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International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

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Executive Summary

The ICES Working Group on Recreational Fishing Surveys (WGRFS) role is to summarize and quality assure recreational fishery data collected under the EU Data Collection Framework (DCF-EC 199/2008 and 2010/93/EU) and control regulations (EC 1224/2009), and provide advice for ICES on recreational fishing issues. As such, the WGRFS is a forum for planning and coordination of recreational fisheries data collection and sharing knowledge. In 2014, 31 scientists from 13 countries attended the WGRFS with the aim of sharing current national surveys, reviewing the use of recreational fishing data in stock assessments, evaluating the quality of national recreational catch sampling schemes, ensuring effective stakeholder engagement, exploring economic impact and valuation studies, and reviewing the potential to extrapolate mortality estimates from one fishery to another (Section 1).

WGRFS compiled and assessed the quality of recreational harvest and release data collected within Europe for use in stock assessment (Section 2). These are summarized by country for four major sea areas and species (European sea bass, cod, sharks, salmon, eels, and tuna) defined under DCF and control regulations. Recreational harvest estimates are provided for stock assessments of flounder in the Baltic and European sea bass and were of sufficient quality for inclusion in stock assessments. No catch data are available for pollack, so it is recommended that pollack are included in catch sampling schemes as recreational removals could be significant. Time-series of recreational catches are needed for stock assessment, but are rare. It is important to review methods for reconstructing time-series and has been included in the 2015 WGRFS terms of reference (ToRs). Recreational catches have been collated by the EC Joint Research Centre (JRC) since 2010 for the Scientific, Technical and Economic Committee for Fisheries (STECF). However, there are severe inconsistencies in recreational catch data collated by JRC making comparisons between countries impossible, so WGRFS will collaborate with JRC and DG MARE to improve the consistency of future recreational catch statistics.

Recreational fishing surveys are difficult to conduct and methods are complex, so WGRFS has developed the 'Quality Assurance Toolkit' (QAT) that provides an assessment of quality for end-users of the data. The quality of national recreational catch sampling schemes in Germany, Poland and Spain (Basque Country) were evaluated using the QAT and were found to be acceptable for use in stock assessments. However, catches were generally underestimated as not all fishing modes and platforms were sampled, non-response and avidity bias needed to be addressed, and catch estimates need to differentiate between harvest and release components.

Stakeholder engagement is a vital part of recreational fishing surveys, as it is central to delivering the highest quality outputs and maximizing the utility of the results for fishing bodies, scientists, and policy-makers. There are many stakeholders in recreational fisheries surveys including fishers, trade organizations, policy-makers, scientists, and the general public, so it is important to consider how best to engage with different groups of stakeholders in order to achieve the desired outcome. Methods for stakeholder engagement were explored, a generic stakeholder map was developed, key challenges were identified, and recommendations made (Section 4). This is not a one-size-fits-all approach as it depends on the specific goals of the survey. Recommendations include tangible benefits, using stakeholder knowledge, shared understanding of the goals of the project, plan effectively, involve stakeholders early in the project, and set aside sufficient resources for the engagement process.

A mini-workshop explored approaches conducting economic impact and valuation surveys and bioeconomic models (Section 5). The US has a good framework for the collection and analysis of economic data in the recreational fishing sector, and has been developing models that incorporate both economic value and biological sustainability. In Europe, there is currently no equivalent management framework that attempts to balance environmental, economic, and social effects of recreational and commercial fishing, or which sets clear management goals within an ecosystem services framework. Development of this framework is the next major challenge for co-management of recreational and commercial stocks. This needs to account for the potential to increase ecosystem services and to assess the potential for growth in both sectors under different management regimes.

Despite high discard rates, species and fishery specific discard mortalities are unknown for most of the relevant European marine hook and line fisheries, so discard mortalities need to be estimated for use in stock assessments (Section 6). A mixture of desk-based study and experimental work is needed to fill this data gap that compiles data on mortality of hook and line-caught fish and underpins the discard survival evidence-base. Vitality assessments provide one mechanism to predict species-specific release survival. Although immediate mortality is a major concern, sublethal effects may have significant consequences, but this is of lower priority to ICES than post-release mortality and should happen through normal research channels.

1 Background and Terms of Reference (ToRs)

The ICES Working Group on Recreational Fishing Surveys (WGRFS) meeting took place between the 2 and 6 June 2014, at AZTI-Tecnalia in Sukarrieta, Spain. A total of 31 scientists from 13 countries contributed to the meeting, including Norway, USA and Australia, and was co-chaired by Harry V. Strehlow and Kieran Hyder (see Annex 1 for list of participants). The agenda was agreed and followed, although some changes were made to timings in order to complete discussions, and was as follows:

Day	Session
2 June 2014	Introduction and ToRs Review of recreational fishing surveys across Europe DC-MAP Update on latest requirements Use of Recreational Fishing Data in Stock Assessments
3 June 2014	Reviewing country data using the Quality Assessment Tool (QAT)
4 June 2014	Stakeholder communication Socio-economic data collection in the US Economic evaluation and bioeconomic models
5 June 2014	Further application of socio-economic surveys Review of post-release mortality estimates Vitality assessments
6 June 2014	Funding opportunities ToRs for next meeting

The ToRs for the 2014 WGRFS meeting were as follows:

Multi-annual ToRs:

a) Collate and evaluate national recreational catch (harvest and release) estimates. Evaluate the use of recreational catch estimates.
b) Assessing different survey designs (onsite, offsite) for improved data collection.

Specific ToRs:

c) Review and update the WGRFS 'Quality Assurance Toolkit' (QAT) based on the experience of filling in the spread sheets at country level.
d) Provide guidelines on effective communication with stakeholders (content, timing).
e) Mini workshop: reviewing and collecting the available information on socio–economic data for marine recreational fisheries (national examples).
f) Mini Review: Evaluate the role of post-release mortality estimates.

ToRS (a), (b), (c) and (f), plus the discussion on new developments related to the EU EU-MAP 2014-2020 were addressed through a mixture of plenary sessions and breakout groups. ToRs (c) was addressed using the national sampling schemes of Poland, Germany and Spain (Basque Country) as case study examples. ToRs (e) and (f) were addressed by individual sessions.

2 Recreational catch estimates in Europe (ToR a)

2.1 Recreational fishing surveys across Europe

Recreational fishing surveys are carried out across Europe covering all species and areas required under the DCF (EC 199/2008 and 2010/93/EU) and control regulations (EC 1224/2009).

The tables in Annex 2 provide an overview of the current/most recent surveys countries have in place to estimate marine recreational catches and Annex 3 gives the most recent harvest/release estimates for the relevant species. The tables cover four major sea areas as defined by the current DCF:

- Baltic Sea (ICES Subdivisions (SD) 22-32)
- North Sea (ICES areas IIIa, IV and VIId) and Eastern Arctic (areas 1 and II)
- North Atlantic (ICES areas V-XIV and NAFO areas)
- Mediterranean Sea and Black Sea

These tables relate solely to surveys of recreational fishing defined by WGRFS (ICES 2013d) as:

"Recreational fishing is the capture or attempted capture of living aquatic resources mainly for leisure and/or personal consumption. This covers active fishing methods including line, spear, and hand–gathering and passive fishing methods including nets, traps, pots, and set–lines".

2.2 Use of recreational fishing data in stock assessments

Flounder (SDs 27, 29–32)

The Benchmark Workshop on Baltic Flatfish Stocks (WKBALFLAT; ICES 2014a) requested that WGRFS evaluates recreational catch estimates for the flounder stock in SDs 27, 29-32, both for sampling design and raising procedures (ICES 2014). This was done and a summary of the outcome is presented below.

Estonia

The recreational fishery in Estonia can be divided into two segments:

- Licensed fishery: this segment mainly fishes with passive gear, e.g. gillnets, longlines, but also uses rod and line for salmon and sea trout in rivers. It is mandatory for license holders to keep logbooks/diaries and provide harvest data.
- Non-licensed fishery: mainly fishing with rod and line (excluding freshwater fishery for salmon and sea trout) and spearfishing. There are no flounder catches in this segment.

The Estonian Fisheries Information System (EFIS) collects data from the licensed recreational fishery (gillnet, longline, salmon fishery in rivers etc.) following a logbook/diary census type programme. These data include length and catch information for harvest only. In 2007, 2010, and 2012, a hobby fishing survey of angling and spearfishing was carried out by telephone. The survey revealed that the non-licensed recreational fishery sector does not target flounder.

According to the EFIS the majority (>99%) of the recreational harvest reported was caught using gillnets. A comparison between the figures provided in Table 1 and those provided in the WKBALFLAT report revealed significant differences. WGRFS advises to use of the harvest estimates provided by Estonia in Table 1 as no further biases could be detected, so are considered accurate and should be used in the assessment.

Finland

Finland collects recreational flounder catches in its nationwide biennial recreational fishing survey. This survey is based on a stratified sample of 6000 household-dwellings with response rates of around 40-45%. The household-dwelling unit consists of people living permanently in the same house and sampling is targeted at people aged 18-74 years. A telephone subsample is done to check for non-response bias and the survey follows a design-based domain estimation technique. The strata are formed taking into account the location of the person's municipality of residence, the type of municipality (urban, densely populated or rural), and the location of the municipality in relation to the sea (archipelago, coast, inland). For those who do not respond to the postal questionnaire, post-sampling is conducted as a telephone interview to establish the proportion of fishing household-dwellings among non-responders.

A weighting factor is formed for each household-dwelling from the inverses of the inclusion probability and the probability of the household-dwelling responding. The survey data (e.g. catch size) for the household-dwelling are then multiplied by the weighting factor. The bias caused by non-response is corrected using the homogeneous response group model. The sample is divided by stratum into two homogeneous response group sets within which the probability of responding is considered to be constant. The first group comprises those responding to the questionnaire at first and second contacts, and the second group those responding at the third contact. This biennial sampling strategy was developed from pilot studies and approved by STECF.

The harvest of flounder in Finland has declined over time from 374 t in 2000 to 38 t in 2012, with a CV of 13 and 32% (Table 2). Although the CVs are higher than the 20% advised for the DCF, the results are believed to be robust as the design of this survey is adequate and these estimates should be included in stock assessment.

WGRFS recommends harvest rates of flounder from Estonia and Finland are of sufficient quality for inclusion in stock assessments. However, this is likely to represent an underestimate of the total catch as no data are available for Sweden.Table 1. Estimates of recreational flounder harvest in Estonia from 2009 to 2013 (licensed fishery only).

Year	Baltic Sea by region (Recreational)						
	28-2	28-5	29-2	29-4	32-1	32-2	Total (kg)
2013	3741,3	2213,2	12167,3	4776,5	19169,4	424,6	**42.492**
2012	1063,2	2552,6	11095,0	3467,8	15291,4	169,1	**33.639**
2011	3707,9	2042,7	20617,6	2207,2	22112,5	306,2	**50.994**
2010	3257,7	2168,0	18809,7	1541,9	20786,8	255,4	**46.819**
2009	3695,2	1677,8	19582,4	2119,6	21210,9	155,5	**48.441**

Table 2. Estimates of recreational flounder harvest by fishing area in Finland from 1998-2012 (1000 kg) with coefficient of variation (%CV) in parentheses.

Subdivision	2000	2002	2004	2006	2008	2010	2012
29 Archipelago Sea and Åland	187 (25)	78 (18)	64 (13)	48 (16)	27 (20)	9 (37)	24 (30)
30 Bothnian Sea	30 (35)	63 (43)	3 (30)	2 (42)	7 (74)	-	1 (93)
31 Bothnian Bay	1 (50)	-	-	-	-	1 (101)	-
32 Gulf of Finland	156 (29)	14 (28)	12 (43)	25 (51)	6 (50)	1 (79)	13 (57)
Total	374 (17)	155 (19)	79 (13)	75 (19)	40 (19)	11 (32)	38 (26)

Pollack in the Celtic Seas and West of Scotland (ICES Subareas VI and VII)

The Working Group on Assessment of New MoU Species (WGNEW) requested recreational pollack catches for inclusion in stock assessments (ICES 2014b). Pollack is a common recreational fish species, so catches could be substantial, but few data are currently available. This represents a significant data gap.

WGRFS recommends that member states assess the relative importance of recreational pollack catches and where relevant include this species in national catch sampling schemes.

European sea bass

The trends and status of the sea bass stock in the North Sea, Channel, Celtic Sea and Irish Sea (ICES areas IVb,c and VIIa,d-h) have been estimated since 2012 using an integrated analytical assessment framework (Stock Synthesis). This was first developed for sea bass by ICES IBP-NEW in 2012 (ICES 2012c), updated by the ICES Working Group for the Celtic Seas Ecoregion (WGCSE) in 2013 (ICES 2013c), then further developed by IBP-Bass in 2014 (ICES 2014c) and updated at the 2014 meeting of WGCSE (ICES 2014d). The results at this stage are provisional pending review. The assessments in 2012 and 2013 did not include any information on recreational fishery catches, although at that time it was known that surveys in France had provided relatively large recreational catch estimates (~1000 t harvest, i.e. kept fish) for the Channel and Celtic Sea areas (Table 3).

In 2014, the results of the Sea Angling 2012 survey in England became available (Armstrong *et al.*, 2013), giving estimates of sea bass catches and releases in 2012 (Table 3). An additional survey estimate of 60 t harvest from Belgium for 2013 was also available. The recent estimates of total recreational harvests of sea bass for France, Netherlands, England and Belgium in Subareas IV and VII amount to 1400–1500 t. This represents around 25% of the total commercial and recreational fishery harvest in 2012, excluding dead discards. Assuming a 20% hooking mortality rate (ICES 2012c), an additional quantity of around 110–130 t of releases may have died, assuming the same release rate in the Netherlands as in England (release rates by number in England and the Netherlands were similar). Discards in the commercial fisheries are around 5% by weight, mainly from trawls, and survival rates are unknown.

Table 3. Estimates of annual recreational fishery catches of sea bass in France, Netherlands and UK (England) from surveys in recent years. RSE = relative standard error. An additional 60t of removals was estimated by Belgium in 2013. (From ICES WGCSE 2014.)

