Public perception of river fish biodiversity in four European countries

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Abstract: Public support for biodiversity conservation is shaped by people's values and their knowledge, beliefs, and attitudes toward the environment. We conducted the first multinational representative survey of the general public’s perceptions of river fish biodiversity in France, Germany, Norway, and Sweden. For the online survey, 1000 respondents per country were randomly selected from large panels following country-specific quotas set on age, gender, and educational level. Questions covered people’s level of knowledge, beliefs, values, and attitudes toward river fish, environmental threats, and conservation measures. We found that the public had limited knowledge of freshwater fishes. Two non-native species, rainbow trout (Oncorhynchus mykiss) and brook trout (Salvelinus fontinalis), were widely perceived as native, whereas native Atlantic salmon (Salmo salar) was mostly classified as native in Scandinavia and largely as non-native in central Europe. These results suggest an extinction of experience paralleling the extirpation or decline of salmon stocks in countries such as Germany and France. Respondents thought pollution was the dominant threat to riverine fish biodiversity. In reality, habitat loss, dams, and the spread of non-native fishes are equally important. Despite limited biological knowledge, respondents from all countries held an overwhelmingly pro-ecological worldview, supported conservation stocking, and appreciated native fishes, although only a minority interacted with them directly. Differences among the 4 countries related to several conservation issues. For example, threats to biodiversity stemming from aquaculture were perceived as more prevalent in Norway compared with the other 3 countries. Promoting fish conservation based on charismatic species and use values of fishes may work well in countries with a strong economic and cultural link to the freshwater environment, such as Norway. In countries where people rather abstractly care for nature, focusing conservation messaging on broader ecosystem traits and non-use values of fishes is likely to win more support.

Keywords: attitudes, biodiversity loss, communications, conservation planning, environmental threats, freshwater ecosystems, public opinion, species introduction

Percepción Pública de la Diversidad de Peces de Río en Cuatro Países Europeos

Resumen: El apoyo público hacia la conservación de la biodiversidad está formado por los valores de las personas y su conocimiento, creencias y actitudes hacia el ambiente. Realizamos el primer censo representativo multinacional de las percepciones generales del público sobre la diversidad de peces de río en Francia, Alemania, Noruega y Suecia. Para el censo en línea se seleccionaron mil respondentes al azar por país a partir de paneles grandes que seguían cuotas específicas por país ajustadas por edad, género y nivel educativo. Las preguntas abarcaron el nivel de conocimiento de las personas, sus creencias, valores y actitudes hacia los peces de río, las amenazas ambientales y las medidas de conservación. Descubrimos que el público tenía un conocimiento limitado sobre los peces de agua dulce. Dos especies no nativas, la trucha arco iris (Oncorhynchus mykiss) y la trucha de arroyo (Salvelinus fontinalis), fueron percibidas extensamente como

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nativos, mientras que salmón atlántico (Salmon salar), una especie nativa, estuvo clasificada en su mayoría como nativa en Escandinavia y como no nativa en Europa central. Estos resultados sugieren una extinción de experiencia similar a la extinción o declinación de los stocks de salmón en países como Alemania y Francia. Los respondientes pensaron que la contaminación es la amenaza dominante para la diversidad de los peces de río. En realidad, la pérdida del hábitat, las presas y la expansión de peces no nativos son igual de importantes. A pesar del conocimiento biológico limitado, los respondientes de todos los países tuvieron una visión pro-ecológica del mundo abrumadora, apoyaron las acciones de conservación, y valoraron a los peces nativos, aunque sólo una minoría interactuaba directamente con ellos. Las diferencias entre los cuatro países se relacionaron con varios asuntos de conservación. Por ejemplo, las amenazas a la biodiversidad derivadas de la acuicultura fueron percibidas como más predominantes en Noruega en comparación con los otros tres países. La promoción de la conservación de peces basada en las especies carismáticas y los valores de uso de los peces pueden funcionar bien en países con un fuerte vínculo económico y cultural con los ecosistemas de agua dulce, como Noruega. En los países en los que las personas más bien cuidan el ambiente de manera abstracta, enfocar los mensajes de conservación en rasgos ambientales más generales y en valores que no sean de uso de los peces tiene mayor probabilidad de obtener más apoyo.

Palabras Clave: actitudes, amenazas ambientales, comunicaciones, ecosistemas de agua dulce, introducción de especies, opinión pública, pérdida de la biodiversidad, planeación de la conservación

