https://doi.org/10.17895/ices.pub.18622016

Stock Annex: Blonde ray (*Raja brachyura*) in Division 9.a (Atlantic Iberian waters)

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Blonde ray
Working Group:	Working Group on Elasmobranch Fishes (WGEF)
Created:	
Authors:	
Last update:	2014
Last updated by:	

A. General

A.1. Distribution

Global distribution: *Raja brachyura* (blonde ray) is a coastal benthic species with a wide geographic distribution in the northeast Atlantic (Stehmann and Bürkel, 1984) being often found in sandbanks (Ellis *et al.*, 2005).

Species distribution in 9.a: The species is distributed along the entire area.

In the west of Galicia the species is found on sand and sand-rock bottoms along the coast at depths ranging from 20 to 120 m.

In the Portuguese continental waters the species occurs along the entire coast at depths ranging from 10 to 700 m (Figure 1), being more abundant at depths shallower than 200 m.

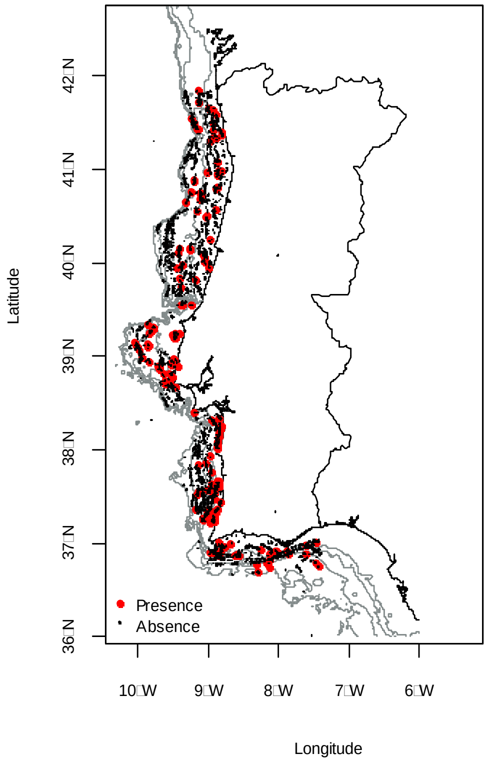

Figure 1 – Portuguese continental waters (ICES division 9.a). *Raja brachyura* distribution in Portuguese Autumn Groundfish Surveys (PT-GFS) and Winter Groundfish Surveys (PtGFS-WIBTS-Q1) from 1990 to 2013.

A.2. Species dynamics

In the west of Galicia no information on nursery or spawning areas is available. The length of specimens caught by the artisanal fleet varied from 26 to 116 cm suggesting that both juveniles and adults are present in this area.

In center off Portugal, the species lives preferentially in areas shallower than 100 m deep, showing different spatial dynamics according to its life stages (Serra-Pereira *et al.*, 2014). Most of the times the two sexes occur in equal proportions but spatial segregation by sex may exist. Nursery and egg deposition grounds are situated inshore, at different types of seabeds, which can vary from sandy to rocky bottoms. A seasonal variation in abundance of juveniles was registered - higher abundances are recorded during the 4rd quarter of the year, showing a temporal spatial overlap between egg-laying and nursery grounds. A higher abundance of adults is recorded during the 2nd quarter of the year, in more offshore grounds characterized by sand surrounding rocks. This different spatial pattern is likely to be related with migrations associated to reproduction; adults migrate to more inshore and shallow waters to reproduce.

A.3. Stock definition

The stock structure of the species along the all ICES areas is unknown. Migrations between different areas are admitted (ICES, 2013). For advice purposes, ICES considered a distinct stock unit for Division 9.a (west of Galicia, Portugal, and Gulf of Cadiz).

A.4. Fisheries

In the Western area of the Iberian Peninsula Rajidae species are usually caught as by-catch from other fisheries. In the past and in the north of Spain, there were direct fisheries to rays and skates. These fisheries mainly operated in coastal areas and inside estuaries, with a special gillnet called *raeiras* (DOG nº 31 15/02/2011). At the present there are no direct fisheries for skates and most of the landings come from the trawl fishery targeting other species (Rodriguez-Cabello *et al*., 2005). Total landings by the Spanish fleet in ICES Division 9.a (for all Rajidae species) increased from 1996 to 2001 up to 416 t and since them remained more or less stable showing fluctuations around 350 tones (Figure 3). In the coastal area inside Galicia estuaries an important artisanal fleet operates catching frequently Rajidae species using different types of gillnets, particularly *miño* (DOG nº 31 15/02/2011). Catches from the artisanal fleet represent around 8.7 % of Galician total landings (Bañón *et al*., 2008). *R. brachyura* and *R. montagui* are the main species caught with this gillnet (Bañón *et al*., 2008).

