

CAN IRRAWADDY DOLPHINS *ORCAELLA BREVIROSTRIS* SURVIVE IN SONGKHLA LAKE, THAILAND?

Brian D. Smith^{1,2}, Dipani Sutaria^{1,3}, Nitikorn Piwpong⁴, Somserm Choorak⁵,
and Wannapa Koedpoem⁶

ABSTRACT

Line-transect surveys conducted in September 2003 and March 2004 of Irrawaddy dolphins *Orcaella brevirostris* in Songkhla Lake, Thailand, indicated an extremely small population of questionable viability. The very low number of recent sightings and a minimum mortality rate of 5.6 dolphins per year recorded during June 2001 through December 2003 implied a probable declining trend. Interview surveys and observations of an extremely high density of fixed fishing gears in the middle and southern portions of the lake suggested the geographical isolation of the animals in the northern portion. These considerations led to the recent classification of the population as “critically endangered” according to IUCN Red List criteria. Recommendations for conserving dolphins in Songkhla Lake include removing barriers from an excessive number of fixed fishing gears, eliminating or severely limiting the use of gillnets and reducing the use of biocides in shoreline agriculture. It is suggested that even if these measures fail to prevent extirpation of the dolphin population, they will be beneficial for protecting sustainable fisheries and the rich diversity of birdlife utilizing the lake.

Key words: Irrawaddy dolphin, *Orcaella brevirostris*, population survey, Songkhla Lake, Thailand

INTRODUCTION

Irrawaddy dolphins *Orcaella brevirostris* are patchily distributed in shallow, primarily estuarine, tropical and subtropical marine waters of the Indo-Pacific, from northeastern India east to Malampaya Sound, Philippines (DOLAR *ET AL.*, 2002), and south to northeastern Australia (STACEY & LEATHERWOOD, 1997; STACEY & ARNOLD, 1999). These animals are known as facultative freshwater cetaceans (LEATHERWOOD & REEVES, 1994, SMITH &

¹ Wildlife Conservation Society, 2300 Southern Boulevard, Bronx, New York 10460 USA

² Current address: 27/16 Soi Naya, Moo 1, Muang, Rawai, Phuket 83130 Thailand

³ Current affiliation: School of Tropical Environment Studies and Geography, James Cook University, Townsville, Queensland 4811 Australia

⁴ Phattalung Inland Fisheries Development Center, Department of Fisheries, Phattalung, Thailand

⁵ Irrawaddy Dolphin Conservation Society, 18/21, Soi Chokchi, Pattana Road, Thambon Kuhaisawon, Amphoe Mung, 93000 Phatthalung, Thailand

⁶ Talalung Non-hunting Area Station, Department of Forestry, 151 Mu 3, Thambon Chong Thanon, Amphoe Khao Chaison, 93130 Phatthalung, Thailand

Received 19 June 2004; accepted 15 October 2004.

JEFFERSON 2002) because they also occur in three river systems—the Mahakam of Indonesia, the Ayeyarwady (formerly Irrawaddy) of Myanmar (formerly Burma) and the Mekong of Laos, Cambodia and Vietnam, and two partially isolated brackish or fresh-water lakes or lagoons—Chilka in India and Songkhla in Thailand. Irrawaddy dolphins were first recorded in Songkhla Lake by PILLERI & GIHR (1974) who examined three stranded specimens from Thale Luang.

Until recently very little information was known about the status of Irrawaddy dolphins in Songkhla Lake, which covers a total area of about 1,100 km². The first systematic surveys were conducted by BEASLEY *ET AL.* (2002) in May 2000 and February 2001 covering 545 linear km of repetitive transects in the inner and middle portions (Thale Luang), north of Papayurn [Pak Payun]. These surveys recorded only four sightings (Figure 1) and a sighting rate of 0.03 dolphins/linear km (mean group size = 4.3 dolphins, SD = 2.9, range = 1–8). All sightings were made in the inner portion, which is the deepest part of the lake (2.1–2.5 m). Due to shallow water and the extremely high density of fixed fishing gears, BEASLEY *ET AL.* (2002) proposed that dolphins were probably absent from the outer portion of the lake (Thale Sap) and the southern part of Thale Luang, and were prevented from moving between the lake and the Gulf of Thailand. The same researchers presented additional evidence of the population's geographic isolation based on interviews with 86 local fishermen. BEASLEY *ET AL.* (2002) also listed 28 records of dolphin carcasses recovered

