ICES Journal of
Marine Science

ICES Journal of Marine Science (2012), 69(10), 1769–1780. doi:10.1093/icesjms/fss152

Cod catches taken by the German recreational fishery in the western Baltic Sea, 2005–2010: implications for stock assessment and management

Harry V. Strehlow*, Norbert Schultz, Christopher Zimmermann, and Cornelius Hammer

Thünen-Institute of Baltic Sea Fisheries, Alter Hafen Süd 2, 18069 Rostock, Germany

**Corresponding Author: tel: +49 381 8116 107; fax: +49 381 8116 199; e-mail: harry.strehlow@vti.bund.de*

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.

Received 27 March 2012; accepted 8 August 2012.

Next to the commercial fishery, the recreational fishery plays an important role in the removal of biomass from fish stocks. In this study, we present estimates of German recreational cod (*Gadus morhua*) catches in the western Baltic Sea between 2005 and 2010. Fishing effort was estimated using a stratified mail survey and annual sales of fishing licences. Catch per unit effort was estimated by stratified random sampling of access points and interviews about completed trips. Length distributions of cod catches were acquired by sampling recreational cod catches from charter boats and data from community fishing events. Estimates of the total cod biomass removed by the recreational fishery fluctuated between 2159 t in 2009 and 4127 t in 2005. Annual recreational fishery cod harvests accounted for a significant share of the total landings, with a yearly variation from 34 to 70% of the German commercial cod landings from the western Baltic Sea. The majority of recreational fishery cod catches were taken from private boats and charter vessels. Because of the amount and specifically the variability of the recreational catches, they are important for the assessment and management of the resource and, therefore, need to be surveyed annually.

Keywords: access-point survey, angling, effort, harvest, recreational fishery management, recreational fishing, release, resource allocation, stock assessment.

Introduction

The importance of recreational fishery catches is widely recognized, but is generally assumed to be negligible in European marine waters compared to commercial fishery removals. However, recreational fishery catches can have a significant share of the total landings for certain species (Coleman *et al.*, 2004). The regular collection of recreational fishery data in Europe began in 2001 with the introduction of the Commission Regulation (EC) No. 1639/2001 requiring Member States (MS) to sample bluefin tuna (*Thunnus thynnus*) catches in all areas and salmon (*Salmo salar*) in the North and Baltic seas (CEC, 2001). With the amendment of this regulation, the recreational species listed in Appendix XI (CEC, 2004) was expanded to also contain cod (*Gadus morhua*) in ICES Subareas III, IV, V, VI, and VII (given that cod was the subject of recovery plans in these areas). MS were obliged to conduct pilot surveys to establish the basis for future requirements. Since anglers are not required to register their catches, conducting recreational fishery surveys is challenging and the first step in understanding the potential impacts of recreational fishing on fish stocks.

We conducted a pilot study from 2004 until 2006 to collect data from the German marine recreational fishery in the North and Baltic seas. The study revealed that significant catches in this recreational fishery were only relevant for cod in the western Baltic Sea, particularly in ICES Subdivisions (SD) 22 and 24. Consequently, a comprehensive survey design was implemented to assess the impact of the recreational fishery catch on the western Baltic cod stock. Since then, this recreational fishery survey has been conducted annually in the Baltic Sea. Selected findings from the pilot study and the annual recreational fishery surveys are reported here.

Recreational fishing in Germany

Marine recreational fishing in Germany is carried out in two seas with very different conditions (Figure 1). The North Sea has a strong tidal influence (mean spring range 4 m) and large tidal flats, where shore angling concentrates on the Frisian Islands and harbors. Boat angling is limited in this area due to challenging boating and unfavorable fishing conditions. The Baltic Sea has minimal tidal currents, and a rugged coastline characterized by alternating sandy beaches and rocky shores that are suitable and popular for shore angling. Boat angling in this area is even more popular due to favorable conditions. Hence, the majority of charter vessels from the for-hire sector are stationed in the Baltic Sea.

Recreational fishing is under the jurisdiction of the German federal states. Consequently, marine recreational fishing is managed by five federal states, each with different legislation (Figure 1). Recreational fishing licences are obligatory in all federal states, with the exception of fishing in the North Sea in the state of Lower Saxony. Applicants are obliged to pass an exam, and the licence is valid for a lifetime provided that an annual fee is paid. The licence does not distinguish between freshwater or saltwater fishing. In the two coastal states bordering the Baltic Sea, anglers without a lifetime fishing licence can obtain a more limited tourist licence multiple times a year, which requires no exam and is valid for 28 days. State authorities may keep registries of licence holders, but these registries are not up-to-date, and are not available for use as sampling frames in recreational fisheries surveys.

In addition to a valid fishing licence, the state of Mecklenburg–Western Pomerania (MV) demands a coastal fishing permit for the Baltic Sea, while no permit is required in Schleswig–Holstein (SH). For an overview of the different regulations in the Baltic Sea, see Table 1. Permit holders are usually not registered. No coastal fishing permit is required for the North Sea by the bordering states.

In 2010, about 1 503 043 fishing licences were sold in Germany, accounting for roughly 1.8% of the German population. About 875 000 anglers are organized in two large societies (Brämick, 2010).

The number of recreational fishers using commercial gears (in the following referred to as "passive gear fishers") and fishing from the German Baltic coast were estimated to be about 1640 people in 2010.

Both anglers and passive gear fishers are not permitted to sell their catch, which is the most prominent difference from commercial fishers.

The main angling methods for targeting cod in the Baltic Sea are as follows:

(i) Surf angling from the beach or jetties using natural baits, mostly at night.

(ii) Wading using artificial baits.

(iii) Boat angling from charter boats. These charter vessels are characteristic for Germany. The majority of vessels are former commercial fish cutters that have been fitted to accompany up to 60 anglers. Equipped with modern electronics and experienced skippers, these charter boats search for fish, also targeting distant fishing grounds. Most full day trips are 8–10 h, and anglers use natural and artificial baits.

(iv) Boat angling from small private boats is popular and has increased rapidly in recent years. Boat types vary from belly boats, inflatables, to solid hulls, resulting in a variety of starting points for fishing trips, such as beaches, boat slips, and/or harbors. Just as from charter boats, both artificial and natural baits are used.

(v) Trolling is a more advanced form of boat fishing using highly specialized equipment (downriggers, side planers, etc.) towing natural and artificial lures behind the boat.

Methods

Survey methodology

The multistage survey design involved the following components: (i) off-site survey (mail-diary) for effort, (ii) on-site survey (data from completed trips for a stratified random sample of access points and days) for catch per unit effort (CPUE), (iii) recreational length samples for recreational length distribution, and (iv) commercial length–weight relationship keys for conversion of numbers into biomass (Figure 2). The survey was structured around five major modes characterized by the five main angling methods described above.

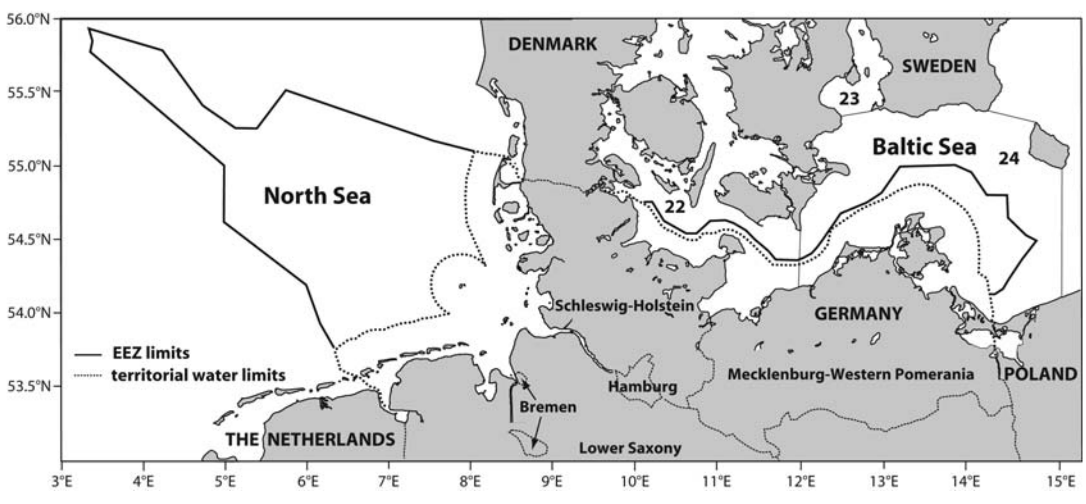

Figure 1. The German territorial waters, Exclusive Economic Zone (EEZ), and the coastal states bordering the North and Baltic seas. Numbers in the Baltic Sea indicate ICES subdivisions.

