# Supporting information: Recreational sea fishing in Europe in a global context – selection of data by country

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**Running title:** Marine recreational fishing in Europe

## TABLE OF CONTENTS

## Introduction

This Supporting Information contains details of the underlying data provided for each country on marine recreational fishing (MRF) participation, effort and expenditure, the reasoning for the selection of data, and the assessment of the quality of the survey data. Where data were not available for a country (hereafter termed "recipient country"), an extrapolation was conducted from a country with data (hereafter termed "donor country"), and justification is provided for the extrapolation in terms of the donor country selected and caveats surrounding the use of these data. MRF in Europe is managed under the European Union (EU) Common Fisheries Policy (CFP) (Council Regulation (EU) 2015/812) and reporting of MRF catches is required under the European Data Collection Framework (DCF) (EU, 2001, 2008, 2010, 2016) and Control Regulations (Council Regulation (EC) No 1224/2009; EU, 2010). The data used in this study represent the highest quality, latest, and most relevant data selected by national experts that are responsible for development and delivery of EU statutory data on MRF that are compiled annually by the ICES Working Group on Recreational Fisheries Surveys (http://www.ices.dk/community/groups/Pages/WGRFS.aspx; ICES, 2010, 2011, 2012, 2013, 2014, 2015, 2017). A summary of the derivation of the semi-quantitative assessment of bias for number of fishers, total fishing effort and expenditure on MRF in each country is provided (Table S1).

## Albania, Bulgaria, Croatia, Cyprus, Malta, Montenegro & Romania

There were no studies of MRF available in Albania, Bulgaria, Croatia, Cyprus, or Romania, so extrapolation was needed for these countries (Table 2). The MRF target species and composition of the sector were assumed to be most similar to Greece and Italy, therefore data from Greece was used for the extrapolation of participation rates, and data from Italy was used for extrapolation of fishing effort and expenditure (Table 2). The bias associated with these estimates was assumed to be the same as for the donor country (Table S1). More information on the surveys in Greece and Italy is provided in the relevant country-specific sections.

## Belgium

### Recreational fishing sector

The MRF sector in Belgium is relatively small compared to neighbouring countries, but catches of some target species can be significant at a national level. MRF in Belgium includes: boat angling (private and charter boats), beam trawling, bottom otter trawling, longline fishing, beach fishing with static gear, shore angling, and wading with small towed nets in the surf zone. The use of trammel and gillnets by recreational fishers is banned. The main MRF target species in Belgium are Atlantic cod (*Gadus morhua*, Gadidae), European sea bass (*Dicentrarchus labrax*, Moronidae), whiting (*Merlangius merlangus*, Gadidae), common dab (*Limanda limanda*, Pleuronectidae), common sole (*Solea solea*, Soleidae) and Atlantic mackerel (*Scomber scombrus*, Scombridae) (van den Stein, 2010). No licence is required for MRF in Belgium.

### National Survey Data

Few estimates of MRF catches in Belgium exist (ILVO, 2007; van den Stein, 2010; Lescrauwaet et al., 2013). Most studies were based on small samples of few participants and it was not possible to raise estimates to the whole population as the numbers of participants was not known. In 2006, a pilot study was conducted to estimate MRF catches of Atlantic cod in Belgian waters. A questionnaire was sent to 50 recreational fishers and 15 responses received, that led to an estimate of MRF cod landings between 100 and 200 tonnes each year by about 2,000 fishers over 40,000 trips (ILVO, 2007). Another study was done on MRF at events organised by the national angling association, and 224 recreational fishers completed the survey (Persoon, 2015). Coastal and boat fishers were targeted and asked about fishing locations, catches, releases and expenditures, and the study revealed an estimated annual expenditure of €1,372 per fisher (Persoon, 2015).

Verleye et al. (2015) used an on-site survey to map the MRF sector in Belgium, that included individual vessel characteristics, estimation of fishing effort, and identification of fishing locations at

sea. A total of 631 boats were identified that were mostly located in four coastal marinas, and effort was estimated using on-site observations of numbers of boats. On-site observation showed that most boats did not operate during high winds (> 5.5 $m.s^{-1}$), resulting in 171 days with outgoing boats and an average of 63 boats active each day. This gave a total of 10,735 boat days with on average 2.4 fishers aboard giving a total of 25,765 individual trips (Verleye et al., 2015). Some boats were observed more than once, so the total number of fishers was 24,409 after correction for multiple trips (T. Verleye, pers. comm.).

### Data used in this study

Total number of fishers and fishing effort were taken from Verleye et al. (2015) (Table 2). Participation and effort were likely to be a high underestimate, as only boat fishers were included (Table S1). Expenditure by individual fishers was not collected using a probability-based sampling scheme (Persoon, 2015), so was likely to be subject to large bias (ICES, 2010). Total expenditure was calculated by multiplying average expenditure (Persoon, 2015) by the number of boat fishers (Verleye et al. 2015), so was likely to be a small underestimate.

## Denmark

### Recreational fishing sector

MRF is a popular leisure activity in Denmark, with two main approaches: passive gear fishing using stationary gear (e.g. gill and fyke nets); and angling (rod and line). Spear fishing is also practiced and is becoming more popular. Passive gear fishing is done from small boats targeting European eel (*Anguilla anguilla*, Anguillidae), European flounder (*Platichthys flesus*, Pleuronectidae), Atlantic cod, and sea trout (*Salmo trutta*, Salmonidae) (Sparrevohn et al., 2010). Angling is done from the shore and boats targeting sea trout, garfish (*Belone belone*, Belonidae), Atlantic cod, various flatfish, and Atlantic salmon (*Salmo salar*, Salmonidae) (Rasmussen & Geertz-Hansen, 2001; Ministeriet for Fødevarer Landbrug og Fiskeri, 2010). All anglers, including tourists, between 18 and 65 years and

passive gear fishers over 12 must purchase a license, with on average 33,433 passive gear and 195,361 angling licences sold annually (Danish Agrifish Agency, 2015).

## National Survey Data

The numbers and effort of the Danish population participating in MRF both with and without a licence was estimated using a national omnibus survey in 2009 and 2010 (Sparrevohn et al., 2010). Catches of European eel, Atlantic cod and sea trout, were estimated every 2 years using a combination of telephone and internet recall surveys. This targeted fishers with a licence, collecting fishing effort in the last six months and numbers of fish kept and released for each species, and was repeated every quarter for individual ICES management areas (Sparrevohn et al., 2010; Sparrevohn & Storr-Paulsen, 2012; Olesen & Storr-Paulsen, 2015). The demographics of anglers have been investigated (Bohn & Roth, 1997) and further surveys were done on demographics, economic impact, willingness to pay, recreational fisher motivations, and recreational fishing tourism (see e.g. Ministeriet for Fødevarer Landbrug og Fiskeri, 2010). The number of fishers was estimated to be 425,000 in 1997 (Bohn & Roth, 1997), 616,000 in 2009 (Ministeriet for Fødevarer Landbrug og Fiskeri, 2010), and 442,000 in 2010 (Sparrevohn & Storr-Paulsen, 2012). The proportion of fishers that fish in the sea was estimated to be 73% (Bohn & Roth, 1997). The numbers of licences purchased each year between 2004 and 2015 was 154,520 year, 17,778 week, and 23,063 day licences (Danish Agrifish Agency, 2015). This was much lower than estimates of numbers of fishers, indicating that many people fish without licences both legally (e.g. under 18 or over 65 years old) or illegally (23% angling and 28% passive fishing - Sparrevohn & Storr-Paulsen, 2012). The number of trips by each fisher each year was 9.4 and 3.6 days for legal and illegal fishers, respectively (Sparrevohn & Storr-Paulsen, 2012). The proportion of sea fishing trips was estimated to be between 54% (Bohn & Roth, 1997) and 56% (Ministeriet for Fødevarer Landbrug og Fiskeri, 2010). Hence, the number of MRF trips each year was 2,369,771 based on 416,926 legal anglers fishing for 9.4 days and 112,074 illegal anglers fishing for 3.6 days, and 55% of trips took place in the sea.

