ICES Journal of Marine Science

ICES Journal of Marine Science (2013), 70(7), 1319–1329. doi:10.1093/icesjms/fst104

Unexpectedly high catch-and-release rates in European marine recreational fisheries: implications for science and management

Keno Ferter[1,2]*, Marc Simon Weltersbach[3], Harry Vincent Strehlow[3], Jon Helge Vølstad[2], Josep Alós[4], Robert Arlinghaus[5,6], Mike Armstrong[7], Malte Dorow[8], Martin de Graaf[9], Tessa van der Hammen[9], Kieran Hyder[7], Harold Levrel[10], Anton Paulrud[11], Krzysztof Radtke[12], Delphine Rocklin[13], Claus Reedtz Sparrevohn[14,15], and Pedro Veiga[16]

[1]*University of Bergen, Department of Biology, PO Box 7803, N-5020 Bergen, Norway*
[2]*Institute of Marine Research, Fisheries Dynamics, PO Box 1870, N-5817 Bergen, Norway*
[3]*Thünen-Institute of Baltic Sea Fisheries (TI-OF), Alter Hafen Süd 2, 18069 Rostock, Germany*
[4]*Instituto Mediterráneo de Estudios Avanzados, IMEDEA (CSIC-UIB), C/Miquel Marqués 21, 07190, Esporles, Illes Balears, Spain*
[5]*Department of Biology and Ecology of Fishes, Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Müggelseedamm 310, 12587 Berlin, Germany*
[6]*Chair of Integrative Fisheries Management, Faculty of Agriculture and Horticulture, Humboldt-Universität zu Berlin, Invalidenstrasse 42, 10115 Berlin, Germany*
[7]*Centre for Environment, Fisheries and Aquaculture Science, Pakefield Road, Lowestoft, Suffolk NR33 0HT, UK*
[8]*State Research Centre for Agriculture and Fishery Mecklenburg-Vorpommern, Institute for Fisheries, Fischerweg 408, 18069 Rostock, Germany*
[9]*IMARES Wageningen UR, Institute for Marine Resources and Ecosystem Studies, PO Box 68, 1970 AB IJmuiden, Netherlands*
[10]*Ifremer, UMR AMURE, Unité d'Economie Maritime, BP 70, F-29280 Plouzané Cedex, France*
[11]*Swedish Agency for Marine and Water management, PO Box 11 930, 40439 Gothenburg, Sweden*
[12]*National Marine Fisheries Research Institute, Kołłątaja St 1,81-332 Gdynia, Poland*
[13]*Université de Brest, UMR AMURE, IUEM, 12 rue du Kergoat, CS 93837, 29238 Brest Cedex 3, France*
[14]*Danmarks Pelagiske Producentorganisation, HC Andersens Boulevard 37.1, 1553 Copenhagen, Denmark*
[15]*Technical University of Denmark, National Institute of Aquatic Resources (DTU Aqua), Jaegersborg Allé 1, 2920 Charlottenlund, Denmark*
[16]*Centre of Marine Sciences (CCMAR), FCT-7, University of Algarve, Campus de Gambelas, 8005-139 Faro, Portugal*

**Corresponding Author: tel: +47 94 10 35 52; fax: +47 55 58 44 50; e-mail: Keno.Ferter@bio.uib.no*

Ferter, K., Weltersbach, M. S., Strehlow, H. V., Vølstad, J. H., Alós, J., Arlinghaus, R., Armstrong, M., Dorow, M., de Graaf, M., van der Hammen, T., Hyder, K., Levrel, H., Paulrud, A., Radtke, K., Rocklin, D., Sparrevohn, C. R., and Veiga, P. 2013. Unexpectedly high catch-and-release rates in European marine recreational fisheries: implications for science and management. – ICES Journal of Marine Science, 70: 1319–1329.

Received 3 April 2013; accepted 1 June 2013; advance access publication 21 July 2013.

While catch-and-release (C&R) is a well-known practice in several European freshwater recreational fisheries, studies on the magnitude and impact of this practice in European marine recreational fisheries are limited. To provide an overview of the practice and magnitude of C&R among marine recreational anglers in Europe, the existing knowledge of C&R and its potential associated release mortality was collected and summarized. The present study revealed that in several European countries over half of the total recreational catch is released by marine anglers. High release proportions of $>$ 60% were found for Atlantic cod (*Gadus morhua*), European sea bass (*Dicentrarchus labrax*), pollack (*Pollachius pollachius*), and sea trout (*Salmo trutta*) in at least one of the studied European countries. In the case of the German recreational Baltic Sea cod fishery, release proportions varied considerably between years, presumably tracking a strong year class of undersized fish. Reasons for release varied between countries and species, and included legal restrictions (e.g. minimum landing sizes and daily bag limits) and voluntary C&R. Considering the magnitude of C&R practice among European marine recreational anglers, post-release mortalities of released fish may need to be accounted for in estimated fishing mortalities. However, as the survival rates of European marine species are mostly unknown, there is a need to conduct post-release survival studies and to identify factors affecting post-release survival. Such studies could also assist in developing species-specific, best-practice guidelines to minimize the impacts of C&R on released marine fish in Europe.

Keywords: angler behaviour, angling, catch-and-release, European recreational fisheries, fishing mortality, motivation, post-release mortality, recreational fisheries management, survival.

Introduction

In the past, the potential impacts of recreational fisheries on marine fish stocks were often neglected, but have gained increasing attention in the last decade (e.g. McPhee *et al.*, 2002; Coleman *et al.*, 2004; Cooke and Cowx, 2004; Lewin *et al.*, 2006). While landings of European marine commercial fisheries have been monitored over decades, with additional efforts to quantify discards over the past years (ICES, 2011), relatively little effort has been undertaken to estimate recreational fishery catches and their potential effects on marine ecosystems (Pawson *et al.*, 2008). In recent years, following the introduction of European legislation requiring estimation of recreational catches of some species, recreational fisheries have gained increasing attention in European fishery research and management. For example, a recent study in Germany showed that the recreational harvest of cod (*Gadus morhua*) in the western Baltic Sea accounted for 34–70% of the German commercial cod landings, indicating that total fishing mortalities need to be adjusted, and that the stock was more productive than previously assumed (Strehlow *et al.*, 2012). As a result of this study, the recreational Baltic Sea cod harvest has been included in the stock assessment since 2013. Another recent study on French marine recreational fisheries showed that, although the overall French recreational catch is low compared with French commercial landings, the recreational catch for some popular target species, e.g. European sea bass (*Dicentrarchus labrax*), can account for up to 100% of the commercial landings (Herfaut *et al.*, 2013). However, if the goal is to incorporate recreational fisheries into future ecosystem-based management, more research on European recreational fisheries is urgently needed (Arlinghaus *et al.*, 2007, 2010; Pawson *et al.*, 2008).

Marine fishery management is dependent on scientific advice based on catch information used for scientific stock assessment. In relation to European recreational fisheries, it was only in 2001 that the European Council initiated the regular collection of recreational fishery data in European Community waters (CEC, 2001). The list of species included in the European Union (EU) Data Collection Framework (DCF) for the Common Fisheries Policy (CFP) was stepwise expanded over the years. National data collection programmes and an ICES Working Group on Recreational Fisheries Surveys (WGRFS) were established to collect data and harmonize survey methods of marine recreational fishery data collection for stock assessment purposes. Since 2009, all EU member states are obligated to evaluate recreational catches of Atlantic cod, European eel (*Anguilla anguilla*), Atlantic salmon (*Salmo salar*), European sea bass, and Atlantic bluefin tuna (*Thunnus thynnus*) in relevant regions (CEC, 2008). Although not further specified, the Commission regulation instructs member states to collect data to estimate marine recreational catches (CEC, 2008, 2009) commonly defined as harvested and released fish (Pollock *et al.*, 1994). However, while catch-and-release (C&R) practices have been thoroughly studied in marine and freshwater recreational fisheries in the USA, Canada and Australia, and for a few freshwater fisheries in Europe (Arlinghaus *et al.*, 2007; Hühn and Arlinghaus, 2011), only very few peer-reviewed publications exist on C&R practices in European marine recreational fisheries (e.g. Alós, 2008; Alós *et al.*, 2009a, 2009b; Veiga *et al.*, 2011; Ferter *et al.*, 2013; Weltersbach and Strehlow, 2013). In addition to hook and line (angling) with rod and reel or handlines, marine recreational fishers in Europe are locally also allowed to use other gears such as crab pots, gillnets, fykenets, spearguns, and longlines (Pawson *et al.*, 2008; FAO, 2012). However, as the motivations and behaviour of fishers using these gears could differ significantly from those only using rod and reel or handlines (e.g. Sparrevohn and Storr-Paulsen, 2012), this paper only focuses on recreational fishers using angling gear, henceforth referred to as anglers.

