Catchwise – A Survey of Marine Recreational Fishing Activity in England and Wales

FISP Project ECM66391

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Executive Summary

Marine recreational fishing (MRF) in the UK is a popular activity with significant ecological, social, and economic effects. Previous surveys, such as Sea Angling 2012 and the Sea Angling Diary Project (SADP), have sought to estimate participation, effort, catch rates, economic impacts, and social benefits. Sea Angling 2012 was the first large-scale probabilistic assessment of sea angling in England, incorporating onsite and offsite data collection to estimate effort, catches, economic impact and social benefits. More recently, SADP has relied on offsite diaries from voluntary sea anglers, generating a time series but introducing potential bias. Catches from the SADP were much higher than Sea Angling 2012, resulting in concerns about bias and highlighting the need for an onsite survey to validate the estimates. Catchwise was developed to generate robust onsite estimates of effort, catch rates, and socio-economic benefits in England and Wales, which could be used to validate the SADP. This was funded by Defra through the Fishery Industry Science Partnership (FISP ECM66391).

The survey utilised a structured probabilistic sampling approach to estimate angling effort, defined as the number of anglers per site and time spent fishing, catch rates based on the number of fish caught per unit effort, and biomass estimates of retained and released fish weights. Data collection was conducted through onsite surveys of shore and private boat angler counts and interviews, charter boat logbook surveys based on weekly activity reports from participating skippers, and follow-up surveys to validate recall bias and refine catch estimates. The sampling frame encompassed all regions, stratified by activity level, and day type. Statistical methods were compared and the best approach selected.

Whilst difficulties in accessing private boat launch sites and encountering returning boats meant that no results could be given, the shore survey was successful. An estimated 11 million angling hours across 2.7 million angling trips were made from the shore, with the highest activity recorded in the South West and South East regions. The total number of retained fish was 5.3 million (2,045 tonnes), while 21.6 million were returned (7,040 tonnes). Mackerel had the highest retention rate, while whiting was the most frequently returned. Comparisons between the model-based and bootstrapping approaches revealed that the model-based method generated more robust estimates due to its ability to incorporate environmental variables and correct for unobserved fishing periods. Larger fish were more frequently retained, but this varied across species and regions.

In the charter boat survey, effort estimates ranged between 3,649 and 5,221 weeks where charter boats fished, depending on the inclusion criteria for participating vessels, for vessels in ICES divisions 4b,c and 7a,d,e&f. Catch estimates for ICES divisions 7.d and 7,e between 350,500 and 480,512 fish caught, with a retention rate of approximately 36 percent. The estimated retained tonnage of fish varied between 139 and 198 tonnes, with conger eel, and tope comprising significant proportions of returned biomass. The highest charter boat activity was recorded in ICES divisions 7.d and 7.e, with significant seasonal trends in participation. However, there was substantial non-response in the Charter Boat survey and so the results may not be representative of the true levels of effort and catch.

The results from the shore component of the survey closely align with the SADP and Sea Angling 2012 study for effort, and produced similar catch estimate to the SADP for most species assessed. However, there were higher tonnage estimates from Catchwise than the SADP for cod (kept), mackerel (kept), pollack (kept), smoothhound (returned), and wrasse species (kept & returned).

For charter boats, Catchwise produced lower numbers of fish caught, but similar tonnage, indicating a larger average weight of fish caught in Catchwise than SADP. Comparing the catch per unit effort data between the SADP and Catchwise revealed very similar estimates, suggesting the difference is due to the reduced effort observed in Catchwise. The differences in effort estimates could be due to reductions in the size of the charter boat fleet since Sea Angling 2012, meaning lower effort estimates. Further, the non-response bias could be reducing the level of effort.

Catchwise significantly advances recreational fisheries data collection through innovative model-based statistical estimation methods, which are novel in MRF surveys and produce more robust estimates by incorporating environmental variables to understand unsampled fishing periods. Additionally, the project's co-design approach with the angling community, which promotes greater angler acceptance and trust in the collected data. Catchwise also enables real-time comparisons between onsite and offsite survey methods, improving understanding of biases and confidence in recreational fisheries monitoring both globally and in the UK.

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1. Introduction

Marine recreational fishing (MRF) is a globally popular activity, with high participation rates documented across various regions (Post *et al.*, 2002; Coleman *et al.*, 2004; Cooke and Cowx, 2004, 2006; Lewin *et al.*, 2006; Ihde *et al.*, 2011; McPhee, 2017). In Europe, approximately 1.6% of the population engages in MRF (Hyder *et al.*, 2018), while previous studies in the UK estimate a participation rate between 1.2-2.2% (Armstrong *et al.*, 2013; Hyder *et al.*, 2020b, 2024). The number of participants results in large catches by MRF for some species (Cooke and Cowx, 2004; Hyder *et al.*, 2014, 2024; Radford *et al.*, 2018), alongside notable economic contributions (Toivonen *et al.*, 2004; Arlinghaus and Cooke, 2009; Cisneros-Montemayor and Sumaila, 2010; Hyder *et al.*, 2018) and social benefits (Arlinghaus *et al.*, 2002; Parkkila *et al.*, 2010; Lynch *et al.*, 2016; Griffiths *et al.*, 2017). Given these ecological, social and economic impacts, MRF is formally recognised within the UK's Fisheries Act 2020, positioning recreational sea fishers as key stakeholders in fisheries management alongside funding to support development.

In many countries, MRF does not require a licence for participation and mandatory catch reporting is limited. Consequently, dedicated survey methods are necessary to estimate participation, effort, and catches (Pollock *et al.*, 1994; Pollock and Pine, 2007; Jones and Pollock, 2012). These surveys can be broadly categorised into onsite and offsite methodologies. Onsite surveys include roving creel surveys, where surveyors intercept anglers during fishing activities to collect effort and catch data; access point surveys, which involve sampling anglers at known fishing locations upon trip completion; bus route surveys, designed to sample fishing locations in a systematic manner; and aerial surveys, which provide broad-scale estimates of angling effort using drones or planes. Offsite surveys, include logbooks completed by anglers, phone surveys to collect recall-based information, and mail surveys distributed to a targeted sample of participants. Conducting these surveys within a probabilistic framework is considered the gold standard (Holt and Smith, 1979; Little, 1993; Pollock *et al.*, 1994), as ideally this ensures that each angler, trip, or site is in the sampling frame and has a known probability of selection, reducing bias and improving the robustness of extrapolated estimates. However, sampling frame errors can occur (Taylor *et al.*, 2025).

Probabilistic survey designs require the establishment of a sampling frame, which could consist of a list of anglers, fishing trips, or sites (Pollock *et al.*, 1994). Stratification is then applied to divide the population into meaningful subgroups based on characteristics such as angler demographics or avidity levels, ensuring representative sampling within each stratum. This approach enhances accuracy and mitigates bias by ensuring all segments of the population are included in post-stratification procedures, where post-stratification is a statistical adjustment applied after data collection to correct for differences between the sample relative to the overall population.

In the absence of a licensing system, probability-based surveys of MRF have primarily relied on site-based sampling frames for onsite surveys, as angler or trip-based frames are unavailable (Strehlow *et al.*, 2012; Vølstad *et al.*, 2019; Lewin *et al.*, 2021). However, these surveys are resource-intensive (Bellanger and Levrel, 2017). As a result, several countries, including the UK, have adopted mixed probability and convenience sampling approaches (van der Hammen and de Graaf, 2013, 2015; Hyder *et al.*, 2020b, 2024; Lewin *et al.*, 2021; Taylor *et al.*, 2025). This hybrid strategy typically employs probability-based surveys to estimate effort, while catch per unit effort (CPUE) data are collected via voluntary logbooks or other convenience-based approaches. While cost-effective (Bellanger and Levrel, 2017), convenience sampling introduces selection bias, as participants self-select into the study rather than being randomly sampled, meaning inclusion probabilities are unknown (Pollock *et al.*, 1994; Galloway, 2004; Khazaal *et al.*, 2014).

Surveys of MRF in the UK have incorporated both probability-based and convenience sampling methodologies and focussed on sea angling. The first large-scale study, Sea Angling 2012 (Armstrong *et al.*, 2013), used a probabilistic approach, combining onsite and offsite data collection to estimate effort and catches. Offsite effort estimates were derived from a probabilistic face-to-face household survey run by the Office for National Statistics (ONS) (see Armstrong *et al.* (2013) for more details), which was complemented by onsite angler counts at fishing locations. The study estimated that 2.2% of the population of Great Britain (1.08 million people) participated in sea angling. Catch estimates were obtained through roving creel and access point surveys of shore and private boat anglers, employing a probabilistic design to sample fishing locations and interview anglers about their retained and released catches. This study estimated 9.2 million fish caught, corresponding to 3,674 tonnes of biomass. Charter boat catches were estimated using a logbook survey, in which a list of 399 charter boats was sampled probabilistically, requesting that skippers record trip details and catches. This resulted in an estimated 106,000 charter boat trips, one million fish caught, and a total biomass caught of 1,078 tonnes.

Since 2016, the Sea Angling Diary Project (SADP) has been the primary source of sea angling data in the UK, providing participation, effort, and economic information (Hyder *et al.*, 2020b, 2021, 2024). Effort estimates were initially derived from the Watersports Participation Survey (WPS), a probability-based face-to-face household survey that estimated the number of sea anglers. The WPS moved to an online survey in 2019 due to the COVID-19 pandemic resulting in unrealistic estimates, with the 2019 estimate indicating a 1.2% participation rate, equating to approximately 688,000 sea anglers. Catch data in SADP are collected via a voluntary logbook programme, in which around 2,500 participants record trip details and catches. SADP estimates suggest that on average since 2016, 32.4 million fish were caught, with a total biomass of 14,876 tonnes (Hyder *et al.*, 2020b, 2021, 2024). These values are higher than those reported in Sea Angling 2012, raising concerns about potential biases.

Previous efforts to quantify and adjust for bias in the SADP panel have employed different methodological approaches. One such approach involved a probability-based mail panel logbook survey (Hyder *et al.*, 2020a), where participants were selected based on WPS angler demographics. The results from this method were very similar to those obtained from the SADP, suggesting that if bias exists, it may stem from differences between those willing to maintain a logbook and those who are not. Additionally, multilevel regression and post-stratification (MRP) has been used to correct for bias in surveys, a technique originally developed in political science for analysing self-selecting exit polling data (Moon and McGregor, 1992; Bautista *et al.*, 2005; Buttice and Highton, 2013; Gelman *et al.*, 2016; Downes *et al.*, 2018). MRP has been shown to better adjust for population-sample differences by borrowing strength from well-represented groups to estimate data for underrepresented ones (Gelman, 1997; Rivers and Bailey, 2009; Ansolabehere and Rivers, 2013; Wang *et al.*, 2015; Gelman *et al.*, 2016). Furthermore, MRP mitigates the influence of outliers, improving the reliability of results (Wang *et al.*, 2015; Gelman *et al.*, 2016). The SADP analysis currently incorporates MRP (Hyder *et al.*, 2024), which has resulted in reduced catch estimates, although they remain higher than those observed in the 2012 survey. Despite these efforts, a comprehensive validation study is still required to accurately quantify potential bias in SADP estimates.

Such a validation requires broad stakeholder engagement and collaboration, including partnerships between non-governmental organisations (NGOs), government agencies, and recreational angling bodies. Existing collaborations, such as the National Angling Strategy (Brown, 2019), the Memorandum of Understanding between Cefas, Substance, and the Angling Trust (in which an onsite study of sea angling to validate the SADP is a core component), and partnerships with organisations such as Angling Cymru (Angling Cymru), the Professional Boatsman's Association (PBA), and the Angling Trades Association (ATA), provide a foundation for future survey development. Additionally, the International Council for the Exploration of the Sea (ICES) Working Group on Recreational Fisheries Surveys (WGRFS) ensure that survey methodologies align with international best practices.

The Catchwise project was developed with the following key objectives: (1) to identify and quantify any self-selection bias in SADP estimates; (2) to generate robust data on the social benefits of sea angling, which is covered in a separate report; and (3) to conduct a probabilistic on-site survey of sea angling effort and catch, applying both MRP and traditional analytical methods. The project aims to compare results between Catchwise and SADP, ensuring survey robustness through collaboration with ICES WGRFS, and to engage anglers and volunteers in data collection through partnerships with the Angling Trust and other stakeholder groups. Additionally, a longitudinal study will assess the social benefits of sea angling over time.

Catchwise is expected to: provide data and estimates to inform sustainable fishery management; generate robust data to inform FMPs and stock assessments; improve utility of the existing Sea Angling Diary; and create an angling community engaged in data collection through co-development and improve confidence in the current evidence base. We expect that Catchwise will enhance evidence on MRF catch and participation alongside increased confidence in MRF estimates, including a comparison to understand biases within the Sea Angling Diary Project. All findings will be made publicly available to benefit the angling sector, government, science and local communities.

2. Methods

2.1. Stakeholder engagement

To ensure the survey methods were robust and secured stakeholder buy-in, all aspects of the study were co-developed with key stakeholders. A Project Advisory Group (PAG) was established, consisting of Defra, the Marine Management Organisation (MMO), Inshore Fisheries Management (IFM), the Association of Inshore Fisheries and Conservation Associations (IFCAs), individual IFCAs, ICES Working Group on Recreational Fisheries Surveys (WGRFS) members, the Angling Trades Association (ATA), the Welsh Government, Angling Cymru, and the Professional Boatman's Association (PBA).

PAG meetings were conducted quarterly to provide input into survey methodologies, assist with project delivery through endorsements and promotion, and suggest improvements to data collection approaches. These meetings facilitated collaboration and strengthened engagement with key organisations involved in MRF data-collection, management and stakeholders. More information on stakeholder engagement and promotional activities can be found in Appendix 1.

2.2. Data collection

2.2.1. Onsite shore and private boat survey

2.2.1.1. General survey approach

The primary objective of this study was to estimate angling effort, the total number of fish caught, and the total biomass of fish caught by shore and private boat anglers in England and Wales. To achieve this, it was necessary to ensure that all angling trips had a known probability of being sampled, allowing for representative estimation of effort and catch. Given that it is not feasible to sample all angling trips, a structured probabilistic sampling approach was required to ensure that estimates accurately reflected the broader population.

The survey methodology, which is outlined in Figure 1, was designed to capture three key components: (1) effort, defined as the number of anglers present at a site; (2) the total number of fish caught; and (3) the length distribution of fish caught. A site-based sampling approach was employed to generate these estimates, involving direct observations and interviews with anglers at selected locations.

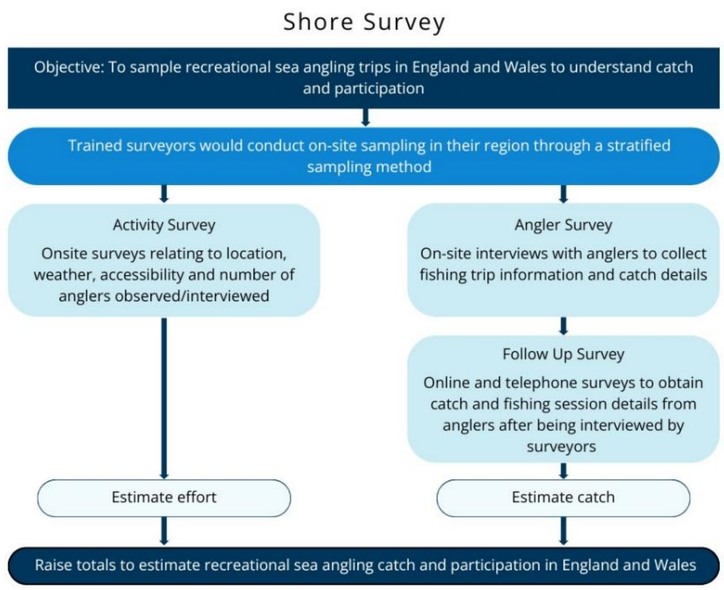

Figure 1: An outline of the data collection processes for the shore and private boat survey.

Surveyors were recruited across England and Wales, to ensure broad geographic coverage. Surveyors were deployed to potential angling locations and boat launch sites where they conducted angler counts and interviews to collect data on effort, catch numbers, and fish lengths. To facilitate site selection and ensure an even distribution of survey effort, an online allocation system was used to manage and assign sampling locations. A full description of this system and its functionality is provided in Appendices 2.

To estimate the number of fishing trips, surveyors completed an 'activity survey' after being on site for four hours. Surveyors collected information on: details of the survey (location, shore or private boat, roving creel or access point, date; time of day sampling duration and time taken to travel to and between sites); information on conditions (weather and tide); the number of shore and private boat anglers observed and interviewed; and any additional information.

To estimate catch rates, the surveyors used a second survey to interview anglers about their session. The 'angler survey' collected information on:

details of interview (location, date, time, consent and information regarding non participation reasons); information on angler(s) (avidity, number of years sea angling, consistency of participation and skill level); details on angling session (type of gear, method, platform, start time, estimated finish time, individual or group angling session); catch details (species, kept and returned, lengths; and if the length could be validated by the surveyor and target species).

Surveyors were provided with online and offline versions of both the activity and angler surveys to ensure they could submit data when internet connection was not available. The online and offline surveys contained the same questions but were accessed through different links. Offline surveys were uploaded by surveyors upon reconnection to the internet. Copies of the activity and angler surveys can be found in Appendix 3. Finally, data from both the activity and angler surveys were linked using a unique identifier to ensure that angler interviews could be linked to site details.

2.2.1.2. Surveyor and volunteer training and engagement

Surveyors were managed by the Project Coordinator at the Angling Trust and were contracted specifically for this study. A full description of the Project Coordinator role is provided in Appendix 4. Surveyor training was delivered through online webinars led by the Project Coordinator, and surveyors were given continuous access to a live guidance document, detailed in Appendix 5.

Surveyor allocation was based on home location and travel time, ensuring that no surveyor was required to travel more than two hours to a site. Recruitment focused on strategic locations to optimise coverage, with a total of eight regions (Figure 2) sampled by a total of 14 surveyors. Some regions required multiple surveyors due to logistical constraints, particularly the North West, North East (for one quarter), and Yorkshire and the Humber. Additional surveyors were assigned to South Wales (Sudbrook to Swansea) and the South West (Frampton on Severn to Burnham-on-Sea) to ensure adequate coverage. Survey assignments varied by month, depending on turnover and availability.

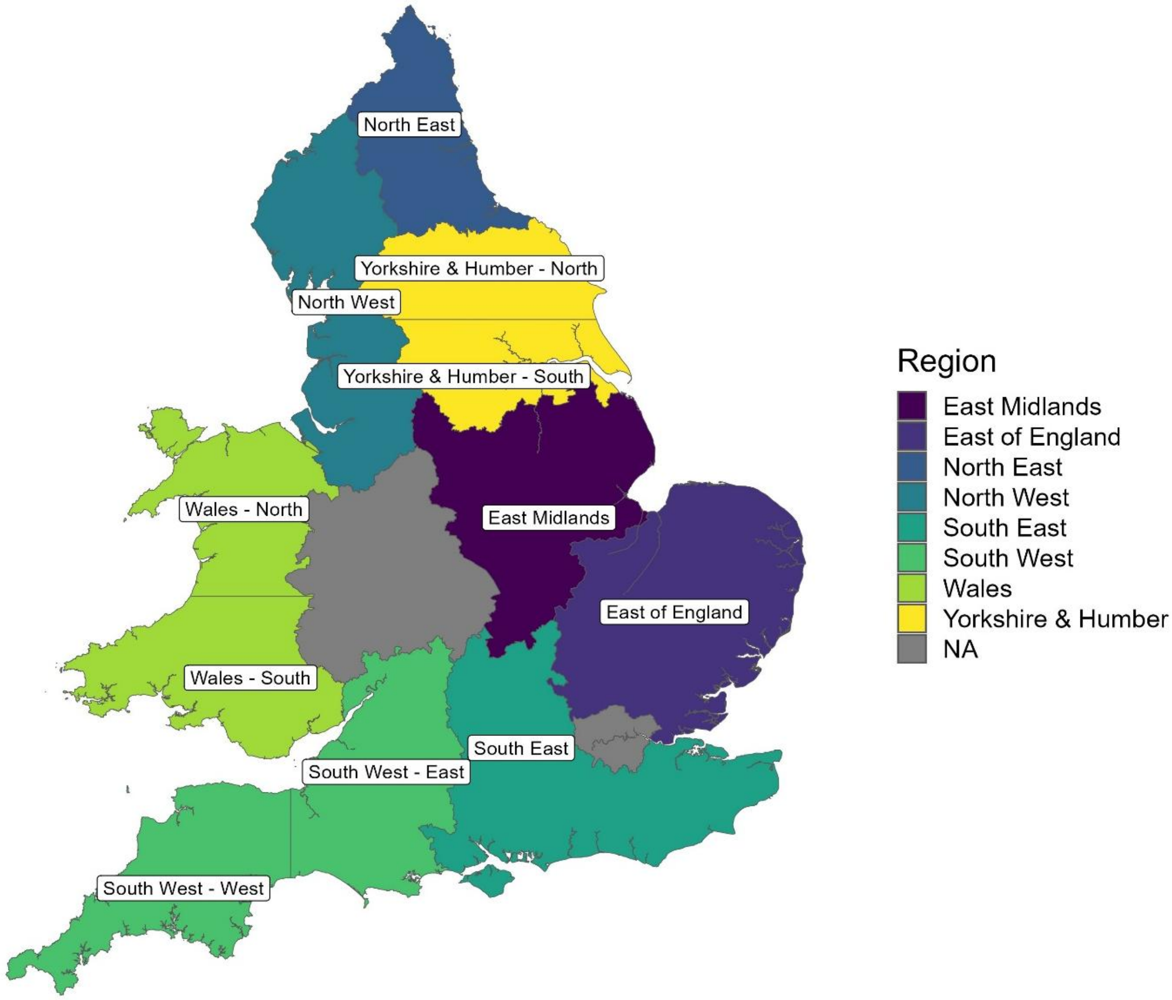

Figure 2: The regions sampled in the site-based shore and private boat survey. The South West and Wales were split to ensure adequate spatial coverage, Yorkshire & Humber was split due to surveyor availability. NA regions were not sampled.

To engage the angling community, a volunteering programme was developed, offering two levels of participation where trained volunteers could complete activity and angler surveys, and untrained volunteers could only complete activity surveys. Citizen scientist volunteers received comprehensive training, including manuals and videos, enabling them to conduct angler interviews and collect activity survey data. Some volunteers underwent the same training regime as the paid surveyors and so were able to complete activity and angler surveys. However, to maximise the number of volunteers providing data, one-off volunteers were recruited without training, and thus could only submit activity survey data. Details of volunteer training are provided in Appendix 6.

To maintain engagement, monthly newsletters were sent to surveyors and volunteers (Appendix 1). Volunteers were also offered reimbursement for travel expenses, with the Project Coordinator at the Angling Trust serving as the primary point of contact for all volunteer communications.

2.2.1.3. Sampling frame, stratification, and selection of primary sampling units

2.2.1.3.1. Generating the sampling frame

A probabilistic onsite survey required the development of a robust sampling frame comprising a comprehensive list of locations and days to sample. The identification of shore and private boat sampling sites was based on recreational fishing activity levels derived from data compiled by MMO (2020) for England and Monkman *et al.* (2015) for Wales. These studies synthesised data from scraped social media, the SADP (Hyder *et al.*, 2024), boat counts from Google Maps, and expert opinion to identify shore and boat angling hotspots along the coastline.

In the MMO (2020) study, these data were used to train a spatially explicit machine learning model that produced a shapefile of polygons delineating areas of shore and boat angling activity, classified by angling activity level (none, low, medium, and high activity). The resulting shore angling activity shapefile served as the initial basis for identifying shore sampling sites in England. For private boat launch sites, polygons in the shapefile were manually associated with specific launch sites using the Google My Maps tool (https://google.com/mymaps). In contrast, Monkman *et al.* (2015) did not aggregate angling activity using machine learning, providing only mapped datapoints. These were overlaid on Google Maps and grouped to represent contiguous stretches of coastline for sampling. Given that the Welsh data were compiled earlier than the English dataset, additional sources such as boatlaunch.co.uk and Google Maps were used to identify new and defunct private boat access points. These sampling sites were used instead of those used in the 2012 study (Armstrong *et al.*, 2013) as they offer a better understanding of current angling activity around the English and Welsh coastline. Furthermore, the shapefiles facilitated spatial analysis and improved communication with surveyors about sampling locations. Using the R sf package (Pebesma, 2018), shore angling locations and private boat access points were combined and assigned to UK NUTS1 regions (including Wales), which formed the sampling strata. Sites with no detectable angling activity or those located on islands with boat-only access from the UK mainland (e.g., the Isle of Wight, with the exception of some volunteer-based sampling) were excluded. High and medium activity sites were grouped as "high" activity to simplify stratification. To ensure the robustness of the resulting site list, the identified sampling sites were overlaid on Google Maps and manually checked for accessibility. This process produced an initial set of sampling locations.

Many sites identified by Monkman *et al.* (2015) and MMO (2020) were small or located in close proximity, making individual site sampling inefficient. To address this, shore sites within a 30-minute walking distance of each other in the same sampling region were grouped into secondary sampling sites (SSSs; Table 1). Walking times were determined using OpenStreetMap's Routing Machine (OSRM) with a custom travel profile that de-prioritised ferries and other boat-based transport (https://github.com/Project-OSRM/osrm-backend). The grouped sites were manually verified using Google My Maps to identify and correct anomalies.

For private boat sites, individual access points constituted the SSSs. Using a similar method to grouping sites within walking distance, SSSs were grouped into primary sampling sites (PSSs; Table 2), but the criterion was a 30-minute driving distance instead of walking. Driving times were calculated using a custom OSRM profile that excluded car ferry routes. A final manual check of PSS travel times was performed to create the definitive list of sampling sites for shore and private boat surveys. These sites are publicly accessible at:

- Shore sampling sites: https://www.google.com/maps/d/edit?mid=1Gm63OWnMYOziA9ZR19Kb-wN4cn0FbHQ&usp=sharing
- Boat sampling sites: https://www.google.com/maps/d/edit?mid=1uo2JNbzKhNb9iwmMkv8Mc0CcHP2Y_dw&usp=sharing

Table 1: The number of secondary sites at the high/low activity level identified within each region.

Type	Activity level	East Midlands	East of England	North East	North West	South East	South West	Wales	Yorkshire & Humber
boat	high	1	21	6	3	13	34	26	5
	low	4	85	37	47	154	194	86	18
shore	high	9	85	46	96	125	244	63	28
	low	5	51	14	59	51	186	277	34

Table 2: The number of primary sites at the high/low activity level identified within each region.

Type	Activity level	East Midlands	East of England	North East	North West	South East	South West	Wales	Yorkshire & Humber
boat	high	1	10	6	2	8	22	18	3
	low	2	28	12	14	43	59	29	6
shore	high	2	26	13	32	36	87	29	10
	low	2	18	6	22	18	72	82	12

A temporal sampling frame was also developed, encompassing all days of the year. For safety reasons, only daylight hours were included (see Table 3 for sampling hours). Finally, the spatial and temporal sampling frames were integrated to create the full sampling frame. This comprehensive frame comprised all days of the year, the primary sampling sites (PSSs), and the associated daylight hours available for sampling. As a result, the primary sampling unit (PSU) was defined as the combination of a PSS and a day (i.e., PSS × day, or site-day). This structure facilitated a systematic approach to sampling, ensuring spatial and temporal representativeness across the survey region.

Table 3: The earliest start and latest finish times for shore and private boat surveys to account for daylight hours.

Month	Earliest start	Latest finish
January – February	07:00	17:00
March	06:30	18:30
All other months	06:00	20:00

2.2.1.3.2. Stratifying the sampling frame

The sampling frame was stratified to ensure a comprehensive and systematic approach to selecting days, times, and locations for the survey. This stratification was designed to account for temporal, spatial, and logistical variations in recreational fishing activity while maintaining a balanced sampling effort across key strata.

As described above, the sampling period encompassed all days within a year, with July 2023 designated as a pilot phase and the primary survey running from 1 August 2023 to 31 July 2024. Days were categorised into weekdays and weekends/bank holidays to capture variation in recreational fishing activity typically associated with these periods. To facilitate analysis and operational planning, the year was further divided into five sampling quarters:

- Quarter 0: 1 – 31 July 2023 (pilot phase).
- Quarter 1: 1 August 2023 – 31 October 2023.
- Quarter 2: 1 November 2023 – 31 January 2024.
- Quarter 3: 1 February 2024 – 30 April 2024.
- Quarter 4: 1 May 2024 – 31 July 2024.

All times within the designated daylight windows were treated with equal probability, ensuring no time bias in the sampling effort.

The spatial sampling frame was stratified by English NUTS1 regions + Wales, with additional sub-stratifications to address regional and logistical considerations:

- Southwest and Wales regions were split into:
    - Wales: North and South subregions.
    - Southwest: East and West subregions.

The split point for these regions were generated by finding the centroid of the region and drawing a straight line horizontally/vertically (for Wales and the South West, respectively) through the region using the sf package for R (Pebesma, 2018).

The final stratification layers included the following:

- Sampling quarter: As defined in the temporal stratification.
- Sampling region: The English NUTS1 region + Wales.
- Survey type: Shore or private boat survey.
- Activity level: Sites/boat access points were classified as either high or low activity based on prior data.
- Day type: Weekday or weekend/bank holiday.

This stratification ensured that the sampling effort was proportional to the variability in fishing activity across regions, times, and site types, facilitating a robust and representative survey design. The finalised number of PSUs in each stratum can be seen in Table 4.

Table 4: The final number of primary sampling units (primary site ID * Day of the year) in each stratum.

Survey Type	Quarter	Day Type	East Midlands		East of England		North East		North West		South East		South West		Wales		Yorkshire & Humber	
			High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
Boat	0	Weekday	21	42	210	588	126	252	42	294	168	903	462	1239	378	609	63	126
		Weekend + public holiday	10	20	100	280	60	120	20	140	80	430	220	590	180	290	30	60
		Total	31	62	310	868	186	372	62	434	248	1333	682	1829	558	899	93	186
	1	Weekday	66	132	660	1848	396	792	132	924	528	2838	1452	3894	1188	1914	198	396
		Weekend + public holiday	26	52	260	728	156	312	52	364	208	1118	572	1534	468	754	78	156
		Total	92	184	920	2576	552	1104	184	1288	736	3956	2024	5428	1656	2668	276	552
	2	Weekday	66	132	660	1848	396	792	132	924	528	2838	1452	3894	1188	1914	198	396
		Weekend + public holiday	26	52	260	728	156	312	52	364	208	1118	572	1534	468	754	78	156
		Total	92	184	920	2576	552	1104	184	1288	736	3956	2024	5428	1656	2668	276	552
	3	Weekday	64	128	640	1792	384	768	128	896	512	2752	1408	3776	1152	1856	192	384
		Weekend + public holiday	26	52	260	728	156	312	52	364	208	1118	572	1534	468	754	78	156
		Total	90	180	900	2520	540	1080	180	1260	720	3870	1980	5310	1620	2610	270	540
	4	Weekday	66	132	660	1848	396	792	132	924	528	2838	1452	3894	1188	1914	198	396
		Weekend + public holiday	26	52	260	728	156	312	52	364	208	1118	572	1534	468	754	78	156
		Total	92	184	920	2576	552	1104	184	1288	736	3956	2024	5428	1656	2668	276	552
	Total		397	794	3970	11116	2382	4764	794	5558	3176	17071	8734	23423	7146	11513	1191	2382
Shore	0	Weekday	42	42	546	378	273	126	672	462	756	378	1827	1512	609	1722	210	252
		Weekend + public holiday	20	20	260	180	130	60	320	220	360	180	870	720	290	820	100	120
		Total	62	62	806	558	403	186	992	682	1116	558	2697	2232	899	2542	310	372
	1	Weekday	132	132	1716	1188	858	396	2112	1452	2376	1188	5742	4752	1914	5412	660	792

Survey Type	Quarter	Day Type	East Midlands		East of England		North East		North West		South East		South West		Wales		Yorkshire & Humber	
			High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
		Weekend + public holiday	52	52	676	468	338	156	832	572	936	468	2262	1872	754	2132	260	312
		Total	184	184	2392	1656	1196	552	2944	2024	3312	1656	8004	6624	2668	7544	920	1104
	2	Weekday	132	132	1716	1188	858	396	2112	1452	2376	1188	5742	4752	1914	5412	660	792
		Weekend + public holiday	52	52	676	468	338	156	832	572	936	468	2262	1872	754	2132	260	312
		Total	184	184	2392	1656	1196	552	2944	2024	3312	1656	8004	6624	2668	7544	920	1104
	3	Weekday	128	128	1664	1152	832	384	2048	1408	2304	1152	5568	4608	1856	5248	640	768
		Weekend + public holiday	52	52	676	468	338	156	832	572	936	468	2262	1872	754	2132	260	312
		Total	180	180	2340	1620	1170	540	2880	1980	3240	1620	7830	6480	2610	7380	900	1080
	4	Weekday	132	132	1716	1188	858	396	2112	1452	2376	1188	5742	4752	1914	5412	660	792
		Weekend + public holiday	52	52	676	468	338	156	832	572	936	468	2262	1872	754	2132	260	312
		Total	184	184	2392	1656	1196	552	2944	2024	3312	1656	8004	6624	2668	7544	920	1104
	Total		794	794	10322	7146	5161	2382	12704	8734	14292	7146	34539	28584	11513	32554	3970	4764

2.2.1.3.3. Determining minimum sampling targets

For paid surveyors, the number of sampling days allocated per region per quarter was determined through a simulation study based on the Sea Angling 2012 study data. In the simulation study, the data collected in the 2012 study were stratified based on the Catchwise stratification and a Bayesian zero-inflated negative binomial model was then fit using brms (Bürknerm, 2017) to estimate the total number of anglers present at each site, where the predictors used were the stratification layers (i.e., survey type, region, day type and activity level).

To attain the required number of PSUs to sample in the simulation study, a sampling frame based on the Catchwise sites was generated. For each region and quarter, between 5-50 PSUs were randomly sampled 20 times based on the quarter 1 sampling probabilities outlined in Table 5. The Sea Angling 2012 angler count model was then used to predict how many anglers were counted be present at each PSU. Using this simulated PSUs sampled and angler count dataset, the srvyr R package (Freedman and Schneider, 2024) was used to calculate the total effort in the survey and the associated relative standard error (RSE), the outputs for this are presented in Figure 3. Whilst 35 PSUs per region and quarter was determined to be the minimum sampling required to reliably achieve acceptable survey RSE’s (less than 25%) for both the shore and boat survey, 45 was selected to ensure there was a buffer in case of changes to the variance in the number anglers per PSU since 2012.

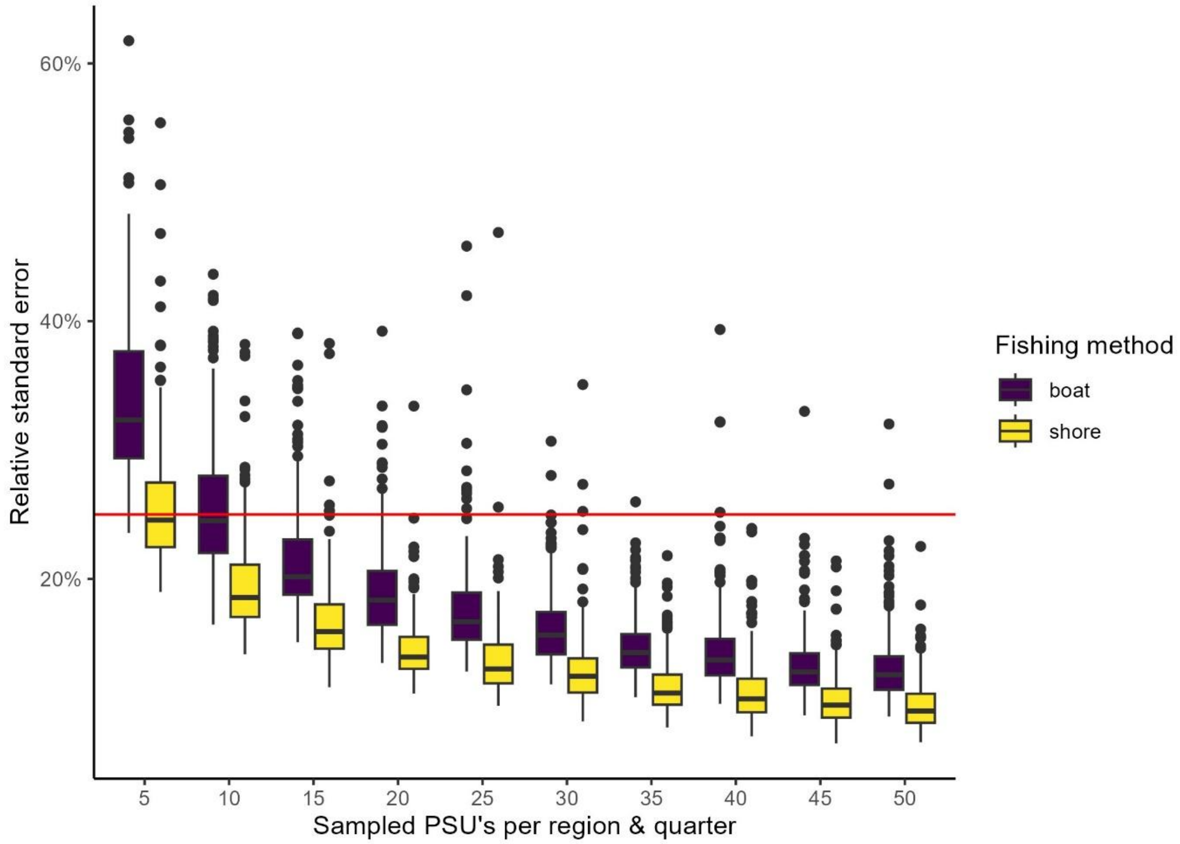

Figure 3: The relative standard error (RSE) for the number of PSUs sampled per region and quarter from the simulation study. The red horizontal line indicates where the RSE is below 25%, which is considered acceptable precision.

2.2.1.3.4. Paid surveyor primary sampling unit selection

The standard allocation was 45 days per region per quarter, with the following exceptions:

- South West and Wales: Each of the subregions were sampled for 45 days per quarter (90 total for the region), doubling the sampling effort.
- East Midlands: This region, characterised by a small coastline and comparatively low angling activity, was allocated only 25 days per quarter, with the remaining resources redistributed to larger higher-activity regions.

Sampling within each stratum was conducted randomly, following these steps:

1. Stratum Selection: Strata were randomly selected based on sampling probabilities outlined in Table 5, where the increase in

high activity sampling towards the end of the survey was done to maximise the number of anglers interviewed.

2. PSU Selection: A random PSU was then chosen within the selected stratum.
3. Time Selection: A random hour within the specified hours was chosen to begin sampling.
4. System Upload: The selected PSUs were uploaded to the allocation system for scheduling and operational management.

Private boat sampling proved challenging within the probabilistic survey design. The presence of private boats at launch sites was highly dependent on tidal conditions, the impact of which varies significantly across different locations. Additionally, logistical barriers, such as restricted access to many harbours due to heightened security measures (e.g., marinas requiring key fob access), further limited the feasibility of accessing these sites. These challenges resulted in a reduction in private boat sampling effort to 5 days per region from sampling quarter 2 onwards, with sampling restricted entirely to high-activity sites only. Further, surveyors could choose what time they went to the boat access point to maximise the chances of encountering returning boats. Whilst this means this portion of the survey is not representative, and will not generate enough data to extrapolate estimates, it was hoped that these modifications would yield enough data to make simple catch-rate comparisons with the SADP.

Finally, to minimise surveyor fatigue and ensure an even temporal distribution of data collection, a maximum of five consecutive sampling days per surveyor was implemented.

Table 5: The sampling probabilities for in dividual strata used per region and quarter.

Quarter	Variable	Probability of being selected (%)
0 & 1	Shore or private boat survey	60/40
	High or low activity site	
	Weekend + Public holiday or weekday	
2	Shore or private boat survey	5 days max per region for private boat sampling
	High or low activity site	60/40
	Weekend + Public holiday or weekday	
3	Shore or private boat survey	5 days max per region for private boat sampling
	High or low activity site	70/30
	Weekend + Public holiday or weekday	60/40
4	Shore or private boat survey	5 days max per region for private boat sampling
	High or low activity site	75/25
	Weekend + Public holiday or weekday	60/40

2.2.1.4. Volunteer based sampling

Initially, a semi-probability-based volunteer surveyor sampling scheme was implemented. Volunteers indicated their travel distance, preferred survey days (weekdays/ weekends) and times (morning/afternoon/ evening), and the number of days they were willing to sample for. They also provided their home location, which was combined with the distance they were willing to travel to identify all sampling sites within their specified travel distance using an OSRM. Using their availability and preferences, sites and days were allocated randomly based on the paid surveyor sampling probabilities. Volunteers were responsible for conducting activity and angler surveys. However, engagement with this approach was low, requiring a modification to the sampling strategy after quarter 2.

To address this, a convenience sampling method was introduced. Volunteers were provided with a modified activity survey that allowed them to conduct sampling at a location and duration of their choosing (with a minimum of 30 minutes). They were required to submit a what3words location for their sampling site. Unlike the previous approach, volunteers did not conduct angler interviews, as they had not undergone the necessary training or received fish identification guides. This revised method aimed to improve participation rates while still capturing valuable effort data.

2.2.1.5. Follow up surveys

Angler interviews were collected onsite by surveyors. At the end of the angler interview survey, participants were asked for consent to be contacted for further research. Further data collection in the follow up aimed to understand what happened post interview, including activity and catch. The follow up survey questions can be found in Appendix 7.

For those who consented to being contacted, the follow up survey was sent via email, and telephone calls were made to non-respondents. Questions included what time anglers finished fishing and what they caught after being interviewed. The date and time they were interviewed and their catches at the time of interview were provided to reduce recall bias. A full description on these methods can be found in Appendix 7.

2.2.2. Charter boat survey

2.2.2.1. General survey approach

The charter boat survey aimed to quantify the level of charter boat fishing activity in England and Wales and estimate the total number and biomass of fish caught. As with the shore and private boat survey, a structured sampling scheme was required to ensure a representative sample of charter boat activities and catches, which is summarised in Figure 4. However, because no official list of charter boats exists due to the lack of licensing requirements, a comprehensive list had to be generated before sampling could begin.

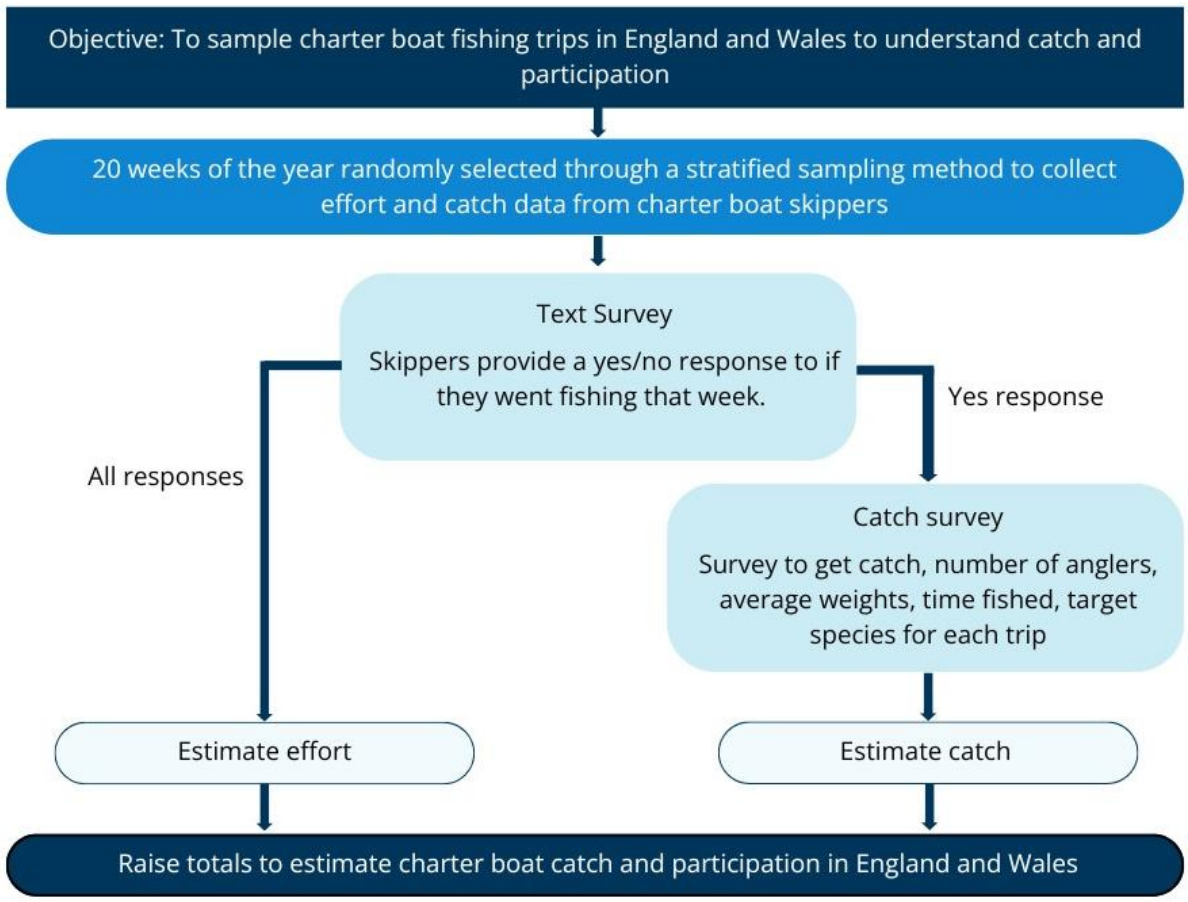

Figure 4: An outline of the data collection processes for the charter boat survey.

An initial list of charter boats was compiled using the Sea Angling 2012 database (Armstrong *et al.*, 2013), Monkman et al. (2020) and an existing database maintained by Substance. This was further updated with information from the Angling Trust and the Patsmith database (Thomas and McMaster, 2025). Additional boats were identified through Charter Boats UK (www.charterboats-uk.co.uk/), Google searches, individual charter boat websites, and social media platforms such as Instagram and Facebook. More details on the development of the charter boat database are provided in Appendix 8.

This list formed the basis of the Fleet Survey, which gathered information on boat locations, seasonality, avidity, and maximum angler capacity. The full outline of the Fleet Survey and analysis of changes in the charter boat fleet in England and Wales provided in Appendix 8.

