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PRELIMINARY OBSERVATIONS ON THE BIOLOGY AND MOVEMENTS OF PORBEAGLE *LAMNA NASUS* AROUND THE BRITISH ISLES

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SUMMARY

Preliminary data are presented from electronic tagging studies conducted in 2010–2012. To date, of the 21 tags released, data were received from 14 sharks, resulting in a total of 2062 days of data, with a further six tags still to be released and data recovered. Sharks showed shallow diving behaviour in shelf seas, and deeper diving over the continental slope. A complementary study investigating bycatch during commercial gillnet fishing operations detailed 18 trips with numbers from 1 to up to 10–50 dead and discarded porbeagle per trip. Discard observer programme data from CEFAS are also presented, with 45 records of porbeagle bycatch detailed by area, gear, sex and length. Although based on a small sample size, biological information is provided for length-weight conversion factors, including for total length (both caudal fin in a natural position, and flexed down), fork length and standard length with both total and gutted weight. Length-length conversion factors for relating total length and standard length to fork length are given. Data on liver, gonads and fin weights, as proportions of total weight, are summarised.

RÉSUMÉ

Des données préliminaires sont présentées d'études de marquage électronique réalisées entre 2010 et 2012. À ce jour, sur les 21 marques remises à l'eau, des données ont été reçues de 14 requins, ce qui donne un total de 2.062 jours de données, six autres marques devant encore être remises à l'eau et les données récupérées. Les requins présentaient un comportement d'immersion court à faible profondeur dans les mers épicontinentales et un comportement d'immersion plus profonde le long du talus continental. Une étude complémentaire visant à déterminer les prises accessoires réalisées pendant les opérations de pêche commerciale au filet maillant a porté sur 18 sorties et a fait apparaître entre 1 et 10-50 requins-taupes communs rejetés morts par sortie. Les données de rejets du programme d'observateurs de CEFAS sont également présentées, avec 45 registres de prises accessoires de requins-taupes communs détaillés par zone, engin, sexe et taille. Même si elle repose sur une taille d'échantillon réduite, l'information biologique est fournie pour des coefficients de conversion taille-poids, y compris pour la longueur totale (nageoire caudale à la fois dans une position naturelle et fléchie vers le bas), la longueur à la fourche et la longueur standard avec à la fois le poids total et le poids éviscéré. Les coefficients de conversion longueur-longueur sont fournis pour mettre en rapport la longueur totale et la longueur standard à la longueur à la fourche. Le document récapitule les données sur les poids du foie, des gonades et des ailerons, comme proportions du poids total.

RESUMEN

En este documento se presentan los datos preliminares de estudios de marcado electrónico realizados en 2010-2012. Hasta la fecha, de las 21 marcas colocadas, se recibieron datos de 14 tiburones, lo que se corresponde con 2.062 días de datos, con seis marcas adicionales que tienen que colocarse todavía y los datos que tiene que recuperarse. Los tiburones mostraron una conducta de inmersión superficial en las zonas marítimas de la plataforma continental e inmersiones a mayor profundidad en las zonas de talud continental. Un estudio complementario que investiga la captura fortuita durante las operaciones de pesca comercial con redes de enmalle informaba sobre 18 mareas en las que se produjeron desde 1 hasta 10-50 muertes y descartes de marrajo sardinero por marea. También se presentan los datos del programa de observadores de descartes del Center for Environment, Fisheries & Aquaculture

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Science (CEFAS), con 45 registros de captura fortuita de marrajo sardinero detallados por zona, arte, sexo y talla. Aunque se basa en un tamaño de muestra reducido, se facilita información biológica para los factores de conversión talla-peso, lo que incluye longitud total (para aleta caudal en posición normal o flexionada hacia abajo), longitud a la horquilla y longitud estándar con peso total y peso eviscerado. Se proporcionan factores de conversión talla-talla para relacionar la longitud total y la longitud estándar con la longitud a la horquilla. Se resumen datos sobre pesos de aletas, hígados y gónadas, como proporciones del peso total.

KEYWORDS

Conversion factors, distribution, fins, maturity, movements, tagging

1. Introduction

Porbeagle shark Lamna nasus was subject to a target fishery to the north of the British Isles, fished mainly by Faroese and Norwegian vessels (see Aasen, 1961, 1963), but also with landings into Scotland (Gauld, 1989). Other nations, including Denmark and Germany, also had occasional fisheries for porbeagle in the North Sea. Targeted longline fisheries in the Bay of Biscay, Celtic Sea and outer Bristol Channel were conducted by French vessels (Lallemand-Lemoine, 1991), with English and Welsh vessels also targeting them seasonally in the Bristol Channel (Ellis & Shackley, 1995). Porbeagle are also taken in Spanish fisheries, although in smaller numbers than blue shark and shortfin mako (Mejuto, 1985; Mejuto & Garces, 1984).

Porbeagle is known to be susceptible to over-fishing, as evidenced by the crash in the Norwegian fishery, and is a long-lived species that produces few young (Francis & Stevens, 2000; Jensen *et al.*, 2002; Natanson *et al.*, 2002; Cassoff *et al.*, 2007). This biological vulnerability and the documented crash in the northern fishery were used by the IUCN to list this stock as 'Critically Endangered' (Stevens *et al.*, 2006).

ICES advice (summarised in **Table 1**) was been based largely on the precautionary approach, and has generally been along the lines of "*Given the state of the stock, no targeted fishing for porbeagle should be permitted and bycatch should be limited and landings of porbeagle should not be allowed*". ICES, however, also advised that "*It is recommended that exploitation of this species should only be allowed when indicators and reference points for stock status and future harvest have been identified and a management strategy, including appropriate monitoring requirements has been decided upon and is implemented".*

In order to better assess and advise on the status of porbeagle stocks in the Atlantic, a joint meeting was held of the ICES WGEF and the ICCAT shark subgroup (ICCAT, 2009; ICES, 2009). During this meeting, analyses of the catch per unit effort (CPUE) in the French longline fishery was examined, and exploratory assessments were undertaken using a Bayesian Surplus Production (BSP) model and an age structured production model.

From this work, ICES (2009) noted that "*The projections (using the BSP model) were that sustained reductions in fishing mortality would be required if there is to be any stock recovery. Recovery of this stock to BMSY under zero fishing mortality would take ca. 15–34 years. Although model outputs suggested that the current TAC (436 t) may allow the stock to remain stable, at its current depleted biomass level, under most credible model scenarios, catches of 200 t or less resulted in higher probabilities of recovery to BMSY within 25–50 years under nearly all model scenarios*."

Despite attempts to assess the stock, there are fundamental problems in that (a) available catch data were considered under-estimates; (b) the projections were based on the BSP model, and this model was generally more optimistic than the age-structured production model; and (c) the index of CPUE for the French fleet was for a target fishery actively seeking areas of high catch rates, and so may not reflect stock abundance. Hence, model outputs were considered highly uncertain (ICES, 2009). The absence of any fishery-independent information on the status of the stock and the absence of recent fishery-dependent information restrict further options for assessing the stock.

In 2010, ICES also advised that "*Further ecological studies on porbeagle, as highlighted in the scientific recommendations of ICCAT (2009) would help further develop management for this species. Such work could usefully build on recent and ongoing tagging projects. Further studies on porbeagle bycatch and post-release survivorship of any discarded porbeagle are required*".