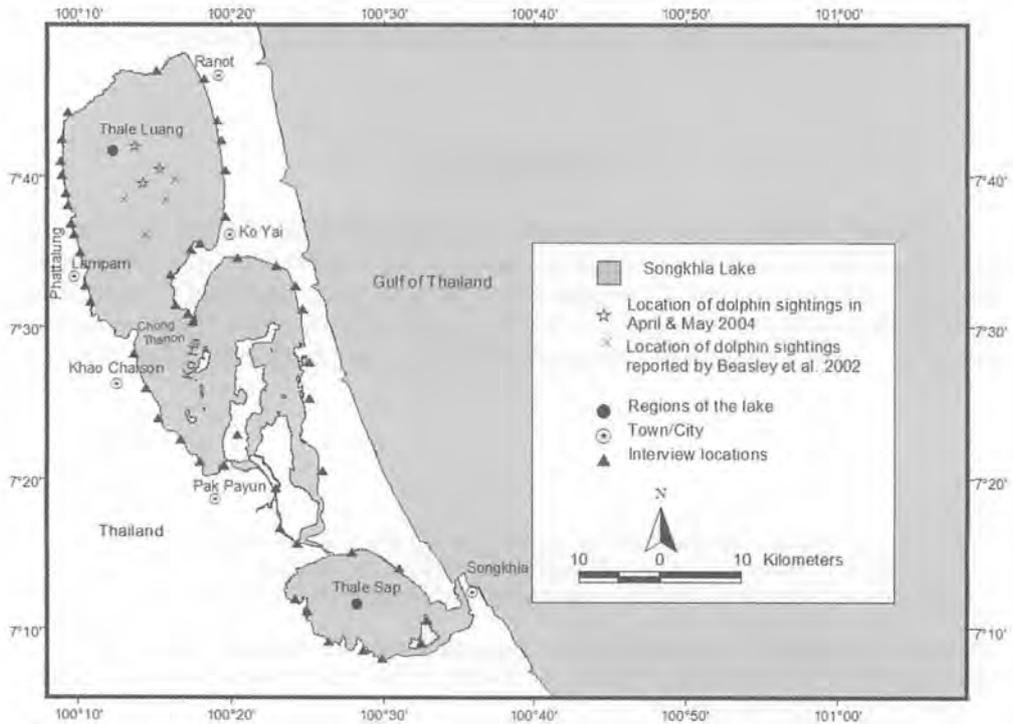


Figure 1. Map of Songkhla Lake showing locations of dolphin sightings and interviews of local fisherman.

between January 1990 and April 2001. At least 13 of these animals were believed to have died from gillnet entanglement, based upon the presence of net scars on the carcass or the reports of local fishermen (S. CHOORUK, unpublished). Of the total strandings, at least nine were calves (i.e., 1 m in length or smaller).

Irrawaddy dolphins have been adopted as the mascot of the Phattalung Province and local people have expressed great enthusiasm for their conservation. The Talalung Non-hunting Area Forestry Station, which is responsible for protecting the lake's wildlife, provides a government infrastructure for dolphin protection. A proclamation from Her Majesty Queen Sirikit of Thailand signed on 3 October 2001 designated Irrawaddy dolphins in Songkhla Lake as a Royal Protected Species. The proclamation makes harming the dolphins or possessing their body parts punishable by four years in jail and/or a fine of 40,000 Baht (ca. US\$1,000). The Irrawaddy Dolphin Conservation Society was established by a local schoolteacher in Phattalung (S. CHOORAK, the fourth author of this paper) in 1996. The Society has conducted numerous awareness-raising activities and keeps detailed records of dolphin strandings that are reported directly to the Queen at regular intervals. In 2001, a collaborative research and conservation program with the Irrawaddy Dolphin Conservation Society was initiated by the Whale and Dolphin Conservation Society, UK. This project was continued and expanded in 2003, with the involvement of the Thailand Departments of Forestry and Fisheries and support from the Wildlife Conservation Society, USA.

The present paper reports on additional line-transect surveys, examinations of carcasses, and interviews with fishermen conducted since BEASLEY *ET AL.* (2002). It also draws attention to an IUCN Red List assessment conducted in 2003/2004 that resulted in the population being classified as "critically endangered" and makes recommendations for conserving the species in Songkhla Lake.

MATERIALS AND METHODS

Line-transect Surveys

Two vessel-based line-transect surveys were conducted in September 2003 and March 2004. A systematic parallel line design was used with transect lines placed perpendicular to the edge of the lake and spaced 3.5 km apart. The spacing of the transect lines was based primarily on logistical considerations and deviations were sometimes necessary to avoid sea grass beds, fishing gears and shallow water. Our survey vessel was a 9.3 m long double outrigger, with a beam of 1.8 m on main hull, and equipped with a 10.5 hp engine. During the surveys, three observers stood watch at all times from an elevated platform about 2 m above the waterline, one stationed on each the port and starboard sides, searching the water surface with handheld binoculars (Fujinon 7X50 with an internal compass) and naked eye from the beam of the vessel to about 10° past the bow, and one in the center searching by naked eye in front of the bow. The center observer also served as the data recorder. The geographic position, speed, course, distance covered along the trackline, Beaufort sea-state and the presence or absence of fog and/or rain were recorded approximately every 30 minutes (which coincided with observer rotations), when dolphins were sighted or if any substantial change occurred in the above parameters. Two casual surveys were also conducted in Thale Luang during April 2004.

