Marine Recreational Fishing Catches in Ireland

Pilot Study Report (2019-2021)

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Pilot Study Report (2019-2021)

Irish Marine Recreational Angling Survey (IMREC)

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Executive Summary

This report presents a review of the pilot study designed to estimate and report annual volumes (numbers and weights or lengths) of catches and releases of sea bass, cod, pollack, elasmobranchs and highly migratory ICCAT species in the Marine Recreational Fishery (MRF) in Ireland to the European Commission. The various surveys (spatial characteristics, angler population and fish catch data), which support this pilot study output, commenced in late 2019 and completed in August 2021. Restrictions on travel and angling activity nationally, due to the COVID-19 pandemic, reduced planned on-site survey activity and also led to disrupted angling effort for lengthy periods. This report summarises progress from a low knowledge base on sector and angling 'mark' (known angling points) identification, angling characterisation, sea angling component identification, survey design, sampling strategy and survey roll-out. Regional and seasonal CPUE data for all angling species across the three main angling components (shore, small boat and charter angling) reported during the study are presented. Estimates of population-wide angling effort are also presented. These were used to attempt to raise catch rates, for the mandatory species and others, up to total national catch for the first time.

The report describes the considerable challenges encountered during the survey programme and proposes solutions to provide a satisfactory estimate of total Irish MRF catch in Ireland in the future. Sense checking against one known component of the MRF fishery (charter angling) demonstrated that the total charter angling catch estimates presented here are overestimated. On this basis it is reasonable to presume that the other components (shore & small boat) are also overestimated. Different biases (mainly angling effort based on recall) and, in some cases, limited sample sizes influenced these estimates and further surveys will be required to adequately sample all angling components to increase precision. For this reason the estimates should not be used for stock assessments or similar. Substantial additional analyses of existing and future data are required. Nonetheless, the results provide a robust qualitative overview of the most frequently caught angling species around the Irish coast and fish retention rates. Additional angler population and catch data are being collected and will be used to refine catch estimates prior to reporting on the survey for the DCF Annual

Work Programme Review and providing preliminary estimate determinations to the EC in Q2 2022. For example, an online angler catch diary was developed during the pilot study. This is now active and will be used to support monitoring of catches in Ireland, alongside the probability-based sampling programmes, which will remain an essential element of any programme in the future.

This pilot study has achieved its objectives by testing and appraising survey methodologies in this field in an Irish context. An adaptive process of amending methodologies to maximise resources and efficiencies as surveys progressed has facilitated an ongoing evolution of a refined approach which aims to address the sampling issues which emerged.

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1. Introduction & Aims

The legal framework for the collection of recreational fisheries data by EU Member States (MS) was given by the EU Data Collection Framework (Council Regulation EU 1004/2017 and Commission Decision EU 1251/2016). Like other MS, Ireland is required to report annual volumes (numbers and weights or lengths) of catches and releases of sea bass, cod, pollack, elasmobranchs and highly migratory ICCAT species in marine recreational fisheries within its waters. As Inland Fisheries Ireland (IFI) is the state agency responsible for the protection, management and conservation of the Republic of Ireland's recreational sea angling resources, it is tasked with collecting these data. To that end and funded under EMFF, IFI initiated the Irish Marine Recreational Angling Survey (IMREC) programme in October 2019.

Three elements comprise the majority of the marine recreational fishing (MRF) activity in Ireland: shore angling, small boat angling and charter boat angling (Fig. 1 & 2). As there is no licensing system or requirement for anglers to report MRF catches in Ireland, surveys are essential to estimate catch rates and angling effort. On-site random sampling methods are considered the gold standard when estimating catch rates in diverse and complex fisheries as they reduce fisher selection biases (Arlinghaus and Cooke, 2009; Pollock et al*.,* 1994) and often allow direct measurement of retained fish (Jones and Pollock, 2012)**.**

All three elements were sampled in this manner with slight variations per angling type to collect survey data and to understand the logistics and challenges associated with on-site surveys. This highlighted the issues related to sampling for each, particularly the difficulty associated with the small boat sector. Through this process, several lessons were learned on how to improve sampling efficiency and data collection for future on-site surveys which is an important part of the pilot study process.

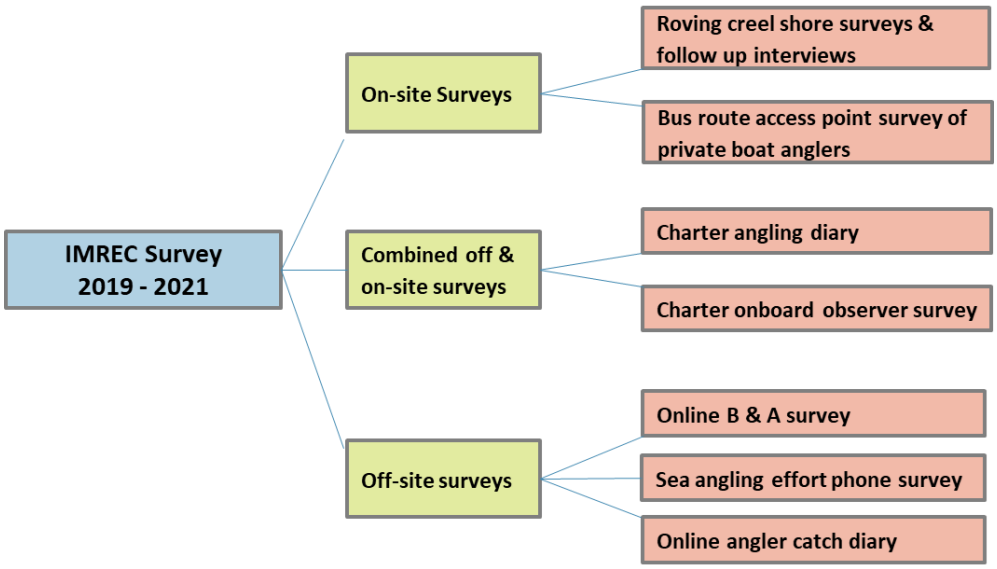


Fig. 1: Survey elements in the ongoing Irish Marine Recreational Angling Survey (IMREC) 2019-2021. Combined, they will allow for a preliminary, pilot study based, estimation of total volumes of all marine fish species caught and released as required under the DCF.

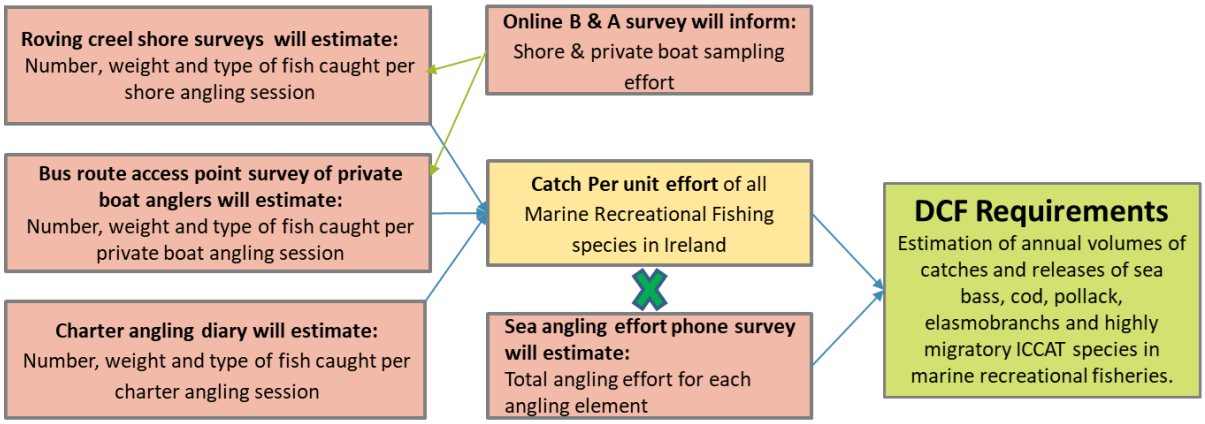


Fig. 2: How the IMREC survey elements (Fig. 1) will meet the requirements of the DCF.

A drawback related to on-site surveys is that they are expensive to carry out (Jones and Pollock, 2012; Pollock et al., 1994; Vølstad et al., 2006). If budget constraints render it unrealistic to conduct on-site surveys on a continuous basis, it is appropriate to also develop off-site survey methods which can continue to collect data during years when on-site surveys are inactive. Although off-site methods are comparatively inexpensive to operate, they rely on self-reporting and are at risk of a range of response and reporting biases of unknown magnitude (Skov et al., 2021; Venturelli et al., 2017). Yet, well designed, diary-based longitudinal studies have been shown to reduce some of these biases (Hyder et al., 2015).

Diary-based survey methods are used extensively throughout the world and have been approved as fit-for-purpose by the ICES Working Group on Recreational Fisheries Surveys (ICES, 2017). Both methods were examined during this pilot study.

Although an angling population study was carried out in Ireland in 2015, which estimated that 127,000 consider themselves marine recreational anglers (IFI, 2015), sea angling effort was not surveyed. Effort is a prerequisite for calculating total catch (Curtis and Grilli, 2019). Therefore, current data on MRF effort in Ireland were required. As Ireland does not currently have a licensing system to monitor MRF activity, the standard method to monitor participation and effort rates is through randomised omnibus surveys, which request respondents to recall their angling activity (Hyder et al., 2018), even though such surveys are subject to recall bias (Lewin et al., 2021; Tarrant et al., 1993). This can lead to uncertainty, when catch rates are raised to estimate total catch.

This pilot study presents and assesses methods used over the course of this extended study to estimate total MRF catch by volume across the three angling elements, shore, small boat and charter boat, as shown in Figs. 1 & 2. The considerations and rationale supporting the shore-based recreational angling (including beach, rock, pier and estuary) and inshore recreational angling (including small boat, kayak and charter) survey approaches are assessed.

2. Material and Methods

Ireland is required to report annual volumes (numbers and weights or lengths) of catches and releases of sea bass, cod, pollack, elasmobranchs and highly migratory ICCAT species in marine recreational fisheries within its waters. Although there are exceptions, sea anglers in Ireland generally target multiple species. For this reason, samplers used the opportunity to collect catch data on all MRF species per ICES recommendation (ICES, 2018).

Shore, small boat and charter sector angling dominate MRF in Ireland. Although there are some records of spear fishing, it is considered a niche pastime. No spear fishing activity was observed during on-site surveys for this study.

Study Area

Ireland is in the Eastern North Atlantic. Its coastline embraces ICES regions (VIIa, VIIg, VIIj, VIIb and Via) (Fig. 3). The IMREC pilot survey was designed to account for all MRF along the Irish coastline and within its inshore waters.

Prior to developing a sampling plan a comprehensive desk study was carried out to assess and characterise MRF in Ireland. It collated and digitised information which could influence MRF; this included angling mark locations and local knowledge on levels of seasonal

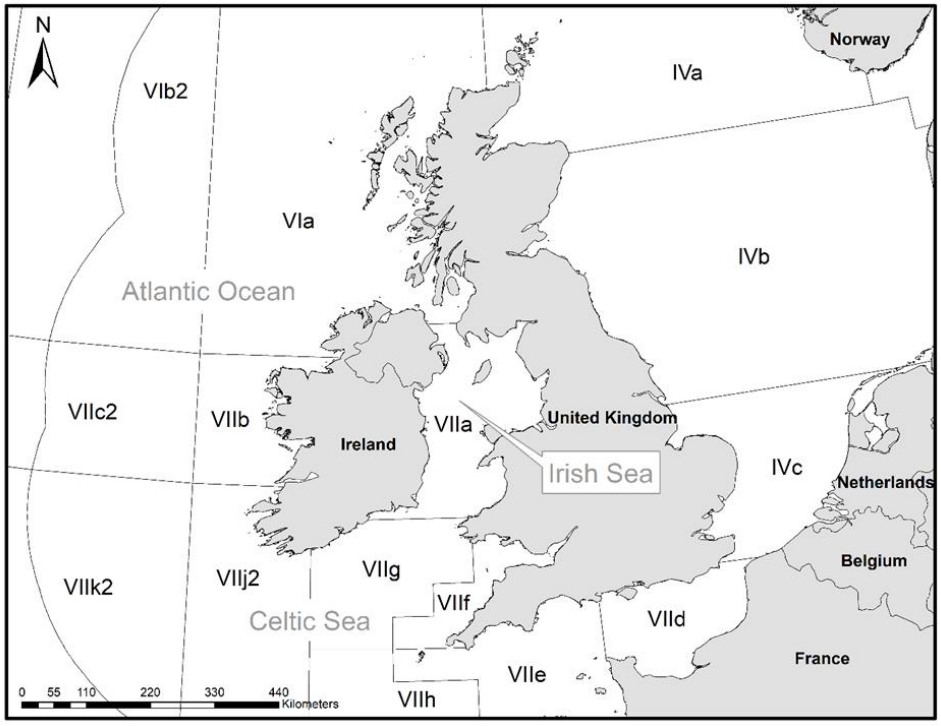


Fig. 3: Ireland's location in a European and ICES region context. The pilot study will assess all marine recreational fishing along the Irish coast and within its inshore waters.

activity, small boat launching sites (Fig. 4) and documenting the number of active charter angling boats around the coast. This information advised the production of evidence-based spatio-temporal sampling frames used in the sampling programmes described below, in addition to providing a comprehensive overview of the contemporary MRF resource in Ireland.

2.1 Steering Group Formation

A common piece of advice emanating from previously completed MRF surveys (Armstrong et al., 2013; Hyder et al., 2018) is that stakeholders should be consulted from the earliest stages of programme design and throughout the process. This engagement is regarded as an important and productive way to advise and discuss survey ideas, obtain well-informed opinions that will work in practice, and modify accordingly. Among the main functions of a Steering Group is to ensure that stakeholders appreciate the reasons for such surveys and also to advise on issues in the sector. With such transparency, it is more likely that there will

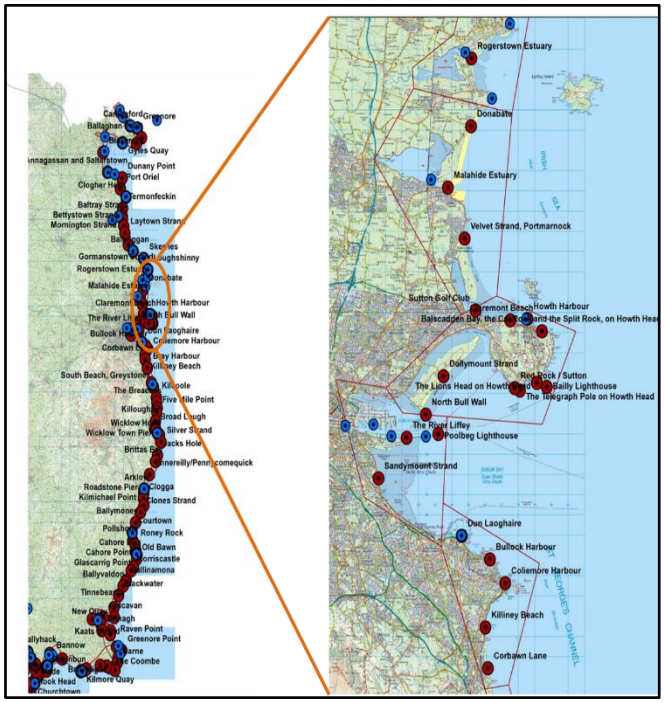


Fig. 4: East coast of Ireland map showing active shore fishing marks (red points) and private boat launching sites (blue points) identified during the IMREC desk study. Red polygons in the detailed map denote roving creel survey of shore angling primary sampling units.

be constructive engagement between parties. This may be a key factor if these survey programmes are to be a success. A Steering Group, which comprised representatives from across the MRF sector in Ireland (charter skippers, members of national angling associations, angling club members, regional IFI representatives, an NGO and administrators) was convened in late 2019. The group contributed substantially to many aspects of survey design across all sampling methods and remains active.

2.2 Survey Programmes

The COVID -19 pandemic had a major disrupting effect on delivery of this pilot study due to restrictions imposed on activity and movement nationally. The national and subsequent county 'lockdowns' impacted on all economic and business activity and all but essential workers were largely confined to home for lengthy periods. No angling was permitted and on-site survey work was not allowed. The term of the project was extended to allow for sampling a full calendar year in an effort to capture seasonal variation in effort and catches. One positive was that the pandemic provided an opportunity to undertake a Behavior and Attitudes (B & A) survey of marine recreational anglers. Fig. 5 below presents survey activity levels over the course of the project and periods where the 'lockdowns' prevented activity.

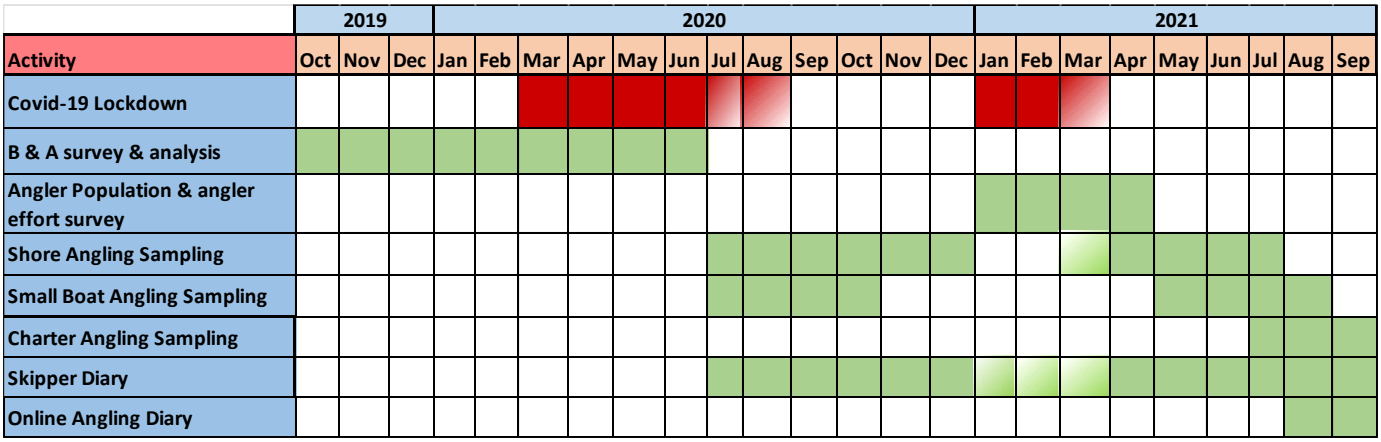


Fig. 5. Gantt chart presenting the timeline of activities carried out during the IMREC pilot study programme. Shaded boxes represent partial lockdown/sampling.

The IMREC visio (Appendix 1) presents the structure of the project's data-connected process flows to final reporting stage.

2.2.1 Online behaviour and attitudes survey of Irish sea anglers

In mid-2020 the IMREC team conducted an extensive national online survey to collect a range of information concerning the behavior and attitudes (B&A) of the sea angling community in Ireland. As well as facilitating sea anglers to express their opinions regarding the current state of sea angling in Ireland, this survey was undertaken primarily to characterise sea angling activity in Ireland. Data collected about when and where angling takes place provided key information for refinement of IMREC survey design. The questionnaire was created in close consultation with the Steering Group so that stakeholder considerations could be properly addressed. This contributed to wider stakeholder buy-in, which was essential, not only to collect sufficient data for this part of the survey, but also to recruit anglers for the proposed online angler catch diary.

Questions for the B&A survey were carefully devised to inform final sampling design for the on-site creel surveys (shore & small boat) and the charter skipper diary-based survey and thus increase sampling efficiency (Jones and Pollock, 2012; Pollock et al., 1997). The survey categorised respondents into shore, small boat and charter anglers, before asking detailed questions on angling location, monthly effort, within week/within day angling preference, species targeted and release rates, among others. As respondents were self-selecting there was a risk of selection bias. Avidity bias was expected as it is enthusiastic anglers who tend engage with angling press and social media and are more likely to be aware of such surveys than those who angle occasionally. However, these surveys are particularly relevant when examining relative trends such as when and where anglers fish, rather than absolute numbers (Armstrong et al., 2013). The B&A survey, comprising 58 questions, was designed using the online platform Survey Monkey (www.surveymonkey.com) and rolled out nationally through press releases and multiple social media (angling and general) platforms.

All survey responses were subject to quality checks in preparation for analysis. Incomplete responses were removed and any responses originating from the same IP address were interrogated to ensure that duplicate data were not used. All remaining data were used to prepare simple summary statistics. The B&A survey report (Ryan et al, 2021) provides detail and analyses of survey responses. An angler friendly summary report was issued in early 2021,

with the intention of promoting the larger angling survey and the impending sea angler catch diary.

2.2.2 Population-wide angling effort survey

A key component of this pilot study (Fig. 1) was determination of the sea angling population angling effort. Obtaining a robust estimate of national marine recreational angling participation/effort was immediately identified as a challenging task, particularly in countries like Ireland where no licensing system for MRF exists. The only proven method is to randomly sample the whole population through telephone or mail surveys. As a low proportion of the total population participate in sea angling (IFI, 2015), a relatively large sample was required to provide a good estimate.

In November 2020, a tender for services was submitted to established Irish survey companies. Ipsos MRBI https://www.ipsos.com/en-ie, a leading provider of research services to Government departments and agencies, was selected to carry out the national marine angling participation and effort survey. Ipsos MRBI is an independent organisation with a reputation for delivering accurate population estimates using survey research.

As a national census was not feasible to measure sea angling effort within the Irish population, random surveys represent an alternative means by which to provide a robust estimate. Ipsos MRBI recommended using a telephone omnibus approach which would satisfy random selection criteria in a cost-effective way.

The survey company used fully random telephone sampling to recruit respondents for participation. To ensure complete population coverage, telephone numbers were randomly generated, based on the list of the most recently published prefixes by ComReg https://www.comreg.ie/. 85% of the numbers dialed were mobile telephone numbers and 15% were landline numbers. Interlocking targets were set on gender within age band (15-24, 25-34, 35-44, 45-54, 55-64, 65+), as well as by overall region (Dublin, Rest of Leinster, Munster, Connaught/ Ulster). Ipsos MRBI Omnipoll randomly samples individuals, rather than households i.e., the person answering the telephone tends to be the person surveyed. As

part of the sampling protocol, younger respondents within the household were actively requested to participate, if available, given under 25s tend to be harder to recruit.

At analysis stage the data were weighted in line with the profile of the population according to the latest Central Statistics Office estimates. For this analysis the Random Iterative Method (or RIM) was used to weight responses, so they reflect the known Irish population profile aged 15+.

Ipsos MRBI uses the latest CSO / Industry estimates available to establish the most up-to-date weights (source indicated in brackets):

a. Gender within age (based on an average of the last quarterly Labour Force Survey (LFS) figures, updated in Q1 and Q3, unless in a CSO release year)

b. Region (latest LFS figures)

c. Social Class (latest AIMRO Industry updates)

The RIM procedure works by choosing a set of variables where the population distribution is known (i.e., gender within age, region and social class as per the sources above) and then iteratively adjusting the weights for each respondent until the weighted sample distribution aligns with the population for those variables.

All respondents start with a weight of 1 – meaning their responses all count equally. The procedure will first adjust the weights so that the gender within age ratio (for example) matches the desired population distribution (from the LFS/CSO). Next, the weights are adjusted so that the region groups are in the correct proportion. If the adjustment for region pushes the gender within age distribution out of alignment, then the weights are adjusted again so age within gender is represented in the correct proportion. The process is repeated for the remaining social class variable until the distribution of all weighted variables match the correct targets.

When the correct distribution of weighting targets has been computed (individual computed targets are called weighting factors), these are assigned to each respondent in accordance

with his/her profile. In the tabular analysis each respondent is multiplied by his/her weighting factor to reflect the overall profile in the target population.

Table 1: Omnibus survey questionnaire used by Ipsos MRBI for IFI to estimate sea angling participation rates and effort in the Irish population

Q.1 Would you consider yourself to be a recreational SEA angler even if you only fish in the sea either from the shore or in a boat in Ireland on the odd occasion?				
IF YES				
Q.2 Do you participate in the following types of sea angling in Ireland, even if very infrequently?				
(A) Shore angling - including from a beach, estuary, pier or rock				
(B) Small boat sea angling – Where a small boat refers to your, or a friend's boat, including a kayak or inflatable, etc				
(C) Charter boat sea angling				
All respondents who participate in Shore **OR** small boat **OR** charter boat sea angling are then asked...				
Q.3 How many days over the course of a typical year do you go shore/small boat/ charter sea angling				
Less than once/year (0.5)	1--2 times (2)	3--4 times (4)	5--6 times (6)	7--10 times (9)
11--20 times (16)	21--30 times (26)	31 --40 times (36)	41--50 times (46)	51--75 times (63)
76--100 times (88)	101--150 times (126)	Over 150 times (170)	Can't say (0.5)	

Five sampling waves were carried out between March 2021 and May 2021. Respondents were asked if they consider themselves to be a recreational sea angler, even if they only fish in the sea, either from the shore or in a boat in Ireland, on the odd occasion. If they answered yes, they were asked if they participated in any of the three types of angling categories: Shore angling, small boat angling and charter angling and if so, how often during a typical year. The respondent was asked to select from a multiple choice of range values to provide a response when asked how often they participate in each type of angling category (Table 1). The 'mean effort' figure is the sum of incidence divided by the effective (incorporating design effect) sample size (ESS) of those participating in the activity. In the mean annual effort calculation all respondents are included, and the formula is the sum of the incidence divided by the ESS. Error variance was calculated by dividing the variance by the ESS.

A shortcoming of this survey approach is the lack of stratification of angling effort between seasons. However, due to budget constraints, a questionnaire which asked respondents to distribute their average angling effort between seasons was deemed unfeasible. A well-characterised shortcoming of this approach, is recall bias, where respondents overestimate their number of previous fishing trips (Lewin et al., 2021; Lynch et al., 2020). The magnitude of recall bias is reported to increase as recall period increases (Andrews et al., 2018). As this survey was a one-off survey asking respondents about their behavior over the course of the past year, across three different types of angling, recall bias must be assumed and attempts were made to correct for it. A number of studies have attempted to quantify recall bias for particular fisheries (Connelly et al., 2000; Forward and Lyle, 2002; Lyle, 2000). This research has been used to account for recall bias among respondents to the Irish angling effort survey. However, angling effort data over shorter temporal scales will be required to address recall bias in the longer term.

The results from the Ipsos MRBI sea angling participation survey for IMREC were validated by comparing with an ESRI general angling survey commissioned by IFI in 2020 (unpublished).

2.2.3 On-site Angling surveys

Roving creel survey of shore anglers

Shore angling is an extremely diverse activity around the coast and many different species can be targeted. Venue types include estuaries, sheltered beach, exposed beach, deep or shallow rocky platforms, piers, jetties and combinations of these.

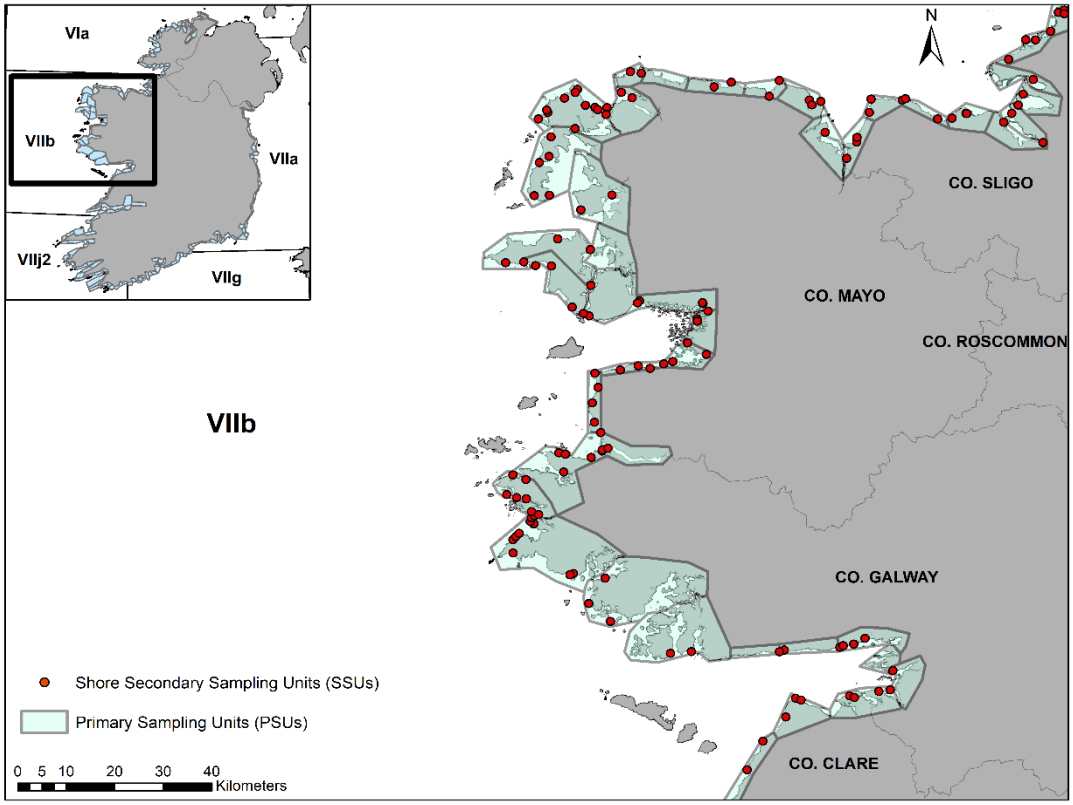


Fig. 6: Map of part of the West Coast of Ireland identifying PSUs and SSUs of the roving creel survey of shore anglers.

