Characterization of artisanal fisheries in Nepal and potential implications for the conservation and management of Ganges River Dolphin (*Platanista gangetica gangetica*)

Shambhu Paudel, Juan C Levesque, Camilo Saavedra, Cristina Pita, Prabhat Pal

The Ganges River dolphin (*Platanista gangetica gangetica*) (GRD) is classified as one of the most endangered of all cetaceans in the world and the second scarcest freshwater cetacean. The population is estimated to be less than 2,000 individuals. In Nepal's Narayani, Sapta Koshi, and Karnali river systems, survival of GRD continues to be threatened by various anthropogenic activities, such as dam construction and interactions with artisanal fisheries. A basic description of the geographic scope, economics, and types of gear used in these fisheries would help managers understand the fishery-dolphin interaction conflict and assist with developing potential solutions to reduce interactions between GRD and local fisheries in Nepal. The main purpose of the study was to collect fishery and socio-economic information by conducting interviews with local fishermen in the Narayani, Sapta Koshi, and Karnali river systems. Based on interviews (n = 163), 79 percent of Nepalese fishermen indicated fishing for local species (e.g., mullet [*Rhinomugil corsula*] or siloroid catfish [*Bagarius bagarius*]) was their primary form of income. Fishermen reported fishing effort was greater in summer than winter; greatest in the afternoon (1430 hrs ± 0.27) and during low water level conditions; and gear was set 4.8 ± 0.2 days/week. Fishermen reported using eight different types of monofilament nets (gillnets and cast nets). Sixty percent used gillnets less than 10 m long, and less than one third preferred gillnets between 10 and 100 m long; a few used gillnets longer than 100 m. Fishermen usually set their gear close to their village, and about 50 percent preferred to fish in tributaries followed by the main channel behind sandbars and islands, and the main channel near a bank. Fishermen reported seeing more GRD in the main river stem in winter. In summer, fishermen spotted more GRD in tributaries. Most fishermen told us they believed education, awareness, and changing occupations were important for GRD conservation, but they indicated that occupational options were currently limited in Nepal. Nepalese fishermen acknowledged that fisheries posed a risk to GRD, but they believed water pollution, and dam/irrigation development were the greatest threats.

Characterization of the Artisanal Fishing Communities in Nepal and Potential Implications for the Conservation and Management of Ganges River Dolphin (*Platanista gangetica gangetica*)

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ABSRACT

The Ganges River dolphin (*Platanista gangetica gangetica*) (GRD) is classified as one of the most endangered of all cetaceans in the world and the second scarcest freshwater cetacean. The population is estimated to be less than 2,000 individuals. In Nepal's Narayani, Sapta Koshi, and Karnali river systems, survival of GRD continues to be threatened by various anthropogenic activities, such as dam construction and interactions with artisanal fisheries. A basic description of the geographic scope, economics, and types of gear used in these fisheries would help managers understand the fishery-dolphin interaction conflict and assist with developing potential solutions to reduce interactions between GRD and local fisheries in Nepal. The main purpose of the study was to collect fishery and socio-economic information by conducting interviews with local fishermen in the Narayani, Sapta Koshi, and Karnali river systems. Based on interviews (*n* = 163), 79 percent of Nepalese fishermen indicated fishing for local species (mullet [*Rhinomugil corsula*] or siloroid catfish [*Bagarius bagarius*]) was their primary form of income. Fishermen reported fishing effort was greater in summer than winter; greatest in the afternoon (1430 hrs ± 0.27) and during low water level conditions; and gear was set 4.8 ± 0.2 days/week. Fishermen reported using eight different types of monofilament nets (gillnets and cast nets). Sixty percent used gillnets less than 10 m long, and less than one third preferred gillnets between 10 and 100 m long; a few used gillnets longer than 100 m. Fishermen usually set their gear close to their village, and about 50 ~~percent~~ preferred to fish in tributaries followed by the main channel behind sandbars and islands, and the main channel near a bank. Fishermen reported seeing more GRD in the main river stem and tributaries in winter and summer, respectively. Most fishermen told us they believed education, awareness, and changing occupations were important for GRD conservation, but they indicated that occupational options were currently limited in Nepal. Nepalese fishermen acknowledged that fisheries posed a risk to GRD, but they believed water pollution, and dam/irrigation development were the greatest threats.

Subjects: Biodiversity, Ecology, Conservation Biology, Fisheries and Fish Science

Keywords: Bycatch; Cetacean Conservation; Endangered Species, Fishery Interactions; River Dolphin

INTRODUCTION

Ganges River dolphin (GRD), Amazon River dolphin (*Inia geoffrensis*), and Indus River dolphin (*Platanista minor*) are the only remaining river dolphins in the world. The GRD is classified as one of the most endangered of all cetaceans in the world and the second scarcest freshwater cetacean (Reeves et al., 2000; Sinha et al., 2010; IUCN, 2012). According to Smith & Braulik (2012), the population is estimated to be less than 2,000 individuals. This obligate cetacean is primarily found in the Ganges and Brahmaputra rivers, including several associated tributaries in Bangladesh, India, and Nepal (Jones, 1982). Similar to other cetaceans, the GRD is long-lived (~ 30 years), matures late, and gives birth to a limited number of calves (1–2 per calving) (IUCN, 2012).

Found in some of the most densely populated areas, the GRD is vulnerable to various anthropogenic activities (Smith & Braulik, 2012). According to Paudel (2012), the main threat to GRD is probably habitat fragmentation caused by the construction of dams, but it is likely that other human-induced activities have also led to a reduced and declining GRD population. For instance, the lack of river and watershed management (open-access resource exploitation) and the geographical expansion of artisanal fisheries are among the greatest threats (Dudgeon, 2000; Manel et al., 2000; Gergel et al., 2002). A conservation action plan was developed and implemented in India to conserve, protect, and recover the GRD (Sinha et al., 2010); however, the species has received limited management attention in other regions, such as Nepal. Recently, the Nepalese government began re-enforcing the mandates of the Department of National Parks and Wildlife Conservation Act of 1973 and designated several protected areas in the Karnali river (Bardiya National Park), Sapta Koshi river (Koshi Tappu Wildlife Reserve), and Narayani river (Chitwan National Park). Despite these management measures, the GRD population continues to decline at an alarming rate, especially in Nepal. In the 1980s, the GRD was commonly found in various rivers in Nepal (Shrestha, 1985), but today it is restricted to the Narayani, Sapta Koshi, and Karnali rivers (Paudel, 2014).

Nepalese river-dependent communities continue to grow and expand so it is no surprise that most of the GRD interactions are associated with heavily populated areas (CBS, 2003), which escalates the human-dolphin interface dilemma. Because communities rely on natural resources for survival and income, some basic daily activities threaten the conservation and recovery of the GRD, such as fisheries. According to Sinha et al., (2010), the GRD continues to be targeted for its oil and meat; the oil is used as bait in some fisheries and the meat is consumed ~~(Sinha et al., 2010~~. The GRD is also incidentally injured or killed in gillnets (Reeves et al., 1993; Smith, 1993). In 2013, a GRD was found dead in the Karnali River (Lalmati area) that was later linked to gillnet gear (Paudel, 2014). Artisanal fisheries directly and indirectly effect the GRD population in various ways, including the availability of prey and habitat (Kelkar et al., 2010). In some ways, fishermen compete with GRD because they take various species of fish that are essential to the GRD's diet (Kelkar et al., 2010), such as mullet (*Rhinomugil corsula*) or siloroid catfish (*Bagarius bagarius*) (Smith, 1993).

