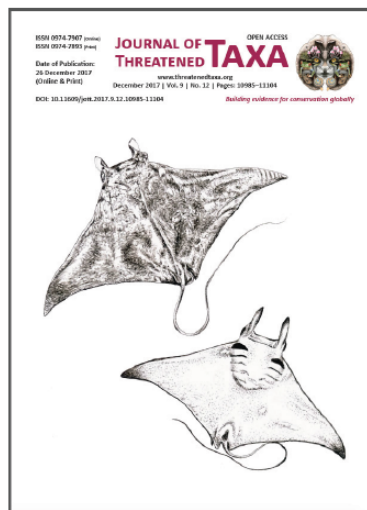


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AN INTERVIEW-BASED SURVEY TO DETERMINE THE CONSERVATION STATUS OF SOFTSHELL TURTLES (REPTILIA: TRIONYCHIDAE) IN THE IRRAWADDY DOLPHIN PROTECTED AREA, MYANMAR

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Abstract: We conducted an interview-based survey to investigate the conservation status of large (adult carapace length >400mm) Softshell Turtles (*Amyda ornata*, *Chitra vandijki*, and *Nilssonia formosa*) in the Irrawaddy Dolphin Protected Area (IDPA) of Myanmar during November 2015. Our objectives were to: (1) determine which species of Softshell Turtles occur in IDPA, (2) assess threats to these populations, (3) evaluate the protected area as a release site for captive-bred Softshell Turtles, and (4) make conservation recommendations. To this end, we interviewed 180 people (mostly males) in 30 villages and verified the occurrence of all three species of Softshell Turtles in IDPA. Softshell Turtle populations appear to have undergone precipitous declines during the last 10–15 years largely driven by commercial demand from the illegal trans-boundary wildlife trade with China. Turtle hunting is no longer considered economically worthwhile, but Softshell Turtles continue to be taken as fisheries by-catch. We recommend that existing regulations designed to protect dolphins be enforced, and most importantly electro-fishing be eliminated from IDPA. We also urge authorities to revisit earlier proposals to reduce or eliminate the use of monofilament gill netting in IDPA. Implementation of a community-based fisheries plan to address these issues is warranted. In lieu of effective action, Softshell Turtle populations in IDPA face almost certain extirpation in the near future. IDPA is currently considered unsuitable as a release site for captive-bred Softshell Turtles.

Keywords: *Amyda ornata*, Ayeyarwady River, *Chitra vandijki*, electro-fishing, fisheries by-catch, *Nilssonia formosa*, *Orcaella brevirostris*, turtle conservation, wildlife trade.

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For Author Details and Author Contribution see end of this article.

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INTRODUCTION

National parks, wildlife sanctuaries, and other protected areas often figure prominently in successful species conservation strategies (Stohlgren et al. 1994; Bruner et al. 2001; Castellano et al. 2003). Protected areas can safeguard habitats for the long-term maintenance of biodiversity while at the same time serve as baselines against which biological and ecosystem change can be measured (Stohlgren et al. 1994). In order to realize these objectives, protected area managers require species inventories, accurate assessments of conservation status, and an understanding of existing and potential anthropogenic threats (Tuberville et al. 2005). Such information is essential for effectively targeting conservation efforts, formulating management policies, prioritizing research, and designing appropriate monitoring protocols, especially where cryptic, rare, and threatened species are concerned (Stohlgren et al. 1994; Tuberville et al. 2005). Unfortunately, such information is lacking for most protected areas in Myanmar owing to a lack of financial and technical resources available to resource managers (Rao et al. 2002).

Three species of large (adult carapace length [CL] > 400 mm) Softshell Turtles (Trionychidae) occur in the rivers of Myanmar. These include the Asian Giant Softshell Turtle *Amyda ornata* [Gray, 1861] (previously *A. cartilaginea*—see Fritz et al. 2014; Auliya et al. 2016; TTWG 2017), Burmese Peacock Softshell Turtle *Nilssonia formosa* Gray, 1872, and Burmese Narrow-headed Softshell Turtle *Chitra vandijki* McCord & Pritchard, 2003 (Image 1), the latter two of which are endemic to Myanmar (Ernst & Barbour 1989; Platt et al. 2014, but see Liebing et al. 2012 for *N. formosa*). *Amyda ornata* (as *A. cartilaginea*; see TTWG 2017) and *N. formosa* are ranked by the IUCN as Vulnerable and Endangered, respectively (IUCN 2017), while *C. vandijki* has been recommended for listing as Critically Endangered (TTWG 2014).