(a) France		Kept	RSE	Released	RSE	Total	RSE	Release rate
2009-2011	Total Atlantic	2,343t		830t		3,173t	26%	26%
	ICES areas IV & VII	940t		332t		1,272t	>26%	26%
2010-2011	Total Atlantic	3,146t		776t		3,922t		20%

RSE was 26% for area VII and VIII combined; area VII represented 40% of total.

~ 80% by weight in 2009/11 was recreational sea angling

(b) Netherlands		Kept	RSE	Released	RSE	Total	RSE	Release rate
March 2010-Feb 2011	By number	234000	0.38	131000	0.27	366000	30%	64%
	By weight	138t	0.37					

98% by weight is recreational sea angling

(c) England		Kept	RSE	Released	RSE	Total	RSE	Release rate
2012	By weight	230– 440t		150-250t		380 – 690t	26-38%	36-39%

Survey covered only recreational sea angling

Table 4. Sea bass in IVb-c, VIIa,d-h: average commercial fishery landings by country and gear group (where available) over 2010–2013. Recreational landings estimates are given for surveys in the same time period.

Fishery	Landings	Percentage
UK(E&W) trawls	147	2.6
France trawls	793	14.0
UK(E&W) midwater	57	1.0
France midwater	1408	24.8
UK(E&W) nets	361	6.4
France Nets	139	2.5
UK(E&W) lines	175	3.1
France lines	305	5.4
UK(E&W) other	65	1.1
France other	142	2.5
Belgium	165	2.9
Netherlands	384	6.8
Channel Isles	54	1.0
recreational France 2009-11	940	16.6
recreational England 2012	335	5.9
recreationalNetherlands 2010-11	138	2.4
recreational Belgium 2013	60	1.1
TOTAL	5667	100

From information available, the precision of the combined international estimate of recreational harvest is likely to be moderate, with relative standard errors of at least 20%. However, the recreational harvest estimate in each country is a very consistent proportion of the combined recreational and reported commercial fishery harvests (France: 25%; England: 28%; Netherlands: 26%; Belgium: 29%) giving greater confidence in the estimates (Table 4). The recreational harvest estimates exclude figures for Wales or any other European countries without surveys that could report sea bass catches. There are also some sources of underestimation of commercial landings.

It is concluded that recreational fishing may account for around a quarter of total fishery removals and fishing mortality (F), and this represents a significant missing catch from the assessment. The ICES inter-benchmark assessment group IBP-bass developed a method to reflect this additional mortality in the Stock Synthesis assessment model, given that there is no time-series of recreational estimates (ICES 2014c). A vector of recreational F at age was developed, with selectivity at age and weights-at-age equivalent to the commercial line fishery in the UK (the length compositions of the harvests from commercial and recreational line fisheries appeared similar). This was included in the model as an additional, year-invariant mortality, added to the base M value of 0.15 (from life-history characteristics), but treated as fishing mortality in the results. A series of assessment runs was carried out, progressively scaling the recreational F vector until the estimated recreational harvests in 2012 were around 1500 t, which is roughly the total of estimates from recent national surveys. ICES WGCSE (2014d) updated the IBP-bass model with the most recent fishery and survey data.

This treatment of recreational fishing as a year-invariant F vector is a novel approach for ICES, but in the absence of a time-series of estimates, was considered the only option to allow recent fishing mortality to be split between commercial and recreational fishing in a way that reflects observations, while preventing all the historical F (based on age compositions of the catches) being attributed to the commercial fishery. For 2012, the split of the mean F at ages 5–11 between recreational and commercial fishing was: recreational F=0.092; commercial F=0.233; total F=0.325; i.e. recreational fishing was responsible for 28% of total F. This split is approximate, as the recreational estimates are not complete (e.g. no survey data for Wales), and are subject to estimation error (CVs >0.20). Assessment runs carried out by IBP-bass including different recreational F vectors from zero to 0.092 showed the same relative stock trends and total F – the effect of the recreational F vector was to scale up the stock numbers and biomass, and increase the proportion of total F due to recreational fishing, without changing trends.

Table 5. Estimated numbers of sea anglers in the UK (England and Wales) from a number of different population surveys

Report	Year of Survey	Estimated Number of Sea Anglers
National Angling Survey	1970	1 280 000
National Angling Survey	1980	1 791 000
National Rivers Authority 1995	1994	1 104 000
Drew Associates 2004	2003	450 000
Simpson and Mawle 2005	2005	2 035 705 (small sample)
Sea Angling 2012. (Armstrong *et al.*, 2013)	2012	960 000

The intention of this modelling approach was to inform fishery managers about the approximate contribution of recreational fishing to total F. Without this, there would be an assumption that all the F (as estimated from the age profile in the catch-at-age data) is due to commercial fishing, yet in reality any management actions applied to the commercial fishery would only affect part of the total F and would be less effective than intended because of the additional F due to recreational fishing.

The provisional assessment results from WGCSE 2014 show that total biomass and SSB are in decline due to a combination of progressively increasing commercial fishing mortality and an extended recent period of very poor recruitment from 2008 onwards (ICES 2014d). The trend of increase occurs against a backdrop of rapidly increasing landings from the mid-1990s to mid-2000s, driven by the very strong 1989 year classes and a series of above-average recruitments formed during an extended period of warmer sea conditions that occurred from the late 1980s.

The historical trends in recreational catches are unknown, but they are likely to differ from commercial catch trends, as it is likely that trends in recreational fishing effort are independent of trends in commercial fisheries. Information from a series of angling surveys in England and Wales since 1970 (Table 5) show random variations around ~1–1.8 m people. Part of the observed variability will relate to differences in survey methodology, but all are based on some form of sampling of the population as a whole.

Sea bass has been a prized target for recreational sea anglers in England and Wales (and southern Ireland) over a much longer period than the current ICES assessment, and sea bass angling was developed to a high level of technical skill and knowledge of the species as far back as the 1970s. There is no information on the actual effort expended by the angling population on sea bass as the stock has changed in abundance, or on changes in efficiency, but an assumption of a constant recreational fishing mortality is a reasonable first approximation for evaluating recreational F. Surveys in the Netherlands (reported to WGRFS 2014) indicate that sea angling participation has been relatively flat since the early 2000s.

It is possible that, before the large growth in biomass of the stock in the 1990s, with associated growth of commercial fisheries on this species, recreational fishing may have been a much larger proportion of total fishery removals of sea bass than at present.

WGRSF recommends that methods for the reconstruction of historical time-series for recreational fisheries are investigated as this will improve the ability to include recreational catches in stock assessment.

2.3 Data quality in European databases

Member States (MS) provide recreational catch data to the European Commission in response to data calls issued by DG MARE (http://datacollection.jrc.ec.europa.eu/dc/fleet/templates). Recreational catch data has been collated since 2011, but these data had not been used before in the STECF report on the Economics of Fishing Fleets. The EC Joint Research Centre (JRC) is responsible for the development of the database, collection of the data, data quality checks, and storage of data for recreational catches statistics. JRCs role in collection of recreational catch data and the system of STECF advice was presented.

WGRFS highlighted significant issues with the recreational catch data collated by JRC that make comparisons between countries or period impossible for the following reasons:

- **Data gaps:** not all countries are collecting recreational catch data and catch data varies between countries.
- **Catch is not defined:** recreational catch includes harvested and released components, but the data are inconsistent and it is unclear which components are included.
- **Inconsistency over time:** not all countries report data each year, as surveys are carried out less frequently (e.g. biennial), so there is no consistency between years in the data submitted.

- **DCF species and regions:** there is variability of the reporting of catches by species and region.

These inconsistencies in recording mean that recreational catch statistics provided by JRC, need to be treated with caution.

WGRFS recommends omission of the recreational data from the annual reports until the above issues are resolved. WGRFS will collaborate with JRC and DG MARE to improve the consistency of the data collated and recreational catch statistics in future.

3 Assessing Different Survey Designs Using QAT (ToRs b, c)

WGRFS 2014 addressed two Terms of References (b and c) related to assessing different survey designs (onsite, offsite) for improved data collection and reviewing and optimizing the WGRFS 'Quality Assurance Toolkit' (QAT) based on the experience of completing at country level. The "toolkit" was developed by WGRFS 2013 to assess and document the quality of recreational fishery surveys and thus recreational catch estimates. The aim of this evaluation is to provide statements of quality of recreational data for end-users including stock assessment scientists, and identify potential improvements to survey design.

3.1 Germany

The German marine recreational catch sampling scheme follows a multistage survey design utilizing an (i) off-site survey (mail-diary) for effort, (ii) on-site survey (data from completed trips for a stratified random sample of access points and days) for catch per unit of effort (cpue), (iii) recreational length samples for recreational length distribution, and (iv) commercial length–weight relationship keys for conversion of numbers into biomass (Strehlow *et al.*, 2012). The on and off-site components of this survey were evaluated using the scorecard questions to detect possible magnitude and direction of bias (Annex 4).

WGRFS recommendations: The target population of marine recreational fishers is not adequately covered by the choice of frame of the off-site survey resulting in a potential bias of the effort estimates. The direction of the coverage error is unknown. Non-response rates for the off-site survey were high with a potential high non-response bias. It can be assumed that respondents were the more avid, experienced anglers resulting in the potential overestimation of the effort estimates. A comparison of the catch estimates with an independent survey from Dorow and Arlinghaus (2011) revealed that harvest estimates from the current dual frame survey were lower, indicating that biases from undercoverage and non-response were of little significance (Strehlow *et al.*, 2012). WGRFS recommends that a subsequent survey draws random samples from the entire population. Overall, the quality of these data is good and can be used for assessment purposes, but is likely to represent an underestimate of the total recreational catch.

3.2 Poland

The recreational cod fishery in Poland is monitored using effort information (number of angling trips in sampling frames - ICES Subdivision and quarter) provided by Harbour Master Offices and mean weight of cod calculated from on-board observed trips. Raising sample mean weight of the anglers catch from observed trips in a given stratum by the known number of trips at the population level, the total recreational cod catch is obtained.

WGRFS recommendations: vessel selection is not fully random and small boats (of the length of a few meters) are not covered by on-board sampling creating potential bias of the total catch estimate and biological information collected, also sampling does not cover cod angling from the beaches, however land-based fishing methods contribute only little to the total catch. Overall, these data are of good quality, but may be biased and are likely to represent an underestimate of the total recreational catch.

3.3 Spain (Basque country)

In the Basque Country three different off-site survey methods were compared to estimate recreational fisheries catch and effort. The three different sampling frames were the list of fishing licenses (for shore fishing), the list of spearfishing licenses (for spearfishing) and the list of registered recreational vessels (for boat fishing). This involved a postal, e-mail and telephone survey to target shore and boat fishing. Spearfishers were contacted using e-mail only. The off-site components of this survey were evaluated using the scorecard questions to detect possible magnitude and direction of bias (Annex 4).

WGRFS recommendations: the coverage of the sampling frame for the postal survey was complete, as the address is a compulsory field when buying a fishing license. However, this was not the case for e-mail and phone surveys, which covered less than 20% of the total surface license holders, and 33% of spearfishing license holders. Accordingly the target population was not adequately covered in the e-mail and phone surveys. Fishers without a license were not covered by the sampling frame. Response rates for postal mail and e-mail surveys were low with a high potential for non-response bias. The postal mail survey revealed a risk of avidity bias in the estimates with more experienced anglers responding to the survey. WGRFS recommends conducting access point intercept surveys to verify the large numbers of zero catch trips before using these data for assessment purposes. Release rates should be estimated in future surveys.

3.4 Recommendations

WGRFS will continue to document and evaluate national recreational fisheries sampling schemes on a multiannual basis (Annex 5). Due to the different national fisheries characteristics and applied surveys WGRFS will continue to explore different quality report formats.

WGRFS recommends identification of the target population including various fishing modes and platforms, and adjust the sampling frame accordingly. Where it is not possible to cover the entire population WGRFS recommends documenting the excluded part. The estimation procedure should follow the survey design and apply weighing procedures to account for non-response or avidity bias. Catch estimates should differentiate between harvest and release components.

WGRFS recommends harvest estimates from Germany and Poland are of sufficient quality for inclusion in stock assessment. Basque Country estimates require verification before using these data for assessment purposes.

4 Communication with Stakeholders (ToR d)

4.1 Stakeholder engagement in recreational fisheries surveys

Stakeholder engagement is a vital part of recreational fishing surveys (RFS), as it is central to delivering the highest quality outputs and maximizing the utility of the results for fishing bodies, scientists, and policy-makers (see for example Armstrong *et al.*, 2013, ICES 2012a). There are many stakeholders in RFS including fishers, trade organizations, policy-makers, scientists, and the general public, so it is important to consider how best to engage with different groups of stakeholders in order to achieve the desired outcome. This is not a one-size-fits-all approach as it depends on the specific goals of the survey, and the role of stakeholders may vary both between surveys and at different times within the same survey. Stakeholder engagement can imply everything from providing input to survey design to practical assistance in data collection/fieldwork to data analysis. This session provided a framework for stakeholder engagement, generated a stakeholder map, and identified key themes for stakeholder engagement.

4.2 Frameworks for stakeholder engagement

There are many frameworks for stakeholder engagement (see e.g. Grey *et al.*, 2007) and extensive literature on the application of stakeholder engagement in fisheries (see e.g. Mackinson *et al.*, 2011) including large European funded projects like GAP2 (http://gap2.eu/). Here, we attempt to synthesize this information with the challenges of communicating with recreational anglers (Dedual *et al.*, 2013) to provide some simple tools that can be applied to recreational fishing projects.

Marine stakeholders can be broadly defined as anyone with an interest in marine fisheries or environment. It covers a broad range of actors including fishers, fisheries dependent industries, fisheries communities, civil society organizations, management agencies, and citizens (Mackinson *et al.*, 2013). It should not be forgotten that scientists are also stakeholders in the process, but this is often not recognized. It is clear that the term marine stakeholder describes a very broad and diverse set of people, making engagement challenging and time consuming. However, it can add significant value to the outputs from a study when done properly. As a result, engagement methods are like to vary between groups and it is important to plan your stakeholder engagement process before starting in order to achieve the desired outcome in the most efficient way. Consideration of the desired outcome informs the level of engagement required and is the key to maximizing the efficiency and effectiveness of interactions with stakeholders. Engagement can happen at a number of different levels and depends on the outcome that you wish to achieve. Levels of engagement fit into the following broad categories: inform, consult, involve, collaborate, and empower (Gray *et al.*, 2007). The cost of delivery increases with engagement, so if your objective is simply to inform, then planning to deliver a programme that empowers is very inefficient and unlikely to work.