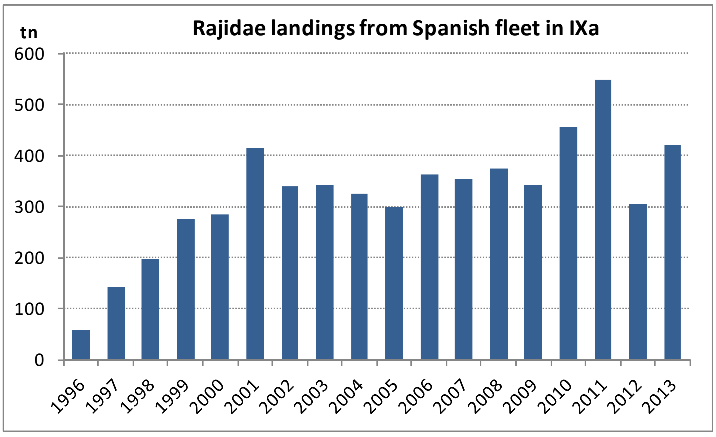

Figure 2 – West of Galicia (ICES division 9.a). Annual total landings (t) of Rajidae species from the Spanish fleet.

In the Portuguese continental coast Rajidae species are mainly landed by the polyvalent segment, which represents around 75% of the total landed weight, followed by the trawl segment that represents around 24%. The trawl segment is defined by vessels that operate wish mesh sizes of 55m, 65 or 70 mm. The Portuguese polyvalent segment includes vessels with length overall (LOA) ranging from 5 to 27 m which generally operate between 10 and 150 m deep and exhibit a multi-species and mixed fisheries, capturing a high diversity of species at different fishing grounds. This segment also includes vessels operating with trawl gear with mesh size of 32 cm, and, for analysis purposes, all trawl vessels with LOA smaller than 12 m irrespective of the mesh size. The latter were included in the polyvalent segment due to their different fishing pattern when compared to larger trawlers: fishing operations closer to the coast and daily trips. All these vessels can have more than one fishing gear (e.g. trammel nets, gillnets, longline, trawl, traps and/or pots) and consequently different fishing gears may be used in one fishing trip. Within the polyvalent segment, Rajidae are mainly caught by nets, i.e. trammel and gillnets; for the period between 2008 and 2013 the landed weight derived from nets represented 65 to 78% of the total landed weight, while longline and artisanal trawl represented 19- 24%, and up to 9% respectively.

In the Gulf of Cádiz area Rajidae are taken as by-catch of fisheries targeting demersal species.

A.5. Ecosystem aspects

In the west coast of the Iberian Peninsula the most important features enhancing primary production are coastal upwelling, coastal runoff and river plumes, seasonal currents and internal waves and tidal fronts. Maximum values of chlorophyll usually occur in spring and summer (Nogueira *et al.*, 1997; Moita, 2001), although high chlorophyll values may be recorded in autumn, particularly in zones with elevated retention characteristics; for example, high chlorophyll concentrations are found in the Rías Baixas, at the time of the seasonal transition from upwelling to downwelling (Nogueira *et al.*, 1997; Figueiras *et al.*, 2002). Most of the west Iberian coast, including Galicia and Cantabrian Sea continental shelf, is occupied by cold waters rich in nutrients (Gil, 2008).

The north-south orientation of the coast causes winds from the north to produce offshore transport. During spring and summer, northerly winds along the coast are dominant causing coastal upwelling and producing a southward current at the surface and a northward undercurrent at the slope (Figure 4a) (Fiúza *et al.*, 1982; Alvarez-Salgado *et al.*, 2003; Peliz *et al.*, 2005; Mason *et al.*, 2006). During winter the prevailing winds are mainly south-westerly, and the atmospheric circulation is dominated by eastward displacement of cyclonic perturbations and their associated frontal systems (Figure 4b) (Relvas *et al.*, 2007). However, in some years the presence of episodic atmospheric anti-cyclonic circulation (the Azores High) could give rise to northerly wind events during winter (Santos *et al.*, 2001; Borges *et al.*, 2003). Indeed, investigations on upwelling along the Galician coast in autumn and winter have been characterized in the Galician rias, indicating that the upwelling process along the Galician coast is not a phenomenon restricted to spring and summer (Alvarez *et al.*, 2012).

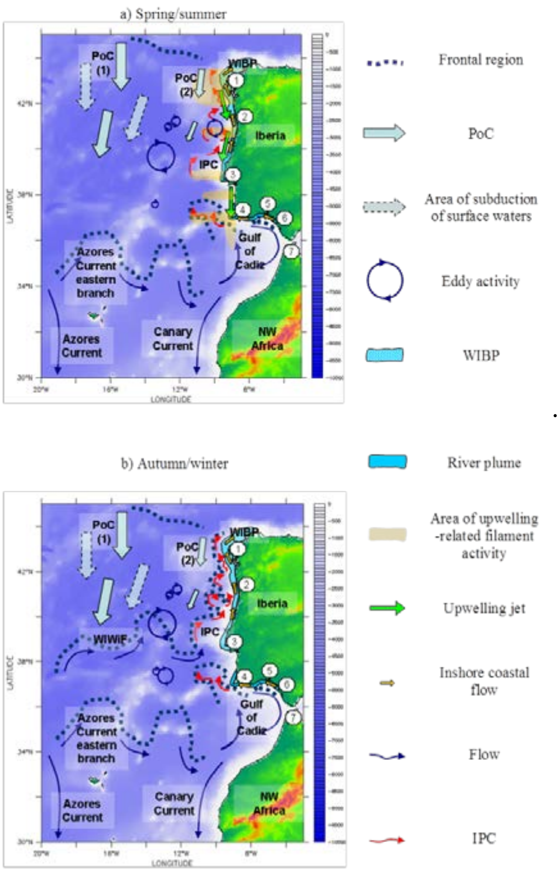

Figure 4 - The western Iberia and Gulf of Cadiz regimes in a) spring and summer, and b) autumn and winter. 1) Cape Finisterre; 2) River Douro; 3) Cabo da Roca; 4) Cape St. Vincent; 5) Guadiana River; 6) Guadalquivir River; 7) Strait of Gibraltar. PoC - southward-flowing Portugal Current, WIBP - Western Iberia Buoyant Plume, IPC - Iberian Poleward Current (Adapted from Peliz *et al.* 2002; Peliz *et al.* 2005).

