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SUMMARY OF DATA FROM THE UNITED KINGDOM RECREATIONAL PORBEAGLE FISHERY FROM 1960-2020

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SUMMARY

Results from analysis of the United Kingdom recreational porbeagle fishery from 1960-2020 are presented for the purpose of the 2020 ICCAT request for data on the species. During this period, 1883 porbeagle were captured in UK waters for which we have records, with captures peaking during the mid-1970s before collapsing in the late 1980s to a point where the species was absent from many areas of UK waters. Since 2015, increases in both the numbers and the spatial distribution of porbeagle captures has occurred, including those adjusted for effort, which has been led by an increase in recruitment. Porbeagle populations within the UK show considerable segregation by size, with captures of mature fish largely restricted to certain areas.

RÉSUMÉ

Les résultats de l'analyse de la pêcherie récréative de requin-taupe commun du Royaume-Uni de 1960 à 2020 sont présentés en réponse à la demande de données sur cette espèce formulée par l'ICCAT en 2020. Au cours de cette période, 1883 requins-taupes communs ont été capturés dans les eaux britanniques pour lesquels nous disposons de données, avec un pic des captures au milieu des années 1970 avant de s'effondrer à la fin des années 1980 jusqu'à ce que l'espèce soit absente de nombreuses zones des eaux britanniques. Depuis 2015, des augmentations du nombre et de la distribution spatiale des captures de requins-taupes communs ont eu lieu, y compris celles ajustées pour l'effort, ce qui a entraîné une augmentation du recrutement. Les populations de requins-taupes communs du Royaume-Uni présentent une ségrégation considérable en fonction de la taille, les captures de poissons matures étant largement limitées à certaines zones.

RESUMEN

Se presentan los resultados de los análisis de la pesquería de recreo del marrajo sardinero del Reino Unido de 1960-2020 en respuesta a la solicitud de ICCAT de 2020 de datos sobre esta especie. Durante este periodo, se dispone de registros de 1883 marrajos sardineros fueron capturados en aguas del Reino Unido. Las capturas alcanzaron un pico a mediados de los 70 antes de colapsar a finales de los 80 hasta un punto en el que la especie estaba ausente de muchas zonas de aguas del Reino Unido. Desde 2015, se han producido aumentos tanto en el número como en la distribución espacial de las capturas de marrajo sardinero, lo que incluye las ajustadas para el esfuerzo, lo que ha conducido a un aumento en el reclutamiento. Las poblaciones de marrajo sardinero en el Reino Unido muestran una considerable segregación por talla, y las capturas de peces maduros están muy restringidas a ciertas zonas.

KEYWORDS

Porbeagle, sport fishing, migration, catch/effort

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Introduction

The Porbeagle shark (*Lamna nasus)* is a large pelagic shark with a widespread distribution in cold and temperate waters in both the southern and northern hemispheres (González et al. 2021; S. E. Campana et al. 2012). *L. nasus* exhibits a complex life history with possible natal philopatry (Biais *et al*. 2017). Although the species in the Atlantic is managed on a basis of an eastern and a western stock, *L. nasus* is highly migratory and individuals can travel over 4000 km in a single year (Biais *et al.* 2017; Hoolihan *et al.* 2011), no significant genetic difference between these stocks has been found (González *et al*. 2021) and transatlantic migrations have been observed (Cameron *et al*. 2018). *L. nasus* occurs in waters around the United Kingdom during its annual migrations and has been a popular sport fish around the British Isles since the 1950s. Since its inception in 1953 the Shark Angling Club of Great Britain (SACGB) has kept detailed records of captures of the species. The species has been heavily commercially exploited by longline, purse seines and longline fisheries (Simpfendorfer *et al*. 2008; Cortés *et al*. 2015) and in the North Atlantic the *L. nasus* subpopulation has seen a reduction of between 50-79% over the last 60 years (Rigby *et al.* 2019). A zero Total Allowable Catch (TAC) has been in place since 2010 in EU waters (ICCAT 2015).

The current recreational fishery for *L. nasus* in the UK has been conducted on a catch and release basis since 1994, largely as an occasional bycatch of blue shark recreational fisheries. This factor, along with a low capture-induced mortality (Campana *et al*. 2009; Anderson *et al.* 2021) and a high degree of motivation among anglers to protect the species, means that the data collected is potentially of high value to fisheries managers. However, a disconnect exists between anglers and scientists, which has led to an under-utilization of this data source. To increase knowledge about this species in the UK, the SACGB, Sportfishing Club of the British Isles (SCBI) and charter skippers are collaborating to collect and collate catch data for *L. nasus* in UK waters through the Pat Smith database. This document presents the combined data from this ongoing project.

1. Data and methods

1.1 Catch and effort data

Data sources
The data from around the UK coastline is largely collated from historical records of the Shark Angling Club of Great Britain (SACGB) and consists of records from 34 different boats that fished for sharks from 1960-2020from the SW of England and from skippers who are members of the club from other areas of the UK.

Additional capture data was submitted to the Pat Smith database by 13 contributing skippers from UK waters. Data was aggregated by ICES sea areas and are shown in **Figure 1**.

