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Stock Annex: Porbeagle (*Lamna nasus*) in subareas 1–10, 12 and 14 (the Northeast Atlantic and adjacent waters)

Stock specific documentation of standard assessment procedures used by ICES.

Stock: Porbeagle

Working Group: Working Group on Elasmobranch Fishes (WGEF)

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General

Stock distribution

WGEF consider that there is a single-stock of porbeagle *Lamna nasus* in the NE Atlantic that occupies the entire ICES area (Subareas 1–14). This stock extends from Norway, Iceland and the Barents Sea to Northwest Africa. For management purposes the southern boundary of the stock is 36°N and the western boundary at 42°W.

Buencuerpo *et al.*, 1998 reported that porbeagle made up 4% of the total catches in longline and gillnet fisheries off the northwest African coast, Iberian Peninsula and Straits of Gibraltar and more information on the distribution and frequency of porbeagle in the CECAF area is needed. Some records of porbeagle south of the ICES area may be misidentified shortfin mako.

The stock is considered separate from that in the NW Atlantic (Campana *et al.*, 1999; 2001; 2003). Tagging studies from Norway, the USA and Canada, resulted in 542, 1034 and 256 porbeagles being tagged respectively. In all 197 recaptures were made (53 from Norwegian, 119 for USA and 25 from Canadian studies). Initial studies did not report any transatlantic migrations (Campana *et al.,* 2003), although a single transatlantic migration has been reported (e.g. Green, 2007 WD; Figure 6.1). Canadian tagging studies have not reported any recaptures east of 42°W.

Genetic evidence suggests some gene flow across the Atlantic, within the northern hemisphere, as dominant haplotypes from the NE were also present in samples from NW Atlantic population (Pade *et al.*, 2006). The same study also found marked differences in haplotype frequencies between northern and southern hemisphere populations, indicating little or no gene flow between them.

Although porbeagle also occurs in the Mediterranean, there is no evidence of mixing with the NE Atlantic stock.

The fishery

Porbeagle has been exploited commercially since the early 1800s, principally by Scandinavian fishers; however, the "boom" period for this fishery in the NE Atlantic began in the 1930s. The target fishery for porbeagles before the Second World War and was mainly a Norwegian longline fishery in the North Sea, starting in 1926 and landing around 500 t annually in the first years. After a peak in 1933 (ca. 3800 t) the fishery declined. After the war, the target fishery resumed with Norwegian, Faroese and Danish vessels involved. Norway took about 2800 t in 1947. By the 1950s this fishery had extended to the Orkney-Shetland area and the Faroes then to the waters off Ireland and offshore banks. After this, the catches began to decline to below 2000 t annually, and in 1961 a fleet of Norwegian longliners extended their fishing for porbeagle to Northwest Atlantic waters.

In the early 1950s, landings for the Danish porbeagle fishery were greater than 1000 t, but by the mid to late 1950S average landings were 500–600 t per year; however, this declined to under 50 t by 1983. During the 1970s several countries including The Faroes, France, England, Iceland, Germany and Sweden started to report landings of porbeagle. French landings are largely from the Bay of Biscay and Celtic Sea. They are mainly provided by a longliner targeted fishery (Table 6.1) which landed relatively large quantities from the early 1970s, with a decline in the mid-1980s where landings decreased to around 200 t, with the number of boats in the targeted fishery also declining at this time. After this, catches fluctuated between ca. 200–500 t, with a peak of 640–840 t between 1993 and 1995.

Porbeagle fisheries have generally been seasonal, and many operations landed porbeagle opportunistically and sporadically rather than through directed fisheries. For instance, local fisheries in the Bristol Channel occasionally deploy longlines for porbeagle (Ellis and Shackley, 1995). The landings from Spain are thought to be taken mainly in fisheries using longlines, targeting swordfish and tuna and tend to be greater during spring and autumn, with a drop in summer, despite being erratic in nature (Mejuto, 1985; Lallemand-Lemoine, 1991). The Norwegian fishery was also mainly run between July–October in the eastern North Sea.

Porbeagle are currently landed by several European countries, principally France and, to a lesser extent, UK, Faeroes, Norway and Spain (although Spanish landings data are from the pelagic fleet, and further details of captures in demersal fleets are required).

The only regular, directed target fishery that still exists is the French fishery (although there have been occasional targeted fisheries in the UK). Catches are primarily made on the continental slope in Division 8.d (32%) and on the continental shelf in Divisions 7.j (23%) and 7.g (20%) (Poisson and Séret, 2008). Maps in Figure 6.2 show the distribution of the French catch by statistical rectangle by year and by gear type for the period 1999–2008. An example of the seasonal variation in catches (for 2000) is illustrated in Figure 6.3. Fishing trips generally last 10–18 days, with an average of 14 days. Porbeagle are targeted with drifting longlines set from near to the surface (e.g. in the outer Bristol Channel) or down to 220–230 m depth in deeper waters in the Bay of Biscay fishing grounds. Each longline is 1500 m long with 84 hooks ballasted with 1 kg of lead every 14th hook. Each vessel has ten such lines. The fishing activity occurs during the day, a first set in the early morning with 3–4 longlines soaking for 3.5–4 hours, and a second set in the afternoon functioning for 4.5–5 hours with all ten longlines deployed in the second set. The location of the second set depends on the catch rates in the first set. Frozen mackerel (*Scomber scombrus*) is used as bait, one third of a fish per hook. Most of the landings take place from March to August.

The number of French vessels landing more than 5 t has been below ten since 1990, fluctuating between three and five vessels (Biais and Vollette, 2009). Average prices, as observed in the Sables d'Olonne and Guilvinec market auctions in 2008, have varied around 3.5 Euros.kg^{-1} of dressed porbeagle. Between 2002 and 2007, the income realized by the porbeagle targeted fishery varies between 26–42% of the annual turnover of the boats (Jung, 2008).

High seas tuna fisheries also take porbeagle but there is little available knowledge of the catches of this fishery (Only Japan reported catches in 1996–1997).

Catch data

Landings

The major landings have been made by Denmark, Norway and France throughout the time-series. Norway and Denmark landings are dominating up to the beginning of the seventies, thereafter France is the major contributor to the international landings.

Most of the Spanish catches are from pelagic fisheries for tuna and tuna-like species, with porbeagle catches mostly from ICES Subareas 7–9 but porbeagle is also caught by the Spanish mixed demersal fisheries.

Portuguese landings data were updated during the joint meeting with ICCAT in 2009.

Japanese landings for the NE Atlantic were reported to ICCAT in 1996 and 1997.

Discards

No information available on the discards of the non-targeted fishery, although as a high value species, it is likely that specimens caught as bycatch are landed and not discarded.

Because the EU adoption of a maximum landing size, some large fish have been discarded by boats of the directed fishery in 2009 but there is no account of the number these discards.