In winter the Poleward Current (PC) flows northerly. It is a salty surface current (about 200 m deep) of subtropical origin (Eastern North Atlantic Water, also known as the 'Navidad' Current, since because it starts to be evident near Christmas and New Year) and relatively warmer than the surrounding ones (Castro *et al.*, 2011). During winter and spring, the PC results in a convergent front at the boundary between coastal and oceanic water. When saline intrusion is weak, the development of fronts and the formation of a seasonal thermocline are enhanced, leading to phytoplankton blooms. When saline intrusion is intense, strong vertical mixing occurs and prevents phytoplankton growth in spring (Moita, 2001; Santos *et al.*, 2004).

The intermediate deep layers are mainly occupied by a poleward flow of Mediterranean Water (MW), which contours the southwestern slope of the Iberia (Ambar and Howe, 1979), generating the mesoscale features called Meddies. The MW along the west coast of the Iberian Peninsula is characterized by a transport of warm and salty water (typical surface anomalies, 1–1.5ºC and 0.1–0.3‰ in salinity) with velocities up to some 0.2–0.3 m s^{-1} reported by Frouin *et al*. (1990).

The Sea Surface Temperature (SST) registered a generalized warming of a few hundredth of degrees a year since 1960, ranging from 0.015°C/year to 0.037°C/year (Relvas *et al.*, 2009). The SST increase has effect on species populations (e.g. recruitment success, migrations changes) (Brander *et. al*., 2003).

In the Gulf of Cadiz the most important oceanographic process is the occurrence of a strong interaction between two masses of water, the Atlantic Ocean and the Mediterranean Sea through the Strait of Gibraltar. In general, the exchange of water masses through Strait of Gibraltar is guided by the highly saline and warm Mediterranean Outflow Water near the bottom, and the turbulent, less saline, cool-water mass of the Atlantic Intermediate Water at the surface. The pattern of surface circulation is ruled by a clockwise movement, with a general W to E superficial current, whereas the deep circulation is controlled by the westerly current of the highly saline (salinity>37 PSU) Mediterranean water existing through the Strait.

Bottom temperatures are extremely variable ranging between 3ºC and 20.6ºC whereas values of bottom salinity along the continental shelf range from 35.8 to 36 PSU (Díaz *et al.*, 2006). In the slope there is a wide band with values around 37 PSU, the lower slope showing the minimum values which correspond to the Deep Atlantic Water Mass (Díaz *et al.*, 2006).

The continental slope can be differentiated into four provinces: a) a narrow belt between 130 and 400 m formed by the steep upper slope; b) two gently dipping wide terraces located between 400 and 700 m depth; c) a central sector between the terraces in which several, steep and narrow curvilinear ridges and valleys are located trending NE-SW to E-W; d) the lower slope-upper continental rise at water depths from 900 down to 1500-1800 m. Below 900 m, the lower slope is steeply dipping and generally smooth except for shallow valleys placed in a NE-SW direction (Nelson *et al.*, 1993). The main sedimentary types occurring over the slope are bioclastic sands, silicoclastic sands and muddy sands, sandy muds, sandy and muddy contourites (Díaz *et al.*, 1985).

B. Data

B.1. Commercial landings and discards

Due to the sampling methodology based on métier it has not been possible to separate accurately the discards made by the Spanish trawl fleet in Galicia and Cantabrian Sea (8.c and 9.a). Annual fluctuations were observed with 7.7 t discarded in 2013 (Table 1).

Table 1. Galicia and Cantabrian Sea (ICES divisions 8.c and 9.a). Estimates of discard (t) of *Raja brachyura* (bold) and of their coefficient of variation (in italics) in Iberian waters (8.c-9.a) from the Spanish bottom trawl fishery.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Raja brachyura	**0,1**	**90,8**	**1,2**	**11,6**	**31,6**	**2,1**	**10,4**	**6,0**	**34,1**	**5,5**	**7,7**
	99,8	*50,6*	*63,9*	*92,7*	*59,2*	*47,8*	*43,8*	*54,8*	*68,5*	*65,1*	*49,1*

Data used to estimate Portuguese landings by species were derived from the DCF skate pilot study that aimed to establish sampling statistical procedures and to define estimators to calculate inputs for stock assessment purposes. During the period 2008-201, *R. brachyura* represented between 11 and 20% (116.5 to 177.3 t) and between 5 and 13% (15.7 to 46.8 t) of the total skates landed weight by the polyvalent and the trawl segments, respectively (Table 2). In 2013 the estimated landed weight was about 165 t for the polyvalent and 21 t for the trawl segment.

