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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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 negative 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% of Nepalese fishermen indicated fishing was their primary form of income. Fishermen reported fishing effort was greater in summer than winter; greatest in the afternoon (14:30 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 nearly 30% preferred gillnets between 10 and 100 m long; a few used gillnets longer than 100 m. Fishermen reported seeing more GRD in the main river stream 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 developments were the greatest threats.

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ABSRACT

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INTRODUCTION

Ganges River dolphin (*Platanista gangetica gangetica*) (GRD) is the only freshwater cetacean recorded in Nepal with their remaining viable population restricted to the Karnali, Narayani and Sapta Koshi river systems of Nepal (Smith et al., 1994; Timilsina et al., 2003; WWF, 2006; Paudel, 2014). 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. 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). This freshwater cetacean ~~is~~ primarily found in the Ganges and Brahmaputra rivers, including several associated tributaries in Bangladesh, India, and Nepal (Jones, 1982). The Ganges river has the largest remaining population ~~in the world~~ (Smith, 1993).

The GRD is vulnerable to various anthropogenic activities because they are usually found in some of the most densely populated areas (Smith & Braulik, 2012). Nepalese river-dependent communities continue to grow and expand, so it is no surprise that most of the GRD interaction issues are associated with heavily populated areas (CBS, 2003), which escalates the human-dolphin interface dilemma. 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 (e.g., fishing, pollution and habitat loss) have also led to the decline of the GRD population. Besides the construction of dams, the lack of river and watershed management (open-access resource exploitation) and the geographical expansion of artisanal fisheries are the greatest threats to GRD (Dudgeon, 2000; Manel et al., 2000; Gergel et al., 2002). Because local communities rely on natural resources for income and survival, some basic daily activities threaten the conservation and recovery of the GRD, such as artisanal fisheries (Berkes, 1985; Turvey et al., 2007). Artisan fisheries affect the GRD population directly and indirectly. According to Sinha et al., (2010), the GRD continues to be directly targeted by some fishermen for its oil and meat; the oil is used as bait in a few 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). Indirect impacts include reducing the availability of prey and habitat (Kelkar et al., 2010). According to Kelkar et al., (2010), fishermen compete with GRD because they target various species of fish that are essential to the GRD's diet, such as mullet (*Rhinomugil corsula*) or siloroid catfish (*Bagarius bagarius*) (Smith, 1993).

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 attention in other regions, such as Nepal (Jnawali et al., 2011). 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 (Bardiya National Park), Sapta Koshi (Koshi Tappu Wildlife Reserve), and Narayani (Chitwan National Park) river systems. Despite these management protective measures, the GRD population continues to decline at an alarming rate in Nepal (Jnawali & Bhuju, 2000). Although officials understand artisanal fisheries are an issue for the conservation and recovery of GRD, fishery management or strategies for reducing fishery interactions are currently lacking. At the foundation of fisheries management is a description of the fisheries. Basic information describing artisanal fisheries and activity is essential for understanding the fishery-GRD problem and developing a potential solution (Rojas-Bracho & Reeves, 2013); however, this type of information is usually unavailable and challenging to obtain, especially in developing countries, such as Nepal. A basic description of the local fisheries would help managers understand the fishery-GRD interaction conflict and it could help them develop a possible resolution. 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 endangered GRD and artisanal fishing communities in the river systems of Nepal. The specific objectives were to identify, compile, and investigate the demographics, economics, fishing characteristics, and perception of fishermen about GRD conservation in the Narayani, Sapta Koshi, and Karnali rivers.

MATERIAL AND METHODS

Study Area

The study was conducted in three major river systems: the Narayani, Sapta Koshi and Karnali rivers of four districts of Nepal (Bardiya, Nabalparasi, Saptari and Sunsari) representing 45 villages settled within 1 km from the riverbank (**Fig. 1**). These river systems serve as habitat for the GRD in Nepal and are major tributaries of the Ganges River. All of these rivers are located downstream of the Siwalik foothills of the Nepalese Himalayas, which represents the extreme upstream limits of GRD distribution in southern Asia. With headwaters in the southern slopes of the Himalayas of Tibet, seasonal snow melt controls much of the fluctuating water levels in these river systems. Fluctuations in water level cause dolphins to migrate downstream through the barrages during flood periods. The flow rates of all three river basins varies seasonally and annually; the velocity is relatively higher upstream than downstream. For the purpose of this study, we defined the main channel mid area as the center of the main river, stream, or tributary;

fastest water velocity. The main channel near the riverbank was defined as the location where the water velocity and depth were lower than the center of the river. Lastly, we defined the area behind sandbars/islands as a parcel of land with sandbars surrounded by water on all sides. We defined the confluence area was located downstream and the distributary was upstream.