Quality of catch data

For some nations, porbeagle will have been reported within “sharks *nei*”.

The confusion with shortfin mako (*Isurus oxyrinchus*) is suspected for some historical Spanish catches that are thought to refer to shortfin mako. Some reported landings of shortfin mako by UK-registered vessels fishing in Subareas 4 and 6 and Divisions 7.d–e are also likely to represent misidentified porbeagle. To avoid this problem, some diagnostic characteristics can be used to distinguish porbeagle and shortfin mako (Table 6.2).

French targeted fishery landings are thought to be correctly documented from 1984 onwards. Prior to this period, there are discrepancies between the national data supplied to WGEF and data on the ICES catch statistics, especially in the 1970s. Further studies to check, confirm and harmonize datasets are needed.

Landings data from Spain (Basque Country) indicate that lamnids are taken in other mixed demersal fisheries (Table 6.3), and better estimates of porbeagle catches by Spanish demersal fisheries are required.

Landings data from non-ICES countries fishing in the NE Atlantic appear incomplete. Data are available for Japan only in two years and, furthermore, Republic of Korea and Taiwan (Province of China) are also expected to take porbeagle as a bycatch in tuna fisheries in the NE.

Further examination of national data suggests that there can be occasional confusion between catch numbers and catch weight, with some individual landings (presumably of one fish) reported as 1 kg. The extent of this problem still needs to be evaluated.

Commercial catch composition

Measurement of the length of porbeagle shark catches is an important parameter for assessing population structure, size composition and growth of the stock. It is therefore important that there is a standardized approach to reporting size measurements. This is not easily achieved with larger elasmobranchs, and inaccuracies/inconsistencies are common between datasets. Therefore, care needs to be taken when comparing length data from different sources, and where appropriate conversion factors are required.

The most commonly documented lengths are total length (L_T) and fork length (L_F), and conversion factors between the two have been calculated. However, even these lengths are not taken identically between samplers. A review of this can be found in Francis, 2006.

The length compositions of porbeagle taken in the French fishery have been provided to WGEF in 2009 (see below). However, these data have been collected only sporadically (e.g. Ellis and Shackley, 1995; Gauld, 1989; Mejuto, 1985).

Launched by the National Fishing Industry Organization Committee (CNPMEM), the French NGO Association Pour l'étude et la Conservation des Sélaciens (APECS, the French representative of the European Elasmobranch Association, EEA) implemented an observer programme in 2008–2009 aiming at gathering information on the main biological parameters of porbeagle. This programme named EPPARTIY (Etude de la Pêcherie Palangrière au Requin Taupe de l'Ile d'Yeu) received the collaboration of the fishing industry of l'Ile d'Yeu, the main French porbeagle fishery for the observers.

The length distribution (Fork length over the body) by sex of porbeagle measured during the EPPARTIY programme between April and July 2008 were presented at the 2009 WGEF (Jung, 2008; Figure 6.4). Mean average length of porbeagle landed by month and sex are presented Figure 6.5. Mean length increased from April to June for both sexes and decreased in August, especially for males caught in the Celtic Sea, south of St George's Channel (Divisions 7.g and 7.h).

Commercial catch-effort data

Preliminary analyses of data from the French fishery were undertaken in 2006 (see Section 6 of ICES, 2006, 2008), based on data supplied in Biseau, 2006, WD. These data provided some indication of effort in an otherwise data-poor fishery; however, the rate of kg/vessel needs to be treated with some caution, and if possible re-parameterizing to account for true effort, in terms of taking days at sea, size of vessel, changes in fishing area, etc. into account.

More detailed data were presented in 2008 (Jung, 2008). Effort from the French targeted fishery were presented in annual number of hooks (Figure 6.8) taking into account the average day of fishing activity multiplied by the average daily number of fishing operation. Effort reached a maximum of 725 760 hooks in 1994 and decreased to 323 576 hooks deployed in 2007. A nominal cpue index was calculated from the individual vessel landings for the top twelve vessels presented in Table 6.4 (1993–2007). Annual variation ranged from 1 kg/hook (1994) to 0.73 kg/hook (2007) across the time-series, with a peak cpue of around 1.5 kg/hook in 1999, and a low of 0.54 kg/hook in 2005, however there is much variance. Further studies were requested to clarify this trend.

Consequently, a longer time-series of logbook data was presented to the 2009 WG to allow a better interpretation of cpue trends (Figure 6.9).

Mejuto and Garcés, 1984 reported that the NW and N Spanish longline fleets had a cpue of 2.07 kg/1000 hooks for porbeagle shark. However, the cpue demonstrated a seasonal trend, with the highest catches being made in the last four months of the year, where the cpue was three to four times higher than in February or March although the effort was of a similar level.

Life-history information

The biology of porbeagle is well described for the NW Atlantic stock (e.g. Jensen *et al.*, 2002; Natanson *et al.*, 2002; Cassoff *et al.*, 2007; Francis *et al.*, 2008), although less information is available for the NE Atlantic stock.

Habitat

Porbeagle shark is a wide-ranging coastal and oceanic species found in temperate and cold-temperate waters worldwide (1–18°C, 0–370 m), and is more common on continental shelves (Stevens *et al.*, 2006a). Campana and Joyce, 2004 reported that more than half of the porbeagle caught were at temperatures of 5–10°C (at the depth of the hook). They suggest that as porbeagle are among the most cold tolerant of pelagic shark species, they could have evolved to take advantage of their thermoregulatory capability to feed on abundant cold-water prey in the absence of non-thermoregulating competitors.

In the North Atlantic, porbeagle abundance varies seasonally and spatially (Aasen, 1961; 1963; Templeman, 1963; Mejuto and Garcés, 1984; Mejuto, 1985; Gauld, 1989). In the NE Atlantic, the limited studies conducted on this population, and historical catch records indicate that porbeagle segregate by sex and size. Mejuto, 1985 found twice as many males were caught off Spain, whereas Gauld, 1989 found 30% more females were caught off Scotland, and Ellis and Shackley, 1995 found the males predominated in catches in the Bristol Channel. These observations have also been made by Hennache and Jung, 2010. On the shelf edge in the south of Ireland, the male/female ratio was 0.7 but 1.2 in the Bristol Channel and in the North of the Bay of Biscay.

Their movements reveal seasonal patterns; however, this knowledge is incomplete for a large part of the year. French catches indicates that porbeagle are mainly present in spring and in summer along the shelf edge (along the 200 m depth line) of the Celtic Sea and of the Bay of Biscay, and in the Saint Georges Channel and in the entrance of the Bristol Channel (Figure 6.3). Two recent studies have been carried out using a limited number of archival satellite tags. In the first one, four porbeagles were tagged caught off the SW England (Pade *et al.*, 2009). During July and August the sharks move erratically within the Celtic Sea. One individual was tracked during autumn, and this shark moved to deeper waters off the continental shelf before moving northwards. Sharks occupied a bathymetric range of 0–552 m and water temperatures of 9–19°C. In the second, archival tags were attached on three porbeagles in Northwest Ireland in September 2008. The tags were programmed to pop after 122 days. All three tagged porbeagles migrated south along the shelf edge (Saunders *et al.*, 2010).