Table 2 – Portuguese continental waters (ICES division 9.a). *Raja brachyura* annual estimates of landed weight, number of vessels and number of trips by fishing segment (polyvalent and trawl); period from 2008 to2013

	Polyvalent segment			Trawl segment		
Year	No. vessels*	No. trips*	Landed weight (ton) (%RJH/Skates)	No. vessels*	No. trips*	Landed weight (ton) (%RJH/Skates)
2008	1444	36149	165.2 (15%)	81	6513	27.7 (8%)
2009	1412	36239	116.5 (11%)	69	5683	46.8 (12%)
2010	1389	34767	177.3 (16%)	59	5461	43.7 (13%)
2011	1289	36761	143.2 (13%)	60	5139	17.6 (5%)
2012	1240	32565	149.1 (18%)	54	5158	15.7 (6%)
2013	1172	28007	164.7 (20%)	51	4658	20.5 (8%)

*** estimates for all skates combined**

Raja brachyura is mainly landed in the center (*Centro*) and Lisbon (*Lisboa e Vale do Tejo*) regions by both polyvalent and trawl segments (Figure 4).

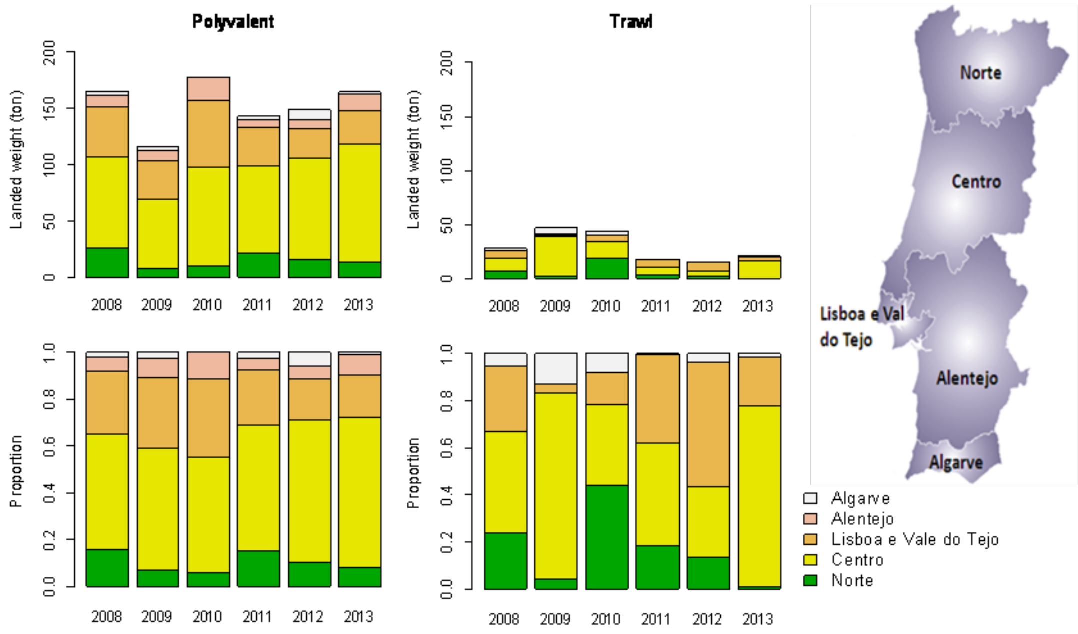

Figure 4 - Portuguese continental waters (ICES division 9.a). ***Raja brachyura*** **landing weight and percentage by major region (NUTSII regions) and fishing segment.**

For the polyvalent segment and during the period 2008-2013, the landing estimates of *R. brachyura* at the five most important landing ports (Póvoa do Varzim, Matosinhos, Peniche, Sesimbra and Setúbal) represented 50 to 54% of the total landed weight of the species. In these landing ports *R. brachyura* is mainly caught by nets, followed by longline and artisanal trawl (Table 3).

Table 3 - Portuguese continental waters (ICES division 9.a). ***Raja brachyura*** **(2008-2013) for the group of landing ports comprising Póvoa do Varzim, Matosinhos, Peniche, Sesimbra and Setúbal - Number of vessels, number of trips in which the species occurred and landing estimates by fishing gear (nets, longline and trawl) of the polyvalent segment. Last column refers to trips for which no information on the fishing gear used is available.**

	Nets			Longline			Artisanal trawl			NA	
Year	No. vessels	No. trips	Landed weight (ton)	No. vessels	No. trips	Landed weight (ton)	No. vessels	No. trips	Landed weight (ton)	No. vessels	No. trips
2008	258	9725	49.0	84	1558	14.3	10	355	4.4	54	235
2009	230	7501	44.6	91	1601	5.6	5	276	2.1	47	157
2010	256	9303	80.6	65	704	4.4	4	361	4.0	33	163
2011	146	6168	68.9	40	388	2.2	13	658	6.6	34	171
2012	236	9049	71.0	47	509	1.8	12	476	4.4	21	107
2013	194	6458	66.3	23	200	1.1	5	409	10.3	3	3

Discards information on *R. brachyura* from the Portuguese polyvalent and bottom otter trawl segments operating in the ICES Division 9.a has been collected by the Data Collection Framework (EU DCR). Two polyvalent fisheries (trammel nets operating deeper than 150m and nets which include both trammel and gillnets, operating shallower than 150m) and two bottom otter trawl fisheries (crustacean fishery and demersal fish fishery) were analyzed. The information available is insufficient to reach robust estimates of discards so preliminary results are presented in Table 4.