Survey Methods

Fishery and socio-economic information was collected using a face-to-face questionnaire approach with registered (fishing associations) fishermen located along the Narayani, Sapta Koshi, and Karnali rivers in Nepal during August 2013. We specifically chose to interview registered fishermen because fishermen associations represented a large number of artisanal fishermen that not only reside near the rivers, but regularly fish these rivers. Three interviewers conducted the survey in the local Nepali language. To reduce any potential sampling bias, we randomly selected 15 percent of registered fishermen residing along the Karnali, Sapta Koshi and Narayani 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 of fisheries, demographic information, fishery description, sightings and interactions with dolphins, dolphin population status, and preferred conservation measures. Questions included both open-ended and multiple-choice answer formats. Demographic and fishing information (i.e., fishing effort, gear, and experience) questions were asked at the beginning and more sensitive (income and interactions with dolphin) questions were asked near the end to further increase the response rate. Income was provided in

Nepali currency, but converted and reported in US dollar ($1 USD = 98 NRs). In general, there were no multiple-choice questions. Questions regarding dolphin interactions/sightings were divided by season (summer/winter) and time (past [>10 years] and present [< 10 years]). The questionnaire ended with multiple-choice questions about potential threats and preferred conservation measures for the GRD in Nepal.

Statistical Analysis

Differences (expected vs observed) in categorical variables (e.g., demographics, fishery description, and fishermen perceptions of the dolphin population conservation status) between fishermen from different rivers were tested with a Chi-square Goodness-of-Fit test (χ^2) using a Yates correction when expected cell frequencies were below 10. To counter the effects of multiple paired testing (i.e., pair-wise comparisons), a χ^2 approach was also applied when differences among rivers were detected (Todorov & Filzmoser, 2009). The χ^2 test was used to test the null hypothesis that there was no significant difference in the frequency of observed responses. The χ^2 test was applied following the guidelines of Koehler and Larntz (1980); k classes > 3 (Zar, 1994). A Fligner-Killen test of homogeneity of variances ($FK\chi^2$) was applied for evaluating continuous variables (e.g., age, years living in the same village, fishing experience, fishing effort, and income). The $FK\chi^2$ test is an adaptation of the Kruskal-Wallis test that is robust against departures from normality (Conover et al., 1981; Rouseeuw et al., 2014). A Dunnett-Tukey-Kramer pairwise multiple comparison test was used to investigate the mean difference in more than two groups with unequal variance and sample size (Lau, 2013). Data were summarized, graphed, and evaluated using descriptive and hypothesis testing statistics. Data were managed using Microsoft Excel® and analyses were conducted using R version 3.0.2 (R Core Team, 2013). Statistical significance was defined as $P < 0.05$.

RESULTS

Survey

A total of 163 fishermen from the Karnali (n = 56), Sapta Koshi (n = 47) and Narayani (n = 60) rivers participated in the study. ~~Every~~ interviewed fisherman ~~we encountered~~ was willing to participate and complete most of the questionnaire. Interviews took 15 to 107 minutes, and the average time was 39.42 ± 1.67 minutes.

Demographics

Fishermen ages ranged from 16 to 94 years-of-age, and the average age was 44.1 years-of-age. Fishermen from Narayani river were significantly older than those from either the Karnali or Sapta Koshi rivers (**Table 1**). Eighty-seven percent of fishermen were men but there were more women fishermen in the Narayani river than in the other two rivers. ~~Artisanal~~ fishermen represented 15 different ethnic groups, mostly Malha (27%) ~~and~~ Sonaha (25.2%) ~~followed by~~ Bote (16.6%), Chaudhary (11%). Most fishermen indicated they had little to no education: sixty-nine percent reported to be illiterate and 23% to have primary education level. The education level of fishermen was lowest in the Karnali river and highest in Sapta Koshi river. Most fishermen (93.9%) reported they had resided in their villages for over 40 years.

