Stock Annex: Cuckoo ray (*Leucoraja naevus*) in Division 9.a (Atlantic Iberian waters)

Stock specific documentation of standard assessment procedures used by ICES.

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

A. General

A.1. Distribution

Global distribution: *Leucoraja naevus* (cuckoo ray) is a species with a wide geographic distribution in the northeast Atlantic and Mediterranean (Stehmann and Bürkel, 1984; Ellis *et al*. 2005).

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

In Galicia waters the species is found along the continental shelf mainly between 70 to 200 m depth.

In the Portuguese continental waters *L. naevus* occurs along the entire coast at depths ranging from 30 m to 700 m (Figure 1), being more abundant in the south-west and southern regions at depths shallower than 500 m.

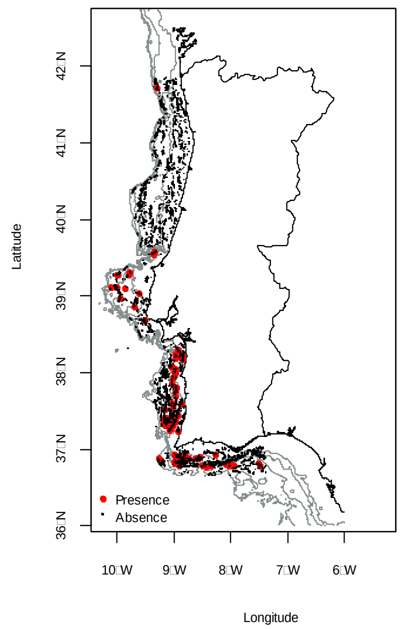

Figure 1 - Portuguese continental coast (ICES division 9.a). *Leucoraja naevus* distribution in Portuguese Groundfish Surveys (PT-GFS) and crustacesn surveys /Nephrops TV Surveys (PT-CTS (UWTV (FU 28-29)) from 1990 to 2013.

In the Gulf of Cadiz *L. naevus* occurs along the whole area at depths ranging from 50 to 800 m, being especially abundant in trawlable grounds placed in the southern area of the Gulf, in the range between 260 and 520 m depth (Figure 2).

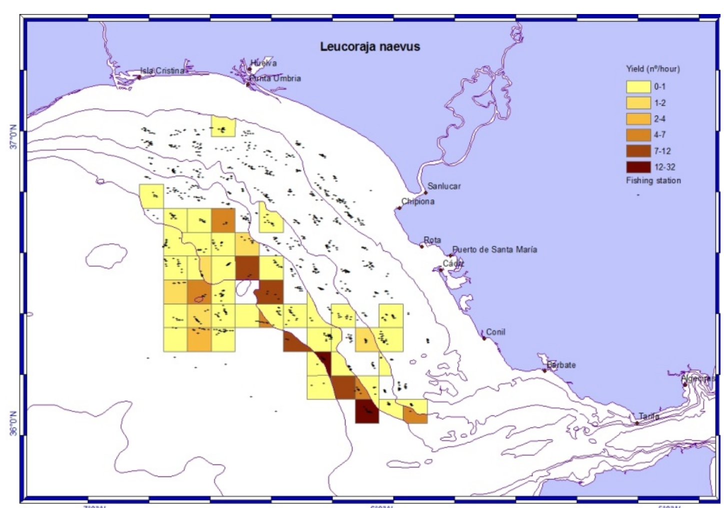

Figure 2 – Gulf of Cadiz (ICES division 9.a). *Leucoraja naevus* distribution and abundance index (no/hour) in the Gulf of Cádiz (from ARSA surveys 1993-2009, Q1 SP – GCGFS and Q4 SP - GCGFS).

A.2. Species dynamics

In the Cantabrian Sea *L. naevus* is most abundant in the central area in sedimentary grounds constituded mostly of sand and mud, contrary to the western region of Galicia where the species is less abundant.

In the center of Portugal, the species is more abundant in offshore grounds, situated at >100 m depth (Serra-Pereira *et al.,* 2014). Those areas are characterized by soft sediments, between mud and fine sand, often forming submarine beaches. All life stages, including egg capsules, were found sharing the same grounds simultaneity. Most of the times the two sexes occur in equal proportions but spatial segregation by sex may occur in certain areas.

In the Gulf of Cadiz the main habitat of *L. naevus* is located in the influence area of the Mediterranean Outflow Water (MOW), which is warmer and more saline than the above Atlantic Water.

A.3. Stock definition

The stock structure of the species along the all ICES areas is unknown, although 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 in other fisheries. In the past, there was a direct fishery to these species in the north of Spain, mainly in coastal areas and inside estuaries, with a special gillnet called *raeiras* (DOG nº 31 15/02/2011). At the present time 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 this area (for all Rajidae species) increased from 1996 to 2001 up to 416 tones 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). These catches from the artisanal fleet represent around 8.7 % of Galicia total landings from different ICES areas (Bañón *et al.,* 2008).

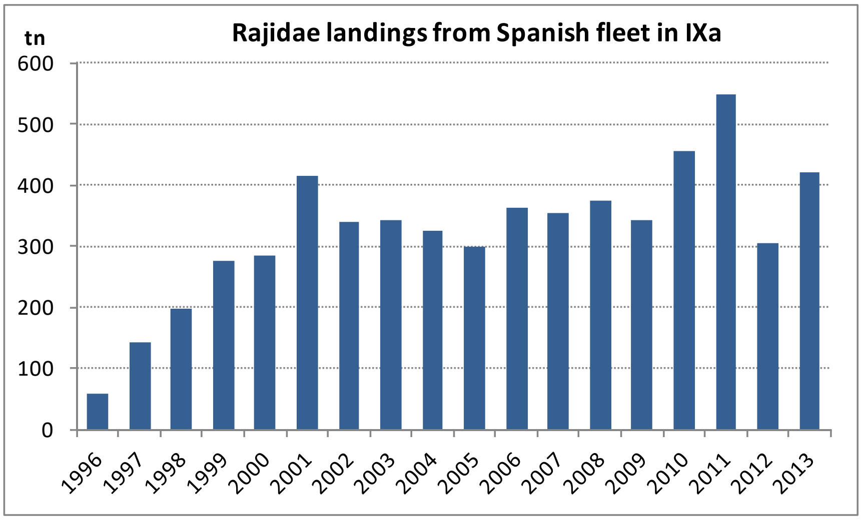

Figure 3 – West of Galicia (ICES division 9.a). Landings (ton) of Rajidae species in 9.a by the Spanish fleet.

