Working Document 5 presented to the ICES Working Group on the Biology and Assessment of Deep Sea Fisheries Resources -ICES WDEEP- Copenhaguen, 2-8 March 2011

Deep Species Results from Spanish Discard Sampling Programme

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Abstract

Estimations of deep species discards from three Spanish bottom otter trawl métiers operating in the Northeast Atlantic ICES VI, VII, $VIII_c$ and North IX_a are presented in this paper. Information has been obtained from the 'Spanish Discard Sampling Programme' carried out by the IEO. Trip was the sampling unit, being raised to fleet level using fishing effort as auxiliary variable. Discard weigth estimates from time series of seven years (2003-2009) is presented for twelve species. Further, discard length distributions are presented for those species that have been observed whitin discarded fraction for more than three years. Estimates show high between-years variation in discard amounts, exceeding 35% CV in almost all cases. Results show that the largest amounts of discards of most of the species occur at depths less than 600m. Low market value is the main factor that forces the fleet to discard most of deep species.

Keywords: Discards, Northeast Atlantic waters, Bottom Trawl.

1 Introduction

The 'Spanish Discards Sampling Programme' for Otter Botton Trawlers (OTB) fleets, covering ICES VI, VII $VIII_c$ and North IX_a, was started in 1988 (Table 1), however, it did not have yearly continuity until 2003. This lack of continuity is the main reason that led to omit the estimates from previous years.

Year	Project
1988-1989	National Project
1994	EC Project: Pem/93/005
1997	EC Project: 95/ 094
1999-2000	EC Project: 98/095
2001	EC Project: 99/063
2003-2009	DCR

Table 1: Summary of funded projects which have supported the Spanish Discards Sampling Programme

Spanish data on deep species discards (in this case from the Instituto Español de Oceanografía (IEO)) have never been provided to ICES WGDEEP in the past.

The main objective of this working document is to provide the information of the most discarded species by the Spanish fleets operating in ICES Subareas VI and VII and Divisions $VIII_c$ and IX_a.

2 Material and methods

2.1 Sampling strategy

The sampling strategy and the estimation methodology used in the 'Spanish Discards Sampling Programme' has been little modified since 1988, and since 2003 follows the guidelines established in the ICES 'Workshop on Discard Sampling Methodology and Raising Procedures' (2003). The observers-on-board programme is based on a stratified random sampling design. Métier is the lower stratum and trips (the sampling unit considered in the raising protocol) are randomly or quasi-randomly selected for sampling within métiers. Until 2009 the DCR asked for annual estimates and, hence, sampling was organised to obtain annual results.

Only trawl fleet is considered herein. Other fleets (i.e. long line fleet) were evaluated, showing low discard levels for deep species along the areas under study (Pérez et al., 1996). Gillnet discard information is also being obtained since 2008, but the short time series available has been considered as insufficient to be presented in the present document.

2.2 Fleets stratification

Fishing area, gear and target species are the auxiliary covariates used to stratify fleets into métiers. Two métiers are considered within the Spanish bottom otter trawl fleets operating in the ICES Subareas VI and VII:

- `OTB-DEF_80_100_0_0 trips targeting Megrim and Monk`
- `OTB-DEF_80_110_0_0 trips targeting Hake and Monk`

Discard information from the former métiers was aggregated in order to present discard estimations from the whole Spanish trawl fleet operating in the area.

In the other hand, one métier is defined in this document for the Northern Spanish coastal bottom otter trawl fleet (ICES $VIII_c$ and IX_a Divisions):

- `OTB_DEF_55_80_0: trips targeting a mixed of demersal species in` $VIII_c$ `and North` IX_a`.`

2.3 Sampling scheme & Raising procedures

Let h_{ij} be the j-th ($j = 1, \ldots, J$) sampled haul in sampled trip i ($i = 1, \ldots, t$). Let d^s_{ij} be a randow sample drawn from the total discards d_{ij} ocurred in h_{ij}.Let

$$r_{ij} = \frac{d_{ij}}{d^s_{ij}} \tag{1}$$

be the ratio of the sampled weigth to the total weight of discards.
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 weigth-length relationship available

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

Further steps will be expressed in terms of numbers

2.3.1 Trip level

Let

$$y_{ijl} = F_{ijl} \times r_{ijl} \tag{3}$$

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

$$y_{ijl}^w = w_{ijl} \times r_{ij} \tag{4}$$

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

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

with variance

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

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

$$Y_i = \sum_{j=1}^{J} y_{ijl} \tag{7}$$

else,

$$Y_i = \bar{y}_{il} \times H_i \tag{8}$$

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

$$Var(Y_i) = (1 - \frac{J}{H}) \times H^2 \times \frac{Var(\bar{y}_{il})}{J} \tag{9}$$

2.3.2 strata level

- Raising by number of trips (assumed known)

Mean discarded by trip is estimated to be

$$\bar{Y} = \frac{1}{t} \sum_{i=1}^{t} \times Y_i \tag{10}$$

with associated variance

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

(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:

$$D = \bar{Y} \times T \tag{12}$$

with variance

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

2.3.3 Species selection for report

Discards estimations in terms of biomass are presented for twelve deep species:

- *Aphanopus carbo*
- *Argentina silus*
- *Argentina sphyraena*
- *Beryx decadactylus*
- *Beryx splendens*
- *Brosme brosme*
- *Coryphaenoides rupestris*
- *Hoplostethus atlanticus*
- *Molva molva*
- *Molva spp.**
- *Pagellus bogaraveo*
- *Phycis blennoides*

* Taxonomic difficulties detected to distinguish onboard between *Molva dypterygia* and *Molva macropthalma* have led to aggregate both species into a higher taxon.

2.3.4 Exploratory Data Analysis

A preliminary EDA has been conducted on the catch estimates of the most discarded species ($\geq 10\ tons/year$) that also showed a continued presence in the yearly discard estimations ($> 3\ years$). Former species selection are presented below:

- Subareas VI-VII:
  - *Argentina silus*
  - *Argentina sphyraena*
  - *Coryphaenoides rupestris*
  - *Molva molva*
  - *Molva spp.*
  - *Phycis blennoides*
- Divisions $VIII_c$-IX_a North:
  - *Argentina sphyraena*
  - *Molva spp.*
  - *Phycis blennoides*

3 Results

Sampling level values (Table 2) on Subareas VI, VII show stability since 2003 and a steady increase has occurred in the Divisions $VIII_c$, IX_a during the last years. Mean proportion of sampled hauls $\hat{p} = \frac{J_i}{H_i}$ within trip is ~ 0.5 in the Northern area, while short trips and low effective hauls characterizing the Southern waters require higher sampling coverage within trip, yielding higher $\hat{p}$ (~ 0.8) than in the Northern trips. The information coming from the analized métiers can be considered representative of the discard behaviour of the whole fleets operating in the areas.