Economic dependence on fisheries

Monthly earnings from fishing was $US 60.2 ± 2.6; most fishermen (44.8%) earned less than $US 50 per month. ~~Though~~ fishing effort (fishing days per week) was not significantly different between rivers, reported monthly earnings in the Karnali significantly lower than in the other two rivers (**Table 2**). Although fishermen were highly dependent upon fishing for their income (78.5%), they reported to have alternative sources of income, mostly agriculture (47.9%). The mean earnings from other activities were $US 101.1 ± 9.9 per month. Monthly earnings from alternative activities were significantly higher in the Narayani river and lower in the Karnali river.

Fishing Activity

Seventy-eight percent of respondents reported that fishing was their primary occupation. On average, fishermen had 36.9±1.1 years of experience; most began fishing at an early age. Eighty-eight percent reported they started fishing before the age of 15. Most fishermen (77.9%; **Table 2**) indicated their fathers were or currently are fishermen. Most fishermen indicated they only owned one small wooden fishing vessel, but eight fishermen (4.9 %) told us they owned more than one fishing vessel (**Table 3**). The mean fishing crew size was 4.7 ± 0.6 fishermen /vessel.

Fishing Effort

Fishermen spend an average of 4.8±0.2 fishing day per week. Overall, fishing effort varied significantly among river segment (χ^2 = 14.0; $P < 0.001$). The highest fishing effort occurred in the Sapta Koshi river (6.2 ± 0.7 days/week) and lowest occurred in the 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 ($P < 0.05$). In winter (dry season), fishermen spent 3.1 ± 0.1 hours/day fishing and in summer (wet season) they spent 5.2 ± 0.2 hours/day. This pattern was similar in the Karnali and Narayani rivers, but fishing effort in the Sapta Koshi river was significantly higher ~~in summer than winter~~.

Most fishermen (90.2%) reported they preferred to fish in the afternoon (14:50 hrs ± 0.16), and during low water levels (65%). The primary fishing period varied among river segment ($P <$ 0.001). Fishermen from the Sapta Koshi river (13:44 ± 0.32) preferred to fish earlier in the day than those from Naryani (14:44 ± 0.32) or Karnali rivers (15:52 ± 0.16). 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 turbid and/or low water levels, while those from the Karnali river preferred to fish during the spawning and low water period (**Table 3**). Fishermen indicated they usually fished close to their village. The mean distance travelled was 2.9 ± 0.1 km; they rarely travelled more than 7 or 8 km to the 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.

Fishing Gear

Fishermen reported using eight different types of fishing gear (**detail given in appendix 1**). Twenty-five percent of fishermen used Phekuwa Jaal (cast net), and another 24.5% used Maha Jaal (gillnet). Slightly fewer fishermen (22.7%) used Pakhure Jaal (cast net), and the rest used various nets (27%), 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 (χ^2=23.80 P < 0.001). 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.

Gillnet gear varied in length, net width, and mesh-size. Gillnets ranged in length from 1.2 to 250 m. Sixty percent of those interviewed reported they used gillnets less than 10 m long, 30.1% were 10 and 100 m long, and another 30.1% used longer than 100 m. Fishermen from the Karnali river used gillnets much longer than fishermen from either Sapta Koshi or Naryani rivers (χ^2 = 9.7; P < 0.008). Most fishermen (69.9%) stated their gillnets were around 3 to 4 m width. The average gillnet length was 65.2 ± 6.7 m and the net width was 4.6 ± 0.4 m. The net width also varied among river segment (χ^2 = 55.1, P < 0.001). Fishermen from the Naryani river used gillnets that were wider 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 (79.8%) stretch-mesh size was around 2.0 cm or less. It should be noted that some fishermen (25.2%) indicated they recently changed to a smaller mesh size expecting to increase catch. Despite this gear change, they told us they did not notice any major difference in catch.

