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STATUS OF IRRAWADDY DOLPHINS *ORCAELLA BREVIROSTRIS* IN THE UPPER REACHES OF THE AYEYARWADY RIVER, MYANMAR

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ABSTRACT. – During 359.6 km (27.6 hours) of search effort from Bhamo to Mandalay in the upper reaches of the Ayeyarwady River, Myanmar, we recorded 14 sightings and observed 55-70 (best estimate 59) Irrawaddy dolphins *Orcaella brevirostris*, including at least five calves. We recorded a sighting rate of 0.16 dolphins/linear km. The mean group size was 4.2 dolphins (SD = 3.8, Range = 1-15). Sightings were concentrated in geomorphologically complex reaches upstream and downstream of channel convergences, islands and constrictions. Conservation threats include accidental killing in gillnets and possibly mercury poisoning from river gold mining operations. Recommendations include establishing traditional throw-net fishing/dolphin sanctuaries and controlling the introduction of mercury into the riverine environment.

KEY WORDS. – *Orcaella brevirostris*, Irrawaddy River, Myanmar, Burma, river dolphins, freshwater cetaceans, conservation.

INTRODUCTION

Irrawaddy dolphins *Orcaella brevirostris* (Fig. 1) are patchily distributed in shallow nearshore tropical and subtropical marine waters of the Indo-Pacific from northern Australia to eastern India, often associated with estuaries and mangrove forests. They also occur far upstream in the Ayeyarwady (formerly Irrawaddy) River system of Myanmar (formerly Burma), Mahakam River system of Indonesia, and Mekong River system of Laos, Cambodia, and Vietnam. Although the species is classified by the IUCN as Data Deficient (Hilton-Taylor, 2000), recent investigations in the two latter river systems have documented range declines, widespread and intensive threats (mainly in the form of fisheries bycatch) and low abundance where the dolphins still occur (Baird et al., 1994; Baird & Mounsouphom, 1997; Smith et al., 1997a; Kreb, 2002). The Mahakam population was recently classified as Critically Endangered (Hilton-Taylor, 2000).

The earliest reference to dolphins in the Ayeyarwady River is from the New T'ang History (Chinese text from 'about 800 A.D.' as cited in Luce, 1966), which mentions trade in 'river pigs' among the Pyu people. The 19th century naturalist John Anderson described Irrawaddy dolphins in the Ayeyarwady River as morphologically distinct from *O. brevirostris* and classified them as a separate species, *Orcella* [sic.] *fluminalis* (Anderson, 1879; see Appendix 1.). Subsequent authors found no consistent differences between

Fig. 1. An Irrawaddy dolphin in the Ayeyarwady River, Myanmar.

marine and riverine populations (Thomas, 1892; Weber, 1923; Lloze, 1973; Pilleri & Gihr, 1974). With systematic examination of a larger sample of specimens, there may still prove to be subspecies or species level variation within the genus (Stacey & Leatherwood 1997; also see LeDuc et al., 1999; Beasley et al., 2002)

During surveys of the Ayeyarwady River between Yangon and Bhamo, Anderson (1879) observed Irrawaddy dolphins no farther downstream than Prome (about 360 km from the sea) during the low-water season and Yenanyoung (about 540 km from the sea) during the high-water season (Fig. 2). These surveys and reports forwarded to him by government officials about the distribution of cetaceans in Myanmar led Anderson (1879) to conclude that in the Ayeyarwady 'two species are met with, one a round-headed dolphin which is essentially fluviatile, and another with a longish snout which frequents the estuaries and is probably a *Steno*' (we suspect that the '*Steno*' is actually the Indo-Pacific humpback dolphin *Sousa chinensis*). Upstream, the local Shan people reported to Anderson (1879) that dolphins are never found 'beyond a point thirty miles above Bhamo, where the course of the river is interrupted by rocks, and which they style [call] *Labine*, or Dolphin Point.' Anderson also reported that the dolphins ascended larger tributaries, such as the Taping, Khyendwen [Chindwin] and Shuaylee [Shweli], when they are in flood.

