Angler behaviour and implications for management - catch-and-release among marine angling tourists in Norway

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Abstract The role of recreational fisheries in the competition for marine resources is increasingly recognised. Their contribution in stock dynamics needs to be accounted for in assessments and management. Management regulations should be based on scientific advice on human and biological dimensions to be effective in reaching their goals. A survey among marine angling tourists staying in fishing camps in two study areas in Norway was conducted to study catch-and-release (C&R) behaviour. Although C&R has been assumed to be low in many marine recreational fisheries, this survey showed that for some species, more than 60% of the catch was released. As C&R may be associated with post-release mortalities, the current management system could be inefficient towards its aim of reducing fishing mortality. It was concluded that it is necessary to quantify release mortalities, to consider C&R behaviour in future management decisions, and to minimise the potential negative impacts of C&R through handling guidelines.

Keywords: fishing mortality, harvest regulations, human dimensions, marine angling tourism, recreational fisheries management.

Introduction

Recreational fisheries are expanding in many parts of the world, and their role in the exploitation of fish stocks is increasingly recognised (Coleman et al. 2004; Arlinghaus & Cooke 2005). Ignoring the potential impact from recreational fishing in management may have unaccounted consequences for economically and ecologically important fish stocks (Cooke & Cowx 2004, 2006; Lewin et al. 2006). It is therefore equally as important to implement management measures for recreational fisheries as it is for commercial fisheries (Post et al. 2002). To avoid undesirable or unintended effects, these measures should be based on scientific advice on both human and biological dimensions (Johnson & Martinez 1995). As anglers do not necessarily act according to intended management objectives (Sullivan 2003a), there is a particular need for a focus on angler behaviour (Beardmore et al. 2011). For example, if the management of a fishery is based on harvest regulations and/or
minimum length limits, and the practice of catch-and-release (C&R) and its associated post-release mortality are high (Bartholomew & Bohnsack 2005), such regulations may be ineffective in meeting the objectives of reducing fishing-induced mortality (Coggins et al. 2007).

There are two main categories of C&R: regulatory C&R as a response to management regulations, and voluntary C&R where fish that legally could be kept are released consciously (Arlinghaus et al. 2007). Voluntary C&R may be practised for several reasons, for example, because of ethical considerations (Cooke & Sneddon 2007) or simply because the fish does not satisfy the angler’s desires, such as size or taste (Policansky 2008). Another reason for voluntary C&R is to conserve the fish stock while still pursuing the hobby of fishing (Arlinghaus et al. 2007). If all viable fish are released (voluntarily and/or because of regulations), then the term total C&R is used (Arlinghaus et al. 2007).

Cooke and Cowx (2004) estimated, based on extrapolations from Canadian recreational fisheries data, that roughly 60% of all global recreational catches are released, which may be in the order of 30 billion released fish per year. While the practice of voluntary C&R for many popular freshwater species in the United States has a long tradition, the practice is relatively rare for many targeted US saltwater species (Salz & Loomis 2005). However, Bartholomew and Bohnsack (2005) showed that C&R is beginning to gain increased popularity in marine recreational fisheries, as 57% of the total catch was released or discarded (return of dead or severely injured fish) by US marine anglers in 2000.

In Norway, voluntary C&R is an increasingly common practice for freshwater anglers targeting Atlantic salmon, Salmo salar L., (Aas et al. 2011) and there are several publications dealing with the impact of C&R on this species (Thorstad et al. 2003, 2007; Halltunen et al. 2010). In marine recreational fisheries research in Norway, the main attention has been on estimating the harvest (landed catch), and no studies have quantified the degree or evaluated the impact of C&R practice in this fishery. One possible reason is that the domestic marine recreational fishery in Norway is by tradition mainly consumptive oriented.