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).

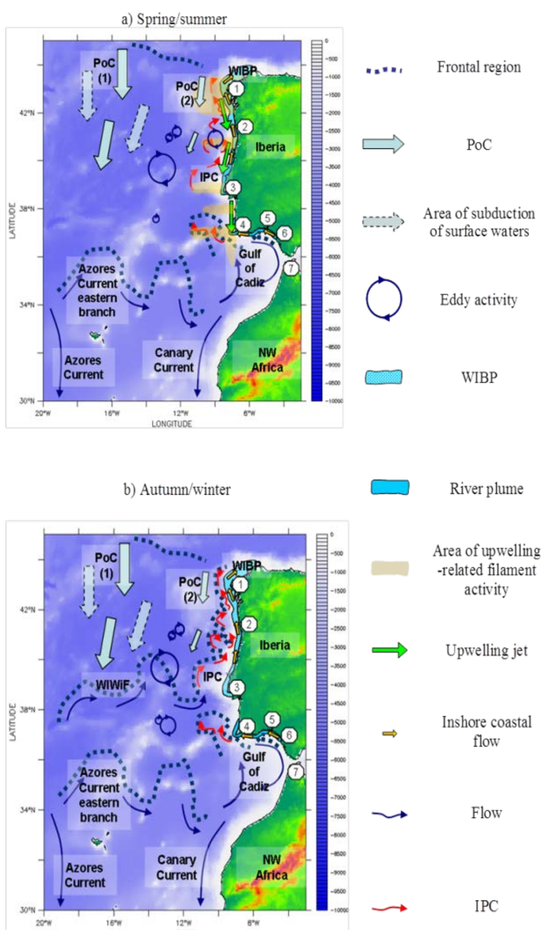

Figure 4 - The western Iberia and Gulf of Cadiz regimes in a) spring and summer, and b) autumn and winter. 1) Cape Finisterre; 2) River Douro; 3) Cabo da Roca; 4) Cape St. Vincent; 5) Guadiana River; 6) Guadalquivir River; 7) Strait of Gibraltar. PoC - southward-flowing Portugal Current, WIBP - Western 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

Spanish landings of *L. naevus* in Galicia and South of Spain reached 10.7 t in 2013 (90 % coming from the southern area). Those were quite similar to the 2012 landings of 12 t. This species represented 3% of the total Rajidae species landed in 2013. 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 29.3 t discarded in 2013, high value compare to the last five years (Table 1).

Table 1 - Galicia and Cantabrian Sea (ICES divisions 8.c and 9.a). Weight discarded (ton) of *Leucoraja naevus* (bold) and CV of estimations (italics) from bottom trawl fishery.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Leucoraja naevus	**73,0**	**187,6**	**6,5**	**63,5**	**19,7**	**2,7**	**14,5**	**9,6**	**2,2**	**5,6**	**29,3**
	56,4	*57,6*	*69,3*	*51,7*	*63,9*	*52,0*	*79,3*	*70,2*	*40,3*	*40,5*	*38,5*

Data used to estimate Portuguese landings by species derived from the DCF skate pilot study that had as main objectives to establish sampling statistical procedures and define estimators necessary to calculate the inputs for stock assessment purposes. In the Portuguese continental waters, between 2008-2013, *L. naevus* represented between 2 and 3% (16.6 to 29.3 ton) and between 4 and 8% (9.7 to 29.1 ton) of the total skates landed weight by the polyvalent and the trawl segments, respectively (Table 2). In 2013 the estimated landed weight of *L. naevus* was 16.6 t for the polyvalent and 9.7 t for the trawl segment.

Table 2 - Portuguese continental coast (ICES division 9.a). *Leucoraja naevus* estimated landed weight, number of vessels and number of trips by fishing segment (trawl and polyvalent), between 2008 and 2013.

	Polyvalent segment			Trawl segment		
Year	No. vessels*	No. trips*	Landed weight (ton) (%RJN/Skates)	No. vessels*	No. trips*	Landed weight (ton) (%RJN/Skates)
2008	1444	36149	25.8 (2%)	81	6513	24.0 (7%)
2009	1412	36239	26.5 (3%)	69	5683	23.7 (6%)
2010	1389	34767	29.3 (3%)	59	5461	25.7 (8%)
2011	1289	36761	27.3 (3%)	60	5139	29.1 (8%)
2012	1240	32565	21.0 (3%)	54	5158	18.2 (6%)
2013	1172	28007	16.6 (2%)	51	4658	9.7 (4%)

*** estimates for all skates combined**

Leucoraja naevus is mainly landed in the center (*Centro*) and Alentejo regions by the polyvalent segment and in Algarve by trawl segment (Figure 5).