During March and April 1996, Smith et al. (1997b) searched along 247.9 km of non-continuous trackline in the upper reaches of the Ayeyarwady between the Sagaing (Ava) Bridge and Ma U Village, concentrating search effort mostly in the approximately 27-km segment between Mandalay and Shin Hla. They observed three dolphin groups (estimated sizes of one, four and seven individuals) and recorded a sighting rate of 0.012 sightings/linear km. The same researchers returned in December 1999 and conducted a continuous survey divided into three components: (1) upstream from Mandalay to the Shweli confluence (205.6 km), (2) downstream from the Shweli confluence to Mandalay (192.6 km), and (3) downstream survey from Mandalay to Bagan (99.0 km). During the entire survey they made 11 sightings with a best estimate of 37 dolphins (mean group size = 3.5, SD = 2.0, range = 1-7). Four dolphin groups were observed while not actively searching (i.e. the boat was tied to the shore). Sighting rates were 0.024 sightings/km for five on-effort sightings (i.e., recorded while actively searching) made during the upstream survey from Mandalay to the Shweli confluence and 0.010 sightings/km for the two on-effort sightings made during the downstream survey of the same segment. The authors cautioned that these indices should be used only as rough indicators of relative density, due to the low number of sightings. On the basis of sightings made during the upstream survey, a minimum count of 16 individuals was made for the Mandalay to Shweli confluence segment.

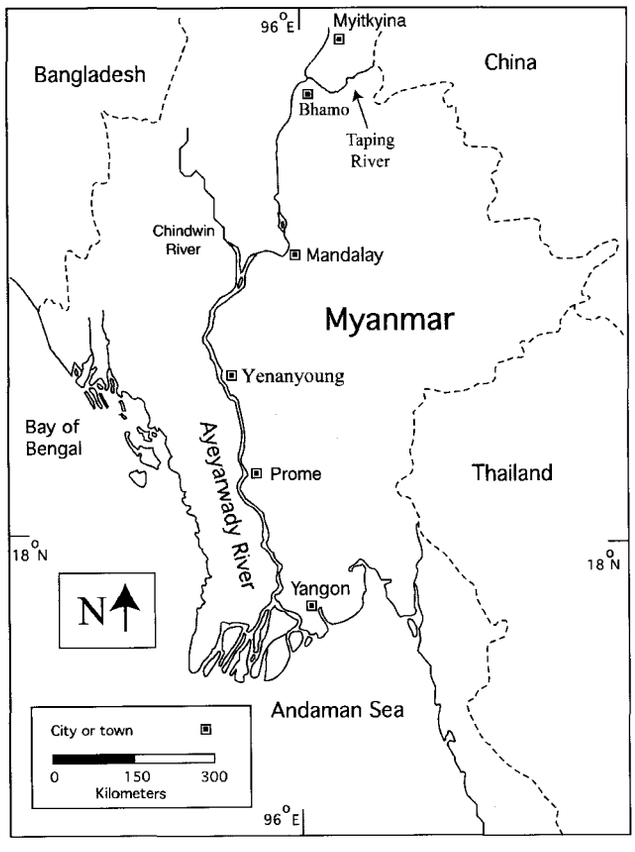

Fig. 2. Map of the Ayeyarwady (Irrawaddy) River, Myanmar.

STUDY AREA

The Ayeyarwady River is about 2,170 km long and has a total drainage of about 411,000 km^2. Its floodplains and forests form the cultural and economic heartland of Myanmar. The catchment above Sangaing (slightly downstream of Mandalay; Fig. 3) is 117,900 km^2 and supplies a mean annual discharge of 8,024 m^3/s (min. = 1,350 m^3/s and max. = 24,782 m^3/s; calculated from 1978-88 records in Vörösmarty et al., 1998). In the upper reaches, channel width ranges from 100-300 m. During the low water season (December through May), riverine morpholgy alternates between single- and multiple-channel reaches, the latter created by sand islands that emerge near the mouths of convergent tributaries, and above and below channel constrictions. Extensive floodplains border the waterways in many places.

The multiple channels of Bhamo, formed by the confluence of the Taping (Daying) River near the Chinese border, mark the limit to year-round navigation, while the river is navigable during the monsoon as far upstream as Myitkyina. Downstream of Bhamo and below Sinkan, the Ayeyarwady makes a sharp westward swing, cutting through a limestone defile (an abrupt constriction and deepening of a channel as it cuts through a mountain range) with lush bamboo forests. The river proceeds west and then south, generally in a single channel, with forested banks and occasional mid-channel islands, until a segment of multiple channels between the Shweli River confluence and Kyaukaing. Below Kyaukaing, the river runs due south, in a remarkably straight single channel, until the next limestone defile at Thabeikkyin. The defile ends at Kyaukmyaung where the river becomes braided until just above Migun.