The identified charter boats were then contacted to determine their willingness to participate in Catchwise. Subsequently, 20 weeks were randomly selected per ICES division and the boats that agreed to participate were sent surveys to collect activity and catch data. This time frame was chosen as an adequate number of weeks to get a representative temporal sample without overburdening skippers. To estimate effort, participating skippers were sent a text message asking if they had gone fishing. A simple yes/no response was recorded, and if they had gone fishing, a follow-up survey was sent to collect additional details, including number of trips conducted, number of anglers per trip, ICES division fished, trip duration, and target species. Number of fish kept and returned per trip and the associated average weight caught were also collected to estimate total charter boat catch and tonnage.

In some instances, charter boat skippers submitted their records via Excel or paper logs, which were then converted into the standardised data recording system. Yes/no responses and associated catch data were linked using a unique identifier.

To facilitate engagement with the charter boat sector, webinars and a face-to-face event were conducted, providing further opportunities for skippers to contribute to the survey. Additional details on these engagement activities can be found in Appendices 8.

2.2.2.2. Sampling frame, stratification, and selection of primary sampling units

2.2.2.2.1. Generating the sampling frame

Similar to the shore and private boat survey, a comprehensive sampling frame was required for the charter boat survey, which included all charter boats in the fleet and the times at which they were available to go fishing. The identification and selection of charter boats is detailed in Section 2.2.2.1.

To ensure adequate temporal coverage across the survey period, a temporal sampling frame was also established. This frame covered each Monday of every week throughout the year, as the PSU was defined as a boat-week. This approach was consistent with the methodology used in the Sea Angling 2012 survey (Armstrong *et al.*, 2013), the SSU was defined as the day of the week. The tertiary sampling unit was the individual trip conducted on that day.

Table 6: The number of charter boats identified and that signed up to be part of the survey within each ICES division.

ICES division	Identified	Signed up
4.b	31	7
4.c	36	6
7.a	27	4
7.d	56	15
7.e	63	20
7.f	45	12
7.g	9	1
Total	267	59

2.2.2.2.2. Stratifying the sampling frame

The stratification of the sampling frame for the charter boat survey was structured to account for both spatial and temporal variation in fishing effort. The spatial component of the sampling frame was defined by the ICES division associated with the home port of each charter vessel. This approach ensured that sampling was representative of distinct regional fisheries and fishing behaviours, allowing for appropriate spatial coverage of charter boat activity.

The temporal stratification of the sampling frame was based on a quarterly division of the year, with Mondays serving as the reference point for defining each quarter. This division facilitated a balanced distribution of sampling effort across different periods, capturing seasonal variations in charter boat activity. The quarters were defined as follows:

- Quarter 0: 16 October 2023 – 5 November 2023 (Pilot phase).
- Quarter 1: 6 November 2023 – 4 February 2024.
- Quarter 2: 5 February 2024 – 5 May 2024.
- Quarter 3: 6 May 2024 – 4 August 2024.
- Quarter 4: 5 August 2024 – 3 November 2024

Further, the seven days following the last date of each quarter were also included within that quarter’s sampling frame.

2.2.2.2.3. Primary sampling unit selection

To ensure a representative and manageable sampling effort, 20 random weeks were selected across the year for each ICES division. This random selection was constrained so that no more than three consecutive weeks were chosen for each boat to minimise survey fatigue. For each selected week, all charter boats that had signed up within the corresponding ICES division were asked to provide data on the trips they had conducted that week, and the associated catches.

To reflect seasonal fluctuations in charter boat activity, quarters three and four were assigned a higher sampling probability of 30%, while the remaining quarters were assigned a probability of 20%. This adjustment was made in recognition of the increased levels of charter boat fishing during these periods.

More information on the weekly data collection allocation can be found in Appendix 8.

2.3. Data analysis

2.3.1. Shore and private boat survey means, variance and survey totals

2.3.1.1. Estimates required and general extrapolation approach

To extrapolate data from the onsite shore and private boat survey three key metrics are required: effort, catch-per-unit-effort (CPUE), and the weight of individual fish caught. For each of these metrics, both the mean and variance must be calculated to ensure robust estimates that account for uncertainty. In addition to the estimation of these metrics, it is necessary to use a method that combines them whilst accounting for the different variances associated with each to ensure that the variability in effort, CPUE, and fish weight is appropriately integrated into the final estimates of total effort, catch, and tonnage.

To estimate total effort, several issues must first be addressed. First, it is necessary to fill in data for unobserved times of the day, as not all hours of the day are sampled. Second, unobserved secondary sites within primary sites must be accounted for. Finally, means and variances must be generated.

For CPUE, the general approach involves understanding how the catch recorded at the time of an interview relates to their total catch for the whole trip as many anglers will be interviewed part way through their fishing session. This is typically achieved by using the time fished as a predictor of total catch. Once this is done, mean number of fish caught with variances are generated.

The weight of a fish caught is estimated using length data where available. Length measurements are converted to weight using established length-weight relationships, with the growth parameters a and b taken from Silva *et al.* (2013). These relationships allow for the calculation of fish weights in kilograms, w_s, for species s:

$$w_s = a_s L_s^{b_s}$$

where L_s is the length of the fish in centimetres. Once calculated, the average weight and variance is calculated.

To extrapolate the survey totals and errors, the first step was to estimate total effort. This was done by multiplying the average effort per PSU (along with its variance) within a stratum by the total number of PSUs in the sampling frame and stratum. For example, if the mean number of anglers observed per PSU within stratum A was 1, and there were 3 sites in the stratum sampled over 365 days in a year, the total effort would be 1 x (3 x 365), which is 1095. Once total effort is estimated, it is combined with CPUE to calculate the total number of fish caught. This is achieved by multiplying the mean CPUE by the total effort. For instance, if the mean CPUE for a particular species is 3, the total number of fish would be 3 x 1095, which is 3285. The total tonnage of fish landed is then derived by multiplying the total catch by the mean weight of a fish and converting the result to tonnes. For example, if the mean weight of a fish is 0.5 kg, the total tonnage is: 3285 x 0.5 / 1000, which is 1.64 tonnes.

Two different approaches were used to derive the total effort, catch and tonnage along with the associated error. In this study, both a bootstrapping and model-based approach were used to do this. Bootstrapping is a statistical resampling technique used to estimate the distribution of a statistic by repeatedly resampling the observed data with replacement (Efron, 1979). This method is particularly useful when analytical solutions to measure uncertainty are difficult to derive as it allows for the direct calculation of confidence intervals and other metrics by simulating the sampling process. By drawing multiple resamples, bootstrapping provides robust estimates of variability and enables the propagation of uncertainty in complex systems. In this study, the bootstrapping approach integrates variability across multiple components of the survey, including the estimation of angling effort, catch rates per trip, and fish weights, to provide comprehensive and reliable metrics of fishing activity and biomass. To ensure the full range of variability was incorporated 2,000 bootstraps were conducted in R (R Core Team, 2022), facilitated with the R packages boot (Canty and Ripley, 2024), and tidyverse (Wickham *et al.*, 2019).

Bayesian regression models were used to predict effort, CPUE and weights caught. Models were fit using brms (Bürknerm, 2017), with support from tidybayes (Kay, 2023) and cmdstanr (Gabry *et al.*, 2024) for Bayesian computation and model visualisation. Predictor selection was guided by approximate leave-one-out cross-validation (loo-CV; Vehtari *et al.*, 2017), which provided an efficient metric for comparing model performance by assessing the models ability to predict out-of-sample data.

When Bayesian regression models are fit, the process involves estimating the posterior distribution of the model's parameters; essentially, a range of plausible values for each parameter based on the data, the model, and prior information. A model draw is a single random sample from this posterior distribution. Each draw represents one possible combination of parameter values that the model considers likely, given the data and uncertainty. For example, in the model predicting the number of fish caught, a draw would include specific values for all model parameters, such as the species and how long someone was fishing for, and a corresponding prediction for the catch. By generating many draws, we can summarise the model's predictions (e.g., average catch) and quantify uncertainty through credible intervals or probabilities of certain outcomes. These draws provide a way to explore the uncertainty inherent in the model's predictions. In total, 2,000 draws were taken from each of the model's expected predictions, essentially representing estimates of what the model believes the average value should be based on the data and the uncertainty accounted for. These draws were then combined to calculate total effort, catch, and tonnages for each species. The final estimate of total catch was calculated as the mean of all draws, and the 95% credible intervals were similarly derived. The use of multi-level (hierarchical) models combined with post-stratification is termed multilevel regression and post-stratification (MRP; Buttice en Highton, 2013; Wang *et al.*, 2015; Gelman *et al.*, 2016; Downes *et al.*, 2018). In MRP, a hierarchical model first estimates relationships between predictors and the outcome using the observed sample, allowing borrowing of information across related groups (partial pooling). Then, post-stratification involves applying these model-derived estimates to the known distribution of predictors within the broader target population. This two-step approach ensures that estimates from sampled units are appropriately weighted and extrapolated to reflect population-level characteristics. Both bootstrapping and MRP provide robust quantification of variability, ensuring that uncertainty in estimates of fishing effort, CPUE, and fish weights is properly propagated through to final extrapolations.

These approaches allow for the calculation of 95% confidence intervals for bootstrapping, and credible intervals for MRP, to quantify the precision of the survey totals. Confidence intervals represent the range of values that would contain the true parameter in a certain percentage of repeated samples, whereas credible intervals represent the range of values within which the parameter lies with a certain probability, given the observed data and prior beliefs. Thus, confidence intervals are frequentist and focus on repeated sampling properties, while credible intervals are Bayesian and reflect posterior probability distributions. For simplicity, confidence and credible intervals will hereafter be termed precision intervals (PI).

The steps required to extrapolate the survey data to the population for both the bootstrapping and model-based approaches are outlined in Figure 5

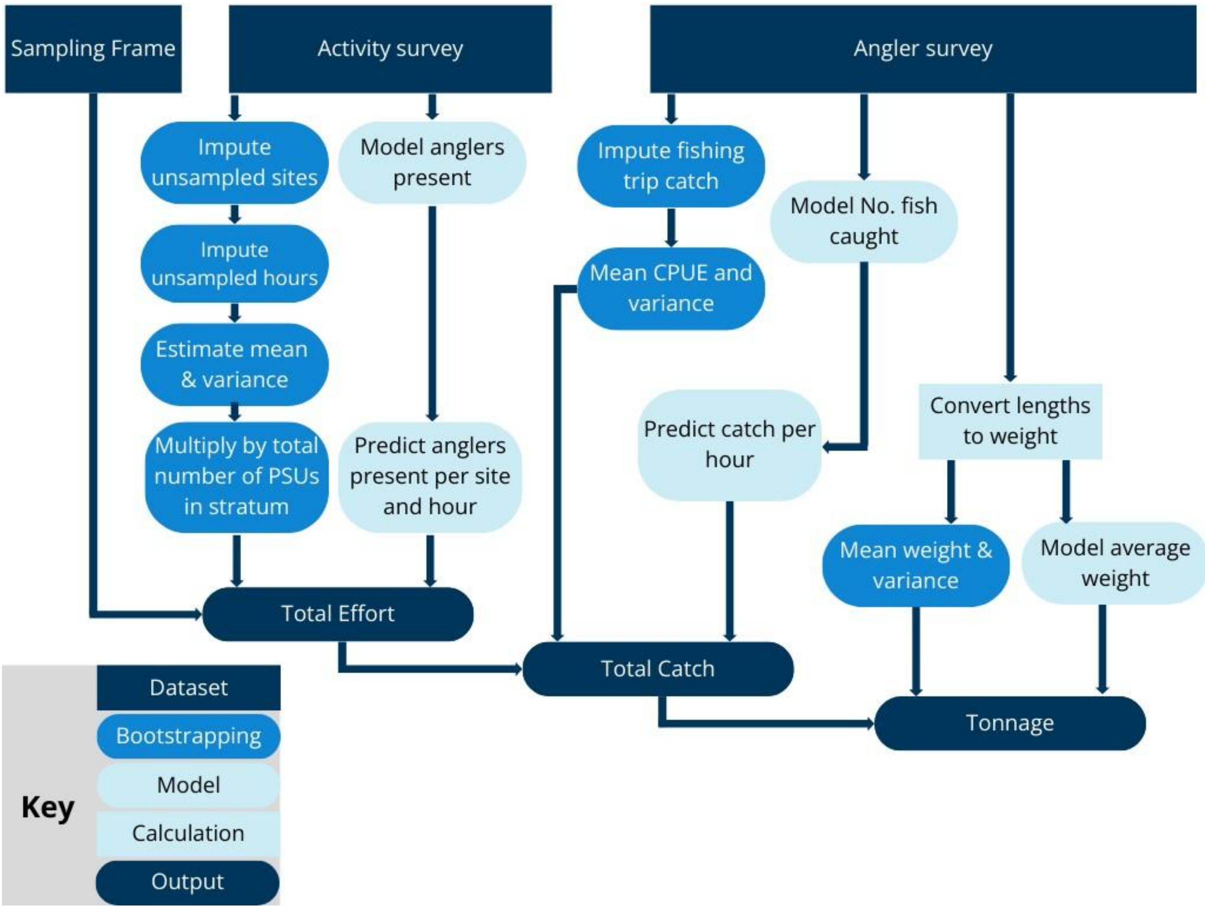

Figure 5: An outline of the steps required to extrapolate the shore and private boat survey to get the total effort, catch and tonnage for both the bootstrapping and model-based approaches.

2.3.1.2. Bootstrapping

2.3.1.2.1. Effort

In some instances, not all the secondary sites within a primary site were sampled due to time constraints. To account for this partial sampling, the total number of anglers, A_d, for the primary site d was estimated by extrapolating the observed number of anglers at the sampled secondary sites using the following formula:

$$A_d = \sum_{i=1}^{n_s} a_i \cdot \frac{n_p}{n_s}$$

where n_s is the number of secondary sites sampled, a_i is the number of anglers in secondary site i, and n_p is the number of secondary sites within the primary site. This assumes that the average number of anglers at sampled and unsampled secondary sites are the same.

Finally, to extrapolate the anglers within a primary site to the primary sampling unit i the following equation was used:

$$A_i = A_d . \frac{24}{4}$$

where 24 is the number of hours in the day and 4 is the number of hours sampled. This assumes that angling within unsampled nighttime hours would be the same as daytime hours. This assumption was checked by following the same extrapolation procedure, but only for the hours that were possible to sample indicated in Table 3. A further extrapolation layer using the percentage of trips that occurred outside of the sampling hours from the SADP was then applied. The extrapolated survey total effort from this check showed little difference, and so the simplest 24-hour unit raising procedure was presented.

2.3.1.2.2. Catch per unit effort

To estimate CPUE, adjustments were made for anglers who were interviewed partway through their fishing trips. Since the total catch for these trips was incomplete at the time of the interview, additional steps were taken to estimate the full trip's catch. This involved calculating the length of the trip, T_i, for angler i:

$$T_i = t_i - s_i$$

where t_i is the time they expected to complete fishing and s_i is the time they started fishing. Subsequently, the catch per hour at the time of interview, H_i, was calculated for each species *j* and catch component (kept or released) *k*:

$$H_{i,j,k} = \frac{p_{i,j,k}}{h_i}$$

where *p* is the catch at the time of interview and *h* is the time the angler had been fishing for. The total catch per trip, *c*, was calculated as:

$$c_{i,j,k} = T_i \cdot H_{i,j,k}$$

This approach assumes that catch rates are constant throughout a fishing trip. To ensure reliability, only anglers who had fished for at least 0.25 hours (15 minutes) were included in the analysis, as shorter durations were deemed insufficient for catch rates to stabilise. Furthermore, species were only included in the extrapolated estimates if they had been caught at least 10 times by three different anglers (e.g., if a species was caught four times by angler one, five times by angler two and once by angler three it would be included). This threshold was implemented to avoid raising catch estimates for species with insufficient data, as doing so could lead to unreliable extrapolations.

2.3.1.2.3. Weight of a fish caught

The procedure for calculating the weight of fish caught is detailed in Section 2.3.1.1. No imputation was required for species with missing length measurements, as the extrapolation procedure outlined below accounted for such cases. The final dataset included the number of each species kept and returned at weight. This dataset allowed for the estimation of average fish weights and their associated variances, ensuring a comprehensive understanding of the biomass removed or returned by recreational anglers. Finally, to ensure there were enough length measurements to reliably estimate an average weight, only species where three lengths in five different trips were included in the analysis.

2.3.1.2.4. Survey totals with variance

As described above, bootstrapping was one method used to combine the fishing effort, number of fish caught and the associated tonnage while quantifying the associated uncertainties.

To bootstrap the total number of angling trips four general steps were taken for a single bootstrap estimate, this process was repeated 2000 times to get the mean and 95% PI for total effort, catch, and tonnage:

1. Randomly sample with replacement, based on the number of number of PSUs sampled, from the effort data the total number of anglers per PSU based on the sampling probabilities in Table 5 to get a bootstrapped activity dataset. Then, multiply by inclusion probability to get the total effort.
2. Randomly sample with replacement, based on the number of trips sampled, the total number of fish kept and returned per trip to get a bootstrapped catch dataset.

    a. Calculate a weighted mean catch per trip.
    b. Combine with the total effort bootstrapped results.
    c. Multiply catch per trip by total effort to get an estimate of total catch.
3. Randomly sample with replacement, based on the number of fish in the survey with length data, the weight of a fish caught data.
    a. Calculate a weighted average for the kg of a species.
    b. Combine with the total catch bootstrap.
    c. Multiply by the total catch to get an estimate of the tonnage of fish caught.

To achieve the first step, the number of anglers per PSU was bootstrapped accounting for the inclusion probability (or survey weight) of the PSU. Total fishing effort is calculated as the weighted sum of anglers across PSUs. To account for variability in this estimate, bootstrapping is applied within strata by repeatedly resampling PSUs and recalculating the total effort. In each bootstrap iteration, the total effort E_b is estimated as:

$$E_b = \sum_{i=1}^{n_b} A_i \cdot w_{b,i}$$

where A_i represents the number of anglers in PSU i, $w_{i,b}$ is the corresponding survey weight and n_b is the number of PSUs sampled in the bootstrapped survey data.

To estimate the total catches, the first step was to calculate the mean catch, $\bar{C}$, per PSU within each stratum using:

$$\bar{C}_{b,j,k} = \frac{\sum_{i=1}^{n_b} c_{b,j,k,i}}{n_b}$$

Where n_b is the number of trips sampled in bootstrap *b*, and $c_{b,j,k,i}$ is the catch of species j, catch component k, within trip *i* of bootstrapped dataset *b*.

Bootstrapping the average weight of a fish caught required data from all strata to be pooled together due to numbers of fish caught with length-estimates given. Thus, the mean weight of a species-component group in each bootstrap $\bar{w}_{j,k,b}$ is defined as:

$$\bar{w}_{j,k,b} = \frac{\sum_{i=1}^{n_{j,k,b}} w_{j,k,b,i}}{n_{j,k,b}}$$

where $w_{j,k,b,i}$ is the weight of each fish i in the bootstrapped dataset.

The total catch, $T_{j,k,b}$, is calculated by multiplying the estimates of total effort and mean catch per trip within each species-component group for each bootstrap:

$$T_{j,k,b} = C_{j,k,b} \cdot E_b$$

and the total weight, $W_{j,k,b}$, is estimated by multiplying the bootstrapped total catch and the bootstrapped mean fish weight for each species-component group:

$$W_{j,k,b} = C_{j,k,b} \cdot \bar{w}_{j,k,b}$$

The total number $\bar{T}_{j,k}$ and tonnage $\bar{W}_{j,k}$ of each species-component group was calculated as the average across all bootstrap iterations:

$$\bar{T}_{j,k} = \frac{\sum_{i=1}^{N_b} T_{j,k,i}}{N_b}$$

$$\bar{W}_{j,k} = \frac{\sum_{i=1}^{N_b} W_{j,k,i}}{N_b}$$

where N_b is the number of bootstraps conducted. The upper and lower 95% PIs of total effort, catch and weight were calculated using the 2.5% and 97.5% quantiles, respectively, of the estimates across all the bootstraps conducted.

2.3.1.3. Model-based estimates

2.3.1.3.1. Effort

A Bayesian zero-inflated negative binomial model was employed to examine relationships between environmental, temporal, and site-specific predictors that were not included in the survey stratification design. This model allows for the analysis of observed data only, eliminating the need to extrapolate for unobserved sites and times. Instead, the model operates on the observed number of anglers recorded in the sampled hour at each secondary site. Consequently, effort when discussing the model-based estimates is defined as the number of anglers present at a site per hour, or "angling hours."

A zero-inflated negative binomial model consists of three distinct components, the count (number of anglers), shape (the over-dispersion parameter), and zero-inflation (probability of encountering an excess zero), each with a set of predictors that are outlined in Table 7 for the fixed/smooth effects and Table 8 for the random effects with the associated varying intercepts. The brms model formula is presented in Supplementary table 3.

Weakly informative priors based on the scaling of the scaling of the data were applied to most parameters to constrain estimates without imposing strong assumptions. However, an informative prior was used to restrict the smoothness for the month of the year, reflecting known seasonal patterns in fishing activity. This prior assumes a peak in activity during summer, with a gradual increase before the peak and a decline afterward.

The varying intercepts for region enabled the model to account for some of the regions high activity sites having more anglers (for example, a high activity site in the East Midlands could have less anglers than a high activity site in the South West). The varying intercept for site ID enabled the model to account for site-specific tidal differences, i.e., some sites being fishable only at high or low tide.

Table 7: The fixed and smooth effect predictors used to predict the number of anglers present in any given hour at a site, the transformation used on the variable. Priors are shown where N is a normal distribution where *N(μ, σ)*.

<table>
<tr><th>Model Component</th><th>Predictor</th><th>Transformation</th><th>Prior</th></tr>
<tr><td rowspan="7">Count</td><td>Site activity level</td><td>-</td><td rowspan="9">N(0, 1.6)</td></tr>
<tr><td>Tide height</td><td>z-score scaled</td></tr>
<tr><td>Day of the week</td><td>z-score scaled</td></tr>
<tr><td>Wind gust speed</td><td>z-score scaled</td></tr>
<tr><td>Time of the day</td><td>z-score scaled</td></tr>
<tr><td>Site has parking</td><td>-</td></tr>
<tr><td>Distance the site is to a pub</td><td>Log+1</td></tr>
<tr><td rowspan="7">Zero-inflation</td><td>Site activity level</td><td>-</td></tr>
<tr><td>Tide height</td><td>z-score scaled</td></tr>
<tr><td>Month (smoothed)</td><td>z-score scaled</td><td>N(0, 5)</td></tr>
<tr><td>Month (splines)</td><td></td><td>N(1, 0.2)</td></tr>
<tr><td>Day of the week</td><td>z-score scaled</td><td rowspan="3">N(0,1.6)</td></tr>
<tr><td>Wind gust speed</td><td>z-score scaled</td></tr>
<tr><td>Time of the day</td><td>z-score scaled</td></tr>
</table>

	Site has parking	-	
	Distance the site is to a pub	Log+1	

Table 8: The random effects and varying intercepts within them used to predict the number of anglers present in any given hour at a site and the prior in the model. LKJ is a Lewandowski-Kurowicka-Joe distribution where *lkj(shape)* and t is a non-centred t distribution where *t(df, μ, σ²)*.

Model Component	Random effect	Varying intercept	Prior	
			Random effect	Varying intercept
Count	Region	Activity level	*t(3, 0, 2.5)*	*lkj(2)*
	Primary site ID	Tide height		
Shape	Region	-		-
Zero-inflation	Region	Activity level		*lkj(2)*
	Primary site ID	Tide height		

2.3.1.3.2. Catch per unit effort

Like the effort model, the catch model employed in this study was also a zero-inflated negative binomial model. Only observed catches were included in the analysis, avoiding imputation for unobserved portions of trips. Additionally, only anglers who had been fishing for a minimum of 15 minutes were considered in the model to ensure meaningful data contributions.

The final model specification is presented in Table 9 and the brms model formula is presented in Supplementary table 3. In addition to variables accounting for differences in catch rates between species, regions and annual differences (along with interactions between these), a random effect for angler ID was included in both the count and zero-inflation components of the model. This ensured that variability between anglers, such as differences in behaviour and skill, was appropriately modelled.

Informative priors for the Catchwise model were derived from posterior parameter estimates of a model fitted to the SADP data to estimate catch per trip. The priors for the SADP trip model were $N(0, 1.6)$ for all fixed effects and $exp(1)$ for the random effects. However, a known bias in logbook surveys is an underreporting of 0-catch trips, meaning adjustments had to be made to reflect this bias. Whilst this bias does not impact the results from the SADP project as catches are extrapolated based on an angler's total catch in a year, and so missing 0- catch trips do not matter as long as all trips where a fish was caught are accounted for, the Catchwise analysis relies on all trips with 0 catches being accounted for. To resolve this bias in the priors, the diary estimates for both the catch and zero-inflation (ZI) parameters were used to construct normally distributed priors for the Catchwise model. Specifically, each prior was defined as $\theta \sim N(\mu, \sigma)$ with the prior mean set so that the diary estimate corresponds to a specified quantile of the distribution. That is, if the diary estimate θ_{diary} is assumed to represent the p^{th} quantile of the normal prior, then the relationship:

$$\theta_{diary} = \mu + \sigma\phi^{-1}(p)$$

can be rearranged to yield:

$$\mu = \theta_{diary} - \sigma\phi^{-1}(p)$$

where $\phi^{-1}(p)$ is the inverse cumulative distribution function of the standard normal distribution. For the catch parameter, the prior standard deviation was fixed at 0.2 and set the target quantile at 0.65, resulting in a prior mean of:

$$\mu_{catch} = \theta_{diary,catch} - 0.2\phi^{-1}(0.65).$$

For the zero-inflated component of the model, given the greater under-reporting of zero-catch trips, we used a standard deviation of 0.4 and set the target quantile at 0.85, leading to:

$$\mu_{zi} = \theta_{diary,zi} - 0.4\phi^{-1}(0.85).$$

This approach effectively shifts the priors so that the diary estimates fall at the desired quantiles of the corresponding normal distributions, thereby incorporating our knowledge of the reporting bias into the Catchwise model. The use of informative priors facilitated model convergence by guiding the parameter space toward more plausible values, improving sampling efficiency. These priors are presented in Supplementary Table 1.

In addition to a catch model with the adjusted priors from the SADP model, a second catch model with weakly informative priors of $N(0, 1.6)$ for all fixed effects and $exp(1)$ for the random effects was run to assess the impact of the informative priors on the results.

Table 9: The predictors used to estimate the number of fish caught by an angler and the transformation used on the variable. : Signifies an interaction between the two predictors. Priors are presented in Supplementary Table 1.

Model Component	Predictor	Transformation
Count	Hours fished	Log
	Species	None
	Component	
	Species: Component	
	Species: Region	
	Quarter of the year	Factor
	Species: Quarter of the year	
	Angler ID (Random effect)	None
Zero-inflation	Hours fished	Log
	Species	None
	Component	
	Species: Component	
	Species: Region	
	Quarter of the year	Factor
	Species: Quarter of the year	
	Angler ID (Random effect)	None

2.3.1.3.3. Weight of a fish caught

A lognormal model was employed to estimate the weight of a fish caught by an angler. The lognormal distribution is particularly suitable for modelling biological data as it represents values that are normally distributed on the logarithmic scale. In this analysis, the model used the weight of a fish given its length, as described in Section 2.3.1.2.3. To ensure robust estimation, only species for which at least 10 length measurements were recorded across 10 different trips were included in the model.

In a lognormal model, two key parameters are estimated: the mean (μ) and standard deviation (or sigma; σ). The final weight model specification, including the variables used to model these components, is detailed in Table 10 and the brms model formula is presented in Supplementary table 3. The only external variable incorporated into this model was the median weight of the species, derived from trawl surveys conducted in the ICES divisions covered by this survey since 2016, using data from the DATRAS database (Millar *et al.*, 2023).

Priors for the weight model were informed by the number of fish at weight from SADP. A sensitivity analysis comparing the model models fit with informative and weakly informative priors demonstrated that these priors enhanced inference through improved model diagnostics, and improved precision without significantly influencing the estimated mean weight of a fish caught. Due to the limited availability of length data in the Catchwise survey, particularly for released fish, more informative priors were necessary compared to those used in the CPUE model. Specifically, priors for the weight model used the SADP-derived μ parameter estimate with a σ of 0.1 (i.e., $N(\mu, 0.1)$). These priors are presented in Supplementary Table 2.

Table 10: The fixed effect predictors used to predict the weight of a fish caught in Catchwise and the transformation used on the variable. : Signifies an interaction between the two predictors. Priors are presented in Supplementary Table 2.

Model Component	Predictor	Transformation
Mean	Species	-
	Component	
	Species: Component	
	Species: Region	
	Median weight from DATRAS	Log
Sigma	Species	-

2.3.1.3.4. Assessing model fits

For each model, a posterior predictive check (PPC) was conducted to evaluate the model's ability to accurately represent the observed data. A PPC is a key diagnostic tool in Bayesian modelling, allowing researchers to assess whether the predictions generated by the model align with real-world data.

A PPC involves simulating new data from the fitted model on the sampled PSUs using the posterior distribution of the model parameters and then comparing these simulated datasets to the actual observed data. The goal is to determine whether the model can generate data that resembles the real-world observations. If the simulated data closely matches the observed data, this suggests that the model is well-calibrated and provides a reasonable representation of the underlying process. If discrepancies exist, such as systematic over or under-predictions, this may indicate model misspecification, issues with prior assumptions, or missing key predictors.

PPCs were created using the R package bayesplot (Gabry *et al.*, 2019), which allows for graphical comparisons between observed and simulated data. Here, a histogram density plot was used to assess whether the distributions of simulated and observed data align.

In addition to PPCs, the conditional effects of model predictors were examined to evaluate how different variables influence the predictions. This was done to understand the relationships between predictor variables and the model outcome while accounting for the uncertainty inherent in Bayesian estimation. A conditional effect in Bayesian regression modelling represents the expected change in the response variable as a function of a predictor variable, while holding all other model parameters constant. In simple terms, it shows how the predicted outcome varies when changing a particular explanatory variable, assuming everything else remains fixed. The R packages brms (Bürknerm, 2017) and ggplot2 (Wickham, 2016) were used to generate the conditional effects plots.

By assessing both posterior predictive checks and conditional effects, the modelling approach ensures that predictions align with observed data and that the impact of each variable is well understood.

2.3.1.3.5. Survey totals with variance

To generate the number of angling hours, predictions were generated for every hour at each site within the sampling frame. These predictions represented the model's estimate of the mean number of anglers present per hour. To calculate total angling hours, the predicted values were summed across all hours and sites for each model draw and output variable (e.g., by region). The total effort was then calculated as the mean of all 2,000 draws, and the 95% PI were derived from the 2.5th and 97.5th percentiles of the draw distributions.

To generate CPUE estimates, a dataset was created containing all combinations of species, catch components (e.g., retained or released), and regions. In this dataset, the number of angling hours was set to one, allowing the model to predict catch rates as the number of fish caught per hour. Furthermore, predictions were generated using only the intercept-level random effect for 'angler ID', excluding individual angler-specific deviations, thus providing catch rates representative of an average angler in the population. Model draws of catch rates were then generated using the CPUE model. These catch rate draws were combined with the effort model draws by multiplying the predicted catch per hour by the corresponding total effort in each draw. For each species, catch component, and region, the total catches were summed across draws. The final estimate of total catch was calculated as the mean of all draws, and the 95% PI were derived.

For the weight model, a simplified dataset was constructed containing the relevant input variables for predicting fish weight (i.e., species, component, region, and median DATRAS weight). Model draws were then generated to estimate the weight of individual fish based on the input data. These weight draws were combined with the total catch draws by multiplying the predicted fish weights by the corresponding total catch for each draw. This provided estimates of the total tonnage for each species, catch component, and region. As with the effort and CPUE models, the mean of all draws was taken as the total tonnage, and 95% PI were calculated from the draw distributions.

This approach allowed the uncertainty from each model to propagate through to the final estimates, providing robust measures of total effort, catch, and biomass, along with PI to quantify uncertainty.

2.3.1.4. Comparing bootstrapping and model-based approaches

With two distinct extrapolation approaches used in this study, it was necessary to compare total estimates and, where differences were found, investigate the underlying causes. The comparison focused on effort, total catch, CPUE, and average fish weight to determine whether methodological differences between bootstrapping and model-based extrapolation influenced the final estimates.

For effort, differences were assessed by examining how the proportion of PSUs sampled compared to the full sampling frame across temporal and environmental characteristics that were not included in the survey's raising stratum but were incorporated into the model. Specifically, this included tide state and high wind conditions, which are known to influence angler participation. Ideally, the distribution of these characteristics in the sampled data would match their distribution in the full frame; for example, if 30% of PSUs in the frame had high wind conditions, then 30% of sampling effort should occur under those conditions to maintain representative coverage. Additionally, the impact of reduced sampling hours during certain months was examined. If the full 24-hour day was divided into four six-hour periods, an ideal sampling distribution would allocate 25% of effort to each period. However, since only daylight hours were sampled, it is likely that late-morning and early-afternoon periods were oversampled, potentially leading to biases in total effort estimates. The analysis sought to determine whether this imbalance affected the extrapolated effort values.

For total catch and CPUE, comparisons were made by first examining overall differences in total catches between the two approaches, followed by a deeper analysis of CPUE to identify potential drivers of these discrepancies. Unlike the effort model, the model for catch did not incorporate multiple environmental variables, meaning that differences in sampled versus unobserved conditions could not be accounted for directly. Given the data limitations, it was not possible to assess whether over or under-sampling of certain environmental conditions influenced CPUE. Instead, to evaluate differences in catch estimation, data from the follow-up survey were used, where anglers provided a known total catch per trip after completing their fishing session.

To directly compare the two extrapolation methods, the linear CPUE extrapolation approach used in bootstrapping was applied to complete trip-level catches, mirroring the method used in the standard bootstrapped estimates. Additionally, model-based estimates of total catch were generated for each trip. These predicted catches were then compared to the known values from the follow-up survey and mean squared error (MSE) was calculated to assess which method produced estimates that more closely aligned with actual catches.

For average fish weights, comparisons were made by simply examining the mean estimated weight of fish caught across the two approaches. Where differences were observed, the sample sizes of weight measurements were assessed to determine whether these discrepancies were driven by limited sample sizes in the available data. Since the model can generate weight estimates even for species with limited observations, any significant differences between the two methods were evaluated in the context of data availability and model reliance on priors.

2.3.1.4.1. Effort

Since effort is measured in trips in the bootstrapping approach and in hours in the model-based approach, a method was required to standardise effort estimates to allow for direct comparison. This was achieved by calculating a weighted average trip length using the survey data, ensuring that effort estimates from both approaches could be expressed in equivalent units.

A key consideration in this calculation was length-of-stay bias, which arises because anglers who fish for longer durations are more likely to be encountered during a survey than those fishing for shorter periods. This bias means that observed trip durations in the dataset may be skewed towards longer fishing sessions, making it necessary to adjust for the probability of encountering different trip lengths. To address this, a weighting factor was applied based on the proportion of the 24-hour day that a trip occupied. The weight was calculated as:

$$W_i = \frac{1}{\left(\frac{H_i}{24}\right)}$$

where W is the weight of trip i and H is the amount of time they expected to go fishing. This means that shorter trips were weighted more heavily to compensate for their lower probability of being observed in the dataset.

A weighted average trip length, $\bar{L}$, was then calculated as:

$$\bar{L} = \frac{\left(\sum_{i=1}^{n} l_i \cdot W_i\right)}{\left(\sum_{i=1}^{n} W_i\right)}$$

where n is the number of trips sampled, and *l* is the length of trip *i*. This weighted average trip length was then used to convert the total angling hours estimated by the model into a comparable trip-based metric. This provided a directly comparable effort measure, ensuring that effort estimates derived from the bootstrapping and model-based approaches could be meaningfully assessed against one another.

Once the effort estimates were made comparable, differences were assessed by examining how the proportion of PSUs sampled compared to the full sampling frame across temporal and environmental characteristics that were not included in the survey’s raising stratum but were incorporated into the model. Specifically, this included tide state and high wind conditions, which are known to influence angler participation. Ideally, the distribution of these characteristics in the sampled data would match their distribution in the full frame; for example, if 30% of PSUs in the frame had high wind conditions, then 30% of sampling effort should occur under those conditions to maintain representative coverage. Additionally, the impact of reduced sampling hours during certain months was examined. If the full 24-hour day was divided into four six-hour periods, an ideal sampling distribution would allocate 25% of effort to each period. However, since only daylight hours were sampled, it is likely that morning and afternoon periods were oversampled, potentially leading to biases in total effort estimates. The analysis sought to determine whether this imbalance affected the extrapolated effort values.

2.3.1.4.2. Total catch and catch per unit effort

For total catch and CPUE, comparisons were made by first examining overall differences in total catches between the two approaches, followed by a deeper analysis of CPUE to identify potential drivers of these discrepancies. Unlike the effort model, the model for catch did not incorporate multiple environmental variables, meaning that differences in sampled versus unobserved conditions could not be accounted for directly. Given the data limitations, it was not possible to assess whether over or under sampling of certain environmental conditions influenced CPUE. Instead, to evaluate differences in catch estimation, data from the follow-up survey were used, where anglers provided a known total catch per trip after completing their fishing session.

To directly compare the two extrapolation methods, a linear CPUE extrapolation approach was applied to complete trip-level catches, mirroring the method used in the standard bootstrapped estimates. Additionally, model-based estimates of total catch were generated for each trip. These predicted catches were then compared to the known values from the follow-up survey and mean squared error (MSE) was calculated to assess which method produced estimates that more closely aligned with actual catches.

2.3.1.4.3. Average weights

For average fish weights, comparisons were made by simply examining the mean estimated weight of fish caught across the two approaches. Where differences were observed, the sample sizes of weight measurements were assessed to determine whether these discrepancies were driven by variations in available data. Since the model can generate weight estimates even for species with limited observations, any significant differences between the two methods were evaluated in the context of data availability and model reliance on priors.

2.3.2. Charter boat survey, variance and survey totals

2.3.2.1. Estimates required and general extrapolation approach

As with the onsite shore and private boat survey, the charter boat survey required estimation of effort, CPUE, and the weight of fish caught, along with their associated variances. Additionally, a method was necessary to combine these estimates while preserving their respective variances, ensuring that the final estimates accurately reflected the uncertainty associated with each component.

The estimation process for the charter boat survey was simpler than that for the shore and private boat survey as the participation of vessels in fishing activities was known for sampled weeks. Furthermore, full catch accounting was available as data were recorded after the completion of each trip. This eliminated the need to account for partial trip reporting or extrapolate catch data within sampled periods. However, an important consideration remained in estimating the number of boats that engaged in fishing during unsampled weeks. Since not all weeks were included in the survey, additional statistical techniques were required to infer fishing effort for these periods.

To address this, a bootstrapping approach was employed for the charter boat survey. This method, fully described in Section 2.3.1.1, was used to estimate the mean effort, CPUE for each species, and the average weight of fish caught. Bootstrapping allowed for the quantification of variance in these estimates by resampling the observed data, ensuring a robust representation of uncertainty while avoiding the need for additional parametric assumptions.

Finally, although charter boats participating in the bluefin tuna fishery provided data on their tuna catches, catches of this species were excluded from this analysis. This was because the licencing and reporting system for participating in this fishery makes catches not-representative of the overall charter boat fleet.

2.3.2.2. Effort

In the charter boat survey, effort was defined as the number of boat-weeks with fishing activity. This measure accounted for the total number of instances where a boat participated in fishing during a sampled week. If multiple boats went fishing within the same week or across different weeks, each instance contributed separately to the total effort. For example, if two boats fished within a given week this would be recorded as two boat-weeks of fishing effort.

2.3.2.3. CPUE

To determine the CPUE in the charter boat survey, the total catch, *C*, per week for each PSU, *p*, was calculated by summing the number of fish, *c*, kept and released, *k*, for each species, *s*, across all trips, *i*:

$$C_{p,s,k} = \sum_{i=1}^{n_p} c_{p,s,k,i}$$

where *n* is the number of trips the boat conducted in the week.

2.3.2.4. Average weights reported

Charter boat skippers were not required to report individual fish weights or lengths. Instead, they were only asked to provide the total number of fish caught and the average weight of the fish they retained or released. This reporting was structured to distinguish between kept and released catches, ensuring that estimates accounted for differences in size composition between retained and returned fish.

As a result, the total weight of fish caught was estimated using the skippers' recorded average weight per species for both kept and released categories. This approach allowed for a practical and efficient estimation of total biomass while minimising the reporting burden on skippers.

2.3.2.5. Survey totals with variance

A similar four-step approach to the shore and private boat survey was used to bootstrap and estimate the total effort, catch and tonnage for the charter boat survey. The bootstrapping process is summarised in the list below for a single bootstrap iteration, and was repeater 2000 times to estimate the mean and 95% PI for total effort, catch, and tonnage:

1. Randomly sample with replacement, based on the number of responses to the weekly fishing activity survey, from the number of charter boats that went fishing to get a bootstrapped effort dataset. For each PSU in the bootstrapped data, multiply by inclusion probability an estimate of total effort.
    a. Do this twice, once including all boats that responded to the survey and the second removing all boats that only responded 'no' to going fishing
2. Randomly sample with replacement, based on the number of PSUs where catch data were provided, the total number of fish kept and returned per PSU to get a bootstrapped catch dataset.
    a. Calculate a weighted mean catch per trip.
    b. Combine with the total effort bootstrapped results.
    c. Multiply the catch per PSU by the total effort to an estimate of total catch.
3. Randomly sample with replacement, based on the number of average weight measurements provided for each species and component, the weight of a fish caught data.
    a. Calculate a weighted average kg of a fish caught.
    b. Combine with the total catch bootstrap.
    c. Multiply by the total catch an estimate of the tonnage of fish caught.

Estimating the total effort, *E*, for each bootstrap iteration, *b*, was calculated as:

$$E_b = \sum_{i=1}^{n_b} e_{b,i} \,.\, w_{b,i}$$

where *n* is the number of PSUs sampled in each bootstrap iteration, *b, e* is an indicator variable representing whether the PSU, *i,* went fishing (1) or not (0), and *w* is the sample weight of the PSU.

To estimate the total catches, the first step was to calculate the mean catch, $\bar{C}$, per PSU within each stratum using:

$$\bar{C}_{b,s,k} = \frac{\sum_{i=1}^{n_{b,a}} C_{b,s,k,i}}{n_b}$$

Subsequently, the total catch, *T*, was then calculated as:

$$T_{b,s,k} = \bar{C}_{b,s,k} \cdot E_b$$

The average weight, $\bar{w}$, of an individual fish caught per trip was taken and applied to the total catches to get the tonnage caught, W:

$$W_{b,s,k} = T_{b,s,k} \cdot \bar{w}_{b,s,k}$$

Finally, the average total number, $\bar{T}$, and tonnage, $\bar{W}$, of fish caught by charter boats in the survey was calculated as the average across all the bootstrapped values:

$$\bar{T}_{s,k} = \frac{\sum_{i=1}^{N_b} T_{s,k,i}}{n_b}$$

$$\bar{W}_{s,k} = \frac{\sum_{i=1}^{N_b} W_{s,k,i}}{n_b}$$

where N_b is the number of bootstraps conducted. The upper and lower 95% PIs of total effort, catch and weight were calculated using the 2.5% and 97.5% quantiles, respectively, of the estimates across all the bootstraps conducted.

2.3.3. Comparison with other surveys

2.3.3.1. Shore survey

To evaluate the consistency of Catchwise estimates with previous studies, total catches and effort estimates were compared with those from the English 2023 estimates in the SADP and the Sea Angling 2012 survey. English only estimates were used to facilitate comparisons with the Sea Angling 2012, which was for England only. Based on the results of the comparison between Catchwise extrapolation methods, only the best extrapolation approach selected was used here. This comparison aimed to assess whether differences in methodology or survey design influenced catch estimates and to identify any systematic discrepancies across the datasets. Since the Sea Angling 2012 survey only covered England, only Catchwise and SADP estimates for England were used in this comparison.

Since the effort estimation methods differed between surveys, total effort was first standardised to total angling trips before making direct comparisons. This was done using the approach outlined in Section

2.3.1.4.1. The total number of angling trips was then compared across the three surveys, and the relative standard error (RSE) was used to assess the precision of each estimate. The degree of overlap in 95% PI was examined to determine whether the estimates were statistically consistent.

For total catch comparisons, estimates were broken down by species and catch component (kept versus returned), and differences between the surveys were assessed using the 95% PI. The comparison focused on species that were commonly recorded across all three surveys, ensuring that any differences were not due to variations in species coverage.

Finally, the average weight of fish between the three surveys were compared, and again the 95% PI used to determine if significant differences occurred.

2.3.3.2. Charter boat survey

2.3.3.2.1. Effort

To assess charter boat effort in Catchwise and compare it with previous surveys, the proportion of weeks with no reported fishing activity was examined across different survey approaches. First, the percentage of no-fishing responses per month was calculated in Catchwise, both when including all boats and when restricting the dataset to only boats that had reported fishing at least once. These values were then compared to equivalent data from the Sea Angling 2012 survey, which used a logbook-based approach similar to Catchwise.

Total charter boat effort estimates from Catchwise, the Sea Angling 2012 survey, and the WPS in 2023 were then compared. The 2012 Sea Angling survey reported effort using a pure logbook approach, while an additional Office for National Statistics (ONS) study, conducted alongside the 2012 survey, used a methodology similar to WPS. Since Catchwise effort estimates are boat-weeks active, additional calculations were required to generate comparable effort metrics across the surveys.

To ensure comparability, raw data from Catchwise were used to determine the average number of trips per week and the average number of anglers per charter trip. These values were then multiplied by the total number of boat weeks recorded in Catchwise to estimate total angler-days. Since Catchwise produced two different estimates based on whether all boats were included or whether only boats that had reported fishing at least once were used, effort estimates were calculated for both cases. The total number of boat weeks was extracted for both scenarios, and the corresponding angler-day estimates were generated. These estimates were then compared with those from the 2012 Sea Angling survey and the 2023 WPS to assess differences in charter boat participation across survey methodologies.

2.3.3.2.2. Total catch and catch per unit effort

Despite differences in effort definitions, total catch estimates were directly comparable across the three surveys. To understand potential drivers of any discrepancies in total catches, CPUE values were also examined across datasets. These CPUE estimates were derived from raw data, with CPUE calculated as the average number of fish caught per angler per hour. Since the Sea Angling 2012 survey and SADP reported angler-level catches, but Catchwise did not collect effort at the individual angler level, CPUE comparisons were only made between SADP and the Sea Angling 2012 survey, as reconstructing an equivalent CPUE for Catchwise was not feasible.