The IMREC survey of shore anglers utilised a spatio-temporal sampling method to collect catch per unit effort (CPUE) data of sea anglers around the Irish coast, whereby the unit of effort is a daily angler session. The roving-creel survey approach was applied due to the disparate nature of shore angling around Ireland and the multiple potential access points to the sea (Armstrong et al., 2013; Lockwood, 2000; Pollock et al., 1997). The survey also incorporated stratification and temporal clustering into its final design to maximise sampling efficiency (Jones and Pollock, 2012; Pollock et al., 1997).

Greater sampling effort was allocated to the venues and times where greater fishing effort was expected, as the precision of the effort estimates will be improved (Hayne, 1991), as well as increasing sampling efficiency (Best and Boles, 1956). The output of the B&A survey provided information on where to focus sampling effort. In exploratory studies such as this, there is a balance to be struck between minimising sampling variance and having adequate

sampling throughout the sampling frame. The sampling programme was designed taking these factors and available resources into account.

Sampling frame components

Primary Sampling Units (PSUs)

To frame the sampling design, the coast was split into 7-12 km sections of coastline (Fig. 6). This unit size provides a balance between ability to sample a complete PSU and likelihood of encountering anglers within a sampling session. The spatio-temporal sampling frame consists of the whole coastline split into 180 separate sampling units X 365 separate sampling days (PSUs), therefore covering every angling trip on the Irish coast over a calendar year.

Secondary Sampling Units (SSUs)

Within most PSUs, secondary sampling units (SSUs) were selected which were well-characterised angling marks (Fig. 4). Surveyors recorded visit time and number of anglers visible every time they approach an SSU. SSUs were selected through desk studies and refined through consultation with colleagues with expert knowledge of the locations.

Stratification variables

Seasonal stratum

Catch rate and fishing effort is assumed to be strongly related to the time of year for all components of recreational sea angling. For this reason, the sampling frame was stratified according to season/quarter (Jan to March, April to June, July to September and October to December).

Regional stratum

The sampling frame was stratified by ICES regions (Fig. 3). This allowed sampling to be clustered within each ICES region so that resources could be better allocated. It also meant that the sampling regime could be structured so that each ICES region could be surveyed at a probability proportional to the number of PSUs within each region.

The order of ICES regions to visit on a weekly basis was randomly selected. Available funding allowed two surveyors, sampling three times a week each, to sample for both the roving creel survey of shore anglers and the bus route survey of small boat anglers.

The three ICES regions with the largest number of PSUs were allocated for 3 weekly visits per season and the others were allocated two. The order of visits was selected randomly.

Fishing activity stratum

This stratum is used to allow for the allocation extra sampling effort within PSUs where it is likely to encounter more anglers and thus collect more data. IFI field staff with local expert knowledge were consulted to advise about activity levels for the 607 active angling marks (SSUs) identified during the characterization phase of this study. Using this information, an index was developed which allowed each PSU in the sampling frame to be designated as a high or low activity site, defined by both the number of angling marks (SSUs) in a PSU and whether each angling mark within a particular PSU was perceived as high activity. The threshold to denote a PSU as high or low activity was decided based on its index value relative to other PSUs in the ICES region. Activity level was season-specific.

Temporal Sampling Clusters

Weekly sampling cluster

Sampling week was not stratified for weekday versus weekend. Although fishing effort is likely to be greater on weekends (Ryan *et al.* 2020) catch rates are likely similar so any gain in CPUE

precision made by stratifying for weekend/weekday would be lost due to reduced number of samples per stratum (Kinloch et al., 1997).

Surveys were carried out on three sequential days per week. This made sampling more efficient and reduced travel time, as in each sampling week 3 x three-day sampling clusters (Mon-Wed, Thurs-Sat and Fri-Sun) were nested in each sampling week period. This method increased the probability of extra sampling effort on weekends.

Within-day fishing period cluster

Due to limited resources, it was not possible to survey over a 24-hour day. Most commonly, the fishing day was partitioned into morning (AM) and afternoon (PM) periods (Pollack, 1994). One of these nested periods is chosen for each sampling day. It was assumed that there was more angling effort in the PM periods (an assumption confirmed through the online B&A survey (Ryan et al*.,* 2021). Therefore, to increase the likelihood of angler encounters, time of day selection was sampled with non-uniform probability whereby Amπ=0.25 and PMπ=0.75

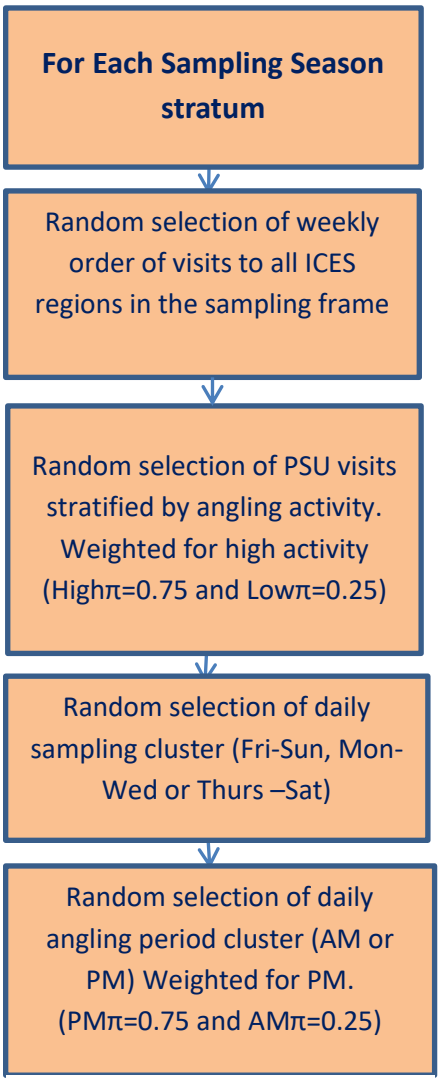


Fig. 7: Schematic illustrating the roving creel site selection methodology.

Sampling protocol

Sampling was selected sequentially for each sampling week. Prior to each sampling season, a sampling programme for each consecutive week was created, taking account of each stratum and cluster in the sampling design (Fig. 7).

The schedule was created using a randomly selected starting location. If either end of the PSU was reached before the sampling day was complete, surveyors retraced their steps rechecking sites until the shift time was completed. Surveyors did not resample anglers which had been interviewed already. Upon conclusion of angler catch rate interviews, the surveyor asks if he can contact the angler after their fishing session to collect complete trip data (Vølstad et al., 2020) to reduce bias associated with incomplete angling data (Hoenig et al., 1997; Pollock et al., 1994). Over 90% of interviews closed with complete angling trip data.

On arrival at each SSU within each PSU an instantaneous count of people actively shore fishing was completed.

If the surveyor encountered large fishing parties and it was not possible to interview all anglers due to time constraints, one or more individuals were randomly selected to answer questions relating to the current fishing trip on behalf of the entire group.

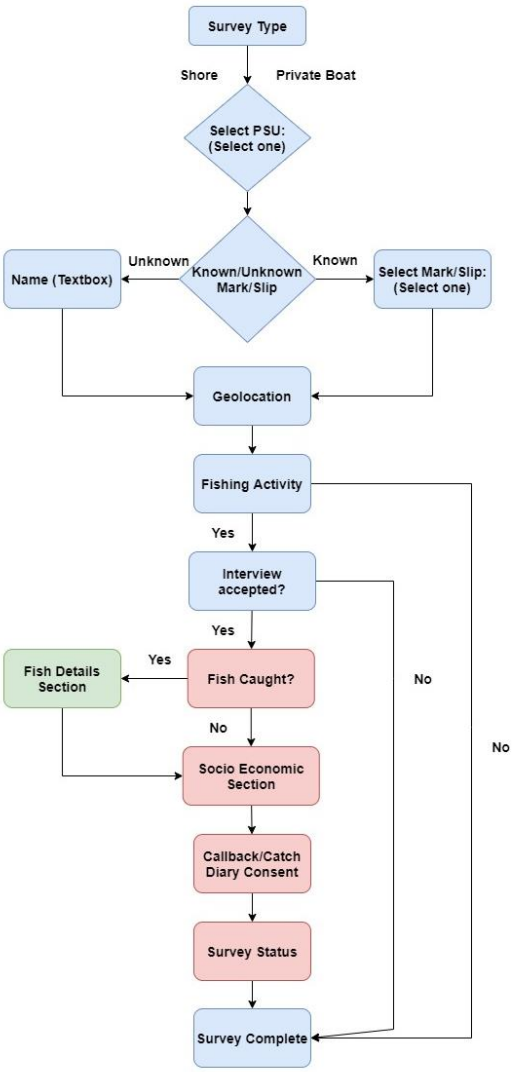


Fig. 8: Schematic illustrating the wireframe coded into the Survey123 data collection tool for the IMREC on-site surveys.

Data collection

To collect the catch survey data a robust in situ questionnaire was designed in Survey123 https://survey123.arcgis.com/(ESRI 2020). This resource allows instant data capture via a tablet and safe storage to a centralised geodatabase (Fig. 8). Length data were collected by surveyors as catches are rarely weighed in situ by Irish anglers. These lengths were converted to weights at analysis using length-weight parameters developed during the charter sampling component of this programme (section 3.4).

Each angler surveyed was asked how long they have been angling and to identify all species which they have retained and/or released during the angling session. If retained fish were available for inspection, each was measured on site by the surveyor. Otherwise, the angler was asked if he had measured released species. If so, this was recorded. The angler provided length estimates otherwise. Prior to concluding the interview, anglers were asked if they would accept a call back after their session to collect complete session data. If they responded

positively, this was organised and the angler was asked to take catch measurements if possible.

As tourist anglers were not included in the population angling effort survey, the contribution of tourist anglers to the total Irish catch is estimated from the on-site survey data. A reasonable estimate of tourist angling effort can be captured by asking some simple questions about previous angling trips to Ireland. This was included in the on-site surveys.

Bus route access point survey of small boat anglers

The IMREC survey of small boat anglers utilised a spatio-temporal sampling method to collect catch per unit effort (CPUE) data of small boat anglers around the Irish coast, whereby the unit of effort is a daily boat session. This unit was chosen as being practical and pragmatic. When small boat anglers return from their angling session they may find it difficult to proportion out the catch, particularly when the session has been successful. Interviews may become time-consuming, which may prevent some anglers in the party from providing complete interviews. An angler count per boat was carried out and CPUE was calculated based on angler numbers.

As with shore angling, there is currently no recording system in place to capture angling activity from small boats (small or rented) around the Irish coast. The IMREC survey of small boat anglers originally used a spatio-temporal sampling method to collect catch per unit effort data around the Irish coast. The most appropriate method of collection of catch data for this aspect of the survey is through a random-access point survey. This method captures complete angling trip data as the interview occurs when the angler is leaving the location. Due to the disparate nature of boat angling around Ireland and the large number of potential access points, a bus route type survey programme was developed. This method combines elements of both roving and access point surveys by allowing a surveyor to travel around a circuit, incorporating access points according to a predetermined schedule (McGlennon and Kinloch, 1997). It allows greater spatial coverage of the sampling frame while keeping within the logistical constraints of the sampling programme. Like the roving-creel survey of Irish shore

anglers, this survey incorporated stratification and temporal clustering into its final design to maximise sampling efficiency.

An important aspect of the pilot study was to firstly identify access points for small boat angling. A desk study identified 428 potential access points (slips, jetties and piers) for small boats (Fig. 4). It was expected that at least some of the potential access points identified would not be fit for purpose (unsuitable for launching, poor access etc). However, this would have necessitated an advance site visit to classify each location suitability which was not feasible. As a result, it was decided to include all potential access points in the sampling frame. Then a sampling protocol was designed which accounted for those which were deemed to be inoperative upon inspection as on-site random sampling was ongoing.

Sampling frame components

Primary Sampling Units (PSUs)

To frame the sampling design, the coast was separated into several sections or bus route circuits. Each coastal circuit contains several access points which a surveyor could visit for a predetermined length of time. The spatio-temporal sampling frame consisted of the entire coastline split into 71 separate sampling units or circuits X 365 separate sampling days which are defined as the sampling programme PSUs (Fig. 9).

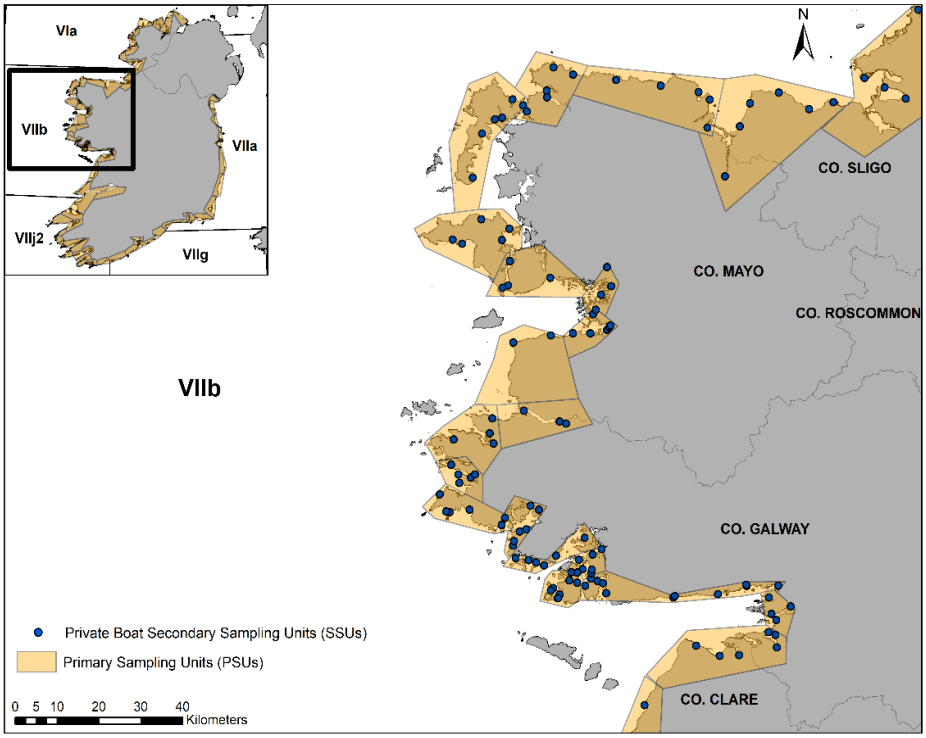


Fig. 9: Map of part of the West Coast of Ireland identifying a selection of PSUs and SSUs of the bus route access point survey of private boat anglers.

Secondary Sampling Units (SSUs)

Within each PSU, there were between two and five access points. These were considered as the 'stops' of the bus route design and were defined as secondary sampling units (SSUs). Surveyors were expected to record time spent at each SSU and evidence of angling activity upon arrival at each SSU.

Stratification variables

Strata developed for the bus route access point survey of small boat anglers broadly followed the procedures described in Section 3.4. Roving creel survey of shore anglers.

Temporal Sampling Clusters

This procedure followed the steps described in Section 3.4. Roving creel survey of shore anglers.

Sampling protocol

This procedure generally followed the steps described in Section 3.4. Roving creel survey of shore anglers. However, in the bus route procedure each access point was sub-sampled. The sampling duration at each access point was deemed a temporal sampling cluster. For PSUs with two or more site clusters, samplers were obliged to remain at the first site for the predetermined amount of time and then move to the second site. Equal sampling time was apportioned to each access point within the PSU. The probability of obtaining interviews is proportional to the cumulative waiting times at access sites (Jones and Robson, 1991; Kinloch et al., 1997). Therefore, it is imperative that bus route design pays close attention to minimising travel time away from each SSU within the PSU selected for sampling. The order in which samplers visit sites is pre-determined as part of the sample selection. The travel time between sites is excluded from the recorded sample time.

Where surveyors arrived at an access point and found that boat access was not feasible (due to disrepair etc) the surveyor moved on to the next site. The unsuitable site was logged and excluded from current and future sampling frames. The time originally allocated for the unsuitable site is shared between the following sites on the route.

Mid-study review of the bus route access point survey of small boat anglers

Early in the small boat bus route access point survey it became apparent that anglers can, and did, access the water from many beach sites if they have a suitable craft. Furthermore, kayak angling is popular in Ireland and the ease of access for kayak anglers means an almost unlimited number of potential access points. This, combined with the fact that samplers encountered few small boat anglers during the survey, meant that data collection for CPUE estimation was extremely low and likely biased. It was clear that to satisfy the main assumption of a probability-based creel survey sampling frame (that every angling trip is

included) would require an extremely large sampling team. Nonetheless, small boat anglers generally have a far higher catch rate than shore anglers, so it is an important aspect of Irish MRF to characterise. For this reason, the sampling frame was revised to focus on a small number of known active small boat access points within the original sampling strata. This approach, termed 'convenience sampling' is commonly used in such surveys. However, convenience sampling methods (ICES, 2020) are not fully probability-based as some anglers have zero probability of being interviewed. Therefore, a high level of bias must still be expected. This technique is acceptable if lack of resources make it necessary (Jones and Pollock, 2012). Potential for bias has been considered and methods will be discussed later to account for this in future surveys.

2.2.4 Charter Catch Surveys

Charter angling trips, as distinct from small boat and shore angling, comprise a significant part of marine recreational fishing (MRF) in Ireland.

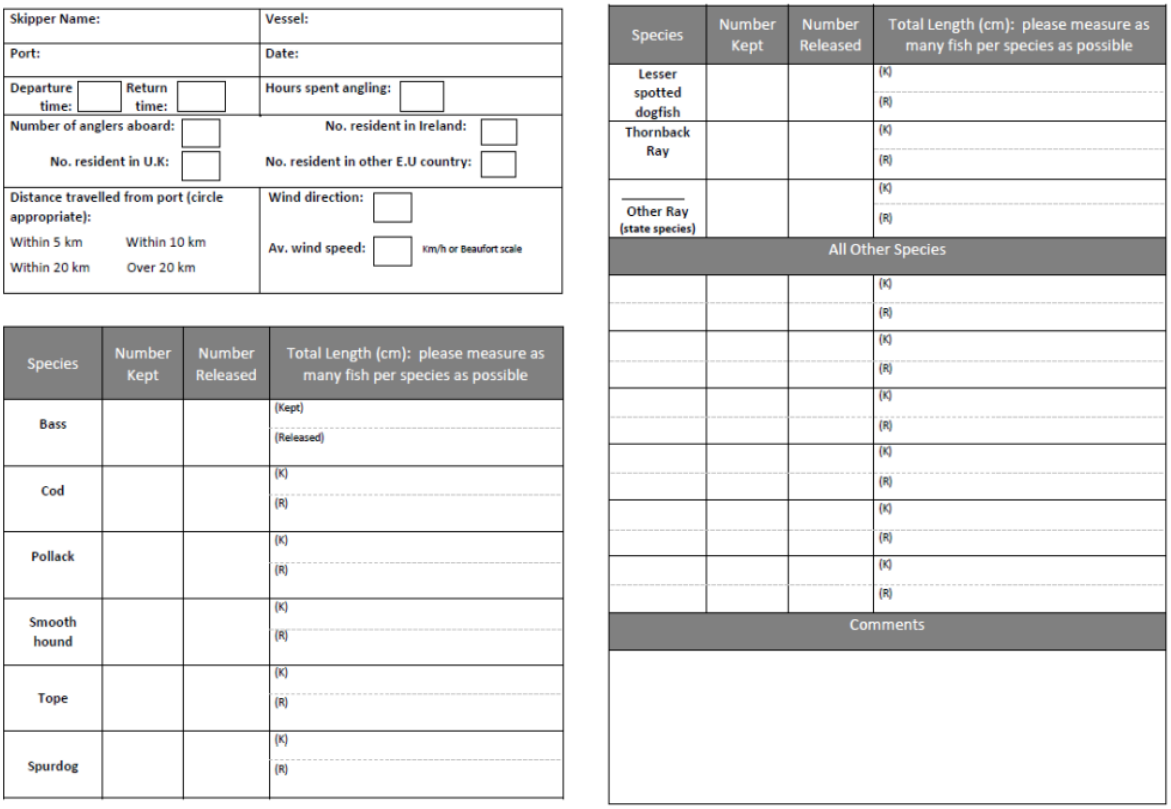
Charter Skipper Diary

Charter boat fishing is available on all Irish coasts with a minimum of 67 registered vessels offering recreational angling trips. Catch type and rate is highly dependent on fishing location. Although it is possible to estimate total angling effort from sub-sampled CPUE data because the size of the registered Irish charter fleet is known, members of the Steering Group advised that numbers of charter vessels and charter activity levels can vary substantially from year to year. For this reason, it was appropriate to also estimate charter angling effort though a population-wide angling effort survey (see Ipsos/MRBI survey), whereby independent effort estimations can be used to estimate total catch. For this aspect of the survey to be successful, agreement from charter skippers was required. To that end all sampling design was planned in close consultation with the members of the IMREC Steering Group.

The IMREC skipper diary built on a voluntary diary scheme previously operated by skippers in partnership with Inland Fisheries Ireland up the late 2000s. Daily effort and species-specific

catch data were collected for each ‘shark’ or ‘ground fishing’ day (both are defined types of charter angling trips) which allowed for CPUE estimation. Aggregated catch data were reported by species (CPUE). This was a successful data collection system as a good rapport was built between IFI staff and charter skippers ensuring a low refusal rate from skippers to participate.

The first iteration of the revised skipper diary was developed in close consultation with skipper representatives on the IMREC steering Group committee, who had contributed to the historical skipper diary. The revised diary was developed which allowed skippers to enter catch data on species, lengths and catch and release rates for each angling voyage (Fig. 10). Charter operators who were identified as potentially receptive to the survey programme were contacted. As the total number of active charter skippers was low (67), a diary was provided to all willing participants (16) in September 2020, when COVID-19 restrictions had eased. Although most of the charter fishing season was lost due to COVID-19, the diary roll-out facilitated collection of some data and resulted in valuable feedback about the diary for the 2021 season. Due to the low number of charter operators active in the sector, all willing participants were requested to record catch details from all angling cruises.



Skipper Name:	Vessel:
Port:	Date:
Departure time: Return time:	Hours spent angling:
Number of anglers aboard: No. resident in U.K:	No. resident in Ireland: No. resident in other E.U country:
Distance travelled from port (circle appropriate): Within 5 km Within 10 km Within 20 km Over 20 km	Wind direction: Av. wind speed: Km/h or Beaufort scale

Species	Number Kept	Number Released	Total Length (cm): please measure as many fish per species as possible
Bass			(Kept) (Released)
Cod			(K) (R)
Pollack			(K) (R)
Smooth hound			(K) (R)
Tope			(K) (R)
Spurdog			(K) (R)

Species	Number Kept	Number Released	Total Length (cm): please measure as many fish per species as possible
Lesser spotted dogfish			(K) (R)
Thornback Ray			(K) (R)
Other Ray (state species)			(K) (R)
All Other Species			
			(K) (R)
			(K) (R)
			(K) (R)
			(K) (R)
			(K) (R)
			(K) (R)
Comments			

Fig. 10: First iteration of the IMREC Skipper Diary.

The revised IMREC skipper diary aimed to collect individual trip data including date, start/end time, number of anglers on board and a breakdown of nationalities, distance travelled from port and wind direction/speed. The fish details aimed to capture species, number caught, number released/retained and a subsample of measurements from released/retained fish per species.

Following the initial roll-out several skippers reported that recording levels required were onerous. Issues focused mainly on the measurement of fish being caught. This was deemed very difficult alongside the other duties a skipper must perform while out at sea with paying customers. Other suggestions to improve uptake related to the size of the daily data sheets and the removal of designated boxes per species.

Skipper Name:	Vessel:
Port:	Date:
Departure time: ☐ Return time: ☐	Hours spent angling: ☐
Number of anglers aboard: ☐	No. resident in Ireland: ☐
No. resident in U.K: ☐	No. resident in other E.U country: ☐
Distance travelled from port (circle appropriate): Within 5 km Within 10 km Within 20 km Over 20 km	Wind direction: ☐ Av. wind speed: ☐ Km/h or ☐ Beaufort scale

Species	No.	No. kept	Species	No.	No. kept	Species	No.	No. kept
Cod								
Pollack								
Bass								
_____ Ray								
_____ Ray								
_____ Ray								

Species	Total Length (cm): if possible, measurements for any species would be greatly appreciated.

Fig. 11: Second iteration of the IMREC Skipper Diary.

The second iteration of the skipper diary reduced data collection requirements (Fig. 11). Trip information data remained the same but a reduction in size to one A4 page along separating catch totals and measurements allowed skippers to quickly fill in catch and released/retained figures. The separate measurement section remained blank to allow skippers manually input any length measurement data gathered without being restricted to a rigid format. This was welcomed by skippers as it bore a closer resemblance to the historical skipper diary. Continuous recruitment attempts saw an increase in participating skippers with a total of 30 skipper diaries distributed to willing skippers around the coast of Ireland.

In consultation with, and to assist skippers, and to improve data collection levels, a small number of surveyors (IFI staff) undertook onboard recording of caught and released fish by species, in addition to measuring (cm) and weighing (g) samples of each.

Onboard Charter Catch Survey

To complement data collected through the charter skipper diary in 2020 and ongoing in 2021, a sampling programme was undertaken in summer 2021 whereby IFI staff and Marine Institute (MI) contractors sampled randomly designated chartered angling trips to record species numbers, and accurately measure lengths and weights of all captured and released fish.

Defining the population and sampling frame

Charter boat angling, defined here as a hireable, skippered vessel used for recreational sea angling on either a full or part-time basis, is available on all Irish coasts (Fig. 12). Chartered vessels target different species, depending on a range of factors, including but not limited to, location, season, weather, and the preferences of the angling party present on the day. As charter angling is primarily a weather dependent pursuit, most effort tends to be around and during the summer months. As it is appropriate to undertake most sampling when angling activity is heaviest to increase the precision of catch estimates (Pollock et al., 1994) the current sampling design did not consider seasonal stratification. However, examination of historical voluntary charter skipper catch diaries collated by IFI (up to 2008) confirmed that disparate catches are evident between regions, while the B&A survey also reported that greater charter angling effort occurs in the west of the country (Table 2) (Ryan et al., 2020). Future programmes will include some level of seasonal stratification.

Table 2: Proportion of charter angling effort as a % by ICES region. Data from the B&A Survey (Ryan e al, 2020).

ICES region	Charter angling effort (%)
VIIa	24
VIIg	21
VIIj2	17
VIIb	26
VIa	12

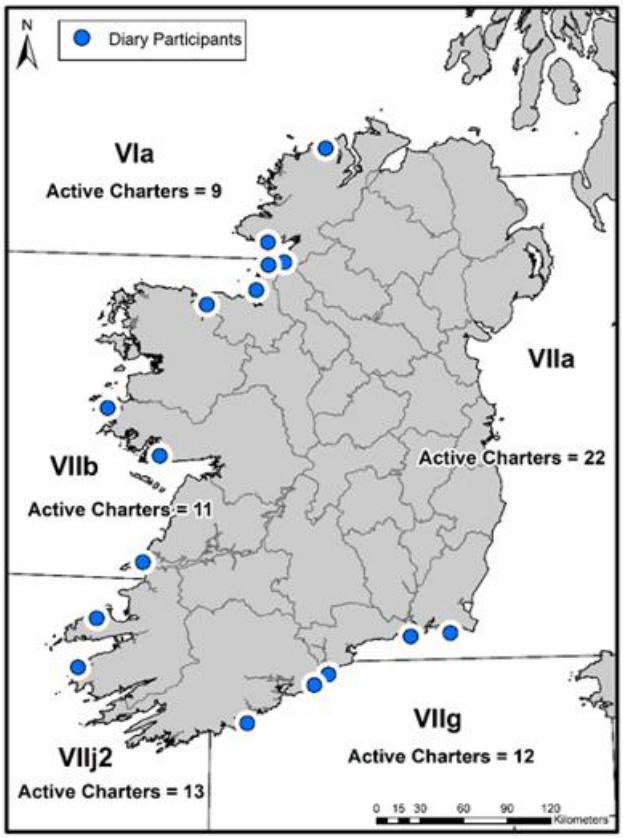


Fig. 12: Map showing locations of confirmed active sea angling charter vessels in 2019 per ICES region (n=67). Blue dots represent main ports of departure.