Since 2010, there has been a zero TAC for porbeagle, and although this has stopped target fisheries, it has also resulted in increased discarding of porbeagle bycatch (both dead and live sharks), and as such has been an unpopular regulation for various fisheries in the Celtic Sea, for which porbeagle have traditionally been a high-value occasional or seasonal bycatch species. Given criticisms from the fishing industry in Cornwall and Devon (UK), and the need for improved ecological studies, there have been efforts to improve our understanding of the species. Here a brief summary is given for:

- Electronic tagging studies currently being undertaken;
- Preliminary results from a Fisheries Science Partnership project on porbeagle bycatch;
- Incidences of bycaught porbeagle as observed in routine discard programmes.
- Biological information that were collected from a sample of dead bycaught porbeagle;

2. Methods

2.1 Field studies for tagging porbeagle

In 2009 a three year DEFRA-funded project was commissioned to better understand what threats accidental bycatch by fisheries posed to porbeagle shark populations through;

- Identifying the times of year and locations where these sharks are most vulnerable to capture in fisheries;
- Collating information and data from stakeholders on the survival of porbeagle caught in fishing gears;
- Assessing the likelihood that sharks will be in areas where they are at risk of capture;
- Evaluating the potential fisheries-induced mortality on porbeagle populations; and
- Assessing the risks to stock sustainability of continuing with current fishing practices.

Seasonal field studies to tag porbeagle sharks using pop-off electronic and mark ID tags have been undertaken since July 2010 (and are still on-going) around the British Isles, using a combination of recreational angling and commercial fishing vessels (**Table 2**). In all, 29 porbeagle have been tagged and released (21 electronic and eight mark ID tagged), since July 2010 to date. Seventeen tag deployments were aboard FV "Charisma" operating in the Celtic Sea (ICES Divisions VIIf-h), seven were aboard the angling vessel "Marco" off the northern coast of Ireland (ICES Division VIa), and four were aboard FV "Fille du Suet" fishing in the Bay of Biscay (ICES Division VIII).

Summary results from this tagging study are given, including release and pop-off electronic tag locations and examples of diving behaviour exhibited by porbeagle whilst at liberty.

2.2 Fisheries Science Partnership

In January 2003, the UK Government announced a package of funding for the fishing industry, which included £1 million in that financial year for fishers and scientists to work in partnership. Following the announcement, industry and Cefas developed a programme to improve knowledge of our fish stocks. The on-going Fishery Science Partnership (FSP) has successfully undertaken work on a variety of fish stocks and fisheries, including three previous studies specifically addressing elasmobranch fish (Catchpole *et al.*, 2007; Ellis *et al.*, 2008, 2010).

In 2011/2012 a FSP project was commissioned to address the issues of bycatch of three elasmobranchs of conservation interest (porbeagle, common skate and spurdog) taken as a bycatch in offshore gillnet fisheries, and their survivability (i.e. health prior to discarding). The five main project aims were to:

- conduct seasonal fishery-dependent surveys of ICES Divisions VIIe-j to improve our knowledge and understanding of catches of spurdog, porbeagle and common skate in relation to target species, and their survival;

- undertake biological sampling of spurdog, porbeagle and common skate bycatch, to enhance the biological understanding of the species (e.g. sex ratio, size composition, age and growth, reproductive state, and stock structure) which can inform on stock assessments and management;
- assess options for reducing the impact of discarding;
- initiate a tag-and-release programme for the three species of interest, including the training of vessel crew in shark handling, tagging and release procedures to maximize the chances of live discarding and survival;
- trial simplistic logbooks/self-sampling schemes to collect information on the quantities (sizes and sex ratio) of the three species, with the potential of creating preliminary fishery-dependent indices of relative abundance.

Summary results from this study are given, including the catch composition taken in gillnets, the locations of porbeagle capture in gillnets, size-frequency of porbeagle observed, and summary details of health state and numbers tagged.

2.3 Porbeagle observed in observer trips

The CEFAS observer programme collects information on catches and discards from English-registered commercial fishing vessels, and has been undertaken since 2002, as required under the EC Data Collection Framework 199/2008. Data used for the purpose of this study were collected over the period 2002−2011. Vessel selection and sampling protocols were described by Enever *et al.* (2007) and Catchpole *et al.* (2011). Discard trips record the numbers at length of discarded and retained fish, with all fish measures to the cm below. Data on biomass are not collected, and information for elasmobranchs has not always been reported by sex.

2.4 Biological data collection

Following on from the FSP project, a number of dead porbeagle were landed, under dispensation from the Marine Management Organisation, so that further biological information could be collected. The sharks were frozen and transported to Lowestoft. The specimens were subsequently examined for:

a) Total length, cm (with caudal fin in a natural position, both under the body and over the body);
b) Total length, cm (with caudal fin in a depressed position, both under the body and over the body);
c) Fork length, cm (both under the body and over the body);
d) Standard length, cm (both under the body and over the body);
e) Sex and maturity; clasper length (males only);
f) Girth;
g) Height and length of first dorsal fin;
h) Whole body weight;
i) Gutted weight;
j) Weight of fins;
k) Liver weight;
l) Gonad weight;
m) Pre-oral length, mouth width and mouth length.

Tissues were also collected for subsequent analyses of contaminants etc., but here only information on the morphometrics and conversion factors are given. Length-weight information was also available for two porbeagles caught during recent groundfish surveys of the Celtic Sea.

3. Results and discussion

3.1 Field studies for tagging porbeagle

To date, data have been retrieved from 15 electronic tags deployed on porbeagle, with six remaining tags hoping to be deployed this coming field season. A summary of the latest data recovery from electronic tags deployed on porbeagle is shown in **Table 3**. Data sets from six of the retrieved tags are shorter than anticipated, owing to premature detachment (usually within a few weeks), while nine data sets were retrieved from the anticipated deployment duration. Four tags failed to report at all, with one tag remaining and due to pop-off in June 2012. One archival tag, deployed opportunistically during the Fisheries Science Partnership trip in August 2011, was also recovered after a two month deployment. In total, the electronic tags have yielded over 2000 days of data (average = 125 days). Four tags have been recovered by beachcombers, enabling recovery of the fully archived dataset (2 min recording interval) for approximately 150 days of data.

The direction and distance of tag pop-off from release varied considerably between releases and seasons as shown in **Figure 1**. Tags attached to sharks in the Celtic Sea in late summer, and which transmitted positions in winter or early spring (November to May), generally popped off to the south of the release position. While tags attached to sharks off the North-west coast of Ireland in summer, and which popped off after various durations, cannot be generalised. These tags reported from positions far to the west in the central Atlantic (the furthest a tagged porbeagle has been confirmed to have travelled from the British Isles), close to the Gibraltar Straits, and within the North Sea. Two tags popped very close to the point of release, once after a few weeks, and the other after a few months. Tags deployed on the shelf edge in summer moved north and west, south and east, or remained in the same area.

The depth data recorded by retrieved electronic tags to date show two main types of behaviour exhibited by porbeagle shark (**Figure 2**). The first, exhibited in relatively shallow water (<150 m), is typified by short and frequent dives from the surface, typically deeper by day. The second, exhibited in deep water (>200 m), is typified by long, deep dives that appear to correspond to the day/night cycle. Four sharks (average dataset length = 42 days) displayed only shallow type behaviour, while 10 sharks (dataset length = 133 days) exhibited both types, with deep dive behaviour occurring on approximately 20% of the days at liberty.

More detailed analyses of these data are due to be undertaken in the coming year. Given that there have been other studies of porbeagle movements in both the North-west Atlantic (Campana *et al.,* 2010) and North-east Atlantic (Pade *et al.*, 2009; Saunders *et al.,* 2011), there will hopefully be a greatly improved understanding of porbeagle behaviour.

3.2 Fisheries Science Partnership

The number of fish (and percentage of total catch and their size range) caught by FV "Charisma" during the period 19–25 September 2011 is shown in **Table 4**. In all, 19 porbeagle sharks were caught, 1% of the total number of fish caught and 3.7% of the total number of discarded bycatch, although porbeagle would obviously comprise a greater proportion of the catch in terms of biomass.

Of the 19 porbeagle caught, three (16%) were thought to be in good condition (lively), one (5%) was recorded as very sluggish, 14 (74%) were considered dead, and one (5%) as dead and scavenged by lice (**Table 5**).

The length distributions varied widely for males and females (**Figure 3**), with mean total lengths of 170 ± 24 cm for males and 183 ± 45 cm for females. However, females covered a considerably broader length range than males. There was an even catch composition of males and females (sex ratio 1.3 : 1).