Table 4 - Portuguese continental waters (ICES division 9.a). ***Raja brachyura*** **number of sampled hauls, number of hauls where the species occurred, probability of the species be caught in a haul and a specimen be discarded (p_{CD}) and expected number of discarded specimens per haul per fishery. Polyvalent segment: i) nets operating at depths shallower than 150 m (i.e. trammel and gillnets) and ii) trammel nets operating deeper than 150 m. Trawl segment: i) Crustacean Fishery and ii) Demersal Fish Fishery.**

	Polyvalent Segment	Trawl Segment	
	Nets <150 m deep	Crustacean Fishery	Demersal Fish Fishery
nº of sampled hauls	41	665	1162
nº of hauls in which the species occurred	15	3	17
p_{CD}	0.04	0.005	0.01
Expected number of discarded specimens per haul	4	3	1

In the Gulf of Cadiz, ray and skate catch and landing data from commercial fisheries are deficient because there is a general lack of species-specific recordings. No management program has been established yet in this area. Research on resources from this area has traditionally been focused on the most commercially important teleosts and few studies on chondrichthyans have been undertaken.

B.2. Length frequency distribution

In the west of Galicia (ICES Division 9.a) no length data from the Spanish bottom trawl surveys is available. Biological data collected from specimens caught by the artisanal fleet (mainly *miño* gillnets) in Galicia coastal area shows that length range from 26-116 cm with a mean length of 66 ± 20 cm (Table 5).

Table 5 - West of Galicia (ICES division 9.a). Length range (cm) , mean length plus and minus standard deviation (s.d.) of ***Raja brachyura*** **.**

	Male		Female		Total	
	Range	Mean (±SD)	Range	Mean (±SD)	Range	Mean (±SD)
R. brachyura	30-112	67 ± 19	26-116	65 ± 18	26-116	66±20

In Portuguese continental waters (ICES division 9.a), length frequency distributions of *R. brachyura* at the five main landing ports (Póvoa do Varzim, Matosinhos, Peniche, Sesimbra and Setúbal) are presented in Figure 5 for nets and longline separately. Length frequency distributions were built with no extrapolation to the total estimated landed weight of the species. The length distribution and the ranges of length are similar between the two gears and among years.

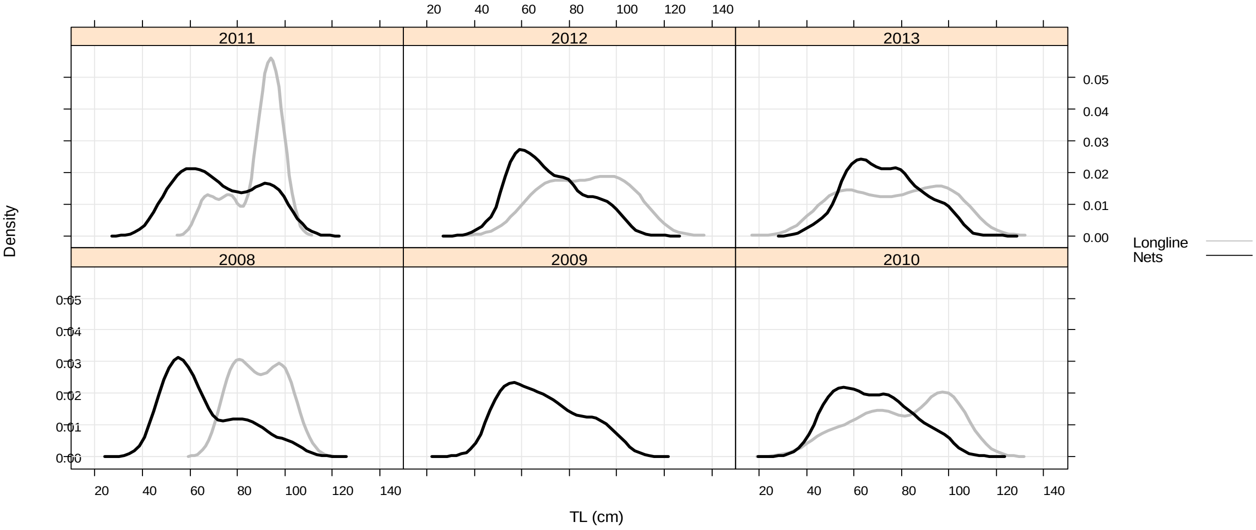

Figure 5 - Portuguese continental waters (ICES Division 9.a). Length frequency distributions of *Raja brachyura* (2008-2013) by fishing gear (nets and loglines).