As recreational fisheries are often regulated through minimum landing sizes (MLS) and daily bag limits, anglers are frequently required to release substantial parts of their catch, a practice referred to as regulatory C&R (Arlinghaus *et al.*, 2007). Furthermore, in some countries, a considerable proportion of anglers practice voluntary C&R, defined as the release of fish that legally could have been harvested (Arlinghaus *et al.*, 2007). Based on Canadian data, Cooke and Cowx (2004) estimated a global release proportion of about 60% for recreational catches (with respect to numbers), corresponding to roughly 30 billion released fish annually.

In some European countries such as the UK, C&R has a long tradition in freshwater fisheries, and its practice has spread to other European countries over the last few decades (Aas *et al.*, 2002; Policansky, 2002, 2008; Arlinghaus *et al.*, 2007). However, public opinion and ethical acceptance of C&R (particularly voluntary C&R) vary considerably between and within European states, leading to controversy and public debates in some countries (Aas *et al.*, 2002; Salmi and Ratamäki, 2011; Arlinghaus *et al.*, 2012). In addition, national legislations regulating recreational fisheries and C&R practices differ substantially across Europe (e.g. Aas *et al.*, 2002; Arlinghaus, 2007; Arlinghaus *et al.*, 2007; Pawson *et al.*, 2008; Salmi and Ratamäki, 2011). Variation in social acceptance and formal institutions regarding C&R make it difficult to provide cross-border recommendations that could be useful for improving future recreational fishery management in Europe.

Considering the increasing awareness of the socio-economic significance of recreational fisheries (e.g. Arlinghaus and Cooke, 2009) and their potential importance for several European marine fish stocks in terms of catch, there is a need for comprehensive investigations of C&R practices to improve fishing mortality estimates for recreational fisheries. Therefore, the existing knowledge of C&R, as practised by European marine anglers, and its potential associated release mortality was collected during a workshop at the ICES WGRFS meeting in 2012 (ICES, 2012). The present paper summarizes the outcomes of that workshop and discusses the role of C&R in all European marine recreational fisheries where data were available by synthesizing published, unpublished, and grey literature from Europe.

Material and methods

In total, fish release data (in numbers) for nine European countries (Denmark, England, France, Germany, Netherlands, Norway, Poland, Portugal and Sweden) were obtained because these countries had fully or partially completed surveys on marine recreational fishery catches that were available for this paper. Standard errors (s.e.) for harvest and release estimates were included when available. This study was restricted to include only the release proportions by marine anglers for species listed in the DCF (CEC, 2009), and species that were suggested by the WGRFS to be additionally included in the DCF [i.e. pollack (*Pollachius pollachius*) and sea trout (*Salmo trutta*)] (ICES, 2012). All contributors were asked to provide existing data (if available) on the post-release mortality for the relevant species. Associated catch estimates and release proportions were based on various surveys conducted in the different countries as described below.

Denmark

The Danish recreational cod and sea trout harvest weights and release numbers in 2010 were estimated through a combined telephone and internet recall-survey implemented during two interview phases, one in July 2010 and one in January 2011, each covering the previous six months of angling. The sample frame included that part of the Danish population issued with a valid annual fishing licence on 1 January 2010, corresponding to 152 723 anglers, and 33 734 passive-gear fishers, where the latter are also allowed to conduct angling (see Sparrevohn and Storr-Paulsen, 2012 for further information). Harvest estimates in numbers of fish were calculated by dividing the harvest in weight by the average weight of individual fish (estimated as 1.5 kg and 1.7 kg for cod and sea trout, respectively; see Sparrevohn, 2013 for further information).

England

Preliminary data on release rates of cod, pollack, and sea bass were available from an online survey set up in 2012 to provide additional information on recreational sea angling alongside a larger programme of stratified-random on-site surveys (see www.seaangling2012.org.uk). Only data from the first-quarter online survey were available for this paper, and only the sample data for 828 shore angling trips by the 89 respondents were considered, without any raising to the population level or reweighting to adjust for non-representative sampling. Respondents were required to recall their catches for January–March in a survey posted from April.

France

The French recreational sea bass harvest and release numbers from July 2009 to July 2010 were estimated using a set of two telephone surveys combined with a panel survey, and did not include the French Mediterranean coast (Rocklin *et al.*, 2012). In 2009, a telephone screening survey sampling 15 090 households was used to identify the number of French recreational sea bass anglers, to describe the main characteristics and practices of the fishery, and to recruit volunteers for a panel. This survey was coupled with an earlier national telephone survey (in 2006) with a sample of 15 085 households to estimate the weighting factor for each angler and to raise the 2009 estimates to the population of all anglers (stratified per month, avidity, and fishing mode). Finally, 258 sea bass anglers were recruited to fill in catch diaries (including length measurements for harvested and released fish) in 2009, and asked to return them every three months during a whole year from mid-July 2009 to mid-July 2010. A total of 1190 fishing trips were recorded, in which 1383 sea bass were caught. Since the panel survey was based on voluntary involvement, it could not be assumed unbiased, and the data were corrected using the weighting factors from the 2006 telephone survey.

Germany I

The German recreational cod harvest and release numbers in the Baltic Sea in 2009–2012 covering the two coastal states of Mecklenburg–Western Pomerania (MV) and Schleswig Holstein (SH) were estimated using a multistage survey design covering all fishing modes (see Strehlow *et al.*, 2012 for details). Effort data were collected by means of mail-diary surveys from 2005/2006. Catch per unit effort for the different fishing methods was estimated by a stratified annual access point intercept survey sampling 1202 site-days and interviewing 9465 anglers between 2009 and 2012. Length distributions for harvested and released fish were obtained through on-board sampling of charter vessels and data from community fishing events. An experimental containment study conducted in 2012 provided a first mortality rate estimate and an overview of factors that affect the post-release mortality of cod in the Baltic Sea recreational fishery (Weltersbach and Strehlow, 2013). The study was conducted from April 2012 to July 2012 and estimated the immediate and delayed (10 d) mortality of cod caught by recreational anglers from a charter boat.

Germany II

Additional data from a one-year diary study conducted in northeast Germany covering MV provided further insights on the release behaviour of German anglers (954 trips by 257 anglers with cod catches). During the angling season 2006/2007, 1121 randomly selected anglers previously identified through a random digit dialling survey of 42 672 (net sample of valid telephone numbers) households in several northern German states and from 4752 randomly selected resident fishing licence holders were asked to document their angling trips in a diary (see Dorow and Arlinghaus, 2011 for details). Beside the documentation of the numbers of harvested and released fish, diary participants also had the option to document their reasons for releasing a fish.

The Netherlands

The Dutch recreational cod, eel, and sea bass harvest and release numbers from March 2010 to February 2011 were estimated through an online screening survey and a subsequent logbook survey (see van der Hammen and de Graaf, 2012 for details). The online screening survey aimed at estimating the number of people participating in freshwater or marine recreational fisheries and was sent to 56 730 households, of which 45 518 (109 293 respondents) completed the survey in 2009. Amongst others, respondents were asked to indicate how often they had fished in the previous 12 months to determine their level of fishing "avidity" to weight the logbook data. Participants interested in completing the logbook survey were selected with a probability of inclusion based on an analysis of demographics, avidity, and water body, such that it matched the ratio found in the screening survey. Participants were approached on a monthly basis from March 2010 to February 2011 and asked to transfer the data recorded in their catch diaries to online questionnaires. Length distributions for harvested and released fish were obtained from the catch diaries and through on-site surveys.