요약: 人们的价值观、知识、信仰和对环境的态度共同决定了公众对生物多样性保护的支持程度。针对公众对河流鱼类生物多样性的认识，我们在法国、德国、挪威和瑞典这四个国家首次开展了一项有代表性的跨国调查。在这项在线调查中，我们根据每个国家的情况分别了年龄、性别和教育程度的分组，并从中随机挑选了每个国家各1,000名受访者。调查的问题涉及人们的价值观、信仰、价值观，以及对河流鱼类、环境威胁和保护措施的态度。我们发现，公众对淡水鱼类的了解有限。许多人认为外来物种虹鳟鱼（Onchorhyncus mykiss）和溪红点鲑（Salvelinus fontinalis）是原生种，而原生种大西洋鲑（Salmon salar）却常常被认为来自斯堪的纳维亚半岛，是欧洲中部的外来物种。这些结果表明德国、法国、德国等国家，区域性灭绝和鲑鱼群体灭绝或数量下降同时发生。受访者认为，河流鱼类多样性面临的主要威胁是污染。事实上，栖息地丧失、水库修建、外来鱼类种群扩张的影响也同样重要。各国的经验者虽然生物学知识有限，但绝大多数都持有类似生态的世界观，支持鱼类保护、更喜欢本土的鱼类，哪怕只有少数人和鱼类有直接接触。四个国家之间的差异涉及到一些保护问题。例如，相比于其他国家，挪威的受访者认为水产养殖对生物多样性的威胁更为普遍。在淡水环境与经济和文化紧密相连的国家（如挪威），立足于有魅力的物种和鱼类的利用价值来推动鱼类保护可能会更有效，而在人们对自然的关心比较概念化的国家，传递较为广泛的社会性特性鱼类非利用价值的保护信息可能会赢得更多支持。【翻译: 胡怡思 审校: 聂永刚】

关键词: 态度, 生物多样性丧失, 沟通, 保护规划, 环境威胁, 淡水生态系统, 公众意见, 物种引入

Introduction

The intense use of rivers by humans worldwide has affected riverine biodiversity and freshwater fishes through habitat modification and simplification, water abstraction, alteration of flow regimes, pollution, eutrophication, and local overfishing (Dudgeon et al. 2006). Consequently, species extinction rates in freshwater ecosystems are surpassing those in terrestrial and marine ecosystems (Pimm et al. 2014), with between one quarter and over one-third of freshwater fish species being threatened or extinct in Europe (Freyhof & Brooks 2011), North America (Jels et al. 2008), and Africa (Darwall et al. 2011). A prominent example is sturgeon (Acipenser spp.), for which all but 1 species are listed as critically endangered (Freyhof & Brooks 2011). New threats posed by climate change (Heino et al. 2015) and the invasion of ecosystems by non-native species (Gozlan et al. 2010) will likely increase over the next decades with the potential to further reduce freshwater biodiversity.

Environmental policies introduced to address the freshwater biodiversity crisis are driven and affected by people’s priorities and their support for conservation (Walker-Springett et al. 2016). These priorities follow prevailing cultural values and material conditions (Inglehart 1997), meaning they are based on both objectively measurable conditions of the environment and the people’s subjective interpretation of nature (Eder 1996). For example, the degree to which people are willing to tolerate wildlife close to their homes is more strongly correlated with the perceived danger from wild animals than with the number of dangerous incidents (Kansky & Knight 2014). In a similar vein, political ideology can be more important for the perception of climate change as environmental threat than scientific descriptions of the phenomenon (Weber 2010). In short, it is the social and cultural context that shapes the mental classification scheme through which an individual and collectively society makes sense of the world; therefore, people in different countries are likely to vary in what they find.
acceptable, desirable, and important (Schwartz 2006; Manfredo 2008).

Several multi- and cross-national studies have been conducted to examine the impact of sociocultural factors on the public’s perception of the marine environment (Ahtiainen et al. 2013; Gellich et al. 2014; Potts et al. 2016). In comparison, it is less known how the public in different countries perceive freshwater biodiversity (Closs et al. 2015). Based on studies of other environmental issues, the expectations among conservation biologists and fisheries scientists are somewhat bleak. The public is expected to be largely ignorant and complacent about environmental quality and biodiversity loss (Angermeyer 2007; Monroe et al. 2009; Closs et al. 2015). People are thought to have a weak connection to freshwater fish and to prefer birds and charismatic mammals (Cooke et al. 2013; Closs et al. 2015) as well as to value direct use of freshwater environments more than biodiversity (Monroe et al. 2009; Beard et al. 2011; Cooke et al. 2013).

Using a cross-cultural online survey, our objectives were to understand whether the members of the public in 4 European countries care about freshwater fishes (values), what people know about fish biodiversity (knowledge), how they view threats to native fish species (beliefs), and what this means for public support for specific conservation measures (attitudes). We used measures of values, knowledge, beliefs, and attitudes following sociopsychological theory that has shown that these constructs play a large role in driving proenvironmental behaviors (Stern 2000; Manfredo 2008; Klöckner 2013). The selection of surveyed countries was based on the study’s interest for charismatic migratory fish species. We surveyed 2 central European countries—Germany and France—where rivers are heavily altered by humans and Atlantic salmon (Salmo salar) has been extirpated (Germany) or is rare (France), and 2 Scandinavian countries—Norway and Sweden—where Atlantic salmon is still present. We also assumed the 4 countries differ in how the public uses and interacts with freshwater ecosystems. Taking recreational fishing as an example activity, previous research suggests the 4 countries form clusters of low (Germany, 4.0%; France, 8.2%) and high recreational use (Norway, 32.2%; Sweden, 23.0%) (Arlinghaus et al. 2015).

Methods

Survey Administration and Sampling

The survey was administered over the internet in September 2015 using large, high-quality online panels with 40,000–100,000 members/country. Panel members were recruited previously by phone with a random digit-dialing method as sampling frame. This probability-based approach to panel recruitment avoids the self-selection bias of nonrandom consumer panels that rely on voluntary participants (opt-in panels) (Baker et al. 2010). To avoid respondent fatigue, panel members are invited to participate in a survey at a maximum of 6 times/year.