In consultation with the Irish Charter Skippers Association (ICSA) https://www.irishcharterskippersassociation.ie/ an estimate of the total number of registered charter vessels operating in Irish waters was determined (n=67). From this number a sampling frame, stratified by ICES region (Table 3), was developed from charter skippers who agreed to participate in the programme (n=22). With the assistance of the Marine Institute, a panel of IFI and MI fisheries samplers was assigned each week between 2nd June and 26th September to travel on a charter cruise to accurately measure and weigh captured fish. The selection of participating charter skippers for sampling was undertaken randomly each week using the following procedure:

Table 3: Total number of registered vessels in the sampling frame stratified by location of port

ICES region	Vessels in frame	Vessels in population[a] ($VESSELS_n$)	Proportion represented (%)
VIa	5	9	55%
VIIb	5	11	45%
VIIj2	5	13	38%
VIIa	3	22	14%
VIIg	4	12	33%
Total	22	67	33%

[a] Number of active charter vessels confirmed in 2019

1. For each week during the sampling window, up to three ICES regions were selected for random sampling via equal probability sampling without replacement (Table 4). The weekly order of visits for each ICES region continued until all regions were ticked, and the process was then repeated.

2. One participating charter boat from the sampling frame that operated within each of the relevant regions was then randomly selected, via equal probability sampling without replacement. To avoid data duplication with the National Tuna CHART programme https://www.fisheriesireland.ie/what-we-do/research/tuna-chart, any charter vessel targeting bluefin tuna was excluded.

3. Each of the randomly selected charter skippers was then contacted about their angling bookings for the sampling week. They were then asked to nominate a day a sampler could come aboard to record angling data.

   If they accepted one or more sampling days a fisheries sampler was then selected from the panel to attend the designated charter cruise. If the charter skipper was unable to facilitate a sampler for that week a second skipper was randomly drawn from the relevant stratum. This process continued until a selected skipper agreed to at least

one trip with a surveyor onboard. If no skipper was available that week, then that ICES region was not sampled for that week.

Table 4: Random sampling matrix to choose which ICES region the weekly sampling of charter CPUE occurs.

	June				July		
ICES Region	Week1 (31-6)	Week 2 (7-13)	Week 3 (14-20)	Week 4 (21 - 27)	Week 5 (28-4)	Week 6 (5-11)	Week X ....
VIIa							
VIIg							
VIIj2							
VIIb							
VIa							

Data collection process

The role of the IFI/MI sampler when onboard a chartered vessel was to record the relevant trip information and biometric catch data that would allow for the estimation of angler Catch Per Unit Effort (CPUE), total retained biomass, and where possible length-weight relationships for individual species. Priority was given to seabass, cod, pollack, elasmobranchs and highly migratory ICCAT species.

A summary of the main trip and biometric information collected by onboard IFI/MI samplers consisted of the following:

Relevant trip information recorded

- Time and date of departure and return to port
- Port of departure
- ICES region of departure
- General fishing location (mean distance from port)
- Total number of anglers aboard
- Number of overseas tourist anglers aboard (EU and non-EU)
- Time fishing commenced and concluded (total angling time)

- Wind direction and speed (Beaufort)

Biometric catch data recorded

- Species caught
- Whether released or retained
- Total length for the first 60 fish of each species (30 retained and 30 released fish)
- Individual weights (g) for the first 60 fish of each species (30 retained and 30 released fish)
- Total counts of all other captured fish (both released and retained) that were not measured or weighed

Measurements and gears

All fish were caught using rod and line gears by recreational anglers. Captured fish were measured onboard by the IFI/MI sampler for the first 60 fish of each species (30 retained, and 30 released). Measurements were recorded as total length (cm, snout to tail) for all species, except for porbeagle and blue shark which were also measured as fork length out of convention (size range 14 – 205 cm total length, 84 – 174 cm fork length). Where possible fish that were brought onboard were also weighed (g) using a hand-held scale (weight range 30 – 17237 g). Total counts of all other captured fish (both released and retained) that were not measured or weighed were also recorded for each species. In a small number of instances sex was also recorded where it could be reliably determined.

Data processing and management

After returning to port digital copies of the handwritten sampling sheets were transcribed into Microsoft® Excel where they were collated for inclusion into the project data frame. Trip information and biometric data were then subject to quality checks in terms of the examination of length-weight plots to identify outliers and anomalies. Suspect entries were then either corrected or excluded from the data frame prior to analysis where there was a high degree of confidence that they were a result of a scribing error, or due to malfunctioning

scales. All data were exported to Survey123 forms for storage in the IMREC ArcOnline Geodatabase.

2.2.5 Online Angler Diary

To collect MRF catch data on a continuous basis, an online angler catch diary was developed in close consultation with the IMREC Steering Group and with MRF researchers who have had previous experience with such a tool.

The aim of the online IMREC Angler Diary (Fig. 13) was to provide a fast and efficient recording platform for willing anglers to submit catch information on fishing trips (shore, small boat or charter vessel). This platform provides qualitative data on species caught, total catches, catch/release rates and length measurements from participating anglers across Ireland. Providing an individual on-line personal catch diary for each angler was also a requirement to encourage angler retention and future feedback.

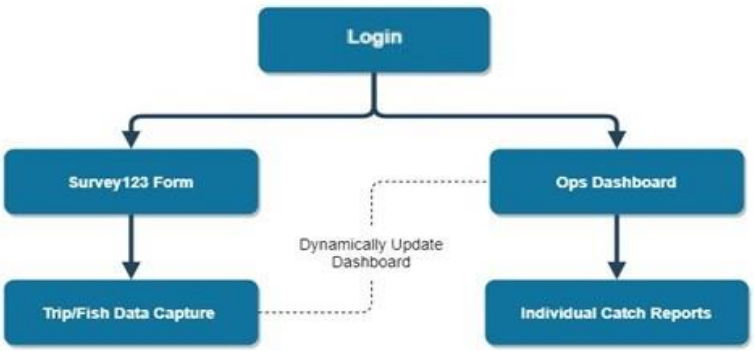


Fig. 13: Structure of the IMREC Online Diary

To ensure the aims of the angler diary app were achieved it was important to identify the requirements needed. They were as follows:

i) Platform accessible to 100s of known diarists continuously contributing (ArcHub Licensing)

ii) Trip and catch information easily captured (Survey123)

iii) Individual and aggregated catch reports (ArcGIS Dashboards)

iv) Secure data storage

ArcGIS products were made available to IFI and after consultation with ArcGIS support, ArcHub, along with several other ArcGIS data collection tools (Esri, 2021), was identified as being suitable for the requirements of the IMREC online diary. ArcHub, a community engagement software accessed through a web browser, allowed IFI to invite potential diarists into a secure online platform with access to ArcGIS Survey123 (data collection software) and ArcGIS Dashboards (Reporting software). This collection of software applications allowed for easy, fast data collection on trip and catch information to hundreds of anglers while also generating individual/aggregated reports on submitted data.

Licensing/Login

IFI acquired a premium license for ArcHub, enabling up to 1000 members to be added to the initiative. An initiative allows multiple apps, datasets and webpages to be bundled around a project. A front facing website was created to allow diarists navigate through the different apps and easily submit shore or small boat fishing sessions. A two-step sign up process for diarists was essential to ensure GDPR and data security regulations were adhered to. It also ensured control over the number of diarists engaged in the IMREC online diary. Once signed up, anglers were given login credentials allowing access to the data collection forms and dashboards on the ArcGIS hosted platform. The login details enables viewing restrictions on data resulting in diarists only having access to their own catch reports.

Data Collection

ArcGIS Survey123 was the application used for data collection. This is a form centric data collection app that allows for in depth customisation (Fig. 14). As this is an ArcGIS application, it enables instant data sharing with other ArcGIS applications.

The data needed to support on-site surveys include:

Trip Details:

1. Fishing Date/Time
2. General Location (Not specific)
3. Fishing Site (Shore, Small Boat, Kayak, Charter)
4. Fishing Method (Bait, Lure, Fly, Spear, Nets)
5. Fish Caught?

If fish were caught, then subsequent questions appear. These questions were repeated per fish/group of fish:

Catch Details:

- Species
- No. Caught
- Individual/average Total Length (cm)
- Released/Retained

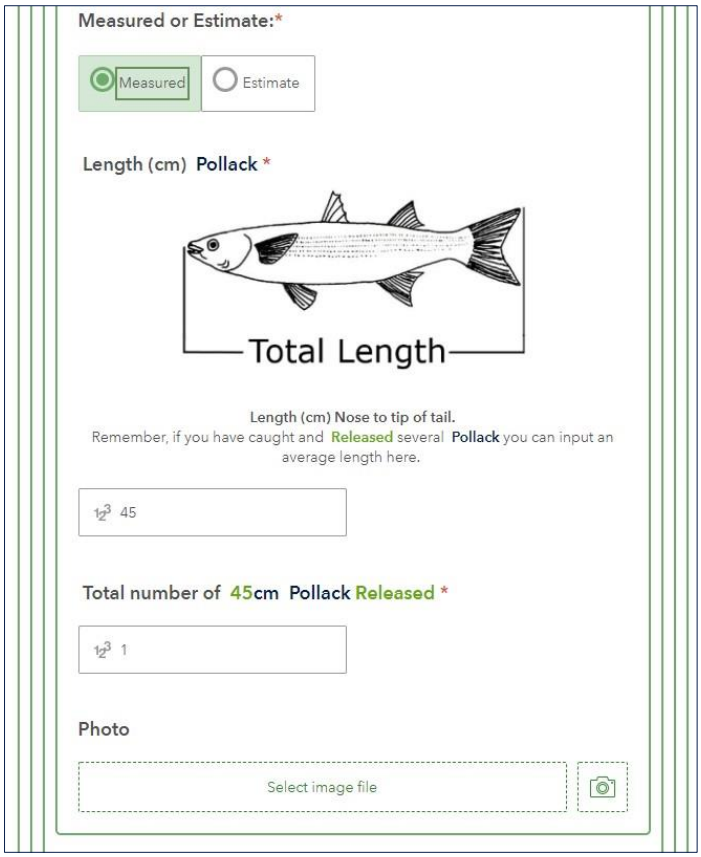


Fig. 14: Example of fish capture Qs from the online IMREC diary on Survey123

Editing of submitted records is reserved for IMREC staff only. Further refinement and enhancement of this data collection tool is ongoing.

Individual and aggregated catch reports

A dashboard, filtered to angler level (based on login credentials) is available to all diarists. This is a vital component in diarist retention. This dashboard can also produce aggregated data that visualises the combined trip/catch data of all anglers for research purposes (Fig. 15). This is an efficient method of identifying potential errors in logged session details. The session details visualised for the catch reports are as follows:

Individual Angler Dashboard:

- Overall Catch details (Total, Released, Retained)
- Trip locations
- Min, max and average lengths of species

Operations Dashboard:

- Overall Catch details (Total, Released, Retained, Measured)
- Trip locations
- Min, max and average lengths at species level.

Developing new features is an important component of angler retention. As new features for dashboards are frequently released, practical updates will be integrated into the angler diary dashboard.

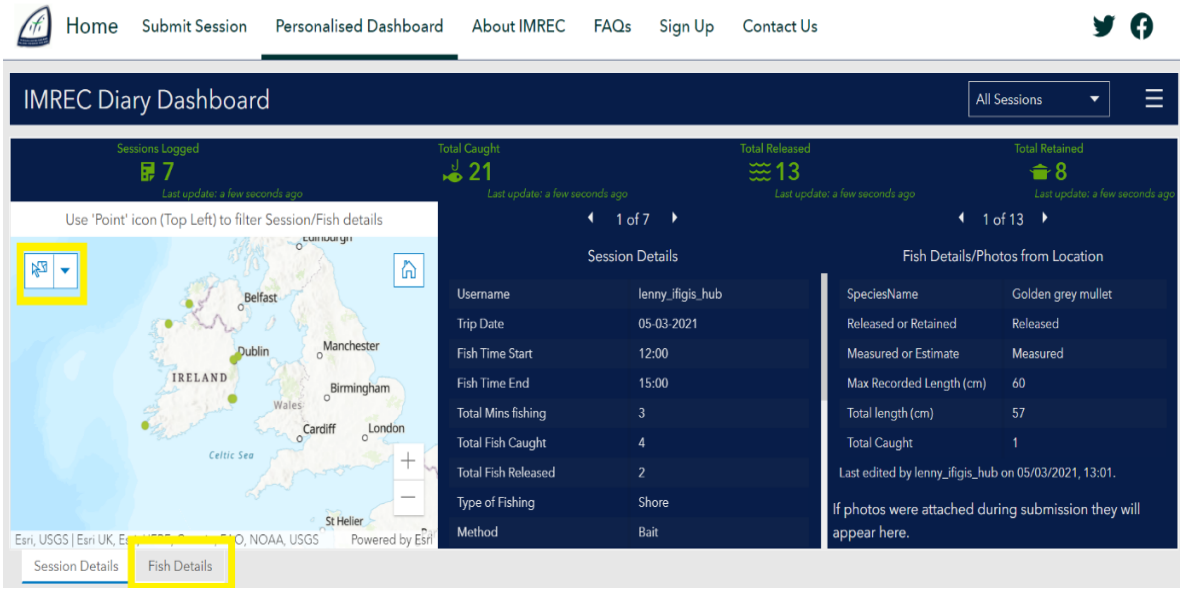


Fig. 15: Personalised Dashboard accessible through the IMREC online diary.

Diarist recruitment and retention

A critical phase in any successful diary programme is recruiting participants. It is difficult to recruit a representative sample of the population, because diarists are self-selecting and likely to be avid anglers. However, it is possible to reduce bias to an acceptable level through a well-designed study over a long temporal timeframe (Brownscombe et al., 2019; Skov et al., 2021; Venturelli et al., 2017). Currently, 70 diarists have completed the sign-up process and are

submitting fishing sessions with 105 sessions logged to date. Further diarist recruitment is required along with managing diarist retention. A well-designed, simple diary, complemented with diarist feedback and reminders as well as the provision of tools (measuring tapes, fish ID booklets) to assist diarists should incentivize potential diarists and limit drop off rates.

2.3 Data analysis

2.3.1 Shore and Small Boat on-site surveys

The shore and small boat surveys were developed with the aim of calculating the mean catch-per-unit-effort (CPUE) of all MRF species caught during each shore and small boat angling session where a session is defined as one daily angler trip for shore angling and one daily boat trip for small boat angling. This definition is used rather than mean catch per hour because of the difficulty in estimating total annual angling effort at such a fine scale. As noted above, it is well characterised that anglers cannot recall their annual number of trips without a level of bias. Therefore, it is assumed that asking anglers to recall how many hours they fished over a year is particularly open to inaccuracies. Roving creel surveyors interview shore anglers during their angling session so the data collected does not necessarily account for their complete session catch. All shore anglers interviewed were asked how long they have fished that day and how long they intended to continue to fish that day. Therefore, if a shore angler refused to accept a follow up call to collect complete session catch rates, constant average catch rates were assumed throughout the angling session. Refusals for follow up interviews were low (7.5%).

It was originally planned to collect small boat catch data during the access point survey only when they had completed their trip. However, due to the low overall number of small boat angler encounters, it was appropriate to also interview small boat anglers as they began their trip and to request a follow up interview when their session was complete. If a follow up interview for this cohort was not completed, the session record was removed from the CPUE sampling frame as an average catch rate could not be estimated.

An individual daily site visit is defined as the PSU. All known angling marks within a PSU as the SSU and all anglers encountered within each PSU as tertiary sampling units (TSU). The method for calculating means and variances for species specific CPUE estimates follows the procedures for random stratified surveys described in (Vølstad et al., 2006). Precision of the final CPUE estimates was based on the variation between daily PSU visits within strata.

Estimating mean CPUE and variance within each survey stratum

A ratio of the means estimator (Armstrong et al., 2013; Pollock et al., 1994; Vølstad et al., 2006) was used to calculate average species specific CPUE across all strata for shore and small boat angling. A stratum (s) is defined for each ICES region, quarter and high/low activity combination. Retained or released fish of a particular species are considered as a separate catch.

$$R_s = \frac{\sum_{i=1}^{n} C_{i,s}}{\sum_{i=1}^{n} A_{i,s}}$$

Where:

n_s = the number of PSUs sampled in each stratum *s.*

$C_{i,s}$ = total catch (retained or released of a given species) in PSU *i* in stratum *s.*

$A_{i,s}$ = total number of anglers/boats observed in in PSU *i* in stratum *s.*

R_s = mean CPUE for a given species (retained or released) in stratum *s.*

and $\sum C_{i,s}$ and $\sum A_{i,s}$ are the summed total catch and angler-day interviews for the stratum respectively. Some anglers observed during PSU visits were not interviewed due to refusals or a decision to sub-sample made by the surveyor. When this occurred, it was assumed that observed anglers not contributing to the PSU CPUE estimate had that same catch rate as those providing data. The catch and associated effort data collected during each sampling day were combined to provide the $C_{i,s}$ and $A_{i,s}$ values of the PSU. If a PSU visit had a record of observed anglers but no interviews, this was removed from the final estimation.

The variance of the mean CPUE for each stratum is calculated using the ratio estimator (Vølstad et al., 2006):

$$var(R_s) = \frac{\sum_{i=1}^{n}(C_{i,s} - \bar{R}_s A_{i,s})^2}{n_s(n_s - 1)\bar{A}_s^2}$$

Where:

$\bar{R}_s$ and $\bar{A}_s$ are the mean CPUE and effort calculated across all PSUs in each stratum.

If more than one PSU was sampled within a stratum but data was collected from only a single PSU, a meaningful variance cannot be calculated using the estimator described above.

Summation of CPUE estimates across strata to estimate annual mean CPUE

It is assumed that level of angling effort varies between strata. Therefore, it is required to assign weighting factors to strata to account for this disparity in angling effort. As the omnibus survey of angling effort does not have the resolution to derive weighting factors which express the relative angling effort between strata, estimates must be obtained from elsewhere. However, it is possible to develop an index of relative angling effort using the data collected during the on-site surveys. This method is appropriate if observed anglers are proportional to the true effort in the strata (Armstrong et al., 2013). As it is likely that angling practices vary between regions and quarters, this relationship is likely to be limited. Nonetheless, this is the only data driven method to derive weighting factors currently available. Further work will attempt to derive how angling effort is apportioned between sampling strata.

Due to COVID-19 restrictions during Q4 2020 and Q1 2021, data were not collected for some strata within this timeframe. To deal with this, a method of simple imputation was used to fill the gaps in the sampling frame. The catch data which was recorded in adjacent strata to the "blank" strata was averaged. To reduce the requirement to impute data, the activity strata were collapsed prior to weighting. Although some loss in precision is likely, catch rates between low and high activity strata were similar compared to the temporal and spatial strata

so any loss in precision would be negated by reliance on estimates of variance calculated from a data set developed by excessive imputation.

All fish records were categorised by the quarter in which the fish were caught, the region the fish were caught and which activity strata they were caught in. Averages were then calculated for each category and matched with the 'blank' cells with the same characteristics where an imputation was needed.

Weighting factors for each stratum are calculated by expanding the total number of observed anglers summed over all the PSUs in a stratum by the ratio of total number of PSUs in the stratum (sites x days) to the number of site-days sampled:

$$W_s = \left(\sum_i A_{i,s}\right) \times \frac{N_s}{n_s}$$

Where:

W_s = the weighting factor for stratum s.

N_s = the total number of PSUs in the sampling frame X the total number of possible sampling days in stratum s.

The weighted mean for combinations of two or more strata was calculated by:

$$R = \frac{\sum_s W_s R_s}{\sum_s W_s}$$

The variance of the weighted mean CPUE (R), was calculated as:

$$V(R) = \frac{\sum_s (V(R_s) \times W_s^2)}{(\sum_s W_s)^2}$$

Mean CPUE estimates were also calculated using the ratio of mean estimator by simply averaging the CPUE for all interviewed anglers without deriving weighting factors to account for variation in angling effort across strata and site selection probabilities defined through the sampling programme. Although variances for the CPUE data are presented, the values are not a true reflection of the variability in the dataset due to the level of imputation required to calculate the combined CPUEs.

Bias corrections

A well characterised bias associated with roving creel surveys (Lockwood, 2000) is length of stay bias. Anglers are encountered with probability proportional to the time they are visible fishing. This means that anglers who fish longer are more likely to be interviewed by surveyors and as such, overrepresented in the sampling frame. This bias can cause, an overestimate of mean CPUE, as the average angler who spends longer fishing is likely to catch more fish. This can be corrected by weighting individual angler CPUE estimates by the inverse of the trip duration:

$$\bar{R} = \frac{\sum_i \left(\frac{R_i}{d_i}\right)}{\sum_i \left(\frac{1}{d_i}\right)}$$

Where:

d_i = Angler trip duration (to the nearest hour).

As per Armstrong et al. (2013), a factor to correct for length of stay bias was calculated using unweighted CPUE (unit of effort is equal to the nearest hour) data with all catches combined for all shore anglers who accepted interviews. This value was applied to the final species specific CPUE estimates calculated through the full analysis. Small boat data were not corrected for this bias, as the access point design means that trip length will not affect the likelihood of a surveyor encountering a small boat angler.

Biological data collection during the on-site surveys was almost exclusively length data. As surveyors could not make direct measurements of released fish, this cohort is dependent on the angler's ability to recall the size of his fish. Therefore, length estimates, particularly those of released fish are expected to be imprecise. Collection of fish weight data was limited during the on-site surveys. However, the onboard charter survey collected length and weight data for a number of species which enabled the development of length-weight relationships (Appendix 2) and derived parameters to convert length data to biomass.

Estimation of total annual catches for shore and small boat angling

The overall CPUE estimates of a selection of species were combined with the effort estimates described in Tables 7 and 8 to calculate total catch of all released and retained species through shore and small boat angling. The small boat CPUE unit of effort described above is defined as a small boat angling trip. However, the total small boat annual effort estimates in Tables 7 and 8 define the unit of effort as one angler trip. Therefore, the CPUE estimates had to be corrected prior to raising up to total catch. An average of 1.78 anglers per small boat were recorded across all small boat interviews. This value is low due to the number of kayak interviews in the sampling frame.

2.3.2 Charter Catch Surveys

The pilot study received two separate streams of data from the charter component of MRF which will be combined to develop a long-term picture of the fishery. A more detailed analysis of data collected during the Onboard Charter Catch Survey has been presented here as the Charter Skipper Diary programme is ongoing and most participants had not returned their records when reporting commenced.

Onboard Charter Catch Survey

Three estimates were computed from a sub-set of the trip information and biometric data collected during the sampling window:

- Estimation of length-weight relationships
- Catch-per-unit-effort (CPUE)
- Total retained catch for the entire charter fleet per year

Estimation of length-weight relationships (LWRs)

Length-weight relationships (LWRs) serve an important function in fisheries research and stock assessments, as they allow the conversion of length-frequency data into biomass estimates (Silva et al., 2013). As fish length is typically more readily measurable parameter onboard a moving vessel than weight, length-weight relationship for individual species was estimated using the standard length-weight equation (Le Cren, 1951)

$$W = a \times L^b \quad (1)$$

where *W* is the fish weight (g), *L* is fish total length (cm), *a* is a constant, and *b* is an exponent.

Using linear regression through natural logarithmic transformation

$$\ln W = \ln a + b \times \ln L \quad (2)$$

the parameters *a* and *b* could be calculated where '*a*' represents the intercept and '*b*' represents the slope of the relation (Silva et al., 2013).

LWRs were calculated for all species where length and weight measurements exceeded 10 observations for an individual species. Where an individual species had either no, or limited data to allow a reliable relationship to be calculated, LWRs estimated by Cefas (Silva et al., 2013) for the nearest geographical area was used as a substitute.

Calculating Catch Per Unit Effort (CPUE)

Catch per unit effort (CPUE) for charter angling was estimated using two approaches.

The first approach represented the number of captured fish for a particular species by the number of charter angler days using the following formulae

$$CPUE_n = \frac{FISH_n}{DAYS_n} \quad (3)$$

where $CPUE_n$ is the number of captured fish (retained and released) for a particular species during the sampling window ($FISH_n$) divided by the total number of charter angler days reported during the sampling window for all ICES regions combined ($DAYS_n$). Note the lower-case subscript '*n*' signifies numbers within the study sample.

CPUE was also estimated for each ICES region separately as a mean retained weight per charter angler day using the following formulae

$$CPUE_{w(ICES)} = WEIGHT_{(ICES)} \times \frac{RETAINED_{n(ICES)}}{DAYS_{n(ICES)}} \quad (4)$$

where $CPUE_{w(ICES)}$ is the mean retained weight (g) of a particular species per angler charter day for an ICES region. $WEIGHT_{(ICES)}$ was calculated for each ICES region separately as the mean weight of a retained fish after applying Eq. (1) to the mean recorded total length of retained fish. $RETAINED_{n(ICES)}$ is the total number of retained fish for that species in the ICES region, and $DAYS_{n(ICES)}$ is the number of recorded angler days analysed for that ICES region.

Estimating total retained catch per year

Total retained catch for each ICES region per year was estimated for individual species using the following formula

$$CATCH_{ICES} = CPUE_{w(ICES)} \times DAYS_{N(ICES)} \quad (5)$$

where $CATCH_{ICES}$ is the total retained biomass per year for a particular species in a particular ICES region, and $DAYS_{N(ICES)}$ is the total number of charter angler days undertaken per year per ICES region. To demonstrate the level of uncertainty, three independent estimates for $DAYS_{N(ICES)}$ were used in the calculations.

Using the following formulae:

$$DAYS_{N(ICES)} = VESSELS_{N(ICES)} \times TRIPS_{N(Fleet)} \times ANGLERS_{N(Fleet)} \quad (6)$$

where $VESSELS_{N(ICES)}$ is the total number of active charter vessels in the population per ICES region (**Table 3**), $TRIPS_{N(Fleet)}$ is mean number of charter trips taken per charter vessel per year for the entire charter fleet (N=62) and $ANGLERS_{N(Fleet)}$ is the mean number of anglers onboard a charter trip (N=6.6). Estimates for $TRIPS_{N(Fleet)}$ and $ANGLERS_{N(Fleet)}$ were calculated using historical charter trip returns for the entire coast (1992-2008). These logbooks were submitted by charter skippers who volunteered to report the number of cruises they undertook annually along with the number of anglers taken onboard. The number of participating skippers varied between years (mean n=60) with vessels reporting from all ICES regions. Note the upper-case subscript 'N' signifies population estimates.

$DAYS_{N(ICES)}$ was also calculated using data collected from an IFI commissioned ESRI general angling survey (unpublished) and the population-wide Ipsos/MRBI telephone survey. After applying a recall bias correction to the results, the total number of charter angler days per year for all ICES regions combined ($DAYS_N$) was estimated to be 87,320 (ESRI, *pers comm*) and 120,904 (Ipsos). These estimates were then divided by the mean number of anglers per charter trip $ANGLERS_{N(Fleet)}$ (N=6.6) to provide an estimated total number of charter cruises for the entire active fleet undertaken annually across all ICES regions. These values were then divided by the total number of active vessels in the fleet $VESSELS_{N(Fleet)}$ across all ICES regions (N=67) to arrive at an estimated mean number of charter cruises per active vessel $TRIPS_{N(Fleet)}$ (**Table 25**). These values were then substituted into Eq. (6) to provide an alternate estimate for the number of charter angler days per ICES region $DAYS_{N(ICES)}$.

3. Results

3.1 Survey Programmes

3.1.1 Online Behavior and Attitudes survey

The IMREC B&A survey (Ryan et al., 2020) was not planned in the original proposal and was undertaken in response to a need identified by the survey team, and the opportunity presented by COVID-19 pandemic travel restrictions. The data collected were used to advise on allocation of sampling effort for the on-site sampling programmes, whereby relatively more surveys were allocated in places and times when angling effort was deemed to be greater. It also provided useful information on angling habits such as catch & release rates for particular species.

Table 5: Breakdown of **r**espondents to survey by age

Age Group	Number of anglers	Percent (%)
16-24	138	11
25-34	291	24
35-44	317	26
45-54	252	21
55-64	156	13
65plus	54	5
not said	3	0.2

A total of 1211 sea anglers responded to the survey. The results showed that sea angling is a male dominated pursuit in Ireland, as only 46 females (4%) responded. There was a wide age distribution across the angling population according to the survey. The largest group was in the 35-44 cohort (**Table 5**). The age distribution is broadly in line with the latest census figures

for the Irish population (CSO, 2016). Less than 2% of respondents were not resident in Ireland. Most respondents classified themselves as shore anglers (1033). Of this cohort 496 shore fished only (Fig. 15). 463 and 417 respondents classified themselves as small boat and charter anglers, respectively. However, only a small percentage of these only fished from a small boat or charter boat (Fig. 16). Nearly half (44%) of all shore anglers live in the east of the country, most of whom live in the coastal counties**.** A large proportion of these tend to angle along the East coast (ICES region VIIa).