Norway

The Norwegian recreational cod and pollack angling tourism harvest numbers in 2009 were estimated through a national probability-based survey in 2009 (see Vølstad *et al.*, 2011 for details) and on-site interviews during 2010/2011 (see Ferter *et al.*, 2013 for details). Data for local, resident Norwegian marine anglers were not available. From a stratified random sample of businesses, angling tourists were recruited systematically over time to record their daily harvest and effort in diaries. Additionally, length measurements for harvested fish were collected from 15 businesses. To estimate the proportion of cod and pollack released by marine angling tourists, on-site interviews at a subsample of tourist angling businesses were conducted in two study areas (referred to as north of 62° and south of 62°) during the main tourist seasons in 2010 and 2011. The study also yielded information on the motivations for releasing cod and pollack in Norway. In both surveys, an angling tourism business was defined as "an enterprise renting out rooms and boats for recreational fishing at sea and with facilities gutting and freezing catches" (Vølstad *et al.*, 2011).

Although these enterprises are mainly utilized by non-Norwegian anglers, 8% were Norwegian in 2008 (Borch *et al.*, 2011).

Poland

The Polish recreational cod harvest and release numbers in 2010 were estimated using effort data provided by the Maritime Offices on the number of angling trips of charter vessels, including the number of anglers on board, and catch per unit effort (cpue) data collected through on-board observers during ten angling trips. During the randomly selected on-board observer trips, the cod harvest and releases in terms of weight and numbers were recorded. Additionally, the lengths of both harvested and released cod were measured. The harvested or released parts of the cod catch were classified depending on the angler's declaration as either harvested or released. The total recreational cod catch from charter vessels was estimated by raising the cpue data from the on-board observer trips with the effort data (number of angling trips) available at the population level (total number of angling trips registered by the Maritime Offices).

Portugal

The Portuguese sea bass harvest and release numbers in 2006/2007 were estimated based on a complementary aerial-roving survey conducted in southern Portugal. The survey focused on shore angling only and covered about one fifth of the mainland coast (ca. 250 km coastline). Roving creel surveys were conducted following a non-uniform probability of sampling and were used to collect socio-economic and fishing-trip-related information (e.g. fishing-trip duration, retained and released catches, target species, motivation for releasing); aerial surveys followed the same stratified random sampling procedure and provided information on fishing effort. During the roving creel surveys, all fish retained by anglers (or released during the interviews) were identified, counted and measured (total length, nearest millimetre). The number of fish released prior to the interviews was based on anglers' reported data. Total harvest and release were calculated using the fishing effort and catch rates estimates (see Veiga *et al.*, 2010 for more details on the sampling strategy and data analysis). In total, 1321 anglers were interviewed during the roving creel surveys, with a high response rate of 95%.

Sweden

The Swedish recreational cod, salmon, and sea trout harvest and release numbers in 2010 were estimated through a national recreational fishing survey conducted in two steps by mail. The first step was a screening survey to identify anglers, and the second step was a follow-up with detailed questions about catches. The survey covered all species, subareas, and fishing modes and was based on a stratified sample of about 10 000 people between 16 and 75 years of age (the sample also included respondents from a panel based on previous studies). The response rate was about 60% after two phases. Telephone interviews with the non-respondents were used for weighting catch data and correcting for non-response bias. Additionally, length distributions for harvested cod were collected through on-site charter boat sampling.

Calculation of release proportions

Except for England, Germany II, and the Norwegian angling tourism, release proportions (in %, rounded to the nearest integer) were calculated using the estimates for total number of fish harvested and total number of fish released (both raised to the total population of marine anglers), i.e. as proportion of the total catch. Only the catches of marine recreational anglers (i.e. using rod and reel or handline) were included, while those of recreational fishers using other gears were not included in this study.

Release proportions for the quarter-1 online survey in England in 2012 were preliminary estimates based on the raw sample data, and are indicative only and subject to recall and self-selection biases (see Discussion). The release proportions for MV in 2006 (Germany II; Dorow and Arlinghaus, 2011) were estimated by averaging the release rates over individual anglers. In the case of Norway, the release proportions were estimated through a separate survey (Ferter *et al.*, 2013), as no release estimates were available for the 2009 national tourist fishery survey.

Results

Release proportions for the DCF species

C&R was found to be a common practice in many European marine recreational fisheries. For several species, anglers released large proportions of their catches (Table 1). Atlantic cod is one of the most important target species in European marine recreational fisheries, and its recreational catches were assessed in seven European countries. Overall release proportions ranged from 24–70% [The Netherlands, 24%; Germany I, 29%; Sweden, 48%; Denmark, 61%; Norway, 62% south of 62°, 66% north of 62° (Ferter *et al.*, 2013); and England, 70%], with the exception of Poland, where only 1% of the recreational catch was released.

Another important target species for marine recreational anglers in Europe is European sea bass. The catches for this species were assessed in four European countries. Similar to cod, the release proportions for this species varied significantly between countries, with lowest release proportions in southern Portugal (19%, Veiga *et al.*, 2010), medium release proportions in The Netherlands (36%) and France (54%), and high release proportions in England for shore anglers (77%).

For both pollack and sea trout, the release proportions ranged from medium to high. In the case of pollack, the release proportion by marine angling tourists in southern Norway was 56% (Ferter *et al.*, 2013), while it was 82% for shore angling in the English online survey. The release proportions for sea trout ranged from 47% in Sweden to 70% in Denmark. For Atlantic salmon and European eel, the release proportions were medium. For Atlantic salmon, the release proportion was 36% in Sweden (marine waters); for European eel, the release proportion was 40% in The Netherlands (marine and some brackish waters).

No recreational release proportions could be obtained for Atlantic bluefin tuna as there were no recreational catch estimates available to the WGRFS.

Variability in release proportions between years

In Germany, the release proportions for cod varied between years (Table 2 and Figure 1). The survey conducted in northeast Germany (Dorow and Arlinghaus, 2011) showed that the average release rate for cod was 22.2% (s.e. = 1) in 2006/2007. However, the survey including both coastal states (Strehlow *et al.*, 2012) showed that release proportions varied substantially from 60% in 2009 to 37% and 27% in 2010 and 2011, respectively. The release proportion in 2012 (29%) was similar to the one in 2011. In contrast, the Norwegian marine angling tourism study (Ferter *et al.*, 2013) showed that release proportions can also be similar between years. In 2010 and 2011, the release proportion estimates for cod north of 62° were 66.8% (s.e. = 4.6) and 66.1% (s.e. = 7.9), respectively.

Table 1. The most recent estimates of number of fish kept and released per year, and the calculated proportion released (in %) by European marine anglers by species and country.

Species by country	Reference(s)	Data collection year(s)	n_{kept}	s.e. n_{kept}	$n_{released}$	s.e. $n_{released}$	Proportion released (%)
Atlantic cod (*Gadus morhua*)							
England	–	2012	–	–	–	–	**70**
Norway (tourists, north of 62°N)	Vølstad *et al.* (2011); Ferter *et. al.* (2013)	2009 – 2011	529 633	118 440	–	–	**66**
Norway (tourists, south of 62°N)	Vølstad *et al.* (2011); Ferter *et. al.* (2013)	2009 – 2011	13 129	5 447	–	–	**62**
Denmark	Sparrevohn and Storr-Paulsen (2012)[a]	2010	986 267	–	1 547 620	108 333	**61**
Sweden	–	2010	371 698	–	346 210	–	**48**
Germany (Baltic Sea)	Strehlow *et al.* (2012)[a]	2012	2 479 569	–	1 033 926	–	**29**
The Netherlands	van der Hammen and de Graaf (2012)[a]	2010/2011	522 000	83 000	168 000	45 000	**24**
Poland	–	2010	1 366 754	–	13 976	–	**1**
Atlantic salmon (*Salmo salar*)							
Sweden	–	2010	40 594	–	22 875	–	**36**
European eel (*Anguilla anguilla*)							
The Netherlands	van der Hammen and de Graaf (2012)[a]	2010/2011	172 000	48 000	114 000	28 000	**40**
European sea bass (*Dicentrarchus labrax*)							
England	–	2012	–	–	–	–	**77**
France (excl. Mediterranean)	Rocklin *et al.* (2012)[a]	2009/2010	1 576 526	–	1 824 114	–	**54**
The Netherlands	van der Hammen and de Graaf (2012)[a]	2010/2011	227 000	88 000	127 000	34 000	**36**
Portugal (southern coast)	Veiga *et al.* (2010)[a]	2006/2007	15 444	2 626	3 524	–	**19**
Pollack (*Pollachius pollachius*)							
England	–	2012	–	–	–	–	**82**
Norway (tourists, south of 62°N)	Vølstad *et al.* (2011); Ferter *et. al.* (2013)	2009	17 167	3 408	–	–	**56**
Sea trout (*Salmo trutta*)							
Denmark	Sparrevohn and Storr-Paulsen (2012)[a]	2010	316 588	–	725 078	58 006	**70**
Sweden	–	2010	148 773	–	131 748	–	**47**

The countries are ordered according to the release proportion in descending order under each species. A reference to the details of the underlying survey and standard errors (s.e.) are provided, where available. For England and the Norwegian marine angling tourism, total harvest and/or release estimates were not available. [a]Additional or updated data were provided for the present study.

