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To cite this article: Shannon D. Bower, Øystein Aas, Robert Arlinghaus, T. Douglas Beard, Ian G. Cowx, Andy J. Danylchuk, Kátia M. F. Freire, Warren M. Potts, Stephen G. Sutton & Steven J. Cooke (2020) Knowledge Gaps and Management Priorities for Recreational Fisheries in the Developing World, *Reviews in Fisheries Science & Aquaculture*, 28:4, 518-535, DOI: [10.1080/23308249.2020.1770689](https://doi.org/10.1080/23308249.2020.1770689)

To link to this article: <https://doi.org/10.1080/23308249.2020.1770689>



Published online: 23 Jun 2020.



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REVIEW



Knowledge Gaps and Management Priorities for Recreational Fisheries in the Developing World

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ABSTRACT

Millions of individuals worldwide rely on recreational fishing activities for leisure, food, and employment. Recreational fishing is the dominant freshwater fisheries sector in much of the highly developed world and plays a growing role in the marine realm, but in developing countries recreational fisheries occur within a different set of contextual conditions. Little is currently known about attributes of the recreational fishing sector in many developing countries. A survey of fisheries experts designed to identify knowledge gaps surrounding recreational fishery development was conducted to gather information on fishery attributes in developing countries. These surveys were supplemented with a review of relevant literature. Results show that recreational fishing is socially important and is expected to grow in most countries surveyed. Recreational fisheries were described as mainly consumption oriented in these regions. Most often, nonresident tourists used marine waters and resident recreational fishers used fresh waters. There was strong agreement among respondents on the need to address data deficiencies. The knowledge gaps and management needs identified can support international bodies and recreational fishing organizations (such as the regional fisheries bodies of the Food and Agricultural Organization of the United Nations, and local and international fishing associations) to support sustainable development and management of the global recreational fisheries sector.

KEYWORDS

Developing world fisheries; global fisheries; fishery development; sport fisheries; sustainable fisheries

Introduction

Defined as the capture of fish that do not constitute a fishers' dominant source of protein and are generally not sold, bartered, or traded at market (FAO 2012), recreational fishing is a highly diverse activity, encompassing numerous gears, methods, and objectives. Recreational fishing is currently recognized as the dominant use of fish stocks in freshwater areas of highly developed nations (Arlinghaus et al. 2002; Cooke et al. 2016), and is practiced by approximately 10% of the population in these countries (Arlinghaus et al. 2015). Conservative estimates suggest that over

\$190 billion USD in expenditures are generated annually on a global basis (Kelleher et al. 2012) through annual capture and harvest or release of over 30 billion fishes (Cooke and Cowx 2004).

Research on recreational fisheries in highly developed countries has identified common potential and realized benefits and impacts associated with the sector (Arlinghaus et al. 2019). Benefits derived from recreational fisheries include substantial economic benefits in the form of expenditures and related infrastructure (Potts et al. 2009; Cisneros-Montemayor and Sumaila 2010), a potential increase in the stability of

the employment buffer through increased seasonal or year-round employment via tourism (as diversification for accumulation, Smith et al. 2005), psycho-social benefits (Fedler and Ditton 1994; Floyd et al. 2006; Parkkila et al. 2010), and recreational fisher participation in conservation efforts such as citizen science, habitat restoration, and research (Granek et al. 2008; Tufts et al. 2015; Copeland et al. 2017). The risks associated with recreational fishing are multi-faceted and often coincide with other industries and environmental threats, rendering the role of recreational fishing and the degree to which it contributes to these risks difficult to quantify. Overfishing (Post et al. 2002, Post 2013), impacts on target species genotype (e.g., through selective mortality, Lewin et al. 2006) and behavior (e.g., Cooke et al. 2007, Arlinghaus et al. 2017a), ecological degradation (through habitat loss and alterations to structure, Lewin et al. 2006), and introduction of invasive species (Johnson et al. 2009) have been identified as some of the key impacts occurring in the sector, in addition to conflicts with other fishing sectors over access to fish and space (Arlinghaus 2005). Important social and cultural conflicts may arise during recreational fishery development, as participants from different sectors may target the same species or adopt varying strategies to catch or consume fish (Ditton et al. 2002; Bower et al. 2014; Øian et al. 2017; Kadagi et al. 2020). This can culminate in conflict wherein more powerful groups marginalize less powerful groups. For example, recreational fisheries regulatory loopholes have resulted in recreational fishers outcompeting commercial fishers for catch sales (Babali et al. 2018). Another example of conflict is a result of cultural clashes where, for example, foreign tourists practice catch-and-release while local values and customs resent this practice of treating fish “for fun” rather than for subsistence and survival (Arlinghaus et al. 2012).

Recreational fishing is growing as a global sector, including through mechanisms such as tourism-based fisheries, alternative livelihood strategies, or as a local leisure activity (Bower et al. 2014; Belhabib et al. 2016; Babali et al. 2018; Arlinghaus et al. 2019). This growth of the recreational fishing sector has potential to lead to increased income and opportunities. For example, an estimated recreational fishery catch of 34000 tonnes in West African countries contributes \$152 million USD annually to the economies of West African countries (Belhabib et al. 2016). To maximize benefits and avoid the risks associated with growth in the recreational fishing sector, however, it is crucial to be able to predict and manage them. While research

funding and interest is growing for recreational fisheries globally, there is still insufficient information available on recreational fisheries in less wealthy countries in the world, and it can be expected that the development of the sector in these countries will not follow the same patterns as it has in highly wealthy countries. Moreover, the risks associated with recreational fishery development are potentially much higher for vulnerable communities and user groups that rely on the resource for survival (e.g., in Brazil, the economic advantages offered by catch-and-release recreational fishing led to some closures and restrictions in commercial activity, Freire et al. 2012), suggesting that research in these regions should be prioritized. Indeed, understanding the factors that enable the development of sustainable recreational fisheries in developing countries has been identified as an important research need in recreational fisheries science (i.e., Holder et al. 2020).

Commercial and subsistence fishing activities provide an important source of protein (Hall et al. 2013) and income (FAO 2016) for millions of people in developing countries. The dominant subsistence and commercial capture fisheries in developing countries share the waters with recreational fisheries but also face challenges not universally characteristic of recreational fishery development. These challenges can include issues of food security, access to markets, and the nature of governance and rights allocation in modern and often globalized fisheries, amidst increasing levels of competition for diverse resources, including with growing recreational fisheries (Andrew et al. 2007; Allison et al. 2009; Tacon and Metian 2009). Therefore, the likely growth of the recreational fishery sector in developing countries raises questions of equity among communities and fishing sectors rarely discussed in the literature on recreational fisheries (FAO 2012). These issues too will need to be prioritized in fisheries research.