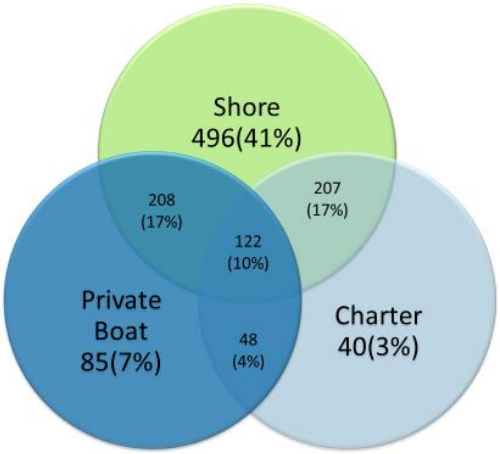


Fig. 16: Venn diagram illustrating the breakdown of fishing types which respondents (n=1211) to the online survey purported to take part in.

Small boat and charter anglers generally fish in ICES regions at the same rate as shore anglers with one notable exception. The west coast (ICES VIIb) is the most popular destination for charter anglers, with 26% reporting that they usually fish there, while 24% fish the east coast (Fig. 17).

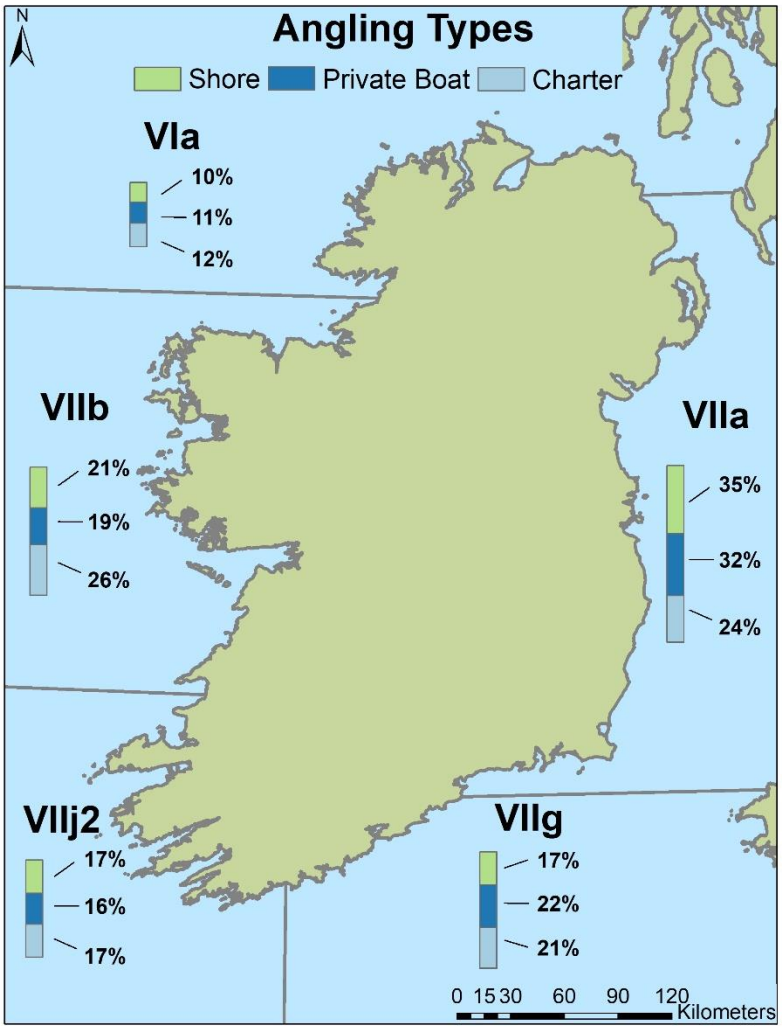


Fig. 17: Percent response when all anglers were asked in what region of the country, they usually fish.

As anticipated August was the most popular month for angling trips across all methods with shore anglers reporting an average of 7 trips and small boat and charter anglers reporting and average of five and two trips respectively (Fig. 18). In February, the least popular angling month according to the survey, shore anglers reported on average 2.5 trips, while small boat and charter anglers reported less than one trip (Fig. 18).

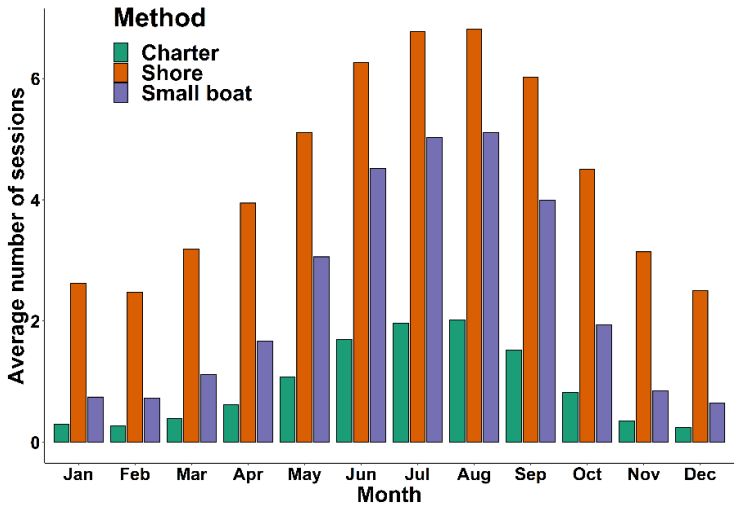


Fig. 18: Average number of fishing trips per month across angling methods reported by anglers in the online behavior and attitudes survey.

The B&A survey also found that nearly half of small boat anglers who responded to the survey fish from their own boat. The remainder either fish from a friend's boat, rent a boat, or fish from a kayak (**Table. 6).**

Although nearly half of all small boat anglers launch from a slip, a substantial proportion access the water via different points. This includes 17% of respondents who confirmed that they usually launch from the beach (Fig. 19). This information has major implications regarding small boat survey design.

Table 6: Percentage of small boat anglers who responded 'yes' when asked if they fished from a particular type of boat (n=459)

Type of boat	Confirmed (%)
Your boat	48.1
A friend's boat	30.9
A hired boat	5.2
A Kayak (incl. pontoon boat, inflatable, etc)	29.6

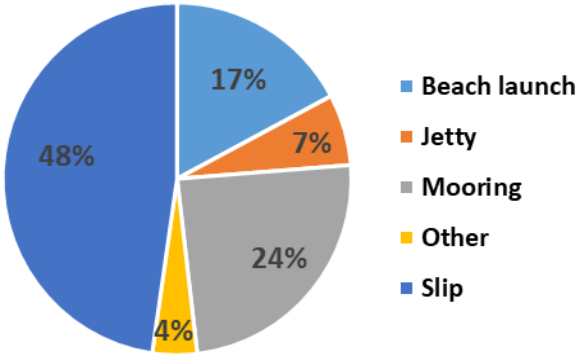


Fig. 19: Pie chart illustrating the percentage response when private boat anglers were asked how they usually launched their boat.

B & A survey respondents were also asked to consider the species which they most commonly encounter when angling. Mackerel and pollack are the most commonly caught fish aboard both small boats and charters. Over 90% of small boat anglers and 87% of charter anglers catch mackerel in particular. Pollack are nearly as common with 86% of charter anglers and 87% of small boat anglers reporting that they catch them often. Surprisingly perhaps, cod are the third most encountered species for anglers reporting on small boat (58%) and charter angling (71%). Ling and conger eel are encountered at a relatively common rate among charter anglers (67% and 45% respectively) compared to small boat anglers (34% and 24% respectively). This is probably as a result of the ability of charter boats to target particular angling marks which may be too distant or exposed for smaller boats. In contrast, 40% of small boat anglers report catching bass during angling sessions, whereas only 16% of charter anglers report the same (Fig. 20).

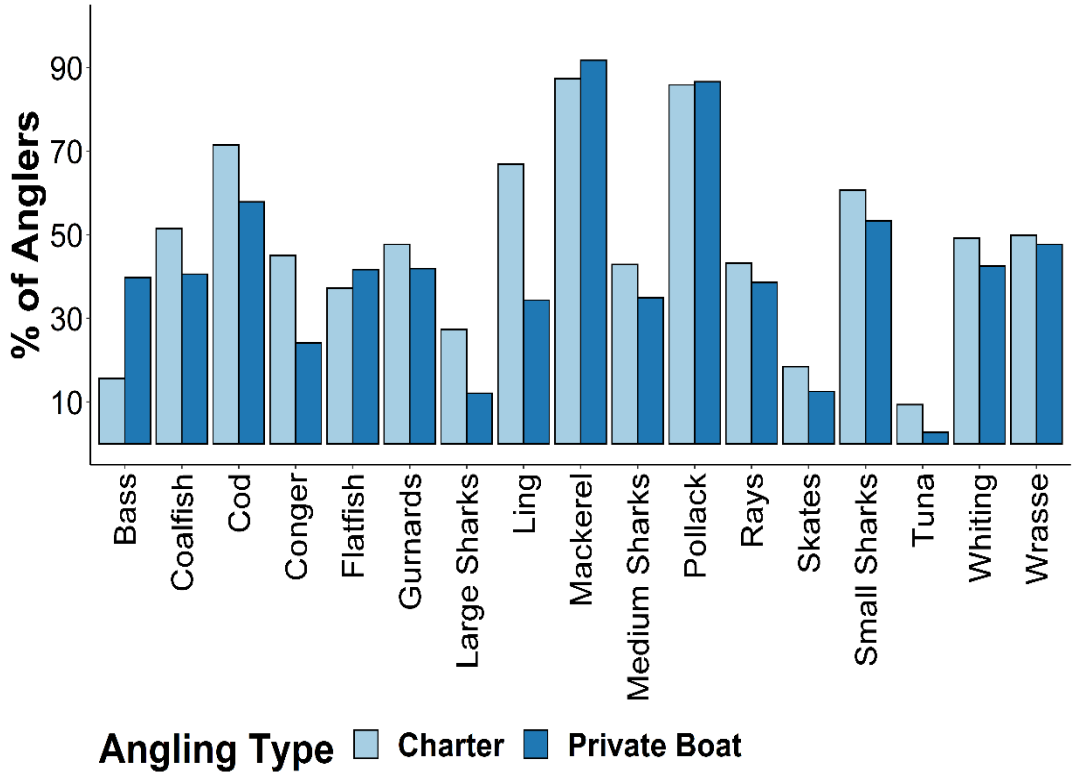


Fig. 20: Percentage of anglers who responded positively when asked if they often encountered a specific fish species/family during their charter or private boat angling sessions.

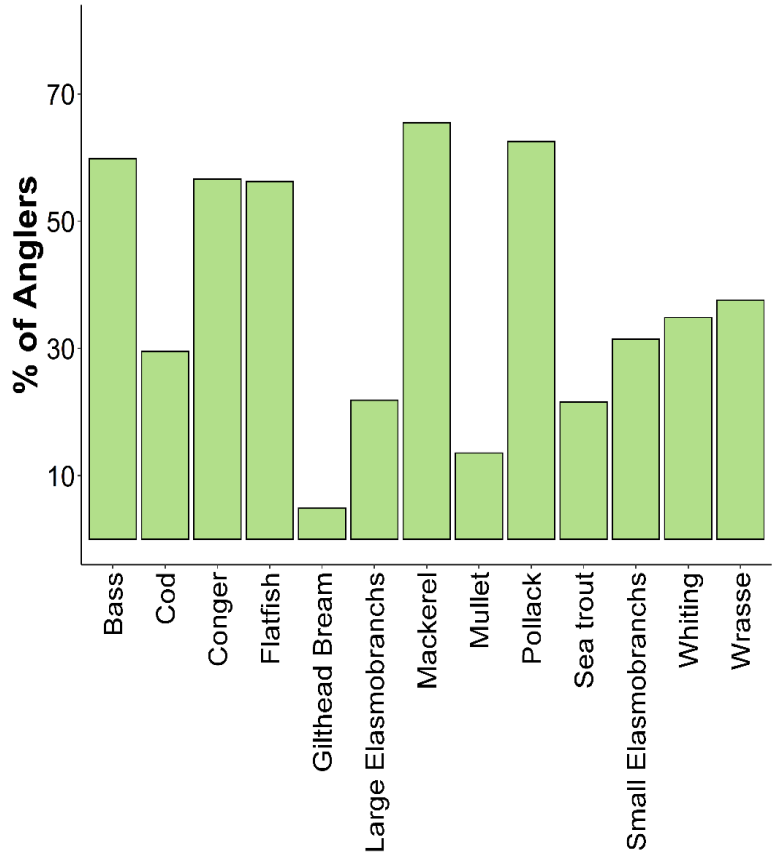


Fig. 21: Percentage of anglers who responded positively when asked if they often encountered a specific fish species/family during their shore angling sessions.

Like boat anglers, mackerel and pollack are the most commonly encountered species amongst shore anglers (65% and 63% report catching these species) (Fig. 21). However, the proportion of shore anglers who report this observation is lower overall than the boat anglers. This is attributed to the difference between the cohort of those shore anglers who usually fish with lures (which will catch pollack and mackerel specifically) from easily accessed platforms (pier or rocks) and those who fish from a beach with bait. The position of bass as the third most encountered species by shore anglers (60% report catching bass) highlights its popularity as a sport fish, its expanded distribution around the Irish coast, and improved bass angling techniques, including lure fishing (Fig. 21). Although mullet fishing is becoming more popular among sea anglers, the B&A survey indicates that relatively few anglers (14 %) have success catching mullet species around the Irish coast (Fig. 21). Only 5% of shore anglers reported

commonly catching gilthead bream, which indicates that this relatively new migrant to Irish shores is still very localised.

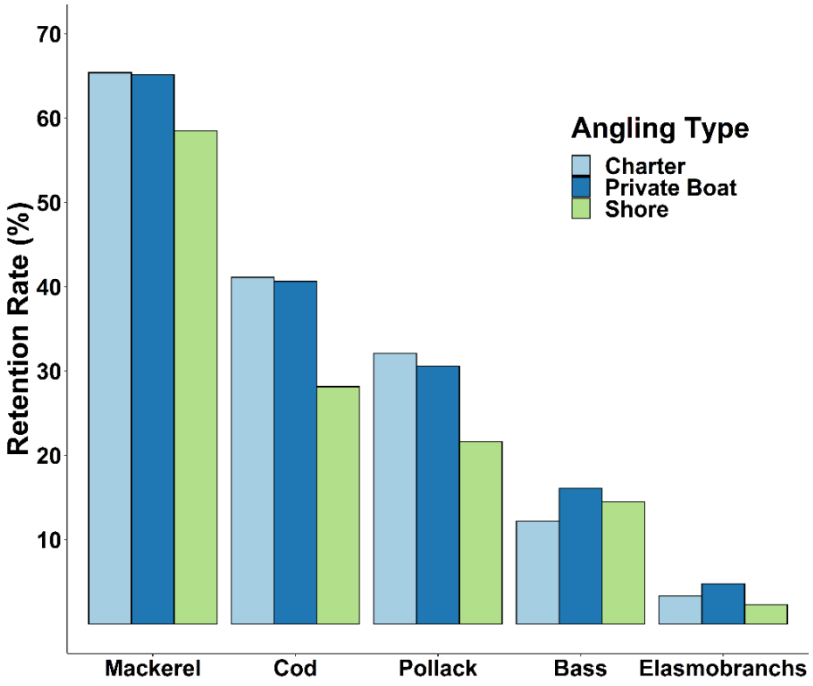


Fig. 22: Retention rates of selected fish species as reported by respondents to the online B&A angling survey.

Shore anglers retained less, on average, of every species listed in the survey except for bass (Fig. 22). However, bass retention rates were relatively low for all angling types (shore, 14%; small boat, 16%; charter 12%). Bass catch in the charter angling sector is low. Elasmobranchs are rarely retained by Irish sea anglers, irrespective of angling type (Fig. 22).

On average, both charter and small boat anglers reported that they retain 41% of their cod catch. Retention rates of pollack was slightly lower at 31% and 32% for small boat and charter angling respectively. In contrast, pollack and cod caught by shore anglers were retained at 22% and 28% respectively (Fig. 22).

3.1.2 Population-wide angling effort survey (Ipsos/MRBI)

In total 5,069 adults aged 15+ in Ireland were asked if they participated in sea angling on a recreational basis; those who responded 'yes' were asked further questions as to the nature of this activity and the frequency of participation (Ipsos MRBI, unpublished survey). Just under 7% of respondents considered themselves recreational sea anglers. Shore angling was the most popular angling type among sea anglers, followed by small boat and finally charter angling (Table 7). Males are more likely to engage in sea angling, with 11% confirming that they fish in the sea, compared to 3% of females.

Like the B&A survey, participation rates are quite evenly distributed through the age groups. Although participation rates are estimated to be slightly higher in the South (Munster 8%) and West (Connaught and Ulster 9%), compared to the East (Dublin 5%, rest of Leinster 6%), due to the disparity in population, overall angling effort is higher in the East (Fig. 23).

In 2020, the Economic and Social Research Institute (ESRI), Dublin carried out a general angling survey, using the same randomised survey methods as those described above, for which 15,000 adults aged 15+ were surveyed. The main difference was that the ESRI survey did not focus on sea angling. However, it was possible to estimate total sea angling participation rates from the responses received. This was estimated to be 185,000 recreational sea anglers in Ireland (ESRI, *pers comm).*

Table 7: Ipsos/MRBI survey results: angling participation rates based on an Irish population of 3,755,312 adults. ESRI sea angling population estimates included for comparative purposes (ESRI, pers comm).

Angling Type	Participation rate %	Participation raised to Irish population (±S.E)	Participation estimate (ESRI Rate)
Any Sea Angling	6.8	255,721 (±14,276)	185,000 (±9,887)
Shore Angling	5.2	193,623 (±12,651)	140,045 (±9,123)
Boat Angling	3.7	139,190 (±10,810)	100,640 (±4,746)
Charter	2	75,565 (±8,035)	54,575 (±772)

Fig. 23: Regional participation of Marine Recreational Angling in Ireland.

The Ipsos MRBI survey estimated that over half (53%) of shore anglers fish 6 times or less per year, with a greater proportion of small boat (66%) and charter (89%) anglers also fishing 6 times or less. Across all responses, it was estimated that the average shore angler makes 12.6 angling trips per annum, while small boat and charter anglers make 10.7 and 2.1 trips per year respectively (Table 8). It is well characterised that the influence of recall bias, particularly over long periods, affects effort estimates in surveys such as this (Andrews et al., 2018; Lewin et al., 2021; Tarrant et al., 1993). Although the magnitude of bias is likely specific to particular surveys, some authors have attempted to quantify it and the magnitude of overestimation is generally very high. Authors have found that recall-based telephone surveys consistently produced significantly higher estimates of effort compared with other sampling approaches. In some instances, recording more than double the effort (Forward and Lyle, 2002; ICES, 2010). Another study compared data collected from a 12 month recall survey and a quarterly

survey and estimated a bias of 29% (Connelly et al., 2000). As this is a universal issue, until processes are developed where this bias can be quantified in an Irish context, or other methods for estimating Irish angling effort become available, it was deemed appropriate to apply a conservative correction factor of 0.75 to the effort estimates (Table 8), which is being used to estimate total MRF catch in Ireland at this juncture. Combining participation rates with average annual effort rates, provides total annual effort, expressed as daily angling trips which will be used to estimate total annual MRF catch in Ireland.

Table 8: Ipsos/MRBI survey results showing the activity levels of anglers across all three sectors.

	Shore% (n=261)	Small Boat% (n=188)	Charter% (n=102)
Less than once/year	5	7	23
1--2 times	20	32	49
3--4 times	13	13	11
5--6 times	15	14	6
7--10 times	16	10	2
11--20 times	14	10	2
21--30 times	6	5	\
31 --40 times	3	4	\
41--50 times	3	1	1
51-75 times	1	\	\
76--100 times	2	\	\
101--150 times	\	2	\
Over 150 times	1	\	\
Can't say	1	2	6
Average number trips/year (±standard error)	12.6 (±1.4)	10.7 (±2.0)	2.1 (±0.4)
Average number trips/year with recall bias correction factor (0.75) (±standard error)	9.5(±1.1)	8.0 (±1.5)	1.6 (±0.3)

Table 9: Estimates for total number of sea angling trip days.
Sense checking (See results) suggests estimated charter angling days exceeds charter angling fleet capacity by a factor of 4. No data are available to sense check shore or small boat angling days but** it is **likely, based on charter angling comparison, that angler recall bias inflated all three sector angl**er **day estimates.

	Total number of daily trips per year (±S.E) (Ipsos/MRBI)	**Total number of daily trips per year with bias correction (Ipsos/MRBI) – Method 1**	**Total number of daily trips per year (ESRI)**	**Total number of daily trips per year with bias correction (ESRI) – Method 2**
Shore	2,439,650 (±15,676)	1,839,419 (±11,363)	1,764,567 (±10,947)	1,330,428 (±8,210)
Small Boat	1,489,333 (±10,105)	1,113,520 (±7,882)	1,076,848 (±7,188)	805,120 (±5,694)
Charter	158,687 (±377)	120,904 (±277)	114,608 (±270)	87,320 (±201)

Standard errors (S.E) around total sea angling trips were calculated from the product of the S.E of the participation rates estimate and S.E of the daily activity estimates.

3.1.3 On-site surveys of angling

Roving Creel Survey of Shore Anglers

Sampling effort was limited to February and March 2020 due to the onset of the COVID-19 pandemic (Fig. 5). Upon relaxation of COVID-19 travel restrictions, sampling recommenced on 10th July until December 2020, when restrictions were reimposed. Further easing of restrictions in early 2021 allowed sampling to continue nationwide from March - August 2021. This allowed some level of sampling coverage for all quarters over a two-year period.

All PSUs were classified as High or Low activity across all four quarters of the year. This allowed for weighted random sampling of shore angling, leading to a higher number of high activity sites being visited. Table 10 shows the breakdown of high/low activity PSUs over four quarters. Predictably, the summer months saw a greater number of high activity PSUs with the winter months having more low activity PSUs.

Table 10: Number of High/Low activity Primary Sampling Units (PSUs) for shore sampling in each ICES region per quarter.

	Activity	Quarter	VIa	VIIa	VIIb	VIIg	VIIj2
Shore	High	1	6	6	11	6	6
		2	14	11	12	9	8
		3	15	13	10	9	6
		4	6	9	7	5	7
	Low	1	33	30	35	11	23
		2	25	25	34	8	21
		3	24	23	36	8	23
		4	33	27	39	12	22

Site Visits

163 shore surveys were conducted between July 2020 and August 2021 consisting of 949 Secondary Sampling Units (SSUs) (Table 11). A large proportion of surveys were conducted on the east coast (VIIa) due to COVID-19 travel restrictions limiting sampler range. As a result, several survey strata with planned sampling has no visits. Out of 40 shore survey strata (ICES region, quarter, activity stratum), 14 had no PSU visits and several others had three or less PSU visits over the duration of the survey programme (Table 11). As the majority of data absent or data poor strata occur in Q4 or Q2 as a result of travel restrictions due to the COVID-19 pandemic, it is likely that an important contribution to the overall catch estimates are missing.

Angler encounters

The number of shore anglers observed while surveying was 436 (Table 12). Relatively large numbers of anglers were observed on the east coast (Fig. 24). This can be calculated as 2.9 anglers observed per survey day (No. anglers observed/No. Surveys per ICES region). The south coast (VIIg) saw 3 anglers observed/survey day while the southwest coast (VIIj2) saw 2.8 anglers observed/survey day. The remaining ICES regions reflect the findings from the online surveys with fewer anglers fishing the west (VIIb) and Northwest coast (VIa) with 1.7 anglers and 1.8 anglers observed/survey day respectively.

Table 11: Number of High/Low activity Primary Sampling Units (PSUs) visited in each ICES region per quarter. (Total visits = 163)

	Activity	Quarter	VIa	VIIa	VIIb	VIIg	VIIj2
Shore	High	1	0	6	0	0	0
		2	3	6	1	3	4
		3	6	12	10	10	6
		4	0	1	0	0	1
	Low	1	0	3	0	0	0
		2	0	11	1	2	6
		3	1	16	6	3	4
		4	0	34	3	0	4
			10	89	21	18	25

The total number of anglers interviewed for the IMREC Survey is lower when compared to the angler observed figures (Table 13) due to interview refusals and sub-sampling of large groups (20-25 anglers mackerel fishing in one location). The southwest coast (VIIj2) had the highest number of anglers interviewed with 2 anglers/survey day. The East coast (VIIa) saw the second highest with 1.8 anglers. The south coast (VIIg) followed with 1.5 anglers/survey day. Angler encounter rates were lowest in the west and northwest coast with 1.2 and 1.1 anglers recorded per survey day respectively.

Table 12: Number of anglers observed (436) during Shore surveys in each ICES region per quarter.

	Activity	Quarter	VIa	VIIa	VIIb	VIIg	VIIj2
Shore	High	1	0	15	0	0	0
		2	16	11	0	2	18
		3	2	90	27	33	22
		4	0	14	0	0	0
	Low	1	0	3	0	0	0
		2	0	36	0	3	8
		3	0	60	1	16	18
		4	0	28	8	0	5
			18	257	36	54	71

Table 13: Number of anglers Interviewed (271) during Shore surveys in each ICES region per quarter.

	Activity	Quarter	VIa	VIIa	VIIb	VIIg	VIIj2
Shore	High	1	0	10	0	0	0
		2	9	7	0	1	16
		3	2	45	21	20	10
		4	0	4	0	0	0
	Low	1	0	3	0	0	0
		2	0	26	0	3	7
		3	0	37	1	3	12
		4	0	27	3	0	4
			11	159	25	27	49

Catch overview

Shore anglers who accepted an interview reported the capture of 716 fish combined (including call-backs post trip completion). Mackerel and pollack dominated shore catch records (Table 14). No cod catches were reported during the shore surveys. Lesser spotted dogfish were the third most common species caught from the shore (43) followed by smooth-hound (18). The only other shore caught elasmobranch record was one tope, caught on the East coast. European seabass represented the lowest shore-caught DCF specific species with 14 recorded.

Mackerel and pollack had a higher retention rate than other angling species in agreement with the results of the B&A survey. One survey recorded 91 juvenile pollack retained by a small group of anglers which considerably increased the overall retention rate. Overall, retention of pollack catch among shore anglers was rare. Omitting these records from the analysis would reduce CPUE of shore caught retained pollack by 99%. The presence of a small number of large values in a data set inflates sample variance but is likely to occur when the overall number of random samples is small compared to the total number of angling trips among the population. This observation merits further analysis before valid catch estimates can be reported. Additional surveys and angler diary data will provide information on the variability of catch rates.

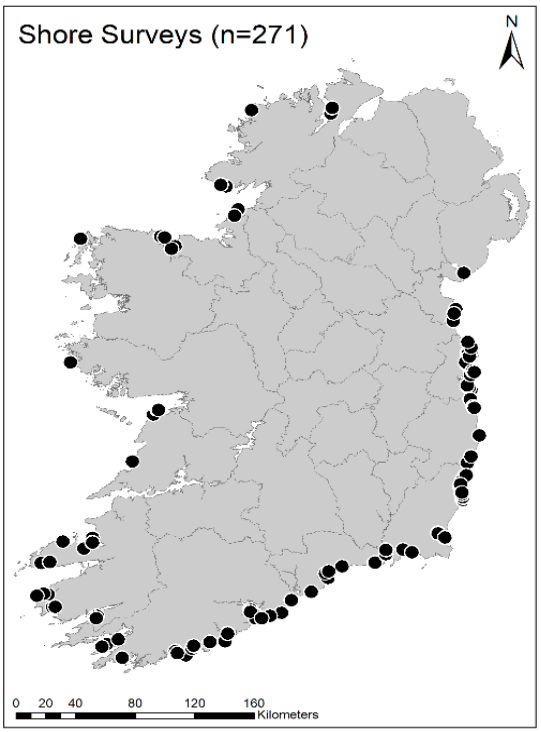


Figure 24: Locations where shore anglers were surveyed during on-site surveys in July 2020- August 2021.

Other notable catches during shore sampling were flounder with 7% of overall shore catches (47 caught, release rate = >90%) and whiting with 6% (40 caught, release rate = 65%). 12 coalfish were also recorded during shore surveys with a release rate of 58%. This is a species that needs to be closely observed as it can be easily misidentified as pollack by anglers.

Table 14: Total shore captures of DCF specific species across all strata

	Total Caught		Avg. Total Length (cm)	
	Released	Retained	Released	Retained
European seabass	12	2	39.8	51.0
Lesser spotted dogfish	41	2	47.5	22.5
Pollack	51	98	25.8	26.0
Smooth-hound	18	0	31.5	-
Tope	1	0	30.0	-

Bus route access point survey of small boat anglers

Site Visits

Between July 2020 and August 2021, a total of 44 PSUs (Table 15) were visited by surveyors. A total of 32 small boat (57 anglers) interviews were completed.