An increasingly important part of the Norwegian marine recreational fishery is angling tourism by mainly non-Norwegian anglers (Borch et al. 2011). This sector has expanded rapidly during the past two decades and has become economically important for many coastal communities (Cap Gemini Ernst &Young 2003; Hallenstvedt & Wulff 2004; Borch 2009; Borch et al. 2011). Until 2006, marine angling tourism was largely unregulated as the only restriction since 1997 was the requirement of using only hand-held tackle by foreign marine angling tourists. However, a decline in Norwegian coastal cod stocks, Gadus morhua L., coinciding with assumed high harvest by marine angling tourists (Hallenstvedt & Wulff 2001), led to a debate on the necessity to further regulate the marine angling tourism industry. Norwegian coastal cod is genetically distinct from the Northeast Arctic cod and found in the fjords and along the coastline of Norway (Stransky et al. 2008). Following the stock decline, the International Council for the Exploration of the Sea (ICES) recommended zero catches of coastal cod north of 62° N (ICES 2010) from 2004, and the stock was subsequently added to the Norwegian Red List as endangered (Kålås et al. 2006). As part of the rebuilding plan and management for Norwegian coastal cod (ICES 2011), the export of marine fish caught by angling tourists was restricted to 15 kg of fillet or other fish products per person in 2006 (Fiskeridirektoratet 2010a). Borch (2009) argued that the implementation of this regulation was largely because of stakeholder pressure from the commercial fishery, as there was insufficient scientific information, for example, on the number or motivations of marine angling tourists, on which the decision could have been based. In 2010, minimum length sizes for selected species (Table 1) were implemented for marine recreational fisheries, including the tourist fishery (Fiskeridirektoratet 2010b).

Vølstad et al. (2011) estimated the total harvest of all species in the marine tourist angling business sector, that is, all commercialised tourist angling enterprises, at 3335 t during 2009, of which 1613 t were cod. They showed that cod was the most common harvested species north of 62° N, whereas saithe, Pollachius virens (L.), and mackerel, Scomber scombrus L., dominated the harvest south of 62° N (details in Vølstad et al. (2011)). The estimated daily average catch for the whole country ranged from 7 to 27 kg, depending on the season, but the highest reported daily catches per boat were above 200 kg in Northern Norway. The total commercial harvest of coastal cod by the Norwegian coastal fishery was around 24 821 t in 2009, and Vølstad et al. (2011)

**Table 1.** Minimum length sizes for the most important target species in the Norwegian marine recreational fishery

<table>
<thead>
<tr>
<th>Region</th>
<th>Cod (cm)</th>
<th>Haddock (cm)</th>
<th>Halibut (cm)</th>
<th>Ling</th>
<th>Saithe (cm)</th>
<th>Tusk</th>
</tr>
</thead>
<tbody>
<tr>
<td>North of 62° N</td>
<td>44</td>
<td>40</td>
<td>80</td>
<td>None</td>
<td>45*</td>
<td>None</td>
</tr>
<tr>
<td>South of 62° N</td>
<td>40</td>
<td>31</td>
<td>80</td>
<td>None</td>
<td>40*</td>
<td>None</td>
</tr>
</tbody>
</table>

* There are no minimum length sizes for saithe when used as bait or for private consumption.

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concluded that the harvest of coastal cod by marine angling tourists was insignificant in comparison.

It has been shown that the implementation of minimum lengths and bag limits can lead to an increased practice of C&R for regulated species (Harper et al. 2000). Considering the introduction of the new regulations for marine angling tourists in Norway, the question arises whether their actual catch is higher than the estimated harvest because of C&R and whether there is a hidden mortality (i.e. release mortality; Bartholomew & Bohnsack 2005; Coggins et al. 2007) that needs to be accounted for (Clark 1983). Moreover, Ditton et al. (2002) suggested that angling tourists are generally more specialised than the average domestic recreational fishers because they invest time and money to go fishing abroad. Other studies showed that there is a high variation in the motivation and preferences among anglers (Bryan 1977; Graefe 1980; Hunt & Ditton 2002) and that specialist anglers may be less consumptive oriented than other groups (Fedler & Ditton 1986; Oh & Ditton 2006). It is therefore possible that marine angling tourists in Norway are more engaged in C&R fishing than generally assumed for Norwegian marine recreational fishermen, which could have implications for the management.

The aim of this paper is to estimate and better understand the practice of C&R within the marine angling tourism sector in Norway, and to demonstrate the importance of including knowledge about C&R behaviour and motivation in recreational fisheries management.