Table 1. Selection of marine recreational fishing regulations in the Baltic Sea.

	Mecklenburg–Western Pomerania	Schleswig–Holstein
Anglers		
Fishing licence & annual fee	yes	yes
Tourist licence	yes	yes
Coastal fishing permit	yes	no
Permitted gear:	3 rods, minnow net 1.2 x 1.2 m	no limitation, minnow net max. 1 m^2, stownet with max. width of 2 m
Passive gear fishermen		
Fishing licence and annual fee	yes	yes
Permitted gear:	max. 8 eel pots, 100 m setnet, 100 hook longline	4 single wing or 2 double wing fykenets, 100 hook longline[a]

[a]With the amendment of the SH fishery legislation in November 2011, longline fishing has been discontinued. Current permits will expire by the end of 2013.

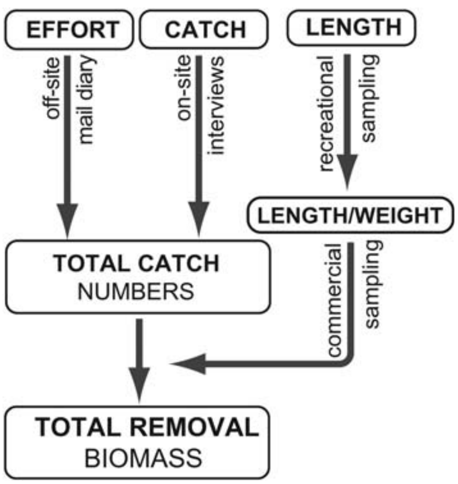

Figure 2. Data flow in the German marine recreational fishing survey.

With catch, we refer to the number or biomass of cod caught (harvested and released/discarded). Harvest refers to the total number or biomass of all fish caught and kept, excluding released fish. (Pollock *et al.*, 1994).

The off-site survey consisted of two mail surveys carried out in MV (2004–2005), with 2004 as the base year, and in SH (2005–2006), with 2005 as the base year. The main objective was to obtain effort data, i.e. how many days did an angler go fishing in the Baltic Sea and by which fishing method? For this purpose, 26 924 questionnaires were distributed to anglers who purchased a coastal fishing permit in MV. In SH, 39 693 questionnaires were distributed to organized anglers with the help of the two regional angler associations. Respondents could indicate if the provided effort data came from their own records, i.e. catch diaries, or was recalled. For the following calculations, only diary data were used, as the recalled data were significantly different and assumed to be biased.

Fishing effort was estimated using different types of list frames, such as the numbers of issued coastal fishing permits in MV (year, week, day) and the numbers of issued fishing licences in MV and SH.

The total Baltic coastline of Germany extends for over 2000 km, including inner coastal lagoons and backwaters. However, salt-water species are mainly targeted in the outer coastal waters with a salinity >10. Thus, sampling of recreational cod catches was limited to the outer Baltic coastline stretching 724 km. The beaches and harbours that formed the sampling frame for the access-point surveys were based on fishing guidebooks and personal experience. Other than some harbours, port facilities, and industrial sites closed to angling, there is virtually no private property preventing access to the sea. The coast is divided into five strata for sampling, with access points and days (site days) as primary sampling units (PSUs). Stratification was based on practical and organizational considerations. Based on experience acquired, sampling effort was increased for sea-based fishing methods and for those days when anglers most frequently go fishing. Access points and days (PSUs) were randomly selected within strata, following Pollock *et al.* (1994, 1997). Sampling for each stratum exploited a spatio-temporal frame covering all access sites and all available fishing days in a year. Sampling assignments were allocated by month, day type (weekday/weekend), and mode, and were spread evenly throughout the year. No alternate site sampling occurred. However, alternate-mode sampling occurred, representing only very few intercepts and covering different species from cod. For the estimation of cod catches, no alternate-mode interviews were included. Site visits were planned so as to sample at peak activity to maximize the number of intercepts. No site-selection probability was employed, i.e. sites were given equal inclusion probabilities. Variations in the sampling procedure (site-days, sites, peak activity time-interval) have evolved over the years according to experience and available resources (time, money, effort). Since 2009, access points in each stratum have been sampled on a monthly basis according to the following regime: (i) surf fishing and wading is sampled once a month on Fridays, Saturdays, or days prior to holidays; and (ii) boat angling, charter-vessel angling, and trolling is sampled twice a month on Saturdays, Sundays, or holidays, and twice a month on weekdays from Monday to Friday. In addition to this, a charter-vessel trip is sampled once a month per stratum with the survey agent on board. This sampling can be conducted during any day of the week and depends on the trip availability. The selection of charter vessels is stratified random based on charter vessel registry. Three charter vessels were randomly selected within each stratum and month. The survey agent determines the final charter vessel and day. The main objective of the charter-vessel trip sampling is to obtain the length distribution of recreational cod catches (harvested and released). Therefore, the survey agent on board measures the length of every fish caught. Other data sources were self-reported length samples from guide boats and fishing events.

The main objective of the stratified random access-point intercept survey was to obtain catch data in terms of CPUE for the different fishing methods applied. In 2009, the survey design was extended to sample released cod. Only completed fishing trips were used for estimates (= secondary sampling unit). During access-point surveys in harbours, this is usually the case when anglers are coming back from boat or charter-vessel trips. In the case of surf angling, sampling is continuous well beyond midnight to allow the majority of anglers to complete their fishing. Anglers fishing all night are asked for their telephone number and are contacted the next day to obtain the numbers of fish they have caught (harvested and released).

Sampling

Between 2004 and 2006, a total of 66 617 questionnaires were distributed, of which 2313 were evaluated (both recall and diary data). In MV, 574 mail diaries were returned and evaluated (2.1%). In SH, the return rate was 1.4%, of which 552 were evaluated.

To estimate the CPUE, 34 ports and 89 beaches (access points) along the German Baltic coast were randomly sampled. During on-site surveys between 2005 and 2010, a total of 1185 site-days were sampled and 11 536 anglers interviewed. Thereby, 405 site-days were carried out targeting shore fishing activities interviewing 1361 anglers, and 780 site-days were realized targeting boat and charter vessel angling yielding 10 175 interviews (Table 2).

Table 2. Numbers of on-site surveys and interviewed anglers, 2005–2010.