Fishing Activity Perceptions

Sixty-one percent of fishermen perceived a decline in catch over time and more than half believed the number of fishing boats in the area was similar to the past. Perceptions were significantly different among fishermen from different rivers (χ^2 = 138.4; P < 0.001). Fishermen from the Karnali and Sapta Koshi rivers believed fishing was worse now than before. In contrast, most fishermen from the Narayani river actually thought fishing was better now than before ~~(70%)~~. Most fishermen from the Karnali River believed there were fewer fishing boats now that before, while fishermen from the other two rivers did not 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%) indicated they wanted their children to work for a private firm followed by a government agency (31.3%) or a non-government organization (12.3%) (**Table 4**).

Ganges River Dolphin Sightings and Observations

Most fishermen (62.6%) indicated they rarely spotted GRD on recent trips, but many (61.3%) 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 = 70.4; P < 0.001).

Karnali river fishermen reported occasionally spotting GRD in the past, while Narayani and Sapta Koshi river fishermen reported frequently spotting them in the past. Karnali river fishermen told us they used to spot around two GRD in the past, while Sapta Koshi and the Narayani river fishermen reported spotting four or more individuals, respectively.

A Chi-square test detected a significant difference in the location ~~when~~ fishermen usually spotted GRD ($\chi^2 = 104.7$; $P < 0.001$). Most fishers reported they seem more dolphins in deep pools and that they tend to be diving during sightings. There are significant differences between fishermen from different rivers. While all fishermen from Narayani river report to see fishers in deep pools, those from Sapta river said most sightings occurred in the confluences and on the straight channel; and those from the Karnali river that they see most dolphins in deep pools and straigt channels. Again when it comes to the behaviour dolphins exhibit during sightings there were differences in reports between fishermen operating in the different rivers ($\chi^2 = 138.2$; $P < 0.001$). All fishermen from Narayani and Sapta Koshi rivers reported that ~~fishers~~ were diving during sightings, while those from Karnali reported they were showing their back and snout. Overall, only one fisherman from the Narayani river told us he had encountered a dead GRD.

Conservation Measures for Ganges River Dolphin

Most fishermen (89.5%) perceived the GRD population had declined. Most fishermen believed the main threat to GRD were humans ~~(53.5%)~~, stating the construction of dams/irrigations systems and fishing as the main threats while 32.1% thought the recent decline in the GRD population was associated with physical changes (width and depth) in the river (**Table 5**). Most fishermen suggested that increasing GRD awareness and establishing new training opportunities using locally available natural and social resources would help reduce fishing pressure and risk to GRD.

DISCUSSION

Anthropogenic activities (e.g., commercial fishing and vessel collisions) are the leading cause of mortality for most cetaceans around the world (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 cetacean bycatch in gillnets. Understanding fishery interactions is essential for preventing further losses of cetacean diversity and abundance (Reeves et al., 2013). In Nepalese rivers, the incidental entanglement of GRD with fishing gear is one of the major threats to the conservation and recovery of the GRD (Kelkar et al., 2010; Sinha et al., 2010); it is also a major problem 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 conservation 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.

Demographics and Economics

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. Because fishermen begin fishing at an early age, it limits their education and ability to pursue other occupations. Despite the importance of fishing to the community, we were surprised to discover that most fishermen did not want their children to pursue fishing as a job. Thus, it is might be possible, with the right training, parents could potential encourage their children to pursue other occupations, especially since some of them 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. Clearly, alternative income opportunities for river-dependent residents in Nepal are limited, but there are still a few options that could benefit locals and the GRD, such as eco-tourism, farming, or simply changing fishing tactics or fishing gear. The farming trade is growing throughout Nepal (Joshi et al., 2012), so it is possible that Nepalese fishermen would consider permanently changing occupations.

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). According to

GON (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. 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). Ecotourism has already been very successful in various remote locations, such as India, Belize, and the Dai villages of Yunnan Province of China (Chan & Bhatta, 2013). 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.