Four porbeagle were tagged and released, three (120 cm TL and 192 cm TL males, 177 cm TL female) were tagged externally with mark ID tags placed on the dorsal fin. One exceptionally lively male (172 cm TL) was tagged externally with an electronic data storage float tag (to record depth and temperature at 1-minute intervals), before being released back to sea (**Figure 4**). The electronic float tag remained on the shark for 66 days before becoming detached from the porbeagle on 24 November 2011, 251 km from the release position. The tag then floated ashore and washed up on Guisseny beach (North Brittany, France) on 20 January 2012, where it was recovered by a member of the public and returned to Cefas. Depth data recorded from the electronic tag showed the porbeagle to have been incredibly lively and mobile with active vertical movements up into the water column during darkness before returning closer to the seabed by day.

Three fishing vessels operating off the SW coast voluntarily trialled a bycatch card recording scheme, and 23 cards were returned in October and November 2011. Two vessels reported porbeagle on a total of 18 occasions. Summary details of these reports are provided in **Table 6**. Records of individual porbeagle captures were widely distributed throughout ICES Divisions VIIf-g during October and November 2011, although large quantities (of 5–50 fish) were also recorded in October 2011.

Overall porbeagles were caught at a variety of locations throughout ICES Divisions VIIf –h, during field studies and bycatch card trials throughout 2011–2012 (**Figure 5**). For further information on these studies, see Bendall *et al.* (2012).

3.3 Porbeagle observed in observer trips

During the years 2002–2011, the CEFAS observer programme recorded 45 porbeagles being discarded or retained (**Table 7**). In terms of gears, porbeagle were recorded mainly on gillnetters (including trammel and tangle nets), and this accounted for 75% of the total observations (n = 34), with more than 60% being retained. Meanwhile, a few specimens (n = 8) were caught by midwater pair trawl, and were all discarded.

Porbeagle were mainly observed in the Celtic Sea, in ICES Division VIIg (n = 26, 58%), with other areas in the south-western approaches (ICES Divisions VIIc, VIIe-f, VIIh) accounting for 17 (38%) of the records. There were only two records reported from the North Sea (IVb), and these were both retained. There seemed to be no apparent pattern to fish being discarded or retained by sex and/or length; fish were retained across a length range of 119–270 cm for females and 106–220 cm for males. Since 2010, all porbeagle have been discarded on observer trips (n = 9), in line with regulations.

These observations are presented here as individual descriptive records. As the data collected during the CEFAS observer programme may be influenced by various factors, such as low/high coverage for specific gear/area/time combinations, no attempts have been made to extrapolate these data to fleet level.

3.4 Biological data collection

The relationships between total (and gutted) weight with various length measurements (total length with the caudal fin extended and depressed in line with the body, total length with the caudal fin in a natural state, fork length and pre-caudal (standard) length) are shown in **Figure 6**. All these length measurements were recorded under the body, so as to reduce the impact of body curvature on length recording.

Measuring the sharks with tape measures over the body resulted in a consistent over-estimation of length, as opposed to measuring true length under the body for all measurements:

- Pre-caudal length = + 3.8% (0.8–5.9%)
- Fork length = +3.9% (1.4–6.0%)
- Total length (caudal fin in a natural position) = +3.6% (1.1–6.9%)
- Total length (caudal fin in a depressed position) = +2.9% (0.6–5.1%)

The relationships between the various length measurements (total length and pre-caudal length) with fork length are shown in **Figure 7**. A summary of other data from these dissections is given in **Table 8**, including the hepatosomatic index (liver weight as a percentage of total weight), which ranged from 6.6–12.2%, and the gonadosomatic index (the weight of the gonads expressed as a percentage of total weight), which ranged from 0.18–0.8%. The ratio of fin weight to total weight ranged from 3.5–6.6% (mean = 5.0%). Various other analyses on material collected are on-going.

In 2009, a maximum landing length (MLL) for porbeagle was in force, in order to promote the discarding of larger females. However, measuring large fish can be problematic. If maximum landing length restrictions are to be used for sharks, there needs to be due consideration of being able to provide fishermen and enforcement officials with the options of other morphometric features that are (a) closely related to fork length, and (b) more easily and safely measured. Here, as an example, the relationships between two measurements (height of the first dorsal fin and pre-oral length) with fork length are presented (**Figure 8**). Further studies, so as to better account for natural variation (e.g. potential ontogenetic variation and sexual dimorphism) in such measurements, are needed to identify the most appropriate options for managing size restrictions.

Acknowledgements

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Table 1. Chronology of ICES advice and EC technical regulations for porbeagle shark

<table>
<tr><th colspan="2">ICES advice</th><th colspan="2">EC regulations</th></tr>
<tr><td>2005</td><td>There is no information to evaluate stock status. The directed fishery for porbeagle stopped in the late 1970s due to very low catch rates. Sporadic small fisheries have occurred since that time. The high market value of this species means that a directed fishery would develop again if abundance increased. There are no indications of stock recovery. Given the apparent depleted state of this stock, no fishery should be permitted on this stock.</td><td rowspan="2">2006–2007</td><td rowspan="2">No management measures</td></tr>
<tr><td rowspan="2">2006 and 2007</td><td rowspan="2">Available information from Norwegian and Faroese fisheries shows that landings declined strongly and these fisheries ceased in the ICES area. These fisheries have not resumed, implying that the stock has not recovered, at least in the areas where those fisheries took place.
The available information from the French fishery suggests that CPUE reached a peak in 1994 and afterwards has declined. The CPUE has been stable at a much lower level since 1999, despite a relatively constant number of vessels involved.
No targeted fishing for porbeagle should be permitted on the basis of their life history and vulnerability to fishing. In addition, measures should be taken to prevent bycatch of porbeagle in fisheries targeting other species, particularly in the depleted northern areas.</td></tr>
<tr><td>2008</td><td>TAC of 581 t</td></tr>
<tr><td rowspan="2">2008 and 2009</td><td rowspan="2">Available information from Norwegian and Faroese fisheries shows that landings have declined strongly and have almost ceased. The stock is considered to be depleted. The directed fisheries have not been resumed.
While the CPUE indices for a targeted fishery may not reflect trends in relative abundance, CPUE data have been relatively stable since 1996. CPUE of the French fishery has declined since a peak in 1994 and has been stable at a lower level since then.
Given the state of the stock, no targeted fishing for porbeagle should be permitted and bycatch should be limited and landings of porbeagle should not be allowed.
It is recommended that exploitation of this species should only be allowed when indicators and reference points for stock status and future harvest have been identified and a management strategy, including appropriate monitoring requirements has been decided upon and is implemented.
A maximum landing length (MLL) in longline fisheries may be a useful precautionary management measure to afford protection to the mature female part of the stock. Although there are no studies to define an MLL that would be most beneficial to the stock, the length at first maturity of females may serve as a precautionary MLL, which would be about 210 cm fork length</td><td>2009</td><td>TAC of 436 t (25% reduction)
A maximum landing size of 210 cm (fork length) shall be respected</td></tr>
<tr><td rowspan="2">2010–2012</td><td rowspan="2">Zero TAC in EC waters; Prohibited species in international waters</td></tr>
<tr><td>2010 and 2011</td><td>There is no assessment available to alter the perception of the depleted nature of the stock. Therefore there is no non-zero catch option that is compatible with the ICES MSY framework.
ICES reiterates the precautionary advice it gave in 2008, for 2009 and for 2010 that given the state of the stock, no targeted fishing for porbeagle should be permitted and bycatch should be limited and landings of porbeagle should not be allowed.</td></tr>
</table>

Table 2. Summary of tagging trips for deployment of electronic and mark ID tags**.**

Date of trip	*Fishing Vessel*	*Gear type*	*ICES Division*	*No. Caught*	*No. Electronic tagged*	*No. Mark ID tagged*
July 2010	Shy-Torque III	Rod & line	IVb	1	1	0
July 2010	Lady Mary	Rod & line	VIIf	0	0	0
July 2010	FV Ceol-na'mara	Longline	VIIf-g	0	0	0
August 2010	FV Ceol-na'mara	Longline	VIIf-g	0	0	0
Sept 2010	FV Ceol-na'mara	Longline	VIIf-g	0	0	0
Sept - Oct 2010	FV Charisma	Longline	VIIf-h	2	1	1
Sept - Oct 2010	FV Charisma	Gillnet	VIIf-h	1	1	0
December 2010	FV Charisma	Longline	VIIf-h	1	1	0
June - July 2011	Marco	Rod & line	VIa	7	7	0
July 2011	FV Fille du Suet	Longline	VIII	5	3	1
August 2011	FV Charisma	Longline	VIIf-h	9	6	3
September 2011	FV Charisma	Gillnet	VIIf-h	19	1	3
			Total	45	21	8

Table 3. Summary of data recovery from the electronic tagging programme for porbeagle (* includes one tag that was recovered by a beachcomber and refurbished to enable a second deployment).