The current conservation status of large Softshell Turtles within Myanmar is especially precarious (Platt et al. 2000, 2014). Populations are threatened by chronic subsistence harvesting, and commercial over-exploitation to supply burgeoning wildlife markets in southern China (Platt et al. 2000, 2004; Kuchling et al. 2004) where Softshell Turtles are in particularly high demand (Lau & Shi 2000; Moll & Moll 2004; Auliya et al. 2016). Other threats to Softshell Turtle populations include illegal electro-fishing, riverine gold-mining, destruction of sandbank nesting habitat by seasonal agriculturists, and hydropower developments that alter



Image 1. Three large (adult carapace length > 400 mm) Softshell Turtles occurring in the Ayeyarwady River of Myanmar: *Amyda ornata* (A), *Chitra vandijki* (B), and *Nilssonia formosa* (C). The latter two species are endemic to Myanmar.

natural hydrological regimes (Dudgeon 2000; Kuchling et al. 2004, 2006; Platt et al. 2005, 2014). As a result of these pressures, Softshell Turtle populations have precipitously declined throughout much of Myanmar (Platt et al. 2000, 2005; Kuchling et al. 2004, 2006). Unfortunately, the larger rivers of Myanmar that potentially harbor globally significant populations of Softshell Turtles are grossly under-represented in the national protected area network (Kuchling et al. 2006;

Beffasti & Galanti 2011).

As one of the few protected riverine corridors in tropical Asia (Smith & Mya Than Thun 2007), the Irrawaddy Dolphin Protected Area (IDPA) has the potential to play a key role in the conservation of large Softshell Turtles in Myanmar. Virtually, however, nothing is known concerning the conservation status of Softshell Turtles in IDPA. Indeed, it is unclear which species (if any) occur within the protected area, and if these turtles are threatened by over-exploitation, egg harvesting, or destruction of critical nesting habitat. To address these questions, we conducted an interview-based survey of IDPA with the following objectives: (1) determine which species of large Softshell Turtles occur within the protected area, (2) assess anthropogenic threats to these populations, (3) evaluate the protected area as a potential release site for captive-bred and head-started Softshell Turtles, and (4) develop conservation recommendations for Softshell Turtles in the protected area.

STUDY AREA

The IDPA encompasses a segment of the Ayeyarwady River in central Myanmar upstream from Mandalay (Smith & Mya Than Thun 2007). The Ayeyarwady (formerly “Irrawaddy”) River originates in the mountains of northern Myanmar and flows southwards over 2,000km before emptying into the Andaman Sea (Cresswell & Huxley 1965). Mean annual flow (136,245m³/sec) is lowest during January and February (24,993m³/sec) and increases when water levels rise sharply in April and May in response to snow melt in the upper catchment, and again in June at the onset of the monsoon (June to August). Maximum flow (351,129m³/sec) occurs in August and is unequaled by any similar-sized river in a monsoonal climate (Cresswell & Huxley 1965; Scott 1989).

In 2005, a 74km stretch of the Ayeyarwady River from Mingun Pagoda in the south to Yay Daw Pagoda at Kyauk Myaung in the north (Image 2), was designated as the IDPA by the Myanmar Department of Fisheries (Fisheries Notification Act 11/205) to safeguard a population of the Critically Endangered Irrawaddy Dolphin (*Orcaella brevirostris* [Owen in Gray, 1866]; hereafter “dolphin”) (Smith & Mya Than Thun 2007). Specifically, Fisheries Notification Act 11/205 designated the boundaries of the sanctuary, prohibits the killing of Irrawaddy Dolphins, bans any trade in dolphin parts, requires fishermen to immediately release any dolphins accidentally captured

in fishing gear, and deems illegal the deployment of any gill net that obstructs the waterway, gill nets >91.4m long or spaced <183.9 m apart (Smith & Mya Than Thun 2007). Follow-on legislation completely banned the use of electricity for taking fish anywhere in Myanmar. The Myanmar Department of Fisheries is charged with enforcing fishing regulations and protecting dolphins within the IDPA.

The Ayeyarwady River within the IDPA is characterized by wide meanders, braided channels, extensive and dynamic sandbars, and numerous islands, some of which support significant areas of wet grasslands. The floodplain is largely devoted to agriculture with numerous small communities along the river where farming and fishing are the primary livelihoods. An all-weather road network links these communities with the larger population centers of Mandalay, Shwebo, and Mogok. Large-scale gold dredging was formerly commonplace in the area now designated as the IDPA, but prohibited by the Government of Myanmar in 2005 owing to health concerns arising from mercury contamination and accumulation in aquatic biota (Smith & Mya Than Thun 2007).