There are many different texts that outline the stakeholder process, but we have found the toolkit developed by Gray *et al.*, (2007) to be a useful framework with simple tools to develop a stakeholder engagement plan. To develop a stakeholder engagement plan, it is necessary to:

1. Set objectives for the stakeholder engagement – what are the desired outcomes?

2. Scope the process – why, what, who, and how?
3. Plan the engagement activities – how will it happen?
4. Carry out the engagement activities.
5. Assess if the desired outcomes were achieved – did the programme work?

These steps and tools for delivery are covered in detailed in Gray *et al.*, (2007), so readers are advised to consult this text for more detail. However, we will describe below some techniques for stakeholder mapping, some key considerations, and some challenges of working with recreational fishers.

4.3 Stakeholder mapping

There are many tools for stakeholder mapping, so it is important to use the framework that works best and this may vary between studies based on the objectives (study and engagement). Here, we will describe one simple stakeholder mapping process and present a generic stakeholder map developed by the WGRFS as an example that can be modified for specific studies.

We have found that simple stakeholder mapping tools have allowed us to identify stakeholders and how to interact with them effectively. One of these tools uses a semi-quantitative method that maps stakeholders with their power and interest (Figure 1). This is slightly subjective process that needs to be repeated regularly during the study as stakeholders may shift position, but it provides a useful tool to frame engagement activities. Stakeholders are categorized in the quadrant on the map and methods for levels of engagement are ascribed accordingly (Figure 1). Stakeholders are categorized as apathetic that should be monitored, latent that should be kept satisfied, defenders that need to be kept informed, and promoters that need to be managed closely.

An example of a stakeholder map for a generic RFS project was developed by the experts at WGRFS that provides a useful starting point for mapping exercises in RFS studies (Figure 2). However, this map is meant to be purely illustrative, so the power and interest of the groups identified is unlikely to relate exactly to a specific study as it depends on the desired engagement outcome and objectives of the study. However, it does identify some key stakeholder groups in RFS that need to be considered in the stakeholder engagement process.

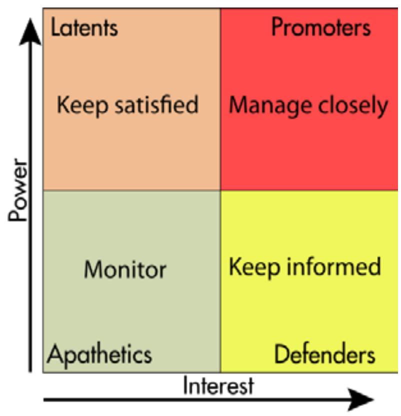


Figure 1. Simple model for stakeholder mapping using the axes of power and interest, and including the actions about communication that should be chosen for stakeholders in each quadrant of the map. Reproduced from Wikipedia (http://en.wikipedia.org/wiki/Stakeholder_analysis) under the Creative Commons CC0 1.0 Universal Public Domain Dedication.

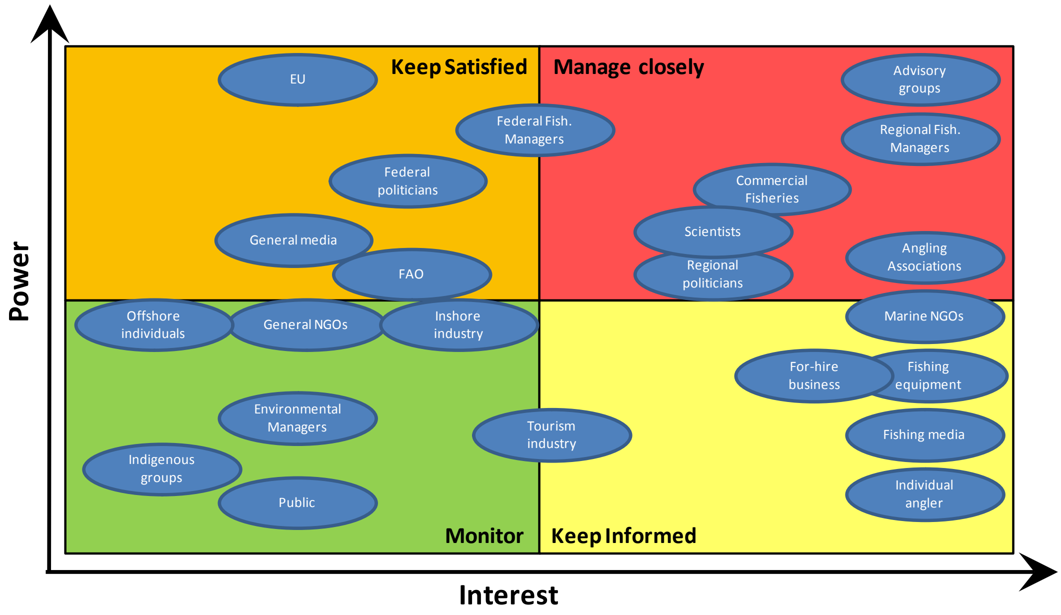


Figure 2. Generic stakeholder map for RSF (quadrant colours are as in Figure 1)

4.4 Key considerations and challenges in stakeholder engagement

There are many studies that outline the key considerations when engaging with stakeholders, so here we present key considerations for fisheries stakeholders and then refine this for recreational fishing and identify some key challenges.

Mackinson *et al.*, (2011) defined the following key considerations for engaging with stakeholders in the fisheries sector:

- Not one-size-fits-all approach;
- Link to governance – role of stakeholders;
- Make a difference – positive effect of relationship;
- Effective communication – to solve problems and communicate outcomes;
- Make the changes sustainable – capacity and scale;
- Create opportunities – structures and time-scales;
- Maintain momentum – long-term process;
- Evaluate the participation process.

Dedual *et al.*, (2013) defined key challenges and potential solutions in communicating with the recreational fishing stakeholders and a synthesized version of these are presented in Table 6. These barriers and the potential solutions need to be taken into account when working with recreational fishing stakeholder.

4.5 Recommendations for stakeholder engagement

Communication is a key part of stakeholder engagement and this is particularly difficult with recreational fishing stakeholders due to the diverse nature of the actors involved. The WGRFS developed the following recommendations for engagement with recreational fishing stakeholders:

- Ensure that there is a tangible benefit for stakeholders engaging in the process that is defined at the start of activity, so that there is a common understanding of what can be developed in collaboration, and the level of input that is required by stakeholders contributing to the process.
- Listen to the knowledge and experience of the stakeholder community, and use this to refine project objectives and goals and, where possible include additional activities that benefit the recreational fishing community.
- Work with stakeholders to understand how engagement activities should be structured and ensure that there is a shared understanding of the long-term goals of the project.
- Have a clear lead for the stakeholder engagement process that understands the requirements to deliver effective stakeholder engagement, and has experience working with the stakeholders involved.
- Spend sufficient time planning, especially mapping stakeholders as this drives the engagement activities. This should include an assessment of stakeholder motives and objectives.
- Define appropriate mechanisms for communicating with each of the stakeholder groups. Tailoring communication for each group should take into account the study objectives, process, results, and communications.
- Where appropriate and possible, involve key stakeholders as early as possible and in every step of the study including experimental design, fieldwork, analysis, and reporting.

This is a bespoke process that needs to be developed for each individual study. This is a significant effort so sufficient resources need to be set aside to engage effectively.Table 6. Challenges and solutions for communication with RSF stakeholders (synthesized from Dedual *et al.*, 2013).

Challenges	Solutions
Language	Plain language
Preconceived fears and suspicions	Sharing knowledge
Conflict of values	Use online resource to share information
Lack of clarity on data use	Appropriate involvement
The media	Bring stakeholders together
Knowledge gap between science and fishers	Neutral facilitators

5 Economic Analysis of Recreational Fisheries (ToR e)

Economic data and analysis of the behaviour and motivations of recreational anglers and the effects of recreational fishing on coastal communities can help managers to efficiently manage fisheries resources. Economic analysis can be used: to estimate the economic benefits derived from recreational fisheries; to describe the economic contributions to coastal communities from expenditures by recreational anglers; and to predict the behaviour of recreational fisheries participants under different management policies. These all lead to a deeper understanding of how alternative management actions can affect the fish stock, anglers, and coastal communities.

Economic analysis provides a systematic and objective method for assessing the economic consequences of different management actions or changes in the environment affecting fisheries. Economics describe who is affected when policies or environmental conditions change, and by how much they are affected. In the USA, the National Marine Fisheries Service (NMFS) as well as state agencies and regional fisheries management councils use economic data and models: to evaluate potential fishery management actions such as bag limits, size limits, or seasonal limits; in damage assessments from natural disasters such as hurricanes or man-made disasters such as oil spills; to evaluate new marine activities such as wind energy areas, aquaculture, or marine-protected areas; to assess investments that support recreational fishing such as building a pier; and in looking at ecological changes such as invasive species or climate change.

There are a number of different types of economic data and analyses commonly used in recreational fisheries management. These include angler expenditure surveys and regional economic impact modelling, angler valuation and preference surveys and net benefit analysis, and cost and earnings surveys and financial analysis of the recreational for-hire industry. These are described below and illustrated using examples from the USA, and methods for socio-economic assessment of recreational fisheries are covered in more detail elsewhere (e.g. sea fisheries - Southwick Associates 2014, inland fisheries - Parkkila *et al.*, 2010).

5.1 Expenditure surveys and regional economic impact models

By purchasing fishing supplies and travelling to fishing sites, anglers spend money in both the local economy of the region where they are fishing and in other regions of a country. In order to capture the effect recreational fishing spending has on a regional economy, economists have developed regional economic impact models. These models are used to estimate how angler expenditures affect economic activity within each sector of an economy. Economic impact models can be used to analyse distributional effects of short-term fisheries policy changes such as impact on businesses, contributions of recreational fishing to a region, or benefits of new facilities (e.g. new marina).

Regional impact models have a set of specific terms to describe the results of the models. Economic contributions and impacts are measured in terms of business sales, labour income, employment, and value-added. Sales are the gross sales by businesses within the economic region affected by an activity. Labour income includes personal income (wages and salaries) and proprietors' income (income from self-employment). Value-added is the contribution made to the gross domestic product of a region from goods and services provided at the final stage of production. Employment includes both full-time and part-time jobs. The first three types of impacts are measured in terms of currency, whereas employment impacts are measured in terms of number of jobs. These impacts are not independent, so it is important to note that adding them together results in some double counting.

Data on angler trip expenditures, purchases of durable goods related to fishing (such as fishing rods and boats), angler characteristics, and details of the fishing trip are required elements for building economic impact models. To collect this type of information, different survey methods can be used such as in-person angler intercept surveys, mail surveys, telephone surveys, or a combination of these. In the USA, nationwide expenditure surveys are done every 5 years, with the last survey in 2011 being a combination of an intercept and phone survey depending on the state. In the Atlantic states, Gulf of Mexico states, and Hawaii, anglers were asked for their trip expenditures in person as an add-on questionnaire to an existing catch survey of intercepted anglers. All anglers were asked to estimate their expenditures for their entire trip (not just for the days spent fishing). The **trip expenditure** data included costs for:

- Auto fuel, auto rental, public transportation (airfare, bus, taxi, subway, ferry);
- Accommodation;
- Food (from grocery stores and from restaurants);
- Bait;
- Ice;
- Boat fuel;
- Boat and equipment rental;
- Guide fees, tips to crew, fish processing;
- Access and parking;
- Gifts and souvenirs.

At the end of the interview, respondents were asked for their postal and e-mail addresses for a follow-up survey about their annual durable expenditures. For states without an angler intercept survey, the entire survey was done by mail using state fishing licenses as a sample frame. Questions related to the purchases of durable goods asked anglers for their expenditures in the prior 12 months and focused on expenditures in the state of the most recent trip. The survey asked about expenditures on **semi-durable goods** such as:

- Fishing tackle and gear (rods, reels, fishing line, hooks, lures, etc.);
- Fishing licenses;
- Special clothing;
- Publications (books, magazines, newspapers, etc.);
- Camping equipment, binoculars, etc.;
- Dues and contributions to fishing clubs;
- Processing or taxidermy costs.

Questions on **durable goods** were related to:

- Boats, boat accessories and related expenses;
- Vehicles and related expenses;
- Second homes and related expenses.

The economic contributions of angler expenditures extend beyond the direct purchases anglers make on fishing trips and fishing related goods. In order to quantify these contributions, a regional input-output model was used to analyse how angler expenditures circulated through each state, territory, and the USA. Input-output models are based on the interrelationship between demand for final goods and services in a regional economy, and the supply of intermediate goods and services needed to produce these final goods and services. Input-output models are capable of tracking quantities and purchasing locations of expenditures by anglers, supporting businesses, and employees in both direct and indirectly affected industries. In analysing the 2011 angler expenditures, a commercially available regional input-output model called IMPLAN (Minnesota IMPLAN Group, Inc., 2010) was used to estimate the economic contributions of marine recreational fishing.

5.1.1 Cost and earnings data on for-hire fishing industry

The for-hire component of recreational fisheries includes for-hire boats, headboats, and guideboats. Models of the for-hire sector are useful for a number of management questions such as the contribution of the industry to a regional economy and the economic impacts and changes in economic benefits related to changes in management policies, natural disasters, or other environmental changes. Models addressing the for-hire industry include both supply and demand models, and economic impact models. To construct models of the for-hire industry, information on the costs and earnings of for-hire vessels is essential and includes information on revenue for for-hire fishing operations, other revenue (such as sightseeing tours), operating costs, and fixed costs. For-hire operating costs are the costs associated with providing a recreational for-hire fishing trip to anglers; these costs include but may not be limited to fuel, oil, bait, ice, food, etc. Operating costs also include payments for hired labour/crew/captain.

For-hire fixed costs are the annual costs associated with operating a for-hire fishing business regardless of the number of trips that may be taken. These costs include, but may not be limited to, maintenance and repair, office space, dock fees, and insurance, etc. Additionally, information on quantities of variable inputs (such as gallons of fuel), employment, catch, vessel characteristics, vessel identification number, owner and crew demographics, and owner and crew identification numbers are important for analyses of the for-hire sector.