The data used in this analysis is summarised in **Tables 1-2** and total catch and nominal Catch Per Unit Effort (CPUE) for ICES sea area *VIIe* by year is presented in **Figures 2-3**.

1.2 Length data

Data sources
Due to the relative scarcity of *L. nasus* in ICES sea area *VIIe* all captures were recorded in the SACGB. Because of the awarding of prizes for numbers of fish over 34 kg for individual boats, accurate records of lengths for mature fish are available as well as total captures per boat. *L. nasus* captures from other sea areas were also submitted to the club by members. The data used in this analysis is summarised in **Table 4** and length distribution is presented in **Figures 4-7**.

2. Analysis

Nominal Catch Per Unit Effort (CPUE) was calculated using the following formula:

$$CPUE = \frac{\sum C}{\sum \mathcal{F}}$$

where *C* is total yearly catch and *F* is annual fishing effort in boat days. Both total yearly catch by ICES sea area and yearly CPUE by ICES sea area (where effort was available) are reported.

Lengths were reported as cm. Where only weights were reported, lengths were back calculated using the rearrangement of the weight calculation:

$$WT = (a)FL^{b}$$

Where:

$$FL = (WT)^{(\frac{1}{b})}/(a^{(\frac{1}{b})}))$$

Where *WT* is total weight in kg, *FL* is fork length in cm and the constants $a = 1.4823*10^{-6}$ and $b = 2.9641$ for *L. nasus*, as described by Kohler, Casey, and Turner (1995).

Ages were assigned to individual fish using the rearrangement of the von Bertalanffy equation described by Ogle and Isermann (2017) where:

$$Tr = (\log\left(\frac{L\infty - Lr}{L\infty - t0}\right))/(-K)$$

Where T_r is age in years of the nth fish, *Lr* the length in cm of the nth fish; $L\infty$ is the asymptotic length, *t0* is the theoretical age where the expected length (*Lt*) is zero and *K*= the exponential rate at which L_t approaches $L\infty$. For the purpose of age allocation the von Bertalanffy growth parameters validated by vertebrae analysis by Campana *et al.* (2002) were used where $L\infty$= 289.4 cm, K= 0.07 and t0= -6.06.

Year classes and probabilities/ errors were assigned to fish using the methods described by Ogle (2018).

All analysis was performed using the r programming language (R Core Team 2021) and the script is available on request from the corresponding author.

3. Results and discussion

During the period 1960-2020, 1883 porbeagle shark captures from UK waters were reported to the SACGB or to the Pat Smith database by recreational anglers, of which 1764 (93.68%) were from ICES sea area *VII* (*subareas a, d, e, f* and *g*) which encompasses the waters of the English Channel, Celtic Sea and Irish Sea (**Figure 1, Table 1**). The largest number of captures (820, 43%) were in ICES sea area *VIIf*, which includes the waters off North Cornwall, North Devon and in the Bristol channel, followed by ICES sea areas *VIIe* (478, 23%), *VIId* (226, 12%) and *VIIg* (219, 11.6%) which encompass the English Channel and the Celtic Sea (**Figure 1**). Reports of captures from other ICES sea areas were more sporadic, but this may reflect lack of reporting as anecdotal evidence suggest that *L. nasus* are occasional captures by recreational anglers in these areas.

The recreational fishery for *L. nasus* was initially a bycatch from the more prolific blue shark fishery on the South Coast of Devon/ Cornwall (included in ICES Sea area *VIIe),* before other fisheries were discovered in the early 1970s where *L. nasus* could be more selectively targeted (**Figure 2**). The numbers of *L. nasus* captures recorded, peaked in 1975 at 85 (**Table 1, Figure 2**) and varied between this peak and 19 fish per annum until 1988 when numbers declined (**Table 1, Figure 2**). This may reflect the sequential depletion of stocks from small areas followed by the discovery of new areas, or variations in environmental conditions which have been shown to influence yearly and seasonal captures of other shark species (Mitchell *et al.* 2014; Báez 2015). However, the reduction in catches of *L. nasus* during the late 1980s closely follows the trend in commercial catches of the species and CPUE during the same period in the northeast Atlantic when these fish were extensively targeted by commercial fishermen within the ICES sea areas covered in this study (ICCAT 2010; Silva and Ellis 2019).

Reductions in catches during the late 1980s were seen in ICES sea areas *VIIa, VIId, VIIe* and *VIIf* (**Figure 3**) and the reduction of Catch Per Unit Effort (CPUE) for *L. nasus* from area *VIIe* suggests that these reflect a reduction in the population of the species in UK waters rather than a reduction in effort (**Figure 4**). This is consistent with stock assessments for the species in the North Eastern Atlantic (ICCAT 2010; 2015). Captures of *L. nasus* remained at low levels in UK waters, with an absence of the species for fourteen years from ICES sea area *VIIe* between 1997 and 2012 (**Table 2, Figure 4**). Similar reductions in catches were seen in other areas (**Figure 3**) before a marked return in numbers in ICES sea areas *VIIa, VIId, VIIe* and *VIIf* (**Table 1, Figure 3**) in 2015-2020. Although an increase in angling pressure may be a factor in some areas it is noted that CPUE increased to levels not seen in previous years in area *VIIe* (**Table 2, Figure 4**). These increases occurred after the imposition of a zero commercial TAC in EU waters for *L. nasus* (ICCAT 2015), but to what degree the increase in numbers is attributable to a reduction in commercial fishing pressure, or to natural fluctuations in populations or movement of stock due to environmental factors is uncertain.

