WORKING PAPER NO. 31 MAY 2007

WILDLIFE CONSERVATION SOCIETY

STATUS AND CONSERVATION OF FRESHWATER POPULATIONS OF IRRAWADDY DOLPHINS

Edited by Brian D. Smith, Robert G. Shore and Alvin Lopez

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WCS Working Papers: ISSN 1530-4426

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Cover photographs by:
Isabel Beasley (top, Mekong), Danielle Kreb (middle, Mahakam), Brian D. Smith (bottom, Ayeyarwady)

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ACKNOWLEDGEMENTS

We gratefully acknowledge the Cambodia Department of Fisheries in Phnom Penh for hosting the workshop and funding contributions from the Ocean Park Conservation Foundation, Whale and Dolphin Conservation Society, Mekong Wetlands Biodiversity Conservation and Sustainable Use Program, and Wildlife Conservation Society (WCS). Logistical assistance from the WCS Cambodia Program was invaluable for organizing the workshop. From WCS, in particular, we would like to thank Joe Walston and Sok Heng. We would especially like to recognize the strong contributions of the workshop participants (Annex 1) and thank them for their thoughtful deliberations

FOREWORD

Freshwater populations of Irrawaddy dolphins are threatened with extinction. Many of the threats faced by these animals are common to the three rivers (Mekong, Mahakam and Ayeyarwady) and two lakes (Chilika and Songkhla) where they live. These threats include incidental killing in fishing gears, collisions and harassment from motorized vessels and increasing levels of pollution. On 21-26 March 2005 the Workshop to Develop a Conservation Action Plan for Freshwater Populations of Irrawaddy Dolphins was convened at the Cambodian Department of Fisheries in Phnom Penh. The workshop brought together a group of international experts and national scientists from Cambodia, India, Indonesia, Lao PDR, Myanmar and Thailand to review the status of the dolphins, share experiences on protective efforts, and develop an action plan for their conservation. The discussions held by this group were invaluable for increasing our knowledge and capacity to implement science- and community-based solutions to prevent the disappearance of this species from freshwater environments. The Cambodian Department of Fisheries has played a key role in conserving the Irrawaddy dolphin population in the Mekong River, and we are proud to have been able to share our experiences at the workshop in Phnom Penh. A great deal of progress was made, and the challenge now is to use newly gained knowledge to guide future conservation action. Publication of this volume is a vital step, and I urge managers, NGOs, scientists, and conservation enthusiasts from all range states supporting freshwater populations of Irrawaddy dolphins to work diligently on implementing recommendations contained in the action plan.

H.E. Nao Thuok
Director General
Cambodian Department of Fisheries

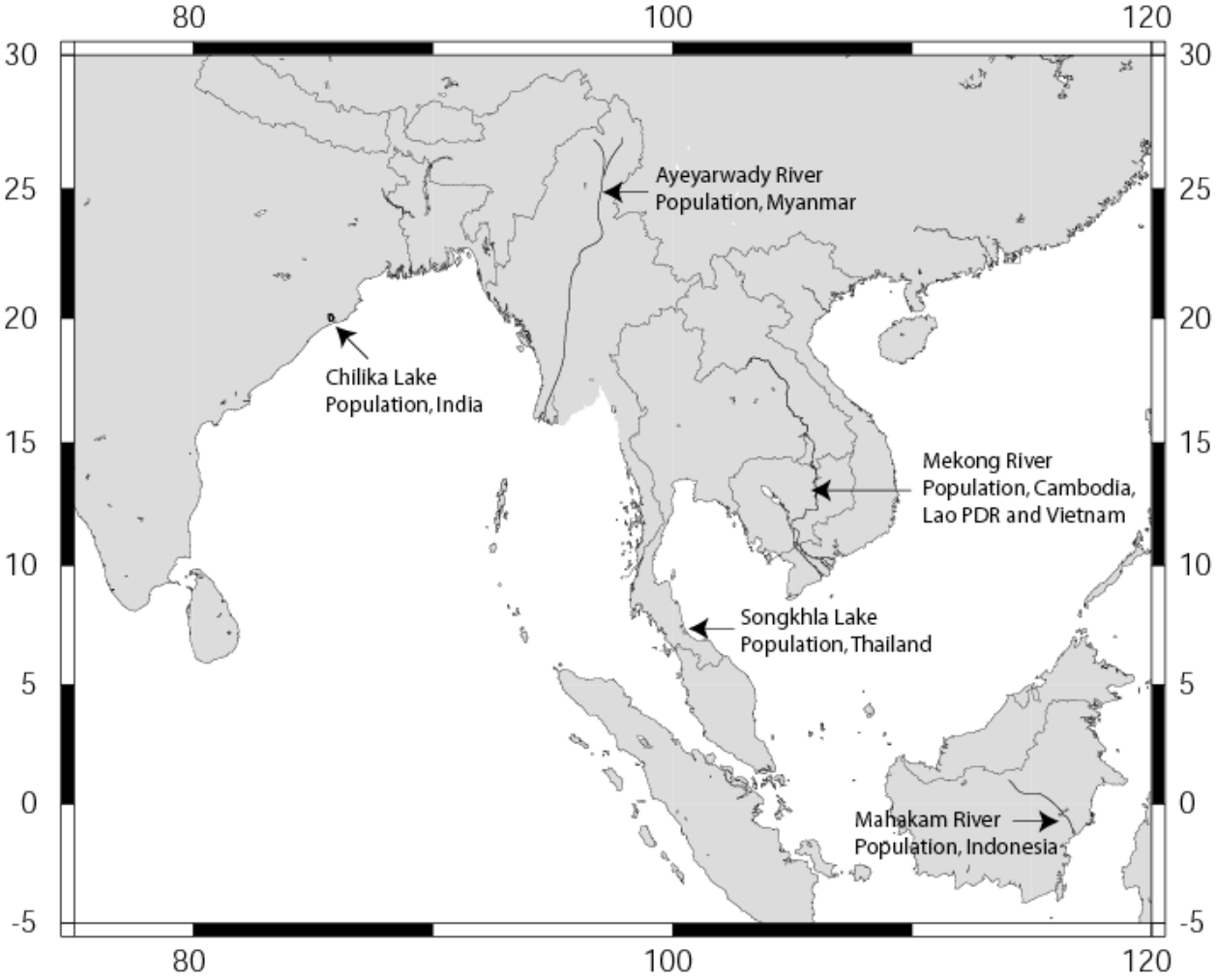
EXECUTIVE SUMMARY

Freshwater populations of Irrawaddy dolphins are threatened with extinction in the near future, and urgent conservation measures are required for their long-term survival. In contrast to the environmental preferences of other members of their species, which inhabit nearshore marine waters, these animals live far upstream in three large rivers (the Mekong in Cambodia, Lao PDR and Vietnam, the Mahakam in Kalimantan, Indonesia, and the Ayeyarwady in Myanmar) and in two brackish lagoons or marine appended lakes (Songkhla in Thailand and Chilika in India, Figure 1). Balancing the resource needs of local human communities with the survival requirements of these large, mobile, aquatic predators is a challenging task due to their restricted distribution in freshwater bodies which are already subjected to high levels of human use. The irony of their endangerment is that Irrawaddy dolphins are generally regarded positively by local people, probably due to their engaging social displays, role in cultural folklore, and in the Ayeyarwady River participation in a cooperative fishery with cast-net fishermen. This positive attitude enhances the potential for working with governments and local communities to find conservation solutions and generate local revenue through sustainable tourism.

The primary threat to most populations is incidental killing from gillnet entanglement. In the Mekong River of Cambodia gillnet entanglement accounted for 87% of the mean yearly, confirmed human-caused mortalities where the cause could be identified, representing at least 5.4% of the current estimated minimum population size. In the Mahakam River, gillnet entanglement accounted for 66% of the mean yearly recorded mortalities and 4.0% of the estimated population size. A particular fisheries problem threatening dolphins in the Ayeyarwady and Mahakam rivers is electrocution from illegal electric fishing. This non-selective fishing technique may also be causing declines in dolphin prey.

Habitat loss and degradation are caused by water developments, gold and coal mining operations, increasing sedimentation from dredging and shoreline development, and large numbers of fixed fishing gears that block access to large sections of the rivers and lagoons. The effects of these factors are difficult to quantify but may be substantial, especially when combined with mortality from fisheries bycatch. Chemical pollution from biocides used in shoreline aquaculture and agriculture, mercury and cyanide used in gold mining operations, and coal spillage from transport barges may be directly affecting the health of

Figure 1. Map showing the locations of the five freshwater populations of Irrawaddy dolphins.



certain populations and indirectly affecting them due to impacts on their prey. Vessel harassment and collisions may also be affecting some populations, particularly boat traffic associated with dolphin watching operations in the mouth of Chilika Lake and possibly in the Mekong River at the Lao PDR-Cambodia transborder and Kampi pools, while large coal transport barges in narrow tributary habitat interfere with dolphin movements in the Mahakam River.

Strategies for mitigating bycatch include: (1) establishing core conservation areas where gillnetting would be banned or severely restricted; (2) promoting net attendance rules and providing training on the safe release of entangled dolphins; (3) initiating a program to compensate fishermen for damage caused to their nets by entangled dolphins that are safely released; (4) providing alternative or diversified employment options for gillnet fishermen; (5) encouraging the use of fishing gears that do not harm dolphins by altering or establishing fee structures for fishing permits to make gillnetting more expensive while decreasing the fees for non-destructive gears; and (6) experimenting with acoustical deterrents and reflective nets.

Multiple-use protected areas will play a key role for conserving dolphins: (1) in the Mekong River, at nine deep pool areas between Kratie and the Lao PDR-Cambodia border; (2) in the Mahakam River, in 10-20 km segments in the Kedang Pahu tributary mouth at Muara Pahu Town, the mouths of the Kedang Kepala and Kedang Rantau tributaries, and the Pela tributary including the southern portion of Semayang Lake; (3) in the Ayeyarwady River, river segments between the Taping river confluence at Bhamo to the upstream end of the second river defile at Sinkan, the downstream end of the second river defile to Tagaung, and the downstream end of the third river defile at Kyaukmyaung to Mingun; (4) in Songkhla Lake, in the middle portion of upper Thale Luang; and (5) in Chilika Lake, in the area between Magamukh and the outer lake mouth.

Research and monitoring will be needed to guide and assess the efficacy of conservation interventions. Recommended methods for abundance estimation include mark-recapture analysis of photo-identified individuals and direct counts that incorporate measures to reduce sighting biases in the field and evaluate and correct them analytically. Recommended methods for evaluating dolphin mortality include interview surveys, carcass recovery programs, and direct counts of fishing operations known or believed to be responsible for dolphin deaths.

Freshwater populations of Irrawaddy dolphins can still be saved if appropriate conservation measures are urgently implemented. To conserve these populations it will be essential to closely involve local people in the development and implementation of conservation plans. This will require sufficient funds and a strong commitment from national governments and local and international NGOs.

INTRODUCTION

The idea for this volume emerged from the Workshop to Develop a Conservation Action Plan for Freshwater Populations of Irrawaddy Dolphins held 21-26 March 2005 in Phnom Penh, Cambodia. The volume aims to publicize the Action Plan and provide science-based justifications for urgent implementation of recommended priority actions. The volume contains the Action Plan for the Conservation of Freshwater Populations of Irrawaddy Dolphins, Report on the Workshop to Develop a Conservation Action Plan for Freshwater Populations of Irrawaddy Dolphins, and reviews of the conservation status of each of the five freshwater populations.

The Action Plan highlights common actions needed for all five populations and more specific actions needed for individual populations. The complexity of devising effective solutions to address the full range of threats to freshwater populations of Irrawaddy dolphins was beyond the scope of this workshop and also arguably beyond the capacity to finance with available funds. Substantial progress was made, however, on formulating some practical actions that must be taken to prevent extinction of these populations.

A recent positive development has been the substantial research progress on assessing the conservation status of all five freshwater populations of Irrawaddy dolphins. This has been made possible by the dedicated work of a relatively small group of local and international scientists and conservationists who were mostly present at the workshop. We are proud to present in this volume reports on the conservation status of all five freshwater populations. These reports gave us a strong foundation for productive discussions at the workshop and development of the Action Plan. All five reports underwent peer-review and were edited for consistency and style, but the content remained the responsibility of individual authors.

Between the time of the workshop and publication of this volume significant steps have been taken to implement recommended conservation actions for some populations. To preserve the accuracy of discussions conducted at the workshop we decided not to revise the workshop report post-hoc but to encourage authors of the conservation status reports on each population to include new developments in these documents, which they have done in this volume.

The strong progress made on devising and implementing conservation actions for freshwater populations of Irrawaddy dolphins gives us a measure of optimism about their survival. Given the perilous situation, the coming few years will be critical for successful conservation. We hope this volume will catalyze and guide ongoing and future work needed to ensure that these dolphin populations do not disappear from the rivers and marine appended lakes of Asia.

Brian D. Smith
Robert G. Shore
Alvin Lopez

ACTION PLAN FOR THE CONSERVATION OF FRESHWATER POPULATIONS OF IRRAWADDY DOLPHINS

Edited by Brian D. Smith, Robert G. Shore, Alvin Lopez, Isabel Beasley, Martin Gilbert, Kim Sokha, Kongkiat Kittawattanawong, Danielle Kreb, Hari Moelyono, Mya Than Tun, Or Channy, Ajit K. Pattnaik, Phay Somany, Chanthone Phothitay, Dipani Sutaria, and Tint Tun

The Action Plan below represents a consensus of range-state and international experts who participated in the Workshop to Develop a Conservation Action Plan for Freshwater Populations[1] of Irrawaddy Dolphins, 21-26 March 2005, Phnom Penh, Cambodia (Annex 2).

NOTING that all known freshwater populations of Irrawaddy dolphins are in immediate danger of extinction and that few actions have been taken to conserve them;

RECOGNIZING that these animals represent a rare evolutionary adaptation within the order Cetacea;

ACKNOWLEDGING that local people generally revere Irrawaddy dolphins and the animals play important roles in the folklore and cultural heritage of human communities;

UNDERSCORING that Irrawaddy dolphins make ideal flagship species for conserving other biodiversity elements of freshwater systems;

EMPHASIZING that mortality rates from incidental killing in gillnets and other non-selective fishing operations are unsustainable, and that additional threats from electric fishing, gold mining operations, vessel collisions and harassment, prey depletion from overfishing, and habitat exclusion from fixed fishing gears and sedimentation are increasing in some areas;

ACKNOWLEDGING recent progress made on assessing the status of populations and factors that threaten their survival; and

ENCOURAGED about the recent interest shown by governments and non-governmental organizations on implementing measures to protect freshwater populations of the species;

Workshop participants recommend the following measures, ordered according to rough priority, that apply to all freshwater populations:

RECOGNIZING that gillnet entanglement is the most critical threat facing most populations, we RECOMMEND that urgent actions be taken to reduce or eliminate this source of human-caused mortality. These actions may include; (a) providing alternative or diversified livelihoods for gillnet fishermen; (b) promoting net attendance rules and providing training on the safe release of entangled dolphins; (c) prohibiting gillnets in core areas of dolphin distribution; (d) establishing and enforcing appropriate mesh size, and net length and spacing regulations throughout dolphin ranges; and (e) altering or establishing fee structures for fishing permits to make gillnetting more expensive while decreasing or eliminating the fees for fishing practices that do not endanger dolphins (e.g., cast-net fishing).

[1] Freshwater populations are defined here as animals inhabiting a river system or marine appended lake or lagoon that are believed to be demographically isolated from members of the same species inhabiting marine waters. Irrawaddy dolphins from marine populations are often found several kilometers upstream of river mouths but the conservation of these animals is not addressed in this action plan.

EMPHASIZING that protected areas and core conservation zones within these areas will play an important role for conserving freshwater populations of Irrawaddy dolphins, we CALL ATTENTION to the need for the location, size and configuration of these areas to be based on sound biological knowledge of the populations they are intended to protect, and for strong and appropriate management structures to be put in place so intended conservation benefits can be realized.

ACKNOWLEDGING that consultations with local communities through workshops, informal meetings and interviews will be essential for devising and implementing effective conservation measures, we RECOMMEND that these activities be fully integrated into the conservation planning and implementation process and that particular effort be made to involve fishermen, religious leaders and women working in the fish trade.

ACKNOWLEDGING that coordination among government agencies involved with managing freshwater resources is essential for implementing effective conservation, we RECOMMEND that roles and responsibilities be clearly defined within a single comprehensive strategy for conserving each population.

NOTING the vital importance of transboundary approaches to conservation, we RECOMMEND that collaborative initiatives among government agencies and non-government organizations be implemented as a matter of priority. Our definition of transboundary is inclusive of cooperative efforts spanning multiple countries (i.e., Mekong River: Cambodia, Lao PDR and Vietnam) and national administrative units (e.g., provinces, districts, townships, etc.).

UNDERSCORING that the support of local people is essential for the long-term success of conservation strategies, we RECOMMEND that awareness raising programs be strengthened in areas where they exist and implemented in communities where they do not. Religious leaders will be key persons to enlist as allies in these efforts and it will be particularly important to provide educational materials in an appropriate format (e.g., colorfully illustrated booklets and posters produced in local languages).

RECOGNIZING that dolphin-watching tourism has become a significant threat to some populations due to harassment and the potential for vessel collisions, but also ACKNOWLEDGING that tourism activities could also have beneficial effects by providing sustainable financing to support conservation programs and local communities, as well as platforms of opportunity for monitoring populations and threats, we RECOMMEND that appropriate guidelines be developed in coordination with local people and responsible government agencies to ensure that dolphin watching operations are conducted in a manner that minimizes detrimental impacts and maximizes conservation and community benefits, and NOTE that the rationale behind dolphin tourism is dependent upon successful dolphin conservation.

ACKNOWLEDGING the continual need for assessing the effectiveness of measures taken to protect Irrawaddy dolphins, we RECOMMEND that programs be developed and supported to systematically monitor the status of freshwater populations. Monitoring techniques will need to be tailored to the individual popula-

tion and may include direct and concurrent counts, density sampling and/or photo-identification.

RECOGNIZING the difficulty of detecting abundance trends in very small populations, we RECOMMEND that threats also be directly monitored using appropriate techniques. These may include systematic counts of the incidences and numbers of non-selective fishing gears and gold mining operations, toxicological analyses of tissues from dolphin carcasses and prey, and documentation of geomorphic and hydrologic alterations to dolphin habitat.

NOTING the current lack of knowledge regarding Irrawaddy dolphin life history, survival and growth rates, we RECOMMEND that a standardized carcass and tissue collection and necropsy protocol be developed, and that carcass recovery programs be initiated. Close cooperation between scientists working with freshwater populations of Irrawaddy dolphins will be essential.

Workshop participants also recommend the following measures, ordered according to rough priority, that apply to individual populations:

AYEYARWADY RIVER POPULATION, MYANMAR

RECOGNIZING that electric fishing and accidental entanglement in gillnets are probably the most significant threats to Irrawaddy dolphins in the Ayeyarwady River and ACKNOWLEDGING the difficulties of providing effective protection from these threats throughout the entire range of the population, we RECOMMEND that a protected area be established in a 74 linear km river segment between Mingun and Kyaukmyaung where gillnetting would be eliminated or dramatically reduced and laws prohibiting electric fishing would be strictly enforced.[2]

EMPHASIZING the importance of local support for measures taken to conserve Irrawaddy dolphins, we RECOMMEND that workshops be conducted to solicit the input of fishermen, Buddhist monks and administrative authorities for developing a comprehensive management strategy for the proposed protected area and an annual review be made to assess conservation progress and plans.

ACKNOWLEDGING the cultural value of the cooperative fishery practiced between Irrawaddy dolphins and cast-net fishermen and its potential to contribute to conserving the Ayeyarwady population, we RECOMMEND that certification courses be conducted which would allow cast-net fishermen to take small groups of tourists with them while searching for the dolphins and engaging in cooperative fishing activities. Funds raised from this activity would be an enormous help to these generally impoverished fishermen and may also be an option to partially compensate local fisheries departments for lost revenue from permits no longer sold for gillnetting concessions as these are eliminated on a stepwise basis. Tourism activities will need to be strictly regulated so that they do not have detrimental effects on the animals.

[2] This protected area was declared by the Department of Fisheries, Myanmar, in December 2005 (Smith and Mya, this volume).

EMPHASIZING the economic significance of the human-dolphin cooperative fishery as a viable alternative to gillnetting, we RECOMMEND that the fishery be promoted by the Myanmar Department of Fisheries and cast-net fishermen be allowed to fish throughout the proposed protected area without being charged permit fees.

RECOGNIZING the vital role of monitoring and enforcement in the proposed protected area, we RECOMMEND that patrols be frequently conducted by a combined team of local police and officers of the Myanmar Fisheries and Forestry Departments during day and night hours and that intelligence be gathered from local villagers on compliance with fisheries regulations.

NOTING that a single protected area is unlikely to ensure the long-term survival of Irrawaddy dolphins in the Ayeyarwady River, we RECOMMEND that, after conservation measures have been have been established in the river segment between Mingun and Kyaukmyaung, additional core areas of dolphin distribution be considered for protected status including the river segments between Bhamo and the upstream end of the second river defile at Sinkan (36 linear km), and the downstream end of the second river defile and Tagaung (165 linear km).

CONCERNED about the potential impacts of gold mining operations on the geomorphology of the deep pools where Irrawaddy dolphins are generally concentrated and the harmful effects of noise produced by these operations and mercury and other toxic chemicals accidentally introduced into the river during the gold amalgamation process, we RECOMMEND that (a) large boat dredges and hydraulic land blasting operations be prohibited in and surrounding (particularly upstream of) the core areas of dolphin distribution described above, (b) educational materials be developed and distributed to mining companies and workers on how to safely handle mercury and other toxic chemicals and (c) simple and inexpensive retorts that recover the majority of mercury emissions be fabricated and promoted. Furthermore, we RECOMMEND that mercury and other toxic chemical levels be monitored in tissues of riverine fishes and in the livers of dolphins if carcasses become available.[3]

ENCOURAGED by the reverence expressed by local people for Irrawaddy dolphins, we RECOMMEND that this positive attitude be reinforced by distributing colorfully illustrated printed materials and videos on the conservation value and needs of dolphins to popular public places in riverside communities such as schools, teashops and cinemas.

NOTING the recent progress made on assessing the status of the Ayeyarwady population and the importance of evaluating the effectiveness of the protective measures proposed above, we RECOMMEND that the program of yearly systematic population and threat assessments conducted during the low-water season, which began in 2002, be continued, and a carcass recovery and necropsy program be initiated to assess mortality rates and causes.

[3] Later in 2005 the government of Myanmar banned gold mining in the Ayeyarwady River and subsequent surveys failed to find a single operation (Smith and Mya, this volume)

RECOGNIZING the cultural and ecological significance of the cooperative fishery between cast-net fishermen and Irrawaddy dolphins as a rare example of a mutualism between humans and wildlife, we RECOMMEND that an intensive investigation be conducted on the fishery, including elements related to animal behavior and the socio-economic contribution of the practice to local fishing communities.

CHILIKA LAKE POPULATION, INDIA

CONSIDERING that Chilika Lake supports the only freshwater population of Irrawaddy dolphins in the South Asian subcontinent and NOTING high mortality rates relative to the small size of the population, we RECOMMEND that a detailed conservation strategy be developed and executed collaboratively by the Chilika Development Authority, local communities, and the State Government Departments of Forest and Environment, Revenue, Tourism, Surface Transport, and Fisheries and Animal Resource Development.

EMPHASIZING that accidental killing in gillnets and prey depletion due to excessive fishing activity are increasing, we RECOMMEND that: (a) the Orissa Marine Fisheries Regulation Act and other fisheries regulations be strictly enforced; (b) alternative or diversified livelihoods be promoted among affected fishermen; (c) the area between Magamukh and the outer mouth of the lake, including Rajhans, be designated as a community wildlife reserve where gillnet fishing would be banned under provision of the Orissa Wildlife Protection Act; and (d) the number of deployed fishing gears be systematically monitored.

RECOGNIZING that unregulated tourism centered on dolphin watching presents a serious threat to the Chilika population due to vessel harassment and collisions, we RECOMMEND that a protocol and community-based program be established to prevent harmful practices. The protocol should include speed limits and a minimum distance of approach to the dolphins, limits on the number of vessels allowed to take tourists for dolphin watching, and the installation of propeller guards to prevent mortal injury to the animals. The community-based program should ensure that the benefits of dolphin watching operations are equitably distributed and that adherence to the mutually agreed upon protocol is enforced.

REITERATING the importance of awareness raising activities, we RECOMMEND that awareness and community-based monitoring programs be initiated to increase the knowledge of local people on the vulnerability of dolphins to human-caused threats and on measures that can be taken to protect them. The program should encourage compliance with proposed measures to regulate dolphin-watching activities (see above) and reporting of dolphin mortalities, illegal fishing operations, and unauthorized shrimp farms.

ACKNOWLEDGING that reliable information on the status and distribution of the dolphin population is critical for prioritizing conservation activities, and that monitoring is essential for assessing the effectiveness of conservation measures, we RECOMMEND that current research activities be strengthened, including population assessments and investigations on distribution patterns, environmental preferences, fishery interactions and causes and rates of mortality, and that a

study be initiated to establish the genetic identity and life history characteristics of the Chilika Lake dolphin population.