Respondents were randomly selected from the panels and invited via email to participate in the survey. Up to 3 reminder emails were sent during the survey period of 21 days. Data collection conformed to the rules given by the national Data Protection Acts as well as standards for social research as outlined by the European Society for Opinion and Market Research (ESOMAR & GRBN 2015; ICC & ESOMAR 2016). The sample selection followed country-specific quotas set on age groups, gender, and the highest education level achieved according to census data (Eurostat 2015). We removed 287 respondents from the sample with implausibly low response times (speeding), 3 respondents who gave the same answers in more than 3 grids (straight lining), and 4 respondents who answered <20% of all questions (item nonresponse) (Grove 2011). Aside from these cases of potentially fraudulent or inattentive participants, 4844 persons started the questionnaire. Overall, 17.4% (n = 844) of the initial sample quit participating.

The final sample of 1000 respondents/country, aged 16 to 74 years, approximated a representative sample relative to the previously defined quota characteristics. Further respondent characteristics are described in Supporting Information. We defined our study population as the general population with internet access, which covered from 83% (France) to 97% (Norway) of all private households (Germany, 90%; Sweden, 91%) (Eurostat 2016). In December 2016, 61% of the respondents took part in a follow-up survey of which one question about Atlantic salmon was relevant for this study.

Survey Questions

The 2015 questionnaire covered human values and the value of native fish populations; self-reported and revealed knowledge; beliefs about environmental threats; and attitudes toward conservation and management measures. The assumption that the countries would differ in relation to outdoor activities bound to water was verified by asking respondents about their recreational activities (Supporting Information). In 2016, respondents were surveyed again and asked whether they thought that salmon and Atlantic salmon were native to 6 European countries, including their own. All questions were worded using neutral and accessible language. The questions were pretested with experts in freshwater ecology and members of the public. The final survey was translated professionally into German, French, Norwegian (Bokmål), and Swedish. Pilot interviews (n = 4 × 30) resulted in only minor adaptations of the questionnaire.
Environmental values were measured with 3 items from the Schwartz (2012) value scale (e.g., “respecting the earth, living in harmony with other animal and plant species”) using a 5-point response format (1, not at all important, to 5, very important). Cronbach’s reliability coefficient for this scale was high (α = 0.89). See Supporting Information for the scale’s item wording. The use and non-use values of native fish populations were assessed (from 1, strongly disagree, to 5, strongly agree) using 6 items adapted from ecosystem valuation frameworks (Hein et al. 2006) (e.g., “Native fish populations should be protected for their own sake”).

Concerning knowledge about native biodiversity and threats from non-native fishes, respondents were asked for a self-assessment (1, not informed at all, to 4, very well informed). Familiarity with river fish species was assessed by presenting the respondents with 3 native freshwater (brown trout [Salmo trutta], grayling [Thymallus thymallus], and bream [Abramis brama]), 2 non-native salmonids (rainbow trout [Oncorhynchus mykiss] and brook trout [Salvelinus fontinalis]), and 5 native diadromous species (Atlantic salmon, sturgeon, and European eel [Anguilla anguilla]). In Scandinavia, sturgeon is only native to the south. Another species, barbel (Barbus barbus), is a key species for the fish-based zonation of rivers in central Europe, but is not native to Scandinavia. Respondents were asked whether they had heard of the species and, if they answered affirmatively, whether they thought the species was native to the inland waters of their country.

People also rated the contribution of 5 threats to fish biodiversity loss (1, no contribution at all, to 4, a very strong contribution). The items reflected major threat categories for freshwater biodiversity (Dudgeon et al. 2006). Attitudes toward conservation and management actions were assessed based on 10 items ranked in a 5-point response format (1, very bad, to 5, very good). The items represented factual information about non-native fish species, stocking as a common practice in rivers in the respective countries (86%). Norwegians felt, on average, expressed stronger use values relative to the other 3 countries (Table 1). The other respondents, particularly the Germans and Swedes, tended to disagree on average with the direct-use value of native fish populations for the respondents’ own benefit (H = 297, df = 3, p < 0.001) and human benefit in general (H = 186, df = 3, p < 0.001) and focused on the non-use benefits derived from the existence and bequest value of fishes (Table 1).

Data Analyses

We used factor analysis with orthogonal Varimax rotation to structure our data and identify indicator items of underlying latent constructs for the established Schwartz value scale. We used principal component analysis to reduce correlated observed attitude items to a smaller set of composite scores. Items with high loadings on the same factor were aggregated to form composite scores as measures of these constructs. Individual items and composite scores that were collected on Likert-type rating scales were analyzed for country differences using the Kruskal–Wallis test and the Tukey–Kramer (Nemenyi) test for pairwise post hoc comparisons. The familiarity with native and non-native fish species was compared between countries with Pearson’s chi-squared tests. All data were analyzed with R version 3.2.2.