METHODS

We conducted fieldwork in IDPA from 1 through 15 November 2015. During this period we traveled along the Ayeyarwady River by boat, stopping at villages and fishing encampments where we conducted semi-structured interviews (Martin 1995; Gilchrist et al. 2005) of fishermen and other knowledgeable individuals. In accordance with the format of a semi-structured interview, we asked participants a series of closed- and open-ended questions that included standard questions prepared in advance and others that arose during the course of the interview. We guided the discussion, but the direction and scope of each interview was allowed to follow the participants’ train of thought (Huntington 1998). In practice, semi-directed interviews are more of an informal conversation than a typical question and answer session, and rather than rigidly adhering to a set of prepared questions, the interview provides an opportunity for collecting and discussing unsolicited and often unanticipated information (Huntington 2000; Gilchrist et al. 2005; Nguyen et al. 2013).

We conducted interviews of groups ranging in size from 2–15 people and began each interview session by explaining the objectives of the survey and the role of the participants in our research. We then queried

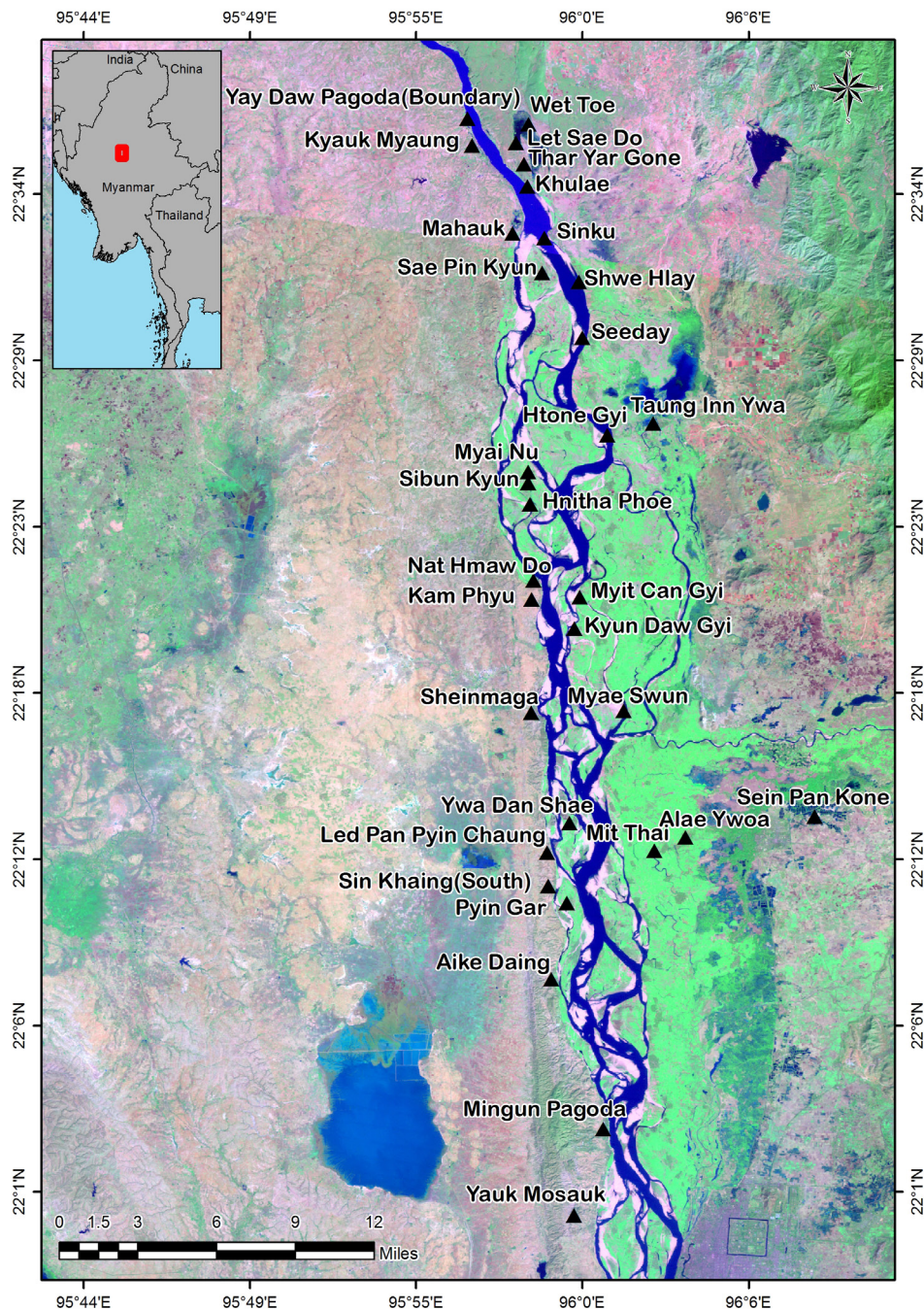


Image 2. Map of the Irrawaddy Dolphin Protected Area (IDPA) showing towns, villages, and fishing encampments where interviews were conducted during the survey. The IDPA includes a 74km stretch of the Ayeyarwady River extending from Mingun Pagoda in the south, upstream to Yay Daw Pagoda near Kyauk Myaung. Inset shows location of IDPA within Myanmar.