The benefits, risks, and potential impacts associated with recreational fisheries as well as the tight coupling of the social and ecological fishery systems (Hunt et al. 2013; Arlinghaus et al. 2017b) create a general context that includes biological, environmental, social, governance, and economic concerns, suggesting that fisheries managers will need to adopt inter- and possibly trans-disciplinary approaches to maximize benefits derived from recreational fishing and minimize associated risks and impacts on other sectors (e.g., complex adaptive social-ecological systems approach, Arlinghaus et al. 2016, 2017b). Given the potential for increased risk related to recreational fisheries

and robust manner suggested that a survey alone was unlikely to suffice in describing general traits and priorities in developing world recreational fisheries. Thus, the surveys were supplemented with a review of relevant literature by elaborating on themes and issues described by respondents.

Methods

Identification and communication with respondents

Individuals with expert knowledge of management of recreational fisheries in their country were the target population for the survey, including individuals whose work experience in fisheries management occurred at the international scale. Potential respondents from the target population were identified through online searches of international-scale fisheries programs (e.g., regional fisheries bodies of the FAO), and/or whose email contact information was available through national- or state-level fisheries departments, non-governmental organizations (NGOs), and university websites. Out of respect for areas undergoing conflict, certain countries were excluded from communications that would otherwise have been included, namely Syria, Sudan, and the Democratic Republic of the Congo.

After confirming email address functionality through the invitation process, the survey was emailed to potential respondents in two waves over an 18-month period. The first wave of the survey ran from January 2013 to January 2014 and the second from February to June 2014. In both waves, reminders were issued on a bi-weekly basis until no further responses were forthcoming.

Survey construction and rationale

The 13-question survey (Ethics approval 13-1355, Carleton University, Canada) was conducted in English only to avoid compounding potential language bias through multiple language translations (Appendix 1). The survey was constructed to elicit responses without prompting respondents with key words or contextual cues, thereby reducing the likelihood of measurement bias associated with lack of topic knowledge (Newing 2010; Dillman et al. 2014). To reduce error associated with language bias, terms used in the survey were accompanied by operationalized definitions (Appendix 2).

The survey was organized around three categories: demographic questions describing the respondent,

closed-ended questions to elicit respondent perspectives and attitudes, and open-ended questions to identify perceived needs in more detail. Demographic questions were used to ascertain respondents' country of employment, area of expertise, years employed in fisheries, and breadth of expertise (i.e., local to international). Closed-ended questions asked for perspectives relating to the importance of recreational fisheries to other sectors, and the extent and modes of national participation in recreational fisheries. Each closed-ended question using a six-point Likert agreement scale included a response of 'I don't know' as a neutral option (Likert 1932). Questions designed to elicit responses that were not perspective-based (e.g., the number of participants in a fishery as factual statement) included requests to indicate the degree of certainty of the response and a request for references if available. Open-ended questions asked for respondents to prioritize management and policy needs, knowledge and development gaps, to describe existing management strategies, and indicate areas of potential conflict. These questions asked respondents to list the top three items they felt were most important for each category. A final question asked for any additional comments respondents wished to add pertaining to issues they felt were unique to the recreational fisheries in their country. Respondents were free to answer as many or as few questions as they wished; as such, the sample size of responses is presented for individual questions.

Data management and analysis

Direct comparison of responses between countries is not advisable due to culturally based differences in perception and differences in language usage (OECD 2013). Thus, respondents were binned into a global pool for analysis. There was a small number of respondents ($n=9$) who were unable to complete the online survey due to language or technical difficulties and so opted to provide as much information as they were able via email. In these circumstances, information provided by respondents that aligned with specific questions was included in the analysis of that question and is indicated as a written response in the results.

Analysis of the survey responses was performed according to question type. Descriptive statistics were generated for demographic questions and closed-ended questions and are presented with the associated percentage of respondents who chose a particular response and the median value for that question

Table 1. Respondent country UN HDI Score and HDI rank (1 – 188), organized by HDI Score, where ‘n/a’ refers to a country with an unavailable HDI score. Countries with unavailable HDI scores were included in the survey based on GDP alone.

Respondent Country	HDI Score	HDI Rank	Respondent Country	HDI Score	HDI Rank
Bahamas	0.79	58	Kiribati	0.59	137
Panama	0.78	60	Ghana	0.58	139
Malaysia	0.78	59	Kenya	0.55	146
Seychelles	0.77	63	Pakistan	0.54	147
Turkey	0.76	71	Tanzania (United Republic)	0.52	151
Mexico	0.76	77	Zimbabwe	0.51	154
Brazil	0.76	79	Solomon Islands	0.51	156
Saint Kitts and Nevis	0.75	74	Papua New Guinea	0.51	154
Thailand	0.73	87	Nigeria	0.51	152
Fiji	0.73	91	Madagascar	0.51	158
China	0.73	90	Uganda	0.48	163
Tonga	0.72	101	Togo	0.48	166
Dominica	0.72	96	Benin	0.48	167
Colombia	0.72	95	Liberia	0.43	177
Belize	0.72	103	Mozambique	0.42	181
Maldives	0.71	105	Guinea-Bissau	0.42	183
Indonesia	0.68	113	Wallis and Futuna	n/a	n/a
Philippines	0.67	116	Montserrat	n/a	n/a
South Africa	0.67	119	Turks and Caicos	n/a	n/a
Fed. States of Micronesia	0.64	127	Martinique	n/a	n/a
Namibia	0.63	125	Marshall Islands	n/a	n/a
India	0.61	131	Cook Islands	n/a	n/a
Vanuatu	0.59	134	Anguilla	n/a	n/a

where meaningful. In 12 cases, respondents were from the same country (e.g., two from Brazil, two from China); however, no two respondents from the same country shared the same demographic profile and the variation in response was consistent with variation between countries. As such, no weighting was applied by country. Closed-ended questions were analyzed in R to compute descriptive statistics and frequency of Likert responses among HDI ranks (psych package Revelle 2016; version 3.3.3, R Development Core Team 2016).