Table 2. The estimated number of Baltic Sea cod kept and released in Germany per year, and the calculated proportion of Baltic Sea cod released (in %) by marine anglers in the two German coastal states Mecklenburg–Western Pomerania (MV) and Schleswig Holstein (SH).

Year	Study area	n_{kept}	$n_{released}$	Proportion released (%)[a]	s.e.
2006	MV only	2 579 130	755 070	**22.2**[b]	1
2009	MV + SH	1 518 492	2 246 732	**60**	–
2010	MV + SH	2 276 620	1 342 531	**37**	–
2011	MV + SH	1 971 747	714 663	**27**	–
2012	MV + SH	2 479 569	1 033 926	**29**	–

[a]The release proportion for MV in 2006 is the mean release proportion averaged over anglers (based on Dorow and Arlinghaus, 2011, additional data provided), while the other release proportions are given as proportions of the total catch (based on Strehlow *et al.*, 2012, additional data provided). [b]When calculated as proportion of the total catch, the released proportion is 22.6%.

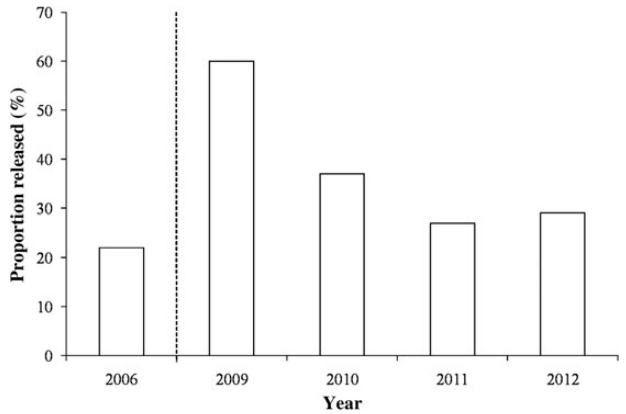

Figure 1. The proportions of the estimated Baltic Sea cod catches (in %) that were released by marine anglers in the two German coastal states Mecklenburg–Western Pomerania (MV) and Schleswig Holstein (SH) in 2006, and from 2009–2012. The release proportion in 2006 is the mean release proportion averaged over anglers in MV (based on Dorow and Arlinghaus, 2011, additional data provided), while the other release proportions are given as proportions of the total catch in MV and SH (based on Strehlow *et al.*, 2012, additional data provided).

Reasons for releasing cod, pollack, and sea bass

Several reasons for releasing cod in the Baltic Sea were documented during the diary survey in northeast Germany. Overall, 954 angling trips were recorded when anglers caught cod. Based on the difference between the number of caught and retained fish, 446 trips (47%) were identified as trips with a release event (at least one fish released). For 325 cod release events, anglers provided descriptive explanations for their release behaviour, which were classified into different categories.

The most common reason for releasing cod in the Baltic Sea was that they were below the MLS (96%). Some anglers indicated that they had personal size limits above the MLS regulations (1.8%). A small proportion of anglers reported that they released mature cod during a fishing trip (0.6%). Cod were also released if anglers judged them to be infected by a disease (0.6%). Additionally, during some trips, cod were released because anglers had too many fish (0.9%). In one case, a cod was released because it was not the target species.

In northern and southern Norway, marine angling tourists mainly released cod because they were too small (60 and 87% in northern and southern Norway, respectively), i.e. in many cases, they had personal size limits. For pollack, this was the only reason for release given by angling tourists in southern Norway (100%). For cod, however, release motivations were more diverse. Minimum size limit regulations were mentioned in both southern (13%) and northern (10%) Norway as the release reason, while in northern Norway, "total C&R" (18%), "too many fish" (9%), "do not like" (2%), and "too big" (1%) were additional reasons for releasing cod (Ferter *et al.*, 2013).

The main reason for releasing sea bass in southern Portugal was the small size of fish, although a high retention of undersized sea bass (73%) was still observed in this region (Veiga *et al.*, 2010).

Post-release mortalities of Atlantic cod

The overall mean release mortality for cod in the Baltic Sea recreational charter boat fishery was estimated to be 11.2% (s.e. = 22.0) after adjustment for handling and caging effects. Bleeding and holding-water temperature were found to be significant factors affecting mortality (Weltersbach and Strehlow, 2013). There were no studies available for other fishing modes in the Baltic Sea (i.e. shore fishing) or for cod caught and released in other ecosystems, where fishing depths are often greater and water temperatures are lower than in the Baltic Sea.

No studies quantifying the mortalities of the other presented species released by recreational anglers in marine environments were identified.

Discussion

This study reviewed the available information on C&R for some of the most important European marine target species for recreational anglers and showed that release proportions in European marine recreational fisheries are substantial. For several recreational fisheries in Europe, the release rates are comparable to those in the USA, Canada, and Australia (Cooke and Cowx, 2004; Arlinghaus *et al.*, 2007). Although a limited number of post-release mortality studies exist on southern European marine species and Atlantic cod (e.g. Alós, 2008; Alós *et al.*, 2009b; Veiga *et al.*, 2011; Weltersbach and Strehlow, 2013), the survival rates for most of the presented species in this paper are unknown. Post-release mortality can contribute substantially to the total recreational fishing mortality (Kerns *et al.*, 2012) and can bias current estimates that are based only on harvest data. Coggins *et al.* (2007) showed that unaccounted hooking mortality of about 30% rendered many fishing regulations ineffective. Therefore, potentially high post-release mortality rates coupled with the substantial release proportions reported here could be a source of concern, particularly because many juvenile fish were found to have been released by anglers in order to comply with regulations.

Release proportions and motivations

The release proportions differed between countries and between species. This is in line with what is reported in the literature, as Aas *et al.* (2002) inferred that anglers of different nationalities exhibit different propensities to engage in C&R. In particular, release proportions for cod and sea bass varied between countries. The lowest release proportions for cod were found in Poland, with less than 1% of the catch being released, while the release proportions exceeded 50% in several other countries. In Portugal, only 19% of the sea bass caught were released, while more than 50% were released in France and in England (by shore anglers). These large differences can, amongst others, probably be attributed to different cultural backgrounds, angler culture (e.g. consumption orientation), angling regulations (Table 3), and catch rates. While C&R fishing has a long tradition in the UK, anglers from eastern

Table 3. The presence/absence of marine recreational (angling) minimum landing sizes (MLS) and bag limits for the presented species when the country surveys were conducted.

	Atlantic cod (*Gadus morhua*)		Atlantic salmon (*Salmo salar*)		European eel (*Anguilla anguilla*)		European sea bass (*Dicentrarchus labrax*)		Pollack (*Pollachius pollachius*)		Sea trout (*Salmo trutta*)	
	MLS	Bag limit	MLS	Bag limit	MLS	Bag limit	MLS	Bag limit	MLS	Bag limit	MLS	Bag limit
Denmark	+	−	+	−	+	−	+	−	+	−	+	−
England	+	−	−/+	−/+	closed	closed	+	−	+	−	−/+	−/+
France (Atlantic)	+	−	+	−	+	−	+	−	+	−	+	−
Germany (Baltic Sea)	+	−	+	−/+[a]	+	−	+	−	−	−	+	−/+[a]
Netherlands	+	−	closed	closed	closed	closed	+	−	+	−	closed	closed
Norway (tourists)	+	+[a]	+	−	closed	closed	−	+[a]	−	+[a]	+	−
Poland	+	+	+	+[a]	+	+	−	−	−	−	+	+[a]
Portugal	+	+[a]	+	+[a]	+	+[a]	+	+[a]	+	+[a]	+	+[a]
Sweden	+	−/+	+	−	closed	closed	−	−	−	−	+	−