Results

Environmental Values and Value of Native Fish Populations

Basic environmental values were assessed with 3 items representing one construct (73% explained variance); it was labeled harmony with nature. This construct was rated, on average, as important in all 4 countries. However, for Norwegians (n = 1000, M = 3.6, SD 0.9) followed by the French (n = 1000, M = 3.8, SD 0.9) achieving harmony with nature was slightly less important than for the respondents in Germany (n = 995, M = 3.9, SD 0.9) and Sweden (n = 999, M = 3.9, SD 0.9). This difference was statistically significant (Kruskal–Wallis H = 75.3, df = 3, p < 0.001).

Coinciding with their values, respondents in all countries highly appreciated native fish populations for their non-use value and less so for their use value (Table 1). The French agreed significantly less than the other countries with the importance of the existence value (H = 61.9, df = 3, p < 0.001) and bequest value (H = 53.6, df = 3, p < 0.001) of native fish populations. Norwegians appreciated native fish populations not only for their non-use but also for the use value that fish bring to humans (Table 1). In comparison to other countries, Norwegians also disagreed most strongly with the idea that they would not personally benefit from the protection of native fish populations (option value: H = 264, df = 3, p < 0.001), and they agreed most strongly with the need to preserve fish populations for the benefits of others (altruistic value; H = 700, df = 3, p < 0.001). French respondents, on average, expressed stronger use values relative to the other 3 countries (Table 1). The other respondents, particularly the Germans and Swedes, tended to disagree on average with the direct-use value of native fish populations for the respondents’ own benefit (H = 297, df = 3, p < 0.001) and human benefit in general (H = 186, df = 3, p < 0.001) and focused on the non-use benefits derived from the existence and bequest value of fishes (Table 1).

Self-reported and Revealed Knowledge of Fish Biodiversity

A large majority of the respondents stated that they did not feel well informed about fish biodiversity (89%) and the potential threats posed by non-native fishes to the rivers in the respective countries (86%). Norwegians felt, on average, significantly better informed about fish biodiversity (H = 171.9, df = 3, p < 0.001) and about possible biological threats posed by non-native fishes (H = 208.2, df = 3, p < 0.001) than the respondents in the other 3 countries (Fig. 1).
Table 1. Mean (SD) approval (1, strongly disagree, to 5, strongly agree) of survey respondents from 4 countries to protect native fish populations for their non-use (existence and bequest value) or use values (direct use, option and altruistic value).a,b,c,d

<table>
<thead>
<tr>
<th>Value category</th>
<th>Survey item</th>
<th>Germany</th>
<th>France</th>
<th>Norway</th>
<th>Sweden</th>
<th>$H^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existence value</td>
<td>Native fish populations should be protected for their own sake.</td>
<td>4.2a (0.8)</td>
<td>4.0c (0.9)</td>
<td>4.1b (1.0)</td>
<td>4.0bc (0.9)</td>
<td>61.9</td>
</tr>
<tr>
<td>Bequest value</td>
<td>I think it is good to preserve native fish populations to maintain an environment worth living in for our children and future generations.</td>
<td>4.3a (0.8)</td>
<td>4.1b (0.9)</td>
<td>4.3a (0.9)</td>
<td>4.3a (0.9)</td>
<td>53.6</td>
</tr>
<tr>
<td>Altruistic value</td>
<td>Native fish populations should primarily be preserved for the benefit of others.</td>
<td>2.6d (1.2)</td>
<td>3.3b (1.0)</td>
<td>3.9a (1.0)</td>
<td>2.8c (1.1)</td>
<td>700</td>
</tr>
<tr>
<td>Option value</td>
<td>I wouldn’t benefit in any way from the protection and conservation of native fish populations. f</td>
<td>3.3b (1.2)</td>
<td>3.1a (1.0)</td>
<td>3.8c (1.2)</td>
<td>3.1a (1.2)</td>
<td>264</td>
</tr>
<tr>
<td>Direct use value</td>
<td>Native fish populations should primarily be managed for human benefit. Native fish populations are valuable only if I get to use them in some way.</td>
<td>2.5d (1.1)</td>
<td>3.2a (1.2)</td>
<td>2.9b (1.2)</td>
<td>2.7c (1.2)</td>
<td>186</td>
</tr>
</tbody>
</table>

Number of observations

<table>
<thead>
<tr>
<th></th>
<th>Germany</th>
<th>France</th>
<th>Norway</th>
<th>Sweden</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>998</td>
<td>998</td>
<td>998</td>
<td>992</td>
<td></td>
</tr>
</tbody>
</table>

$a,b,c,d$ Any 2 means in a row that do not share a letter are significantly different ($p < 0.05$) according to pairwise comparisons made with the Tukey-Kramer (Nemenyi) test.

$e$ Differences between countries were tested for significance with the Kruskal-Wallis test.

$f$ Scoring reversed because of negatively worded item.

Figure 1. Self-reported level of feeling informed about fish biodiversity ($n = 4000$) and the threats caused by the introduction of non-native fish species ($n = 3991$) (black, not informed at all; dark gray, not well informed; light gray, well informed; white, very well informed).