interview groups on the past and present occurrence of turtles in the Ayeyarwady River, folk taxonomy (Berlin 1966), traditional ecological knowledge (Berkes et al. 2000) about these species, harvest practices, levels of exploitation and perceived abundance, and potential threats. We used a photographic guide to Myanmar turtles (Platt et al. 2012a) to facilitate species identification and match vernacular names (i.e., folk taxa) to scientifically recognized taxa. Interviews were conducted by a single native-Burmese speaker also

fluent in English, and later translated into English and transcribed. Interview transcripts are contained in field notes archived in the Campbell Museum, Clemson University, Clemson, South Carolina, USA.

During interviews we also asked to examine any turtle shells that might be available in villages. Turtle shells are often kept for hunting trophies, medicinal purposes, food containers for domestic animals, rice scoops, or future sale to visiting traders (Stuart & Platt 2004). Unlike trade specimens for which the provenance can be difficult

or impossible to reliably determine, shells obtained in villages are generally from turtles collected nearby (Stuart & Platt 2004). We identified the dried shells of Softshell Turtles on the basis of carapace characteristics; the presence of tubercles on the anterior carapacial margin was used to distinguish *Amyda ornata* from others, and prominent (although sometimes faded) carapacial ocelli to identify *Nilssonina formosa*. Plastrons without an accompanying carapace could not be reliably identified. We then measured straight-line CL with tree calipers (± 1 mm) and photographed each specimen. Body mass was generally given by participants in 'Viss', a measure of weight unique to Myanmar. We converted Viss to Kg as 1.0 Viss = 1.6 Kg. We determined geographic coordinates (India-Bangladesh Datum) and elevation with a Garmin GPS Map 76. Place names are in accordance with a countrywide gazetteer currently being compiled by the Myanmar Forest Department, although local names are used for seasonal fishing encampments and agricultural settlements along the river.

RESULTS

We interviewed 180 people in 30 towns, villages, and fishing encampments in IDPA during our survey (Image 2). The information provided by three illegal fishers at Sibun Kyun Camp, however, was considered unreliable and excluded from our subsequent analysis. Thus our results are based on information provided by 177 people from 29 villages and encampments in IDPA (i.e., 29 interview groups). Because fishing is traditionally a male-dominated occupation, with the exception of 15 female fishmongers in Sheinmaga, the participants in our survey were overwhelmingly male ($n = 162$).

Softshell Turtles in the IDPA are known by a confusing and often over-lapping array of vernacular names (Table 1), which frequently made it difficult to determine what species was being referenced during an interview. An illustrated photographic guide to the turtles of Myanmar (Platt et al. 2014) proved invaluable in reliably assigning vernacular descriptions to scientifically recognized taxa. Based on the information provided by survey participants, three species of large Softshell Turtles (*Amyda ornata*, *Nilssonina formosa*, and *Chitra vandijki*) occur within IDPA (Table 2). *Amyda ornata* and *N. formosa* were reported during interviews at 19 (65.5%) and 27 (93.1%) villages, respectively, located throughout the protected area. In contrast, *C. vandijki* was only reported by interview groups in 11 (37.9%) villages, all located downstream from Nat Hmaw Do. According to

Table 1. Vernacular names of large Softshell Turtles (*Amyda ornata*, *Chitra vandijki*, and *Nilssonina formosa*) occurring in the Irrawaddy Dolphin Protected Area of the Ayeyarwady River, Myanmar.

Species	Vernacular name and comments
<i>Amyda ornata</i>	Anar Pyaw Leik (= "Soft-margin Turtle", an obvious reference to cartilaginous shell)
	Khaba Leik (= "World Turtle", an oblique reference to large body size, i.e., "as big as the world"; see also Platt et al. 2004)
	Ohn Thi San Leik (= "Coconut Pulp Turtle" because the meat is similar in taste to coconut)
	Paung Taung Leik (non-descriptive name of uncertain meaning)
	Si Cho Leik (= "Oil Cup Turtle" because dried carapace can be used to measure and dispense cooking oil)
<i>Chitra vandijki</i>	Anar Pyaw Leik (see <i>A. ornata</i>)
	Khaba Leik (see <i>A. ornata</i>)
	Ohn Thi San Leik (see <i>A. ornata</i>)
	Pyaw Can Thi (= "Small-headed Turtle")
	Pyay Ganga Kyar (= "Watermelon-headed Turtle", because the head stripes resemble coloration of a watermelon).
<i>Nilssonina formosa</i>	Ye Gaung Kyar Leik (non-descriptive name of uncertain meaning)
	Can Gyi Leik (= "Big-headed Turtle")
	Kyi Leik (= "Star Turtle", probably a reference to carapacial ocelli)
	Si Cho Leik (see <i>A. ornata</i>)