Interview Surveys

A questionnaire was developed to obtain information on the present and historical distribution of Irrawaddy dolphins in the lake and attitudes of fishermen towards establishing a protected area for the dolphins. The interviews were conducted in Thai language by W. KOEDPOEM and other Department of Forestry staff from the Talalung Non-hunting Area Station at 49 locations surrounding the lake.

Examination of Dolphin Carcasses

A data base of stranded specimens has been maintained since 1990 (BEASLEY *ET AL.*, 2002). This effort is coordinated by the Irrawaddy Dolphin Conservation Society (see above). When strandings are reported and carcasses recovered information is collected on the date and location, total length and condition of the carcass, and on the cause of death when known. Before the present project started photo-illustrated pamphlets were produced in Thai language with contact information for reporting dolphin strandings to the Departments of Fisheries and Forestry. These were distributed to local villages during the interview surveys described above.

Fishing Gear Investigation

Reports were examined and interviews conducted with officials from the Phattalung Provincial Fisheries Department, Songkhla Provincial Fisheries Department and Phattalung Fisheries Law Enforcement Station to determine which types of gear directly threaten dolphins with incidental killing or indirectly threaten them by creating barriers to their movements and demographic interaction with other individuals of the species in the Gulf of Thailand. Information was also collected on the numbers, technical specifications, and target catches of these gears.

RESULTS

Vessel-based Line-transect Surveys

No dolphins were observed during the 18–24 September 2003 survey (Fig. 2) Shallow water, dense sea grass and a high density of fishing gears prevented us from following the track lines designed for the southern portion of the lake. A total of 234.3 linear km were searched during 21.3 h of search effort (vessel speed = 9.8–11.8 km/h). Sighting conditions were generally good, with Beaufort sea-states of 0–3 recorded during 29.2%, 39.2%, 27.2% and 4.4% of the time, respectively. Clear skies were recorded during 39% of the time, hazy skies during 59%, and rain/fog during 2%. Water depth ranged from 0.2–2.0 m (mean = 1.0, SD = 0.48). Fishing boats were rarely encountered in the northern portion of the lake (Thale Luang), while the southern portion, including the canal leading to Thale Sap, was densely covered with fixed fishing gears making it difficult to navigate and impossible to follow the transect lines.

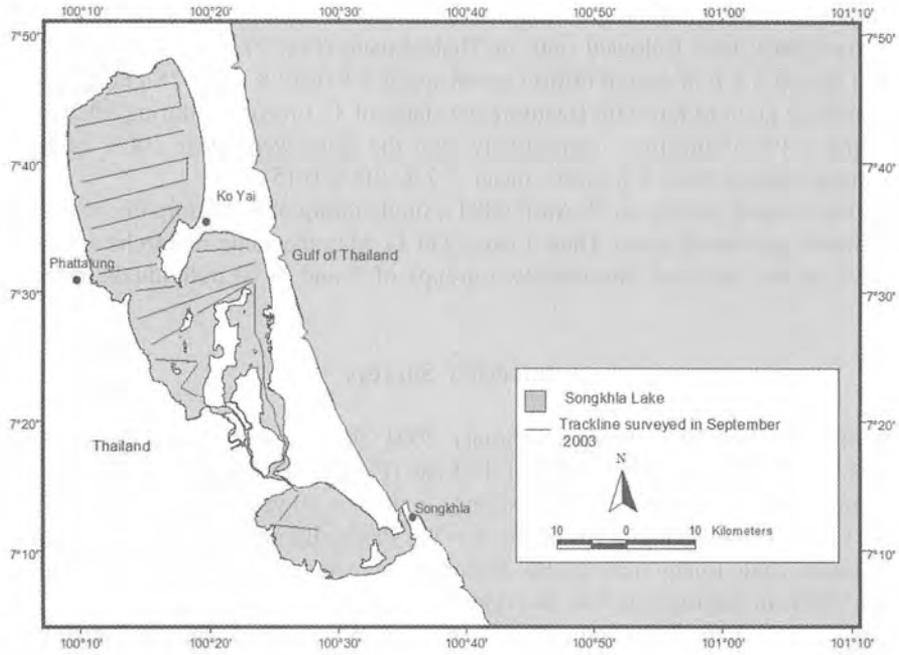


Figure 2. Map of Songkhla Lake showing tracklines followed during the 18-24 September 2003 survey.