2.3.3.2.3. Tonnage and average weights

Tonnage estimates and average fish weights were directly comparable across the three surveys, allowing for a more detailed assessment of biomass estimates. However, RSE values were not available for neither the Sea Angling 2012 survey nor SADP, limiting the ability to quantify uncertainty in these estimates. The Sea Angling 2012 survey did not report RSE values, while SADP aggregates weight data across multiple angling platforms, preventing the separation of error estimates specifically for charter boat catches. To partially address this limitation, raw data averages from SADP were used to approximate species-level weight estimates, ensuring a consistent basis for comparison. These analyses provided insight into the relative alignment of total catches, CPUE, and biomass estimates across the three surveys, while also identifying methodological constraints that must be considered when interpreting differences in effort and catch estimates.

3. Results

3.1. Shore and private boat survey

3.1.1. Primary sampling units sampled

The achieved sampling effort was lower than the initial target of 45 PSU-days per quarter (Figure 6). This original target included boat sampling, but as this component was later removed the overall sampling requirement was reduced. Additionally, minor reductions in coverage occurred due to inaccessible sites and surveyor availability constraints.

A simulation study based on Sea Angling 2012 survey data indicated that 35 PSU-days per quarter were sufficient for robust estimation. This target was met in all quarters except Q1 in most regions, where surveyor recruitment challenges at the start of the project resulted in fewer samples. However, as the original 35 PSU target included boat sampling, which accounted for 40% of the total sampling effort, the minimum requirements for robust estimation in the shore survey were still met, despite the lower sampling in this quarter.

As described in the methods, the East Midlands region was purposefully undersampled due to the limited coastline and angling activity. However, as shown in Table 11, whilst the total number of PSUs sampled across the survey strata demonstrates good overall coverage, in the East Midlands region the reduced sampling effort resulted in inadequate samples across both the working and non-working day strata. To address this, these strata were combined to improve estimation reliability.

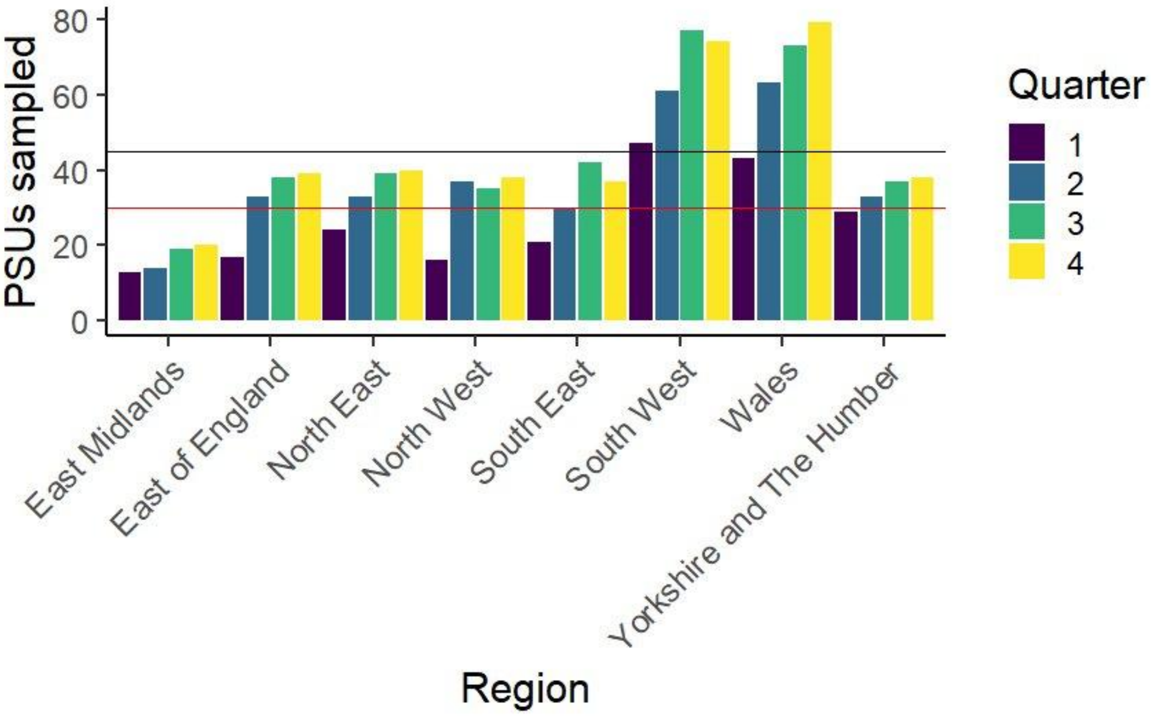

Figure 6: The number of primary sampling units sampled per region and quarter. The black horizontal line is an indicator for 45 PSU's sampled, the red line is the indicator for 35 PSUs sampled.

Table 11: The number of primary sampling units sampled for private boat and shore per region, quarter and day type (weekday, weekend + public holiday).

Survey Type	Quarter	Day Type	East Midlands		East of England		North East		North West		South East		South West		Wales		Yorkshire & Humber	
			High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
Boat	0	Weekday	0	3	0	0	3	0	0	0	0	0	5	2	3	1	1	0
		Weekend + public holiday	0	0	0	0	1	1	1	0	0	0	4	0	0	0	0	0
		Total	0	3	0	0	4	1	1	0	0	0	9	2	3	1	1	0
	1	Weekday	0	3	3	2	7	5	4	6	11	1	11	8	14	7	5	6
		Weekend + public holiday	0	1	3	0	0	5	1	6	3	4	4	4	5	2	4	3
		Total	0	4	6	2	7	10	5	12	14	5	15	12	19	9	9	9
	2	Weekday	2	0	4	1	5	0	0	2	5	2	5	6	10	3	3	6
		Weekend + public holiday	1	1	3	0	3	0	0	0	1	1	4	2	4	1	1	2
		Total	3	1	7	1	8	0	0	2	6	3	9	8	14	4	4	8
	3	Weekday	2	0	3	0	2	0	0	2	2	0	7	0	7	0	0	3
		Weekend + public holiday	1	0	1	0	3	0	0	2	0	0	2	0	3	0	0	2
		Total	3	0	4	0	5	0	0	4	2	0	9	0	10	0	0	5
	4	Weekday	3	0	4	0	3	0	0	3	4	0	8	0	5	0	0	5
		Weekend + public holiday	0	0	1	0	1	0	0	2	0	0	0	0	5	0	0	1
		Total	3	0	5	0	4	0	0	5	4	0	8	0	10	0	0	6
	Total		9	8	22	3	28	11	6	23	26	8	50	22	56	14	14	28
Shore	0	Weekday	3	2	0	0	3	2	1	2	0	0	7	2	2	5	0	3
		Weekend + public holiday	2	0	0	0	0	1	0	4	0	0	3	4	1	3	0	2
		Total	5	2	0	0	3	3	1	6	0	0	10	6	3	8	0	5

Survey Type	Quarter	Day Type	East Midlands		East of England		North East		North West		South East		South West		Wales		Yorkshire & Humber	
			High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
	1	Weekday	7	5	11	4	13	8	4	9	14	7	27	13	17	12	4	16
		Weekend + public holiday	4	2	6	3	8	4	2	4	4	6	8	3	14	8	6	6
		Total	11	7	17	7	21	12	6	13	18	13	35	16	31	20	10	22
	2	Weekday	8	2	17	8	20	7	9	16	14	8	34	14	31	15	8	14
		Weekend + public holiday	4	0	7	2	9	3	6	7	6	3	8	8	17	5	5	6
		Total	12	2	24	10	29	10	15	23	20	11	42	22	48	20	13	20
	3	Weekday	8	2	19	9	21	6	5	15	20	7	33	20	39	9	6	17
		Weekend + public holiday	8	0	10	3	10	4	4	12	8	7	20	8	27	3	2	13
		Total	16	2	29	12	31	10	9	27	28	14	53	28	66	12	8	30
	4	Weekday	14	1	23	7	26	5	9	22	26	4	40	15	46	28	4	24
		Weekend + public holiday	7	1	12	3	10	4	4	11	12	1	22	8	16	6	4	9
		Total	21	2	35	10	36	9	13	33	38	5	62	23	62	34	8	33
	Total		65	15	105	39	120	44	44	102	104	43	202	95	210	94	39	110

3.1.2. Anglers encountered

A total of 2,738 and 359 anglers were observed during the shore and private boat survey, respectively (Figure 7). Of these, 1,376 shore anglers participated in interviews, with a total of 1,334 completed interviews. Among these, 1,199 interviews were conducted with explicit consent, resulting in a response rate of 89.9%. Response rates were consistent across regions, ranging between 80% and 100% (Figure 8). This suggests that non-response bias was minimal and that angler willingness to participate did not vary significantly by location. Furthermore, the primary reason for not participating in the survey was due to the angler wanting to fish in peace rather than being worried about how the data would be used.

Table 12 presents the number of anglers observed per stratum. As expected, higher numbers of anglers were recorded at high-activity sites, aligning with the stratified sampling design. Additionally, more anglers were encountered during quarters that included summer months, reflecting increased participation in sea angling during warmer periods. Some variation was also observed between working and non-working days, though the extent of this difference varied by region.

Table 13 summarises the number of interviews conducted with consent per stratum. No clear pattern emerged in response rates across different strata, indicating that non-response was unlikely to introduce significant bias into the survey estimates. The high and relatively uniform response rates across regions and strata suggest that the collected data are representative of the angling population within the surveyed areas.

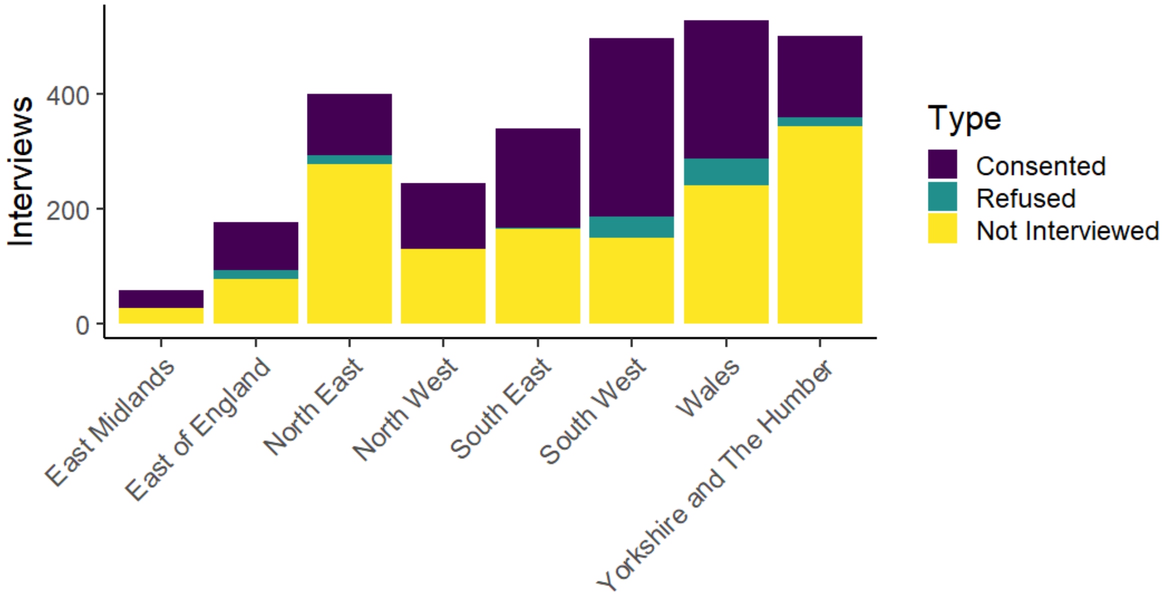

Figure 7: The total number of anglers in each region, split by if they were/were not interviewed and if they consented to the interview or not.

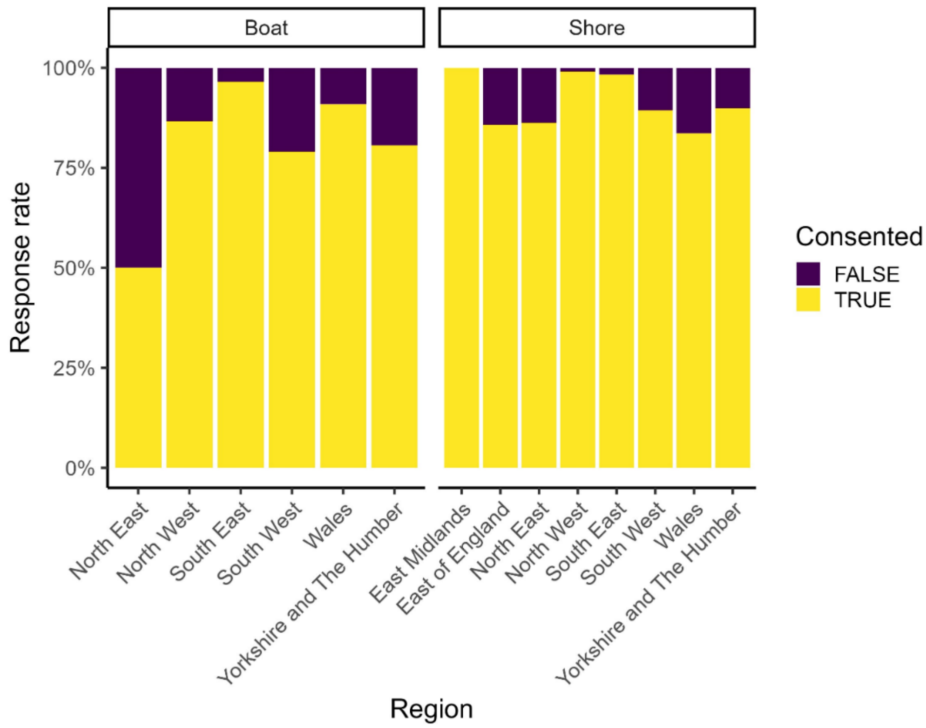

Figure 8: The percentage of anglers that did/did not consent to being surveyed within each region. The East Midlands and East of England are missing from the boat survey plot as no anglers were encountered.

Table 12: The number of anglers observed during private boat and shore surveys per region, quarter and day type (weekday, weekend + public holiday)

Survey Type	Quarter	Day Type	East Midlands		East of England		North East		North West		South East		South West		Wales		Yorkshire & Humber	
			High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
Boat	0	Weekday	0	0	0	0	0	0	0	0	0	0	5	0	6	0	0	0
		Weekend + public holiday	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
		Total	0	0	0	0	0	0	0	0	0	0	7	0	6	0	0	0
	1	Weekday	0	0	0	0	3	2	0	0	8	0	24	9	2	0	0	11
		Weekend + public holiday	0	0	0	0	0	0	0	23	7	57	7	11	7	4	4	0
		Total	0	0	0	0	3	2	0	23	15	57	31	20	9	4	4	11
	2	Weekday	0	0	0	0	2	0	0	0	7	0	2	1	0	0	1	12
		Weekend + public holiday	0	0	0	0	0	0	0	0	3	0	1	0	0	0	5	0
		Total	0	0	0	0	2	0	0	0	10	0	3	1	0	0	6	12
	3	Weekday	0	0	0	0	0	0	0	2	1	0	1	0	0	0	0	0
		Weekend + public holiday	0	0	0	0	6	0	0	0	0	0	5	0	0	0	0	7
		Total	0	0	0	0	6	0	0	2	1	0	6	0	0	0	0	7
	4	Weekday	0	0	0	0	3	0	0	21	7	0	12	0	0	0	0	14
		Weekend + public holiday	0	0	0	0	5	0	0	40	0	0	0	0	4	0	0	5
		Total	0	0	0	0	8	0	0	61	7	0	12	0	4	0	0	19
	Total		0	0	0	0	19	2	0	86	33	57	59	21	19	4	10	49
Shore	0	Weekday	1	0	0	0	1	10	0	0	0	0	21	0	3	1	0	2
		Weekend + public holiday	19	0	0	0	0	0	0	1	0	0	30	0	3	5	0	3
		Total	20	0	0	0	1	10	0	1	0	0	51	0	6	6	0	5

Survey Type	Quarter	Day Type	East Midlands		East of England		North East		North West		South East		South West		Wales		Yorkshire & Humber	
			High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
	1	Weekday	1	0	3	1	17	1	0	9	35	22	59	17	18	6	5	24
		Weekend + public holiday	4	0	14	12	63	10	0	3	41	23	23	3	29	11	15	4
		Total	5	0	17	13	80	11	0	12	76	45	82	20	47	17	20	28
	2	Weekday	2	0	17	1	41	2	4	12	9	0	22	6	31	4	6	67
		Weekend + public holiday	0	0	14	0	34	0	1	18	44	5	28	8	55	1	26	14
		Total	2	0	31	1	75	2	5	30	53	5	50	14	86	5	32	81
	3	Weekday	5	0	5	12	24	2	1	20	10	0	31	10	38	2	6	40
		Weekend + public holiday	7	0	25	0	64	0	3	20	50	11	32	9	23	0	0	208
		Total	12	0	30	12	88	2	4	40	60	11	63	19	61	2	6	248
	4	Weekday	15	0	31	15	57	4	9	97	49	5	79	24	161	30	8	46
		Weekend + public holiday	3	0	26	0	63	7	2	44	29	5	89	5	94	12	7	19
		Total	18	0	57	15	120	11	11	141	78	10	168	29	255	42	15	65
	Total		57	0	135	41	364	36	20	224	267	71	414	82	455	72	73	427

Table 13: Interviews conducted that consented.

Survey Type	Quarter	Day Type	East Midlands		East of England		North East		North West		South East		South West		Wales		Yorkshire & Humber	
			High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
Boat	0	Weekday	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0
		Weekend + public holiday	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
		Total	0	0	0	0	0	0	0	0	0	0	4	0	1	0	0	0
	1	Weekday	0	0	0	0	0	0	0	0	4	0	14	7	3	0	3	0
		Weekend + public holiday	0	0	0	0	0	0	6	0	5	9	5	5	3	0	0	4
		Total	0	0	0	0	0	0	6	0	9	9	19	12	6	0	3	4
	2	Weekday	0	0	0	0	1	0	0	0	5	0	0	0	3	0	5	1
		Weekend + public holiday	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	2
		Total	0	0	0	0	1	0	0	0	6	0	1	0	3	1	5	3
	3	Weekday	0	0	0	0	0	0	0	0	1	0	1	0	2	0	0	0
		Weekend + public holiday	0	0	0	0	0	0	1	0	0	0	0	0	1	0	5	0
		Total	0	0	0	0	0	0	1	0	1	0	1	0	3	0	5	0
	4	Weekday	0	0	0	0	0	0	2	0	3	0	12	0	0	0	3	0
		Weekend + public holiday	0	0	0	0	1	0	4	0	0	0	0	0	6	0	2	0
		Total	0	0	0	0	1	0	6	0	3	0	12	0	6	0	5	0
	Total		0	0	0	0	2	0	13	0	19	9	37	12	19	1	18	7
Shore	0	Weekday	1	0	0	0	1	4	0	0	0	0	14	0	3	0	1	0
		Weekend + public holiday	0	0	0	0	0	0	0	0	0	0	18	0	0	1	3	0
		Total	1	0	0	0	1	4	0	0	0	0	32	0	3	1	4	0
	1	Weekday	1	0	4	1	6	2	2	0	18	4	43	12	11	2	14	3

Survey Type	Quarter	Day Type	East Midlands		East of England		North East		North West		South East		South West		Wales		Yorkshire & Humber	
			High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
		Weekend + public holiday	3	0	2	6	12	0	1	0	24	14	20	3	9	6	1	8
		Total	4	0	6	7	18	2	3	0	42	18	63	15	20	8	15	11
	2	Weekday	2	0	9	1	9	1	8	2	6	0	13	6	19	3	22	2
		Weekend + public holiday	0	0	7	0	6	0	8	0	24	2	22	6	14	1	4	11
		Total	2	0	16	1	15	1	16	2	30	2	35	12	33	4	26	13
	3	Weekday	5	0	4	7	9	0	9	1	7	0	16	10	23	0	19	2
		Weekend + public holiday	5	0	12	0	9	0	10	2	26	4	22	5	12	0	17	0
		Total	10	0	16	7	18	0	19	3	33	4	38	15	35	0	36	2
	4	Weekday	10	0	10	9	19	2	40	9	29	2	38	16	73	14	23	4
		Weekend + public holiday	3	0	12	0	21	6	21	1	8	3	42	5	40	9	4	4
		Total	13	0	22	9	40	8	61	10	37	5	80	21	113	23	27	8
	Total		30	0	60	24	92	15	99	15	142	29	248	63	204	36	108	34

3.1.3. Catches recorded

Figure 9 presents an overview of the total number of fish kept and returned across the boat and shore surveys. In the boat survey, a total of 227 fish were kept, while 258 were returned. In contrast, in the shore survey, 480 fish were kept, and 2,014 were returned. These results indicate that fish release was considerably more common among shore anglers compared to those fishing from boats.

Among all species recorded, mackerel exhibited the lowest release rate in both surveys, suggesting a higher retention preference for this species. Conversely, whiting was the most frequently caught species in the shore survey, while mackerel was the most caught species in the boat survey.

Table 14 provides further insight into regional variations in catch rates for certain species. While differences were observed across regions, the proportion of fish released relative to those kept was generally consistent. This suggests that regional differences in fishing activity and species composition did not substantially influence the overall trend of fish retention and release behaviour.

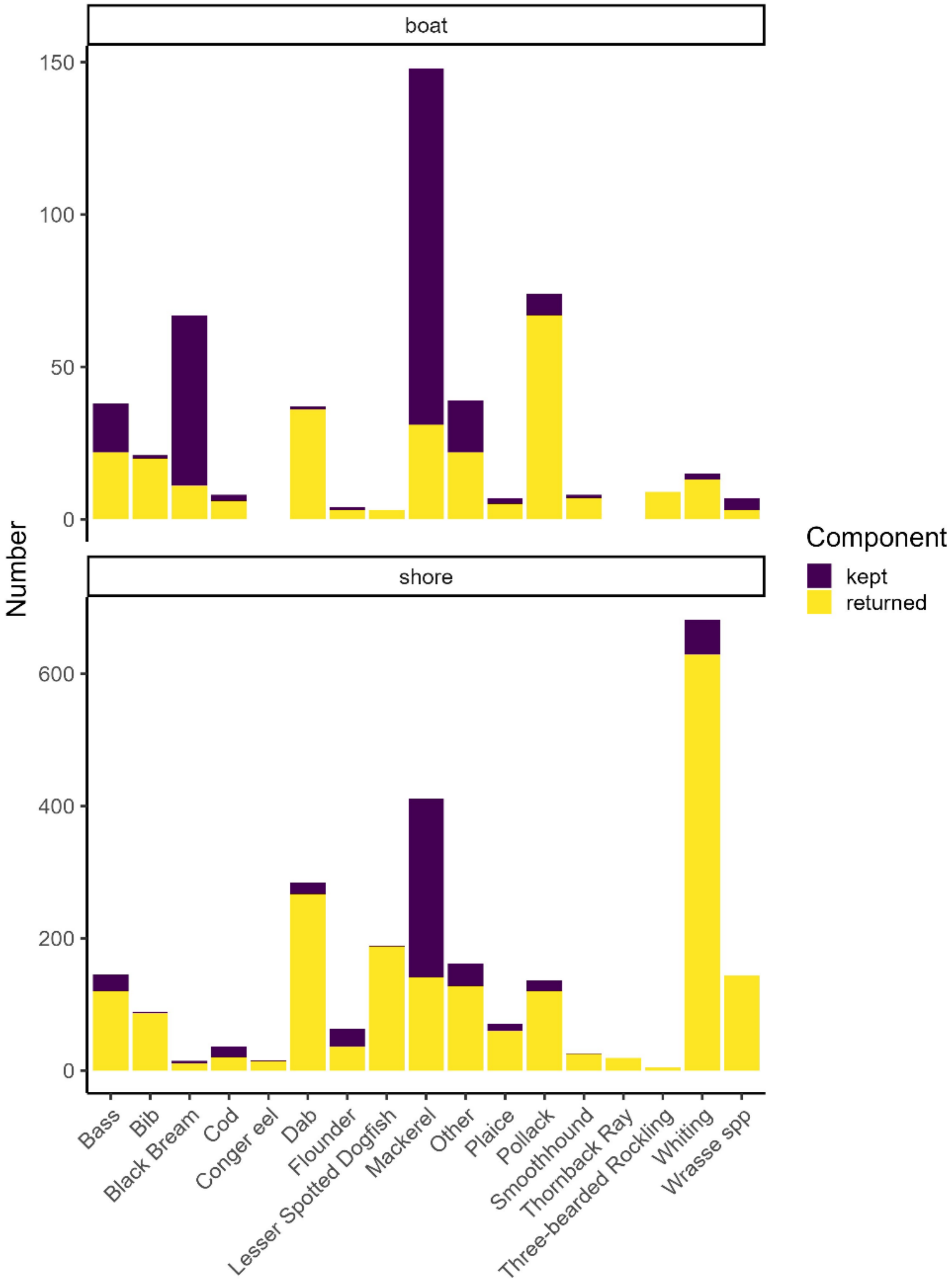

Figure 9: The number of fish caught in the raw data of the Catchwise shore and private boat survey.

Table 14: The number of species caught across all fishing trips interviewed. To maintain data quality, at least 10 individual fish across three different trips had to be reported across the survey. If these conditions were not met, the species was classed as 'Other'.

Survey Type	Species	East Midlands		East of England		North East		North West		South East		South West		Wales		Yorkshire & Humber	
		Kept	Ret	Kept	Ret	Kept	Ret	Kept	Ret	Kept	Ret	Kept	Ret	Kept	Ret	Kept	Ret
Boat	Bass	0	0	0	0	0	0	2	0	0	7	5	10	9	5	0	0
	Bib	0	0	0	0	0	0	0	0	1	0	0	20	0	0	0	0
	Black Bream	0	0	0	0	0	0	0	0	53	3	3	8	0	0	0	0
	Cod	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6
	Conger eel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Dab	0	0	0	0	0	0	0	3	0	1	0	0	0	0	1	32
	Flounder	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	1
	Lesser Spotted Dogfish	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0
	Mackerel	0	0	0	0	0	12	70	1	41	1	5	13	0	0	1	4
	Plaice	0	0	0	0	0	2	2	2	0	1	0	0	0	0	0	0
	Pollack	0	0	0	0	0	0	0	0	0	0	6	56	0	2	1	9
	Smoothhound	0	0	0	0	0	0	1	1	0	2	0	4	0	0	0	0
	Thornback Ray	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Three-bearded Rockling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
	Whiting	0	0	0	0	0	0	0	2	0	0	0	0	0	1	2	10
	Wrasse spp	0	0	0	0	0	0	0	0	1	2	3	0	0	0	0	1
	Other	0	0	0	0	0	0	1	0	0	2	16	11	0	2	0	7
	Total	0	0	0	0	0	14	76	11	96	20	38	124	9	10	8	79
Shore	Bass	0	2	3	16	0	0	0	2	2	38	19	53	1	8	0	1
	Bib	0	0	0	2	0	0	0	0	0	8	2	75	0	0	0	2
	Black Bream	0	0	0	0	0	0	0	0	2	8	1	3	1	0	0	0

Survey Type	Species	East Midlands		East of England		North East		North West		South East		South West		Wales		Yorkshire & Humber	
		Kept	Ret	Kept	Ret	Kept	Ret	Kept	Ret	Kept	Ret	Kept	Ret	Kept	Ret	Kept	Ret
	Cod	0	0	1	0	0	4	1	0	0	1	8	7	0	1	7	7
	Conger eel	0	0	1	0	0	0	0	0	0	8	1	5	0	1	0	0
	Dab	0	15	6	49	0	7	9	33	0	5	0	0	0	40	2	118
	Flounder	0	0	0	0	0	12	0	10	1	2	0	0	1	1	25	11
	Lesser Spotted Dogfish	0	0	0	2	0	0	0	4	0	41	0	24	1	113	0	4
	Mackerel	0	0	0	0	36	26	0	0	0	5	138	30	58	57	38	23
	Plaice	0	0	1	1	0	1	1	17	9	22	0	0	0	0	0	19
	Pollack	0	0	0	0	0	0	0	0	0	2	9	39	7	78	0	1
	Smoothhound	0	2	0	4	0	0	0	3	0	1	0	2	1	6	0	7
	Thornback Ray	0	1	0	14	0	0	0	1	0	1	0	0	0	2	0	0
	Three-bearded Rockling	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
	Whiting	9	42	2	146	4	12	2	70	1	90	4	19	8	210	23	40
	Wrasse spp	0	0	0	0	0	0	0	0	0	16	0	75	0	49	0	4
	Other	0	1	0	1	2	3	0	11	2	12	25	46	3	32	2	22
	Total	9	63	14	235	42	65	13	151	17	265	207	378	81	598	97	259

3.1.4. Average lengths and weights caught

A total of 3,407 length measurements were recorded across the survey, with 429 of these being from the boat survey and 2,978 being from the shore survey (Table 15). On average, kept fish were larger than released fish, with a mean length of 36.2 cm for kept compared to 32.8 cm for released fish. This trend was consistent across most species, meaning that anglers tend to retain larger fish while releasing smaller ones.

Notable differences in mean fish lengths were observed between the shore and boat surveys. Among the largest differences, Lesser Spotted Dogfish exhibited the most pronounced size variation, with a mean length of 45 cm in the shore survey compared to 75.0 cm in the boat survey. However, this is likely due to the limited sample size in the boat survey.

Table 15: The average length (cm) and weight (kg), standard deviation and number of fish reported with a length for each species and survey type.

Survey type	Species	Component	Sample size	Length (cm)		Weight (kg)	
				Mean	SD	Mean	SD
Boat	Bass	Kept	8	46.38	4.17	1.17	0.29
	Black Bream		56	28.46	1.68	0.35	0.07
	Cod		2	44.50	4.95	0.92	0.30
	Mackerel		116	28.72	3.67	0.22	0.16
	Plaice		2	40.00	0.00	0.64	0.00
	Pollack		5	45.20	0.45	0.91	0.03
	Whiting		2	29.00	0.00	0.20	0.00
	Bass	Returned	22	28.23	16.51	0.51	0.61
	Bib		20	20.00	0.00	0.10	0.00
	Black Bream		11	26.27	1.85	0.28	0.06
	Coalfish		2	22.50	21.92	0.26	0.36
	Cod		6	38.50	4.42	0.60	0.22
	Dab		36	13.00	3.73	0.03	0.03
	Flounder		3	23.00	5.20	0.16	0.11
	Lesser Spotted Dogfish		3	75.00	25.98	1.94	1.40
	Mackerel		31	26.42	5.55	0.18	0.10
	Plaice		5	29.00	10.25	0.32	0.29
	Pollack		67	25.37	11.37	0.26	0.30
	Smoothhound		7	81.43	30.78	2.58	2.19
	Three-bearded Rockling		9	18.56	4.22	0.06	0.04
	Whiting		13	20.96	6.58	0.10	0.09
	Wrasse spp.		3	20.00	15.59	0.32	0.53
Shore	Bass	Kept	28	47.68	3.81	1.27	0.33
	Black Bream		10	30.90	6.69	0.50	0.31
	Cod		11	50.27	16.30	1.76	2.40

Survey type	Species	Component	Sample size	Length (cm)		Weight (kg)	
				Mean	SD	Mean	SD
	Dab		17	21.18	15.36	0.32	1.07
	Flounder		29	32.03	1.15	0.38	0.04
	Mackerel		327	25.39	8.38	0.19	0.17
	Plaice		14	34.86	4.77	0.45	0.18
	Pollack		15	47.93	8.86	1.20	0.63
	Whiting		42	26.60	8.59	0.20	0.17
	Bass	Returned	267	27.83	8.15	0.32	0.32
	Bib		88	14.66	2.25	0.04	0.02
	Black-mouthed Dogfish		13	37.69	10.92	0.20	0.18
	Black Bream		33	25.24	7.25	0.30	0.20
	Blonde Ray		20	63.15	25.15	3.41	5.46
	Coalfish		10	24.10	7.50	0.17	0.18
	Cod		35	25.23	10.41	0.24	0.21
	Conger eel		26	65.19	22.53	0.97	1.14
	Dab		264	18.67	5.46	0.09	0.07
	Dover Sole		5	27.00	8.72	0.24	0.21
	Flounder		56	18.70	7.56	0.12	0.14
	Lesser Spotted Dogfish		415	44.97	7.37	0.35	0.22
	Mackerel		163	27.98	8.27	0.26	0.20
	Plaice		62	24.27	7.91	0.20	0.20
	Pollack		121	26.73	12.47	0.31	0.32
	Small-Eyed Ray		12	46.00	8.43	0.76	0.39
	Smoothhound		31	77.77	38.58	2.98	3.97
	Thornback Ray		28	44.54	16.63	0.87	1.34
	Three-bearded Rockling		11	25.00	5.48	0.15	0.10
	Whiting		666	24.50	6.77	0.15	0.14
	Wrasse spp.		159	24.24	13.04	0.54	1.47

3.1.5. Survey estimates

3.1.5.1. Bootstrapping

3.1.5.1.1. Effort

Figure 10 presents the average number of angling trips per primary sampling unit (site-day), estimated using the bootstrapping approach. This represents the total number of anglers expected to fish at a site over a 24-hour period. In all regions except the East of England, where the 95% PIs for the average number of anglers overlapped, high-activity sites had a greater number of anglers compared to low-activity sites, reflecting the stratification design.

The South East recorded the highest average number of angling trips in both high- and low-activity sites, indicating a consistently high level of recreational fishing participation. Conversely, the East Midlands had the lowest angling effort, with no anglers observed in low-activity sites throughout the survey period.

Table 16 provides a detailed breakdown of these averages across all strata. The results show a seasonal trend, with higher levels of angling activity during quarters that included summer months. Additionally, non-working days consistently exhibited greater fishing effort.

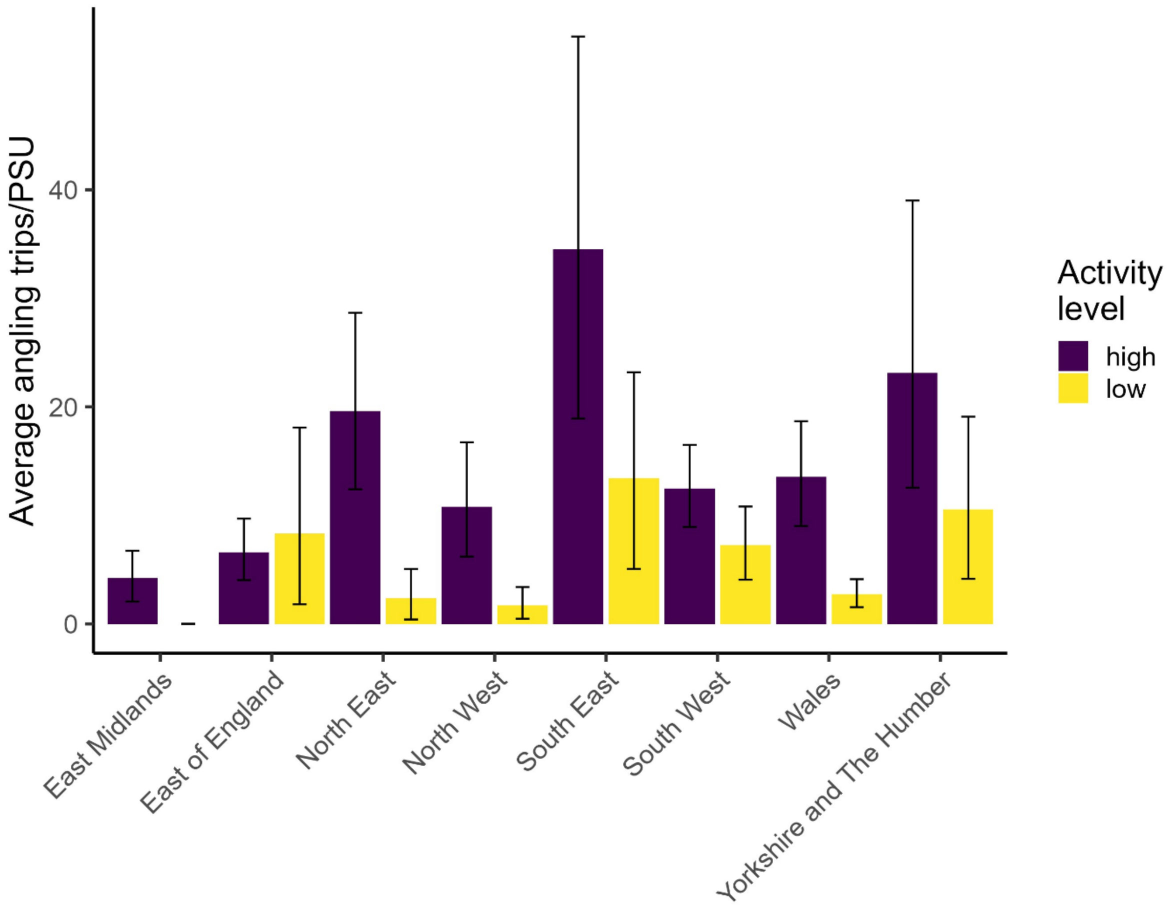

Figure 10: The average number of angling trips per high/low activity primary sampling unit (PSU; site*day) from the bootstrapping approach.

Table 16: The weighted average number of angling trips per primary sampling unit within each stratum. The numbers in brackets are the 95% PI. --- indicates where no anglers were observed, and so the mean is zero and calculating the 95% PI is not possible.

Quarter	Day Type	East Midlands		East of England		North East		North West		South East		South West		Wales		Yorkshire & Humber	
		High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
1	Weekday	3.45 (0.55-7.81)	---	---	2.66 (<0.01-8.00)	10.82 (4.36-17.45)	---	8.38 (1.71-19.71)	---	41.26 (7.11-85.32)	13.07 (<0.01-33.75)	16.58 (6.00-30.26)	9.73 (1.69-21.23)	2.77 (<0.01-7.38)	3.28 (0.55-6.00)	13.17 (1.29-29.28)	7.46 (<0.01-22.50)
	Weekend + public holiday			6.00 (<0.01-12.00)	24.81 (<0.01-54.00)	83.43 (24.40-156.00)	6.09 (<0.01-18.00)	---	---	130.96 (<0.01-324.00)	52.99 (14.40-111.60)	22.22 (10.50-34.50)	6.88 (<0.01-12.00)	12.29 (0.46-33.69)	5.02 (1.33-9.00)	3.99 (<0.01-12.00)	24.83 (2.40-61.80)
	Total			1.74 (<0.01-4.53)	9.30 (1.33-23.88)	31.18 (11.24-60.13)	1.71 (<0.01-5.64)	5.91 (0.63-14.14)	---	66.52 (16.58-128.75)	25.36 (6.05-54.13)	18.43 (9.84-29.29)	8.98 (2.87-17.60)	5.59 (0.62-12.94)	3.80 (1.56-6.27)	10.78 (1.94-22.35)	12.88 (0.99-30.57)
2	Weekday	3.08 (<0.01-8.50)	---	7.09 (1.59-17.06)	0.87 (<0.01-2.57)	12.78 (4.80-24.30)	1.26 (<0.01-3.60)	4.82 (0.81-10.00)	3.31 (<0.01-10.00)	7.51 (1.14-16.00)	---	3.33 (0.97-6.71)	2.58 (<0.01-6.43)	11.13 (1.50-27.64)	1.71 (<0.01-3.86)	37.18 (11.43-71.36)	4.49 (<0.01-9.00)
	Weekend + public holiday			12.46 (2.86-26.00)	---	25.59 (5.14-57.43)	---	15.84 (1.71-39.43)	1.31 (<0.01-4.00)	65.59 (3.00-139.00)	---	18.19 (4.52-36.00)	19.26 (<0.01-57.00)	17.23 (2.62-36.00)	1.16 (<0.01-3.60)	14.39 (<0.01-38.00)	31.01 (2.40-71.94)
	Total			8.44 (3.02-16.08)	0.63 (<0.01-2.00)	16.51 (7.00-28.25)	0.90 (<0.01-3.00)	7.71 (1.91-15.86)	2.75 (<0.01-7.92)	24.63 (4.19-52.52)	---	7.60 (2.86-13.49)	7.44 (0.62-19.62)	12.87 (3.81-25.99)	1.56 (0.31-3.14)	30.25 (10.75-56.78)	12.07 (3.29-25.90)
3	Weekday	6.45 (1.50-12.38)	---	2.37 (<0.01-6.33)	9.47 (0.86-22.29)	6.47 (1.50-12.20)	---	8.35 (2.40-15.60)	1.54 (<0.01-4.50)	8.31 (<0.01-23.50)	---	5.75 (1.74-10.65)	4.10 (0.63-8.84)	6.68 (3.17-10.83)	1.98 (<0.01-6.00)	15.41 (5.88-26.50)	5.96 (<0.01-18.00)
	Weekend + public holiday			14.92 (1.80-32.59)	---	36.78 (9.00-75.60)	---	15.00 (2.50-35.74)	5.04 (1.50-7.50)	72.90 (9.00-156.00)	13.24 (2.57-25.71)	9.12 (3.70-15.70)	6.85 (1.50-14.25)	5.53 (2.64-8.64)	---	99.72 (8.92-260.77)	---

Quarter	Day Type	East Midlands		East of England		North East		North West		South East		South West		Wales		Yorkshire & Humber	
		High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
	Total			5.90 (1.49-12.00)	6.73 (<0.01-17.16)	15.19 (5.63-27.84)	---	10.21 (4.18-18.14)	2.59 (0.49-5.13)	26.33 (3.42-56.37)	3.98 (0.40-9.43)	6.73 (3.42-10.71)	4.85 (1.74-8.84)	6.39 (3.56-9.57)	1.40 (<0.01-4.42)	40.12 (10.42-93.70)	4.38 (<0.01-13.49)
4	Weekday			8.43 (2.00-16.33)	23.47 (<0.01-68.50)	13.46 (3.00-30.65)	6.02 (<0.01-18.00)	21.82 (5.90-46.42)	0.73 (<0.01-2.25)	15.14 (4.80-27.90)	12.30 (<0.01-27.00)	12.89 (5.12-21.97)	9.09 (3.17-16.25)	23.67 (13.58-35.50)	4.00 (1.00-7.67)	11.47 (3.82-23.18)	18.77 (<0.01-52.50)
	Weekend + public holiday	4.11 (0.71-8.47)	---	14.87 (4.25-29.00)	---	22.33 (6.67-38.00)	8.97 (<0.01-22.50)	11.93 (2.57-24.00)	2.99 (<0.01-9.00)	35.85 (10.25-74.25)	60.00 (<0.01-<0.01)	26.52 (9.90-51.00)	4.31 (0.86-8.57)	43.49 (19.14-77.57)	4.91 (<0.01-14.40)	14.94 (2.00-31.33)	2.01 (<0.01-6.00)
	Total			10.12 (4.49-16.87)	16.87 (<0.01-49.68)	15.86 (6.67-28.21)	7.02 (0.35-15.88)	18.99 (6.70-37.36)	1.41 (<0.01-3.46)	21.27 (9.76-36.43)	24.60 (2.40-47.51)	16.90 (9.16-26.57)	7.69 (2.99-13.02)	28.98 (18.44-40.93)	4.18 (1.18-7.73)	12.50 (5.61-22.01)	13.77 (0.52-37.66)
Total		4.20 (2.00-6.69)	---	6.65 (4.03-9.56)	6.55 (3.99-9.66)	8.19 (1.90-18.01)	19.77 (12.26-28.63)	2.37 (0.37-5.19)	10.75 (6.45-16.87)	1.65 (0.52-3.12)	34.13 (18.34-54.24)	13.21 (4.89-22.78)	12.43 (8.66-16.58)	7.31 (4.18-11.13)	13.45 (9.19-18.24)	2.76 (1.56-4.22)	23.14 (12.37-37.76)

3.1.5.1.2. Catch per unit effort

Figure 11 presents the average kept and returned CPUE (catch per trip) for each species across the survey. Among all species recorded, whiting had the highest returned CPUE. In contrast, mackerel had the highest kept CPUE, being the most retained species across all fishing trips.

Table 17 provides a more detailed breakdown of CPUE across different regions, highlighting some regional variations in catch rates. The East of England and East Midlands exhibited the highest returned CPUE, yet had some of the lowest kept CPUE, suggesting that anglers in these regions were more likely to release their catches. Conversely, the South West had the highest kept CPUE, though the difference between regions was relatively small.

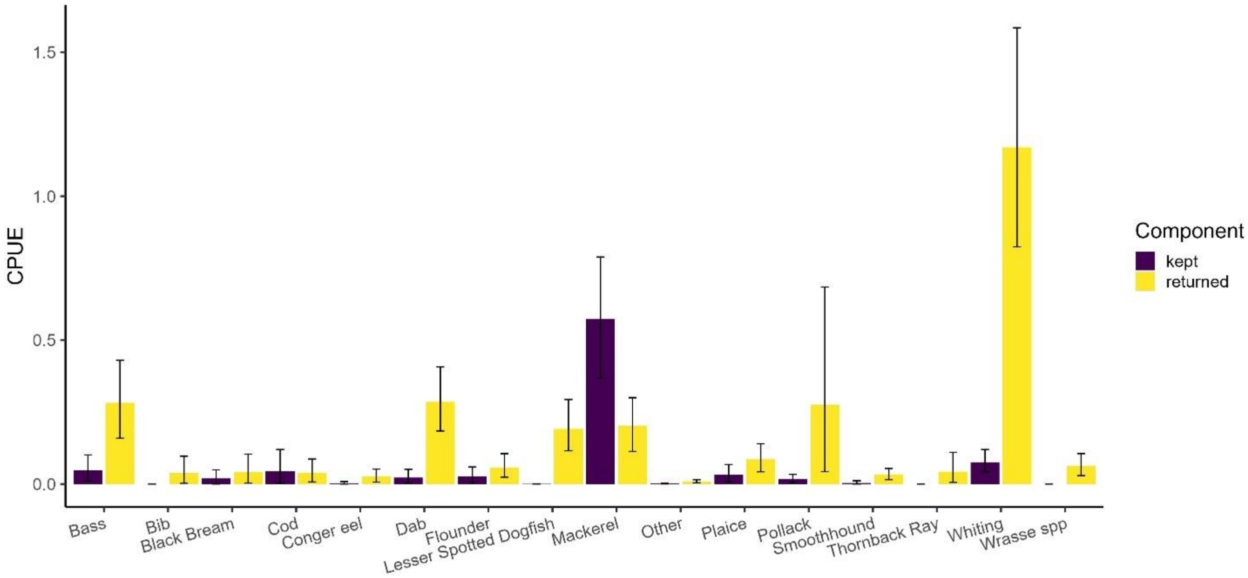

Figure 11: The bootstrapped average kept and returned catch per unit effort (CPUE; catch per trip) for each species where enough data were collected to perform robust estimation ± 95% PI.