Nursery and pupping grounds

The nurseries are probably in continental waters, but there are few published data (Castro *et al.*, 1999). However, according to French catch length distribution (Hennache and Jung, 2010), the Saint Georges Channel is likely a nursery area (porbeagle length below 170 cm for 90% of the catches and below 125 cm for 25%).

Four gravid females were caught in the South of Ireland (Statistical rectangle 25D8) with full-term pups (embryo total lengths being 80–81 cm) within a few days in May 2008 (Hennache and Jung, 2010), possibly indicating a pupping ground. This limited knowledge would probably benefit from further satellite archival tagging to examine the movements of gravid females to infer where pupping grounds may be. Comparable studies have recently been undertaken in the NW Atlantic; and this study suggested that pupping grounds may occur in warmer waters south of the main stock area (Campana *et al*., 2010).

Diet

Porbeagles are opportunistic piscivores (Campana *et al*., 2003). Stomachs of 1022 porbeagles from the Canadian fishery were examined by Joyce *et al*., 2002. Teleosts made up 91% of the diet by weight, with cephalopods being the second most important prey item and were found in 12% of stomachs. Pelagic fish and cephalopods constituted the largest proportion of the diet in spring, whereas groundfish dominated in the fall. This seasonal change follows a migration from deep to shallow water. No diet differences were found between the sexes.

The diet of porbeagle was also analysed by Cherel (unpublished, cited by Hennache and Jung, 2010) who looked at 168 stomachs from French catches. The results are similar to the NW Atlantic study: 90% of the diet is constituted in fish and the remaining part is cephalopods. The main prey species are whiting, blue whiting and horse mackerel.

Life-history parameters

Biological data of the NE Atlantic porbeagle shark are very scarce; with very few published studies (e.g. Mejuto and Garcés, 1984; Gauld, 1989; Stevens, 1990; Pade *et al*., 2006; Green, 2007). The majority of other biological parameters are available from studies conducted elsewhere in the world, mainly in the NW Atlantic, but also in the Pacific to a limited extent (see Table 6.5).

However, recent information has been collected by Hennache and Jung in 2008–2009 by sampling the catches of the French targeted fishery (sex ratio, length–weight relationship). The age has been determined on a sample of vertebrae (n=120). This study indicated that NE Atlantic porbeagle are slower growing than NW Atlantic porbeagle. However, further age and growth studies are needed to provide growth parameters for the NE Atlantic porbeagle stock.

The maturity estimates provided by Jensen *et al.* (2002) for NW Atlantic porbeagle (see Table 6.5) have been used in assessments for NE Atlantic in the absence of appropriate, recent data for NE Atlantic porbeagle.

Estimates of natural mortality include 0.18 (Aasen, 1963), 0.1–0.2 for immature and mature fish (Campana *et* al., 2001) and 0.114 (E. Cortes, unpublished).

Exploratory assessment models

Previous studies

The first assessment of the NE Atlantic stock was carried out in 2009 by the joint ICCAT/ICES meeting using a Bayesian Surplus Production (BSP) model (Babcock and Cortes, 2009) and an age structured production (ASP) model (Porch *et al*., 2006).

Stock assessment

The 2009 assessments cannot be updated by the 2010 WGEF because the lack of available cpue in 2009. The models used during the 2009 assessment should be made available at any future benchmark assessment for these species.

** BSP model*

The BSP model uses catch and standardized cpue data (see Section 6.5.2 and ICCAT, 2009). Because the highest catches occurred in the 1930s and 1950s, long before any cpue data were available to track abundance trends, several variations of the model were tried, either starting the model run in 1926 or 1961, and with a number of different assumptions. An informative prior was developed for the rate of population increase (*r*) based on demographic data of the NW Atlantic stock. The prior for *K* was uniform on log *K* with an upper limit of 100 000 t. This upper limit was set to be somewhat higher than the total of the catch series from 1926 to the present (total catch= 92 000 t). All of the trials showed that the population continued to decline slightly after 1961, consistent with the trend in the French cpue series.

The model runs used the most biologically plausible assumptions about unfished biomass or biomass in 1961. The relative 2008 biomass (B_{2008}/B_{MSY}) can be estimated between 0.54 and 0.78 and the relative 2008 fishing mortality rates (F_{2008}/F_{MSY}) between 0.72 and 1.15.

**ASP model*

An age-structured production model was also applied to the NE Atlantic stock of porbeagle to provide contrast with the BSP model (see ICCAT 2009). The same input data used in the BSP model were applied but incorporating age-specific parameters for survival, fecundity, maturity, growth, and selectivity. The stock–recruitment function is also parameterized in terms of maximum reproductive rate at low density.

Depending on the assumed F in the historical period (the model estimated value was considered to be unrealistic), the 2008 relative spawning–stock fecundity (SSF_{2008}/SSF_{MSY}) was estimated between 0.21 and 0.43 and the 2008 relative fishing mortality rate (F_{2008}/F_{MSY}) between 2.54 and 3.32.

The conclusions of these assessments were that the exploratory assessments indicate that current biomass is below B_{MSY} and that recent fishing mortality is near or possibly above F_{MSY}. However, the lack of cpue data for the peak of the fishery adds considerable uncertainty in identifying the current status relative to virgin biomass.

Quality of assessments

The assessments (and subsequent projections) conducted at the joint ICCAT/ICES meeting that are be presented in this report must be considered exploratory assessments, using several assumptions (carrying capacity for the SSB model, F in the historical period in the ASP model).

Hence, it must be noted that:

- There was a lack of cpue data for the peak of the fishery.
- Catch data are considered underestimates, as not all nations have reported catch data throughout the time period.
- The cpue index for the French fleet is for a targeted fishery that actively seeks areas where catch rates of porbeagle are higher. Furthermore, the index (catch per day) does not allow many factors to be interpreted, such as fishing strategies, including searching behaviour and patterns, fleet dynamics (e.g. more vessels may operate when good catches are made), changes in numbers of vessels (aggregations may be easier to find when more vessels are operating), number of lines and line deployments per day, and the number of hooks. Hence, this series may not be reflective of stock abundance.

Consequently, the model outputs should be considered highly uncertain (ICCAT Report).

Reference points

No reference points have been proposed for this stock.

ICCAT uses F/F_{MSY} and B/B_{MSY} as reference points for stock status of pelagic shark stocks. These reference points are relative metrics rather than absolute values. The absolute values of B_{MSY} and F_{MSY} depend on model assumptions and results and are not presented by ICCAT for advisory purposes.