Of the 1776 captures of *L. nasus* for which length or weight data was available, the mean and median lengths for 1960-2020 were 167.5 and 168.5 cm respectively (**Table 3**) with 72.13% of fish less than the mean length at 95% maturity for both sexes. Information on the sexes of captured fish was not available. The distribution of lengths was multimodal (**Figure 5**) which reflected both spatial (**Table 3, Figure 6**) and temporal changes (**Figure 7 and 8**) the distribution of different life stages of *L. nasus*. Spatial segregation is common amongst large pelagic elasmobranchs (Campana, Joyce, and Fowler 2010; Vandeperre *et al*. 2014; Saunders, Royer, and Clarke 2011) and is reflected in the differences in length distribution for *L. nasus* between ICES sea areas (**Figure 6**) with increased mean and median lengths in areas *IVa, VIId* and *VIIf* compared to other areas (**Figure 6**).

Immature fish were more commonly captured in ICES sea areas *VIIa*, *VIIe* and *VIIg*, with the lower median FL (**Figure 7**) driven by large numbers of immature fish captured in area *VIIe* since 2015 (**Figure 8**) indicating numbers of year 0 fish in this area (**Figure 9**). Whether this reflects an increase in recruitment or relocation of existing spawning fish is uncertain, but given the low fecundity of *L. nasus* (Campana *et al*. 2010) and the possibility of natal philopatry (Biais *et al.* 2017), the possibility of a large spawning stock of the species in this or nearby areas exists.

The data presented here represents an ongoing effort to utilize information derived from recreational anglers to inform fisheries scientists and decision makers and we are attempting to increase the scope and quality of this data through a new collaborative initiative between anglers, angling groups and scientists, Shark Hub UK (https://anglingtrust.net/sea/shark-hub-uk/). Although data is available since 1960 only those from ICES sea area *VIIe*, courtesy of the SACGB records, have an effort component, so information from some areas may be biased by changes in effort. However, the results presented here suggest that *L. nasus* numbers in UK waters, and their spatial distribution, have increased since 2015 and, although the role in redistribution and climatic variation are uncertain, these may represent a tentative recovery of stocks of the species in the North East Atlantic.

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Table 1. Porbeagle captures ICES sea area from UK waters by recreational anglers for 1960 to 2020.

	ICES sea area								
Year	***IVa***	***IVb***	***VIa***	***VIIa***	***VIId***	***VIIe***	***VIIf***	***V11g***	**Total**
1960	0	0	0	0	0	3	0	0	3
1961	0	0	0	0	1	9	0	0	10
1962	0	0	0	0	0	9	0	0	9
1963	0	0	0	0	0	8	0	0	8
1964	0	0	0	0	0	2	0	0	2
1965	0	0	0	0	0	3	0	0	3
1966	0	0	0	0	0	6	0	0	6
1967	0	0	0	0	0	0	1	0	1
1968	0	0	0	0	0	5	0	0	5
1969	0	0	0	0	0	0	0	0	0
1970	0	0	0	0	0	7	0	0	7
1971	0	0	0	0	0	10	0	0	10
1972	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0
1974	0	0	0	1	14	8	3	0	26
1975	0	0	1	0	12	16	56	0	85
1976	0	0	0	3	0	2	48	0	53
1977	0	1	0	5	2	11	39	0	58
1978	5	0	0	2	6	2	29	0	44
1979	6	0	0	1	0	8	47	0	62
1980	1	0	0	5	2	2	33	0	43
1981	1	0	0	2	3	7	65	0	78
1982	2	0	0	4	3	2	47	0	58
1983	0	0	0	3	4	2	10	0	19
1984	0	0	0	6	5	8	24	0	43
1985	2	0	1	6	11	3	28	0	51
1986	1	0	0	3	9	1	22	0	36
1987	31	0	0	0	4	0	26	0	61
1988	2	0	0	2	0	2	14	0	20
1989	0	0	0	0	0	0	4	0	4
1990	0	0	0	0	4	1	4	0	9
1991	1	0	0	4	2	0	3	0	10
1992	2	0	0	0	1	1	1	0	5
1993	1	0	0	0	0	0	1	0	2
1994	1	0	0	0	0	0	0	0	1
1995	0	0	0	1	0	0	0	0	1
1996	1	0	0	3	0	2	1	0	7
1997	2	0	0	0	0	0	0	0	2
1998	1	0	0	0	0	0	0	0	1
1999	0	0	0	0	3	0	2	0	5
2000	0	0	0	0	2	0	0	0	2
2001	0	0	0	0	3	0	6	0	9