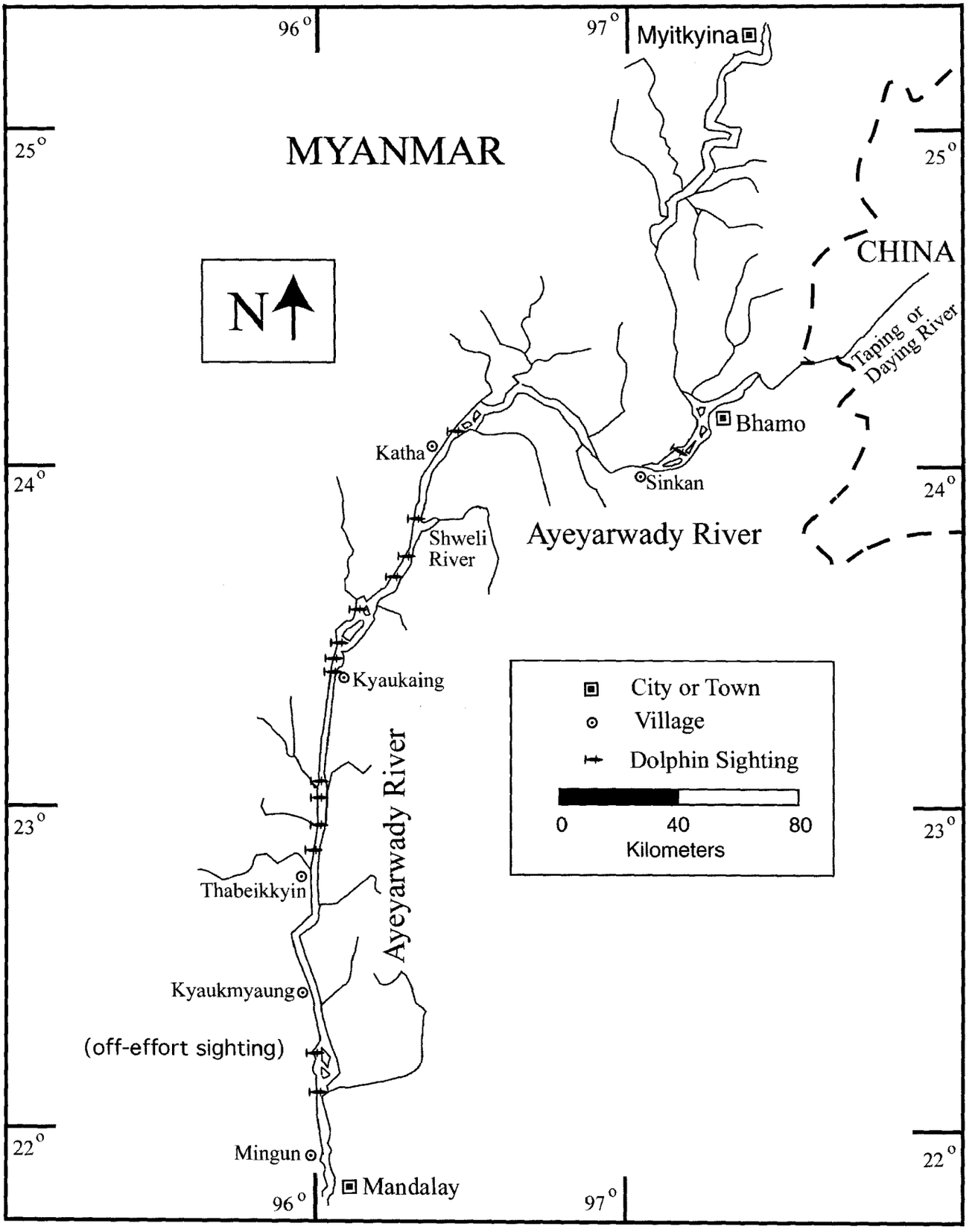

Fig. 3. Upper reaches of the Ayeyarwady (Irrawaddy) River above Mandalay, Myanmar, showing the locations of dolphin sightings.