Table 3 shows estimations on biomass discarded (*tons*) for the selected species. Amounts of discarded is clearly higher in the Northern fishing area for all species. Only Silver Smelt (*Argentina sphyraena*) and Greater Forkbeard (*Phycis blennoides*) appeared continuously in the discarded catch along the years sampled in both areas. Greater Silver Smelt (*Argentina silus*), Greater Forkbeard and Silver Smelt are the most discarded deep species in Subareas VI and VII. Maximum biomass discarded for Greater Forkbeard, Ling (*Molva molva*) and Roundnose Grenadier(*Coryphaenoides rupestris*) have ocurred simultaneously in 2005 (Figure 1).

Silver Smelt, Greater Forkbeard and *Molva spp.* represents the bulk of deep species biomass discarded in Divisions $VIII_c$ and IX_a (table 3). Years 2006 and 2007 show the highest discard values for Silver Smelt, *Molva spp.* and Greater Forkbeard, while largest amounts of Roundnose Grenadier discard was found in 2004 (Figure 2).

Only discard length distributions from the most important species are presented in the paper (Figures 3 and 4). High yearly variation in length sizes of

discarded catch are found for all species and areas.*Molva spp.*,Greater Forkbeard and Ling show the widest length range over the species under study.Silver Smelt and Greater Silver Smelt species show the opposite length size estructure.

Figures 5 to 11 plot haul catches of the selected species (log) in relation with setting depth and year. Most of the sampling hauls ocurred at depths $< 600mts$. Only Greater Forkbeard catches show a clear positive relation with setting depth (Figures 11 and 13). Opposite trend is found for Ling when setting depth exceeds $\sim 300mts$ (Figure 9).

By-haul discards in a Spatio-temporal basis are showed in Figures 14 to 22. Northern discards of Silver Smelt took place mostly in the *Grand Sole Bank* except in 2005, where highest values took place in *Porcupine Bank* (Figure 14). Great Silver Smelt discards present a wider dispersion along the Northern area (Figure 15). Roundnose Grenadier discards were found mostly in *Porcupine Bank* and *Rockall Bank* during 2004 and 2005 (Figure 16). No clear spatial trend were found for Discarded of *Molva spp.* and Ling in the northern area (Figures 17 and 18). Greater Forkbeard discards were found in *Grand Sole Bank* and *Porcupine Bank* (Figure 19).

Discards in the southern area took place mostly off the Galician western coast (IX_a) and Gulf of Viscay ($VIII_c$/East)

4 Conclusions

Negligible discards were found for Golden Eye Perch (*Beryx spp.*), Tusk (*Brosme brosme*), Orange Roughy (*Hoplostethus atlanticus*)in Subareas VI-VII and for Orange Roughy (*Hoplostethus atlanticus*), Greater Silver Smelt and Ling in Divisions IX_a and $VIII_c$. Low and high variable discards were found for Black scabbard fish (*Aphanopus carbo*) in both Fishing Areas. No discards were observed for Seabram in Subareas VI-VII and for Tusk and Golden Eye Perch in IX_a and $VIII_c$.

Different factors including market value, species availability, length sizes or quotas interacts during onboard catch sorting process. Greater Silver Smelt, Silver Smelt, Roundnose Grenadier are species with no commercial value to the Spanish markets, being the main reason to discard the bulk of their catches. Greater Forkbeard is one of the most discarded species both in Northern and Southern Fishing Areas and the main factor is the low market value for small fishes. Ling is also discarded due to the same reason. Further research efforts must be employed in determining discard causes for Southern Sea Bram.

Sampling trips show that most of the fishing effort takes place at depths $< 600mts$ and therefore catches information from this métiers should not be considered as part of a deep fisheries fleet. Only Greater Forkbeard catches has found to be positive related with fishing depth. This trend and the change in fishing behavior observed in northern areas along 2005 to deeper waters may explain the peak of discards for the species estimated in the same year.

Fishing Area	Year	Trips Sampled	Quarter	Hauls Sampled	$\hat{p}$	Total Trips
Subareas VI, VII	2003	9	1	0	0.63	1172
			2	107		
			3	121		
			4	141		
	2004	11	1	102	0.58	1222
			2	118		
			3	86		
			4	94		
	2005	10	1	71	0.49	1194
			2	105		
			3	109		
			4	52		
	2006	13	1	131	0.46	1152
			2	122		
			3	109		
			4	14		
	2007	12	1	82	0.49	1233
			2	99		
			3	71		
			4	116		
	2008	11	1	57	0.53	1206
			2	66		
			3	112		
			4	118		
	2009	15	1	91	0.53	1304
			2	144		
			3	118		
			4	75		
Divisions $VIII_c$, IX_a	2003	23	1	0	0.80	6214
			2	32		
			3	33		
			4	35		
	2004	26	1	46	0.88	10343
			2	15		
			3	34		
			4	26		
	2005	32	1	56	0.92	4929
			2	37		
			3	38		
			4	26		
	2006	25	1	28	0.78	6648
			2	37		
			3	31		
			4	15		
	2007	37	1	17	0.81	7961
			2	35		
			3	41		
			4	64		
	2008	32	1	19	0.69	4476
			2	33		
			3	30		
			4	17		
	2009	33	1	12	0.86	5549
			2	43		
			3	48		
			4	51		