B.3. Survivorship

Under the scope of the EU DCF skate pilot study carried out in mainland Portugal, data on survivorship of *R. clavata* after fishing was collected onboard fishing trips of polyvalent vessels operating with trammel or gillnets. Survivorship was qualitatively evaluated by assuming that the health status of fish after capture is a good indicator of the survivorship index (Enever *et al.*, 2009). The following scale was used to assign health status to each sampled individual (Enever *et al.*, 2009): 1) Good: vigorous wing/body movement and rapid spiracle movement; 2) Moderate: limp wing/body and spiracle movement and; 3) Poor: dead or nearly dead, no body movement, slight spiracle movement. In general, this species presents high levels of survivorship.

There are no studies on skates survivorship neither in the west of Galicia nor in the Gulf of Cadiz.

B.4. Commercial LPUE

The index of abundance of *R. brachyura* was estimated for the Portuguese polyvalent segment as the landed weight of the species per trip (fishing effort unit), LPUE, using official commercial data. In the polyvalent segment, landings from trips in which nets were used as fishing gear are relatively more important in terms of landed weight than longline. Since no major differences on length structure of the specimens caught among the two fishing gears are observed, it is admitted that the standardized LPUE using fishery data derived from nets are representative of the polyvalent segment.

B.5. Biological

In Portuguese continental waters, size-at-first-maturity of *Raja brachyura* is 97 cm for females and 88 cm for males. Reproduction occurs between March and July (Pina-Rodrigues, 2012). Juveniles and adults prey on a variety of bony fishes as *Gymnammodytes semisquamatus*, polychaetes, mysids and shrimps (Farias et al. 2006).

B.6. Surveys

The surveys available for this area were not designed primarily to inform on the populations of *R. brachyura*, which presents a patchy and shallower distribution. The gears used, timing of the surveys and distribution of sampling stations are considered not optimal for informing on the species and/or life-history stages.

C. Assessment: data and method

C.1. Data:

Fishery dependent data:

- Landings estimates by species
- Fishing effort (unit: number of fishing trips) by fishing gear
- Length frequency distribution for the polyvalent fishing segment
- Discards

C.2. Methods:

1. Landings estimates by species for polyvalent and trawl segment in Portuguese continental waters

For each year y and landing port p, the landing estimates of each species were estimated based on the proportion of the species by sampled trip. A weighted proportion $\widehat{pa}_{(y,p)}$ was determined as:

$$\widehat{pa}_{(y,p)} = \sum_{i=1}(pa_{(y,p)i} \times w_{(y,p)i}) \Big/ wt_{(y,p)}$$

where the $pa_{(y,p)i}$ is the proportion of the species at the i^{th} fishing trip, $wt_{(y,p)}$ is the landed weight of skates in the i^{th} fishing trip and $w_{(y,p)i}$ is the total landed weight of skates in all the sampled trips at landing port p in year y. The estimate of the variance of $\widehat{pa}_{(y,p)}$is determined as:

$$var(\widehat{pa}_{(y,p)}) = \frac{1}{\left(wt_{(y,p)}\right)^2} \frac{\sum_{i=1}\left(\left(w_{(y,p)i}\right)^2 . pa_{(y,p)i}(1 - pa_{(y,p)i})\right)}{n_{(y,p)} - 1}$$

where $n_{(y,p)}$ is the number of sampled trips for the y year and p landing port.

For the selected species the total landed weight $\widehat{w}_{(y,p)}$ () in landing port p and year y was calculated as:

$$\widehat{w}_{(y,p)} = \widehat{pa}_{(y,p)} \times W_{(y,p)}$$

where $w_{(y,p)}$ is the total landed weight of skates.

At landing ports for which fishing effort was estimated by group (groups correspond to set of vessels determined as function of vessel size, seasonality in fishing skates and fishing gear), the proportion of the species for the year y, port p and group g were obtained as:

$$\widehat{pa}_{(y,p,g)} = \sum_{i=1}(pa_{(y,p,g)i} \times w_{(y,p,g)i}) \Big/ wt_{(y,p,g)}$$

where $pa_{(y,p,g)i}$ is the observed proportion of the species in i^{th} fishing trip, $w_{(y,p,g)i}$ is the landed weight of skates in the i^{th} fishing trip and $wt_{(y,p,g)}$ is the total landed weight of skates in the sampled trips. The variance of $\widehat{pa}_{(y,p,g)}$ was estimated in the same way as for $\widehat{pa}_{(y,p)}$.

The total landed weight of the species $\widehat{w}_{(y,p)}$ in landing port p and year y was calculated as:

$$\widehat{w}_{(y,p)} = \sum_g \widehat{pa}_{(y,p,g)} \times W_{(y,p,g)}$$

Note that when there were gaps of information to estimate the proportion, the median of the proportion estimates for the previous 3 years was assigned to the gaps.

2. Fishing effort (unit: number of fishing trips) by fishing gear for the main landing ports in Portuguese continental waters

The fishing effort by fishing gear for each main landing ports was estimated using a stepwise procedure that has been already described by Maia *et al.* (2013 WD) and that can be summarized as:

Step 1

Definition of homogeneous groups of vessels characterized by sharing similar fishing regimes, according to: a) vessel size further subdivided into small, medium or large that corresponds to 25%, 50% and 75% quartiles of the vessel's LOA; b) seasonality pattern, that includes three levels "occasional", "seasonal" or "constant". Seasonality levels were established based on: i) the number of trips with positive landings of skates, ii) the total landed weight of skates, and iii) the frequency of months of activity with skates.