Fishery information is essential for understanding the fishery-interaction problem and developing a solution (Rojas-Bracho & Reeves, 2013); however, this type of information is usually unavailable and challenging to obtain, especially in remote regions, such as Nepal. A basic description of the fisheries would help managers understand the fishery-dolphin interaction conflict and assist them with developing a potential solution. Given the lack of information about artisanal fishing communities in Nepal, the main goal was to collect fishery and socio-economic information to serve as a baseline for understanding the dilemma between the most endangered upstream river dolphin and artisanal fishing communities. The specific objectives were to identify, compile, and investigate the demographics, economics, fishing characteristics, and perception of fishermen about GRD conservation fishermen in three rivers of Nepal.

MATERIAL AND METHODS

Study Area

The survey was conducted in four districts of Nepal (Bardiya, Nabalparasi, Saptari and Sunsari) consisting of 45 villages established within 1 km of the Narayani, Sapta Koshi and Karnali river systems (**Fig. 1**). The Narayani, Sapta Koshi and Karnali rivers were specifically selected because they are major tributaries of the Ganges River and serve as habitat for the GRD; the Ganges River has the largest remaining population of GRD in the world (Smith, 1993). These three rivers are located within the floodplain and tropical region of Nepal, which is currently under intense pressure from various anthropogenic activities (e.g., dam construction and artisanal fisheries).

Survey Methods

Fishery and socio-economic information was collected using a face-to-face interview approach with fishermen registered with various fishing associations located along the Narayani, Sapta Koshi, and Karnali rivers in Nepal during August 2013. The Department of National Parks and Wildlife Conservation approved the study (Reference Number 353). We specifically chose this approach because fishermen associations represented a large number of artisanal fishermen that not only reside near the rivers, but regularly fish these rivers. To reduce any potential sampling bias, we randomly selected 15 percent of registered fishermen residing along the Karnali (n = 56), Sapta Koshi (n = 47) and Narayani (n = 60) rivers to interview.

To increase the response rate and the quality of responses, the purpose and importance of the study was explained to fishermen before they were asked to participate in the survey. The questionnaire format was explained to each fisherman and then a point of contact for the study was provided to them. The questionnaire was composed of 87 simple and direct questions arranged into six themes: general description, demographics, fishery description, dolphin sightings and interactions, population status, and potential conservation measures. Questions included both open-ended and multiple-choice answer formats. Basic demographic and fishing information (i.e., fishing effort, gear, and experience) questions were asked at the beginning and more sensitive (income and dolphin interactions) questions were asked near the end to further increase the response rate. In general, fishermen could only give one answer for most of the questions. Questions regarding dolphin interactions/sightings were divided by season (summer/winter) and time (past [>10 years ago] and present). Lastly, the questionnaire included questions about potential threats and conservation measures for the GRD in Nepal. For these questions, fishermen could choose among various conservation measures (i.e., education awareness, monitoring, and enforcement actions), but they could only give one answer.

Statistical Analysis

Differences (expected vs observed) in categorical variables (e.g., demographics, fishery description, and fishermen attributes) between fishermen from different rivers were tested with a Chi-square Goodness-of-Fit test using a Yates correction; a Yates correction is often recommended to use if the expected cell frequencies are below 10. To counter the effects of multiple paired testing (i.e., pair-wise comparisons), a Chi-square approach was also applied when differences among rivers were detected. The Chi-square test was used to test the null hypothesis that the frequency of observed responses was equal to the frequency of expected responses. The Chi-square test was applied following the guidelines of Koehler and Larntz (1980); k classes > 3 (Zar, 1994). A Fligner-Killen (FK) test of homogeneity of variances was applied for evaluating continuous variables. The FK test is an adaptation of the Kruskal-Wallis test that is robust against departures from normality (Conover et al., 1981). A Dunnett-Tukey-Kramer pairwise multiple comparison test was used to investigate mean differences in more than two groups with unequal variances and sample sizes. Data were summarized, graphed, and evaluated using descriptive and hypothesis testing statistics. All analyses were conducted using R version 3.0.2 (R Core Team, 2013), Microsoft Excel®, and SYSTAT® version 12. Statistical significance was defined as $P < 0.05$.

RESULTS

Survey

A total of 163 fishermen participated in the study. ~~Overall, every fisherman we encountered~~ was willing to participate and complete most of the questionnaire. The total time to interview one fisherman ranged from 15 to 107 minutes, and the average time was 39.42 ± 1.67 minutes. A significant difference in interview time was detected among fishermen from the three river segments ($H = 124.03$; $P < 0.05$). Fishermen from Narayani took longer to interview than those from either the Sapta Koshi or Karnali rivers.

Community Demographics

Fishermen ages ranged from 16 to 94 years-of-age, and the average age was 44.1 years-of-age. Eighty-six percent of fishermen were men ~~(n = 142)~~. Women fishermen were comprised of all age classes except the “over 75” age group. There were more women fishermen in the Narayani river than in the other two rivers. Based on the responses, artisanal fishermen represented 15 different ethnic groups. The most common ethnic groups were Malha (~~n = 44;~~ 27%) and Sonaha (~~n = 42;~~ 25.2%) followed by Bote (~~n = 28;~~ 16.6%), Chaudhary (~~n = 19;~~ 11%), Tharu (~~n = 13;~~ 7.4%) Majhi (~~n = 9;~~ 4.9%), Musahar (~~n = 2;~~ 4.3%); a few belonged to other minority groups (3.7%). The proportion of ethnic groups was significantly different among the rivers. Most indicated they had little to no education. Sixty-nine percent ~~(n = 114)~~ were illiterate followed by primary (22.7%~~; n = 37~~) and secondary (6.8%~~; n = 11~~) education. One fisherman told us he had some higher education ~~(0.6%)~~. The education level of fishermen was lower in Karnali river and higher in Sapta Koshi river. Most fishermen (~~n = 153;~~ 93.9%) reported they had resided in their village for many years~~; the mean number of years residing in the same village was 43.6 (**Table 1**~~). The mean age of fishermen from the Narayani river was significantly higher than either the Karnali or Sapta Koshi rivers (**Table 1**). The mean number of years residing in the same village was significantly higher in Karnali river than either the Narayani or Sapta Koshi rivers.

Economics

Monthly earning from fishing was $US 60.2 ± 2.6; most fishermen (~~45%; n = 73~~) earned less than $US 50 per month. Earning from fishing was significantly lower in the Karnali river and higher in the Sapta Koshi river reflecting the differences in fishing effort (hours per day and months fishing per year). Fishermen (~~n = 114;~~ 70%) were highly dependent upon fishing for their income, but they also told us they had another source of income, such as agriculture (~~n = 70;~~ 43%) and buying/selling fish (~~n = 33;~~ 20%). Monthly income from these activities ranged from a few dollars ($US 25) up to $US 1,200. The mean earnings from other activities were $US 101.1 ± 9.9 per month. Monthly earnings were significantly higher in the Narayani river and lower in the Karnali river (**Table 2**).

Fishing Activity

Fishing was the main form of income with 78.5 ~~percent~~ of respondents (~~n = 130~~) reporting that fishing was their primary occupation. On average, fishermen had 36.9 years of experience, which was associated with the early age they began fishing. Eighty-eight percent ~~(n = 143)~~ reported they started fishing before the age of 15. Since most of them were from a fishing family (77.9%~~;~~ ~~n = 127~~), they indicated their fathers had also been or were fishermen. Most fishermen (~~n = 106;~~ 65%) indicated they owned one small wooden vessel, but eight fishermen (5%) told us they owned more than one vessel. The mean fishing crew size was 4.72 ± 0.46 fishermen/day, but occasionally there were more crew members (maximum = 30 fishermen). A significant difference was detected in crew size among river segment (H = 95.65; P < 0.05). Fishermen from the Naryani river had a larger crew size than those from either the Karnali or Sapta Koshi rivers.