Year	Angling method	Numbers of on-site surveys	Numbers of interviews
2005	Charter boat angling	93	1 114
	Boat angling		213
	Trolling		8
	Shore angling	90	121
	Wading		37
	Total	183	1 493
2006	Charter boat angling	89	313
	Boat angling		1 905
	Trolling		2
	Shore angling	79	137
	Wading		40
	Total	168	2 397
2007	Charter boat angling	80	1 256
	Boat angling		196
	Trolling		4
	Shore angling	82	371
	Wading		71
	Total	162	1 898
2008	Charter boat angling	81	786
	Boat angling		128
	Trolling		3
	Shore angling	48	90
	Wading		43
	Total	129	1 050
2009	Charter boat angling	204	1 694
	Boat angling		346
	Trolling		18
	Shore angling	49	172
	Wading		51
	Total	253	2 281
2010	Charter boat angling	233	1 783
	Boat angling		366
	Trolling		40
	Shore angling	57	178
	Wading		50
	Total	290	2 417

In 2006, 180 passive gear fishers in MV were in possession of a valid licence. From the address list frame, 20 individuals were randomly selected and interviewed. Thereby, 15 passive gear fishers were interviewed on the telephone, four were visited directly and sampled during in-depth interviews, and one was contacted via mail survey. All participants were responsive. In SH, gillnets used to specifically target cod are prohibited (cf. Table 1). Therefore, we refrained from sampling passive gear fishers in SH.

To estimate the length composition of catches from beach fishing and boat/charter boat angling between 2005 and 2010, a total of 232 samples were obtained – from fishing events (surf angling and charter vessels), boat angling, trolling and charter-vessel trip sampling – whereby 11 577 harvested cod were measured in total (Table 3). In 2009 and 2010, 3576 released cod were measured.

Data analysis

To estimate the mean effort of anglers (angling days y^{-1}), the results from the mail surveys in 2004–2006 were used. The numbers of marine anglers in MV were estimated according to the numbers of coastal fishing permits sold. These figures were corrected for the numbers of sold weekly/daily fishing permits using the effort data from the mail-diary survey. The numbers of marine anglers in SH were estimated using an analogy comparing the numbers of issued fishing licences in SH to the numbers of issued fishing licences in MV.

The annual effort $A_{i,j,k}$ per angler i, angling method j, and according to permit type k was used to estimate the mean annual effort $\bar{A}_{j,k}$ as

$$\bar{A}_{j,k} = \frac{1}{n_{j,k}} \sum_{i=1}^{n_{j,k}} A_{i,j,k} \quad (1)$$

where $n_{j,k}$ is the number of respondents by angling method j and permit type k.

To calculate the total annual effort $E_{j,k}$ (angling days y^{-1}) for the coastal waters of MV, the number of anglers $m_{j,k}$ according to angling method j and permit type k was multiplied by the mean effort of anglers according to angling method and permit type $\bar{A}_{j,k}$

$$E_{j,k} = \bar{A}_{j,k} * m_{j,k} \quad (2)$$

and the total annual effort E_j according to angling method j was estimated as

$$E_j = \sum_k E_{j,k} \quad (3)$$

Total annual effort in MV is the sum of E_j of all angling methods j.

To estimate effort in SH, the same formulae were used, with the exception that calculations according to permit type were excluded, since a coastal fishing permit is not required.

The CPUE was calculated by fishing mode within a federal state as estimates of the unweighted mean, expressed as number of fish caught per fishing trip. CPUE and effort data were used to extrapolate the total annual harvest in numbers.

The annual cod harvest in biomass was calculated separately for SD 22 and 24, distinguishing between land- and sea-based fishing methods using the half-yearly length composition of catches from

Table 3. Numbers of samples and length measurements of cod from recreational angling events (charter vessels trips and shore angling), boat and trolling self-measurements, as well as charter vessel sampling, 2005–2010.

Year	Sample type	Samples	Harvest *n*	Release *n*
2005	Charter vessel events – self-measurement	13	2 862	
	Shore angling events – self-measurement	4	1 026	
	Total	17	3 888	
2006	Charter vessel events – self-measurement	8	352	
	Shore angling events – self-measurement	1	10	
	Total	4	362	
2007	Charter vessel events– self-measurement	3	26	
	Shore angling events – self-measurement	4	506	
	Total	4	532	
2008	Charter vessel sampling – survey agent	1	64	
	Charter vessel events– self-measurement	2	90	
	Boat – self-measurement	4	19	
	Trolling – self-measurement	15	93	16
	Shore angling event – self-measurement	4	346	
	Total	26	612	16
2009	Charter vessel sampling – survey agent	41	1 239	766
	Boat – self-measurement	24	100	117
	Trolling – self-measurement	12	45	1
	Shore angling event – self-measurement	3	3	10
	Total	80	1 384	894
2010	Charter vessel sampling – survey agent	55	2 296	2 602
	Charter vessel events – self-measurement	10	1 212	
	Boat/Trolling – self-measurement	24	226	63
	Shore angling – self-measurement	5	20	31
	Shore angling events– self-measurement	7	1 045	
	Total	101	4 799	2 666

shore angling and boat/charter boat angling and the respective commercial length–weight relationships. Due to insufficient length data for these fishing methods in some subdivisions, the yearly cod harvest in 2005–2008 was calculated using the length distribution of recreationally caught cod in 2010. Since 2009, calculations of sea-based catches (boat, charter vessel, and trolling) were based on the recorded length distributions of angler landings obtained through sampling of charter-vessel trips, in addition to those from angling events and self-sampling. The assumption that length distributions between recreational cod catches from private boats and charter vessels are comparable was verified in a complementary study by Weltersbach and Strehlow (2011). The same authors found that the length–weight relationships from private boats and charter vessels were very similar, and that the bias using the commercial length–weight relationships to scale up recreational catches was negligible (weighted mean overestimation 2.6%). Calculations of land-based harvests (surf angling and wading) were based on self-reported data from surf angling events. Self-reported length data were corrected to the lower centimetre, since it is usually measured to the upper centimetre. Calculations of land-based releases were based on the length distributions from at-sea sampling. In cases where such data were unavailable, estimates from the neighboring SD or half years were used.

Bootstrap was used to estimate the 95% confidence intervals of the annual cod harvests (Shao and Tu, 1996; Lehtonen and Pahkinen, 2004). Random samples of the $n_{j,k}$ datasets from the different angling methods j were drawn from the mail-diary data, such as annual effort per angler i, by permit type k, where $n_{j,k}$ denotes the number of available datasets of angling methods j. For each angling method, CPUE per angler was randomly sampled from the on-site data. The randomly selected data were used to estimate annual cod harvests according to the method described above. This procedure was repeated 1000 times to estimate the confidence intervals.

Results

Effort and CPUE

The mail-diary survey revealed that, on average, marine anglers in MV completed 6.3 fishing days per angler and year in 2004. Thereby, owners of annual coastal fishing permits spent 6.8 days, owners of a weekly permit 2.7 days, and owners of a daily permit 2.9 days going fishing per year. Accordingly, the annual numbers of issued coastal fishing permits were corrected. For the purpose of this study, fishing effort in inner coastal waters and targeting herring (*Clupea harengus*) was excluded. In SH, respondents reported angling 9.0 days per year in the German Baltic Sea in 2005 on average. The most popular angling methods by annual permit owners in MV were boat angling, surf angling, and charter-boat angling (Table 4). In contrast to MV, the fishing effort from sea-based angling methods in SH was lower than that from land-based angling methods (Table 4).

The qualitative inquiry of passive gear fishermen in MV revealed that the annual fishing effort for gillnets was 9721, for eel traps 7645, and for longlines 862 fishing days in 2005. No data were collected for SH. Cod were caught exclusively with gillnets. The catch per fishing day was only 1.3 cod.

From the on-site survey data, the CPUE was calculated for the various fishing methods and for each federal state. It is, however, impossible to present all the available information, which would go beyond the scope of this paper. Strikingly, CPUE data varied

Table 4. Average effort (angling days y^{-1}) of anglers with annual, weekly, and daily permits in MV in 2004, and anglers in SH in 2005 in the coastal waters of the German Baltic Sea.