MAHAKAM RIVER POPULATION, INDONESIA

CONSIDERING that Irrawaddy dolphins in the Mahakam River are concentrated in relatively small river segments at tributary junctions where high mortality rates from gillnet entanglement have been documented, and that these areas play an important role for calf rearing, we RECOMMEND that core conservation zones be established at key river confluences inclusive of about 10 km extending in both upstream and downstream directions. Specific confluence areas requiring protection include: (a) the Kedang Pahu tributary mouth at Muara Pahu Town, including 20 linear km segments upstream in the main river and tributary; (b) the mouths of the Kedang Kepala and Kedang Rantau tributaries; and (c) the Pela tributary including the southern portion of Semayang Lake. Furthermore, we ADVOCATE that these zones be managed according to the priorities detailed below.

UNDERSCORING that gillnet entanglement is almost certainly the greatest threat to Irrawaddy dolphins in the Mahakam River, we RECOMMEND that a strict ban on gillnetting in the proposed core conservation zones be implemented on a step-wise basis as alternative gears or employment options are provided. This process will require extensive consultations with fishermen and their full involvement with implementation and monitoring of compliance.

NOTING that the depletion of dolphin prey may be an important factor threatening Irrawaddy dolphins, we RECOMMEND that fish reserves be established in spawning locations of the swamp lakes situated adjacent to the proposed core conservation zones. This measure would also contribute to sustainable fisheries management.

ACKNOWLEDGING that vessel traffic represents a significant threat to dolphins due to the potential for collisions and harassment, we RECOMMEND that a "no-wake" speed limit be established and enforced within the proposed core conservation zones. In addition, we RECOMMEND that large coal-carrying ships be excluded in the Kedang Pahu tributary and, if deemed appropriate after further study, a small channel be dredged in the southern portion of Semayang Lake to provide a movement corridor for dolphins to the Pela tributary, which connects the lake to the Mahakam mainstem.

REITERATING the critical threat posed by gillnet entanglement, we RECOMMEND that outside of the core conservation zones: (a) current regulations prohibiting the use of gillnets with a mesh size other than 10 cm be enforced; (b) additional regulations requiring net attendance and prohibiting nighttime fishing be adopted; and (c) a fund to compensate fishermen for nets damaged in the process of releasing entangled dolphins be established.

COMMENDING efforts by local communities to prevent illegal fishing activities through the establishment of river patrolling networks, we RECOMMEND that these activities be supported by local governments and repeat offenders remanded to the appropriate courts for prosecution.

ACKNOWLEDGING the ongoing need for community and political support for dolphin conservation, we RECOMMEND that existing environmental awareness campaigns be expanded to include the increased participation of fishermen, boatmen, women, schoolchildren and local and national political organizations.

RECOGNIZING that small-scale, well-regulated eco-tourism centered on dolphin watching may increase political and community support for establishing core conservation zones, we RECOMMEND that existing guidelines be enforced to ensure that dolphins are not adversely affected by any future tourism activities.

NOTING that long-term population trends must be monitored to assess the effectiveness of protective measures, we RECOMMEND that the current program of systematic surveys and investigations on mortality rates, residency patterns and home ranges be continued. Additionally, we SUGGEST that tissues be collected from recovered dolphin carcasses for analysis of bioaccumulating chemicals and to assess genetic viability of the population.

CONSIDERING the socio-economic costs of banning gillnets and the vital necessity of ensuring that dolphin entanglements are eliminated or dramatically reduced, we RECOMMEND that experiments be conducted to test behavioral responses of the animals to acoustic deterrents (i.e., pingers) and acoustically reflective gillnets (e.g., ones coated with barium sulphate).

MEKONG RIVER POPULATION, CAMBODIA, LAO PDR AND VIETNAM[4]

ACKNOWLEDGING significant progress on transboundary cooperation on conservation planning for Irrawaddy dolphins, we RECOMMEND that joint research (e.g., population and mortality assessments) and conservation (e.g., dolphin-watching management and alternative employment strategies for gillnet fishermen) initiatives be initiated as a matter of priority.

COMMENDING the development of the Cambodian "Royal Decree on Determination of Protected Areas and Conservation of Dolphin", we RECOMMEND that a series of discussions and workshops be initiated to ensure that local communities are fully involved with the development of management measures for the proposed protected areas.

RECOGNIZING the low-level of legal protection given to Irrawaddy dolphins and their habitat within Cambodia, we RECOMMEND that national fisheries legislation be finalized as a matter of priority, additional national wildlife legislation for protecting the dolphins developed, and support given for enforcing and raising local awareness of these laws. Particular attention should be paid to

[4] Several of these recommendations were adapted from the Ministry of Agriculture, Forestry and Fisheries, Department of Fisheries 2005. Cambodian Mekong Dolphin Conservation Strategy, unpublished report; and Lopez, A. 2005. The Cambodia – Lao PDR Transboundary Workshop for the Conservation and Management of the Mekong Irrawaddy Dolphins, 7-9 December 2004, Stoeng Treng, Cambodia, unpublished report.

regulating the use of gillnets so that accidental entanglements of dolphins are eliminated or dramatically reduced.

ACKNOWLEDGING the critical threat faced by Irrawaddy dolphins in the Mekong River from entanglement in gillnets, we RECOMMEND that a significant portion of the revenue from dolphin-watching tourism activities be used to support alternative employment options and sustainable development programs for gillnet fishermen living in villages adjacent to the core conservation zones proposed in the Royal Decree mentioned above.

EMPHASIZING the vital importance of local support for dolphin conservation and sustainable fisheries management, we RECOMMEND that community-based committees be established to support these goals. Several fisheries management committees have already been established in the Mekong in northern Cambodia and we ADVOCATE that these be further developed to include dolphin protection objectives.

NOTING that illegal fishing continues to threaten dolphins in the Mekong River, we RECOMMEND that regulations prohibiting electric and dynamite fishing be strictly enforced by responsible authorities. This will require frequent patrols during day and night, and close bi-national coordination between government agencies in the Lao PDR-Cambodia transboundary pool.

RECOGNIZING the need for all relevant agencies to be fully aware of and involved with the implementation of national legislation and activities aimed at conserving Irrawaddy dolphins, we RECOMMEND that education programs for government officials be strengthened, and cooperation facilitated through interagency workshops and informal discussions.

NOTING that intensive tourism activities centered on dolphin watching take place in two of the nine proposed core conservation zones of the Royal Decree mentioned above and that these operations may be having detrimental impacts on the dolphins, we RECOMMEND that appropriate regulations be developed, communicated to dolphin watching operators and enforced as a matter of priority. These regulations should include a speed limit for vessels operating in dolphin pools, a minimum allowable distance of approach to the animals, and restrictions on the number of dolphin-watching vessels that are allowed to operate simultaneously in the pools. Regulations that have already been developed and implemented in Kampi Pool provide a good model for those to be adopted elsewhere.

UNDERSCORING that long-term monitoring of the dolphin population is essential for establishing whether or not conservation activities have been successful, we RECOMMEND that yearly systematic abundance surveys be conducted during the low-water season using direct count and photo-identification methods. We also RECOMMEND that the current carcass recovery and necropsy program be continued, and that particular emphasis be given to determining the cause(s) for the apparent low survivorship of calves documented in recent years.

RECOGNIZING that local needs and perceptions will play an important role in

determining the success of conservation actions, we RECOMMEND that socio-economic surveys be periodically conducted using a standardized format so that results can be compared over time.

NOTING the lack of information on the effects of dolphin-watching boats on Irrawaddy dolphins in the Lao PDR-Cambodia transboundary and Kampi pools, we RECOMMEND that a study be conducted to compare dolphin behavior in these pools when vessels are present and absent, and in other pools where dolphin-watching vessels do not exist. The results of this study should be used to adaptively manage dolphin-watching operations so that no harm comes to the animals and to guide decision makers on whether or not these operations should be allowed in other pools where they currently do not exist.

SONGKHLA LAKE POPULATION, THAILAND

ACKNOWLEDGING that the abundance of Irrawaddy dolphins in Songkhla Lake probably numbers no more than 10-30 individuals, and that the current mortality rate is clearly unsustainable, we RECOMMEND that urgent actions be taken to eliminate deaths from entanglement in gillnets. These should include establishing a gillnet-free zone in the middle portion of upper Thale Luang and educating fishermen on how to safely release dolphins if the animals become entangled in gillnets set outside of this zone. Additionally, we RECOMMEND that non-destructive fishing gears and alternative livelihoods should be promoted among gillnet fishermen.

COMMENDING the designation of Irrawaddy dolphins in Songkhla Lake as a Royal Protected Species by Her Majesty Queen Sirikit of Thailand, and the adoption of the animals as the official mascot of the Phattalung Province, we RECOMMEND that the enthusiasm of local people for the animals be used to encourage the integration of dolphin conservation into the Master Plan for Development of the Songkhla Lake Basin. A major component of this plan is to conserve and rehabilitate natural resources and biodiversity including endangered wildlife species.

RECOGNIZING that the most immediate threat to the Songkhla population is bycatch in fisheries, we EMPHASIZE that measures must also be taken to improve habitat. These should include reducing sediment and chemical loads through changes in forestry, agriculture and aquaculture practices.

NOTING that the high mortality of calves documented for the Songkhla population may be due to high levels of persistent contaminants, especially those used as biocides in shoreline agriculture and shrimp farms, we RECOMMEND that alternatives to toxic biocides be promoted, prohibitions on the use of the 12 persistent organic pollutants (POPs) covered by the 2001 Stockholm Convention on POPs be enforced, and tissue samples be collected from all dolphin carcasses to investigate chemical concentrations.

UNDERSCORING the importance of cooperation among government agencies and non-government organizations, we RECOMMEND the creation of a collaborative Irrawaddy Dolphin Conservation Team with representation from the Irrawaddy

Dolphin Conservation Club and Departments of Marine and Coastal Resources, Fisheries and Forestry, and various other local agencies.

EMPHASIZING that the extremely high density of fixed fishing gears deployed in the middle and outer portions of Songkhla Lake has dramatically reduced available habitat for Irrawaddy dolphins and prevents any possible demographic interaction with members of the species inhabiting marine waters in the Gulf of Thailand, we **RECOMMEND** that these gears be substantially reduced in number, and a corridor be created to allow the animals to move freely in and out of the lake.

RECOGNIZING that visual, vessel-based density sampling or photo-identification techniques are unlikely to yield a reasonably precise estimate of dolphin abundance due to the low frequency of sightings, we **RECOMMEND** that alternative population assessment techniques be investigated, including aerial and acoustic surveys. We also **RECOMMEND** that the existing stranding network be strengthened to obtain better information on the rates and causes of mortality.

ACKNOWLEDGING the socio-economic importance and increasing ecological deterioration of Songkhla Lake, we **RECOMMEND** that information on environmental parameters and socio-economic conditions of lakeside human communities be gathered and registered in a geographic information system (GIS) for use by decision makers to manage natural resources in ways that provide adequate protection to Irrawaddy dolphins and their habitat.

REVIEW OF THE STATUS AND CONSERVATION OF IRRAWADDY DOLPHINS *Orcaella brevirostris* IN THE AYEYARWADY RIVER OF MYANMAR

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EXECUTIVE SUMMARY

The dry season range of Irrawaddy dolphins in the Ayeyarwady River has declined dramatically (by 488 km in river length or by 56.7% compared with historical reports), and the population size was estimated in December 2004 to number only 72 individuals.

Electric fishing was reported by local fishermen to be the greatest threat to the dolphins due to the direct effects from electrocution and indirect effects from prey depletion. Gillnet fishing was also identified as a probable threat due to the high number of gears (5,701) recorded during a survey of the entire length of the river in December 2002, and because the nets were present in higher frequencies in areas where dolphins were reported to occur historically but not observed during this survey.

During the December 2002 survey, 890 gold mining operations were recorded, including large boat dredges (15.8% of the total operations) and hydraulic land blasters (13.4% of the total operations). These operations cause excessive sedimentation in river channels, and mercury is used to amalgamate gold during the mining process. In December 2004, the mean mercury concentration in fish muscle tissues from 51 *Ompok* sp. was 182 ng/g (SD = 96, range = 82-684). Although this level is not dramatically high when measured against standards established for human consumption, the biomagnification potential of mercury and piscivorous feeding habits of Irrawaddy dolphins make pollution by this element a source of concern. Based in part on this analysis, in 2005 gold mining was banned in the Ayeyarwady River, and a survey in November 2005 recorded no gold mining operations in the river segment between Mingun and Kyaukmyaung. This was in contrast to the result of a similar survey in December 2004 that documented 73 large dredging operations in the same area.

Dolphins receive traditional protection by virtue of the positive role they play in a cooperative fishery practiced between the animals and cast-net fishermen in the river segment between Mingun and Kyaukmyaung. In December 2005, the Department of Fisheries, Myanmar, announced establishment of a protected area in this river segment. In collaboration with the Wildlife Conservation Society and Whale and Dolphin Conservation Society, the Department of Fisheries is currently in the process of implementing a long-term program for conservation management in the protected area with the intention of extending similar protection to other river segments that support relatively high densities of dolphins in the near future.

OVERVIEW OF POPULATION RANGE

During surveys of the Ayeyarwady River between Rangoon [Yangon] and Bhamo, Anderson (1879) observed Irrawaddy dolphins no farther downstream than Prome [Pyay] (about 360 km from the sea) during the low-water season and Yenanyoung (about 540 km from the sea) during the high-water season. Upstream, the local Shan people reported to Anderson (1879) that dolphins were never found upriver of a point 30 km above Bhamo, where the course of the river was interrupted by rocks. They called the site Labine, or "Dolphin Point." Anderson (1879) also reported that the dolphins ascended larger tributaries, such as the Taping, Khyendwen [Chindwin] and Shuaylee [Shweli], when these were in flood (Figure 1).

Figure 1. Map of Myanmar showing the Ayeyarwady River.

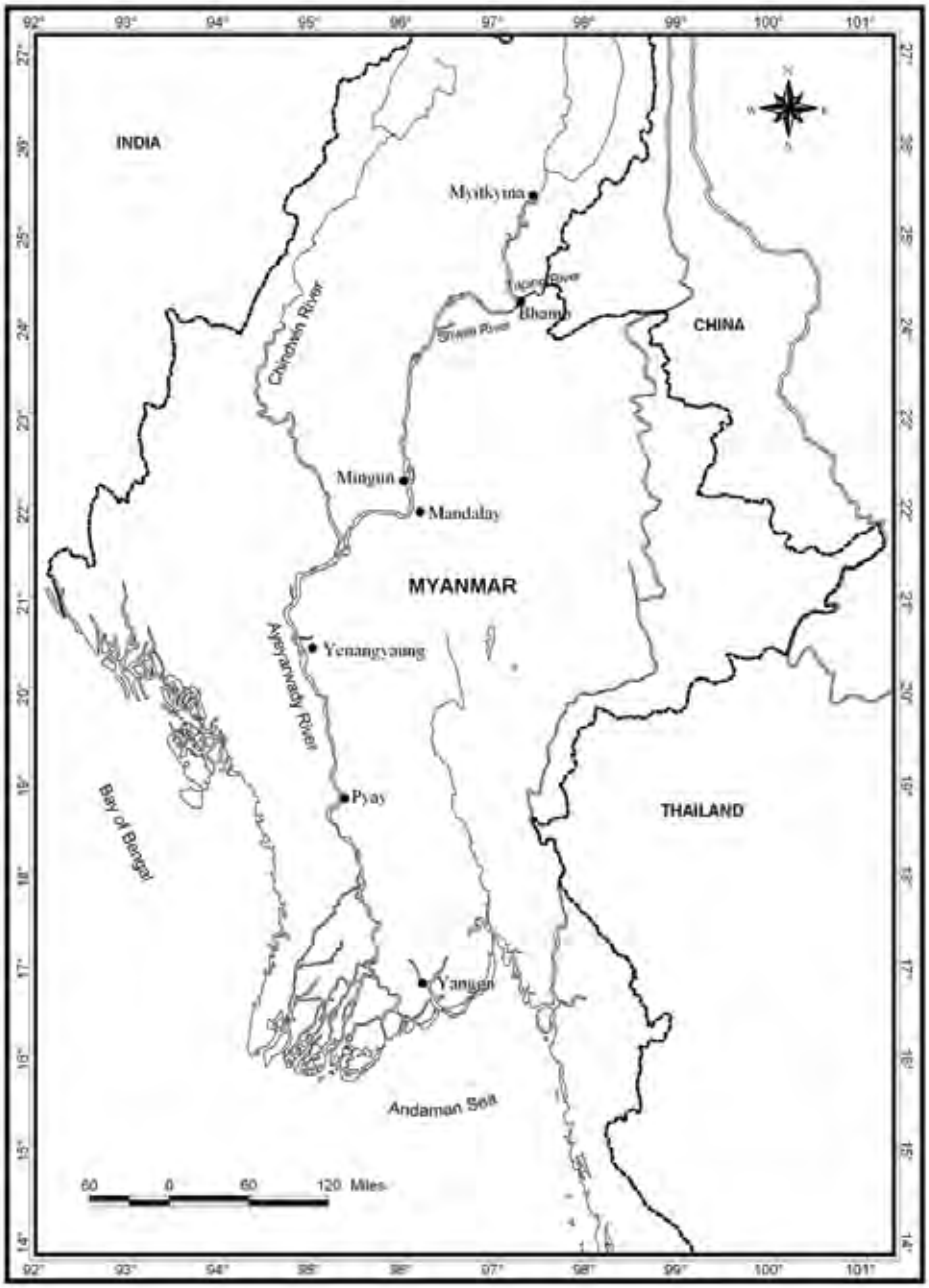
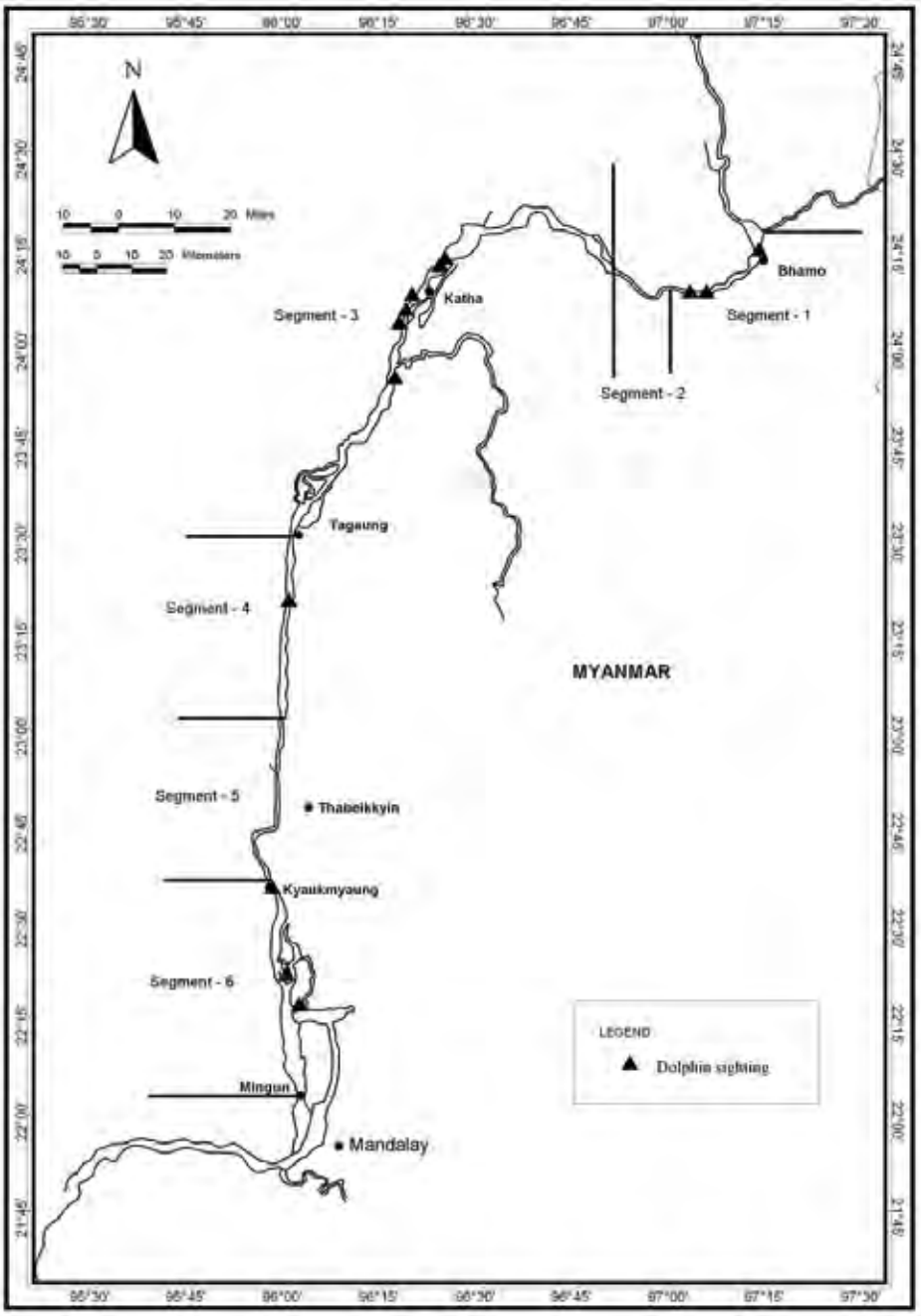


Figure 2. Map of the upper reaches of the Ayeyarwady River showing the locations of dolphin groups detected during the December 2004 upstream survey and the six geomorphically defined river segments summarized above.

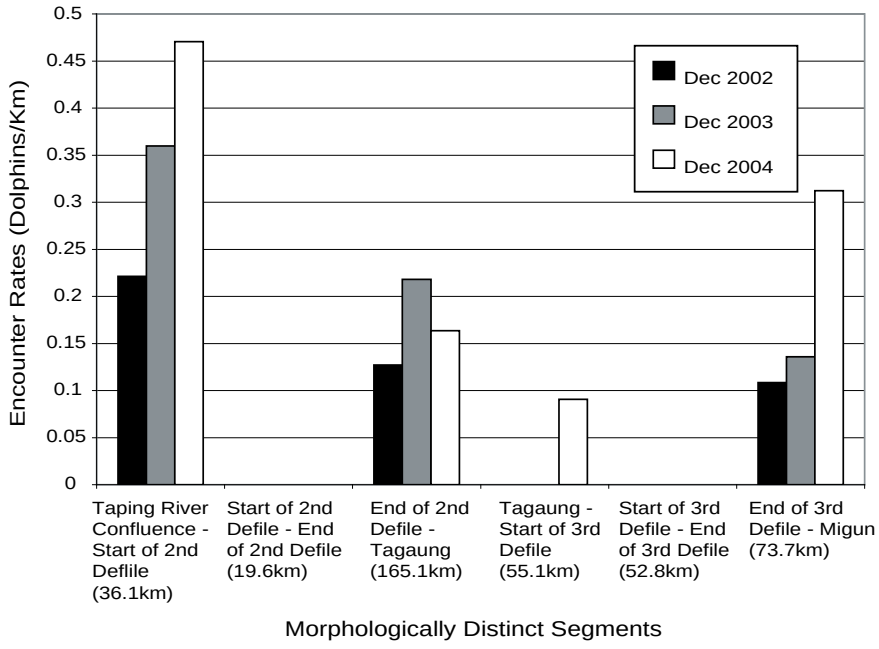


Based on a visual boat-based survey conducted in December 2002 of the entire length of the Ayeyarwady River (1,788 km of continuous trackline in the main channel and 202 km in side channels), the current dry-season distribution of the dolphin population is believed to be limited to a 398-km river segment located between Mingun (about eight km upstream of Mandalay and 970 km from the sea) and Bhamo (about 88 km downstream of the river's origin at the confluence of the Maykha and Maylikha rivers). Irrawaddy dolphins were reported to have occurred a few decades ago in Saiging (U Than Tun, Director General, Myanmar Department of Fisheries, pers. comm.), about 25 river km downstream of Mingun, and in Bagan (Leatherwood *et al.* 1984) about 200 river km downstream of Mingun. The species' range contraction in the Ayeyarwady River is discussed more fully in "Abundance and Trends" below.

HABITAT AND AREAS OF HIGH DENSITY OCCURRENCE

Dolphins in the Ayeyarwady are concentrated in geomorphically complex reaches upstream and downstream of channel confluences (especially at tributaries), islands, and defiles (where an alluvial channel becomes abruptly narrow and deep as it cuts through a mountain range). These conditions are present in three river segments that make up 69% of the total river length between Bhamo and Mingun: (1) the Taping river confluence at Bhamo to the upstream end of the second river defile at Sinkan (36 km); (2) the downstream end of the second river defile to Tagaung (165 km); and (3) the downstream end of the third river defile at Kyaukmyaung to Mingun (74 km), providing habitat for 22.6%, 50.0% and 24.4% of the total number of dolphins, respectively, observed (N = 168) during three surveys conducted between 2002-2004 (Figures 2 and 3). During these surveys only a single sighting of five individuals was observed outside of these river segments.

Figure 3. Encounter rates of Irrawaddy dolphins in six morphologically distinct river segments located between the Taping River confluence at Bhamo and Mingun during surveys conducted in December 2002-2004.



ABUNDANCE AND TRENDS

Direct count surveys have been conducted to assess the abundance of Irrawaddy dolphins in the Ayeyarwady River (Table 1). The best available information indicates a population size of 59-72 individuals, based on the sum of best group size estimates for upstream surveys conducted between Bhamo and Mandalay in December 2003 and December 2004. During both surveys sighting conditions were generally good. Measures were also taken in the field to increase sighting efficiency. These included using a team of trained and mostly experienced observers, three looking forward and one backwards on the main vessel and two looking forward on the smaller vessel, all alternating between searching with 7x50 binoculars and naked eye, and given sufficient rest to help keep vigilance high. The relatively narrow cross section of the main channel (mean = 434 m; SD = 203 m; range = 130–1,600 m; determined during the 2004 survey by laser range-finder readings, when the distances from the survey vessel to both banks were less than about 600 m and there were suitable reflective targets [e.g., steep sand slope, defile walls], or by visual estimation when these conditions were not met); and the limited deep water area within the cross-section where the dolphins were typically found (and where the vessel's survey path was confined) also ensured a high level of sighting efficiency.