Fishing Effort

The number of fishing days varied between 1 to 7 days per week, and the average (number of days per week fishermen spent fishing) was 4.8 ± 0.2 days/week. Seventy percent ~~(n = 114)~~ fished more than 4 days per week and about 20 ~~percent (n = 33)~~ report~~ing~~ fishing one or two days per week. Overall, fishing effort varied significantly among river segment (H = 50.25; P < 0.05). The highest fishing effort occurred in the Sapta Koshi river (6.2 ± 0.7 days/week) and lowest occurred in Naryani river (3.7 ± 0.3 days/week). Overall fishing effort was 3.3 ± 0.1 months per year in all river systems, but it was significantly higher in the Sapta Koshi river than the other two rivers (**Table 2**). Fishing effort was significantly different between seasons (P < 0.5). In winter (dry season), fishermen spent 8 hours/day fishing and in summer (wet season) they spent 12 hours/day. This pattern was the same in the Karnali and Narayani rivers, but fishing effort in the Sapta Koshi river was significantly higher in the summer and winter than the Karnali (H = 49.34; P < 0.05) or Naryani rivers (H = 94.78; P < 0.5).

~~The preferred fishing period also varied among river segment (H = 8.89; P = 0.01).~~ Most fishermen (~~n = 147;~~ 90%) reported they preferred to fish in the afternoon (1430 hrs ± 0.27), and during low water levels (~~n = 105; 65~~%). Fishermen from the Sapta Koshi river preferred to fish earlier in the day than those from Naryani or Karnali rivers. They also told us they preferred to fish during certain conditions. Most fishermen (> 50%) from the Naryani and Sapta Koshi rivers indicated they preferred to fish during high turbidity or low water levels, while those from the Karnali river primarily preferred to fish during the spawning and low water period.

Fishing Gear

Fishermen reported using eight different types of monofilament nets (gillnets and cast nets). Twenty-five percent of fishermen ~~(n = 40)~~ used Phekuwa Jaal (cast net) and another 25~~ percent~~ used Maha Jaal (gillnet). Slightly less fishermen (22.7%~~; n = 37~~) used Pakhure Jal~~l~~ (cast net), and the rest used other nets (~~27~~%~~; n = 44~~), such as Bagaune Jaal (gillnet), Dadiya (cast net), Ghumauwa or Khaap Jaal (cast net), Paat or Hate Jaal (cast net) or Tiyari Jaal (gillnet). Differences in gear characteristics were detected among river segment (H = 23.80; P < 0.5). Fishermen from the Naryani river primarily used Pakhure Jaal cast nets, whereas fishermen from the Karnali and Sapta Koshi rivers preferred to use Maha Jaal gillnets and Phekuwa Jaal cast nets, respectively.

Fishermen used a variety of gillnets that varied in length, width, and mesh-size. Gillnets ranged in length from 1.2 to 250 m. Sixty percent ~~(n = 98)~~ told us they used gillnets less than 10 m long, 30~~ percent (n = 49) were~~ 10 and 100 m long, and another 30~~ percent (n = 49) were~~ longer than 100 m. The length of gillnet fishermen used varied significantly by river segment (H = 120.82; P < 0.05). Fishermen from the Karnali river used gillnets much longer than fishermen from either Sapta Koshi or Naryani rivers. Most fishermen (~~n = 114;~~ ~~70~~%) stated their gillnets were around 3 to 4 m in depth. The average gillnet length was 64.42 ± 6.67 m and the depth (width) was 4.55 ± 0.35 m. The depth of gillnet used by fishermen also varied among river segment ($H = 120.73$; $P < 0.05$). Fishermen from the Naryani river used gillnets that were deeper than fishermen from Sapta Koshi and Karnali rivers (**Table 3)**. The stretch-mesh size ranged from 0.23 to 7 cm, but the most common ($n = 130$; 80%) stretch-mesh size was around 2.0 cm or less. A Mann-Whitney test showed a significant difference in the mesh size between what they use now and before ($P < 0.5$). It should be noted that some fishermen (25%; $n = 41$) indicated they recently changed to a smaller mesh size expecting to see an increase in catch. Despite this gear change, they did not notice any difference in catch.

Fishing Location

Fishermen indicated they usually fished close to their village. The mean distance travelled was 2.9 ± 0.13 km; they rarely travelled more than 7 or 8 km to their fishing grounds. We did not detect a significant difference in the distance travelled upstream, but fishermen from the Narayani river travelled further downstream than those from either Sapta Koshi or Karnali rivers.

About 50 percent ($n = 80$) of the fishermen specified they preferred to fish in tributaries rather than in the main channel behind sandbars and islands or the main channel near a bank. A Chi-square test detected a significant difference between the observed and expected counts in preferred fishing location (tributary) among river segment (χ^2 [4, 279] = 9.82; $P = 0.04$). More fishermen from the Karnali river preferred to fish in tributaries than those from Narayani and Sapta Koshi rivers. A Chi-square test also showed a significant difference in preferred fishing location (main channel behind sand bars and islands) among river segment (χ^2 [4, 172] = 72.6; $P < 0.05$). In the Narayani and Sapta Koshi rivers, more fishermen indicated they fished near a bank, while those from the Karnali river told us they usually fished near a bank (χ^2 [4, 172] = 31.0; $P < 0.05$).

Fishing Activity Perceptions

Sixty-one percent (*n* = 99) of fishermen perceived a decline in catch over time and more than half (54%; *n* = 88) thought the number of fishing boats in the area was similar to the past. Differences in perceived fishing activity were significantly different among fishermen (χ^2 [4, 169] = 139.02; $P < 0.05$). Fishermen from the Karnali river and the Sapta Koshi river believed fishing was worse now than before. In contrast, fishermen (70%; *n* = 114) from the Narayani river thought that fishing was better now than before. Most fishermen from the Karnali River thought there were fewer fishing boats now that before, while fishermen from the other two rivers didn't think there was a difference. Interestingly, every fisherman we interviewed indicated they did not believe fishing was a good job and preferred their children pursued another occupation. Some fishermen (35%; *n* = 57) indicated they wanted their children to work for a private firm followed by a government agency (31.3%; *n* = 51) or a non-government organization (12.3%; *n* = 20) (**Table 4**).

Ganges River Dolphin Sightings and Observations

Most fishermen (62.6%; *n* = 102) indicated they rarely spotted GRD on recent trips, but many (61.3%; *n* = 99) told us they used to regularly spot them in the past (> 10 years). Fishermen from the Karnali river indicated they occasionally spotted GRD on recent fishing trips, while most fishermen from the Narayani and Sapta Koshi rivers told us they seldom spotted GRD (χ^2 [4, 172] = 49.94; $P < 0.05$). Karnali river fishermen reported occasionally seeing GRD in the past, while Narayani and Sapta Koshi river fishermen reported frequently seeing GRD. Karnali river fishermen indicated they used to spot around two GRD in the past, while Sapta Koshi and the Narayani river fishermen reported seeing four or more individuals, respectively.