	MV			SH
	Coastal angling permit			
Angling method	**Annual**	**Weekly**	**Daily**	
Surf angling	1.9 (± 0.5/12.5)	1.1 (± 0.9/41.1)	0.5 (± 0.3/26.6)	3.0 (± 0.6/10.7)
Wading	0.6 (± 0.2/17.6)	0.4 (± 0.9/100)	0.1 (± 0.1/100)	2.6 (± 0.7/14.1)
Boat angling	2.3 (± 0.5/10.1)	0.6 (± 0.6/51.5)	1.7 (± 1.4/41.5)	2.6 (± 0.7/12.7)
Charter boat angling	1.7 (± 0.3/9.3)	0.4 (± 0.4(45.4)	0.7 (± 0.4/25.4)	1.4 (± 0.3/10.3)
Trolling	0.1 (± 0.1/44.3)	0.0 (± 0.0)	0.1 (± 0.2/84.7)	0.2 (± 0.1/34.5)
Total	6.6 (± 0.8/6.4)	2.5 (± 1.3/25.9)	3.1 (± 1.4/22.9)	9.8 (± 1.4/7.1)

The 95% confidence limits are in parentheses; the second number is the corresponding relative standard error.

Table 5. CPUE of harvested cod for different angling methods—aggregated by federal states—from 2005–2010.

	State	Charter boat angling	Boat angling	Trolling	Shore angling	Wading
2005	MV	4.5 (± 0.4/4.9)	4.9 (± 0.7/7.4)	7.0 (± 4.6/29.6)	1.7 (± 0.6/17)	0.1 (± 0.1/100)
	SH	9.7 (± 0.4/2.3)	0.6 (± 0.7/57.5)		1.5 (± 0.6/20)	0.3 (± 0.3/49)
	Total	8.4 (± 0.4/2.2)	5.5 (± 0.7/6.6)	7.0 (± 4.6/29.6)	1.6 (± 0.4/13)	0.2 (± 0.2/44.8)
2006	MV	5.4 (± 0.4/4.1)	4.2 (± 0.5/5.6)	4.0 (± 12.7/25)	0.7 (± 0.6/37.3)	0.1 (± 0.1/68.8)
	SH	3.5 (± 0.2/2.7)	1.8 (± 0.8/21.8)		0.5 (± 0.3/31.6)	0.1 (± 0.1/68.8)
	Total	4.1 (± 0.2/2.3)	4.0 (± 0.4/5.6)	4.0 (± 12.7/25)	0.6 (± 0.3/25.3)	0.1 (± 0.1/48)
2007	MV	4.3 (± 0.3/4.0)	3.1 (± 0.5/8.2)	2.0 (± 25.4/100)	1.5 (± 0.2/8.1)	0.07 (± 0.1/69.4)
	SH	2.2 (± 0.2/4.2)	2.8 (± 0.6/11.0)	10.3 (± 13.7/30.8)	0.5 (± 0.3/32.5)	0.03 (± 0.1/100)
	Total	3.1 (± 0.2/3.1)	3.0 (± 0.3/5.8)	7.0 (± 6.8/35.1)	1.4 (± 0.2/8.3)	0.04 (± 0.1/56.9)
2008	MV	5.7 (± 0.7/5.9)	3.3 (± 1.3/19.1)		0.3 (± 0.2/39.0)	0.0
	SH	2.0 (± 0.2/5.7)	2.2 (± 0.6/14.6)	1.0 (± 0.9/36.5)	0.2 (± 0.2/34.8)	0.0
	Total	3.4 (± 0.3/4.7)	2.9 (± 0.8/14.6)	1.0 (± 0.9/36.5)	0.2 (± 0.1/28.1)	0.0
2009	MV	5.7 (± 0.5/4.9)	3.1 (± 0.5/7.8)	1.3 (± 0.8/28.2)	0.7 (± 0.2/18.2)	0.8 (± 1.5/63.8)
	SH	0.9 (± 0.1/4.1)	1.0 (± 0.3/12.3)	1.8 (± 0.8/21.1)	0.5 (± 0.2/19.7)	0.0
	Total	2.6 (±0.2/4.4)	2.3 (± 0.3/7.2)	1.6 (± 0.6/17)	0.6 (± 0.2/13.4)	0.1 (± 0.1/73.9)
2010	MV	5.7 (± 0.4/3.6)	4.6 (±0.8/9.1)	3.9 (± 0.8/9.7)	0.5 (± 0.2/20.5)	0.0
	SH	2.3 (± 0.1/3.2)	3.4 (± 0.6/8.6)	1.3 (± 1.2/43.9)	0.7 (± 0.3/24.8)	0.4 (± 0.2/26.8)
	Total	3.3 (± 0.2/2.7)	4.0 (±0.5/6.4)	2.9 (± 0.7/12.8)	0.6 (± 0.2/17.0)	0.4 (± 0.2/27)

The 95% confidence limits are in parentheses; the second number is the corresponding relative standard error.

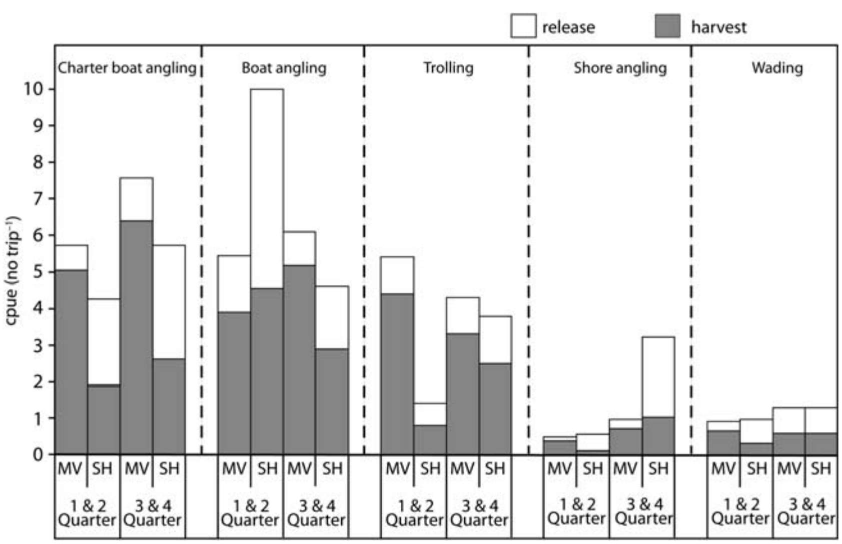

Figure 3. Half-yearly CPUE variations (no. of fish per angling day) of different angling methods in MV and SH in 2010.

considerably between strata, years, and fishing methods (Table 5). As an example, CPUE data – based on on-site surveys in 2010 – are depicted for the different fishing methods (Figure 3).

According to the estimation method, the total numbers of anglers fishing in the German Baltic Sea varied between 126 864 and 143 315 between 2005 and 2010. Thereby, estimations were based on the number of issued angling licences and coastal angling permits (Table 6). The total effort in the Baltic Sea was estimated between 962 907 (2010) and 1 103 134 (2006) angling days distributed among the different fishing methods.

Length and weight distribution

Average weight data were also highly variable between years, SDs, fishing methods, and the first and the second halves of the year, mainly as a consequence of seasonal changes in average length. The average weight of recreational cod catches in 2010 is summarized in Table 7. Thereby, sea-based catches originate from charter boat angling, boat angling, and trolling, whereas land-based catches come from surf angling and wading.

Average weight data to scale up passive-gear fishers' cod catches came from the commercial fishery. In 2005, the mean weight for cod in the western Baltic was 1101g (ICES, 2006) – all age groups weighted by abundance.

Catch

Based on effort data from the mail-diary surveys, the number of issued licences/permits from list frames and CPUE data from on-site sampling catches in numbers varied from 1.8 to 3.7 million cod between 2005 and 2010 (Table 8).

Based on effort data from gillnets, estimated catches from passive gear fishers in MV amounted to 12 500 cod weighing 13.8 t in 2005.