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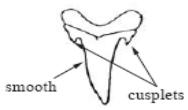
Table 6.1. Porbeagle in the NE Atlantic. French landings (%) of porbeagle by broad categories of gear type, 1999–2007.

Gear Type	1999	2000	2001	2002	2003	2004	2005	2006	2007
Longline	77.5%	60.9%	81.0%	78.8%	82.1%	72.3%	74.9%	67.9%	89.0%
Net	12.1%	28.6%	8.1%	10.6%	10.9%	15.9%	11.4%	18.2%	5.0%
Trawl (demersal)	5.8%	6.0%	7.5%	3.5%	4.0%	6.3%	6.2%	8.2%	4.8%
Trawl (pelagic)	4.6%	4.2%	2.6%	5.6%	2.8%	4.8%	7.3%	3.8%	0.8%
Unclassified	0.1%	0.2%	0.7%	1.6%	0.2%	0.8%	0.1%	1.9%	0.4%

Table 6.2. Porbeagle in the NE Atlantic. Characteristics for the identification of porbeagle and shortfin mako (adapted from Compagno, 1984).

	Porbeagle	Mako
Teeth	Lateral cusps present on teeth*	No cusplets on teeth
		
Origin of first dorsal fin	Over or anterior to posterior margins of pectoral fins	Over or behind posterior margin of the pectoral fins
Origin of second dorsal fin	Over origin of anal fin	In front of the origin of the anal fin
Caudal fin	Secondary keel present below main keel on caudal fin	No secondary keel

*** However, sometimes these cusplets appear to be absent in young porbeagle, as they may be covered by some skin, which can lead to misidentification.**

Table 6.3. Porbeagle in the NE Atlantic. Landings of Porbeagle and Shortfin mako (*Lamnidae*) from Spain (Basque Country).

Year	6	7	8	Total
1996			20	20
1997	0	0	12	12
1998	1	2	24	27
1999	0	8	33	41
2000	0	3	35	38
2001		7	39	45
2002	0	1	15	16
2003		1	21	22
2004		0	10	10
2005	0	1	10	11
2006			5	5
2007		0	15	16
2008			13	13
2009			3*	3

*** porbeagle alone.**

Table 6.4. Porbeagle in the NE Atlantic. Number of fishing trip per year for vessels involved in the targeted porbeagle fishery 1993 to 2007 (Jung, 2008).

Vessel	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	9	10	9	5	5	6	2	3	2	9	9	9	7	8	7
2	4	12	6	9	5	7	4	4	6	4	5	7	2	3	3
3	1	5	6	1	5	5	3	6	5	5	7	6			
4	10	7	6	5	8	3	3	3	1	6	2				
5	6	9	6	4	4	5	4	3	6	2					
6	3	9	9	10	8	7	8	8	5						
7	4	2	4	4	2										
8									5	6	5	7	3		5
9				1	1	2	3	2	2						
10											5	2			3
11					5								5	3	5
12	7	6	7	5											
13					3	3	2	3							
14			6	5	6										
15	11	12													
16				3											
17	4														
18	10														

Table 6.5. Porbeagle in the NE Atlantic. Life-history parameters for porbeagle from the scientific literature.

Parameter	Values	Sample Size	Area	Reference
Reproduction	Ovoviviparous with oophagy			Campana *et al*., 2003
Gestation period	8–9 months			Aasen, 1963; Francis and Stevens, 2000; Jensen *et al*., 2002
Litter size	4 (3.7–4 per year)		Scotland and NW Atlantic	Gauld, 1989; Francis and Stevens, 2000; Jensen *et al*., 2002
Size at birth	60–75 cm		NW Atlantic	Aasen, 1963; Compagno, 1984
	58–67 (LF)		SW Pacific	Francis and Stevens, 2000
Sex Ratio (males : females)	1:1.3	1368 (1954–1987- year-round samples)	Scotland	Gauld, 1989 (data from 1954–1987)
	1:1	1228 (year-round samples)	NW Atlantic	Kohler *et al*., 2002
	1:0.25	65 (year-round samples)	NE Atlantic	Kohler *et al*., 2002
	1:0.5		NE Atlantic (Spain and Azores)	Mejuto, 1985
	1:0.6		N and NW Spain	Mejuto and Garcés, 1984
	1:0.84		Saint Georges Channel	Hennache and Jung, 2010
	1:0.85		North of Bay of Biscay	Hennache and Jung, 2010
	1:1.35		South Ireland	Hennache and Jung, 2010
Embryonic sex ratio	1:1			Francis and Stevens, 2000; Jensen *et al*., 2002
Male age at 50% maturity (years)	~ 8		NW Atlantic	Natanson *et al*., 2002
Female age at 50% maturity (years)	~ 13		NW Atlantic	Natanson *et al*., 2002
Male length at maturity (LF)	150–200 cm 166–184 cm (L50 ~ 174 cm)			Aasen 1961 Jensen *et al*., 2002

Parameter	Values	Sample Size	Area	Reference
Male mean length (LF)	116 cm		NW Atlantic	Kohler *et al.*, 2002
	147 cm		NE Atlantic	Kohler *et al.*, 2002
Female length at maturity (LF)	210–230 cm (L50 ~ 218 cm) 200–250			Jensen *et al.*, 2002 Aasen, 1961
Female mean length (LF)	108 cm		NW Atlantic	Kohler *et al.*, 2002
	154 cm		NE Atlantic	Kohler *et al.*, 2002
Maximum length (LF)	250 cm (male) 302 cm (female)		NW Atlantic	Campana (unpublished data*)
	253 cm (male) 278 cm (female)		NE Atlantic	Gauld, 1989
Average growth rate	25.2 cm y–1	3	NE Atlantic	Stevens 1990
Life span (years) Maximum age	29–45		NW Atlantic	Campana *et al.*, 1999
	40+ (unfished popn. based on natural mortality estimates) 25 (fished, maximum observed)			Campana *et al.*, 2001
	males: 25 females: 24 (vertebral counts) Longevity calcs. indicate 45–46 in unfished popn.			Natanson *et al.*, 2002
Length–weight relationship	W = (1.4823 x 10–5) LF 2.9641			Kohler *et al.*, 1995
	W = ('4 x 10–5) LF 2.7767	1022	Bay of Biscay and Celtic Sea	Hennache and Jung, 2010
	W = ('4 x 10–5) LF 2.7316	564	Bay of Biscay and Celtic Sea	Hennache and Jung, 2010
	W = ('4 x 10–5) LF 2.8226	456	Bay of Biscay and Celtic Sea	Hennache and Jung, 2010
Fork length-total length relationship	LF = 0.8971LT + 1.7939			Kohler *et al.*, 1995
Male growth parameters	l∞ = 257.7 k = 0.080 t0 = -5.78		NW Atlantic	Harley, 2002