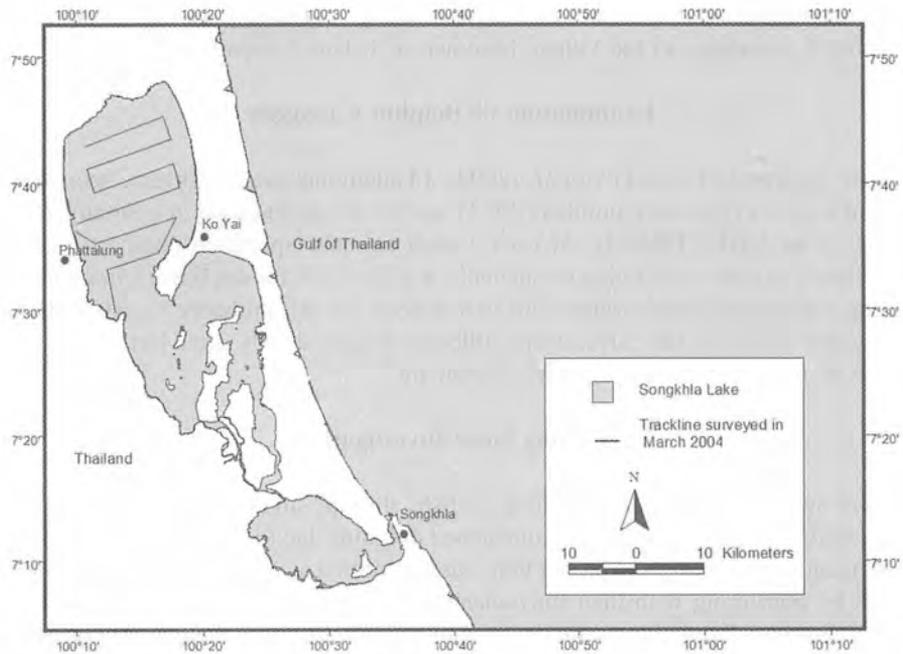


Figure 3. Map of Songkhla Lake showing tracklines followed during the 11-12 March 2003 survey.

No dolphins were observed during the 11–12 March 2004 survey (Fig. 3). During this survey tracklines were followed only in Thale Luang (Fig. 2). A total of 61.8 km was searched during 5.5 h of search effort (vessel speed = 9.0–12.8 km/h). Sighting conditions were generally good to fair with Beaufort sea-states of 1–4 recorded during 19.2%, 41.6%, 35.6% and 3.4% of the time, respectively, and the skies were clear 100% of the time. Water depth ranged from 2.1–2.8m (mean = 2.4, SD = 0.15).

During a casual survey on 28 April 2004 a single group of 8–15 dolphins was observed in the middle portion of upper Thale Luang. On 11 May the same researchers went to the same area of the lake and observed two groups of 3 and 5–10 individuals, respectively (Fig. 1).

Interview Surveys

During October 2003 through February 2004, 90 interviews were conducted at 49 locations located around the perimeter of the Lake (Fig. 1). Sixty per cent of the interviewed fishermen had observed dolphins at least once in the last 50 years. Of these, 85% had seen them in upper Thale Luang north of the Ko Yai Peninsula and Cape Chong Thanon and 15% in lower Thale Luang near Ko Ha. Reported estimates of group size ranged from 2–20 animals, with an average of 7.6 individuals. Only 19% of the fishermen had sighted dolphins since January 2000 and only 7% in 2003. When asked about the desirability of establishing one or more protected areas for conserving dolphins and sustainable fisheries in the lake, 78% of the fishermen responded positively. All of the interviewed fishermen used gillnets and 84% fished everyday, except when it rained, while the rest fished at least 5 days a week. None of the fishermen reported catching dolphins in their nets, while 42% reported having seen dolphin carcasses, either floating or stranded. Two of these fishermen had reported strandings to the village headman or fisheries department.

Examination of Dolphin Carcasses

Since the report of BEASLEY *ET AL.* (2002), 14 additional strandings have been recorded, including 8 calves (specimen numbers 29, 35 and 37–42; including 4 in February 2003 and 2 in December 2003) (Table 1). At least 2 adult animals (specimen numbers 34 and 36) were believed to have been killed accidentally in gillnets set for sea bass (*Lates calcarifer*), including a pregnant female whose flukes had been cut off, probably to extract her body from the net. Some of the calves were stillborn or died shortly after birth, based on the presence of fetal folds and a non-erect dorsal fin.