Step 2

Definition of discriminant rules later used to assign the fishing gear to fishing trips for which the fishing gear was not known. The discriminant rules were established through the application of the flexible discriminant analysis (FDA; Leisch *et al.*, 2009) to the interview data collected from each sampled trip. In the FDA the input data matrix include: i) the relative weight and value, in each fishing trip, of the main accompanying species or genera by gear, ii) the group assigned to each trip in Step 1); and iii) fishing licences for each vessel. The data were previously transformed through factor analysis for mixed data (Pages J. 2004; Le *et al.*, 2008). This procedure involves the data transformation of qualitative and quantitative variables that will later constitute the input data matrix of FDA. The selected main accompanying species corresponded to the top five species in terms of occurrence, of landed weight and of value in the sampled trips.

3. Standardized LPUE for the polyvalent fleet using nets in Portuguese continental waters s

In the standardization process of LPUE, a stepwise generalized linear model (GLM) procedure was applied to find the best GLM model and to estimate LPUE index time series based on the relationship between LPUE vs. available predictive factor variables.

The function bestglm implemented in R software was used to select the best subset of inputs variables (McLeod and Xu, 2010). The selection was based on a variety of information criteria and their comparison, following a simple exhaustive search algorithm (Morgan and Tatar, 1972). This algorithm uses a lexicographical method that evaluates the loglikelihoods for all possible glm models. Lognormal error distribution was assumed in the standardization. This distribution is commonly assumed for standardizing catch and effort data, assuming that the expected value of a transformed response variable is related to a linear combination of exploratory variables (Maunder and Punt, 2004).

Different diagnostic plots, e.g. the distribution of residuals and the quantile-quantile (Q-Q) plots, were used to assess the error distribution (assuming lognormal distribution), as well as the model fits for the standardization of the LPUE. Changes in deviance explained by the selected model and the proportions of deviance explained to the total explained deviance was determined and used as indicative of r^2.

The standard errors of the year effects and LPUE for a reference condition, in the present case: nets as fishing gear, large vessel size and constant seasonality landing in the Peniche fishing port, were calculated by the delta method. The delta method is commonly applied when functions are too complex for analytically computing their variance. According to this method, a linear approximation of the function, usually with a one-step Taylor approximation, is firstly obtained and then its variance is computed (Oehlert, 1992). In the polyvalent segment, landings from trips in which nets were used are relatively more important than those from longlines. Since no major differences on length structure of the specimens caught among the two fishing gears are observed, it is admitted that the standardized LPUE using fishery data derived from nets are representative of the polyvalent segment.

4. Length-based yield per recruit

Length data collected under the DCF sampling program on the main landing Portuguese ports for skates from both polyvalent and trawl fleets, were used to estimate an estimated of total fishing mortality (Z). Length compositions were raised to the total landed weight of *R. brachyura* from polyvalent and trawl fisheries. However given the fact polyvalent fleet represents nearly 85% of the total landing of the species a length based catch curve proposed by Cadima (2003) was applied to this segment.

Since no major changes on the length structure of the exploited population among years within the period 2009-2013 nor changes on fishing regime on vessels catching this species were evidence it as assumed a steady state- A combined length frequency distribution was considered for the whole period (Figure 6). The mean annual catch by length, class of 3 cm interval, was used as input data.

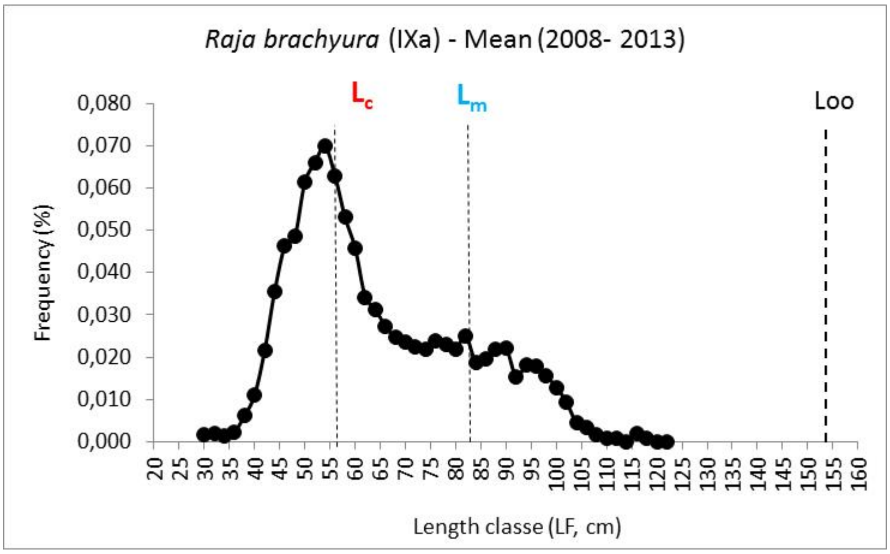

Figure 6 - Length frequency data of *Raja brachyura* catches from the Portuguese polyvalent fleet with indication of length of first capture (Lc) and Length of first capture to the fishery (Lm).

The Beverton-Holt yield-per-recruit model approach (Beverton and Holt, 1957) was used to calculate yield-per-recruit curves following the formulation suggested by Cadima (2003) which accounts for the exploitable spawning biomass. Input data used in the analysis is summarized on following table (Table 6).