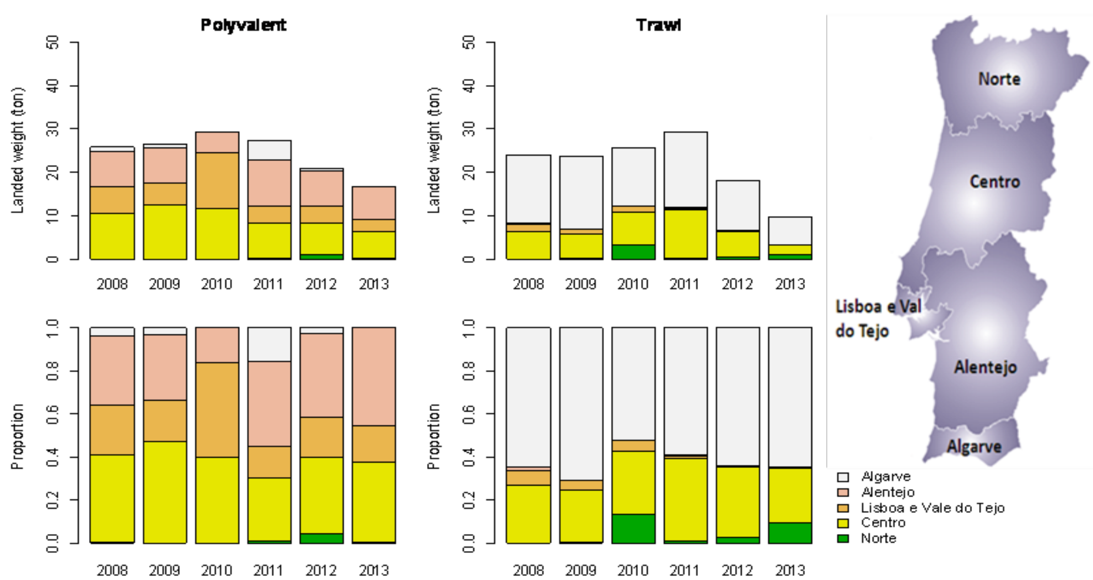

Figure 5 - Portuguese continental coast (ICES division 9.a). ***Leucoraja naevus*** **landing weight and percentage by major region (NUTSII regions) and segment.**

For the polyvalent segment and during the period 2008-2013, the landings estimates of *L. naevus* for the group of the five most important landing ports (Póvoa do Varzim, Matosinhos, Peniche, Sesimbra and Setúbal) represented 33 to 57% of the total landed weight of the species. The sampling program carried out in those landing ports allowed to conclude that *L. naevus* was mainly caught by nets (Table 3) and trawl.

Table 3 – Portuguese continental coast (ICES division 9.a). *Leucoraja naevus* (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 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	73	2507	1.6	64	1365	4.9	2	122	0.9	54	235
2009	53	1301	3.2	67	1404	5.2	3	163	0.0	47	157
2010	71	3043	10.1	39	458	2.5	3	224	1.2	33	163
2011	81	2369	2.5	23	362	1.9	4	319	1.0	34	171
2012	156	5822	4.5	23	450	2.4	5	363	0.6	21	107
2013	107	2974	3.7	17	311	1.0	5	378	0.6	3	3

Information on discards of *L. naevus* produced by the Portuguese polyvalent and bottom otter trawl segments operating in the ICES Division 9.a has been collected under the Data Collection Framework (EU DCR). Two polyvalent fisheries (trammel nets operating deeper than 150m and 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 coast (ICES division 9.a). *Leucoraja naevus* 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	Trammel nets >150 m deep	Crustacean Fishery	Demersal Fish Fishery
nº of sampled hauls	41	57	665	1162
nº of hauls in which the species occurred	4	22	4	16
p_{CD}	0.02	0.17	0.006	0.02
Expected number of discarded specimens per haul	3	12	2	1

In the Gulf of Cadiz, catch and landing data from commercial fisheries are often poor because of a general lack of species-specific recordings. No management program has been established yet in this area. Fisheries research has traditionally been focused on the most commercially important teleosts and poor research has been undertaken on chondrichthyans.

B.2. Length frequency distribution

In the Portuguese continental waters, sampling length frequency distributions of *L. naevus* at the five main landing ports (Póvoa do Varzim, Matosinhos, Peniche, Sesimbra and Setúbal) are presented in Figure 6 for nets and longlines separately. Length frequency distributions were built with no extrapolation to the total estimated landed weight of the species. The length distributions, as well as the length ranges, are similar between the two gears among years.

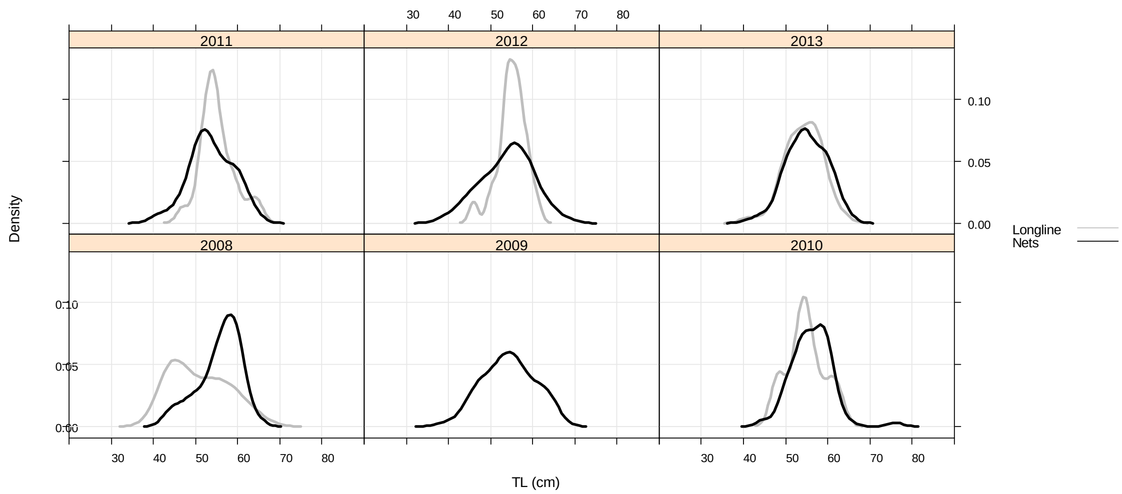

Figure 6 - Portuguese continental coast (ICES division 9.a). Sampling length frequency distributions of *Leucoraja naevus* at the five main landing ports (Póvoa do Varzim, Matosinhos, Peniche, Sesimbra and Setúbal) during the period 2008-2013.

In the Gulf of Cadiz length frequency distributions data are obtained from the ARSA survey series (Table 4; Figure 7).