Parameter	Values	Sample Size	Area	Reference
Female growth parameters	l_∞ = 309.8 k = 0.061 t0 = -5.90		NW Atlantic	Harley, 2002
Combined sex growth parameters	l_∞ = 289.4 k = 0.066 t0 = -6.06		NW Atlantic	Harley, 2002; Natanson *et al.*, 2002
	l_∞ = 267.6 ± 9.3 k = 0.084 ± 0.009 t0 = -5.39 ± 0.47	577	NW Atlantic	Cassoff *et al.*, 2007 (1993–2004 data)
Population growth rate	~ 2.5% per year max ~ 5% per year in unfished popn.			Campana *et al.*, 2003
Generation time (years)	~ 18		NW Atlantic	Campana *et al.*, 2003
	~ 11		Atlantic	Cortés, 2000
Intrinsic rate of increase	0.05–0.07		NW Atlantic	Campana *et al.*, 2001
Potential rate of increase per year	0.8%		Atlantic	Cortés, 2000
Trophic level	4.2	115 (stomachs)	various (4 studies)	Cortes, 1999
Total mortality coefficient	0.18		NW Atlantic	Aasen, 1963

*** Cited in Francis *et al.*, 2008**

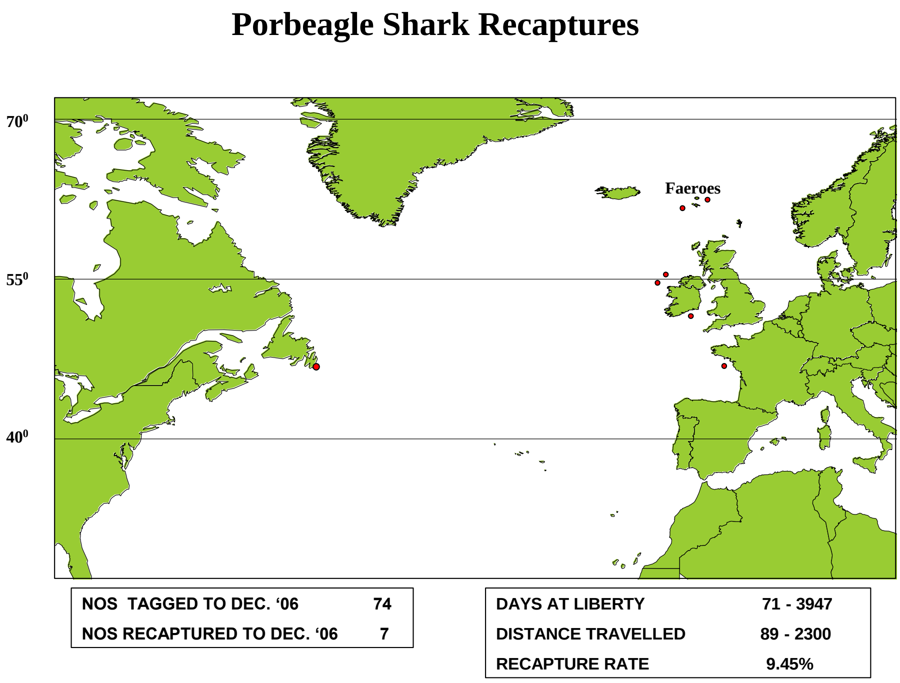
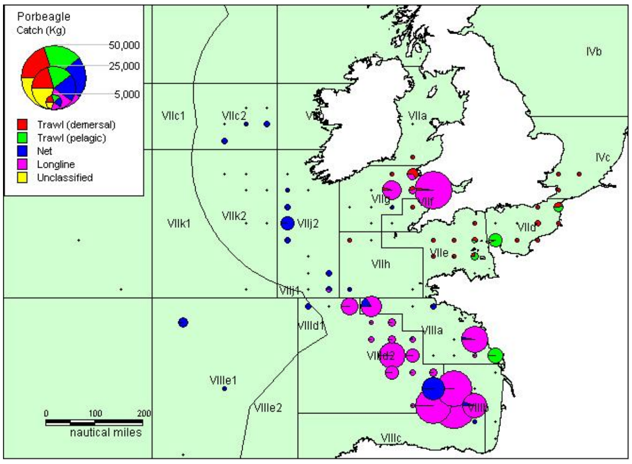
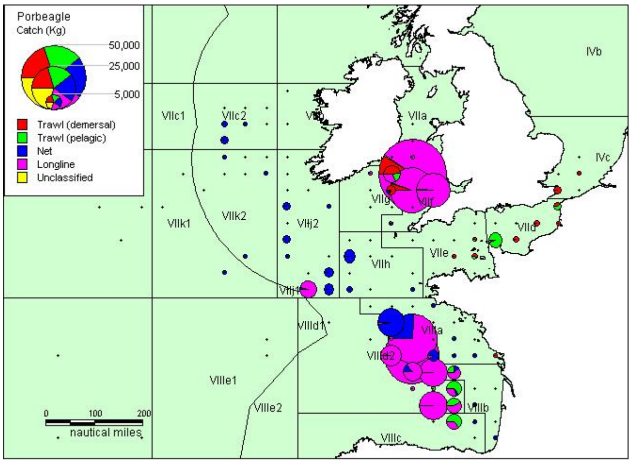


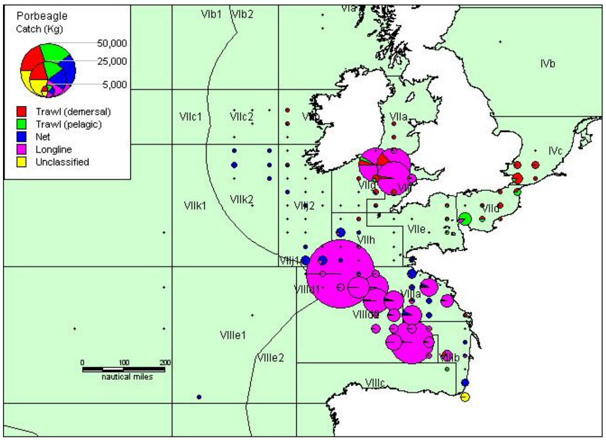
Figure 6.1. Porbeagle in the NE Atlantic. Recapture locations of porbeagle sharks, from Irish Central Fisheries Board tagging programme (Green, 2007 WD).