Over 85% of the respondents in Germany, Sweden, and Norway indicated they had heard of the salmonids brown trout and rainbow trout, whereas in France, these species were significantly less known (brown trout: 64%; rainbow trout: 70%). Two other salmonids, brook trout and grayling, were less well known overall (Fig. 2). Atlantic salmon and the other diadromous fishes in the survey—sturgeon and European eel—were recognized in the 2015 survey by at least 85% (salmon, eel) and at least 79% (sturgeon) of the respondents. Atlantic salmon and European eel were well known in Norway and Sweden (>96%), but significantly less so in France (81%) and Germany (58%). In contrast, sturgeon was significantly better known in Germany (92%) and...
France (84%) than in Norway (65%) and Sweden (76%). The same was true for the cyprinid barbel, which was recognized by less than 5% of respondents in the Scandinavian countries, but by about half of the respondents in Germany and France (Fig. 2). Bream was recognized by half of the respondents in Germany, France, and Norway, and by 85% of the Swedish respondents (Fig. 2).

When a respondent indicated familiarity with a fish species, the next question asked whether the respondent believed the fish species was native or non-native. Rainbow trout and brook trout—2 salmonids introduced to Europe a century ago—were perceived by over half the respondents as native (Fig. 2). Two native migratory fish species, Atlantic salmon and sturgeon, were perceived by only 40% of the respondents as native species (Fig. 2). The exception to this pattern was Norway, where 90% of the respondents correctly considered Atlantic salmon as a native species to their country.

A follow-up question that was asked in 2016 showed that respondents from all countries associated salmon with the Scandinavian countries Norway (82–97% of respondents) and Sweden (77–92%), but to a lesser degree with the central European countries Germany (34–58%) and France (28–61%), the landlocked Czech Republic (28–36%), and the southern European country Spain (8–29%) (Table 2), although in reality, Atlantic salmon is native to all 6 countries. This pattern remained the same when asking about Atlantic salmon rather than salmon (Table 2). In comparison with salmon, more people believed Atlantic salmon to be native in France (32–59% of respondents across countries) and Spain (21–26%), and fewer people believed it to be native in Norway (78–95%), Sweden (56–74%), Germany (18–35%), and the Czech Republic (6–21%).

Beliefs about Environmental Threats to Riverine Fishes

With regard to environmental threats, respondents in all 4 countries believed that water pollution contributed most to fish biodiversity loss (mean [SD] = 3.4 [0.72]) (Fig. 3). Averaged across the 4 countries, the second most serious threat was perceived to be habitat loss (mean = 3.0 [0.76]), followed by the introduction of non-native species (mean = 2.9 [0.80]) and overfishing (mean = 2.9 [0.86]). Dams built for hydropower plants were overall seen as the least serious threat (mean = 2.9 [0.77]) (Fig. 3), and the concern about this threat was equal in all 4 countries (H = 0.7, df = 3, p = 0.878). The French were significantly more concerned about water pollution (H = 65.9, df = 3, p < 0.001) than respondents in the other countries. Habitat loss was seen as a significantly more pronounced threat in Germany and France than in Sweden and Norway (H = 242.7, df = 3, p < 0.001). Norwegians were significantly more concerned about...
Table 2. Percentage of survey respondents\textsuperscript{a} in Germany (\(n = 642\)), France (\(n = 578\)), Norway (\(n = 500\)), and Sweden (\(n = 586\)) who perceived salmon and Atlantic salmon as native in 6 European countries (Czech Republic [CZ], France [FR], Germany [DE], Norway [NO], Spain [ES], and Sweden [SE]).

<table>
<thead>
<tr>
<th>Respondent country</th>
<th>Salmon native to country</th>
<th>Atlantic salmon native to country</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CZ FR DE NO ES SE CZ FR DE NO ES SE</td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>30 32 58 96 8 92</td>
<td>8 42 29 87 24 74</td>
</tr>
<tr>
<td>France</td>
<td>33 61 44 82 27 77</td>
<td>21 59 31 78 26 72</td>
</tr>
<tr>
<td>Norway</td>
<td>36 40 51 97 29 92</td>
<td>11 32 35 95 23 70</td>
</tr>
<tr>
<td>Sweden</td>
<td>28 28 34 94 18 92</td>
<td>6 36 18 88 21 56</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Most of the data presented in this study was obtained in 2015. The information underpinning this table was obtained during a follow-up survey in 2016.

Figure 3. Mean (SE) survey respondents’ perceived degree to which water pollution, loss of natural river bank habitat, introduction of non-native species of plants and animals, including fishes, to rivers by humans, overfishing, and the construction of dams for hydroelectric power generation threaten native fish species in Germany (\(n = 898\)), France (\(n = 831\)), Norway (\(n = 809\)), and Sweden (\(n = 789\)) (1, no contribution at all, to 4, very strong contribution). Differences between countries were tested for significance with the Kruskal–Wallis test. Any 2 means for each threat that do not share a letter are significantly different (\(p < 0.05\)) according to pairwise comparisons made with the Tukey–Kramer (Nemenyi) test.

Discussion

Most of the previous social science studies on freshwater fish and biodiversity have been conducted on specific stakeholder groups and single countries (Bremner & Park 2007; Riepe & Arlinghaus 2014; Walker-Springett et al. 2016). Our study broadens the perspective in relation to the public’s perception of river fish biodiversity in central and northern Europe using identical questionnaires. Cross-national studies, such as ours, shed light on which perceptions are confined to or shared by single countries or cultures. We found that the publics of our 4 countries shared high levels of proenvironmental concern, positive attitudes toward fish conservation, and limited knowledge about biological realities under water. But we also found important differences in the beliefs and attitudes reflecting national specificities.