Table 5 – Gulf of Cadiz (ICES division 9.a). *Leucoraja naevus* mean length (cm) in the depth strata of the ARSA survey series (Q1 SP – GCGFS and Q4 SP – GCGFS)

***Leucoraja naevus* ARSA series total mean length (cm)**			
Depth strata / Season	**SPRING**	**AUTUMN**	**BOTH**
A (15 - 30 m)			
B (31 - 100 m)	**11**	**45**	**28**
C (101 - 200 m)	**40**	**42**	**42**
D (201 - 500 m)	**37**	**35**	**36**
E (501 - 800 m)	**38**	**36**	**37**
All (15 - 800 m)	**37**	**36**	**36**

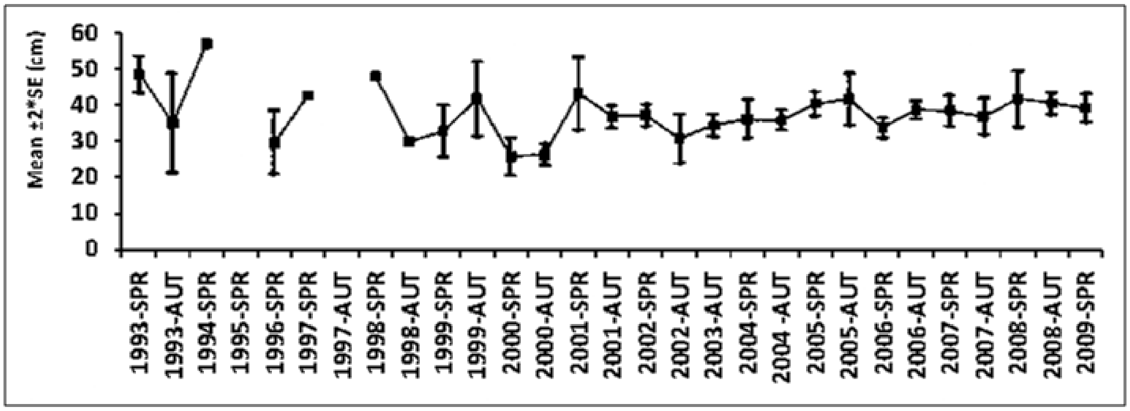

Figure 7- Gulf of Cadiz (ICES division 9.a). Trend of the mean size for *L. naevus* in ARSA surveys (1993-2009) (Q1 SP – GCGFS and Q4 SP – GCGFS).

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 about skates′ survivorship neither in the west of Galicia nor in the Gulf of Cadiz.

B.4. Commercial LPUE

Polyvalent and trawl segments contributed with around 50% each for the *L. naevus* total estimated landed weight and both segments were considered to estimate LPUE. The landed weight of the species per trip (fishing effort unit), LPUE, was used as the index of abundance. LPUE was determined from the commercial data collected from 2008 to 2013. 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. Among the two fishing gears there are no major differences on length structure of the specimens caught (Fig. 7). In face of that, it is admitted that the standardized LPUE using fishery data derived from nets are representative of the polyvalent segment.

B.5. Biological

In Portuguese waters, *L. naevus* size-at-first-maturity is 56 cm for both males and females. Egg laying females are more frequent between January and May, although reproductively active females can be found throughout the year. Fecundity is estimated to be around 63 eggs female^{-1} year^{-1} released in nine batches of seven follicles each (Maia *et al*. 2012). Juveniles of *L. naevus* feed on indiscriminate small crustaceans as *Lophogaster* *typicus* and *Solenocera membranacea* and mysids, while adults prey preferentially on bony fishes such as the species *Gymnammodytes semisquamatus* (Farias *et al*. 2006).

In Galicia and Cantabrian Sea, the diet of L. *naevus* is fundamentally based on crustacea for individuals less than 50 cm, which represents more than the 80% of volume (%V) (Figure 8). Larger specimens feed preferably on fishes (nearly 70%V). The main species within the Crustacea were (*Processa* spp. y *Solenocera membranácea*) althouh in smaller specimens also small crustacea like the mysid *Lophogaster typicus* and amphipods are included. Regarding fish prey, small rays (<50) feed mainly on gobidae and callyonymus species while large rays feed on flatfish like *Microchirus variegates (*13.4%) and *Micromesistius poutassou* (9.6%), *Calionymus* spp. (7%) and *Antonogadus macrophtalmus* (2.7%). The presence of poliqueta is also constant along the length range but only (5% V)

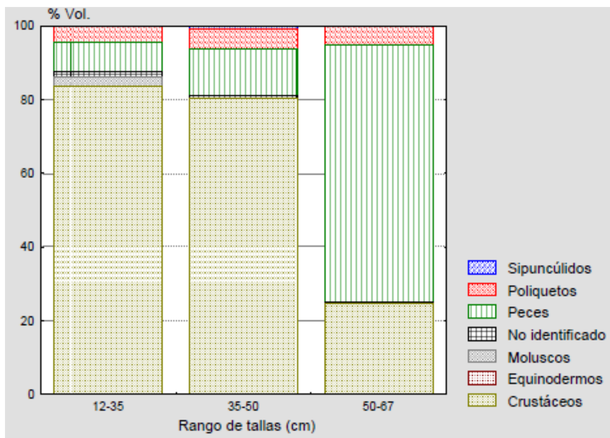

Figure 8 – Galicia and Cantabrian Sea (ICES divisions 8.c and 9.a). Diet of *Leucoraja naevus* (data from Velasco *et al*., 2002).

B.6. Surveys

Spanish bottom trawl surveys (SP-GFS) are carried out annually along the continental shelf of Galicia and Cantabrian Sea (north of Spain) during autumn (September–October). The historical series begun in 1980 however not until 1983 were standardized. These surveys are based on a stratified random sampling design, using an otter trawl 44/60 gear with a mesh size of 60 mm, and 20 mm in the cod-end (Sánchez, 1993; ICES, 2010). The survey area was stratified according to depth and biogeographically criteria (Figure 9). Five geographical sectors (MF, FE, EP, PA and AB) and three depth strata at the 70,120, 200 and 500 meter isobaths were defined. The first geographical sector (MF) corresponds to ICES area (9.a). The number of hauls per stratum is proportional to the trawlable surface area. Trawl tow duration is 30 min at a speed of 3 knots (Sánchez *et al*., 2002). An average of 122 ± 3.76 hauls (coverage of 5.4 hauls for every 1000 Km^2) is usually performed each year during the whole survey. Supplementary hauls in deeper bottoms (500-700 m) and shallows waters (30–80 m) may be conducted depending of the ship time available at sea In particular, in the 9.a area, an average of 19 hauls are preformed. This survey does not provide sufficient data to assess the stock status of *L. naevus* which can possibly be related with species distribution pattern and/or with inadequate survey design to catch this species.

