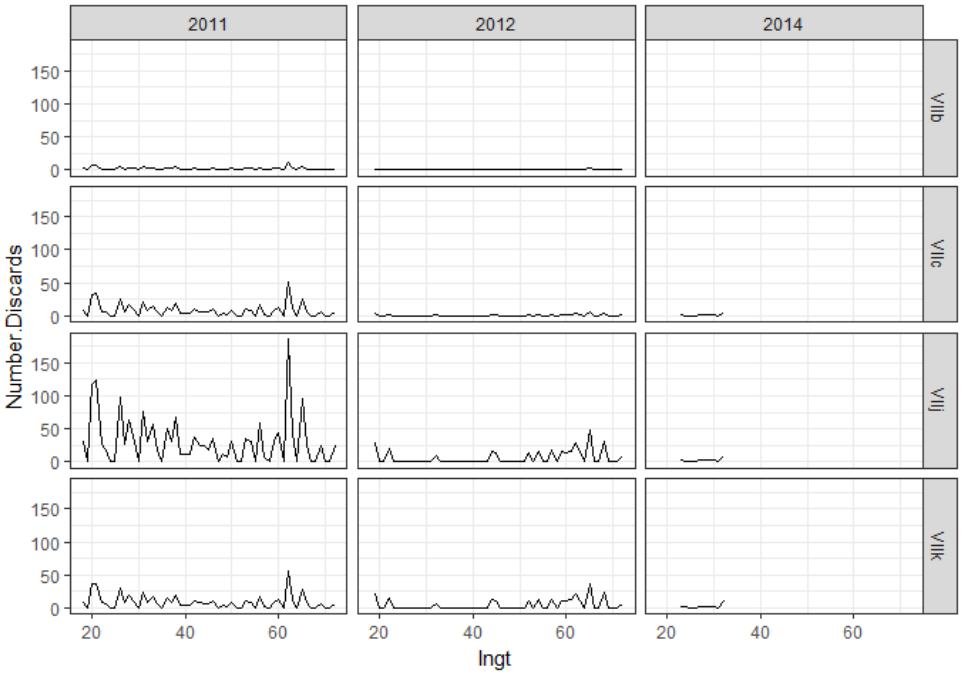

Figure 7. Annual length size distribution of Blackmouth catshark discarded in Celtic Sea (in thousands of indivuals)