A significant difference in the observed and expected counts in the location where GRD were sighted was detected among river segment (χ^2 [4, 167] = 106.39; $P < 0.05$). Fishermen reported seeing more GRD in deep (> 3 m) pools (56%~~; *n* = 91~~) than in straight channels or shallow (< 3 m) pools (~~26.4%; *n* = 42~~). Specifically, ~~more~~ fishermen from the Karnali and Narayani rivers spotted GRD in deep ~~(> 3 m)~~ pools ~~than in confluence or meandering areas. Karnali river fishermen reported seeing GRD~~ in the main channel (> 3 m), while Sapta Koshi river fishermen reported seeing more GRD near confluence and main channel areas. In every river, fishermen reported seeing GRD near their vessel (< 3 m) and displaying diving behavior (66.5%~~; *n* = 109~~) (**Table 5**). A Chi-square test detected a significant difference in the location and season when fishermen usually spotted GRD (χ^2 [4, 126] = 19.42; $P < 0.05$). In summer, fishermen indicated they observed more GRD in the tributary (*n* = ~~47~~; 61%) than in the main channel (*n* = ~~25~~; 39%). However, in winter, fishermen spotted more GRD in the main channel (*n* = ~~37~~; 78%) than in the tributary (*n* = ~~12~~; 22%). Overall, only one fisherman from the Narayani river told us he had encountered a dead GRD.

Ganges River Dolphin Conservation Measures

Most fishermen perceived the GRD population had declined (89.5%; *n* = ~~146~~) and 77.6% (*n* = ~~127~~) thought the population had specifically declined within their region. Most fishermen believed that the main threat to GRD were humans, ~~with 53.5 percent (*n* = 88)~~ stating the construction of dams/irrigations systems and fishing (10.7%~~; *n* = 18~~) ~~being~~ the main threats~~.~~ ~~Thirty-two percent (*n* = 52)~~ thought the recent decline in the GRD population was associated with physical changes (width and depth) in the river (**Table 5**). A Chi-square test detected a significant difference in the observed and expected counts in the reasons why fishermen perceived the GRD population had declined (χ^2 [12, 177] = 140.12; $P < 0.05$). In general, fishermen from the Karnali and Narayani rivers believed the decline was associated with low water conditions.

The conservation of the GRD seemed to be important to every fisherman that participated in the study. Most fishermen suggested that increasing awareness, establishing training facilities, or changing occupations would help protect and recover GRD. Seventy percent of fishermen thought it was possible to develop eco-tourism in Nepal. Karnali and Sapta Koshi river fishermen indicated they wanted eco-tourism, but many Narayani river fishermen were opposed to the idea. Of the fishermen that wanted to be re-trained, almost half of them chose masonry or carpentry professions. Another conservation concept that fishermen thought could be important to GRD conservation was the establishment of water hyacinth (*Eichhornia* spp) as an alternative occupation; water hyacinth is used to construct baskets and decorative materials, which are sold in local markets.

DISCUSSION

Anthropogenic activities (e.g., commercial fishing and vessel collisions) are the leading cause of mortality for most cetaceans (van der Hoop et al., 2013). Although cetacean injuries and mortalities have been associated with vessel strikes and other human-induced activities (Silber et al., 2015), many are attributed to the incidental entanglement with fishing gear; especially monofilament gillnets (Reeves et al., 2013). According to Reeves et al., (2013), limited information is available describing marine mammal bycatch in gillnets. Understanding fishery interactions is essential for preventing further losses of marine mammal diversity and abundance

(Reeves et al., 2013). Information describing artisanal fisheries is almost non-existent, but the incidental entanglement with fishing gear is a major threat to the conservation and recovery of the GRD in Nepalese rivers (Kelkar et al., 2010; Sinha et al., 2010), and in the Brahmaputra River in India (Wakid & Braulik, 2009). Developing and implementing effective recovery actions for the GRD requires having adequate socio-economic and fishery information. Without this type of information, it is almost impossible for managers to make informed and effective decisions. Given the economic constraints of researchers in Nepal, in terms of available research funding, information describing artisanal fisheries and potential conservation implications for the GRD has been unavailable until now.

Community Demographics

In this study, we collected basic socio-economic and fishery information from fishermen residing along three major rivers (Naryani, Karnali, and Sapta Koshi rivers) that serve as habitat for the GRD in Nepal. Interviews revealed that established communities and associated ethnic groups (e.g., Malaha, Sonaha, Bote, and Chaudary) residing (< 1 km) along major rivers in Nepal rely almost exclusively on fishing for their income. Fishing has been not only a way of life for many residents since an early age (~ 15 years old), but they tend to fish for most of their lives. We discovered most fishermen are men between the ages of 16 and 94, and their average age is 44 years old. The interviews also showed that many fishermen begin fishing at an early age, so most have little to no formal education, which limits their ability to pursue other occupations. Despite the importance of fishing, we were surprised to learn that most fishermen did not want their children to pursue fishing as a job. Because of this situation, it is might be possible that with the right training parents could potential encourage their children to pursue other occupations, especially since some fishermen already have a second job, such as agriculture. Obviously, reducing the fishing pressure in the region would have a positive impact on the GRD even though the construction of dams and other anthropogenic activities are still a major problem for GRD.

~~Commercial fishing with~~ monofilament gillnet gear was a traditional fishing gear for many coastal fishing communities, but various protective measures have been implemented over the past 20 years. Commercial fishermen have been forced to change occupations in various U.S. states, such as California, Texas, Louisiana, Florida, and Georgia. Despite many U.S. fishermen only having a high school education, most have either found an alternative trade or changed the way they fish (fishing gear) to comply with new regulations. For example, in Florida (USA), many commercial fishermen preferred to use monofilament gillnets before they were prohibited in 1996. Today, many commercial fishermen in Florida use cast or seine nets; cast nets have little to no bycatch, especially cetacean bycatch. Clearly, alternative income opportunities for commercial fishermen in the United States are significantly different than in Nepal, but there are still a few options for Nepalese fishermen that could benefit GRD, such as eco-tourism, farming, or simply changing fishing tactics or gear. The farming trade is growing throughout Nepal (Joshi et al., 2012), so it is possible that Nepalese fishermen would consider changing occupations.

Fishery Description

Most fishermen only own one small wood vessel, so it appears that local river residents are simply attempting to support their families rather than establishing large thriving fishing businesses with a fleet of vessels. Our findings suggest that fishing is not expanding in Nepal. According to responses, the mean crew size is between 4 and 5, but fishermen from the Naryani River use larger crews for some unknown reason. Assuming larger crew corresponds to less gear in the water than this actually reduces the overall risk to GRD in the area. We also learned that fishermen from the Naryani River prefer to use cast nets rather than gillnets, which is a safer for GRD. Bycatch associated with gillnets is a major issue for cetaceans worldwide (Kennelly & Broadhurst, 2002). Given this situation, there may be an option for fishermen from Karnali and Sapta Koshi river to start using cast nets and still make an average income, especially since Sapta Koshi fishermen told us they thought fishing was better now than before. Unfortunately, this perception could potentially intensify localized fishing pressure and increase the risk to GRD inhabiting the Sapta Koshi River. The GRD population in the Sapta Koshi River has been declining at an alarming rate over the last 25 years, so additional fishing pressure poses an immediate risk to the conservation of the species, especially since immense fishing pressure is still a problem in the Sapta Koshi River (Chaudhary, 2007). Fishermen also told us they thought fishing was worse now than before in the Naryani River. Assuming this is accurate description and fishermen are taking fish that are essential to the GRD diet, then fishing could be indirectly impacting the GRD in the Naryani River. In Brazil, fishermen have indirectly impacted the diet of Franciscana (*Pontoporia blainvillei*) through gillnetting (Secchi & Wang, 2002). Is this situation occurring in Nepal?