Potential sighting biases were evaluated according to frequency distributions of linear sighting distances ahead of the survey vessel to the point of perpendicular alignment to dolphin groups (calculated from the product of radial sighting distances and the cosine of sighting angles relative to the bow of the survey vessel estimated at the time of detection) and group dive times recorded during the December 2003 and 2004 surveys. According to the distance estimates for dolphin sightings (N = 48), sighting frequency declined at around 236.4 m. Mean vessel speed was 9.6 km/hr or 2.7 m/sec, which means that on average it took 88.2 seconds to cover the 236.4 m distance where dolphins had a high probability of being detected (otherwise there would have been a decline in sighting frequency before this distance). Group dive times (N = 1,259) were recorded during 19 sightings (mean = 15.0 sec, range = 1–184, SD = 19.4). A frequency distribution of these times indicated that 98.6% of dolphin groups within this distance increment would be at the surface (i.e., 'available' for detection) at least once and, on average, during about six surfacings. The dolphins would also be available during the same number of surfacings while within the 236.5-472.9 m distance increment where the proportion of detections was 70% of the number detected at 0–236.5 m. This analysis indicated that during the 2003 and 2004 surveys sighting efficiency was relatively high and therefore the abundance estimates reasonably unbiased.

The increase in the number of dolphins recorded during the 2003 upstream survey (best estimate 59), compared to the 2002 downstream survey (best estimate 37; Table 1), can probably be attributed to the slower speed of the survey vessel and the increased visual coverage of downstream facing tributaries and braided channel confluences (where the dolphins were often found) while surveying in an upstream direction. This hypothesis is supported by similar differences in the number of dolphin groups observed during surveys in upstream and downstream directions between Mandalay and the Shweli River confluence in

Table 1. Survey details for Irrawaddy dolphins in the Ayeyarwady River.

Dates	River Segment, Distance and Direction	Mean Vessel Speed (km/hr)	Number of Observers	Number of Dolphin Groups	Encounter Rates	Sum of Best-High-Low Estimates of Group Size	References
March & April 1996	248km of non-continuous trackline between Saigaing (Ava) Bridge and Ma U Village, concentrated in a 27km segment between Mandalay and Shin Hla	10.2km/hr	2 in the front	3	0.012 groups/km; 0.048 dolphins/km	12-14-9	Smith ***et al.*** (1997)
December 1996	206km heading upstream from Mandalay to the Shweli tributary confluence	6.8km/hr	3 in the front	5	0.024 groups/km; 0.063 dolphins/km	13-14-13	Smith ***et al.*** (1997)
December 1996	193km heading downstream from the Shweli tributary confluence to Mandalay	11.9km/hr	3 in the front	2	0.010 groups/km; 0.036 dolphins/km	7-8-7	Smith ***et al.*** (1997)
December 1996	99km heading downstream from Mandalay to Bagan	8.2km/hr	3 in the front	0	----------	0-0-0	Smith ***et al.*** (1997)
January & February 1998	360km heading downstream from Bhamo to Mandalay	13km/hr	3 in the front and one in back	14	0.039 groups/km; 0.164 dolphins/km	59-70-55	Smith and Hobbs (2002)
November & December 2002	1,787km in the mainstem heading downstream from the confluence of the Maykha and Maylikha rivers to the Gayetgyi Island in the delta and 201km in side channels from a smaller vessel along the way.	11.4km/hr in the main vessel and 10.4 in the small vessel	2 independent teams of 3 in the front and two in the small vessel	8 (all in a 373km segment of the mainstem above Mandalay)	0.021 groups/km; 0.100 dolphins/km*	37-47-33	Smith (2003)

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Table 1. Survey details for Irrawaddy dolphins in the Ayeyarwady River.

Dates	River Segment, Distance and Direction	Mean Vessel Speed (km/hr)	Number of Observers	Number of Dolphin Groups	Encounter Rates	Sum of Best-High-Low Estimates of Group Size	References
December 2003	420km in the mainstem heading upstream from Mandalay to Bhamo and 120km in side channels from a smaller vessel along the way	7.8km/hr in the main vessel and 8.2km/hr in small vessel	3 in the front and 1 in the back on the main vessel and 2 in the smaller vessel.	16 (all in the mainstem)	0.038 groups/km; 0.140 dolphins/km	59-83-51	Smith (2005a)
December 2003	414km in the mainstem heading downstream from Bhamo to Mandalay	11.1km/hr	3 observers in front and 1 in the back	10	0.024 groups/km; 0.104 dolphins/km	43-50-40	Smith (2005a)
December 2004	425.2km in the mainstream heading upstream from the Saigaing Bridge to Bhamo and 103.5km in side channels from a smaller vessel along the way.	9.6km/hr in the main vessel and 9.6 km/hr in the small vessel	3 in the front and 1 in the back on the main vessel and 2 in the smaller vessel.	13 (all in the mainstem except for one group of 6-7 individuals)	0.031 groups/km; 0.169 dolphins/km	72-76-65	Smith (2005b)
December 2004	426.3km in the mainstem heading downstream from Bhamo to the Saigaing Bridge and 118.6km in side channels from a small vessel along the way.	12.4km/hr in the main vessel and 14.3km/hr in the small vessel	3 in the front and 1 in the back on the main vessel and 2 in the smaller vessel.	10 (all in the mainstem except one group of 3 individuals)	0.023 groups/km; 0.077 dolphins/km	33-35-31	Smith (2005b)

* Encounter rate calculated only for the 373km segment above Mandalay.

December 1996 (Smith *et al.* 1997) (five and two, respectively) and during the 2003 surveys themselves (16 and 10, respectively) (Smith 2003). The increase in the number of dolphins recorded during the 2004 upstream survey (best estimate 72) compared to the 2003 upstream survey may reflect the greater searching efficiency of a more experienced team (several members participated in all three surveys), random variation due to variable sighting frequencies (see Smith and Reeves 2000b), the possibility that one or more groups were double counted if they moved upstream of the vessel when the survey was suspended during the night (a sighting was indeed made late in the afternoon on one day and another sighting with an identical group size estimate (8) was made early the next), or a small increase in population size.

An abundance trend cannot be deduced from available data, but there is clear evidence of a major reduction in this population's range. If the absence of sightings downstream of Mingun is interpreted to mean that this is the range limit for the species, this would indicate a range decline of 488 km in river length (or 56.7%) compared with the historical distribution reported by Anderson (1879) and that the distance from the nearest reported record of this species in the delta is almost 1,000 km. Irrawaddy dolphins are known to occur in the Ayeyarwady Delta, with 31 sightings (mean group size 2.4, SD = 1.5, range = 1-5) documented during patrols by rangers at the Manmahla Kyun Wildlife Sanctuary in 2003 (U Soe Lwin, Chief Warden, Manmahla Kyun Wildlife Sanctuary; pers. comm.). However, it seems highly unlikely that there is demographic connectivity between animals inhabiting estuarine waters and those inhabiting the Ayeyarwady River above Mingun.

The three longest distances recorded between dolphin sightings during the November-December 2002 downstream survey (172 km, 124 km, and 33 km), the December 2003 upstream survey (120 km, 89 km, and 23 km), and the December 2004 upstream survey (92 km, 89 km, and 79 km) suggest that the remaining population is fragmented to some extent and that opportunities for interaction among dolphin groups are limited (at least during the dry season), thereby contributing to projected future population declines. The relatively high percentage of calves observed during the 2003 and 2004 surveys, 15.3% and 12.5% respectively, indicates that the population probably has the capacity to increase if human-caused mortality is reduced.

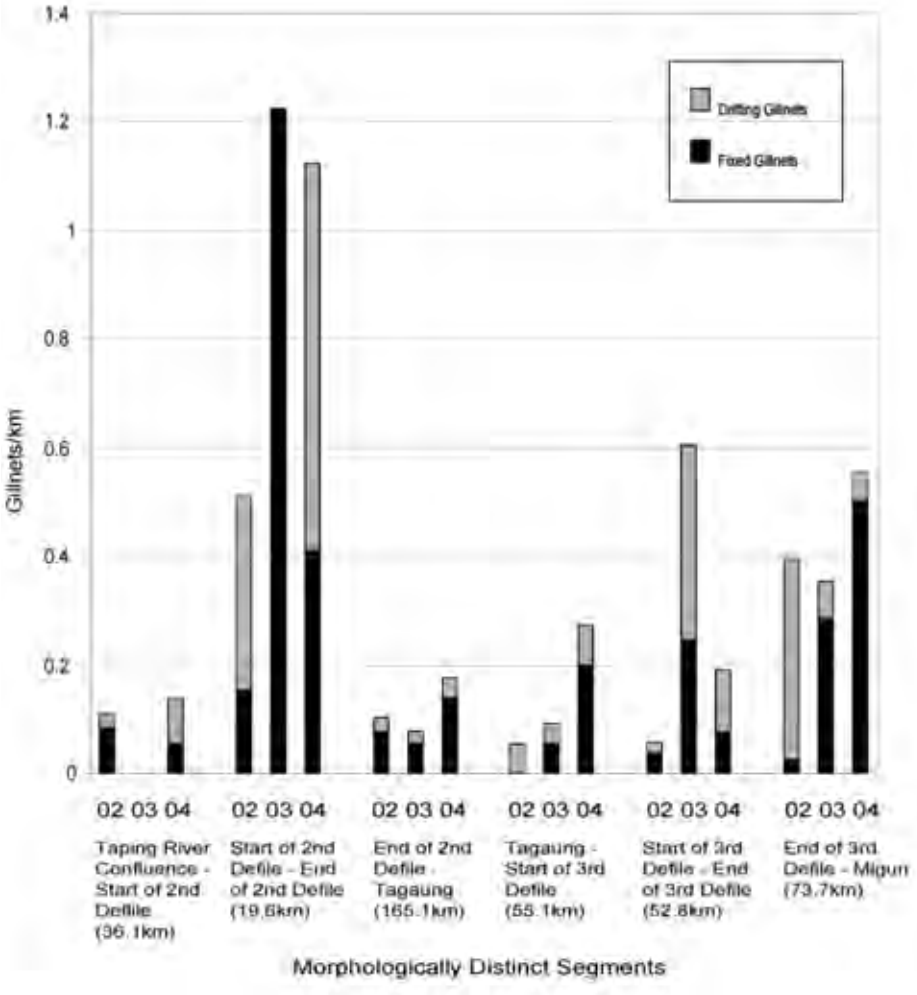
CURRENT AND POTENTIAL FUTURE THREATS

During interviews conducted in 2005, Department of Fisheries officials, fish contractors and local fishermen reported that electric fishing represents the greatest threat to dolphins in the Ayeyarwady due to the risk of electrocution. Several fishermen stated that fish catches had declined substantially since electric fishing became widespread several years ago and that dolphins now avoided certain areas because the animals were afraid of being shocked. Electric fishing is popular in the Ayeyarwady because the equipment is relatively inexpensive (and the battery can be used in the home for other purposes), needs little maintenance (unlike nets, longlines, bamboo traps and fishing fences which require constant repair), and results in relatively large catches with little effort. Electric fishing has been cited as being responsible for the largest number of recent known deaths of the baiji *Lipotes vexillifer*, a "Critically Endangered" dolphin

in the Yangtze River of China, and has come to be regarded as the main anthropogenic threat to the survival of that species (Zhang *et al.* 2003).

Smith (2003) recorded a total of 5,701 fishing gears in the main channel of the Ayeyarwady during the November-December 2002 survey. Gill nets accounted for the majority of gear clusters (defined as a grouping of gears within 500 m of the first one observed; 57.4%) and, if sticks with small multiple hooks are excluded (which were used mostly downstream of dolphin distribution and were not regarded as a threat to the animals), the majority of individual gears (53.5%). Gill nets were also the most widespread gear in terms of their distribution throughout the river, and there was a significant positive relationship between gillnet encounter rates (i.e., number of gears observed each day) regressed against downstream progress on the survey (df = 19; fixed gillnets P = 0.0176, F = 6.8321, R^2 = 0.2750; drifting gillnets P = 0.0002, F = 20.7149, R^2 = 0.5351). Within the river segment between Bhamo to Mingun 66, 100 and 122 gillnets were recorded during the 2002-2004 surveys, respectively, which suggests that the use of gillnets has increased in intensity during this period (Figure 4).

Figure 4. Encounter rates of gillnets in six morphologically distinct river segments located between the Taping River confluence at Bhamo and Mingun during surveys conducted in December 2002-2004.



Wherever gillnets and cetaceans occur together there will be entanglements and mortality (see International Whaling Commission 1994). The fact that gillnets were present in higher frequencies in areas where dolphins were reported to historically occur, but were not observed during the 2002 survey, implies that these fishing gears are at least partially responsible for the range decline of the species. During interviews conducted in December 2005 fishermen reported observing at least two dolphins becoming entangled in a large-mesh gillnet and dying. Large-mesh gillnets used to catch large fish were thought to represent the greatest danger to the dolphins but apparently this type of net is rarely used in the river section where dolphins occur (Smith and Mya 2006).

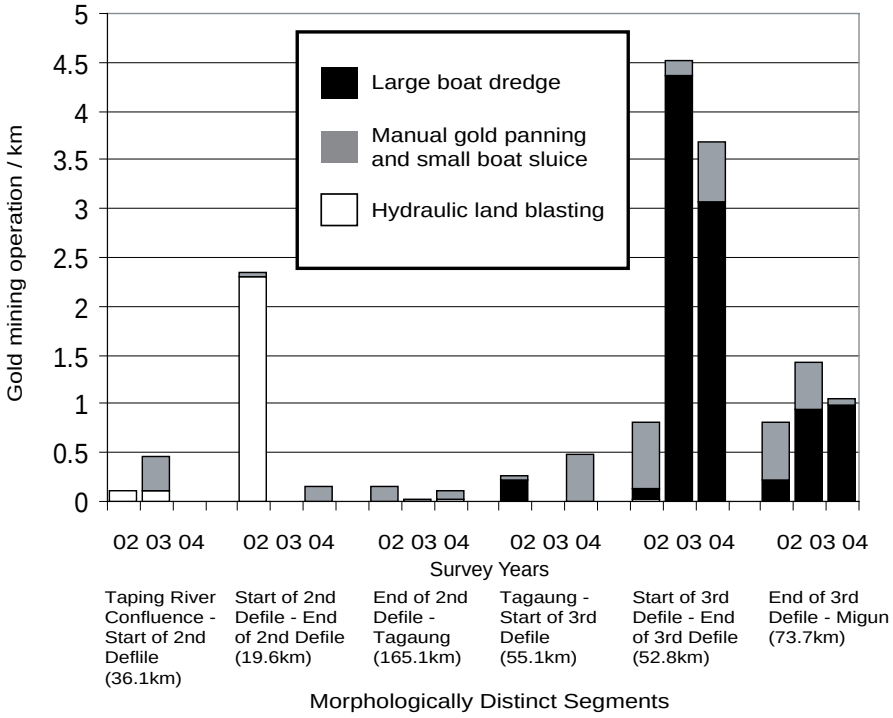
For small cetaceans it is generally recommended that yearly removals not exceed 1-2% of the population size (Wade 1998) – the lower bound being more applicable to very small populations that are already vulnerable to extirpation due to demographic, genetic and other factors. If there are only about 72 animals in this population (the highest 'best' estimate of abundance from December 2004 survey; Table 1), any more than a single death every one or two years from human activities may be unsustainable.

During the all-river survey conducted in 2002 (see above), Smith (2003) recorded a total of 890 gold mining operations (180 in the river segment where dolphins were recorded and 506 above the downstream extent of their range in Mingun), concentrated primarily in areas of reduced current, above and below defiles and near channel convergences – the same areas that constitute the preferred habitat of Irrawaddy dolphins. Large boat dredges (15.8% of the total operations) and hydraulic land blasters (13.4% of the total operations) introduce, break up, and redistribute large quantities of gravel and fine sediments. This causes major changes in the geomorphologic and hydraulic features of river channels that make them suitable for dolphins. These operations are also very noisy, which may disturb or displace dolphins, or interfere with their ability to navigate, detect and catch their prey and communicate.

During surveys in 2002-2004 of the Bhamo to Mingun river stretch, 25.8% of the total number of recorded gold mining operations (N = 935) were located in the Kyaukmyaung to Mingun segment, with large boat dredges positioned just downstream of the third river defile accounting for 78.6% of these (Figure 5). During the 2004 survey of the river segment between Mingun and Bhamo, encounter rates of all operations were slightly lower (12%) than recorded during the 2003 survey, primarily due to the 22% decrease in the number of large boat dredges, particularly those located in the third defile. However, the total number of large boat dredges was still much higher (690%) than the number recorded in 2002 survey. Similar to results from the 2003 survey, of particular concern was the high concentration of large boat dredges in the third defile, which contained 163 dredges (encounter rate = 3.1/km), and between the end of the third defile at Kyaukmyaung and Mingun, which contained 73 dredges (encounter rate = 1.0/km).

Gold mining operations in the Ayeyarwady use mercury (Hg) to amalgamate the gold. Benthic bacteria process mercury into highly toxic methylmercury (CH_3Hg+ or MeHg). The bacteria are then consumed by other aquatic organisms and the methylmercury bioaccumulates up the food chain or is released, absorbed by phytoplankton, and reintroduced into the food chain by aquatic

Figure 5. Encounter rates of gold mining operations in six morphologically distinct river segments located between the Taping River confluence at Bhamo and Mingun during surveys conducted in December 2002-2004.



herbivores (Krabbenhoft and Rickert 1996). Methylmercury bioaccumulates to the highest levels in wildlife that feed high up the food chain, and piscivorous animals (i.e., fish eaters) are at the greatest risk of toxic effects (Environmental Protection Agency 1997). A study of stranded bottlenose dolphins in the Atlantic Ocean found liver abnormalities associated with elevated mercury accumulation (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.

During a survey in December 2004 between Mandalay and Bhamo, 61 samples of fish muscle tissue were collected (51 of *Ompok* sp. and 10 of *Crossocheilus burmanicus*). The mean mercury concentration for the *Ompok* specimens was 182 ng/g (SD = 96, range = 82-684), and for the *C. burmanicus* samples was 30 ng/g (SD = 18, range = 15-75). Similar to the results from samples collected in 2002 (see Smith 2003), *Ompok* fish did not have dramatically elevated levels. However, the measured concentrations were high enough to give reason for concern about their potential effects on piscivorous wildlife and humans. Three of the *Ompok* samples (5.8%) were above the 300 ng/g limit established for human consumption by the United States Environmental Protection Agency and one sample was above the 500 ng/g standard set by the World Health Organization. It is important to note that these criteria are human-based and assume that fish are only a small portion of an individual's diet. The United States Fish and Wildlife Service is currently defining a mercury concentration effect level for the prey of piscivorous wildlife, and it will prob-

ably be set at around 100 ng/g (Darell Slotton, Department of Environmental Science and Policy, University of California, Davis, pers. comm.). Forty nine of the *Ompok* samples (or 96% of the total) were above this level. This is significantly higher than the levels recorded for *Ompok* fish during the 2002 investigation when only one out of 26 (or 4% of the total) samples of *Ompok* tested for mercury was above 100 ng/g.

In early 2005, based in part on the mercury results reported above, the government of Myanmar banned gold mining in the Ayeyarwady River. During a dolphin monitoring survey in November 2005, no gold mining operations were observed in the river segment between Mingun and Kyaukmyaung (Smith and Mya 2006). This contrasts with observations made in December 2004 of 73 large boat dredges and four manual sluice operations (Smith 2005b). A note of concern about mercury levels in the Ayeyarwady, however, is that these are also determined by gold mining operations located in tributaries. It will therefore be important to continue the existing mercury monitoring program because intensification of gold mining activities in areas outside the river mainstem could potentially cause mercury levels to increase to toxic levels.

There are no known plans to construct dams in the Ayeyarwady River or its major tributaries in Myanmar, however, Department of Fisheries officers in Bhamo reported that one or more dams in the Taping River upstream of the Myanmar/China border were causing reduced flow during the dry season. Dolphins have been observed in the deep pool area at the Taping and Ayeyarwady confluence during all three surveys conducted in 2002-2004, and these animals represent the farthest upstream range of the species. If flows are further reduced it could result in habitat loss and a decline in the upstream range of the dolphin population in the Ayeyarwady.

LEGISLATION, FISHERIES REGULATIONS AND PROTECTED AREAS

Irrawaddy dolphins are protected from deliberate killing by The Protection of Wildlife and Conservation of Natural Areas Law, 8th June, 1994. Penalties for violation of the law are imprisonment for a term which may exceed five years or a fine which may exceed 30,000 kyat (ca. US $30), or both.

In December 2005, the Myanmar government announced the establishment of a protected area for Irrawaddy dolphins in a ca. 74-km segment of the Ayeyarwady River between Mingun and Kyaukmyaung. Key provisions of Fisheries Notification No. 11/2005 include requiring fishermen to immediately release dolphins if found alive and entangled in their nets, prohibiting the catching or killing of dolphins and trade in whole or parts of them, and prohibiting the use of gill nets that obstruct the water-course, are more than 300 feet (91.4 m) long, or spaced less than 600 feet (183.9) apart. Also in December 2005, Fisheries Notification No. 10/2005 was announced which prohibits the use of electricity to catch fish.

RESEARCH AND CONSERVATION ACTIVITIES

Anderson (1879) conducted visual surveys and solicited reports from colonial government officials about the distribution of Irrawaddy dolphin in the Ayeyarwady River system (see above). He also carried out a detailed anatomical

and morphological study of two adult male specimens which led him to classify the Ayeyarwady population as a separate species, *Orcella* [sic.] *fluminalis*. Subsequent authors (Thomas 1892; Weber 1923; Lloze 1973; Pilleri and Gihr 1974) rejected Anderson's arguments and the population is currently considered synonymous with *O. brevirostis*. Thein (1977) recounted reports from local fishermen that dolphins in the Ayeyarwady were "summoned by acoustical means, of fishermen tapping the sides of their wooden fishing boats with the handle of oars" and that the animals "swam around the boats in large circular movements, in ever diminishing circles, until the driven fish rushed wildly into the nets."

The first modern surveys were conducted in March-April 1996 by Smith *et al*. (1997) who searched along 248 km of non-continuous trackline in the upper reaches between the Sagaing (Ava) Bridge and Ma U Village, concentrating mostly in the approximately 27-km segment between Mandalay and Shin Hla. They observed only three dolphin groups (estimated 12 individuals). The same researchers returned in December 1996 and conducted a continuous survey divided into three components: (1) upstream from Mandalay to the Shweli confluence (206 km), (2) downstream from the Shweli confluence to Mandalay (192.6 km), and (3) downstream survey from Mandalay to Bagan (99 km). During the entire survey, they recorded 11 dolphin groups (estimated 37 individuals). On the basis of sightings made during the upstream survey, 16 dolphins were estimated as the minimum count for the Mandalay to Shweli confluence segment. During February 1998, Smith and Hobbs (2002) surveyed 360 km from Bhamo to Mandalay. They observed 14 dolphin groups and estimated the minimum population size as 59 individuals.

Starting in 2002, the Department of Fisheries, Myanmar, and the Wildlife Conservation Society (WCS) initiated a collaborative research project to assess the distribution, abundance, and factors threatening the population of Irrawaddy dolphins in the Ayeyarwady River (Smith 2003, 2005a, 2005b; Smith and Mya 2006). During 2005 the focus of this project was expanded to include the establishment of one or more protected areas for the dolphins. In December of the same year, the first of these protected areas was announced by the Department of Fisheries, Myanmar, in the river segment between Mingun and Kyaukmyaung (see above).

Management plans for the protected area will capitalize on the already positive attitude of fishermen to the dolphins by promoting a cooperative fishery practiced between Irrawaddy dolphins and cast-net fishermen. Fishermen search for dolphins and summon them by tapping the sides of their boat with a conical wooden pin called a *Labai Kway*. If the dolphins "agree" to help the fishermen, one animal slaps the water surface with its tail flukes. One or two lead dolphins then swim in smaller and smaller semi-circles, corralling the fish towards the shore, while the other animals remain outside to guard against escapees. With a wave of their half-submerged flukes, the dolphins then deliver a concentrated mass of fish to the fishermen and "signal" them to cast their net. The dolphins are believed to benefit from this activity by preying on fish whose movements are confused by the sinking net and those that are momentarily stuck on the mud bottom after the net is pulled up.

Within the protected area there are at least 47 cast-net fishing teams that fish cooperatively with dolphins (17-18 in Mytkangyi, 10-11 in Mayazun and 20 in Sein Ban Gone). This number is almost certainly an underestimate due to the lack of interviews with cast-net fishermen residing in other villages and towns along the river (e.g., Singu, Shwe Hlay, Hsithe, Htone Gyi, Hmaw Oo and Indown). The cast net fishermen reported earning about 50,000 kyat per month (ca. US$50) from fishing. They reported that a good catch while cooperating with dolphins was about 16.5 viss (27.2 kg) per day and a good catch while fishing without dolphins was about 3 viss (5.0 kg) per day. Most fishermen said that they fished every day in good weather, and that during the prime time of the cooperative fishing season (between November and January) they were able to engage the dolphins to fish cooperatively with them on about 50% of the fishing days (Smith and Mya 2006).