The "+" indicates that a regulation was implemented at the time of the survey, the " − " that it was not present, and " −/+" that the presence and absence of regulations differed regionally within the country. "Closed" means that the species was protected all year (C&R may be permitted). [a]In this case, a general (not species-specific) bag limit comprising two or more species was in place, e.g. maximum weight or number of several species per angler and day/holiday.

and southern European countries are often more consumption oriented (Arlinghaus *et al.*, 2007; Veiga *et al.*, 2010), which may be reflected by the low release proportions for cod in Poland and relatively low rates for sea bass in Portugal. Bag limits and MLS can also lead to an increase in C&R for regulated species (Harper *et al.*, 2000; Veiga *et al.*, 2010), e.g. the introduction and increased compliance with size-based harvest regulations was suggested as a reason for the increased release proportions for sea bass in the UK (Pickett *et al.*, 1995). Alós *et al.* (2009b) similarly argued that recreational anglers in Spain have to release large amounts of their catch due to MLS, as more than 90% of the striped seabream (*Lithognathus mormyrus*) catches and 48% of the annular seabream (*Diplodus annularis*) catches were under the MLS during a scientific research test angling. However, Lloret and Font (2013) found that the average size (16.2 cm) of two-banded seabream (*Diplodus vulgaris*) in the harvest of shore anglers in a study area in northern Spain was under the legal MLS (18 cm), indicating that shore anglers did not follow the MLS for this species. Similarly, Veiga *et al.* (2010) found relatively low release rates for sea bass in Portugal and a large retention of undersized fish, possibly due to the fact that many Portuguese anglers disagreed with the MLS in place for this species (36 cm) or due to a lack of awareness of the specific MLS in place (Veiga *et al.*, 2013). Catch rates have also been shown to play an important role for certain target species as anglers become more likely to release parts of their catch if catches are high (Sullivan, 2002). This was observed in Norway, where marine angling tourists staying in northern Norway, where they had higher catch rates than in southern Norway, released a larger proportion of their catch compared with tourists staying in the south (Ferter *et al.*, 2013). Thus, a variety of reasons can contribute to high release proportions, many of which include regulatory reasons, but also a range of voluntary angler behaviour is involved.

Interestingly, the release proportions not only varied between countries and between species, but in some cases also varied from year to year within the same fishery. Thus, although the presented release proportions were based on the most current catch estimates, the calculated release proportions may only be representative for these particular years. The two German surveys showed that the release proportions for Baltic cod caught in German waters varied significantly from 2006 to 2012. The high release proportions in 2009/2010 appeared to be an indication of the large 2008 year class, which was the single largest in the 2005–2011 time-series (Strehlow *et al.*, 2012). This is in line with the finding that German anglers mainly release fish that are not legal to retain. Strehlow *et al.* (2012) argued that the availability of juvenile cod to anglers in coastal areas is higher due to high abundance of juvenile cod, and more anglers than commercial fishers exploiting these waters. Pickett *et al.* (1995) found a similar development for the release proportions of sea bass by recreational anglers in the UK. They showed that the release proportions had increased in 1990 compared with previous years, parallel with an increased number of juvenile sea bass stemming from strong 1988 and 1989 year classes. Where assessed, the most common reason for releasing cod, pollack, and sea bass was indeed that the caught fish were too small. Thus, if a strong year class enters the fishery, one can generally expect an increase in the release proportions in that year. However, release proportions do not necessarily differ on small time-scales if external factors, i.e. fish recruitment and angling regulations, are similar between the years, as in the case of the Norwegian marine angling tourism in 2010 and 2011.

EU discard ban for commercial fisheries and post-release mortalities

Discard mortalities in commercial fisheries (particularly trawl fisheries) are often assumed to be very high (Mesnil, 1996; Davis, 2002). Therefore, in 2012, the European Council agreed to "gradually eliminate discards on a case-by-case basis [...] ensuring that catches are landed" (European Council, 2012) as one of the main objectives of the new CFP. In practice, that means that by 2018, "all catches subject to catch limits [...] caught during fishing activities in Union waters [...] shall be brought and retained on board the fishing vessels, recorded, landed, and counted against the quotas where applicable" (European Council, 2012). As post-release mortalities in recreational fisheries can be equated to discards in commercial fisheries (Cooke and Wilde, 2007), the question arises whether the high release proportions among marine recreational anglers in Europe are reconcilable with these objectives.

Generally, the average survival rates of released fish are likely less than 100% (Bartholomew and Bohnsack, 2005; Hühn and Arlinghaus, 2011), which may not only lead to biased estimates of the overall

fishing mortality based only on harvest, but also counteract any well-meant regulation (Coggins *et al.*, 2007). Several studies, however, have shown that the survival of fish released after being caught by hook and line can be high for some marine species, with post-release mortalities of less than 15% (e.g. Albin and Karpov, 1998; Duffy, 2002; Bartholomew and Bohnsack, 2005). Cooke *et al.* (2006), therefore, argued that C&R could even be compatible with no-take marine protected areas, provided that lethal and sublethal effects on the released fish are low, and that there are no negative ecological consequences for the ecosystem. The CFP document by the European Council (2012) states that "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" should not be included in the landing obligation. Thus, if the survival of presented species in this paper is high, the practice of C&R for these species will consequently not be in conflict with the new objectives of the CFP.

The overall mean release mortality of cod released by anglers from charter boats in the Baltic Sea was estimated to be 11.2% (Weltersbach and Strehlow, 2013). Compared with other species, this percentage is in the lower range (Bartholomew and Bohnsack, 2005) and may, therefore, not be in conflict with the new CFP. As bleeding was the main predictor for cod release mortality, there may even be a potential for further reduction by using barbless single hooks or circle hooks instead of triple hooks in the Baltic sea charter boat fishery. However, for other recreational fishing modes in the Baltic Sea (e.g. shore fishing with natural baits) and for other ecosystems (e.g. fjords with deep water in Norway), cod release mortalities could be different, and thus need to be investigated further (Weltersbach and Strehlow, 2013).

For Atlantic salmon in freshwater (Thorstad *et al.*, 2003; Halttunen *et al.*, 2010) and during spawning migrations (Thorstad *et al.*, 2007; Jensen *et al.*, 2010), the impacts of C&R have been studied thoroughly. The results of these studies generally showed very low mortalities (<10%) and minor sublethal effects in terms of spawning migration. Booth *et al.* (1995) showed that the survival of eggs spawned by Atlantic salmon caught and released shortly before spawning was not affected by the C&R event. Despite these finding on the effects of C&R on Atlantic salmon in freshwater, it has to be noted that studies on the release mortality of Atlantic salmon in the ocean phase are not available, and that the survival may be lower than in freshwater. This was, for example, demonstrated for coho salmon smolts (*Oncorhynchus kisutch*), where the experimental removal of slime and scales caused 75% mortality in saltwater and no mortality in freshwater (Bouck and Smith, 1979). Therefore, the effects of C&R on Atlantic salmon in saltwater should be investigated, as freshwater estimates are not necessarily applicable for marine environments.

To our knowledge, there are no published studies to date that have quantified the post-release mortalities of European sea bass, pollack, sea trout, or European eel released by recreational anglers in marine environments. Although data for similar species are available in the literature, these might not be applicable for the presented species or the particular recreational fisheries. For example, the predicted long-term mortality for striped bass (*Morone saxatilis*) released in saltwater ranged from 3–26%, depending on a range of conditions (Diodati and Richards, 1996). As post-release mortalities can vary significantly by species and fishery, and can depend on many factors, including water temperature, fishing depth, overall injury, and handling time (Bartholomew and Bohnsack, 2005; Cooke and Suski, 2005; Hühn and Arlinghaus, 2011), it is recommended that release mortality studies be conducted for each of the presented species. This is necessary to allow estimation of overall fishing mortality based on all fishing-induced deaths (Clark, 1983) (i.e. by adding the instantaneous C&R fishing mortality F_{cr} to total fishing mortality; Kerns *et al.*, 2012) and to identify factors that have a significant impact on the survival of the released species (Alós *et al.*, 2009b). Once critical factors have been identified, it may be possible to derive post-release mortalities for different fisheries, e.g. by combining knowledge on the critical factors with information on the typical fishing depths and types of gear used in the respective fishery. Moreover, it will be possible to develop species-specific, best-practice guidelines to reduce potentially negative impacts of C&R (Cooke and Suski, 2005; FAO, 2012).