Table 17: The weighted average kept and returned catch per fishing trip for each species from the bootstrapping approach. The numbers in brackets are the 95% PI. --- Indicates where a species was not caught and so the mean is zero and calculating the 95% PI is not possible.

Species	East Midlands		East of England		North East		North West		South East		South West		Wales		Yorkshire & Humber	
	Kept	Ret	Kept	Ret	Kept	Ret	Kept	Ret	Kept	Ret	Kept	Ret	Kept	Ret	Kept	Ret
Bass	---	0.068 (<0.001-0.228)	0.101 (<0.001-0.249)	0.514 (0.135-1.023)	---	---	---	0.025 (<0.001-0.068)	0.065 (<0.001-0.190)	0.460 (0.160-0.860)	0.070 (0.003-0.197)	0.334 (0.125-0.646)	0.011 (<0.001-0.034)	0.060 (0.015-0.120)	---	0.008 (<0.001-0.023)
Bib	---	---	---	0.045 (<0.001-0.140)	---	---	---	---	---	0.101 (<0.001-0.293)	---	---	---	---	---	0.073 (<0.001-0.210)
Black Bream	---	---	---	---	---	---	---	---	0.057 (<0.001-0.161)	0.134 (0.012-0.359)	0.007 (<0.001-0.023)	---	0.004 (<0.001-0.013)	---	---	---
Cod	---	---	0.018 (<0.001-0.057)	---	---	0.206 (0.009-0.591)	0.015 (<0.001-0.048)	---	---	0.013 (<0.001-0.042)	0.117 (<0.001-0.346)	0.054 (<0.001-0.172)	---	0.009 (<0.001-0.027)	0.069 (0.012-0.143)	0.067 (0.018-0.126)
Conger eel	---	---	0.009 (<0.001-0.029)	---	---	---	---	---	---	0.058 (<0.001-0.138)	0.007 (<0.001-0.021)	0.027 (0.004-0.056)	---	0.004 (<0.001-0.013)	---	---
Dab	---	1.522 (<0.001-4.597)	0.090 (<0.001-0.237)	0.788 (0.239-1.524)	---	0.093 (<0.001-0.300)	0.183 (<0.001-0.538)	0.778 (0.240-1.512)	---	0.038 (0.006-0.081)	---	---	---	0.247 (0.013-0.648)	0.041 (<0.001-0.118)	1.808 (0.863-2.945)
Flounder	---	---	---	---	---	0.501 (0.037-1.263)	---	0.153 (0.042-0.298)	0.021 (<0.001-0.069)	0.027 (<0.001-0.070)	---	---	0.008 (<0.001-0.025)	0.004 (<0.001-0.013)	0.257 (0.011-0.721)	0.137 (0.036-0.269)
Lesser Spotted Dogfish	---	---	---	0.020 (<0.001-0.049)	---	---	---	0.064 (0.007-0.140)	---	0.216 (0.095-0.363)	---	0.208 (0.028-0.469)	0.002 (<0.001-0.007)	0.441 (0.252-0.661)	---	0.018 (<0.001-0.048)

Species	East Midlands		East of England		North East		North West		South East		South West		Wales		Yorkshire & Humber	
	Kept	Ret	Kept	Ret	Kept	Ret	Kept	Ret	Kept	Ret	Kept	Ret	Kept	Ret	Kept	Ret
Mackerel	---	---	---	---	0.689 (0.205-1.295)	0.633 (0.081-1.430)	---	---	---	0.046 (<0.001-0.120)	1.435 (0.841-2.110)	0.320 (0.131-0.549)	0.357 (0.133-0.643)	0.288 (0.005-0.691)	0.486 (0.088-1.078)	0.237 (0.009-0.573)
Plaice	---	---	0.016 (<0.001-0.048)	0.020 (<0.001-0.058)	---	0.026 (<0.001-0.081)	0.020 (<0.001-0.063)	0.253 (0.105-0.423)	0.103 (0.021-0.222)	0.170 (0.041-0.331)	---	---	---	---	---	0.227 (<0.001-0.554)
Pollack	---	---	---	---	---	---	---	---	---	0.028 (<0.001-0.076)	0.033 (<0.001-0.083)	0.688 (0.005-1.991)	0.050 (0.007-0.112)	0.418 (0.077-0.888)	---	0.011 (<0.001-0.035)
Smoothhound	---	0.124 (<0.001-0.421)	---	0.081 (<0.001-0.192)	---	---	---	0.038 (<0.001-0.102)	---	0.022 (<0.001-0.067)	---	0.016 (<0.001-0.041)	0.031 (<0.001-0.094)	0.068 (0.004-0.161)	---	0.066 (<0.001-0.152)
Thornback Ray	---	0.043 (<0.001-0.147)	---	0.574 (0.033-1.574)	---	---	---	0.015 (<0.001-0.048)	---	0.019 (<0.001-0.060)	---	---	---	0.012 (<0.001-0.031)	---	---
Whiting	2.080 (<0.001-6.455)	4.179 (1.088-7.422)	0.019 (<0.001-0.058)	2.763 (1.251-4.517)	0.101 (<0.001-0.286)	0.433 (0.110-0.880)	0.094 (<0.001-0.277)	1.437 (0.436-2.906)	0.020 (<0.001-0.060)	1.828 (0.844-3.066)	0.025 (<0.001-0.066)	0.262 (0.034-0.583)	0.163 (0.011-0.421)	1.659 (0.758-2.682)	0.356 (0.110-0.674)	0.518 (0.200-0.864)
Wrasse spp.	---	---	---	---	---	---	---	---	---	0.095 (0.009-0.230)	---	0.067 (0.022-0.124)	---	0.091 (0.035-0.162)	---	0.010 (<0.001-0.026)
Other	---	---	---	<=0.001 (<0.001-0.001)	0.002 (<0.001-0.007)	0.005 (<0.001-0.014)	---	0.026 (0.002-0.065)	<=0.001 (<0.001-0.002)	0.005 (<0.001-0.011)	0.002 (<0.001-0.007)	0.013 (0.003-0.029)	0.001 (<0.001-0.003)	0.004 (0.002-0.007)	<=0.001 (<0.001-0.002)	0.007 (0.002-0.015)
Total	0.033 (<0.001-0.097)	0.093 (0.027-0.179)	0.004 (0.001-0.007)	0.074 (0.045-0.109)	0.014 (0.005-0.025)	0.033 (0.017-0.053)	0.005 (<0.001-0.011)	0.062 (0.034-0.097)	0.005 (0.002-0.008)	0.061 (0.042-0.083)	0.028 (0.017-0.041)	0.046 (0.027-0.071)	0.010 (0.006-0.016)	0.064 (0.045-0.086)	0.019 (0.009-0.032)	0.055 (0.036-0.075)

3.1.5.1.3. *Weight of a fish caught*

Table 18 presents the bootstrapped average weight of fish caught, showing a clear pattern where kept fish were almost always larger than released fish. This aligns with expectations, as anglers typically retain larger fish while returning smaller ones, which is at least partly due to minimum conservation reference sizes resulting in anglers returning smaller fish.

Due to limited sample sizes for certain species in specific regions, regional differences could not be accounted for in this analysis. Instead, only overall weight estimates for each species, separated into kept and returned categories, were calculated.

Table 18: The average weight (kg) of fish caught along with the 95% precision intervals using the bootstrapping approach. Only species where three lengths in five different trips were calculated. '–' Indicates where not enough length measures were given.

Species	Kept	Returned
Bass	1.25 (1.15-1.36)	0.33 (0.30-0 37)
Bib	-	0.05 (0.05-0.06)
Black Bream	0.37 (0.34-0.41)	0.29 (0.24-0.34)
Black-mouthed Dogfish	-	0.20 (0.11-0.30)
Blonde Ray	-	3.40 (1.21-5.76)
Coalfish	-	0.18 (0.08-0.30)
Cod	1.63 (0.84-2.90)	0.29 (0.22-0.37)
Conger eel	-	0.97 (0.60-1.44)
Dab	0.31 (0.06-0.85)	0.08 (0.07-0.09)
Dover Sole	-	0.23 (0.08-0.41)
Flounder	0.38 (0.37-0.40)	0.12 (0.09-0.16)
Lesser Spotted Dogfish	-	0.36 (0.33-0.39)
Mackerel	0.20 (0.19-0.22)	0.25 (0.22-0.27)
Plaice	0.47 (0.39-0.56)	0.21 (0.16-0.26)
Pollack	1.13 (0.91-1.38)	0.29 (0.25-0.34)
Small-Eyed Ray	-	0.77 (0.57-0.98)
Smoothhound	-	2.90 (1.80-4.14)
Thornback Ray	-	0.85 (0.48-1.41)
Three-bearded Rockling	-	0.11 (0.07-0.15)
Whiting	0.20 (0.16-0.26)	0.15 (0.14-0.16)
Wrasse spp.	-	0.54 (0.35-0.79)

3.1.5.1.4. Survey totals

3.1.5.1.4.1. Effort

The total estimated number of angling trips using this method was 1,846,002, with a 95% PI ranging from 1,516,006 to 2,208,148.

Figure 12 illustrates how these trips were distributed by region. The South West recorded the highest number of angling trips, with an estimated 586,670 trips, with a relative standard error (RSE) of 13.4%. The South East had a similarly high estimate of 544,282 trips, though with greater uncertainty, with a 24.7% RSE. In contrast, the East Midlands had by far the lowest estimated number of trips, with an estimate of only 3,095, and exhibited the highest relative standard error at 28.0%, indicating a higher degree of uncertainty due to the reduced sampling in this region.

The remaining English regions (East of England, North East, North West, and Yorkshire & Humber) all had similar estimated number of trips, ranging between 99,000 and 139,000 angling trips, with RSE values of approximately 20-26%. These results suggest a broadly even distribution of recreational fishing effort across much of England, except for the notably higher participation in the South West and South East and the much lower effort in the East Midlands.

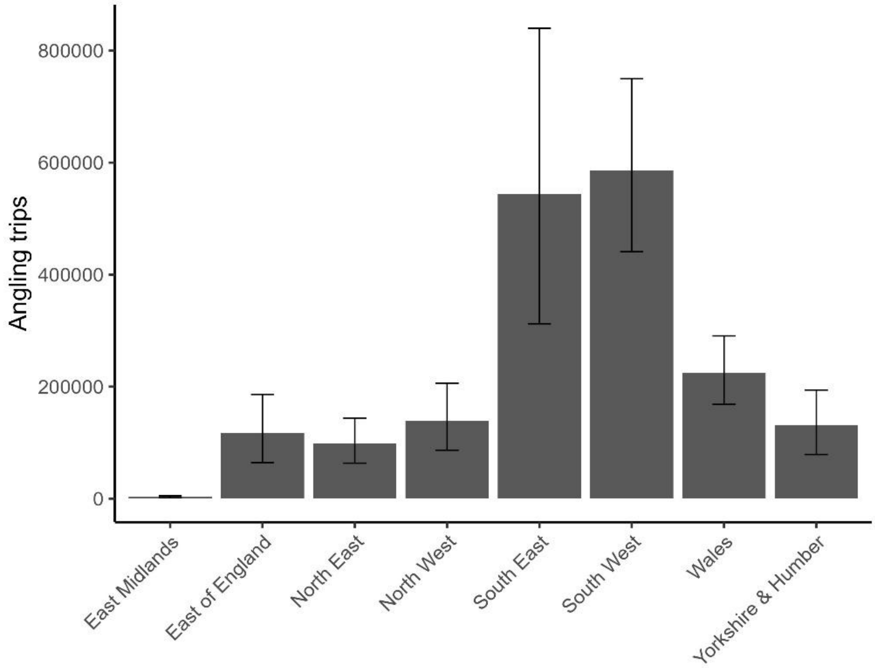

Figure 12: The total effort (angling trips) from the bootstrapping approach in the different regions. Error bars are 95% PI.

3.1.5.1.4.2. Number of fish

A total of 2,432,574 fish were kept, while 6,782,386 fish were returned, with relative standard errors (RSE) of 21.5% and 13.3%, respectively. Figure 13 presents the breakdown of kept and returned total catches by species. Whiting was the most frequently returned species, while mackerel was the most retained species. Notably, mackerel and black bream were the only species where more fish were kept than released, though the difference for black bream was marginal, indicating a near-equal proportion of kept and returned fish. However the 95% PI for the kept and returned components overlapped so although the mean estimates show differences, they may not be statistically significant. The results also highlight substantial uncertainty for some species, with total catch RSE exceeding 50% for bib (80%), black bream (60.1%), pollack (59.7%) and thornback ray (67.9%).

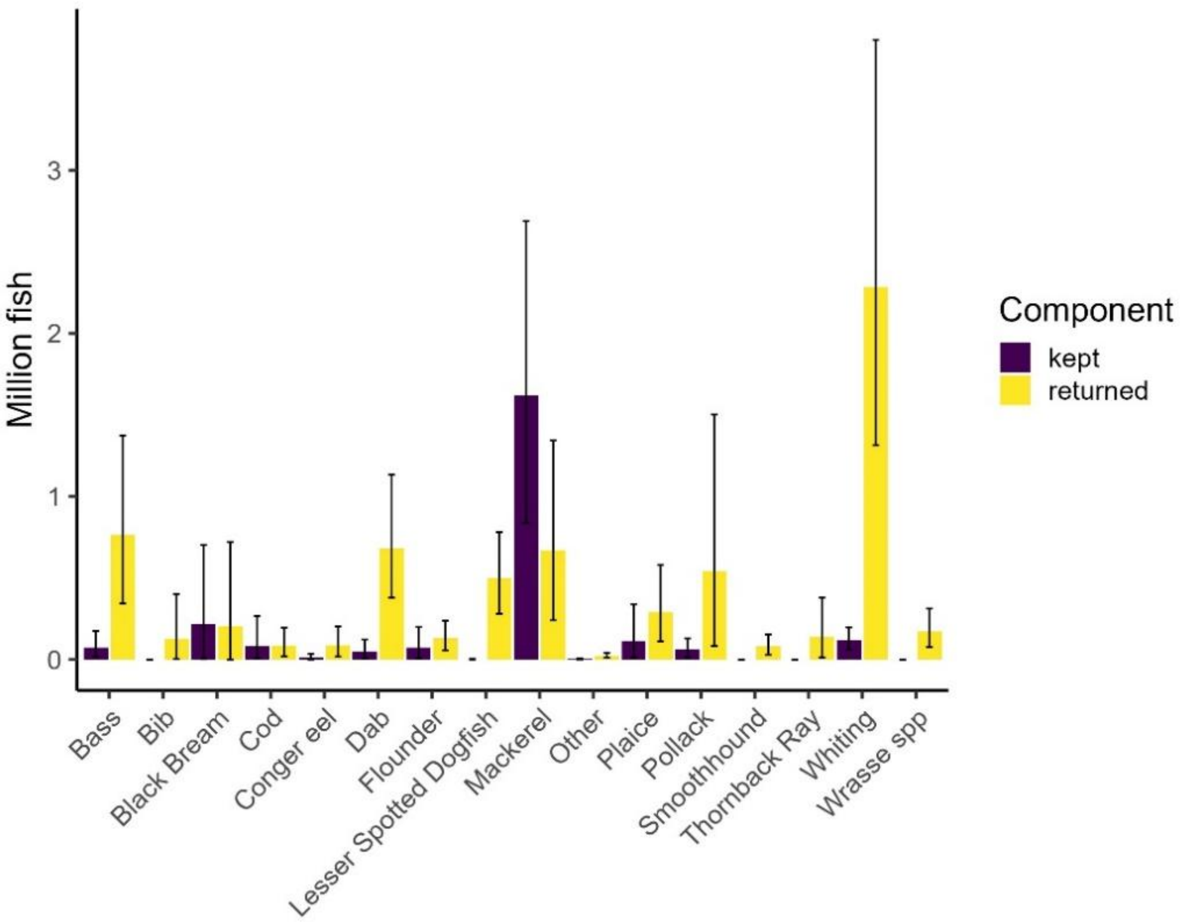

Figure 13: The total number of each species kept and returned by sea anglers in England and Wales estimated using the bootstrapping extrapolation approach. Error bars are 95% PI.

3.1.5.1.4.3. Tonnage

The total estimated tonnage of fish retained by anglers was 787.2 tonnes, with an RSE of 22.5%, while 1,865.1 tonnes were returned, with an RSE of 14.3%. Figure 14 presents the breakdown of kept and returned tonnages by species. Whiting was the most caught species, with an estimate of 341.2 tonnes (RSE: 27.7%), while mackerel had the highest retained tonnage at 294.3 tonnes (RSE 29.9%). Despite the substantial difference in the number of fish caught between kept and returned categories, kept tonnages were much closer to returned tonnages as the average size of retained fish is larger than those returned.

As with total catch estimates, some species exhibited high levels of uncertainty, with RSE values exceeding 50%. The highest RSEs were observed for bib (80.2%), black bream (61.8%), cod (74.3%), conger eel (62.2%), and thornback ray (78.7%). These elevated error margins reflect high variability in the data and low sample sizes for these species, making precise estimation more difficult. Despite this, the overall trends in tonnage estimates highlight key species contributing to the total retained and released biomass in the fishery.

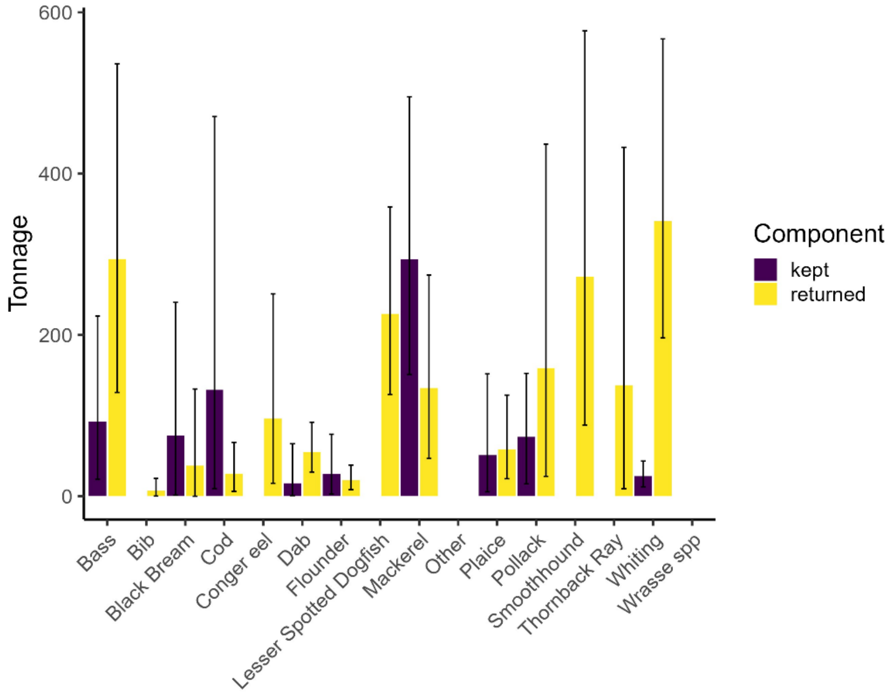

Figure 14: The tonnage of each species kept and returned by sea anglers in England and Wales estimated using the bootstrapping extrapolation approach. Error bars are 95% PI.

3.1.5.2. Model-based

3.1.5.2.1. Effort

Figure 15 presents a PPC (see Section 2.3.1.3.4 for a detailed explanation) of the mean number of angling hours per secondary sampling unit across the survey period, generated using the model.

The results of the PPC indicated that the model provided a close fit to the raw survey data across most regions. Even in the Yorkshire and Humber region where the largest discrepancy between the model and observed value was found (1.09 modelled average vs 1.29 anglers per hour true value), the observed value was well within the models predictive intervals. However, this region still had the highest estimated angling effort, closely followed by the

South East, which had an estimated 1.07 anglers per hour. In contrast, the East Midlands had the lowest predicted effort at just 0.28 anglers per hour.

Figure 16 presents the conditional effects plot from the model, which illustrates how the predicted number of anglers changes in response to different factors, while keeping all other variables constant (see Section 2.3.1.3.4 for a detailed explanation). The results demonstrate several key patterns in angling behaviour. High-activity sites consistently had more anglers than low-activity sites, reinforcing the stratification approach used in the survey design. Angler presence was positively associated with tide height, suggesting that certain tidal conditions could be more favourable for fishing. Fishing activity increased as the week progressed, with higher numbers of anglers observed later in the week. Wind gust speed was negatively associated with angler presence, suggesting that poor weather conditions deterred participation. Time of day also impacted angler presence and counts, with more anglers observed later in the day compared to early morning, possibly reflecting a preference for afternoon and evening fishing.

The distance to a car park was correlated with a small change in the angler numbers, with sites which had car parks closer having more anglers. Further, distance from a pub was negatively correlated with angling effort, suggesting that anglers may favour sites near amenities. Seasonal trends were also evident, with angler numbers increasing as summer approached, peaking mid-year, and then declining as winter set in.

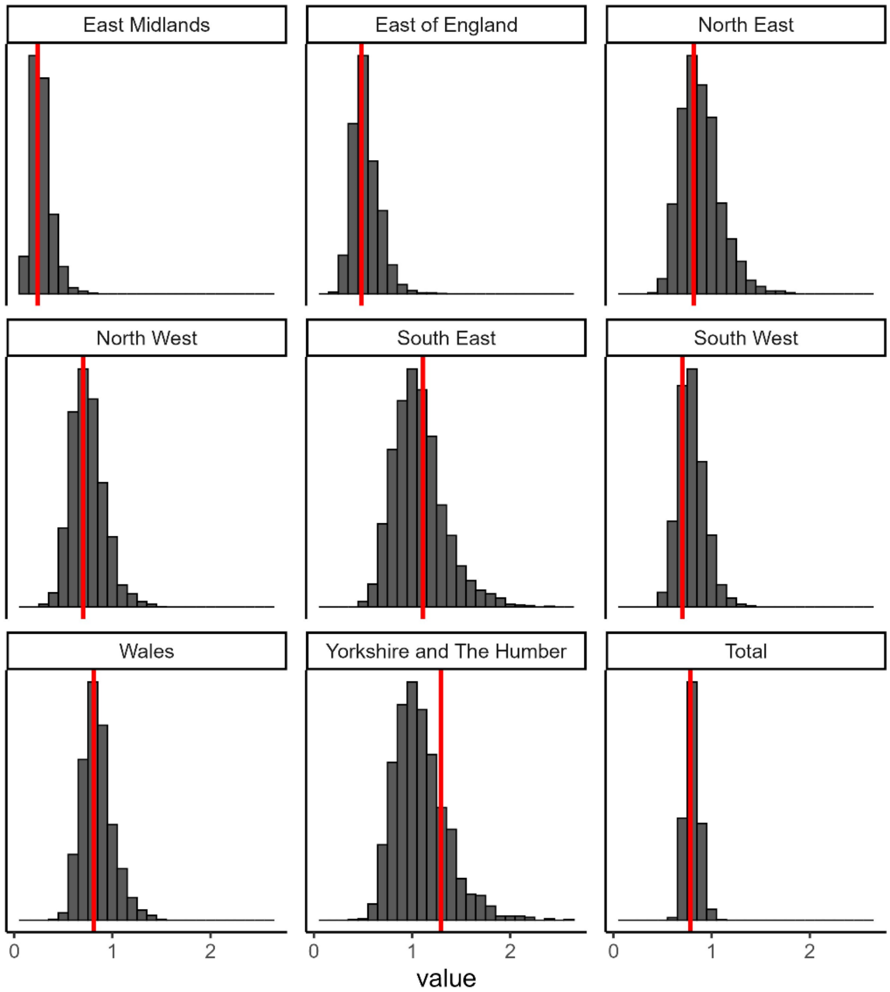

Figure 15: A posterior predictive check on the mean number of angling hours per secondary sampling unit across the survey period generated using the model. The bars are the number of times the model estimate occurred, and the red line is the average value from the raw data. The Total panel is the average across all regions.

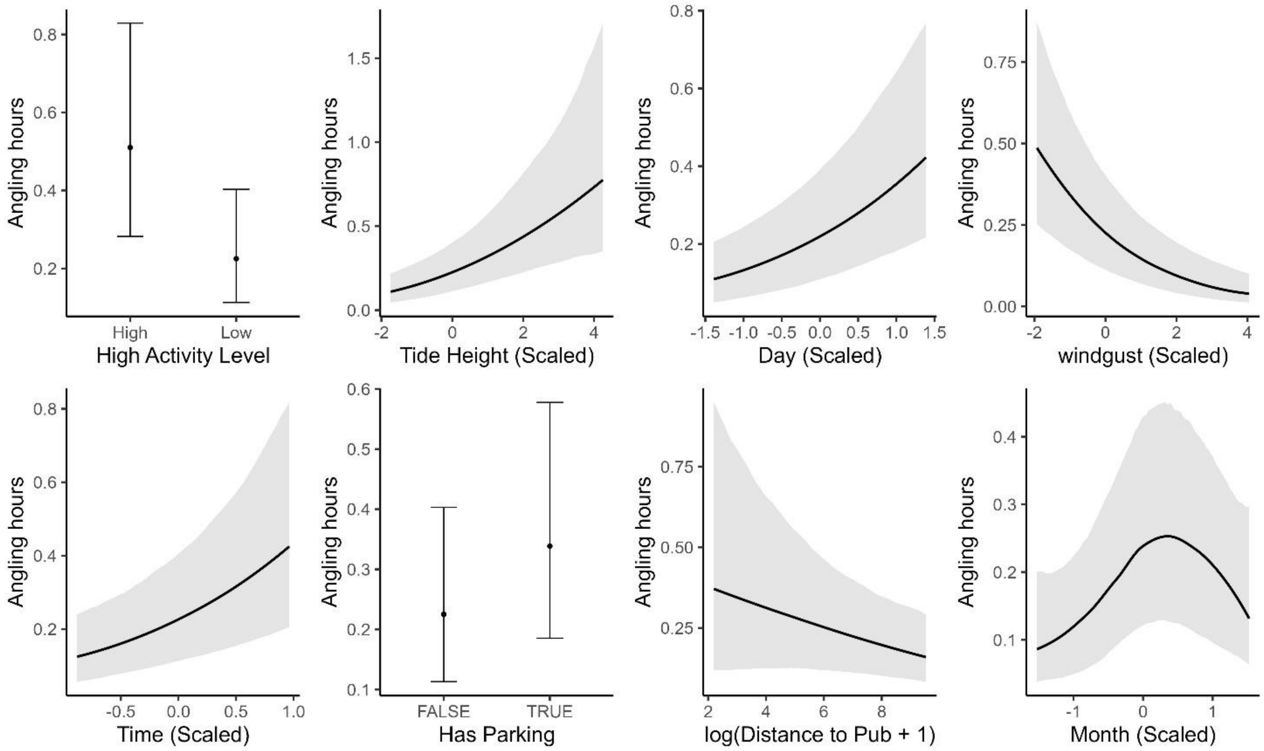

Figure 16: The conditional effects from the effort model. This plot shows the impact of changing individual variables on the model predictions.

3.1.5.2.2. Catch per unit effort

Figure 17 presents a PPC for the CPUE for each species across the survey when the effect of angler ID was included when generating the predictions. The results indicate a good fit to the raw data across most species but showed a slight overestimate for mackerel, where the model predicted an average CPUE of 0.33, compared to 0.19 in the raw data. However, Figure 18 shows that when estimates were generated using only the intercept-level random effect for 'angler ID', excluding individual angler-specific deviations, giving a more robust population level average and what is used for subsequent post-stratification, this overestimate does not occur. Instead, underestimates occur for dab, whiting and wrasse species, indicating the raw data averages could be skewed by a small number of trips with high catch rates.

After removing the effect of angler ID whiting and mackerel exhibited the highest CPUEs (0.22 and 0.21, respectively), reflecting its frequent capture across trips. However, the spread in estimates for whiting was also the largest, suggesting substantial variation in catch rates between individual trips. In contrast, conger eel and thornback ray had the lowest CPUE values, with estimates of 0.006 and 0.007, respectively, indicating that these species were rarely caught relative to others.

Figure 19 and Figure 20 present the conditional effects plot from the model, illustrating how CPUE varies across different factors while keeping all other variables constant. To improve interpretability, a logarithmic transformation (base 10) was applied to CPUE, allowing for clearer visualisation of differences, particularly when comparing species with low and high catch rates.

Several patterns in catch rates emerged from the model results. Fishing for longer durations was associated with higher CPUE as expected. Whiting had the highest catch rate among species, while bib had the lowest CPUE. In general, released fish had higher CPUE than retained fish, suggesting that many species were primarily caught and returned rather than kept. Seasonal variation was evident, with higher CPUE in quarters 2 (April–June) and 3 (July–September) coinciding with the warmer months when many species are more active.

Apart from mackerel, all species exhibited higher CPUE for released fish compared to kept fish. Some regional differences in CPUE were also observed for specific species, though overlapping error bars suggest that these differences were not always significant. Nonetheless, the results highlight geographic variability in species distribution and catchability.

Seasonal trends in catch rates were more pronounced for certain species. For example, whiting exhibited higher CPUE in Q1 (January–March) and Q4 (October–December), whereas mackerel had peak CPUE in Q3. In contrast, species like flounder showed relatively stable catch rates throughout the year, indicating less seasonal variability.

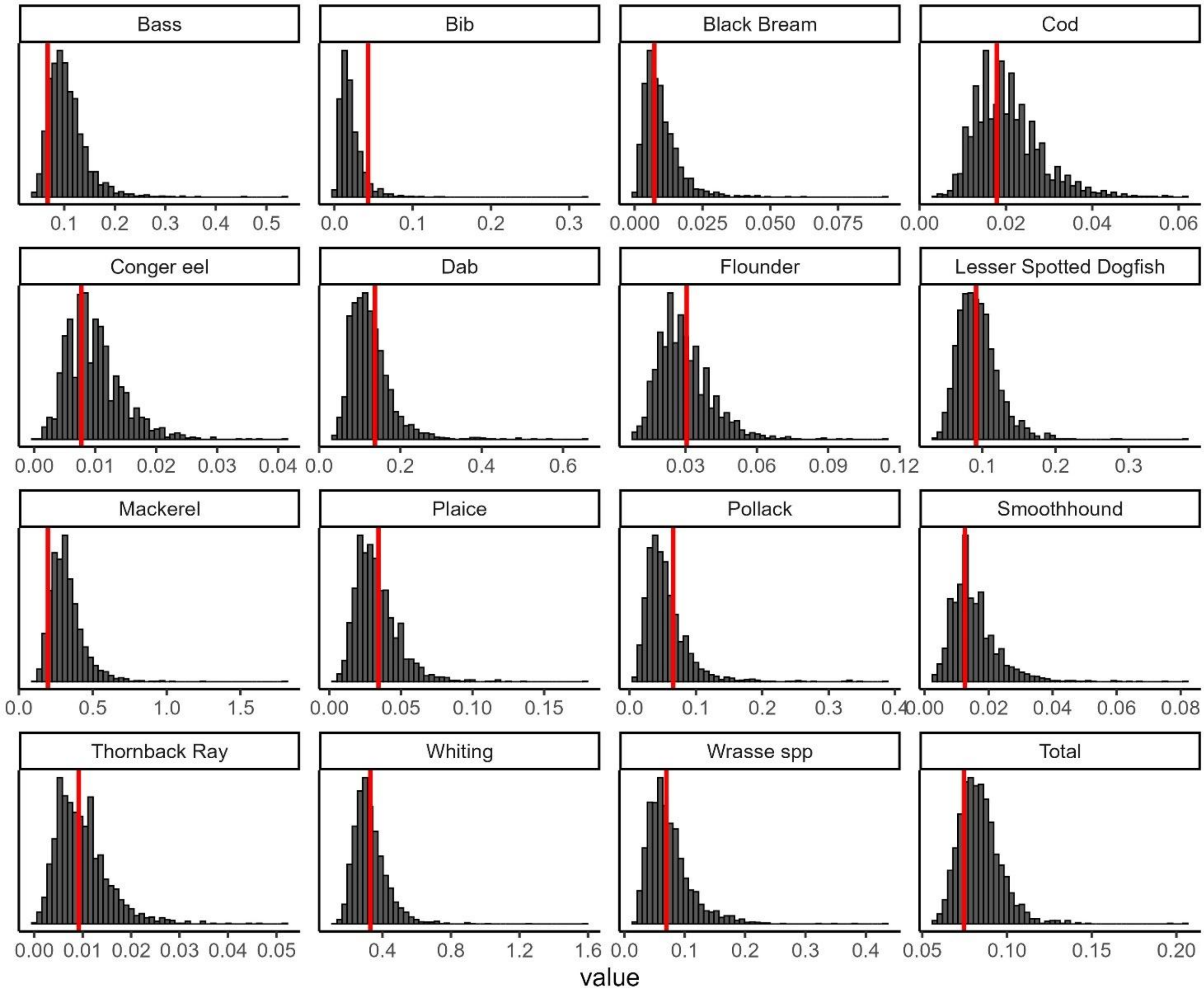

Figure 17: A posterior predictive check on the catch per unit effort (CPUE) per species across the survey period generated using the model when the angler ID random effect is included when generating the predictions. The bars are the number of times the model estimate occurred, and the red line is the average value from the raw data. The 'Total' panel is the average across all species.

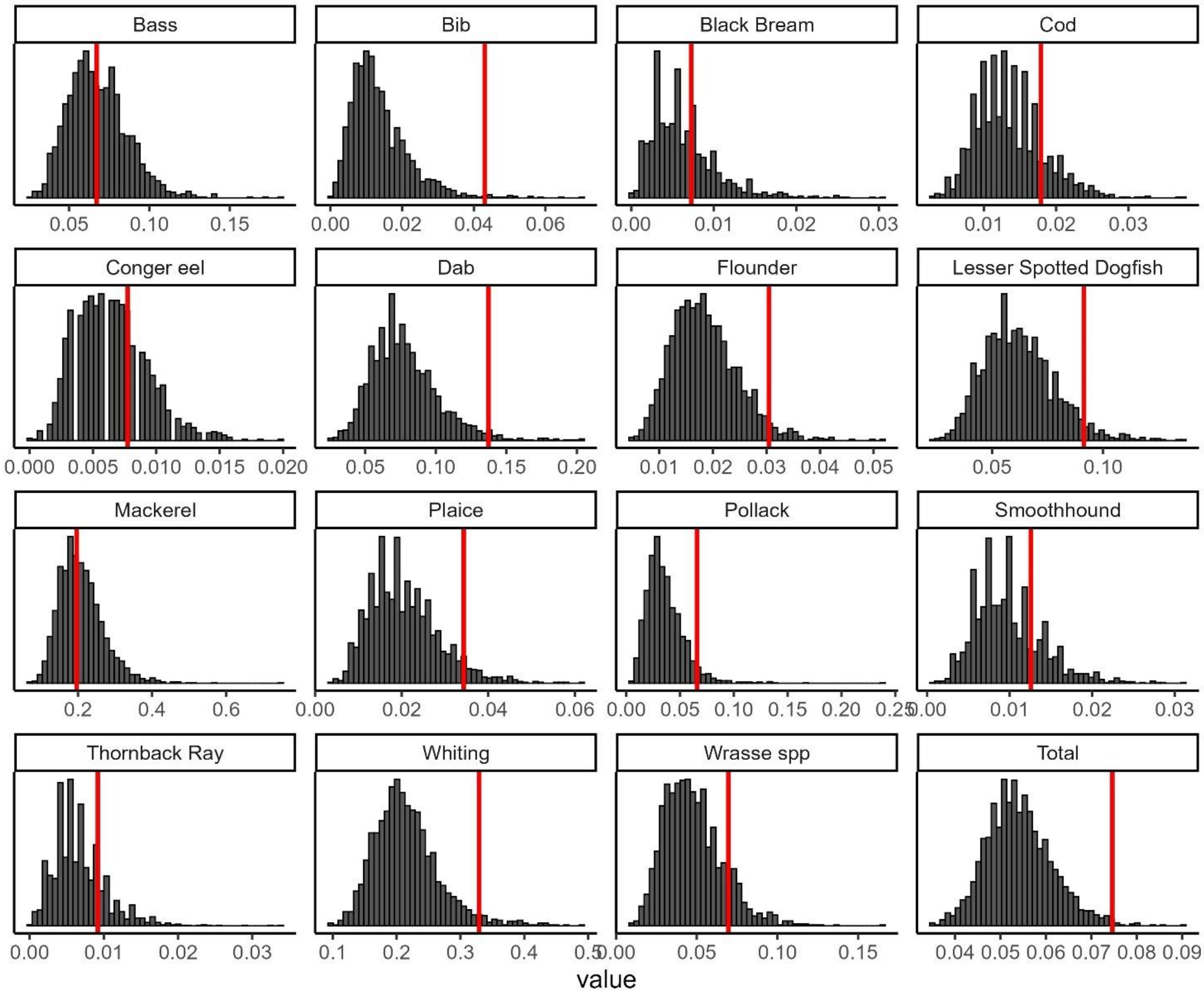

Figure 18: A posterior predictive check on the catch per unit effort (CPUE) per species across the survey period generated using the model when predictions were generated using only the intercept-level random effect for 'angler ID', excluding individual angler-specific deviations. The bars are the number of times the model estimate occurred, and the red line is the average value from the raw data. The 'Total' panel is the average across all species.

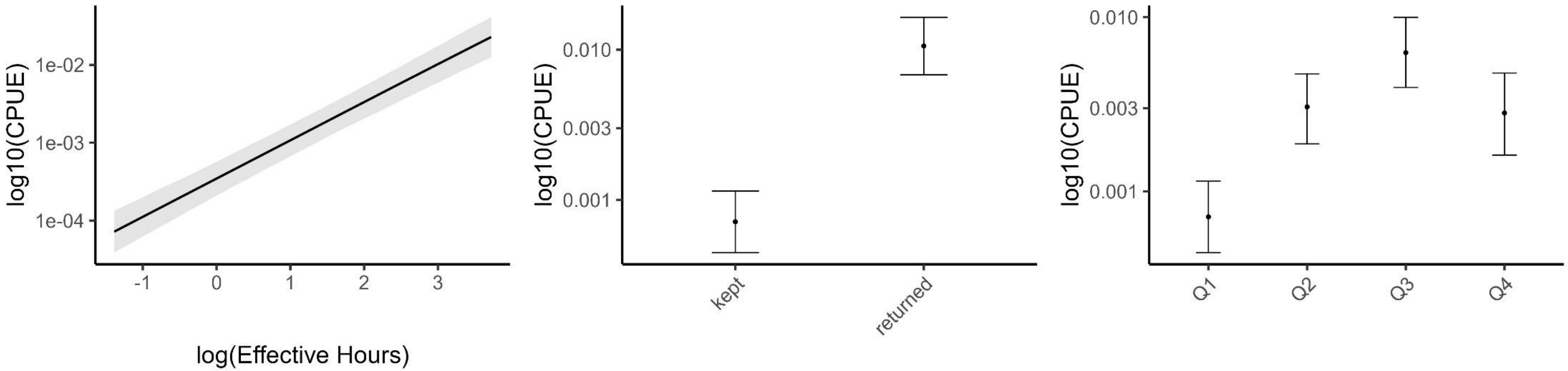

Figure 19: The conditional effects from the non-species-specific predictors in the catch per unit effort (CPUE) model. This plot shows the impact of changing individual variables on the model predictions. A log10 transformation on the CPUE was used aid in visualisation the impact of each variable on catch rates.

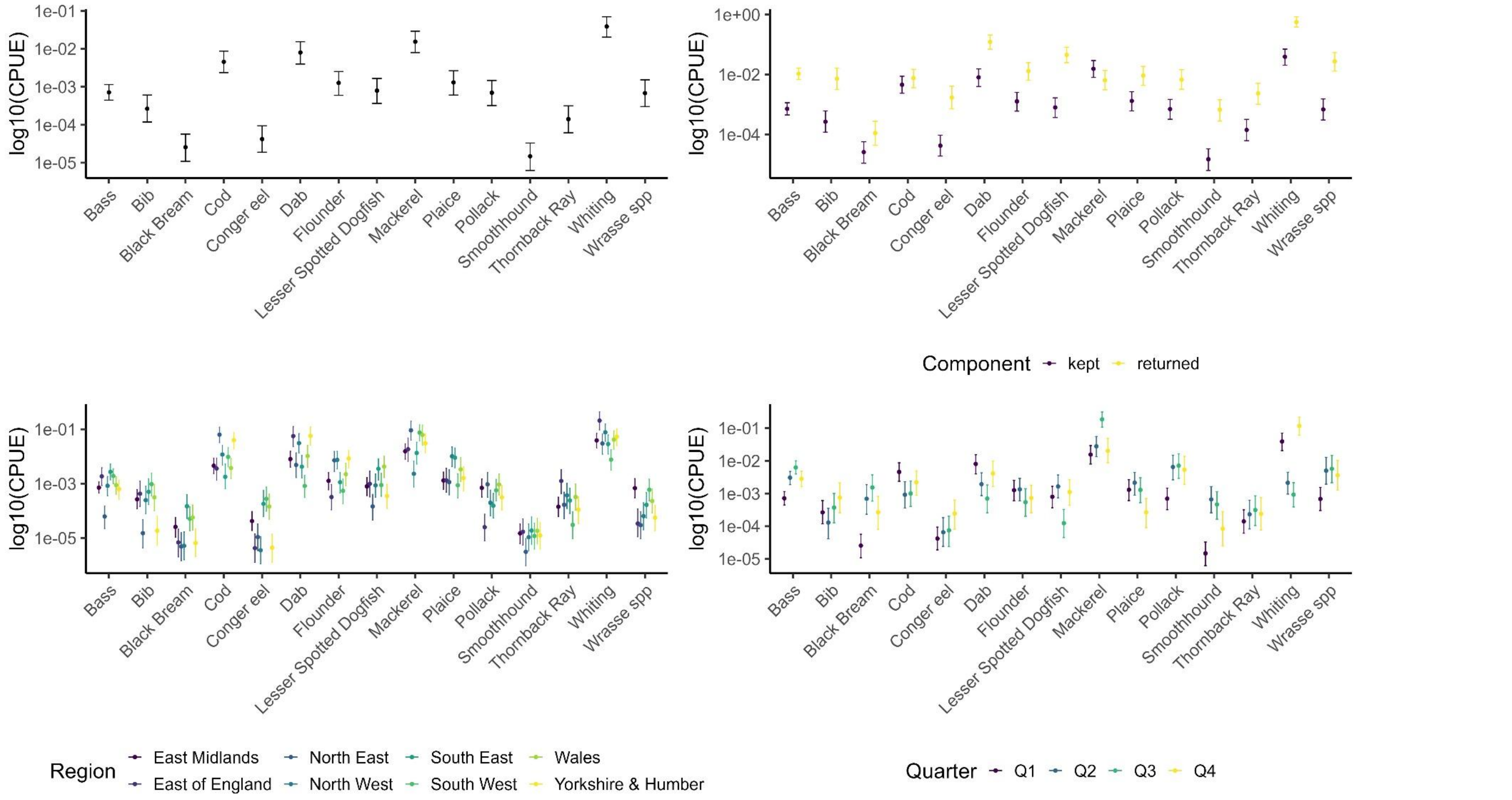

Figure 20: The conditional effects from the species-specific predictors in the catch per unit effort (CPUE) model. This plot shows the impact of changing individual variables on the model predictions. A log10 transformation on the CPUE was used aid in visualisation the impact of each variable on catch rates.

3.1.5.2.3. Weight of a fish caught

Figure 21 presents PPC for the weight model. The results indicate that where good sample sizes were available, the model fitted to the raw data well, as seen for species such as bass, black bream, and mackerel. This suggests that the model was able to accurately capture weight distributions when sufficient length and weight measurements were provided. For species where limited length measurements (e.g., conger eel, thornback ray and smoothhound), the PPC showed large tails. Whilst for conger eel and smoothhound the observed value was in the high predictive density region, meaning a good model fit, thornback ray average weight was in a low predictive density region of the PPC, meaning the model may be underestimating the weight caught. This could be due to the reliance of the weight model on the informative priors set.

Figure 22 presents the conditional effects plot from the weight model, illustrating how predicted fish weights change based on different explanatory variables while keeping all other factors constant. The results show that conger eel and smooth hound exhibited the largest variance in predicted weight, reflecting the wide range of sizes observed for these species and limited sample sizes. In contrast, other species displayed more consistent weight distributions, suggesting lower variability in the individual fish caught.

The model confirmed that kept fish were generally larger than returned fish, reinforcing the expected angler behaviour of retaining larger individuals. The relationship between median DATRAS weights and the size of fish caught by anglers was highly informative, indicating that fishery-independent trawl survey data provided a good source of information for predicting fish size in the recreational fishery.

Several species showed a significant difference in weight between retained and released fish, including bass, black bream, cod, pollack, and whiting, where returned fish were consistently smaller than those retained. While there was some evidence of regional differences in the weight of fish caught, these differences were not statistically significant. Despite the similarity in conditional effects, the model performed better according to the LOO-CV score when including region-species interactions, suggesting that accounting for geographic variation improved overall predictive accuracy, even if the regional effects themselves were not strongly differentiated in the conditional effects plot.