The Myanmar Department of Fisheries will be the lead agency for implementing the protected area, with technical and financial support provided by WCS, the Ocean Park Conservation Foundation, the Whale and Dolphin Conservation Society, and the Blue Moon Fund. The proposed management plan for the protected area includes the following components:

Education and Consultation

1) A series of workshops will be conducted with local communities and government authorities to solicit their input on management of the protected area and to educate them on the status of the dolphins, factors that threaten them, and measures needed to prevent their extinction. Information will also be given on the close connection between dolphin conservation and sustainable fisheries and on opportunities for fishermen to diversify their employment.
2) Colorfully illustrated printed materials and videos on the conservation value and needs of dolphins will be distributed to schools, teashops and cinemas in riverside communities.
3) A participatory approach will be taken to ensure that the socio-economic impact of establishing the protected area is positive for local communities.

Regulation and Enforcement

1) The cooperative fishery practiced between the dolphins and cast-net fishermen will be promoted by allowing cast-nets to be used throughout the proposed protected area without being charged permit fees. Also, efforts will be made to reduce or eliminate the number of gillnets being used in the protected area by altering fee structures for fishing permits to make gillnetting more expensive.
2) Local and national authorities will be lobbied to pass and enforce regulations to prohibit large boat dredges and hydraulic land blasting used for gold mining from operating in the protected area.
3) Frequent patrols will be conducted during day and night hours with a combined team from the Myanmar Fisheries and Forestry Departments and local police officers to educate fishermen on fisheries regulations and enforce compliance among repeat offenders.

Economic Development

1) Certification courses will be conducted for cast-net fishermen to take small groups of tourists with them while searching for the dolphins and engaging in cooperative fishing activities. Funds raised from this activity will be an enormous help to these generally impoverished fishermen and may also be an option to partially compensate local fishery offices for lost revenue from permits no longer sold for gillnetting concessions as these are eliminated on an incremental basis. Tourism activities will need to be strictly regulated so that they do not have detrimental effects on the animals.
2) A support network will be created to market and coordinate dolphin watching trips among tourists visiting Mandalay and Mingun.
3) Pending the availability of funds and manpower, efforts will also be made to educate local fishermen on other options for diversifying their income (small-scale aquaculture, mushroom farming, etc.).

Research and Monitoring

1) The program of yearly, systematic population and threat assessments that began in 2002 will be continued.
2) A carcass recovery and necropsy program to assess mortality rates and causes will be initiated.
3) An intensive investigation will be conducted on the human-dolphin cast-net fishery, including elements related to animal behavior and the socio-economic contribution of the practice to local fishing communities.
4) Fishermen will be interviewed before and after an initial two-year period to test whether there was a change in their awareness about dolphin conservation and on how the project may have affected their livelihoods.

LIST AND DESCRIPTION OF CONSERVATION PARTNERS AND MANAGEMENT AUTHORITIES

Department of Fisheries, Myanmar
The Department of Fisheries, Myanmar, has been engaged in research activities on freshwater dolphins in the Ayeyarwady River since 2002. They are strongly committed to conserving the populations and the human-dolphin cooperative fishery.

Wildlife Conservation Society (WCS)
WCS has been conducting wildlife conservation activities in Myanmar since 1994 and played key roles in establishing Lampi Island Marine Park, Hkakabo Razi National Park, Hukaung Valley Tiger Reserve and the newly established Ayeyarwady Dolphin Protected Area..

Whale and Dolphin Conservation Society (WDCS)
WDCS has been involved with conserving freshwater cetaceans in Asia for more than 15 years and has supported research, training and awareness raising projects for all five freshwater populations of Irrawaddy dolphins.

Ocean Park Conservation Foundation (OPCF)
OPCF has supported research projects for all five freshwater populations of Irrawaddy dolphins and provided funds for the first modern survey of the Ayeyarwady populations in 1996. More recently OPCF provided funds for establishment of the protected area between Mingun and Kyaukmyaung.

National Geographic Conservation Trust (NGCT)
NGCT provided funds to assess the feasibility of establishing a protected area for Irrawaddy dolphins and the human-dolphin cast-net fishery in the Ayeyarwady River.

Blue Moon Fund
The Blue Moon Fund provided funds for establishing the protected area between Mingun and Kyaukmyaung.

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REVIEW OF THE STATUS AND CONSERVATION OF IRRAWADDY DOLPHINS *Orcaella brevirostris* IN CHILIKA LAGOON OF INDIA

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EXECUTIVE SUMMARY

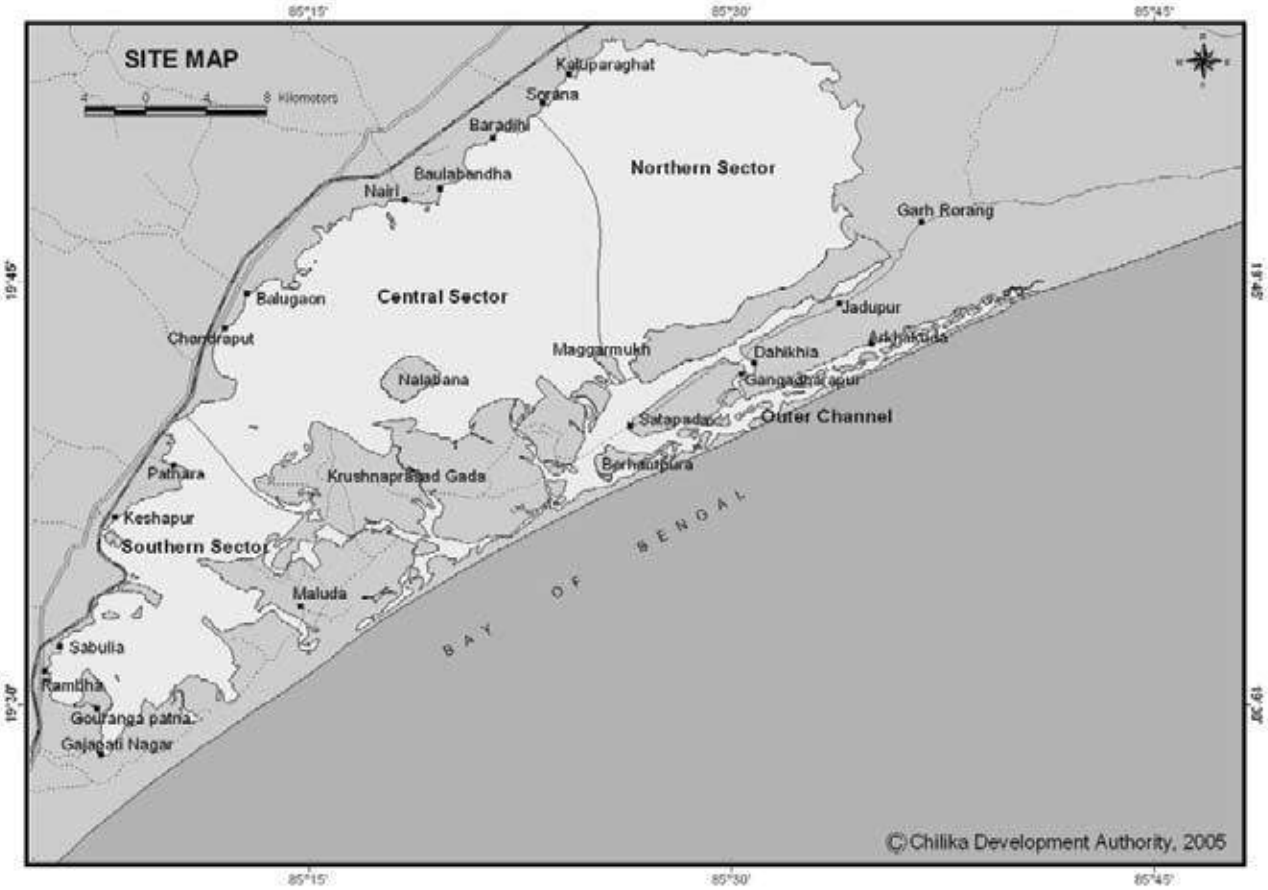
Chilika Lagoon (or lake) is located along the east coast of India and it is the country's largest marine appended brackish water body. The lagoon was declared a Ramsar site in 1981, and it is recognized as one of the most significant hotspots for aquatic biodiversity in Asia. The lagoon supports a "freshwater" population of Irrawaddy dolphins *Orcaella brevirostris* that appears to be isolated from coastal marine waters. Based on direct count surveys conducted in 2003-2006 the population size was estimated to be 85 individuals (SD = 18.5, range = 62-98), distributed primarily (65%) in the outer channel (13 km^2 and 30 km^2 of habitat during low and high tides, respectively) with the remaining population inhabiting the central and southern sectors (178 km^2 of habitat). The main threats to the population are from entanglement in fishing gears and collisions with mechanized boats. Research projects initiated by the Chilika Development Authority in 2002 and the School of Tropical Environment Studies and Geography at James Cook University (JCU) in 2004 focus on investigating the distribution and abundance of Irrawaddy dolphins, the factors that threaten their survival, and the perceptions of local people towards the animals. This information will be used to develop a long-term, participatory management plan that will include training boat operators on safe conduct around dolphins and increasing participation of lagoon stakeholders in the conservation process. Destructive fishing practices that pose a threat to both the ecosystem and the dolphins will be addressed by a task force from the Forest, Fishery and Revenue Departments of the Government of Orissa.

OVERVIEW OF POPULATION RANGE

Irrawaddy dolphins occur along the east coast of India from Vishakhapatnam in the south to Calcutta in the north (James *et al.* 1989). The species was first recorded in Chilika Lagoon (Figure 1) by Annandale (1915). There is a published record of a carcass in Gahirmatha, approximately 250 km north of the Chilika lagoon mouth (James *et al.* 1989). Irrawaddy dolphins have also been recorded further north in the Sundarbans Delta of West Bengal. To the south Irrawaddy dolphins were recorded in Madras where a live animal stranded in 1977 (Miller 1997). Five carcasses of Irrawaddy dolphins have been documented by Khan (unpublished) along the Orissa coast since 2001, two in Gahirmatha, two from seven km south of the Devi River mouth, and one from nine km north of the Chilika Lagoon mouth (Figure 2).

To investigate if Irrawaddy dolphins are moving in and out of the lagoon, the Chilika Development Authority (CDA) conducted visual surveys from a land-based station totalling more than 700 hrs of search effort during November 2002 through March 2005. No dolphin movements through the channel were detected. The mouth of the lagoon is about 250 m wide so visual coverage was considered complete. Sutaria (unpublished) conducted 84 semi-structured interviews in six fishing villages in the vicinity of the lagoon mouth. No respondent reported observing or hearing about Irrawaddy dolphins moving in or out of the lagoon, however, Indo-Pacific humpback dolphins *Sousa chinensis* and bottlenose dolphins *Tursiops sp.* were reported to sometimes venture from the sea into the lagoon mouth.

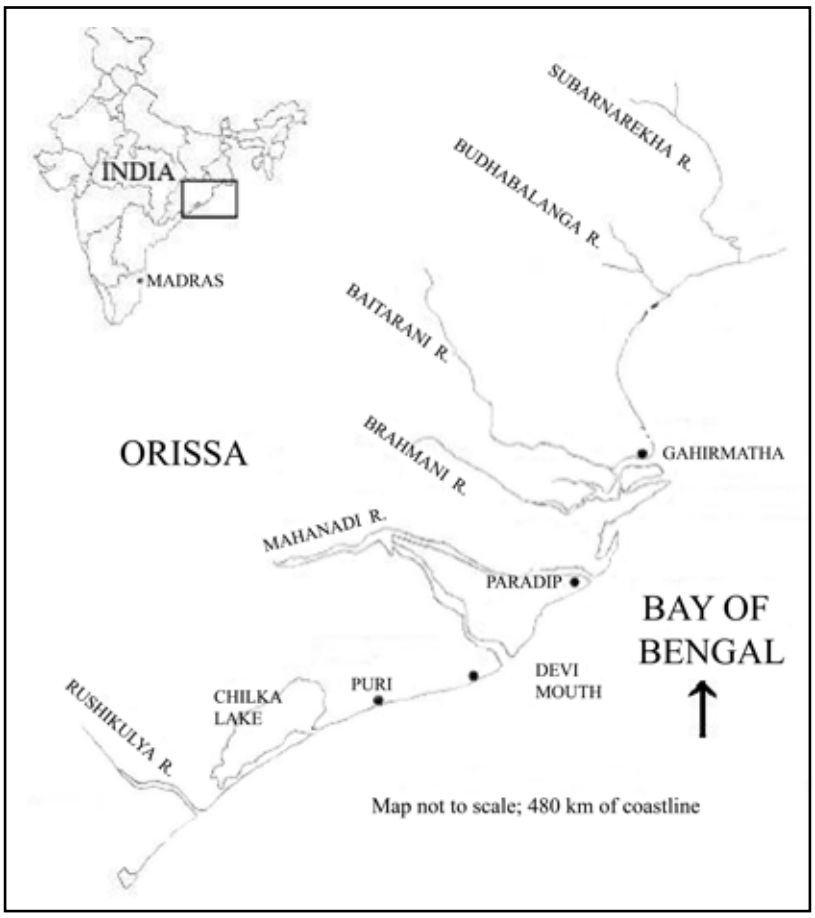
Figure 1. Map of Chilika Lagoon showing the four ecological sectors: southern, central, northern and outer channel.



Sutaria (unpublished) conducted a coastal survey to search for Irrawaddy dolphins along the Orissa coast during 6-21 December 2004. A zig-zag transect line was followed in one direction while the return trip surveyed along the shore. The survey covered a total of 770.3 km during 89 hours of search effort extending six kilometers offshore. Depth in the study area ranged from 2.7 to 33.1 m (Mean = 14.1, SD = 6.1) and salinity from 18 to 34 ppt (Mean = 23, SD = 2.47). In February 2005, Sutaria (unpublished) surveyed the Mahanadi, Devi, Subernekha and Bhubdabalanga River mouths during 10, 15, 20 and 17 km of search effort, respectively. In March 2005 Sutaria (unpublished) collaborated with the Orissa Forest Department Trawler Monitoring Team to survey along 42 km of trackline over 11.7 hours in and around the Brahmani and Baitrani river mouths north of Chilika Lagoon. During all three surveys, no Irrawaddy dolphins were observed, however, four other cetaceans were documented, including three groups of Indo-Pacific humpback dolphins, one group of spinner dolphins *Stenella longirostris,* one group of bottlenose dolphins *Tursiops aduncus* or *T. truncatus*, and one group of finless porpoises *Neophocaena phocaenoides*.

Based on evidence from visual and interview surveys, the Irrawaddy dolphin population in Chilika Lagoon is considered to be isolated from other individuals of the species occurring in coastal marine waters. This raises important issues about the long-term viability of the population in the face of relatively high mortality and low abundance (see below).

Figure 2. The coastline of Orissa showing the main rivers flowing into the Bay of Bengal.



HABITAT AND AREAS OF HIGH DENSITY OCCURRENCE

Chilika Lagoon was created by the accretion of coastal sediments following the stabilization of sea levels 3,000-4,000 years ago. The submerged area varies between 850-1,100 km^2 according to monsoon rains and tidal fluctuations. The spit that separates the lagoon from the Bay of Bengal is 1.5 km wide and 60 km long. Fresh water input comes from 52 rivers and streams entering the northwestern portion of the lagoon. Tidal fluctuation is about 0.2 to 0.5 m. Due to its rich biodiversity and socio-economic importance, Chilika Lagoon was designated as a Ramsar site in 1981.

During monthly surveys the highest concentrations of dolphins were found in the outer channel, followed by the central and southern sectors of the lagoon (Figure 1). These areas are not as affected by the intensive fisheries or submerged vegetation which prevent the dolphins from using potential habitat in the northern sector of the lagoon. Dolphins in the outer channel have approximately 13km^2 and 30km^2 of lagoonal habitat available to them during low and high tides, respectively, and about 173 km^2 in the central and southern sectors. Dolphins have been recorded in the lagoon at depths of 0.3 – 5.0 m, temperatures of 18.8-34.5°C, salinities of 0.2-37.1 ppt, turbidities of 3-98 NTUs, and pHs of 7.9 to 8.9.

The outer channel currently supports about 65% of the entire dolphin population while the central and southern sectors support the remaining individuals. The outer channel has been identified as a primary habitat for focal conservation attention based on the relatively high density of dolphins found there throughout the year, followed by the central and southern sectors. The distribution of the dolphins seems to change seasonally within the different sectors of the lagoon but this needs further research.

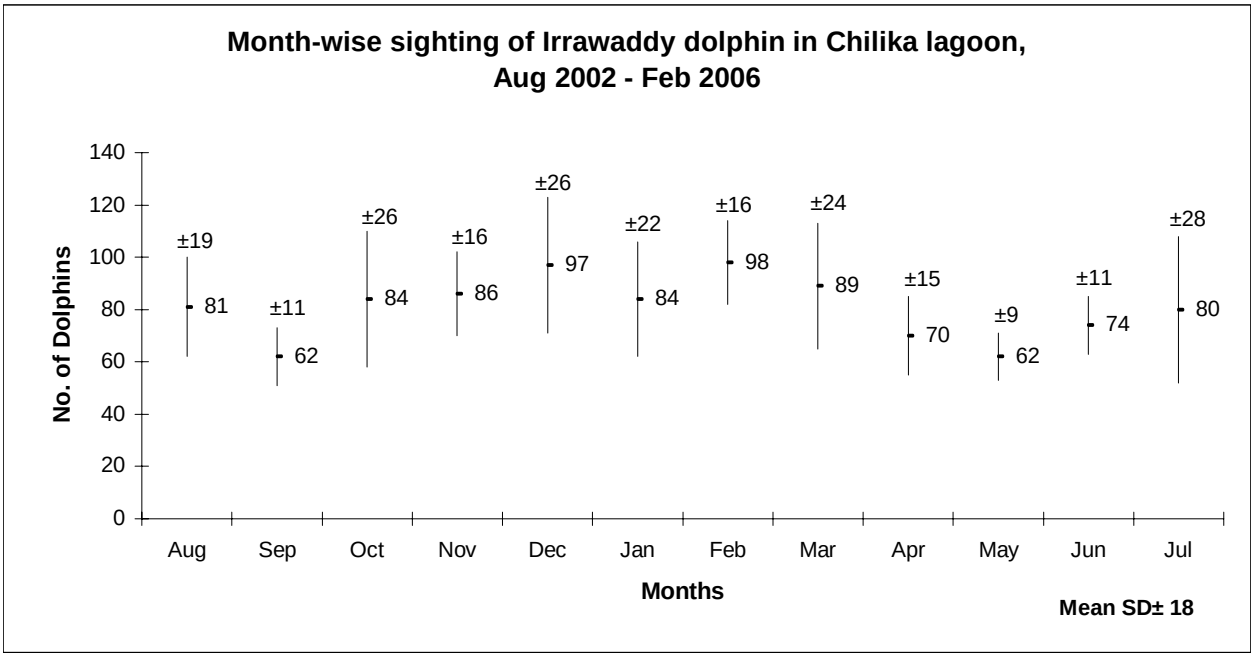
ABUNDANCE AND TRENDS

Surveys conducted by Sinha (2004) suggested that the Irrawaddy dolphin population in Chilika Lagoon could number as few as 50 individuals. Starting in August 2002, the CDA began a comprehensive study on the status of the population. Monthly, vessel-based surveys employed a four-member team comprised of three observers and one data recorder. One observer was positioned at the bow searching ahead, and one observer each on the port and starboard sides searching in an estimated 2.5 km survey strip (or to the point of closest land) at an average speed of 10 km/hr. A dedicated recorder registered information on search effort, dolphin sightings and environmental parameters including depth, salinity, pH and turbidity. The transect lines were designed to uniformly cover all the sectors of the lagoon at roughly 5 km intervals When dolphins were sighted, group sizes were estimated and the GPS locations and environmental parameters recorded. Surveys were carried out only in Beaufort conditions 3 or less. Population size was estimated to be 85 individuals, based on the mean number of dolphins recorded during the monthly direct count surveys (SD = 18.5, range = 62-98) conducted during 2003-2005. The mean group size was 5.0 individuals (SD= 5.5, range = 10-37). The apparent seasonal variation in sighting frequencies (Figure 3) was probably related to changes in survey conditions, from Beaufort 0 – 2 in October through March to Beaufort 2-4 in April through September.

CURRENT AND POTENTIAL FUTURE THREATS

Forty-five Irrawaddy dolphin carcasses were recovered from Chilika Lagoon between August 2002 and February 2006, or about 13 per year, which represent 15% of the total population size estimated at 85 individuals. Of the total number of carcasses, 29 (64.4%), 12 (26.7%) and 4 (8.9%) were from the outer channel, central and southern sectors, respectively. Thirty-four (75.6%), six (13.3%) and five (11.1%) were adults, sub-adults and calves, respectively. Eighteen (40.0%), 18 (40.0%), and nine (20.0%) were males, females and unconfirmed, respectively. The probable causes of death were believed to be due to entanglement in fishing gears (16 (35.6%)), collisions with mechanized boats (16 (35.6%)) and undetermined (13 (28.8%)). The number of recovered carcasses appeared to increase during the winter season (October to February), which coincides with both the peak tourist and fishing seasons. The major identified threats were the extensive use of 4-12 cm mesh size gill nets and collisions (and probably also disturbance) from mechanized boats, particularly those used for dolphin-watching tourism.

Figure 3. Means and standard deviations of the results of monthly direct count surveys conducted during August 2002 to February 2006.



The large numbers of large and medium mesh-size gill nets operating in the lagoon, particularly in the outer channel, are a source of major concern due to the high mortality of dolphins caused by entanglement in these nets. Although fixed trap nets do not directly cause dolphin mortalities, they obstruct free movement in the northern and central sectors and outer channel of the lagoon, and occur in such high densities in the northern sector that they preclude inhabitation by dolphins. Enclosures for prawn culture (*gherries*) cover about 130 km^2 of littoral waters, thus reducing the amount of habitat available for the dolphins. These enclosures also result in the loss of nursery and breeding habitat for lagoonal fishes thereby reducing the recruitment of dolphin prey and economically important fishes.

More than 350 mechanized boats are operated for dolphin watching tourism. The potential for collisions, especially when boat drivers are pressured by tourists to get closer to the animals, is high. Dolphins have been observed with injuries consistent with being hit by the propellers of these boats, especially in the outer channel where most dolphin watching activities take place.

Although there are no major sources of industrial pollution to the lagoon, the extensive use of agrochemicals in adjacent fields and large inputs of raw sewage and wastewater from peripheral villages and towns may pose significant problems for biodiversity in the absence of appropriate management measures.

LEGISLATION, FISHERIES REGULATIONS AND PROTECTED AREAS

Irrawaddy dolphins are protected under the Indian Wildlife (Protection) Act 1972, wherein all cetaceans are included under Schedule I. The penalties for violation of the law are imprisonment for a term which shall be not be less than three years but which may extend up to seven years. There is also a fine, which shall be not less than 10,000 Indian Rupees (US$220). For the second and sub-

sequent offenses the term of imprisonment is the same but the fine increases to 25,000 Indian Rupees (US$550).

Fisheries are regulated under the Orissa Marine Fisheries Regulation Act of 1982 and Orissa Marine Fisheries Rules of 1983. Fishing is banned during December and January, and gillnetting is prohibited throughout the year in the outer channel, where the dolphins are most concentrated. To regulate the movement of boats inside the lagoon, the Orissa Boat Rule was enacted in March 2004. Under this rule, boats inside the lagoon need to be licensed and display their registration number affixed at a prominent place on the boat. This helps the concerned task force to monitor the movement of tourism vessels, particularly the outer channel.

RESEARCH AND CONSERVATION ACTIVITIES

The CDA has developed (1) a visitor centre at Satapada that targets tourists who come to the lagoon for dolphin watching, and includes realistic models of the dolphins and interactive computer exhibits about their conservation; (2) media materials including pamphlets, stickers and posters for educational outreach to local fishermen, school children and tourism boat operators; and (3) a dolphin-safe watching protocol for visitors and boat operators which is promoted in the pamphlets mentioned above. To reduce dolphin mortalities from vessel interactions, the CDA has (1) put together a task force to monitor dolphin watching activities; (2) collaborated with the Indian Institute of Tourism and Travel Management and World Wildlife Fund - India to provide training to about 240 boatmen on safe conduct around dolphins; and (3) designed and tested propeller guards. The CDA is currently working with tourism operators to install these guards on their boats. Discussions have also been held in local communities to inform fishermen about fisheries regulations that apply to the lagoon and why these are necessary for protecting fish and the dolphin populations.

Due to excessive sedimentation caused by deforestation and land use changes in the catchment area, the connecting channel between the lagoon and the Bay of Bengal shifted 17 km north and became much smaller, resulting in dramatic declines in biological productivity and diversity in the lagoon. Decreased salinity promoted the spread of fresh water aquatic weeds (*Eichhornia crassipes*, *Azolla pinnata* and *Potamogeton pectinatus*) from an estimated coverage of 20 km^2 in 1973 to almost 400 km^2 in 1993. Aquatic plant coverage reduced the feeding and breeding grounds of several economically important fishes and further reduced the flushing of sediments from the lagoon. These considerations led to Chilika Lagoon being placed on the Montreux Record of the Ramsar Convention in 1993 due to changes in its ecological character.