Open-ended responses were qualitatively analyzed for content following procedures described by Neuendorf (2017), wherein responses were coded by binning them into suggestion subject (categories) and then analyzed for frequency of occurrence. Each novel suggestion was catalogued and formed an individual ‘node’. Nodes could contain a single response if the suggestion was not repeated, or multiple responses if the same suggestion was supplied by multiple respondents. Nodes were then binned according to subject category. For example, responses that knowledge of target species’ biology, habitat usage, or trophic level represented key knowledge gaps would be counted as three single response nodes included under the broader subject category of ‘target species life history’. The subject categories containing the highest number of nodes were considered to reflect respondent priorities. In the case of a tie, the subject category containing nodes with the most agreement (highest number of responses per node) were assigned

priority. To protect anonymity, only Bower was involved in the preliminary coding effort, however all authors then discussed and refined the nodes and categories.

Results

Response statistics

Of the 809 potential respondents identified, 278 proved to be unreachable due to incorrect or nonfunctioning email addresses, leaving 531 remaining potential respondents. Each of these potential respondents received a survey invitation, and 136 potential respondents went on to view the survey. Of these, 75 respondents from 46 countries went on to complete the survey (online, 66; email correspondence, 9), resulting in an overall response rate of 14% (all potential respondents).

Respondent demographics

Survey respondents represented 39 countries with HDI (UN 2015) scores ranging from 0.42 – 0.79 (Figure 1; Table 1) and seven countries without an HDI rank. Of the HDI-ranked respondent countries, 15 countries with high HDI scores (0.70 – 0.8), 13 countries with medium HDI scores (0.55 – 0.69), and 11 countries with low HDI scores (0.35 – 0.54) were represented. The respondents from seven countries that were not ranked on the HDI list were included in descriptive statistics and qualitative analysis. Respondents tended to have many years of experience

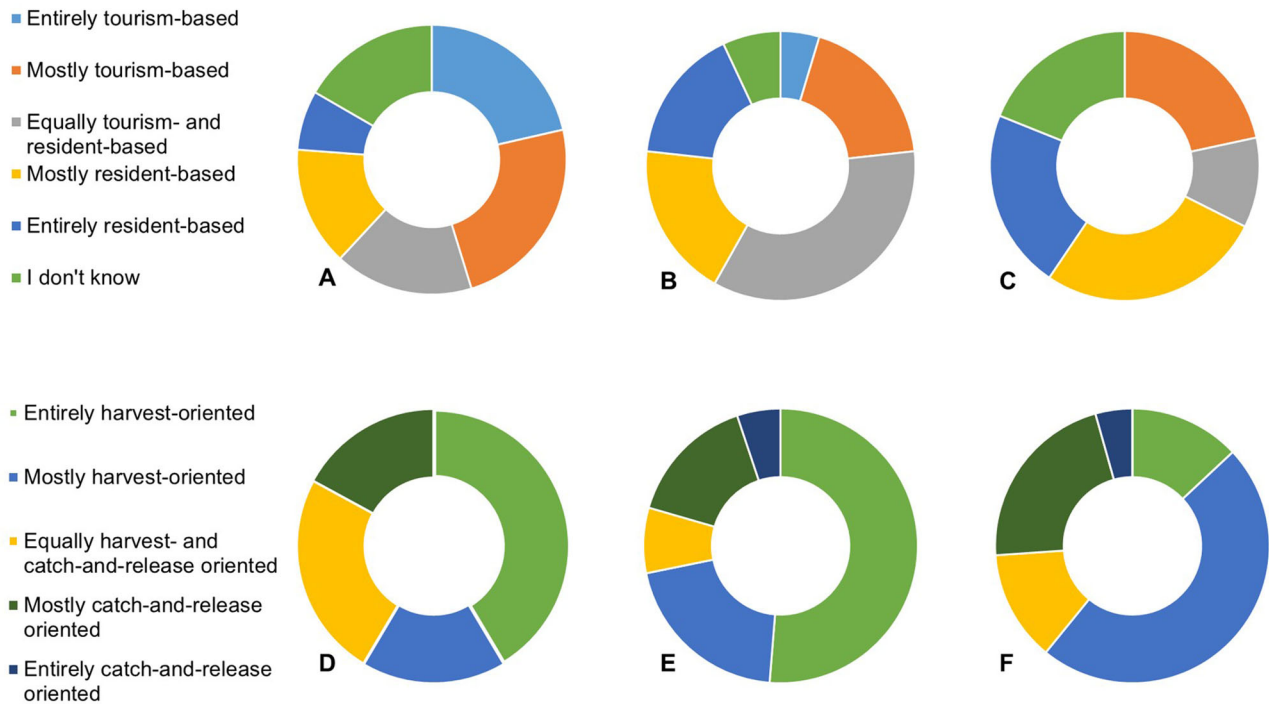


Figure 2. Respondent perceptions of recreational fishery attributes (ranging from entirely tourism-based to entirely resident-based) are shown at top for offshore (A), coastal (B), and freshwater (C) zones. Respondents estimated recreational fisher behavior (ranging from entirely harvest-based to entirely catch-and-release) in each of these zones, shown at bottom as offshore (D), coastal (E), and freshwater (F).

in their respective fields, selecting either over 20 years of experience (43.1%, $n = 28$) or 15–20 years of experience (18.5%, $n = 12$).

Perspectives relating the importance of recreational fisheries to other sectors, Q1 – Q3

Respondents were more likely to respond to the request to rank commercial, subsistence and recreational fisheries sectors for social and economic importance ($n = 63$ for both categories) than they were to rank these same sectors for biological/ecological impact ($n = 50$, Q1). Commercial fisheries were most commonly viewed as being ecologically impactful (very important, 65%), economically important (very important, 63%), and socially important (very important, 57%). Similarly, subsistence fisheries were most commonly viewed as very important in all categories: socially important (very important, 52%), economically important (very important, 40%), and ecologically impactful (very important and somewhat important, 26%). Recreational fisheries were considered the least important of all sectors, but were still considered somewhat important or very important by many respondents: socially important (somewhat or very important, 49%), economically important

(somewhat or very important, 43%), and ecologically impactful (somewhat or very important, 38%).

When considering the relative importance of each fishery sector by zone (Q2), the majority of respondents indicated that commercial fisheries were the most important sector in offshore zones (93%) and subsistence fisheries were the most significant sector in freshwater zones by small margin (47%; commercial, 42%). Respondents indicated recreational fisheries were the most important sector in some offshore (2%), coastal (7%), and freshwater zones (11%). When asked the degree to which recreational fisheries overlap with the primary fisheries sector in offshore, coastal, and freshwater zones (Q3), most respondents indicated there was a degree of spatial overlap (occupying the same waterbodies; sectors overlap somewhat [offshore 42%; coastal 48%; freshwater 39%]) and resource overlap (targeting the same species; sectors overlap somewhat [offshore 47%; coastal 49%; freshwater 42%]) in all three zones.