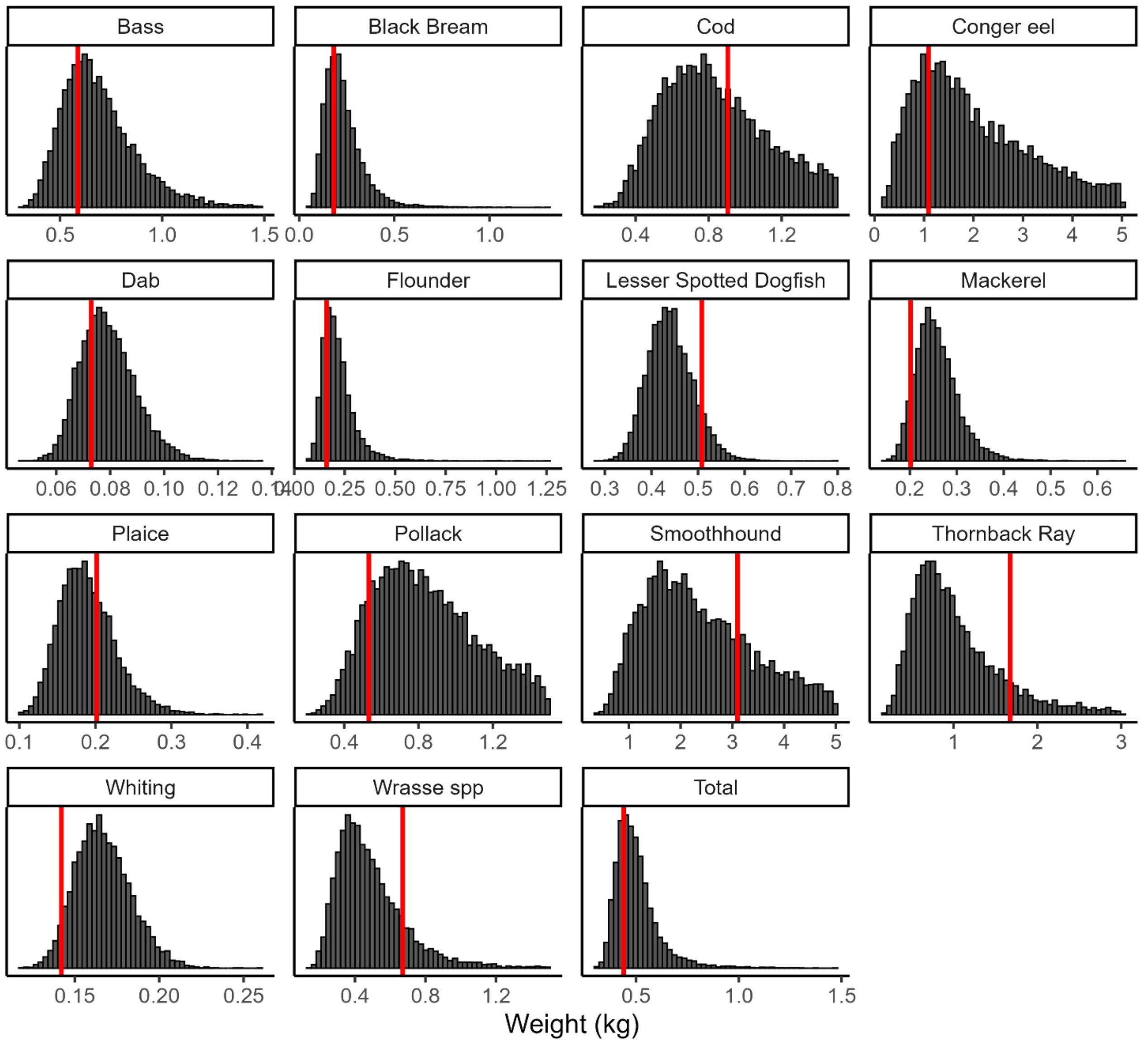

Figure 21: A posterior predictive check on the weight (kg) of fish caught across the survey period generated using the model. The bars are the number of times the model estimate occurred, and the red line is the average value from the raw data. The 'Total' panel is the average across all species. To aid visualisation, estimated weights are limited to 1.5kg for all species except conger eel and smoothhound, which are limited to 5kg, and thornback ray, which is limited to 3kg.

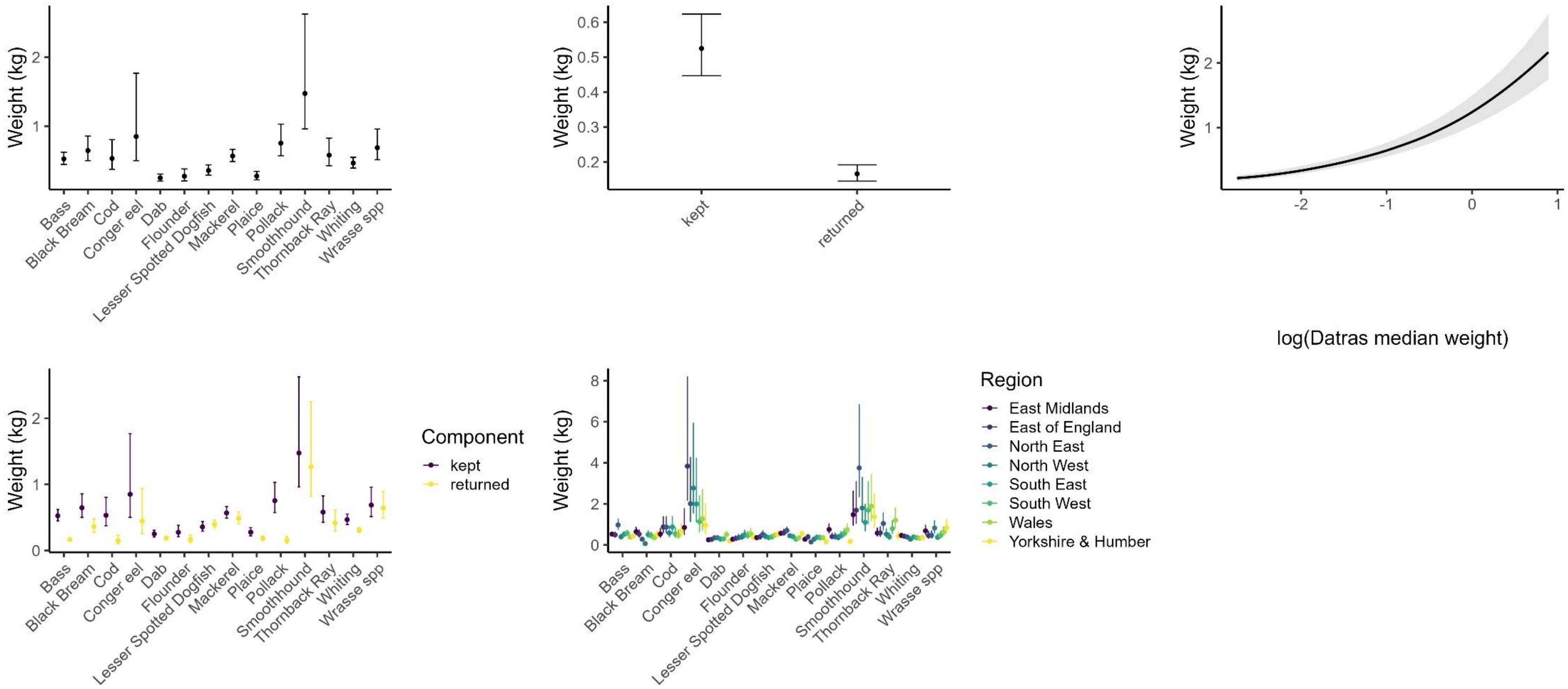

Figure 22: The conditional effects from the weight model. This plot shows the impact of changing individual variables on the model predictions.

3.1.5.2.4. Survey totals

3.1.5.2.4.1. Effort

The total estimated angling effort across all surveyed regions amounted to 10,961,697 angling hours, with a relative standard error (RSE) of 12.8%, indicating a relatively precise estimate of overall fishing activity. Regional variations in effort were evident, with the South West recording the highest total angling effort at 3.18 million hours, though with a slightly higher RSE of 15.8% (Figure 23). The South East and Wales followed, with 2.10 million hours (RSE 18.9%) and 1.95 million hours (RSE 19.2%), respectively, reflecting significant levels of participation in these coastal regions. In contrast, the East Midlands recorded the lowest angling effort, with only 43,505 total hours (RSE 33.4%), substantially lower than all other regions. This is largely attributable to the region's much smaller coastline which inherently limits the availability of shore-based angling opportunities. Among all regions, only the East Midlands and Yorkshire & Humber had RSE values exceeding 25%, with Yorkshire & Humber showing an RSE of 37.9%.

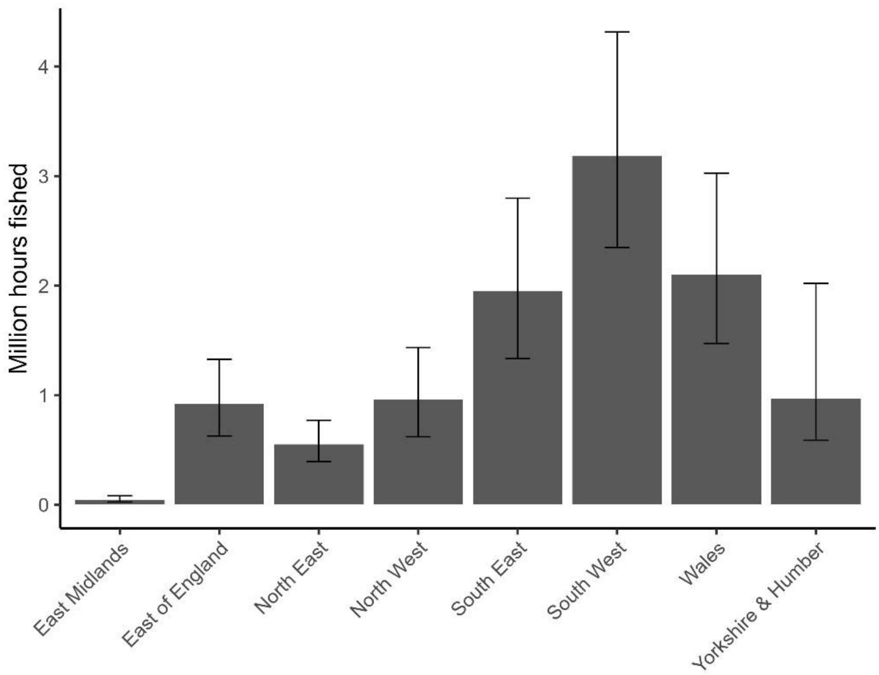

Figure 23: The total effort (angling hours) from the model-based extrapolation approach in the different regions. Error bars are 95% PI.

3.1.5.2.4.2. Number of fish

When extrapolating total fish kept using the catch model with adjusted priors from the SADP, hereafter referred to as the ‘informative priors model’, the total estimated retained catch was 5,332,213 fish (RSE 20.9%), while the total returned catch was 21,597,378 fish (RSE 18.4%). These estimates provide a more refined assessment of sea angling effort by incorporating prior knowledge from established logbook data.

Figure 24 presents the species-specific breakdown of catches by kept and returned components. Whiting had the highest estimated number of returned fish, with 9.2 million fish (RSE 23.2%), representing nearly half of all returns in the survey. In contrast, mackerel was the most commonly retained species, with an estimated 3.4 million fish kept (RSE 24.2%). Notably, mackerel was the only species where more fish were retained than released, with only 33.9% of the total catch returned.

Figure 25 illustrates the impact of setting informative priors on model results. The comparison demonstrates that only minor differences that were not statistically significant were observed between the results across all species and components, so the priors are not impacting inference. As there was limited impact of the priors on the models inference, additional sensitivity analysis to assess the impact of different quantiles to set informative priors were not conducted. The use of informative priors resulted in substantially lower RSE values, indicating improved precision in the estimates. The highest RSE in the informative priors’ model was 45.9% for bib kept, and the overall RSE across all estimates was 9.6%. In contrast, when using weaker priors, the highest RSE was 85.6% for thornback ray kept, with an overall RSE of 11.9%. Thus, subsequent analyses will rely exclusively on these estimates, as they provide the most robust and reliable assessment of recreational catches.

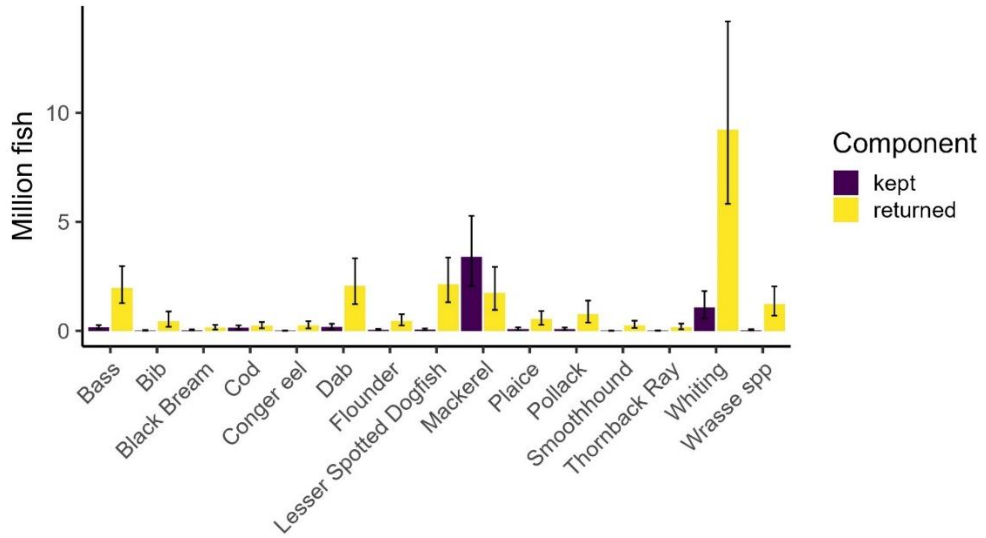

Figure 24: The total number of each species kept and returned by sea anglers in England and Wales estimated using the model-based extrapolation approach with strong priors. Error bars are 95% PI.

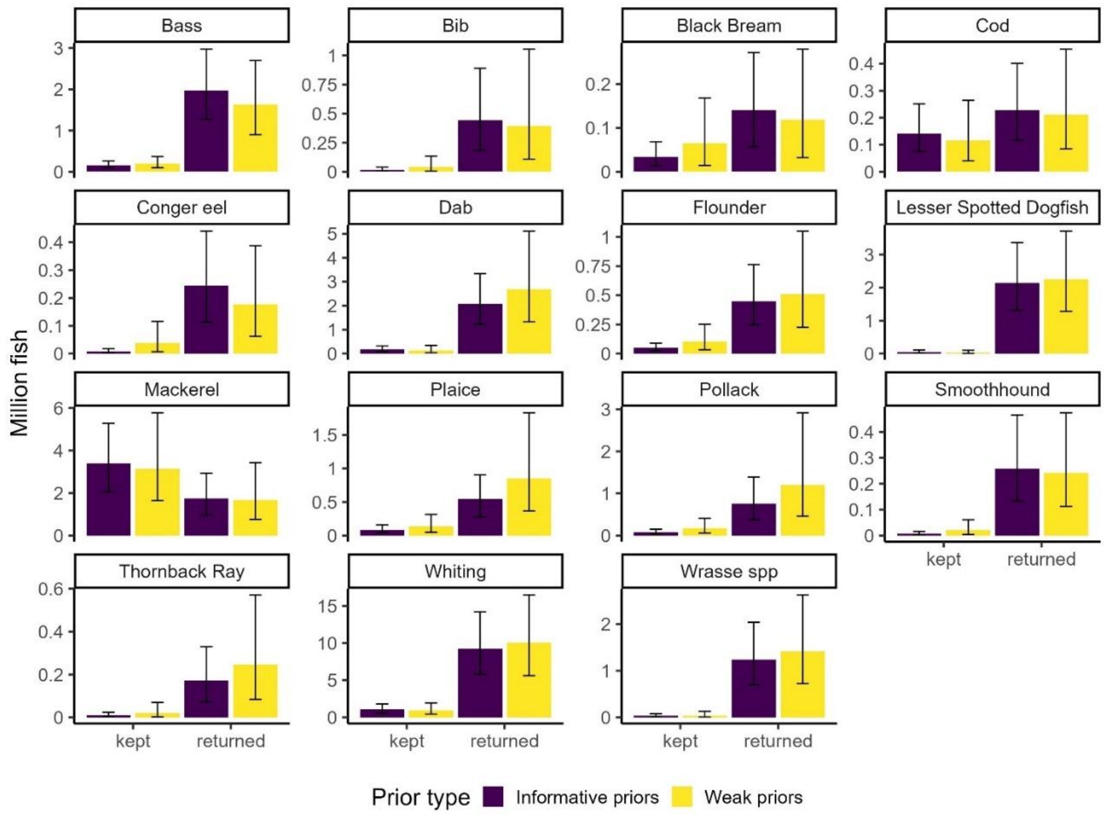

Figure 25: A comparison of the estimated total number of fish kept and returned by sea anglers in England in Wales when extrapolated using the catch model with informative and weakly informative priors. Error bars are 95% PI.

3.1.5.2.4.3. Tonnage

The total estimated tonnage of fish caught in the survey was 2,045.5 tonnes retained (RSE 21.7%) and 7,040.0 tonnes returned (RSE 19.3%), highlighting the predominance of catch-and-release practices in recreational sea angling.

Figure 26 presents the species-specific breakdown of retained and returned tonnages. Whiting had the highest total returned biomass, with an estimated 1,452.1 tonnes (RSE 23.8%), followed closely by bass, which had a returned weight of 1,005.7 tonnes (RSE 23%). In contrast, mackerel had the highest retained biomass, with an estimated 879.7 tonnes kept (RSE 26.1%). Further, mackerel and cod were the only species where retained biomass exceeded returned biomass, with both species exhibiting a kept proportion of 69%, indicating a strong angler preference for retaining these species relative to others.

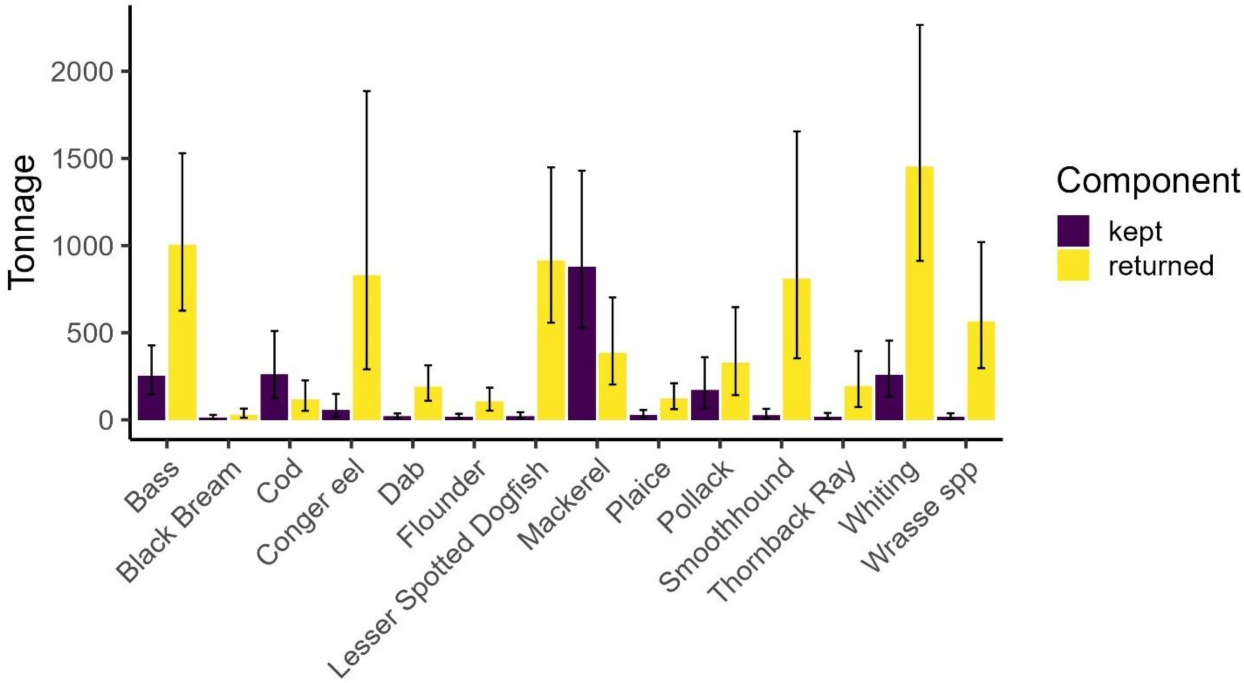

Figure 26: The tonnage of each species kept and returned by sea anglers in England and Wales estimated using the model-based extrapolation approach. Error bars are 95% PI.

3.1.6. Comparing bootstrapping and model-based approaches

3.1.6.1. Effort

Figure 27 compares the total number of angling trips estimated using the bootstrapping and model-based approaches. The model-based approach calculates effort by dividing the total number of angling hours by the weighted average trip length of four hours, allowing for direct comparability with the bootstrapped estimates. Although the 95% PIs overlap, the model-based approach consistently produces higher estimates of effort compared with the bootstrapping method. Understanding why this discrepancy occurs is critical for evaluating the strengths and limitations of each method.

The model fits, presented in Section 3.1.5.2.1, suggest that three key environmental and temporal characteristics influence participation, yet these factors were not explicitly included in the survey stratification. These factors are tide height, wind gust speed, and time of day. Unlike static stratification factors such as region or activity level, some of these variables are dynamic and cannot be predicted far enough in advance to be incorporated into the sampling design in a logistically feasible way. Ideally, survey effort should be proportionally distributed to match the occurrence of these conditions in the full sampling frame. However, if deviations in sampling effort across these environmental factors exist they could lead to differences in effort estimates between the two approaches.

A clear pattern observed in the model was the increase in angling participation at higher tide heights. To assess the representativeness of the sampling effort, a scaled tide height value of zero (i.e., the average tide height) was used to distinguish between high and low tides. Table 19 presents the proportion of survey effort conducted during high and low tides, showing that while an ideal distribution would be 50:50, the survey slightly oversampled during low tide conditions. This imbalance would influence the bootstrapping approach, as total angler counts were raised to a 24-hour unit based on the sampled data. Since participation is higher at high tide, an underrepresentation of these conditions in the dataset would result in effort being underestimated when extrapolated to full-day estimates.

A similar issue arises with wind gust speed, which was also found to affect angler presence. The model indicated that a drop in participation observed when wind speeds exceed a scaled value of zero, equivalent to 40 km/h.

Table 20 compares the proportion of high and low wind PSUs in the full sampling frame versus those sampled. While there were slightly more high-wind PSUs in the full sampling frame compared to what was sampled, the difference was small and not substantial enough to significantly impact estimates. Therefore, while wind gust speed correlates with angling participation, it does not appear to be a primary driver of the discrepancy between the model-based and bootstrapping approaches.

Time of day is likely the most significant factor affecting differences in effort estimates. Due to practical constraints, sampling was only conducted during daylight hours, meaning that fishing activity occurring outside of these periods was not directly observed. The model-based approach can predict participation for unobserved times by leveraging the estimated relationship between time of day and angling activity while also accounting for uncertainty when extrapolating to these unobserved periods.

Table 21 compares the percentage of total sampling effort across different times of day and the model-estimated average number of anglers present. The key findings highlight several biases in the sampling effort that likely contributed to lower effort estimates in the bootstrapping approach. No sampling was conducted before 6 am, meaning that any early-morning fishing activity was entirely unobserved. Afternoon periods were slightly undersampled compared to mornings, yet model results indicate that angler numbers tend to be higher in the afternoon, which would reduce bootstrapped estimates. Very little sampling occurred after 6 pm, particularly in winter months, when sampling ended before the conclusion of typical working hours. This is particularly important as participation rates during evening hours would not be well represented in the bootstrapped dataset.

Taken together, the evidence suggests that unintended biases in the sampling effort, particularly the underrepresentation of high tide conditions and evening fishing activity likely led to lower effort estimates in the bootstrapping approach. Since the model-based method directly estimates effort based on observed relationships rather than extrapolating from a restricted sampling window, it is better suited to accounting for these differences. By incorporating environmental and temporal effects within the modelling framework, rather than applying a uniform extrapolation factor to observed data, the model-based approach provides a more reliable estimate of total angling effort.

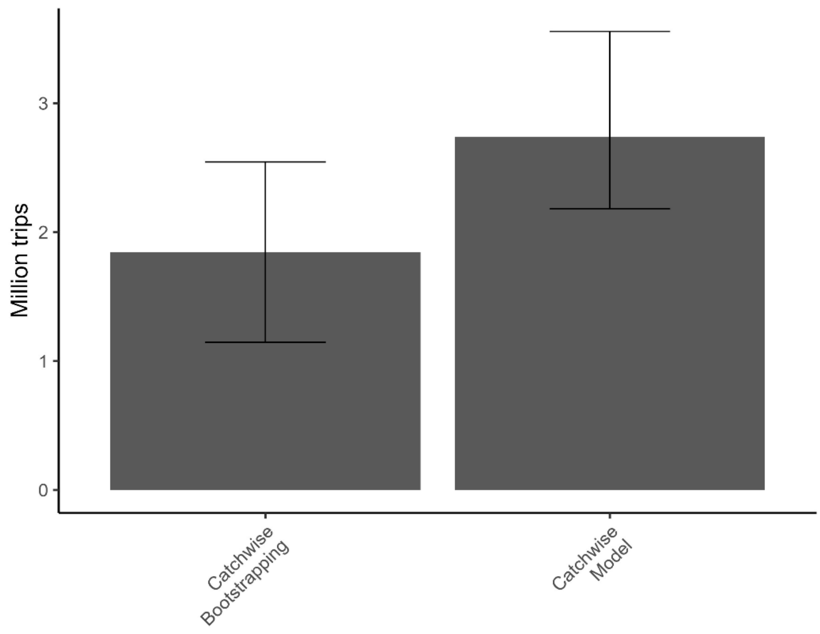

Figure 27: The total number of angling trips estimated by the bootstrapping and model-based approaches. Error bars are 95% PI.

Table 19: The number of primary sampling units (PSUs) sampled at high or low tide.

Tide state	% sampled PSUs
High	45.10
Low	54.90

Table 20: The number of primary sampling units (PSUs) sampled and in the stratification frame with a high wind speed (above 40km/h).

High wind	% sampled PSUs	% PSUs in frame
True	43.00	46.52
False	57.00	53.48

Table 21: The percentage of sampling effort within each time window, the average number of anglers observed and from the model in each time window.

Time of day	Sampling effort
Pre 06:00	0.00%
06:00 – 12:00	54.46%
12:00 – 18:00	42.87%
Post 18:00	2.67%

3.1.6.2. *Total catch and catch per unit effort*

Figure 28 compares the total catch estimates between the two extrapolation approaches. In general, the model-based approach produced higher total catch estimates while consistently generating lower RSEs. Since the model-based method also yielded higher effort estimates, as demonstrated in the previous section, this increase in catch estimates is at least partially attributable to the higher fishing effort accounted for in the model.

Figure 29 and Figure 30 further break down catch per trip estimates for each species, with the former showing absolute values and the latter presenting results as a percentage scale. The kept CPUE was generally similar or slightly lower in the model-based approach compared to bootstrapping for most species, except for mackerel and elasmobranch species, where the model produced slightly higher estimates. Notably, elasmobranch species had zero predictions in the bootstrapping approach, whereas the model produced very small values suggesting that the bootstrapping method may have struggled to capture rare species in the dataset. In contrast, returned catch per trip was consistently higher in the model-based approach.

To determine which extrapolation approach provided the most accurate estimates of total catch, a validation analysis was conducted using data from the follow-up survey, which provided a known total catch per trip. This dataset was used to assess how well the bootstrapping and model-based approaches aligned with actual observed catches. The bootstrapping method's linear CPUE extrapolation was applied to complete trip-level catches, while the model was used to predict expected catches for the same trips. The accuracy of each approach was then evaluated by calculating the mean squared error (MSE), providing a direct comparison of the alignment between estimated and known values.

The results indicated that the model-based approach produced lower MSE values for both kept and returned fish, suggesting that it more accurately reflected actual catches. The model produced an MSE of 0.16 for kept fish, compared to 0.49 in the bootstrapping approach, and an MSE of 2.51 for returned fish, compared to 2.75 in bootstrapping. These differences suggest that the model-based method achieved better overall alignment with known values, supporting its use as the preferred approach for extrapolating total catches.

Figure 31 presents the breakdown of MSE values by individual species, highlighting where the two approaches performed similarly and where discrepancies were observed. For several species, both methods produced comparable MSE values, including bass (kept and returned), black bream (returned), cod (kept), conger eel (returned), lesser spotted dogfish (kept), mackerel (returned), plaice (returned), pollack (kept and returned), whiting (kept), and wrasse species (returned). These results indicate that for these species, each approach provided similar predictive accuracy.

The model-based approach demonstrated additional advantages by predicting a CPUE for species and components that were not directly observed. Although these predictions were very low, they contributed to small MSE values, particularly for bib (kept and returned), black bream (kept), conger eel (kept), flounder (kept), smoothhound (kept), thornback ray (kept), and wrasse species (kept). This suggests that while these species were not always recorded in the survey, the model's ability to infer low but plausible CPUE values provided an estimation of rare catches compared to bootstrapping, which relies entirely on direct observations.

In a few cases, the model exhibited higher MSE values, indicating slightly poorer alignment with the follow-up survey data. These species included cod (returned), dab (returned), flounder (returned), and plaice (kept). However, for whiting (returned), which also exhibited the largest discrepancy in CPUE between methods, the model produced a lower MSE, indicating a better fit to actual catches. The model produced lower MSE values for dab (kept), lesser spotted dogfish (returned), mackerel (kept), pollack (kept), smoothhound (returned), and wrasse species (returned), reinforcing its accuracy across a broader range of species.

The overall reduction in modelled MSE values, particularly for key species and total catches, strongly suggests that the model-based approach provides more accurate CPUE predictions. The model not only aligns better with known catches from the follow-up survey but also consistently produces lower RSE values, making it a more reliable and flexible method for extrapolating catches, especially for species that are rarely caught and difficult to observe in a standardised survey without extensive sampling effort. Given these advantages, the model-based approach is the preferred method for estimating total recreational catches.

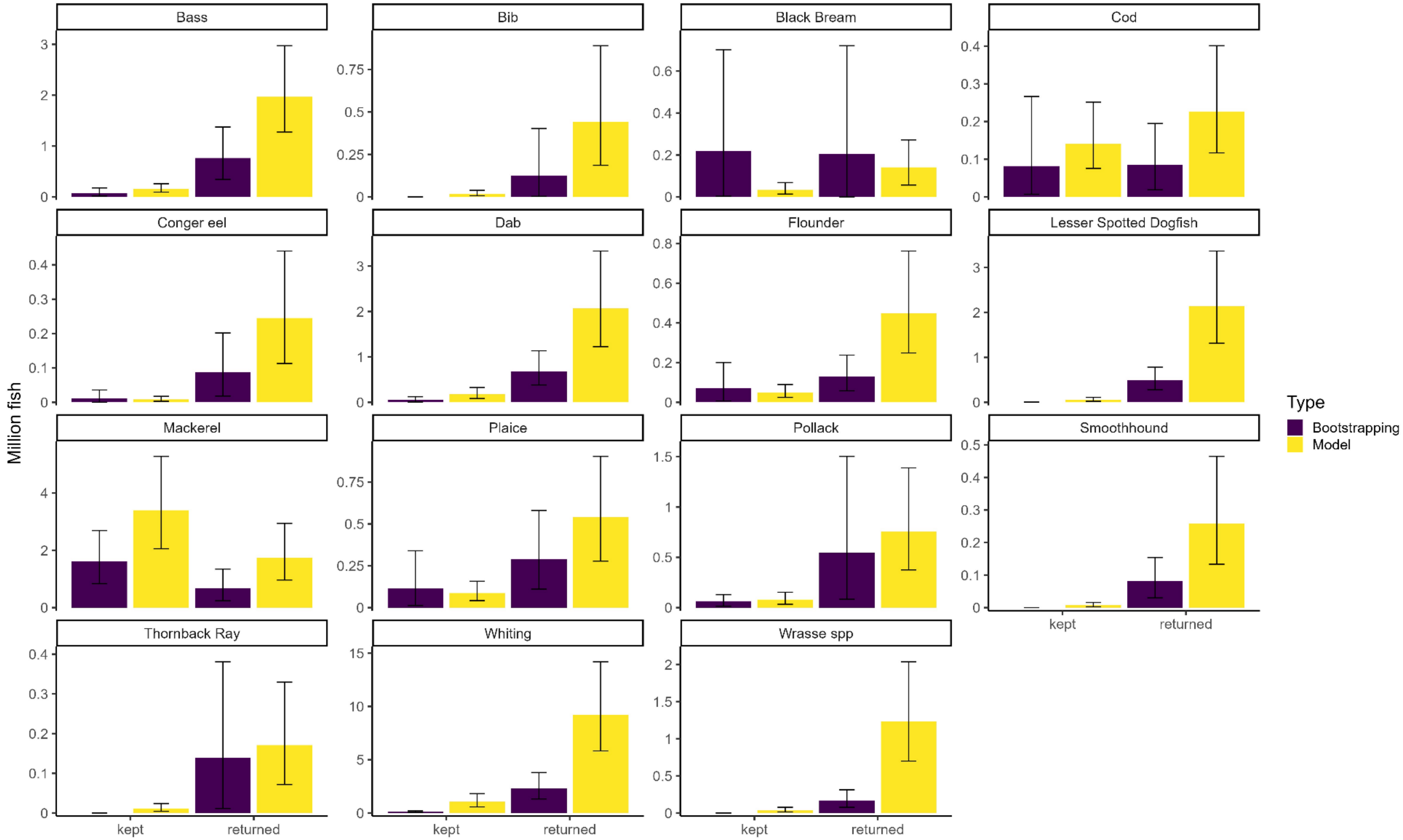

Figure 28: The total catch from the bootstrapping and model-based extrapolation approaches. Error bars are 95% PI.

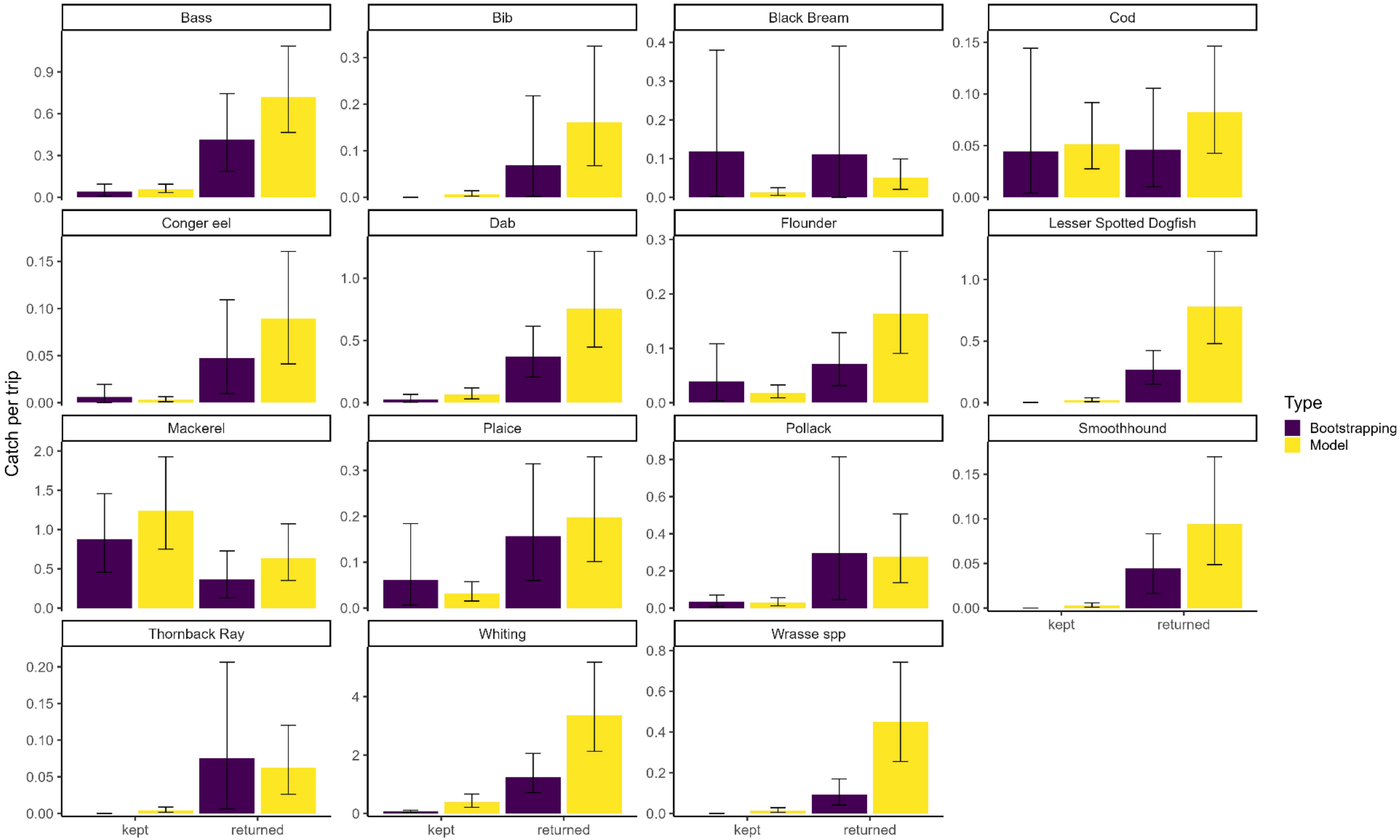

Figure 29: The average catch per trip from the bootstrapping and model-based extrapolation approaches. The numbers in text boxes are the relative standard errors. Error bars are 95% PI.

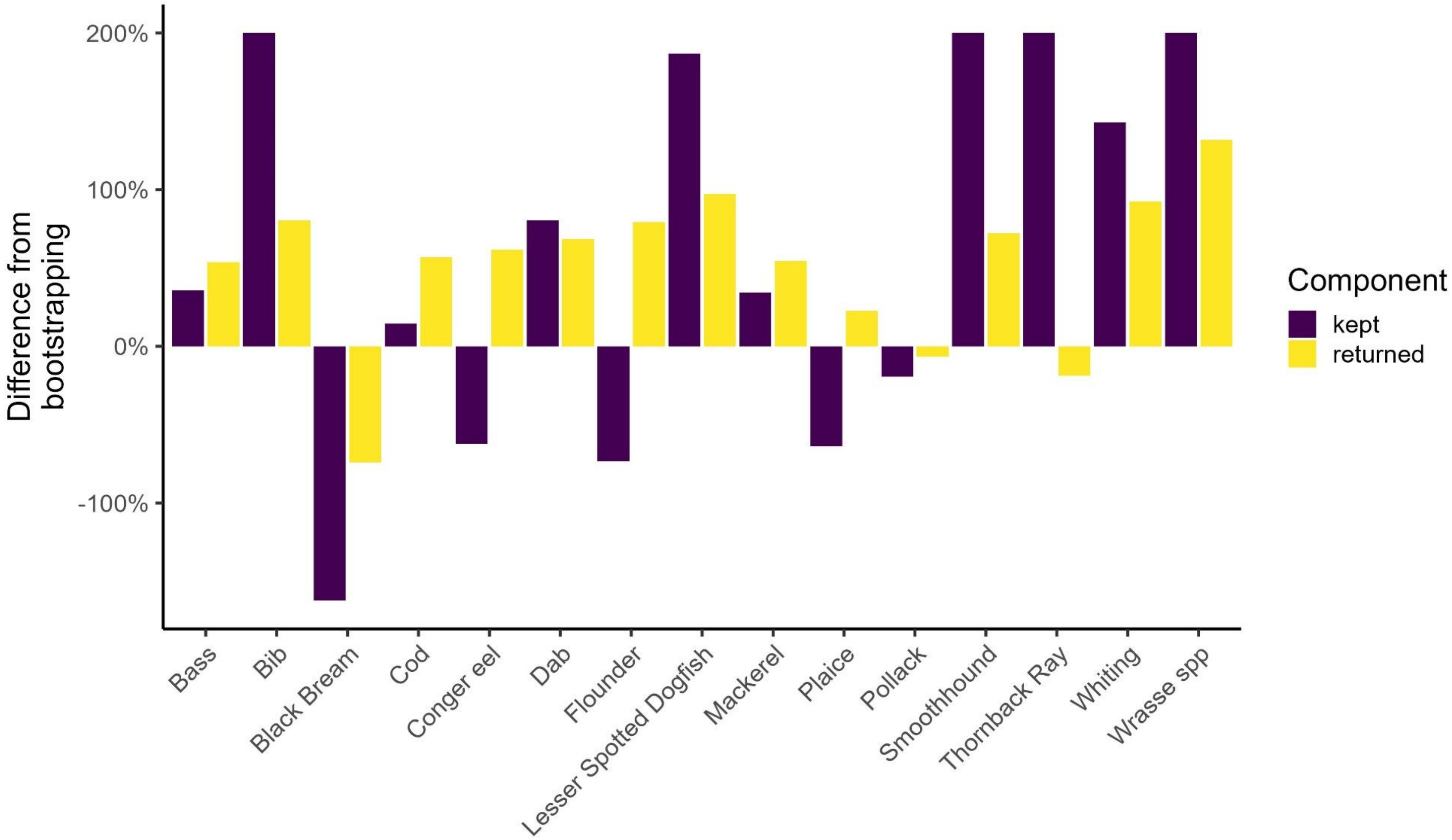

Figure 30: The percentage difference between the model-based catch per trip and bootstrapping catch per trip. Values closer to 0 indicate closer agreement. +200% values occur when a value exists for the model, but not bootstrapping.

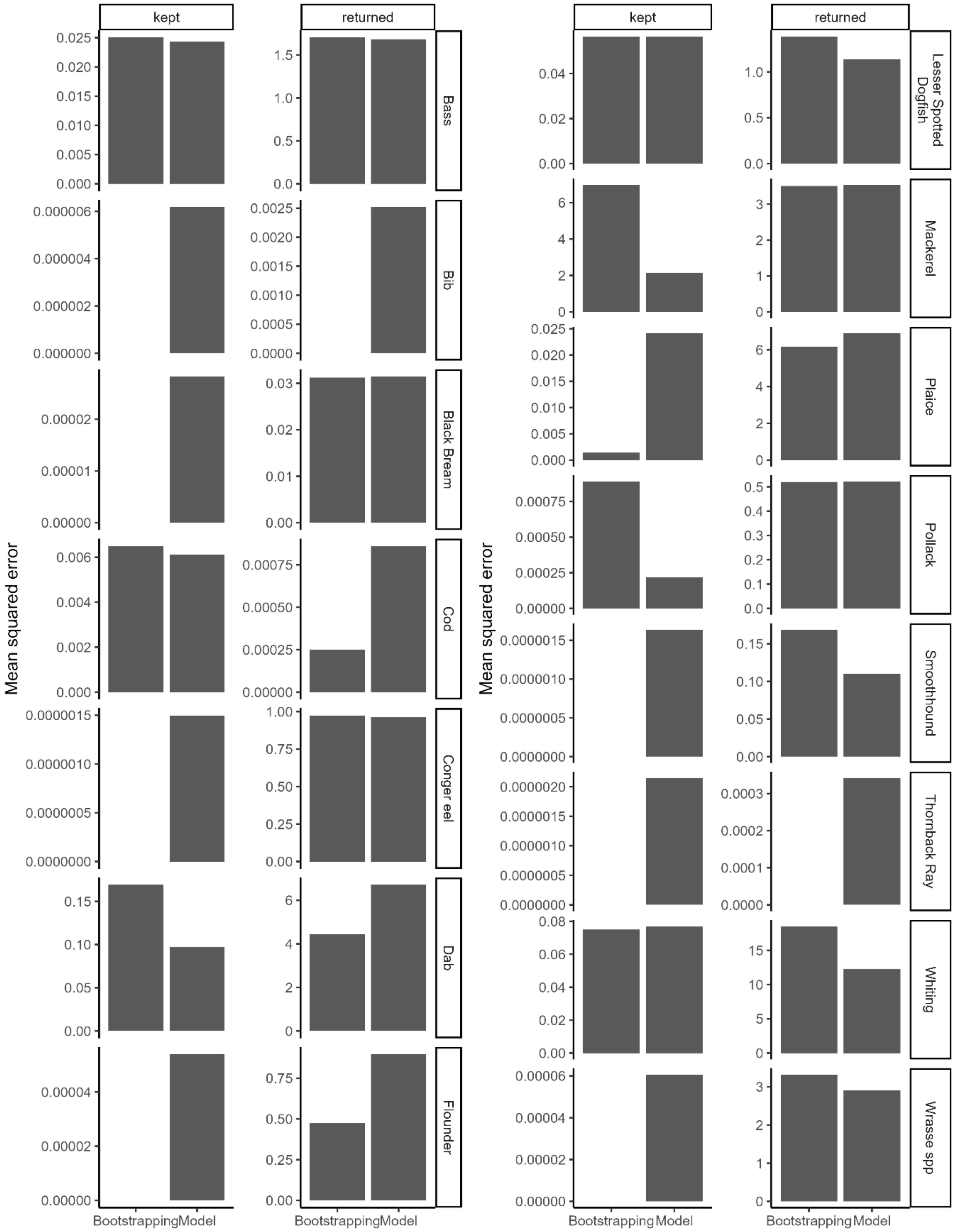

Figure 31: The mean squared error against the follow up survey data catches in the number of fish caught estimated when using the linear CPUE trip catch completion approach employed in the bootstrapping approach and the model-based approach. Values closer to 0 are better.

3.1.6.3. Average weights

Figure 32 presents the average weight estimates derived from the bootstrapping and model-based approaches. For most species, the differences between the two methods are minimal, and where differences do exist, they remain well within the 95% PI, suggesting strong overall agreement. However, notable differences were observed for conger eel (returned) and pollack (kept), where the model produced higher weight estimates than bootstrapping. These species had low sample sizes, meaning that the model relied more heavily on priors from external datasets such as the Sea Angling Diary Project and DATRAS. This reliance increases uncertainty in the model's predictions as it must borrow information from broader species trends rather than relying solely on direct observations. These cases also represent the only instances where bootstrapping produced a lower relative standard error (RSE) than the model, highlighting how resampling from limited empirical data can sometimes yield artificially lower uncertainty estimates.

Several factors may explain why the bootstrapping approach sometimes appears to produce lower errors in weight estimates, even though the model is expected to be more reliable overall. Bootstrapping is constrained to observed data, meaning it does not attempt to infer weights for species or components with very few observations, whereas the model must make predictions even in cases with sparse data. This results in higher uncertainty in the model-based estimates, especially when species are rarely caught or when weight data are limited. The model's use of on priors can also introduce differences, particularly if the size structures observed in the survey differ from those assumed in the prior data. However, for species where weight estimates differ significantly between the two methods, the model is likely a better reflection of reality as it accounts for uncertainty in unobserved data rather than assuming that the available sample is perfectly representative. Given its greater flexibility and ability to correct for biases in species with low sample sizes, the model-based approach remains the preferred method for weight estimation, particularly when species exhibit differences between the two methods.