In response to this ecological crisis, in September 2000 an artificial mouth of 200 m wide was dredged through the sandbar at a location seven kilometers from Satapada to facilitate the exchange of sea water. A lead channel of 3.2 km was also dredged near Magarmukh for flushing sediments. This latter channel is 1.5-1.8 m deep, although some parts passing through the former channel are as deep as four meters. Documented changes that have occurred since these channels were dredged include restoration of tidal and salinity fluxes,

reappearance of several economically valuable fishes, and a reduction in the rate of weed expansion. Fish, prawn and crab yields increased by more than 400%, and the Irrawaddy dolphins expanded their range to regularly include the central and southern sectors. In 2002, Chilika Lagoon was removed from the Montreux Record and, in the same year, the CDA was awarded the Ramsar Wetland Conservation Award. In collaboration with the Wetlands International South Asia Program, the CDA monitors hydrobiological parameters with the overall objective of adaptively managing freshwater and salinity regimes for the benefit of native biological diversity and productivity. In September 2005, the Palur channel mouth that flows into Chilika in the southeast was also dredged to facilitate tidal exchange and the recruitment of fish, prawns, and crabs in the southern sector of the lagoon.

Sutaria has been holding frequent discussions with fishing communities and tourist boat operators to gain an understanding about their attitudes towards the dolphins and to develop participatory strategies for protecting the Chilika population. A meeting was held in October 2005 among concerned persons representing tourist associations, fishermen, conservation NGOs, CDA and the Orissa Forest Department to develop plans for reducing dolphin mortality from net entanglement and vessel collisions. Follow-up meetings are planned for finalizing a comprehensive strategy.

Future research activities to be conducted by the CDA, JCU and the Indian Institute of Technology-Delhi aim to (1) monitor dolphin group composition in different seasons and areas, (2) photo-identify dolphins to assess abundance, movements and habitat use, (3) investigate whether or not dolphins in Chilika Lagoon are genetically distinct, and (4) study feeding habits through analyses of the gut content of carcasses and development of a fish otolith reference collection.

The CDA is working together with the Japan International Cooperation Agency, United Nations Development Program, and the India-Canada Environment Facility to develop alternative livelihood projects for gill net fishermen that focus on increasing the value of fisheries products. These include crab grow-out pens and dry fish preparation. Capacity building for offshore fisheries will also be promoted to decrease the pressure on tourism and lagoonal and coastal fisheries.

Meetings and discussions among the CDA and Forest Department Authorities, NGOs and tourism associations are planned to raise their awareness about dolphin-safe watching practices. Eco-guides will be placed on each tourism vessel to provide information about the dolphins and the lagoon environment. Nature trails and observation stations for observing dolphin groups from land are also planned.

The Orissa State Fisheries Department will form a task force composed of officials from the Forest, Police, Fisheries and Revenue Departments to intensify action against destructive fishing nets and gears operated in the outer channel, consistent with the Orissa Marine Fisheries Regulation Act of 1982.

The success of all current and future conservation activities will depend on how receptive the local community is to these requests and enforcement efforts and on the scope of long-term economic benefits for the local community. It will be important to maintain a continuous flow of communication between the local communities, scientists and the enforcement agencies to sustain the population of dolphins in the lagoon.

LIST AND DESCRIPTION OF CONSERVATION PARTNERS AND MANAGEMENT AUTHORITIES

Chilika Development Authority
The Chilika Development Authority, Department of Forest and Environment, Government of Orissa, is the focal agency for coordinating dolphin conservation efforts in Chilika Lagoon.

Wildlife Wing of the Orissa State Forest Department
The Wildlife Wing of the State Forest Department, Government of Orissa is working with the CDA on the conservation of the Irrawaddy dolphins and has primary responsibilities for enforcing the Indian Wildlife (Protection) Act.

Fisheries and Animal Resource Development Department
The Fisheries and Animal Resource Development Department, Government of Orissa, is charged with regulating fishery activities in the lagoon and enforcing the Orissa Marine Fisheries Regulation Act of 1982.

School of Tropical Environment Studies and Geography, James Cook University
The School of Tropical Environment Studies and Geography, James Cook University, Townsville, Australia, has been conducting research and conservation activities to conserve dolphins in the lagoon since 2004 with a focus on learning from traditional knowledge of fishing communities and building capacity for local participation in natural resource management.

Whale and Dolphin Conservation Society
The Whale and Dolphin Conservation Society, U.K., has provided funds to CDA for dolphin awareness raising activities.

Ocean Park Conservation Foundation and Wildlife Conservation Society
The Ocean Park Conservation Foundation and Wildlife Conservation Society Research Fellowship Program are funding Sutaria's research work as part of her Ph.D. program at James Cook University.

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REVIEW OF THE STATUS AND CONSERVATION OF IRRAWADDY DOLPHINS *Orcaella brevirostris* IN THE MAHAKAM RIVER OF EAST KALIMANTAN, INDONESIA

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EXECUTIVE SUMMARY

Data were collected during a preliminary survey for Irrawaddy dolphins in the Mahakam River in 1997 and then during more intensive efforts conducted from early 1999 until mid-2002, and again in 2005, on the abundance, habitat use, population dynamics and threats related to the conservation of Indonesia's only freshwater dolphin population. Dolphin distribution ranged from ca. 90 km upstream from the coast to ca. 600 km farther up the river at the rapids past Long Bagun, including several tributaries and two appended lakes: Semayang and Melintang. The 195-km segment of the main river from Muara Kaman, located ca. 180 km from the mouth to Muara Benangak, had the highest dolphin densities. The most recent (2005) best estimates of total population size varied between 67 and 70 dolphins (CV = 10%; CL = 59-79), based on direct counts and Petersen mark-recapture analyses of photo-identified dolphins, respectively. Mean minimum annual birth and mortality rates were 8% and 6%, respectively, for a total estimated population of 70 individuals. No significant trends in abundance were detected, although minimum mortality rates showed an apparent decrease over time. Dolphins occurred mainly at confluences, moving daily within an average of 10 linear km, and exhibited strong site-fidelity among individuals. These areas were also primary fishing grounds and subjected to intensive motorized vessel traffic. Fifty percent of dolphin deaths with known locations from 1995-2005 (N = 46) occurred in dolphin core habitat areas (i.e., at confluences). The main cause of death, based primarily on interviews and official reports, was from gill net entanglement (66%), mostly involving adults (81%).

In addition to mortality, legal and illegal live captures for dolphinariums have probably affected the population. Other threats include habitat degradation from noise pollution by speedboats and coal-carrying tugboats, chemical pollution from mining activities and sedimentation due to devegetation of riparian areas. Potential future threats include prey depletion from the use of unsustainable and illegal fishing techniques (e.g., electric and poison fishing) and possibly inbreeding. Irrawaddy dolphins have been fully protected by law in Indonesia since 1990 and were adopted by the East Kalimantan Province as their official symbol. However, their habitat remains unprotected. Conservation activities have been undertaken by a local NGO, Yayasan Konservasi RASI (Conservation Foundation for Rare Aquatic Species of Indonesia) and include awareness campaigns, monitoring the dolphin population, conducting socio-economic surveys in fishing communities, identifying and demarcating important dolphin sites, and establishing patrolling teams to report illegal fishing activities. Based on a population viability analysis the population has only a 1-4% chance of survival to the next century without reductions in human-caused mortality. Preventing the deaths of two dolphins per year reduced the probability of extinction to 50-75%, whereas preventing the deaths of three dolphins per year increased the probability of survival to almost 100%.

OVERVIEW OF POPULATION RANGE

During 14 extensive surveys of the entire potential range of dolphin distribution in the Mahakam River, from the delta to rapids located ca. 600 km upstream of the mouth, including all tributaries in between, we made 98 "on-effort" sightings

of Irrawaddy dolphins. Sightings were confined to the main river from between Muara Kaman (ca. 180 km from the coast) and Datah Bilang (ca. 480 km from the coast) and to the Belayan, Kedang Rantau, Kedang Kepala, Kedang Pahu and Ratah tributaries and Melintang and Semayang lakes (Kreb and Budiono 2005; Kreb *et* al. 2005). The 195-km length of the main river from Muara Kaman to Muara Benangak (located ca. 375 km from the coast) had the highest dolphin densities (Figure 1). Based on sightings and interviews with fishermen, dolphins occur from ca. 90 km upstream from the coast at Loa Kulu to ca. 600 km upstream at the rapids past Long Bagun. All river distances were measured from a map incorporating river bends and were cross-checked during the first survey using the thalweg (area of deepest cross section) distance.

Four sightings of Irrawaddy dolphins in the Mahakam Delta were made at low tide, and one sighting was made 10 km upstream from the coast at high tide (mean salinity = 22 ppt, range = 11-31) (Kreb and Budiono 2005). According to interviews with fishermen, the farthest inshore occurrence is ca. 20 km upstream from the coast at high tide. Because coastal Irrawaddy dolphins have not been sighted or reported to move farther upstream, and apparently only enter the delta at high tide, we consider these animals to be isolated from the freshwater population inhabiting the Mahakam River.

Figure 1. Study area showing dolphin distribution in the Mahakam River, areas of high dolphin density, and coastal distribution area. The coastal dolphin area is based on observations and interviews. Identified core dolphin conservation areas are marked by the two dark grey highlighted circles. A proposed larger protected area, using zone-based management for extractive, restrictive and prohibited natural resources uses, is indicated by the larger circle encompassing the two smaller ones.

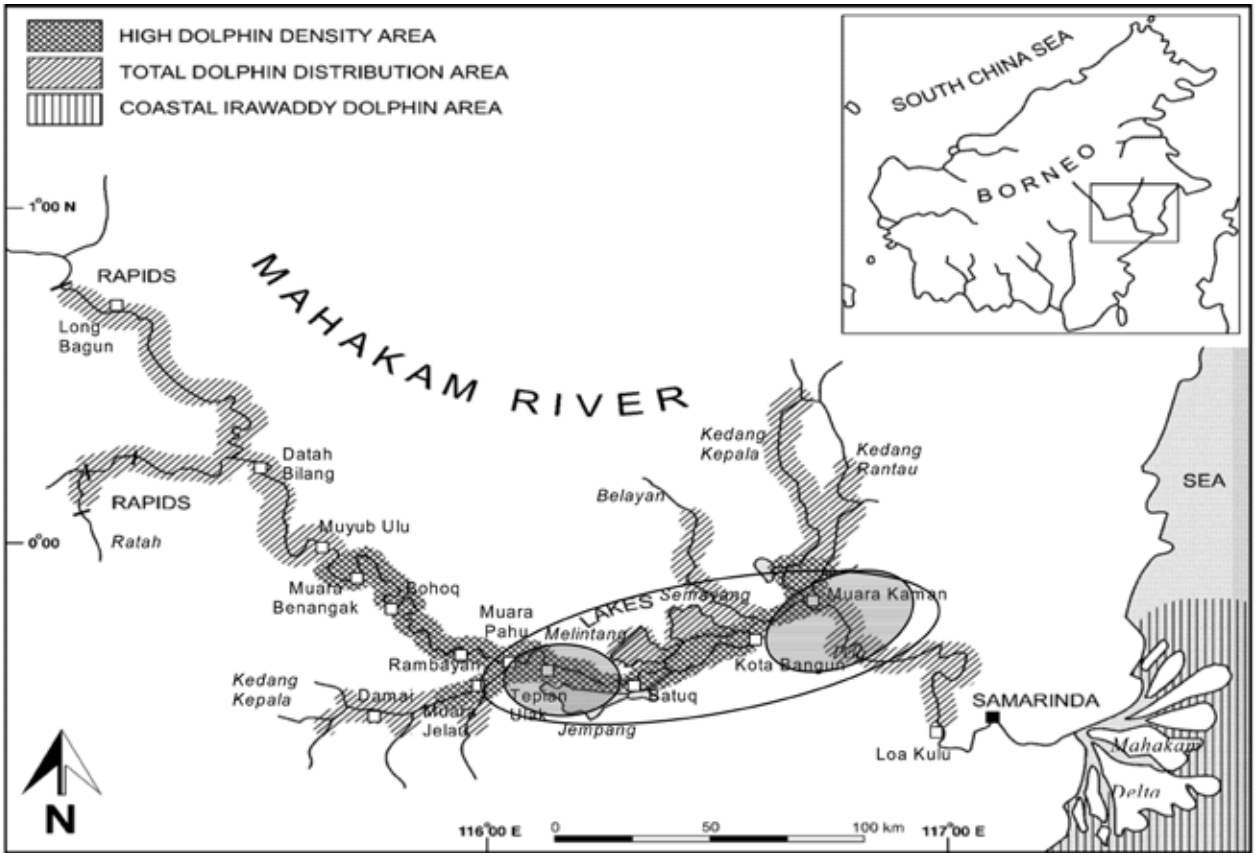


Table 1. Number of dolphins per km, newborns sighted, observed mating events, and recorded deaths in 40-km segments of the Mahakam River.

40-km river survey segments[1]	No. per km	No. of newborns	Mating events	Deaths[2]
Muara Kaman – Kota Bangun	0.13			12
Kota Bangun – Batuq	0.16	1		1
Batuq – Tepian Ulak	0.10		1	1
Tepian Ulak – Rambayan – Muara Jelau	0.31	8	1	13
Rambayan – Bohoq	0.04			2
Bohoq – Muara Muyub Ulu	0.04			
Ratah	0.12			1
Muara Jelau – Damai	0.04			1

[1] See Figure 1.
[2] Recorded in 1995 – 2001. In addition, five dolphins died outside the survey area and two died at unknown locations.

HABITAT AND AREAS OF HIGH DENSITY OCCURRENCE

There were significant differences among encounter rates of dolphins in eight 40-km long segments of the river mainstem and tributaries ($X^2 = 35.91$, df = 7, $P < 0.01$) (Table 1). The three segments where most sightings were made included particularly large numbers of confluences and appended lakes.

At medium water levels sighting rates in the main river and tributaries were similar, 0.12 and 0.14 sightings/km, respectively (Table 2). At high water level dolphins were found more often in the main river versus tributaries, whereas at rising high water levels the lowest mean sighting rate (0.03 dolphins/km) was recorded in the main river indicating that dolphins had probably moved upstream into the tributaries (Kreb 2002). At low water levels dolphins were not sighted in the tributaries of the middle reaches of the mainstem. One group has been "trapped" in an upstream tributary between two rapids since 1998 until present, but their presence here does not reflect normal seasonal distribution pattern.

With the exception of depth, dolphin preference for reaches of the middle Mahakam appeared to be unrelated to environmental parameters sampled at random locations and those collected at the locations of dolphin sightings (T-test $P > 0.05$) (Kreb and Budiono 2005) (Table 3). Only for depth at low water levels in the tributaries of the middle river section did we find a significant difference between the mean of random samples (7.5 m) and those recorded at the locations of dolphin sightings (16.7 m; T-test = 2.85, df = 16, $P < 0.05$). The greater availability of fish in the middle Mahakam river segment appears to be the factor determining dolphin distribution. Commercial fisheries occur only in the middle river segment (including tributaries and lakes), which has the highest dolphin density. At low water levels, significantly more sightings occurred in deep-water pools compared to river bends ($X^2 = 8.5$, df = 1, $P < 0.01$), in spite of the fact that river bends were significantly more numerous ($X^2 = 24.3$, df = 1, $P < 0.01$) (Figure 2). More than one-third (38%) of the 85 dolphins photo-identified in the Mahakam River between 1999 and 2005 were observed at

Table 2. Number of dolphin groups detected, mean group size, encounter rate, density and abundance based on strip transects (see Kreb 2002; Kreb and Budiono 2005) per river segment during high, medium, and low water levels. High water levels were > 3m higher than medium water levels and low water levels were > 3m lower than medium levels.

Survey area	No. transects	Total length (km)	Mean strip width (m)	No. of groups detected	Mean group size	Encounter rate km^{-1}	Dolphins km^{-2}	Abundance (strip transects)	CV
Middle main river[1]									
High water	6	414	200	12	4.6	0.13	0.67	28	24%
Medium water	9	621	200	16	4.5	0.12	0.58	23	27%
Low water	12	828	200	28	4.3	0.15	0.73	30	9%
Middle tributary[1]									
High water	2	152	43	2	4.6	0.06	1.4	5	0%
Medium water	3	228	43	7	4.5	0.14	3.2	12	62%
Low water	4	304	43	0	4.3	0	0	0	0%
Upper tributary[2]									
High water	2	33	75	2	4.6	-	-	5	0%
Medium water	3	33	75	3	4.5	-	-	5	0%
Low water	4	33	75	4	4.3	-	-	4	0%

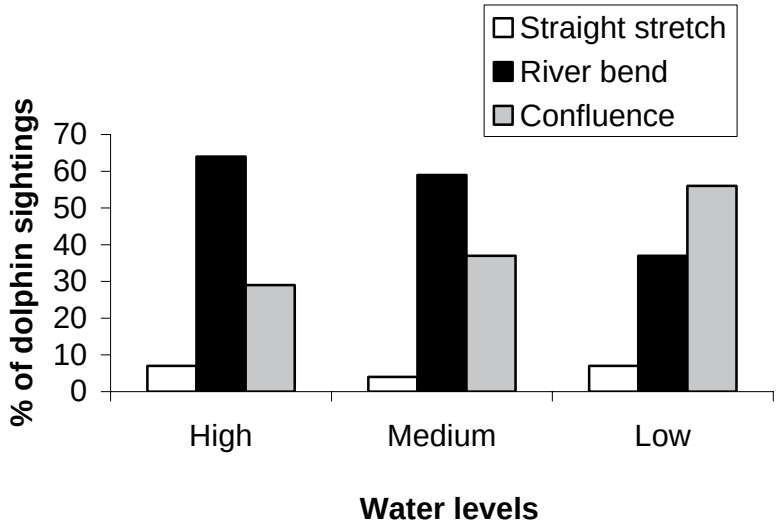
[1] Cross-shaded area in Figure 1.
[2] Distance from tributary mouth until rapids, however the dolphins sighted there are trapped in a 2-km segment between two rapids, so no sighting rates have been calculated.

Table 3. Environmental characteristics of various segments of the Mahakam River (see Figure 1) sampled at medium water level, and total fish production in 1999 (methods described in Kreb 2002; Kreb and Budiono 2005).

River segment	Depth (m)	Surface flow ($m\ s^{-1}$)	Width (m) or mean	Bottom substrate	Total fish production (tons)[1]
Lower river	15 ± 5	0.8 ± 0.4	370 ± 65	Mud	0
Middle river	17 ± 6	0.8 ± 0.3	200 ± 54	Mud	23,201
Upper river	12 ± 7	1.1 ± 0.3	161 ± 48	Sand, cobbles	0[2]
Middle river tributary	9 ± 4	0.7 ± 0.5	41 ± 14	Mud	-
Upper river tributary	12 ± 8	0.8	75 ± 12	Rocks	-
Lakes	2 ± 0.3	0	-	Mud	-
Delta	5 ± 4	-	-	Mud, sand	6931

[1] Data estimated from direct catches in dolphin habitat (excluding aquaculture) for market sale by the Kutai Fisheries Department (Dinas Perikanan Kabupaten Kutai Tenggarong, 2000). Data for tributaries and large lakes are not available separately and have therefore been combined with the middle river segment to which they are connected;
[2] Fish production data in the upper river segment available only for 425 km upstream, whereas dolphin distribution extends 560 km upstream.

Figure 2. Graph showing dolphin preferences for straight, bend and confluence segments during high, medium and low water levels. A significant preference was indicated for bends and confluences (X2 = 112.3, df =2, P<0.01) and bends were significantly more numerous than confluences (X2 = 24.3, df = 1, P<0.01).



least once in the confluence area of Muara Pahu during a single survey period in 2001 at low water levels. This suggests that deep-water pools, especially at confluences, are important habitat for the dolphins during the dry season.

Dolphins were observed at the confluence of Muara Pahu during 42% of surveyed daytime hours at all water levels, with the highest occupancy at high water levels (65%) when fish density was greater (Table 4). During medium and low water levels dolphins remained nearby (< 10 km). On average three different dolphin groups (range = 2-6 groups), consisting of a combined mean of 12 individuals (range = 5-24), frequented the confluence area every day. Out of 85 photo-identified dolphins in the Mahakam population, 76 (79%) were recorded at least once in the Muara Pahu confluence. Seventeen individuals were photo-identified exclusively within a 20-km radius of the confluence during an average of five different survey days (range: 2-14 survey days).

The confluence at Muara Pahu and another confluence about 10 km upstream, in the Kedang Pahu tributary, accounted for 89% of the sightings of newborns (N = 9) (Table 1). The majority of deaths (54%) with known location (N = 46) between 1995 and 2005 also occurred in confluences. Mating was observed within different groups in the confluence of Muara Pahu and at one location between Batuq and Tepian Ulak (Figure 1).

The average daily home ranges of 27 groups, which were followed for more than six hours, was 10 km of river length (SD = 8.6, range = 1-45 km) or 1.1 km^2 (SD = 1.8 km, range = 0.1-9.0 km^2). The group of six dolphins 'trapped' between rapids in the Ratah River has survived for seven years in a 2-km long and 100-m wide river segment. River length ranges were calculated for 53 photo-identified dolphins during 3.5 consecutive years. Individuals were identified on average 12.5 times (SD = 9.5, range = 2-39) and during 6.2 different survey days (SD = 3.7, range = 2-20). These dolphins moved within the river an average of 61 linear km (SD = 44, range = 4-181) and 10 km^2 (SD = 9.1 km^2,

Table 4. Search effort and observed dolphin presence during daylight hours in the confluence area of Muara Pahu.

Water level (year)								Total
	Medium-low	Medium-high			High	Low	Very low	
	2000	2000	2001	2005	2001	2001	2001	
Search effort (km)	46.2	48.2	35.9	28	51.2	45.9	58.7	314.1
Dolphins present (h)	18.0	23.7	15.4	13.5	33.4	17.3	11.8	133.6
Mean daily presence in % search effort	39%	49%	43%	48%	65%	38%	20%	42% (mean)

range = 0.3-35.5 km^2). No correlation was found between the number of survey days and river length range (r = 0.071, df = 51, P > 0.05).

ABUNDANCE AND TRENDS

Mean abundance estimates derived from strip-transect analysis and direct counts made during nine surveys conducted between early 1999 and mid 2001 within the entire range of dolphin distribution were 37 (34-40) and 33 (32-36) individuals, respectively. A mark-recapture analysis of individuals photo-identified during upstream and downstream surveys conducted in 2001 indicated a slightly larger population size of 55 (CV=6%) and 48 (CV=15%) individuals according to Peterson and Jolly-Seber estimators, respectively (Kreb 2005). Based on upstream and downstream photo-identification surveys in 2005, using a Peterson estimator, the population was estimated at 70 individuals (CV=10%; 95% CL = 58-79) (Kreb *et al.* 2005). Direct counts based on total number of identified dolphins in 2005 estimated the population at 67 individuals. The higher 2005 estimates probably do not indicate population growth but instead represent greater precision due to the higher photo-identification capture rates in 2005 (mean 90% per sighting), compared with a mean capture rate of 63% per sighting during whereas 1999 through 2002. Higher capture rates in later years are attributed to the use of digital photography starting in 2005. Earlier direct count and strip-transect estimates were most likely underestimates due to sighting biases.

The total number of dolphins identified between 1999 and 2005 was 85. The minimum annual number of newborns during the years 1999 and 2002 was six, and annual birth rate was 8% (N = 70). Newborns (< 1 month of age) were observed at all water levels and in all months of the year. Between 1995 and 2005, on the basis of interviews and our own observations, 48 deaths were documented (Kreb and Budiono 2005). Mean annual mortality was four dolphins per year (6% of N = 70). Most dead dolphins were adults (81%), then juveniles (15%), and calves (4%). Regression analysis showed a significant decrease in minimum mortality detected over time (p < 0.05). When the data were split and minimum mortality analyzed separately from 1995 until 1999, and 2000 until 2005, the mean minimum annual mortality was six dolphins (8% of N =70) for the first period and three for the second (4% of N = 70). Because dead dolphins are not usually buried, carcasses are easily detected by villagers along the river. The low number of

calf mortalities might be explained by the fact that calves are less conspicuous when floating.

Simulations of population survival were performed using the individual-based VORTEX program for initial population sizes of $N = 55$ and $N = 76$ (2001 abundance estimates). The results showed that without reducing mortality from a mean of five dolphin deaths per year recorded during 1995-2001, the population had only a 1-4% chance of survival to the next century (Kreb 2004). Preventing the deaths of two dolphins per year reduced the probability of extinction to 50-75%, whereas preventing the deaths of three dolphins per year increased the probability of survival to almost 100%.