Fishing Gear Investigation

Fixed sea bass gillnets and drifting catfish, shrimp, small fish and pipefish gillnets were identified as gears that directly threatened dolphins due to the potential for incidental entanglement. Fixed sitting and barrier traps were identified as gears that indirectly threatened dolphins by interfering with their movements and displacing them from potential habitat (Table 2). Sea bass fixed gillnets are believed to be responsible for the majority of incidental dolphin kills according to net marks observed on at least one carcass, and because these nets are left unattended and set in the middle portion of upper Thale Luang, which is the

Table 1. Record of carcasses examined since BEASLEY *ET AL.* 2002 (p. 77).

#1	Date found	Length (m)	Location	Condition	Cause of death	Location of remains ²
29	4 June 01	1.0	Ku Khud (near Ban Pak Sawa)	Unknown	Unknown	Discarded
30	25 June 01	1.8	Pak Bang (near Laem Yanng)	Decomposed	Unknown	PIFDC
31	12 Dec 01	2.3	Ban Laem Chong Thannon	Bloated, rope marks on tail	Unknown	PIFDC
32	12 Feb 02	1.5	Wat Pa Lae Lai (ca. 1km north Lampam)	Decomposed	Unknown	Discarded
33	9 May 02	1.5	Wat Lam Chao, Ko Yai	Decomposed	Unknown	Discarded
34	19 Sep 02	1.8	Ban Pak Phaniat	Fresh; net marks on tail stock and head	Gillnet entanglement	PIFDC
35	13 Dec 02	1.0	Lampam	Decomposed with no head and tail	Unknown	PIFDC
36	6 Feb 03	2.30	Ban Nok (3km south of Lampam)	Fresh; tail cut off; female pregnant with 0.8-m fetus	Gillnet entanglement	TLNHA
37	9 Feb 03	1.00	Ban Nok (3km south of Lampam)	Fresh	Unknown	TLNHA
38	11 Feb 03	1.00	Ban Pa Lae Lai Moo 11, Tambon Lampam	Decomposed; no head and tail	Unknown	PIFDC
39	28 Feb 03	1.00	Same as above	Decomposed	Unknown	PIFDC
40	9 Apr 03	1.00	Lampam	Decomposed	Unknown	PIFDC
41	7 Dec 03	<100	Lampam	Decomposed	Unknown	Discarded
42	19 Dec 03	0.9	Lampam	Dorsal fin not erect	Unknown	Discarded

1 Numbers are sequential starting from the last specimen reported in BEASLEY *ET AL.* 2002.

2 TLNHA = Talalung Non-hunting Area Station; PIFDC = Phattalung Inland Fisheries Development Center

Table 2. Details on fishing gears known or believed to threaten dolphins in Songkhla Lake.

Gear name in English [Thai] and description	Target Catch	Area and season used	Estimated numbers	Effects on dolphins	Gear name in English [Thai] and description
			Phattalung Province*	Songkhla Province [‡]	
Fixed seabass gillnet [Oun pla kapong]—braided thread, 10 cm mesh size, 10–20 ca. 50m long panels (i.e. total length 500–1000m), ca. 1.5–2m deep, each one suspended between vertical bamboo poles, left unattended and checked every 3–5 days.	Sea bass <i>Lates calcarifer</i>	Middle portion of upper Thale Luang, mostly between Ban Wei and Ko Yai, in the monsoon season. [‡]	10–12 [^]	Unknown but probably less in number than in the Phattalung Province.	Incidental killing from entanglement. Believed to be responsible for most human-caused deaths.
Drifting catfish gillnet [Oun lou pla savai] - heavy braided thread, 10 cm mesh size, 10 ca. 50m long panels (total length ca. 500m), ca. 1.5–2m deep, drifting and generally attended by fishermen.	Sutchi catfish <i>Pangasius hypophthalmus</i>	Southern portion of upper Thale Luang near Ko Yai during monsoon season.	10–15 [^]		
Drifting shrimp gillnet [Oun lou krung]—monofilament nylon, 1cm mesh size, 10–30 ca. 40m long panels and 2m deep, 10–30 linked together.	Small shrimps including <i>Matapenaus equidens</i> , <i>Macrobrachium lanchesteri</i> and <i>Peneaus</i> spp.	Middle portion of Thale Luang during the non-monsoon season.	6,106		Potential threat of incidental killing from entanglement.
Drifting fish gillnet [Oun lou pla]—monofilament nylon, 2.5–10cm mesh size, multiple panels ca. 40m long and 2m deep each, 10–30 linked together.	Small fishes including <i>Puntius leiacanthus</i> , a species recorded in the stomach contents of an Irrawaddy dolphin from Songkhla Lake [#]	6,106	21,081	12,000 [^]	

Table 2. (continued)