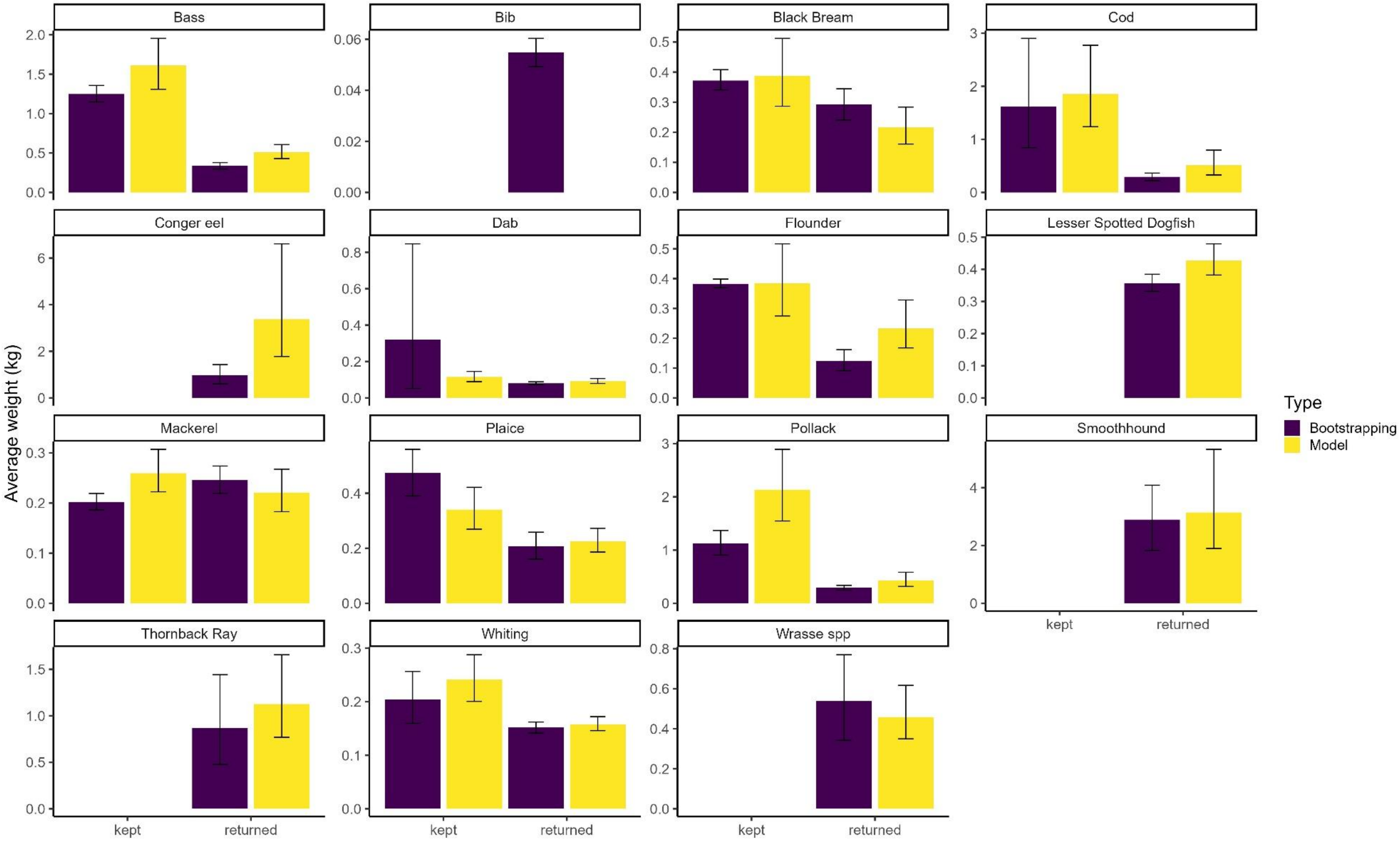

Figure 32: The average weight of fish caught from bootstrapping and the model. Error bars are 95% PI.

3.2. Charter boat survey

3.2.1. Primary sampling units sampled

In the charter boat survey, a total of 735 boat-weeks were sampled from the 13,884 total boat-weeks that could have been fished (number of boats in population x 52; Table 22), equating to 5.29% PSUs sampled. Of these, 190 boat-weeks recorded active fishing, representing 25.85% of responses. However, obtaining responses in 7.g proved challenging, primarily due to the low number of charter boats in the population and the limited number that opted to participate in the survey.

An issue was identified where a subset of boats consistently responded "no" to going fishing throughout the survey. There were concerns that this might not be truly representative, as it could indicate reporting bias rather than an accurate reflection of fishing activity. To investigate this,

Table 23 examines the effect of removing boats that only ever responded "no" to fishing. Excluding these boats reduced the number of sampled weeks to 487, decreasing the number of PSUs sampled to 3.51%. However, this adjustment also increased the percentage of boat-weeks with recorded fishing activity to 39.01%. The most substantial impact of this adjustment occurred in ICES divisions 7.a, where removing these boats reduced the total sampled PSUs by 60%. 7.g and 4.b also showed considerable reductions of 55.56% and 52.33%, respectively. Conversely, 7.d was the least affected, with a 10.28% reduction in sampled weeks due to the limited PSUs sampled in this region. Should there be a difference in both fishing activity and catch patterns in the boats not responding to the survey, there may be bias in the charter boat survey's sample.

Table 22: The total number of boat weeks in each quarter, the number sampled in the charter boat survey per stratum, and the number of responses where the boat went fishing.

ICES division	Boat weeks/ Quarter	Quarter 1		Quarter 2		Quarter 3		Quarter 4	
		Sampled	Fishing	Sampled	Fishing	Sampled	Fishing	Sampled	Fishing
4.b	403	20	1	35	1	17	1	14	7
4.c	468	21	3	35	9	13	2	22	6
7.a	351	12	0	29	0	22	5	12	2
7.d	728	43	10	66	18	42	28	63	30
7.e	819	44	9	57	16	27	13	22	12
7.f	585	45	3	37	4	16	5	12	3
7.g	117	5	0	3	1	0	0	1	1

Table 23: The total number of boat weeks in each quarter, the number sampled in the charter boat survey per stratum where boats responded yes to fishing in at least one week throughout the survey, and the number of responses where the boat went fishing.

ICES division	Total boat weeks	Quarter 1		Quarter 2		Quarter 3		Quarter 4	
		Sampled	Fishing	Sampled	Fishing	Sampled	Fishing	Sampled	Fishing
4.b	403	11	1	13	1	8	1	9	7
4.c	468	15	3	24	9	9	2	15	6
7.a	351	5	0	11	0	8	5	6	2
7.d	728	35	10	63	18	40	28	54	30
7.e	819	27	9	36	16	18	13	15	12
7.f	585	21	3	20	4	12	5	8	3
7.g	117	1	0	2	1	0	0	1	1

3.2.2. Catches recorded

A total of 12,604 fish were reported in the charter boat survey, of which 8,423 (66.83%) were released, which was considerably lower than the shore survey. Among all species recorded, black bream was by far the most caught, with a total of 3,755 fish reported (Figure 33). Of these, 68.58% were released. In contrast, cod and turbot were the least frequently caught species, with only 15 and 16 fish recorded, respectively.

Mackerel had the lowest release rate among commonly caught species, with only 19.95% of mackerel released, followed by pollack, where 25.56% of fish were returned. Cod had a similarly low release rate, with only one of the 15 cod caught being returned. At the other end of the spectrum, small-eyed ray, and starry smoothhound had 100% release rates. Several other species, including bull huss, conger eel, dab, lesser spotted dogfish, smoothhound, spurdog, thornback ray, tope, and wrasse species, also exhibited release rates exceeding 90%.

Table 24 presents the number of surveys in which catch data were recorded for each region and quarter. The results show limited conversion of effort data into actual catch records for most areas, except for divisions 7.d and 7.e. This discrepancy presents challenges for estimating total catches in other regions, where data availability was much more limited.

Table 25 summarises the total kept and returned catches of each species by region. The low number of catch records from regions outside of 7.d and 7.e means that drawing meaningful conclusions about regional differences in catches is difficult. However, for the two regions with higher data availability, overall release rates were similar, with 7.d exhibiting a 70.1% release rate and 7.e a 60.08% release rate. Black bream was the most frequently caught species in both regions, but made up far higher proportion of the total catch in 7.d (42.31%) compared with 7.e (19.71%). This contributed significantly to the overall differences in catch totals between regions. In contrast, bass catches were a higher proportion of the total catch in 7.e (9.13%) compared with 7.d (1.92%). Finally, more widely distributed species, such as whiting, exhibited similar proportions of total catches across the two regions.

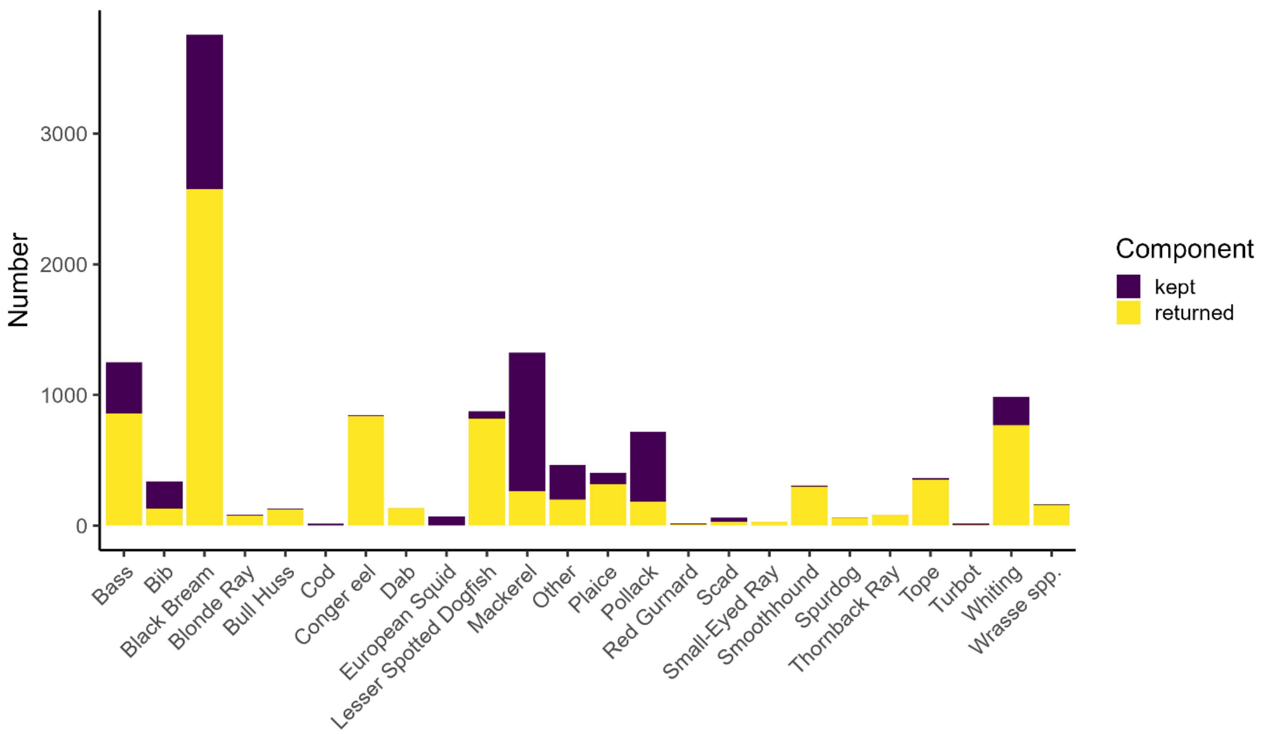

Figure 33: The total number of fish kept and returned in the charter boat fishing survey. Unknown, or species with less than 10 catch records across 3 trips, are grouped into 'Other'.

Table 24: The number of surveys where catch information was provided per region and quarter

ICES division	Pilot	Q1	Q2	Q3	Q4	Total	
						With Pilot	Without Pilot
4.b	0	1	1	0	1	**3**	**3**
4.c	0	2	5	1	1	**9**	**9**
7.a	0	0	0	0	1	**1**	**1**
7.d	3	8	13	20	22	**66**	**63**
7.e	2	7	15	9	5	**38**	**36**
7.f	1	1	2	3	1	**8**	**7**
7.g	0	0	1	0	0	**1**	**1**
Total	**6**	**19**	**37**	**33**	**31**	**126**	**120**

Table 25: The total number of fish kept and returned by charter boats by home port location. Unknown, or species with less than 10 catch records across 3 trips, are grouped into 'Other'.

Species	4.b		4.c		7.a		7.d		7.e		7.f		7.g	
	Kept	Returned	Kept	Returned	Kept	Returned	Kept	Returned	Kept	Returned	Kept	Returned	Kept	Returned
Bass	0	0	6	117	0	0	74	65	94	230	0	0	0	0
Bib	0	0	0	0	0	0	80	0	30	66	0	0	0	0
Black Bream	0	0	0	0	0	0	941	2115	239	460	0	0	0	0
Blonde Ray	0	0	0	0	0	0	6	60	4	17	0	0	0	0
Cod	1	0	0	0	0	0	2	0	1	0	0	0	0	0
Conger eel	0	0	0	0	0	0	8	524	0	305	8	0	0	0
Dab	0	0	1	95	0	0	0	40	0	0	0	0	0	0
European Squid	0	0	0	0	0	0	60	0	11	0	0	0	0	0
Lesser Spotted Dogfish	0	0	4	160	0	0	42	453	9	170	38	0	0	0
Mackerel	50	0	0	0	0	0	362	67	343	37	150	284	20	10
Other	10	1	14	62	0	0	285	556	386	248	62	173	0	0
Plaice	0	0	0	0	22	20	59	274	5	24	0	0	0	0
Pollack	0	0	0	0	0	0	68	7	212	101	0	8	5	14
Red Gurnard	0	0	0	0	0	0	5	8	0	1	4	0	0	0
Small-Eyed Ray	0	0	0	0	0	0	0	7	0	20	3	0	0	0
Smoothhound	0	0	0	111	0	0	8	161	0	18	9	0	0	0
Spurdog	0	0	0	0	0	0	0	12	3	48	0	0	0	0
Thornback Ray	0	0	2	29	0	0	1	27	0	23	5	0	0	0
Tope	0	0	0	0	0	0	12	346	0	6	1	0	0	0
Turbot	0	0	0	0	0	0	6	1	4	5	0	0	0	0
Whiting	0	0	0	330	0	0	141	318	72	122	0	5	0	0
Wrasse spp.	0	0	0	0	0	0	0	22	3	138	0	0	0	0
Total	**61**	**1**	**27**	**904**	**22**	**20**	**2160**	**5063**	**1416**	**2131**	**280**	**470**	**25**	**24**

3.2.3. Average weights reported

A total of 190 trips spanning 97 weeks provided data on the average weight of fish caught, with 4,928 fish recorded with associated weight measurements. These records offer valuable insight into species-specific weight distributions and retention patterns within the recreational fishery.

Table 26 presents the average weights of retained and released fish. In general, the average weights of fish recorded in the charter boat survey were higher than those observed in the shore survey, except for conger eel, which were smaller than in the shore and boat survey. Retained fish were generally larger than those that were released. Among all species recorded, mackerel and dab were the smallest on average.

Table 26: The average weight (kg) of each species kept and returned where enough fish (≤10) and trips (≤5) were reported by charter boats and after applying average weight filters. Averages were weighted based on the number of fish reported in each trip.

Species	Component	Total trips	Total fish	Average weight	SD
Bass	Kept	35	131	2.62	1.02
Black Bream		26	273	1.09	0.15
Cod		5	13	4.78	2.25
Lesser Spotted Dogfish		9	21	1.25	0.37
Mackerel		23	509	0.35	0.13
Plaice		5	7	1.21	0.17
Pollack		12	25	2.34	1.25
Turbot		5	6	4.23	1.47
Whiting		15	97	0.71	0.49
Bass	Returned	37	617	1.64	0.60
Black Bream		48	555	0.75	0.33
Blonde Ray		8	30	10.87	3.81
Bull Huss		17	73	5.76	1.89
Conger eel		59	563	11.20	5.97
Dab		10	132	0.37	0.29
Lesser Spotted Dogfish		22	269	0.98	0.17
Mackerel		8	114	0.39	0.17
Plaice		10	75	0.62	0.29
Pollack		9	88	1.68	0.47
Small-Eyed Ray		6	21	6.29	1.55
Smoothhound		38	265	6.66	1.31
Thornback Ray		20	78	7.33	11.68
Tope		15	103	16.44	9.74
Undulate Ray		6	7	10.70	4.56
Whiting		21	626	0.57	0.29
Wrasse spp.		10	138	1.34	0.69

3.2.4. Survey estimates

3.2.4.1. Effort

ICES division 7.g contained too little data to produce robust estimates, and it was therefore removed from the analysis. The results suggested a probability range of 0 to 100% for a boat going fishing in this division, reflecting the low sample size, which made meaningful inference impossible. Other ICES divisions also exhibited relatively high uncertainty, so caution is advised when interpreting their results.

Figure 34 presents the average probability of a boat being active in any given week by ICES division. As expected, the probability estimates increased when removing boats that only ever reported “no” to fishing. The highest probability of fishing activity was recorded in divisions 7.e and 7.f, where the probability of a boat being active was 57.5% and 45.7%, respectively, when excluding boats that only reported “no”, compared with 37.7% and 41.2% when including all boats. Division 7.a exhibited the highest uncertainty, with RSE values of 37% when excluding boats that only said “no” and 32.5% when including them. This reflects the lower sample size available for this division, making precise estimation more difficult.

Table 27 provides a further breakdown of the probability of a boat being active by survey stratum (ICES division and quarter). A clear seasonal trend was observed, with higher probabilities of fishing activity in quarters 3 and 4 compared to quarters 1 and 2. Notably, division 7.a showed no recorded fishing activity during the first two quarters, further highlighting its limited sample size. Regardless of the quarter, divisions 7.d and 7.e consistently exhibited the highest probabilities of fishing activity, suggesting that these areas experienced more stable charter boat participation throughout the year.

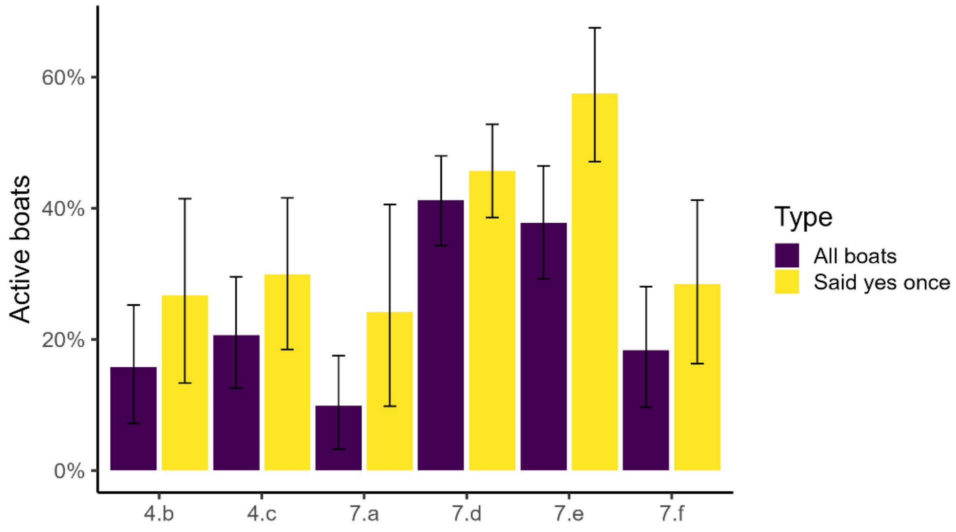

Figure 34: The average probability of a boat being active in any given week per ICES division when all boats are included in the analysis and when boats that only responded no were removed. Error bars are 95% PI.

Table 27: The average probability (%) of a boat fishing in any given week within each of the survey stratum (ICES division and quarter). Numbers in brackets are the upper and lower 95% PI. Quarters are not quarters of the year with Q1 covering November-January, Q2: covering February-April, Q3: May – July and Q4: August – October.

ICES Division	Quarter 1		Quarter 2		Quarter 3		Quarter 4	
	All boats	Said yes once	All boats	Said yes once	All boats	Said yes once	All boats	Said yes once
4.b	5.02 (0.00-15.00)	9.03 (0.00-27.27)	2.90 (0.00-8.57)	7.60 (0.00-23.08)	5.88 (0.00-17.65)	12.61 (0.00-37.50)	49.86 (21.43-78.57)	77.84 (44.44-100.00)
4.c	14.28 (0.00-28.57)	19.77 (0.00-40.00)	25.65 (11.43-40.00)	37.62 (20.83-58.33)	15.35 (0.00-38.46)	22.24 (0.00-55.56)	27.36 (9.09-45.45)	39.97 (13.33-66.67)
7.a	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.00 (0.00-0.00)	22.88 (9.09-40.91)	62.45 (25.00-87.50)	16.37 (0.00-41.67)	32.83 (0.00-66.67)
7.d	23.41 (11.63-37.21)	28.45 (14.29-42.86)	27.26 (16.67-37.88)	28.56 (17.46-39.68)	66.68 (52.38-80.95)	69.93 (55.00-82.50)	47.69 (34.92-60.32)	55.71 (42.59-68.52)
7.e	20.42 (9.09-34.03)	33.51 (18.52-51.85)	28.03 (17.54-40.35)	44.47 (27.78-61.11)	48.22 (29.63-66.67)	72.41 (50.00-94.44)	54.39 (31.82-72.73)	79.98 (60.00-100.00)
7.f	6.58 (0.00-15.56)	14.30 (0.00-33.33)	10.74 (2.70-21.62)	20.02 (5.00-40.00)	31.21 (12.50-56.25)	41.78 (16.67-66.67)	24.71 (0.00-50.00)	37.89 (12.50-75.00)

3.2.4.2. Catch per unit effort

Sufficient catch data for robust CPUE estimates was only available for ICES Divisions 7.d and 7.e, with other divisions lacking adequate sample sizes to produce reliable estimates. As a result, further analyses were restricted to these two divisions.

Figure 35 presents the mean CPUE for divisions 7.d and 7.e combined, while Table 28 provides separate estimates for each division. The results indicate that black bream had the highest CPUE, though this was primarily driven by division 7.d, where catch rates were notably higher. Mackerel was the next most frequently caught species, and unlike black bream, CPUE estimates for mackerel were similar between the two regions, suggesting more uniform catch rates across these divisions. For most species, CPUE estimates were broadly similar between divisions 7.d and 7.e, suggesting that catch rates for many species remained relatively consistent across these adjacent fishing areas.

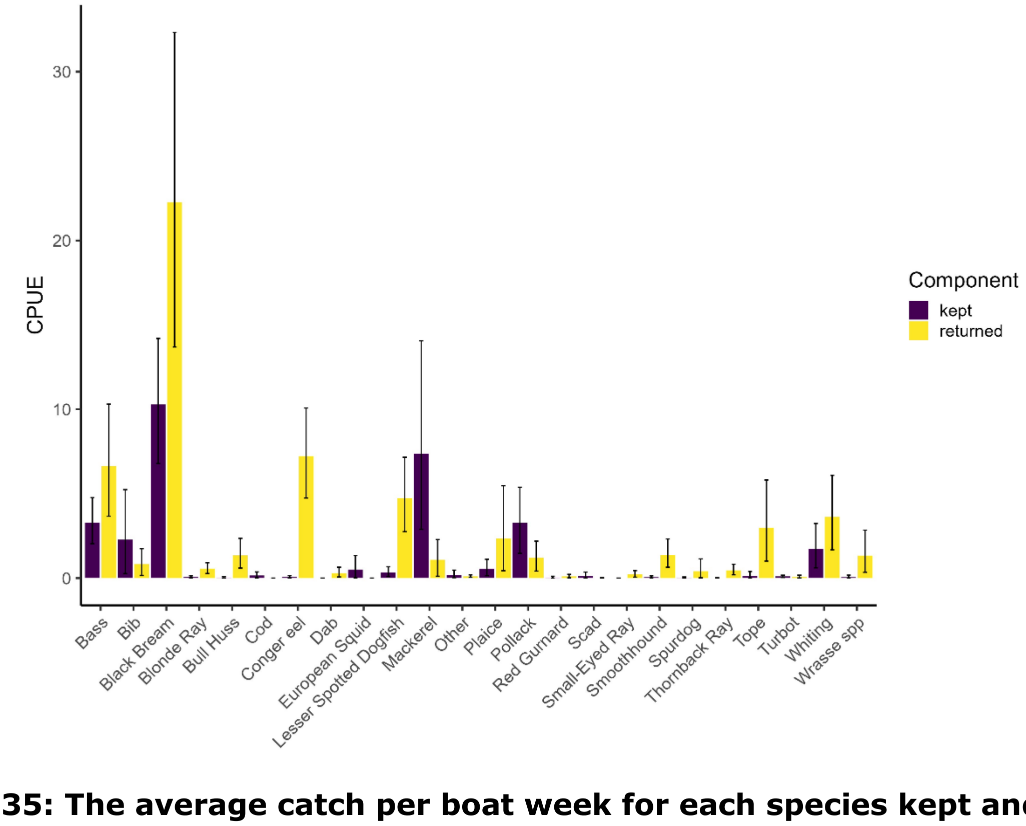

Figure 35: The average catch per boat week for each species kept and returned in ICES divisions 7.d and 7.e. Error bars are 95% PI.

Table 28: The average catch per boat week for each species kept and returned in ICES divisions 7.d and 7.e. The numbers in brackets are the lower and upper 95% PI.

Species	7.d		7.e	
	Kept	Returned	Kept	Returned
Bass	3.98 (2.15-6.13)	7.35 (3.15-12.75)	2.61 (0.94-4.64)	6.00 (1.87-11.26)
Bib	1.99 (0.16-5.26)	0.79 (0.00-2.15)	2.58 (0.00-7.74)	0.90 (0.00-2.31)
Black Bream	15.62 (9.78-22.57)	34.37 (19.55-52.65)	5.14 (2.54-8.32)	10.28 (4.88-16.76)
Blonde Ray	0.07 (0.01-0.15)	0.75 (0.38-1.17)	0.05 (0.00-0.18)	0.37 (0.00-0.93)
Bull Huss	0.02 (0.00-0.06)	0.88 (0.34-1.53)	0.05 (0.00-0.14)	1.80 (0.42-3.68)
Cod	0.10 (0.00-0.25)	0.00 (0.00-0.00)	0.19 (0.00-0.60)	0.00 (0.00-0.00)
Conger eel	0.12 (0.00-0.29)	7.50 (4.25-11.46)	0.00 (0.00-0.00)	7.05 (3.52-11.50)
Dab	0.00 (0.00-0.00)	0.59 (0.14-1.24)	0.00 (0.00-0.00)	0.00 (0.00-0.00)
European Squid	0.80 (0.00-2.31)	0.00 (0.00-0.00)	0.22 (0.00-0.69)	0.00 (0.00-0.00)
Lesser Spotted Dogfish	0.50 (0.03-1.14)	6.26 (3.06-10.13)	0.17 (0.04-0.34)	3.29 (1.12-6.23)
Mackerel	5.80 (2.15-10.30)	0.93 (0.00-2.57)	8.90 (1.71-21.33)	1.27 (0.00-3.17)
Other	0.01 (0.00-0.01)	0.06 (0.02-0.13)	0.36 (0.05-0.94)	0.14 (0.03-0.30)
Plaice	0.92 (0.16-1.98)	3.80 (0.62-9.51)	0.17 (0.00-0.51)	0.85 (0.00-2.85)
Pollack	1.72 (0.39-3.48)	0.37 (0.11-0.74)	4.79 (1.62-9.03)	2.02 (0.54-4.01)
Red Gurnard	0.07 (0.00-0.20)	0.15 (0.01-0.38)	0.00 (0.00-0.00)	0.04 (0.00-0.12)
Scad	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.25 (0.00-0.74)	0.01 (0.00-0.05)
Small-Eyed Ray	0.00 (0.00-0.00)	0.09 (0.01-0.20)	0.00 (0.00-0.00)	0.35 (0.01-0.80)
Smoothhound	0.12 (0.01-0.26)	2.52 (1.11-4.36)	0.00 (0.00-0.00)	0.24 (0.04-0.56)
Spurdog	0.00 (0.00-0.00)	0.16 (0.00-0.46)	0.04 (0.00-0.14)	0.66 (0.00-2.11)
Thornback Ray	0.01 (0.00-0.04)	0.43 (0.19-0.72)	0.00 (0.00-0.00)	0.48 (0.06-1.20)
Tope	0.24 (0.00-0.74)	5.95 (2.09-11.19)	0.00 (0.00-0.00)	0.08 (0.00-0.28)
Turbot	0.09 (0.02-0.18)	0.01 (0.00-0.04)	0.10 (0.00-0.22)	0.13 (0.00-0.32)
Whiting	2.11 (0.45-4.66)	5.25 (1.96-9.47)	1.39 (0.18-3.30)	2.12 (0.40-4.55)
Wrasse spp	0.00 (0.00-0.00)	0.35 (0.02-0.78)	0.11 (0.00-0.35)	2.32 (0.41-5.49)

3.2.4.3. Weight of a fish caught

Table 29 summarises the bootstrapped average weight (kg) of fish caught in the charter boat survey, categorised by whether the fish were kept or returned. Mean weight estimates are presented alongside their 95% PI. Among the returned fish, tope had the highest average weight (16.44 kg, 95% PI: 14.65–18.32 kg), followed by conger eel (11.20 kg, 95% PI: 10.72–11.70 kg). Larger-bodied species such as blonde ray and undulate ray also exhibited relatively high mean weights of 10.86 kg and 10.67 kg, respectively. For fish that were kept, cod had the highest mean weight at 4.78 kg (95% PI: 3.59–5.88 kg), making it the largest retained species in the survey. In contrast, smaller species such as mackerel (kept) had an average weight of 0.35 kg (95% PI: 0.34–0.36 kg).

Table 29: The average weight of a fish caught in the charter boat survey. The numbers in brackets are the lower and upper 95% PI.

Species	Kept	Returned
Bass	2.62 (2.45-2.79)	1.64 (1.59-1.68)
Black Bream	1.09 (1.07-1.11)	0.75 (0.72-0.78)
Blonde Ray	-	10.86 (9.60-12.27)
Bull Huss	-	5.76 (5.32-6.20)
Cod	4.78 (3.59-5.88)	-
Conger eel	-	11.20 (10.72-11.70)
Dab	-	0.37 (0.32-0.42)
Lesser Spotted Dogfish	1.25 (1.11-1.41)	0.98 (0.96-1.00)
Mackerel	0.35 (0.34-0.36)	0.39 (0.36-0.43)
Plaice	1.22 (1.11-1.32)	0.62 (0.56-0.69)
Pollack	2.34 (2.00-2.88)	1.68 (1.58-1.77)
Small-Eyed Ray	-	6.28 (5.71-6.95)
Smoothhound	-	6.66 (6.50-6.81)
Thornback Ray	-	7.31 (5.29-10.20)
Tope	-	16.44 (14.65-18.32)
Turbot	4.22 (3.33-5.40)	-
Undulate Ray	-	10.67 (7.36-13.43)
Whiting	0.71 (0.62-0.81)	0.57 (0.54-0.59)
Wrasse spp.	-	1.34 (1.22-1.46)

3.2.4.4. Survey totals

3.2.4.4.1. Effort

The total estimated number of boat-weeks varied depending on the inclusion criteria for participating vessels. When all boats were included in the analysis, the total was 3,649 boat-weeks, whereas restricting the analysis to boats that had reported fishing at least once ("yes" at least once) increased this estimate to 5,221 boat-weeks. Excluding boats that only ever responded "no" to fishing resulted in slightly improved precision, with the RSE decreasing from 6.9% to 6.6%. However, the results from both of these samples may be bias by the substantial non-response in the survey.

Figure 36 presents the distribution of boat-weeks by ICES division. Division 7.e exhibited the highest total effort, closely followed by 7.d, highlighting these areas as key regions of charter boat activity and better response rates in these divisions. The largest relative increase in effort estimates occurred in 7.e when excluding boats that never reported fishing, indicating that these vessels may have disproportionately influenced effort estimates in this region. Across divisions, RSE values remained below 30% for all areas except 7.a when only boats that had reported fishing at least once were included, suggesting that estimates were generally more stable when non-fishing boats were excluded. When all boats were included, division 4.b. also met the inclusion threshold, though the higher uncertainty in this division indicates that effort estimates here should be interpreted with caution.

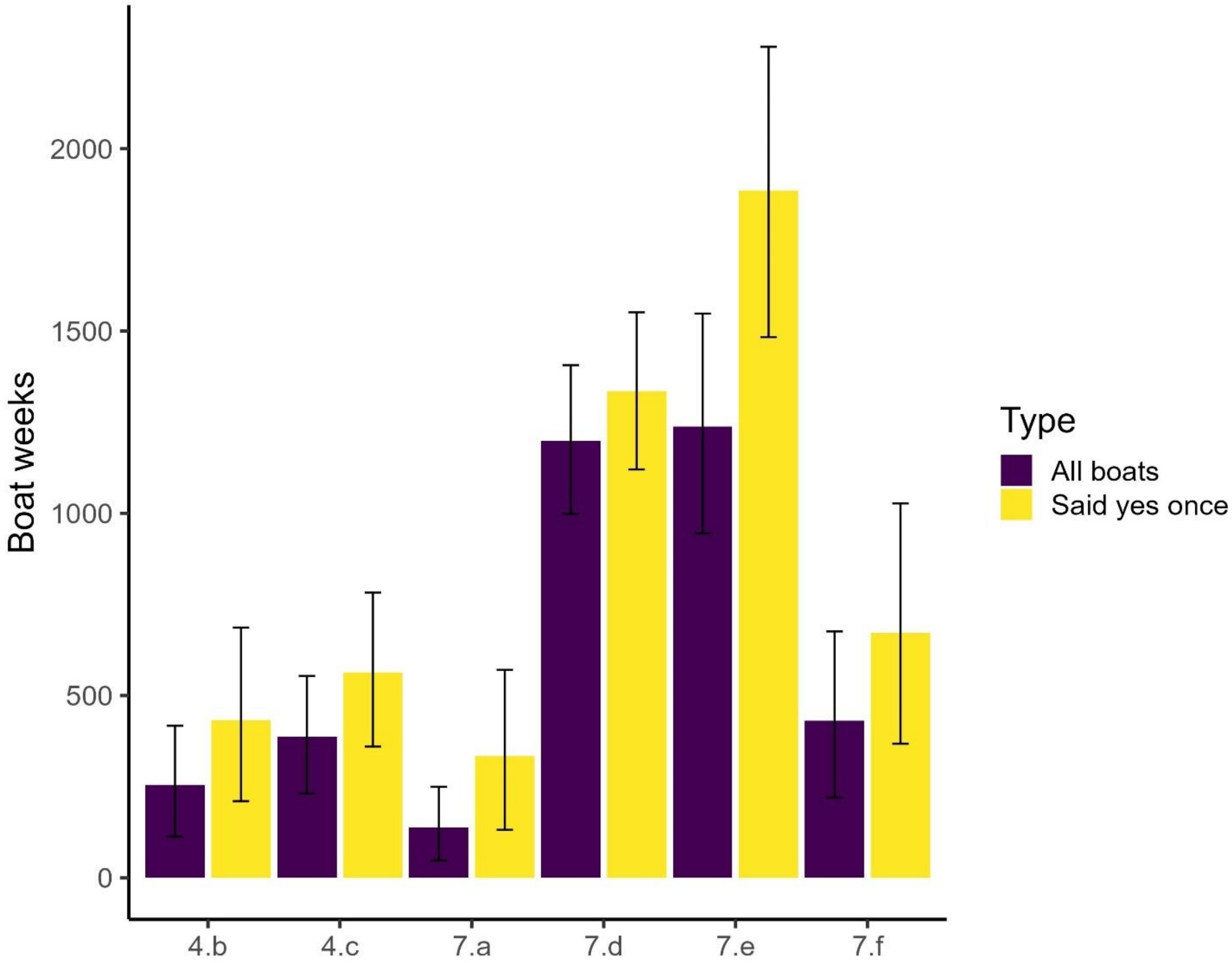

Figure 36: The total number of boat weeks fished per ICES division when all boats are included in the analysis and when boats that only responded 'no' were removed. Error bars are 95% PI.

3.2.4.4.2. Number of fish

Due to the limited availability of catch data in other regions, only ICES Divisions 7.d and 7.e are presented in the results. In total, when all boats were included on the effort calculations 350,500 fish were estimated, whereas when only boats that said yes once were included in the effort calculations this number increased to 480,512. For both methods, there was an 8% RSE in the total number of fish, and 64% of the fish caught were released. The species-specific catch estimates from the survey are shown in Figure 37.

Among all species recorded, black bream had the highest estimated total catch, with 71,285 fish returned (RSE 20%), followed closely by mackerel, which had the highest retained catch at 63,060 fish (RSE 36%).

Mackerel, pollack, bib, and European squid were the only species where more fish were retained than returned. However, for bib and squid, the differences between kept and returned numbers were small, and overlapping 95% PI suggest that the observed differences may be due to the survey error. Both species also exhibited higher levels of uncertainty, with broad error margins affecting the reliability of their estimates.

Among all species recorded, only a few had RSE values below 30%, reflecting the generally high error levels in the catch portion of the survey. Lesser spotted dogfish (returned), bass (kept and returned), black bream (kept and returned), conger eel (kept), pollack (kept), plaice (kept), and bull huss (returned) were the only species meeting this threshold, suggesting that these estimates are relatively more precise compared with others.

Overall, the results highlight substantial variability and uncertainty in species-specific catch estimates, particularly for species with lower sample sizes or highly variable catch rates. This reinforces the need for cautious interpretation of species-level results, particularly where RSE values exceed 30% and PI indicate high uncertainty.

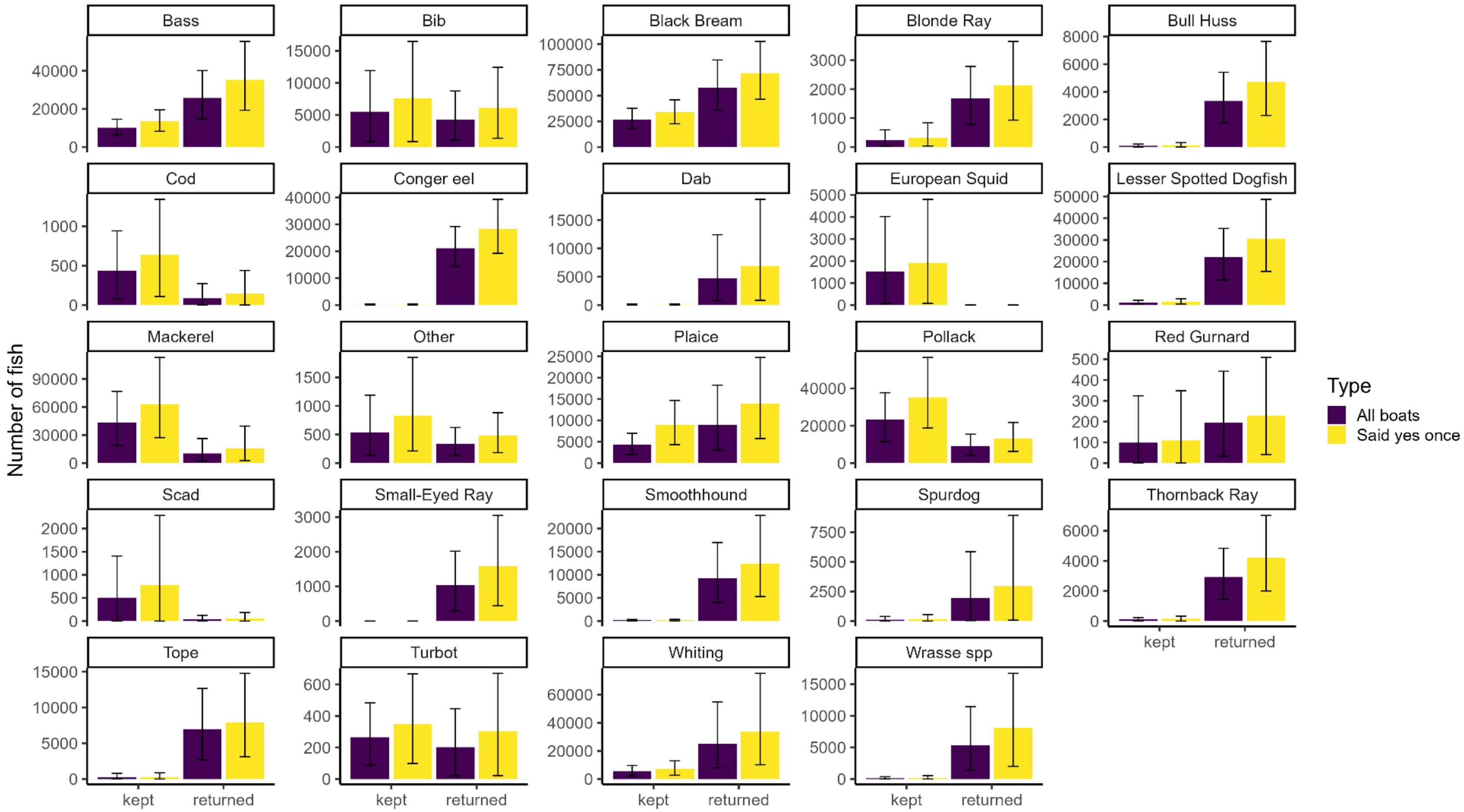

Figure 37: The total number of fish caught in the Catchwise charter boat survey that had a home port in ICES divisions 7.d and 7.e, both when all boats are included in the analysis and when boats that only responded no were removed. Error bars are 95% PI.

3.2.4.4.3. Tonnage

The total estimated charter boat catch in ICES Divisions 7.d and 7.e varied depending on whether boats that only ever reported “no” to fishing were included in the effort calculations. When all boats were included, the estimated retained tonnage was 139.2 tonnes (RSE 13.9%), with 924.6 tonnes (RSE 19.5%) returned. When only boats that had reported fishing at least once were included, these estimates increased to 198.6 tonnes retained (RSE 14.4%) and 1,263.5 tonnes returned (RSE 20%).

Figure 38 presents the species-specific breakdown of total tonnage, highlighting the contribution of different species to the overall catch. Large-bodied species with high return rates, such as conger eel (314 tonnes) and tope (130 tonnes), also exhibited substantial estimated tonnage despite lower catch numbers. Among species where retained tonnage exceeded returned biomass, pollack and mackerel stood out, with both species showing a clear preference for retention. Plaice exhibited similar total tonnage estimates regardless of whether fish were kept or returned, suggesting a more balanced distribution in retention patterns. As with the total number of fish caught, the species-specific tonnage estimates were highly uncertain, with large RSE values for many species. This reflects high variability in individual fish weights and limited sample sizes for certain species, making precise estimation of species-level biomass more challenging. While the overall trends in species retention and return patterns provide valuable insights, caution is required when interpreting individual species estimates due to the broad PI and high uncertainty associated with many of these values.

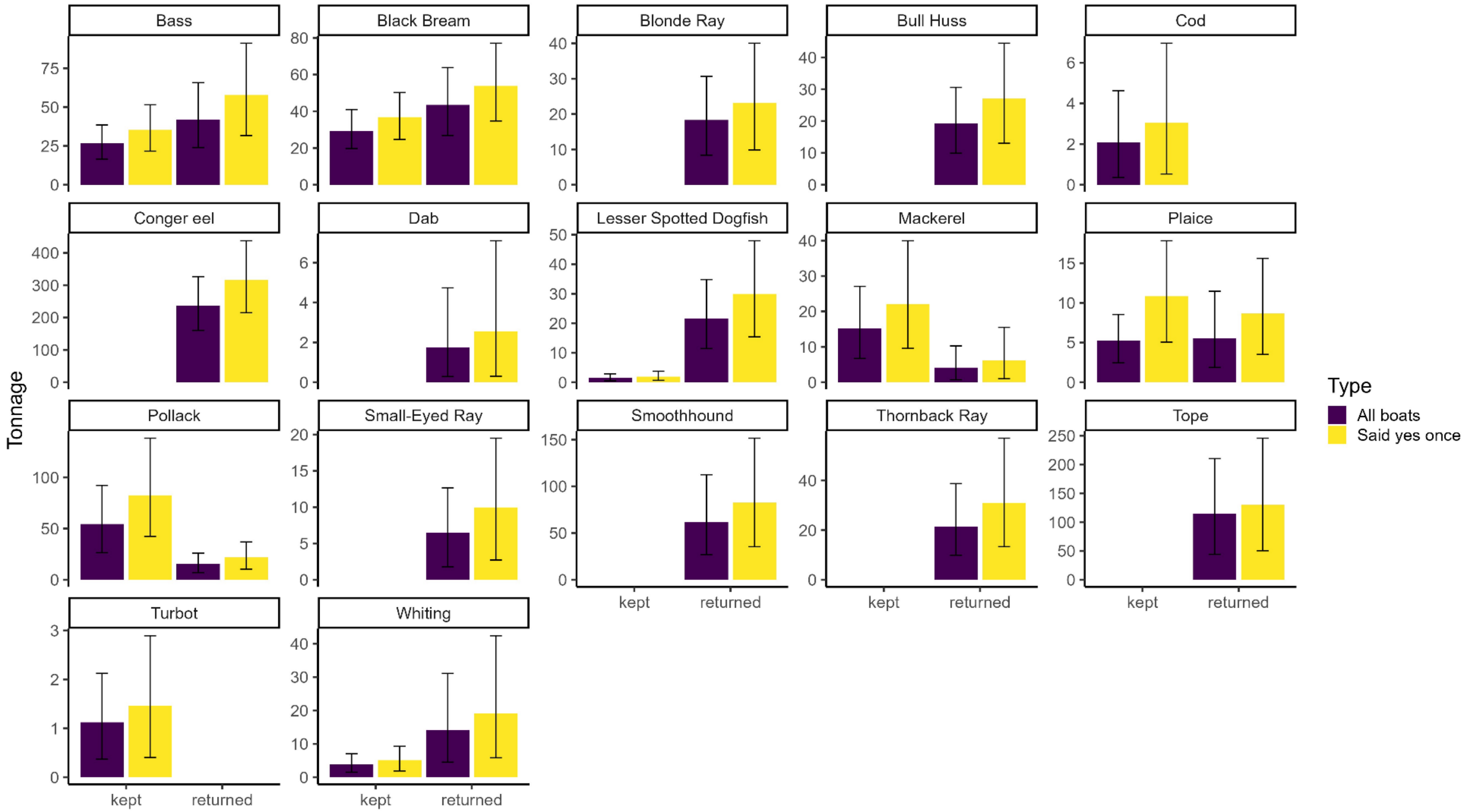

Figure 38: The tonnage of fish caught in the Catchwise charter boat survey that had a home port in ICES divisions 7.d and 7.e, both when all boats are included in the analysis and when boats that only responded no were removed. Error bars are 95% PI.