Table 2: Sampling effort in recent years for VI-VII and VIIIc-IXa

Fishing Area	Species	2003	2004	2005	2006	2007	2008	2009
Subareas VI-VII	*Aphanopus carbo*	0.00	0.00	69.50	0.00	125.2	1.80	0.00
				99.70		99.7	99.40	
	Argentina silus	2210.70	2978.30	2148.70	1147.00	1822.6	3080.10	4203.70
		63.50	44.00	61.90	40.00	55.3	33.60	36.60
	Argentina sphyraena	318.60	200.30	662.80	975.30	209.8	617.40	369.30
		43.50	54.10	54.40	82.50	49.5	50.00	41.80
	Beryx decadactylus	0.00	8.10	8.40	0.90	0.0	0.00	0.00
			74.10	99.70	99.60			
	Beryx splendens	0.00	0.00	1.90	0.00	0.0	4.70	0.00
				99.70			99.50	
	Brosme brosme	0.00	0.00	308.10	4.90	0.0	0.00	0.00
				99.70	99.40			
	Coryphaenoides rupestris	0.00	345.20	729.20	54.20	15.2	0.00	0.00
			58.90	83.80	51.50	52.2		
	Hoplostethus atlanticus	0.00	0.00	74.10	0.00	<0.1	0.00	0.00
				99.70		82.9		
	Molva spp.	103.90	174.00	190.60	18.70	108.5	458.70	112.80
		57.60	43.30	44.90	57.70	59.0	65.00	36.70
	Molva molva	23.80	8.30	188.50	28.00	9.6	6.30	13.30
		97.70	67.90	98.70	80.30	90.2	90.80	90.90
	Pagellus bogaraveo	0.00	0.00	0.00	0.00	0.0	0.00	0.00
	Phycis blennoides	914.30	586.30	3096.20	492.80	617.3	1184.20	537.20
		42.50	31.70	62.30	35.80	34.8	70.40	41.00
Divisions $VIII_c$, North IX_a	Aphanopus carbo	3.40	0.00	0.00	2.90	10.2	0.20	1.30
		99.40			99.40	59.6	111.40	68.20
	Argentina silus			0.10	0.00	5.7	4.80	
				99.70		87.8	64.10	
	Argentina sphyraena	36.60	57.10	35.60	203.40	39.4	9.30	40.20
		37.10	67.40	43.40	62.20	39.2	59.20	48.00
	Beryx decadactylus	0.00	0.00	0.00	0.00	0.0	0.00	0.00
	Beryx splendens	0.00	0.00	0.00	0.00	0.0	0.00	0.00
	Brosme brosme	0.00	0.00	0.00	0.00	0.0	0.00	0.00
	Coryphaenoides rupestris	0.00	100.70	16.60	0.20	2.0	0.10	4.80
			86.60	72.90	96.10	68.5	88.10	90.80
	Hoplostethus atlanticus	0.00	0.10	0.00	0.70	3.3	0.00	0.00
			99.90		95.60	68.8		
	Molva spp.	0.00	0.90	4.90	6.00	67.1	11.40	37.10
			99.90	65.40	62.10	37.3	35.10	38.50
	Molva molva	0.00	2.90	0.00	0.00	0.0	0.00	0.70
			100.20					88.60
	Pagellus bogaraveo	0.00	63.10	5.50	41.60	0.0	0.00	0.00
			65.70	85.50	88.00			
	Phycis blennoides	13.80	6.80	8.20	23.80	114.8	11.20	69.00
		45.80	58.20	77.30	67.30	70.4	55.40	31.60

Table 3: Discard estimates in terms of biomass ($tons$) and associated CV in recent years for VI-VII and VIIIc-IXa

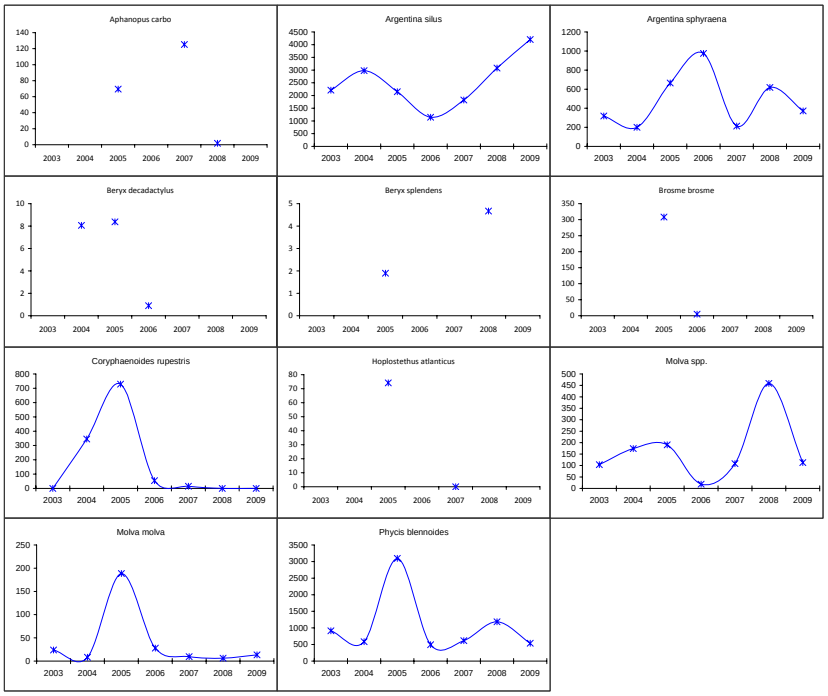

Figure 1: Biomass discarded ($tons$) of deep species in ICES VI, VII

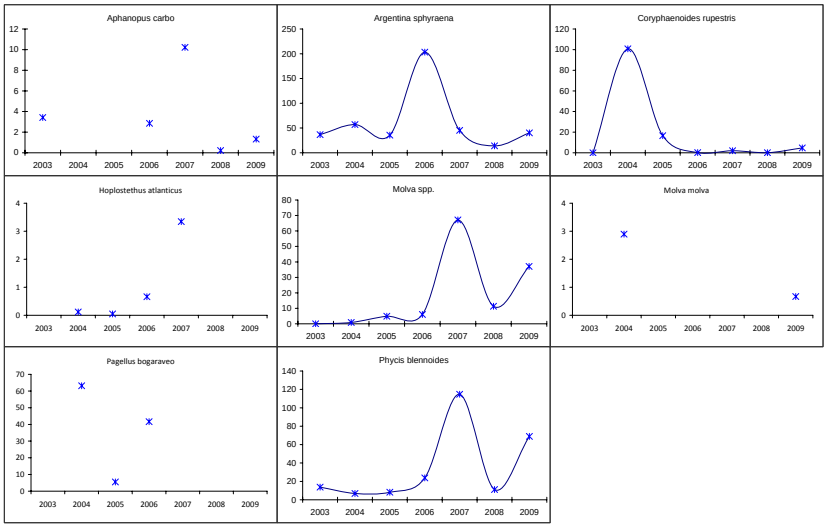

Figure 2: Biomass discarded ($tons$) of deep species in ICES $VIII_c$, North IX_a