survey participants, *A. ornata* and *N. formosa* occur both in the main river channel and seasonal wetlands in the adjacent floodplain, while *C. vandijki* is restricted to the main river channel. Carapaces from four turtles were provided by survey participants in Myae Swun and Thar Yar Gone (Table 3). Survey participants stated these turtles were captured for domestic consumption near the respective villages.

Survey participants were in unanimous agreement that Softshell Turtle populations have dramatically declined over the previous 10 years (since ca. 2005). This conclusion was based on two lines of evidence. First, Softshell Turtles are much more difficult to capture now than in past years (declining catch-per-unit-effort) and second, basking Softshell Turtles, once a common sight along the river, are now rarely observed (declining encounter rate). According to the interview groups, captures of 2–10 Softshell Turtles/fisherman/day were commonplace 10–15 years ago, but today capture rates of 1–2 turtles/fisherman/year are considered typical. Capture rates are now so low that turtle hunting is no longer deemed an economically viable endeavor. In the past, buyers made regular visits to riverside villages to purchase captured turtles, which fishermen kept alive until a trader arrived. Because so few turtles are now

Table 2. Softshell Turtles reported during interviews conducted at 30 towns, villages, and fishing encampments in the Irrawaddy Dolphin Protected Area of the Ayeyarwady River, Myanmar. Locations presented in the order visited during the survey and generally follow a south → north axis.

Location	<i>Amyda ornata</i>	<i>Chitra vandijki</i>	<i>Nilssonia formosa</i>
Yauk Mosauk	X	X	X
Aike Daing		X	
Viper Island Camp	X		X
Pyin Gar	X	X	X
Sin Khaing	X	X	X
Sein Pan Kone	X	X	X
Ywa Dan Shae	X	X	X
Led Pan Pyin	X	X	X
Myae Swun	X		X
Sheinmaga		X	X
Kam Phyu		X	X
Nat Hmaw Do		X	X
Myit Can Gyi		X	X
Kyun Daw Gyi		X	X
Seeday	X		X
Kyauk Myaung	X	X	X
Khulae	X		X
Wet Toe	X		X
Thar Yar Gone			X
Let Sae Oo	X		X
Mahauk			X
Sae Pin Kyun	X		X
Shwe Hlay	X		X
Khulae Camp			X
Taung Inn Ywa	X		X
Sibun Kyun Camp			X
Sibun Kyun	X		X
Myai Nu	X		X
Hnitha Phoe	X		X

available for sale, regular visits are no longer worthwhile for traders, and fishermen must instead transport turtles to local markets or wildlife traffickers in one of the nearby larger towns.

Interview groups in 24 villages (82.7%) attributed declines in Softshell Turtle populations to over-harvesting for commercial markets, while widespread electro-fishing (not specifically targeting turtles) was held responsible in one village (3.4%), and participants in another village (3.4%) stated that local scarcity was simply the result of turtles having migrated elsewhere. Interview groups in three villages (10.3%) were unsure

Table 3. Recent (2011–15) captures of Softshell Turtles (*Amyda ornata*, *Chitra vandijki*, and *Nilssonia formosa*) reported during interviews at villages in the Irrawaddy Dolphin Protected Area, Myanmar. Also included are four specimens that we examined in Myae Swun and Thar Yar Gone. Body weight reported as *Viss* during interviews and converted to kg (1 *viss* = 1.6 kg) in this table.

Species	Year	Location	Notes/comments
<i>Amyda ornata</i>	2015	Seeday	Two turtles each with CL ca. 300mm
	2015	Kyauk Myaung	One turtle weighing 3.2kg
	2015	Myae Swun	Three turtles (CL = 310, 310, and 360 mm).
	2011	Taung In Ywa	One turtle weighing about 15kg
<i>Chitra vandijki</i>	2014	Myit Can Gyi	Two turtles captured with combined weight of 6.4kg
	2012	Nat Hmaw Do	One turtle weighing ca. 14.4kg
<i>Nilssonia formosa</i>	2015	Seeday	One turtle, CL ca. 300mm
	2015	Kyauk Maung	One turtle weighing about 8kg
	2015	Shwe Hlay	One turtle, CL ca. 250mm
	2015	Thar Yar Gone	One turtle (partial carapace examined; estimated CL ca. 100mm)
	2014	Khulae	Four turtles, each weighing ca. 0.64kg
	2014	Nat Hmaw Do	One turtle weighing about 2.4kg
	2013	Myit Can Gyi	One turtle weighing about 2kg
	2012	Thar Yar Gone	Small turtle, but not weighed