Based on the recreational fishery length samples and the commercial length–weight relationships, annual German cod catches in the Baltic Sea (SD 22 + 24) varied between 2159 t in 2009 and 4127 t in 2005. The total recreational and commercial cod catches from 2005 to 2010 are depicted in Figure 4.

Table 6. Total numbers of estimated anglers by state and total annual estimated effort between 2005 and 2010.

Year	MV anglers (*n*)	SH anglers (*n*)	Total anglers (*n*)	Total effort (angling days y^{-1})
2005	76 453	53 494	129 947	997 427
2006	81 327	61 988	143 315	1 103 134
2007	79 128	55 460	134 588	1 031 124
2008	80 175	56 776	136 951	1 052 515
2009	82 188	57 301	139 489	1 069 231
2010	78 360	48 504	126 864	962 907

An analysis of the calculated harvest data by means of bootstrapping estimated a relative deviation between 14.9% as a minimum and 17.3% as a maximum for the different estimated numbers of landings (Table 9).

Recreational fishery characteristics

The estimated cod harvests (2005–2010) suggest that sea-based fishing methods (85–96%) contribute the most to total recreational fishing mortality of cod compared with land-based fishing methods (4–17%). For example, the distribution of the recreational cod harvest from 2010 was 53% from boat angling, 37% from charter boat angling, 7% from shore angling, 2% from trolling, and 1% from wading. Deviations from this pattern between years were small. Despite similar fishing effort between the two methods – 484 458 sea-fishing days vs. 478 449 land-fishing days in 2010 – land-based fishing methods (surf angling and wading) had no significant effect on the recreational cod harvest. In 2010, sea-based fishing methods were responsible for the majority of released cod (79%). However, in 2009, the majority of released cod came from land-based fishing methods (57%).

In 2010, less than 30% of the sampled charter vessel anglers starting their fishing trip from one of the two coastal states originated from those states. The majority of charter vessel anglers came from bordering states. In the case of MV, 25% came from Brandenburg and 11% came from Berlin; in the case of SH, 16% came from North Rhine–Westphalia, 12% from Lower Saxony, 11% from Hesse, and 7% from Hamburg. The number of anglers fishing from private boats was higher according to the federal states their fishing trip originated from, i.e. 48% in MV and 34% in SH. In MV, the other two major groups of boat anglers originated from Berlin and Brandenburg, 29 and 17%, respectively. In SH, the second biggest group of boat anglers originated from Hamburg (22%). The composition of origin of shore anglers from the two coastal states was nearly equal concerning the majority of anglers, whereby approximately 65% originated from the coastal states itself and 7–17% of the anglers from the respective border states. The rest of the surf anglers originated from the remaining German federal states. Virtually no foreign tourist anglers were encountered during on-site surveys; encounters during the entire study period were limited to only a few people annually (0–14).

Discussion

Survey design and data quality

Although the survey design followed a two-stage approach, the estimation procedure followed a single-stage design, pooling trip

Table 7. Mean lengths and weights of western Baltic cod catches in the German recreational fishery (land- and sea-based) in 2010.

			First half-year		Second half-year	
	Angling method	SD	Length (cm)	Weight (g)	Length (cm)	Weight (g)
Cod harvested	Sea-based	22	47.3	995	48.5	1 303
		24	53.5	1 262	49.9	1 697
	Land-based	22	41.3	657	47.6	1 234
		24	–	–	45.3	1 289
Cod released	Sea-based	22	29.1	226	31.0	354
		24	31.6	248	31.3	450
	Land-based	22	32.3	310	25.2	194
		24	–	–	34.0	569

Table 8. Estimated catches in numbers of recreationally caught cod, divided into harvested and released[1] cod from 2005 to 2010 and by angling method in 2010.

Year	Angling method	Cod harvested (*n*)	Cod released (*n*)	Total (*n*)
2005		3 189 305	340 392	3 529 697
2006		2 037 060	169 999	2 207 059
2007		2 026 611	154 100	2 180 711
2008		1 768 527	123 840	1 892 367
2009		1 518 492	2 246 732	3 765 224
2010	Boat angling	1 214 521	644 121	
	Charter boat angling	758 156	322 015	
	Shore angling	206 452	267 535	
	Wading	50 044	91 974	
	Trolling	47 447	16 886	
	Total	2 276 620	1 342 531	3 619 151

[1]Accurate surveying of released cod was developed in 2008 and introduced to the survey design in 2009.

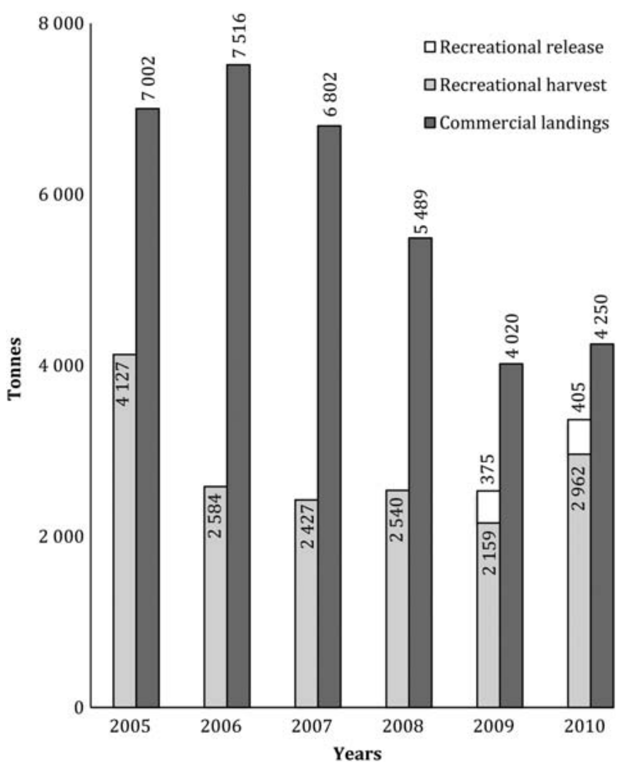

Figure 4. Cod harvest in t y^{-1} in the German Baltic Sea (SD 22 + 24), and total landings in the German commercial fishery (SD 22 + 24) from 2005 to 2010, including recreational cod releases in 2009/2010.

data for a given fishing mode within a federal state and per half-year. We argue that the CPUE data are effectively self-weighting since we are sampling year-round on an annual basis with equal inclusion probability. The current German marine recreational fishing survey incorporates a simple estimation procedure to determine total catch. The future access-point intercept survey will be changed using selection probabilities for each site proportional to activity levels. Accordingly, the estimation method will be changed to reflect the multistage sampling design, i.e. clustering

Table 9. Deviation from total estimates in numbers (and %) of the bootstrap analysis (95% confidence interval, $\alpha = 0.025$) of the estimated annual cod harvest in numbers from 2005 to 2010.

	Minimum estimates ($\alpha = 0.025$)	Maximum estimates ($\alpha = 0.025$)
2005	2 765 127 (−13.3)	3 591 157 (12.6)
2006	1 796 687 (−11.8)	2 283 544 (12.1)
2007	1 809 764 (−10.7)	2 279 937 (12.5)
2008	1 505 016 (−14.9)	2 074 482 (17.3)
2009	1 333 236 (−12.2)	1 718 933 (13.2)
2010	2 010 255 (−11.7)	2 570 304 (12.9)

of trip data (SSU) per site day (PSU) and the use of weights or inverse inclusion probabilities of PSU and SSU.