Attitudes toward Fish Conservation and Management Measures

The reestablishment of Atlantic salmon and sturgeon to rivers where they had been extirpated through human influence was supported in all 4 countries, and the approval was significantly highest in Germany (\(H = 312, df = 3, p < 0.001\); Table 3). Culture-based enhancement stocking of rainbow trout and brook trout (both non-native species) for fisheries purposes received less support than conservation stocking of Atlantic salmon and sturgeon; however, people did also not oppose it on average (Table 3). In Germany, culture-based stocking of brook trout and rainbow trout was viewed more positively relative to the other 3 countries (\(H = 295, df = 3, p < 0.001\)).

Respondents in all countries felt rather negative toward escapees from aquaculture (Table 3). Despite this concern, respondents did not support the treatment of farmed fish that could render the fish infertile, thus reducing the genetic risks associated with escapees. Norwegians felt significantly more positive toward these aquaculture management measures (\(H = 112, df = 3, p < 0.001\)) and significantly more negative toward escapees from aquaculture (\(H = 442, df = 3, p < 0.001\)) than the public in the other 3 countries. Despite being more concerned about the associated risks, Norwegian respondents did not have a more negative attitude toward aquaculture than the other 3 nations (Table 3).

General Patterns Held across Countries

The public in all 4 countries valued native fish species for their existence (Table 1) and supported conservation...
Table 3. Mean (SD) attitudes (1, very bad, to 5, very good) of survey respondents from 4 countries toward conservation stocking (2 items), culture-based enhancement stocking (3 items), aquaculture management (3 items), and the biodiversity risk of aquaculture (2 items).\textsuperscript{a,b,c,d}

<table>
<thead>
<tr>
<th>Survey item</th>
<th>Loading</th>
<th>Germany</th>
<th>France</th>
<th>Norway</th>
<th>Sweden</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conservation stocking</strong></td>
<td>-</td>
<td>4.2\textsuperscript{a} (0.8)</td>
<td>3.7\textsuperscript{b} (1.0)</td>
<td>3.5\textsuperscript{c} (1.1)</td>
<td>3.6\textsuperscript{bc} (1.0)</td>
<td>312</td>
</tr>
<tr>
<td>Sturgeon are being reintroduced by stocking to some European waters where they were native and extirpated through human influence.</td>
<td>0.904</td>
<td>4.2\textsuperscript{a} (0.8)</td>
<td>3.7\textsuperscript{b} (1.0)</td>
<td>3.4\textsuperscript{c} (1.1)</td>
<td>3.6\textsuperscript{c} (1.0)</td>
<td>330</td>
</tr>
<tr>
<td>Atlantic salmon are being reintroduced by stocking to some European rivers where they were native and extirpated through human influence.</td>
<td>0.899</td>
<td>4.1\textsuperscript{a} (0.8)</td>
<td>3.6\textsuperscript{b} (1.0)</td>
<td>3.6\textsuperscript{b} (1.1)</td>
<td>3.6\textsuperscript{b} (1.0)</td>
<td>217</td>
</tr>
<tr>
<td><strong>Culture-based stock enhancement</strong></td>
<td>-</td>
<td>3.3\textsuperscript{a} (0.9)</td>
<td>2.7\textsuperscript{d} (1.0)</td>
<td>2.9\textsuperscript{c} (0.9)</td>
<td>3.0\textsuperscript{b} (0.9)</td>
<td>295</td>
</tr>
<tr>
<td>At the end of the 19th century, brook trout and rainbow trout were deliberately introduced from North America as edible fishes to the rivers of (insert country).</td>
<td>0.742</td>
<td>3.2\textsuperscript{a} (0.8)</td>
<td>3.0\textsuperscript{b} (0.9)</td>
<td>3.0\textsuperscript{b} (0.9)</td>
<td>3.2\textsuperscript{a} (0.8)</td>
<td>60.7</td>
</tr>
<tr>
<td>Some nature conservationists demand that non-native brook trout and rainbow trout be extirpated from the rivers in (insert country) to protect the native species biodiversity.\textsuperscript{f}</td>
<td>0.725</td>
<td>3.4\textsuperscript{a} (0.9)</td>
<td>2.5\textsuperscript{c} (0.9)</td>
<td>2.9\textsuperscript{b} (0.9)</td>
<td>2.8\textsuperscript{b} (0.9)</td>
<td>474</td>
</tr>
<tr>
<td>Fisheries managers release hatchery-bred brook trout and rainbow trout into the wild to increase fisheries catch.</td>
<td>0.648</td>
<td>3.1\textsuperscript{a} (0.9)</td>
<td>2.7\textsuperscript{c} (1.0)</td>
<td>2.8\textsuperscript{bc} (1.0)</td>
<td>2.9\textsuperscript{b} (1.0)</td>
<td>113</td>
</tr>
<tr>
<td><strong>Aquaculture management</strong></td>
<td>-</td>
<td>2.2\textsuperscript{c} (1.0)</td>
<td>2.4\textsuperscript{ab} (1.1)</td>
<td>2.5\textsuperscript{a} (1.1)</td>
<td>2.4\textsuperscript{b} (1.0)</td>
<td>112</td>
</tr>
<tr>
<td>Rainbow trout raised in fish farms can be made infertile by thermal treatment of eggs. As a result they achieve a higher slaughter weight.</td>
<td>0.860</td>
<td>2.0\textsuperscript{d} (0.9)</td>
<td>2.3\textsuperscript{b} (1.0)</td>
<td>2.5\textsuperscript{a} (1.0)</td>
<td>2.2\textsuperscript{c} (1.0)</td>
<td>143</td>
</tr>
<tr>
<td>It is possible to intentionally alter the expression of specific genes of salmon and trout to achieve a higher slaughter weight.</td>
<td>0.795</td>
<td>1.7\textsuperscript{b} (0.9)</td>
<td>2.2\textsuperscript{a} (1.0)</td>
<td>2.2\textsuperscript{a} (1.0)</td>
<td>2.1\textsuperscript{a} (1.0)</td>
<td>135</td>
</tr>
<tr>
<td>Across Europe, Atlantic salmon and rainbow trout are often bred in net cages placed in coastal zones or in fish farms on land for human consumption.</td>
<td>0.585</td>
<td>2.7\textsuperscript{b} (1.1)</td>
<td>2.8\textsuperscript{ab} (1.0)</td>
<td>2.8\textsuperscript{ab} (1.1)</td>
<td>2.9\textsuperscript{a} (1.0)</td>
<td>14.9</td>
</tr>
<tr>
<td><strong>Biodiversity risk of aquaculture</strong></td>
<td>-</td>
<td>2.1\textsuperscript{b} (0.9)</td>
<td>2.4\textsuperscript{a} (1.1)</td>
<td>1.7\textsuperscript{d} (0.8)</td>
<td>2.0\textsuperscript{c} (0.9)</td>
<td>442</td>
</tr>
<tr>
<td>Sometimes Atlantic salmon and rainbow trout unintentionally escape from fish farms into the wild and then interbreed with their wild conspecifics.</td>
<td>0.861</td>
<td>2.6\textsuperscript{a} (0.8)</td>
<td>2.7\textsuperscript{a} (1.0)</td>
<td>1.9\textsuperscript{c} (0.9)</td>
<td>2.5\textsuperscript{b} (0.9)</td>
<td>488</td>
</tr>
<tr>
<td>Sometimes Atlantic salmon and rainbow trout unintentionally escape from fish farms into the wild and then transmit parasites or diseases to their wild conspecifics.</td>
<td>0.784</td>
<td>1.6\textsuperscript{b} (0.7)</td>
<td>2.0\textsuperscript{a} (1.0)</td>
<td>1.4\textsuperscript{c} (0.7)</td>
<td>1.6\textsuperscript{b} (0.8)</td>
<td>201</td>
</tr>
<tr>
<td>Number of observations</td>
<td>-</td>
<td>998</td>
<td>999</td>
<td>997</td>
<td>996</td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{a,b,c,d} Any 2 means in a row that do not share a letter are significantly different (p < 0.05) according to pairwise comparisons made with the Tukey–Kramer (Nemenyi) test. Survey items grouped by principal component analysis with Varimax orthogonal rotation.