Table 1. continued **ICES sea area**

Year	*IVa*	*IVb*	*VIa*	*VIIa*	*VIId*	*VIIe*	*VIIf*	*V11g*	Total
2003	8	0	0	0	8	0	0	0	16
2004	9	0	0	0	1	0	0	0	10
2005	4	1	0	0	6	0	0	0	11
2006	1	0	0	0	0	0	1	2	4
2007	2	0	0	0	0	0	1	0	3
2008	0	0	0	0	3	0	0	1	4
2009	0	0	0	0	1	0	1	1	3
2010	0	0	0	0	0	0	0	3	3
2011	1	0	0	0	0	0	0	0	1
2012	0	0	0	0	1	2	1	1	5
2013	0	0	0	0	4	3	0	1	8
2014	0	0	0	0	1	0	0	1	2
2015	0	0	0	0	0	24	63	14	101
2016	0	0	0	0	1	41	58	38	138
2017	0	0	0	0	23	38	51	42	154
2018	0	0	0	0	24	115	48	38	225
2019	0	0	0	0	32	47	53	46	178
2020	0	0	0	0	29	68	28	31	156
Grand Total	85	2	2	51	226	478	820	219	1883

Table 2. Shark fishing catch, effort (trips) and CPUE for ICES sea area *VIIe* for 1960-2020.

Year	*VIIe* catch	Total effort *VIIe*	CPUE *VIIe*
1960	3	1534	0.00196
1961	9	1719	0.00524
1962	9	1600	0.00563
1963	8	1539	0.00520
1964	2	1595	0.00125
1965	3	1581	0.00190
1966	6	1584	0.00379
1967	0	1742	0.00000
1968	5	1683	0.00297
1969	0	2209	0.00000
1970	7	1872	0.00374
1971	10	1803	0.00555
1972	0	1600	0.00000
1973	0	1600	0.00000
1974	8	1600	0.00500
1975	16	1600	0.01000
1976	2	1600	0.00125
1977	11	800	0.01375
1978	2	800	0.00250
1979	8	500	0.01600
1980	2	500	0.00400
1981	7	500	0.01400
1982	2	500	0.00400
1983	2	500	0.00400
1984	8	400	0.02000
1985	3	400	0.00750
1986	1	400	0.00250
1987	0	400	0.00000
1988	2	400	0.00500
1989	0	400	0.00000
1990	1	400	0.00250
1991	0	420	0.00000
1992	1	420	0.00238
1993	0	395	0.00000
1994	0	420	0.00000
1995	0	500	0.00000
1996	2	520	0.00385
1997	0	567	0.00000
1998	0	665	0.00000
1999	0	765	0.00000
2000	0	700	0.00000
2001	0	787	0.00000
2002	0	770	0.00000

Table 2. **Continued.** Shark fishing catch, effort (trips) and CPUE for ICES sea area *VIIe* for 1960-202

Year	*VIIe* catch	Total effort *VIIe*	CPUE *VIIe*
2003	0	697	0.00000
2004	0	739	0.00000
2005	0	640	0.00000
2006	0	373	0.00000
2007	0	332	0.00000
2008	0	273	0.00000
2009	0	272	0.00000
2010	0	276	0.00000
2011	0	333	0.00000
2012	2	309	0.00647
2013	3	368	0.00815
2014	0	377	0.00000
2015	24	379	0.06332
2016	41	397	0.10327
2017	38	461	0.08243
2018	115	637	0.18053
2019	47	589	0.07980
2020	68	389	0.17481
Total	**478**	**50131**	**0.00954**

Table 3.
Median length (cm) of porbeagle from ICES sea areas in UK waters for 1960-2020

	ICES Sea area								
Results (cm)	*IVa*	*IVb*	*VIa*	*VIIa*	*VIId*	*VIIe*	*VIIf*	*V11g*	***Total***
Mean	200.3	195.1	N/A	159.3	175.3	116.3	195.6	148.4	**167.5**
Median	200.8	208.3	N/A	156.8	176.0	102.7	195.5	143.0	**168.5**
Standard deviation	22.1	41.3	N/A	13.5	22.9	36.9	31.8	28.5	**46.5**
Standard error	2.4	23.9	N/A	1.9	1.5	1.7	1.1	3.0	**1.1**
Max size	266.7	228.3	215.6	188.0	246.3	249.0	274.1	261.6	**274.1**
Min size	146.0	148.8	215.6	140.6	113.2	70.9	131.3	108.2	**70.9**
n	85.0	3.0	1.0	51.0	225.0	497.0	821.0	93.0	**1776.0**

Figure 1. Map of ICES sea areas for which yearly recreationally-captured porbeagle data from 1960-2020 is available.