Materials and methods

Study sites

Field studies to assess the practice of C&R by marine angling tourists were conducted in two study areas: (1) the county of Hordaland (southern study area) and (2) the counties of Nordland and Troms (northern study area), where the focus was on the tourist angling business sector. A tourist angling business was defined as an enterprise renting out rooms and boats for recreational fishing at sea and with facilities for gutting and freezing catches (Vølstad et al. 2011). Vølstad et al. (2011) identified 445 tourist angling businesses in Norway, of which a stratified random sample of 91 businesses provided data in the harvest survey in 2009. For this study, a subsample of seven tourist angling businesses in the northern study area and five businesses in the southern study area of the 91 businesses were re-visited during the summer tourist seasons in 2010 and 2011 (Fig. 1). The subsamples of businesses were selected systematically to provide the best spatial coverage of the two study areas within the given time-frame and budget and were used as access points for intercepting and interviewing marine angling tourists (Pollock et al. 1994).

Access-point survey

The subsample of seven businesses (sites) in the northern study area was visited twice during each of the peak tourist seasons in 2010 and 2011. Sampling days were determined prior to the visits so that each of these businesses could be observed for at least 24 h within a time frame of 3 weeks, starting the second Monday of the month. Thus, site-days (Pollock et al. 1994) formed the primary sampling units (PSUs). The duration of the sampling period per business ranged from 24 to 72 h, depending on angler fishing effort and weather conditions. The subsample of five businesses (sites) in the southern study area was visited from one to three times during each of the peak tourist seasons in 2010 and 2011. After the sampling days were scheduled, the businesses to be sampled on a selected day were randomly selected from the subsample with replacement (Pollock...
et al. 1994). One interview per angling group, that is, for the entire group of anglers on one boat, was conducted during each visit to an access-point. Thus, the interviewed angling groups (fishing trips) within a selected site and day formed the secondary sampling units (SSUs) (Cochran 1977).

A questionnaire of 14 questions (in English, Norwegian, or German) was used for the on-site interviews immediately after the fishing trip was completed. The questions asked for the number of anglers in the angling group, the duration of the last fishing trip, and the targeted species. Moreover, it was asked whether any fish were caught, and if yes, how many individuals of each species were kept and how many individuals of each species were released. If one or several species were released, the reasons for release were asked separately for each species (not per individual fish) as an open-ended question. The reasons given for release were grouped into the categories too many fish, do not like, total C&R, too big, too small and minimum length size. For example, if an angling group said that the fish were not big enough without giving further details, this answer was assigned to the category too small, but if the angling group said that fish were consciously released because of the minimum length regulation, the answer was assigned to the category minimum length size. Additionally, each angling group was tested on the knowledge of minimum length regulations, and demographic information was collected. Either the entire angling group or one spokesperson for the group was interviewed. The response rate for the angling groups that were approached for an interview was 100% in the northern study area and 97.9% in the southern study area.

Analytical methods

Design-based estimators (Cochran 1977) were used to estimate the proportions of fish that were released by species, the proportions of angling groups that released fish by motivation category and the proportion of angling groups that knew about the cod minimum length. For the analysis, it was assumed that the site-days sampled in each study area formed a simple random sample. It was further assumed that for the $i^{th}$ PSU ($i = 1, \ldots, n$), the sample of $m_i$ fishing trips was a random sample from a set of all $M_i$ fishing trips at site-day $i$. As the number of SSUs differed among the PSUs, a ratio estimator (Cochran 1977) was used to estimate population proportions. To estimate the true mean release proportion $\hat{p}$ over all site-days in a study area, the following formula was used:

$$\hat{p} = \frac{\sum_{i=1}^{n} M_i \times \bar{r}_i}{\sum_{i=1}^{n} M_i \times \bar{c}_i}$$ (1)