The lower figure for small boat surveys compared to shore surveys is due to several factors. The seasonality of recreational small boat angling became apparent after consultation with IMREC Steering Group members and results from the online B&A survey. A refined sampling window of May-August 2021, when most small angling occurs, was agreed upon to best utilise sampling resources. The shift to 'convenience sampling' (ICES, 2018; Lewin et al., 2020) in the small boat sector can be seen with twice as many high activity PSUs visited compared to low activity PSUs.

Table 15: Number of High/Low activity Primary Sampling Units (PSUs) for small boat sampling in each ICES region per quarter.

	Activity	**Quarter**	**VIa**	**VIIa**	**VIIb**	**VIIg**	**VIIj2**
Small Boat	High	1-4	0	18	3	9	3
	Low	1-4	4	2	1	0	4

Anglers observed

The number of small boat anglers observed while surveying was 72 (Table 16). As noted for the shore angling sampling frame, most anglers were observed on the east coast (VIIa). The 46 anglers observed in this ICES region was calculated as 2.3 anglers observed per survey day (No. anglers observed/No. Surveys per ICES). The south coast (VIIg) saw 2 anglers observed/survey day while the north coast (VIa) saw 1.75 anglers observed/survey day. The west coast (VIIb) saw only 0.25 anglers/survey day and no small boat anglers were observed in the southwest coast (VIIj2) despite the introduction of convenience sampling. As with the shore surveys, a number of strata in Q4 and Q1 did not have site visits. Although this may not have the same impact on time of year, blank strata require imputation steps during analysis, which reduces the robustness of overall catch estimates. This must be considered in future programmes.

Table 161: Number of anglers observed (72) during small boat surveys in each ICES region per quarter.

	Activity	Quarter	VIa	VIIa	VIIb	VIIg	VIIj2
Small Boat	High	1	0	4	0	0	0
		2	0	0	0	13	0
		3	0	38	1	5	0
		4	0	0	0	0	0
	Low	1	0	0	0	0	0
		2	0	0	0	0	0
		3	7	4	0	0	0
		4	0	0	0	0	0

Like the shore survey results, less small boat anglers were interviewed than observed (Table 17). This was mostly due to refusals or instances where anglers were observed angling but an opportunity for a survey was not possible (e.g. anglers going out from a marina, launching kayaks before samplers could approach). The east coast saw the greatest number of small boat anglers with 1.1 anglers interviewed/survey day (Fig. 25). The south coast produced 0.78 anglers interviewed/survey day. A successful example of convenience sampling was recorded in the north coast (VIa) with 0.75 anglers interviewed/survey day.

Table 17: Number of complete interviews (32) during small boat surveys in each ICES region per quarter.

	Activity	Quarter	VIa	VIIa	VIIb	VIIg	VIIj2
Small Boat	High	1	0	2	0	0	0
		2	0	0	0	5	0
		3	0	15	1	2	0
		4	0	0	0	0	0
	Low	1	0	0	0	0	0
		2	0	0	0	0	0
		3	3	4	0	0	0
		4	0	0	0	0	0

This was the closest resemblance to shore anglers interviewed/survey day in all ICES regions and was also a problem area for sampling prior to the introduction of convenience sampling. The west coast followed with 0.25 anglers interviewed/survey day. No anglers were interviewed in VIIj2.

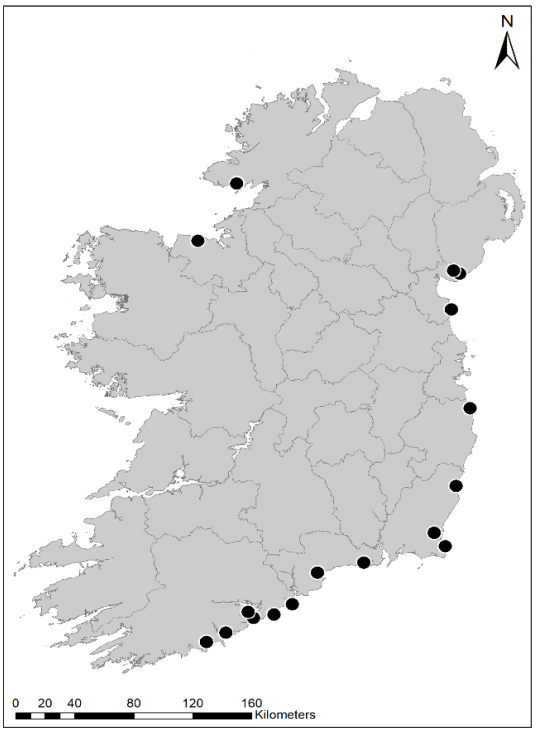


Fig. 25: Locations of Small Boat angler interviews July 2020- August 2021.

Catch overview

As recorded for shore angling mackerel and pollack dominated catches from small boats (Table 18). In total, 16 cod were caught from small boats with a 50:50 retained/released ratio. Lesser spotted dogfish were the only elasmobranch species recorded from small boats with European seabass again representing the lowest caught DCF specific species with 8 being recorded.

Mackerel and pollack also had a higher retention than released rate with small boat anglers. Surprisingly, cod release rates were 50% with all other species recording at least a 75% release rate.

Table 18: Total small boat captures of DCF specific species for all ICES regions.

Species	Total Caught		Avg. Total Length (cm)	
	Released	Retained	Released	Retained
Cod	8	8	35.0	44.6
European seabass	6	2	36.7	44.0
Lesser spotted dogfish	10	0	60.0	-
Pollack	22	58	41.7	44.0

3.2 Catch per unit effort estimates

3.2.1 Shore and Small Boat on-site surveys

Roving creel CPUE estimates are subject to length of stay bias because anglers who fish for longer are likely to catch more fish. To account for this, a correction factor must be applied to the stratified CPUE estimates. When hourly CPUE rates for all catches combined were weighted by the inverse of trip duration, a correction factor of 0.9 emerged, meaning that catch rates are inflated by about 10% due to length or stay/avidity bias. This effect is probably species-specific; however, many species were caught in low numbers. In this instance it was deemed appropriate to determine a universal picture of length of stay bias. Future work on this bias can focus on species of particular interest.

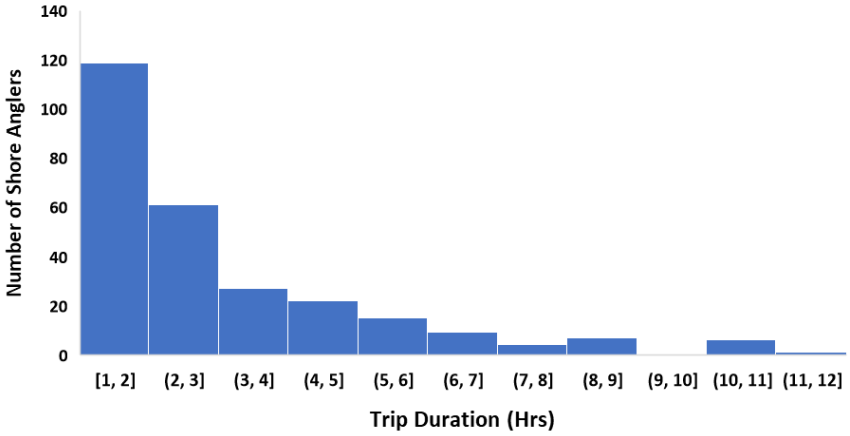


Fig. 26. Histogram of average shore angling trip duration, as reported by anglers interviewed during roving creel surveys.

Shore anglers interviewed reported spending an average of 3.2 hours fishing. However, the majority spent less than 2 hours (Fig. 26).

CPUE estimates for all species caught during the on-site surveys were calculated across all strata. Mackerel and pollack were the most commonly caught species in both the shore and small boat sectors. Small boat sampling rates were low and CPUE estimates are based on an extremely limited data set (n = 32). Therefore, the CPUE values presented, provide a useful qualitative overview of prominent species in small boat angler catches but any conclusions drawn on small boat catch estimates based on these CPUE data have low confidence.

Catch & release

For shore angling, mackerel release rates were low (4% of total catch). Pollack release rates were higher at 34%. All other species showed high release rates exceeding 85% (Fig. 27).

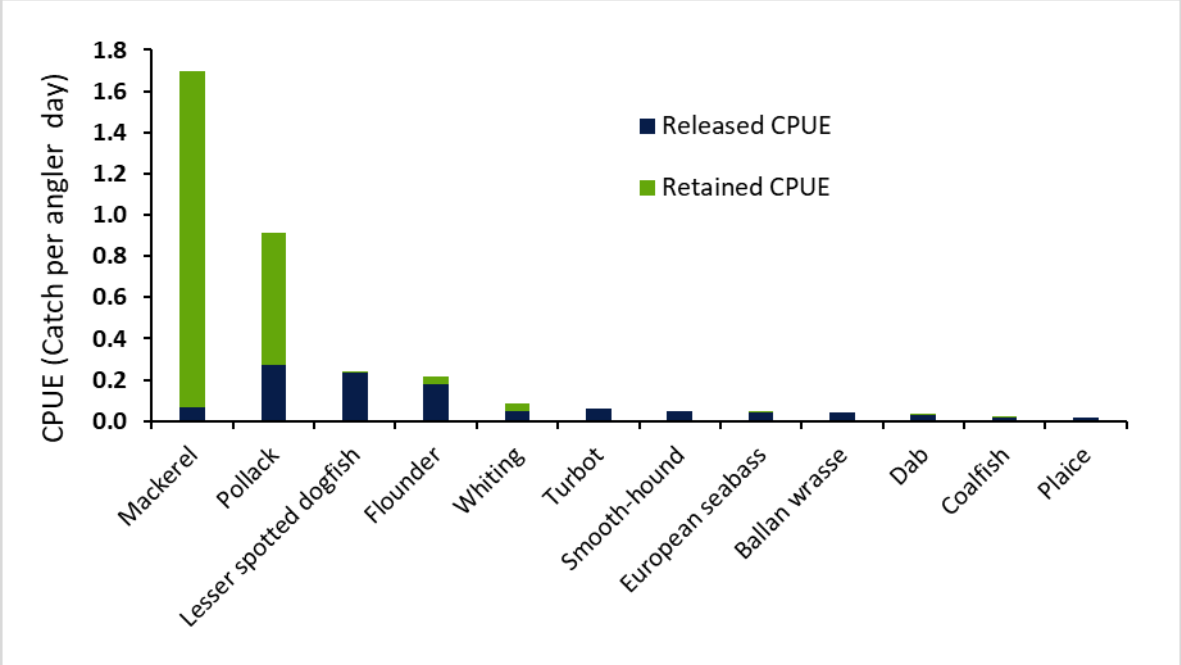


Fig 27. Comparison of release rates of the 12 most commonly shore caught species recorded during the on-site surveys by mean weighted mean CPUE records.

Release rates for mackerel were higher in small boat surveys than shore surveys at 15%. Small boat pollack release rates were slightly lower than shore release rates at 28%. 16 cod were

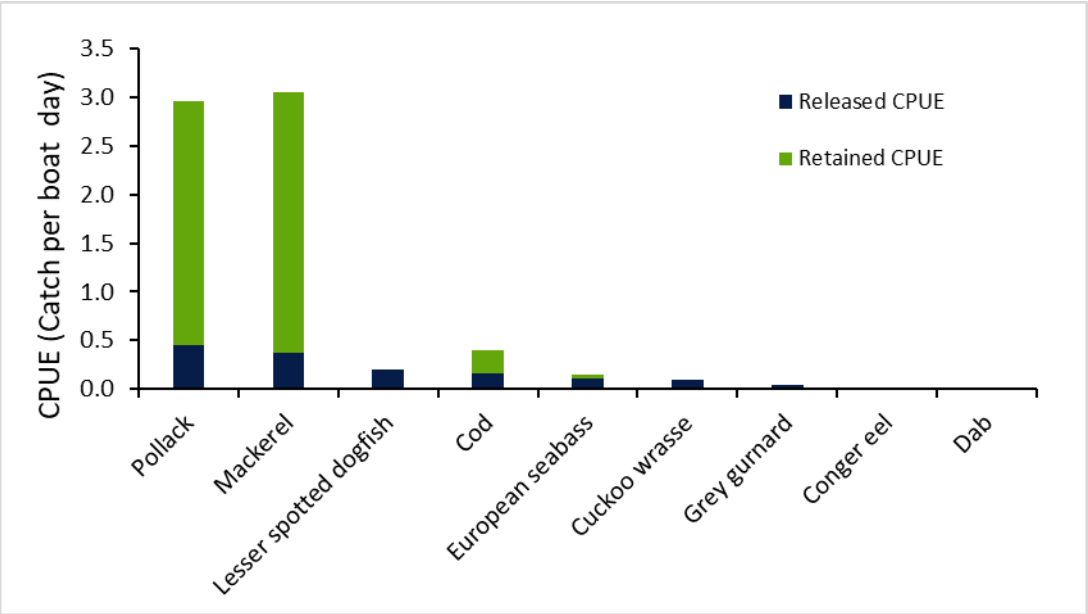


Fig 28. Comparison of release and retention rates of all records of small boat caught species recorded during the on-site surveys by mean weighted mean CPUE.

caught from small boats representing 6% of overall small boat captures with a 50:50 retained/released ratio. Lesser spotted dogfish were the only elasmobranch species recorded representing 4% of overall small boat captures with European seabass accounting for 3% of the catch (with 75% being released (Fig. 28).

Lengths of retained and released fish

Retained European seabass were, on average, longer (51 cm shore, n=2, 44 cm small boat, n=2) than released fish, for both shore (40 cm, n=12) and small boat angling (37 cm, n=6). This may reflect the legal length limit of 42cm (https://fishinginireland.info/regulations/) for retained bass currently in place (Fig. 29).

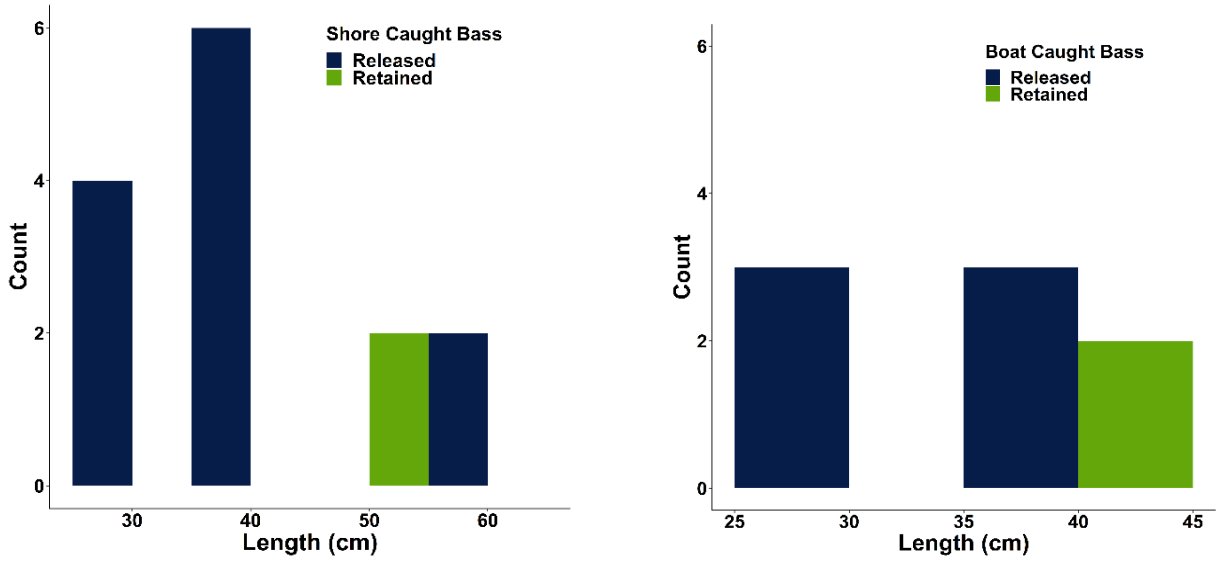


Fig.29 Length frequency distributions of shore and small boat caught European Sea bass recorded during the on-site surveys. Released and retained fish presented.

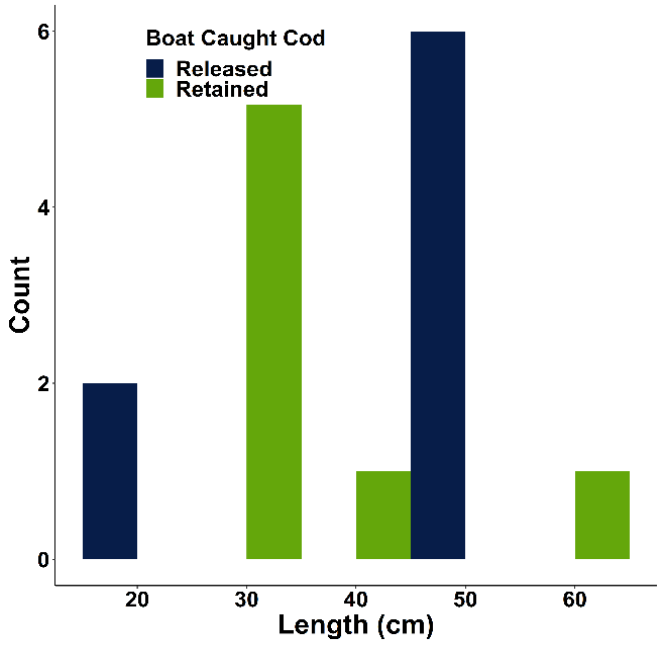


Fig.30 Length frequency distributions of small boat caught Cod. Released and retained fish presented (no shore caught cod data were collected during the survey).

Surveyors did not encounter any shore anglers who had caught cod during the sampling programme, probably due to limited sampling during the winter months. The average length of retained and released small boat caught cod was 36 (n=8) cm and 43 cm (n=8) respectively (Fig. 30).

Lengths of retained and released pollack varied considerably, due in part to the number of catch records collected during surveys. Both retained (n=98) and released (n=51) shore caught pollack were on average 26cm. Small boat caught pollack were generally larger,

with released fish (n=22) on average 47cm in length and retained fish (n=58) 42cm on average (Fig. 31).

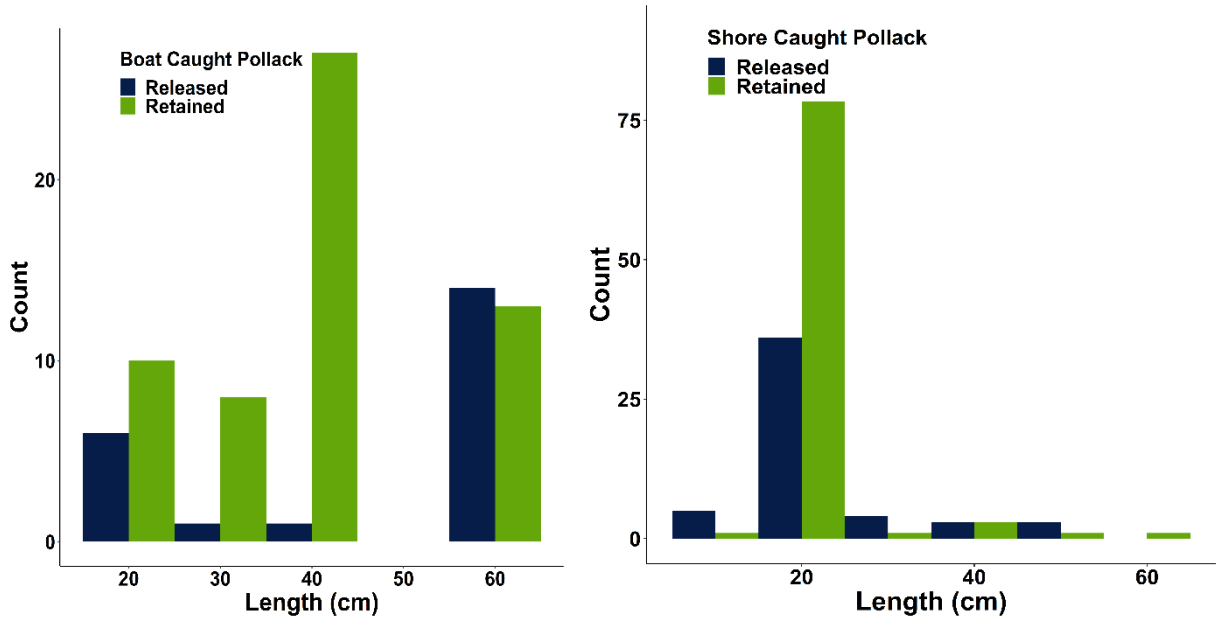


Fig.31: Length frequency distributions of shore and small boat caught pollack. Released and retained fish presented.

Average lengths and CPUEs for all retained or released species during the on-site surveys are presented in Tables 19 and 20. These tables report all species caught; many catches are based on extremely limited sample sizes, often a single fish record. These figures are for comparative purposes only and should not be regarded as accurate estimates for further analysis.

Table 19: CPUE estimates and average lengths of all retained fish recorded during the IMREC on-site small boat and shore surveys.

Angling type	Species	Weighted* CPUE	Average length (cm)	Unweighted** CPUE
Small Boat (CPUE= catch per boat day)	Cod (n=8)	0.24	36.0	0.25
	European seabass (n=2)	0.04	44.0	0.06
	Mackerel (n=117)	2.68	29.5	3.66
	Pollack (n=58)	2.51	41.6	1.81
Shore (CPUE= catch per angler day)	Coalfish (n=5)	0.01	46.6	0.02
	Dab (n=4)	<0.01	18.3	0.01
	European seabass (n= 2)	<0.01	51.0	<0.01
	Flounder (n=4)	0.04	31.3	0.01
	Gilthead bream (n=1)	<0.01	32.0	<0.01
	Herring (n=1)	<0.01	12.0	<0.01
	Lesser spotted dogfish (n=2)	<0.01	22.5	0.01
	Mackerel (n=323)	1.63	29.4	1.19
	Pollack (n= 98)	0.64	26.0	0.36
	Scad (n=1)	0.01	32.0	<0.01
	Three-bearded rockling (n=2)	<0.01	8.0	<0.01
	Whiting (n=14)	0.04	15.2	0.05

For comparative purposes weighted mean CPUE*, using the survey design approach, and mean CPUE** using a basic estimator without stratum weighting are presented.

Table 20: CPUE estimates and average lengths of all released fish recorded during the IMREC on-site small boat and shore surveys.

Angling type	Species	Weighted CPUE*	Average Length (cm)	Unweighted CPUE**
Small Boat (CPUE= catch per boat day)	Cod (n=8)	0.16	42.5	0.25
	Conger eel (n=1)	0.02	70.0	0.03
	Cuckoo wrasse (n=2)	0.09	25.0	0.06
	Dab (n=1)	0.02	10.0	0.03
	European seabass (n=6)	0.11	36.7	0.19
	Grey gurnard (n=1)	0.05	30.0	0.03
	Lesser spotted dogfish (n=10)	0.2	60.0	0.31
	Mackerel (n=20)	0.38	17.0	0.63
	Pollack (n=22)	0.45	46.6	0.69
Shore (CPUE= catch per angler day)	Ballan wrasse (n=10)	0.04	23.3	0.04
	Coalfish (n=7)	0.01	33.9	0.03
	Corkwing wrasse (n=1)	<0.01	6.0	<0.01
	Cuckoo wrasse (n=1)	<0.01	15.0	<0.01
	Dab (n=10)	0.03	15.0	0.04
	European seabass (n=12)	0.04	39.8	0.04
	Flounder (n=43)	0.18	23.5	0.16
	Gilthead bream (n=1)	<0.01	60.0	<0.01
	Grey gurnard (n=2)	<0.01	15.0	0.01
	Launce (n=1)	<0.0	10.0	<0.01
	Lesser spotted dogfish (n=41)	0.23	47.5	0.15
	Mackerel (n=15)	0.07	24.3	0.06
	Plaice (n=5)	0.02	23.4	0.02
	Pollack (n=51)	0.27	25.8	0.19
	Red gurnard (n=1)	<0.01	10.0	<0.01
	Sea trout (n=2)	0.01	23.5	0.01
	Smooth-hound (n=18)	0.05	31.5	0.07
	Thick-lipped grey mullet (n=2)	<0.01	61.0	0.01
	Tope (n=1)	<0.01	30.0	<0.01
	Turbot (n=9)	0.06	16.8	0.03
	Whiting (n=26)	0.05	20.1	0.10

For comparative purposes weighted mean CPUE*, using the survey design approach, and mean CPUE** using a basic estimator without stratum weighting are presented.

Total Annual Catch Estimation for popular angling species

The design-based CPUE estimates of the most frequently caught species, based on on-site interviews, were combined with two separate angler effort estimates (to provide a range for total catch estimates of all caught retained or released species. The first was obtained through the Ipsos/ MRBI telephone survey (M1) (this study) and the second is a combination of the Ipsos/MRBI and ESRI surveys (M2) as described in detail above. All total catch estimates presented include an adjustment for likely recall bias in the effort estimates (refer to section 2.2). Effort recall bias, which tends to be a feature of these studies, and inherent in the current effort data were highlighted when total charter angling effort estimated from the IPSOS/MRBI survey was compared to total charter angling effort estimated from the historical charter angling data. This 'sense checking' found that over 4 times as many charter angling trips were estimated from the IPSOS/MRBI data compared to the historical charter angling data (additional detail and data in Table 25). This difference raises questions about the accuracy of the catch estimates. If the IPSOS/MRBI data are correct, it would mean that the average charter vessel in the Irish fleet would have to fish over 200 times a year, which is highly unlikely and does not reflect historical levels of angling charter vessel activity. Although no data are available currently to sense check the IPSOS/MRBI effort estimates for shore and small boat angling in Ireland, this conclusion also raises questions about their validity, which will be further investigated.

Shore angling species catch estimates

No catches of cod were recorded during the on-site shore sampling surveys (Table 21a). Mackerel made up the largest proportion of retained fish by shore anglers (Table 21a) with total retained estimates ranging between 334 (M2) and 462 (M1) tonnes (Table 21a). Pollack were the most released species by number and weight. Although released numbers of European sea bass were relatively small, biomass was substantial due to the average size of caught fish (Table 21a). Two separate scenarios for retained pollack are provided in Table 21a to highlight the effect a small sample of anglers can have on overall catch estimates. Surveyors encountered a party of three anglers at a single angling mark who had retained 90 pollack between them. This sample had a marked effect on shore retained pollack CPUE However all

retained fish were small juveniles so the effect on shore retained pollack CPUE biomass was not so distinct (Table 21a).

Although overall shore angling catch rates for European sea bass are relatively low, the average size is larger than most other shore caught species, particularly for retained fish. The estimate of retained bass through shore angling ranged between 8 (M2) and 11 (M1) tonnes. Apart from retained pollack and released mackerel, precision of CPUE estimates for shore caught fish described in Table 21a is generally high. However, it should be noted that due to the level of imputation required to estimate Irish catch rates precision estimates are biased.

Small boat angling species catch estimates

The small boat angling data collected during the pilot study estimated that total pollack retention ranged between 852 (M2) and 1179 (M1) tonnes and cod retention ranged between 127 (M2) and 176 (M1) tonnes (Table 21b). However, precision of small boat caught CPUE biomass estimates for species described in Table 21b was poor for retained Pollack (RSE 1.04) and Cod (RSE 0.80). As with shore angling, CPUE estimates for retained mackerel are the highest of all recorded MRF species. Small boat anglers also retained between 15 (M2) and 20 (M1) tonnes of European sea bass. It was estimated that almost twice as much European sea bass was released by small boat anglers, by biomass, as was retained during the survey (Table 21b). Precision of CPUE biomass estimates was poor for both retained and released European sea bass (Table 21b). These imprecise estimates were largely due to the difficulty in sampling small boat anglers and as a result, the small sample size. Sampling effort must be increased considerably to have any confidence in small boat catch estimates in the future.

Table 21a: Shore angling preliminary estimates of total catch weight for selected species.
NOTE: ANNUAL CATCHES SHOULD NOT BE QUOTED OR USED FOR ASSESSMENTS. As estimates are based on small, highly variable samples collected during a pilot study with the main aim of characterising the sector, absolute estimates should not be assumed to be valid.