Extent and modes of national participation in recreational fisheries, Q4–Q7

Some respondents ($n = 33$) offered estimates for future increases or decreases in participation and harvest (Q4). These respondents indicated they expected

Table 2. Subject categories for open-ended questions. Each subject category contained nodes representing shared and unique ideas identifying a theme (as described in the Methods section). The number of nodes contained in each subject category is shown in brackets after the subject category title. Subject categories containing the three highest numbers of nodes were identified as the top three priorities. The first, second and third priority subject categories are bolded, and the associated percentage of respondents who voted for each priority is included with the number of nodes in brackets.

Question, Section	Subject categories
Q8, Management Needs (54 suggestions)	Begin data collection and management (n = 17; 31%) Develop or update legislation and regulations (n = 14; 26%) Develop management plan (n = 9; 17%) Improve management capacity (n = 4) Develop conflict management strategies (n = 3) Institute protected areas (n = 3) Develop public education strategies (n = 2) Promote recreational fishing (n = 2)
Q8, Policy Needs (45 suggestions)	Develop or update national policy (n = 10; 22%) Promote control strategies for recreational fisheries (n = 10; 22%) Promote support policies for recreational fisheries (n = 8; 18%) Improve administrative capacity (n = 7) Adopt cooperation in recreational fisheries management (n = 6) Update or reform legislation (n = 4)
Q9, Knowledge Gaps (47 suggestions)	Identify current state of recreational fisheries (n = 20; 40%) Measure impact of recreational fishing (n = 13; 28%) Characterize life history attributes of recreational fish species (n = 7; 16%) Identify recreational fishing locations (existing and potential; n = 3) Identify best practices (n = 2) Identify fishery-appropriate management systems (n = 1) Train staff in recreational fisheries management (n = 1)
Q9, Development Gaps (40 suggestions)	Develop physical infrastructure supports (n = 9; 23%) Develop enforcement systems for recreational fisheries (n = 7; 18%) Develop management institutions for recreational fisheries (n = 7; 18%) Improve collaboration among recreational fisheries organizations (n = 6) Develop economic management systems for recreational fisheries (n = 6) Develop research programs to generate recreational fisheries data (n = 5)

considerable increases in both participation and harvest rates in their national recreational fisheries (participation, 41%; harvest, 34%). Current participant (i.e., recreational fisher) characteristics (Q5) were described by respondents per zone as mostly tourism-based (24%) or entirely tourism-based (21%) in offshore recreational fisheries, equally tourism-based or resident-based (35%) in coastal recreational fisheries, and mostly resident-based (27%) or entirely resident-based (22%) in freshwater recreational fisheries (Figure 2).

Of 23 responses for the question asking whether recreational competitive angling events were permitted in their country (Q6), 21 respondents (88%) indicated they were allowed. Competitive events were described as occurring ‘occasionally’ almost equally in offshore (25%), coastal (24%), and freshwater (23%) zones. The most commonly targeted species in competitive events were tunas (22% of 23 mentions), marlins (17%), dolphinfish (17%) and wahoo (17%).

Respondents (n = 46) also described the overall practices used by recreational fishers in their countries as mostly or entirely harvest-oriented (48%), with mostly catch-and-release and equally harvest- and catch-and-release oriented fisheries described in 24% and 15% of fisheries respectively (Q7). When asked to

describe the practices used by recreational fishers to catch the three most commonly targeted species in their countries, recreational fisheries were described by respondents as mostly or entirely harvest-oriented in all three zones (coastal, 72%; freshwater, 61%; offshore, 58%; Figure 2). Catch-and-release fisheries (mostly or entirely catch-and-release) were also included in all three zones (freshwater, 26%; coastal, 20%; offshore, 17%). The most popular recreational species groups in marine waters were billfishes (15% of 144 species mentioned) and tunas (10%) in offshore zones, and snappers (6% of 144 species mentioned) and barracuda (4%) in coastal zones. The most popular recreationally fished species in fresh water were tilapias and carps (4% each of 144 species mentioned). We acknowledge that some of these groups, e.g., barracuda, can be caught in multiple zones (Freire et al. 2018).

Prioritizing management and policy needs, knowledge and development gaps, Q8–Q9

“All the knowledge on recreational fisheries is missing, especially in terms of conservation.”

(Survey respondent)

Open-ended questions received fewer responses than closed-ended questions. Respondents to Q8 (n=28) and Q9 (n=26) were asked to rank top three priorities for management and policy needs, and knowledge and development gaps (Table 2). Eight subject categories were identified in responses prioritizing management needs, six for policy needs, seven for knowledge gaps, and six for development gaps (Table 2). Addressing data deficiencies through data collection occurred as a priority response for both Q8 (Management Needs) and Q9 (Knowledge Gaps). Other major themes included socio-economic assessment and regulation enforcement. Responses included within a node were sometimes contradictory, as different respondents recommended contrasting strategies to address similar problems, e.g., focusing on decentralization versus nationalization.

Management of the recreational fishing sector, Q10

Just over half of respondents (n=45) indicated that recreational fisheries were managed in their countries (managed, 53%; not managed, 47%). Of the respondents who indicated management occurred (see Appendix 2 for operative definition of fisheries management), too few described the bodies responsible for managing and controlling offshore, freshwater, and coastal recreational fisheries for a feasible analysis.

Areas of potential conflict and emerging issues, Q11–Q13

When asked to identify any issues that may serve to constrain the sustainable development of recreational fisheries in their respective countries (Q11), respondents (n=26) were almost evenly divided, with 42% (n=11) of respondents suggesting there were no priority issues constraining sustainable development of recreational fisheries. The remaining 58% (n=15) indicated that the top issues constraining the sustainable development of recreational fisheries in their country were resource or spatial conflict among fishing sectors (31%, n=5), and concerns regarding resource limitations (27%, n=4) such as overharvest and coastal development.