An important part of this study was based on a mail survey. Therefore, the reliability of the results of this survey was critically reviewed. The non-response rate for the mail survey was in both instances over 90%, and no analysis was carried out to estimate the bias introduced by non-respondents. We are well aware that the low mail survey response rates are below the acceptable response rates of 25% (Groves, 2006). However, these effort estimates were the only available data covering the entire Baltic coast (MV and SH). The bias is strongest when the proportion of non-respondents increases, and if their fishing behavior is different from the respondents (Pollock *et al.*, 1994). Applied to the effort data used, it can be assumed that respondents are the more avid and experienced anglers and non-respondents go fishing less frequently. Connelly *et al.* (2000) compared estimates from a 12-month recall mail survey, non-respondent phone follow-ups, and a quarterly phone survey in a statewide angler survey. They calculated a correction factor of 29%, adjusting for a combined non-response and recall bias, and concluded that failure to adjust may result in overestimates of as much as 25%. One weakness of the present mail survey is the lack of phone follow-ups to estimate non-response bias. A further potential source of bias arises from coverage error associated with the SH mail-diary survey. Thereby, the sample frame consisted of members of organized angling associations in SH, not accounting for non-resident anglers from neighboring states. In order to check for the effect of the non-response bias and coverage error, catch estimates from the present mail-diary survey were compared to those from a telephone-diary-mail survey from Dorow and Arlinghaus (2011). Their 1-year diary survey – from September 2006 until August 2007 – focused on MV only and was based on a nationwide telephone screening using high-quality incentives (gift of an angling reel). In their study, Dorow and Arlinghaus (2011) assigned individual weighting factors to responding diarists based on a representative sample of resident anglers ($n = 566$) to correct for potential non-response and avidity bias. No weighting factor was developed for non-resident diarists due to insufficient sample size of non-resident anglers ($n = 63$). For comparison, we extracted MV data from our mail-diary study using the 2004 effort data and CPUE data from 2007. Total harvest estimates from the telephone-diary-mail survey were found to be unexpectedly higher than those derived from our own mail-diary survey (Table 10).

Although the total harvest estimates of the telephone-diary-mail survey were largely influenced by an overrepresentation of unweighted and, therefore, more avid non-resident anglers, harvest estimates from resident anglers (weighted) still exceeded

Table 10. Comparison between 2007 cod harvest estimates in the recreational fishery in MV, based on the present mail-diary survey and a telephone-diary-mail survey by Dorow and Arlinghaus (2011).

	Mail-diary (this study)	Telephone-diary-mail (Dorow and Arlinghaus, 2011)
Total catch (t)	Harvest total 1 464	Harvest total 3 860 ($\pm$ 1 799) Resident 1 505 ($\pm$ 382) Non-resident 2 355 ($\pm$ 1 417)
Diary participants (n)	574	648
Cod mean weight (kg)	1.3	1.5

Mean weight of cod from the mail-diary survey was calculated using the underlying length distributions of recreational fishery samples for both half-years and the commercial length–weight relationship from 2007.

those from the present mail-diary survey. Consequently, the bias from non-response and undercoverage appears to be of little significance to the harvest estimates from the present mail-diary study, i.e. the non-respondents from the mail-diary survey seemed to be similar to the set of respondents. Our total catch figures of the recreational fishery sector are probably lower-bound estimates, since our estimates of total annual cod harvest from 2007 in MV and SH (2427 t) are lower than the estimated total harvest from Dorow and Arlinghaus (2011) in MV (3860 t). Moreover, our survey did not include anglers without a valid licence, which could result in underestimation of the total harvest (Dorow and Arlinghaus, 2011), and increased harvest estimates of marine recreational fishermen in Denmark by 20% (Sparrevohn and Storr-Paulsen, 2012). A new effort survey is planned to validate/check for changes in the existing effort data. Another source of error that is often mentioned by critiques of recreational fishing surveys is the deliberate misreporting of data. This bias does not only affect the mail survey, and hence effort data, but also the on-site survey estimates of CPUE and length measurements from fishing events. Concerning the mail-survey effort estimates, this bias should be more pronounced for "recalled data" not used in this study and less for the "diary data" used in this study. Concerning the estimates from on-site surveys, this bias is countered by building mutual trust and understanding. First and foremost, this has been done through the establishment of relationships and contacts with district and regional angler associations. Public relations and outreach efforts have included visiting fishing events or association meetings with speaking engagements, writing press releases/comments for angler magazines and internet fora, and the production of annual reports. Of equal importance was the recruitment of local anglers as survey agents in their respective stratum. Since the survey agents are familiar with the local/regional aspects of recreational fishing, they are well accepted by the anglers. This local involvement not only promotes and enables the communication between the survey agent and the respondents, but also increases the response rate of intercepted anglers during on-site surveys, which was approximately 100%, with only few refusals. Without the involvement of local agents, it is uncertain if we would obtain reliable reporting.

A main challenge when conducting the effort survey was the lack of a sampling frame based on an address list. A major improvement in the German marine recreational fishing survey could be achieved if we had access to a complete angler licence file. This problem is intensified, since marine recreational fishing rules and regulations are treated differently by each federal state. Although the state of MV requires a coastal fishing permit, the database only contains the names and birthdates of those who purchased a licence. Moreover, access to this rather limited data is restricted due to confidentiality protection requirements. In the coastal state of SH, the statewide database of fishing licence holders is not up to date, while the number of anglers fishing in the Baltic Sea is totally unknown, since no coastal fishing permit is required. Unfortunately, the latest revision of the fisheries state law in SH has not addressed this issue. These circumstances induce both high survey costs and lead to a higher burden on the data collector. The ability to use administrative data such as registries with complete address lists as sampling frames would allow more cost-effective panel surveys, with reduced sampling errors and less burden on the data collector.

Concerning the land-based angling methods, length distributions were based on data from self-sampling during surf angling events. Since surf fishing is less popular in MV and fishing events are rare, length data from land-based angling methods in SD 24 are often patchy and were replaced in most cases by the length distribution from land-based harvests in SD 22. However, the possible resulting underestimation of land-based harvests is negligible since land-based angling methods were only responsible for 4–17% of the total cod harvest.

Release rates of undersized cod (fish <38 cm, which cannot be landed legally) are relatively high. Selected results showed a release rate of 60% in number and 15% in biomass for 2009, and 37% in number and 12% in biomass for 2010. In fact, the high discard rates in 2009/2010 may be a result of the large 2008 year class, which was the single largest in the time-series from 2005 to 2011 (ICES, 2011). Although we argue that release and discards are not the same, since the mortality rate of released cod caught in the recreational fishery is believed to be relatively low compared to that in the commercial fishery, we acknowledge that release mortality in recreational fishing and bycatch discards in commercial fisheries are considered analogous (Cooke and Cowx, 2004). A pilot project has recently been commenced to estimate mortality rates of released western Baltic cod in order to inform future use of released cod data. Our own observations indicate that mortality rates for land- and sea-based angling methods differ considerably.

The recreational fishery along the German Baltic coast shows spatial variability, evident in recreational cod catches and in the number of released cod. Thereby, the CPUE of the cod harvest increases from west to east. In 2010, the CPUE of cod harvest estimates from angling cutters increased from 2.3 in SH to 5.7 in MV. The CPUE of released cod (mostly undersized cod) showed an opposite pattern (2010: decrease from 2.7 in SH to 1.0 in MV).

The on-site surveys revealed that nearly 70% of charter vessel anglers do not live in the two coastal states bordering the Baltic Sea. For anglers fishing from private fishing boats, this ratio is smaller, yet roughly 52% of the interviewed anglers in MV and 66% in SH were not from these states. Unlike in other countries, such as in Norway, for example (Borch, 2009, Vølstad *et al.*, 2011), angling by non-citizens plays no role in Germany. Consequently, the applied survey design is sufficient to deliver precise harvest estimates of the German marine recreational fishery. However, applied to a country with a significant tourist fishery, an alternative survey approach would be needed to estimate the tourist harvest. Marine recreational fishing, and particularly non-resident fishing tourists, are known to have a strong impact on the local economy, i.e. travel costs, expenses for fishing trips, off-vessel expenditures, and economic multiplier effects (Pawson *et al.*, 2008). The potential economic importance of the marine recreational fishing sector is also illustrated by the estimated number of 126 864 marine anglers in 2010, compared to the German commercial fishery in the Baltic Sea with 1232 fishing vessels <12 m employing 1549 fishers, and 105 fishing vessels >12 m employing 152 fishers in 2010 (BMELV, 2012).