Gear name in English [Thai] and description	Target Catch	Area and season used	Estimated numbers	Effects on dolphins	Gear name in English [Thai] and description
			Phattalung Province*	Songkhla Province ^{&}	
Drifting pipefish gillnet [Oun jimfunjawrakai]–monofilament nylon, 1–2 cm mesh size, multiple panels ca. 40m long and 2m deep each, 10–30 linked together.	Common freshwater pipefish <i>Doryichthys boaja</i> , dried and used for medicine in China	Southern portion of lower Thale Luang during non-monsoon season	3,561		
Fixed sitting trap [Sai nong]–Wings (each side ca. 100m long) composed of small mesh nets suspended between bamboo poles deployed in a V-formation with a large trap at the apex	Brackish water prawns, <i>Metapenaeus ensis</i> , <i>M. moyebi</i> and <i>M. lysianassa</i> .	Lower Thale Luang and Thale Sap during the monsoon season but wings left in place year round.	1,470	25,178 (distributed in 133 rows in Thale Sap)	Barrier to dolphin movement; habitat displacement; prevents demographic interaction with individuals in the Gulf of Thailand.
Fixed barrier trap [Sang sai]–Closely spaced bamboo poles, sometimes with a net suspended in between, starting from the shore and extending 2–300m out with bamboo traps placed periodically along its length.	Giant freshwater prawn, <i>Macrobrachium rosenbergii</i> , gray eel-catfish <i>Plotosus canius</i> and Nile tilapia <i>Oreochromis niloticus</i> (introduced species)	Southern portion of Thale Luang during the non-monsoon season but bamboo barriers left in place year round.	12,740	300	

* Information taken from Eitcheroon, C. 2004. Analysis of fishing gears in Phattalung area of Songkhla Lake. Thailand Department of Fisheries, Phattalung Province (unpublished report in Thai language)

[&] Information taken from Sainamkeo, P. 2004. Analysis of fishing gears in Songkhla area of Songkhla Lake. Thailand Department of Fisheries, Songkhla Province (unpublished report in Thai language)

[@] Monsoon season in Songkhla Lake is normally from August to February.

[^] Best guess of fisheries department official

[#] Siritmontrapon, P. 1995. Preliminary report on the biology of Irrawaddy dolphin in Songkhla Lake. Publication of the National Institute of Coastal Aquaculture, Thailand Fisheries Department. 12 pages (unpublished report in Thai language with English abstract).

only area where the animals have been observed in recent years. The lack of closely spaced net marks on the examined carcasses suggests that drifting shrimp, small fish and pipefish gillnets probably threaten dolphins to a lesser extent. The fact that these nets, as well as drifting catfish gillnets, are generally attended by fishermen also means that entangled dolphins may be released if discovered alive. However, the large number of these nets (ca. 42,000) used in the lake may still profoundly affect the animals by interfering with their movements and depleting their prey. The large number of fixed sitting and barrier traps (ca. 40,000 gears, which equals more than 8000 km of linear barrier distributed in multiple rows) that remain in place year round in lower Thale Luang and Thale Sap almost certainly restricts dolphin movements such that the potential for demographic interaction with individuals in the Gulf of Thailand is eliminated and their habitat is substantially reduced.

DISCUSSION

Compared to the 2001–2002 surveys reported in BEASLEY *ET AL.* (2002), the 2003 and 2004 surveys used three rather than two observers and search effort was conducted from a raised platform about 2 m above the water surface. This should have improved searching efficiency. Based on the encounter rate recorded by BEASLEY *ET AL.* (2002), even with no change in efficiency, these surveys should have produced at least two sightings. It is possible that the difference in results simply reflects random variation in sighting biases, but a precautionary interpretation would be that the very small population that existed in 2001 and 2002 has been reduced even further. This interpretation is reinforced by the large number of recorded deaths (see above) in relation to the extremely low (although precisely unknown) population size.

The 2003 and 2004 surveys were conducted using a similar vessel/observation platform and the same methods and number of observers as had been used for line-transect surveys for Irrawaddy dolphins in Malampaya Sound, Philippines (see SMITH *ET AL.* 2004), a population that will also be listed as “critically endangered” in the 2004 IUCN Red List. If the sighting rate in Songkhla Lake had been equivalent to that recorded in Malampaya Sound (0.0865 sightings/km), 25 or 26 dolphin groups should have been detected. If the two water bodies supported approximately the same number of groups and individuals, even accounting for the difference in size between the area occupied by dolphins in Malampaya Sound (ca. 134 km²) and the total area searched during the 2003 and 2004 surveys (ca. 755 km²), 4–5 groups consisting of 21–27 individuals (based on the mean group size of 5.3 dolphins recorded in Malampaya Sound) should have been detected.

The increase in the number of recorded strandings, from 2.5 per year between January 1990 and April 2001 (see Table 1 in BEASLEY *ET AL.*) to 5.6 per year between May 2001 and December 2003 (see above) probably reflects: (1) an increase in reporting due to the increased awareness of local people about the dolphins and efforts to conserve them, (2) the developing capacity of local agencies to respond to stranding reports and (3) a rise in mortality within the population itself. Given the paucity of recent sightings despite extensive survey effort (see above), it is unlikely that any real increase in mortality could be explained by an increasing population size.