Potential for improvements in angler education

Compared with the USA and Australia, little attention has been given to improving angling practices in European marine waters. In the USA and Australia, it is common to set up information panels at popular angling spots and to distribute information brochures to anglers together with the licence before they start fishing. Although some of these brochures need improvements (Pelletier *et al.*, 2007), they provide information on the existing angling regulations and, not less importantly, contain guidelines on fishing techniques and treatment for releasing fish. Additionally, in some marine recreational fisheries in the USA, it is mandatory to carry release tools while fishing (National Marine Fisheries Service, 2008), e.g. venting needles or release weights (Bartholomew and Bohnsack, 2005), and although these tools have either no effect or a negative effect on some fish species (Wilde, 2009; Brown *et al.*, 2010), they significantly increase the survival of others (Collins *et al.*, 1999). In Europe, most of the information available to marine anglers includes only aspects on regulations, while information on how to handle and release fish is very limited. To ensure a sustainable marine recreational fishery in Europe, angler information and education should be one of the main objectives in the future (FAO, 2012). Educational programmes have been widely recommended to increase anglers' awareness of regulations (e.g. MLS), potentially shape moral attitudes and values, increase the release proportions of undersized fish, and promote better handling and release procedures (Raakjær Nielsen and Mathiesen, 2003; Cooke and Suski, 2005; Edison *et al.*, 2006; Lewin *et al.*, 2006; Smallwood and Beckley, 2012; Veiga *et al.*, 2013). One example of improved angling practice and the importance of correct angler education in C&R fisheries is the use of circle hooks. A review by Cooke and Suski (2004) suggested that circle hooks can be useful in reducing post-release mortalities when used properly. In fact, a study by Alós *et al.* (2009c) provides evidence that the use of this hook type can reduce post-release mortality rates without a significant reduction in catch rates.

Potential sources of error

The presented release proportions are based on a range of surveys conducted in the different countries and may have varying levels of random and systematic errors (accuracy), depending on survey type, survey design, and sampling effort (if s.e. were available from the survey, they were included in this paper). Therefore, it was not possible to merge harvest and release estimates across countries; if this were a goal, one would have to ensure that national sampling schemes were harmonized to provide overall estimates (ICES, 2013). Recall bias and particularly non-response bias play an important role in the majority of survey types. Recall bias occurs when survey respondents fail to accurately recall their effort and catch (Tarrant *et al.*, 1993), which often is the case when the recall

period is long or when many non-memorable fish were caught (Pollock *et al.*, 1994). For example, Connelly and Brown (1995) showed that, in comparison to estimates based on diaries, effort was overestimated by 45% when using a 12-month recall period. Sullivan (2003) showed that anglers reported 2.2-fold higher catches of undersized walleyes (*Stizostedion vitreum*) per legal-sized walleye than the ratio obtained in a scientific angling test. Another problem in recall surveys is that harvest is often requested in weight, whereas releases are often reported in numbers. Hence, a transformation between weight and numbers is needed, which has the potential to inflict large biases in the estimates (Sparrevohn, 2013). A main problem associated with non-response bias is that anglers with lower participation rates may have higher non-response rates (Tarrant and Manfredo, 1993); thus, results would be biased towards more avid anglers.

Online surveys (as in the small English study reported here) can be very time- and cost-efficient, but may be subject to non-coverage bias and self-selection bias (Fricker and Schonlau, 2002; National Research Council, 2006; Couper *et al.*, 2007). Furthermore, the data may be biased towards more avid anglers (Graefe *et al.*, 2011), as they are more likely to hear about the survey and may be more likely to participate (Aas and Kaltenborn, 1995; Oh and Ditton, 2006). These anglers may also be more specialized and thus be more likely to release parts of their catch (Aas and Kaltenborn, 1995; Oh and Ditton, 2006).

Overall, the data presented in this paper were the best available, but each of the studies noted were of different quality; hence, some of the presented release proportions are, to some degree, uncertain. This caveat, however, does not disqualify the main finding of our work: that the release proportions are high and in many cases higher than 50% of the total catch.

Conclusion

The present study showed that not only the harvest of European marine recreational fisheries is important as anglers frequently release large amounts of their catch, either due to regulations, voluntary decisions, or both. Although information on post-release survival for recreational marine species in Europe is still limited, studies elsewhere have shown that the survival can be highly variable between species and fisheries and can be related to a series of external and internal factors. Thus, it is recommended that the factors influencing post-release mortality of released fish be studied in order to make it possible to account for post-release mortalities when estimating fishing mortalities and to assist in the development of best-practice guidelines. These best-practice guidelines could be used in angler education, which is urgently needed to reduce potentially negative impacts of C&R. If post-release impacts can be limited to a minimum, C&R will be reconcilable with the new EU discard ban. If its practice is ethically and legally accepted, the release of fish can reduce fishing mortality and, at the same time, maintain angling opportunities.

Funding

Part of this work was cofunded by the European Commission's Data Collection Framework. The project in Mecklenburg–Western Pomerania was funded by the European FIFG (Financial Instrument for Fisheries Guidance 2000–2006, 75%) and the State of Mecklenburg–Vorpommern (25%). Further funding was provided by the Adaptfish and Besatzfisch projects to RA through the Leibniz-Association (www.adaptfish.igb-berlin.de) and the German Federal Ministry for Education and Research in the Program on Social-Ecological Research (grant #01UU0907, www.besatz-fisch.de).

Acknowledgements

The authors would like to thank the Mediterranean Institute for Advanced Studies (IMEDEA) Mallorca for providing the venue for the C&R workshop. Moreover, we would like to thank Ian Burrett, Håkan Carlstrand, Jan Kappel, Beatriz Morales-Nin, and David Turnbull for providing supporting material and for contacting some of the contributing authors. We are also grateful to two anonymous reviewers for providing helpful feedback on an earlier version of the paper.

References

Aas, Ø., and Kaltenborn, B. 1995. Consumptive orientation of anglers in Engerdal, Norway. Environmental Management, 19: 751–761.

Aas, Ø., Thailing, C. E., and Ditton, R. B. 2002. Controversy over catch-and-release recreational fishing in Europe. *In* Recreational Fisheries: Ecological, Economic and Social Evaluation, pp. 95–106. Ed. by T. J. Pitcher, and C. E. Hollingworth. Blackwell Science, Oxford, UK.

Albin, D., and Karpov, K. A. 1998. Mortality of lingcod, *Ophiodon elongatus*, related to capture by hook and line. Marine Fisheries Review, 60: 29–34.

Alós, J. 2008. Influence of anatomical hooking depth, capture depth, and venting on mortality of painted comber (*Serranus scriba*) released by recreational anglers. ICES Journal of Marine Science, 65: 1620–1625.

Alós, J., Arlinghaus, R., Palmer, M., March, D., and Álvarez, I. 2009a. The influence of type of natural bait on fish catches and hooking location in a mixed-species marine recreational fishery, with implications for management. Fisheries Research, 97: 270–277.

Alós, J., Palmer, M., and Grau, A. M. 2009b. Mortality of *Diplodus annularis* and *Lithognathus mormyrus* released by recreational anglers: implications for recreational fisheries management. Fisheries Management and Ecology, 16: 298–305.

Alós, J., Palmer, M., Grau, A. M., Cabanellas-Reboredo, M., and Box, A. 2009c. Performance of circle hooks in a mixed-species recreational fishery. Journal of Applied Ichthyology, 25: 565–570.

Arlinghaus, R. 2007. Voluntary catch and release can generate conflict within the recreational angling community: a qualitative case study of specialised carp, *Cyprinus carpio*, angling in Germany. Fisheries Management and Ecology, 14: 161–171.

Arlinghaus, R., and Cooke, S. J. 2009. Recreational fisheries: socioeconomic importance, conservation issues and management challenges. *In* Recreational Hunting, Conservation and Rural Livelihoods: Science and Practice, pp. 39–58. Ed. by B. Dickson, J. Hutton, and W. M. Adams. Wiley-Blackwell, Oxford, UK.

Arlinghaus, R., Cooke, S. J., and Cowx, I. G. 2010. Providing context to the global code of practice for recreational fisheries. Fisheries Management and Ecology, 17: 146–156.

Arlinghaus, R., Cooke, S. J., Lyman, J., Policansky, D., Schwab, A., Suski, C., Sutton, S. G., *et al.* 2007. Understanding the complexity of catch-and-release in recreational fishing: an integrative synthesis of global knowledge from historical, ethical, social, and biological perspectives. Reviews in Fisheries Science, 15: 75–167.