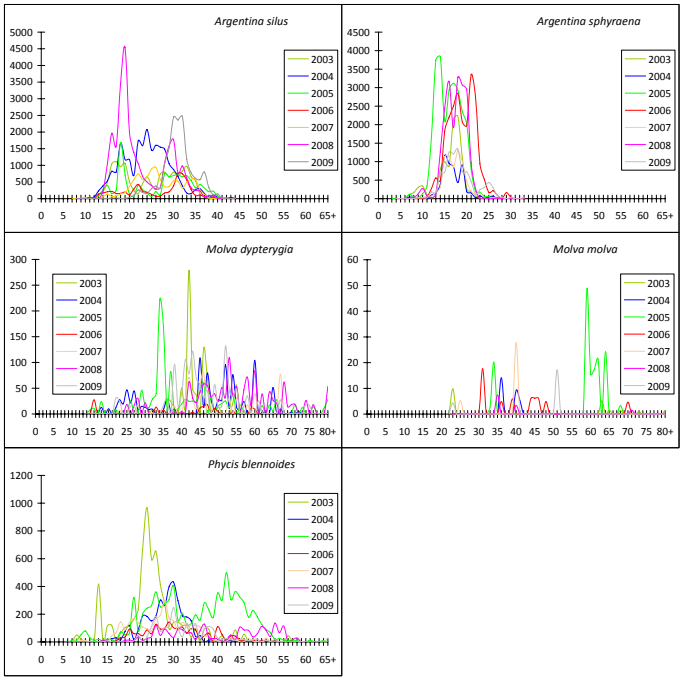

Figure 3: Annual length size distribution (n) for deep species in ICES VI, VII

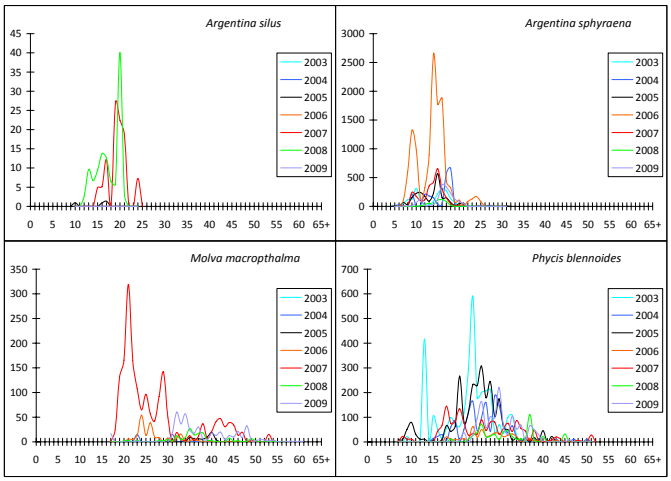

Figure 4: Annual length size distribution (n) for deep species in ICES $VIII_c$, North IX_a

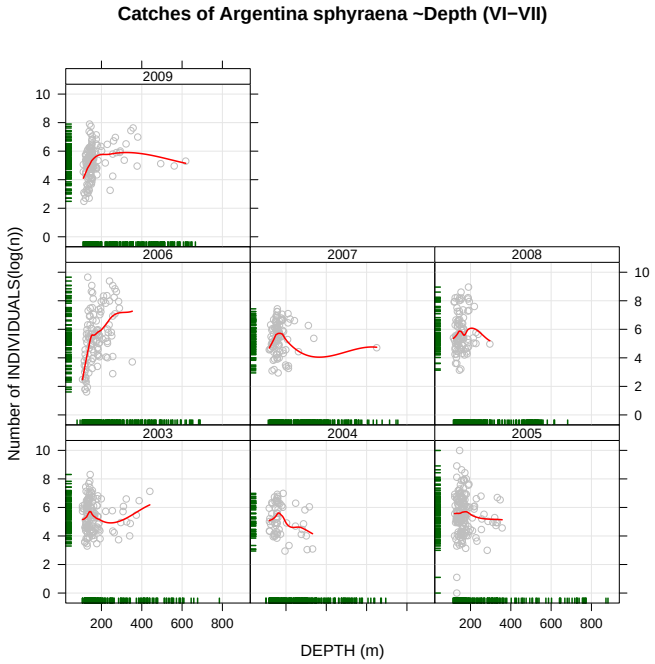

Figure 5: Catches of Silver Smelt by setting depth and year (VI-VII)

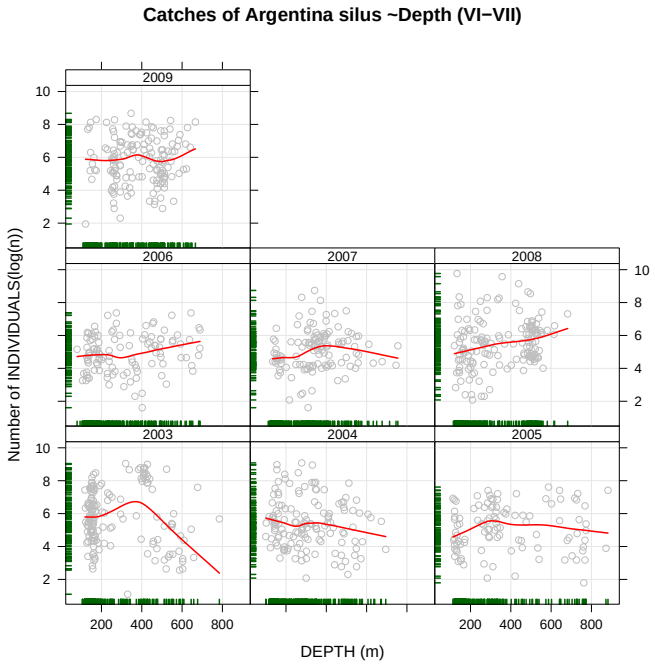

Figure 6: Catches of Greater Silver Smelt by setting depth and year VI-VII)