CURRENT AND POTENTIAL FUTURE THREATS

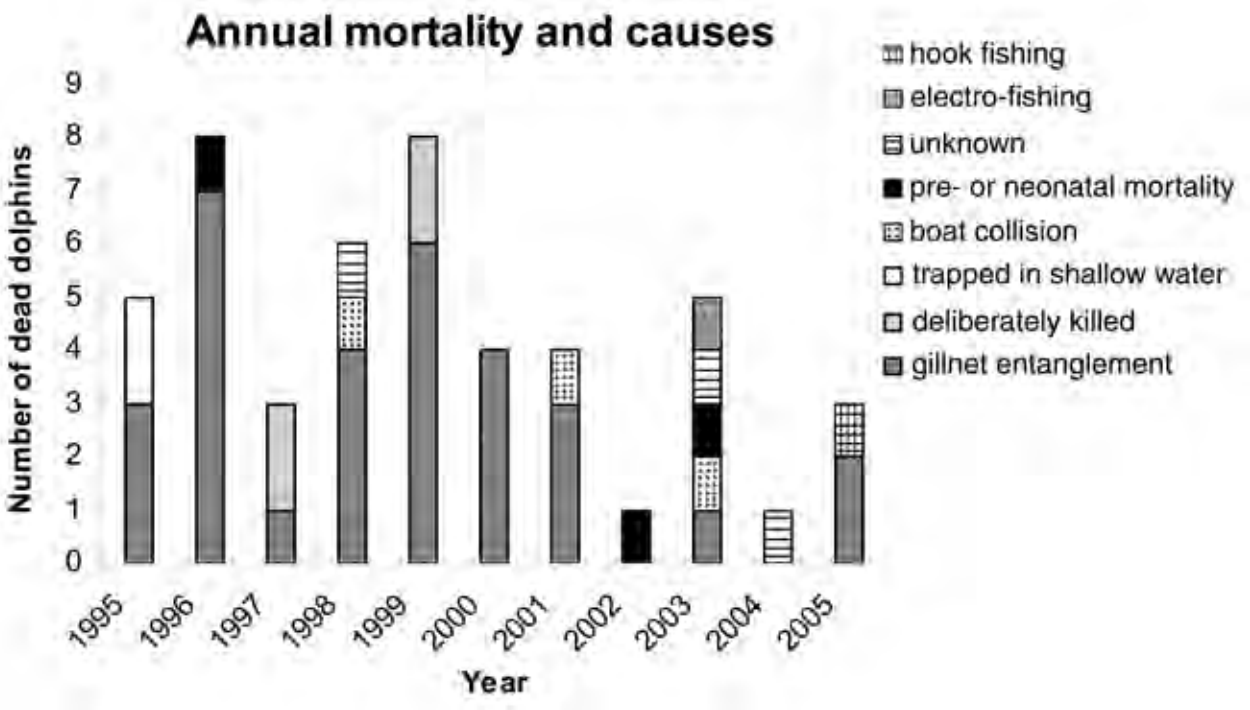
Most dolphins (66%) died as a result of entanglement in gillnets with mesh sizes of 10-18 cm. Dolphins were often observed feeding in close proximity to these nets and fishermen use the dolphins' feeding patterns as indicators of the location and time to set gillnets, thereby increasing the potential for entanglement. However, fishermen also reported that on several occasions they had successfully released dolphins from gillnets. Five of the dolphins killed incidentally in gillnets were eaten by local people and the skins of two were used as medicine for skin allergy.

Deliberate kills accounted for 9% of the documented deaths, occurring mostly in isolated areas where the dolphins were rarely found. Vessel strikes caused 7% of the deaths. Pre- or neonatal mortality included 7% of deaths and electro-fishing and hook-fishing each caused 2% of deaths (Figure 3).

From 1974 until 1988, 28 dolphins were live-captured and taken to Jaya Ancol oceanarium in Jakarta. Two detailed accounts were reported by local people of illegal captures in 1997 and 1998 of three and four dolphins, respectively. The fate and destination of these animals remain unknown. In 2002, a request for live captures was submitted to the General Directorate of Forest Protection and Conservation of Nature (PHKA) by the Regent of Central Kutai Province, East Kalimantan, for a new oceanarium along the Mahakam River (proposing to capture 8-12 dolphins) and by Jaya Ancol Oceanarium in Jakarta (proposing to capture 4-5 dolphins). Following intensive lobbying by local NGOs, the request for the captures was denied by the Ministry of Forestry.

Direct observations and semi-structured interviews with local residents indicated that the historic range of Irrawaddy dolphins in the Mahakam River included 820 linear km in the main river and its tributaries. In the early eighties, dolphins were still commonly reported in Samarinda at ca. 60 km from the coast, but in the early nineties they rapidly disappeared and have only been observed by the authors at sections at and upstream of 180 km from the coast, in spite of extensive survey coverage in the lower river reaches. The apparent 120 km range decline represents a loss of 15% of their historic distribution. The range decline coincides with increased industrial activities, boat traffic and a decline in fish populations, according to Fisheries Department data. Another recent range decline involves the disappearance of the species from Jempang Lake, probably due to a reduction in its depth due to excessive sedimentation from devegeta-

Figure 3. Annual dolphin mortality and causes based on interviews.



tion of the surrounding watershed. Sedimentation and high densities of gillnets also limit dolphin movements in Melintang and Semayang Lakes. Except during high water levels, dolphins are mostly confined to a narrow boat transport lane between the two lakes. This transport lane is especially hazardous due to the danger of collision and noise harassment from these vessels. Since 1998 at least three dolphins are known to have died from boat collisions.

Other factors that have degraded dolphin habitat include noise pollution, habitat displacement from container barges, chemical pollution, and prey depletion. The main source of noise pollution is high-speed vessels (40-200 hp) (mean = 4.6 boats/hour in dolphin habitat), which cause the dolphins to dive significantly longer when the boats are within 300 m (Kreb and Rahadi 2004). Container barges pass daily (mean = 8.4 boats per day) through the Kedang Pahu, a narrow tributary that is considered a core dolphin habitat. These vessels occupy over two-thirds of the width and over half the dry-season depth of the tributary. Dolphins consistently changed their swimming direction if headed upstream when they encountered container barges. During low water levels they actively avoided the tributary, whereas according to information from local fishermen and our own observations, dolphins entered the tributary before container barges started to use the river regularly. Mercury and cyanide are introduced into the river from leaks in dams that retain wastes from a large-scale legal gold mining operation and small-scale illegal operations located along the river. Coal dust is frequently dumped accidentally into the river in this area and this may have caused occasionally observed changes in the skin pigment of the dolphins. Prey depletion due to intensive fishing with gillnets, electricity and poison may also be affecting the animals.

LEGISLATION, FISHERIES REGULATIONS AND PROTECTED AREAS

Since 1990 the Irrawaddy dolphin has been fully protected by law in Indonesia (*Undang-undang RI No. 5, 1990*) and is the adopted symbol of East Kalimantan Province. However, habitat protection is lacking. Several swamp (lake) areas have been proposed for fish reserves, including Semayang Lake, however, no official national protected status has been give to any river segment within the Mahakam. Historically, there were 11 fish sanctuaries, of which nine have been seriously degraded due to sedimentation. Two fish conservation areas, one near Kota Bangun (Loa Kang), which encompasses 930 ha and the other near Muara Muntai (Batu Bumbun), which encompasses 450 ha, are still relatively intact. Both reserves were established during the Kutai Moslim Sultanate some 500 years ago and have been managed under Kutai Regency since 1978 (*Perda Kabupaten Kutai No. 18, 1978*). The use of poison and electricity for fishing is forbidden but often practiced illegally in these fish sanctuaries. Gillnets with mesh sizes of 10 cm are allowed, but smaller or larger sizes are not. Enforcement is lacking.

RESEARCH AND CONSERVATION ACTIVITIES

Dolphin conservation activities in the Mahakam River began in 1999 with cooperation from the East Kalimantan Nature Conservation Agency (Forestry Department) and involved raising public awareness of the protected status of the dolphins through leaflet distribution and dissemination of information to all village heads. In 2000, a local NGO, Yayasan Konservasi RASI (Conservation Foundation for Rare Aquatic Species of Indonesia) was established with the aim to protect the dolphins and their habitat. Activities so far have included awareness campaigns targeting both government and community levels, yearly monitoring of the dolphin population, a socioeconomic investigation of riverine fisheries, an assessment of the attitudes of local communities towards dolphin conservation, workshops to train fishermen on how to safely release dolphins entangled in fishing nets and encourage them to practice more sustainable fishing techniques, organization of patrolling teams to report illegal fishing activities, and demarcation of a core dolphin habitat area and establishment of an environmental education center at Muara Pahu (Plate 1).

Based on interviews conducted in 2001 (N = 258) and 2005 (N = 230), we found that most residents along the Mahakam River were positively inclined towards the dolphins and supported the establishment of protected fish spawning and dolphin areas. In the core dolphin habitat area at Muara Pahu all fishermen interviewed expressed a willingness to abandon gillnetting and engage in alternative sustainable fisheries or aquaculture activities if low-interest loans and subsidized fish spawn and food were provided.

In 2002, the entire village of Pela helped the provincial wildlife conservation department (BKSDA) and YK-RASI capture and transport a dolphin that was trapped in a shallow lake appended to the main river. Afterwards villagers held a symbolic meal to mark their commitment to dolphin conservation. The generally positive attitude of local people towards the dolphins may be linked to the local belief that the animals have a human origin. The dolphins also had reported value in aiding fishermen by driving fish into their nets, and fishermen

Plate 1. Signboard welcoming visitors to the Mahakam Information Center.

stated that on several occasions they had successfully released dolphins from gillnets.

Current plans are to convene a district workshop for creating a constituency among stakeholders to strengthen dolphin and habitat protection. The core dolphin habitat at Muara Pahu will be proposed as the site of the first dolphin conservation area protected under local district law. The main focus of the workshop will be to encourage the application of gillnet regulations and gradual removal of these nets in core dolphin habitat areas, and promote boat speed regulations, exclusion of coal container tugboats in tributary habitat, and patrols by local villagers to monitor illegal fishing activities.

Current and future research activities include (1) monitoring threats, mortality rates and population size (using photo-id and mark-recapture analysis methods) to detect long-term trends; (2) updating the photo-identification catalogue to investigate site fidelity and social ecology with specific reference to breeding; (3) assessing the long-term fidelity to previously identified core habitat areas; (4) collecting tissues from recovered carcasses to assess genetic variation and demographic connectivity between the coastal and riverine populations; and (5) conducting field tests on the efficacy of acoustically reflective gillnets (e.g., coated with barium sulphate) and acoustic deterrent devises (i.e., pingers) for reducing gillnet entanglement.

Conservation plans include establishing protected core conservation areas in 10-20 km radius segments in the Mahakam River at (1) the Kedang Pahu tributary mouth at Muara Pahu Town; (2) the mouths of the Kedang Kepala and Kedang Rantau tributaries; and (3) the Pela tributary, including the southern portion of Semayang Lake (Figure 1). Measures to manage fisheries in core conservation areas will be implemented in two phases. Phase one will entail (1)

establishing regulations on the type of gill-nets (mesh size of 10 cm) and on where and when they can be set (e.g., not directly in confluences and nowhere in the conservation area at night); (2) promoting alternative fishing techniques that do not directly harm dolphins and, if deemed environmentally sound after further study, reducing pressure on fisheries by encouraging aquaculture techniques such as floating cages financed by low interest loans from the government for breeding valuable fish species using fish food and spawn not derived from the river; (3) providing alternative employment options for gill-net fishermen; (4) requiring fishermen to attend their nets; and (5) compensating fishermen for nets damaged in the process of releasing entangled dolphins alive. Phase two will include (1) excluding gill-nets altogether after extensive consultations with the fishermen and alternative gears or employment options have been provided; (2) enforcing laws that prohibit destructive fishing techniques (e.g., electric and poison fishing), logging of riparian areas, dumping of toxic contaminants and live-captures of dolphins; (3) conducting environmental awareness campaigns among local communities and government officials; (4) establishing fishing reserves in spawning locations of the swamp lakes situated adjacent to the proposed core conservation areas; and (5) encouraging small-scale, well-regulated ecotourism centered on dolphin watching to increase political and community support for establishing core conservation zones. Additional management measures that will be promoted include (1) establishing speed limits for boats; (2) excluding large coal-carrying ships in the narrow Kedang Pahu tributary (alternative transport options include trucking the coals over improved road); and (3) improving habitat in Lake Semayang and the Pela tributary by dredging a channel from the lake to the Mahakam mainstem to avoid collisions with fast-moving vessels.

LIST AND DESCRIPTION OF CONSERVATION PARTNERS AND MANAGEMENT AUTHORITIES

Yayasan Konservasi RASI (YK-RASI) [Conservation Foundation for Rare Aquatic Species of Indonesia]
YK-RASI is an NGO that gathers biological and socio-economic information and conducts education awareness campaigns related to the conservation of riverine, lake and wetlands habitat and fauna with particular reference to freshwater dolphins. They will organize district workshops involving local communities, governments and other stakeholders to discuss the establishment of protected dolphin and fish spawning areas.

Balai Konservasi Sumber Daya Alam Kalimantan Timur (BKSDA Kal-Tim) [East Kalimantan Nature Conservation Agency]
The responsibility of BKSDA Kal-Tim is to enforce laws and patrol nationally protected areas and fauna and flora. If protected dolphin areas of national status are established, they will perform the law enforcement.

Direktorat Jendral Perlindungan Hutan dan Konservasi Alam (Dirjen PHKA) [Directorate General for Forest Protection and Nature Conservation]
Dirjen PHKA will take the ultimate decision about the national protection status of core dolphin areas as they are the highest decision-making agency concerned with the conservation of natural resources.

Pemerintah Daerah (Pemda) Kutai Kartenegara dan Kutai Barat [District Government of Central and West Kutai]
The District Government of Central and West Kutai provide local protection of dolphin and fish spawning areas.

Dinas Perikanan Kutai Kartenegara dan Kutai Barat [Fisheries Department of Central and West Kutai].
The Fisheries Department of Central and West Kutai is responsible for regulating fisheries in the Mahakam River system.

Badan Pengendalian Dampak Lingkungan Daerah (Bapedalda) [Regional Environmental Impact Controlling Body] and Dinas Lingkungan Hidup Kutai Kartenegara dan Kutai Barat [Environmental Department of Central and West Kutai].
The Regional Environmental Impact Controlling Body and Environmental Department of Central and West Kutai play key roles in safeguarding healthy riverine habitat for people and aquatic fauna.

Universitas Mulawarman (UNMUL) [University of Mulawarman in Samarinda, East Kalimantan].
The responsibility of UNMUL is to inform departments and governments as mentioned above on juridical conservation aspects, fish technology, and biological information on fish and dolphin ecology as well as abiotic components (e.g., effects of logging on sedimentation).

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REVIEW OF THE STATUS AND CONSERVATION OF IRRAWADDY DOLPHINS *Orcaella brevirostris* IN THE MEKONG RIVER OF CAMBODIA, LAO PDR AND VIETNAM

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EXECUTIVE SUMMARY

Irrawaddy dolphins inhabiting the Mekong River were Red Listed as 'critically endangered' by the World Conservation Union (IUCN) in 2004. Preliminary mark-recapture estimates indicate that the population numbers a minimum of 127 individuals (CV = 0.07; 95% CI = 108 – 146). The range of the population has declined substantially and is now primarily restricted to nine deep water areas in a 190-linear km river segment between Kratie and Khone Falls just upstream of the Lao PDR/Cambodia border. Dolphins are rarely reported south of Kratie and have not been documented alive in the Vietnamese portion of the Mekong and in Tonle Sap Great Lake since the late 1990s.

Between January 2001 and June 2005, 48 dead dolphins were documented, 50% adults/juveniles and 50% calves. Anthropogenic factors were implicated in the deaths of 15 adult dolphins (62.5%). Of these, 13 were due to entanglement in fishing gears described as "large mesh gillnets" (6-14 cm mesh size recorded in four cases), one was reported to have been shot, and one was deliberately killed by explosives over concerns about access to fishing rights. Between July 2005 and March 2006 an additional 18 dolphin carcasses were recovered, including two adults, one juvenile and 16 calves. The large number of recent calf mortalities is worrisome and may indicate a problem with environmental contaminants. Analyses of mercury as a possible threat indicated that levels were not high. Other potential threats that warrant further investigation are illegal dynamite and electric fishing, water pollution, and noise, collisions and harassment from dolphin watching and high-speed transport vessels.

The Cambodian Mekong Dolphin Conservation Strategy was jointly developed by the Mekong Dolphin Conservation Project of James Cook University and the Cambodian Department of Fisheries. This strategy was recently adopted by the Ministry of Agriculture, Forestry and Fisheries. Key components include (1) calling for the Senate of the Kingdom of Cambodia to adopt the new fishery law (which has already been approved by the National Assembly) establishing protected areas in nine core habitat areas (provisionally identified according to the results of sighting surveys conducted since January 1991); (2) extending dolphin-watching and ecotourism regulations to additional core conservation areas other than Kampi Pool where appropriate rules are already in place; (3) enforcing the prohibition of gillnets inside the nine provisionally identified core habitat areas; (4) informing local fishermen and community leaders about fisheries regulations; (5) conducting photo-identification studies to monitor dolphin abundance; (6) patrolling to enforce fisheries regulations; (7) strengthening the dolphin stranding program; (8) interviewing local people to investigate their perceptions of dolphins; and (9) developing an Irrawaddy Dolphin Management Committee to establish conservation priorities at the Lao PDR/Cambodia transborder pool. The Cambodian Mekong Dolphin Conservation Strategy will be implemented by the Cambodian Mekong Dolphin Conservation Project, which is a collaborative initiative being implemented by the Cambodia Department of Fisheries, World Wide Fund for Nature, and Mekong Conservation Wetland Biodiversity and Sustainable Use Programme (MWBP).

OVERVIEW OF POPULATION RANGE

Based on 249 days (1044 hours) of boat-based surveys conducted along 13,200 km of linear river length during 2001 – 2005, the current range of Irrawaddy dolphins in the Mekong is believed to be generally limited to a 190 km segment between Kratie (about 500 km upstream of the river mouth in Vietnam) to slightly upstream of the Lao PDR/Cambodia border at Khone Falls (Figure 1).[4] Khone Falls physically obstructs further upstream movement. Based on interview surveys conducted by Baird and Mounsouphom (1994) dolphins are believed to have been once fairly common in the Sekong River and its tributaries as far upstream as the Kalaum District (approximately 950 km upstream of the river mouth in Vietnam). The Sekong River branches off the Mekong at Stung Treng and then further divides into the Sesan and Srepok Rivers. Recent interview surveys indicate dolphins now rarely ascend the Sekong River and its tributaries. No dolphins have been reported in Tonle Sap Great Lake since 1997 (Baird and Beasley 2005).

Dolphins are now rarely found south of Kratie, except occasionally during the wet season (June to October) when some animals probably follow fish migrations downstream. During a survey of almost the entire length (224 km) of the two main distributaries of the Mekong River (Tien and Hau Giang) in April 1996, Smith *et al.* (1997) were unable to find a single dolphin. A more recent survey of the Mekong River in Vietnam was conducted in May 2005 by researchers from James Cook University, Cantho University and the Vietnamese Fisheries Department (Beasley *et al.* 2005). A total of 486 km were searched during 42 hours. No dolphins were sighted. During the same survey, interviews of 84 local residents along the river indicated that Irrawaddy dolphins are no longer found in the upper portion of the Mekong in Vietnam. However, the species was reported to occasionally occur in the lower reaches, probably originating from coastal waters of the Vietnamese Delta. Although no dolphins have been recorded alive in the Mekong River of Vietnam during recent years, one dolphin was accidentally caught in a set bag net in April or May 2002 in Vam Nao of the Phu Tan District, An Giang Province (Chung and Ho 2000), and another dolphin in October 2005 in Vinh Xuong Commune of the Tan Chau District, An Giang Province (adjacent to the Cambodia border) (Beasley *et al.* 2005).

HABITAT AND AREAS OF HIGH DENSITY OCCURRENCE

During the dry season, dolphins occur most frequently in nine deep water areas (Kampi, Chroy Banteay, Koh Phdau, Khsach Makak, Sampan, Tbong Klar, Kang Kon Sat, Koh Santuak and Cheuteal (also called Veun Nyang in Lao PDR) (Figures 2 and 3) located at the up- or downstream ends of islands and downstream of rapids. These areas also provide habitat for a large number of fishes and other aquatic fauna. Dolphin habitats are unknown during the wet season, but the animals have been observed to move out of Koh Phdau, Sampan and Khsach Makak deep water areas, probably due to increased water velocity.

[4] Editors' note: In instances of inconsistency in the spelling of place names between the text and the maps in Figures 1-3, the spellings in the text should be considered authoritative.

Figure 1. The lower Mekong River showing critical dolphin habitat from Kratie upstream to the Lao PDR/Cambodia border. The presence of Khone Falls just north of the border prevents any further dolphin movement north.

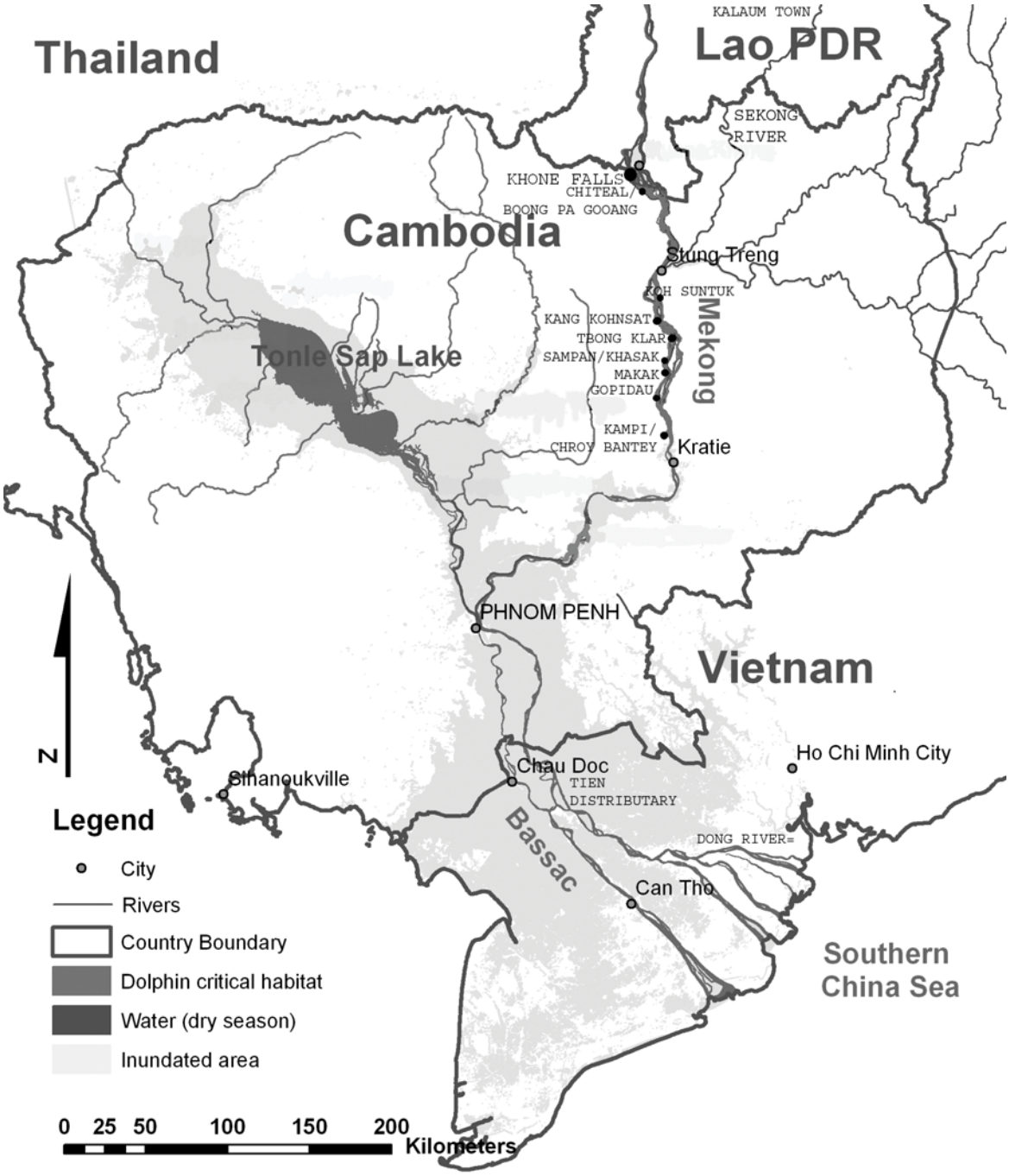


Figure 2. The upper Mekong River in Cambodia showing the Kratie Province. Dolphins are commonly found in four deep water areas, with some sightings being observed in the Kontoy Koh Rongue and Koh Dombong areas.