An economic evaluation of the recreational fishery emphasised the importance in Denmark (Roth et al., 2001; Toivonen et al., 2004). A panel of 1,500 respondents was used to estimate the direct and indirect economic impact of angling which was €389 million or €147 million excluding taxes and imports, and supporting 2,473 Full Time Equivalents (FTEs) (Ministeriet for Fødevarer Landbrug og Fiskeri, 2010). Danish recreational fishers spent on average €543 each year, with large variations between fisher types and fishing locations. Sea fishers generally spent more than freshwater fishers, especially those specialised in trolling for salmon (Ministeriet for Fødevarer Landbrug og Fiskeri, 2010).

### Data used in this study

The number of fishers used was derived from the average of the two most recent surveys and was 529,000 (Ministeriet for Fødevarer Landbrug og Fiskeri, 2010; Sparrevohn & Storr-Paulsen, 2012). The proportion of sea anglers was assumed to be 0.73 (Bohn & Roth, 1997) giving a total of 386,000 sea fishers in Denmark (Table 2). The number of fishing trips per angler was taken from the omnibus survey as it separated legal and illegal fishers (Sparrevohn & Storr-Paulsen, 2012), giving on average 6.15 days per year and total effort of 2,369,771 days (Table 2). The economic impact of MRF cannot be separated from freshwater fishing, so the average expenditure estimate of €543 each year (Ministeriet for Fødevarer Landbrug og Fiskeri, 2010) was used (Table 2). Country level data was high quality (negligible bias), but some avidity bias exists in the expenditure (small overestimate) and uncertainties in proportion of sea fishers (Table S1).

## Estonia

### Recreational fishing sector

MRF in Estonia is comprised of three sectors: (1) licenced fishers mainly using passive gears with mandatory logbooks (e.g. gill nets, longlines, crayfish traps); (2) licenced anglers and spear fishers that purchase fishing rights; and (3) non-licenced fishery using one hand line or rod with a single

hook without a reel. The most popular species caught by MRF are European flounder, Eurasian perch (*Perca fluviatilis*, Percidae) and northern pike (*Esox lucius*, Esocidae).

## National Survey Data

The licenced recreational fisheries (e.g. gillnet, longline, salmon fishery in rivers etc.) have mandatory logbooks for catches. There were 3,615 individual fishers that purchased a monthly gill net licence and 13,934 monthly licences were issued in 2014, with on average 115 days fished each year and 123 tonnes of catch reported. The number of fishers that purchased fishing rights was 46,346, and 8,563 people that bought a fishing licence. Some fishers bought both, so there were 51,092 recreational fishers paying for fishing in 2014. There were an additional 14,000 recreational fishers that did not have to purchase fishing rights, including children under 16 years of age, pensioners, people with disabilities, and fishers using a hand line or a single rod without a reel (Rakko, 2014). Thus, there were approximately 65,000 recreational fishers or a 5% participation rate in recreational fisheries. The length of the shoreline and regional distribution of the population meant that around 30% of these fished in the sea resulting in a total number of 19,500 sea fishers. A recent survey of recreational fishing estimated that the average annual expenditure per fisher was €275 in 2013 (Ender et al., 2013).

## Data used in this study

The number of fishers used in this study was derived assuming that 30% of all recreational fishers or 19,500 individuals fished in the sea (Table 2), and average annual expenditure per fisher was €275 (Ender et al, 2013). The biases associated were a small underestimate for participation and a small overestimate for expenditure (Table S1).The recreational sea fishing effort data was extrapolated from Latvia (see Table 2 and country-specific section for details) as the target species and the composition of the MRF sector are similar to Estonia and the bias associated with this estimate was assumed to be the same as for the donor country (Table S1).

## Finland

### Recreational fishing sector

In 2012, there were 1.5 million recreational fishers in about 850,000 households in Finland, representing a participation rate of 28%. The catch was 24,500 tonnes from both freshwater and marine waters, with the majority in freshwater and only 300,000 marine fishers in the Baltic Sea. The most important MRF species are Eurasian perch, northern pike, Baltic herring (*Clupea harengus membras*, Clupeidae), roach (*Rutilus rutilus*, Cyprinidae) and pikeperch (*Sander lucioperca*, Percidae). MRF is mostly done from small, private boats using gill nets, fish traps and trap nets (http://stat.luke.fi/en/recreational-fishing). In 2012, the MRF catch from the Baltic Sea was 6,000 tonnes with a first sale value of €11 million (http://stat.luke.fi/en/producer-prices-fish). The most economically important species were pikeperch, Eurasian perch, whitefish (*Coregonus lavaretus*, Salmonidae), and northern pike (http://stat.luke.fi/en/recreational-fishing). No licence is needed for angling (i.e. bait fishing, ice fishing and herring fishing with a rig), but a governmental management fee must be paid by individuals aged between 18 and 64 years for all other types of fishing including lure fishing.

### National Survey Data

Biannual surveys are conducted to estimate participation, fishing effort and catches of the recreational fishery in Finland (http://stat.luke.fi/en/recreational-fishing). In the national household surveys, probability-based samples of 7,500 households are drawn from the Finish population register and the number of fishers, demographics, fishing activity by fishing area, and catches are collected by the Natural Resources Institute Finland (www.luke.fi).

### Data used in this study

The numbers of fishers and fishing effort derived from the latest household survey were used in this study (Table 2). The biases associated with Finish participation and fishing effort estimates were

assumed to be negligible (Table S1). There were no estimates of expenditure for MRF in Finland, as the only study that exists includes both marine and freshwater fishing (Toivonen et al., 2004). Therefore, the average expenditure per recreational fisher per year was extrapolated from Sweden (see Table 2 and country-specific section for details). The bias associated with this estimate was assumed to be the same as for the donor country (Table S1).

## France

### Recreational fishing sector

MRF in France is practiced with passive gears, rod and line, and spear guns from the shore and boats (Herfaut et al., 2013; Levrel et al., 2013; Rocklin et al., 2014). Rod and line fishing with live bait or lures and spear fishing are the main methods used from shore, with both angling and nets used from boats (Herfaut et al., 2013; Levrel et al., 2013; Rocklin et al., 2014). In 2011, there were 1,319,000 fishers in France making around 9,000,000 fishing trips each year, with around 60% and 40% of the effort in Atlantic and Mediterranean waters, respectively. There was an even split of effort between shore and boat fishing, with about 60% of the trips resulting in any catch. Trips from the shore represented 52% of all trips and on average 2.9 fish were caught per trip, whereas 48% were boat fishing trips with 7 fish caught during an average trip duration of 3 hours (Levrel et al., 2013). The main species caught are European sea bass, Atlantic mackerel, pollack (*Pollachius pollachius*, Gadidae), whiting, pouting (*Trisopterus luscus*, Gadidae), cuttlefish (*Sepia officinalis*, Sepiidae), and sea breams (S*pondyliosoma cantharus* and *Sparus aurata*, both Sparidae). There is no licencing system or registry of recreational sea fishers in France.