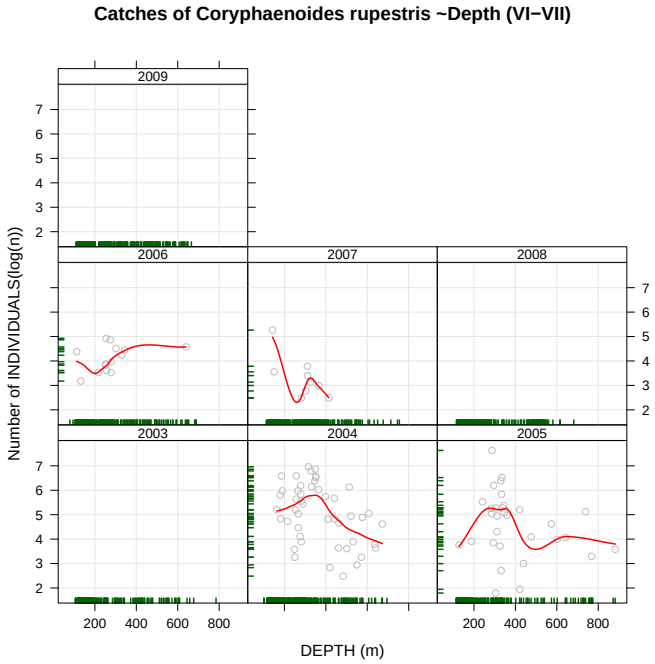

Figure 7: Catches of Roundnose Grenadier by setting depth and year (VI-VII)

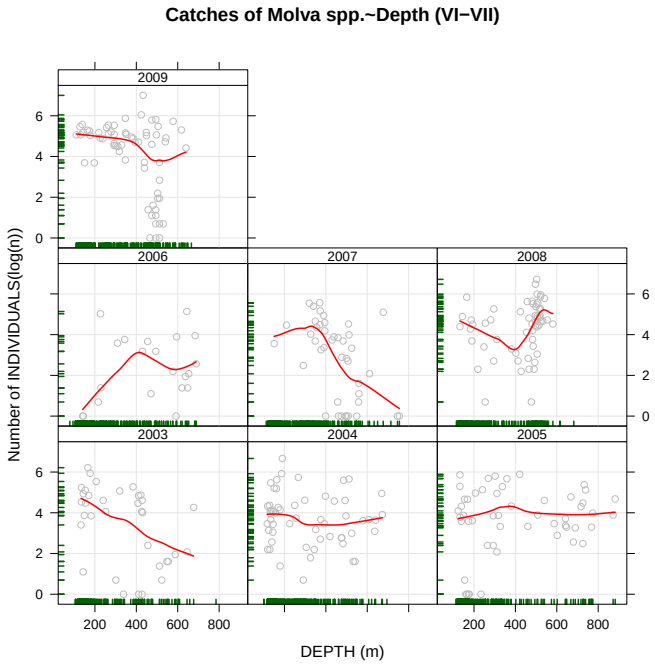

Figure 8: Catches of Molva spp. by setting depth and year (VI-VII)

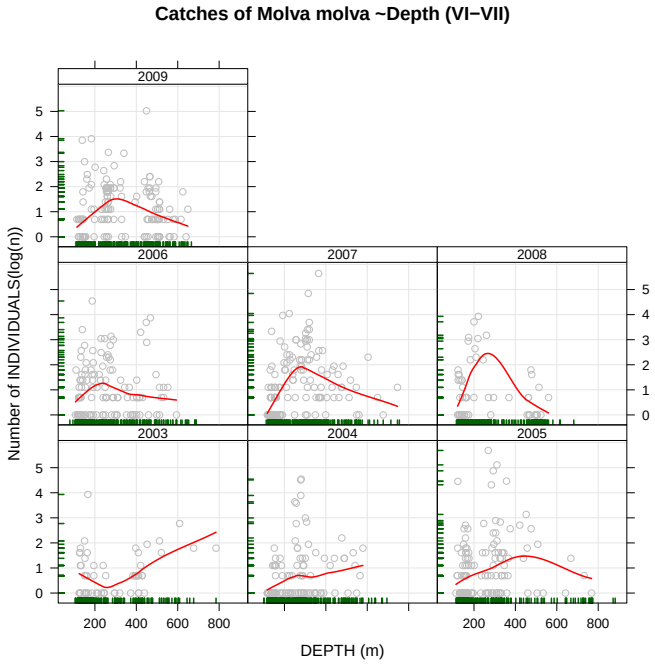

Figure 9: Catches of Ling by setting depth and year (VI-VII)

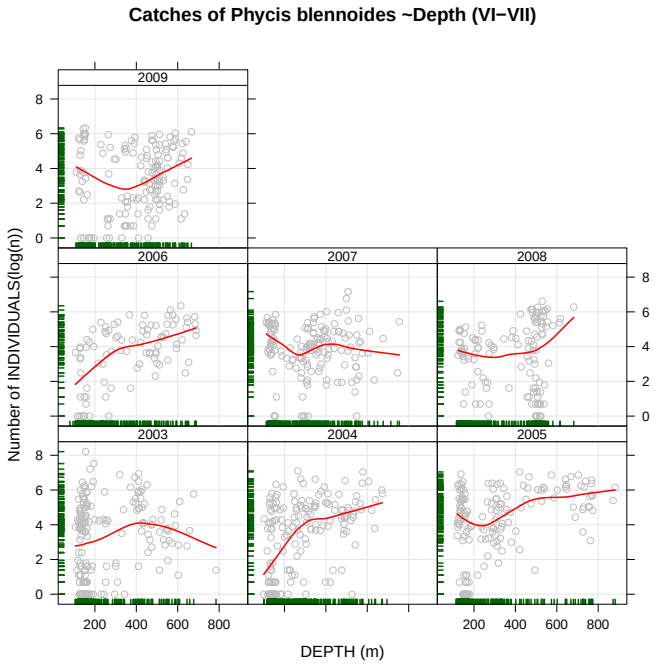

Figure 10: Catches of Greater Forkbeard by setting depth and year (VI-VII)