Species	CPUE per angler day ±S.E (RSE)	CPUE Biomass per angler day ±S.E (g) (RSE)	Total annual catch (tonnes) M1*	Total annual catch (tonnes) M2**
	RELEASED			
Cod	NO RECORDS			
European seabass	0.04 ±0.002 (0.05)	38 ±6 (0.15)	70	51
Mackerel	0.06 ±0.002 (0.05)	8 ±1 (0.11)	20	15
Pollack	0.25 ±0.02 (0.08)	50 ±8 (0.16)	92	67
	RETAINED			
Cod	NO RECORDS			
European seabass	0.004 ±0.000 (0.05)	6 ±1 (0.17)	11	8
Mackerel	1.47 ±0.08 (0.06)	251 ±30 (0.12)	462	334
Pollack‡	0.58 ±0.05 (0.09)	102 ±30 (0.16)	188	136
Pollack‡‡	0.04 ±0.001 (0.03)	37 ±6 (0.17)	69	50

Final design based shore angling CPUE estimates include length of stay bias correction factor (0.9). Total catch estimates were calculated as the product of mean CPUE (mean catch per day per angler) derived from the Ipsos MRBI survey (M1*) or a combination of the Ipsos MRBI and ESRI surveys (M2**). Required information is currently unavailable to estimate the true sampling design error on the total annual effort estimates (M1 & M2) so error around total annual catch estimates are not currently provided. RSE values indicate the precision of the CPUE estimates.
Two retained pollack estimates are presented. ‡denotes all catch data collected during the on-site shore survey and ‡‡ ignores the catch of a party of three anglers encountered during a survey day who retained 90 small pollack (25-30cm) between them. This is provided to illustrate the effect of an unusually high retention rate.

Table 21b: Small boat angling preliminary estimates of total catch weight for selected species. ***NOTE. ANNUAL CATCHES SHOULD NOT BE QUOTED OR USED FOR ASSESSMENTS. As estimates are based on small, highly variable samples collected during a pilot study with the main aim of characterising the sector, absolute estimates should not be assumed to be valid.***

Species	CPUE per angler day ±S.E (RSE)	CPUE Biomass per angler day ±S.E (g) (RSE)	Total annual catch (tonnes) M1*	Total annual catch (tonnes) M2**
			RELEASED	
Cod	0.09 ±0.03 (0.37)	84 ±63 (0.75)	93	68
European seabass	0.06 ±0.02 (0.38)	35 ±24 (0.69)	39	28
Mackerel	0.21 ±0.06 (0.30)	9 ±5 (0.53)	10	7
Pollack	0.25 ±0.08 (0.31)	334 ±236 (0.71)	372	269
			RETAINED	
Cod	0.13 ±0.02 (0.18)	158 ±125 (0.80)	176	127
European seabass	0.02 ±0.01 (0.38)	18±13 (0.69)	20	15
Mackerel	1.50 ±0.4 (0.26)	295 ±152 (0.51)	329	238
Pollack	1.41 ±0.10 (0.12)	1059 ±1105 (1.04)	1179	852

Final design based small boat angling CPUE estimates include a correction factor of 0.56 (average of 1.78 anglers/boat trip) to convert CPUE per boat day to CPUE per angler day.
Total small boat catch estimates were calculated as the product of mean CPUE (per angler day) and total annual angler-day effort, derived from the Ipsos MRBI survey (M1*) or a combination of the Ipsos MRBI and ESRI surveys (M2**). Required information is currently unavailable to estimate the true sampling design error on the total annual effort estimates (M1 & M2) so error around total annual catch estimates are not currently provided. Relative standard errors (RSEs) are provided which reflect the low precision of a number of the CPUE estimates provided.

3.2.2 Onboard Charter Catch Survey

The onboard charter catch survey (n = 33 sampling trips) collected data on a total of 33 different angling species (n = 3389 fish), including eight elasmobranch species. All

elasmobranchs were released. Release rates for most species were high (Table 22 & 23). Highest retention was observed for cod, mackerel, pollack and scad. Edible species tend to be retained at the highest rates (Table 24).

Table 22: Unweighted *CPUE$_n$* of all teleost species recorded during the onboard charter catch survey and % released for all ICES regions combined (VIa, VIIb, VIIj2, VIIg & VIIa). Total number of angler days (n=193).

Species	Catch per angler day ($CPUE_n$)	% Released
Ballan Wrasse	0.08	93.8%
Coalfish	1.82	77.0%
Cod	0.09	23.5%
Conger Eel	0.01	100.0%
Cuckoo Wrasse	0.17	90.9%
Dab	0.26	70.6%
Flounder	0.01	100.0%
Goldsinny	0.01	100.0%
Grey Gurnard	0.08	100.0%
Haddock	0.01	100.0%
Launce	0.02	33.3%
Ling	0.08	46.7%
Mackerel	5.94	0.4%
Plaice	0.01	100.0%
Pollack	5.06	39.4%
Poor Cod	0.15	100.0%
Pouting	0.20	53.8%
Red Gurnard	0.03	66.7%
Sandeel	0.05	55.6%
Scad	1.91	14.9%
Tub Gurnard	0.03	100.0%
Whiting	0.26	66.0%

Generally, fish length did not influence retention. The average length of retained pollack was 45 cm (n=585) while the mean for released fish was 42 cm (n=385). Retained cod were longer on average (Fig. 32).

Table 23: Unweighted $CPUE_n$ of all elasmobranch species recorded during the onboard charter catch survey and % released for all ICES regions combined (VIa, VIIb, VIIj2, VIIg & VIIa). Total number of angler days (n=193)

Species	Catch per angler day ($CPUE_n$)	% Released
Blue Shark	0.20	100%
Bull Huss (GSD)	0.17	100%
Homelyn Ray	0.01	100%
L.S. Dogfish	0.72	100%
Painted Ray	0.01	100%
Porbeagle	0.02	100%
Smoothound	0.04	100%
Spotted Ray	0.02	100%

Table 24: Total numbers of retained fish analysed from sub-sampled data per ICES region.

Species	VIa	VIIb	VIIj2	VIIa	VIIg	Total
Cod	0	4	4	3	2	13
Coalfish	12	20	44	1	4	81
Pollack	80	213	224	15	59	591
Mackerel	367	398	121	143	112	1141

Table 25: Number of charter angler days by ICES region. Estimates for the total number of charter angler days undertaken annually were estimated from historic skipper diaries (1992-2008), the Ipsos MRBI marine angling participation telephone survey (current study) and the ESRI survey (unpublished data). Effort per ICES region was designated based on the number of known active charter vessels operating in each ICES region (**Table 3**). Also presented is the total number of charter angler days reported by onboard surveyors during the sampling window that were used in analysis.

Charter Angler Days	Source	VIa	VIIb	VIIj2	VIIa	VIIg	Total
Population estimate ($DAYS_N$)	Historic skipper diaries	3660	4473	5286	8946	4879	27243
Population estimate ($DAYS_N$)	ESRI survey	11730	14336	16943	28672	15639	87320
Population estimate ($DAYS_N$)	Ipsos/ MRBI survey	16241	19850	23459	39700	21654	120904
Sub-sample ($DAYS_n$)	This study	40	61	28	38	26	193

Similar to the on-site shore angling and small boat angling surveys pollock was the most retained species by biomass based on on-site charter survey data, followed closely by mackerel (Table 26).

Where n=>10 fish, over a broad length range, length weight relationships were developed. Some estimations are based on a limited sample size and should be treated with caution until additional data are collected over a longer timeframe (Table 27).

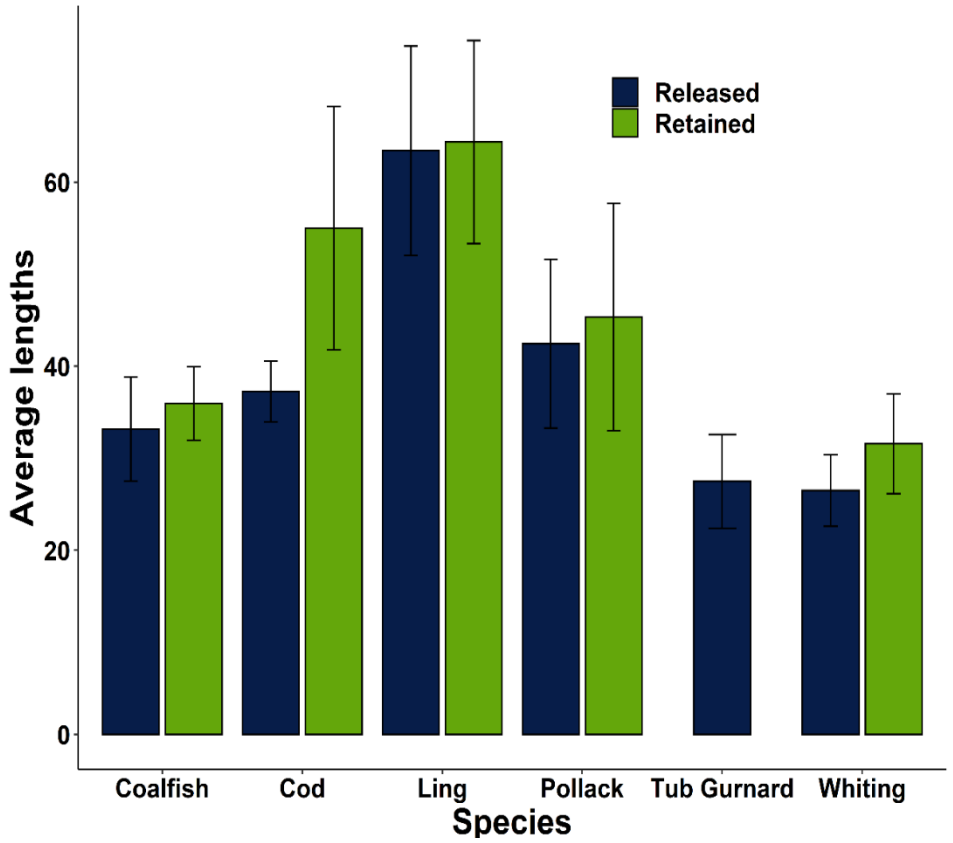


Fig.32: Average lengths of a selection of species caught during the on-site charter survey. Error bars = Standard deviation.

Table 26: Estimated mean weight (g) of individual retained species per charter angler day ($CPUE_W$) by ICES region.

Species	VIa (g±S.E)	VIIb (g±S.E)	VIIj2 (g±S.E)	VIIa (g±S.E)	VIIg (g±S.E)
Cod	- -	206±35 *RSE*=0.17	210±91 *RSE*=0.43	51±31 *RSE*=0.60	70±30 *RSE*=0.44
Coalfish	184±6 *RSE*=0.03	159±14 *RSE*=0.09	669±23 *RSE*=0.03	7±0 *RSE=0.00*	69±7 *RSE*=0.10
Pollack	2537±160 *RSE*=0.06	4896±211 *RSE*=0.04	2808±218 *RSE*=0.08	166±36 *RSE*=0.21	1505±95 *RSE*=0.06
Mackerel	1873±31 *RSE*=0.02	1493±22 *RSE*=0.02	1044±24 *RSE*=0.02	724±30 *RSE*=0.04	1011±31 *RSE*=0.03

Table 27: Length-weight relationships for fish species encountered by charter angling vessels during the sampling window. sample sizes represent sub-sampled data where individual fish (both released and retained) had both length and weight recorded.

Scientific name	Common name	Sample size	Total length range (cm)	Weight range (g)	a	b	R^2
Trachurus trachurus	Scad	119	22 - 42	120 - 700	0.0813	2.3474	0.9139
Pollachius virens	Coalfish	181	24 - 57	220 - 1800	0.0460	2.5783	0.8993
Gadus morhua	Cod	15	34 - 75	274 - 4420	0.0048	3.1818	0.9517
Pollachius pollachius	Pollack	550	21 - 77	80 - 4400	0.0084	3.0151	0.9443
Trisopterus minutus	Poor cod	18	14 - 24	30 - 140	0.0245	2.7324	0.8465
Trisopterus luscus	Pouting	33	18 - 38	60 - 700	0.0052	3.2262	0.8412
Merlangius merlangus	Whiting	13	18 - 42	65 - 543	0.0212	2.7142	0.9132
Labrus bergylta	Ballan wrasse	15	21 - 36	81 - 810	0.0005	4.0401	0.8920
Labrus mixtus	Cuckoo wrasse	33	14 - 31	40 - 390	0.0296	2.6980	0.9106
Molva molva	Ling	11	47 - 82	550 - 2800	0.0033	3.1060	0.9438
Raja clavata	Thornback ray	11	46 - 60	700 - 1400	0.0033	3.1914	0.8225
Scomber scombrus	Mackerel	246	20 - 39	65 - 550	0.0343	2.5781	0.6535
Scyliorhinus stellaris	Bull huss	23	44 - 104	461 - 5200	0.0047	2.9722	0.8582
Scyliorhinus canicula	Lesser-spotted dogfish	42	42 - 71	260 - 1200	0.0074	2.8044	0.7978
Eutrigla gurnardus	Grey gurnard	12	15 - 26	35 - 230	0.0065	3.2063	0.6827

To sense check effort estimation for this pilot study, data from the charter angling sector was reviewed. Detailed effort and catch data (1992-2008) from a charter skipper voluntary diary scheme, operated by IFI, were analyzed and compared with Ipsos MRBI and ESRI 2020 angling participation data. Although the temporal differences may contribute to some variability, comparisons are justified as effort is based on a combination of angler interest and opportunity, suitable weather conditions for charter boat fishing and vessel capacity. Although there were more vessels in the fleet in the 1992-2008 period it was assumed that charter angling opportunity determinants/characteristics would have been similar in the earlier period as those observed over the course of this current study. From these historical data it was determined that, on average, charter vessels undertook 62 angling trips per year and had 6.6 anglers onboard.

For catch estimations and sense checking three annual effort estimations are presented. One is collated from the historical data and the size of the current charter fleet which is estimated to be 67. The other two estimates used data collected during the Ipsos/MRBI omnibus telephone survey and the ESRI (unpublished data) general angling survey. Annual charter angling effort estimated by the Ipsos/MRBI was shown to be more than 4 times greater than the historical logbook data estimate (Table 25).

Total charter vessel catch estimates varied considerably depending on which dataset was used to estimate total angling effort in the charter sector. From historical logbook data pollack retained catch was estimated at 54.9 tonnes (Table 28). This estimate is dependent on an assumption that the average charter takes clients on a fishing trip on average 62 times per year. If the ESRI survey is used to estimate pollack removal through charter fishing, retained catch raises to 175.8 tonnes, while catches rise to 243.4 tonnes if the Ipsos/MRBI telephone survey is used. The other popular angling species showed similar distinct differences (Tables 29 & 30). These major disparities are the likely effect of sampling biases inherent in population-based estimates.

Table 28: Estimated retained catch ($CATCH_{ICES}$) for the entire charter fleet per year by ICES region in Ireland using the historical charter skipper logbook data. Data are presented for the four commonly retained species.

Species	VIa	VIIb	VIIj2	VIIa	VIIg	Total
	(kg±S.E)	(kg±S.E)	(kg±S.E)	(kg±S.E)	(kg±S.E)	(t±S.E)
Cod	-	920±185 *RSE*=0.20	1111±522 *RSE*=0.47	459±293 *RSE*=0.64	340±161 *RSE*=0.47	2.8±1.2 *RSE*=0.41
Coalfish	675±40 *RSE*=0.06	709±81 *RSE*=0.11	3538±212 *RSE*=0.06	64±2 *RSE*=0.03	337±43 *RSE*=0.13	5.3±0.4 *RSE*=0.07
Pollack	9283±837 *RSE*=0.09	21898±1526 *RSE*=0.07	14845±1560 *RSE*=0.11	1485±365 *RSE*=0.25	7343±661 *RSE*=0.09	54.9±4.9 *RSE*=0.09
Mackerel	6855±290 *RSE*=0.04	6679±273 *RSE*=0.04	5517±269 *RSE*=0.05	6475±436 *RSE*=0.07	4933±282 *RSE*=0.06	30.5±1.5 *RSE*=0.05

Table 29: Estimated retained catch ($CATCH_{ICES}$) for the entire charter fleet per year by ICES region using the ESRI (2020) general angling survey data. **NOTE - ANNUAL CATCHES ARE OVERESTIMATED AND SHOULD NOT BE QUOTED OR USED FOR ASSESSMENTS.**

Species	VIa	VIIb	VIIj2	VIIa	VIIg	Total
	(kg±S.E)	(kg±S.E)	(kg±S.E)	(kg±S.E)	(kg±S.E)	(t±S.E)
Cod	-	2950±537 *RSE*=0.18	3560±1590 *RSE*=0.45	1471±901 *RSE*=0.61	1089±491 *RSE*=0.45	9.1±3.5 *RSE*=0.39
Coalfish	2163±92 *RSE*=0.04	2274±218 *RSE*=0.10	11339±489 *RSE*=0.04	205±2 *RSE*=0.01	1079±118 *RSE*=0.11	17.1±0.9 *RSE*=0.05
Pollack	29754±2169 *RSE*=0.07	70188±3700 *RSE*=0.05	47582±4167 *RSE*=0.09	4761±1076 *RSE*=0.23	23537±1712 *RSE*=0.07	175.8±12.8 *RSE*=0.07
Mackerel	21970±567 *RSE*=0.03	21409±520 *RSE*=0.02	17685±568 *RSE*=0.03	20755±1046 *RSE*=0.05	15811±639 *RSE*=0.04	97.6±3.3 *RSE*=0.03

Table 30: Estimated retained catch ($CATCH_{ICES}$) for the entire charter fleet per year by ICES region using the IMREC 2020 – 2021 (Ipsos MRBI) marine angling participation and effort survey data. **NOTE - ANNUAL CATCHES ARE OVERESTIMATED AND SHOULD NOT BE QUOTED OR USED FOR ASSESSMENTS.**

Species	VIa	VIIb	VIIj2	VIIa	VIIg	Total
	(kg±S.E)	(kg±S.E)	(kg±S.E)	(kg±S.E)	(kg±S.E)	(t±S.E)
Cod	-	4084±743 *RSE*=0.18	4929±2201 *RSE*=0.45	2037±1247 *RSE*=0.61	1508±680 *RSE*=0.45	12.6±4.9 *RSE*=0.39
Coalfish	2995±127 *RSE*=0.04	3149±302 *RSE*=0.10	15700±677 *RSE*=0.04	283±3 *RSE*=0.01	1494±163 *RSE*=0.11	23.6±1.3 *RSE*=0.05
Pollack	41197±3002 *RSE*=0.07	97183±5122 *RSE*=0.05	65882±5769 *RSE*=0.09	6592±1490 *RSE*=0.23	32590±2370 *RSE*=0.07	243.4±17.8 *RSE*=0.07
Mackerel	30420±784 *RSE*=0.03	29643±720 *RSE*=0.02	24486±786 *RSE*=0.03	28737±1448 *RSE*=0.05	21892±884 *RSE*=0.04	135.2±4.6 *RSE*=0.03

3.2.3 Online Catch Diary

The IMREC online diary was developed as an off-site sampling alternative to on-site survey results. Potential angler diarists who expressed an interest in participating were identified during the course of on-site and online surveys. Once diary panel membership was set up, diarists can access the online diary and log session details including length of session, location, fishing type, method and fish biometrics. Session information is made available to each diarist through ArcGIS Dashboards giving anglers an overview of all their sessions.

The off-site diary was circulated on a trial basis at the end of July 2021 with a number of anglers invited to engage. Within 6 weeks, 105 sessions were logged across 25 anglers. The west coast saw the highest number of sessions logged followed by the east and south coasts. Similar to the on-site surveys, minimal activity was seen in the Northwest region.

VIIb was the most common area for angling activity making up 36% of all sessions recorded, followed by VIIa with 30%. 21% were recorded in VIIj2 with VIIg representing 10% of session locations. VIa followed on-site results with only 3% of sessions recorded (Table 31). Similarities with on-site survey % effort figures can be seen with VIIb being an exception.

Table 31: Diary sessions per ICES region. n=105. Survey % = Anglers interviewed in on-site surveys.

ICES	No. Sessions	%	Survey %
VIa	3	3%	5%
VIIa	31	30%	59%
VIIb	38	36%	9%
VIIg	11	10%	11%
VIIj2	22	21%	16%

A single angler recorded 19 trips in the west coast, substantially increasing the % effort for this region. By omitting these trips (Table 32), the diary locations bear a similar resemblance to the on-site angler interview locations carried out in the survey sampling.

Table 32: Diary sessions per ICES region (1 avid angler omitted). n=78. Survey % = Anglers interviewed in on-site surveys.

ICES	No. Sessions	Diary %	Survey %
VIa	3	4%	5%
VIIa	27	35%	59%
VIIb	19	24%	9%
VIIg	8	10%	11%
VIIj2	21	27%	16%

Four options for fishing types are given to online diarists (Table 33). Kayaks and small boat catch data are combined to allow for comparisons between surveys. At time of reporting shore angling accounted for 77% of all recorded sessions followed by small boat angling with 20% and charter sessions accounting for 3%.

Table 33: Number of online diary sessions per fishing type. n=105

Fishing Type	No. Sessions	%
Shore	81	77%
Small Boat	16	15%
Kayak	5	5%
Charter	3	3%

A wider distribution of shore angling is evident but a limited number of sessions were recorded in the west/northwest. Other data gaps being filled from the online diary are shore angling in VIIb. On-site surveys resulted in 22 shore anglers being interviewed. The diary has to date gathered 36 shore sessions from this region (Table 34).

Charter sessions highlight the distances travelled by skippers to get access to productive fishing marks. Such distances would not be undertaken by most small boat anglers.

Table 34: Breakdown of online diary sessions by Fishing Type & ICES region**.**

	VIa	VIIa	VIIb	VIIg	VIIj2
Charter			1	1	1
Small Boat	3	12	1	1	4
Shore		19	36	9	17

Capture Data

Shore Catches

Like the on-site survey results, online diary capture data show mackerel and pollack being the two most common fish caught overall. Around the coast, 81 shore sessions, 21 small boat sessions and three charter boat sessions were recorded (Fig. 33).

European seabass are the most common shore caught fish recorded with 49 captures (28% of overall shore captures) and a release rate of 88% (Table 35). It is interesting to note that the average lengths of released bass were above the legal take home size of 42 cm, indicating a healthy stock level where anglers are potentially catching more legal-size fish than their bag limit allows per day (2) or there is a pro-release approach among bass anglers. A single avid bass angler can be attributed to 32 (65%) of these captures.

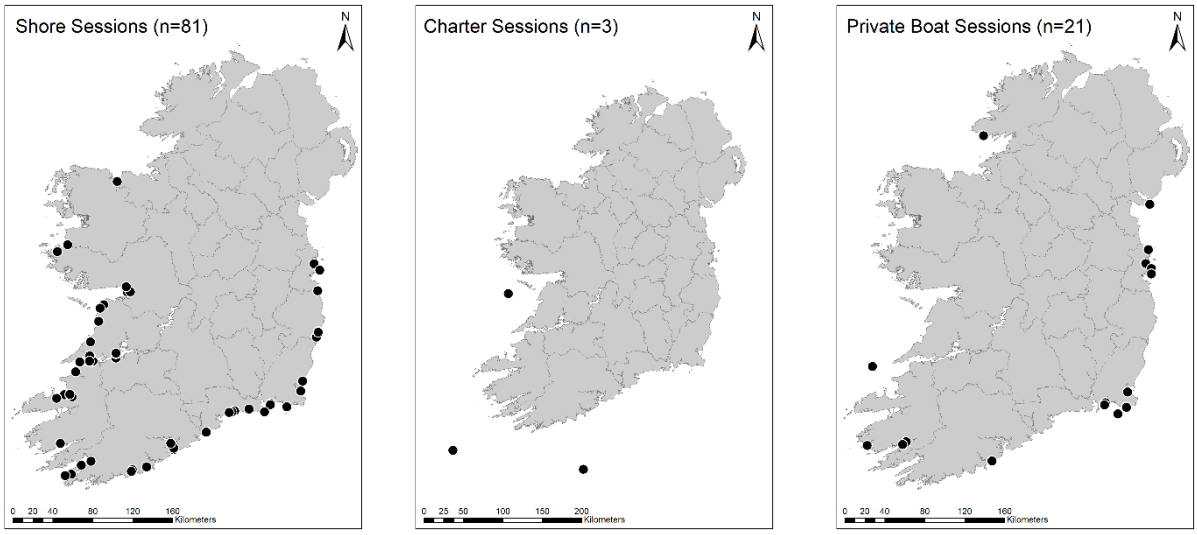


Fig. 33: Online diary session locations/Fishing Type

Pollack was the second most recorded shore caught species with 22 being caught (12%). All shore caught pollack were released. Bull huss (*Scyliorhinus stellaris*) were the third most common DCF specific species caught with 18 recorded captures (10%). Mackerel only accounted for 8 captures, 4% of overall shore catches with a low release rate of 13%.

Table 35: Online diary shore catches. Number sessions=81. DCF Species = 114.

	Total Caught		Avg. Total Length (cm)	
Species	Released	Retained	Released	Retained
Bull huss (GSD)	18		70.0	
European seabass	43	6	42.9	53.5
Lesser spotted dogfish	2		35.0	
Mackerel	1	7	28.0	27.6
Pollack	22		15.2	
Smooth-hound	12		95.0	
Thornback ray	2		70.0	
Undulate ray	1		69.0	

Overall, online shore catches showed a high release rate (88%) across all DCF specific species (excl. mackerel) and a 93% release rate across all cumulative records (Fig. 34). The high CPUE figure for European seabass resulted from one avid bass angler, highlighting the need for differing streams of data collection to avoid biased data.

Small boat catches (Table 36) are higher than shore caught catches. Mackerel and pollack are the two most common species caught on small boats with 155 and 68 captures respectively equating to 31% and 13% of overall small boat catches. Mackerel release rates were low (1%). Pollack release rates were 38%. The average size of pollack caught from small boats was 39.6cm, double the average size of shore caught pollack. This may explain high release rate in shore caught pollack compared to small boat figures.

Lesser spotted dogfish comprised 9% of all small boat catches with a release rate of 100%. Smooth-hound accounted for 5% of all small boat catches, again with a release rate of 100%.

Far less European seabass were recorded from small boats compared to shore captures. A total of 9 bass were caught, only 2% of overall small boat captures. A lower release rate was seen in the small boat records with 56% being released.

Table 36*:* Online diary small boat catches, Number of sessions=21. DCF Species = 322**.**

	Total Caught		Avg. Total Length (cm)	
Species	Released	Retained	Released	Retained
Bull huss (GSD)	7		110.0	
Cod		3		46.0
European seabass	5	4	48.0	54.0
Lesser spotted dogfish	46		50.6	
Mackerel	1	154	25.0	28.5
Pollack	26	42	32.1	44.3
Porbeagle shark	1		188.0	
Smooth-hound	26		51.2	
Spurdog	5		42.4	
Tope	2		125.0	

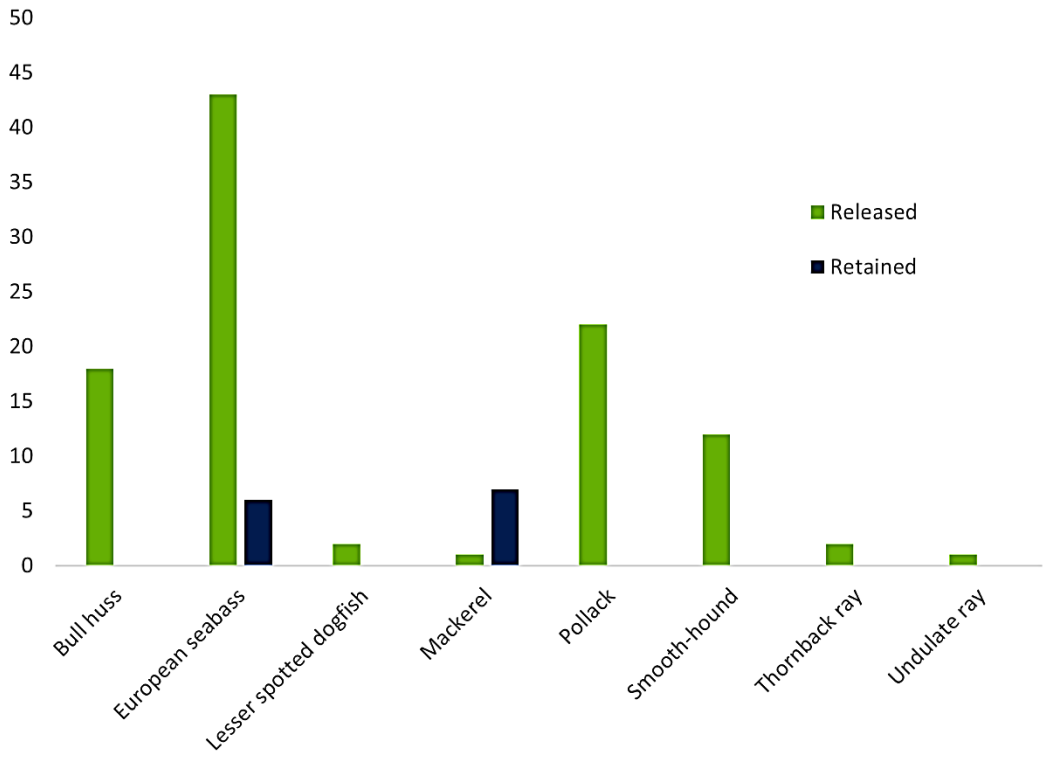


Fig. 34: Count of online diary shore catches, DCF Species. Released=101; Retained =13.