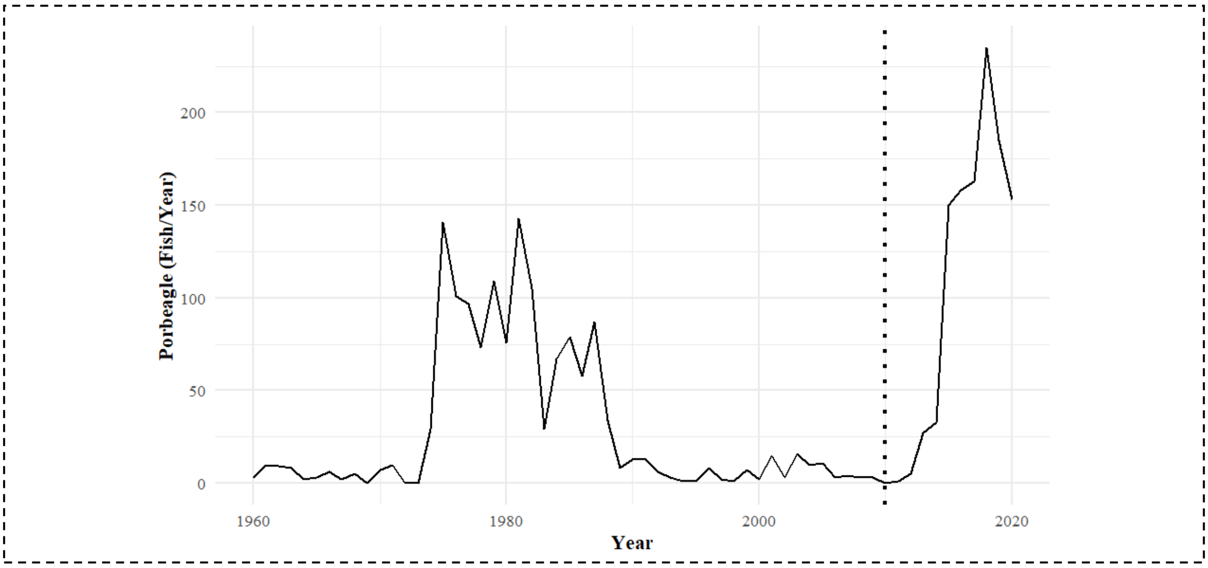

Figure 2. Recreational Porbeagle captures from the United Kingdom from 1960-2020. Vertical dotted line represents imposition of zero TAC for the species by the EU.

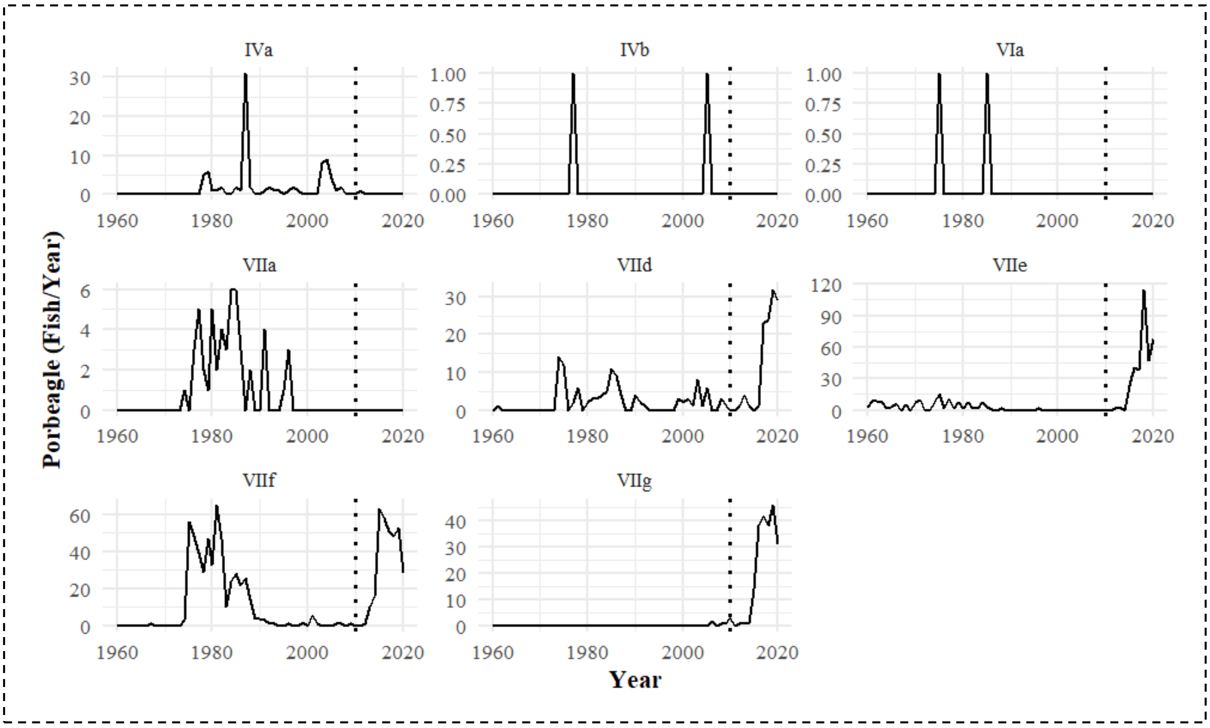

Figure 3. Recreational Porbeagle captures by ICES Sea areas from the United Kingdom from 1960-2020. Vertical dotted line represents imposition of zero TAC for the species by the EU.