3.3. Comparison with other surveys

3.3.1. Shore survey

3.3.1.1. Effort

Figure 39 presents a comparison of total shore angling trips in England across three available survey estimates: the Sea Angling 2012 survey, Catchwise, and the 2023 WPS, which provides effort estimates for the SADP. While total angling trips from the WPS are not the primary effort estimate used for extrapolation in the SADP, its estimates provide a benchmark for comparison. Due to difficulties in encountering private boat anglers, effort estimates could not be produced and so are not compared here.

The results show strong alignment between the three surveys, with WPS estimating 2.7 million angling days (RSE 13.8%), the Sea Angling 2012 survey producing an identical estimate of 2.7 million days (RSE 15.9%), and Catchwise estimating 2.4 million days (RSE 15.0%). Although the Catchwise estimate is slightly lower, the PI overlap, suggesting that these differences fall within expected variability. The close agreement between independent survey approaches reinforces confidence in the validity of these estimates, indicating that recreational fishing effort in England is being consistently captured across multiple methodologies.

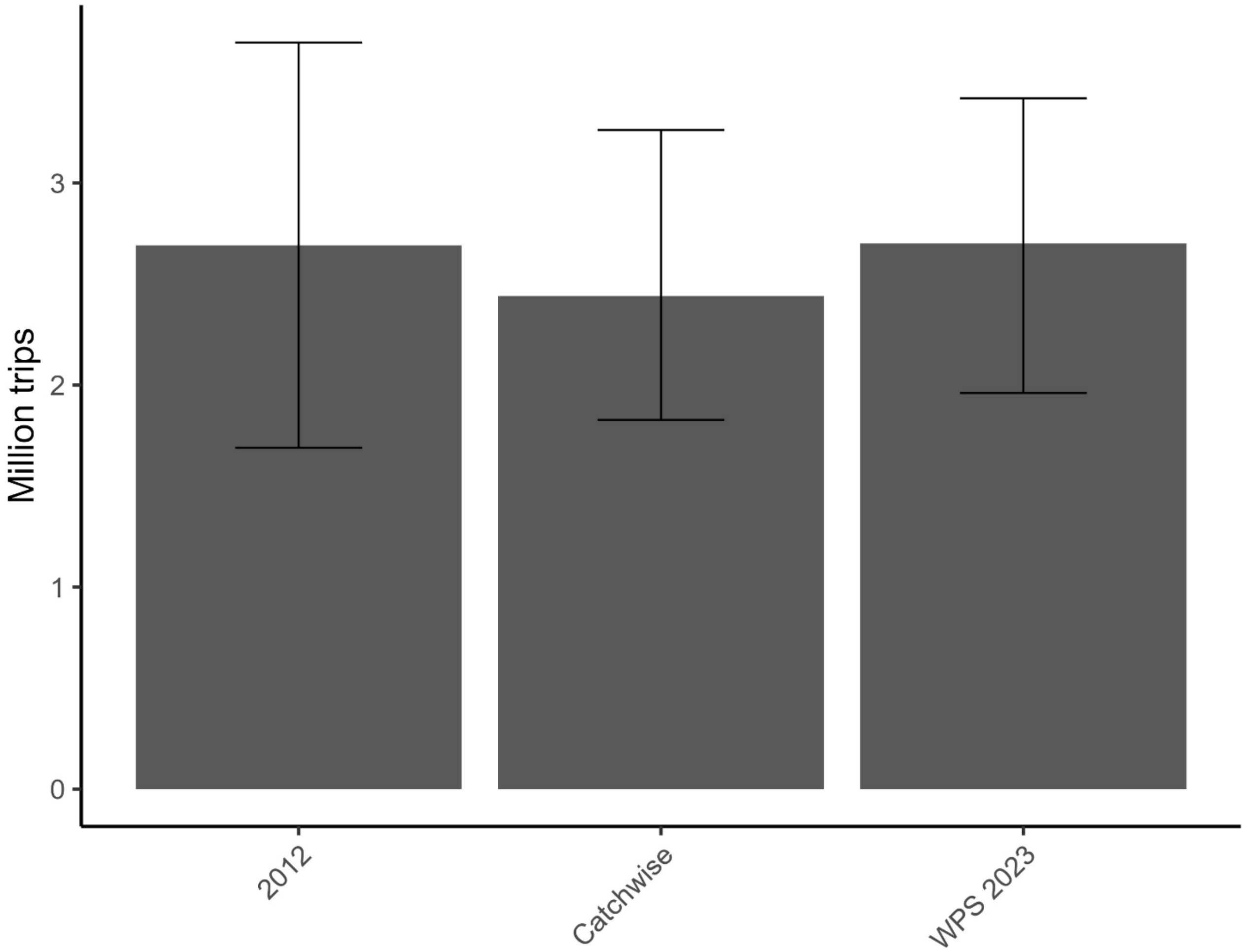

Figure 39: The total number of fishing trips in England estimated in the Sea Angling 2012 study, Catchwise, and the Watersports Participation Survey (WPS) results from 2023.

3.3.1.2. Total catch

Figure 40 presents a comparison of total shore catch estimates across the three surveys, highlighting similarities and differences in species-specific catches between the SADP, Catchwise, and the 2012 survey.

For many species, Catchwise and SADP produced similar total catches, with overlapping 95% PI, indicating consistency in catch per trip estimates. These species included bass, bib, black bream, cod, conger eel, dab (kept), flounder, lesser spotted dogfish, mackerel (returned), plaice, pollack, smoothhound, and thornback ray. The strong agreement between these two independent survey approaches suggests that these species' catch rates are being captured reliably across both datasets. Despite this overall alignment, Catchwise produced higher estimates than SADP for certain species, particularly dab (returned), mackerel (kept), pollack (kept), whiting (returned), and wrasse species (returned). These differences may be due to variations in catch composition across the survey methodologies, differences in angler reporting behaviour or the SADP estimate being for 2023 not 2024.

Catch estimates from the 2012 survey were generally lower than those from both Catchwise and SADP, particularly for bass (returned), bib (returned), black bream, dab (returned), lesser spotted dogfish (returned), mackerel (kept and returned), smoothhound (kept and returned), whiting (kept and returned), and wrasse species (kept and returned). The higher catches in the Sea Angling 2012 survey may reflect shifts in fish populations over time. Additionally, differences in survey methodology and extrapolation approaches may contribute to the observed discrepancies, with Catchwise and SADP using MRP estimate total catch.

The overall patterns suggest that while there is strong agreement between Catchwise and SADP for many species, the higher estimates in the 2012 survey may indicate historical differences in fishing effort, stock abundance, or methodological factors that should be considered when interpreting long-term trends in recreational fishing catches.

3.3.1.3. Tonnage and average weights

Figure 41 presents a comparison of tonnage estimates across the three surveys, highlighting similarities and differences in species-specific tonnage estimates between Catchwise, the SADP, and the Sea Angling 2012 survey. As observed with total catch numbers, tonnage estimates were largely similar between Catchwise and SADP, with most species having overlapping 95% PI, indicating consistency between these two datasets. Some notable differences were observed, with mackerel (kept) and smoothhound (returned) having higher estimated tonnages in Catchwise. However, the smoothhound estimates in Catchwise were associated with high uncertainty due to the limited number of length measurements available, making interpretation more challenging. Across most species, tonnage estimates in the 2012 survey were lower than those in Catchwise and SADP.

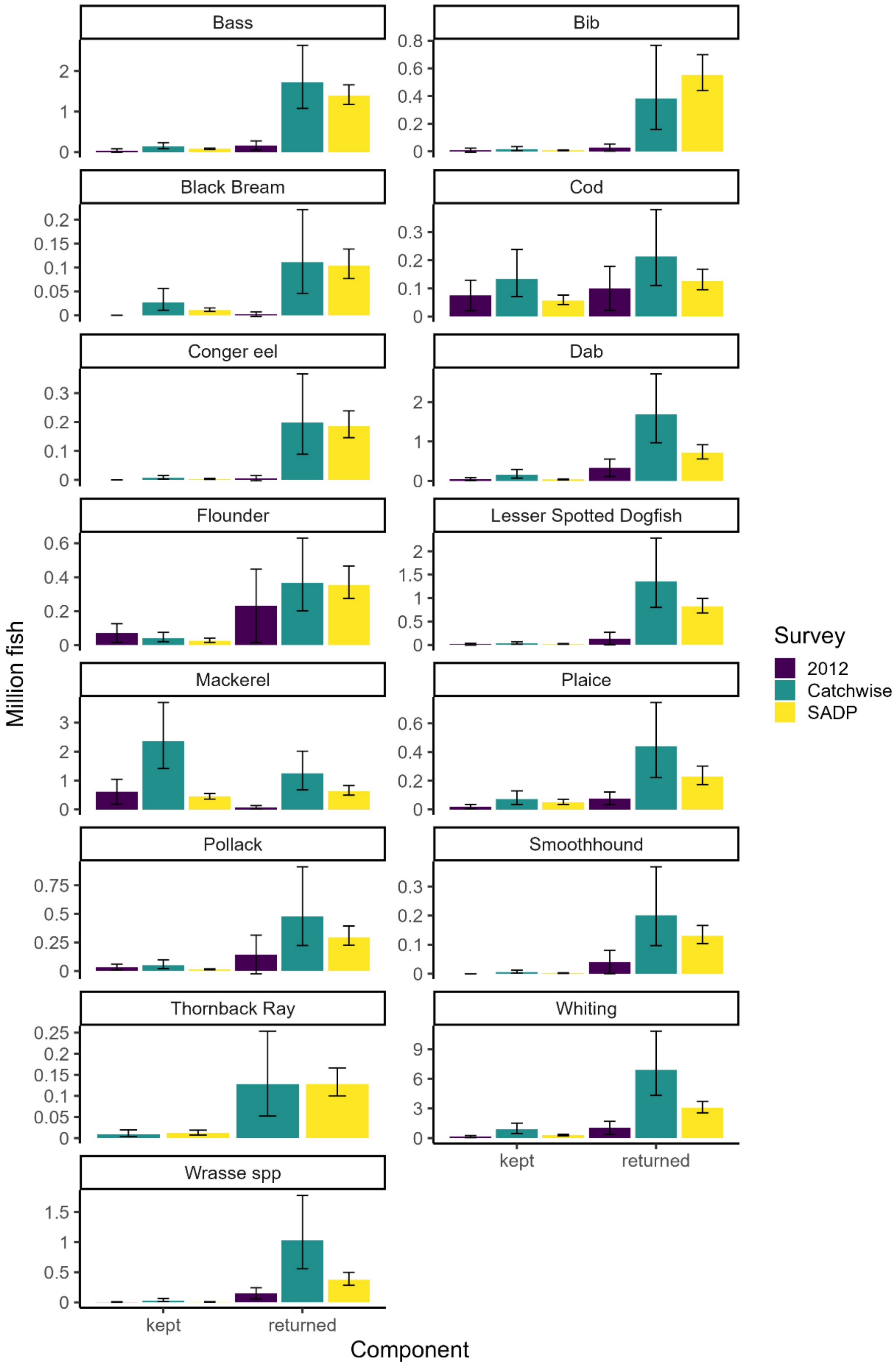

Figure 40: The total catch estimates in England from the Sea Angling 2012 survey, Catchwise, and the 2023 SADP catches. Error bars are 95% PI.

To further investigate differences in tonnage, Figure 42 compares the average fish weights across the three surveys. A key limitation in this analysis is the lack of reported errors for average weights in the 2012 survey, making direct statistical comparisons difficult. Instead, the alignment of mean values with 95% PI from Catchwise and SADP was examined to assess potential differences. In general, most species exhibited similar average weights across all three surveys, suggesting a consistent size distribution of retained and released fish. However, some differences were observed, particularly in the 2012 dataset, where bass (kept), cod (kept), mackerel (returned), pollack (kept and returned), and wrasse species had lower average weights. The discrepancy for wrasse species may be explained by differences in species composition, as the wrasse category includes multiple species with varying size distributions. Conversely, the 2012 survey recorded higher average weights for lesser spotted dogfish (returned), suggesting that larger individuals may have been more commonly reported in that dataset.

SADP exhibited higher average weights for dab (kept and returned), flounder (kept), plaice (kept and returned), and whiting (kept and returned), while smoothhound (returned) and wrasse species (returned) had lower average weights compared with the other surveys. Again, the differences in the wrasse species composition across datasets could account for these discrepancies. Mackerel (kept) had similar average weights across all surveys, indicating that the higher tonnage estimate in Catchwise was primarily driven by differences in the number of fish caught rather than variations in individual fish size.

Some of these observed differences may be attributable to sample size variations across surveys. The SADP dataset is based on thousands of fish reported since 2016, providing a more extensive record of weight measurements. In contrast, Catchwise and the 2012 survey relied on a more limited number of observed fish, making them potentially more sensitive to sampling variability.

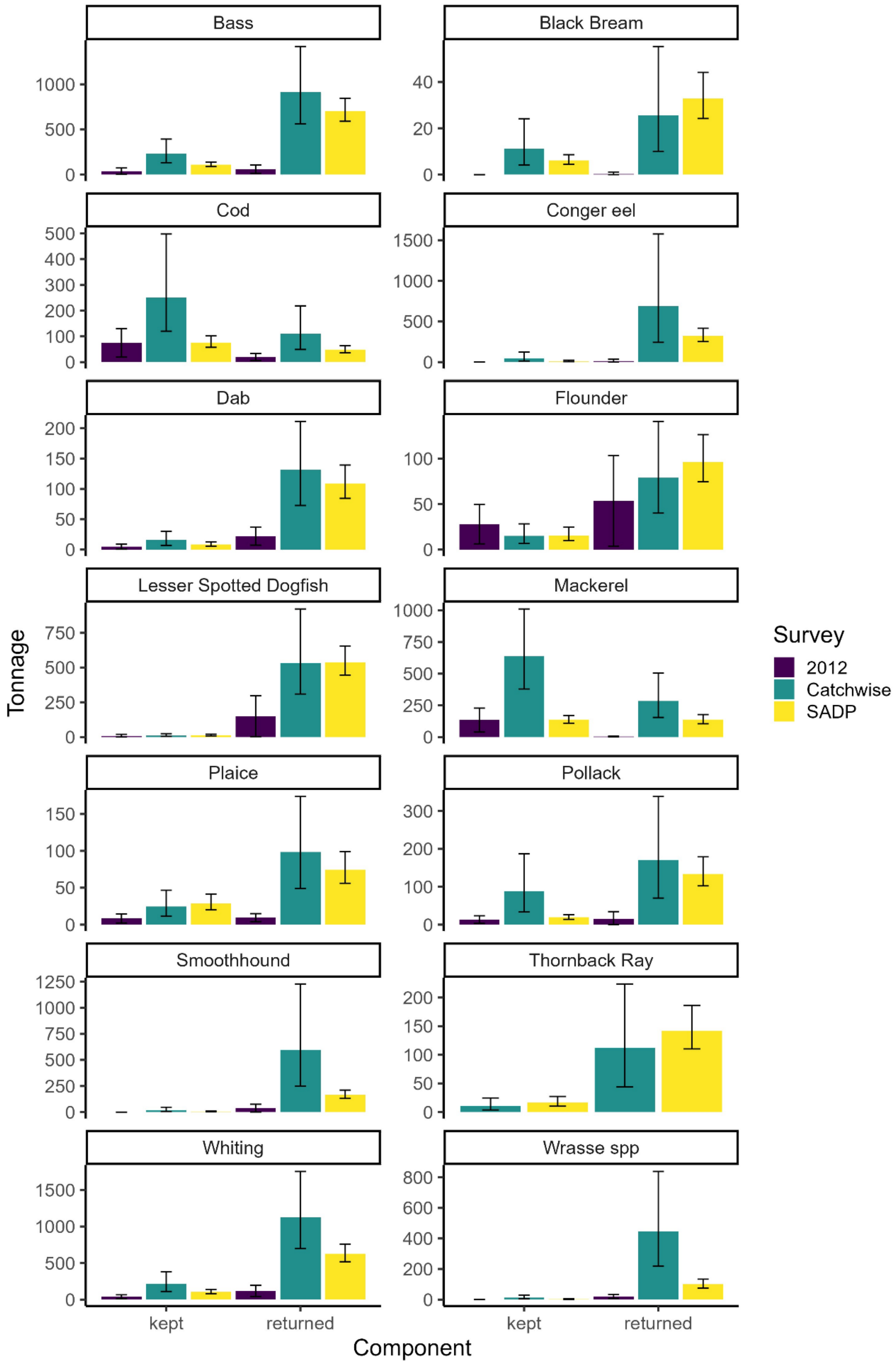

Figure 41: The total tonnage estimates in England from the Sea Angling 2012 survey, Catchwise, and the 2023 SADP catches. Error bars are 95% PI.

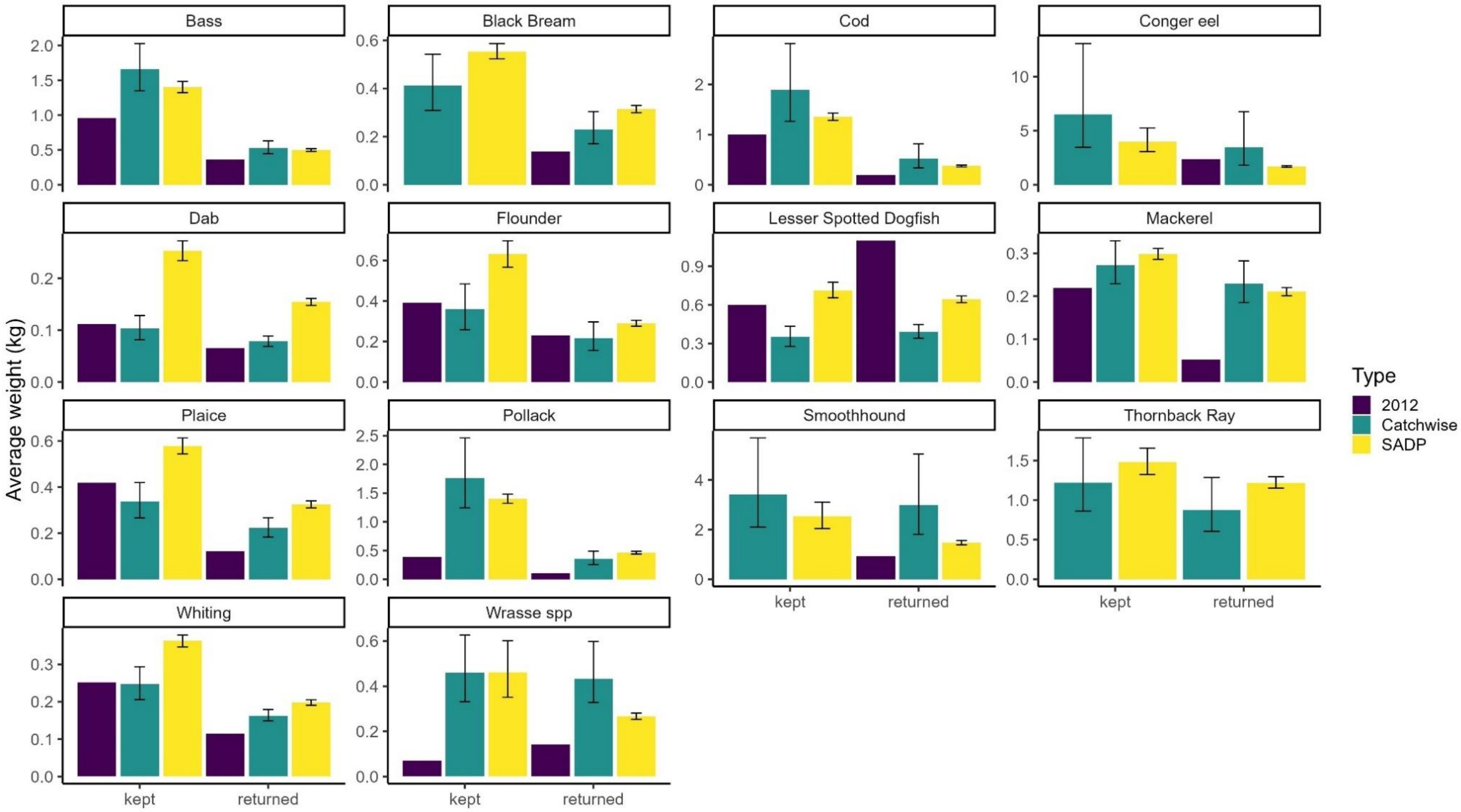

Figure 42: The average weight estimates in England from the Sea Angling 2012 survey, Catchwise, and the 2023 SADP catches. Error bars are 95% PI. Average weight PI's were not available for 2012.

3.3.1.4. Differences between Catchwise and the SADP

Figure 43 depicts an additional comparison between Catchwise and the SADP to see where percentage differences occur between the total number of fish, tonnage and average weight of fish caught occurred, alongside if the 95% PI for these estimates overlapped. For most species, the kept component in Catchwise was higher than the SADP, but with overlapping 95%. Similarly, the returned component of the catch was typically between slightly lower and slightly higher, again with overlapping 95% PI. Differences in average weights were generally lower for the kept component, but the estimates were within 25% of the SADP estimate for the returned component. Pollack, smoothhound whiting and wrasse species were the only species where significant differences in the total numbers of fish or tonnage caught were observed, where Catchwise gave higher estimates of total catch.

From these data we can see that Catchwise and the SADP typically align in terms of number, tonnage and average weights. Whilst there are some differences, the SADP data is based on a substantially larger sample size of lengths provided by anglers and so may be more representative.

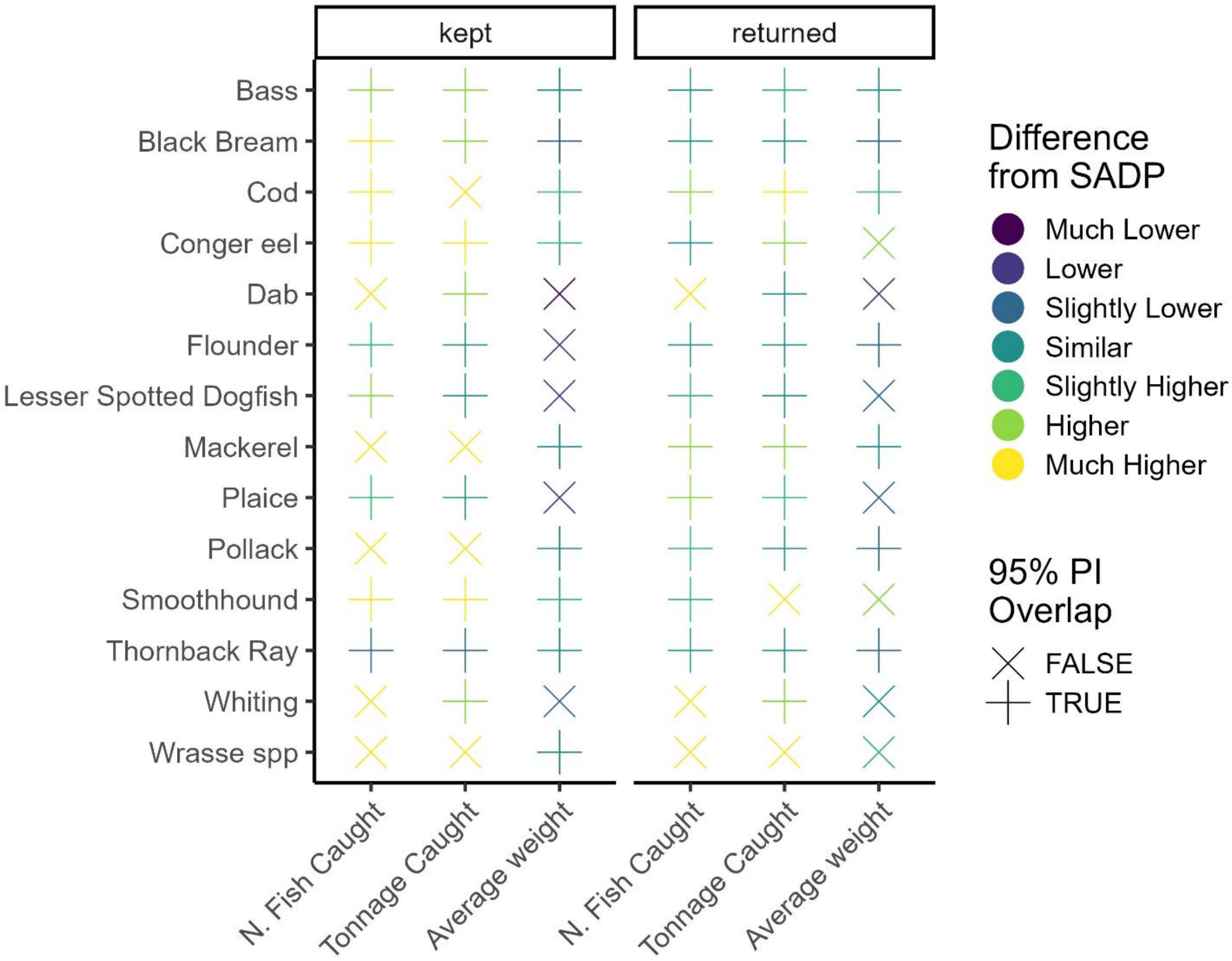

Figure 43: A comparison of the total number of fish and tonnage caught alongside the average weights between Catchwise and the sea angling diary project estimates. The colours represent the scale of the difference between the two surveys with the different colours representing >=75% to <=75% difference at 25% intervals. The 'X' or '+' indicates if the 95% PI's for the survey estimates overlapped, depicting if the differences are significant.

3.3.2. Charter boat survey

3.3.2.1. Effort

Figure 44 presents the percentage of responses in each month where no fishing trips occurred in Catchwise, comparing both all boats and only boats that reported fishing at least once, alongside data from the Sea Angling 2012 survey. Across all months, Catchwise reported a higher proportion of no-fishing responses, regardless of whether boats that consistently reported no activity were excluded. This trend was particularly pronounced in the summer months, suggesting potential differences in charter boat fishing patterns between the surveys.

The Sea Angling 2012 survey estimated a total of 105,871 charter boat angling trips (95% PI: 80,970 – 130,772) using a pure logbook-based approach, similar to the methodology employed in Catchwise. However, an additional effort estimate was produced using an Office for National Statistics (ONS) study, which followed a methodology comparable to the WPS. This alternative approach yielded a significantly higher estimate of 370,825 trips (95% PI: 130,975 – 610,674), highlighting a substantial difference depending on the effort estimation method used. The 2023 WPS produced an estimate of 300,836 trips (95% PI: 218,390 – 380,826), which, while lower than the 2012 ONS study, remained considerably higher than Catchwise estimates.

To generate a comparable estimate for Catchwise, raw data were used to calculate the average number of trips per week (2.28) and the average number of anglers per boat (6.3). These values were then multiplied by the total number of boat weeks recorded in Catchwise, which was 5,221 when including all boats and 3,649 when excluding boats that never reported fishing. This resulted in estimates of 52,311 angler-days for all boats and 74,847 angler-days when trimming boats that reported yes to going fishing once within the survey. These estimates are substantially lower than all other surveys, suggesting that Catchwise has recorded lower effort compared to previous studies.

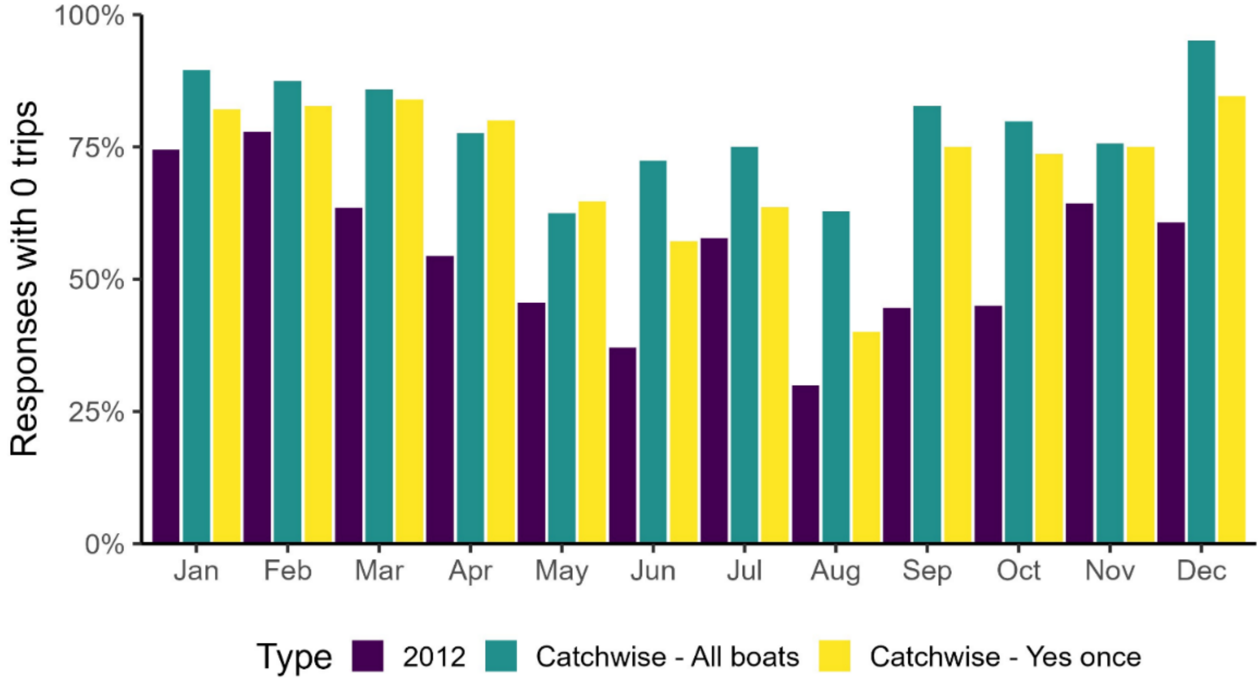

Figure 44: The percentage of responses received in the survey where a charter boat did not go fishing in a week in each month in Catchwise, comparing both all boats (Catchwise – All boats) and only boats that reported fishing at least once (Catchwise- Yes once), alongside data from the Sea Angling 2012 survey.

3.3.2.2. Total Catch and CPUE

Figure 45 presents the total number of fish caught by charter boats in ICES divisions 7.d and 7.e across the Sea Angling 2012 survey, Catchwise (both All boats and only boats that reported fishing at least once (Yes once) and the 2023 estimate from the SADP. The comparison focuses on species reported in both Catchwise and at least one of the other surveys to assess the consistency of total catch estimates.

For most species, Catchwise estimates were lower than those from SADP, with exceptions including blonde ray (kept), dab (returned), pollack (kept), spurdog (kept and returned), and tope (kept and returned), where Catchwise produced higher values. Tope (kept) and spurdog (kept and returned) were higher in Catchwise than in SADP. In contrast, cod (kept) and plaice (kept) had higher total catch estimates in the 2012 survey than in any of the other datasets, which may reflect declines in stock sizes over the past decade, influencing both catch rates and retention behaviour. Despite some variability in species-level estimates, the skipper-based logbook approach used in both the 2012 survey and Catchwise consistently produced lower total catch estimates compared to SADP. However, as demonstrated in the effort analysis, Catchwise also recorded much lower fishing effort than SADP and Sea Angling 2012. To determine whether effort alone accounts for the differences in total catches, further analyses of CPUE were required.

Figure 46 presents a boxplot of catch per angler per hour, plotted on a log10 scale, for all trips in Catchwise and SADP (2023 trips only) where at least one fish was recorded. This is complemented by Figure 47, which shows the percentage of charter boat trips that reported zero catches for each species in both surveys. The results indicate that CPUE estimates were highly similar between Catchwise and SADP, suggesting that differences in total catches were not driven by large discrepancies in per-trip catch rates. The only notable differences in CPUE were observed for cod (kept), blonde ray (kept), and thornback ray (kept), along with smaller differences for turbot (kept and returned), red gurnard (returned), small-eyed smoothhound (kept), and small-eyed ray (returned), all of which were higher in SADP. However, for blonde ray (kept) and thornback ray (kept), the low number of recorded trips in SADP makes it difficult to draw firm conclusions about true differences in catch rates.

Furthermore, the percentage of trips reporting zero catches was similar between Catchwise and SADP, reinforcing the consistency in CPUE estimates across both datasets. In some cases, Catchwise even recorded a higher proportion of trips with successful catches than SADP, such as for bass and conger eel (returned). These findings suggest that differences in total catches are primarily driven by effort differences rather than significant variations in CPUE.

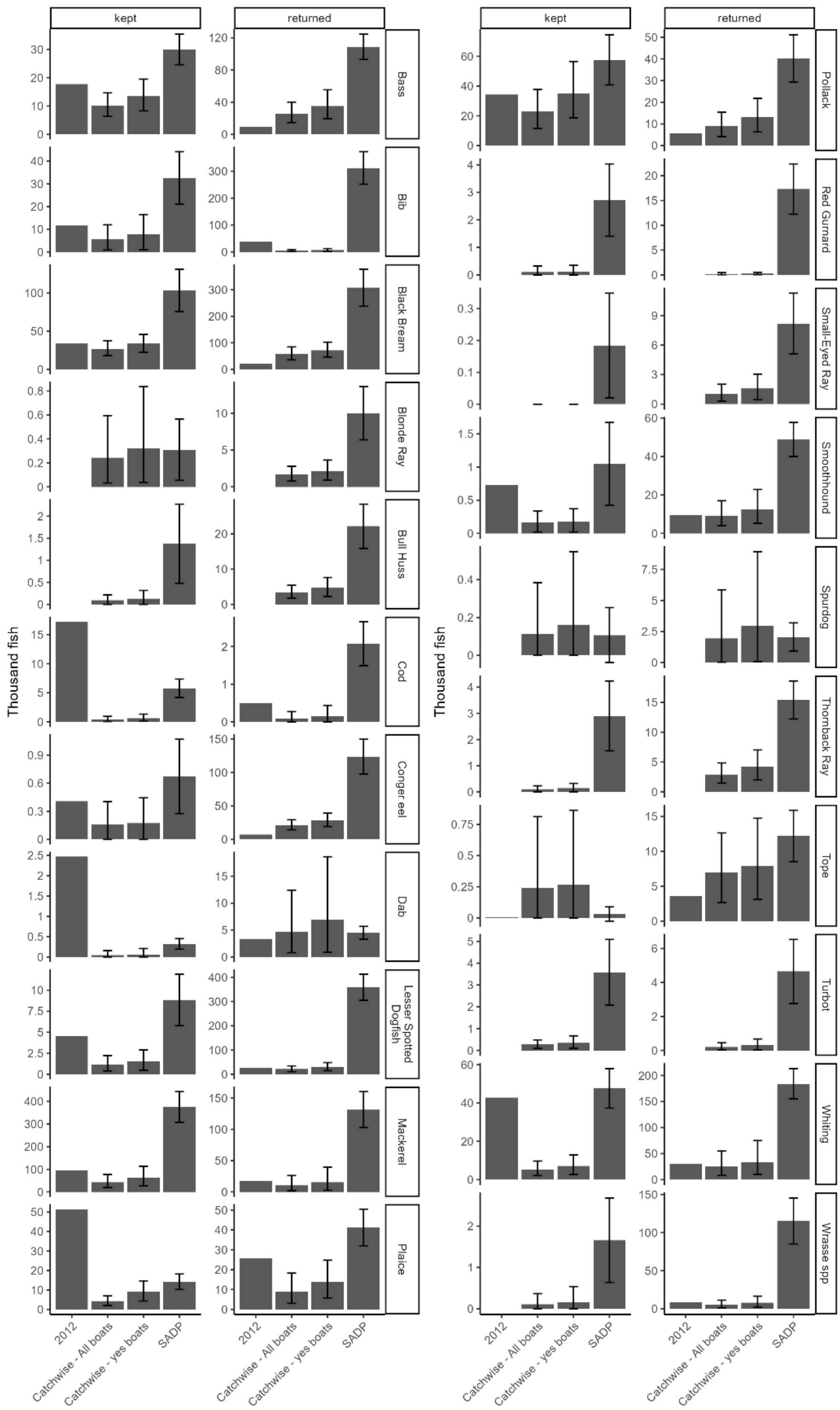

Figure 45: The total number of fish caught by Charter Boats fishing in ICES divisions 7.d and 7.e in the Sea Angling 2012 survey, Catchwise (inclusion and exclusion of the boats that only said no to going fishing) and the Sea Angling Diary Project (SADP; 2023 estimate). Error bars are 95% PI.

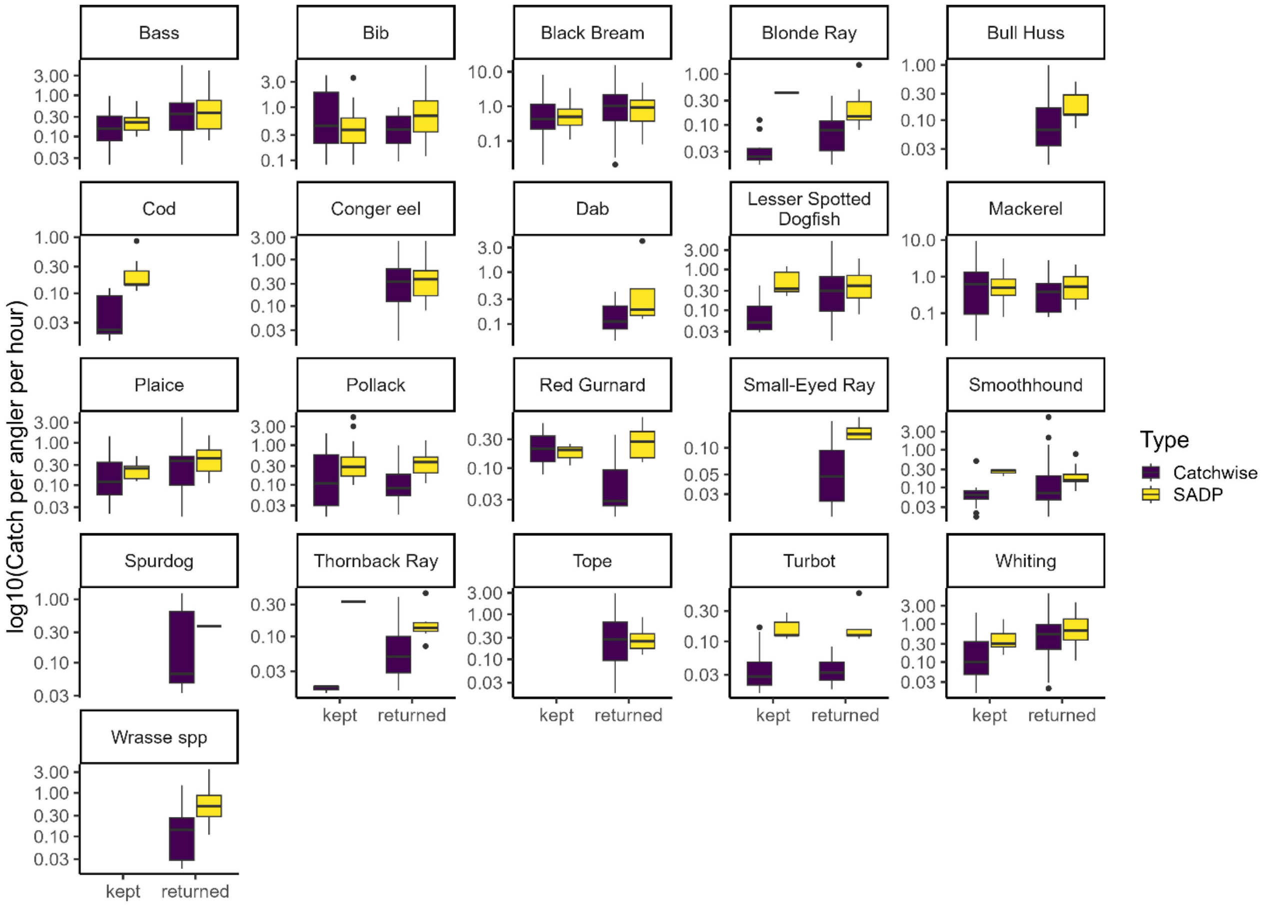

Figure 46: The catch per angler per hour, presented on a log10 scale, for each trip in the Catchwise and sea angling diary project (SADP; 2023 trips only) where an above 0 catch was recorded, for each species reported in both surveys.

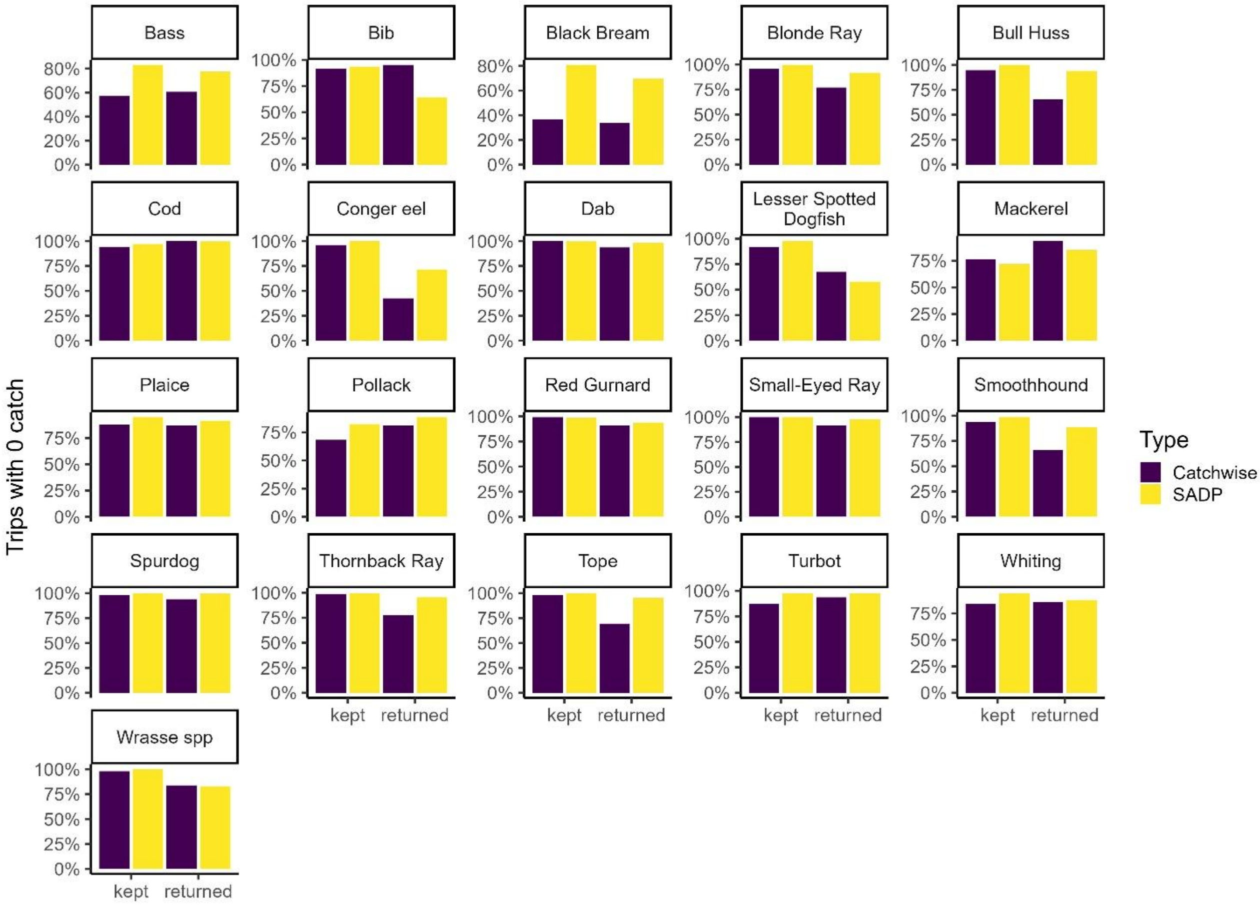

Figure 47: The percentage of charter boat trips that did not report catching a species in the Catchwise and sea angling diary project (SADP; 2023 trips only), for each species reported in both surveys.

3.3.2.3. Tonnage and average weights

Despite the lower number of fish recorded in the 2012 Sea Angling survey and Catchwise compared to SADP, tonnage estimates were often more similar between these surveys for many species, as shown in Figure 48. Species where tonnage estimates in Catchwise and 2012 were closely aligned with the SADP included bass, black bream, blonde ray, bull huss, conger eel, plaice (returned), pollack, small-eyed ray, smoothhound, thornback ray, tope, and whiting (returned). One key exception was cod, where both total catch and tonnage were higher in the 2012 survey than in the other datasets, although this could be due to reductions in cod biomass.

To further explore these patterns, Figure 49 examines average fish weights across the three surveys. The results indicate that SADP consistently reported the lowest average weights for most species, suggesting that smaller fish were more commonly reported in that dataset. In contrast, Catchwise produced higher average weights than both 2012 and SADP, with the largest differences observed in elasmobranch species. Additionally, whiting in Catchwise were significantly larger on average than in the other surveys.