METHODS

We conducted a continuous visual survey for dolphins in the Ayeyarwady River between Bhamo and Mandalay using a local motorised vessel from 30 January - 6 February 1998. The survey was part of a nature tourism program in which participants stood watches and recorded data on search effort and sightings. Prior to field activities, a short presentation was given to the survey team on data collection procedures and dolphin sighting cues (splashes, circling and diving birds, visible blow, and the sound of respirations). Observers were reminded of these frequently during watches and dolphin sightings. Observers were situated in port, starboard, center, and rear positions and rotated through the four positions in 30-minute shifts, followed by at least a two-hour break. One or both authors were always on watch as part of the observer rotation (which included a total of 10 persons) and present to record sighting data. Breaks were taken from survey effort for interviewing fishermen and visiting villages. Our course generally followed the thalweg (path connecting the deepest points in a series of cross-sections, often zigzagging from one side to the other) to avoid becoming grounded in shallow waters. Three observers searched forward of the bow (center person also served as the data recorder) and a single observer searched towards the rear, all by naked eye and with the aid of 7 X 35 binoculars. We recorded our position with a Global Positioning System (GPS) every 30 minutes, at course changes, and at the location of dolphin sightings. We also recorded information on sighting conditions (wind and presence or absence of fog or rain), environmental features (channel morphology and vegetation), and human activities (fishing, mining, agriculture, etc.) every time a new position was taken. We considered sighting conditions to be poor when wind, rain, and/or fog significantly affected our ability to see dolphins (e.g., frequent whitecaps or a compromised view to either bank). For all dolphin sightings, we made best, high, and low estimates of group size (based on a consensus of the observers on watch) and recorded information on habitat, behavior, and the presence of calves. One or both of the authors confirmed all sightings and data entries. Calves were identified according to their small size (about 1.0 meter; see Anderson, 1879; Marsh et al., 1989; Stacey & Leatherwood, 1997) and close proximity to an adult animal about twice their size.

RESULTS

We surveyed a total of 359.6 km during 27.6 hours of search effort (average speed = 13.0 km/h). Except for slightly more than one hour, all search effort was conducted during good sighting conditions. During the entire survey, while actively searching for dolphins we recorded 14 sightings of dolphin groups for a minimum total estimate of 59 (best), 70 (high), and 55 (low) dolphins, including 5-7 calves. The mean number of dolphins per group, based on best group size estimates, was 4.2 (SD = 3.8, Range = 1-15). The overall sighting rate was 0.16 dolphins/linear km.

Dolphin sightings were concentrated in deep pools or areas of slow or non-moving water created by the interaction of flow and geomorphological features. These included: 1) the slack water area upstream of the defile at Sinjan (one sighting of two dolphins); 2) the short braided section created by the tributary confluence and sharp meander above Katha (one sighting of 15 dolphins); 3) the braided section starting just above the Shweli River confluence until Kyaukaing (seven sightings for a total of 30 dolphins); 4) a small segment with at least four small tributary convergences and scattered mid-channel islands starting slightly more than half-way downstream of Kyaukaing to Thabeikkyin (four sightings for a total of six dolphins); and 5) a braided section downstream of the defile above Kyaukmyaung until Mingun (two sightings - one 'off effort' (while stopped and not actively searching for dolphins); these dolphins were not counted in the sighting rate or minimum abundance estimate because some may have been already counted – for a total of 12 dolphins).

Nylon gillnets were frequently observed drifting in the main channel and set in the deep pools where dolphins were often found. A fisherman in a small oar-powered boat was observed banging two iron bars together around his net. He told us that this was to prevent the dolphins from stealing fish from his net. We also observed large gold mining dredges operating from motorised vessels in the mid-channel slack waters above defiles at Sinkan and Thabeikyin. At Sinkan, there were six dredges, manned by about 60 workers, and we observed them using mercury in pans and sluices to amalgamate the gold.