why populations had declined. Rarity notwithstanding, Softshell Turtles continue to be harvested by fishermen and recent (since 2010) captures were reported by 8 of 29 (27.5%) interview groups, indicating that at least residual populations survive in the protected area. Tellingly, most recently captured Softshell Turtles are relatively small individuals (Table 2).

According to interview groups, turtle hunting was formerly a seasonal activity conducted from December through April, a period coinciding with minimal river levels during the annual dry season. Fishermen employed several stratagems to harvest Softshell Turtles, the most common being baited hooks. One interview group stated that fishermen would search sandbanks for tracks of Softshell Turtles (possibly females emerging from the river to deposit eggs) and saturate these areas with numerous baited hooks. Baited hooks were deployed singly or in an array attached to a long line; the latter were often stretched across river channels and weighted to insure baits were lying on the river bottom. Baits used to capture Softshell Turtles included eels and small fish, whole roasted rats, and pieces of roasted domestic cats;



Image 3. Fish traps continue to pose a threat to Softshell Turtles in the Irrawaddy Dolphin Protected Area. Extensive bamboo fences occlude river channels and funnel fish and turtles into a smaller enclosure where the catch is sorted (left). Softshell Turtles are frequently captured in drop-door bamboo fish traps used to harvest catfish (right). The use of these traps is currently permitted in the protected area.



Image 4. An Irrawaddy Dolphin found dead in the protected area on 13 November 2015. A subsequent necropsy and reports from villagers indicated the dolphin succumbed to the effects of electrical shock as a result of illegal electro-fishing activity.

roasting meat is reputed to enhance odors and make the bait more attractive to turtles. Softshell Turtles were also captured in bamboo cage traps, often in association with lengthy drift fences that funneled turtles into the trap. Harpoons and spears were used to harvest turtles in shallow water when turbidity was low. In the past, the nests of Softshell Turtles were occasionally found on sandbanks during the dry season, excavated, and the eggs harvested for household consumption or sold in local markets.

Although no longer deliberately targeted by fishermen, Softshell Turtles continue to be taken as by-catch incidental to other river fisheries. Our interview groups identified four fishing practices that pose a continued threat to Softshell Turtles. Of particular hazard are extensive bamboo fences that occlude river channels and tributary streams, and direct fish (and turtles) through one-way funnels and into smaller

enclosures where the catch is extracted (Image 3). Drop-door fish traps set in conjunction with bamboo fences also reportedly take Softshell Turtles; these traps are deployed primarily during high water periods (June through September) to capture catfish (Image 3). Softshell Turtles become entangled in monofilament fishing nets and others are taken on baited hooks set for fish and by electro-fishing. Of the four Softshell Turtle specimens we examined during the survey (Table 2), three were taken in bamboo fish traps and one by electro-fishing. Some turtles taken as fisheries by-catch are kept for domestic consumption (usually smaller turtles), but most are sold to fish buyers in riverside towns or wildlife traffickers in Mandalay.

Although we did not directly query survey groups regarding illegal activities in the protected area, voluntary mention was made by 14 (48.2%) interview groups of electro-fishing activity. Based on the information provided, electro-fishing appears widespread in IDPA and under the control of well-organized gangs that openly intimidate fisheries officers on the river. On 13 November 2015 we found a fresh dolphin carcass (Image 4) which an autopsy suggested had succumbed to electrical shock (Platt & Lwin 2015). In addition to electro-fishing, our cursory inspection of several large monofilament net arrays suggests regulations concerning net placement in the protected area are being ignored by fishermen. Overall, our impression was that enforcement of fisheries regulations was weak to non-existent in the sanctuary. Planned efforts by the Department of Fisheries to reduce or eliminate the use of gillnets in the protected area (Smith & Mya Than Thun 2007) have apparently been abandoned.