Fate of tag	*Number of datasets*	*Total data holdings (d)*	*Future data (d)*
Full deployment	9	1337	1500
Partial deployment	5	239	382
Failure to report	4	0	0
At large	1	0	180
Remaining	6*	0	*Uncertain*
Total	25	*2062*	*Uncertain*

Table 4. Species composition (numbers and %) for total catches, and retained/discarded parts of the catch, observed for 21 sites fished with fixed nets during a field study aboard FV "Charisma". Hake and cod were the primary target species, with anglerfish, haddock, megrim, pollack and saithe also of importance. Three species (*) which would have traditionally been landed (porbeagle, common skate and spurdog), now have to be discarded.

	Total catch			*Retained catch*			*Discarded catch*		
Species	*N°*	*%*	*Length range (cm)*	*N°*	*%*	*Length range (cm)*	*N°*	*%*	*Length range (cm)*
Hake	**650**	**34.48**	**29–110**	**622**	**45.20**	**50–110**	**28**	**5.50**	**29–96**
Cod	**516**	**27.37**	**46–99**	**506**	**36.77**	**46–99**	**10**	**1.96**	**50–85**
Haddock	126	6.68	30–69	99	7.19	30–69	27	5.30	30–63
Ling	56	2.97	63–105	54	3.92	63–105	2	0.39	87–96
Whiting	46	2.44	31–56	30	2.18	36–56	16	3.14	31–52
Pollack	29	1.54	54–66	29	2.11	54–66			
Saithe	18	0.95	44–64	16	1.16	44–63	2	0.39	52–64
Megrim	16	0.85	30–49	14	1.02	33–49	2	0.39	30–34
Anglerfish	6	0.32	29–57	3	0.22	46–57	3	0.59	29–31
Anglerfish, black-bellied	1	0.05	50	1	0.07	50–50			
Dover sole	1	0.05	31	1	0.07	31–31			
Lemon sole	1	0.05	31	1	0.07	31–31			
Spurdog *	187	9.92	60–123				187	36.74	60–123
Lesser-spotted dogfish	139	7.37	42–76				139	27.31	42–76
Porbeagle *	**19**	**1.01**	**117–250**				**19**	**3.73**	**117–250**
Edible crab	15	0.80	16–21				15	2.95	16–21
Mackerel	15	0.80	24–36				15	2.95	24–36
Grey gurnard	8	0.42	22–37				8	1.57	22–37
Blue shark	6	0.32	104–235				6	1.18	104–235
Blue whiting	5	0.27	22–31				5	0.98	22–31
Common skate *	5	0.27	113–132				5	0.98	113–132
Bib	4	0.21	18–36				4	0.79	18–36
Witch	3	0.16	33–35				3	0.59	33–35
Allis shad	2	0.11	55–58				2	0.39	55–58
Black-mouth dogfish	2	0.11	66–67				2	0.39	66–67
Red gurnard	2	0.11	26–29				2	0.39	26–29
Crayfish	1	0.05	8				1	0.20	8
Dab	1	0.05	26				1	0.20	26
Greater-spotted dogfish	1	0.05	38				1	0.20	38
Herring	1	0.05	25				1	0.20	25
Poor cod	1	0.05	20				1	0.20	20
Shagreen ray	1	0.05	82				1	0.20	82
Stone crab	1	0.05	8				1	0.20	8
Grand total	**1885**	**100.00**		**1376**	**100.00**		**509**	**100.00**	

Table 5. Sex composition, length range (total length) and survivability of 19 porbeagle sharks taken as a bycatch in fixed gillnets in ICES Divisions VIIf-h by FV “Charisma” (September 2011).

Soak time (h)	*Sex*	*No.*	*Sex composition %*	*Length Range (cm)*	*Survivability*							
					Lively		*Sluggish*		*Dead*		*Dead and scavenged*	
					No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
11–15 h	Male	1	10%	117	1	100						
	Female	6	60%	144–250	1	17			4	66	1	17
	Unknown	3	30%						3	100		
	Total	**10**	**100%**	**117–250**	**2**	**20%**			**7**	**70%**	**1**	**10%**
16–26 h	Male	8	89%	156–194	1		1		6			
	Female	1	11%	245					1			
	Total	**9**	**100%**	**156–245**	**1**	**12%**	**1**	**12%**	**7**	**76%**		
All catches	Male	9	47	117–194	2	33	1		6	67		
	Female	7	37	144–250	1	14			5	72	1	14
	Unknown	3	16						3	100		
	Total	**19**	**100%**	**117–250**	**3**	**16%**	**1**	**5%**	**14**	**74%**	**1**	**5%**

Table 6. Summary details of voluntary bycatch card recordings by gillnetters operating in the south-west UK during October/November 2011.

Date of trip	*No.*	*Sex*	*Lengths*	*Discarded Condition*	*ICES Division*	*Fishing Vessel*	*Mesh size*	*Soak time (h)*	*Discard time after hauling*
18/10/2011	2	Female	>2 m	Dead	VIIg	Vessel A	120–220 mm	18	10 min
18/10/2011	10–50	Mostly females	>1 m	Mostly dead	VIIg	Vessel A	140 mm	18	10 min
19/10/2011	5	Mostly females	>1 m	Dead	VIIf	Vessel A	140 mm	20	10 min
20/10/2011	1	Female	>2 m	Dead	VIIf	Vessel A	140 mm	18	10 min
20/10/2011	1	Female	>1 m	Dead	VIIf	Vessel A	140 mm	18	5 min
20/10/2011	5	Mostly males	>1 m	Mostly dead	VIIf	Vessel A	140 mm	18	5 min
20/10/2011	1	Unknown	>1 m	Dead	VIIg	Vessel A	140 mm	18	5 min
21/10/2011	1	Unknown	>2 m	Dead	VIIg	Vessel A	140 mm	16	5 min
22/10/2011	5–10	Mixed catch	>1 m	Dead	VIIg	Vessel A	140 mm	18	10 min
17/11/2011	1	Female	>1 m	Dead	VIIg	Vessel B	4 7/8 inch	18	5 min
18/11/2011	1	Male	>1 m	Dead	VIIg	Vessel B	6 7/8 inch	20	5 min
18/11/2011	1	Male	>2 m	Dead	VIIg	Vessel B	5 7/8 inch	18	5 min
18/11/2011	1	Unknown	<1 m	Dead	VIIg	Vessel B	7 7/8 inch	18	5 min
19/11/2011	1	Unknown	<1 m	Dead	VIIg	Vessel B	10 7/8 inch	18	1 min
19/11/2011	1	Male	>1 m	Dead	VIIg	Vessel B	9 7/8 inch	18	2 min
19/11/2011	1	Female	>2 m	Dead	VIIg	Vessel B	8 7/8 inch	18	2 min
20/11/2011	1	Unknown	>1 m	Dead	VIIg	Vessel B	11 7/8 inch	18	Fell out of net
20/11/2011	1	Female	>2 m	Dead	VIIg	Vessel B	12 7/8 inch	18	2 min

Table 7. Summary details of porbeagle recorded by CEFAS observers on commercial vessels, giving information on length, sex and fate (D = discarded; R = retained). One record (denoted *) was from a sub-sampled catch, and was raised by a factor of two.