Fishing Effort and Fishing Location

Fishermen depend on catching fish to support their families, so most of them fish as much as possible (> 4 days per week). Interestingly, we learned that fishermen from the Sapta Koshi River fished every day, which clearly increases the risk to the GRD in that region. Fishermen also told us they preferred to fish in the morning rather than in the afternoon, which is the opposite tactic used by fishermen from either the Naryani or Karnali rivers. It is difficult to speculate whether fishing in the morning rather than the afternoon poses a greater danger to the

GRD. Regardless, it is likely both periods pose a similar risk since it has been reported that GRD depredate from gillnets; depredation and interacting with gillnets is a common behaviour for many cetaceans around the world (Read et al., 2003; Waples et al., 2013). According to Sinha et al., (2010b), the GRD is most active in the morning (08:00-11:00 hrs) and afternoon (13:30-16:00 hrs), and the least active between 11:00 and 15:00 hrs. Given this behavioural information, is it possible that Nepalese fishermen could set their gear during this period instead of the morning and late-afternoon without compromising their catch?

Interviews also revealed that fishermen spent almost twice as many hours fishing in the summer (5.7 hours) than they did in winter (3.7 hours). In contrast, we ~~learned~~ that fishermen from the Sapta Koshi River fished more hours in winter then they did in summer. The GRD is known to migrate seasonally according to water level (dry vs wet season). Smith & Braulik (2008) and Kelkar et al., (2010) all reported that GRD were found in deep pools or the main channels of rivers in the dry season (October−May), and migrate upstream to tributaries following the monsoon period (June−September). Seasonal distribution in association with the low water period has also been reported for GRD in the Brahmaputra River from the Assam-Arunachal to India-Bangladesh border (Wakid & Braulik, 2009). Paudel (2014) reported that GRD occurrence was more probable in river segments with deep pools. Given GRD movement patterns, fishing in winter during the wet season poses a greater risk to the GRD because they are more concentrated in specific areas. Most fishermen told us they preferred to fish in tributaries, especially in the Karnali River. Fishing in Karnali River area poses a greater risk to GRD. According to Paudel (2014), the Karnali and Sapta Koshi rivers are more critical to GRD than the Narayani River given their relative abundance (occurrence probability). Even though abundance is lower (Kelkar et al., 2010; Paudel, 2014) in the post-monsoon period than the premonsoon period (Paudel, 2014), it should be noted that fishing in the dry season could also pose a threat to GRD because the lower water level makes it more difficult for the GRD to avoid being entangled in gillnets; the average depth of gillnets used by fishermen is 4.5 m. In general, GRD are found in water depths around 4.4 m, which is much deeper than most of the river sections during the dry season (Paudel, 2014).

The proximity to the fishing grounds also poses a serious threat to the GRD. Based on interviews, fishermen indicated that almost all of them set their nets within 5.4 km of their village (2.9 km upstream or 2.5 km downstream). Given this tactic, it appears that nets are concentrated in specific areas (fishing hotspot), which could reduce the mobility for the GRD and increase the risk of being accidentally entangled. More nets in specific areas have been shown to increase the risk to marine mammals (e.g., Kinsas, 2002). In addition, it is likely that GRD are attracted to these fishing hotspots because they commonly depredate catch from nets; cetaceans depredate from fishing gear throughout the world (Mathias, 2012). According to Chaudhary (2007), a hotspot for the GRD is the southern section of the Koshi barrage, which is also an area fishermen prefer to set their nets. Spatial overlap between GRD distribution and fishing activity was previously been reported by Kelkar et al., (2010). Smith (1993) reported that the primary habitats of GRD also coincide with the areas of greatest human use. Interestingly, interviews with Narayani River fishermen indicated they tend to travel further downstream, which suggests that they are expanding their fishing range. Expanding the fishing range could further increase the risk to GRD in the Narayani River.

Fishing Gear

Fishermen use a variety of monofilament gillnets and cast nets, but we did find some differences in fishing gear among river segment. Fishermen from the Naryani and Sapta Koshi rivers preferred to use cast nets, whereas fishermen from the Karnali River primarily used gillnets. Plainly, cast nets pose a lower risk to the GRD than gillnets given their smaller size and the deployment method. Cast nets are thrown off a vessel and immediately retrieved, while gillnets are allowed to soak for an extended period; soak time and cetacean entanglement are positively correlated (Rossman & Palka, 2011). It is difficult to understand why most fishermen from the Karnali River are inclined to use gillnets instead of casts, but it is probably associated with some sort of local tradition or river characteristic. We recommend additional research to understand fishing tactics and gear in the Karnali River.

Fishermen reported using gillnets between 2.5 and 250 m in length, but most used gillnets less than 10 m long. Thirty percent (*n* = 49) told us they used gillnets longer than 100 m, which increases the entanglement risk; net length and fishery interactions are generally correlated. Although most of the gillnets were less than 10 m long, these still pose a risk to the GRD, especially if they are allowed to soak for extended periods. We don't know much about the soak time, but this could be a major problem for GRD, especially if fishermen soak their nets overnight. The length of gillnet and cetacean entanglement risk is probably correlated, but is difficult to predict what factor contributes the greatest impact to potential entanglement. Interviews pointed out that gillnet length varied significantly by river segment. Fishermen from the Karnali River used longer gillnets than fishermen from either the Sapta Koshi or Naryani rivers. Again, we do not know why this is the case, but understanding this tactic could help us recommend alternatives that might reduce the risk to GRD in the Karnali river. Despite the fact that fishermen from the Naryani river used shorter gillnets, they told us their gillnets were much deeper than those used by fishermen from either the Karnali or Sapta Koshi rivers. Using deeper nets could actually be more harmful to the GRD than longer nets since the GRD is known to chase prey along the bottom (Sinha et al., 2010). ~~Based on interviews, fishermen told us they used a mesh size between 0.23 and 7.0 cm, but~~ most fishermen used gillnets constructed with a mesh size less than 2.0 cm. We ~~also learned~~ that fishermen continued to construct nets with a smaller meshes over the years, which suggests that catch is decreasing over time. Because gillnets are selective, mesh size is an important factor to evaluate since it relates to catch composition and size-frequency. The type and size of catch could be an important factor affecting the GRD given their diet requirements. In the Vikramshila Gangetic Dolphin Sanctuary, a 65-km stretch of the Ganga River between Sultanganj and Kahalgaon towns in Bhagalpur, Bihar, India, Kelkar et al., (2010) found that distributions of sampled fish lengths were mostly (75%) within the size range preferred by GRD. This finding suggests that fishermen are affecting the GRD diet. Should local officials consider implementing gillnet mitigation measures to reduce entanglement risk for GRD, such as acoustic deterrents (Dawson et al. 2013)? Other mitigation options that have been used before to reduce the frequency of marine mammal fishery-interactions include changing human behavior (time-area closures) and gear modifications (twine size, gillnet length, soak time, and tie-downs). We recommend research into gear modification, and suggest that fishermen are encouraged to use best management practices, such as reduced soak times or continuous monitoring of nets. Removing entangled fish on a regular basis would likely reduce GRD depredation and overall risk.

Ganges River Dolphin Sightings and Observations

Based on responses, fishermen observe fewer GRD now than before; thus, it appears the GRD continues to decline in Nepal river systems – a finding that is consistent with previous studies (Smith, 1993; Reeves et al., 2000; Reeves et al., 2003; Paudel, 2014). Interview responses also showed that the average group size is declining. Fishermen reported seeing up to eight individuals in a group in the past, but recently they often see single GRD. Little is known about the social aspects of the GRD, but it is likely that small group sizes, including reports of single individuals is indicative of the fragmentation of the population as a whole and habitat degradation. Small groups may lack the benefits associated with social living (e.g., predator avoidance, detection of prey, and facilitated reproductive activities) (Baird & Whitehead, 2000). Fishermen also indicated that fewer GRD are seen in the Narayani and Karnali rivers than in the Sapta Koshi, a finding consistent with that of Paudel (2014). ~~Paudel (2014)~~ also reported that the GRD range is shrinking and few dolphins are using the remaining available habitat in the Karnali river system, leading to the suggestions that GRD may unable to recover to previous population levels (Smith, 1993; Paudel, 2014).