DISCUSSION

Abundance and distribution. - The number of dolphins observed in the upper reaches of the Ayeyarwady River suggests that there are still a sufficient number of animals for early conservation efforts to be effective. We acknowledge that some dolphins were probably missed due to availability and perception biases (see Marsh & Sinclair, 1989; Smith & Reeves, 2000) but believe (on the basis of our field experience) that our minimum estimate of 59 dolphins is a fairly accurate reflection of the actual number of dolphins present in the river segment surveyed. The distance from our vessel to both banks was small enough so that surfacing dolphins could be easily detected. The dolphins appeared at the surface for sufficient time that they would be fairly difficult to miss and their respirations could be seen as diffuse blows when backlit. Sighting conditions were good during the vast majority of the time we conducted the survey. Un-surveyed channels appeared generally too shallow to support dolphins (we investigated several using small canoes), or their length and configuration were such that the great majority of wetted area could be searched as we surveyed down the main channel. We incorporated the use of a rear observer to reduce the possibility of missing animals that may have been submerged while they were within our field of view or inhabiting the downstream end of convergent channels. The probability of double counting groups, due to dolphin movements downstream of our vessel

when we were stopped, was presumably balanced by the probability that groups were missed altogether, due to upstream movements. Although we did not record information on dive times during this study, the mean group dive time reported in Stacey (1987) for Irrawaddy dolphins in the upper reaches of the Mekong River (115.3 sec. or 0.032 hrs; n = 277) multiplied by our average vessel speed (13.0 km/hr) crudely indicates that most dolphin groups would be expected to surface at a distance of less than 418 m from our vessel. Especially considering our use of a rear observer, we believe that this distance was well within our ability to detect dolphin surfacings. Channel meanders and islands did, however, obstruct our view of this distance in some places. Clearly better information on group dive times and sighting distances is needed to evaluate the problem of sighting biases and to develop a statistically tested correction factor for estimating absolute abundance, if found to be needed.

Similar to reports of habitat preferences for other river dolphin species in Asia (see Chen & Hua, 1989; Hua et al., 1989 for the Yangtze River dolphin or baiji *Lipotes vexillifer*; Kasuya & Haque, 1972; Smith, 1993; Smith et al., 1998 for the Ganges River dolphin or susu *Platanista gangetica gangetica*; and Pilleri & Zbinden, 1974; Bhatti & Pilleri, 1982 for the Indus River dolphin or bhulan *P. g. minor*), Irrawaddy dolphins in the Ayeyarwady were concentrated in areas of hydraulic refuge created by flow deflected by geomorphological features, including channel convergences, meanders, defiles, and mid-channel islands. These areas support greater biological productivity than adjacent flows and allow the dolphins to maintain their longitudinal position in the river with a minimum expenditure of energy (see Smith 1993)

Threats. - Nylon gillnets have replaced traditional fishing methods in many areas because these nets enable fishermen to catch more fish with less effort. Gillnets were generally set in or adjacent to the deep pools where dolphins were typically found. Although we have no firsthand information on fisheries bycatch in the Ayeyarwady, it is reasonable to assume that, where dolphins and gillnets are found in close proximity, some animals will invariably be killed (see Perrin et al., 1994). Irrawaddy dolphins have been recorded as accidentally killed in gillnets in the Mekong (Baird & Mounsouphom, 1997) and Mahakam rivers (Kreb, 2002), Songkhla (Beasley et al., 2002) and Chilka lakes (Dhandapani 1995), and Malampaya Sound (Dolar et al., 2002). Fishermen in the Ayeyarwady reported occasionally catching dolphins in gillnets and beach seines but said they always release them if found alive. The close relationship among certain throw-net fishermen and dolphins in a "cooperative fishery" and the favorable comments they shared with us about the animals lend credibility to these reports (see Smith et al., 1997b).

Mercury (Hg) is often unintentionally introduced into river systems when the element is used in pans and sluices for gravity concentration of gold amalgam. Benthic bacteria process Hg into highly toxic methylmercury (CH_3Hg+). The bacteria is then directly consumed by organisms and the CH_3Hg+ bioaccumulates up trophic communities, or the contaminant is released and often absorbed by phytoplankton to be reintroduced back into the food chain by aquatic herbivores (Krabbenhoft & Rickert, 1996; Wiener & Krabbenhoft, 1999). Whatever pathway it may take, methylmercury reaches its greatest concentration in the top carnivores (humans and dolphins). The deaths of several hundred people and permanent neurological damage to thousands more from ingesting fish contaminated with mercury in Minamata Bay, Japan during the 1950's (Kurland *et al.*, 1960) should give ample reason for concern about introducing the metal into any aquatic environment. Stranded bottlenose dolphins *Tursiops truncatus* in the Atlantic Ocean were found to have liver abnormalities associated with elevated mercury levels (Rawson et al., 1993). The potential for mercury to have toxic effects on Irrawaddy dolphins may be especially high, due to their affinity for areas of reduced flow where entrained metals probably settle in higher concentrations than elsewhere in the river channel.