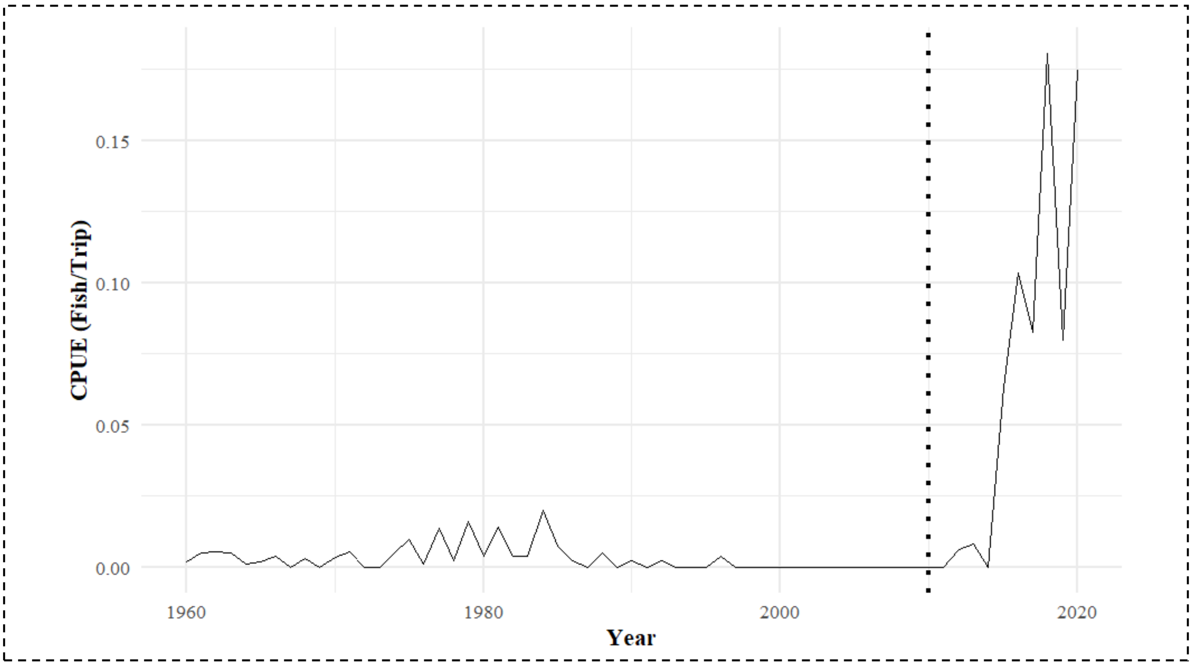

Figure 4. CPUE (fish/ trip) of porbeagle captured from the ICES sea area *VIIe* from 1960-2020. N=478. Vertical dotted line represents imposition of zero TAC for the species by the EU.

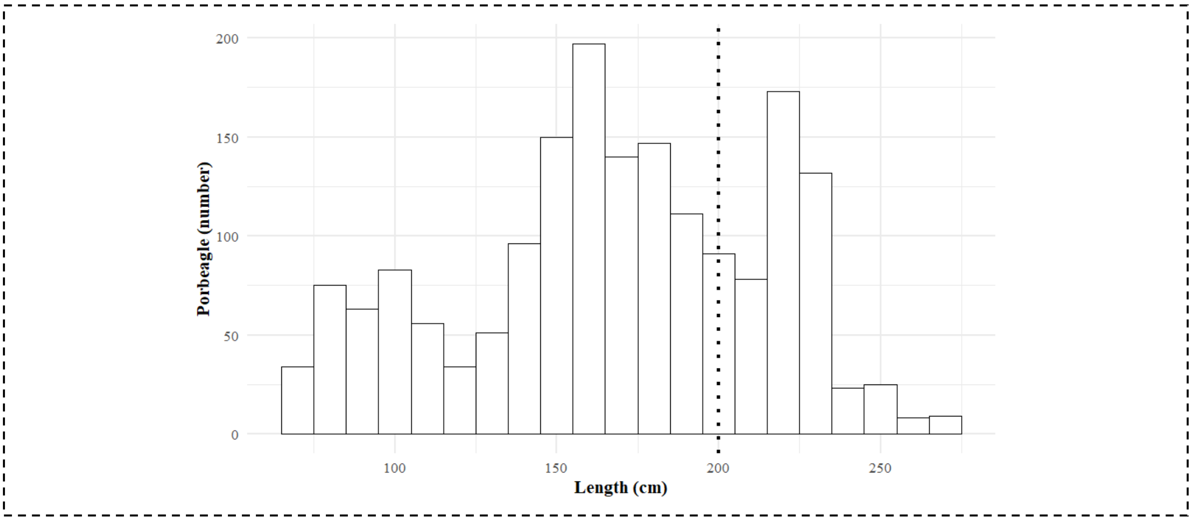

Figure 5. Length distribution of porbeagle captured from the UK from 1960-2020. N=1776. Vertical dotted line indicates size at maturity (95%) for both sexes.