### National Survey Data

France has conducted three nationwide studies on MRF: a national MRF pilot study in 2006 (Herfaut et al., 2012, 2013); a national study between 2009 and 2011 to assess sea bass catches on the Atlantic coasts (Rocklin et al., 2014); and a national study from 2011 to 2013 estimating catches in both the

Atlantic and Mediterranean (Levrel et al., 2013). The pilot study produced a comprehensive assessment of MRF by combining telephone and self-reporting surveys, and assessed a wide variety of gears and methods (Herfaut et al., 2012, 2013). The study produced estimates of the numbers of fishers, fishing effort, and catches (Herfaut et al., 2012, 2013). Catches of European sea bass on the Atlantic coast were assessed using a large-scale telephone survey and fishing diary panel (Rocklin et al., 2014). A total of 467 sea bass fishers completed an in-depth telephone interview, and 256 fishers submitted catch diaries covering 1,190 fishing trips and 1,383 catches, along with information on fishing methods (Rocklin et al., 2014). The second national study combined telephone and diary surveys with 16,000 households selected using random digit dialling. A two-step interview process was used: a short screening interview to collect demographic information and numbers of fishers in the household; and a second longer interview including detailed questions for 792 fishers that were identified during the screening interview. Catch diaries were kept by 364 fishers, 213 from the telephone survey and 151 from an association of recreational fishers, providing catch information from 2,836 trips (Levrel et al., 2013).

## Data used in this study

The data used in this study was from the 2011-2013 telephone and diary survey after exclusion of diarists recruited from the angling association (Levrel et al., 2013) as the earlier surveys had higher levels of bias. The country level estimates used are shown in Table 2 and were of high quality with negligible bias (Table S1). A relative effort split was assumed to partition the estimates in Atlantic (60%) and Mediterranean (40%) waters (M. Bellanger, pers. comm.). The German expenditure data was used for extrapolation as this was considered to be the most similar (see Table 2 and country-specific section for details). The bias associated with this estimate was assumed to be the same as for the donor country (Table S1).

## Germany

### Recreational fishing sector

There were 174,000 recreational sea fishers in Germany in 2013/2014, with the majority fishing in the Baltic Sea (163,000) and 32,000 in the North Sea (H.V. Strehlow & M.S. Weltersbach, unpublished data). In the North Sea, shore fishing is restricted to harbours and the north and east Friesian Islands and boat fishing opportunities are limited. The Baltic Sea is popular for shore and boat fishing and most German charter vessels operate in this area (Strehlow et al., 2012). Fishing effort was almost 1.4 million days, with 90% of the effort exerted in the Baltic Sea (H.V. Strehlow & M.S. Weltersbach, unpublished data). Fishing from the shore (surf angling and wading with rod and line) and sea-based fishing methods (boat and charter vessel angling with rod and line) are equally popular with the fishing effort being almost evenly split in the Baltic Sea (Strehlow et al., 2012). Furthermore, 1,684 active, recreational fishers (1,020 in the Baltic Sea and 664 in the North Sea) used passive gear in 2012 (H.V. Strehlow & M.S. Weltersbach, unpublished data). The main species targeted are Atlantic cod, Atlantic herring (*Clupea harengus*, Clupeidae), Atlantic mackerel, European flounder, European plaice (*Pleuronectes platessa*, Pleuronectidae), common dab, sea trout and Atlantic salmon. Recreational fishing licences are obligatory in all federal states, apart from Lower Saxony. In addition, to a valid fishing licence, the Baltic Sea states require a coastal fishing permit (Mecklenburg-Western Pomerania) or a federal fishing licence (Schleswig-Holstein).

### National Survey Data

Several surveys have been conducted estimating participation, catch, and effort in Germany (Grosch et al., 1977; Möller & Tiffert, 1988; Hilge 1998; Wedekind et al., 2001; Wolter et al., 2003; Arlinghaus, 2004; Dorow & Arlinghaus, 2011; Strehlow et al., 2012; Ensinger, 2015), but few explicitly collected data for MRF. Möller & Tiffert (1988) counted the numbers of herring anglers, sampled one charter vessel, and conducted interviews with beach anglers to estimate catch rates and

total catch of Atlantic herring and Atlantic cod, yearly expenditure for angling equipment, and total yearly income per charter vessel in Kiel Bight (western Baltic Sea).

A nationwide telephone survey and diary study with 648 panellists was conducted in northern Germany and produced estimates of the number, effort and catch of recreational fishers in Mecklenburg-Western Pomerania (Dorow & Arlinghaus 2011). Recreational landings of Atlantic cod in Mecklenburg-Western Pomerania exceeded 3,000 t in 2007 and were higher than the commercial landings of cod in the same state (Dorow & Arlinghaus 2011).

A nationwide MRF study was done involving a mail-diary survey with 66,000 questionnaires sent to angling clubs. A total of 2,313 responses were used to estimate numbers and effort of anglers, and showed significant catches of Atlantic cod in the western Baltic Sea (Zimmermann et al., 2007). The corresponding catch per unit effort was estimated using a multi-annual on-site access point intercept survey and recreational length distributions were obtained onboard charter vessels (Strehlow et al., 2012). The on-site survey has been done annually since 2005, with over 21,100 anglers interviewed by 2015.

A national telephone-diary survey covering nine out of 16 federal states was done in 2014, with two states far from the sea used as proxies for the seven states not covered by the survey. A random digit dialling telephone survey resulted in a sample of 50,200 valid telephone numbers of private households, 678 anglers were identified, and 348 panellists recruited. In addition, a non-representative sample of coastal fishing permit holders resulted in 582 panellists. During the screening survey respondents were asked to provide an estimate of the number of days fished and expenditure each year (H.V. Strehlow & M.S. Weltersbach, unpublished data).

## Data used in this study

The number of fishers, fishing effort and expenditure estimates (Table 2) used in this study were derived from a recent national 1-year telephone-diary study from 2014-2015 (H.V. Strehlow & M.S.

Weltersbach, unpublished data) as the former mail-diary survey included both coverage and non-response biases (Strehlow et al., 2012). Catch estimates for western Baltic Sea cod originated from the on-site access point intercept survey as described in Strehlow et al. (2012). The estimates were considered to contain only negligible bias (Table S1).

## Greece

### Recreational fishing sector

Greek marine fisheries exploit many different species using various gear types, and the reported fisheries landings currently exclude recreational catches (Tsikliras et al., 2007). MRF is done for leisure and consumption, and divided into boat and shore fishing, spear fishing, and shellfish collection. The complexity of the coastline and the variety of different gear types used means that surveying MRF in Greece is a significant challenge (Lloret & Font 2013; Moutopoulos et al., 2013). Shore fishing is a common activity with estimates of catch representing on average 8% of total removals between 1950 and 2010, with a range of 3 to 22% (Moutopoulos & Stergiou, 2012). Between 11 and 48 demersal species are important MRF target species depending on the area, with European sea bass and sea breams (Sparidae) accounting for around 40% of the total recreational catch (Moutopoulos et al., 2013).