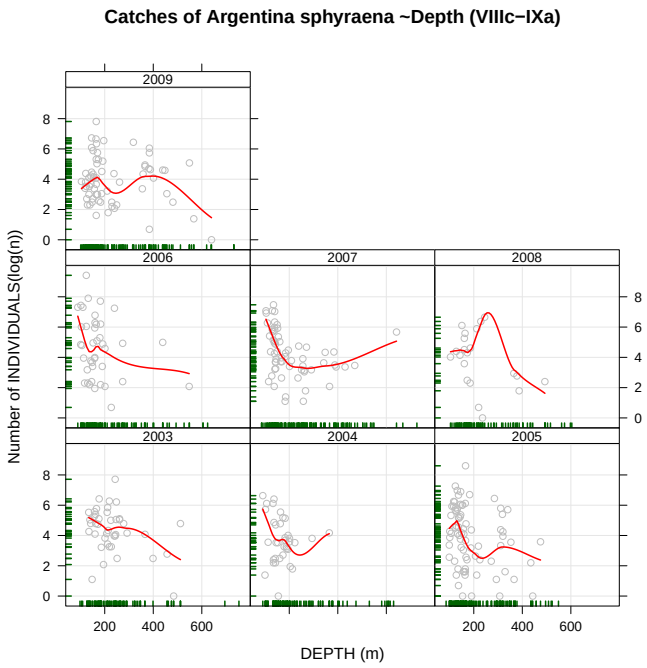

Figure 11: Catches of Silver Smelt by setting depth and year ($VIII_c$-North IX_a)

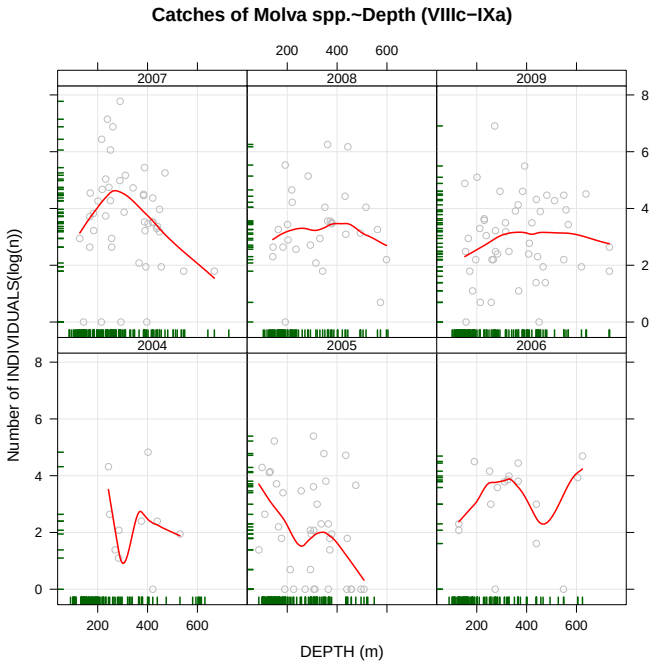

Figure 12: Catches of *Molva spp.* by setting depth and year ($VIII_c$-North IX_a)

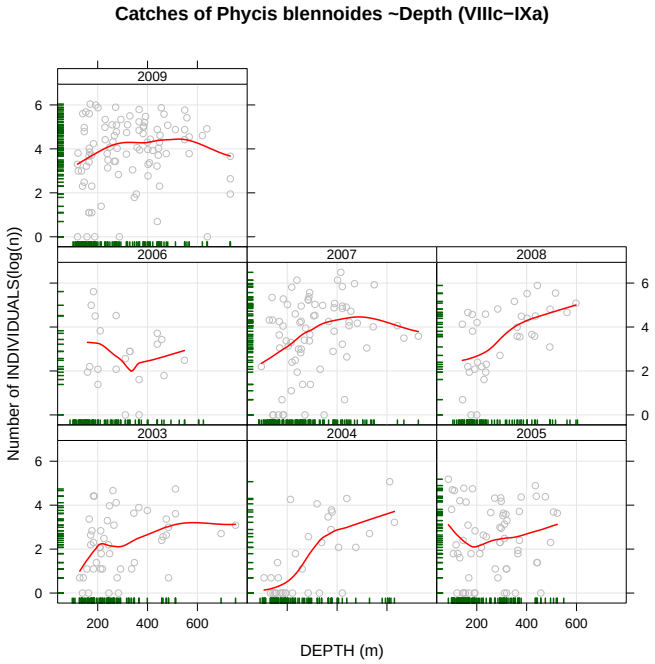

Figure 13: Catches of Greater Forkbeard by setting depth and year ($VIII_c$-North IX_a)

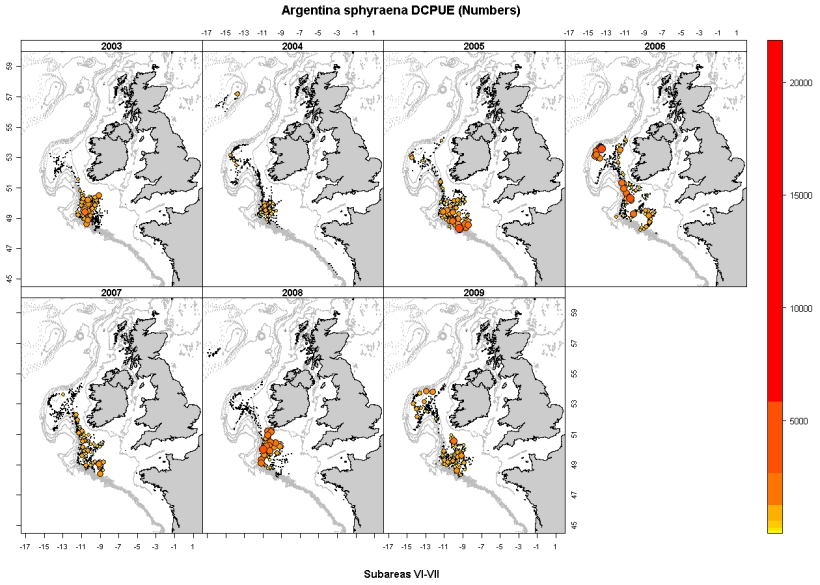

Figure 14: Spatio temporal trends of Silver Smelt discards (VI-VII))