\textsuperscript{e} Differences between countries tested for statistical significance with the Kruskal–Wallis test.

\textsuperscript{f} Scoring reversed because of negatively worded item.
stocking (Table 3). These findings coincided with the predominantly proenvironmental values of the public. Modernization and postindustrialization have resulted in a rise of abstract proenvironmental values within many wealthy societies (Inglehart 1990, 1997) and fostered the cultural value of egalitarianism, broadly defined as the desire to take care of the well-being of fellow humans, but also animals and the environment (Schwartz 2006). In this study, people cared about fish conservation in a positive way, likely because this animal group was perceived as part of nature that they felt should be protected. We would expect to find similar results in other western European countries featuring high scores in egalitarian cultural values (Schwartz 2006). However, there is the limitation that we did not study the relative importance of different taxa or ecosystem characteristics, such as water quality (Hanley et al. 1998). Further studies on the perceptions of freshwater fishes in countries with other national value priorities (Schwartz 2006) and on people’s preferences for various ecosystem traits are needed to fully understand the values underlying freshwater fish conservation.

The self-reported level of knowledge of river fish biodiversity was low in all 4 countries (Fig. 1), in line with the expectations expressed in the scientific literature (Monroe et al. 2009; Cooke et al. 2013; Closs et al. 2015). Well-known species included both native (e.g., brown trout) and non-native (e.g., rainbow trout) salmonids, but there were also native (e.g., grayling) and non-native (e.g., brook trout) salmonids that were less well known (Fig. 2). Respondents were familiar with migratory fish, such as sturgeon and Atlantic salmon, but were less certain about these species’ range of natural occurrence. It is highly likely that this pattern represents an example of an “extinction of experience” (Miller 2005) because, for example, Atlantic salmon were extirpated from Germany in the mid-20th century (Wolter 2015) and its abundance declined greatly in other European countries (Chaput 2012). Given that all surveyed countries showed that loss of memory with regard to the situation in their own or other countries (Table 2), we would expect similar results for other European countries.