Fishing Activity

Most fishermen only own one fishing 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 probably 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 because many of them cannot purchase their own vessel. Assuming a larger crew corresponds to less gear in the water then overall risk to GRD could be relatively less in the Naryani river. Our survey revealed 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). Thus, there may be an option for fishermen from Karnali and Sapta Koshi river to switch from using gillnets to 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 also 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, particularly since immense fishing pressure is still a problem in the Sapta Koshi river (Chaudhary, 2007). Fishermen also told us they believed fishing was worse now than before in the Naryani river. Assuming this is an 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? We recommend future studies investigate this potential phenomenon.

Fishing Effort

Fishermen depend on catching fish to support their families, so most of them fish as much as possible (> 4 days per week). Interestingly, fishermen from the Sapta Koshi river told us they fished every day, which clearly increases the risk to the GRD in that region. These 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. Based on some evidence, (e.g. Sinha et al., 2010; Sasaki -Yamamoto et al., 2013) it appears GRD are more active during early-morning (0800-1100 hrs) and late-afternoon (1330-1600 hrs) than during the day. It is clear from our study that fishermen also prefer to fish during these periods, which poses a greater risk to the GRD. It is likely that GRD are depredating and interacting with gillnets, which is a common behavior for many cetaceans around the world (Read et al., 2003; Waples et al., 2013). Given this behavior, is it possible that Nepalese fishermen could set their gear during day instead of the morning and late-afternoon without compromising their catch? Additional research is warranted.

The GRD is known to migrate seasonally according to water level (dry vs wet season). Kelkar et al., (2010) 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). Paudel (2014) also reported that GRD occurrence in Nepal was more probable in river segments with deep pools. Seasonal movement in conjunction 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). Given GRD movement patterns, fishing in winter during low water season poses a greater risk to the GRD because they are more concentrated in specific areas like deep pools where fisherman prefer to fish. Although interviews revealed that fishermen spent almost twice as many hours fishing in summer (5.7 hours/day) than in winter (3.7 hours/day), fishing in winter still poses a threat to GRD. Most fishermen told us they preferred to fish in tributaries, especially in the Karnali river. Fishing in Karnali river area poses a threat to GRD during wet season because the Karnali and Sapta Koshi rivers are more critical to GRD population than the Narayani river population given their lower relative abundance (Paudel, 2014). Even though abundance is generally lower (Kelkar et al., 2010; Paudel, 2014) in the post-monsoon than the pre-monsoon period (Paudel, 2014), it should be noted that fishing in the dry season could also endanger the GRD because the lower water level makes it more difficult for the GRD to avoid being entangled in gillnets; the average width 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 ~~(~~Malla, 2009; 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.

Most fishermen used gillnets less than 10 m long. Thirty percent 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).

The majority of fishermen used gillnets constructed with a mesh size less than 2.0 cm. We also observed that fishermen continued to construct nets with smaller mesh 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;

GRD prey on Reba carp (*Cirrhinus reba*) and Baam (*Mastacembelus armatus*) (Bashir et al., 2010). 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 (mesh-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). 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) 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).

Conservation Measures for Ganges River Dolphin

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 seasonal distribution of GRD; this species have never been observed in water levels less than 2.0 m (Biswas & Boruah, 2000; Braulik et al., 2012; Paudel, 2014). Construction of dams in Nepal is likely to continue since only about 50 % of urban and 5 % of the rural population has access to electricity (Bergner, 2012). The construction of dams in Nepal also negatively impacts GRD habitat and causes population fragmentation. 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.

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. Although river-dependent residents residing along the Narayani, Sapta Koshi, and Karnali rivers have other sources of income, artisanal fishing is their main occupation. Based on interviews with local fishermen, it is evident there is spatial overlap between the fishing grounds and potential 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, especially since most fishermen told us they use monofilament gillnets. Although we did not directly sample catch, artisanal fisheries could be indirectly impacting the GRD's diet by taking preferred prey. We recommend additional research into this topic. The GRD and fishery interaction problem in Nepal is challenging to solve given the socio-economic situation, but gear modifications (mesh-size, gillnet length, soak time, and tie downs), changing human behaviour (time-area closures), and switching professions (eco enterprise business using natural and socio economic resources) are a few options that have been implemented in other regions. Making these changes could potentially reduce the risk to the GRD in Nepal. Further research is warranted. Lastly, we believe 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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Study Area. Map of Nepal and five main river systems, and associated tributaries of the Ganges River. Interview surveys were conducted on the Karnali, Narayani and Sapta Koshi rivers