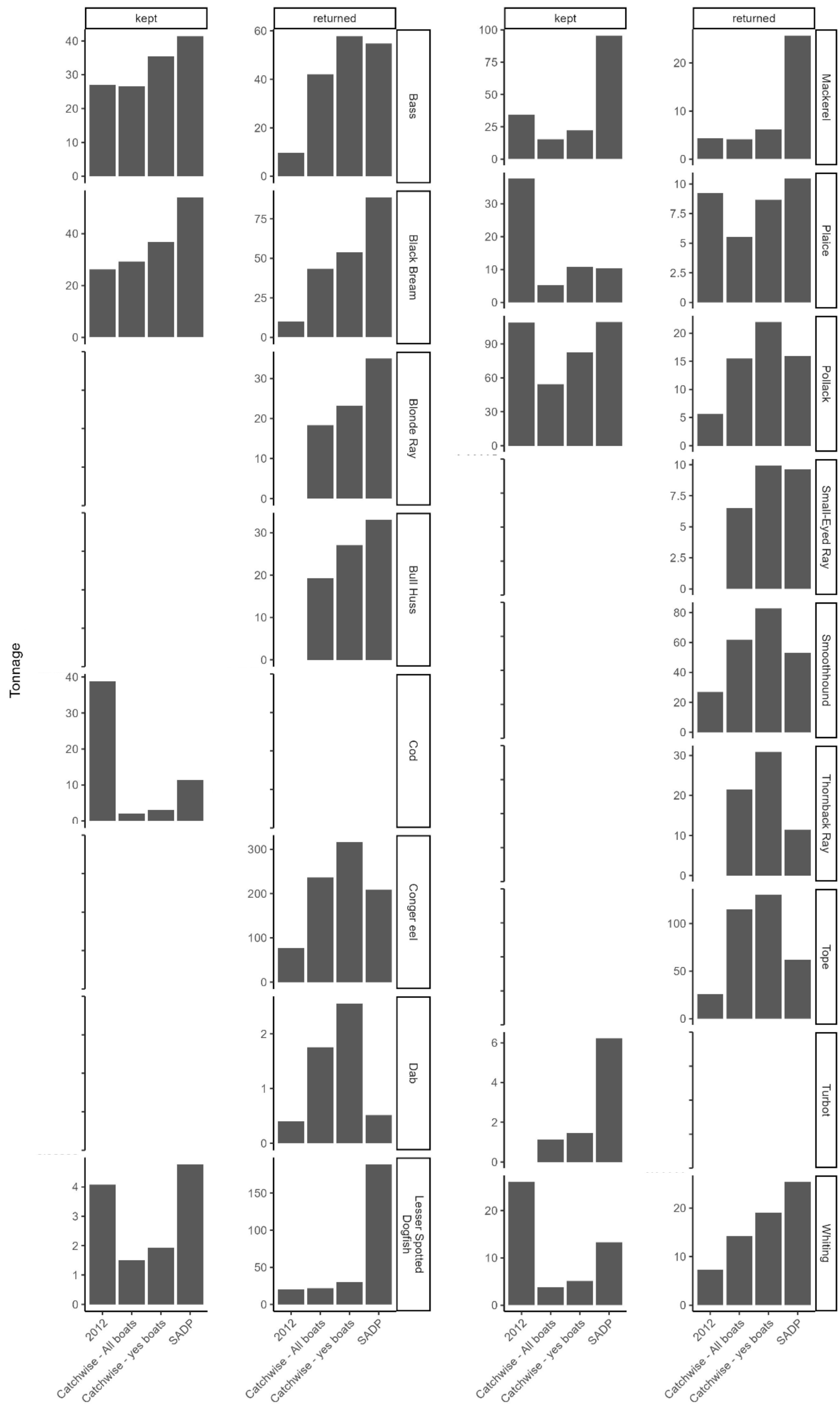

Figure 48: The tonnage of fish caught by charter boats fishing in ICES divisions 7.d and 7.e in the Sea Angling 2012 survey, Catchwise (including/excluding boats that only said no), and the Sea angling diary project (SADP; 2023 estimate).

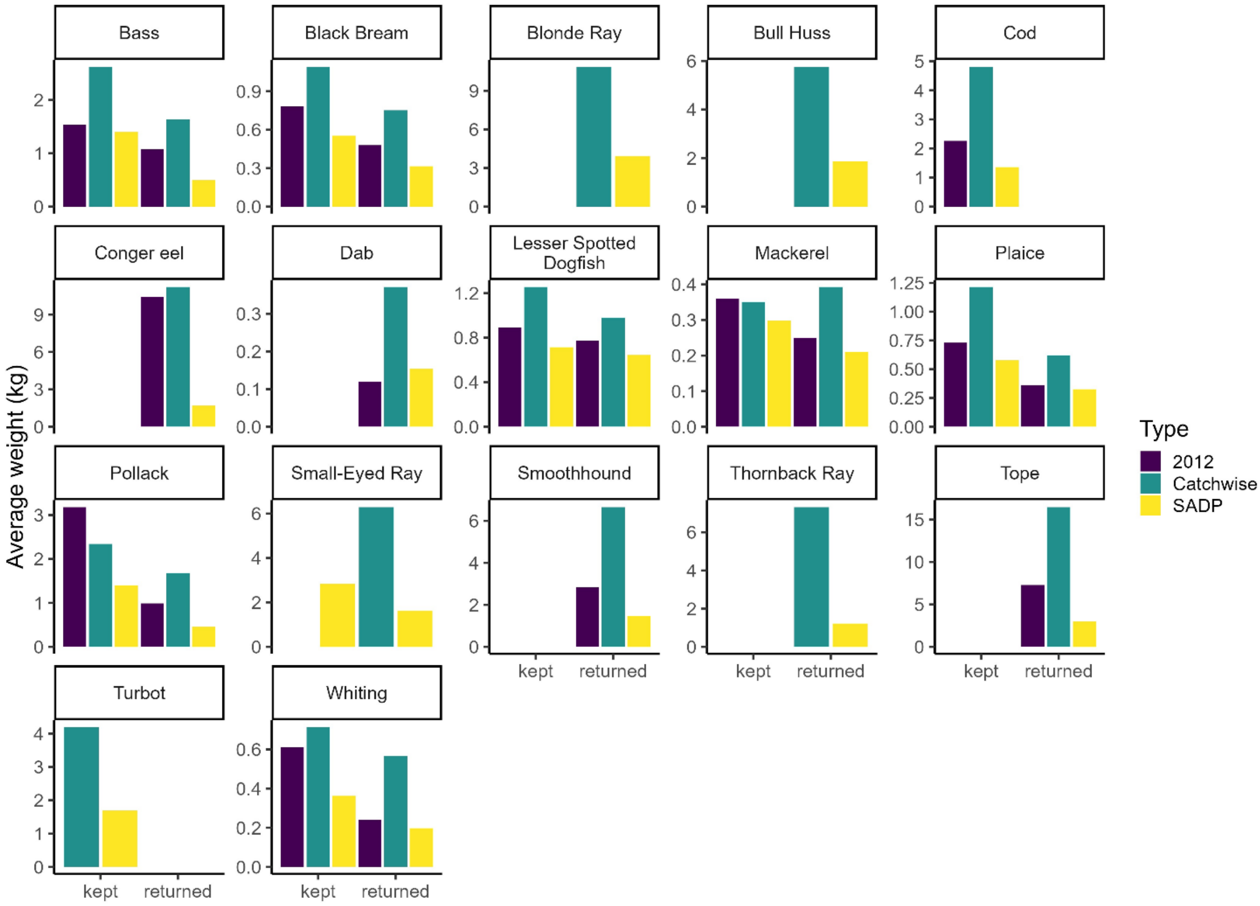

Figure 49: The average weight (kg) of fish caught by charter boats fishing in ICES divisions 7.d and 7.e in the Sea Angling 2012 survey, Catchwise, and the Sea angling diary project (SADP).

4. Discussion

Catchwise represents the most comprehensive probabilistic onsite survey of shore and charter boat MRF effort and catch conducted in England since Sea Angling 2012 (Armstrong *et al.*, 2013), and the first of its kind implemented across the whole of Wales. The survey was co-designed with key stakeholders and the angling community, ensuring its methodology aligned closely with sector needs and practical to implement. Importantly, Catchwise provided a valuable opportunity to validate and compare findings with the SADP, the current primary method for monitoring MRF participation and catches in England and Wales (Hyder *et al.*, 2024). By using rigorous probabilistic sampling techniques, Catchwise has identified limited biases inherent in previous methodologies, delivering robust data to support management strategies and inform future decisions under the Fisheries Act 2020. Additionally, the project has enhanced engagement within the recreational angling community, demonstrating strong public willingness to participate in data collection and fostering closer relationships between anglers and fisheries managers in England and Wales.

The shore survey was the most successful component of the Catchwise study, demonstrating robust spatial and temporal coverage combined with consistently high response rates. These factors significantly reduce the potential for bias and suggest that the survey provides a representative estimate of shore angling activity across England and Wales. Two analytical methods were explored to extrapolate survey results: mode-based approaches that follow the MRP process, and bootstrapping. Differences between these approaches were predominantly driven by the inclusion of environmental variables; specifically, tidal conditions and the time of day in the MRP model. Such environmental influences have previously been documented in other recreational fisheries studies (Bian and Hartill, 2015; Hyman *et al.*, 2024). Additionally, the MRP model demonstrated superior capability in accurately completing partial trip records compared to traditional methods.

MRP has received extensive attention in recent literature due to its capacity to generate robust estimates from survey data, especially when certain groups or conditions are underrepresented in direct sampling (Gelman, 1997; Rivers and Bailey, 2009; Ansolabehere and Rivers, 2013; Wang *et al.*, 2015; Gelman *et al.*, 2016). The use of models for post-stratification can also effectively incorporate continuous predictors, or predictors it is challenging to stratify a survey by (such as weather), which can be critical in understanding nuanced environmental or behavioural relationships influencing angler effort and catch rates (Wang *et al.*, 2015; Gelman *et al.*, 2016). Hierarchical models, similar to those applied in this study, have consistently outperformed traditional methods such as reweighting and boosted regression trees when predicting recreational fishing effort and catch from probabilistically collected data (Martínez-Rincón *et al.*, 2012; Navarro *et al.*, 2020; Tate *et al.*, 2020; Mars *et al.*, 2022).

In contrast to effort modelling, the catch model did not integrate environmental variables, a limitation also observed in previous studies where environmental factors are frequently excluded due to limited sample sizes available to quantify correlations (Taylor *et al.*, 2011; Aidoo *et al.*, 2015; Wikstrom, 2015). However, given the increasing availability of detailed datasets, there is potential for future application of more sophisticated analytical approaches, such as machine learning techniques, to better incorporate and leverage environmental data for modelling catch rates (Wikstrom, 2015).

The private boat survey faced significant challenges, largely stemming from the practical difficulties in identifying and accessing private boat launch sites within a probabilistic sampling framework. Increased security measures, including restricted access with keypad entry and extensive physical barriers, severely limited surveyor interactions with boat anglers. A reconsideration of the survey design would therefore be necessary to enhance the effectiveness of future surveys targeting this angling segment. Alternative survey methodologies such as at-sea, aerial, and digital camera monitoring offer potential solutions to these challenges. At-sea surveys, which involve direct interaction with anglers during fishing activities, have been successfully implemented elsewhere (Vølstad *et al.*, 2019; Ferter *et al.*, 2023) demonstrating superior coverage and data quality compared to traditional onsite and offsite sampling approaches. However, their high logistical complexity and associated costs may limit their feasibility (Bellanger and Levrel, 2017). Aerial surveys are effective primarily in delineated marine areas and must typically be paired with supplementary catch surveys, such as roving creel approaches, to produce comprehensive data on both effort and catch (Vølstad *et al.*, 2006; Veiga *et al.*, 2010; Hartill *et al.*, 2011). Although effective, aerial methods face scalability issues due to high operational costs and coverage constraints (Bellanger and Levrel, 2017). Nevertheless, due to the large sea area and complex coastline that would have to be patrolled, an offsite logbook study like the SADP is the most cost-effective method to collect MRF data.

Digital camera monitoring offers a more cost-effective and operationally practical alternative to aerial surveys, capable of efficiently capturing angling effort data (Smallwood *et al.*, 2012; van Poorten *et al.*, 2015; Hartill *et al.*, 2016, 2020; Keller *et al.*, 2016). When combined with machine learning approaches for boat detection (Cooke *et al.*, 2021), these systems could significantly reduce analytical labour requirements. Although logistical challenges concerning camera placement, data retrieval and how to effectively sample paddleboard and kayaks persist, digital camera methods present substantial advantages over traditional survey methods.

The charter boat survey followed a logbook study approach similar to the SADP, but was designed for skippers to complete rather than anglers. This method required strong engagement from the fleet, which was not successfully achieved outside of ICES divisions 7.d and 7.e. A large proportion of participating boats consistently reported no fishing activity, raising concerns about whether these vessels represent a non-response bias rather than an accurate reflection of their actual fishing behaviour. Several factors likely contributed to this pattern, including time constraints preventing skippers from completing the survey and concerns about the potential regulatory implications of reporting data. Some skippers attributed these concerns to bass regulations that they associated with the Sea Angling 2012 survey (Monkman, 2013; Williams *et al.*, 2018). Beyond potential reporting hesitancy, there is evidence of a broader decline in the charter boat sector since 2012 (Armstrong *et al.*, 2013). In that year, 399 charter boats were identified operating in England, whereas Catchwise recorded only 220 representing a 45% decline over 12 years. A similar pattern was observed in Wales, where 61 charter boats were documented in Monkman *et al.* (2015) and MMO (2020), compared to 48 in Catchwise, equating to a 22% loss over four years. Several factors may have contributed to this decline, including rising business costs (e.g., increased fuel costs), increased cost of living reducing customer demand, declining fishing opportunities, more extreme weather events linked to climate change, skippers retiring with limited recruitment into the sector, and competition from other research projects, such as the black bream and pollack FISP projects, and the bluefin tuna fishery opening. Further research is needed to disentangle these drivers and determine their relative impact on charter boat participation.

Due to uncertainties surrounding non-response bias in the charter boat survey, additional validation is required. Further analysis should focus on disaggregating platform-specific catches within SADP data to provide a clearer comparison with Catchwise results. Future survey efforts could explore the use of onboard observers, as implemented in Irish charter boat studies (Ryan and Roche, 2023), or. While such an approach offers valuable direct observations, it is costly and its feasibility depends on the level of engagement from skippers. Alternatively, camera-based surveys at access points could be considered, similar to those applied in private boat monitoring, or building personal relationships with the charter boat skippers to build a data-collection community. However, these approaches would require consultation with skippers to ensure its practical implementation and acceptance within the industry, and could be challenging to extrapolate to the population.

The charter boat survey relied upon the engagement of business owners and their skippers to provide data as part of the sampling method. The quantity of data collected was lower than expected from the initial engagement with the angling community. Overall, there was a general lack of engagement from the charter boat fleet in England and Wales despite a variety of methods and adaptation to the charter boat offer.

The primary aim of this project was to validate the results of the SADP, which was successfully achieved for the shore survey, but comparing estimates between private and charter boat survey estimates was challenging due to the low sampling achieved. The shore survey demonstrated very similar estimates of effort in terms of days fished, which is notable as previous studies have indicated that onsite surveys often underestimate effort compared to offsite approaches as they only sample a subset of fishing locations and times, missing anglers who fish in less accessible areas or outside regular survey hours (Wynne-Jones *et al.*, 2019). This agreement may be attributed to the model-based approach used in Catchwise, which better accounts for environmental and temporal factors influencing effort than traditional post-stratification techniques. Total catch and tonnage estimates were also closely aligned between Catchwise and SADP, despite the known positive bias in trip-level catches within SADP due to the non-reporting of zero-catch trips (Radford *et al*., unpublished data). The SADP uses the angler-year as the PSU rather than individual trips, which can mitigate the impact of missing zero-catch trips on total catch estimates. This contrasts with trip-based extrapolation, where failing to account for zero-catch trips would lead to overestimation.

Prior research has generally suggested that offsite surveys overestimate CPUE compared to onsite methods (Hartill *et al.*, 2015; Holdsworth *et al.*, 2018; Wynne-Jones *et al.*, 2019; Gundelund *et al.*, 2020; Lai *et al.*, 2021; Lewin *et al.*, 2021). This discrepancy arises primarily due to recall bias and social desirability bias in offsite surveys, where anglers may unintentionally overestimate their catch rates or selectively recall their most successful trips. In contrast, onsite surveys, which involve direct observation and angler interviews at access points, typically provide more accurate trip-level CPUE estimates since zero-catch trips are fully accounted for (Hartill *et al.*, 2015).

Holdsworth *et al.* (2018) demonstrated that biases vary by species and targeting behaviours, with offsite surveys often reporting higher catch rates for popular target species, likely due to angler specialisation and recall bias. In contrast, onsite surveys, while benefiting from verifiable trip-level data, may be affected by observer effects, where anglers modify their fishing behaviour due to the presence of survey personnel (Lai *et al.*, 2021). Given these trade-offs, several studies have advocated for integrated survey approaches, such as the hybrid model used in Catchwise, where onsite CPUE estimates are combined with offsite effort estimates to improve the reliability of total catch extrapolations (Holdsworth *et al.*, 2018; Lai *et al.*, 2021). This aligns with broader recommendations that multi-method approaches yield the most robust and unbiased estimates of recreational fishing effort and catch, as they compensate for the inherent strengths and weaknesses of each survey type.

The findings from this study demonstrate that the SADP provides robust estimates of effort and catch for shore-based MRF when comparing 2023-24 Catchwise data and 2023 SADP estimates. Whilst interannual variation in catches from the SADP are minimal, an update to this comparison will be required once 2024 SADP data are processed. The strong agreement between Catchwise and SADP estimates suggests that the diary-based approach produces reliable data for shore anglers. However, further investigation is required to assess the validity of SADP estimates for charter boat activities. While CPUE was similar between Catchwise and SADP, effort was significantly lower in SADP, leading to lower total catch estimates. This discrepancy may be due to survey fatigue among the charter boat fleet, and skippers being less engaged in logbook reporting. Additionally, new probabilistic methods are needed to quantify private boat fishing effort, as traditional survey approaches have proven challenging due to access restrictions to boat launch areas and finding private boats within a probability-based framework. Digital camera monitoring presents a promising avenue for future research, offering a cost-effective alternative for effort estimation while reducing the burden on surveyors, but would need to be augmented with further surveys to attain catch information.

Despite these challenges, the diary-based approach remains the most cost-effective method for collecting MRF data over long timescales. The Catchwise social survey further reinforces the broader benefits of sea angling participation, particularly its positive impact on mental health and well-being, which could contribute to reduced healthcare costs. Overall, Catchwise has provided a critical evaluation of current MRF data collection methods, demonstrating that SADP produces reliable CPUE estimates for shore and charter boats. However, discrepancies in effort estimation between the two survey approaches, particularly for private and charter boats, require further investigation. Addressing these uncertainties will strengthen the evidence base for marine recreational fisheries management, offering stakeholders, fisheries managers, and stock assessors greater confidence in using SADP data for sustainable stock management.

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Supplementary Table 1 – Priors used within the catch model

Coefficient	Count	Zero-Inflation
EffectiveHours_log	*N(0.65, 0.179)*	*N(-0.65, 0.179)*
Returned	*N(1.63, 0.2)*	*N(-2.37, 0.4)*
Bass:EastofEngland	*N(-0.67, 0.2)*	*N(-1.3, 0.4)*
Bass:NorthEastEngland	*N(-2.37, 0.2)*	*N(-0.05, 0.4)*
Bass:NorthWestEngland	*N(-1.7, 0.2)*	*N(-2.23, 0.4)*
Bass:SouthEastEngland	*N(-0.26, 0.2)*	*N(-1.59, 0.4)*
Bass:SouthWestEngland	*N(-0.3, 0.2)*	*N(-1.42, 0.4)*
Bass:Wales	*N(-0.13, 0.2)*	*N(-0.52, 0.4)*
Bass:YorkshireandTheHumber	*N(-0.84, 0.2)*	*N(-1.41, 0.4)*
Bib	*N(0.5, 0.2)*	*N(1.13, 0.4)*
Bib:returned	*N(0.05, 0.2)*	*N(-0.88, 0.4)*
Bib:EastofEngland	*N(-0.62, 0.2)*	*N(-1.14, 0.4)*
Bib:NorthEastEngland	*N(-2.19, 0.2)*	*N(0.66, 0.4)*
Bib:NorthWestEngland	*N(-0.18, 0.2)*	*N(-0.19, 0.4)*
Bib:SouthEastEngland	*N(-0.05, 0.2)*	*N(-0.72, 0.4)*
Bib:SouthWestEngland	*N(-0.03, 0.2)*	*N(-1.56, 0.4)*
Bib:Wales	*N(0.51, 0.2)*	*N(0.12, 0.4)*
Bib:YorkshireandTheHumber	*N(-2.26, 0.2)*	*N(0.74, 0.4)*
Bib:Q2	*N(-1.44, 0.2)*	*N(0.59, 0.4)*
Bib:Q3	*N(-1.49, 0.2)*	*N(1, 0.4)*
Bib:Q4	*N(-0.76, 0.2)*	*N(-0.84, 0.4)*
BlackBream	*N(-1.74, 0.2)*	*N(1.65, 0.4)*
BlackBream:returned	*N(-0.54, 0.2)*	*N(0.48, 0.4)*
BlackBream:EastofEngland	*N(-1.03, 0.2)*	*N(0.27, 0.4)*
BlackBream:NorthEastEngland	*N(-1.3, 0.2)*	*N(0.32, 0.4)*
BlackBream:NorthWestEngland	*N(-0.8, 0.2)*	*N(0.78, 0.4)*
BlackBream:SouthEastEngland	*N(-0.17, 0.2)*	*N(-1.51, 0.4)*
BlackBream:SouthWestEngland	*N(-0.36, 0.2)*	*N(-1.28, 0.4)*
BlackBream:Wales	*N(0.77, 0.2)*	*N(-0.1, 0.4)*
BlackBream:YorkshireandTheHumber	*N(-1.1, 0.2)*	*N(0.21, 0.4)*
BlackBream:Q2	*N(1.51, 0.2)*	*N(-0.14, 0.4)*
BlackBream:Q3	*N(1.01, 0.2)*	*N(-1.22, 0.4)*
BlackBream:Q4	*N(0.75, 0.2)*	*N(-0.06, 0.4)*
Cod	*N(0.41, 0.2)*	*N(-1.55, 0.4)*
Cod:returned	*N(-1.23, 0.2)*	*N(0.95, 0.4)*
Cod:EastofEngland	*N(-0.57, 0.2)*	*N(-0.38, 0.4)*
Cod:NorthEastEngland	*N(1.23, 0.2)*	*N(-2.36, 0.4)*
Cod:NorthWestEngland	*N(0.17, 0.2)*	*N(-1.12, 0.4)*
Cod:SouthEastEngland	*N(-0.23, 0.2)*	*N(0.83, 0.4)*
Cod:SouthWestEngland	*N(0.83, 0.2)*	*N(0.16, 0.4)*
Cod:Wales	*N(-0.85, 0.2)*	*N(-0.93, 0.4)*
Cod:YorkshireandTheHumber	*N(1.28, 0.2)*	*N(-0.66, 0.4)*
Cod:Q2	*N(-1.65, 0.2)*	*N(1.39, 0.4)*
Cod:Q3	*N(-3.22, 0.2)*	*N(0.85, 0.4)*
Cod:Q4	*N(-2, 0.2)*	*N(0.2, 0.4)*
Congereel	*N(-2.07, 0.2)*	*N(0.55, 0.4)*
Congereel:returned	*N(0.75, 0.2)*	*N(-0.7, 0.4)*
Congereel:EastofEngland	*N(-2.45, 0.2)*	*N(0.04, 0.4)*
Congereel:NorthEastEngland	*N(-1.45, 0.2)*	*N(-0.12, 0.4)*
Congereel:NorthWestEngland	*N(-2.25, 0.2)*	*N(0.23, 0.4)*
Congereel:SouthEastEngland	*N(1.27, 0.2)*	*N(-0.17, 0.4)*
Congereel:SouthWestEngland	*N(1.19, 0.2)*	*N(-0.78, 0.4)*

Coefficient	Count	Zero-Inflation
Congereel:Wales	*N(0.8, 0.2)*	*N(-0.71, 0.4)*
Congereel:YorkshireandTheHumber	*N(-2.2, 0.2)*	*N(0.06, 0.4)*
Congereel:Q2	*N(-2.16, 0.2)*	*N(-1.03, 0.4)*
Congereel:Q3	*N(-2.11, 0.2)*	*N(-1.04, 0.4)*
Congereel:Q4	*N(-1.7, 0.2)*	*N(-2.2, 0.4)*
Dab	*N(2.11, 0.2)*	*N(-0.01, 0.4)*
Dab:returned	*N(-1.26, 0.2)*	*N(-1.06, 0.4)*
Dab:EastofEngland	*N(0.82, 0.2)*	*N(-1.25, 0.4)*
Dab:NorthEastEngland	*N(-0.38, 0.2)*	*N(-0.03, 0.4)*
Dab:NorthWestEngland	*N(-0.14, 0.2)*	*N(-1.34, 0.4)*
Dab:SouthEastEngland	*N(-0.71, 0.2)*	*N(-0.18, 0.4)*
Dab:SouthWestEngland	*N(-1.2, 0.2)*	*N(0.79, 0.4)*
Dab:Wales	*N(1.06, 0.2)*	*N(0.55, 0.4)*
Dab:YorkshireandTheHumber	*N(-0.02, 0.2)*	*N(-1.54, 0.4)*
Dab:Q2	*N(-2.01, 0.2)*	*N(0.82, 0.4)*
Dab:Q3	*N(-1.9, 0.2)*	*N(2.74, 0.4)*
Dab:Q4	*N(-1.63, 0.2)*	*N(0.17, 0.4)*
Flounder	*N(-0.6, 0.2)*	*N(-1.32, 0.4)*
Flounder:returned	*N(0.16, 0.2)*	*N(0.08, 0.4)*
Flounder:EastofEngland	*N(-0.86, 0.2)*	*N(0.42, 0.4)*
Flounder:NorthEastEngland	*N(0.42, 0.2)*	*N(-1.38, 0.4)*
Flounder:NorthWestEngland	*N(0.06, 0.2)*	*N(-2, 0.4)*
Flounder:SouthEastEngland	*N(-1.63, 0.2)*	*N(-1.76, 0.4)*
Flounder:SouthWestEngland	*N(-0.1, 0.2)*	*N(0.47, 0.4)*
Flounder:Wales	*N(0.86, 0.2)*	*N(-0.13, 0.4)*
Flounder:YorkshireandTheHumber	*N(0.33, 0.2)*	*N(-1.48, 0.4)*
Flounder:Q2	*N(-1.32, 0.2)*	*N(0.22, 0.4)*
Flounder:Q3	*N(-1.8, 0.2)*	*N(1.11, 0.4)*
Flounder:Q4	*N(-1.57, 0.2)*	*N(0.55, 0.4)*
LesserSpottedDogfish	*N(0.87, 0.2)*	*N(0.59, 0.4)*
LesserSpottedDogfish:returned	*N(-0.48, 0.2)*	*N(-1.77, 0.4)*
LesserSpottedDogfish:EastofEngland	*N(0.06, 0.2)*	*N(-0.52, 0.4)*
LesserSpottedDogfish:NorthEastEngland	*N(-1.65, 0.2)*	*N(-0.05, 0.4)*
LesserSpottedDogfish:NorthWestEngland	*N(-0.73, 0.2)*	*N(-0.74, 0.4)*
LesserSpottedDogfish:SouthEastEngland	*N(0.55, 0.2)*	*N(-1.03, 0.4)*
LesserSpottedDogfish:SouthWestEngland	*N(-0.12, 0.2)*	*N(-0.01, 0.4)*
LesserSpottedDogfish:Wales	*N(0.38, 0.2)*	*N(-0.86, 0.4)*
LesserSpottedDogfish:YorkshireandTheHumber	*N(-0.07, 0.2)*	*N(0.56, 0.4)*
LesserSpottedDogfish:Q2	*N(-1.07, 0.2)*	*N(-0.4, 0.4)*
LesserSpottedDogfish:Q3	*N(-2.31, 0.2)*	*N(1.69, 0.4)*
LesserSpottedDogfish:Q4	*N(-1.1, 0.2)*	*N(-0.2, 0.4)*
Mackerel	*N(3.69, 0.2)*	*N(0.93, 0.4)*
Mackerel:returned	*N(-1.47, 0.2)*	*N(2.13, 0.4)*
Mackerel:EastofEngland	*N(0.64, 0.2)*	*N(0.01, 0.4)*
Mackerel:NorthEastEngland	*N(0.47, 0.2)*	*N(-1.13, 0.4)*
Mackerel:NorthWestEngland	*N(-0.67, 0.2)*	*N(1.15, 0.4)*
Mackerel:SouthEastEngland	*N(0.05, 0.2)*	*N(-0.28, 0.4)*
Mackerel:SouthWestEngland	*N(-0.26, 0.2)*	*N(-1.17, 0.4)*
Mackerel:Wales	*N(1.06, 0.2)*	*N(-0.13, 0.4)*
Mackerel:YorkshireandTheHumber	*N(-0.31, 0.2)*	*N(-0.72, 0.4)*
Mackerel:Q2	*N(-1.7, 0.2)*	*N(-1.19, 0.4)*
Mackerel:Q3	*N(-1.89, 0.2)*	*N(-1.98, 0.4)*
Mackerel:Q4	*N(-1.34, 0.2)*	*N(-0.43, 0.4)*
Plaice	*N(0.41, 0.2)*	*N(0.14, 0.4)*
Plaice:returned	*N(-0.57, 0.2)*	*N(0.32, 0.4)*
Plaice:EastofEngland	*N(0.24, 0.2)*	*N(0.33, 0.4)*
Plaice:NorthEastEngland	*N(0.62, 0.2)*	*N(0.82, 0.4)*

Coefficient	Count	Zero-Inflation
Plaice:NorthWestEngland	*N(-0.16, 0.2)*	*N(-1.66, 0.4)*
Plaice:SouthEastEngland	*N(0.51, 0.2)*	*N(-0.97, 0.4)*
Plaice:SouthWestEngland	*N(-0.36, 0.2)*	*N(-0.38, 0.4)*
Plaice:Wales	*N(1.38, 0.2)*	*N(-0.32, 0.4)*
Plaice:YorkshireandTheHumber	*N(-0.72, 0.2)*	*N(-0.74, 0.4)*
Plaice:Q2	*N(-1.94, 0.2)*	*N(-0.74, 0.4)*
Plaice:Q3	*N(-1.8, 0.2)*	*N(0.14, 0.4)*
Plaice:Q4	*N(-2.04, 0.2)*	*N(0.95, 0.4)*
Pollack	*N(0.1, 0.2)*	*N(0.49, 0.4)*
Pollack:returned	*N(-0.33, 0.2)*	*N(-0.13, 0.4)*
Pollack:EastofEngland	*N(-2.87, 0.2)*	*N(0.42, 0.4)*
Pollack:NorthEastEngland	*N(-0.27, 0.2)*	*N(-1.14, 0.4)*
Pollack:NorthWestEngland	*N(-0.28, 0.2)*	*N(0.88, 0.4)*
Pollack:SouthEastEngland	*N(-1.09, 0.2)*	*N(0.45, 0.4)*
Pollack:SouthWestEngland	*N(-1.03, 0.2)*	*N(-0.62, 0.4)*
Pollack:Wales	*N(-0.59, 0.2)*	*N(0.07, 0.4)*
Pollack:YorkshireandTheHumber	*N(0.18, 0.2)*	*N(0.93, 0.4)*
Pollack:Q2	*N(0.76, 0.2)*	*N(0.18, 0.4)*
Pollack:Q3	*N(0.41, 0.2)*	*N(0.17, 0.4)*
Pollack:Q4	*N(1.16, 0.2)*	*N(0.22, 0.4)*
Smoothhound	*N(-3.07, 0.2)*	*N(0.87, 0.4)*
Smoothhound:returned	*N(0.25, 0.2)*	*N(-0.87, 0.4)*
Smoothhound:EastofEngland	*N(-0.05, 0.2)*	*N(-0.03, 0.4)*
Smoothhound:NorthEastEngland	*N(-1.74, 0.2)*	*N(-0.26, 0.4)*
Smoothhound:NorthWestEngland	*N(0.23, 0.2)*	*N(0.71, 0.4)*
Smoothhound:SouthEastEngland	*N(-0.42, 0.2)*	*N(-0.94, 0.4)*
Smoothhound:SouthWestEngland	*N(0.19, 0.2)*	*N(0.07, 0.4)*
Smoothhound:Wales	*N(-0.27, 0.2)*	*N(-0.32, 0.4)*
Smoothhound:YorkshireandTheHumber	*N(-0.6, 0.2)*	*N(-0.32, 0.4)*
Smoothhound:Q2	*N(0.87, 0.2)*	*N(-1.28, 0.4)*
Smoothhound:Q3	*N(1.13, 0.2)*	*N(-0.29, 0.4)*
Smoothhound:Q4	*N(0.57, 0.2)*	*N(0.02, 0.4)*
ThornbackRay	*N(-1.41, 0.2)*	*N(0.07, 0.4)*
ThornbackRay:returned	*N(-0.34, 0.2)*	*N(-0.44, 0.4)*
ThornbackRay:EastofEngland	*N(0.57, 0.2)*	*N(-1.37, 0.4)*
ThornbackRay:NorthEastEngland	*N(0.32, 0.2)*	*N(0.05, 0.4)*
ThornbackRay:NorthWestEngland	*N(0.02, 0.2)*	*N(-1.01, 0.4)*
ThornbackRay:SouthEastEngland	*N(0.42, 0.2)*	*N(-0.21, 0.4)*
ThornbackRay:SouthWestEngland	*N(-0.99, 0.2)*	*N(0.45, 0.4)*
ThornbackRay:Wales	*N(0.86, 0.2)*	*N(-0.11, 0.4)*
ThornbackRay:YorkshireandTheHumber	*N(-0.99, 0.2)*	*N(-0.91, 0.4)*
ThornbackRay:Q2	*N(-0.21, 0.2)*	*N(0.44, 0.4)*
ThornbackRay:Q3	*N(-0.33, 0.2)*	*N(0.67, 0.4)*
ThornbackRay:Q4	*N(-1.13, 0.2)*	*N(-0.2, 0.4)*
Whiting	*N(2.61, 0.2)*	*N(-1.12, 0.4)*
Whiting:returned	*N(-1, 0.2)*	*N(-1.99, 0.4)*
Whiting:EastofEngland	*N(0.98, 0.2)*	*N(-0.99, 0.4)*
Whiting:NorthEastEngland	*N(-0.75, 0.2)*	*N(-0.73, 0.4)*
Whiting:NorthWestEngland	*N(-0.13, 0.2)*	*N(-0.89, 0.4)*
Whiting:SouthEastEngland	*N(-0.07, 0.2)*	*N(0.47, 0.4)*
Whiting:SouthWestEngland	*N(-1.12, 0.2)*	*N(0.31, 0.4)*
Whiting:Wales	*N(0.11, 0.2)*	*N(0.17, 0.4)*
Whiting:YorkshireandTheHumber	*N(-0.44, 0.2)*	*N(-1, 0.4)*
Whiting:Q2	*N(-2.51, 0.2)*	*N(2.21, 0.4)*
Whiting:Q3	*N(-2.31, 0.2)*	*N(3.44, 0.4)*
Whiting:Q4	*N(-1, 0.2)*	*N(-0.77, 0.4)*
Wrassespp	*N(1.76, 0.2)*	*N(1.96, 0.4)*

Coefficient	Count	Zero-Inflation
Wrassespp:returned	*N(-0.74, 0.2)*	*N(-1.31, 0.4)*
Wrassespp:EastofEngland	*N(-2.45, 0.2)*	*N(0.39, 0.4)*
Wrassespp:NorthEastEngland	*N(-1.92, 0.2)*	*N(1.1, 0.4)*
Wrassespp:NorthWestEngland	*N(-2.51, 0.2)*	*N(-0.32, 0.4)*
Wrassespp:SouthEastEngland	*N(-1.59, 0.2)*	*N(-0.07, 0.4)*
Wrassespp:SouthWestEngland	*N(-0.61, 0.2)*	*N(-0.38, 0.4)*
Wrassespp:Wales	*N(-1.44, 0.2)*	*N(0.28, 0.4)*
Wrassespp:YorkshireandTheHumber	*N(-2.13, 0.2)*	*N(0.35, 0.4)*
Wrassespp:Q2	*N(0.27, 0.2)*	*N(-0.22, 0.4)*
Wrassespp:Q3	*N(-0.29, 0.2)*	*N(-0.01, 0.4)*
Wrassespp:Q4	*N(0.01, 0.2)*	*N(0.01, 0.4)*
Q2	*N(1.33, 0.2)*	*N(-0.76, 0.4)*
Q3	*N(1.64, 0.2)*	*N(-1.14, 0.4)*
Q4	*N(1.05, 0.2)*	*N(-0.67, 0.4)*
Intercept	*N(-3.4, 0.2)*	*N(2.17, 0.4)*
Angler ID Intercept	*N(0.22, 0.2)*	*N(-0.37, 0.4)*
Shape	*N(0.37, 0.2)*	*NA*

Supplementary Table 2 – Priors used within the weight model

Coefficient	*Mu*	*Sigma*
Returned	*N(-1.3, 0.1)*	
Bass:EastofEngland	*N(0.002, 0.1)*	
Bass:NorthEastEngland	*N(0.618, 0.1)*	
Bass:NorthWestEngland	*N(-0.313, 0.1)*	
Bass:SouthEastEngland	*N(0.001, 0.1)*	
Bass:SouthWestEngland	*N(-0.081, 0.1)*	
Bass:Wales	*N(-0.232, 0.1)*	
Bass:YorkshireandTheHumber	*N(-0.208, 0.1)*	
BlackBream	*N(0.588, 0.1)*	*N(-0.303, 0.1)*
BlackBream:returned	*N(0.583, 0.1)*	
BlackBream:EastofEngland	*N(-0.203, 0.1)*	
BlackBream:NorthEastEngland	*N(-0.851, 0.1)*	
BlackBream:NorthWestEngland	*N(-2.29, 0.1)*	
BlackBream:SouthEastEngland	*N(-0.239, 0.1)*	
BlackBream:SouthWestEngland	*N(-0.36, 0.1)*	
BlackBream:Wales	*N(-0.638, 0.1)*	
BlackBream:YorkshireandTheHumber	*N(-0.249, 0.1)*	
Cod	*N(-0.257, 0.1)*	*N(0.057, 0.1)*
Cod:returned	*N(-0.095, 0.1)*	
Cod:EastofEngland	*N(0.484, 0.1)*	
Cod:NorthEastEngland	*N(0.52, 0.1)*	
Cod:NorthWestEngland	*N(0.076, 0.1)*	
Cod:SouthEastEngland	*N(0.506, 0.1)*	
Cod:SouthWestEngland	*N(0.069, 0.1)*	
Cod:Wales	*N(-0.122, 0.1)*	
Cod:YorkshireandTheHumber	*N(0.165, 0.1)*	
Congereel	*N(-0.227, 0.1)*	*N(0.377, 0.1)*
Congereel:returned	*N(0.52, 0.1)*	
Congereel:EastofEngland	*N(1.504, 0.1)*	
Congereel:NorthEastEngland	*N(0.857, 0.1)*	
Congereel:NorthWestEngland	*N(1.178, 0.1)*	
Congereel:SouthEastEngland	*N(0.851, 0.1)*	
Congereel:SouthWestEngland	*N(0.302, 0.1)*	
Congereel:Wales	*N(0.394, 0.1)*	
Congereel:YorkshireandTheHumber	*N(0.104, 0.1)*	
Dab	*N(-0.217, 0.1)*	*N(-0.649, 0.1)*
Dab:returned	*N(0.904, 0.1)*	
Dab:EastofEngland	*N(0.175, 0.1)*	
Dab:NorthEastEngland	*N(0.311, 0.1)*	
Dab:NorthWestEngland	*N(0.196, 0.1)*	
Dab:SouthEastEngland	*N(0.161, 0.1)*	
Dab:SouthWestEngland	*N(0.174, 0.1)*	
Dab:Wales	*N(0.611, 0.1)*	
Dab:YorkshireandTheHumber	*N(0.216, 0.1)*	
Flounder	*N(-0.449, 0.1)*	*N(-0.181, 0.1)*
Flounder:returned	*N(0.711, 0.1)*	
Flounder:EastofEngland	*N(0.122, 0.1)*	
Flounder:NorthEastEngland	*N(0.298, 0.1)*	
Flounder:NorthWestEngland	*N(0.315, 0.1)*	
Flounder:SouthEastEngland	*N(0.582, 0.1)*	
Flounder:SouthWestEngland	*N(0.51, 0.1)*	
Flounder:Wales	*N(0.727, 0.1)*	

Coefficient	Mu	Sigma
Flounder:YorkshireandTheHumber	N(0.323, 0.1)	
LesserSpottedDogfish	N(0.096, 0.1)	N(-0.458, 0.1)
LesserSpottedDogfish:returned	N(1.182, 0.1)	
LesserSpottedDogfish:EastofEngland	N(0.036, 0.1)	
LesserSpottedDogfish:NorthEastEngland	N(0.381, 0.1)	
LesserSpottedDogfish:NorthWestEngland	N(0.128, 0.1)	
LesserSpottedDogfish:SouthEastEngland	N(0.196, 0.1)	
LesserSpottedDogfish:SouthWestEngland	N(0.174, 0.1)	
LesserSpottedDogfish:Wales	N(0.022, 0.1)	
LesserSpottedDogfish:YorkshireandTheHumber	N(0.354, 0.1)	
Mackerel	N(0.153, 0.1)	N(-0.271, 0.1)
Mackerel:returned	N(0.873, 0.1)	
Mackerel:EastofEngland	N(0.047, 0.1)	
Mackerel:NorthEastEngland	N(0.265, 0.1)	
Mackerel:NorthWestEngland	N(-0.472, 0.1)	
Mackerel:SouthEastEngland	N(-0.362, 0.1)	
Mackerel:SouthWestEngland	N(-0.192, 0.1)	
Mackerel:Wales	N(-0.651, 0.1)	
Mackerel:YorkshireandTheHumber	N(-0.148, 0.1)	
Plaice	N(-0.143, 0.1)	N(-0.532, 0.1)
Plaice:returned	N(0.719, 0.1)	
Plaice:EastofEngland	N(0.31, 0.1)	
Plaice:NorthEastEngland	N(-0.609, 0.1)	
Plaice:NorthWestEngland	N(0.091, 0.1)	
Plaice:SouthEastEngland	N(0.129, 0.1)	
Plaice:SouthWestEngland	N(0.255, 0.1)	
Plaice:Wales	N(0.225, 0.1)	
Plaice:YorkshireandTheHumber	N(-0.446, 0.1)	
Pollack	N(0.168, 0.1)	N(0.267, 0.1)
Pollack:returned	N(-0.296, 0.1)	
Pollack:EastofEngland	N(-0.616, 0.1)	
Pollack:NorthEastEngland	N(-0.628, 0.1)	
Pollack:NorthWestEngland	N(-0.753, 0.1)	
Pollack:SouthEastEngland	N(-0.49, 0.1)	
Pollack:SouthWestEngland	N(-0.001, 0.1)	
Pollack:Wales	N(-0.143, 0.1)	
Pollack:YorkshireandTheHumber	N(-1.576, 0.1)	
Smoothhound	N(0.281, 0.1)	N(0.29, 0.1)
Smoothhound:returned	N(0.927, 0.1)	
Smoothhound:EastofEngland	N(0.134, 0.1)	
Smoothhound:NorthEastEngland	N(0.932, 0.1)	
Smoothhound:NorthWestEngland	N(0.207, 0.1)	
Smoothhound:SouthEastEngland	N(-0.301, 0.1)	
Smoothhound:SouthWestEngland	N(0.125, 0.1)	
Smoothhound:Wales	N(0.201, 0.1)	
Smoothhound:YorkshireandTheHumber	N(-0.109, 0.1)	
ThornbackRay	N(0.189, 0.1)	N(-0.107, 0.1)
ThornbackRay:returned	N(0.834, 0.1)	
ThornbackRay:EastofEngland	N(0.026, 0.1)	
ThornbackRay:NorthEastEngland	N(0.585, 0.1)	
ThornbackRay:NorthWestEngland	N(-0.111, 0.1)	
ThornbackRay:SouthEastEngland	N(-0.365, 0.1)	
ThornbackRay:SouthWestEngland	N(0.315, 0.1)	
ThornbackRay:Wales	N(0.716, 0.1)	
ThornbackRay:YorkshireandTheHumber	N(-0.294, 0.1)	
Whiting	N(0.256, 0.1)	N(-0.341, 0.1)
Whiting:returned	N(0.584, 0.1)	

Coefficient	*Mu*	*Sigma*
Whiting:EastofEngland	*N(-0.251, 0.1)*	
Whiting:NorthEastEngland	*N(-0.078, 0.1)*	
Whiting:NorthWestEngland	*N(-0.401, 0.1)*	
Whiting:SouthEastEngland	*N(-0.228, 0.1)*	
Whiting:SouthWestEngland	*N(-0.149, 0.1)*	
Whiting:Wales	*N(-0.302, 0.1)*	
Whiting:YorkshireandTheHumber	*N(-0.111, 0.1)*	
Wrassespp	*N(-0.21, 0.1)*	*N(0.342, 0.1)*
Wrassespp:returned	*N(0.954, 0.1)*	
Wrassespp:EastofEngland	*N(-0.411, 0.1)*	
Wrassespp:NorthEastEngland	*N(-0.385, 0.1)*	
Wrassespp:NorthWestEngland	*N(0.177, 0.1)*	
Wrassespp:SouthEastEngland	*N(-0.574, 0.1)*	
Wrassespp:SouthWestEngland	*N(-0.413, 0.1)*	
Wrassespp:Wales	*N(-0.228, 0.1)*	
Wrassespp:YorkshireandTheHumber	*N(0.179, 0.1)*	
median_weight_log	*N(0.7, 0.1)*	
Intercept	*t(3, -1.7, 2.5)*	*t(3, -1.7, 2.5)*

Supplementary Table 3 – Model formulas used

Model	Formula
Effort	fldTotalShoreAnglers ~ 1 + fldHighActivityLevel + fldTideHeight_scale + fldDay_scale + windgust_scale + fldTime_scale + has_parking + pub_log1p + (1 + fldHighActivityLevel | fldRegionMajor) + (1 + fldTideHeight_scale | fldPrimarySiteID) shape ~ 1 + (1 | fldRegionMajor) zi ~ 1 + fldHighActivityLevel + fldTideHeight_scale + s(fldMonth_scale) + fldDay_scale + windgust_scale + fldTime_scale + has_parking + pub_log1p + (1 + fldHighActivityLevel | fldRegionMajor) + (1 + fldTideHeight_scale | fldPrimarySiteID)
Catch	fldNumberCaught ~ 1 + fldEffectiveHours_log + fldSpecies * fldKeptorReturned + fldSpecies:fldRegionMajor + quarter_annual + fldSpecies:quarter_annual + (1 | fldAnglerID) zi ~ 1 + fldEffectiveHours_log + fldSpecies * fldKeptorReturned + fldSpecies:fldRegionMajor + quarter_annual + fldSpecies:quarter_annual + (1 | fldAnglerID)
Weight	kg ~ 1 + fldSpecies * fldKeptorReturned + median_weight_log + fldSpecies:fldRegionMajor sigma ~ 1 + fldSpecies

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