Sources of potential and realized social, biological, and economic conflict were identified by respondents in Q12. All but three of the 32 suggestions could be categorized under two themes: potential and realized conflict among commercial and recreational fishers (63%, n=20) and cultural conflict among recreational

fishers and other recreational resource users (28%, n=9). The potential and realized conflict among commercial, subsistence, and recreational fishers theme included nodes related to spatial competition (e.g., in preferred fishing areas, at fishing ports; n=6), resource competition arising from shared target species (n=5), and loss of commercial revenue to recreational fishing profits (n=4). Concerns regarding conflict specific to recreational fishers congregating around commercial fish aggregating devices were also mentioned (n=4). The cultural conflict among recreational fishers and other resource users theme included references to conflict between tourism- and resident-based activities (n=4), and challenges related to the acceptability of catch-and-release practices (n=4).

There were 15 responses to Q13, asking respondents to describe situations unique to their recreational fisheries. The responses addressed conflict and data deficiency issues already discussed in earlier results; however, no agreement occurred among respondents that would identify global scale emerging issues.

Discussion

The results of this survey and review reinforce the need to acknowledge recreational fisheries as an important global fisheries sector and point toward knowledge and development gaps that should be addressed to promote long-term sustainability of the activity (consistent with recent FAO State of the Resource reports; e.g., see Funge-Smith et al. 2018; Arlinghaus et al. 2019). While recreational fishing is studied widely in much of North America, Europe, and Australia and New Zealand, i.e., highly developed economies, comparatively few studies have been conducted elsewhere in the world, despite an increasing level of sector activity in many countries (Cooke and Cowx 2004; Bower et al. 2014; Barnett et al. 2016; Belhabib et al. 2016; Bower 2018) and the potential for conflict among the different fishing sectors (Bower et al. 2014; Kadagi et al. 2020).

Although not definitive, these preliminary findings can be used to prioritize areas of focus for addressing knowledge gaps and data deficiencies. Overall, the traits respondents chose to describe recreational fishery activity were similar to those shown in the broader literature described in this paper: the sector is operating in the developing world, it is viewed as important, it is not consistently managed, and individual fisheries have unique conditions and traits (i.e., different angler behaviors and different target species).

Survey results indicate that there are patterns of use occurring in developing world recreational fisheries, whereby tourist anglers are often using marine, off-shore fisheries while local residents tend to favor freshwater fisheries. Additionally, recreational fisheries were most commonly categorized as consumptive, but catch-and-release fisheries were described as occurring relatively frequently in the most popular recreational fisheries (freshwater, 26%; coastal, 20%; offshore, 17%). While these findings require additional research for support and confirmation, there are numerous examples of these topics in the existing literature described in this review such that the findings should not be dismissed (e.g., see mentions of catch-and-release fishery development in Cooke and Schramm 2007; recreational fisheries tourism topics in Borch et al. 2008; and the catch-and-release bonefish fishery in the Bahamas, Danylchuk et al. 2007, among many others).

Similarly, though the responses to the open-ended questions were few, the themes described were clear and strongly supported in literature. These themes of food security, conflict, the socio-ecological nature and interpretation of fisheries issues, and data deficiencies are presented below in detail.

Food security

The perceived importance of harvest-oriented recreational fisheries to respondents, particularly in freshwater and coastal fisheries, highlights the potential for recreational fishing to act as a source of additional nutrition in responding countries. A review of recreational fisheries contributions to nutrition by Cooke et al. (2018) suggested that while the proportion of recreational fishing harvest to total harvest varies widely within and among regions (e.g., 24.5% in Greece, 13.0% in Argentina, 10.0% in USA, 0.4% in Senegal), recreational fishing can be found to contribute substantially to total fish harvest rates overall. Despite a clear harvest orientation in respondent countries, there were also reports of catch-and-release activities even in the resident fisher-dominant freshwater fisheries. This may, in some areas, be attributed to mandatory catch-and-release associated with regulations (e.g., in some parts of India; Gupta et al. 2015) or with development of tourism-oriented fisheries (e.g., the Niugini black bass fishery in New Guinea, Sheaves et al. 2016; the taimen fishery in Mongolia, Jensen et al. 2009, among many others). In other areas, catch-and-release can develop due to an increase in economic prosperity and growing middle

class and the concomitant decrease in reliance on fishing activities for the immediate protein needs of the population. It is also possible that catch-and-release behavior evolved along with the introduction of some sport fish species (e.g., rainbow trout, *Oncorhynchus mykiss*; tucunarés, *Cichla* spp.), which are perceived to be “valuable” sport fishes that are worth protecting (Cooke et al. 2016).

Potential conflict issues

In conflicts between recreational fishers and other recreational resource users described in highly wealthy countries, tension can arise when overlapping activities occur, for example, recreational fishers may disturb other users through loss or inappropriate discard of fishing gear or disturbance of habitats (e.g., O’Toole et al. 2009; Yorio et al. 2014), while other users may disturb fishers by traveling through fishing sites while fishing is occurring (e.g., Lynch et al. 2004). In addition, there is considerable conflict between fish-eating birds and fisheries (Cowx 2003). In conflicts among recreational and other sector fishers (commercial, subsistence), the opposing sectors may blame the other for poor conditions such as decreased catches (e.g., see the rockfish fishery conflict, Granek et al. 2008; Freire et al. 2017). Research from several European countries has demonstrated that conflict within the recreational fishery also occurs among those fishers who support catch-and-release and those who do not, often based on the concept of animal cruelty (Aas et al. 2002; Arlinghaus et al. 2007).

It is important to acknowledge that the dominant lens through which recreational fisheries conflict is viewed are from the perspective of wealthy and highly industrialized countries, often with social safety nets that reduce risks to livelihood and survival for affected citizens. Similar conflicts to those described above have emerged in developing countries (e.g., in Brazil; Freire et al. 2016; conflict between artisanal and recreational fishers in the Kenyan billfish fishery, Kadagi et al. 2020). While these examples show that the conflict types described above can and do happen in developing countries also, realization of risks associated with developing world recreational fisheries conflict can have more severe consequences for fishers and communities (Bower et al. 2014), a risk that may heighten the conflict itself. Indeed, there are examples of the importance of access to fisheries activity for food and economic security (Lynch et al. 2016), the role such security can play for communities during

armed conflict (Glaser et al. 2019a), and the role that illegal, unreported and unregulated fisheries play in conflict relationships in Somalia (Glaser et al. 2019b). These are additional issues not often described in literature when perspectives from the developing world and the Global South are ignored. While these latter examples may not be directly attributable to recreational fisheries, they do form part of the broader fisheries social-ecological system in which some developing world recreational fisheries occur. Thus, researchers engaging in recreational fishery assessments in the developing world should ensure that local culture, context, and conflict situations are incorporated into their perspectives.