where $\bar{r}_i$ is the estimated mean number of fish released and $\bar{c}_i$ is the estimated mean total catch in numbers across all trips at site-day $i$. Because only a small fraction of all possible site-days was sampled, the variance of (1) was estimated based on the PSU only (Cochran 1977; Williams 2000). A similar ratio estimator was used to estimate the other proportions, that is, proportion of anglers. The survey package (Lumley 2004) in R (version 2.11.1, R Development Core Team 2010) was used to analyse the survey data. The analysis was carried out separately for the northern and the southern study area, but the data collected for 2010 and 2011 were pooled as the anglers showed similar C&R behaviour between the 2 years. Although the number of retained and released fish was recorded for all species, this paper only reports the release rates for species that are commonly caught in both study areas. In addition to the estimation of release proportions for all angling tourists staying in tourist angling businesses in the two study areas, the release proportions were calculated by nationality for both study areas.

Statistical significance in the differences between the estimated release rates for all analysed species in the northern and southern study area were tested using the standard method (Schenker & Gentleman 2001) with a 95% confidence level. The standard method tests the null hypothesis that two estimates are equal by examining whether the nominal 95% confidence interval of the difference contains zero.

Results

Release proportions in the business sector of the two study areas

Release proportions varied by species and study area (Fig. 2). Generally, the release rates were higher in the northern study area than in the southern study area. Release of cod was similar between study areas, with 66% (SE: 4%) and 62% (SE: 8%) of captured cod released in the north and south, respectively. The release rates of saithe, haddock, Melanogrammus aeglefinus (L.), tusk, Brosme brosme (Ascanius), and ling, Molva molva (L.), differed significantly between the study areas (standard method). The highest release rates were recorded for saithe (78%; SE: 7%) in the north. In the southern study area, 41% (SE: 16%) of the captured

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saithe were released. While in the northern study area, 71% (SE: 6.0%) of the captured haddock were released and only 23% (SE 9.0%) were released in the south. Another significant difference was found for the release rates for ling, as 48% (SE: 6%) of the captured ling were released in the north, but only 1% (SE: 1%) were released in the south.

Release proportions by nationality in the northern study area

There was an indication that the release proportions varied by nationality, but no final conclusions could be drawn because of low sample sizes for several nationalities (Table 2). Generally, Eastern European angling tourists seemed to release a lower proportion of their catch than angling tourists of other nationalities. Angling tourists from the Scandinavian countries and from Central and Western Europe released less than Dutch, Finnish and British angling tourists in the northern study area. German angling tourists in the northern study area released around twice as much as Germans in the southern study area.

Table 2. The number of interviewed angling groups, and the reported number of all fish harvested, fish released, and fish caught by nationality in the business sector of the northern and southern study-area during the surveys in 2010 and 2011. The nationalities are ordered according to the calculated release percentages in ascending order.

<table>
<thead>
<tr>
<th>Region</th>
<th>Nationality</th>
<th>nangling groups</th>
<th>nharvested</th>
<th>nreleased</th>
<th>ncaught</th>
<th>Percent released</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern study-area</td>
<td>Lithuanian</td>
<td>1</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Russian</td>
<td>4</td>
<td>45</td>
<td>17</td>
<td>62</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Austrian</td>
<td>4</td>
<td>56</td>
<td>28</td>
<td>84</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Polish</td>
<td>1</td>
<td>10</td>
<td>11</td>
<td>21</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>Slovakian</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>9</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>Swiss</td>
<td>3</td>
<td>51</td>
<td>76</td>
<td>127</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Estonian</td>
<td>4</td>
<td>69</td>
<td>104</td>
<td>173</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Norwegian</td>
<td>10</td>
<td>82</td>
<td>132</td>
<td>214</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>Danish</td>
<td>4</td>
<td>32</td>
<td>62</td>
<td>94</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td>German</td>
<td>25</td>
<td>289</td>
<td>575</td>
<td>864</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>French</td>
<td>3</td>
<td>53</td>
<td>108</td>
<td>161</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>Swiss</td>
<td>56</td>
<td>750</td>
<td>1594</td>
<td>2344</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>Dutch</td>
<td>8</td>
<td>163</td>
<td>456</td>
<td>619</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>Finnish</td>
<td>10</td>
<td>54</td>
<td>410</td>
<td>464</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td>British</td>
<td>3</td>
<td>17</td>
<td>202</td>
<td>219</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>Belarusian</td>
<td>1</td>
<td>0</td>
<td>20</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>138</td>
<td>1705</td>
<td>3800</td>
<td>5505</td>
<td>69</td>
</tr>
<tr>
<td>Southern study-area</td>
<td>Polish</td>
<td>1</td>
<td>62</td>
<td>6</td>
<td>68</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Russian</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Austrian</td>
<td>2</td>
<td>25</td>
<td>7</td>
<td>32</td>
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</tr>
<tr>
<td></td>
<td>German</td>
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<td>1481</td>
<td>808</td>
<td>2289</td>
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<tr>
<td></td>
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<td>4</td>
<td>3</td>
<td>7</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>Norwegian</td>
<td>4</td>
<td>39</td>
<td>68</td>
<td>107</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>Swedish</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>Danish</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>94</td>
<td>1616</td>
<td>898</td>
<td>2514</td>
<td>36</td>
</tr>
</tbody>
</table>
**Reasons for releasing fish**