Several species were recorded from small boats that did not appear in the shore caught records. Small boat diarists retained three cod in total. Larger elasmobranch species were also captured from small boats including spur dogs tope and 1 porbeagle shark measuring 188 cm. All were released.

Overall, release rate of small boat catches was 37% for DCF specific species and 60% across all species (Fig. 35).

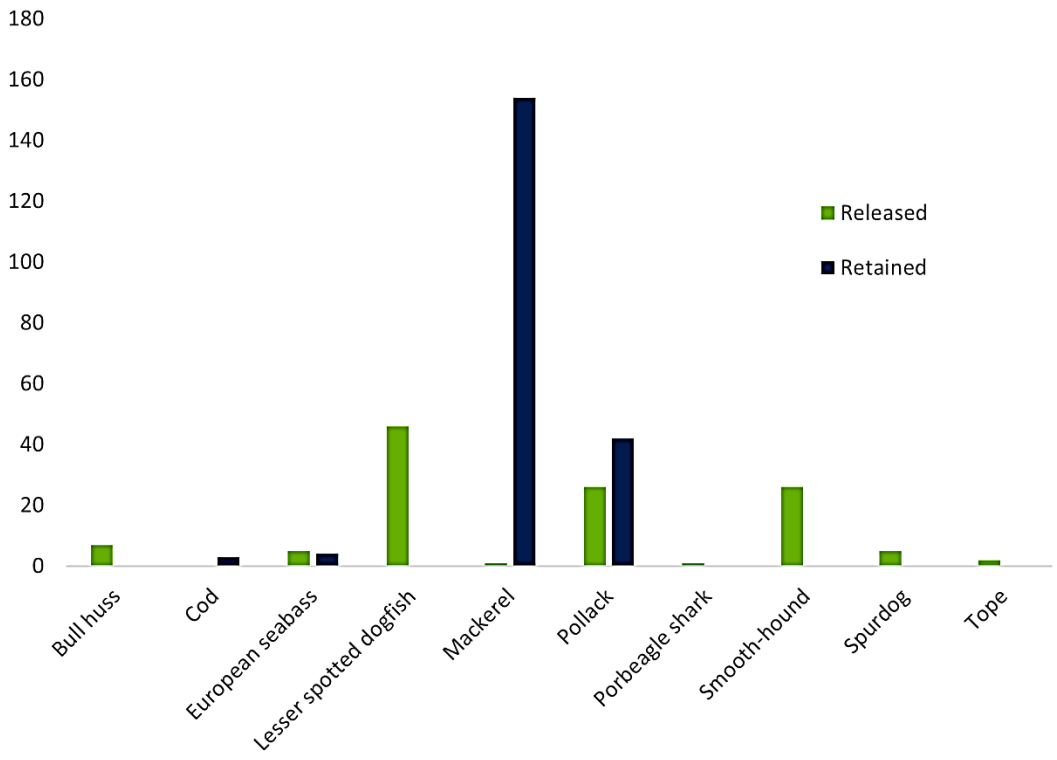


Fig. 35: Count of online diary small boat catches, DCF Species. Released=119; Retained=203.

Charter Catches diary data

Only 3 charter sessions were logged with 4 species being recorded overall (Table 37). DCF specific species recorded were 20 blue shark and 10 pollack, all released. Other notable species caught were albacore tuna and ling.

Table 37: Online diary Charter catches. Number sessions = 3.

	Total Caught		Avg. Total Length (cm)		
Species	Released	Retained	Released	Retained	CPUE
Blue shark	20		170		6.67
Pollack	10		50		3.33

Overall catches

The overall online diary capture figures across all fishing types show that 163 mackerel were recorded, equating to 22% of the overall recorded catches with an extremely low release rate of 1%. Overall pollack captures across shore, small boat and charter catches saw 100 being recorded (14% of overall catches) with a release rate of 58%. Capture figures for European seabass saw 58 fish being recorded (8% of overall catches) with a release rate of 83%.

The combined catches from the online diary catches (Fig. 36) show, similarities and discrepancies in online and on-site catch data. Mackerel and pollack are the most common species caught but release rates differ for both. Mackerel had a release rate of 7% in on-site surveys but only 1% release rate from online diary figures. Pollack had a 32% release rate from on-site surveys but a release rate of 58% from online diary figures.

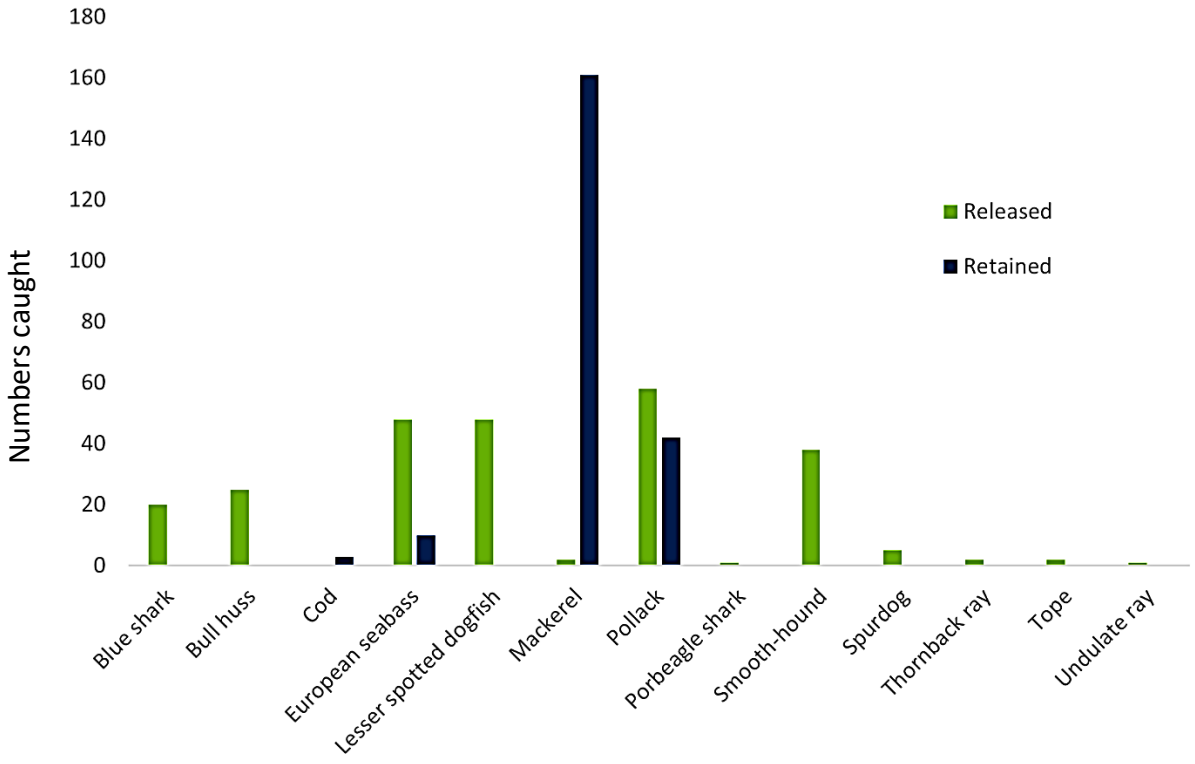


Fig. 36: Online Diary catches of DCF species across all fishing types n=466. Released = 250; Retained = 216.

In a separate programme, authorised by EU/ICCAT, Ireland was permitted to operate a limited Atlantic Bluefin Tuna scientific data collection programme (Tuna CHART https://www.fisheriesireland.ie/Fisheries-Research/tuna-chart.html). The programme commenced in 2019. In Q3 and Q4, in each year, a limited number of authorised and trained charter skippers operated a highly controlled catch, tag and release programme. All fish were captured by angling, measured and tagged in the water, and released. Zero mortalities have been recorded to date. The programme will continue to operate in 2022. Catch data are reported to ICCAT https://www.iccat.int/GBYP/en/overview.asp. No records of catches of Albacore Tuna were recorded during the course of this pilot survey.

3.3 Comparison of MRF Catch to Commercial Catch

The main aim of the pilot study was to characterise the marine recreational angling sector, develop methods to sample the sector, capture data on recreational catches and provide some relative catch estimates, and to make recommendations on refining methodologies for future sampling in the sector. Comparisons with commercial catch were also to be considered.

MRF estimates presented in this report are based on small, highly variable samples collected during a pilot study. Many MRF catches presented are likely to be overestimated for the reasons stated throughout this report and require further analysis which will be complemented by additional data.

Comparisons with commercial catch data are presented for cod and pollack in Table 37 as MRF catches of other mandatory reporting species were limited. Across all MRF surveys a single elasmobranch was retained which suggests that MRF will have no discernible impact on any elasmobranch stocks. Further studies on post-release survival rates of elasmobranch species will confirm this but long-term tagging data suggest good survival when fish are handled properly (IFI, unpublished data). Bass is a popular angling species but catch rates are relatively low across the MRF sector and the majority of captures are released unharmed,

according to pilot study data and other IFI studies (IFI National Bass Programme, unpublished).

MRF cod catches were extremely low compared to the commercial sector (Table 37). Further survey work will discern if winter cod angling can have an impact on the overall fishery. Even though pollack were assessed as the most retained sea angling species in Ireland, with the exception of mackerel, overall MRF landings are limited compared to commercial fishing in Irish waters (Table 37). The largest proportion of estimated pollack catch through MRF was in the small boat sector (Table 37), which is based on a limited sample. Further sampling must be undertaken to resolve data quality issues.

Table 37: Estimated average bass, cod and pollack harvest by all methods in Irish waters. **MRF CATCH ESTIMATES ARE UNRELAIBLE AND SHOULD NOT BE QUOTED OR USED FOR ASSESSMENTS.**

Species	Method	(t)
Cod	Commercial	6786*
	Shore	-
	Small boat	127-176
	Charter	3-13
Pollack	Commercial	4172**
	Shore	136-188
	Small boat	852-1179
	Charter	55-243
European Sea Bass	Commercial	Not available
	Shore	8-11
	Small boat	15-20
	Charter	-

*Av annual catch in Irish waters (2018-19) (P. Bouch, Marine Institute *pers comm.*)

**Av annual catch in Irish waters(2011-18) (P. Bouch, Marine Institute *pers comm.*)

4. Discussion, Conclusions and Recommendations

This pilot study has, for the first time, attempted to estimate MRF participation rates, angling effort and fish catch rates in Ireland (Figs. 1 & 2). By its nature a pilot study is primarily designed to determine the best research methods to use, to identify and troubleshoot any sampling shortcomings or challenges, to advise on a way forward and assess overall project feasibility. From a low knowledge base, due to previous surveys of the sector being focused primarily on socio-economic aspects of sea angling, the pilot study has characterised sea angling in Ireland and provided baseline data, based on angling/angler surveys, which will inform the development of a standardised approach to MRF catch sampling and estimation for future reporting.

The challenges encountered during the pilot sampling programme have made it difficult to provide a reliable estimation of total MRF catches in Ireland. However, the lessons learnt will allow Irish recreational fisheries scientists and managers to continue to refine and adapt MRF catch per unit effort (CPUE) data collection methods for Irish angling, some of which have been successfully in other jurisdictions. The study has:

- identified biases in data collection techniques which will be used to continue to refine sampling methods over the coming years.
- provided a strong qualitative spatio-temporal assessment of relative catch rates of many popular angling species.
- identified many of the variables which cause temporal and spatial variation in angling effort around Ireland which will allow future surveys to be designed with more precision by allocating sampling effort in more accurate proportions in the future.
- produced an extensive knowledge base so that ongoing work can continue to develop and improve methods to characterise MRF in Ireland into the future.

Within the recreational angling survey sector generally the accuracy of annual MRF catch estimates tends to depend on two primary components. These are the accuracy of the of the annual effort estimates which, in this study, were primarily derived from population

telephone survey data, and mean CPUE estimates from on-site surveys. Due to the relatively low sampling effort across many strata during the on-site surveys, particularly the small boat surveys, several estimates in this study are assumed to be unreliable. This is corroborated by sense checking outlined in the Results section.

4.1 Angler population effort estimates

Although estimates of Irish sea angling participation rates have been published in the past, there has never been a survey which focused solely on MRF anglers in Ireland. This pilot study estimated that 256,040 people aged 15 years or older participated in sea angling. In 2015 IFI commissioned a survey in conjunction with Milward and Brown (IFI, 2015) which estimated that 127,000 fish in the sea based on a national population of 3,600,000. However, this estimate assumed that a proportion of the general angling population, who responded that a particular type of sea angling was their "favourite" type of sea angling, were actually sea anglers. This method would clearly underestimate the total number of sea anglers. For example, many could have responded that their "favourite" type of angling was trout angling. If this cohort occasionally participate in sea angling, they would not have been captured as sea anglers. With recent increases in population size in Ireland changes in participation rates were expected.

The most recent sea angling participation survey conducted by Ipsos/MRBI for this study, directly asked participants if they engaged in sea angling, even occasionally. This form of survey question may have inflated the response level for some who may have recalled sea fishing in their youth but are now 'lapsed' sea anglers. When asked how often they went fishing in the past year, they are most likely to say that they did not or could not recall. This type of respondent did not influence annual effort estimations. For comparison, a 2020 ESRI general angling survey on behalf of Inland Fisheries Ireland, estimated 185,000 sea anglers in the Irish population. The disparity between this estimate and the Ipsos MRBI estimate may be that the ESRI survey respondents were specifically asked which species they "target" (*ESRI, Unpublished data*). Many occasional sea anglers do not necessarily target any specific species and the ESRI survey question may have led to their exclusion from that sampling frame. On

the other hand, anecdotal evidence (reports to IFI, tackle dealers reporting high levels of fishing gear purchases etc) of a COVID-19 participation 'bounce' in the period immediately following lifting of restrictions of localised travel and subsequently. These new sea anglers may have been captured in the more recent Ipsos MRBI survey but not the earlier ESRI survey. Surveying angling participation and effort during the COVID-19 pandemic was unavoidable given reporting timeframes. The total sea angling participation estimates calculated from these separate surveys, conducted approximately one year apart, differ by less than 2% (5-7%) of the total population of ROI. However, this difference equates to around 70,000 extra anglers, or an increase in the sea angling population of nearly 35%. When this value is combined with annual effort and catch rates, differences in annual harvest can be substantially inflated. The 2021 CSO General Household Survey (Environment Module) has a sea angling participation question; these additional survey data will assist in refining national sea angler participation rates.

Although overall participation rates from the IMREC study clearly influence final catch estimates, this value must be combined with average angler effort rates to estimate total catch. Survey data suggest that estimation of angling effort is the major complicating factor in estimating total catch in Ireland. A recent face to face survey of 1,014 respondents, which estimated activity levels of various types of domestic coastal tourism found that active sea angler respondents (n=42) went on an average of 7.2 shore angling day trips per year but only 3.5 boat angling day trips per year (Hynes et al., 2020), which is lower than the effort estimates produced from the Ipsos/MRBI survey.

The Ipsos/MRBI telephone survey conducted for this study is based on a proven and statistically sound design and should, in principle, be unbiased. However, only 7% of the population consider themselves sea anglers. When this small proportion of the population is parsed into angling type preferences (shore, small boat or charter boat) the potential for sampling error increases. For example, only 2% of the population consider themselves charter boat anglers; this limited national sample (102) cannot be expected to capture the full variability of charter angling effort across Ireland. The effect of catch recall bias over lengthy temporal scales is another compounding factor.

The sample size issue becomes evident when comparing the difference between total charter angling catch using an historical data set and charter angling catch based on the Ipsos/MRBI effort estimate data. Total charter angling effort based on Ipsos/MRBI survey data, and assuming charter angling fleet is 67 boats suggests that every vessel in the fleet would have taken a charter angling trip, on average, over 200 times in a year. Historical data shows that this is unrealistic, due to unsuitable weather conditions, angler preferences and angling seasons, even for the most enthusiastic charter skipper. A more extensive nationwide telephone survey (> 5,000 units) to capture the patchy distribution of charter angling effort within the Irish population, would be required. This shortcoming for the charter boat sector was anticipated and is one of the reasons that the charter skipper diary was developed. In addition to collecting catch data, this diary can provide data to estimate how many angling trips per year the average charter takes. However, the diaries were distributed during travel restrictions caused by the COVID-19 pandemic, so effort data will not be reflective of a normal year, particularly due to the sector's reliance on tourism. For this reason, effort estimates were not calculated from the charter diary input for this report. It will be a more valuable resource in the future, when travel and movement of people is normalised. Although no comparable data are available, it is likely that small boat and shore angling effort estimations may also be unreliable due to the same underlying issues.

To compound the issues described above, positive recall bias in telephone surveys is a major bias (Andrews et al., 2018; Lewin et al., 2021). To address this a conservative correction factor (Connelly et al., 2000; Lyle, 2000) was applied to the current data. This correction is not a long-term solution. Data driven methods to quantify recall bias in an Irish MRF context are in development. Even where CPUE estimates are accurate, total catch estimates will remain unreliable until there is confidence in angling effort. One solution is to have a sufficiently large panel of sea anglers signed up as active anglers and diary panellists. Fisheries managers could then access this database to perform effort surveys over short temporal scales, which would not be subject to recall bias. The current online diary programme will improve effort estimation in addition to collecting CPUE data. However, self-selecting diarists are likely to be avid anglers and effort overestimation may continue. The combination of the angler diary and targeted regional surveys will serve to address and refine such biases.

Tourist anglers are excluded from total effort estimates because the telephone survey sampled only the Irish population. As the on-site sampling programme took place during travel restrictions in Ireland it was not possible to estimate the proportion of tourist anglers to resident anglers, as planned. Future on-site surveys and submitted charter diaries shall be used to estimate the proportion of angling effort through tourism once normal international travel resumes.

The B&A survey of sea anglers in Ireland (Ryan et al., 2021), although garnering > 1200 responses, was self-reporting and likely to be completed by more avid anglers, with attendant biases. The absolute figures obtained, such as annual sea angling trips are likely overestimates compared to the entire sea angling population. Nonetheless, it provided high quality data on where and when angling effort was apportioned countrywide. Many of the outputs, including distribution of regional angling site preferences, preferred species and retention rates were reflected in data collected subsequently in randomised on-site surveys. This provides an extra level of confidence that the B&A survey data can be used to define distribution of angling effort and that sampling programmes can be designed accordingly.

4.2 Catch per unit effort estimations

When this pilot study commenced CPUE estimates of the mandatory reporting species were identified as one of the key data requirements. The B&A report (Ryan et al, 2020) identified, and survey data confirmed, that pollack is the most popular angling species for which catch rates must be reported under the DCF. This was evident for small boat and charter angling. Although cod was reported to be an important angling species in the B&A survey (30% of shore anglers reported cod as a common catch), no shore anglers interviewed during the on-site surveys caught cod. This is likely because limited surveys took place in the winter months due to travel restrictions caused by COVID-19.

MRF pollack retention was high relative to the other aforementioned species, regardless of the sampling component (Fig. 37). Compared to pollack catch records, catches of sea bass and cod were relatively rare. Although, elasmobranch catch records were quite common,

particularly in the charter sector, surveyors recorded one instance of a shore angler retaining one lesser spotted dogfish. All other elasmobranch catches were released unharmed across all surveys.

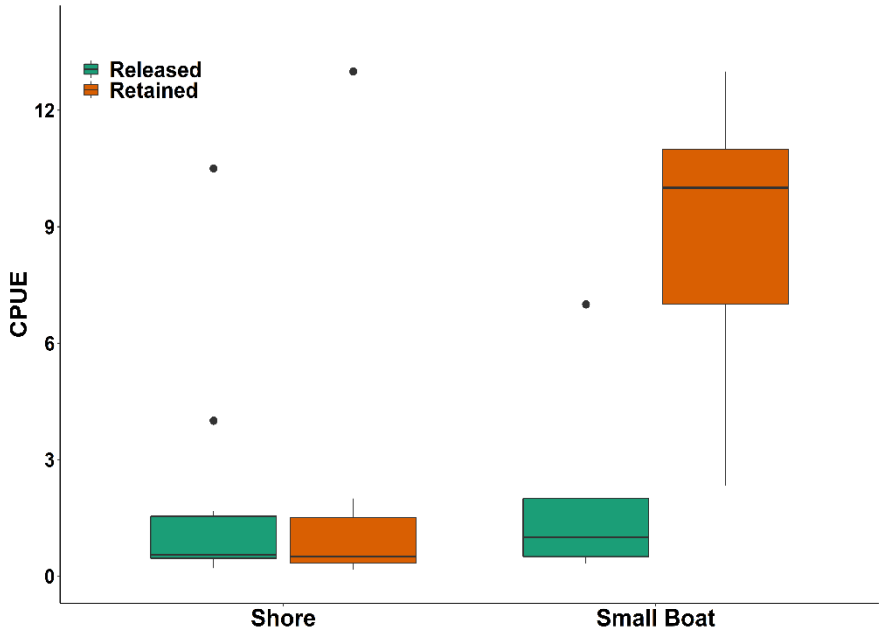


Fig. 37: Catch per unit effort (per angler trip for shore angling; per boat trip for small boat angling) of pollack per PSUxDay of all interviews when pollack catches were recorded during a survey.

Unlike the exceptionally high small boat CPUE estimate by pollack, which is likely driven by sampling bias compounded by low sample size, the high mean CPUE for retained shore-caught pollack is driven by data collected during a single sampling day which elevated the CPUE of retained shore-caught pollack by 99%. This was not considered an outlier because limited catch data were available to review deviance from overall sample distribution. Such variance justifies increased sampling future effort. To illustrate the variance of CPUE data collected during the onsite surveys, boxplots of CPUE per PSUxDay for pollack catches recorded during on-site small boat and shore surveys are presented.

A large portion of angling effort in Ireland generally is attributable to mackerel angling. This was observed directly during on-site IMREC sampling. CPUE calculations have been calculated

at species level to limit the impact of mackerel angler cohort on other species. Mackerel anglers usually fish at particular marks in large groups and were recognisable by their gear and angling methods. An updated protocol introduced to the shore survey SOP in 2021 whereby, if surveyors encountered groups of mackerel anglers at an SSU, they could subsample 10%. This resulted in greater sampling efficiency. Surveyors could cover their allotted PSU within the allotted timeframe. Until such time as shore angling effort estimations can exclude the mackerel angling cohort this will continue. Some data has already been collected on the proportion of mackerel anglers to other anglers encountered during the on-site shore surveys. However, mackerel is a season-specific pursuit, and adjustments to accommodate this will have to be written into further effort estimations. In future surveys anglers targeting mackerel on the survey day will be asked if they only target mackerel. This information should enable researchers to estimate what proportion of total Irish angling effort can be attributed to mackerel fishing only.

4.3 On-site Sampling Effort

COVID-19 hindered sampling effort, particularly in the winter months, leading to a lack of shore catch estimates in some strata. However, a number of strata had limited site visits over the course of the sampling programme, leading to poor quality estimates, where a low number of angler interviews were found to skew catch estimates. In order to increase to number of samples per stratum in future surveys, it is appropriate to reduce the number of strata in the sampling frame. Even though precision can be negatively impacted (Pollock et al., 1994), the effect of limited data points due to over-stratification is more likely to produce poor quality catch estimates. Analysis of data collected during the pilot study has informed which are the most appropriate strata to combine to ensure minimal impact on survey precision. A refined spatio-temporal sampling frame has been designed for future shore surveys with the aim of increasing sampling effort per stratum without the requirement to increase overall sampling effort. For example, shore angling effort and catch in VIIa (Irish Sea) varies considerably from the rest of the country. Therefore, this spatial stratum will be retained. On the other hand, catch type and angling effort along the entire western seaboard

(VIIj2, VIIb and Via) was found to be relatively similar. Therefore, it is appropriate to pool these strata into a single 'west coast' stratum for future surveys. This will mean that the same sampling effort will provide three times as many datapoints per stratum and thus reduce or remove the need for imputation. As the temporal strata will be reduced from four quarterly strata to two biannual strata, sampling coverage will be increased, without decreasing sample precision, as identified through the pilot study. The two activity strata will be retained in the sampling frame. This aspect of the design has increased the number of shore angler interviews while retaining the integrity of the probability-based sampling programme. Issues related to low or no data points in a number of strata during pilot study data analysis meant that the activity stratification had to be ignored to avoid unacceptably high levels of imputation. As the number of spatio-temporal strata will be reduced, this is not expected to be an issue in future on-site shore surveys.

4.4 On-site Small Boat surveys

As the pilot study progressed it became evident from the probability-based sampling frame, that sampling effort would have to increase substantially to encounter sufficient small boat anglers to obtain a robust CPUE estimate. Consequently, as only two full-time surveyors were available and sampling time was limited (due to COVID-19 restrictions), resources were diverted towards capturing additional shore angling data through the roving creel survey. The introduction of convenience sampling for small boat surveys (ICES, 2020; Pollock et al., 1994) in 2021 allowed for samplers to focus efforts on high activity small boat launching sites. This change resulted in an increase in anglers interviewed, particularly in the Donegal region (VIa), which was previously a region when angler encounters proved difficult.

This shift to convenience sampling involved targeting specific high activity slips in each ICES region. Further consultations with Steering Group members and regional fishery officers allowed for a significant reduction in potential slips to sample. A total of 3 to 6 slips were identified per ICES region and the random sampling plan was adjusted to facilitate more weekend sampling days. This resulted in small boat sampling taking place on the newly

weighted randomly scheduled dates but with a targeted approach to slips rather than randomly sampling slips within each ICES region.

The convenience sampling allowed for a more refined approach to sampling locations resulting in the random component for location being expanded to the ICES region only. The refined slip count for the coastline was reduced from 353 to 25 confirmed high activity slips. Once the ICES region was randomly selected, a further random selection was conducted on the refined list of slips leading to a greater number of successful sampling days.

A predictable consequence of convenience sampling was that high avidity anglers with good angling equipment were likely interviewed at a higher rate than their true representation in the small boat angling population. The occasional small boat angler, who make up a significant proportion of the population (Vølstad et al., 2020), but who do not have the gear to target large numbers of fish were not well represented in the pilot sampling programme. Not only must sampling effort be increased to improve confidence in CPUE estimates, but the sampling frame must be redesigned to capture small boat anglers at levels of experience and ability which is a true representation of the total population. Online diaries alone will not suffice as this are also likely to contain an avidity bias. A possible solution to this is to develop a roving creel design whereby the sampling frame consists of PSU polygons over the fishery. Surveyors would interview anglers on the water, while they fish (Vølstad et al., 2020). However, this method would be constrained by logistical difficulties. The other option is to design a more inclusive convenience sampling frame, where popular launching slips are included but other access points, such as sandy beaches and popular tourist areas are also sampled.

According to the IMREC B&A survey, less than 40% of Irish sea anglers fish from a small boat. However, catch rates are higher and the size of fish caught tend to be larger than from the shore. The data collected during this survey has confirmed this assertion and further that it may comprise a substantive component of the MRF total catch due in Ireland. Although some success was observed with the introduction of convenience sampling, small boat survey data collected was limited. An increase in samplers along with further convenience sampling would result in greater numbers of anglers being interviewed. Further research into high activity

locations for both small boats and kayak angling will help in refining the sampling locations for future surveys.

The on-site small boat survey combined with effort estimates derived from the omnibus survey estimated up to 730 tonnes of pollack are retained annually. If the annual effort estimations are correct, this equates to every person who fishes from a small boat retaining over one pollack (average weight of retained pollack is 645g), on average, for every trip which is highly unlikely as it would require daily success and catch retention. A review of the survey data found that it is a result of a combination of two catch records with high catch rates in a stratum with a low number of site visits and relatively large numbers of anglers observed during those few site visits. More generally, the small boat programme as it currently exists, is likely to have a high degree of bias due its constraints.

Prior to the onset of the bus route access point survey of small boat anglers, it was decided that interviewing all anglers returning from a boat trip on-site would not be feasible. Therefore, the total numbers of caught fish were recorded for the entire party and a CPUE per boat trip was calculated. This added an extra level of complexity at analysis because total effort estimates were based on average annual small boat trips per angler. Future small boat surveys will be redesigned with this in mind.

4.5 Onboard Charter Survey

Although the onboard charter survey was successful, it operated over a limited window in summer 2021. For this reason, it cannot be considered a true sample of total charter angling catch. A strong addition to the survey would be to re-run the programme outside the summer months. Even though most charter fishing effort occurs in the summer months, winter charter trips are popular with some sea anglers. Not only is catch composition likely to be different, but length/weight relationships of important angling species change throughout the year. Reasons for this include, but are not limited to, weight of stomach contents, maturity stage, sex, gonad development, parasite load, food availability and overall condition of an individual at time of capture (Silva et al., 2013).