Particular issues concerning the design of the economic for-hire survey were related to non-fishing related trips, e.g. at-sea-buries, sunset dinner cruises, etc. In many cases costs often exceeded revenues due to personal bias. During face-to-face interviews the use of computation tables for real-time calculations of net profit proved helpful to immediately check the collected data.

5.2 Economic valuation surveys and analysis

Expenditure survey data and regional input-output modelling approaches should not be considered a substitute for economic approaches such as cost–benefit analysis. Cost–benefit analysis seeks to determine whether resources are being put to their best use by examining the difference between total economic value and total costs. In the context of recreational fishing, total net economic value is generally defined as willingness to pay in excess of actual expenditures. There are two types of data that can be used to estimate the economic benefits to anglers of recreational fishing opportunities and the effects of management changes on those benefits. The first is stated preference data and the second is revealed preference data which focuses on characteristics of the fishing trip, fishing site, or the angler. *Stated preference data* are data on anglers' preferences for hypothetical management options that are used to value the trade-offs among proposed management options. *Revealed preference data* are characteristics of anglers (e.g. age, household income, fishing experience, avidity) or fishing trips (e.g. location, length, primary purpose, species targeted) and are typically collected in conjunction with expenditure surveys or stated preference surveys. These data are used in behavioural models that assess the value of accessing fishing sites, natural resource damage assessment, and measuring the benefits of improving fishing quality.

Stated preference (SP) models are used to elicit consumer consumption behaviours. Stated preference studies can be used for the same purposes as revealed preference (RP) studies, including the identification of patterns in angler behaviour, gauging reactions to management and stock changes, examining species trade-offs, evaluating large-scale environmental issues or policies, valuation of fish or angling trips, and cost–benefit analyses. The results of SP studies may be used to provide context for management issues or as predictive assessments of potential policy changes. Unlike RP studies, SP techniques can be used when there are no natural sources of variation because choice scenarios presented to respondents are hypothetical. For example, the effect of new bag limit changes on angler behaviour can be evaluated for bag limits that have not been implemented previously in a fishery.

Contingent valuation and a class of techniques commonly known as conjoint analysis are the two main SP techniques used in the USA. There are three basic forms of contingent valuation used by economic researchers. The first method, known as *open-ended contingent valuation*, asks survey respondents “How much would you be willing to pay for product or service X?” This method elicits a direct measure of someone’s willingness-to-pay (WTP) for a particular environmental product or service and models are often estimated using simple regression analysis of WTP. The second method, known as *referendum contingent valuation*, asks survey respondents “Would you be willing to pay $Y for product or service X?”, thus measuring WTP indirectly. In the third method, known as *payment card contingent valuation*, respondents are shown tables or “cards” with an array of values and asked to select the value that is the maximum amount they would be willing to pay for a product or service. The latter two survey methods are usually based in random utility theory, which looks for correlations between the level of an environmental good or service and the probability that the WTP equals a specific value. Contingent valuation methods have limited application because only one good or service can be accurately assessed at a time.

Conjoint analysis techniques span a variety of survey instrument designs and present respondents with alternatives comprised of different levels of environmental goods or services. Each environmental good or service is broken down into several attributes or characteristics that vary between the alternatives. For example, one choice could be a trip that resulted in 15 landed fish with an average size of 10 lbs and a cost of $75, while a second choice could be a trip with 20 landed fish, an average size of 7 lbs, and a cost of $80. Depending on the type of survey instrument used, respondents may be asked to select the best alternative, select the best and worst alternatives, or rank or rate the alternatives.

5.2.1 The value of saltwater recreational fishing in Massachusetts: separating truth from fiction

This study compared nonmarket values estimated from responses to hypothetical questions to those based on actual cash transactions. The nonmarket good that served as the subject matter of the study was an early season 2012 Massachusetts saltwater recreational fishing permit. Modelling results indicate that nonmarket values estimated from simulated market transactions were significantly different then values calculated from identical hypothetical transactions. The mean value of a 2012 Massachusetts saltwater recreational fishing permit estimated from actual cash transactions was $317. Values based on hypothetical willingness to sell (accept) and willingness to pay transactions were $593 and $80, respectively. These findings align with previous studies that found differences in economic valuation measures calculated from hypothetical vs. actual behaviour. While a full set of conclusions must come after additional analyses, our results suggest that hypothetical measures of willingness to sell and willingness to pay for a saltwater recreational fishing permit in Massachusetts will be biased, but in opposite directions. This has important implications because economists typically employ hypothetical surveys to estimate recreational fishing values for use in ocean planning and prioritizing competing uses, when evaluating future claims of lost access due to a natural or man-made disaster, and when determining the proper investment to support the recreational industry.

5.3 Bioeconomic models

Marine recreational fisheries management affects both anglers and fish stocks, but predicting how regulatory policies will affect angler behaviour and fishing mortality is challenging. Policymakers often evaluate the economic and biological consequences of proposed management measures without an understanding of how the regulations will alter angler fishing effort, fishing mortality, and future stock levels. This has led to ineffective regulations for meeting mortality objectives of fishery management plans.

Under the 2006 Reauthorization of the Magnuson-Stevens Fisheries Conservation and Management Act, NOAA Fisheries is required to set Annual Catch Limits (ACLs) and Accountability Measures (AMs) to prevent overfishing for all managed fisheries in the USA. Typically, a combination of possession limits, size limits, and seasonal closures are implemented to constrain or reduce the ability of marine recreational fishers to catch a given species. If management controls fail to prevent an ACL from being exceeded, the requirement for AMs necessitates adjusting the measures to address the unanticipated overage. The process of adjusting the measures should be informed by changes in angler behaviour, species availability, and fishing mortality, but these changes are rarely considered due to the difficulty of constructing coupled biological and economic models.

In 2013 and 2014, NOAA Fisheries relied on a bioeconomic simulation model of recreational fishing to determine fishing regulations in the Gulf of Maine groundfish fishery. The bioeconomic model takes into account how changes in both biophysical and regulatory environments map to changes in angler behaviour and fishing mortality (Figure 3). The model uses angler behavioural data collected from an angler stated preference conjoint survey, biological information about the current and projected stock structures of Gulf of Maine cod and haddock, and historical recreational catch and effort data. The model accounts for length-based selectivity by anglers, is dynamic, and is characterized by feedback loops between stock structures and angler participation. Monte Carlo simulations are conducted and the model aggregates from the microlevel choice occasion up to the yearly level to estimate the costs and benefits of alternative fisheries policies and the probability that those policies will achieve short-run conservation objectives (meeting ACLs) and long-run conservation objectives (rebuilding depleted fish stocks). Ultimately, the model is used to predict how proposed size limits, possession limits, and/or closed seasons will affect recreational fishing mortality, angler effort, and angler welfare. This is the first time that NOAA Fisheries has relied solely on a bioeconomic simulation model to set marine recreational fishing regulations for any fishery in the United States.

The general modelling approach begins with a behavioural model for recreational trips that is a function of expectations about the number of fish that will be retained and released under alternative management scenarios. Data for the behavioural model were obtained from a hypothetical stated preference conjoint survey of anglers conducted in 2009 (Figure 4). Stated preference conjoint surveys are frequently used to estimate the effects of changes in regulations when historical data are inadequate or non-existent. For this stated preference conjoint survey, anglers were asked to simultaneously compare features of different hypothetical fishing trips and then to choose the trip they liked best. The features or attributes varied across trips and included bag and size limits for both Gulf of Maine cod and haddock, the number of legal-sized fish caught of each species, the number of sublegal sized fish caught of each species, the number of other types of fish that were legally kept, the trip length in hours, and the total trip cost.

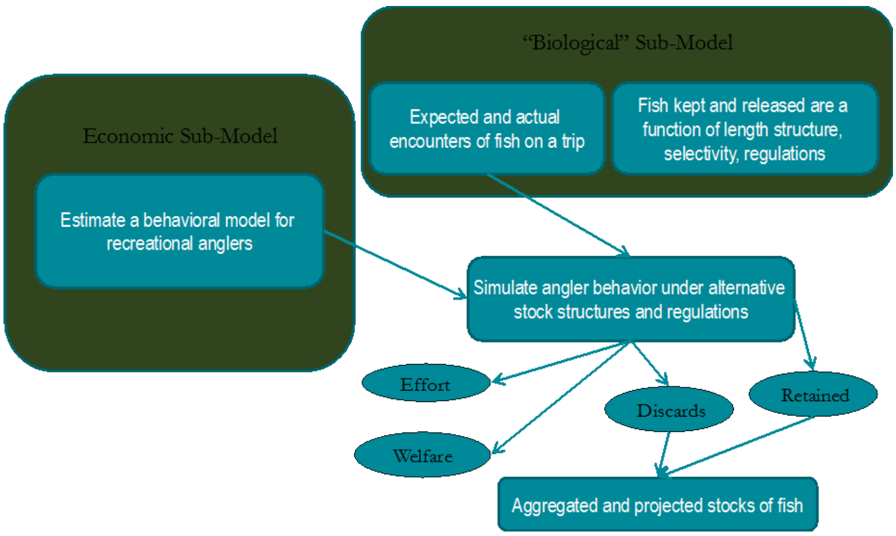
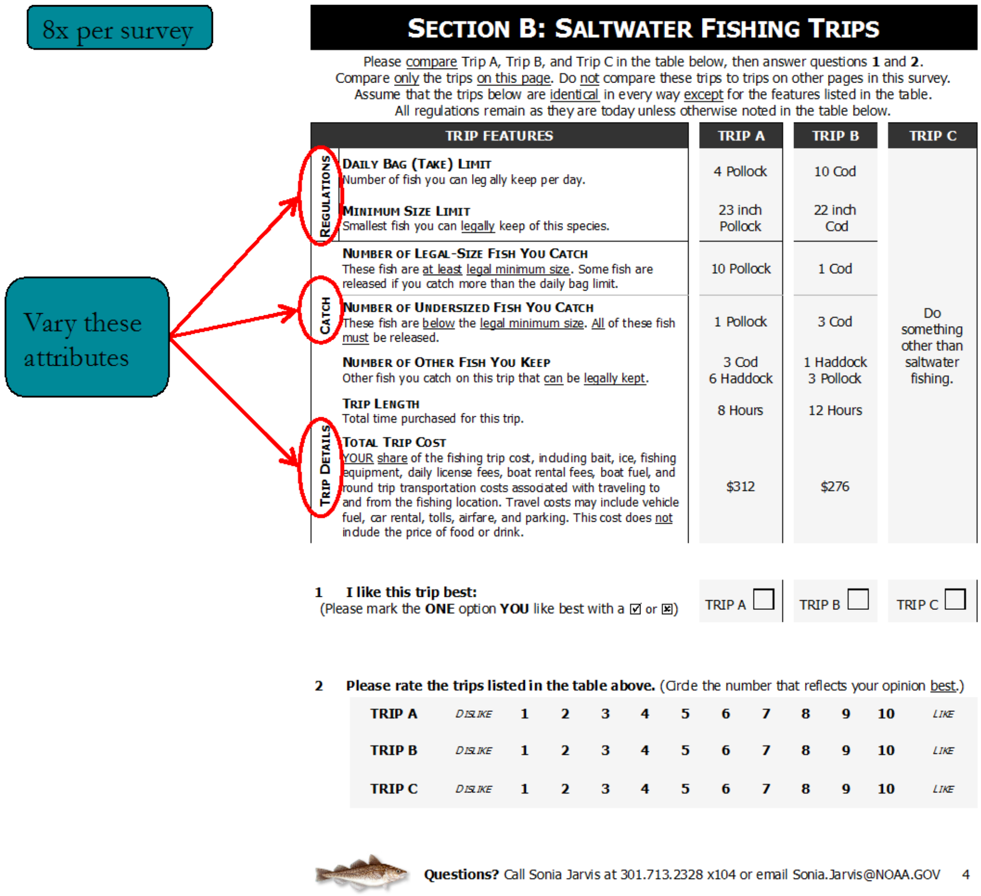


Figure 3. Bioeconomic model overview.



SECTION B: SALTWATER FISHING TRIPS

Please compare Trip A, Trip B, and Trip C in the table below, then answer questions **1** and **2**.
Compare only the trips on this page. Do not compare these trips to trips on other pages in this survey.
Assume that the trips below are identical in every way except for the features listed in the table.
All regulations remain as they are today unless otherwise noted in the table below.

	TRIP FEATURES	TRIP A	TRIP B	TRIP C
REGULATIONS	DAILY BAG (TAKE) LIMIT Number of fish you can legally keep per day.	4 Pollock	10 Cod	Do something other than saltwater fishing.
	MINIMUM SIZE LIMIT Smallest fish you can legally keep of this species.	23 inch Pollock	22 inch Cod	
CATCH	NUMBER OF LEGAL-SIZE FISH YOU CATCH These fish are at least legal minimum size. Some fish are released if you catch more than the daily bag limit.	10 Pollock	1 Cod	
	NUMBER OF UNDERSIZED FISH YOU CATCH These fish are below the legal minimum size. All of these fish must be released.	1 Pollock	3 Cod	
	NUMBER OF OTHER FISH YOU KEEP Other fish you catch on this trip that can be legally kept.	3 Cod 6 Haddock	1 Haddock 3 Pollock	
TRIP DETAILS	TRIP LENGTH Total time purchased for this trip.	8 Hours	12 Hours	
	TOTAL TRIP COST YOUR share of the fishing trip cost, including bait, ice, fishing equipment, daily license fees, boat rental fees, boat fuel, and round trip transportation costs associated with traveling to and from the fishing location. Travel costs may include vehicle fuel, car rental, tolls, airfare, and parking. This cost does not include the price of food or drink.	$312	$276	

1 **I like this trip best:**
(Please mark the **ONE** option **YOU** like best with a ☑ or ☒) TRIP A ☐ TRIP B ☐ TRIP C ☐

2 **Please rate the trips listed in the table above.** (Circle the number that reflects your opinion best.)