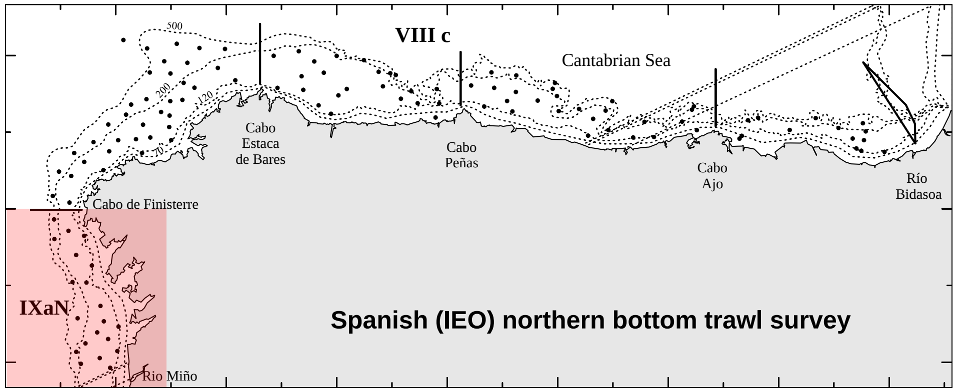

Figure 9 – West of Galicia (ICES division 9.a). Spanish (IEO) northern bottom trawl survey (SP-GFS) stratification design.

The Portuguese crustacean surveys /Nephrops TV Surveys (PT-CTS (UWTV (FU 28-29)) has been conducted by the Portuguese Institute for the Sea and Atmosphere (IPMA, ex-IPIMAR) and has the main objective is to monitor the abundance and distribution of the main crustaceans species, namely *Nephrops norvegicus* (Norway lobster), *Parapenaeus longirostris* (rose shrimp) and *Aristeus antennatus* (red shrimp). The PT-CTS (UWTV (FU 28-29) have been carried out during the 2nd quarter (May-July) of the year and covers the southwest coast (Alentejo, FU 28) and south coast (Algarve, FU 29). The surveys have been carried with the Portuguese RV "Noruega", which is a stern trawler of 47.5 m length, 1500 horse power and 495 GRT. A regular grid composed by 22 rectangles in FU 28 and 59 rectangles in FU 29 is used, with one station within each rectangle. Each rectangle has 6.6 minutes of latitude x 5.5 minutes of longitude for the SW coast and vice-versa for the south coast, corresponding approx. to 33 nm2. The grid was designed for a trawl survey to cover the main crustacean fishing grounds within the range of 200-750 m. The areas deeper than 750 m, where the giant scarlet prawn occurs, are not covered. The hauls fishing operations are carried out during daytime with a speed of 3 knots and the duration of each tow change in 2005 from 60 to 30 min. Although the crustacean species are the target (Norway lobster, rose shrimp and red and blue shrimp), data from all other taxa and species are also collected, as well as marine litter.

The Spanish bottom trawl survey IBTS-GC-Q1-Q4 (ARSA) in the Gulf of Cadiz has been carried out in the spring and autumn from 1993 to 2013. The surveyed area corresponds to the continental shelf and upper-middle slope from the latitude 6º 20′ W to 7º 20′ W and from 15 m to 800 m depth covering an area of 7224 Km^2. The surveys were carried out on board of the R/V *Cornide de Saavedra*, a stern trawler of 67 m length and 1133 GRT until spring 2013. Since autumn 2013 surveys were carried out on board the R/V Miguel Oliver. Hauls were performed with a standard Baka 44/66 bottom trawl gear, the standard sampler used by the Instituto Español de Oceanografía in their surveys sampling the Spanish Atlantic shelf, with a 60.3 m headline and 43.8 m footrope. The gear employed had a stretched mesh of 40 mm in the codend and it was covered internally with a 20 mm mesh size. Mean vertical and horizontal opening were 1.8 m and 21 m, respectively. Sampling design followed a random stratified scheme with 5 depth strata (15-30 m, 31-100 m, 101-200 m, 201-500 m, 501-800 m). The number of hauls per strata was proportional to the trawlable surface adjusted to the ship time available at sea, with coverage of around 5.4 hauls for every 1000 Km^2. Haul duration was 60 minutes and they were carried out during daylight at a mean towing speed of 3.0 knots.

C. Assessment: data and method

Data:

- Fishery dependent data:
    - Landings estimates by species
    - Fishing effort (unit: number of fishing trips) by fishing gear
    - Length frequency distribution by fishing gear
    - Discards
- Fishery independent data
    - Portuguese Crustacean Surveys / Nephrops TV Surveys (PT-CTS (UWTV(FU 28-29)) catch rate ($kg.hl^{-1}$)
    - Spanish bottom trawl survey IBTS-GC-Q1-Q4 (ARSA) in the Gulf of Cadiz ($kg.h^{-1}$)
    - Length distribution

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 $\hat{w}_{(y,p)}$ () in landing port *p* and year *y* was calculated as:

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

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:

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

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

In the standardization process of LPUE, a stepwise generalized linear model (GLM) procedure was applied to find the best GLM model and an 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 AI 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, the polyvalent present case: net as fishing gear, 1st quarter of the year; medium vessel size and constant seasonality and; the trawl present condition: vessel, 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. 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).