Gear	*Dates*	*ICES Division*	*ICES Rectangle*	*Length (cm)*	*Sex*	*Fate*	*Total Catch*
Midwater pair trawl	Feb 2003	VIIc	34D7	90	M	D	1
				100	M	D	1
				180	M	D	1
				200	M	D	2
				220	M	D	1
Tangle / Trammel net	Mar 2003	VIIg	29E2	175	M	R	1
				270	F	R	1
Gillnet	Sept 2004	VIIe	28E4	106	M	R	1
				107	M	R	1
Otter trawl	Apr 2005	VIIe	28E3	119	F	R	1
Midwater pair trawl	Nov 2005	VIIe	29E6	230	U	D	2*
Gillnet	Jan 2006	VIIf	29E3	177	F	R	1
Gillnet	Jul 2006	VIIg	29E2	130	F	R	1
Gillnet	Oct 2006	VIIg	29E2	227	F	R	1
Gillnet	Jun 2007	VIIg	31E1	119	M	R	1
Gillnet	Aug 2007	VIIg	32E4	176	M	R	1
				191	M	R	1
				237	F	R	1
Gillnet	Jul 2008	VIIf	29E3	175	F	R	1
				185	F	R	1
				190	F	R	1
Tangle / Trammel net	Sept 2008	VIIg	31E4	136	F	D	1
				154	F	D	1
Gillnet	Nov 2008	VIIg	29E2	167	U	R	1
Nephrops otter trawl	Apr 2009	IVb	39F0	224	U	R	1
Bottom pair trawl	Sept 2009	IVb	37E9	203	M	R	1
Gillnet	Oct 2009	VIIg	29E1	174	M	D	1
				178	F	R	1
				220	M	R	1
Gillnet	Oct 2009	VIIh	28E1	136	M	R	1
		VIIg	29E1	142	M	R	1
				146	F	R	1
				179	M	R	1
				242	F	R	1
Gillnet	Nov 2009	VIIg	30E3	182	M	D	1
Trammel net	Jun 2010	VIIg	29E1	135	M	D	1
Gillnet	Oct 2010	VIIg	29E2	185	M	D	1
Trammel net	Nov 2010	VIIh	27E4	125	F	D	1
Trammel net	Apr 2011	VIIg	30E1	113	F	D	1
				128	M	D	1
			30E2	175	M	D	1
				185	F	D	1
Trammel net	Jul 2011	VIIg	31E3	210	F	D	1

Table 8. Summary details of biological information for 12 porbeagle from examination of dead bycatch, giving sex, fork length (under the body), total weight, maturity, liver weight (and hepatosomatic index, I_H), gonad weight (and gonadosomatic index, I_G), and the weight of the fins.

Sex	*Fork length (cm)*	*Total weight (W, kg)*	*Maturity*	*Liver*		*Gonads*		*Fins*	
				Wt. (g)	I_H *(%W)*	*Wt. (g)*	I_G *(%W)*	*Wt. (g)*	*%W*
Female	116.5	20.8	Immature	2009.6	9.7	104.5	0.50	1054.5	5.1
Female	117	26.7	Immature	2491.2	9.3	48.0	0.18	1196.7	4.5
Female	118	23.6	Immature	2356.0	10.0	132.8	0.56	1208.9	5.1
Female	124	25.5	Immature	2286.0	9.0	141.7	0.56	1260.0	4.9
Female	199	94.2	Maturing	6200.0	6.6	514.8	0.55	–	–
Male	92	12.1	Immature	1479.0	12.2	30.1	0.25	422.8	3.5
Male	123	23.0	Immature	1934.8	8.4	93.2	0.41	1272.4	5.5
Male	125	30.2	Maturing	2007.1	6.6	106.3	0.35	1353.1	4.5
Male	143	40.3	Mature	3306.0	8.2	143.8	0.36	1931.8	4.8
Male	146	41.3	Mature	3138.8	7.6	330.0	0.80	2223.1	5.4
Male	148	40.2	Mature	2772.6	6.9	226.9	0.56	2255.7	5.6
Male	154	44.2	Mature	4165.0	9.4	227.5	0.51	2921.2	6.6

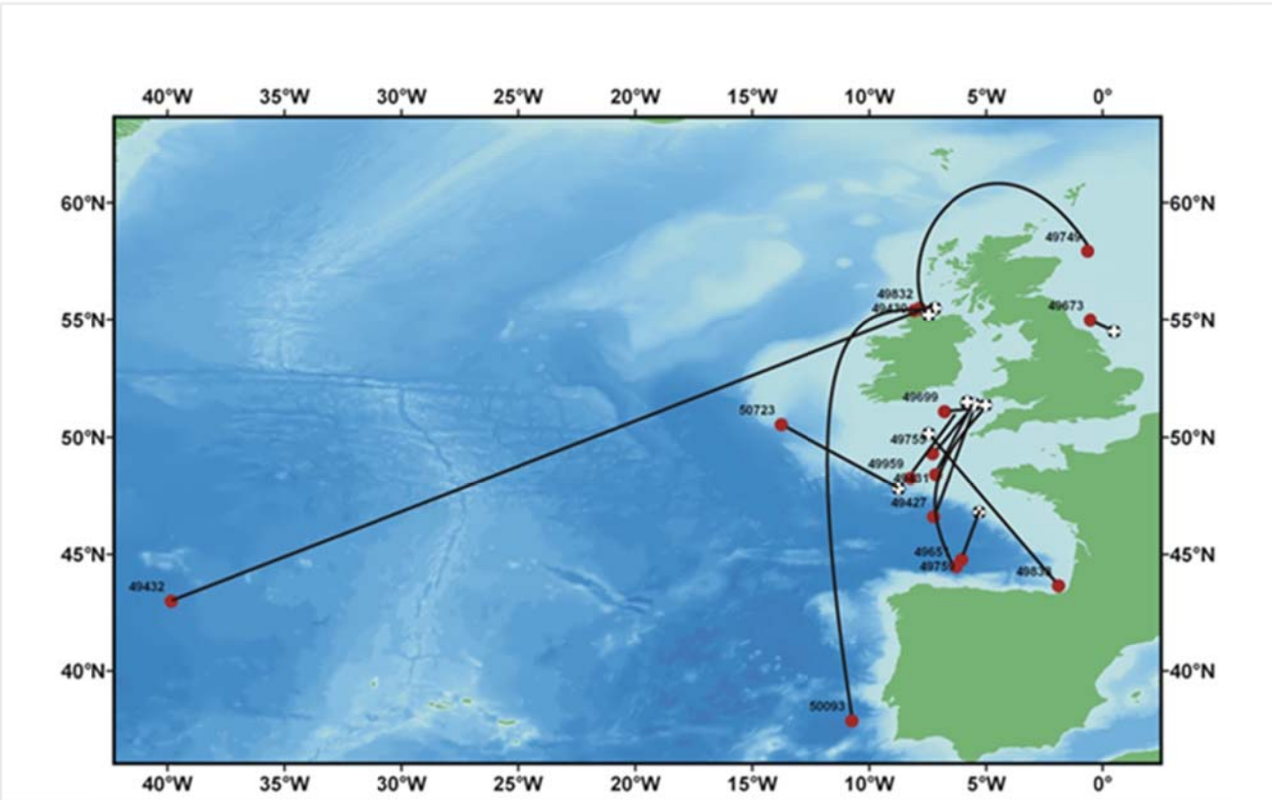

Figure 1. Release (cross) and pop-off locations (red circles) of the 14 PSAT tags that have reported back to CEFAS.