Ganges River Dolphin Conservation

Most fishermen believed the conservation of the GRD is related to water pollution, and/or dam/irrigation development. The construction of dams and other water diversion projects for hydro-electric power production and irrigation lowers local water levels not only permanently alters river ecology, but it causes the range of GRD to be limited and changes the daily and seasonal movement patterns. Water level is an important habitat factor that controls the season distribution of GRD; ~~GRD~~ have never been observed in water levels less than 2.0 m (Paudel, 2014). Construction of dams in Nepal is likely to continue since only about 50 ~~percent~~ of urban and 5 ~~percent~~ of the rural population has access to electricity (Bergner, 2012). The construction of dams in Nepal ~~has caused various issues for GRD, such as~~ habitat and population fragmentation ~~and range decline~~. Water flow diversion by the construction of a barrage during the dry season led to the stranding of a GRD in very low (Smith & Braulik, 2012). Smith & Reeves (2000) stated that building a high dam in the Karnali river would "almost certainly eliminate the small amount of dolphin habitat in Nepal's last river with a potentially viable dolphin population". The same scenario is found in the Sapta Koshi river, where Koshi barrage, above 7 km from Nepal/India boarder, deters the upstream movement of river dolphin during summer season.

Economics

~~Fishermen in Nepal earn around $US 60 per month with Karnali fishermen earning less than those from either the Sapta Koshi or Narayani rivers.~~ According to the FAO (2011), Nepal was the 12th poorest country in the world during 2010 with a per capita income of $US 480. Although employment opportunities are limited, the economic status in Nepal is improving, which could give fishermen other options to making a living in the near future. Agriculture (paddy, maize, wheat, millet, and legumes) is a large industry in Nepal, but there are other non-agricultural industries that provide jobs, such as manufacturing, construction, and personal services (CBS, 2011). Regrettably, these options are limited in rural areas (river communities) so fishermen have less economic opportunities. Based on interviews, fishermen indicated they would be interested in establishing some sort of ecotourism, which is possible for Nepal. Actually, tourism is already a major industry (US$170 million annually) in various regions of Nepal, so expanding this industry could help reduce poverty in both urban and rural areas (GON, 2013). Tourism contributes to about 7.4 percent of Nepal's National gross domestic product and 5.8 percent of the total employment (Chan & Bhatta, 2013). Most tourists are from India, China, Sri Lanka, United States, and the United Kingdom. Most tourists indicated the primary purpose for visiting Nepal was for holiday/pleasure, and visiting National Parks and Wildlife Reserves ~~(GON, 2013)~~. Thus, it is very possible that Nepal could develop an ecotourism industry in rural areas, but to do it correctly it will take a lot of planning and support from various groups (government institutions, NGOs, and private companies), especially since infrastructure will need to be developed in these remote locations (Chan & Bhatta, 2013). Chan & Bhatta (2013) stated that ecotourism has already been very successful in various remote locations, such as India, Belize, and the Dai villages of Yunnan Province of China. Maybe expanding ecotourism would provide other job options for fishermen while at the same time provide a way to promote the conservation and recovery of the GRD in Nepal?.

CONCLUSIONS

The GRD is recognized as one of the most endangered cetacean in the world. In Nepal, its distribution is restricted to the Narayani, Sapta Koshi, and Karnali river systems. Regrettably, various anthropogenic activities continue to jeopardize the GRD's survival, such as fishing. Nepal is one of the poorest countries in the world, so economic opportunities are limited, especially in rural remote areas. Thus, artisanal fishing provides a substantial portion of income for river-dependent residents residing along the Narayani, Sapta Koshi, and Karnali rivers. Based on interviews with local fishermen, it is evident that there is spatial overlap between the fishing grounds and GRD suitable habitat. This spatial overlap between fisheries and GRD increases the risk of fishery-interactions and threatens the recovery of the GRD in Nepal. Besides the higher likelihood of entanglement, artisanal fisheries are probably indirectly impacting the GRD's diet by taking preferred prey. The problem is challenging to solve given the socio-economic situation, but gear modifications (twine size, gillnet length, soak time and tie downs), changing human behaviour (time-area closures), and switching professions are a few options that could reduce the overlapping pressure between fishing and GRD in Nepal. More importantly, conservation managers need to seriously consider using the non-transboundary management approach with neighbouring countries to protect the remaining GRD population before it's too late.

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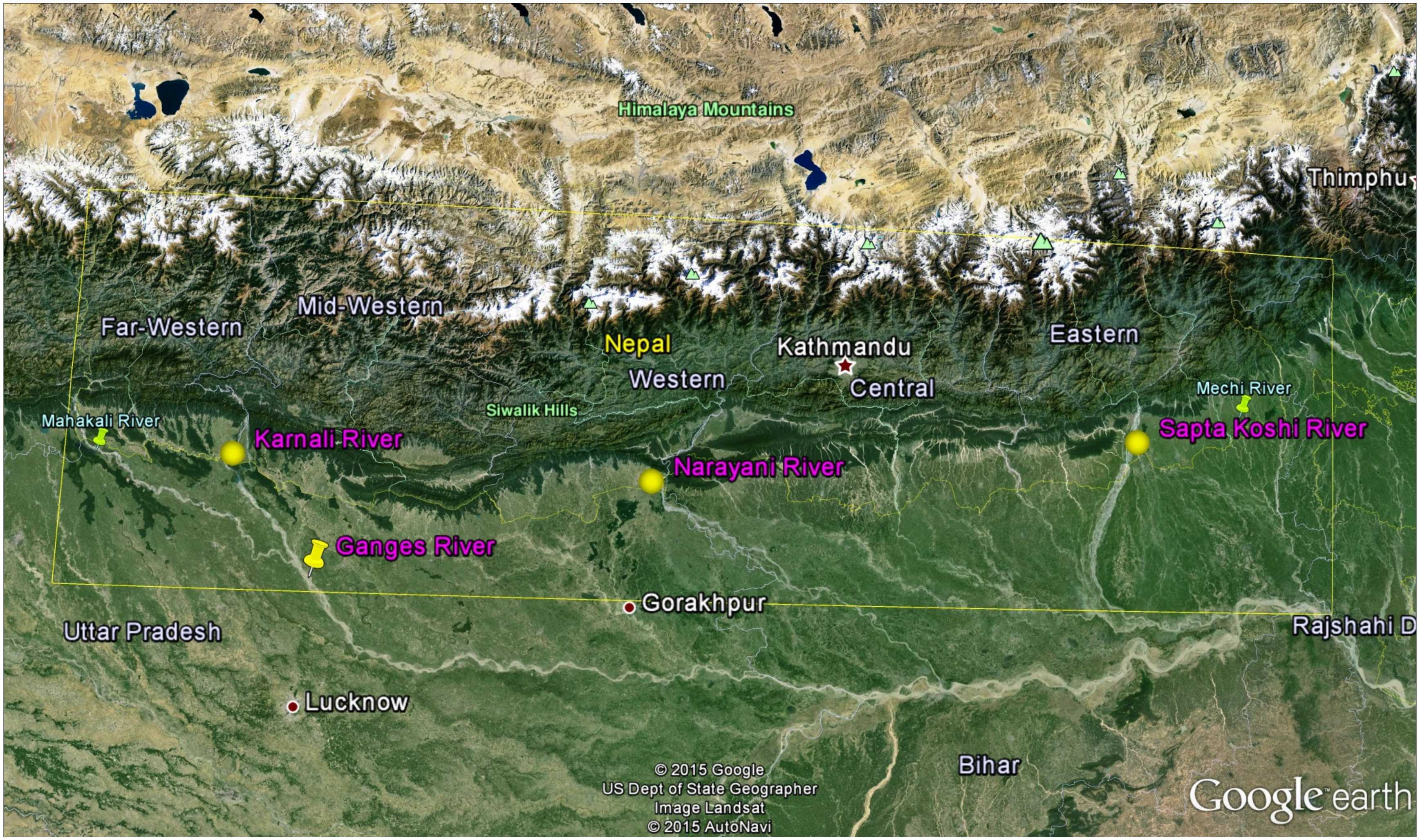