Arlinghaus, R., Schwab, A., Riepe, C., and Teel, T. 2012. A primer on anti-angling philosophy and its relevance for recreational fisheries in urbanized societies. Fisheries, 37: 153–164.

Bartholomew, A., and Bohnsack, J. 2005. A review of catch-and-release angling mortality with implications for no-take reserves. Reviews in Fish Biology and Fisheries, 15: 129–154.

Booth, R. K., Kieffer, J. D., Tufts, B. L., Davidson, K., and Bielak, A. T. 1995. Effects of late-season catch and release angling on anaerobic metabolism, acid–base status, survival, and gamete viability in wild Atlantic salmon (*Salmo salar*). Canadian Journal of Fisheries and Aquatic Sciences, 52: 283–290.

Borch, T., Moilanen, M., and Olsen, F. 2011. Marine fishing tourism in Norway: structure and economic effects. Økonomisk Fiskeriforskning, 21: 1–17.

Bouck, G. R., and Smith, S. D. 1979. Mortality of experimentally descaled smolts of coho salmon (Oncorhynchus kisutch) in fresh and salt water. Transactions of the American Fisheries Society, 108: 67–69.

Brown, I., Sumpton, W., McLennan, M., Mayer, D., Campbell, M., Kirkwood, J., Butcher, A., *et al.* 2010. An improved technique for estimating short-term survival of released line-caught fish, and an application comparing barotrauma-relief methods in red emperor (*Lutjanus sebae* Cuvier 1816). Journal of Experimental Marine Biology and Ecology, 385: 1–7.

CEC. 2001. Council Regulation (EC) No. 1639/2001 of 25 July 2001 establishing the minimum and extended Community programmes for the collection of data in the fisheries sector and laying down detailed rules for the application of Council Regulation (EC) No. 1543/2000. Official Journal of the European Communities EN 2001.

CEC. 2008. Commission Decision of 6 November 2008 adopting a multiannual Community programme pursuant to Council Regulation (EC) No. 199/2008 establishing a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the common fisheries policy (2008/949/EC). Official Journal of the European Communities EN 2008.

CEC. 2009. Commission Regulation (EC) No. 1224/2009 of 20 November 2009 establishing a Community control system for ensuring compliance with the rules of the common fisheries policy, amending Regulations (EC) No. 847/96, (EC) No. 2371/2002, (EC) No. 811/2004, (EC) No. 768/2005, (EC) No. 2115/2005, (EC) No. 2166/2005, (EC) No. 388/2006, (EC) No. 509/2007, (EC) No. 676/2007, (EC) No. 1098/2007, (EC) No. 1300/2008, (EC) No. 1342/2008 and repealing Regulations (EEC) No. 2847/93, (EC) No. 1627/94 and (EC) No. 1966/2006. Official Journal of the European Communities EN 2009.

Clark, R. D. 1983. Potential effects of voluntary catch and release of fish on recreational fisheries. North American Journal of Fisheries Management, 3: 306–314.

Coggins, L. G., Catalano, M. J., Allen, M. S., Pine, W. E., and Walters, C. J. 2007. Effects of cryptic mortality and the hidden costs of using length limits in fishery management. Fish and Fisheries, 8: 196–210.

Coleman, F. C., Figueira, W. F., Ueland, J. S., and Crowder, L. B. 2004. The impact of United States recreational fisheries on marine fish populations. Science, 305: 1958–1960.

Collins, M. R., McGovern, J. C., Sedberry, G. R., Meister, H. S., and Pardieck, R. 1999. Swim bladder deflation in black sea bass and vermilion snapper: potential for increasing postrelease survival. North American Journal of Fisheries Management, 19: 828–832.

Connelly, N. A., and Brown, T. L. 1995. Use of angler diaries to examine biases associated with 12-month recall on mail questionnaires. Transactions of the American Fisheries Society, 124: 413–422.

Cooke, S. J., and Cowx, I. G. 2004. The role of recreational fishing in global fish crises. BioScience, 54: 857–859.

Cooke, S. J., Danylchuk, A. J., Danylchuk, S. E., Suski, C. D., and Goldberg, T. L. 2006. Is catch-and-release recreational angling compatible with no-take marine protected areas? Ocean & Coastal Management, 49: 342–354.

Cooke, S. J., and Suski, C. D. 2004. Are circle hooks an effective tool for conserving marine and freshwater recreational catch-and-release fisheries? Aquatic Conservation: Marine and Freshwater Ecosystems, 14: 299–326.

Cooke, S. J., and Suski, C. D. 2005. Do we need species-specific guidelines for catch-and-release recreational angling to effectively conserve diverse fishery resources? Biodiversity and Conservation, 14: 1195–1209.

Cooke, S. J., and Wilde, G. R. 2007. The fate of fish released by recreational anglers. *In* By-catch Reduction in the World's Fisheries, pp. 181–234. Ed. by S. J. Kenelly. Springer, Dordrecht, The Netherlands.

Couper, M. P., Kapteyn, A., Schonlau, M., and Winter, J. 2007. Noncoverage and nonresponse in an internet survey. Social Science Research, 36: 131–148.

Davis, M. W. 2002. Key principles for understanding fish bycatch discard mortality. Canadian Journal of Fisheries and Aquatic Sciences, 59: 1834–1843.

Diodati, P. J., and Richards, R. A. 1996. Mortality of striped bass hooked and released in salt water. Transactions of the American Fisheries Society, 125: 300–307.

Dorow, M., and Arlinghaus, R. 2011. A telephone-diary-mail approach to survey recreational fisheries on large geographic scales, with a note on annual landings estimates by anglers in northern Germany. *In* The Angler in the Environment: Social, Economic, Biological and Ethical Dimensions, pp. 319–344. Ed. by T. D. Beard, R. Arlinghaus, and S. G. Sutton. American Fisheries Society, Bethesda, MD.

Duffy, J. 2002. Catch-and-release mortality studies of spotted seatrout and red drum in coastal Alabama. *In* Catch and Release in Marine Recreational Fisheries, pp. 110–113. Ed. by J. A. Lucy, and A. L. Studholme. American Fisheries Society, Bethesda, MD.

Edison, T. W., Wahl, D. H., Diana, M. J., Philipp, D. P., and Austen, D. J. 2006. Angler opinion of potential bluegill regulations on Illinois lakes: effects of angler demographics and bluegill population size structure. North American Journal of Fisheries Management, 26: 800–811.

European Council. 2012. Proposal for a Regulation of the European Parliament and of the Council on the Common Fisheries Policy – General approach. 11322/12. 78 pp.

FAO. 2012. Recreational fisheries. FAO Technical Guidelines for Responsible Fisheries, No. 13. FAO, Rome. 176 pp.

Ferter, K., Borch, T., Kolding, J., and Vølstad, J. H. 2013. Angler behaviour and implications for management – catch-and-release among marine angling tourists in Norway. Fisheries Management and Ecology, 20: 137–147.

Fricker, R., and Schonlau, M. 2002. Advantages and disadvantages of internet research surveys: evidence from the literature. Field Methods, 14: 347–367.

Graefe, A., Mowen, A., Covelli, E., and Trauntvein, N. 2011. Recreation participation and conservation attitudes: differences between mail and online respondents in a mixed-mode survey. Human Dimensions of Wildlife, 16: 183–199.

Halttunen, E., Rikardsen, A. H., Thorstad, E. B., Naesje, T. F., Jensen, J. L. A., and Aas, Ø. 2010. Impact of catch-and-release practices on behavior and mortality of Atlantic salmon (*Salmo salar* L.) kelts. Fisheries Research, 105: 141–147.

Harper, D. E., Bohnsack, J. A., and Lockwood, B. R. 2000. Recreational fisheries in Biscayne National Park, Florida, 1976–1991. Marine Fisheries Review, 62: 8–26.

Herfaut, J., Levrel, H., Thébaud, O., and Véron, G. 2013. The nationwide assessment of marine recreational fishing: a French example. Ocean & Coastal Management, 78: 121–131.