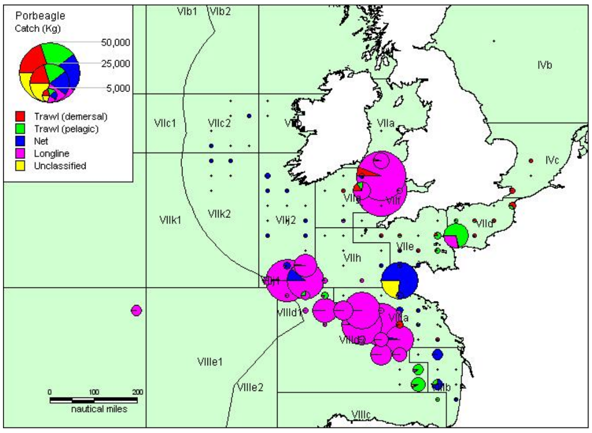
1999



2000



2001



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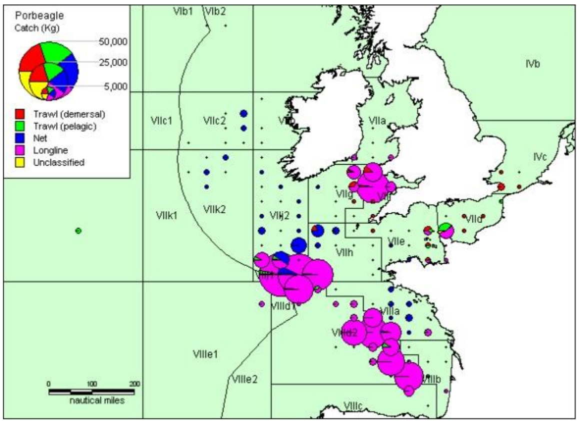

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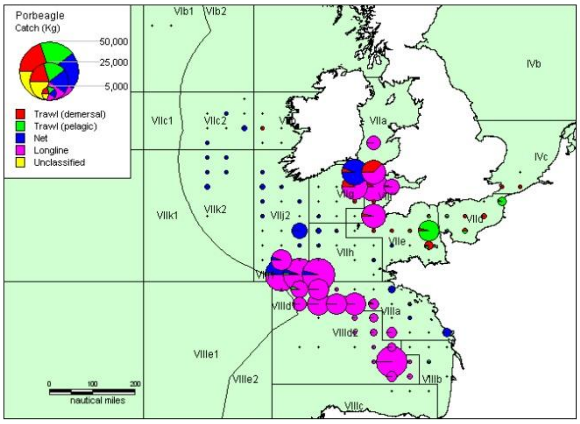

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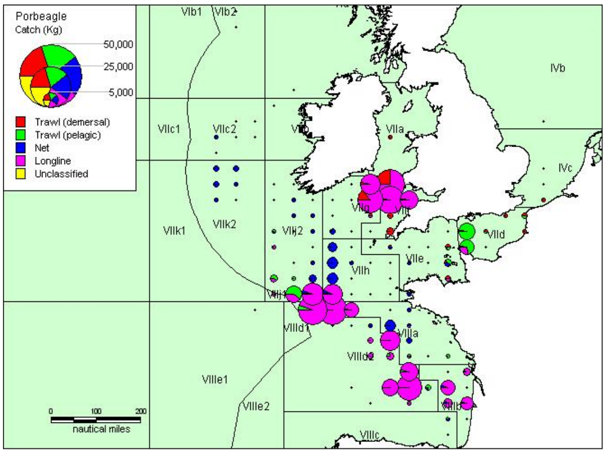
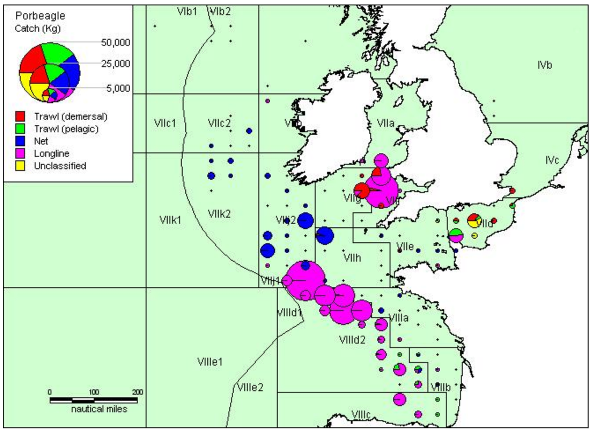
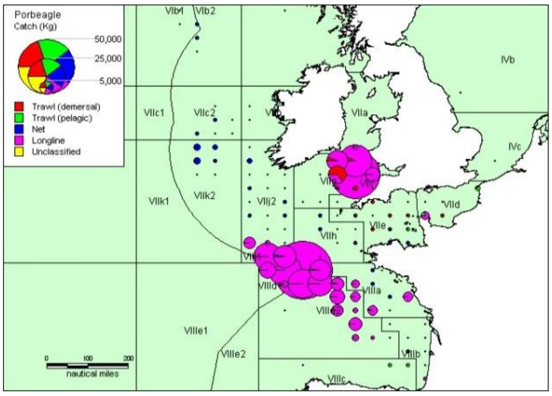