5. Standardized survey biomass index

In Portuguese continental waters, biomass indexes of *L. naevus* were standardized using the catch rates by fishing haul obtained for Portuguese Crustacesn Surveys / Nephrops TV Surveys (PT-CTS (UWTV (FU 28-29)). Generalized linear mixed models (GLMM; Bolker *et al*., 2009) were used in the standardization process (see Figueiredo *et al.*, 2013 WD for further details). In the essayed models catch rate of the species in each haul (Kg.h^{-1}) was the response variable and several linear predictors were considered: i) type of fishing net (NCT or CAR); ii) year; iii) fishing sector; iv) initial depth (in meters); v) trawling duration (in minutes); vi) period (morning or afternoon). Apart from factor year, the remaining predictors were selected depending on their significance after the model adjustment. Interactions were not considered because, if included, the degrees of freedom available decreased substantially and the adjustment was very poor.

GLMM models were adjusted to the survey data through the use of package 'MASS' (Venables and Ripley, 2002) implemented in R software. In the model, error of the catch rate was assumed to follow a Tweedie random variable, whose probability density function is expressed as:

$$f(y:\mu,\sigma^2,p) = a(y:\sigma^2,p)exp\left\{-\frac{1}{2\sigma^2}d(y:\mu,p)\right\}$$

where μ is the location parameter; σ^2 is the diffusion parameter and; p is the power parameter.

The Tweedie family of distributions is a family of exponential dispersion models with variance $Var(Y) = \sigma^2.\mu^p$, that depending on the value of p includes other distributions (Dunn and Smyth, 2008; Jørgensen, 1997). When $1<p < 2$ the distribution corresponds to mixed distributions known as compound Poisson models (Jørgensen, 1997) that in the present case, and due to the high frequency of zeroes, seems to be the most appropriate distribution to use.

The estimation of the p parameter was done following the procedure proposed by Shono (2008). According to this, the power parameter (p) is estimated by maximizing the profile log-likelihood across the grid values of (p) in the range of $1 < p < 2$ through the explicit form of the probability density function. The package 'Tweedie' (Dunn, 2009) implemented in R was used to estimate p.

In the GLMM adjustment, the factor Sector was considered as a random effect and since the random terms do not contribute to the fixed part of the mean its influence was isolated. The estimation of regression coefficients was done under the framework of quasi-likelihood and by fixing the value of p in the estimate obtained.

Model adequacy was check based on residual analysis. Fitted values were transformed ($2\mu^{1-(p/2)}$) to the constant information-scale, so that the expected pattern for the compound Poisson distribution was a straight line (McCullagh and Nelder, 1989; Draper *et al.*, 1998; Ortiz and Arocha, 2004). Residuals were also analysed using Tweedie quantiles, and the graphical tools for residuals set with the Tweedie distribution (qqplots) were constructed. Three types of plots were examined: (i) histogram of the deviance residuals; (i) deviance residuals and Pearson residuals against the standardized fitted values to check for systematic departures from the assumptions underlying the statistical distribution; and (iii) Tweedie QQ-plot (with Tweedie quantiles) for deviance residuals and for Pearson residuals.

The annual biomass index predictions for the selected statistical model were obtained following the procedure referred in Candy (2004) and by considering the depth fixed at a reference level (mean depth). The estimates of the variance of the sum of linear predictors used to estimate the approximate confidence intervals of annual indices were determined using the delta method which is implemented at the R package 'msm' (Jackson, 2013). The delta method is a general approach for computing confidence intervals for functions of maximum likelihood estimates. This method allows finding approximations of the variance of functions of random variables based on Taylor series (Oehlert, 1992).

Software used:

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

I. References

Alvarez-Salgado, X., Figueiras, F., Perez, F., Groom, S., Nogueira, E., Borges, A., Chou, L., Castro, C., Moncoiffe, G., Rıos, A., Miller,A., Frankignoulle, M., Savidge, G., Wollast, R. 2003. The Portugal coastal counter current off NW Spain: new insights on its biogeochemical variability. Progress in Oceanography 56, 281–321.

Álvarez, I. Prego, R., de Castro, M. and Varela, M., 2012. Galicia upwelling revisited: out-of-season events in the rias (1967–2009). Ciencias Marinas (2012), 38(1B): 143–159

Ambar, L., and Howe, M.R. 1979. Observations of the Mediterranean outflow-I Mixing in the Mediterranean outflow. Deep-Sea Research, 26: 535-554.

Bañón Díaz, R., Quinteiro Fernández,R, García Tasende, M., Juncal Caldas,L.M., Campelos Álvarez, J.M., Gancedo Baranda, A., Lamas Rodríguez, F., Morales de la Fuente,C. and Ribó Landín, J, 2008. Composi-ción, distribución y abundancia de rayas (Elasmobranchii: Rajidae) en aguas costeras de Galicia. Foro Ac. Rec. Mar. Rías Gal. 10: 325-331 2008.

Bolker, B.M., Brooks, M.E., Clark, C.J., Geange, S.W., Poulsen, J.R., Stevens, M.H.H. and White, J-S.S. 2009. Generalized linear mixed models: a practical guide for ecology and evolution. Trends in ecology and evolution 24: 127-135.

Borges, M.F., Santos, A.M.P., Crato, N., Memdes, H., Mota, B. 2003. Sardine regime shifts off Portugal: a time series analysis of catches and wind conditions. In Fish Stock Assessments and predictions: Integrating Relevant knowledge (editors O. Ulltang and G. Blom) Scientia Marina Volume 67, Suplement 1, April 2003.

Brander, K., Blom, G., Borges, M., Erzini, K., Henderson, G., MacKenzie, B., Mendes, H., Santos, A. and Toresen R. 2003. Changes in fish distribution in the eastern North Atlantic: Are we seeing a coherent response to changing temperature? ICES Mar. Sci. Symp., 219, 261–270.

Candy, S. 2004. Modelling catch and effort data using generalised linear models, the Tweedie distribution, random vessel effects and random stratum-by-year effects. CCAMLR Science 11: 59-80.