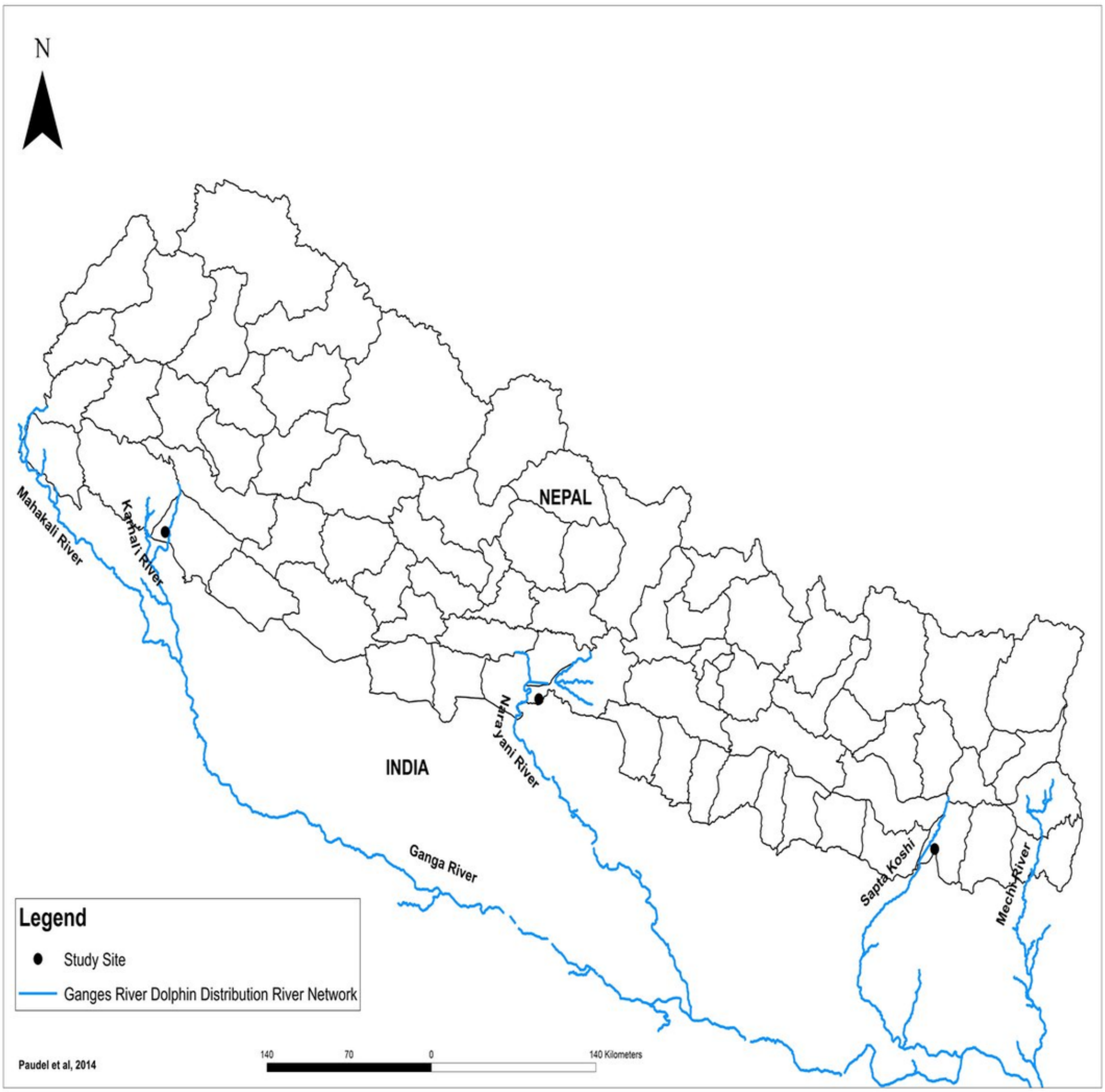

Table 1(on next page)

Demographic characteristics of fishermen from 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 respectively tested with Fligner-Killeen and Dunnett-Tukey-Kramer test for continuous variables, and a Chi-square test with Yates correction (when required) 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	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 (on next page)

Characteristics of the fishing activity 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
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	

~~Fishing activity characteristics~~	~~Total~~	~~Karnali River~~	~~Narayani River~~	~~Sapta Koshi River~~	~~Statistics, p-value~~

Table 3 (on next page)

(on next page)

Fishery description in the Karnali (n = 56), Narayani (n = 60), and Sapta Koshi (n = 47) rivers.