Relative to environmental threats, the respondents perceived pollution to pose the biggest threat to freshwater biodiversity (Fig. 3), possibly remembering high level of discernible pollution in the 1960s and 1970s. Since then water quality has improved across many rivers due to advances in water purification and the implementation of the European Water Framework Directive (Directive 2000/60/EC). Our results parallel findings for the marine environment where pollution was also perceived to be the dominant threat in many different countries (Gelcich et al. 2014; Potts et al. 2016), possibly because of the high media coverage of marine pollution events. Similar incidents in the freshwater environment date back decades (Reinhard 2008), but recent media campaigns on plastic waste, micro-pollutants, and micro-plastics could have had an impact on public perception. For river conservation, it will be important to increase people’s awareness about less visible threats (Dudgeon et al. 2006; Gozlan et al. 2010; Freyhof & Brooks 2011).

**Country-Specific Patterns**

Norwegians felt better informed and were more concerned about non-native species (Figs. 1 & 3) and biodiversity risks from aquaculture farms than the members of the public in the other countries (Table 3). This may be related to the debate about the expanding salmon aquaculture industry in Norway and its significant media coverage (Olsen & Osmundsen 2017). Through escapes and introgression of aquaculture genotypes into wild stocks, there is evidence that farmed salmon have had direct and indirect negative impacts on wild salmon populations (Bolstad et al. 2017). Despite being more concerned with risks, Norwegian respondents did not have a more negative attitude toward aquaculture than the other nations (Table 3), possibly trading off the biodiversity risks related to aquaculture against the economic benefits to Norwegian society.

The use value of fish populations was seen as less important than their non-use value in Germany and Sweden compared with Norway (Table 1), where fish and fisheries are important for recreational and commercial purposes (Borch et al. 2008; Arlinghaus et al. 2015). Despite low use values, Germany evaluated culture-based stocking comparatively positive (Table 3), possibly because brook trout and rainbow trout are legally considered to be native and intensively stocked into German waters (Arlinghaus et al. 2015) seemingly with limited ecological impacts (Wolter & Röhr 2010). An interesting case is France, where the public expressed a comparably high use value and a lower importance of the non-use values bequest and existence. In cross-cultural studies, France showed less egalitarian cultural values compared with the other 3 countries, and it scored higher on intellectual autonomy as cultural value (Schwartz 2006). This may explain why the instrumental use value of fish populations was larger in France compared with the other 3 countries. Overall, country-specific factors were more important for explaining use values than non-use values, because western Europeans share high levels of environmental values (Schwartz 2006), but differ with regard to other value dimensions, have differently structured economies, and different preferences with regard to recreation and food (EUMOFA 2017).

**Implications for Fish Conservation**

Human behavior is complex and multifaceted. It is informed by a person’s psychological disposition as well as by situational and contextual factors (Stern 2005; Steg...
& Vlek 2009). Psychological constructs (such as knowledge, values, beliefs, and attitudes) do not always translate into action (Kollmuss & Agyeman 2002), but they can be important drivers of proenvironmental behavior when the contextual factors are favorable (Stern 2000, 2005; Riepe et al. 2017). Given that we did not observe actual behavior, we limit our conclusions for fish conservation to implications for conservation messaging.

Conservation messaging can achieve behavioral change, especially when combined with other interventions (Osballistan & Schott 2012). Our results suggest that public outreach campaigns promoting fish conservation based on use values may not be effective in those European countries where society cares abstractly about fishes and considers overfishing to be a key reason for population declines (e.g., in Germany). Threat-related messages with the purpose of increasing support for aquatic conservation measures are well known from the marine environment (e.g., campaigns focusing on bycatch or marine litter) but are currently limited in the freshwater context due to misconceptions of the public (as seen in this study) and the complexity of interacting threats (Dudgeon et al. 2006; Cooke et al. 2013). Instead, focusing messaging on broader ecosystem traits (e.g., unpolluted and free-flowing water) that will indirectly help extirpated or threatened riverine species recover is likely to win more public support.

A new approach to freshwater conservation is concentrating conservation messages on charismatic species (Carrizo et al. 2017; Kalinkat et al. 2017), such as migratory fish (Bolster 2008; Kalinkat et al. 2017). This approach may be effective in countries where the public has a connection to a species (e.g., Atlantic salmon in Norway). For central Europe, we found the situation was more complex: the general public supported conservation stocking despite not recognizing the species. This finding suggests knowledge is not essential for conservation support, but what matters are proecological beliefs and attitudes (Manfredo et al. 2017). We suggest enhancing the connection between native fish biodiversity and the general public by involving groups, such as anglers, that directly interact with the aquatic environment (Fujitani et al. 2017), as well as historians and artists who can highlight historical relationships with native fish species (Rathwell & Armitage 2016), in conservation research and outreach activities.

Acknowledgments

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Supporting Information

Respondents’ characteristics (Appendix S1), details for the Schwartz value scale (Appendix S2), the recreational activities respondents performed in the 12 months prior to the survey (Appendix S3), and the survey questions (Appendix S4) are available online. The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

Literature Cited

Closs GP, Angermeier PL, Darwall WR, Balcombe SR. 2015. Why are freshwater fish so threatened? Pages 37–75 in Closs GP, Krkosek C.