In the northern study area, the release motivations were different for different species (Fig. 3). One of the main reasons for releasing fish was that the captured fish were too small. It was estimated that 64% of the angling groups released saithe and 60% released cod because they were too small. About one-third of the angling groups gave this reason for releasing tusk (36%) and haddock (35%). While three quarters (74%) of the angling groups stated that they had released ling because they were too small, one-fifth (17%) named the practice of total C&R as a reason for releasing this species. Total C&R was also named as a release reason for haddock, cod, saithe and tusk. Regarding tusk, more than half of the angling groups released this species because they do not like it. This reason was also given for haddock, ling, saithe and cod. Another motivation for releasing fish was that the angling groups already had too many. This reason was stated for saithe (10%), cod (9%), haddock (5%) and tusk (4%). 10% of the angling groups released cod because they were under the minimum length, 9% of the angling groups released haddock for this reason, and 1% of the angling groups released saithe for this reason. Surprisingly, a small fraction (2 and 1%, respectively) of the angling groups released saithe and cod, because they were too big, that is, too big for being used as bait in the case of saithe and too big for being used for consumption in the case of cod.

The relatively low percentage of angling groups that stated that minimum length was a reason for releasing cod is in line with the estimated proportions of angling groups who actually knew the exact minimum length for cod. Although 88% (SE: 2%) of the angling groups in the northern study area claimed to know that there were minimum length regulations for angling tourists, only 29% (SE: 7%) of those who released cod actually knew the correct minimum length.

In contrast to the northern study area, the release motivations in the south were similar for different species. None of the respondents mentioned total C&R or too big as an explanation for release in the southern study area (Fig. 3). For all species, the most important release motivation in the south was that fish were too small; for haddock and ling, this was the only release reason. Thirteen per cent of the angling groups in the south released cod because they were under the minimum length. A small proportion (13%) released tusk because they do not like it; 6% released saithe because they already had too many.

**Discussion**

This study found that for various reasons, a substantial proportion of the catch is released by marine angling tourists staying in tourist angling businesses in two study areas in Northern and Southern Norway. Incidental practice of C&R in the Norwegian marine angling tourism was mentioned by Hallenstvedt and Wulff (2004), but this study is the first to estimate the degree of and reasons for C&R. Although C&R is relatively uncommon for many targeted US saltwater species (Salz & Loomis 2005) and in many parts of Northern Europe release rates can approach 0% if fish caught are used for human consumption (Arlinghaus et al. 2007), this study found that marine angling tourists in Norway release a large proportion of their catch. This indicates that C&R practice is not only common in freshwater recreational fisheries, but that there is also a need to include C&R in research and management of European marine recreational fisheries.

**Sources of bias**

Due to logistical and cost constrains, it was not feasible to visit a simple random sample of businesses and site-days from each study area. The data could be biased if,
for example, only businesses that cater to certain angling groups were chosen. However, the businesses visited in each study area were a subset from a list of randomly selected businesses included in the 2009 harvest survey. The businesses included in this study were chosen systematically to provide the best spatial coverage in each area within the available travel time. It is therefore argued that the angling groups interviewed are representative for tourist anglers staying in tourist angling businesses in each study area. The release rates of local recreational fishermen and those of angling tourists staying in alternative accommodations, for example, private cottages may, however, be different, and were not part of this study.