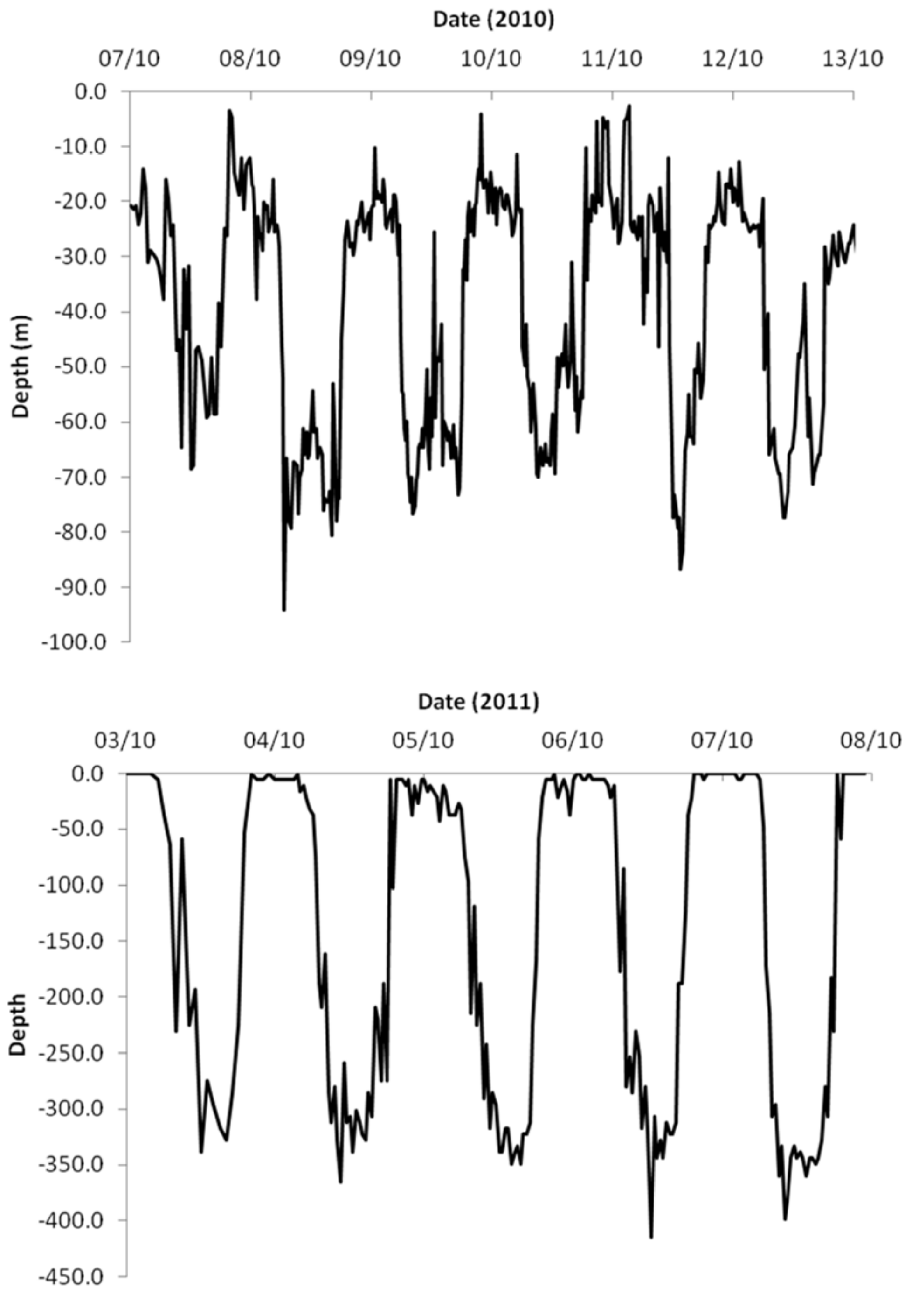

Figure 2. Examples of diving behaviour exhibited by porbeagle showing shallow diving in shelf waters (top), and deep diving over the continental slope (bottom).

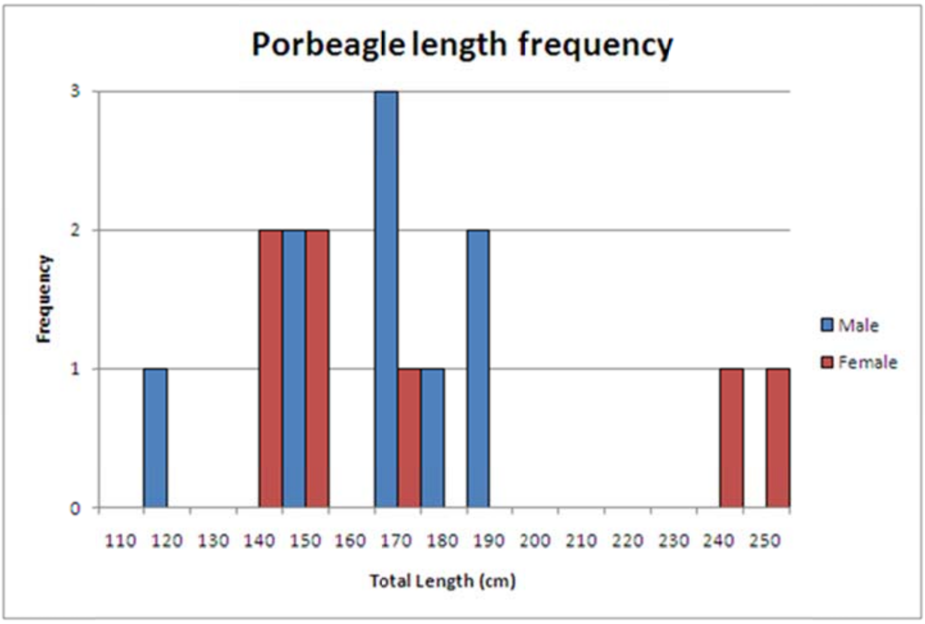

Figure 3. Length-frequency distribution of male and female porbeagle taken as a bycatch in fixed gillnets within ICES Divisions VIIf-h on board FV "Charisma" during September 2011.

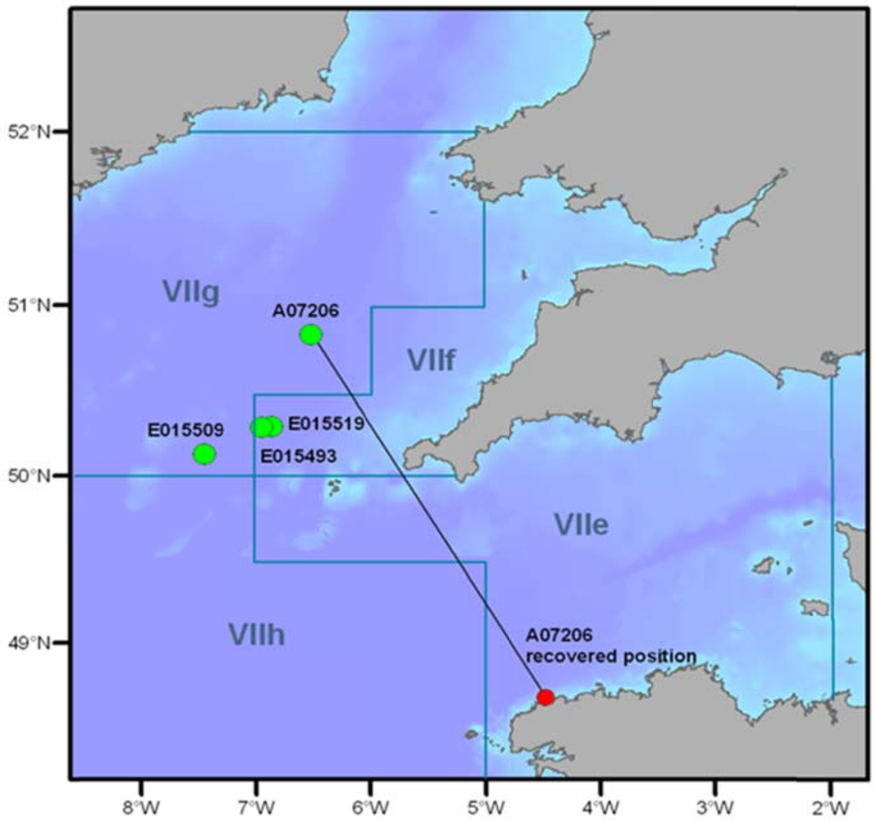

Figure 4. Release positions (green circles) of four porbeagle sharks tagged aboard FV "Charisma" in September 2011, and position of electronic tag (red circle) recovered off Guisseny (North Brittany).