### National Survey Data

There were no regular surveys of MRF in Greece, but historical removals have been reconstructed (Moutopoulos et al., 2013) and some data has been collected from the sport fishing community (Anagnopoulos et al., 1998) mainly related to tuna (Scombridae) (HCMR, 2004). All studies used interviews with recreational and commercial fishing associations, coast guard, port offices, fisheries administrations, and retail shops (Anagnopoulos et al., 1998; HCMR, 2004; Moutopoulos et al., 2013). In addition, an independent estimate of the magnitude of MRF was provided by the National Statistical Service of Greece (General Secretary of Fishery, pers. comm.).

The legal aspects, magnitude, and the socioeconomic role of MRF in Greece and Italy was reviewed in a study by Anagnopoulos et al. (1998), but the results should be interpreted carefully due to issues with the study design. Another study was carried out to assess the recreational tuna fishery that focussed on the Aegean Sea (HCMR, 2004). Unreported shore-based MRF catches have also been estimated regionally and by species for the period 1950-2010 (Moutopoulos et al., 2013), but are likely to represent a large underestimate of the true values. The most recent estimate of numbers of recreational sea fishers in Greece (2011-2012) was 300,000 boat, shore and spear fishers accounting for 2.75% of the Greek population (General Secretary of Fishery, pers. comm.).

### Data used in this study

An estimate of the participation in MRF was available for Greece, but there were no studies on fishing effort or expenditure available, and therefore extrapolation was needed (Table 2). The MRF target species and the composition of the sector were thought to be most similar to France and Italy, therefore data from France and Italy was used for fishing effort and expenditure extrapolation, respectively (see Table 2 and country-specific section for details). The biases associated with these estimates were assumed to be the same as for the donor countries (Table S1). The bias associated with the participation estimate was assumed to be a high underestimate (Table S1).

## Iceland

### Recreational fishing sector

The four main MRF target species in Iceland are Atlantic cod, Atlantic halibut (*Hippoglossus hippoglossus*, Pleuronectidae), wolf fish (*Anarhichas spp.*, Anarhichadidae) and haddock (*Melanogrammus aeglefinus*, Gadidae) (Solstrand, 2013). In Iceland, catch and release is forbidden by law and all fish must be landed, except for Atlantic halibut, which must be returned alive if viable. Tourists are required by law to use hook and line and cannot use other methods. Quotas are

issued to charter vessels, all catches must be reported, and additional quota can be purchased from other vessels. No fishing licence is required for MRF in Iceland.

### National Survey Data

MRF statistics and interviews with charter vessel skippers showed that there were 48 charter vessels operating with an average catch of 48 to 61 kg per vessel per day, fishing for 80 days per year, resulting in a total seasonal catch of 232 tonnes (Solstrand, 2015). There were few studies of MRF in Iceland that collected data on all fishing sectors, and only the participation rate was available (Toivonen, 2002).

### Data used in this study

As only information on participation was available (Toivonen, 2002) extrapolation was needed for fishing effort and expenditure. The MRF target species and the composition of the sector were assumed to be most similar to Norway, therefore data from Norway was used for fishing effort, and data from Denmark for expenditure (see Table 2 and country-specific sections for details). The biases associated with these estimates were assumed to be the same as for the donor countries (Table S1). The bias associated with the participation estimate was assumed to be negligible (Table S1).

## Ireland

### Recreational fishing sector

Ireland has an extensive coastline and its recreational fishery is almost exclusively confined to rod and line fishing and limited spear fishing, but participation levels for the latter are unknown. MRF comprised of shore, charter vessel and private boat fishing. Around 120 charter vessels operate mainly on the north-west, west, and south coasts, with a capacity of between 6 and 8 fishers per vessel. Two discrete categories exist: pelagic and demersal fishing; and shark fishing (< 5% of total fishing days) (Wögerbauer et al., 2015).

The main species targeted by shore anglers are: European sea bass, Atlantic mackerel, Atlantic cod, pollack, European flounder, whiting, common dab and lesser spotted dogfish (*Scyliorhinus canicula*, Scyliorhinidae). Other elasmobranchs including tope (*Galeorhinus galeus*, Triakidae) and rays (Batoidea) are targeted at specific locations. Shore angling is primarily a bait angling fishery targeting all available species, but a sea bass fishery has emerged using artificial lures. Boat fishers (charter and private boat fishers) target species including pollack, Atlantic cod, ling (*Molva molva*, Lotidae), saithe (*Pollachius virens*, Gadidae), conger eel (*Conger conger*, Congridae), wrasse (cuckoo - *Labrus mixtus* and ballan - *Labrus bergylta*, both Labridae), European sea bass, gurnards (*Triglidae spp.*), blue shark (*Prionace glauca*, Carcharhinidae), spurdog (*Squalus acanthias*, Squalidae), rays, and tope. High levels of catch and release are found for all species except gadoids and mackerel. No MRF licence is required.

## National Survey Data

A survey of the socioeconomic impacts of recreational fishing was done with 903 fishers interviewed using face-to-face interviews (692) and online methods (211) (TDI, 2013). The interviews were conducted at randomly selected marine and freshwater locations, and fishers who provided contact details were asked to complete the online survey. The total economic contribution of recreational fishing in Ireland was €755 million with an estimated 252,000 domestic and 154,000 tourist fishers (TDI, 2013). Participation rates were estimated from 4,044 interviews and 7.6% of the population aged over 15 years were recreational fishers, giving 273,600 domestic fishers of which 76,600 were sea fishers. The ratio of shore-based sea fishers to boat fishers was estimated at approximately 3:1 giving 57,450 shore fishers and 19,150 boat fishers from current participation rates (Whelan & Marsh, 1988). The average expenditure associated with Irish sea fishers was thought to be in the region of €1,641 per angler per annum giving a total direct expenditure of about €126 million. Sea fishers visiting from outside of the Republic of Ireland are thought to contribute a further €44 million in direct expenditures.

### Data used in this study

The data selected for this study were from the IFI omnibus study in 2015 (Table 2) and were considered to contain negligible bias (Table S1).

## Italy

### Recreational fishing sector

Italy has between 600,000 and 1,000,000 marine recreational fishers, MRF effort was estimated to be 4.8 million days, and total expenditure was €240 million. Most fish from shore, but around one third use either private or charter boats. The most commonly used gears are lines (rod and line 50%, longline 18%) and pots (7%); with spear fishing accounting for about 12% of the total effort. Commonly targeted species with significant catches include Sparidae (sea breams), tuna species, European sea bass, common dolphin fish (*Coryphaena hippurus*, Coryphaenidae), little tunny (*Euthynnus alletteratus*, Scombridae), cuttlefish (Sepiidae), squid (*Loligo vulgaris*, Loliginidae), and sharks as bycatch in the tuna fishery (Cingolani et al., 2005; Pranovi et al., 2015). No licence is required for MRF in Italy.

### National Survey Data

Some data on MRF exist for Italy, but the few studies provided varying estimates due to different sampling methods (Cautadella & Spagnolo, 2011). The main sources of data were interviews (AC Nielsen, unpublished data), self-reporting during mandatory registration (MiPAAF, 2010), and follow-up data collection (MiPAAF, 2012). Other partial or anecdotal information also existed, but no reliable effort or catch data was available for the whole country.