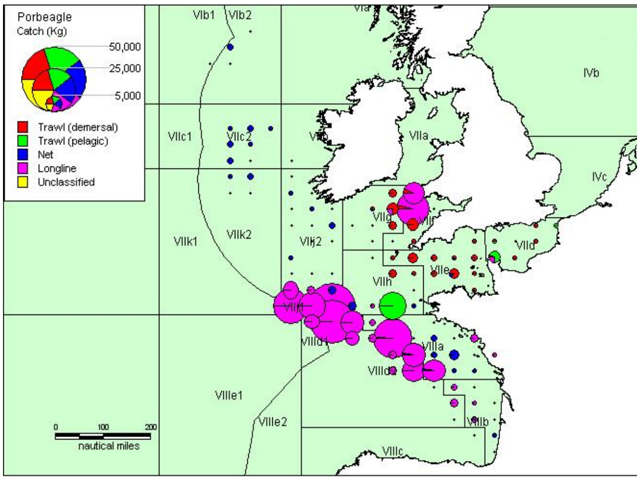
2005



2006

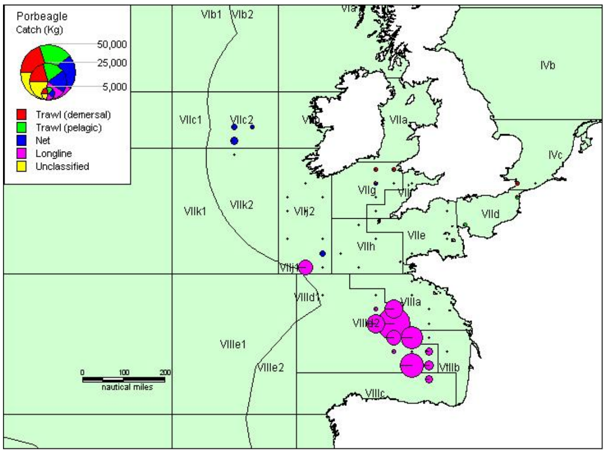


2007

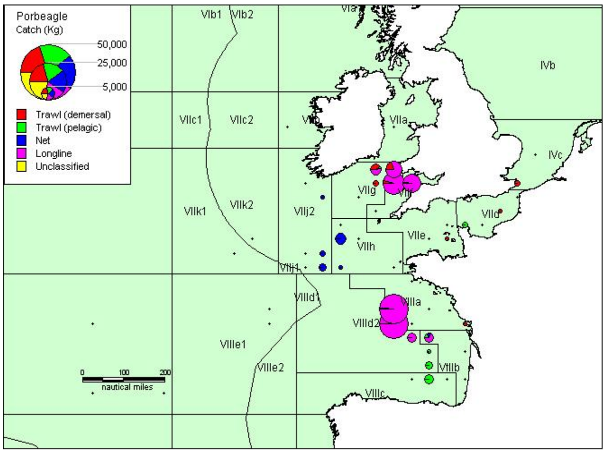


2008

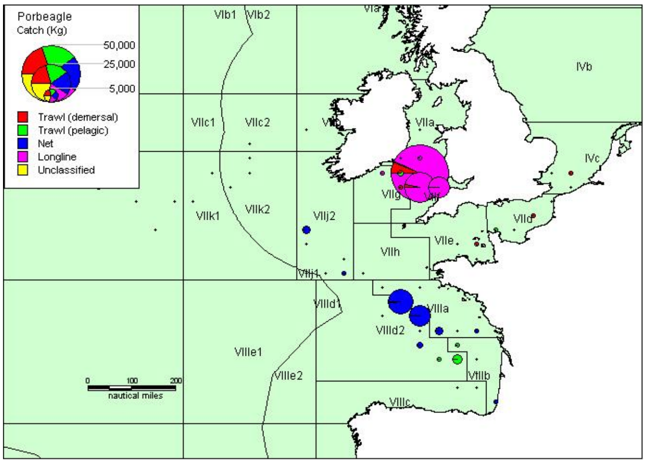
Figure 6.2. Porbeagle in the NE Atlantic. Annual distribution of Porbeagle (*Lamna nasus*) catch by gear and ICES statistical rectangles, 1999–2008.



April–May 2000



June–July 2000



August–September 2000

Figure 6.3. Porbeagle in the NE Atlantic. Seasonal distribution of Porbeagle (*Lamna nasus*) catch by gear and ICES statistical rectangles (2000).

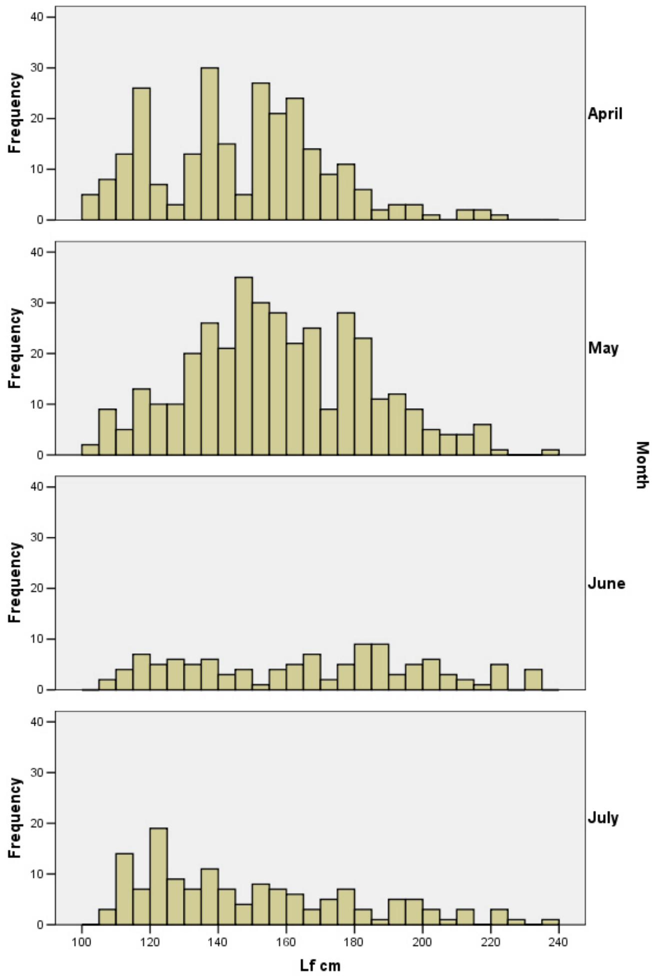


Figure 6.4. Porbeagle in the NE Atlantic. Length–frequency distribution of the landings of the Yeu porbeagle targeted fishery by month in 2008 (April, n = 164; May, n = 350; June, n = 113; July, n = 142) 2008. Source: Jung, 2008.

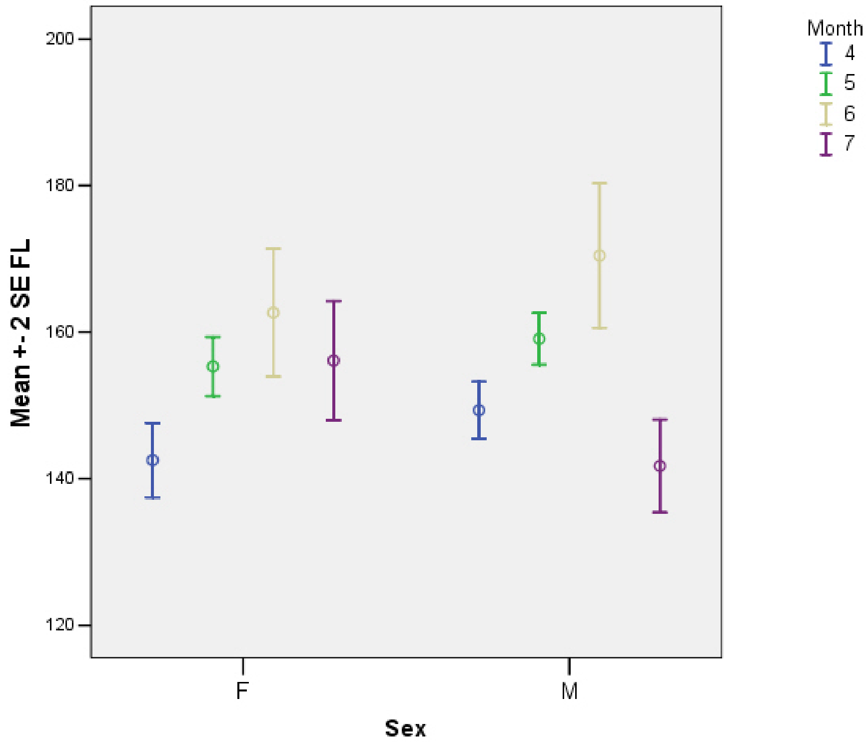


Figure 6.5. Porbeagle in the NE Atlantic. Mean average length of the porbeagle landed in the French targeted fishery by sex for April (blue), May (green), June (yellow) and July (purple). Source: Jung, 2008.