The proportion of stranded calves has also increased, possibly due to the habituation of some adults to the presence of nets and fish traps. Another explanation is that the calves

died at an unusually high rate for different reasons; their causes of death could not be determined. Although we have no supporting evidence, an additional possible explanation could be that the calves were stillborn or died shortly after birth due to high toxic loads from bioaccumulating agrochemicals used intensively in fields along the shore of the lake.

Currently, there is only a single connecting channel between the lake and the Gulf of Thailand. This channel is located at the southern tip of the lake. It is almost certainly inaccessible to dolphins due to the extremely high density of fixed fishing gears (which remain set throughout the year) and gillnets (some of which are set throughout the year, others of which are removed when some fishermen are engaged in other occupations during the monsoon season—May through December, peaking from September through November). A second smaller connecting channel previously existed at the northern tip of the lake but it was blocked by a closure dam constructed in 1955 to prevent saline inputs, so that the lake could be used to irrigate surrounding agricultural fields. The geographically closest records of Irrawaddy dolphins to the southern connecting channel are of two specimens reported in 1901 at Pattani (ca. 100 km to the south; BONHOTE, 1903—not seen; cited in PILLERI & GIHR, 1974) and one stranding in 1994 at Surat Thani (ca. 300 km to the north; CHANTRAPORN SYL *ET AL.*, 1996). The absence of records near the connecting channel (although this may also be explained by a lack of survey effort), the extremely high density of fixed fishing gears that probably constitute a physical barrier to dolphin movement and interview surveys indicating that dolphins do not occur in the outer portion of the lake imply that there is little, if any, demographic exchange between dolphins in Songkhla Lake and those in the Gulf of Thailand—almost certainly fewer than one successful migrant per year (the criterion for defining a subpopulation according to the IUCN Red List Categories and Criteria Version 3.1; see http://www.redlist.org/info/categories_criteria2001.html).

Information from the visual and interview surveys reported in this paper and in BEASLEY *ET AL.* (2002) makes it difficult to envisage that the number of dolphins remaining in the lake constitute a long-term viable population. The low numbers of dolphin groups detected during line-transect surveys, despite extensive, rigorous searching effort, indicate that the population in Songkhla Lake certainly contains fewer than 50 mature individuals, thereby qualifying it for listing as “critically endangered”. The evidence for thus listing is particularly strong when these survey results are compared to the sighting rates recorded for the “critically endangered” Malampaya Sound Irrawaddy dolphin population (see SMITH *ET AL.* 2004).

Small isolated populations are vulnerable to extirpation, due to demographic stochasticity, inbreeding depression and catastrophic environmental and epizootic events (SOULÉ & WILCOX, 1980; GILPIN & SOULÉ, 1986; LYNCH, 1996). It is important to emphasize, however, that we know nothing about the historical movement patterns of Irrawaddy dolphins between the lake and the Gulf of Thailand. It is conceivable that, if dolphins could move freely in and out of the lake (a situation currently prevented by the high density of fixed fishing gears in middle and outer portions) and incidental killing in gillnets was eliminated or dramatically reduced, that a viable population could once again reestablish itself. We believe that measures taken to restore a suitable environment for dolphins in Songkhla Lake, even if unsuccessful at saving the population, would also be beneficial for protecting sustainable fisheries and the diversity of water birds that depend on this productive wetland area. These measures should include removing barriers from

excessive fixed fishing gears, eliminating or severely limiting the use of gillnets (especially those used to catch sea bass) and reducing the use of biocides in shoreline agriculture.

The establishment of a gillnet free zone in the middle portion of upper Thale Luang would be an important first step for protecting dolphins in the lake. An example of how this might be accomplished is the network of fishing reserves for protecting fish reproduction in the lake. This network currently consists of 11 fishing reserves (not including one in Thale Noi, a small lake north of Thale Luang) covering a total of 9,890 rai (16 km²). The largest one is located in upper Thale Luang surrounding the Ko Yai peninsula and covers 4,375 rai or 7 km². Another reserve in an area close to where dolphins have been observed covers 400 rai or 0.6 km² along the shoreline near Lampam. These reserves were established after extensive consultations with local fishermen and violators are reported to the Fisheries Department by community guards. Outside of the proposed gillnet free zone, fishermen should be required to attend their nets at all times and be educated on the how to release dolphins safely if they become entangled. Reducing the number of fixed sitting and barrier traps will be necessary to reestablish a movement corridor between Thale Luang and the Gulf of Thailand. This will require a compensation program for fishermen and strict enforcement to ensure that removed gears are not replaced.