### Data used in this study

The survey used in this study (MiPAAF, 2012; AC Nielsen, unpublished data) covered marine recreational boat-fishing activities in Italy, but did not sample shore-based fisheries effectively and

underrepresented participants such as occasional fishers, children, and tourists. Thus, the bias in the number of fishers, fishing effort and expenditure was considered a moderate underestimate (ISMERI, 2015) (Table S1).

## Latvia

### Recreational fishing sector

MRF in Latvia is carried out in the Baltic Sea (ICES subdivisions 26 and 28). Recreational fishing comprises of two sectors: registered fishers fishing with passive gears for personal consumption that cannot sell catch (e.g. gillnets, fyke nets, longlines); and active methods including angling (rod and line fishing) and spear fishing. Passive gear fishers must report catches and these catches are included in the national catch statistics. Angling is more common from the shore than from boats, and ice fishing is done in the Gulf of Riga. European flounder, Eurasian perch, Atlantic cod, garfish, Atlantic herring and round goby (*Neogobius melanostomus*, Gobiidae) are the main species targeted by MRF. Recreational fishers between 16 and 65 years must have a licence, but do not need to report catches (Latvijas Nacionālās, 2013) and are not allowed to sell their catch (Anonymous, 2007).

### National survey data

There were no regular surveys of MRF in Latvia, with the only data collected from the logbooks of passive gear fishers by the Ministry of Agriculture and Fisheries. In 2014, 887 passive gear fishers were registered as consumption fishers, with 24,600 fishing trips reported and total landings of approximately 104 tonnes. The main target species were European flounder (28 tonnes), Atlantic herring (18 tonnes), vimba bream (*Vimba vimba*, Cyprinidae) (17 tonnes) and Eurasian perch (8 tonnes). Between 100,000 and 120,000 licences were purchased by anglers, with about 30% of the 2,200 interviewed anglers being involved in MRF (Birzaks, 2007; Korņilovs, 2013).

### Data used in this study

The data used for Latvia related to the passive gear consumptive fishers (Table 2), and therefore excluded around 40,000 anglers that fish in the Baltic Sea (Birzaks, 2007; Korņilovs, 2013). Thus, the numbers, participation, and fishing effort were likely to significantly underestimate the actual situation in Latvia, but the consumptive fishers were likely to fish more often than anglers, and so the average effort per fisher was likely to be a significant overestimate (Table S1). No expenditure data existed for Latvia, therefore Estonia was used for extrapolation (see Table 2 and country-specific section for details) and the bias was assumed to be the same as for the donor country (Table S1).

## Lithuania

### Recreational fishing sector

MRF occurs mainly from the shore and in coastal waters in the Baltic Sea, and targets a range of species including European plaice, Atlantic herring, Atlantic cod, turbot (*Scophthalmus maximus*, Scophthalmidae) and salmonids (Salmonidae) (Lithuanian Fishing Services, 2016). Rod and line fishing is the only permitted method, with trawls, nets, pots and traps banned.

### National survey data

A recent study estimated Baltic cod catches using a recall-based interview survey, where a sample of recreational vessels were interviewed and an on-board survey of smaller vessels was undertaken. Small charter angling boats are licenced, so the numbers of trips and anglers were obtained from census, direct interviews, and questionnaires. However, there was under-coverage of other sectors (A. Svagzdys, pers. comm.).

## Data used in this study

There was limited data available for Lithuania, so data for participation and effort was extrapolated from Latvia and expenditures from Estonia (see Table 2 and country-specific sections for details). The biases were assumed to be the same as for the donor countries (Table S1).

# Netherlands

## Recreational fishing sector

In 2013, 3.2% of the Dutch population participated in MRF with the majority taking between one and five fishing trips each year. Most fishing was conducted with rod and line, and occurred from the shore, charter vessels and private boats. The main species caught were flatfish (European plaice, European flounder and common dab), Atlantic mackerel, Atlantic cod and European sea bass. Average release rate was 30%, but varied between 10% (mackerel) and 60% (flounder). MRF occurs also with gill nets, targeting mainly European sea bass, but catches are a very small fraction of the total and a licence is required. No MRF licence is required for rod and line fishing in marine waters.

## National Survey Data

The Dutch survey involved a two-phase design: a screening survey and a logbook survey (van der Hammen et al., 2016). The screening survey was part of a marketing survey of households and approximated the ratio of gender, age, completed education, and region of residents in the Dutch population. The screening survey provided the number and demographics of recreational fishers in the Netherlands and the logbook survey collected catches by individual fishers. These surveys were carried out every two years. The screening survey was sent to around 50,000 households in 2011 to collect data on participation in recreational fishing and gears used, and recruiting participants for a logbook survey. Logbooks were completed between March 2012 and February 2013 with participants selected from a representative probability-based sample of respondents. Monthly diaries were completed by 1,800 participants for each fishing trip including: location, start and end times,

gear, species caught, and numbers retained or released. The combination of logbooks with regular contacts with participants was used to minimise recall bias and encourage participation (van der Hammen and de Graaf, 2013, 2015; van der Hammen et al., 2016).

### Data used in this study

The data selected for this study were from the screening survey in December 2011 and the logbook survey from March 2010 to February 2011 for expenditure and March 2012 to February 2013 for fishing effort (Table 2) (van der Hammen and de Graaf 2015). The estimates for participation and fishing effort were considered to contain negligible bias, whereas the expenditure estimate was considered to be a moderate underestimation (Table S1) (van der Hammen et al., 2016).

## Norway

### Recreational fishing sector

MRF in Norway is a popular activity with around 33% of the population fishing on average 11.5 days each year (Table 2) (based on Vaage, 2015). Domestic recreational fishers can fish with rod and line, jigging machines, traps, pots, gill nets, and longlines (Anonymous, 2006). The main target species are Atlantic cod, ling, tusk (*Brosme brosme*, Lotidae), saithe, haddock and Atlantic mackerel (ICES, 2010). Fishing tourism is important in Norway (Borch et al., 2011; Vølstad et al., 2011) with foreign tourists allowed to use hand-held tackle and export 15 kg of marine fish or fish products and one trophy fish. Atlantic cod and saithe dominate the tourist catch (Vølstad et al., 2011) and a large proportion of fish are released (Ferter et al., 2013a, 2013b). Boat fishing is the predominant platform used with 63% of over 750,000 private recreational boats used for recreational fishing (KNBF and NORBOAT, 2012). Shore fishing is also popular due to the access to high quality shore fishing. There are many charter fishing companies in Norway, but the magnitude of the activity is unknown. Spearfishing and hand collecting using SCUBA is allowed for most species in Norway. No fishing licence is required for MRF.

## National Survey Data

Monitoring of recreational fishing started in the 1970s using a one-year recall survey (Vorkinn et al., 1997) and six surveys partitioned recreational fishing into freshwater and marine, with the MRF participation rate varying between 37 and 44% of the population. A large recall survey of MRF activity integrated in an omnibus survey estimated that 43% of the Norwegian population fished and 48,000 tonnes fish were caught in marine waters (Hallenstvedt & Wulff, 2003). However, these studies were likely to have significant recall bias, so the validity of estimates of participation and catch is uncertain. Smaller in-depth studies that looked at aspects of MRF have been conducted. A national probability-based survey was conducted to obtain harvest and effort estimates in tourist MRF using weekly catch diaries recorded by a sample of angling tourism businesses (Vølstad et al., 2011). Field-based sampling of effort and volunteer catch diaries and interviews were used to collect catch per unit effort of MRF on European lobster (*Homarus gammarus*, Nephropidae) and showed that MRF was responsible for 65% of the catches in southern Norway (Kleiven et al., 2012).