Social-Ecological systems or inter/transdisciplinary approaches

Respondents framed similar responses to all open-ended questions from differing biological, social, and economic perspectives, demonstrating the multi-disciplinary nature of recreational fishing attributes and issues. For example, respondents agreed on sources of conflict in recreational fisheries, but framed them differently as social, ecological, and economic context. Indeed, respondents were more likely to rank all fishing sectors (commercial, subsistence, recreational) in terms of social and economic importance rather than biological/ecological importance. Using social-ecological systems or inter/transdisciplinary approaches in recreational fisheries would not only facilitate study and understanding of complex linkages among recreational fisheries system attributes (Arlinghaus et al. 2016), but encourage the consideration of variation in cultural values, norms, and traditions that have rarely been explored in the context of recreational fisheries (see Barnett et al. 2016; Bower 2018). In addition to accounting for social and cultural diversity, applying a social-ecological systems approach to recreational fisheries research will serve to identify critical variables and overarching social-ecological processes (Arlinghaus et al. 2017b), offering opportunities to develop an evidence base for management and policy.

Data deficiencies

The knowledge gaps identified by the respondents underline the severity of data deficiencies in the recreational fisheries of the developing world. All three top knowledge gaps described the need for baseline data (e.g., the population size and natural history of target species, the number and behavior of recreational

fishers, the amount of economic benefit accrued through recreational fishing activity). Data deficiencies also accounted for the majority of knowledge gaps suggestions, making up 45 of 47 responses, while the related category 'data collection and data management' were considered the most important management need, making up 17 of 54 responses. These same data-gaps were identified in a more generic sense in a global research prioritization exercise for recreational fisheries emphasizing that this topic is equally relevant to developed and developing nations (Holder et al. 2020).

Data deficiencies do not apply solely to recreational fisheries occurring in developing countries, nor even just to recreational fisheries globally (see Lorenzen et al. 2016 and Bartley et al. 2015 on data issues in inland fisheries). Policy makers at the international level have expressed concern about the lack and quality of fisheries data available to support policy decisions (see CEFAS 2013; FAO 2016 for examples of regional- and national-level data deficiencies; see de Graaf et al. 2011 and Lorenzen et al. 2016 for discussion of data deficiencies related to small-scale fisheries). This trend appears to be increasing, with omissions of reported catches from fisheries and of distinct species on the rise (Bartley et al. 2015). Attempts are underway to account for data quality issues in fisheries catch reporting using multiple data sources and including reference to recreational fisheries (Belhabib et al. 2016; Pauly and Zeller 2016; Arlinghaus et al. 2019; Freire et al. 2020). While some European countries provide estimates for recreational fishing catches (but again mostly economically important species such as salmon) to the FAO, few other countries do so and consistent reporting is rare (Bartley et al. 2015). Similarly, Cooke and Suski (2005) noted that catch-and-release research findings related to recreationally fished species tend to be limited to highly economically profitable species, particularly those fished in North America even though some isolated initiatives have been seen in developing countries (see, e.g., Thomé-Souza et al. 2014; Bower et al. 2016a, 2016b). Addressing global data deficiencies should thus be considered a priority for recreational fisheries research.

Paradigm shifts

The current fisheries management paradigm in many developing countries favors the marine commercial sector over recreational fisheries because of the crucial economic and social benefits associated with

commercial fisheries. The additional perception that recreational fisheries are inconsequential because the activity is driven by choice rather than by necessity needs to be challenged. Several studies have demonstrated that recreational fisheries can provide considerable economic benefits in developing countries (e.g., Shrestha et al. 2002; Potts et al. 2009; Cisneros-Montemayor and Sumaila 2010; Kelleher et al. 2012; Friere and Sumaila 2019), even potentially exceeding those of commercial fisheries. Indeed, Belhabib et al. (2016) found that developing recreational fisheries in West Africa would increase the value of each fish sevenfold, whether those fish were retained or released. These economic benefits may accrue directly to local people through the provision of jobs as service personnel in resorts (Potts et al. 2009), angling guides, and the charter of commercial vessels (Pawson et al. 2008). If these recreational fisheries are dominated by catch-and-release angling practices (e.g., Potts et al. 2009), these benefits can be obtained with limited resource competition between sectors. For these benefits to be realized, however, catch-and-release practices will have to reflect science-based best practices to achieve conservation value (Brownscombe et al. 2017). Thus, the Cooke and Suski (2005) argument that recreationally fished species should be individually researched for responses to catch-and-release needs to be extended to examine fishery-specific traits to account for social and cultural differences and particular attention should be paid to developing world recreational fisheries to support truly sustainable development of the sector (Bower 2018).

The life cycle of fisheries metaphor predicts that in economically less developed countries commercial and subsistence fisheries dominate over recreational fisheries, but that the importance of recreational fisheries rises as economic development evolves (Smith 1986; Cowx et al. 2010; FAO 2012). Our findings align with the life cycle of fisheries metaphor in that in developing countries the dominant fisheries are commercial and subsistence fisheries and not recreational fisheries. All responding developing countries reported some level of recreational fishing activity, however, and respondents thought the sector would grow. Whether these survey results genuinely aligned with the model, and whether the model itself was a likely predictor for recreational fishery growth in the developing world was a source of debate among the author group. While these findings accord with the theory that increased leisure time and economic growth might lead to growing recreational fisheries (FAO 2012), it was acknowledged that this would not hold true in all

cases or in all countries. Specifically, different countries have diverse perspectives on the value and importance of fisheries that may constrain recreational fishery growth in favor of policies promoting aquaculture, while in other cases recreational fisheries may remain a peripheral, tourist-oriented activity. Additionally, some consideration was given to trends such as urbanization, which could result in negative growth in recreational fisheries (Arlinghaus et al. 2015; Hunt et al. 2017). Equally important, the discussion highlighted the need to address local differences in fishing culture more effectively in recreational fisheries research so that Western views and cultural norms are not preferentially endorsed as a result of comparative research abundance. This issue has widely been noted in the context of the difficulties in incorporating traditional or local ecological knowledge into data collection and interpretation (e.g., Huntington 2000; Berkes et al. 2016), but also applies to recreational fisheries.