TRIP A	DISLIKE	1	2	3	4	5	6	7	8	9	10	LIKE
TRIP B	DISLIKE	1	2	3	4	5	6	7	8	9	10	LIKE
TRIP C	DISLIKE	1	2	3	4	5	6	7	8	9	10	LIKE

Questions? Call Sonia Jarvis at 301.713.2328 x104 or email Sonia.Jarvis@NOAA.GOV 4

Figure 4. Information page shows basic information about the species and current management. Screener questions target the respondent's familiarity and avidity for the species in the survey.

The attribute levels contained in the surveys were intended to represent historical and potential future values as best as possible and were determined by data from past angler expenditure surveys, interviews with for-hire companies, and feedback from survey focus groups. The range of regulation levels chosen for the survey reflected size and possession limits in place at the time of the survey and also accounted for potential future alternative measures. Respondents were also permitted to choose an opt-out option which was "Do something other than saltwater fishing." The collection of choice responses from the various choice scenarios allows for the examination of trade-offs and behavioural responses to regulatory changes in the model.

The behavioural model is then integrated with an age-structured, discrete-time stock model to construct the age-distribution of fish in the Gulf of Maine. The most recent Gulf of Maine cod and haddock stock assessment data are the basis for much of the biological modelling. Additional data used to parameterize the biological model are derived from bottom-trawl survey data, and recreational catch and effort estimates. The age-structured projection models are used to bridge the gap between the terminal years in the stock assessments and a fishing year under consideration. Integrating the age-structured population models with the length-based fishery regulations requires information about the age–length relationship of both stocks, the length-based selectivity of recreational anglers, and catch per trip. The age–length relationship is necessary in order to incorporate targeting behaviour by recreational anglers, since recreational fisheries regulations are based on length not age. The bottom-trawl survey data are used to construct age–length relationships. Incorporating this relationship converts the age-based population models into a length-denominated stock structure. Length-based recreational selectivity is then calculated for each two month period from the length-denominated stock structures and historical recreational length-based catch data.

Historical recreation catch data are also used to compute a frequency distribution of cod and haddock catch-per-trip. Trips which "targeted" cod, "caught" cod, "targeted" haddock, or "caught" haddock are retained for the model runs. The catch-per-trip data are used to assign a maximum amount of cod and haddock catch per trip in the simulations. This assumes that trips within a wave are homogeneous and draw the maximum encounter rates directly from the observed encounter rates. Instantaneous natural mortality is set to 0.2 for all age classes of both species and commercial fishing mortality is set based on recent historical use patterns. The length-weight relationships for cod and haddock used in the most recent assessments are employed to convert individual fish into weights to verify compliance with sub-ACLs.

Recreational fishing activity is then simulated at the level of a potential trip (Figure 5). First, a potential trip is simulated by assigning all trip-specific variables based on the values contained in the stated preference conjoint survey (costs, mode, and length of trip). After the trip-specific variables are assigned, *expected* landed and discarded fish are simulated in a two-step process. For each potential trip, the maximum number of caught fish is randomly drawn based on the catch-per trip probability distribution estimated from historical recreational data. For trips with positive expected cod catch, the length of the first fish is randomly drawn from the probability distribution function for recreational catch-at-length. Next, the length of this fish is checked against the minimum size and retained if it above the legal limit. This continues until the angler either catches the bag limit or reaches the maximum number of randomly assigned caught fish. The same process is completed for both cod and haddock.

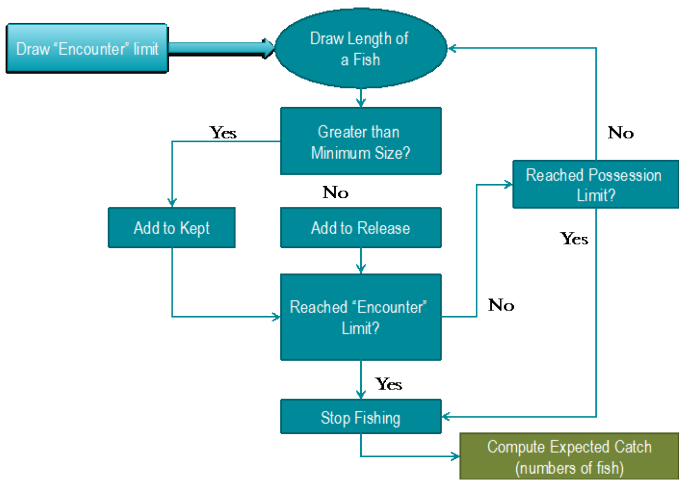


Figure 5. The algorithm randomly assigns the maximum expected number of cod and haddock (separately) caught on the trip based on the probability distribution functions estimated from catch data. The lengths are randomly drawn from the probability distribution function for recreational catch-at-length.

The catch expectations and the assigned trip-specific variables for the potential trip are then combined with the estimated parameters in the behavioural model to compute the probability that the potential trip will be taken. This probability weight is then used to predict actual trips under alternative policies. Instead of assuming that "expected" catch is equivalent to "actual" catch, catch is simulated a second time for angler trips that were considered to be acceptable (P>0.50). The assignment of actual catch proceeds identically to the simulation of expected catch. Angler trips where the probability of acceptance exceeded 50% are randomly assigned a maximum number of caught cod and haddock from the same probability distribution function. The length of a cod is simulated and checked against the minimum size regulations: if it meets the minimum size, the number of kept cod is increased by one. Otherwise, the number of released cod is increased by one. This continues until the angler either catches the bag limit or reaches the maximum number of assigned caught cod for the trip. The same process is repeated to construct kept and released haddock for trips where the probability of acceptance exceeded 50%. Actual kept and released fish as well as WTP corresponding to trips where P>50% are aggregated to compute total recreational kept and discarded cod and haddock. Aggregation of simulated trips continues until either the annual harvest limit is reached or the maximum number of allotted trips occurs.

The model is calibrated by inserting the possession and size limits in effect for the previous fishing year and adjusting the number of potential trips in each wave so that the probability-weighted number of trips approximates the observed number of trips in the previous year. Also, due to uncertainty in initial stock conditions and stock growth, two hundred starting stock structures for both cod and haddock are randomly selected. For each initial stock structure, the simulation model is run for three years with a set of possession limits and minimum size limits. This provides the ability to gain some insight into the effects of changes in possession/size limits in addition to understanding how much variability of effort, landings, discards, and angler welfare might be due to natural variability of stock composition.

The bioeconomic simulation model represents a substantial improvement in recreational fisheries management. Nevertheless, there are definite shortcomings worth noting. First, due to data limitations, it is not possible to specify a stock-catch relationship. Therefore, it is assumed that changes in stock levels do not affect the maximum numbers of fish that are encountered on a trip. Nonetheless, this may be reasonable for fish that aggregate, like cod or haddock. Second, anglers are assumed to stop catching a species when they hit the "assigned encounter limit" or when the bag limit is reached. Additional assumptions include no highgrading and no heterogeneity in catch rates across fishing modes.

A final point worth mentioning is that the model-estimated recreational removals of cod are highly dependent on assumptions about discard mortality. When regulatory policy produces few discards by the recreational fishery, the total removals of cod and haddock are less sensitive to assumptions about the discard mortality rate. In contrast, total removals resulting from policies where MLS lead to high release rates are quite sensitive to the post-release mortality rate.

5.4 Recommendations for economic analysis of recreational fisheries

The USA has a good framework for the collection and analysis of economic data in the recreational fishing sector, and has been developing models that incorporate both economic value and biological sustainability. In Europe, there is currently no equivalent management framework that attempts to balance environmental, economic, and social effects of recreational and commercial fishing, or which sets clear management goals within an ecosystem services framework. Development of this framework is the next major challenge as it involves a multidisciplinary approach that includes biologists, ecologists, economists, social scientists, modellers and policy-makers, and works closely with stakeholders to co-produce knowledge. This also needs to take into account the potential for increasing the value of these ecosystem services and to assess the potential for growth in the value of both the recreational and commercial fisheries under different management regimes.

6 Evaluation of Post-release Mortality Estimates ToR (f)

6.1 The role of post-release mortality estimates

The European Commission has pledged to end discarding in the period 2014–2018, only excluding "species for which scientific evidence demonstrates high survival rates, taking into account the characteristics of the gear, of the fishing practices and of the ecosystem" from the landing obligation. European marine recreational anglers often release more than 50% of their Atlantic cod, European sea bass, pollack, and sea trout catches (Ferter *et al.*, 2013b). Moreover, European eel and some elasmobranch species are protected in many European countries, so must be released. Hence, post-release mortality in recreational fisheries is a large uncertainty in the assessment of stocks that are targeted by both commercial and recreational fishers. This is particularly important if discard proportions and mortalities are high, which may lead to a significant underestimation of actual fishing induced mortality (Kerns *et al.*, 2012). Studies have shown that unaccounted hooking mortalities of over 30% in released fish have rendered fishing regulations like minimum sizes and bag limits ineffective (Coggins *et al.*, 2007).

Discard mortalities of hook and line-caught fish are not easy to measure and can vary significantly between species and fisheries. Many factors are important including water temperature, hooking damages and on-board handling (Bartholomew and Bohnsack 2005; ICES 2014e). In recent years, the mortality estimates for some European marine target species have become available. For example, Weltersbach and Strehlow (2013) estimated an overall post-release mortality of 11.2% for Baltic Sea cod in the German charter boat fishery. In addition, Ferter *et al.*, (2014) showed that some cod may suffer sublethal effects after catch and release even under best practice conditions (shallow hooking, capture depth less than 20 m), but that these fish recover within 10 to 15 hours after the release event. Although both studies showed that Atlantic cod is generally a robust species, they are limited to certain fisheries and/or conditions. Cod that are caught in other fisheries (e.g. land-based surf fishing in the Baltic Sea or deep-sea fishing in Norway) may be subject to higher post-release mortalities due to more significant hooking damages and/or barotrauma issues. Hence, mortality estimates for a species in a certain fishery are not necessarily transferable to another fishery, particularly if fishing practices (i.e. fishing depths, choice of bait or lure, shore or boat, season) vary considerably between fisheries.

To extrapolate mortality estimates, it is important to cover a range of factors which may influence the post-release mortality. In combination with information on typical fishing practices (e.g. the main fishing season, typical fishing depths) in a fishery for which post-release mortalities are unknown, it may be possible to apply the results from mortality studies on other similar species.

6.2 Vitality assessments

Vitality is an integrated measure of the state of an animal without confounding influences of other factors including motivation, size, sex, and context. Vitality can be linked with stressor factors to predict mortality and related to mortality using Reflex Action Mortality Predictor (RAMP) scores. Vitality assessment excludes many secondary mortality factors including predation, crushing and wounding by fishing gears, and pollution. Vitality can be assessed using simple objective scoring systems that, despite shortcomings, can provide a simple alternative to complex experimental studies of post-release mortality and sublethal effects of capture. By calibrating the vitality impairment scores with survival estimates derived from experimental studies (including known vitality status) they can be used as an indicator for release mortality.

Healthy animals have full vitality, but vitality becomes impaired as animals become stressed by capture and handling. Severe vitality impairment can result from the effects of physical injury or other stressors (e.g. fatigue, temperature, light, sea state, air exposure). Maladaptive stress responses or critical injury associated with severe vitality impairment can result in immediate and delayed mortality. Post-release mortality is often cryptic, so vitality assessments based on reflex can be used to predict post-release mortality. Reflex actions are fixed behaviour patterns that are directly related to vitality impairment, without control by volitional behaviour factors, e.g. motivation, hunger, fear, shelter seeking, migration, and reproduction. Reflex actions reflect the state of neural, muscle, and organ functions. Injuries are directly related to vitality impairment because they can control neural, muscle, and organ functions. Any type of reflex action or injury that is related to vitality can be summed to score vitality impairment. The important point is that the sum of presence/absence scores for vitality characteristics produces an index of vitality impairment. This vitality index can then be used as a measure of variability for sublethal stressor effects in fisheries and a validated predictor of post-release mortality. The relationship between vitality impairment scores and delayed mortality can be used to calculate a RAMP.

More detailed information on vitality assessment and RAMP can be found in the report of the Workshop on Methods for Estimating Discard Survival (WKMEDS; ICES 2014e) and on Michael Davis' blog (http://yesheflowers.blogspot.co.uk/). However, steps for creating and using a RAMP are shown in Figure 6 and key considerations when creating a RAMP include:

- Choose reflex actions that are consistently present in unstressed animals.
- Clearly define what is meant by present and absent for reflex actions and injuries.
- Score reflex actions as present/absent because scoring strength of actions depends on size or weight.
- Standardize testing for reflex impairment and injury.
- Clearly identify relevant stressors in the fishery that will be evaluated using RAMP and include them in stressor experiments.
- Design stressor experiments that will result in vitality impairment and delayed mortality ranging from 0 to 100%, to produce a complete RAMP relationship.
- Minimize stress for animals in captive observation or tagging methods for observing delayed mortality.
- Delayed mortality for control animals indicates that holding conditions are stressful and should be improved.

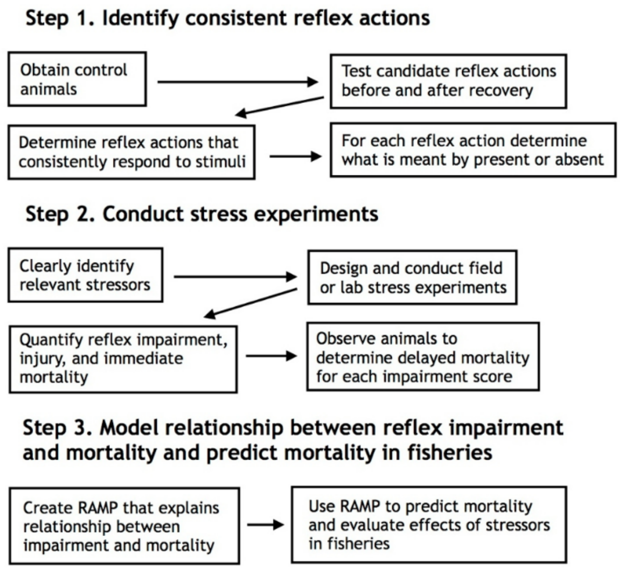


Figure 6. Steps for creating Reflex Action Mortality Predictor (RAMP) in fisheries.