Table 6 - Input data used in the yield-per-recruit analysis.

Parameters	Value	Definition
Loo (cm)	154,7	Assymptotic average maximum length
K (year^{-1})	0,129	Growth coefficient of the Von Bertalanfy growth model
To (year^{-1})	-0,84	Hypotetical age at which the species a zero length
a=	0,0020	Condition factor parameter of length-weight relationship
b=	3,20	Slope parameter of length-weight relationship
Lmax (LT, cm)	147	Maximum length usualy oberved on the population.
Lr (LT,cm)	42	Length of recruitment to the fishing area
Tr (year^{-1})	1,6	Age of recruitment to the fishing area
Lc (LT, cm)	56	Length of first capture to the fishery (L50% from selectivity curve)
Tc (year^{-1})	3	Age of first capture to the fishery (age at L50%)
Lm (LF, cm)	83	Length of first maturity (Lm50% from the maturity ogive)
Tm (year^{-1})	5	Age of first maturity (age at Lm50%)
M	0,19	Natural mortality
Zcurrent	0,36	Current total fishing mortality
Lopt (LF)	103	Length class (L_{opt}) with the highest biomass in an unfished population
Tmax	22	Maximum age (age at Lmax)
c=Lc/Loo	0,36	Relative size at entry (Exploitation pattern).Usually=0.4 range 0.2-0.7.
cm=Lm/Loo	0,54	Relative size at maturity (Maturity ogive).
Fcurrent	0,17	Current fishing mortality (F=Z-M)
Ecurr=F/Z	0,47	Current exploitation rate

The total fishing mortality Z was estimated using the length-converted catch curve under the assumption of a steady-state for the *R. brachyura* population and Z constant throughout the life of a cohort. To correct from the fact that fish growth in length is not linear, but slows down as length and age increase, determining that older size groups contain more age groups than younger size groups. The approach here used is the one proposed by Ricker (1975, p. 33 and pp. 60–64).

The natural mortality (M) parameter was assumed as the mean value of estimates obtained following methods presented in table 7.

Table 7 - Natural mortality estimates according Hoening (1983), Alagaraja (1984), Pauly (1980), Gunderson and Dygert (1988) and Jensen (1996). M: considered natural mortality.

Hoenig (1983)	Alagaraja (1984)	Pauly (1980)	Gunderson & Dygert (1988)	Jensen (1996)	M
0.13	0.21	0.21	0.21	0.19	0.19

5. Discards

Information on discards has been collected by the Data Collection Framework (EU DCF/NP) for two main segments: bottom otter-trawl and polyvalent.

Information on bottom otter trawl discards derived from the Portuguese on-board sampling program started in 2003 that collects data, amongst other, on i) bottom otter trawl Crustacean fishery targeting deep-water rose shrimp, Norway lobster and blue whiting and; ii) bottom otter trawl demersal fish fishery targeting horse-mackerel, cephalopods and other finfish (Prista *et al.* 2013 WD). The programme is based on a quasi-random sampling of trips from a set of cooperative vessels known to operate in each target fishery. The protocol consists in sort a sample from the catch of each haul into a retained fraction and a discarded fraction following instruction by fishermen. Number, weight and length composition of each taxa in each fraction are recorded. The sampling protocol did not suffered significant changes between 2003 and 2013, apart from in 2011 that the size of catch samples doubled from one to two boxes and the within-trip selection of hauls was standardized to "at least, every other haul/segment" (see Prista *et al.* (2012) for more detail).

Information on polyvalent segment is obtained from two fisheries: i) net fisheries which includes the trammel or gillnets as fishing gear that operate at depths shallower than 150 m and target a multi-species complex and; ii) trammel nets fishery targeting anglerfish that operate at depth deeper than 150 m.

Data on net fisheries discards was obtained from the pilot study on the métiers where skates are caught. In this sampling scene all the hauls performed with nets (trammel or gillnets) were sampled. Collected information included: number, length and sex of all caught skate specimens caught, as well as, its final destination (landed or discarded). Information on trammel discards was derived from the pilot study on the Portuguese trammel nets fishery. The onboard protocol involve to sampling every hauls performed with trammel nets operating from 200 to 600 m deep. The information collected onboard consisted in total length of all individuals caught (identified at a species level) and categorization into discarded or retained individuals (for more detail see Moura *et al.* 2013 WD).

The procedure adopted for each fishery and for each skate species analyzed was similar and take into account the fact that the skates are not the target species for any fishery studied. The probability of the species be caught in a haul and a specimen of that species be discarded (p_{CD}) is determined as:

$$p_{CD} = p_C \times p_D$$

where p_C corresponds to the probability of the species be caught in one fishing haul and p_D is the probability of a specimen be discarded within the whole set of specimens caught in the sampled hauls.

The expected number of discarded specimens per haul $E[D]$ was calculated:

$$E[D] = \sum_{i=1}^{n} x_i \times p_i$$

where x_i is the number of discarded specimens at the i^{th} haul and p_i is the probability that a specimen is derived from i^{th} within the whole set of sampled hauls (n).

D. Software used:

All the data analysis was performed in R software (R Development Core Team, 2009).

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