Study limitations

The results of this study represent the first effort to conduct a survey of developing world recreational fisheries experts. Though expert knowledge offers high value, interpretation of the results must nonetheless be considered within the limits of analysis based on a small sample size. Although language bias derived from the use of an English language survey was accounted for in the survey design and subsequent analysis (see Data Management and Analysis), other sources of bias and associated assumptions should be considered. For example, responses to demographic questions were assumed and accepted as true, however, the likelihood of any deception is limited given the anonymity of the survey. Furthermore, any impacts of demographic exaggeration would be minimal as demographics did not contribute to analysis. Additionally, although all countries having an HDI of low to high were targeted, there was a distinct lack of response from the northern region of Africa and a high response rate from island nations, a source of geographic bias that may have also resulted in a bias toward marine and possibly offshore recreational fisheries.

We attempted to reduce as many sources of error as possible but acknowledge that given the language limitations and the impossibility of locating every expert responsible for managing recreational fisheries in developing countries, combined with the high degree of non-response, unknown degrees of coverage

and sampling errors will have occurred. Thus, these results should be viewed as a preliminary assessment and a first step, rather than an exact characterization of developing world recreational fisheries. Nonetheless, what is clear is that recreational fisheries are important in developing countries and the identified knowledge gaps and management needs should be addressed in a timely manner to foster sustainable development. As such, these findings amplify recent calls by Funge-Smith et al. (2018), Arlinghaus et al. (2019), and Holder et al. (2020) to support sustainable recreational fisheries development in the developing world and provide some of the first empirical, albeit preliminary, information on the global desire and need for capacity building related to recreational fisheries science and management.

Conclusion

Recreational fisheries have the potential to act as an important contribution to livelihoods through their development, but certain factors such as community engagement and sharing of economic benefits must be in place to ensure sustainable growth that can both benefit local communities and limit the negative impacts of recreational fishing activity (Barnett et al. 2016). While the results from the survey described herein may not be definitive, the supports found in the literature review are numerous and confirm that recreational fishing is a global sector with an important role to play in livelihood (Potts et al. 2009), economic security (Kelleher et al. 2012; Belhabib et al. 2016), and food security (Cooke et al. 2018). We have confirmed that conflict surrounding recreational fishing activity is occurring in the developing world (Freire et al. 2016; Babali et al. 2018; Kadagi et al. 2020, among numerous other examples) and have described ways in which these conflicts pose risks to fishers, fishes, and fishing communities. Our respondents firmly agreed with observations in research about the severity of data deficiencies in global recreational fisheries (Holder et al. 2020). Thus, the recreational fisheries field now requires a genuinely multicultural and interdisciplinary approach to incorporate the interests and needs of a truly global industry (Aas 2002).

Acknowledgements



The authors would like to thank all of the survey participants for sharing their knowledge and expertise of recreational fisheries in their respective countries. Their views

contributed greatly to understanding this global sector and their engagement was much appreciated.

Funding

Bower was supported by Too Big to Ignore (TBTI), the Social Science and Humanities Research Council (SSHRC) and the Ontario Graduate Scholarship fund during this project while a graduate student at Carleton University. Freire acknowledges the support of an *Estágio Sênior* CAPES Fellowship (n. 99999.005773/2015-06). Cooke is supported by the Canada Research Chairs program, the Natural Science and Engineering Research Council, TBTI and SSHRC. These funding sources do not lend themselves to any conflicts of interest, nor did they influence interpretation in any way. Any use of trade names is for descriptive purposes only and does not imply endorsement by the U.S. Government. Due to the anonymous nature of the survey, it is not possible to share this data on open access platforms, but any data-related queries are welcome and can be directed to the corresponding author.

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Appendix

Appendix I. Global Recreational Fisheries Survey

Preliminary Information

1. Please enter the name of your country, or the name of the country in which you are/were employed in the fisheries sector:
2. Please select the level of management which best describes your experience in fisheries:
3. Please select the choice that best describes your area of expertise in fisheries:
4. Please select the choice that best describes your years of experience in fisheries:

Survey Questions

- Q1. Please indicate the degree of social and economic importance and degree of ecological/biological impact of the commercial, subsistence and recreational fishing sectors in your country using the scale from 1 (very unimportant) to 5 (very important) provided in the drop-down menu.
- Q2. Based on the number of participants, amount of catch (total catch, including fish voluntarily released) and economic expenditure, please estimate the size of the recreational fisheries in your country. (This included estimates of “number of participants per year”, “amount of catch per year in tonnes”, “economic expenditures gained per year” and estimates of certainty /references for categories “total recreational fisheries”, “offshore marine recreational fisheries”, “coastal marine recreational fisheries”, and “freshwater recreational fisheries”. Please also indicate the relative degree of certainty for any estimates provided using the accompanying drop-down menu. If you are unable to offer an estimate due to a lack of information, please select “I don’t know”. (Click on menu to see options.) If you are able to offer estimates and have a reference available, please complete the resource section.
- Q3. Please identify the most important fishery sector (commercial, subsistence or recreational) in each of your country’s fishing zones and if recreational fisheries are not the most important sector, please indicate whether the commercial or subsistence sectors occupy the same bodies of water (spatial overlap) or target the same species (resource overlap) as those used by recreational fishers. If recreational fisheries are the most important sector, please leave the

overlap fields blank. (This question applied to offshore marine, coastal and freshwater fisheries.)

- Q4. Please estimate the growth potential for recreational fishing in your country over the next decade in terms of harvest and number of participants by completing the sentences below. (A scale of 1-5 from “increase considerably” to “decrease considerably”, plus a 6th “I don’t know” option.)
I believe that there is potential for the amount of harvest in the recreational fishing sector in my country to:
I believe that there is potential for the number of participants in the recreational fishery sector of my country to:
- Q5. Which of the following options (on a scale from entirely tourism-based to entirely resident-based) best characterizes the recreational fisheries in your country? (A scale of 1-5 scale ranging from “entirely tourism-based to “entirely resident-based”, plus a 6th “I don’t know” option.)
Offshore marine recreational fishing in my country is:
Coastal marine recreational fishing in my country is:
Freshwater recreational fishing in my country is:
- Q6. Are competitive fishing events permitted in your country?
Yes/No
If you answered ‘Yes’ above, please use the drop-down menu provided to describe the frequency of competitive fishing events that occur in the offshore marine, coastal marine and freshwater recreational fisheries in your country. (Options ranged from ‘frequently’ to ‘never’ on a four-point scale [‘always’ was omitted], plus a 5th “I don’t know” option). If your country hosts any national or international tournaments, please describe them briefly in the space provided (Open ended).
- Q7. On a scale from ‘Entirely harvest-oriented’ to ‘Entirely voluntary catch-and-release’, please indicate which option best describes the overall recreational fishing practices in your country and describe the fishing practices for the three most commonly targeted species in your country’s recreational fishing sector.
Overall, the recreational fishing practices in my country are: (Options ranged from ‘entirely catch and release oriented’ to ‘entirely harvest oriented’ on a 5-point scale, plus a 6th “I don’t know” option).
Open-ended options for listed the top 3 target species included pull-down menus for target locations (offshore, coastal, freshwater) and the same scale per fishery.
- Q8. In order of importance from 1 to 3, please list the top three most important management needs and policy needs you feel should be prioritized in managing your country’s recreational fisheries. (Open-ended.)
- Q9. In order of importance from 1 to 3, please list the top three most important knowledge gaps and development gaps that pertain to your country’s recreational fisheries. (Open-ended.)
- Q10. Do your country’s fisheries management plans include specific strategies (i.e. catch/size limits, gear types, seasonal closures, etc.) for managing recreational fisheries in freshwater, coastal and/or offshore areas?