6.3 Recommendations for post-release mortality estimates

Despite high discard rates, species and fishery specific discard mortalities are unknown for most of the relevant European marine hook and line fisheries, so discard mortalities need to be estimated for use in stock assessments. A mixture of desk-based study and experimental work is needed to compile data on mortality of hook and line-caught fish, to underpin the evidence-base to account for discard survival. This should consist of reviewing existing literature, assessing the potential for extrapolation between species and fisheries, setting up generic mortality profiles, and conducting species-specific mortality studies to fill existing data gaps. It needs collaboration across Europe and with other countries including the USA to ensure that the best use of existing data is made. A WGRFS proposal has been submitted to ICES ACOM to develop an EU funded project to address these data gaps.

Sublethal effects on fish that survive the discard event are also unknown and need to be studied as they can have significant effects on the stock, e.g. due to predation or reproductive loss. Vitality assessments provide one mechanism to predict species-specific release survival. Although immediate mortality is a major concern sublethal effects may have significant consequences. However, WGRFS recommends that this should happen through normal research channels and is of lower priority to ICES than post-release mortality data gaps at present.

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Annex 1: List of participants

NAME	ADDRESS	E-MAIL
Alf Ring Kleiven	Institute of Marine Research (IMR) PO Box 1870 5817 Bergen Norway	alf.ring.kleiven@imr.no
Anastasios Papadopoulos	Fisheries Research Institute Nea Peramos 64007 Hellas Greece	eiadirect@gmail.com
Andrei Baikov	Fisheries Resources Department Ministry of Environment Narva mnt 7a 15172 Tallinn Estonia	andrei.baikov@envir.ee
Anssi Ahvonen	Finnish Game and Fisheries Ressource Institute PO Box 2 00791 Helsinki Finnland	anssi.ahvonen@rktl.fi
Arina Motova	European Commission Joint Research Center Institute for the Protection and Security of the Citizen (IPSC) Maritime Affairs Unit Via Enrico Fermi 2749 21027 Ispra (VA) Italy	arina.motova@jrc.ec.europa.eu
Arvydas Svagzdys	Ministry of Agriculture Fisheries Service Nanjoji Uosto 8a 92119 Klaipeda Lithuania	arvydasrusne@gmail.com
Christian Skov	Technical University of Denmark National Institute of Aquatic Resources (DTU Aqua) Vejlsøvej 39 8600 Silkeborg Denmark	ck@aua.dtu.dk
Dave van Voorhees	National Marine Fisheries Services (NOAA) 1315 East West Highway Silver Spring, MD, 20910 United States	dave.van.voorhees@noaa.gov
David Turnbull	Marine Scotland Scottish Government 1B-South Victoria Quay Edinburgh EH6 6QQ UK Scotland	david.turnbull@scotland.gsi.gov.uk

Emma Björkvik	Institute of Freshwater Research Swedish University for Agricultural Sciences Stångholmsvägen 2 17893 Drottningholm Sweden	emma.bjorkvik@slu.se
Estanis Mugerza	AZTI-Tecnalia Txatxarramendi ugartea z/g 48395 Sukarrieta (Bizkaia) Spain	emugerza@azti.es
Graham Monkman	Bangor University and Cefas UK	gmonkman@mistymountains.biz
Hans Jakob Olesen	Technical University of Denmark National Institute of Aquatic Resources (DTU Aqua) Jaegersborg Allé 1 2920 Charlottenlund Denmark	hjo@aqua.dtu.dk
Harry V. Strehlow Chair	Thünen Institute of Baltic Sea Fisheries (TI-OF) Alter Hafen Süd 2 18069 Rostock Germany	harry.strehlow@ti.bund.de
Jeremy Lyle	Institute for Marine and Antartic Studies - Taroona University of Tasmania Private Bag 49 Hobart TAS 7001 Australia	jeremy.lyle@utas.edu.au
Jon Ruiz	AZTI-Tecnalia Txatxarramendi ugartea z/g 48395 Sukarrieta (Bizkaia) Spain	jruiz@azti.es
Kapiris Kostas	Hellenic Centre for Marine Research (HCMR) Institute of Marine Biological Resources and Inland Waters 46,7 km, 19013, Anavisso Greece	kkapir@hcmr.gr
Keno Ferter	University of Bergen PO Box 7800 N-5020 Bergen Norway, and Institute of Marine Research (IMR) PO Box 1870 Nordnes 5817 Bergen Norway	keno@imr.no
Kieran Hyder Chair	Cefas Pakefield Road NR33 0HT Lowestoft Suffolk UK	kieran.hyder@cefas.co.uk
Krzysztof Radtke	National Marine Fisheries Research Institute (MIR) ul. Kollataja 1 81-332 Gdynia Poland	krzysztof.radtke@mir.gdynia.pl

Lucia Zarauz	AZTI-Tecnalia Txatxarramendi ugartea z/g 48395 Sukarrieta (Bizkaia) Spain	lzarauz@azti.es
Martin de Graaf	IMARES PO Box 68 1970 AB IJmuiden The Netherlands	martin.degraaf@wur.nl
Mike Armstrong	Cefas Pakefield Road NR33 0HT Lowestoft Suffolk UK	mike.armstrong@cefas.co.uk
Michael Davis	3404 Englewood Ave. Yakima, WA 98902 United States	yesheflowers@gmail.com
Ryszard Grzebielec	National Marine Fisheries Research Institute (MIR) ul. Kollataja 1 81-332 Gdynia Poland	ryszard.grzebielec@mir.gdynia.pl
Sabrina Lovell	NOAA Fisheries 1315 East-West Highway Silver Springs, MD 20910 United States	sabrina.lovell@noaa.gov
Scott Steinback	NOAA Fisheries 166 Water Street Woods Hole, MA 02543 United States	scott.steinback@noaa.gov
Simon Weltersbach	Thünen Institute of Baltic Sea Fisheries (TI-OF) Alter Hafen Süd 2 18069 Rostock Germany	simon.weltersbach@ti.bund.de
Tomas Zolubas	Ministry of Agriculture Fisheries Service Nanjoji Uosto 8a 92119 Klaipeda Lithuania	tomas.zolubas@zuv.lt
Trude Borch	NOFIMA PO Box 6122 Langnes 9291 Tromsø Norway	trude.borch@nofima.no
Vidar Øresland	Institute of Marine Research Swedish University of Agricultural Sciences Turistgatan 5 453 30 Lysekil Sweden	vidar.oresland@slu.se

Annex 2: Current/most recent marine recreational fishing surveys

A2.1. Baltic Sea (ICES Subdivisions 22–32)

Table A2.1. Most recently carried out, ongoing and/or planned marine recreational fishing surveys in the sampling period 2012–2013.

Country	Cod	Eel	Salmon	Sharks	Comments
Denmark	A combined telephone and Internet survey was designed together with Statistic Denmark. Two recall surveys, with their own questionnaires and group of respondents, were carried out. The first survey, the “licence list survey”, specifically targeted that part of the Danish population with a valid annual fishing licence. When a licence is issued, the Danish social security number of the purchaser is registered, providing an efficient way to contact these persons. However, the list does not cover: (i) tourists (since they do not have a Danish social security number), (ii) those fishing without a valid licence, and (iii) people with a valid reason not to have a licence. The second survey, the “omnibus survey”, targeted a subsample of the entire Danish population. This survey was intended to estimate the number and effort of fishers who fished without a valid licence. In this survey, no questions concerning their harvest were asked. Data on average size of eel, cod and seatrout are obtained by a reference panel of 75 fishers. No data on average size of catches are available.	Sampled similar to cod.	Baltic salmon is mainly caught by trolling. The harvest is not monitored but guestimated e.g. from surveing the catches during the major trolling competitions in the Baltic. Catch is set to be around 3000 individuals including recreational fishing with longlines.	Catches of sharks by Danish recreational fishers are assumed to be negligible.	From 2010, catch of seatrout has also been estimated. From 2013 the annual license list recall survey is web-based only. Catch estimates should therefore be interpreted with caution. No results are avaialble in missing categories for the group of non-respondents as a consequence of the new approach.
Estonia	Catch data are reported and stored in Estonian Fisheries Information System (EFIS) for passive gears.	Catch data are reported and stored in EFIS for passive gears.	Catch data (length and numbers) are reported and stored in EFIS for passive gears.		Catch reporting has been mandatory since 2005 For licensed recreational fishery with passive gears.

Country	Cod	Eel	Salmon	Sharks	Comments
Finland	Cod catch known to be very low. Catch estimate by postal survey of the whole Finnish population (see comments).	Catch estimate by postal survey of the whole Finnish population (see comments).	Catch estimate by postal survey of the whole Finnish population (see comments). For Salmon rivers there is an additional postal survey conducted on the basis of local fishing licenses.		A nationwide biennal recreational fishing survey is done for all species and gears. A stratified sample of about 6000 household-dwellings is done with response rates of around 40-45% after a maximum of 3 contacts. A telephone interview is done for a sample of the non-respondents. Harvested catch and released catch is measured separately by species.
Germany	data from annual stratified random access point survey covering all access points along the Baltic coast. Effort estimates by postal survey from 2006–2007 will be replaced by effort data from a nationwide CATI-Bus telephone screening, followed by a 1-year telephone diary recall survey. Length distributions from on-board sampling of charter vessels by survey agents. Length-weight key from commercial sampling for conversion to weight.	A telephone-diary survey to estimate eel harvests of the recreational passive gear fishery was implemented in 2011–2012 as a pilot study. The panel consists of 180 recreational passive gear fishers of which 120 have been recruited from the Baltic Sea across 7 strata. Participants are called every 4 months to remind them to fill in the diary.	Derogation pending. A survey is planned for 2014.	Derogation requested, as there is no recreational fishery for sharks in German waters or from German vessels.	In 2014 a seatrout survey (1-year diary recall survey) was completed. During the spring season a bus route intercept survey was used to recruit diarists and collect biological samples (length, weight, scales, tissue samples). Alongside catch data, diarists collected biological samples themselves.
Latvia	No sampling - low catches, derogation pending.	Sampling on triennial basis in lakes and rivers - on-site survey.	All river salmon catches have to be reported (low catches).		The catches taken in recreational fishery with commercial gears should be reported and added to commercial catches.

Country	Cod	Eel	Salmon	Sharks	Comments
Lithuania	Small commercial angling boats are licensed, for number of trips and anglers can be obtained from census, direct interviews and questionnaires. From 2013 Lithuania implemented new system of data collection. Total number of charter vessels and boats enaged in recreational fishery can be obtained from daily reports of border police. For inspection of recreational fishery twice per week joint surveys with fishery inspectors at sea are performed, where data on number of fishers, catch volumes by species as well as length-weight distribution of catches have been collecting.	Information on catch volumes can be obtained from census, direct interviews and questionnaires only. Respondents selected in gathering places of fishers where they come to fish from all parts of Lithuania. For example smelt fishing in Curonian Lagoon.	All salmon catches have to be reported to Ministry of Environment protection.	There is no recreational fishery for sharks in Lithuanian waters or from Lithuanian boats.	All recreational fishers are licensed
Poland	In 2013, 11 on-board observer recreational trips were performed to collect biological data and 10 Maritme Offices were visited to collect number of trips and number of anglers on-board in Polish cod recreational fishing.	In 2013, the eel recreational fishery will be investigated within the framework of the Polish Eel Management Plan following Council Regulation 1100/2007 adopting the Eel Management Plan (EMP). For derogation see “Polish annual report on the collection of fisheries data for 2013”	Recreational fishing for salmon takes place mainly in freshwaters, but sea angling in Polish waters started in 2011. Six boats were reported to have been angling. Some data on catches and biological information was collected directly by scientific staff or delivered by boat owners. The same sampling design was applied in 2013 and the data collected has not been compiled yet. For derogation see “Polish annual report on the collection of fisheries data for 2013”.		

Country	Cod	Eel	Salmon	Sharks	Comments
Sweden	National survey supported by regional studies (see comments).	It is prohibited to fish for eel - additional information to RCM.	National survey, regional studies (see comments)	It is prohibited to fish for sharks - additional information to RCM)	A national biennal recreational fishing survey (mail and telephone), including all species, subareas and all gears has been done. However, a new improved design was implemented during 2013, but results are not yet available. The national survey is supported by a regioinal study on cod (tourboat fishing) that has been done for the last two years in the Sound between Sweden and Denmark (2011–2013) and continues in 2014. This is the most important area in Swedish waters for recreational cod fishing. The collection of data on recreational salmon fishing is exhaustive and contains regional studies. The regional studies are adapted to different catch areas and are based on postal surveys, gear inventories and catch reports on the web.

A2.2. North Sea (ICES IIIa, IV and VIId) and Eastern Arctic (ICES I and II)

Table A2.2. Most recently carried out, ongoing and/or planned marine recreational fishing surveys in the sampling period 2012–2013.