## Data used in this study

The data used for Norwegian participation and fishing effort in this study (Table 2) were derived from Statistics Norway as this was the longest time-series, had the largest sample size, and represented the most recent estimate (Vaage, 2015). The survey covers the population between the ages of 16 and 79 years (in 2014 a population of 3,894,435), which means that the population under 16 years and above 79 years are excluded from the estimate (total population of 1,213,535). Thirty-three percent of the sample population said that they fished in the sea in 2014. The mean number of annual MRF trips per year was 11.5 trips per year per fisher. The estimates of participation and effort were assumed to be moderate and small underestimates, respectively (Table S1). No national estimates of expenditure by marine recreational fishers exist, so expenditure data from Denmark was used (see Table 2 and country-specific section for details) and the bias was assumed to be the same as for the donor country (Table S1).

## Poland

### Recreational fishing sector

MRF includes two main fishing methods: angling and spear fishing, that are conducted from shore and boats in the Baltic Sea. An increase in shore angling has been observed over the last decade, mainly targeting European flounder, common bream (*Abramis brama*, Cyprinidae), sea trout, garfish, Atlantic herring and European eel. Trolling for Atlantic salmon from boats has also increased in popularity in the last five years. Angling in brackish estuaries and lagoons targets mostly freshwater species including Eurasian perch, pikeperch, roach and common bream. No data were available on the numbers, effort, or catches by spear fishers. The number of fishing licences issued by the Regional Maritime Fisheries Inspectorates has increased to almost 37,000 licences in 2014.

### National Survey Data

Boat MRF in Poland was monitored using effort information (numbers of trips and fishers per trip) collected by the Harbour Master Offices. Each fishing trip, registered as individual record by a local Maritime Office, included vessel name, the date and hour of departure and return, as well as the number of fishers onboard. Data were available from 1999 onwards, indicating very rapid development of sea fishing in Poland as the number of fishing days had increased in recent years. Catch composition and biological information were collected during onboard sampling by observers selected at random from the charter vessel registry focusing on the recreational cod fishery (Radtke and Dąbrowski, 2007, 2010). Catches were raised by quarter and ICES subdivision using the number of MRF trips and the catch estimates from sampled vessels, and these estimates were summed to produce total annual boat angling catches of cod for Poland.

In 2014, 11,217 boat angling trips were recorded and the total boat angling effort was 142,598 fishing days, although this may represent multiple trips by the same angler as angler details were not recorded (Radtke & Dąbrowski, 2015). Eleven observer trips were conducted on charter vessels in

2014 to determine species captured, numbers of harvested and released fish, and biological information (weight, length, sex, maturity and age) in the recreational cod fishery. The vessel selection excluded very small boats potentially leading to bias (underestimation) in the total catch estimates and uncertainty in the biological information. The survey did not cover shore fishing, but this was thought to represent only a small proportion of the total cod catch.

### Data used in this study

The recreational fishing effort from boats in Poland (Radtke & Dąbrowski, 2015) was the only information available (Table 2). These data were of good quality, but the total sea angling effort was likely to be a moderate underestimation as shore based MRF was not covered by the survey (Table S1). Data on participation and expenditure were not available (Table S1). Germany was deemed the most reasonable donor country for extrapolation of participation as the platforms, target species, and angling seasons were similar. Expenditure data was extrapolated from Estonia (see Table 2 and country-specific sections for details). The bias associated with these estimates was assumed to be the same as for the donor countries.

## Portugal

### Recreational fishing sector

MRF is a very popular leisure activity in Portugal. No recent estimates were available, but the number of fishers was likely to be between 170,000 and 200,000 in recent years based on the number of licences issued (DGRM, 2015b; Regional Fisheries Department of Azores, unpublished data). The most common fishing mode is shore angling, followed by demersal boat fishing, and spear fishing. In some regions such as southern Portugal, Azores, and Madeira, the charter boat angling segment is economically important. MRF is restricted to: hook and line for shore and boat angling; spear fishing; and specific handheld instruments for shellfish and bait collection. Recreational fishers capture many fish species, with targeted and captured species varying by fishing mode and region.

On the mainland, important target species are sea breams (Sparidae; particularly of the genus *Diplodus* spp.), and European and spotted sea bass (*Dicentrarchus punctatus*, Moronidae). Intertidal collectors target common octopus (*Octopus vulgaris*, Octopodidae), velvet swimming crab (*Necora puber*, Macropipidae), bivalves (*Ruditapes* ssp., Veneridae and *Donax* spp., Donacidae), and stalked barnacles (*Pollicipes pollicipes*, Pollicipedidae) (Cruz et al., 2015). In the Azores, important targeted species are sea breams, parrotfish (*Sparisoma cretense*, Labridae), wrasse (e.g. ballan wrasse), grouper (e.g. *Serranus atricauda*, Serranidae), jacks (e.g. *Seriola* spp., Carangidae), and mackerel (e.g. *Scombrus colias*, Scombridae). Intertidal collectors target mainly limpets (*Patella* spp., Patellidae), common octopus, and crabs (e.g. *Pachygrapsus marmoratus*, Grapsidae) (Diogo & Pereira, 2013a, 2013b, 2014). Captured fish are mainly for human consumption, with catch-and-release uncommon. Restrictions to control catch and effort in MRF have been in place on the mainland since 2006 and in the Azores since 2008. These include fishing licences, bag limits, minimum landing sizes, and closed areas and periods (Veiga et al., 2013; Diogo & Pereira, 2014). In Madeira, spear fishing is the only regulated activity and subject to fishing licences.

## National Survey Data

Despite European requirements for catch reporting (EU 2008, 2010, 2016), there is no systematic monitoring of MRF in Portugal. The first national survey of MRF started in 2015 and targeted all fishers to collect demographics, participation, effort, expenditure, catch, and attitudes towards current regulations, but results are not available yet (DGRM, 2015a). Participation in the survey was voluntary, with licenced fishers invited to participate via text messages to improve response rates.

The information on MRF came from several surveys covering specific fishing modes and regions of Portugal and the Azores. In 2001, a roving creel survey in northern Portugal (ca.120 km of coastline) was conducted to obtain socioeconomic (expenditure, demographics) and fishing activity related information (e.g. catch, effort, target species) of shore anglers (Rangel & Erzini, 2007). Interviews

had a high response rate (90%) and 2,081 were completed. The most targeted species were European sea bass and sea breams (Sparidae), with estimated shore angling catches of 7 and 2 tonnes, respectively. Information was obtained on recreational boat and shore angling activity in the Tagus estuary and Lisbon area (Vale, 2003; Lopes, 2004). A survey was conducted to describe the recreational boat fishing activity in northern Portugal (Lima, 2006). Most boat fishing took place in summer months with 27 fishing trips each year. Boat owners spent €2,727 annually, more than half of which was related to boat maintenance (€1,415). In southern Portugal, several studies have also been conducted (Castro, 2004; Veiga et al., 2010, 2013; Costa, 2012). Mean daily estimated densities of anglers and shellfish collectors on the south-west coast were 2 and 9.4 persons per kilometre of coastline, respectively, and yielded 4.3 tonnes biomass per kilometre (Castro, 2004). Veiga et al. (2010) conducted a large-scale aerial-roving creel survey to estimate socioeconomics, effort, and catch by shore anglers. There were 166,430 fishing trips per year, yielding a total of 147 tonnes biomass. Each angler conducted on average 65 fishing trips and spent €865 each year. White sea bream (*Diplodus sargus*, Sparidae) was the most targeted and captured species, with 82 tonnes retained. The only spear fishing data for the mainland was from a nationwide online pilot survey (Assis et al., 2012).