Hühn, D., and Arlinghaus, R. 2011. Determinants of hooking mortality in freshwater recreational fisheries: a quantitative meta-analysis. *In* The Angler in the Environment: Social, Economic, Biological and Ethical Dimensions. Proceedings from the Fifth World Recreational Fishing Conference, pp. 141–170. Ed. by T. D. Beard, Jr., R. Arlinghaus, and S. G. Sutton. American Fisheries Society, Symposium 75, Bethesda, MD.

ICES. 2011. Report of the Study Group on Practical Implementation of Discard Sampling Plans (SGPIDS), 27 June – 1 July 2011, ICES, Denmark. ICES Document CM 2011/ACOM: 50. 110 pp.

ICES. 2012. Report of the Working Group on Recreational Fisheries Surveys (WGRFS), 7–11 May 2012, Esporles, Spain. ICES Document CM 2012/ACOM: 23. 51 pp.

ICES. 2013. Report of the Second Workshop on Practical Implementation of Statistical Sound Catch Sampling Programmes. 6–9 November 2012, ICES, Denmark. ICES Document CM 2012/ACOM: 54. 71 pp.

Jensen, J. L. A., Halttunen, E., Thorstad, E. B., Næsje, T. F., and Rikardsen, A. H. 2010. Does catch-and-release angling alter the migratory behaviour of Atlantic salmon? Fisheries Research, 106: 550–554.

Kerns, J. A., Allen, M. S., and Harris, J. E. 2012. Importance of assessing population-level impact of catch-and-release mortality. Fisheries, 37: 502–503.

Lewin, W-C., Arlinghaus, R., and Mehner, T. 2006. Documented and potential biological impacts of recreational fishing: insights for management and conservation. Reviews in Fisheries Science, 14: 305–367.

Lloret, J., and Font, T. 2013. A comparative analysis between recreational and artisanal fisheries in a Mediterranean coastal area. Fisheries Management and Ecology, 20: 148–160.

McPhee, D. P., Leadbitter, D., and Skilleter, G. A. 2002. Swallowing the bait: is recreational fishing in Australia ecologically sustainable? Pacific Conservation Biology, 8: 40–51.

Mesnil, B. 1996. When discards survive: accounting for survival of discards in fisheries assessments. Aquatic Living Resources, 9: 209–215.

National Marine Fisheries Service. 2008. Fisheries of the Caribbean, Gulf of Mexico, and South Atlantic; reef fish fishery and shrimp fishery of the Gulf of Mexico. Amendment 27/14, Federal Register, pp. 5117–5128.

National Research Council. 2006. Review of Recreational Fisheries Survey Methods. The National Academies Press, Washington, DC. 202 pp.

Oh, C. O., and Ditton, R. B. 2006. Using recreation specialization to understand multi-attribute management preferences. Leisure Sciences, 28: 369–384.

Pawson, M. G., Glenn, H., and Padda, G. 2008. The definition of marine recreational fishing in Europe. Marine Policy, 32: 339–350.

Pelletier, C., Hanson, K., and Cooke, S. 2007. Do catch-and-release guidelines from state and provincial fisheries agencies in North America conform to scientifically based best practices? Environmental Management, 39: 760–773.

Pickett, G. D., Eaton, D. R., Cunningham, S., Dunn, M. R., Potten, S. D., and Whitmarsh, D. 1995. An appraisal of the UK bass fishery and its management. Laboratory Leaflet 75, MAFF, Directorate of Fisheries Research, Lowestoft. 47 pp.

Policansky, D. 2002. Catch-and-release recreational fishing: a historical perspective. *In* Recreational Fisheries: Ecological, Economic, and Social Evaluation., pp. 202–236. Ed. by T. J. Pitcher, and C. E. Hollingworth. Blackwell Publishing, Oxford, UK.

Policansky, D. 2008. Trends and developments in catch and release. *In* Global Challenges in Recreational Fisheries, pp. 202–236. Ed. by Ø. Aas. Blackwell Publishing, Oxford, UK.

Pollock, K. H., Jones, C. M., and Brown, T. L. 1994. Angler Survey Methods and Their Applications in Fisheries Management. American Fisheries Society, Bethesda, MD. 371 pp.

Raakjær Nielsen, J., and Mathiesen, C. 2003. Important factors influencing rule compliance in fisheries lessons from Denmark. Marine Policy, 27: 409–416.

Rocklin, D., Levrel, H., Drogou, M., and Veron, G. 2012. La pêche récréative au bar sur les façades Atlantique, Manche et Mer du Nord – Résultats de l'enquête 2009–2011, Ifremer, Brest. 4 pp.

Salmi, P., and Ratamäki, O. 2011. Fishing culture, animal policy, and new governance: a case study of voluntary catch-and-release fishing in Finland. American Fisheries Society Symposium, 75: 235–249.

Smallwood, C. B., and Beckley, L. E. 2012. Spatial distribution and zoning compliance of recreational fishing in Ningaloo Marine Park, north-western Australia. Fisheries Research, 125: 40–50.

Sparrevohn, C. R. 2013. Estimating recreational harvest using interview-based recall survey: implication of recalling in weight or numbers. Fisheries Management and Ecology, 20: 52–57.

Sparrevohn, C. R., and Storr-Paulsen, M. 2012. Using interview-based recall surveys to estimate cod *Gadus morhua* and eel *Anguilla anguilla* harvest in Danish recreational fishing. ICES Journal of Marine Science, 69: 323–330.

Strehlow, H. V., Schultz, N., Zimmermann, C., and Hammer, C. 2012. Cod catches taken by the German recreational fishery in the western Baltic Sea, 2005–2010: implications for stock assessment and management. ICES Journal of Marine Science, 69: 1769–1780.

Sullivan, M. G. 2002. Illegal angling harvest of walleyes protected by length limits in Alberta. North American Journal of Fisheries Management, 22: 1053–1063.

Sullivan, M. G. 2003. Exaggeration of walleye catches by Alberta anglers. North American Journal of Fisheries Management, 23: 573–580.

Tarrant, M. A., and Manfredo, M. J. 1993. Digit preference, recall bias, and nonresponse bias in self reports of angling participation. Leisure Sciences, 15: 231–238.

Tarrant, M. A., Manfredo, M. J., Bayley, P. B., and Hess, R. 1993. Effects of recall bias and nonresponse bias on self-report estimates of angling participation. North American Journal of Fisheries Management, 13: 217–222.

Thorstad, E. B., Naesje, T. F., Fiske, P., and Finstad, B. 2003. Effects of hook and release on Atlantic salmon in the river Alta, Northern Norway. Fisheries Research, 60: 293–307.

Thorstad, E. B., Naesje, T. F., and Leinan, I. 2007. Long-term effects of catch-and-release angling on ascending Atlantic salmon during different stages of spawning migration. Fisheries Research, 85: 316–320.

van der Hammen, T., and de Graaf, M. 2012. Recreational fishery in the Netherlands: catch estimates of cod (*Gadus morhua*) and eel (*Anguilla anguilla*) in 2010. Report Number C014/12, IMARES Wageningen UR. 61 pp.

Veiga, P., Gonçalves, J., and Erzini, K. 2011. Short-term hooking mortality of three marine fish species (Sparidae) caught by recreational angling in the south Portugal. Fisheries Research, 108: 58–64.

Veiga, P., Pita, C., Leite, L., Ribeiro, J., Gonçalves, J. M. S., and Erzini, K. 2013. From a traditionally open access fishery to modern restrictions: Portuguese anglers' perceptions about newly implemented recreational fishing regulations. Marine Policy, 40: 53–63.

Veiga, P., Ribeiro, J., Goncalves, J. M. S., and Erzini, K. 2010. Quantifying recreational shore angling catch and harvest in southern Portugal (north-east Atlantic Ocean): implications for conservation and integrated fisheries management. Journal of Fish Biology, 76: 2216–2237.

Vølstad, J. H., Korsbrekke, K., Nedreaas, K., Nilsen, M., Nilsson, G. N., Pennington, M., Subbey, S., *et al.* 2011. Probability-based surveying using self-sampling to estimate catch and effort in Norway's coastal tourist fishery. ICES Journal of Marine Science, 68: 1785–1791.

Weltersbach, M. S., and Strehlow, H. V. 2013. Dead or alive – estimating post-release mortality of Atlantic cod in the recreational fishery. ICES Journal of Marine Science, 70: 864–872.

Wilde, G. R. 2009. Does venting promote survival of released fish? Fisheries, 34: 20–28.

Handling editor: Emory Anderson