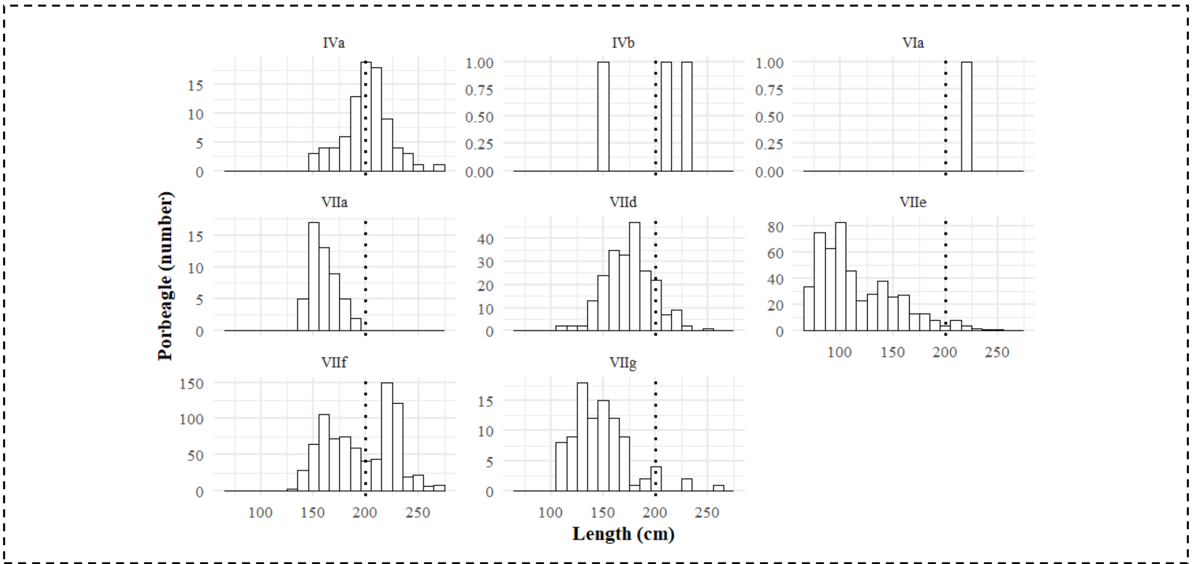

Figure 6. Length distribution of porbeagle captured from the UK from 1960-2020 by ICES sea area. N=1776. Vertical dotted line indicates size at maturity (95%) for both sexes.

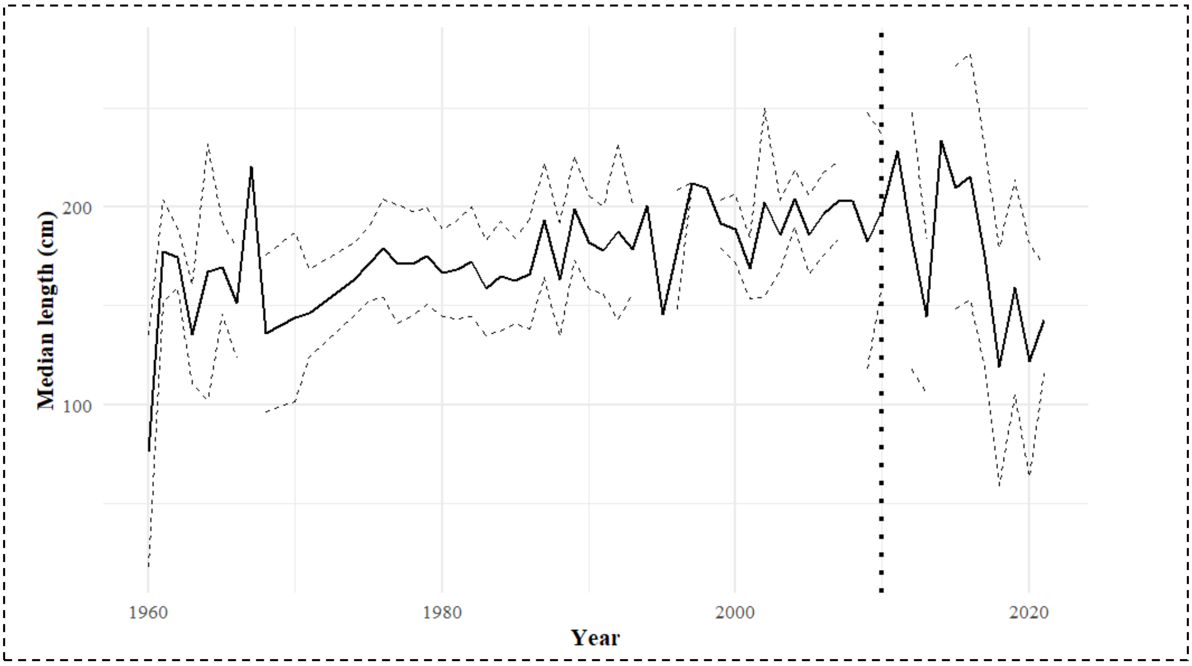

Figure 7. Median fork lengths of Porbeagle captures from UK waters for 1960-2020. Vertical dotted line represents imposition of zero TAC for the species by the EU. N= 1776. Dotted lines represent median values plus or minus 1 standard deviation.