DISCUSSION

Our findings in IDPA are significant for the conservation of large Softshell Turtles in Myanmar. Indawgyi Lake Wildlife Sanctuary (ILWS) is the only other protected area in the country known to harbor all three species of large Softshell Turtles native to Myanmar (Kuchling et al. 2006). Unfortunately, as in IDPA, large Softshell Turtles in ILWS remain subject to illegal harvesting and mortality associated with fisheries by-catch is common (Kuchling et al. 2006). Other protected areas in Myanmar known to harbor up to two species of large Softshell Turtles include Inle Lake and Htamanthi wildlife sanctuaries and Natma Taung National Park (Platt et al. 2004; Kuchling et al. 2006; Platt et al. 2012b). In sum, populations of large Softshell Turtles in Myanmar exist largely outside of the national protected area network where implementing effective protection will prove challenging given the paucity of resources available to conservation authorities.

The ecological relationships underpinning the sympatric occurrence of the three large Softshell Turtles in Myanmar remain largely unknown. Pritchard (2001) classified Softshell Turtles according to body size (small, medium, large, and giant), and hypothesized that gross sympatry among trionychids almost always involves species of different size categories. Thus, the two large species (*A. ornata* and *N. formosa*) in Myanmar would be expected to occur with the giant species (*C. vandijki*) but not with each other, a prediction inconsistent with the results of our survey. Similarly, Platt et al. (2005) found no evidence of microhabitat partitioning between *A. ornata* and *N. formosa* in the upper Ayeyarwady River, with fishermen reporting the capture of both species from the main river channel. In contrast, Kuchling et al. (2004) concluded from interviews of fishermen along the Chindwin River (a major tributary of the Ayeyarwady) that *A. ornata* was most abundant in tributary streams, whereas *N. formosa* and *C. vandijki* were more likely to be captured in the main river channel. Reports by survey participants suggesting that *C. vandijki* is restricted to the lower (downstream) reaches of IDPA are somewhat puzzling as this species is known to occur much farther upstream in the Ayeyarwady River (Platt et al. 2005).

Our survey strongly suggests that populations of all three species of large Softshell Turtles occurring within IDPA are now severely reduced. Although the lack of quantitative baseline data make statements regarding long-term population trends somewhat speculative, our conclusion is strongly supported by: (1) dramatic declines in catch-per-unit-effort (perhaps an order of

magnitude), (2) the small body size of turtles captured in recent years, and (3) the paucity of basking turtles now apparent along the river. Over-exploited populations of chelonians typically yield fewer turtles per unit of capture effort (Klemens & Moll 1995; Eisenberg et al. 2011) and become dominated by small to medium-sized individuals because few turtles survive to attain maturity (Close & Seigel 1997; Stiner et al. 2000; Aponte et al. 2003). Indeed, a reduction in CL over time in archaeological profiles is considered indicative of over-exploitation by foraging humans (Klein 1999; Stiner et al. 2000). Moreover, the number of basking turtles observed along a river is considered a powerful index of relative abundance (Hartson et al. 2014; Ilgen et al. 2014), and as such, the declines reported by fishermen over time strongly suggest a precipitous decrease has occurred in Softshell Turtle populations.

These results are unsurprising given the past harvest levels and continuing loss of turtles taken as by-catch in fishing gear as reported by survey participants. Owing to a unique suite of life history traits (long life span, delayed sexual maturity, high rates of nest loss, high adult survival, and low juvenile survival), chelonian populations are especially vulnerable to over-harvesting and can rapidly collapse in the face of sustained harvest pressure (Congdon et al. 1993; Sung et al. 2013; Zimmer-Shaffer et al. 2014). Even the annual removal of small numbers of adult turtles from a population can result in long-term decline and eventual extinction (Congdon et al. 1993; Zimmer-Shaffer et al. 2014; Colteaux & Johnson 2017). Similar to our survey, Kuchling et al. (2006) reported declines of a comparable magnitude among Softshell Turtles on the Ayeyarwady River, upstream from Bhamo based on interviews of local inhabitants.

Commercial demand from wildlife markets in southern China appears to be the primary driver of the over-exploitation of Softshell Turtles in IDPA. This situation is not unique to IDPA as population declines of Softshell Turtles in many areas of Myanmar have been linked to commercially driven over-harvesting (Kuchling et al. 2004, 2006; Platt et al. 2004, 2012b). The trans-border wildlife trade with southern China, albeit illegal under Myanmar law, began in the mid-1990s (Behler 1997; Altherr & Freyer 2000; Platt et al. 2000; Kuchling et al. 2006) and continues to the present. Mandalay is the hub of this illegal trade, with the Mandalay-Lashio Highway serving as a major conduit for smuggling wildlife, including turtles, into China (Platt et al. 2000; Kuchling et al. 2004). The close proximity of IDPA to Mandalay coupled with the well-developed road network linking riverside villages to the city means that

Softshell Turtles in the sanctuary remain vulnerable to illegal harvest. Even though turtle hunting is no longer an economically viable activity in itself, ready access to clandestine wildlife markets in Mandalay allows fishermen to profitably dispose of turtles taken as fisheries by-catch in IDPA.