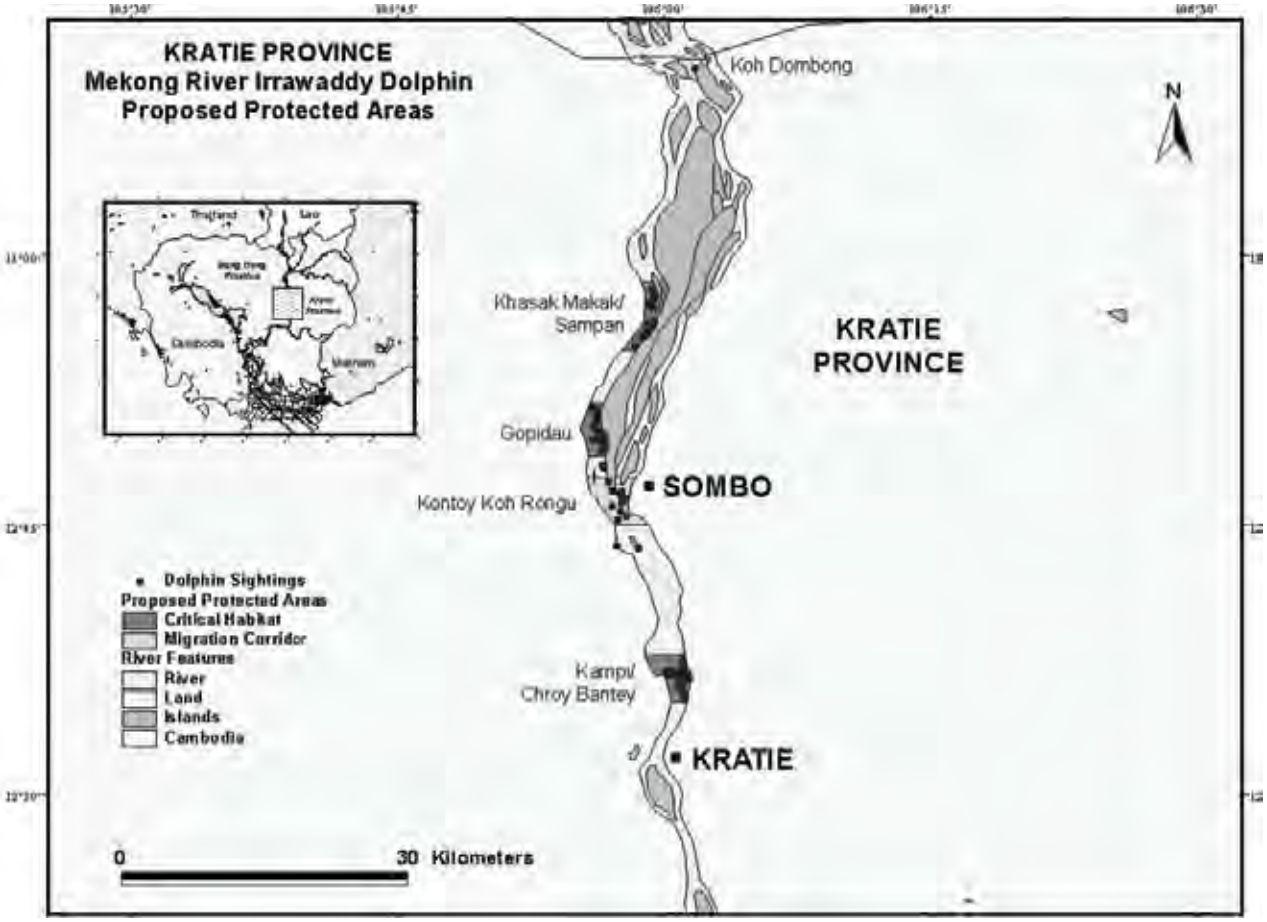


Table 1. Minimum estimates of dolphin abundance in the Mekong River from 2001-2004 based on direct counts.

Upstream Direct Count		Downstream Pool Count	
Month/Year	**Best estimate (low-high estimates)**	**Month/Year**	**Best estimate (low-high estimate)**
May 2001	68 (54-88)	--	--
May 2002	43 (36-56)	May 2002	50 (35-70)
April 2003	63 (50-81)	May 2003	69 (57-84)
April 2004	66 (54-83)	May 2004	66 (58-83)
April 2005	55 (49-65)	April 2005	40 (33-55)

ABUNDANCE AND TRENDS

Dolphins in the Mekong were classified as "critically endangered" by the World Conservation Union (IUCN) in 2004 (Smith and Beasley 2004), based on small population size and projected declines. The best estimate of minimum abundance from upstream direct counts and downstream pool counts was 69 dolphins in May 2003 (Table 1). Associated land-based observations indicated that few dolphins were missed by the boat-based observer team in known deep-water habitats (Beasley *et al*. 2003).

Figure 3. The upper Cambodian Mekong River section showing Stung Treng Province. Dolphins are commonly found in four deep water areas, with occasional sightings made in downstream areas.

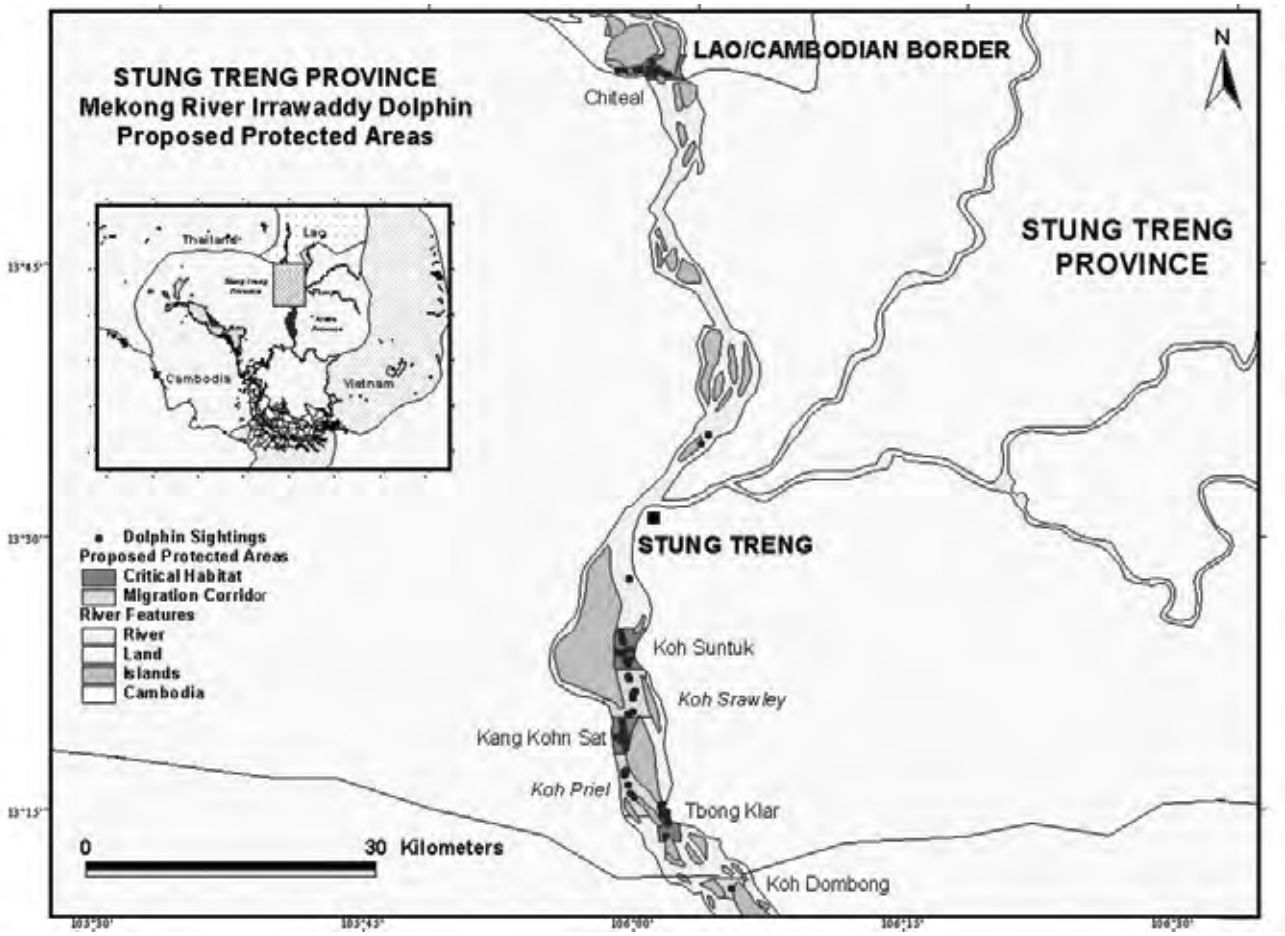


Photo-identification studies conducted between January 2004 and April 2005 identified a total of 90 individuals. A mark-recapture analysis, which assumed a closed population model with variable capture probabilities, was used to estimate population size. Accounting for the proportion of unmarked dolphins in the population (17%), minimum early survival (0.7%; only three calves were confirmed to live more than two months from 2004 through 2005) and minimum annual mortality rate (5.5%), the analysis resulted in a minimum total population estimate of 127 individuals (CV = 0.07; 95% CI = 108 – 146), as of April 2005. A comparison between boat-based direct counts and mark-recapture estimates indicated that the former method could be underestimating the total population size by as much as 50% (Beasley, in prep).

Range declines in Tonle Sap Great Lake and the Mekong mainstem below Kratie imply that dolphin abundance has decreased substantially (Beasley *et al.* 2003). An analysis of survival and mortality rates indicates that the population is declining at a minimum rate of around 4.8% each year (Beasley, in prep). This rate is clearly unsustainable, given that for small cetaceans yearly removals should not exceed 1-2% of the population size (Wade 1998). Adult mortality generally has a greater impact on the potential survival of the population in the long-term, however, this assumes that a reasonable portion of calves survive to reproduce as adults. The high mortality rates of calves from 2003 through the present make this assumption doubtful. Additionally, the lack of evidence

directly connecting calf mortality with anthropogenic activities (e.g., entanglement in gillnets) suggests that indirect threats such as water pollution and/or waterborne disease could be negatively affecting the population (see below).

CURRENT AND POTENTIAL FUTURE THREATS

In total, 48 dead dolphins were recorded between January 2001 and June 2005, with an additional four reports remaining unconfirmed (Table 2; Figure 4). These numbers probably underestimate total mortality in the dolphin population because some deaths were almost certainly undetected, especially during 2001 and 2002 when mortalities were only investigated opportunistically during population surveys. With increased community involvement and awareness, reporting has improved dramatically, and since 2003 the majority of dolphin mortalities were verified within one or two days of their discovery.

Table 2. Confirmed and unconfirmed dolphin mortality recorded between 1 January 2001 and 30 June 2005.

Year	Confirmed deaths	Unconfirmed deaths	Confirmed, Adults	Confirmed, Calves/ neonates	Confirmed, Unknown age
Pre-2001	8	0	4	0	4
2001	3	0	2	1	0
2002	4	1	3	1	0
2003	15	3	10	5	0
2004	16	0	5	11	0
2005 (Jan-Jul)	10	0	4	6	0

Figure 4. Annual confirmed adult (N = 24) and calf (N = 24) mortalities recorded between 1 January 2001 and 30 June 2005. Distinction is made between dolphin mortalities occurring during the first and second two quarters to facilitate comparison of 2005 mortalities with previous years.

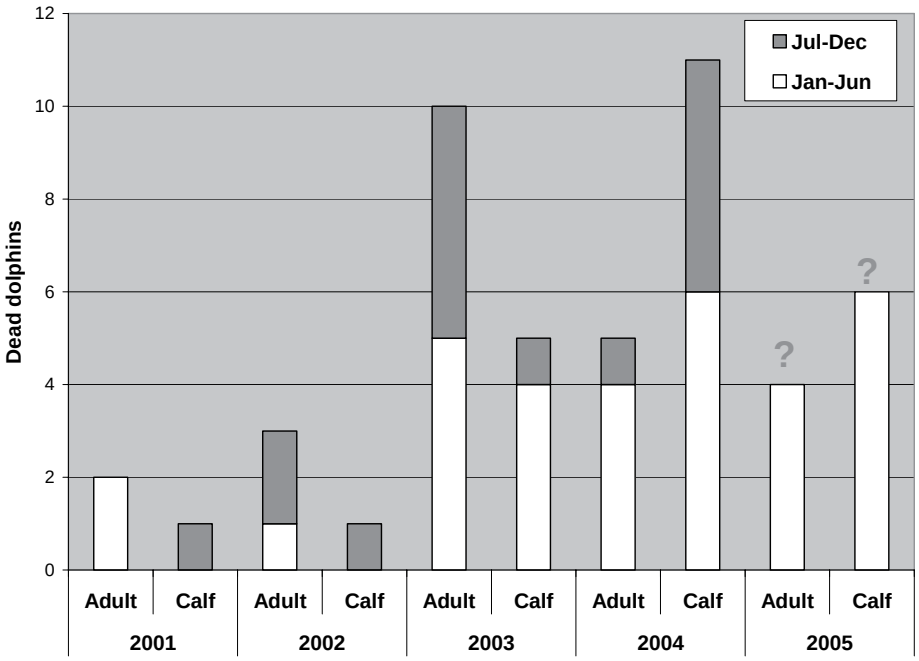
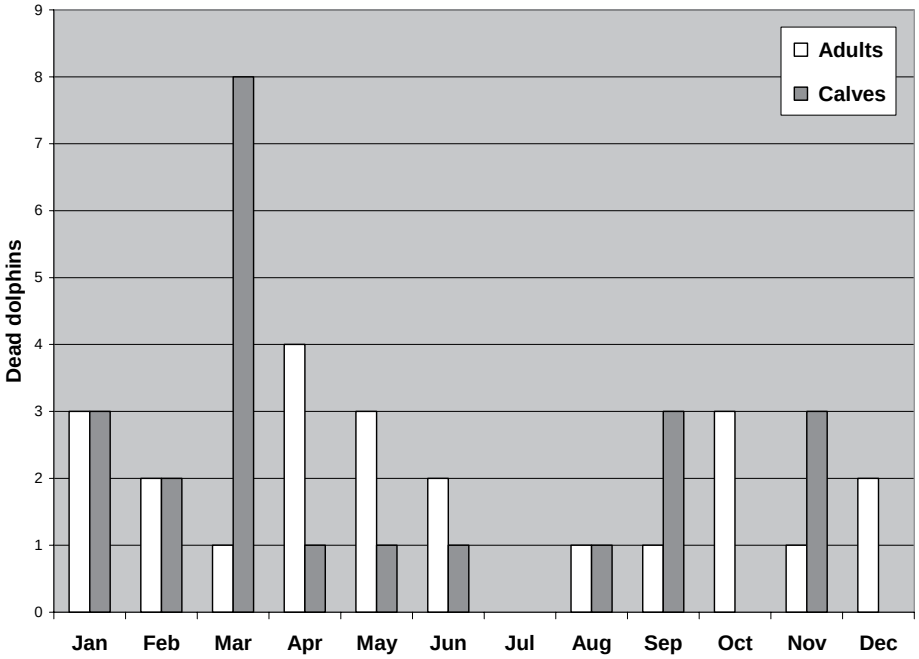


Figure 5. Monthly adult (N = 23) and calf (N = 23) mortality between 1 January 2001 and 30 June 2005. Data were insufficient to estimate the month of death for two dolphins and these have been excluded from the figure. One "juvenile" dolphin was included with the adults to distinguish it from present season calves.

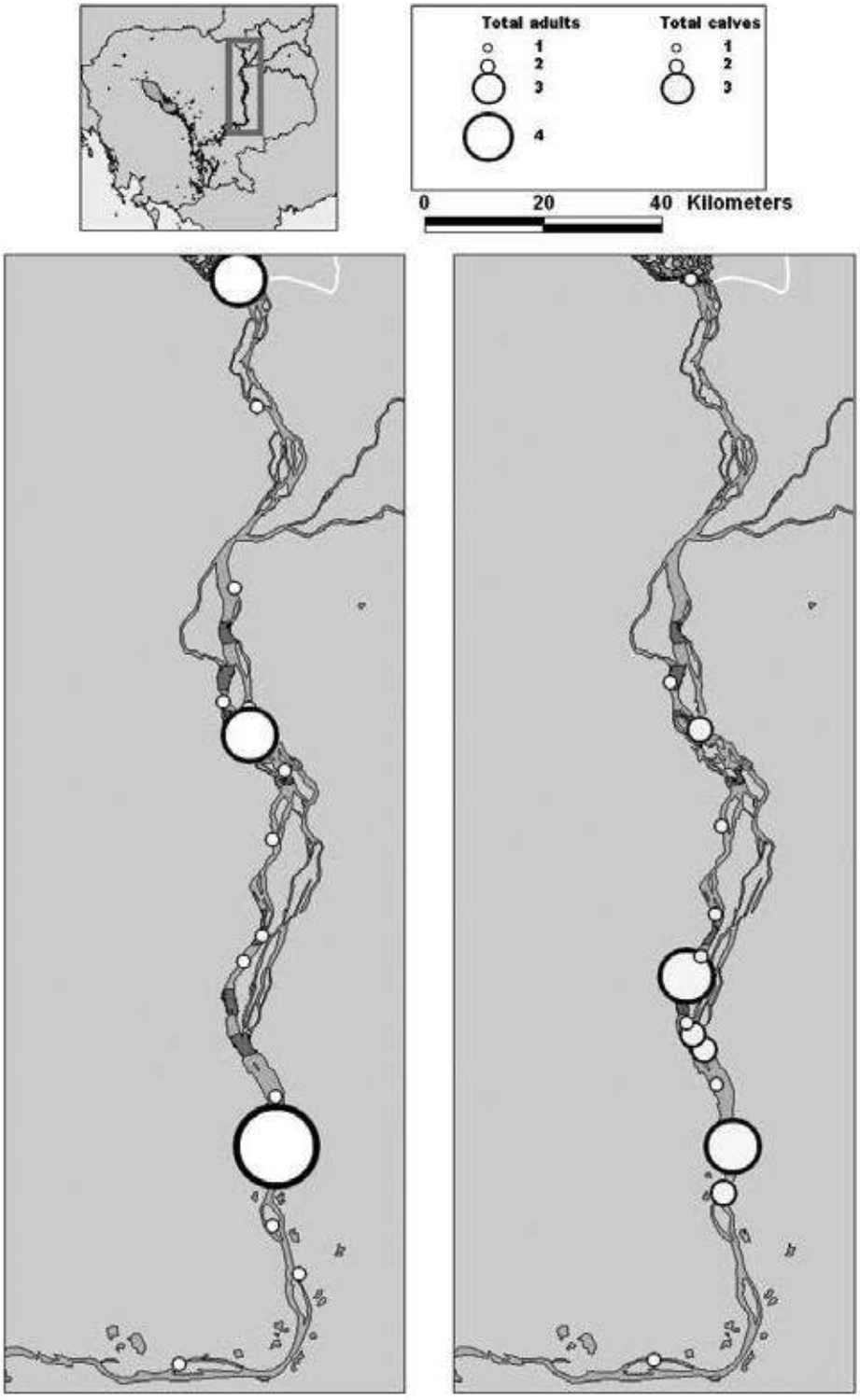


Of the dead adult dolphins, seven were male and six or seven were females (one adult was recorded as "probably female") with poor carcass condition preventing the determination of sex in the remaining 11. Among the confirmed calves there have been eight females and nine males, with no record of sex available for six. Adult dolphin mortalities have been recorded in all months except July (Figure 5), with no clear temporal peaks. Calf mortalities were recorded in all months except July, October and December, with a clear peak in March (two in 2003, three in 2004 and three in 2005).

Carcass recovery locations were available for 23 adult dolphins and 23 calves (Figure 6). All dolphins were found dead along the Mekong River with the exception of a single adult that was killed by fishermen along the Srepok River in Khaoh Nheaek District, Mondulkiri Province, approximately 157 km upstream from its confluence with the Mekong. Three areas accounted for ten of the adult mortalities: Cheuteal (three), Tbong Klar (three) and Kampi/Chroy Banteay (four).

Anthropogenic factors were implicated in the deaths of 15 adult dolphins (62.5%, N = 24). Of these, 13 were due to entanglement in fishing gears described as "large mesh gillnets" (6-14 cm mesh size recorded in four cases), one was reported to have been shot, and one was deliberately killed by explosives over concerns for access to fishing rights. The pathology and circumstances surrounding the deaths of three additional adult dolphins were suggestive of human involvement, although this could not be confirmed. By contrast, only one calf (4.2%, N = 24) showed signs indicating mortality caused by anthropogenic factors. This animal became trapped in a bamboo fence and was unable to free itself. At least five dolphin calves had similar skin lesions limited to the ventral neck. The aetiology of these lesions has yet to be resolved.

Figure 6. Distribution of confirmed dolphin strandings between 01 January 2001 and 30 June 2005. The size of each point has been scaled to represent the number of dolphins found dead within a radius of two km. One dolphin found at a remote site has not been represented.



Between July 2005 and March 2006 an additional 18 dolphin carcasses were recovered, including two adults, one juvenile and 16 calves. Although a comprehensive analysis of the factors responsible for the death of these animals has not been completed, the large proportion of calf mortalities is particularly worrisome and may indicate a problem with environmental contaminants. The criteria for determining the age of neonatal Irrawaddy dolphins has yet to be described. However, based on the measurements of an individual born in an aquarium whose mother was from the Mahakam River population (Tas'an 1980), lack of substantial dental development, and presence of lateral fetal folds and/or umbilical tissue, the majority of calf deaths were assumed to have occurred within the first weeks of life.

Gold mining operations along Mekong tributaries are a potential source of mercury (Hg), which could have toxic effects on dolphins. Ten liver samples from three adults and seven calves that died between September 2002 and November 2004 were analyzed by Environment Canada (Burlington, Ontario) for mercury concentrations. With the exception of one dolphin, all samples were found to contain mercury concentrations in the range 0.9-3.7 µg/g (wet weight). One adult female was found to have a considerably higher concentration of liver mercury (67 µg/g). As expected liver mercury residues were consistently higher in adults compared to calves due to the bioaccumulative properties of the trace metal. Blubber mercury concentrations were obtained for seven adult dolphins including the three animals for which liver mercury concentrations were available. Mercury does not accumulate in blubber as efficiently as liver, however, one dolphin was found to have blubber mercury concentrations at least three times greater than the other adult animals analyzed. The tissue concentrations of inorganic mercury in this study were generally low in comparison to values published for other small cetaceans and no samples approached the 300 ug/g limit established for human consumption by the United States Environmental Protection Agency and the 500 ug/g limit set by the World Health Organization. At present, given the low concentrations and absence of associated pathology, there is no evidence to suggest that Irrawaddy dolphins in the Mekong River are suffering from the toxic effects of mercury. Further analyses of blubber samples for polychlorinated biphenyls (PCBs) and fluorinated organic compounds will be conducted by Environment Canada and the Canadian National Laboratory for Environmental Testing.

Additional human activities that could currently be threatening Irrawaddy dolphins in the Mekong River include illegal fisheries (e.g., electric or dynamite fishing) and collisions with motorized boats. However, at present there is no evidence to implicate any of these activities in dolphin deaths. Threats that have the potential to cause problems in the future include (1) resumption of the use of dolphin body parts for traditional medicine that was previously common in Cambodia; (2) habitat degradation from factors such as deforestation, which leads to increased sedimentation; (3) over-fishing which could affect the availability of dolphin prey; and (4) dam construction which could detrimentally affect ecosystem functioning and fragment populations.

LEGISLATION, FISHERIES REGULATIONS AND PROTECTED AREAS

In Lao PDR dolphins are legally protected from hunting, capture and trade, with fines of US$65 - 650 and imprisonment for three months to one year (Perrin *et al*. 1996). No fisheries regulation or protected areas have been established to protect dolphins.

In Cambodia there is currently no specific legislation protecting Irrawaddy dolphins in the Mekong River. Passage of the new Fisheries Law will provide protection for all cetaceans in Cambodian waters. This law has been signed by the Prime Minister and adopted by the National Assembly of the Royal Government of Cambodia and will be submitted soon to the National Assembly. The Prime Minister also issued Urgent Order No. 01 on Mekong River Dolphin Conservation and Tourism Development, which consists of the following points:

(1) The Ministry of Agriculture, Forestry and Fisheries must co-operate with relevant agencies and provincial authorities to ban all types of nets, eliminate illegal fishing activities such as electric and dynamite fishing, and bamboo and wood rafts which have been floating across the dolphin habitats from the Lao PDR/Cambodia border at Stung Treng.

(2) The Ministry of Public Work and Transportation must study techniques and educate all boat owners on how to protect dolphins from injuries or death from propeller strikes. The Ministry of Public Work and Transportation must also cooperate with all relevant agencies, ministries and provincial authorities to install signboards for informing high-speed transport boats to reduce speed and noise, and ban waste oil from draining into the river particularly in dolphin habitats

(3) The Ministry of Environment, in collaboration with other relevant Ministries and local authorities, must take measures to educate local people on how to protect the environment and stop pollutants from draining into the river, particularly in dolphin habitats.

(4) The Ministry of Tourism must pay attention to management and education guidelines and improve the quality of tourist services in critical dolphin habitat.

(5) The National Tourism Authority must cooperate with all relevant agencies and authorities to educate all levels of the public, including local communities, and establish offices in Kratie and Stung Treng Provinces for leading conservation efforts and creating patrol teams to stop illegal fishing activities which cause dolphin deaths.

(6) The Ministry of Agriculture, Forestry and Fisheries, Ministry of Tourism, Ministry of Environment, Ministry of Public Work and Transportation, and provincial authorities of Kratie and Stung Treng Provinces must help the Cambodian National Tourism Authority to conserve Irrawaddy dolphins in the Mekong River and develop tourism activities for reducing the poverty of people living along the Mekong River from Kampi Pool in Kratie to the Lao PDR/Cambodia border.

(7) The Ministry of Agriculture, Forestry and Fisheries, Ministry of Tourism, Ministry of Environment, Ministry of Public Work and Transportation, Ministry of Interior, Ministry of National Defense and other Ministries and

relevant agencies, National Tourism Authority and Governor's of Kratie and Stung Treng Provinces must follow this order. People who act in contrast with it will be responsible to the law.

There are currently no officially designated protected areas for dolphins in Cambodia, however, a proposed Royal Decree developed by the Ministry of Agriculture, Forestry and Fisheries has been submitted to the Cambodian Council of Ministers for final approval. This Royal Decree will create nine dolphin conservation areas in the upper Cambodian Mekong River.

In Vietnam, all cetaceans are protected by a decree of the national assembly but this is not generally enforced (Perrin *et al*. 2005). No fishery regulations or protected areas are known that protect Irrawaddy dolphins in Vietnam.