Implications for management

The survey revealed that the recreational fishery removes a considerable amount of cod from the western Baltic cod stock. In comparison to the German commercial cod fishery in SD 22 and 24, the recreational fishery harvest of western Baltic cod amounted to between 34 and 70% of the commercial fishery landings (Figure 4). The effect of this is twofold: (i) a currently unaccounted fishing mortality (recreational F), and (ii) an underestimation of stock productivity. Thereby, the recreational fishery does not compete with the commercial fishery, but if included in the stock assessment, the perceived stock productivity increases proportionately to recreational catches. The findings highlight the importance of including recreational catch data in the western Baltic cod stock assessment and subsequently in the management of the stock. Even more important from a stock assessment and management point of view is the variability in the recreational cod catches. Ideally, if the recreational catches were constant over time or proportional to the commercial catches, one could argue that the productivity of the stock could just be scaled accordingly. In this case, it would be sufficient to test for stability or proportionality in larger intervals, and management advice could still be given for the commercial fishery only. However, recreational catches are highly variable (between 2159 and 4127 t annually) and seem to be independent from the commercial catch, which is—in contrast to the recreational catch—constrained by catch and effort limits. The reason for this variability and independence from the commercial catch is likely the availability of fish to anglers. Juvenile cod are mostly found in shallow waters (Hüssy, 2011), so when a stronger year class enters the fishery, there is more cod accessible to anglers in coastal waters. Moreover, there are clearly more anglers than commercial fishers exploiting the coastal waters. Besides, the coastal commercial fishery using passive gear is highly size-selective, and thus will not catch juvenile cod proportionally to anglers. This variability adds a large amount of uncertainty to stock assessment and forecast, impeding the management of fish stocks according to the principle of maximum sustainable yield. The only solution to this problem is annual precise recording of the recreational catch, and catch composition, as input into the stock assessment.

Furthermore, it should be noted that the introduction of a total allowable catch (TAC) for the recreational fishery would require a high monitoring effort to be effective. In light of the current multiannual management plan for the cod stocks in the Baltic (CEC, 2007), the specification of a target fishing mortality rate (target *F*) fails to include the recreational fishing mortality. Recreational fishery catches of western Baltic cod should be included in the assessment, stratified in age groups according to the length distributions acquired in the on-site recreational fishing survey. This approach would allow estimating the recreational *F*. In a next step, the recreational *F* could be used to calculate a new target *F* for a new and revised multiannual management plan.

The question of how to handle a new, and possibly higher, calculated total yield using the data from the recreational fishery, as described above, requires thoughtand discussion, since this could have considerable impact on how political decision-makers view the scientific advice provided annually by ICES. One needs to be aware that higher TACs due to a higher perceived stock productivity raise the question of how to distribute them between EC Member States, and may touch upon the Common Fisheries Policy's principle of relative stability. Subsequently, this will initiate a debate on resource allocation between the commercial and recreational fisheries sectors. However, the recent proposal for the establishment of a multiannual plan for the Baltic salmon stocks and the fisheries exploiting that stock (CEC, 2011), where recreational catches are counted against the commercial catches and the national quota, could act as a precedent for future cases and cause conflict. Counting the recreational catches against the commercial fishery quota is futile and counterproductive because it supports the general misconception that recreational and commercial fishers compete for the same quota. As described above, present catch limits and quota allocations are solely based on commercial fishery data. The inclusion of recreational fishery data in stock assessments would result in increased estimates of productivity, and a resulting higher catch limit. Only after implementation of this higher catch limit would it be feasible to count the recreational catches against the national commercial quota. However, we do not advocate applying this management approach to recreational fisheries. To safeguard against the issue of quota allocation and avoid conflict over access to resources, recreational fishery catches could be added into the stock assessment, but then subtracted from the total potential yield, so that the resulting numerical advice would still only refer to commercial catches. An intermediate solution would be to deduct the expected recreational catch annually from the projected yield. This projection could include information on year-class strength, thus incorporating some of the variability. The remaining part would be accessible to the commercial fishery. The expected recreational catch would be corrected in the following year by survey estimates. With this approach, there would be virtually no impediment for the recreational fishery, while safeguarding the development of the stock. The commercial fishery could, however, perceive such an approach as unfair privilege to the recreational fishery. In light of these new developments, we envision recreational management measures that create fairness between the two resource user groups and document the willingness of the recreational fishery to participate in the sustainable management of the cod stock.

It might be desirable to minimize the pronounced interannual variability in recreational catches. Possible attempts to do so include bag limits, gear restrictions, and seasonal and spatial closures, but they all have the potential to jeopardize the recreational fishing sector, while at the same time showing limited effect in most instances (Cox *et al.*, 2002). A recent study by Post and Parkinson (2012) demonstrated that management actions intended to reduce angling efficiency can only be successful when total fishing effort is low. Their model showed that even the most restrictive bag limit of one fish per day could not prevent collapse. The reason for this is that—in fisheries at intermediate distances to population centres—additional anglers act as an influx and replace any angler terminating his activities once the bag limit is reached (Post and Parkinson, 2012). A similar situation may be assumed for the western Baltic cod stock fishery in the German portion of the Baltic Sea, since the human population size in Germany is high; angling effort is distributed over a large geographical scale and largely originates from distant federal states. We advocate being cautious with the introduction of new management measures, whose economic effects are largely unknown. In particular, the charter boat fishery is largely dependent on angling tourists, who go fishing with the ulterior motive to catch a lot of fish, although, on average, only 4.6 cod per day per angler were harvested in the study period. Furthermore, harvest monitoring of the private boat sector, responsible for 37–53% of the total cod harvest, would induce huge administrative costs and effort, not taking into account noncompliance issues (Gigliotti and Taylor, 1990; Sullivan, 2002, 2003). However, choosing a bag limit affecting only a small proportion of the anglers, while at the same time not affecting the for-hire sector, could lessen the recreational harvest variability. Simple calculations showed that a daily bag limit of 9 cod per angler in 2005 would have affected only 11% of the anglers, but would have reduced the harvest by 33%. In subsequent years, the effect on the harvest would have been less (approximately 10%), but also the number of affected anglers (approximately 5%). Determining the optimal bag limits—minimum impact of affected anglers with maximum harvest reductions in years with strong recruitment—could be determined using simple models. Nevertheless, the implementation of such bag limits might meet strong resistance by the recreational fishing community and risk raising anglers' expectations (Cook *et al.*, 2001; Radomski *et al.*, 2001).

In addition to the catch limit and a number of technical regulations, the commercial fishery is also regulated by a closed period meant to protect spawning aggregations. There is an ongoing debate on the effect of this spawning closure; however, it should be noted that the closure does not apply to the recreational fishery. This circumstance is also the impetus for disputes within the German recreational fishing community about whether to introduce a closed season during spawning. An evaluation of the multiannual management plan should explore the possibility of expanding the closed periods covering both the commercial and recreational fisheries. This would not only benefit the stock, but also ensure equitable commercial and recreational access to fisheries resources.