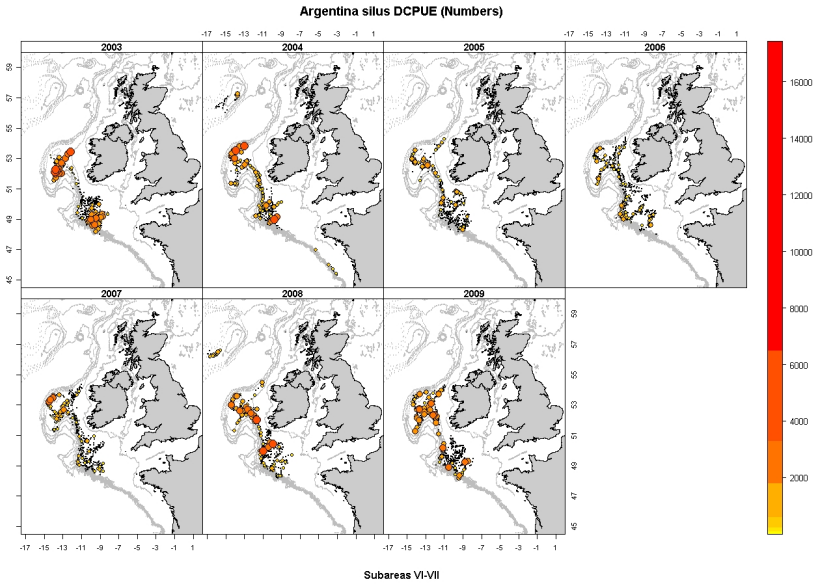

Figure 15: Spatio temporal trends of Greater Silver Smelt discards (VI-VII))

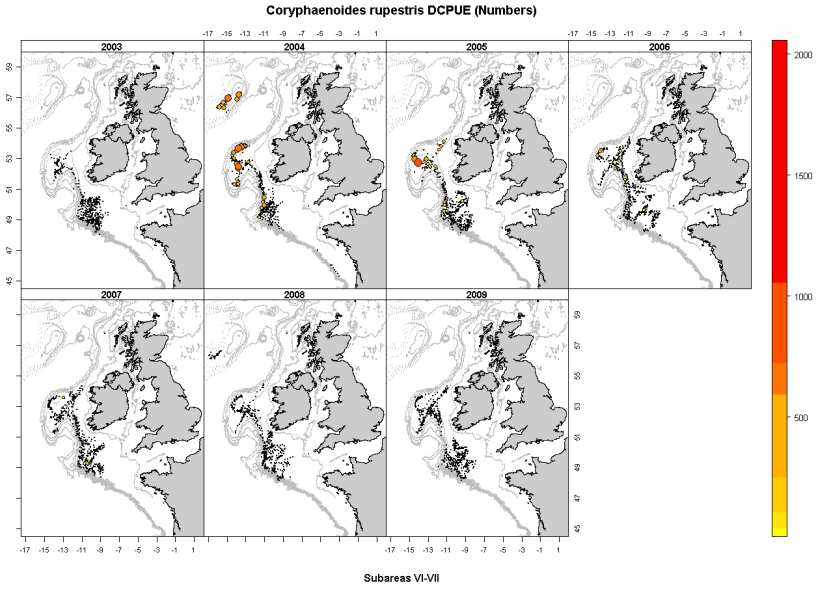

Figure 16: Spatio temporal trends of Roundnose grenadier discards (VI-VII))

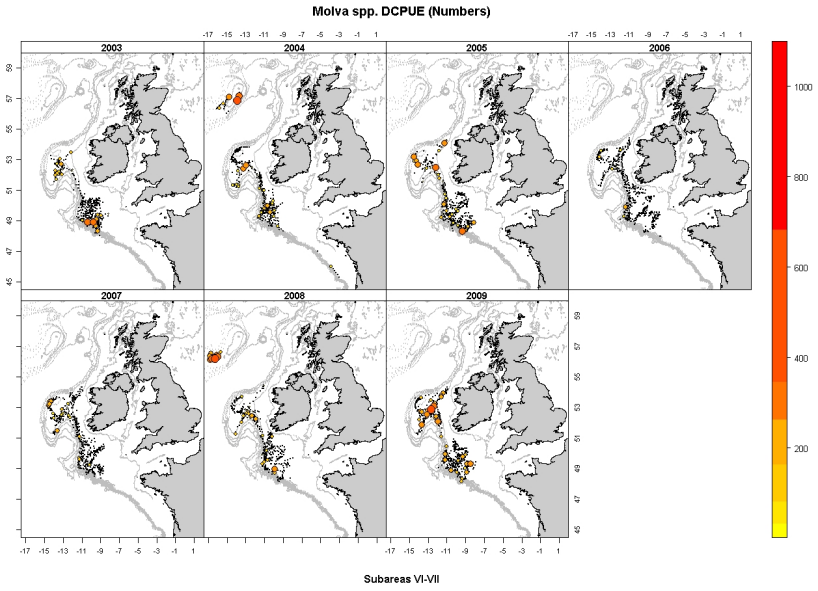

Figure 17: Spatio temporal trends of *Molva spp.* discards (VI-VII))

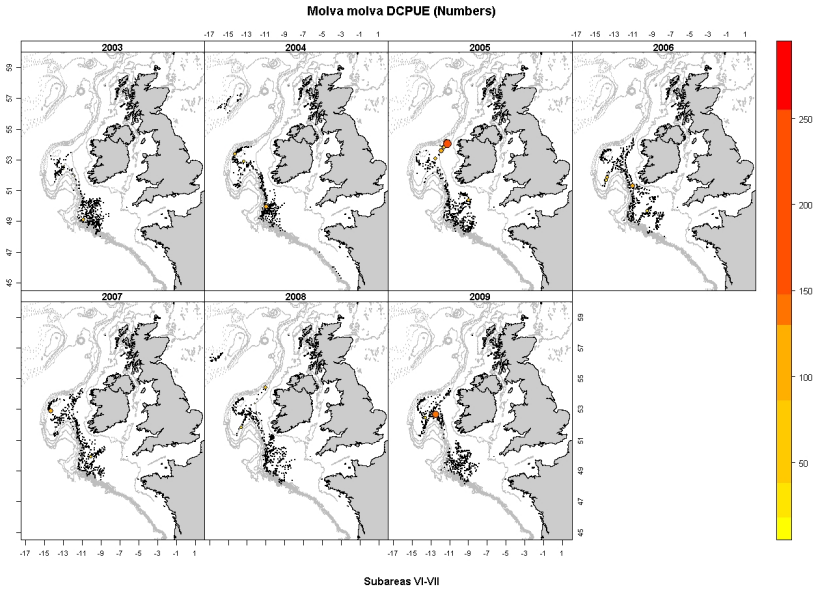

Figure 18: Spatio temporal trends of Ling discards (VI-VII))