Several studies were available on the impact of MRF on the Azores. A small study was carried out to assess the spear fishing activity of São Miguel Island (Diogo & Pereira, 2013a). On-site surveys were conducted on Pico and Faial to collect socioeconomic and fishery related information on the main methods of recreational fishing (Diogo & Pereira 2013b, 2014). Catch composition varied by fishing mode, as well as fishing pressure and expenditures. For Madeira, the only data available was from a small survey on the Big Game fishery (Graça, 2009).

## Data used in this study

No country level estimates on MRF participation, effort, or expenditure were available. Thus, the data used in this study was based on the available information, both from fishing licence statistics and the regional studies. The number of fishers was estimated from the number of fishing licences and was reliable as compliance with fishing licences in Portugal was high (Veiga et al., 2010; Costa, 2012). For Portugal and the Azores, the number of fishers was estimated directly from the average annual number of licences between 2012 and 2014 (Portugal: 166,041: Azores: 4,413) (DGRM, 2015b; Regional Fisheries Department of Azores, unpublished data). For Madeira, the number of fishers (4,413) was estimated assuming the same participation as on the Azores (1.68%). Non-licenced fishers (e.g. hand collectors and fishers under the age of 16) were excluded, but non-resident fishers were included in number of licences, so was assumed to be a small underestimate (Table S1). The effort and expenditure estimates for Portugal were based on the data available from the regional surveys currently available (Lima, 2006; Veiga et al., 2010; Assis et al., 2012; Diogo & Pereira 2013a, 2013b). A nationwide study was used for effort and expenditure, and the expenditure was corrected to constant 2015 prices using Harmonised Consumer Price Index for Portugal (Eurostat, 2016). The main potential source of bias came from the weighted averages used to estimate effort and expenditure that were based on specific areas and fishing modes (which may not be representative for the entire country). The estimates of effort and expenditure were assumed to be a small overestimate and a small underestimate, respectively (Table S1)

## Slovenia

MRF is carried out from the shore and boats in Solvenia, with sea breams being the main target from the shore, and picarels (*Spicara spp*., Sparidae), sea breams, European sea bass and squid from boats (Gaudin & De Young, 2007). No licence is required for shore fishing (Gaudin & De Young, 2007), but an annual licence is required, and gear restrictions and daily bag limits are in place for boat fishing (Ministry of Agriculture, Fisheries and Food, 2016). There were no studies of MRF in

Slovenia, so extrapolation was needed. Target species and composition were thought to be most similar to Italy, therefore data from Italy was used for extrapolations of participation, effort, and expenditures (see Table 2 and country-specific sections for details). The biases were assumed to be the same as for the donor country (Table S1).

## Spain

### Recreational fishing sector

MRF management is conducted by the Spanish Autonomous Regions for inshore areas and the Ministry of Fisheries for offshore areas. The fisheries differ considerably between the Atlantic and the Mediterranean, with shore, boat (mainly road and line), and spear fishing occurring. The main target species in the Atlantic are albacore (*Thunnus alalunga*, Scombridae), ballan wrasse, conger eel, horse mackerel (*Trachurus trachurus*, Carangidae), Atlantic mackerel, common octopus, European sea bass, sea breams, and squid; while amberjack (Carangidae), European sea bass and diverse species of Scianenidae, Sparidae, and Serranidae are the main targets in the Mediterranean. An MRF licence is mandatory and is issued by the administrations of the Autonomous Regions.

### National Survey Data

There were few studies on MRF in Spain, but some information has been gathered in the Basque Country and Galicia (Pita & Freire, 2011, 2014; Veiga et al., 2013; Zarauz et al., 2013; Pita & Fernández-Márquez, 2014; Ruiz et al., 2014). Estimates of spear fishing expenditure (Pita & Fernández-Márquez, 2014) and effort and catches (Pita & Freire, 2011, 2014) were made for Galicia. In the Basque Country, shore, boat, and spear fishers were interviewed, and catch and effort of recreational fishers were estimated (Ruiz et al., 2014). The performance of e-mail, phone, and off-site mail surveys was compared and effort was calculated independently for shore fishing, boat fishing, and spear fishing (Zarauz et al., 2013, 2015). Mean expenditure for the Basque recreational boat fishing sector was available from 555 interviews (Zarauz et al., 2013).

For the Mediterranean, several studies on the impact of recreational fishing from boats were conducted. Questionnaires were done by direct poll (Tragsatec, 2004) or received by mail from a randomly selected subset of licence holders. These studies provided catch composition, catch rates and economic impact of the boat fishery. Detailed studies have been done in smaller geographical areas (Morales-Nin et al., 2005, 2015; Font & Lloret 2011; Lloret & Font 2013).

## Data used in this study

For the Atlantic coast, the number of fishers was calculated using the number of licences when available (Galicia, Basque Country and Canary Islands). The participation rate in these regions was extrapolated to the regions where the number of licences was not available (Asturias and Cantabria). Fishers without licences and fishers under the age of 16 were not considered, which may result in a small underestimation of the actual number. Effort estimates were calculated independently for shore fishing, boat fishing, and spear fishing using the data collected in the Basque Country (Ruiz et al., 2014), and then weighted by the total number of fishers using each fishing method. Mean effort was 30 days per fisher per year. Mean expenditure estimates were available for Basque boat fishing (Zarauz et al., 2013) and for spear fishing in Galicia (Pita & Fernández-Márquez, 2014), and expenditure data for shore fishers was estimated from spend on baits by boat fishers. These estimates were extrapolated to the whole Atlantic coast (Table 2) which was reasonable because fisheries in the Cantabrian Sea are very similar. Fisheries in the Canary Islands are different, so the estimation may be biased (Table S1). The population of Spain fishing in the north and south was estimated from the relative numbers of days fished and participation rates calculated (Table 2).

For the Mediterranean, the numbers of fishers were obtained from the number of licences (Franquesa et al., 2004). The number of boat fishing licences was estimated to be around 93,168 for the Spanish Mediterranean and an average boat angler fished 33 days each year (Tragsatec, 2004). The expenditure of boat fishers was available (Gordoa et al., 2004; Tragsatec, 2004), but because the

expenditure of other fishing methods was unknown, the estimates of expenditure for the Atlantic were used to estimate the total expenditure in the Mediterranean and the bias was assumed to be the same as for the Atlantic (Table S1). Estimates for participation and fishing effort in the Mediterranean were a moderate underestimate due to the non-coverage of some sectors (Table S1).

## Sweden

### Recreational fishing sector

Sweden has a long coastline on the North Sea in the west and Baltic Sea in the east. A range of fishing methods and opportunities exist, including passive and active gear, shore and boat (private and charter) fishing. Recreational fishing is a popular activity in Sweden, with over 1.7 million recreational fishers (both marine and freshwater) (Svergies Officiella Statistik, 2013) making it one of the most common recreational pursuits. Recreational fishing includes all fishing activities by those without a commercial fishing licence, both using passive gears such as gill nets and fyke nets, and active methods like angling. Few surveys have been carried out evaluating recreational catches, so there was limited knowledge of catches, but some local scale information exist. The main marine species targeted are Atlantic cod, Atlantic mackerel, flatfish species, Atlantic herring, sea trout, crabs, and European lobster (Karlsson et al., 2014). A fishing license is not generally needed in Sweden, but there are some exceptions (e.g. coastal trolling and net fishing).