But when is active management of a recreational fishery necessary, and what defines the good status of a recreational fishery (Pereira and Hansen, 2003)? Foremost, one needs to be aware not to apply commercial management measures and objectives to recreational fisheries (Radomski, 2003). Recreational management objectives are more about angling quality and less about yield per recruit; thus, larger stocks with a biomass greater than that delivering the maximum sustainable yield (MSY) are desirable (Cox *et al.*, 2003; Radomski, 2003; Pereira and Hansen, 2003; Hussain and Tschirhart, 2010; Post and Parkinson, 2012). In other words, the angling effort that produces MSY may differ from the level that provides maximum total satisfaction (Cox *et al.*, 2003). In their model-based evaluation of active management of recreational fishing effort, they identify the catch rate or CPUE as an indicator of angling quality, and conclude that angler attitudes towards different management options need to be incorporated in the decision-making process. Ultimately, the predator–prey dynamics unique to recreational fisheries, i.e. spatial and temporal dynamics of angling effort, fish abundance, and fishery utility, act as a primary source of uncertainty in recreational fisheries management (Pereira and Hansen, 2003). The same authors point out that recreational fisheries also have a tendency to be self-regulating, i.e. when CPUE declines, anglers leave the fishery. One of the main challenges in developing effective recreational fishery management in the Baltic Sea is incorporating the various aspects mentioned above in an adaptive management context to allow for adjustments.

Conclusion

Fishery agencies are mandated to ensure the sustainable use of fishery resources. The basis for management decisions is scientific advice, which is based on annual stock assessments and catch forecasts. The high cod harvest estimates from the recreational fishery recommend incorporating these data in the stock assessment and multiannual management plan. Therefore, fishery managers require biological and sector information regarding marine recreational fishing. The multistage survey design, with its stratified random sampling, guarantees the effective monitoring of recreational fishing activities over a large geographical scale. The high spatial and temporal variation of CPUE data, as well as the variability between the different angling methods, requires conducting yearly on-site surveys. The estimation procedure must reflect the complexity of the survey design.

The relatively high numbers of released cod require subsequent studies to determine the rate of release mortality. The survey underlines the (economic) importance of the recreational fishery sector and highlights its importance as an interest group. Because the Baltic cod stocks are recovering, the time could never be better to engage in a public discourse on recreational fishery management options. As such, one could envision that recreational fishing could act as a qualitative indicator of good environmental status, MSY, and maximum angling satisfaction in the present development of the European Marine Strategy Framework Directive.

Acknowledgements

We thank the thousands of anglers who were contacted in the field surveys, and the survey agents who conducted the interviews. The annual survey benefited tremendously from the length measurements provided by angling associations and guides. We would like to thank the members for their cooperation and their interest in this work. Particular thanks go to Olga Goni and Tino Schmedemann for setting up the database and developing the queries.

Funding

This work was cofunded by the European Commission's Data Collection Framework.

References

BMELV. 2012. Die deutsche Fischereiflotte nach Bundesländern (Stand: 1. Januar 2011). Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, Bonn, Germany. www.bmelv.de (last accessed 26 March 2012).

Borch, T. 2009. Contested coastal commercialisation: marine fishing tourism in Norway. MAST Maritime Studies, 8: 33–51.

Brämick, U. 2010. Jahresbericht zur Deutschen Binnenfischerei 2010. Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, Bonn, Germany. 50 pp. www.portal-fischerei.de (last accessed 6 August 2012)

CEC. 2001. Commission Regulation (EC) 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) 1543/2000.

CEC. 2004. Commission Regulation (EC) 1581/2004 of 27 August 2004 amending Regulation (EC) 1639/2001 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) 1543/2000.

CEC. 2007. Council Regulation (EC) 1098/2007 of 18 September 2007 establishing a multiannual plan for the cod stocks in the Baltic Sea and the fisheries exploiting those stocks, amending Regulation (EEC) 2847/93 and repealing Regulation (EC) 779/97.

CEC. 2011. Proposal for a Regulation of the European Parliament and of the Council establishing a multiannual plan for the Baltic salmon stock and the fisheries exploiting that stock. COM (2011) 470 final – 2011/0206 COD.

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.

Connelly, N. A., Brown, T. L., and Knuth, B. A. 2000. Assessing the relative importance of recall bias and nonresponse bias and adjusting for those biases in statewide angler surveys. Human Dimensions of Wildlife, 5: 19–29.

Cook, M. F., Goeman, T. J., Radomski, P. J., Younk, J. A., and Jacobson, P. C. 2001. Creel limits in Minnesota: a proposal for change. Fisheries, 26: 19–26.

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

Cox, S. P., Beard, T. D., and Walters, C. 2002. Harvest control in open-access sport fisheries: hot rod or asleep at the reel? Bulletin of Marine Science, 70: 749–761.

Cox, S. P., Walters, C. J., and Post, J. R. 2003. A model-based evaluation of active management of recreational fishing effort. North American Journal of Fisheries Management, 23: 1294–1302.

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. Proceedings of the 5th World Recreational Fishing Conference. American Fisheries Society, Symposium 75, pp. 319–344. Ed. by T. D. Beard, Jr., R. Arlinghaus, and S. G. Sutton. Bethesda, MD.

Gigliotti, L. M., and Taylor, W. W. 1990. The effect of illegal harvest on recreational fisheries. North American Journal of Fisheries Management, 10: 106–110.

Groves, R. M. 2006. Nonresponse rates and nonresponse bias in household surveys. Public Opinion Quarterly, 70: 646–675.

Hussain, A. M. T., and Tschirhart, J. 2010. Optimal harvest licensing when harvest success is uncertain. American Journal of Agricultural Economics, 92: 125–140.

Hüssy, K. 2011. Review of western Baltic cod (*Gadus morhua*) recruitment dynamics. ICES Journal of Marine Science, 68: 1459–1471.

ICES. 2006. Report of the Baltic Fisheries Assessment Working Group (WGBFAS), 18–27 April 2006, Rostock, Germany. ICES Document CM 2006/ACFM: 24. 640 pp.

ICES. 2011. Report of the ICES Advisory Committee on Fishery Management, 2011. ICES Advice, 2011. Book 8. 135 pp.

Lehtonen, R., and Pahkinen, E. 2004. Practical Methods for Design and Analysis of Complex Surveys, 2nd edn. John Wiley & Sons Ltd, Chichester, West Sussex. 349 pp.

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

Pereira, D. L., and Hansen, M. J. 2003. A perspective on challenges to recreational fisheries management: summary of the symposium on active management of recreational fisheries. North American Journal of Fisheries Management, 23: 1276–1282.

Pollock, K. H., Hoenig, J. M., Jones, C. M., Robson, D. S., and Greene, C. J. 1997. Catch rate estimation for roving and access point surveys. North American Journal of Fisheries Management, 17: 11–19.

Pollock, K. H., Jones, C. M., and Brown, T. L. 1994. Angler survey methods and their applications in fisheries management. American Fisheries Society, Special Publication 25, Bethesda, MD.

Post, J. R., and Parkinson, E. A. 2012. Temporal and spatial patterns of angler effort across lake districts and policy options to sustain recreational fisheries. Canadian Journal of Fisheries and Aquatic Sciences, 69: 321–329.

Radomski, P. 2003. Initial attempts to actively manage recreational fishery harvest in Minnesota. North American Journal of Fisheries Management, 23: 1329–1342.

Radomski, P. J., Grant, G. C., Jacobson, P. C., and Cook, M. F. 2001. Visions for recreational fishing regulations. Fisheries, 26: 7–18.

Shao, J., and Tu, D. 1996. The Jackknife and Bootstrap. Corr. 2nd printing. Springer, New York. 516 pp.

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.

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. Active management of walleye fisheries in Alberta: dilemmas of managing recovering fisheries. North American Journal of Fisheries Management, 23: 1343–1358.

Vølstad, J. H., Korsbrekke, K., Nedreaas, K. H., 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. 2011. Comparison of sea-based recreational and commercial cod catches in the German Baltic Sea. Poster presentation at the 6th World Recreational Fishing Conference, 1–4 August 2011, Berlin.