Yes/No

If you answered “yes”, please describe them briefly and include the type of management body responsible and the body of ownership, if different from that of the management body. Drop-down menus were provided for categories labelled “offshore recreational fisheries”, “coastal recreational fisheries” and “freshwater recreational fisheries”. Each contained a menu of 9 possible management and ownership bodies. Management unit/ Ownership body options: national agency, state agency, regional fisher community association, local fisher community association, regional fisher clubs, local fisher clubs, private governance or ownership, Non-Governmental Organization (NGO), and “I don’t know”. Management strategies for each of the three categories were open-ended.

Q11. Are there any specific issues in your country that would constrain the sustainable growth of your country’s recreational fisheries?

Yes/No

If you answered “yes”, please describe them briefly. (Open-ended.)

Q12. Please briefly describe any areas of potential social, biological or economic conflict surrounding the development of recreational fisheries in your country. (Open-ended.)

Q13. Are there any comments you would like to add regarding any emerging issues that you feel would influence the governance, management or growth of recreational fisheries in your country? (Open-ended.)

Appendix II. Operational Definitions (in Alphabetical Order):

Catch: Defined here as the total number of live animals caught during fishing activities, not solely those retained for distribution or consumption.

Commercial fisheries: Those fisheries (whether large scale, small scale and/or artisanal) undertaken for the purpose of sale on the commercial market or through other forms of trade (FAO, 2005).

Commonly targeted species: Defined here as a very commonly fished or iconic species that is targeted during recreational fishing.

Competitive fishing event: Defined here as a competitive event targeting a specific species or group of species in which fishers compete and winners are judged based on criteria such as catch size, weight, etc.

Constraint: Defined here as any variable related to recreational fishing that is known or suspected to present difficulties or unwanted complexity in sustainable management of the aquatic ecosystem.

Coastal marine fisheries: Defined here as salt water fishing activities which occur in coastal zones.

Development gaps: Defined here as the areas of organizational, infrastructure or social development that are considered essential to successful, sustainable resource management but are either lacking or unavailable.

Ecological/biological impact (of recreational fishing): Defined here as the degree to which fisheries contribute to

negative impacts on the ecological and/or biological components of the ecosystem.

Economic importance: Defined here as any and all economic factors (including, but not limited to employment, labour costs, interest rates, inflation, etc.) that may benefit from or be constrained by commercial, subsistence or recreational fisheries sectors.

Fisher: Any person of any age, gender, culture or socio-economic status who participates in fishing activities of any type (FAO, 1998).

Fisheries management: The integrated process of information gathering, analysis, planning, decision making, allocation of resources and formulation and enforcement of fishery regulations by which the fisheries management authority controls the present and future behaviours of the interested parties in the fishery, in order to ensure the continued productivity of the living resources (FAO, 1995).

Governance: Defined here as the sum of legal, social, economic and political factors involved in governing at multiple scales (i.e. local, national, international). This also includes the process of governing, the individuals involved in, and the manner/ methodology employed in the process of governing.

Harvest-oriented fisheries: Defined here as those fisheries which target fish for consumption and/or resource-related harvest but do not commonly return unwanted fish to the water.

Freshwater fisheries: Defined here as those fisheries which occur apart from the ocean, typically in fresh water bodies such as lakes, rivers and streams but may include inland brackish water bodies and confluences (FAO, 2005).

Knowledge gaps: The areas of knowledge/research that are considered essential to successful, sustainable resource management but are either lacking or unavailable.

Management needs: Defined here as any and all institutional, structural, regulatory, legislative, informational or applied tools required to manage recreational fisheries effectively and in a sustainable manner.

Marine fisheries: Defined here as those fisheries which target species in salt or brackish waters such as oceans, estuaries and lagoons (FAO, 2005).

Offshore marine fisheries: Defined here as salt water fisheries activities which occur beyond coastal zones but within a country’s Exclusive Economic Zone (EEZ) boundaries.

Policy needs: Defined here as any and all tools required to establish goals, objectives and strategies to guide management of recreational fisheries effectively and in a sustainable manner.

Recreational fishing: Any type of fishing (including, but not limited to angling, netting and spear fishing) that does not constitute the fishers’ primary source of food, nor is it used to sell or trade on the commercial market (FAO, 2012).

Resident-based (recreational fishing): Defined here as recreational fishing activities undertaken by individuals who live in the host country, state or locality on a permanent basis.

Social importance: Defined here as any and all social factors (including, but not limited to religion, ethnicity, family, education, cultural attributes, etc.) that may derive benefit from or be constrained by activities related

to the commercial, subsistence or recreational fisheries sectors.

Subsistence fisheries: Fisheries in which harvested fish are consumed directly by the fisher/kin and not sold or traded (FAO, 1998).

Sustainable growth: Defined here as the expansion of recreational fisheries activities, as measured by increased participation, increased catch or harvest and/or an increase in economic benefits, that does not significantly reduce virgin target population sizes nor negatively impacts ecological or cultural systems in a manner that prevents rehabilitation or mitigation.

Tourism-based (recreational fishing): Defined here as recreational fishing activities undertaken by individuals who do not live in the host country, state or locality on a permanent basis (i.e. non-resident to the fished area).

Voluntary catch-and-release: Defined here as the unlegislated practice of returning all or most fish to the water after catch on the basis of conservation, desirability and/or palatability.

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