Country	Cod	Eel	Sharks	Comments
Germany	According to a pilot study from 2004–2006, German recreational fishery cod catches in the North Sea have no impact on the stock. Annual cod catches from charter vessels amount to approximately 30 t. Other fishing techniques (e.g. boat angling, shore angling) as well as the recreational passive gear fishery have no further relevance concerning cod catches. A second pilot study was carried out in August 2011 to verify these findings. Results show that there has been no change and that catches have even declined.	A telephone-diary-recall survey to estimate eel harvests of the recreational passive gear fishery was implemented in 2011–2012 as a pilot study. The panel consists of 180 recreational passive gear fishers of which 60 have been recruited from the North Sea across 2 strata. Participants are recalled every 4 months to remind them to fill in the provided diary.	A pilot study was carried out in August 2011 to estimate recreational shark catches in the German North Sea. Findings show that recreational shark catches are negligible and have no impact on the stocks.	
Denmark	See the Baltic (Table A2.1).	See the Baltic (Table A2.1).	See the Baltic (table A2.1).	See the Baltic (table A2.1).
Sweden	See the Baltic (Table A2.1).	See the Baltic (Table A2.1).	See the Baltic (Table A2.1).	See the Baltic (Table A2.1).
Norway	A rowing-creel survey is conducted in Southern Norway from April–August 2012 to: - Estimate the proportion of angling tourists vs. Norwegian recreational anglers targeting cod. - Get a size frequency distribution of cod landed by recreational anglers - Estimate the cpue for cod among Norwegian recreational anglers - Estimate the release proportion for cod catches			
UK (Scotland)				

Country	Cod	Eel	Sharks	Comments
UK (England)	A major survey programme (Sea Angling 2012) took place in England in 2012 and part of 2013. The survey components were: • Monthly surveys of households, using face-to-face interviews, to estimate recreational sea angling effort (angler-days) by region and fishing mode. • On-site surveys of anglers at shore angling sites and private boat launching sites in nine regional strata in England, to estimate mean catch per unit of effort (cpue), length compositions by species, angling effort and trip expenditure. • Sampling from a known population of sea angling charter vessels to estimate total effort and catches by species. • A separate survey of economic and social benefits of recreational sea angling involving online surveys and direct interviews at sites around the coast of England. • Quarterly online catch surveys to collect additional information and to help interpret the other survey results.	Marine recreational survey estimates as for cod	Marine recreational survey estimates as for cod	Results available at: http://webarchive.nationalarchives.gov.uk/20140108121958/http://www.marinemanagement.org.uk/seaangling/index.htm
France	A pilot study from 2010–2011 of French recreational cod catches in the North Sea showed no impact on the stock. In 2012, the French recreational cod catches in the North Sea were monitored through a national telephone and diary survey covering all species.	As for cod.	As for cod.	The National Survey covers cod, eel and sharks, but the marginal nature of these fisheries does not allow obtaining a reliable estimate of harvest for these species. The French recreational fisheries cod, eel, sharks and bluefin tuna catches have no (or low) impact on the stocks.
Belgium				

Country	Cod	Eel	Sharks	Comments
Netherlands	The RECFISH programme consists of the following elements: • Online Screening Survey (panel) to estimate the number of receational fishers (marine and freshwater). Surveys were carried out in 2009, 2011 and 2013. In 2013 a parallel online and random digit dialling survey was done. • Online monthly Diary Survey to estimate the annual cod and eel catches. 12 month surveys were carried out in 2010, 2012 and the latest survey started in April 2014. • Onsite surveys to determine length frequency of landed (marine) species	As for cod.	As for cod, however, the national RECFISH survey does not appear to be suitable for providing reliable estimates of sharks catches.	Weight estimates are based on poor length estimates. Numbers are therefore more accurate then weights.

A2.3. North Atlantic (ICES areas V–XIV and NAFO areas)

Table A2.3. Most recently carried out, ongoing and/or planned marine recreational fishing surveys in the sampling period 2012–2013.

Country	Sea bass	Salmon	Eel	Sharks	Comments
UK (Scotland)					
UK (England)	See North Sea (Table A2.2).	Recreational fishing for salmon is almost entirely in inland waters and is monitored by the Environment Agency.	See North Sea (Table A2.2).	See North Sea (Table A2.2).	See North Sea (Table A2.2).
Ireland					
France	See North Sea (Table A2.2).	n.a.	See North Sea (Table A2.2).	See North Sea (Table A2.2).	See North Sea (Table A2.2).
Spain (Basque Country)	A DCF-funded pilot study was carried out in 2012 to estimate sea bass recreational catches in the Basque Country. Telephone, mail and e-mail surveys were used and resulted in an estimate of 166 tonnes. A new survey has been carried out in 2013 to estimate recreational catches in 2012 and 2013. Apart from sea bass, the main speceis targeted by recreational fishers were included in the surveys. These species were different depending on the fishing technique used (shore, boat, spearfishing). Telephone, mail and e-mail surveys were used. Three independent surveys were carried out. The three diferent sampling frames were the list of surface licences (for shore fishing), the list of spearfishing liceces (for spearfishing) and the list of registered recreational vessels (for boat fishing). Contact information is complete for post , but incomplete for e-mail (14% aprox) and telephone (19% aprox). Surveys were done in June 2013 and December 2013. Total estimated sea bass catches: 2012: 178 (136-231) tonnes 2013: 145 (112-180) tonnes		A routinary glass eel sampling is carried out since 2004. Fishers have to fill in a diary logbook in order to obtain the fishing license. These logbooks are used to estimate total catches and cpues. The results were presented in WGEEL.		
Portugal					

A2.4. Mediterranean Sea and Black Sea

Table A2.4. Most recently carried out, ongoing and/or planned marine recreational fishing surveys in the sampling period 2012–2013.

Country	Bluefin tuna	Eel	Sharks	Comments
Spain	Reported to ICCAT collected by IEO.	Regional governments Valencia and Catalonia collect information provided to the DGFisheries.	Negligible catches.	No standard surveys performed in Balearic Islands. Only in the framework of research projects. No current sampling on 2012.
France	See North Sea (Table A2.2).	See North Sea (Table A2.2).	See North Sea (Table A2.2).	See North Sea (Table A2.2).
Italy				
Greece	The fishery of tunas is practised only by professional fishers and is strictly prohibited for receational fishers according to the Minestrial Decision 170317/162669	The recreational fishery of eel is strictly prohibited in the frame for the application of the framework of Reg. (EU) 1100/07.	The recreational fishery of various species of sharks is strictly prohibited according the Reg. (EC) 53/2010.	There are not standard surveys performed in Greece and only few and scant data exist in the frame of very few research projects.

Annex 3: Most recent harvest/release estimates for the relevant species

Harvest estimates are either provided in tonnes (t) or in numbers (#) the second figure indicates the year.

A3.1. Baltic Sea (ICES Subdivisions 22-32)

Table A3.1. Most recent marine recreational harvest estimates – in tonnes (t) or numbers (#); figures in brackets indicate differing years – in the sampling period 2012-2013.

	Cod		Eel		Salmon		Sharks		Comments
Country	Harvest	Release	Harvest	Release	Harvest	Release	Harvest	Release	
Denmark	1046.1 t (2013)	1 158 563 # (2013)	30.2 t (2013)	32 493 # (2013)	3000 # (2013)				Data on seatrout is also available.
Estonia									
Finland	3 t (2012)	0 t (2012)	2 t (2012)	0 t (2012)	36 t (2012)	3 t (2012)			Data from the nationwide biennal recreational fishing survey.
Germany	2 377 215 # 3206 t	2 146 471 # 924 t							Eel catch estimates (recreational passive gear fishery) will be available in 2014
Latvia									
Lithuania	10 t (2013) 40.1 t (2012) 6700 # (2013) 26 733 # (2012)		3.0 t (2013) 1.3 t (2012)		120 # (2013) 0.5 t (2013)				Salmon catches estimates with seatrout
Poland	1 545 454 # 850 t								Salmon estimates will be available in 2015

Country	Cod		Eel		Salmon		Sharks		Comments
	Harvest	Release	Harvest	Release	Harvest	Release	Harvest	Release	
Sweden	142 t (2013)				73 t (2013)				Cod estimate are from tour boat fishing in the Sound. Salmon estimate are based on regional surveys from coastal and offshore areas.

A3.2. North Sea (ICES IIIa, IV and VIId) and Eastern Arctic (ICES I and II)

Table A3.2. Most recent marine recreational harvest estimates – in tonnes (t) or numbers (#); figures in brackets indicate differing years – in the sampling period 2012–2013.

	Cod		Eel		Sharks		Comments
Country	Harvest	Release	Harvest	Release	Harvest	Release	
Germany	30 t (2007)				50–100 # (2011)		Pilot survey for recreational eel catches initiated in August 2011 will end in July 2012 (1-year telephone-diary survey). Findings from a pilot study in 2011 show that recreational shark catches (mainly tope shark Galeorhinus galeus) are marginal and have no impact on the stocks.
Denmark	544.6 t (2013)	276 497 # (2013)	19.3 t (2013)	35 172 # (2013)			Data on seatrout are also available.
Sweden	226.3 t (2010)	275.9 t (2010)					National survey (ref.year 2010)
Norway	Marine angling tourists1: 1613 t (2009) 543 000 # (2009) (RSE 22%) Local Norwegian recreational fishery (all gear types, high potential for bias)2: 23 040 t (2003)	Marine angling tourists Northern Norway3: 66% (SE 4%) (2010–2011) Marine angling tourists Southern Norway: 62% (SE 8%) (2010–2011) Norwegian Skagerrak recreationl fishery4: 55% (2012)	Eel is a protected species in Norway since 2010. No recreational harvest of this species is allowed. No recreational catch estimates are available.		Spiny dogfish, porbeagle, basking shark and silky shark are protected species. No targeted fishing is allowed. No recreational catch estimates are available for other shark species.		1Vølstad *et al.*, (2011) 2Hallenstvedt and Wulff (2004) 3Ferter *et al.*, (2013a) 4Kleiven *et al.*, (2012)

	Cod		Eel		Sharks		Comments
Country	Harvest	Release	Harvest	Release	Harvest	Release	
UK (Scotland)							
UK (England)	430-820 t 281 000# (RSE 30%) (2012)	50 t 201 000# (RSE 36%) (2012)	5300# (RSE 140%) (2012)	32 000# (RSE 62%) (2012)	skates and rays: 41 000# (RSE 51%) smooth-hound (*Mustellus*): 4200# (RSE 42%) tope (*Galeorhinus*): 20# (RSE 92%) dogfish (all species): 46 000# (RSE 37%) (all 2012)	skates and rays: 39 000# (RSE 43%) smooth-hound (*Mustellus*): 190 000# (RSE 35%) tope (*Galeorhinus*): 6800# (RSE 36%) dogfish (all species): 448 000# (RSE 30%) (all 2012)	These results cover the catches for the whole of England including North Sea, Channel, Celtic Sea and Irish Sea. The range of estimates for cod catches by weight represents different methods of estimating seasonal and annual shore and private boat effort. Catches by number for cod and other species are for the method that is likely to be most consistent with future surveys.
France							The National Survey covers cod, eel and sharks, but the marginal nature of these fisheries does not allow obtaining a reliable estimate of harvest for these species. The French recreational fisheries cod, eel, sharks and bluefin tuna catches have no (or low) impact on the stocks.
Belgium							
Netherlands	522 000 (83 000) # 631 (101) t	168 000 (45 000)# 70 (41) t	294 000 (85 000) # fresh 75 (23) t fresh 172 000 (48 000) # marine 36 (10) t marine	862 000 (181 000)# fresh 132 (33) t fresh 114 000 (28 000)# marine 24 (7) t marine			Anglers only for March 2010–February 2011 with standard error in parentheses. Numbers are more accurate than weights. Data from van der Hammen and de Graaf (2013). Weights of retained cod are based on lengths measured in an onsite-survey. Only lengths of retained marine fish are available in this onsite survey. Other weight estimates are based on lengths in the logbook survey which are considered less reliable.

A3.3. North Atlantic (ICES areas V–XIV and NAFO areas)

Table A3.3. Most recent marine recreational harvest estimates – in tonnes (t) or numbers (#); figures in brackets indicate differing years – in the sampling period 2012–2013.

	Sea bass		Salmon		Eel		Sharks		Comments
Country	Harvest	Release	Harvest	Release	Harvest	Release	Harvest	Release	
UK (Scotland)									
UK (England)	230–440 t (2012) 243 000# (RSE 38%) (2012)	150–250 t (2012) 467 000# (RSE 43%)	No marine catches	No marine catches	5300# (RSE 140%) (2012)	32 000# (RSE 62%) (2012)	skates and rays: 41 000# (RSE 51%) smooth-hound (*Mustellus*): 4200# (RSE 42%) tope (*Galeorhinus*): 20#(RSE 92%) dogfish (all species): 46 000# (RSE 37%) (all 2012)	skates and rays: 39 000# (RSE 43%) smooth-hound (*Mustellus*): 190 000# (RSE 35%) tope (*Galeorhinus*): 6800# (RSE 36%) dogfish (all species): 448 000# (RSE 30%) (all 2012)	These results cover the catches for the whole of England including North Sea, Channel, Celtic Sea and Irish Sea. The range of estimates for bass catches by weight represents different methods of estimating seasonal and annual shore and private boat effort. Catches by number for bass and other species are for the method that is likely to be most consistent with future surveys.
Ireland									
France	3922 t (2012, provisional)	776 t(2012, provisional)							The National Survey covers cod, eel and sharks, but the marginal nature of these fisheries does not allow obtaining a reliable estimate of harvest for these species. The French recreational fisheries cod, eel, sharks and bluefin tuna catches have no (or low) impact on the stocks.
Spain (Basque Country)	166 t (2011)				1.5 t (2012–13)				Reported eel catches correspond to glass eel.
Portugal									

A3.4. Mediterranean Sea and Black Sea

Table A3.4. Most recent marine recreational harvest/release estimates – in tonnes (t) or numbers (#); figures in brackets indicate differing years – in the sampling period 2012–2013.