In access-point surveys, the catch landed can be measured without recall bias or prestige bias (exaggeration of fish number and size), and fish are identified by scientific staff (Pollock et al. 1994). The estimation of the total catch (released fish included) is more likely to be biased because one has to rely on the anglers’ recollection about the species and number of fish that were released (National Research Council 2006). When many non-memorable fish are released, the bias can be substantial (Pollock et al. 1994). Sullivan (2003b) compared the ratios of undersized and legal-sized walleye, Stizostedion vitreum (Mitchell), reported by anglers, similar to ratios obtained from test anglings, and showed that anglers reported 2.2 times more undersized walleye per legal size walleye than found in the test angling. Thus, the release rates presented in this study may be overestimations of the actual release amounts. Yet, even if only half the number of fish reported in the interviews were actually released, the amounts would still be considerable.

**Release proportions and reasons**

Generally, the release rates were higher in the northern than in the southern study area. One reason could be that catch rates are generally higher in Northern Norway (Fig. 4). Sullivan (2002) found that anglers are more likely to release protected fish with increasing catch rates. Fish that are less valuable from an angler’s perspective may be more likely to be released, which may be exacerbated when the catch rates of highly valued species are high. Tusk is generally not highly valued in the north and can be considered as an unwanted bycatch, as 52% of the angling groups in the northern study area released this species because they did not like it. By contrast, tusk can be a welcome bycatch in Southern Norway, as catches for the target species are lower (Volstad et al. 2011). Hunt et al. (2002) showed a similar substitution behaviour of freshwater angling tourists as they harvested more smallmouth bass, Micropterus dolomieu, Lacepède, when catch rates for pike, Esox lucius, L., were low.

One of the main release reasons given by the angling groups was that the fish were too small. In this context, too small does not necessarily mean that the fish were under the legal minimum length, as some anglers considered a legally caught cod of 50 cm as too small. These anglers could have legally kept the fish, but instead they deliberately released it meaning they practised voluntary C&R. While the introduction of minimum sizes has been shown to increase the practice of C&R (Harper et al. 2000), only a few angling groups used the minimum length regulations as a reason for releasing cod or haddock. One explanation can be that some of the marine angling tourists had personal size limits that were above the legal landing size. Moreover, these regulations were introduced in the beginning of 2010, and this study was conducted during 2010 and 2011. Once the knowledge about the minimum length regulations becomes more widespread, more anglers could practise C&R for this reason. As this may also be true for Norwegian local recreational fishermen, one should follow this up in a further survey.

It is possible that the introduction of the 15-kg export limit in 2006 may have contributed to an increased release of fish. As the daily catch of an angling boat can be over 100 kg in Northern Norway (Volstad et al. 2011), angling tourists can in principle fill their quota on the first days of fishing. Thus, when they want to continue fishing, they may release parts of their catch to abide by the rules. However, it was also observed that anglers targeted more challenging fish species [e.g. haltibut, Hippoglossus hippoglossus (L.)] or simply stopped angling when their quota was filled instead of practising C&R.

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**Figure 4.** The estimated mean landed catch per angling tourist boat and day (kg) in the business sector by month and geographic region ([as defined in Volstad et al. 2010]) during the main tourist season in 2009. — Northern Norway, -- Mid Norway, --- Western Norway, and -----Southern Norway [modified from Volstad et al. (2010)].
The practice of total C&R was still quite limited in this survey, but an increase can be expected in the future as the angling tourism industry is becoming more diverse, and some anglers will become more and more specialised (e.g. Bryan 1977). Several studies have shown that specialised anglers may be less consumptive oriented (Aas & Kaltenborn 1995; Oh & Ditton 2006) and that they are, in many cases, more likely to release their catch (Chipman & Helfrich 1988).