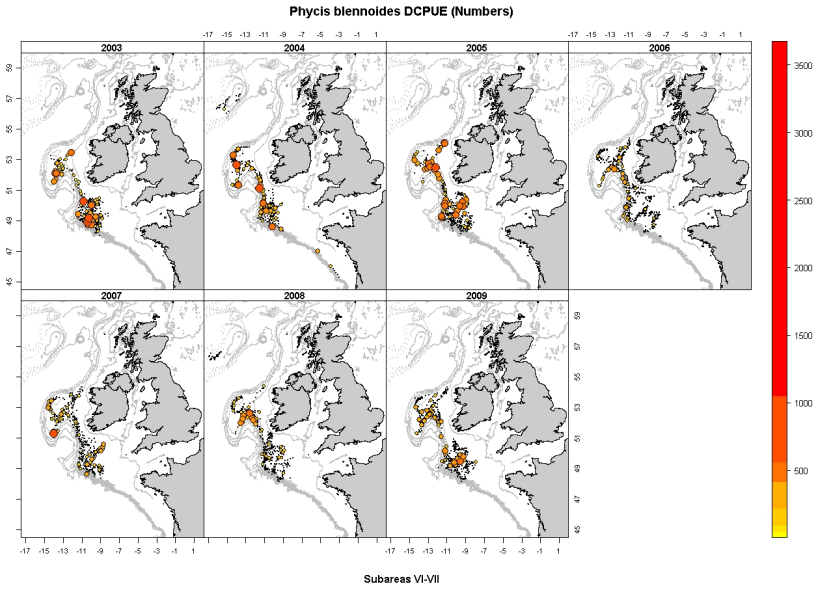

Figure 19: Spatio temporal trends of Greater Forkbeard discards (VI-VII))

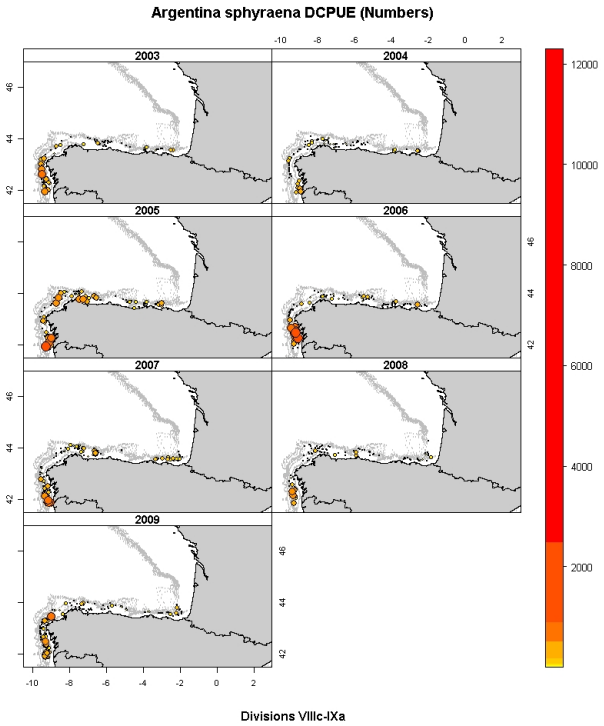

Figure 20: Spatio temporal trends of Silver Smelt discards ($VIII_c$-IX_a)

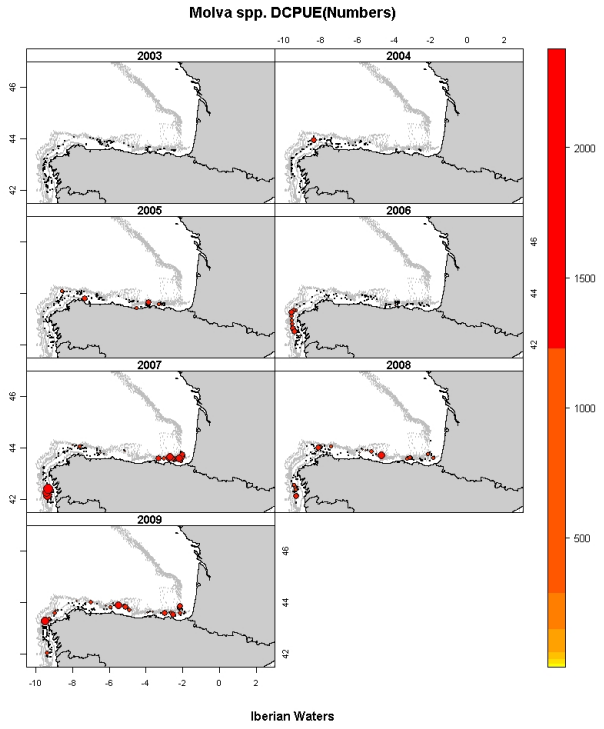

Figure 21: Spatio temporal trends of *Molva spp.* discards ($VIII_c$-IX_a)

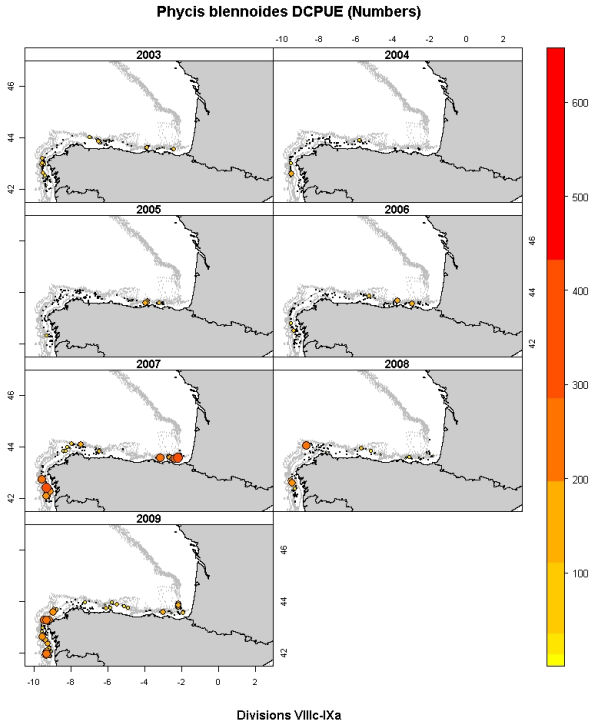

Figure 22: Spatio temporal trends of Greater Forkbeard discards ($VIII_c$-IX_a)

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