### National Survey Data

The Swedish national survey of recreational fishing was done in 2013. A postal questionnaire was sent to 10,000 randomly selected permanent residents in Sweden (Svergies Officiella Statistik, 2013). Around 1.7 million Swedes aged 16 to 80 went fishing and there were approximately 565,634 individuals fishing for 4.5 million days in the sea (assuming the number of days fished in the sea is proportional to the number of days fished in total). Recreational cod catches in Swedish coastal waters were estimated at 689 tonnes and there were 8,000 tonnes of all marine species retained.

## Data used in this study

The data used in this study were derived from the survey of recreational fishing in Sweden in 2013 (Svergies Officiella Statistik, 2013) as this was the most recent, highest quality, and comprehensive dataset available. The average expenditure per fisher was converted to euro using an exchange rate of 0.11. The survey did not distinguish between freshwater and marine fishers, so the numbers and expenditure of marine fishers were derived assuming the same ratio as the numbers of days fished (Table 2). The statistics did not include MRF carried out by tourists and so the number of fishers and fishing effort were likely to be moderate underestimates. The expenditure was likely to be higher for marine fishers than for the general fishing population due to higher costs (e.g. boat ownership), so represented a moderate underestimate of the true expenditures (Table S1).

# UK

## Recreational fishing sector

MRF in the UK is diverse, with most effort by fishers on the shore and boats (private and charter vessels) (Armstrong et al., 2013). There were 1,080,000 recreational sea fishers in Great Britain, with 2.2% of all adults going sea fishing (Armstrong et al., 2013) and an additional 64,800 in Northern Ireland (McMinn, 2013). Annual expenditure was £1.23 billion in England (Armstrong et al., 2013), £140.9 million in Scotland (Radford & Riddington 2009), £87.1 million in Wales (Monkman et al., 2015) and a further £54.6 million in Northern Ireland (McMinn, 2013). Sea angling also had important social and well-being benefits including relaxation, physical exercise, and a route for socialising. In England, around 3.8 million sea fishing days were recorded, with shore angling most common, followed by private or rented boats, and charter vessels were the least common. Average catches per trip were highest in England on charter vessels, followed by private boats, and lowest from shore. The most common species caught were Atlantic mackerel, whiting, European sea bass,

Atlantic cod, and elasmobranchs. Shore and boat anglers released around 75% and 50% of fish, respectively (Armstrong et al., 2013). No MRF licence is required in the UK.

## National Survey Data

Several different surveys of recreational fishing participation, activity, catch, expenditure, and social benefits have been done that cover different regions of the UK (Drew, 2004; Simpson & Mawle, 2005, 2010; Richardson et al., 2006; Radford & Riddington 2009; Brown et al., 2010, 2012; Brown, 2012; Armstrong et al., 2013; McMinn 2013; Monkman 2013; Monkman et al., 2015). The most recent and comprehensive survey collected data on activity and catch from shore, private boats and charter vessels using a variety of different survey methods (Armstrong et al., 2013). This comprised of six surveys that included interviewing of over 12,000 households, contributions from 11,000 anglers, and visiting of over 2,000 stretches of coastline (Armstrong et al., 2013). Retained catches for European sea bass and Atlantic cod were estimated to be around 30-40% of the reported English commercial fishery landings (Armstrong et al., 2013). In Northern Ireland, questions were added to an economics landscape study to assess participation and an online survey was used to look at areas visited, species targeted, catch rates, and attitudes of sea fishers, but no estimates of catches were made (McMinn, 2013).

## Data used in this study

The data used in this study were derived from recent surveys of MRF in England (Armstrong et al., 2013), Northern Ireland (McMinn, 2013), Scotland (Radford & Riddington, 2009), and Wales (Monkman et al., 2015). MRF was mainly angling (rod and line), so the number of fishers were derived from the Great Britain national survey (Armstrong et al., 2013) and the estimates for Northern Ireland (McMinn, 2013), giving a total of 1,149,988 sea fishers (Table 2). Fishing effort estimates were derived from the national surveys in England, Wales, and Scotland (Radford & Riddington, 2009; Armstrong et al., 2013; Monkman et al., 2015) and angling effort in Northern

Ireland was calculated from the numbers of anglers (McMinn, 2013) multiplied by the average effort per angler for England. This gave a total MRF effort of 7.1 million days (Table 2). Finally, expenditure was summed from the estimates for the individual countries (Radford & Riddington, 2009; Armstrong et al., 2013; McMinn, 2013; Monkman et al., 2015) and the average expenditure per fisher calculated before conversion to euro using an exchange rate of 1.25 euro to 1 GBP (Table 2). These figures were assumed to be representative of the UK and represent only negligible biased estimates (Table S1).

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**Table S1: Semi-quantitative assessment of bias associated with the assessment. A scoring system of + and - was used to represent over- and under-estimates, respectively, and the number of each sign represents the magnitude of the bias (--- = high underestimate, -- = moderate underestimate, - = small underestimate, +/- negligible bias, + small overestimate, ++ = moderate overestimate, +++ = high overestimate). Where extrapolation is used the magnitude of the bias is assumed to be the same as in the donor country (indicated in brackets).**

| Country | Recreational Sea Fishing Information | | |
|---|---|---|---|
| | **Number of fishers** | **Total effort (days)** | **Expenditure (€)** |
| Albania | --- (Greece) | -- (Italy) | -- (Italy) |
| Belgium | --- | --- | - |
| Bulgaria | --- (Greece) | -- (Italy) | -- (Italy) |
| Croatia | --- (Greece) | -- (Italy) | -- (Italy) |
| Cyprus | --- (Greece) | -- (Italy) | -- (Italy) |
| Denmark | +/- | +/- | + |
| Estonia | - | +++ (Latvia) | + |
| Finland | +/- | +/- | -- (Sweden) |
| France | +/- | +/- | +/- (Germany) |
| Germany | +/- | +/- | +/- |
| Greece | --- | +/- (France) | -- (Italy) |
| Iceland | +/- | - (Norway) | + (Denmark) |
| Ireland | +/- | +/- | +/- |
| Italy | -- | -- | -- |
| Latvia | --- | +++ | + (Estonia) |
| Lithuania | --- (Latvia) | +++ (Latvia) | + (Estonia) |
| Malta | --- (Greece) | -- (Italy) | -- (Italy) |
| Montenegro | --- (Greece) | -- (Italy) | -- (Italy) |
| Netherlands | +/- | +/- | -- |
| Norway | -- | - | + (Denmark) |
| Poland | +/- (Germany) | -- | + (Estonia) |
| Portugal | - | + | - |
| Romania | --- (Greece) | -- (Italy) | -- (Italy) |
| Slovenia | -- (Italy) | -- (Italy) | -- (Italy) |
| Spain (AT) | - | - | - |
| Spain (MED) | -- | -- | - (Spain (AT)) |
| Sweden | -- | -- | -- |
| UK | +/- | +/- | +/- |