The survey data also indicated that the release proportions varied by nationality, but no final conclusions could be drawn because of low sample sizes for many of the nationalities. However, different angling behaviour is shown by different nationalities (Aas et al. 2002), and the patterns observed in this study were generally in line with the literature. Eastern European anglers are still more consumptive oriented, while C&R is a common practice in the UK and The Netherlands (Arlinghaus et al. 2007). Thus, if the composition of nationalities changed within the marine angling tourism in Norway, one should also expect a change in C&R behaviour and release proportions.

**Biological consequences of catch-and-release**

Many studies, in the US and Australia in particular, have shown that some fish may die as a consequence of C&R (for example Albin & Karpov 1998; Broadhurst et al. 2005; Butcher et al. 2006; Veiga et al. 2011; Stein et al. 2012). Release mortality rates can differ significantly between species and depend on several factors including fishing depth, temperature, fighting time, air exposure, hooking location, angler experience and fish size (Bartholomew & Bohnsack 2005). The stress and potential pain from hooking may have consequences on behaviours such as predator avoidance after release (Cooke & Sneddon 2007). The anglers interviewed in this study reported that many of the smaller cod and saithe were foul hooked which could have lead to higher mortality because of the injury, infections or reduced predator avoidance (Bartholomew & Bohnsack 2005).

Fish with swim bladders have difficulties re-submerging when brought up from deep water, because the swim bladder expands because of decompression (Bartholomew & Bohnsack 2005; Rummer & Bennett 2005; Alós 2008). These fish may also suffer from various other effects such as gas bubbles in the blood and tissue emphysema (Feathers & Knable 1983; Rogers et al. 1986). These so-called barotrauma issues are relevant in Norway in particular as the capture depth for cod, saithe and haddock is typically between 10–70 m, and for ling and tusk often deeper than 100 m.

**Implications for management**

To date the management system of the Norwegian marine angling tourism is based primarily on measures aimed at controlling harvest, and one aspect that appears to be overlooked is C&R behaviour. Knowledge about what motivates anglers and influences angler behaviour is important for ecological, social and economic reasons (Fedler & Ditton 2001; Arlinghaus 2006; Gentner & Sutton 2008). Anglers are likely to respond differently to the introduction or alterations of management regulations. The anglers may, for example, substitute angling with other recreational outdoor activities (Ditton & Sutton 2004), change their angling effort (Beard et al. 2003), move to other target species (Gentner 2004; Metcalf et al. 2010) or practice C&R (Harper et al. 2000). Some of these responses may put unintended fishing pressure on unregulated species or make the intentions of management regulations ineffective if, for example, release mortalities are high (Post & Parkinson 2012).

Vølstad et al. (2011) estimated the total harvest of cod by marine angling tourists to be around half a million fish (1586 t) from angling businesses in Northern Norway in 2009. Assuming that the estimated release rate for cod in the northern study area is representative for all of Northern Norway in 2009, approximately 1 million cod, or twice as much as the estimated harvest, could have been released. With such a high number of released cod, and the potential occurrence of release mortality, it needs to be studied and discussed whether the 15-kg export limit achieves its intentions, that is, a reduction in fishing mortality caused by angling.

Management authorities should take C&R and its associated effects into account when deciding on regulations, and it is recommended that new management regulations are based on a better understanding of C&R behaviour and of the motivations leading to C&R. An important objective of scientists and fisheries managers in Norway should be to estimate post-release mortalities and to minimise the potential impacts of C&R. Initially, before in-depth studies on the survival of the Norwegian species have been carried out, broader guidelines could be handed out as is common elsewhere, for example, in the US. These guidelines could explain and guide on the minimisation of fighting duration and air exposure of the fish, and the use of barbless hooks (Cooke & Suski 2005), in addition to lure size and bait type as tools to reduce the capture of undersized or unwanted fish (Wilde et al. 2003; Alós et al. 2009).

In conclusion, C&R fishing seems to be increasingly common in marine fisheries in Europe and, if ethically and legally accepted, could minimise fishing mortality...
while maintaining angling opportunities. However, to reduce potential negative consequences for the fish, this requires the practice of C&R to be considered in both science and management.

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