There is considerable scope for refined analysis in the charter angling element of MRF in Ireland due to the availability of historical data and charter diary data. These data streams will enable further sense-checking of the pilot project output. This will allow for contextualising and identifying potential sources of bias which may be common to the MRF sector generally.

4.6 Temporal Angling Activity

The pilot study confirmed that the majority of small boat and charter angling effort occurs in the summer months so future sampling effort will be weighted for this period. Although shore fishing effort is lower in the winter months, on-site surveys and the B&A survey found it is a year-round activity. As a result of the COVID-19 pandemic, sampling was limited during the winter period. To get a comprehensive overview of CPUE, further sampling is required during this period to gap fill. For example, the roving creel shore survey estimated that no shore-caught cod are captured in Ireland. However, cod move inshore during the winter months and can be targeted by shore anglers. This data gap was further highlighted by the B&A survey where 30% of respondents said that they commonly catch cod during shore angling sessions.

4.7 Biological data collection

The onboard charter catch survey collected data which allowed for the development of LxW relationships for a number of important MRF species this should continue to ensure that data sets account for spatio-temporal variation. These have been used in the pilot study to convert length data collected to during the other on-site surveys, to biomass. Although lengths were recorded for all reported shore and small boat caught fish, the vast majority were estimated. Only 45 fish were directly measured during shore surveys by surveyors on site due to high release rates generally. Despite a focus on gathering further measurement figures, the difficulty still remained in collecting accurate measurement data. Roving creel surveyors cannot measure released fish and must rely on angler recall. This was aided by providing visual cues such as demonstrating a measuring board on site. As direct measurements were made

by surveyors of retained fish during interviews and interviewees were reminded that they would be asked for the lengths of caught fish during call backs, length data used for harvest estimation is more accurate. CPUE from the shore tended to be relatively low and fish size tended to be relatively small.

4.8 Online Angling Diary

Online angling diaries are being developed around the world (Holder et al., 2020; Venturelli et al., 2017) to allow recreational fishers to voluntarily record and share fishing information. Although the magnitude of bias continues to be studied, it is generally agreed that these can provide valuable recreational fisheries data that could support the monitoring and management of the fisheries and augment more traditional survey methods (Gundelund et al., 2020; Skov et al., 2021). The geographical coverage of each fishing type highlights the importance of an off-site sampling programme, particularly in the small boat sector. Several small boat sessions were logged in VIIj2, an area where small boat sampling was unsuccessful during on-site surveys. VIa shows little activity with only 3 sessions logged to date.

The Irish online sea angling diary was released in July 2021. The original release was accompanied with limited marketing so that any minor technical problems could be rectified quickly. Even so, as of December 2021 over 90 anglers have signed up and over 2000 individual catch records have been logged. The next phase of the survey will see a focused effort to expose the sea angling community to the diary. Processes will be integrated into the programme which will ensure that as many diarists as possible continue to submit their data. Diarist fall off has been identified as one of the problems associated with such novel data collection techniques (Skov et al., 2021; Venturelli et al., 2017).

Recording of unsuccessful (blank) sessions is also vital in calculating accurate CPUE figures. Thus far, the proportion of unsuccessful angling sessions submitted has been low compared to on-site survey data, supporting the theory that anglers tend not to record blank sessions.

Methods to incentivise anglers to record all sessions may help in this regard and are currently in development.

Further angler diarist recruitment and retention is key to the success of off-site data collection. As such, engagement with diarists on improvements to dashboards, session logging issues etc. will be essential. Avenues of communication between diarists (forums, small messaging) may benefit the online diary as friendly competitions encourage more fishing sessions being logged. To increase anglers' recordings of unsuccessful sessions, periodic reminders will be sent. However, a balance needs to be struck as excessive periodic emails may have a negative affect leading to diarists opting out of the diary.

As the diary results have shown, this off-site data collection tool is particularly useful at collecting data in areas where on-site surveys were relatively unsuccessful (small boats and west coast shore anglers). It is essential to identify the inherent bias that comes with this data. As all diarists are self-selected to some degree, this data alone cannot be used to accurately calculate angling effort and catch rates. The lack of representation from occasional/tourist anglers in the dairy would skew CPUE figures as most diarists would often be avid anglers. Conducting on-site surveys in parallel with operating a diary allows for the random sampling of anglers, such as the less avid or tourist angler, to be represented in the dataset.

At this at this early stage, sea bass capture rates for many species are far higher in the diary compared to the on-site probability-based surveys. These relationships will be monitored closely over future survey programs and ultimately an index can be created whereby the data obtained from diary can be utilized to monitor catch per unit effort.

4.9 Final Comments

To conclude, the pilot study of marine recreational fishing in Ireland, has substantially enhanced knowledge of the sea angling sector. The expansive nature of the study has provided considerable detail from which the necessary additional surveys identified here, and reporting requirements, can be delivered. A number of programmes are now in place which

are continuing to collect off-site angling data. On-site sampling programmes have been developed and refined and infrastructure is in place to continue the data collection process. Further refinements are required to address the issues identified in this study. Although the quality of some data streams is highly variable, which inevitably resulted in low confidence in overall catch estimates, the main issues have been identified and solutions are proposed. Finally, this work has produced a strong qualitative assessment of where and when anglers fish and what species they tend to retain. Further data collection and survey refinement will ultimately allow a robust assessment of species-specific removal rates from the Irish marine recreational fishery.

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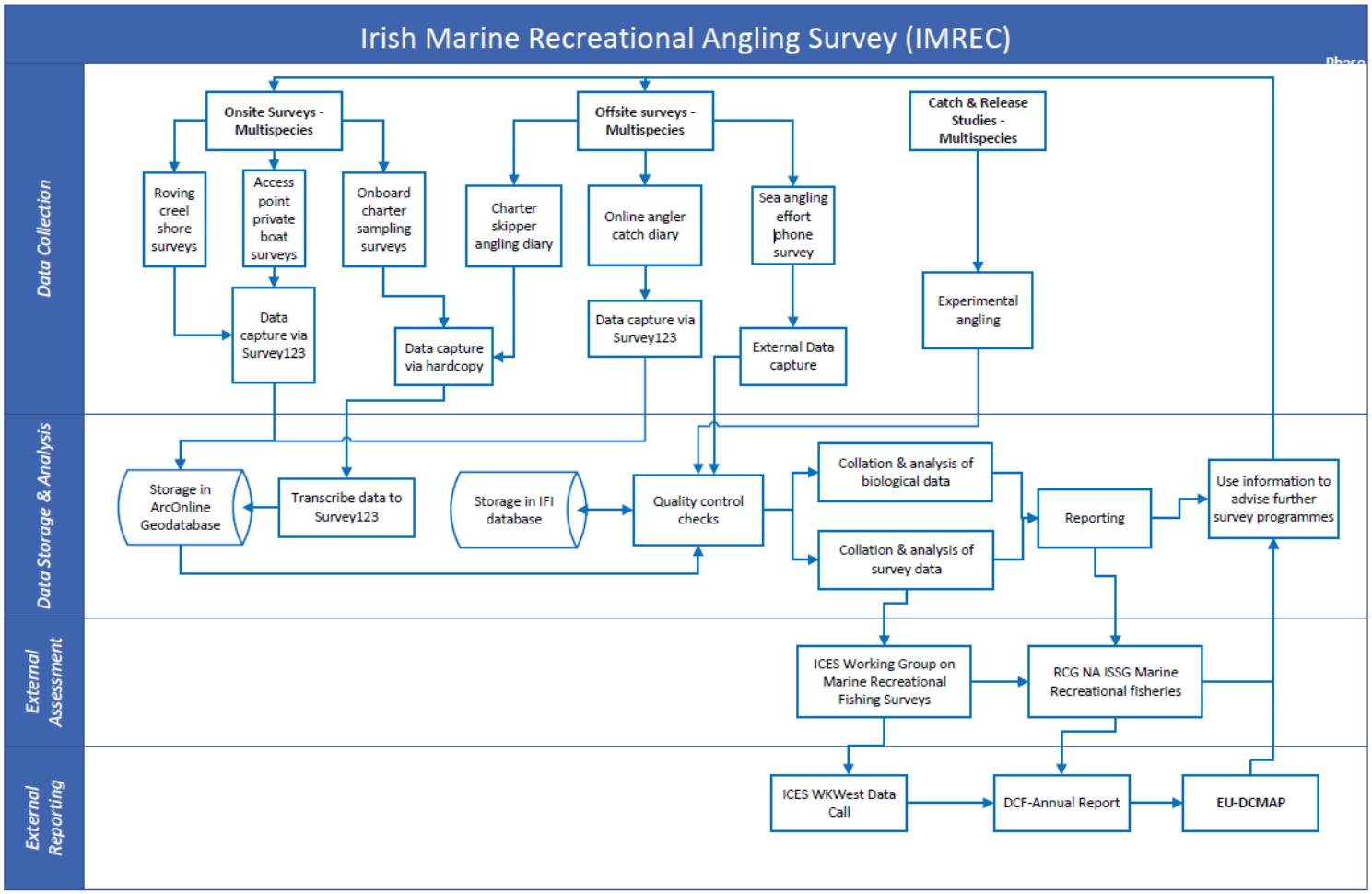
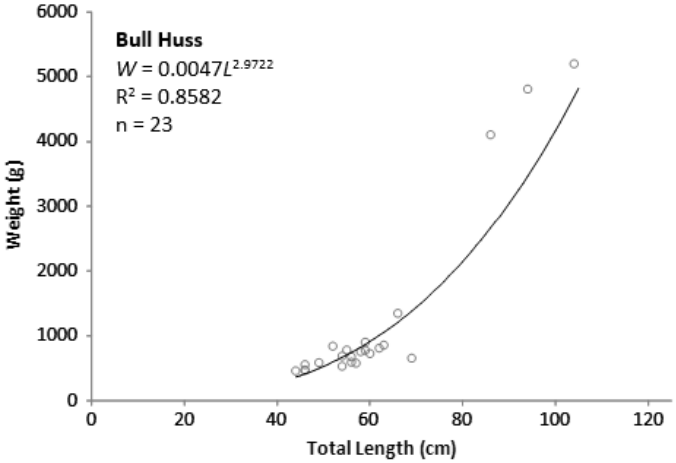
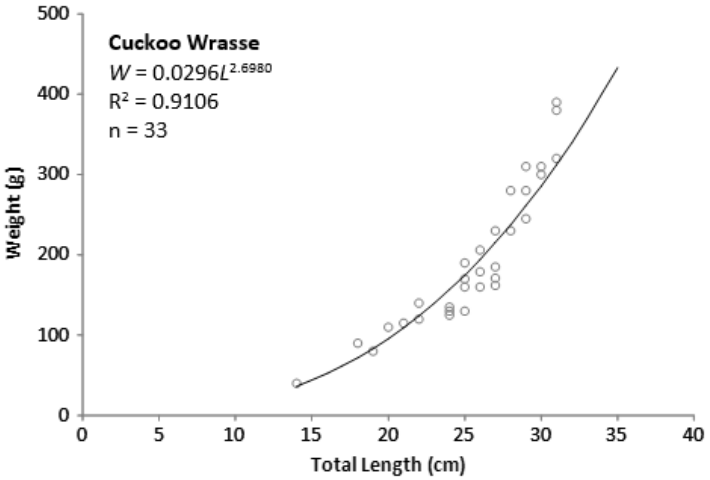
7. Appendices

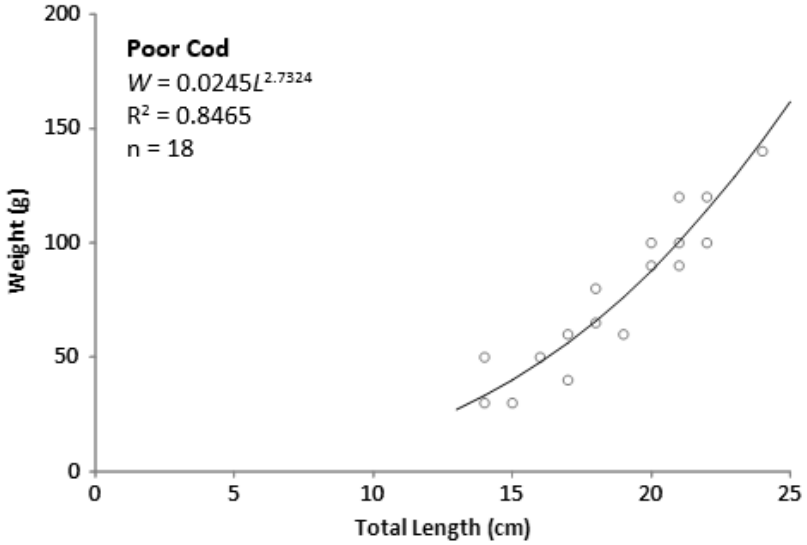
Appendix 1 Flow Diagram illustrating the data collection and storage protocols used for the Irish Marine Recreational Angling Survey

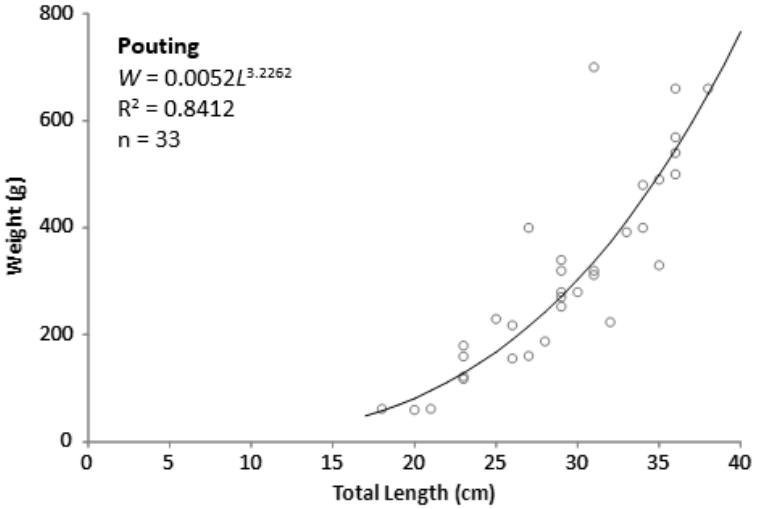


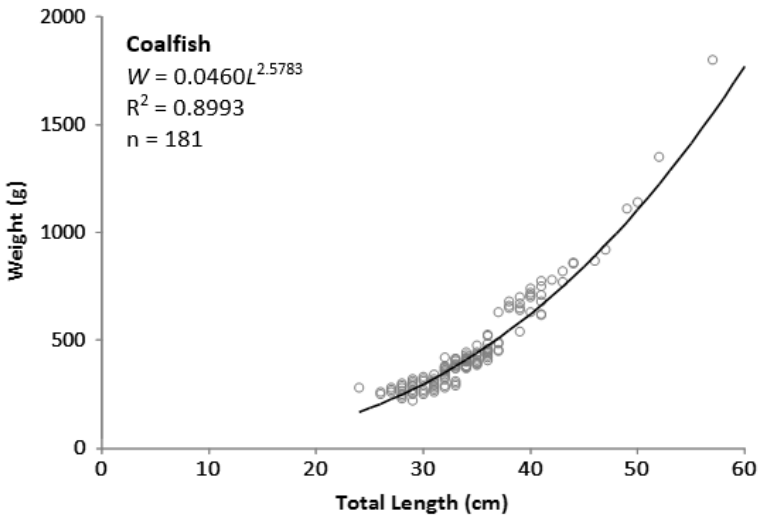
Appendix 2 Length Weight Relationships of selected species caught during the on-site charter angling survey.

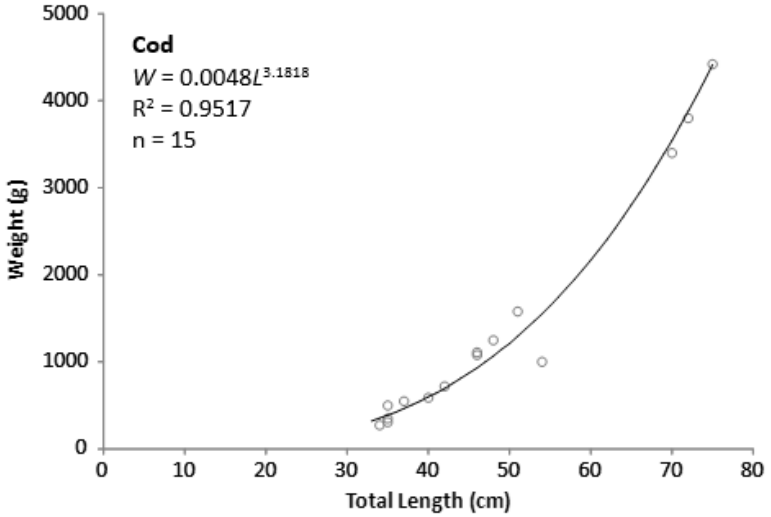


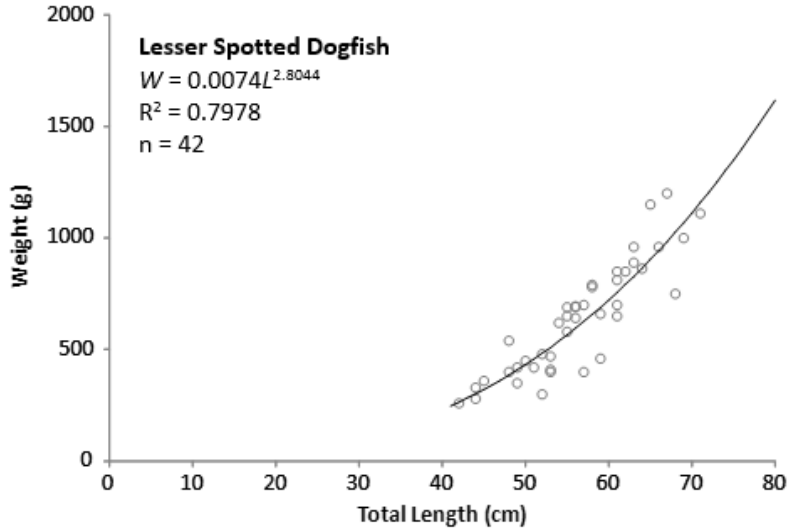


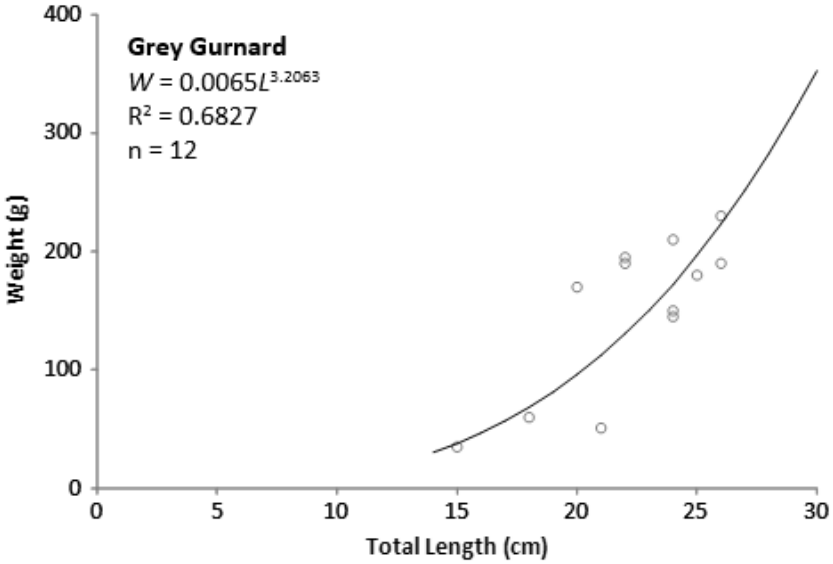


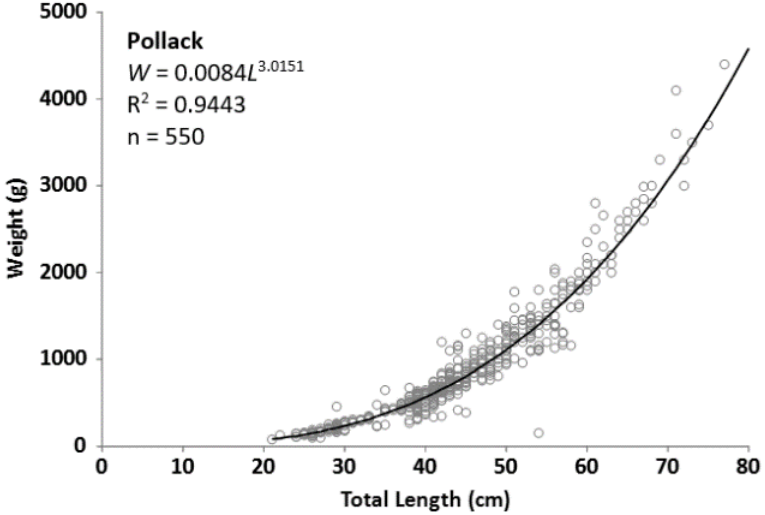


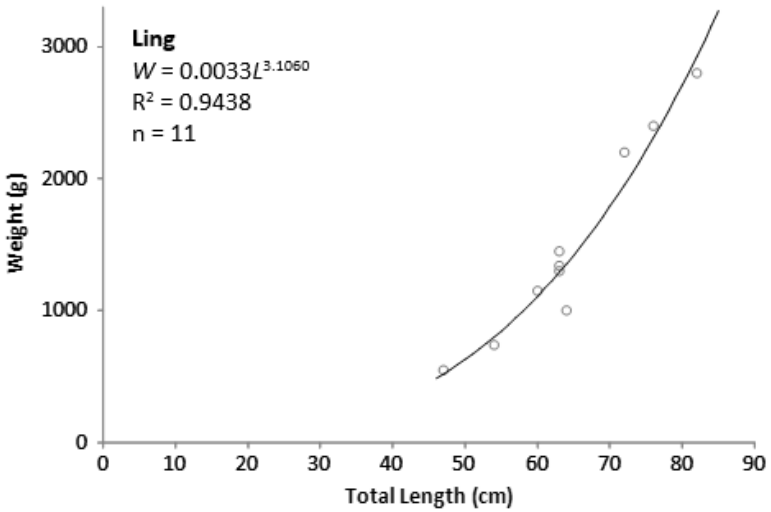

Coalfish
$W = 0.0460L^{2.5783}$
$R^2 = 0.8993$
n = 181
Weight (g)
Total Length (cm)

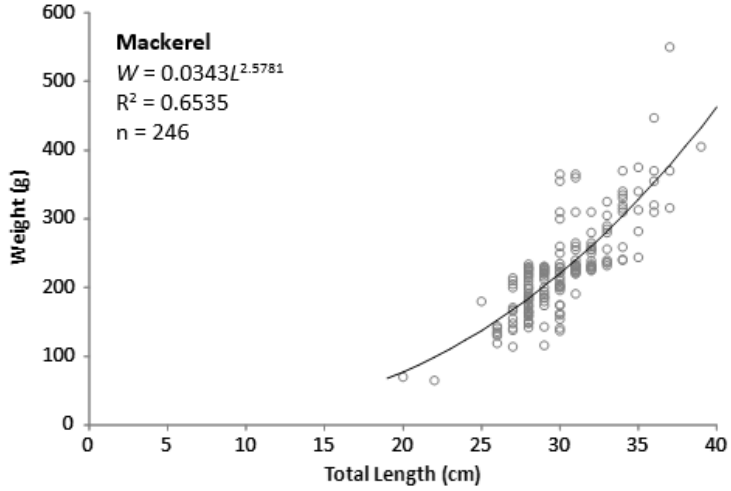

Cod
$W = 0.0048L^{3.1818}$
$R^2 = 0.9517$
n = 15
Weight (g)
Total Length (cm)

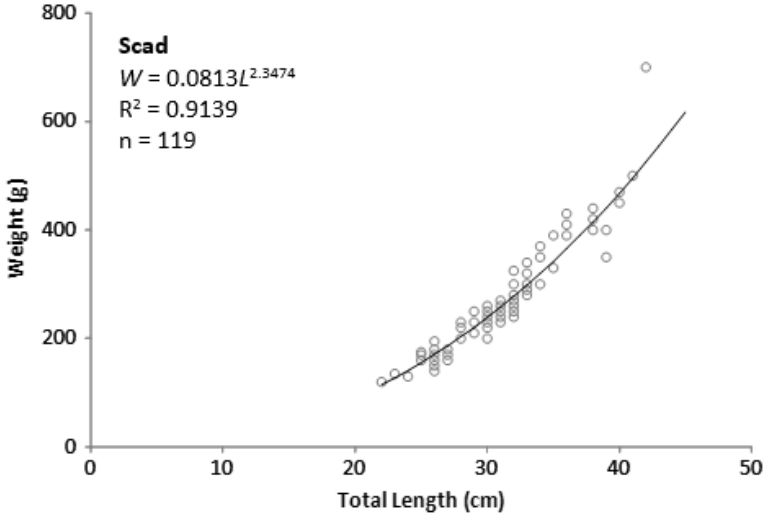

Lesser Spotted Dogfish
$W = 0.0074L^{2.8044}$
$R^2 = 0.7978$
n = 42
Weight (g)
Total Length (cm)

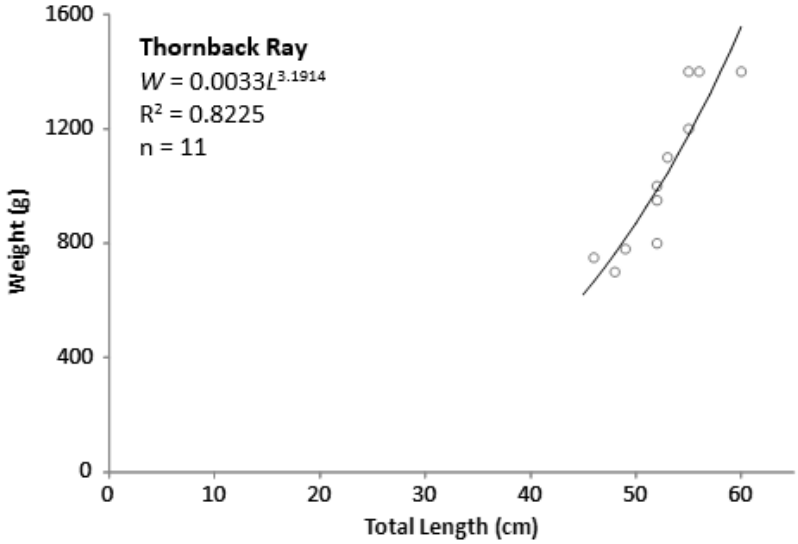

Grey Gurnard
$W = 0.0065L^{3.2063}$
$R^2 = 0.6827$
n = 12
Weight (g)
Total Length (cm)

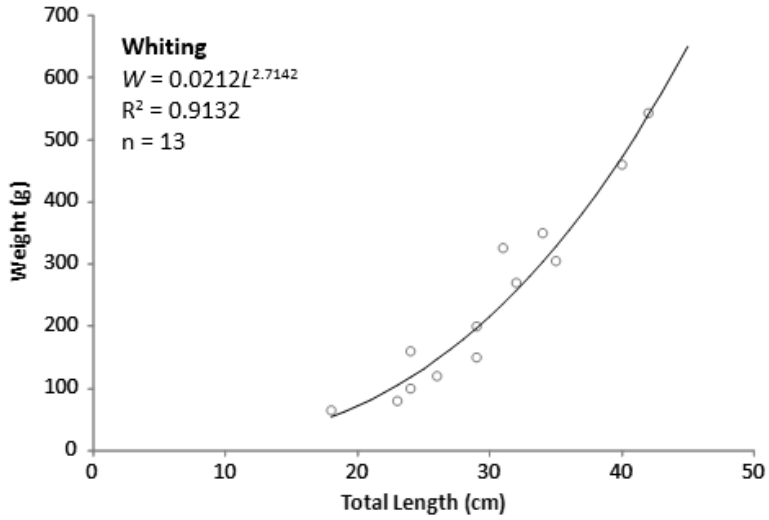

Pollack
$W = 0.0084L^{3.0151}$
$R^2 = 0.9443$
n = 550
Weight (g)
Total Length (cm)


Ling
$W = 0.0033L^{3.1060}$
$R^2 = 0.9438$
n = 11
Weight (g)
Total Length (cm)


Mackerel
$W = 0.0343L^{2.5781}$
$R^2 = 0.6535$
n = 246
Weight (g)
Total Length (cm)


Scad
$W = 0.0813L^{2.3474}$
$R^2 = 0.9139$
n = 119
Weight (g)
Total Length (cm)


Thornback Ray
W = 0.0033L^3.1914
R² = 0.8225
n = 11
Weight (g)
Total Length (cm)
0
400
800
1200
1600
0
10
20
30
40
50
60


Whiting
W = 0.0212L^2.7142
R² = 0.9132
n = 13
Weight (g)
Total Length (cm)
0
100
200
300
400
500
600
700
0
10
20
30
40
50