From a research and monitoring perspective, due to the low density of dolphins in the lake, it is difficult to justify further line-transect surveys. We suggest that an alternative would be to strengthen the existing stranding network and to create dolphin conservation clubs among fishing communities who would report sightings to authorities of the local fisheries and forestry departments. An additional component should be the collection of tissue samples from all dolphin carcasses for investigating levels of persistent contaminants, especially those used as biocides in shoreline agriculture.

ACKNOWLEDGMENTS

Funds for this project were provided by the Wildlife Conservation Society, Whale and Dolphin Conservation Society and Chicago Zoological Society. We gratefully acknowledge the support given to this project by Prapat Senong, Chief of the Talalung Non-hunting Area Station, Department of Forestry, and Chaiwat Ratanadadat, Chief of the Phattalung Inland Fisheries Development Center. We also thank our survey staff, Parsert Musigajaern, Somboon Chujean, Paitoon Sutenalouprakarn and Preecha Kaiwchutong. Information on fisheries was provided by Chalum Hoisakun from the Phattalung Provincial Fisheries Department, Paradon Sainamkeo from the Songkhla Provincial Fisheries Department and Sombat Sompong, Fisheries Law Enforcement Station, Phattalung. The manuscript was improved by reviews from Isabel Beasley, Danielle Kreb and John Wang.

REFERENCES

- BEASLEY, I., S. CHORUK, AND N. PIWONG. 2002. The status of the Irrawaddy dolphin, *Orcaella brevirostris*, in Songkhla Lake, Southern Thailand. *Raffles Bull. Zool. Suppl.* 10: 75–83.
- BONHOTE, J. L. 1903. Report on the mammals. In: Fasc. Malay-Anthropol. and Zool. Results of the Exp. to Perak and Siamese Malay States, 1901–1902, Zoology, Part 1: 42–43. University Press, Liverpool.
- CHANTRAPORN SYL, S., K. ADULYANUKOSOL, AND K. KITTIWATTANAWONG. 1996. Records of cetaceans in Thailand. *Phuket Marine Biol. Ctr. Rsch. Bull.* 61: 39–63.
- DOLAR, M. L. L., W. F. PERRIN, J. P. GAUDIANO, A. A. S. P. YAPTINCHAY, AND J. M. L. TAN. 2002. Preliminary report on a small estuarine population of Irrawaddy dolphins *Orcaella brevirostris* in the Philippines. *Raffles Bull. Zool. Suppl.* 10: 155–60.
- GILPIN, G., AND M. E. SOULÉ. 1986. Minimum viable populations: process of species extinction. Pages 13–34 In: M. E. Soulé (ed.), *Conservation Biology: The Science of Scarcity and Diversity*. Sinauer, Sunderland, Massachusetts. i-xiii+584pp.
- LEATHERWOOD, S., AND R. R. REEVES. 1994. River dolphins: a review of activities and plans of the Cetacean Specialist Group. *Aquatic Mammals* 20:137–154.
- LYNCH, M. 1996. A quantitative-genetic perspective in conservation issues. Pages 471–475 In: J. C. Avise and J. L. Hamrick (eds.), *Conservation Genetics*. Chapman & Hall, New York. i-xvii + 512pp.
- PILLERI, G. AND M. GIHR. 1974. Contribution to the knowledge of the cetaceans of southwest and monsoon Asia (Persian Gulf, Indus Delta, Malabar, Andaman Sea and Gulf of Siam). *Investigations on Cetacea* 5: 95–153.
- SOULÉ, M. E., AND M. WILCOX (eds.). 1980. *Conservation Biology: An Evolutionary-Ecological Perspective*. Sinauer, Sunderland, Massachusetts. 395pp.
- SMITH, B. D., AND T. A. JEFFERSON. 2002. Status and conservation of facultative freshwater cetaceans in Asia. *Raffles Bull. Zool. Suppl.* 10: 173–87.
- SMITH, B. D., I. BEASLEY, M. BUCCAT, V. CALDERON, R. EVENA, J. LEMMUEL DE VALLE, A. CADIGAL, E. TURA, AND Z. VISITACION. 2004. Status, ecology and conservation of Irrawaddy dolphins *Orcaella brevirostris* in Malampaya Sound, Palawan, Philippines. *J. Cetacean Res. Manage.* 6(1): 41–52.
- STACEY, P. J., AND S. LEATHERWOOD. 1997. The Irrawaddy dolphin, *Orcaella brevirostris*: a summary of current knowledge and recommendations for conservation action. *Asian Marine Biol.* 14: 195–214.
- STACEY, P. J., AND P. W. ARNOLD. 1999. *Orcaella brevirostris*. *Mammalian Species* 616: 1–8.