	Bluefin tuna		Eel		Sharks		Comments
Country	Harvest	Release	Harvest	Release	Harvest	Release	
Spain							
France							The National Survey covers cod, eel and sharks, but the marginal nature of these fisheries does not allow obtaining a reliable estimate of harvest for these species. The French recreational fisheries cod, eel, sharks and bluefin tuna catches have no (or low) impact on the stocks.
Italy							
Greece							

Annex 4: Quality assessment of national recreational catch sampling schemes

A4.1. Germany – Dual-frame survey

DESIGN				
			Off-site	on-site
QUESTION		Answer	Comments (including Magnitude and Direction of Bias)	
Target population	Are all sectors contributing to the total catch, harvest or release well-known and documented?	Yes/No/Unknown	Yes	Yes – Wading maybe underrepresented
	Is there illegal/tourist fishery, which is not accounted for?	Yes/No/Unknown	No – Non residents (tourists) not covered but magnitude of this subpopulation minor; No – Illegal fishery believed to be low	No – no tourist anglers encountered
	Are there elements of the target population that are not accessible?	Yes/No/Unknown	No national registry (no complete sampling frame available)	No – no private sites
Target frame	Is the PSU identified and documented?	Yes/No/Unknown	Yes – individual angler	Yes – individual angler
	Does the sampling frame fully cover the target population?	Yes/No/Unknown	No – Anglers not organized in fishing associations not covered (potential coverage error); No – Organized anglers from non-coastal states not covered (potential geographical coverage error)	Yes – entire list of access points sampled
	Are there elements of the target population that are excluded from the frame (e.g. non-residents, private access sites)?	Yes/No/Unknown	No – Non-residents not covered but magnitude low	No – all potential anglers covered
Stratification	Are the strata well defined, known in advance and stable?	Yes/No/Unknown	n/a	Yes
	Is there an overstratification leading to excessive imputation?	Yes/No/Unknown	n/a	No – stratifcation according to regions and survey agents
Selection	Is sampling probability based (e.g. stratified random with spatial strata, PPS)?	Yes/No/Unknown	No – distribution mechanism unknown	Yes – random sample of access points and dates

IMPLEMENTATION

	QUESTION	Answer	Comments (including Magnitude and Direction of Bias)	
Selection	Has the survey been designed to maximize precision?	Yes/No/Unknown	Unknown	Yes
	Are there protocols in place and have they been followed to select subsamples (selection of individuals, times, boats, biological samples)?	Yes/No/Unknown	n/a	Yes – subsamples pseudorandom selected It is not fully documented yet.
	Are the right sites, times, respondents, biological data sampled?	Yes/No/Unknown	n/a	Yes – but peak activity sampling
	Is there a language barrier (tourist fishery)?	Yes/No/Unknown	No	No
	Is there a preference not to engage with illegal fishers (e.g. threatening behavior)?	Yes/No/Unknown	n/a	Yes – partly (mainly anglers violating MSL) but magnitude low
	Has the assignment been completed?	Yes/No/Unknown	Unknown	Yes
Nonresponse	Are response rates recorded and evaluated?	Yes/No/Unknown	Yes – high nonresponse	n/a
	Are refusal rates (e.g. according to spatial issues, fishing in MPAs or fishing for high value species) recorded and evaluated?	Yes/No/Unknown	n/a	No – in general refusal rates are low < 5%
	Have you re-evaluated refusals?	Yes/No/Unknown	n/a	No (see abvove)
	Have you accounted for not completed assignments (unobserved sample bias)?	Yes/No/Unknown	n/a	Yes – non completed assigments are replaced by random selection
Recall	Is the recall period appropriate?	Yes/No/Unknown	n/a	Yes – recall same day
	Does recall period match fishing season?	Yes/No/Unknown	Yes – 1-year diary	Yes (see above)

IMPLEMENTATION				
Effort	Is effort well defined (unit, fishing mode, target species, location) and related to cpue measures?	Yes/No/Unknown	Yes – fishing day, boat, charter, trolling, shore fishing, herring, location	Yes – fishing day, boat, charter, trolling, shore fishing, herring, location
	Is the concept of effort understood by respondents?	Yes/No/Unknown	Yes	Yes
	Is it possible to record incorrect fishing areas?	Yes/No/Unknown	Yes – partly	No
Catch	Is catch verified by survey agents (e.g. all filleted, don't show)?	Yes/No/Unknown	n/a	No – partly, don't dear to ask (all filleted)
	Is species identification and naming reliable?	Yes/No/Unknown	Yes – exept flatfish species	Yes – exept flatfish species
	Is there a clear division between fish kept and fish released?	Yes/No/Unknown	Yes	Yes
	Are there any high-valued/threatened species taken in the fishery that might be unreported?	Yes/No/Unknown	Yes – maybe salmon and sea trout	Yes – maybe salmon and sea trout
	Is there a digit preference in the reports?	Yes/No/Unknown	Unknown	Unknown
ANALYSIS				
QUESTION		**Answer**	**Comments (including Magnitude and Direction of Bias)**	
General	Does the estimation procedure follow the survey design?	Yes/No/Unknown	Yes – taking into account the drawbacks of the survey design	Yes – partly, e.g. avidity data collected but currently not used for weighting cpue data
	Has imputation been used to account for missing observations and, if so, is the procedure documented?	Yes/No/Unknown	No	No
	Has the precision of the estimates been calculated and, if yes, where are they documented?	Yes/No/Unknown	Yes – Strehlow *et al*,. (2012)	Yes – Strehlow *et al.*, (2012)
	Has there been weighting to correct for nonresponses/avidity bias	Yes/No/Unknown	No – not accounted for (potential high nonresponse bias)	No – nonresponse/refusal rates low; avidity bias currently not taken into account
	In panel surveys, have those seleted changed their fishing pattern or activity?	Yes/No/Unknown	Unknown	n/a
	Is the bias caused by drop-outs and drop-ins in a panel corrected for?	Yes/No/Unknown	No – number of drop-ins/drop-outs unknown	n/a

A4.2. Spain (Basque Country) – Off-site survey

DESIGN

	QUESTION	Answer	**Off-site** Comments (including Magnitude and Direction of Bias)
Target population	Are all sectors contributing to the total catch, harvest or release well-known and documented?	Yes/No/Unknown	No-Three independent surveys were carried out. The three diferent sampling frames were the list of surface licences (for shore fishing), the list of spearfishing liceces (for spearfishing) and the list of registered recreational vessels (for boat fishing). Contact information is complete for postal mail , but incomplete for e-mail (14% aprox) and telephone (19% aprox). Non licenced fishers were not accounted for but considered to be minor (<10%). Catch and release was not estimated.
	Is there illegal/tourist fishery, which is not accounted for?	Yes/No/Unknown	Yes – Non licenced fishers were not accounted for but considered to be minor (<10%) Yes – Tourist fishery is considered to be minor (<10%)
	Are there elements of the target population that are not accessible?	Yes/No/Unknown	Yes- Non licenced fishers Yes- People whose telephone or e-mail information is not available Yes- Fishers under 16 years.
Target frame	Is the PSU identified and documented?	Yes/No/Unknown	Yes – The list of licences. PSU: licence
	Does the sampling frame fully cover the target population?	Yes/No/Unknown	No – Non licenced fishers were not included in the samping frame
	Are there elements of the target population that are excluded from the frame (e.g. non-residents, private access sites)?	Yes/No/Unknown	Yes– Non licenced fishers were exluded. Yes- Tourist can get the licence on the Internet, but probably they don’t do it.
Stratification	Are the strata well defined, known in advance and stable?	Yes/No/Unknown	Yes- Geographic stratification made by province (2).
	Is there an overstratification leading to excessive imputation?	Yes/No/Unknown	No
Selection	Is sampling probability based (e.g. stratified random with spatial strata, PPS)?	Yes/No/Unknown	Yes- Stratified random.

IMPLEMENTATION			
QUESTION		**Answer**	**Comments (including Magnitude and Direction of Bias)**
Selection	Has the survey been designed to maximize precision?	Yes/No/Unknown	No- The sampling probability was the same in the two strata.
	Are there protocols in place and have they been followed to select subsamples (selection of individuals, times, boats, biological samples)?	Yes/No/Unknown	Yes- There is a protocol to select the samples (randomization, etc). This protocol was followed. It is not fully documented yet.
	Are the right sites, times, respondents, biological data sampled?	Yes/No/Unknown	Yes- The protocol was followed
	Is there a language barrier (tourist fishery)?	Yes/No/Unknown	No- The surveys were made both in Basque and in Spanish.
	Is there a preference not to engage with illegal fishers (e.g. threatening behavior)?	Yes/No/Unknown	No- Not relevant.
	Has the assignment been completed?	Yes/No/Unknown	Yes- The assigned sample was fully completed.
Nonresponse	Are response rates recorded and evaluated?	Yes/No/Unknown	Yes – Non contact and refusal rates were registered. Non response bias was evaluated comparing the experience of the respondent fishers and the % of catches >0 between different survey methods.
	Are refusal rates (e.g. according to spatial issues, fishing in MPAs or fishing for high value species) recorded and evaluated?	Yes/No/Unknown	Yes- Non contact and refusal rates were registered.
	Have you re-evaluated refusals?	Yes/No/Unknown	No
	Have you accounted for not completed assignments (unobserved sample bias)?	Yes/No/Unknown	No- The assigned sample was fully completed.
Recall	Is the recall period appropriate?	Yes/No/Unknown	It was 1 year in 2011 and 2012 and six months in 2013. Its propably too large.
	Does recall period match fishing season?	Yes/No/Unknown	Yes – Different species with different seasonality were addressed.
Effort	Is effort well defined (unit, fishing mode, target species, location) and related to cpue measures?	Yes/No/Unknown	Yes – Days of fishing targeting any species was asked. (Only lines are allowed).
	Is the concept of effort understood by respondents?	Yes/No/Unknown	Unknown- We didn’t consider the misunderstanding of this question. What does a day mean? Trip/24h?
	Is it possible to record incorrect fishing areas?	Yes/No/Unknown	No- It was an open question.

Catch	Is catch verified by survey agents (e.g. all filleted, don't show)?	Yes/No/Unknown	No.
	Is species identification and naming reliable?	Yes/No/Unknown	Yes – Species difficult to identify have been merged into groups. Local names have been revised to assign reported species to their group.
	Is there a clear division between fish kept and fish released?	Yes/No/Unknown	A question about the % of catch released was included in the sea bass survey (2011). In the 2012 and 2013 surveys the catch of more species wer included and release was not estimated.
	Are there any high-valued/threatened species taken in the fishery that might be unreported?	Yes/No/Unknown	Yes – Maybe Bluefin tuna (they are not allowed to fish it).
	Is there a digit preference in the reports?	Yes/No/Unknown	Unknown- It was not evaluated.

ANALYSIS

QUESTION		Answer	Comments (including Magnitude and Direction of Bias)
General	Does the estimation procedure follow the survey design?	Yes/No/Unknown	Yes – The strata are combined because the sampling probability is similar in both strata.
	Has imputation been used to account for missing observations and, if so, is the procedure documented?	Yes/No/Unknown	Yes –To be checked.
	Has the precision of the estimates been calculated and, if yes, where are they documented?	Yes/No/Unknown	Yes – Zarauz *et al.,* (submitted). Standard deviations of estimates and bootstrapping for accuracy of methods.
	Has there been weighting to correct for nonresponses/avidity bias	Yes/No/Unknown	No
	In panel surveys, have those seleted changed their fishing pattern or activity?	Yes/No/Unknown	n/a
	Is the bias caused by drop-outs and drop-ins in a panel corrected for?	Yes/No/Unknown	n/a

A4.3. Poland – On-site survey

AT-SEA-SAMPLING	
Stock - Species - Area - Year (eastern Baltic cod - 2013)	
	Poland
	Design
	Implemention
Importance: Contribution to stock landing	850 t
Sampling / design effect/diagnostic for randomness… (Description according to best practice)	
Sampling design	drawing from vessel list
Primary sampling unit	Vessel
Sampling frame	yearly vessel list
Periodicity	ca. 1 sample per month during a year
Contact protocol	no
Sampling manual available	under preparation
…	
Strata from the sampling frame	Fleet 1 - angling with fishing rod on boats and vessels
Importance: Contribution to national landing	850 t
Importance: Contribution to national discards	marginal
Quality indicator	
Total number of vessels in the fleet	360
Number of trips sampled onboard of vessels	11
Number of unique vessels sampled	10
Total number of trips conducted by the fleet	11229
Number of trips sampled where stock occurred in the discards	
Number of trips sampled where stock occurred in the landings	11
Age key quality indicator (e.g. Mean number of age samples per trip sampled)	50
Non-response rate	
Industry decline (refusal rate)	
Goodness of fit	
Bias 1: Spatio-temporal coverage	considered all right
Bias 2: Vessel selection	smaller vessels rejected observers
Bias 3: …	comment
Precision levels of e.g. parameter a, b, …	
e.g. CV, variance, relative sampling error	possible to estimate
e.g. Input data for XSA model:	
maturity at age	yes
stock weight	no
catch weight	yes
catch at age	yes

Annex 5: ToRs for WGRFS in 2015

The **Working Group on Recreational Fisheries Surveys** (WGRFS), co-chaired by Harry V. Strehlow, Germany and Kieran Hyder, UK, will take place from 1–5 June 2015 in Sukarrieta, Spain. The ToRs for the meeting were split into multi-annual ToRs that will be addressed each year as they represent core outputs and specific ToRs for issues that will be addressed at this particular meeting.

Multi-annual ToRs:

a. Collate and evaluate national estimates of recreational catch, activity, and socio-economic values.
b. Assess different survey designs for improved data collection.
c. Evaluate national surveys using WGRFS quality assessment tool (QAT).

Specific ToRs:

d. Review recreational catch estimates for candidate stocks (e.g. Baltic salmon, western and eastern Baltic cod, Atlantic sea bass), including assessing the relative importance of recreational fisheries and identifying data gaps.
e. Provide recommendations on the reconstruction of recreational fisheries time-series for use in stock assessments.
f. Identify post-release mortality estimates, potential sublethal effects, and reasonable extrapolations across species and fisheries for inclusion in stock assessments.
g. Review updates of the EU MAP data requirements for recreational fishing effort, catches, and socio-economic aspects.
h. Assess methods for estimating recreational catches of diadromous species in freshwater and identify potential synergies with marine recreational fisheries catch sampling schemes.
i. Identify potential interactions between recreational fishing and environmental legislation including MSFD, WFD, and marine spatial planning.

WGRFS will report by 1 September 2015 to the attention of ACOM.

Supporting Information

Priority	High – Because recreational catches can be high for some stocks
Scientific justification	This work is required under the EC-ICES MoU that requests ICES to provide support for the Data Collection Framework (EC Reg. 199/2008 and EC Decision 2008/949/EC). WGRFS is the ICES forum for planning and coordination of marine recreational fishery data collection for stock assessment purposes. DG MARE should engage with WGRFS to ensure proper coordination with the DCF activities. WGRFS shall develop and approve standards for best sampling practices within its remits and for marine recreational fisheries in the ICES area, in line with the ICES Quality Assurance Framework.
Resource requirements	Expertise on recreational fisheries surveys from areas outside Europe would be beneficial
Participants	The Group is normally attended by some 20–25 members and guests.
Secretariat facilities	Normal backstopping support in the organization of the group.
Financial	None.
Linkages to advisory committees	ACOM

Linkages to other committees or groups	WGBFAS, WGEEL, WGBAST, WGCSE, WGNSSK, WGBIE, WKMEDS and EU Regional Coordination Groups
Linkages to other organizations	WECAFC/OSPESCA/CRFM/CFMC Working Group on Recreational Fisheries Many linkages to national angling associations, since WGRFS members estimate national marine recreational catches.