Cardador, F., Sanchéz, F., Pereiro, F.J., Borges, M.F., Caramelo, A.M., Azevedo, M., Silva, A., Pérez, N., Martins, M.M., Olaso, I., Pestana, G., Trujillo, V. and Fernandez A. 1997. Groundfish surveys in the Atlantic Iberian waters (ICES divisions VIIIc and IXa): history and perspectives. ICES CM 1997/Y:8.

Castro, M., Gómez-Gesteira, M., Álvarez, I., and Crespo, A.J.C. 2011. Atmospheric modes influence on Iberian Poleward Current variability. Continental Shelf Research, 31:425–432.

Diaz, J.I., M. Farrán and A. Maldonado. 1985. Surfical sediment distribution patterns in the Gulf of Cádiz controlled by the geomorphic features and physical oceanographic parameters. *6th European Regional Meeting of Sedimentology*. I.A.S., Lleida 85: 129-132.

Díaz, V., L.M. Fernández, J. Gil, F. Ramos and M.P. Jiménez. 2006. Gulf of Cadiz Regional Ecosystem. *ICES Working Group for Regional Ecosystem Description*. ICES/WGRED 2006.

Draper, N. R., Smith, H. and Pownell, E. 1966. Applied regression analysis (Vol. 3). New York: Wiley.

Dunn, P.K., 2009. Tweedie: Tweedie exponential family models. R package version 1.6.2.

Dunn, P.K. and Smyth, G.K. 2008. Evaluation of Tweedie exponential dispersion model densities by Fourier inversion. Statistics and Computing 18: 73–86.

Ellis, J. R., Cruz-Martinez, A., Rackham, B. D. and Rogers, S. I. 2005. The distribution of chondrichthyan fishes around the British Isles and implications for conservation. Journal of Northwest Atlantic Fishery Science 35: 195-213.

Enever, R., Catchpole, T.L., Ellis, J.R. and Grant, A. 2009. The survival of skates (Rajidae) caught by demersal trawlers fishing in UK waters. Fish.Res.97(1–2):72-76.

Farias, I., Figueiredo, I., Moura, T., Gordo, L.S., Neves, A. and Serra-Pereira, B. 2006. Diet comparison of four ray species (*Raja clavata, Raja brachyura, Raja montagui* and *Leucoraja naevus*) caught along the Portuguese continental shelf. Aquat. Living Resour. 19, 105–114.

Figueiras, F. G., Labarta, U. and Fernández-Reiriz, M. J. 2002. Coastal upwelling, primary production and mussel growth in the Rías Baixas of Galicia. Hydrobiologia, 484: 121-131.

Figueiredo, I. and Serra-Pereira, B. 2012. Modelling *Raja clavata* abundance from Portuguese IBTS data (1990-2011) using GLMM with Tweedie distribution. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–21th June, 2013-09.

Fiúza, A.F.G., Macedo, M.E. and R. Guerreiro, 1982. Climatological space and time variations of the Portu-guese coastal upwelling. Oceanol. Acta, 5: 31-40.

Frouin, R., Fiúza, A.F.G., Ambar, I. and Boyd, T.J. 1990. Observations of a poleward surface current off the coasts of Portugal and Spain during winter. J. Geophys. Res., 95: 679–691.

Gil, J., 2008. Macro and mesoscale physical patterns in the Bay of Biscay. J. Mar. Biol. Ass. UK., 88 (2): 217-225.

ICES. 2007. Report of the International Bottom Trawl Survey Working Group (IBTSWG). 27–30 March 2007, Séte, France, pp. 182.

ICES, 2010. Manual for the International Bottom Trawl Surveys in the Western and southern Areas. pp. 58.

ICES. 2013. Report of the Working Group on Elasmobranch Fishes (WGEF), 17–21 June 2013, Lisbon, Portugal. ICES CM2013/ACOM:19. 680pp.

Jackson, C. 2013. Package 'msm': Multi-state Markov and hidden Markov models in continuous time. R package version 1.1.4.

Jennings, S., Greenstreet, S.P.R. and Reynolds, J.D. 1999. Structural change in an exploited fish community: a consequence of differential fishing effects on species with contrasting life histories. Journal of Animal Ecology 68, 617-627.

Jensen, A.L. 1996. Beverton and Holt life history invariants result from optimal trade-off of reproduction and survival. Canadian Journal of Fisheries and Aquatic Sciences 53, 820–822.

Jørgensen, B. 1997. The Theory of Dispersion Models. Chapman and Hall, London, p. 237.

Le S., Josse J. and Husson. F. 2008. FactoMineR: An R package for multivariate analysis. Journal of Statistical Software. Vol 25 (1).

Leisch F., Hornik K. and Ripley B.D. 2009. Mixture and flexible discriminant analysis. R package version 0.4-2.

Maia, C., Serra-Pereira, B. and Figueiredo, I. 2013. Skates and rays estimates of landings by species from the Portuguese vessels operating in ICES Division IXa. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–21th June, 2013-09.

Maia,C., Erzini, K., Serra-Pereira, B. and Figueiredo, I. 2012. Reproductive biology of cuckoo ray *Leucoraja naevus*. Journal of Fish Biology 81 (4): 1285–1296.

Mason, E., Coombs, S., Oliveira, P., Angélico, M.M. and Stratoudakis, Y. 2006. An overview of the literature concerning the oceanography of the eastern North Atlantic region. Relat. Cient.Téc. Inst. Invest. Pescas Mar. Série Cooperação, 51pp.

Maunder, M.N. and Punt, A.E. 2004. Standardizing catch and effort data: A review of recent approaches. Fish.Res. 70: 141-159.

Ortiz, M. and Arocha, F. 2004. Alternative error distribution models for standardization of catch rates of non-target species from a pelagic longline fishery: billfish species in the Venezuelan tuna longline fishery, Fish.Res. 70(2–3): 275-297.

McCullagh, P. and Nelder, J.A. 1989. Generalized Linear Models. London, Chapman Hall.

McLeod AI and Xu C 2010 bestglm: Best Subset GLM. URL http://CRAN.R-project.org/package=bestglm.