The methods used by fishermen to harvest Softshell Turtles in IDPA are similar to those reported elsewhere in Myanmar (Platt et al. 2004; Kuchling et al. 2004; Platt et al. 2005; Kuchling et al. 2006). According to Kuchling et al. (2004), a minority of fishermen along the Chindwin River employed fish poisons and dynamite to harvest Softshell Turtles. These practices were not mentioned by our interview groups, although participants might have been hesitant to volunteer knowledge of these illegal activities, especially since the unauthorized possession of explosives is considered a serious crime under Myanmar law. Electro-fishing, despite being strictly prohibited, is also widely used to harvest fish and Softshell Turtles on the upper Ayeyarwady River (Kuchling et al. 2006). The incidental take of Softshell Turtles as fisheries by-catch appears ubiquitous throughout Myanmar and constitutes a serious threat to the continued survival of remaining populations (Platt et al. 2004; Kuchling et al. 2004; Platt et al. 2005; Kuchling et al. 2006).

Unless IDPA is to remain a protected area in name only (i.e., “paper park”), it is imperative that at minimum, management authorities move to effectively implement existing fisheries regulations designed to safeguard dolphins. In particular, regulations governing the spacing and placement of monofilament nets must be strictly enforced. Most importantly, a sustained effort—in conjunction with local police if necessary—must be made to eliminate electro-fishing from IDPA. Smith & Mya Than Thun (2007) regarded electro-fishing as the single greatest threat to the continued survival of dolphins in IDPA and considered the loss of >1 dolphin/1–2 years to be unsustainable, a rate that is probably now being exceeded.

Given their cultural and economic significance to local fishers, and obvious ecotourism value (Smith & Mya Than Thun 2007), using dolphins as an “umbrella species” (organisms with large area requirements and/or specialized habitat needs; Roberge & Angelstam 2004; Thorton et al. 2016) when designing and implementing conservation plans would seem a worthwhile approach to achieving the overall objectives of the IDPA. While stricter control of monofilament fish nets and elimination of electro-fishing from IDPA will go far towards protecting both dolphins and turtles, even legal fishing practices (e.g., small-mesh monofilament nets, fishing weirs, and

fish traps) are probably incompatible with the recovery and conservation of Softshell Turtle populations in the protected area. We, therefore, urge management authorities to resuscitate earlier plans to significantly reduce or eliminate the use of monofilament gill netting in IDPA as outlined by Smith & Mya Than Thun (2007). Perhaps this issue could best be addressed through the development and implementation of a community-based fisheries program (Meusch & Mellot 2009) in the sanctuary with the objective of enhancing local fisheries resources through sustainable management practices while effectively safeguarding turtles and dolphins at the same time. Furthermore, an education and awareness program focused on turtles and dolphins and targeting riverside villages would go far towards engaging local communities in stewardship and conservation. A community education and awareness program that is yielding positive conservation dividends in the recovery of the Critically Endangered Burmese Roofed Turtle (*Batagur trivittata* Duméril & Bibron, 1835) on the Upper Chindwin River (Platt et al. 2015) could serve as the template for a similar program in IDPA.

In lieu of such conservation actions, we consider it likely that populations of large Softshell Turtles in IDPA will decline to the point of functional extinction in the near-future. Given the level of existing threats and lack of effective control by management authorities over legal and illegal fishing activity, we cannot at this time recommend the release of head-started Softshell Turtles into the protected area. Should this situation change in the coming years, our recommendation will need to be reassessed. If effective protection can be implemented, the extensive sandbanks, deep channels, and floodplain oxbow lakes would provide excellent habitat for recovering populations of Softshell Turtles.

Finally, our survey and accompanying recommendations may be criticized for a perceived over-reliance on data obtained from scientifically untrained observers. In this regard, we acknowledge that our conclusions are largely based on local or traditional ecological knowledge (sensu Huntington 2000) and might be considered by some as lacking scientific rigor. Although science has, for a variety of reasons, been slow to embrace traditional knowledge as a research methodology (Huntington 2000; Nabhan & Martinez 2012), a growing body of evidence indicates indigenous peoples are keen observers of the natural world and can contribute reliable information on local fauna that is useful for informed conservation planning (Newton et al. 2008; Meijaard et al. 2011; Nabhan & Martinez 2012; Prado et al. 2013). Furthermore, traditional

ecological knowledge can serve as the springboard for launching more rigorous science-based studies of fauna and flora as well as implementing effective measures for biodiversity conservation (Gadgil et al. 1993; Nabhan & Martinez 2012; Forth 2017).

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