Conservation. - Implementing conservation measures for cetaceans is a formidable challenge in any river. The lack of well-developed agencies for addressing riverine issues in Myanmar makes the situation particularly difficult. The favorable disposition of local people towards the dolphins gives us a measure of hope for their persistence.

To conserve dolphins in the Ayeyarwady we recommend that:

1. Dolphin/throw-net fishing reserves be established in river segments where dolphins are frequently found (see above). The idea behind the reserves would be to encourage traditional fishing practices, while prohibiting gillnetting, gold mining, and excessive motorised boat traffic. The success of the proposed sanctuaries will depend greatly upon the involvement of local communities. Ideally, the size and configuration of the reserves would be based on the complete range of dolphin movements. However, we have little knowledge about this aspect of dolphin behavior and implementing effective protection for the animals in a reserve of such size may not be feasible. The establishment of one or more reserves should be viewed as an initial step to be followed by monitoring of the efficacy of protective measures and possible redesign or expansion as more information becomes known.
2. A comprehensive population and habitat assessment for Irrawaddy dolphins be conducted of the entire the Ayeyarwady River. A rigorous evaluation of sighting biases and the development of a statistically tested correction factor should be included as integral components of abundance estimates. Special emphasis should be made on identifying 'hotspots' of dolphin occurrence and determining if there is indeed a range hiatus in the lower reaches. The assessment will require the training and involvement of local scientists.
3. A public awareness program be initiated to promote the cultural and economic value of Irrawaddy dolphins as a living resource. Popular media such as posters, comic

books, and videos should be produced in Burmese and used to spread information in local villages. The program should be interactive and respectful of local values and traditions. The already positive attitude of fishing communities to the dolphins should be used to advance their conservation.

4. The use of mercury in gold mining operations be prohibited or strictly controlled. Educational material on how to safely handle mercury and eliminate or reduce its toxic effects should be made available and promoted among mining companies and workers. Simple and inexpensive retorts (vessel used to separate metal from ore by distillation or sublimation) that recover more than 95% of Hg emissions should be fabricated and their use encouraged (see Meech et al., 1995). A program should be initiated to systematically monitor mercury concentrations in fish and tissue samples from dolphins, if carcasses become available from accidental deaths.
5. Research be conducted on genetic variation among putative marine and freshwater populations of Irrawaddy dolphins (see Smith & Jefferson, 2002). If animals in the Ayeyarwady are indeed demographically isolated from congeners inhabiting nearby marine waters, this would lend an even greater urgency to the need for timely conservation action.

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Appendix 1.

Anderson (1879) cited the following characteristics as distinguishing *O. fluminalis* from *O. brevirostris*: (1) body - head (more pointed), dorsal fin (smaller, lower, and more falcate), coloration (streaky), pectoral fin (shorter and broader); (2) skull - occipital (more flattened and directed downwards and backwards); supra-occipital and interparietal region (more depressed), maxillaries (shorter, broader, and flatter distal edge), premaxillaries (no contraction opposite the pre-orbital notch), intermaxillary space (wider), and nasals (located more anterior and lower), palatines (larger with middle margins first directed backwards and inwards, and then markedly outwards and backwards), supra-orbital plate of the maxillary (more concave), periotic (external half of its interior border is prolonged backwards and outwards toward the mastoid process and anterior and internal to the border is pyramidal verses rounded), and tympanic (larger, slightly more pointed and the posterior inferior border is more rounded); and (3) post-cranial skeleton – atlas (articulating facets are more widely divergent and almost oval verses more narrower below than above), all vertebrae (lesser height and breath of neural arch, greater breadth of spinal processes, greater anterior-posterior extent of laminae), sternum (narrower, dilated where the first sternal rib is attached, and the presence of a deep notch separating the anterior wings), scapula (greater overall length and expansion and more oval surface of the articulating surface for the humerus). While Anderson's observations were exhaustive, many of the features he described are variable among individuals and his comparisons were limited to two adult males (body lengths 2.2 m and 2.3 m long, respectively) from the Ayeyarwady and two females, one immature and one pregnant (1.8 m and 2.1 m long, respectively), presumably from the Bay of Bengal. We list Anderson's observations above in the hope that they will encourage other researchers to examine the same (or similar features) among a larger sample of adult specimens from a variety of regions.