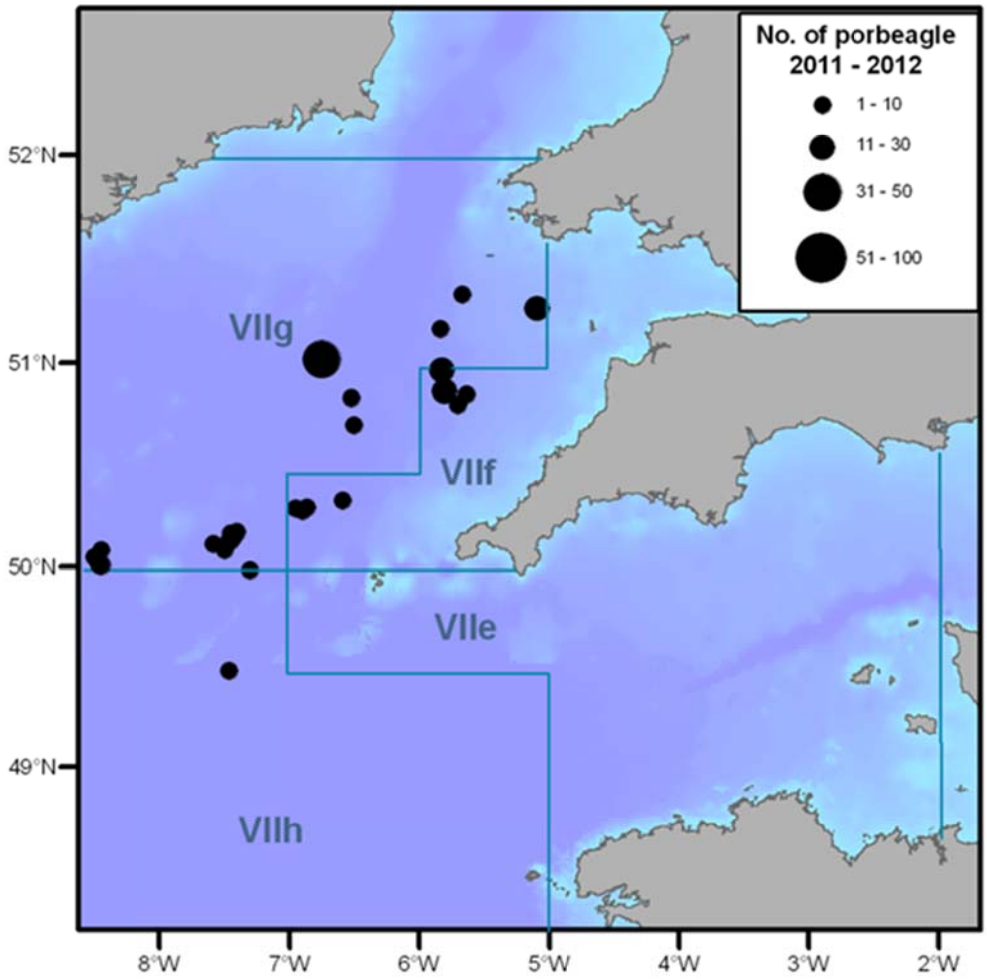

Figure 5. Summary of porbeagle catches observed during field studies and normal commercial fishing operations within Fisheries Science Partnership project 2011–2012.

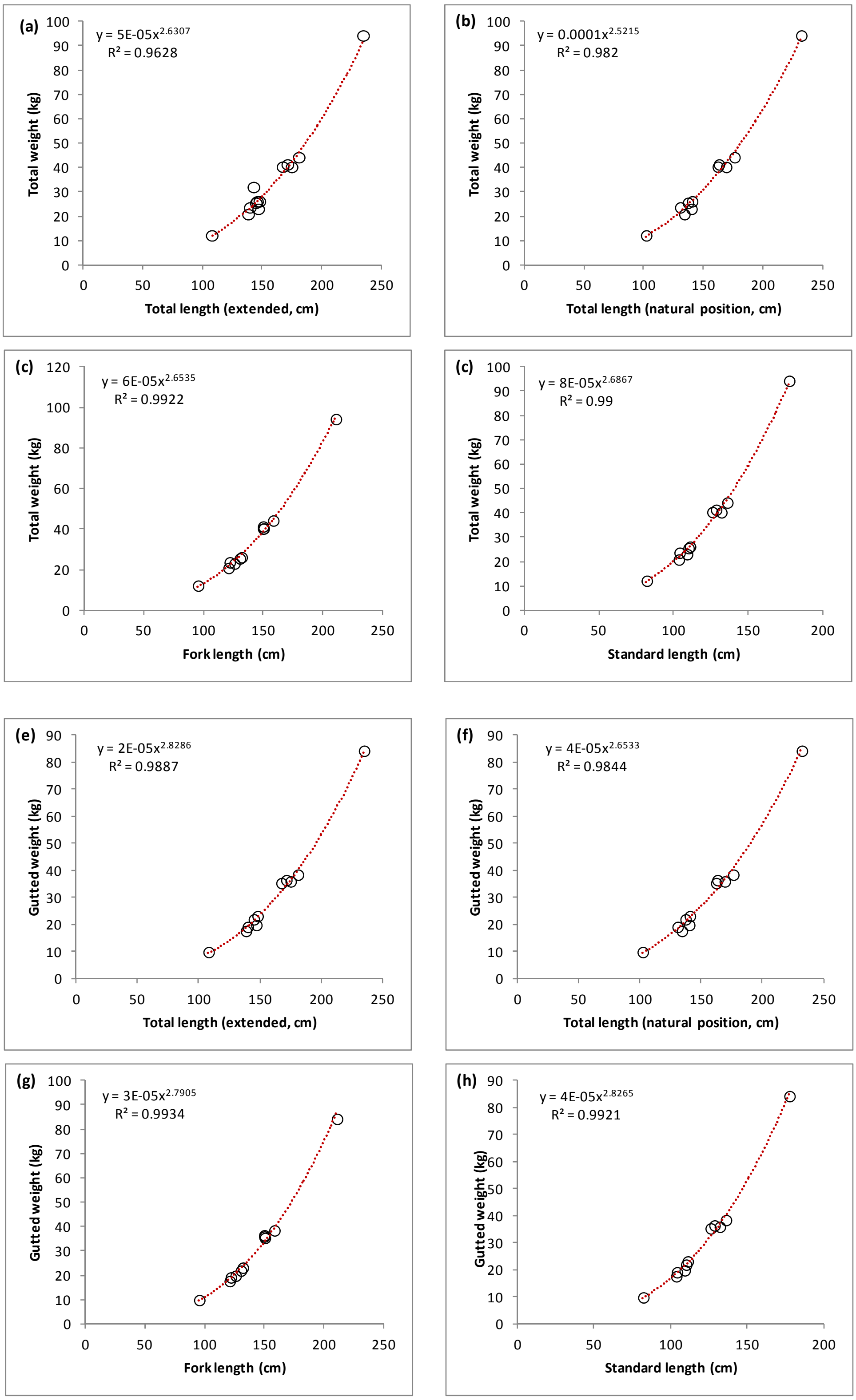

Figure 6. Biological information for porbeagle showing relationships between total weight with (a) total length (caudal fin extended), (b) total length (caudal fin in a natural position), (c) fork length and (d) standard (or pre-caudal length). All length measurements recorded below the shark so as to minimise the impact of body curvature on accuracy. Corresponding relationships for gutted weight and the various length measurements also given (e-h). Sample size = 11 (except for (a), where n = 13).