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 ± 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	-	1.7 ± 0.2 [a]	1.9 ± 0.2[b]	FKχ^2=0.1, p=0.990
Net length (m)	65.2± 6.7	170.2 ± 7.8 [a,b]	5.6 ± 1.2 [a]	14.1 ± 3.6[b]	FKχ^2=9.7, p=0.008
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=0.110
Preferred fishing time (hrs)	14:50 ± 0:16	15:52 ± 0:16 [a]	14:44 ± 0:32 [b]	13:44 ± 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	
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(on next page)

Fishermen perception about the fishing activity and fisheries as a job 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
Perception about fishing					
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=99.3, $p<0.001$
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(on next page)

Fishermen perceptions about dolphin population and conservation status 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 about dolphins and their conservation	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	
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	

Perceptions about dolphins and their conservation	Total	Karnali river	Narayani river	Sapta Koshi river	Statistic, p-value
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	

Table 6(on next page)

Appendix 1. An overview of fishing gear use in Narayani, Sapta Koshi, and Karnali rivers.

1 **Appendix 1. An overview of fishing gear use in Narayani, Sapta Koshi, and Karnali rivers.**

Gear Type	Gear Name	General Description	Mesh-Size	Scope of Use
Gillnet	Maha Jaal	A long simple net with small weights distributed around its bottom edge.	Mesh size ranges from 0.5 to 1 mm	Mainly in ponds or narrow river channel
	Bagaune Jaal	A net that is dragged or hauled across a river or along the bottom of a lake or sea. The fishing depth of this net can be adjusted by adding weights to the bottom.	Varies in size based on target species.	Narrow channel river
	Tiyari Jaal	A net that is used by two people in small wooden boat where one hand is hitting the water with paddle and other is catching fish.	Varies in size based on target species.	Narrow river channel with slow water current
	Maha Jaal	A long simple net with small weights distributed around its bottom edge which is hold by two persons on two ends.	Mesh size ranges from 0.5 mm to 1 mm	Mainly in ponds or narrow river channel by two persons or more
	Paat or current Jaal	Drift netting (locally called *Current or Paat jaal),* is a fishing technique where drift nets hang vertically in the water column and drift with the current	Varies in size based on target species.	Main river channel

Gear Type	Gear Name	General Description	Mesh-Size	Scope of Use
		without being anchored to the bottom. The nets are kept vertical in the water by floats attached to a rope along the top of the net and weights attached to another rope along the bottom of the net.		
Cast Net	Phekuwa jaal or Haate jaal	A cast net (locally known as *Phekuwa jaal*), also called a throw net. It is a circular net with small weights distributed around its edge.	Ranges from 1.2 to 3.6 m (4- 12 ft)	Ponds, lake, or river
Other	Ghumauwa or Khaap Jaal	A kind of lift net that has an opening that faces upwards and submerged to a desired depth, and then lifted or hauled from the water manually or mechanically.	Ghumauwa or Khaap Jaal	Stream or river
	Dadhiya	Locally knitted bamboo stick is placed in flowing water path as the obstruction for the fishes.	Dadhiya	Stream or river
	Pakhure Jall	A hand net, also called a scoop net or dip net,	Mesh size varies from 1 to 2 mm; it can be larger	Shallow water

Gear Type	Gear Name	General Description	Mesh-Size	Scope of Use
		(locally *pakhure jaal*) is a net or mesh basket held open by a hoop. A hand net with a long handle is often called a *dip net*. The basket is made of wire or nylon mesh. The hand net is sometimes used to help land a fish it is called a *landing net*.	depending on the target species.	