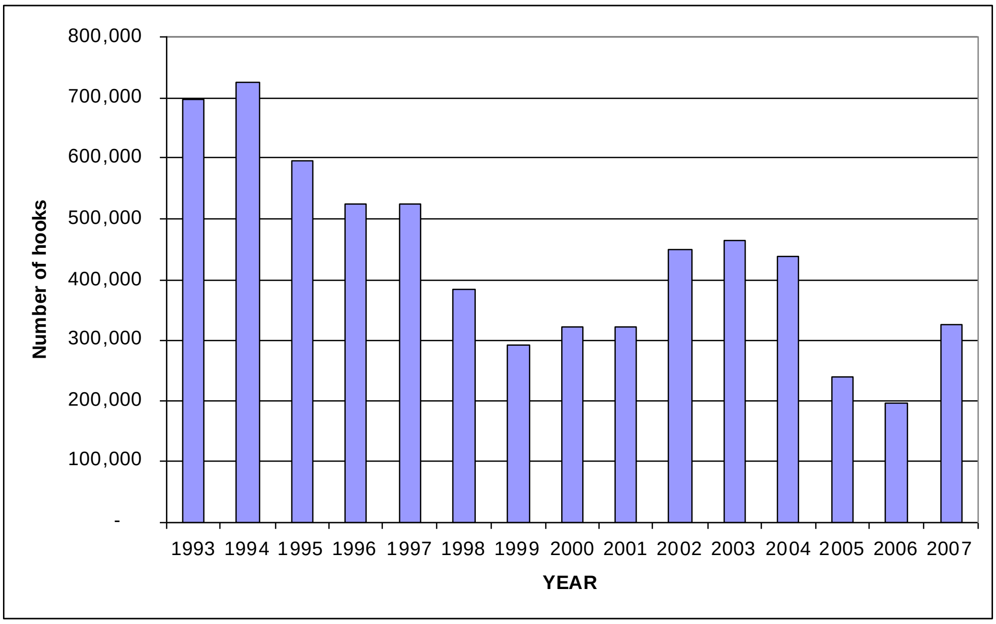


Figure 6.8. Porbeagle in the NE Atlantic. Temporal trend in estimated effort (number of hooks per year) in the French porbeagle fishery, 1993–2007.

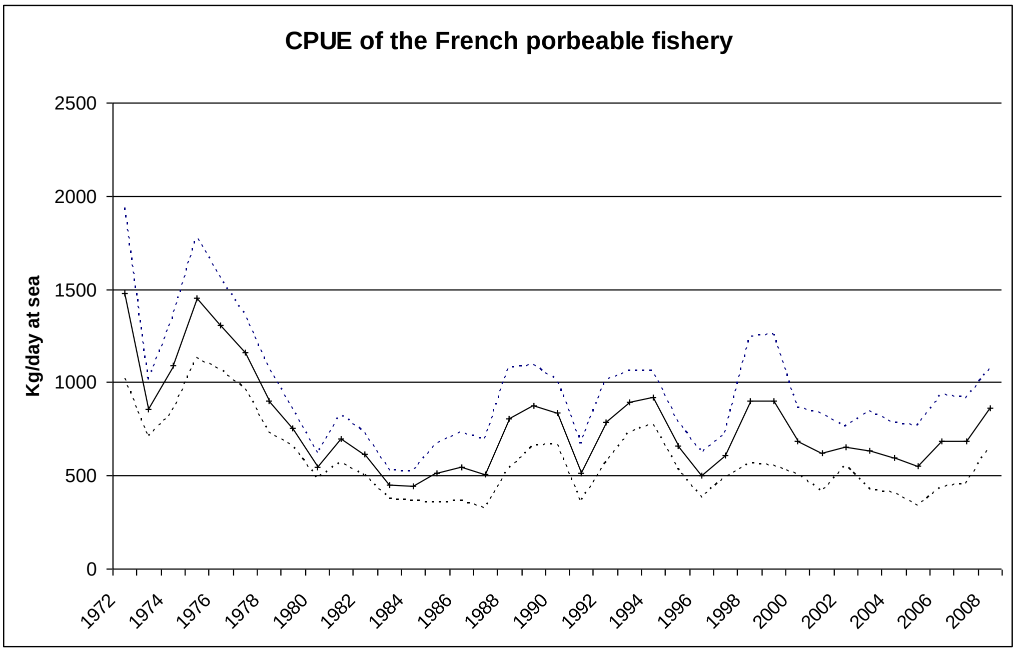


Figure 6.9. Porbeagle in the NE Atlantic. Nominal cpue (kg/day at sea) for porbeagle taken in the French fishery (1972–2008) with confidence interval (± 2 SE of ratio estimate). From Biais and Vollette, 2009, WD.

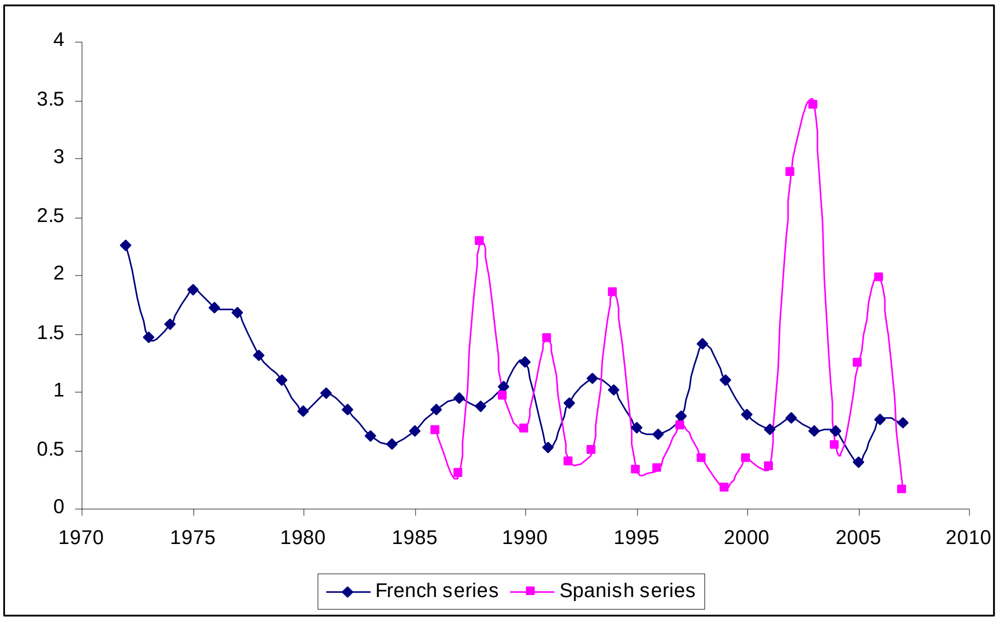


Figure 6.10. Porbeagle in the NE Atlantic. Temporal trends in standardized cpue for the French target longline fishery for porbeagle (1972–2007) and Spanish longline fisheries in the NE Atlantic (1986–2007).