Moita, T. 2001. Estrutura, variabilidade e dinâmica do Fitoplâncton na costa de Portugal Continental. PhD Thesis. University of Lisbon, Portugal. 272 pp.

Morgan, J.A. and Tatar J.F. 1972. Calculation of the Residual Sum of Squares for all Possible Regressions." Technometrics, 14, 317-325.

Moura, T., Fernandes, A., Figueiredo, I., Alpoim, R. 2013. Pilot Study on the Portuguese trammel net fishery in ICES Division IXa. Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–21th June, 2013-10.

Nelson, C.H., J. Baraza and J. Maldonado. 1993. Mediterranean undercurrent sandy contourites, Gulf of Cadiz, Spain. In: D.A.V. Stow and J.C. Faugeres (Editors), *Contourites and bottom currents. Sediment*. Geol., 82: 103-131.

Nogueira, E., Pérez, F.F. and Ríos, A.F. 1997. Modelling thermohaline properties in an estuarine upwelling ecosystem (Ria de Vigo; NW Spain) using Box-Jenkins transfer function models. Est. Coast. Shelf Sci., 44: 685-702.

Oehlert, G. W. 1992. A note on the delta method. The American Statistician, 46: 27-29.

Pages J. 2004. Analyse factorielle de donnees mixtes. Revue Statistique Appliquee. LII (4). pp. 93-111.

Peliz, A., Dubert, J., Santos, A., Oliveira, P. and Le Cann, B. 2005. Winter upper ocean circulation in the Western Iberian Basin – Fronts, Eddies and Poleward Flows: an overview. Deep Sea Research I 52, 621–646.

Peliz, A., Rosa, T., Santos, A. and Pissarra, J. 2002. Fronts, jets, and counter flows in the Western Iberian upwelling system. Journal of Marine Systems 35, 61–77.

Prista. N., Jardim, E., Fernandes, A.C., Silva, D., Ferreira, A.L., Abreu, P., Fernandes, P. 2012. Manual of Onboard Sampling Procedures: Fixed Gears. Relatórios Cientícos e Técnicos do Instituto Investigação das Pescas e do Mar, 56 (pp. 23 + Annexes).

Prista, N. and Fernandes, C. 2013. Discards of elasmobranchs by the Portuguese bottom otter trawl and deep-water set longline fisheries operating in ICES Division XIa (2004–2012).

Working Document presented at the Working Group on Elasmobranch Fishes (WGEF) meeting, 17–21th June, 2013-15.

R Development Core Team. 2009. R: A language and environment for statistical computing. R Foundation for Statistical Computing. Vienna. Austria. ISBN 3-900051-070. http://www.R-project.org.

Relvas, P., Barton, E., Dubert, J., Oliveira, P., Peliz, A., da Silva, J. and Santos, A. 2007. Physical oceanography of the western Iberia, ecosystem: Latest views and challenges, Prog. Oceanogr., 74, 149–173.

Relvas, P., Luís, J. and Santos, A.M.P. 2009. Importance of the mesoscale in the decadal changes observed in the northern Canary upwelling system, Geophys. Res. Lett., 36, L22601, doi:10.1029/2009GL040504

Rodríguez-Cabello, C. Fernández A., I. Olaso, F. Sánchez, F., Gancedo, R., Punzón, A. and Cendrero, O.2005. Overview of Continental Shelf Elasmobranch Fisheries in the Cantabrian Sea. J. Northw. Atl. Fish. Sci., Vol. 35:

Sánchez, F., 1993. Las comunidades de peces de la plataforma del Cantábrico. Publicaciones Especiales del Instituto Español de Oceanografía, 13, 137 pp.

Sánchez, F., Blanco, M., Gancedo, R., 2002. Atlas de los peces demersales y de los invertebrados de interés comercial de Galicia y el Cantábrico. Otoño 1997-1999. Instituto Español de Oceanografia. MYC Ed.CYAN. Madrid, pp. 158

Sánchez, F., Rodríguez-Cabello, C. and Olaso, I., 2005. The Role of Elasmobranchs in the Cantabrian Sea Shelf Ecosystem and Impact of the Fisheries on Them. J. Northw. Atl. Fish. Sci., Vol. 35: 467–480

Santos, A.M.P., Borges, M.F. and Groom, S. 2001. Sardine and horse mackerel recruitment and upwelling off Portugal. ICES Journal of Marine Science. Vol 58, No 3, 589-596.

Santos, A.M.P., Peliz, Á.J., Dubert, J., Oliveira, P.B., Angelico, M.M. and P. Ré. 2004. Impact of a winter upwelling event on the distribution and transport of sardine (Sardina pilchardus) eggs and larvae off western Iberia: a retention mechanism. Continental Shelf Research, 24: 149-165.

Serra-Pereira, B., Erzini, K., Maia, C. and Figueiredo, I. 2014. Identification of potential essential fish habitats for skates based on fishers' knowledge. Environmental Management, 53(5):985-98.

Shono, H. 2008. Application of the Tweedie distribution to zero-catch data in CPUE analysis. Fisheries Research 93: 154-162.

Stehmann, M.F.W. and Bürkel, D.L. 1984. Rajidae. In Fishes of the North-eastern Atlantic and the Mediterranean, volume 1, pp. 163-196. Ed. by P. J. P. WHITEHEAD, M. BAUCHOT, J. HUREAU, J. NIELSEN and E. TORTONESE. UNESCO, Chaucer Press, UK.

Steven, G. A. 1936. Migrations and Growth of the Thornback Ray (*Raja clavata* L.). Journal of the Marine Biological Association of the United Kingdom 20: 605-614.

Velasco, F, Olaso, I. and Serrano, A., 2002. Alimentación de tres especies de la familia Rajidae en el sur del Golfo de Vizcaya. ICES CM/2002

Venables, W.N. and Ripley, B.D. 2002. Modern Applied Statistics with S, Fourth ed. Springer, New York.

Walker, P. A., Howlett, G. and Millner, R. 1997. Distribution, movement and stock structure of three ray species in the North Sea and eastern English Channel. ICES Journal of Marine Science 54: 797-808.