709 **Figure 1:** Study Area. Map of Nepal and the primary tributaries of the Ganges River (Google Earth, 2015).

Table 1: Demographic characteristics of fishermen ~~(n = 163) in~~ the Karnali (n = 56), Narayani (n = 60), and Sapta Koshi (n = 47) rivers. Continuous data are shown as mean ± standard error and categorical data are shown as percentages. Differences between rivers and pairwise multiple comparisons were tested with Fligner-Killeen and Dunnett-Tukey-Kramer test ~~respectively~~ for continuous variables, and a Chi-square test with Yates correction was used for categorical variables. It should be noted that subscripts (a, b, c) sharing the same letter are statistically significantly different.

Demographic characteristics	Total	Karnali River	Narayani River	Sapta Koshi River	Statistics, p-value
Age	44.1 ± 1.1	38.7 ± 1.4^{a}	50.7 ± 1.8^{a,b}	42.1 ± 2.0^{b}	FKχ^2=6.3, p=0.043
Gender					
Male	86.5	87.5^{a}	75.0^{a,b}	100.0^{b}	χ^2=14.2, p=0.001
Female	13.5	12.5	25.0	0.0	
Ethnicity					
Bote	16.6	0.0^{a}	45.0^{a}	0.0^{a}	χ^2=283.0, p<0.001
Chaudhary	11.0	10.7	18.3	0.0	
Malha	27.0	0.0	0.0	93.6	
Sonaha	25.2	73.2	0.0	0.0	
Other	20.3	16.1~~3.6~~	36.6	8.3	
Education level					
Illiterate	69.4	82.1^{a}	80.0^{b}	42.6^{a,b}	χ^2=30.0, p<0.001
Primary education	22.7	8.9	15.0	48.9	
Secondary education	6.8	7.1	5.0	8.5	
Higher education	0.6	1.8	0.0	0.0	
Permanent local resident	93.9	96.4^{a}	86.7^{a}	100.0^{a}	χ^2= 9.1, p=0.011
Years living in the same village	43.6 ± 0.9	47.7 ± 1.1^{a,b}	41.8 ± 1.5^{a}	41.1 ± 2.0^{b}	FKχ^2=15.3, p<0.001

Table 2: ~~Demographic characteristics of fishermen (*n* = 163)~~ in the Karnali (*n* = 56), Narayani (*n* = 60), and Sapta Koshi (*n* = 47) rivers. Continuous data are shown as mean ± standard error and categorical data are shown as percentages. Differences between rivers and pairwise multiple comparisons were tested with Fligner-Killeen and Dunnett-Tukey-Kramer test respectively for continuous variables, and a Chi-square test with Yates correction was used for categorical variables. It should be noted that subscripts (a, b, c) sharing the same letter are statistically significantly different.

Fishing activity characteristics	Total	Karnali River	Narayani River	Sapta Koshi River	Statistics, p-value
Fishing activity					
Fishing is main occupation (%)	78.5	75.0 ^{a}	70.0^{b}	93.6^{b}	χ^2=9.3, p=0.009
Years of experience fishing	36.9 ± 1.1	35.5 ± 1.53 ^{a}	43.0 ± 2.0 ^{a,b}	30.7 1.5 ^{b}	FKχ^2=17.7, p<0.001
Age started fishing	13.6 ± 0.3	15.2 ± 0.1 ^{a}	11.4 ± 0.5 ^{a,b}	14.5 ± 0.7^{b}	FKχ^2=35.8, p<0.001
Occupation of father (%)		^{a}	^{b}	^{a}	χ^2=10.2, p=0.006
Fisher	77.9	75.0	31.7	93.6	
Other	22.1	25.0	68.3	6.4	
Fishing Effort					
Days fishing per week	4.8 ± 0.2	5.0 ± 0.2 ^{a}	3.7 ± 0.3 ^{b}	6.2 ± 0.7 ^{c}	FKχ^2=14.0, p<0.001
Time spent fishing per day in winter (h)	3.1 ± 0.1	2.8 ± 0.1 ^{a}	2.6 ± 0.2 ^{b}	4.1 ± 0.2 ^{a,b}	FKχ^2=18.8, p<0.001
Time spent fishing per day in summer (h)	5.2 ± 0.2	3.7 ± 0.1 ^{a}	3.6 ± 0.1 ^{b}	9.0 ± 0.4 ^{a,b}	FKχ^2=50.3, p<0.001
Effective number of months fishing	3.3 ± 0.1	2.6 ± 0.2 ^{a}	2.6 ± 0.1 ^{b}	5.1 ± 0.2 ^{a,b}	FKχ^2=20.5, p<0.001
Economy					
Monthly earnings from fishing ($)	60.2 ± 2.6	26.0 ± 2.3 ^{a,b}	78.0 ± 3.7 ^{a}	78.2 ± 2.5^{b}	FKχ^2=26.8, p<0.001
Annual earnings from fishing ($)	233.5 ± 16.3	84.0 ± 3.8 ^{a}	208.1 ± 18.0 ^{a}	418.6 ± 33.4 ^{a}	FKχ^2=38.5, p<0.001
Monthly earnings from other activities ($)	101.1 ± 9.9	41.8 ± 2.0 ^{a}	171.0 ± 23.9 ^{a}	82.1 ± 3.5 ^{a}	FKχ^2=32.2, p<0.001

Fishing activity characteristics	Total	Karnali River	Narayani River	Sapta Koshi River	Statistics, p-value
Secondary occupation		[a]	[a]	[a]	FKχ^2=191.1, $p<0.001$
Agricultural labor	47.9	5.4	71.7	68.1	
Gold filtering	25.8	75.0	0.0	0.0	
Fishing unbanned areas	3.1	0.0	0.0	10.6	
Daily wages	9.8	0.0	26.7	0.0	
Other	10.4	17.9	1.7	10.7	
No secondary occupation	3.1	0.0	0.0	10.6	

Table 3: ~~Demographic characteristics of fishermen (n = 163)~~ in the Karnali (n = 56), Narayani (n = 60), and Sapta Koshi (n = 47) rivers. Continuous data are shown as mean ± standard error and categorical data are shown as percentages. Differences between rivers and pairwise multiple comparisons were tested with Fligner-Killeen and Dunnett-Tukey-Kramer test respectively for continuous variables, and a Chi-square test with Yates correction was used for categorical variables. It should be noted that subscripts (a, b, c) sharing the same letter are statistically significantly different.