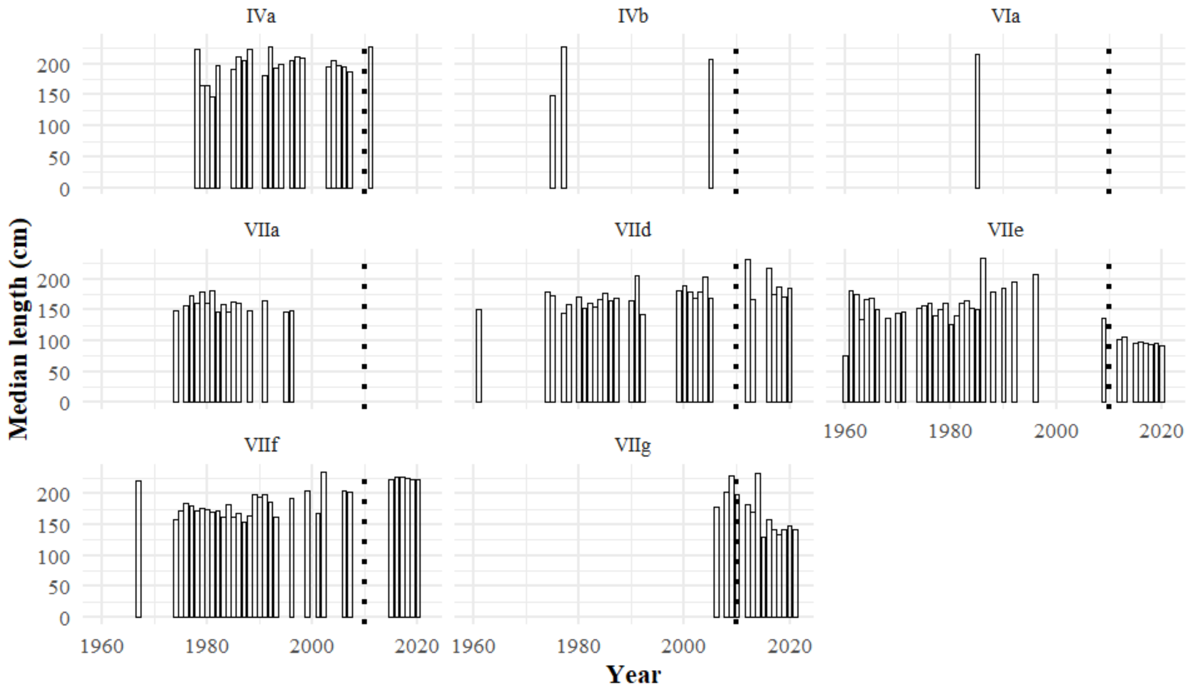

Figure 8. Median length of recreationally-captured porbeagle for ICES sea areas around the coast of the UK from 1960-2020. Vertical dotted line represents imposition of zero TAC for the species by the EU. N= 1776.

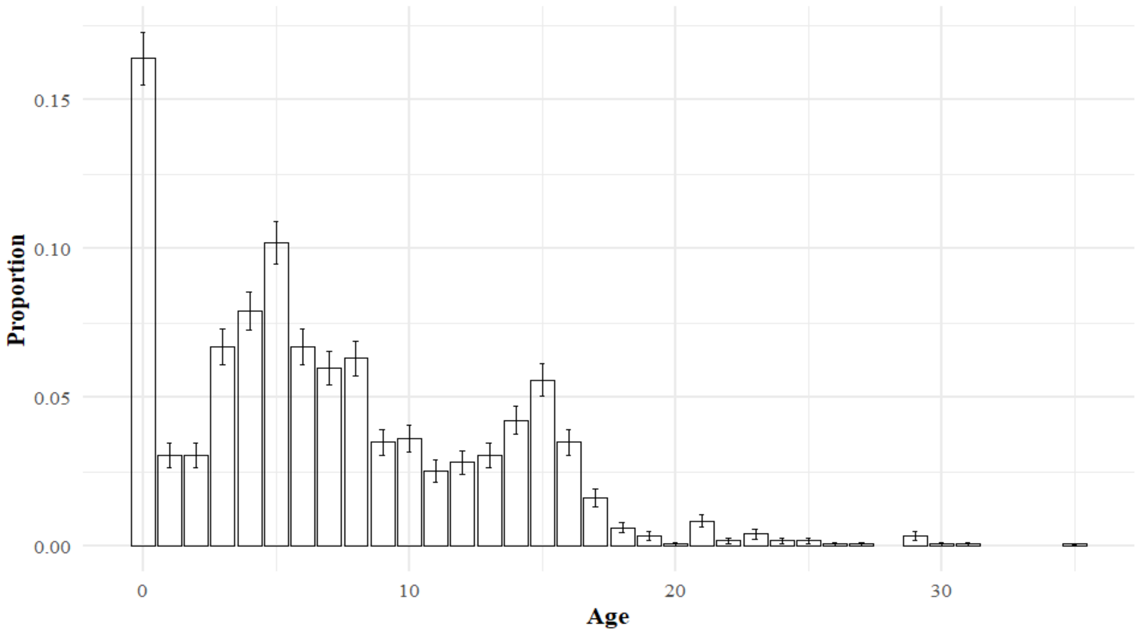

Figure 9. Year classes of porbeagle captured by recreational anglers for 1960-2020. Error Bar denote standard errors associated with year class allocation. N= 1776.