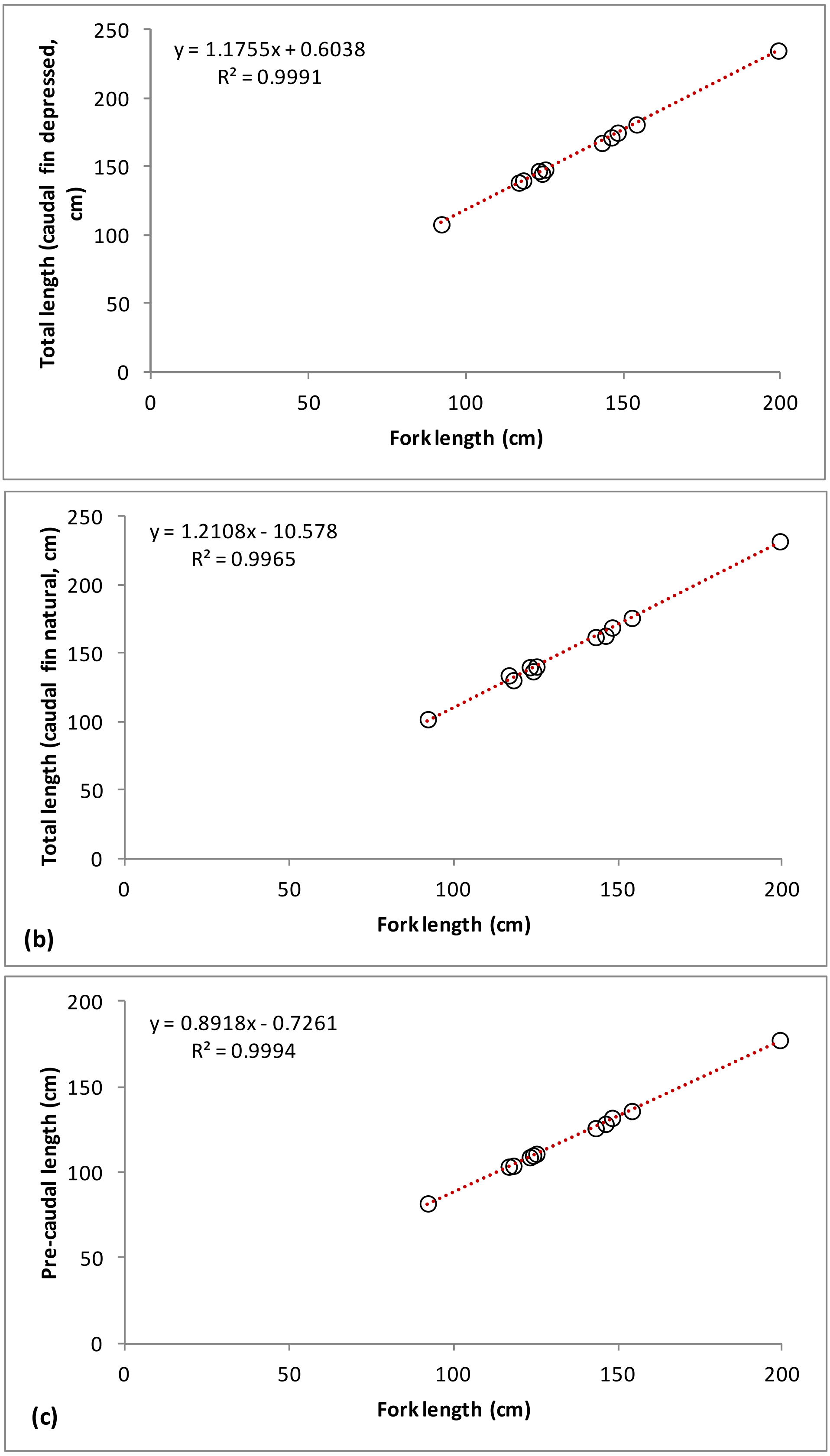

Figure 7. Biological information for porbeagle (n = 11) showing relationships between (a) total length (caudal fin extended and depressed), (b) total length (caudal fin in a natural position) and (c) pre-caudal length with fork length. All length measurements recorded below the shark so as to minimise the impact of body curvature on accuracy.

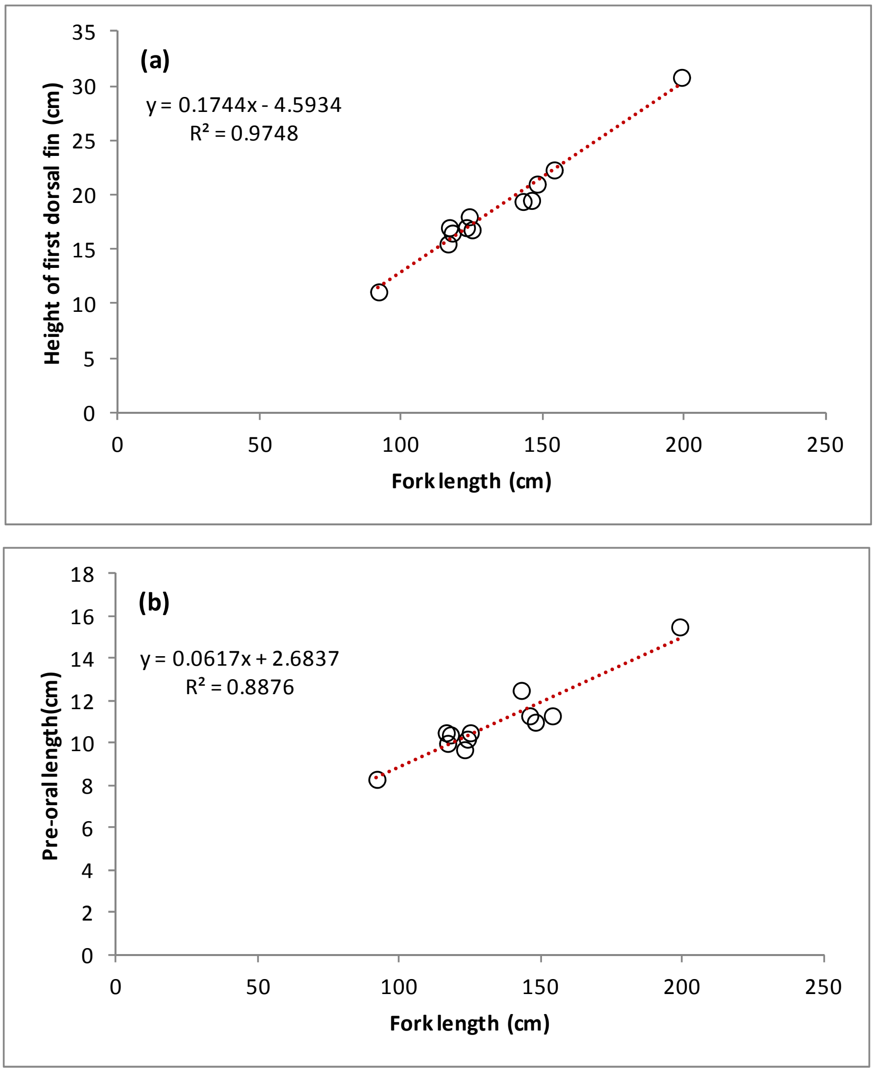

Figure 8. Biological information for porbeagle (n = 12) showing relationships between (a) height of the first dorsal fin, and (b) pre-oral length with fork length.