Fishery description	Total	Karnali River	Narayani River	Sapta Koshi River	Statistics, p-value
Fishing boats					
Owner of one boat	64.8	$82.1^{a,b}$	52.5^{a}	59.6^{b}	χ^2=11.8, p=0.003
Type of boat		^{a}	^{b}	^{a,b}	χ^2=94.3, p<0.001
Single man traditional wooden boat	81.0	100.0	100.0	17.9	
More than one man modern boat	19.0	0.0	0.0	82.1	
Average number fishermen per vessel	4.7 ± 0.6	2.1 ± 0.1^{a}	$11.8 \pm 1.1^{a,b}$	2.3 ± 0.1^{b}	FKχ^2= 26.8, p<0.001
Fishing gears					
Fishing gear		^{a}	^{a}	^{a}	χ^2=23.8, p<0.001
Phekuwa Jaal	25.8	14.3	3.3	68.1	
Maha Jaal	24.5	71.4	0.0	0.0	
Pakhure Jaal	22.7	0.0	58.3	2.3	
Other	26.9	14.3	38.3	27.7	
Net mesh size (cm)	1.8 ± 0.2	NA	1.7 ± 0.2^{a}	1.9 ± 0.2^{b}	FKχ^2=0.1, p=0.099
Net length (m)	65.2± 6.7	$170.2 \pm 7.8^{a,b}$	5.6 ± 1.2^{a}	14.1 ± 3.6^{b}	FKχ^2=9.7
Net width (m)	4.6 ± 0.4	1.2 ± 0.1^{a}	9.1 ± 0.6^{a}	3.0 ± 0.1^{a}	FKχ^2=55.1, p<0.001
Fishing time					
Travel distance	2.9 ± 0.1	2.6 ± 0.1^{a}	2.7 ± 0.2^{a}	3.3 ± 0.3^{b}	FKχ^2=4.5, p=0.11
Preferred fishing time (hrs)	14:50 ± 0:16	$15:52 \pm 0:16^{a}$	$14:44 \pm 0:32^{b}$	$13:44 \pm 0:32^{a,b}$	FKχ^2=18.8, p<0.001
Preferred fishing time		^{a}	^{a}	^{a}	χ^2=48.7, p<0.001
Breeding time for fish	10.4	12.5	16.7	0.0	

Fishery description	Total	Karnali River	Narayani River	Sapta Koshi River	Statistics, p-value
High turbidity	22.1	0.0	43.3	21.3	
Low water season	65.0	85.7	36.7	76.6	
Summer season with hot water	1.2	1.8	0.0	2.1	
Other	1.2	0.0	3.4	0.0	

Table 4: Demographic characteristics of fishermen (n = 163) in the Karnali (n = 56), Narayani (n = 60), and Sapta Koshi (n = 47) rivers. Continuous data are shown as mean ± standard error and categorical data are shown as percentages. Differences between rivers and pairwise multiple comparisons were tested with Fligner-Killeen and Dunnett-Tukey-Kramer test respectively for continuous variables, and a Chi-square test with Yates correction was used for categorical variables. It should be noted that subscripts (a, b, c) sharing the same letter are statistically significantly different.

Fishermen perceptions and opinions	Total	Karnali River	Narayani River	Sapta Koshi River	Statistic, p-value
Fishing activity					
Perception about changes in the amount of fish caught over time		[a]	[a]	[a]	χ^2=138.4, p<0.001
Worse than before	61.3	100.0	6.4	66.1	
Same as before	18.4	0.0	23.4	33.9	
Better than before	20.2	0.0	70.2	0.0	
Perception about changes in the quantity of boats in the river		[a]	[a]	[a]	χ^2=89.4, p<0.001
Fewer than before	36.8	78.3	14.9	10.7	
Same as before	54.0	10.0	68.1	89.3	
More than before	9.2	11.7	17.0	0.0	
Fishing job					
Don't want their children will be a fisher	100.0	100.0[a]	100.0[b]	100.0[c]	χ^2=1.6, p=0.442
Don't think fishing is a good job	100.0	100.0[a]	100.0[b]	100.0[c]	χ^2=1.6, p=0.442
Which job they would like for their children		[a]	[a]	[a]	χ^2=99.31, p<0.001
Agriculture	10.4	1.8	21.7	6.4	
Fishing business	3.7	3.6	0.0	8.5	
Governmental job	31.3	10.7	51.7	29.8	
NGO	12.3	3.6	11.7	23.4	
Private firm	35.0	80.4	5.0	19.1	
Other small business	7.4	0.0	10.0	12.8	

Table 5: ~~Demographic characteristics of fishermen (n = 163)~~ in the Karnali (n = 56), Narayani (n = 60), and Sapta Koshi (n = 47) rivers. Continuous data are shown as mean ± standard error and categorical data are shown as percentages. Differences between rivers and pairwise multiple comparisons were tested with Fligner-Killeen and Dunnett-Tukey-Kramer test respectively for continuous variables, and a Chi-square test with Yates correction was used for categorical variables. It should be noted that subscripts (a, b, c) sharing the same letter are statistically significantly different.

Perceptions and opinions	Total	Karnali river	Narayani river	Sapta Koshi river	Statistic, p-value
Dolphin sightings					
Does not know (saw or heard) of dead dolphins	99.4	100.0[a]	98.3[b]	100.0[c]	χ^2=1.7, p=0.422
Perceives to seeing dolphins often in the past	61.3	28.6[a,b]	73.3[a]	85.1[b]	χ^2=53.5, p<0.001
Perceives to rarely see dolphins now	62.6	23.2[a]	98.3[a]	63.8[a]	χ^2=70.4, p<0.001
Type of habitat where dolphins are most often sighted		[a]	[a]	[a]	χ^2=104.7, p<0.001
Deep pool (depth >3m)	56.0	50.0	100.0	10.6	
Confluence	12.6	7.1	0.0	34.0	
Straight channel (depth<3m)	26.4	42.9	0.0	38.3	
Meandering	5.0	0.0	0.0	17.0	
Type of behavior when dolphins are sighted		[a,b]	[a]	[b]	χ^2=138.2, p<0.001
Diving	66.5	7.1	100.0	100.0	
Showing back and snout	31.6	87.5	0.0	0.0	
Swimming	1.9	5.4	0.0	0.0	
Distance dolphin to boat during sightings (m)	48.1 ± 8.4	1.8 ± 0.1[a]	131.4 ± 19.3[a,b]	3 ± 0.0[b]	FKχ^2=74.8, p<0.001
Dolphin conservation					
Perceives decrease in number of dolphins over time	89.5	87.5[a]	100.0[a,b]	78.7[b]	χ^2=13.0, p=0.002
Perceived major threats to dolphins		[a]	[a]	[a]	χ^2=64.7, p<0.001
Habitat overlapped with fishermen	10.7	0.0	28.3	0.0	
Low depth and width of river	32.1	12.5	36.7	51.2	
High human disturbances	53.5	85.7	26.7	48.8	

Perceptions and opinions	**Total**	**Karnali river**	**Narayani river**	**Sapta Koshi river**	**Statistic, p-value**
Decrease in prey density	3.7	1.8	8.3	0.0	
Ways to conserve dolphins		[a,b]	[a]	[b]	χ^2=64.3, p=0.001
Awareness among the fishermen/river dependent communities	53.4	89.3	30.0	40.4	
Enterprise training facilities for river dependents	23.3	1.8	38.3	29.8	
Monitoring of fishing activities through watch group	8.6	3.6	13.3	8.5	
Punishing people engaged in illegal activities according to law	5.5	0.0	5.0	12.8	
Careful fishing by avoiding killing dolphins	4.9	5.4	1.7	8.5	
Other	4.3	0.0	11.7	0.0	