RESEARCH AND CONSERVATION ACTIVITIES

The first known modern record of Irrawaddy dolphins in the Mekong River is from Mouhot (1966) who sighted dolphins near Phnom Penh. Studies on the internal anatomy of Irrawaddy dolphins from Kratie, Cambodia, were conducted by Lloze (1973). In the early 1990s, field research confirmed the presence of Irrawaddy dolphins in southern Lao PDR and northeast Cambodia (Baird and Mounsouphom 1994, 1997; Baird *et al*. 1994). Behavior patterns were studied by Stacey (1996) and Stacey and Hvenegaard (2002) and acoustic and visual studies were undertaken by Borsani (1999) in the Lao PDR/Cambodia transborder pool. Surveys conducted by Baird *et al*. (1994) and Baird and Beasley (2005) revealed that dolphins occasionally occur in the Sekong sub-basin of northern Cambodia and southern Lao PDR. In a report submitted to Perrin *et al*. (1996), hunting for oil extraction during the mid 1970's was reported to be have caused dramatic declines of the Mekong Irrawaddy dolphin population. In March and May 1997, approximately 350 km of the Mekong River in southern Lao PDR and northeastern Cambodia were surveyed. Approximately 40 dolphins were sighted, and no more than 200 individuals were estimated to occur in the river basin (Baird and Beasley 2005). Skeletal materials from Irrawaddy dolphins were documented in various "whale temples" in Vung Tau and Binh Thang near the Mekong River Delta, Vietnam (Smith *et al*. 1997; Beasley *et al*. 2002).

The Mekong Dolphin Conservation Project (MDCP) was initiated in January 2001. The primary goals of the project were to undertake a comprehensive status assessment of Irrawaddy dolphins in the Mekong River, develop effective conservation and management initiatives incorporating socio-economic considerations, and build capacity among local government officials (Beasley *et al*. 2003). Activities of the project included: (1) conducting research on the biological and socio-economic factors relevant to the conservation of the Irrawaddy dolphin population in the Mekong River; (2) implementing a public education and awareness program which includes workshops and discussions with local communities about social factors influencing potential conservation strategies; (3) developing regulations to manage dolphin-watching tourism, primarily at Kampi Pool, and attempting to secure community benefits from these activities; (4) building capacity among government officials (particularly within the Department of Fisheries) and local people to conduct research and conservation activities; (5) strengthening an existing program to collect data on

mortality rates and causes; (6) initiating and encouraging community development and livelihood diversification projects in villages near critical dolphin habitats in partnership with the Cambodian Rural Development Team (CRDT); and (7) developing the Cambodian Mekong Dolphin Conservation Strategy, which includes detailed recommendations for protected areas and community-based management. This strategy was adopted by the Cambodian Department of Fisheries as national policy and approved by the Ministry of Agriculture, Forestry and Fisheries in January 2005.

In September 2004, the Cambodian Department of Fisheries initiated the Cambodian Mekong Dolphin Conservation Project (CMDCP) with support from the World Wide Fund for Nature (WWF), Wildlife Conservation Society (WCS), and the MWBP. In response to the Prime Minister's Urgent Order No. 01 on Mekong River Dolphin Conservation Ecotourism Development, the CMDCP is urgently implementing the following high priority activities in Cambodia:

1. Publishing and disseminating the Cambodian Mekong Dolphin Conservation Strategy.
2. Calling for the Royal Government to fully adopt the *Prakas* banning all fishing activities at the nine provisional core dolphin conservation areas and the new Fisheries Law.
3. Extending regulations on dolphin-watching ecotourism management to the provisional core dolphin conservation areas, other than Kampi Pool where regulations are already in place, starting with the Cheuteal Pool.
4. Enforcing provincial community fisheries regulations, old fisheries law, *Prakas* No. 02 of the Royal Government of Cambodia on the prohibition of electric fishing and small mesh size nets, and Prime Minister's Urgent Order No. 01. This enforcement will also apply to the *Prakas* banning all fishing activities in dolphin core conservation areas as proposed in the Royal Decree and new Fisheries Law.
5. Educating local fishermen, community representatives and students about fisheries regulations (see above) through village meetings, school and pagoda visits.
6. Conducting upstream direct counts and downstream pool counts to estimate population size and detect abundance trends.
7. Patrolling to enforce fisheries regulations during day and night hours.
8. Strengthening the Mekong Irrawaddy Dolphin Stranding Program
9. Conducting interviews to examine the perceptions of local people about dolphins.
10. Developing a Lao PDR/Cambodia Irrawaddy Dolphin Management Committee to develop conservation priorities at Cheuteal Pool.

Concerning the last action, in December 2004 a workshop was held in Stung Treng, Cambodia, (Lopez 2004) involving a total of 60 participants from Cambodia and Lao PDR. This trans-boundary workshop built on existing cooperation, and participants agreed to make additional efforts to address dolphin conservation issues through existing mechanisms and to establish a trans-boundary dolphin management committee.

LIST AND DESCRIPTION OF CONSERVATION PARTNERS AND MANAGEMENT AUTHORITIES

Cambodian National Tourism Authority
In February 2006, the Prime Minister of Cambodia appointed the Cambodian National Tourism Authority to be primarily responsible for guiding dolphin conservation in Cambodia.

Cambodian Mekong Dolphin Conservation Project (CMDCP)
The CMDCP was initiated by the Cambodian Department of Fisheries in September 2004, with support from WCS, WWF and MWBP.

Mekong Dolphin Conservation Project (MDCP)
The MDCP was initiated by James Cook University in January 2001 and focuses on dolphin research and raising awareness.

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REVIEW OF THE STATUS AND CONSERVATION OF IRRAWADDY DOLPHINS *Orcaella brevirostris* IN SONGKHLA LAKE OF THAILAND

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EXECUTIVE SUMMARY

Although abundance has not been estimated, surveys using direct counts indicate that the Irrawaddy dolphin population in Songkhla Lake, Thailand, has reached critically low numbers. Additionally, an increasing number of stranded Irrawaddy dolphin calves together with a more restricted distribution indicate that the population is strongly threatened. Intensive conservation efforts are thus needed. A protected area should be declared with the acceptance of stakeholders. No harmful fishing gears should be allowed, and the number of boats should be limited inside the protected area. The Thailand Department of Marine and Coastal Resources, as one of management authorities, should take the lead on organizing the development an adaptive conservation action plan. Information on existing natural resources and environment and social-economic data of Songkhla Lake should be gathered in the form of a database and geographic information system (GIS) which can be used for further decision making. Public participation should be encouraged to give a better understanding of the importance of dolphin conservation and to exchange thoughts on developing an action plan. Besides direct protection of the population, environmental improvement programs should be developed and issues on minimizing sedimentation and pollutants loads prioritized. In case the situation can not be improved, translocation of the population might be considered as the last solution.

OVERVIEW OF POPULATION RANGE

Several populations of Irrawaddy dolphins have been recorded in both the west and east coasts of Thailand (Chantrapornsyl *et al.* 1999; Atichat *et al.* in press; Kittiwattanawong, unpublished). The population sizes range from one to fifteen individuals (Surasak Tongsukdee, Department of Marine and Coastal Resources, personal communication; Kittiwattanawong, unpublished). The only freshwater population was found in Songkhla Lake.

HABITAT AND AREAS OF HIGH DENSITY OCCURRENCE

Songkhla Lake is comprised of three parts: Thale Noi, Thale Luang, and Thale Sab. Thale Noi is a freshwater lake covering an area of 27 km^2. The depth ranges from 0.5-1.9 m. Thale Luang is the largest part of Songkhla Lake, covering an area of 830 km^2. Thale Luang has a facultative haline system that remains fresh during the rainy season (October-January). The salinity is between 3-6 ppt during the dry season (March-May). The depth ranges from 1-4 m. Thale Sab covers an area of 185 km^2. The salinity ranges from 26-32 ppt and the depth ranges from 1.4-2.9 m (Penchai 2003).

Data gathered from stranding records and field surveys revealed that Irrawaddy dolphins tend to aggregate in the mid-upper part of Thale Luang (Figure 2; Piroj and Tanate 1995; Beasley *et al.* 2002; Piwpong and Aungsunee, in press; Ninwat, unpublished). Kernel home range (see Worton 1989) was calculated based on sighting records (N = 24) during 2000-2004 and showed that 95% of sighting locations remained within 241 km^2, while at 50% probability the distribution covered an area of 26 km^2.

Figure 1. Distribution of known Irrawaddy dolphin populations in Thailand and southern Myanmar (shown as dark ovals). There is only one freshwater population in Thailand (Songkhla Lake).

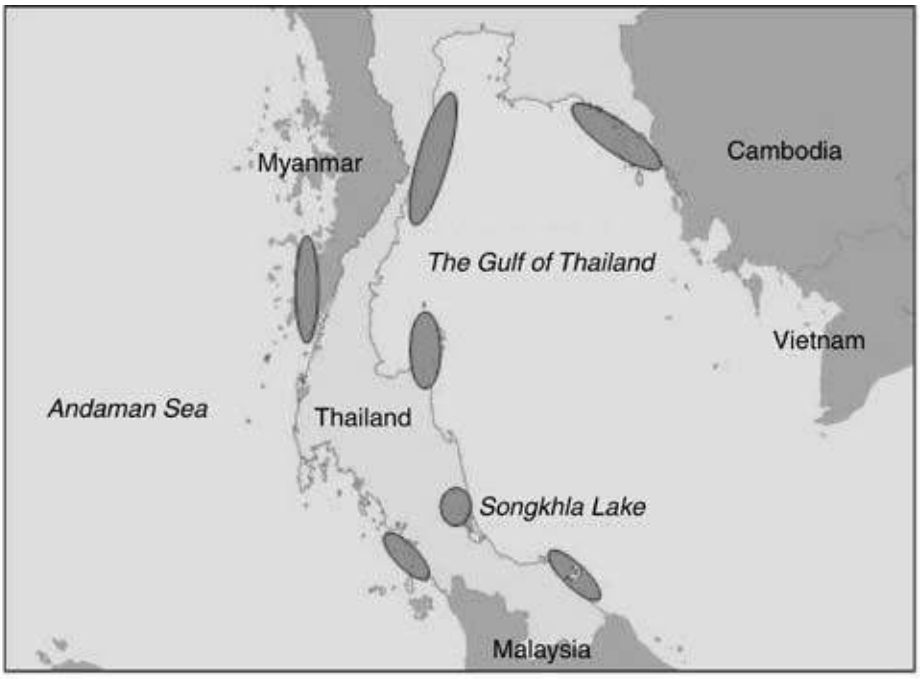
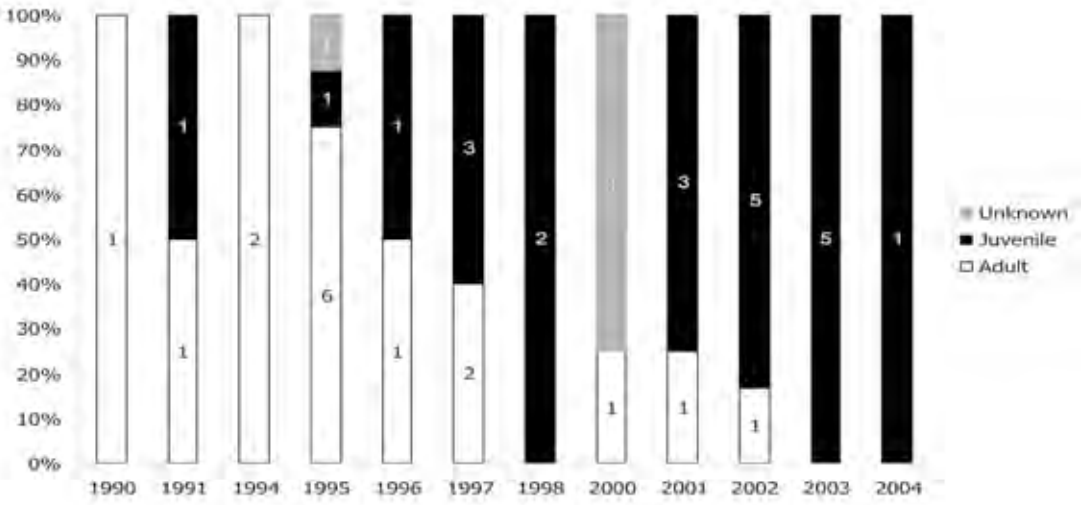


Figure 2. Yearly mortality of Irrawaddy dolphins in Songkhla Lake. Note the increasing mortality trend of juvenile dolphins.[5]



[5] Editors' note: For the years 2001-2003, there is a discrepancy in the mortality numbers reported here versus those reported in Smith *et al.* 2004 using the same data from Somserm Choorak. However, the number of deaths for the overall period is similar (15 reported in this paper and 16 reported in Table 1 of Smith *et al.* (2004) combined with those reported in Table 1 of Beasley *et al.* (2002) for the first half of 2001, and all authors agree about the apparent increasing trend in the proportion of calf or juvenile mortalities.

ABUNDANCE AND TRENDS

No rigorous abundance estimate of the Irrawaddy dolphin population in Songkhla Lake has been reported. Results of previous surveys are reported in Beasley *et al.* (2002) and Smith *et al.* (2004). An aerial survey conducted in August 2004 by the Department of Marine and Coastal Resource using a microlite aircraft flying at an altitude of 300 feet indicated that the population did not exceed 20 individuals.

Chooruk (unpublished data) reported that Irrawaddy dolphins in Songkhla Lake died at a rate of between one and seven individuals each year. Analysis of this data by age class revealed an increasing proportion of deaths of juvenile Irrawaddy dolphins between 1990 and 2004 (Figure 2). The use of large mesh nets for catching giant catfish, and pollution in the lake have been identified as probable causes of mortality.

CURRENT AND POTENTIAL FUTURE THREATS

Although there has been no evidence of directed takes of Irrawaddy dolphins in Songkhla Lake, non-natural mortality is still going on. Bycatch of Irrawaddy dolphins caused by gillnets has been reported. Other fishing gears, such as shrimp traps and set bag nets, are heavily used in the lake. These gears are non-destructive to Irrawaddy dolphins, however, they compete with the animals for food and limit their movements. Habitat degradation by both physical and chemical factors is considered an ongoing threat. In addition, depletion of food sources for Irrawaddy dolphins due to overfishing is a candidate for a future threat.

LEGISLATION, FISHERIES REGULATIONS AND PROTECTED AREAS

Irrawaddy dolphins are given protected status in Thailand. Existing legislation and regulations related to Irrawaddy dolphins are listed below.

- Wildlife Reservation and Protection Act 1992: Dolphins and whales as well as their products are protected.
- National Park Act 1961: Protective areas for whales and dolphins.
- Fisheries Act 1947: Three km from the shoreline is claimed as no trawling zone.
- CITES: Thailand is a member nation and Irrawaddy dolphins are listed on Appendix I of the Convention.

RESEARCH AND CONSERVATION ACTIVITIES

In general, Irrawaddy dolphins in Songkhla Lake are considered in positive ways. The dolphin is shown as a symbol of Pattalung Province and used as a mascot of the Pattalung Provincial Games. Irrawaddy dolphins also receive protection under patronage of Her Majesty the Queen of Thailand. The Irrawaddy Dolphin Lovers Project led by Somserm Choorak has been successful in drawing public attention and participation to dolphin conservation. Exhibitions and education programs have been conducted to promote conservation awareness.

Monitoring of Irrawaddy dolphin population in Songkhla Lake by the Department of Marine and Coastal Resources has been conducted since 2004. The monitoring program will be continued for the next five years. Along with this program, behavior and life history information will be collected. Cooperation among government and non-government organizations will be required to fulfill conservation plans. Public hearings will be conducted with stakeholders to ensure the success and feasibility of protective plans.

LIST AND DESCRIPTION OF CONSERVATION PARTNERS AND MANAGEMENT AUTHORITIES

Department of Marine and Coastal Resources (DMCR)
DMCR is under the Ministry of Natural Resources and Environment. It has a direct role in the conservation of Irrawaddy dolphins. The department played an important role in up-listing Irrawaddy dolphin from CITES Appendix II to Appendix I in 2004.

Department of Fisheries (DoF)
DoF is under Ministry of Agriculture and Cooperative. Its function is to enhance and regulate fishing activities.

Department of Plant and Wildlife Resources (DPWR)
DPWR manages conservation areas that have been established for various purposes along the shoreline of Songkhla Lake. Special regulations are enforced inside these protected areas.

Pattalung and Songkhla Provincial Offices
These provincial offices cover the extent of Songkhla Lake and play important roles in regulating activities that occur in the area.

Prince of Songkhla University
The Prince of Songkhla University is located in the southern part of Songkhla Lake. The University takes the lead on conducting research and gathering information on natural resources and environment in Songkhla Lake.

Irrawaddy Dolphin's Lovers Project
The Irrawaddy Dolphin Lovers Project has been run by Somserm Chooruk, who is a school teacher in Pattalung Province, since 1995. Currently there are about 150 members.

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ANNEX 1.

REPORT ON THE WORKSHOP TO DEVELOP A CONSERVATION ACTION PLAN FOR FRESHWATER POPULATIONS OF IRRAWADDY DOLPHINS

Held at the Cambodian Department of Fisheries, 21-26 March 2005, Phnom Penh, Cambodia

Organized by the Wildlife Conservation Society in collaboration with the Cambodia Department of Fisheries, Ocean Park Conservation Foundation, Mekong Wetlands Biodiversity Conservation and Sustainable Use Program, and the Whale and Dolphin Conservation Society.

Edited by Brian D. Smith, Robert G. Shore and Alvin Lopez

CONTENTS

1.0 INTRODUCTION

The Workshop to Develop a Conservation Action Plan for Freshwater Populations of Irrawaddy Dolphins was called to order on 21 March 2005 at the Cambodia Department of Fisheries in Phnom Penh. Mr. Ing Try, Deputy Director of the Cambodia Department of Fisheries, welcomed participants to the workshop and spoke about progress on conserving Irrawaddy dolphins in the Mekong River, including the recent order from Prime Minister Hun Sen that provides protection to dolphins from deliberate killing and prohibits gillnet fishing in the river segment between Stung Treng and the Lao PDR – Cambodia border. His Excellency Por Try, Secretary of State of the Ministry of Agriculture, Forestry and Fisheries, gave the opening speech during which he expressed his appreciation to participants for traveling to Cambodia to participate in the workshop and wished everyone productive deliberations. Brian D. Smith, Associate Conservation Zoologist for the Wildlife Conservation Society (WCS) and Asia Coordinator for the IUCN Species Survival Commission Cetacean Specialist Group, acknowledged funding contributions for convening the workshop from the Ocean Park Conservation Foundation, Whale and Dolphin Conservation Society, Mekong Wetlands Biodiversity Conservation and Sustainable Use Program, and WCS. He also spoke about how freshwater populations of Irrawaddy dolphins in Songkhla Lake and the Ayeyarwady, Mekong and Mahakam Rivers were classified as "critically endangered" according to IUCN Red List criteria and mentioned that the workshop was one of 57 priority projects included in the 2002-2010 IUCN Conservation Action Plan for the World's Cetaceans (see Reeves *et al.* 2003).

2.0 OBJECTIVES

The objectives of the workshop were to review information on the status of freshwater populations of Irrawaddy dolphins in the Mekong, Ayeyarwady, and Mahakam river systems and Songkhla and Chilika lakes, share lessons and experiences on protection efforts to date, and develop an action plan for their conservation.

3.0 GLOBAL STATUS AND FRESHWATER OCCURRENCE OF THE SPECIES

Irrawaddy dolphins were recently split into two species, with *O. brevirostris* occurring in five freshwater systems (see below) and nearshore marine waters associated with freshwater inputs of Southeast and South Asia extending as far west as Vishakhapatnam along the east coast of India, and the newly described snubfin dolphin *O. heinsohni* occurring in the coastal waters of northern Australia and southern Papua New Guinea (Beasley *et al.* 2005). The specific conservation status of Irrawaddy dolphins is unknown but they are generally believed to occur in scattered pockets of less than 100 individuals (Stacey and Leatherwood 1977). A significantly larger population of at least a few thousand individuals occurs in the inner and outer Sundarbans Delta of Bangladesh (Smith *et al.* 2005; 2006). Interestingly, Irrawaddy dolphins do not occur in fluvial waters of the Ganges-Brahmaputra-Meghna river system upstream of the Sundarbans Delta, possibly due to inter-specific competition from Ganges

River dolphins *Platanista gangetica*, which are obligate freshwater specialists, or historic speciation processes related to sea level changes that led to adaptive differences between freshwater and marine populations (for an explanation of the latter see Kreb 2004).

Freshwater populations of Irrawaddy dolphins occur in three river systems - the Ayeyarwady (formerly Irrawaddy) of Myanmar (formerly Burma), Mahakam of Indonesia, and Mekong of Cambodia, Lao PDR and Vietnam, and two partially isolated brackish or freshwater lakes – Chilika of India and Songkhla of Thailand (Figure 1). The Ayeyarwady, Mahakam, Mekong and Songkhla populations are classified as "critically endangered" according to IUCN Red List Criteria (see Kreb and Smith 2000; Smith 2004; Smith and Beasley 2004a; Smith and Beasley 2004b, respectively). The criteria used for classifying all four populations were that (1) the numbers of reproductively mature individuals were estimated to be < 50 and (2) continuing population declines were projected based on known and potential threats. Insufficient information was available to assess the Chilika Lake population according to IUCN criteria, however, preliminary evidence suggests that it may be classified as "endangered" due to low population size and projected abundance declines. These five freshwater populations of Irrawaddy dolphin represent a fairly unique adaptation within the Order Cetacea as members of a species that is found in both nearshore marine and fresh waters. They share this attribute with only two other cetaceans: the finless porpoise *Neophocaena phocaenoides* in the Yangtze River of China and the tucuxi *Sotalia fluviatilis* in the Amazon and Orinoco rivers of South America.

All five freshwater populations of Irrawaddy dolphins are believed to be demographically isolated from members of the species occurring in marine waters. The downstream range extents of the riverine populations are about 180, 500 and 1000 km from the sea in the Mahakam, Mekong and Ayeyarwady rivers, respectively, and only a few strandings and no sightings of Irrawaddy dolphins have been documented along adjacent coastlines within 80 km of both Chilika and Songkhla lakes.

4.0 REVIEW OF FRESHWATER POPULATIONS

4.1 Ayeyarwady River, Myanmar

In the Ayeyarwady River (formerly known as the Irrawaddy River, from which the dolphin takes its name) the linear extent of Irrawaddy dolphin occurrence has declined by nearly 60% (or 488 km) since the 19th century (Smith 2004). The current range of the species is confined during the dry season to a 373 km river segment between the Taping tributary confluence at Bhamo and Mingun (located slightly upstream of Mandalay), with the distance from the nearest other reported record of this species almost 1000 km downstream in the river delta (Smith 2003). The best available information on the abundance of dolphins in the Ayeyarwady indicates a population size of 59-72 individuals, based on direct count surveys conducted between Bhamo and Mandalay in 2003 and 2004 (Smith *et al.* this volume). In total, 5,701 fishing gears, 54% of them gillnets, were recorded in the main channel of the entire river during 2002. Gillnets were the most widespread gear and encounter rates increased significantly as the survey progressed downstream (Smith 2003). Electric fishing was reported

by local fishermen to be a significant threat due to the direct effects of electrocution and indirect effects from prey depletion. A total of 890 gold mining operations were recorded during the all river survey in 2002, including large boat dredges (15.8%) and hydraulic land blasters (13.4%; Smith 2003). These operations cause excessive sedimentation and relatively high levels of mercury, which is used during the mining operations to amalgamate gold, were found in the muscle of 104 fish belonging to 22 different species (Smith 2003). The high biomagnification potential of mercury makes this finding a source of concern to the dolphin population due to the toxic effects of the trace metal.

4.2 Chilika Lake, India

The population size of Irrawaddy dolphins in Chilika Lake was estimated to be 85 individuals (SD = 18.5, range = 62-98) based on the mean number of dolphins recorded during monthly direct count surveys conducted between 2003 and 2005. Dolphin distribution was concentrated in the outer channel (16 km^2, 66% of individuals), central portion (59 km^2, 23% of individuals) and southern portion (34 km^2, 11% of individuals) (Pattnaik *et al*. this volume). After dredging a new outlet to the sea in 2000, dolphins were recorded more frequently and expanded their range in the southern and central portions of the lake. The new opening apparently also increased fish production and led to an increase in the number of fixed trap nets, gillnets and seine nets used in the lake (Pattnaik *et al*. this volume). A minimum mortality rate calculated from direct observation of dolphin carcasses from 2003-2004 was 13 dolphins/year or about 12% of the total population size as reported above. The causes of death for most animals were unclear but gillnet entanglement and collisions with dolphin-watching vessels were probably major factors (Pattnaik *et al*. this volume).

4.3 Mahakam River, Indonesia

Irrawaddy dolphins in the Mahakam River are generally confined to a 195-km segment of the mainstem starting from about 180 km above the mouth between Muara Kaman and Muara Benangak. Within this segment they are also found in the lower reaches of the Kedang Rantau, Kedang Kepala, Belayan, Kedang Pahu, and Ratah tributaries, and in the southern portion of Semayang Lake and its connecting channel to Melintang Lake (at high water) and the Mahakam (Kreb and Budiono 2005). Based on eight direct count surveys of the entire range of the species in the Mahakam River from February 1999 to July 2000, the minimum population size was estimated to be 34 individuals (Kreb 2002). Based on mark-recapture analyses of photo-identified individuals in 2001 a slightly larger population size of 55 (CV=6%) and 48 (CV=15%) individuals was estimated using Peterson and Jolly-Seber estimators, respectively (Kreb 2005). In 2005, the population was estimated at 70 individuals (CV=10%; 95% CL = 58-79) using a Peterson estimator (Kreb *et al*. 2005). The higher 2005 estimates probably does not represent population growth but rather greater precision due to an increase in the proportion of identified individuals during the latter survey when digital photography was used. The Mahakam population was subject to mean annual mortality rates of 8% and 4% during 1995-2000 and 2001-2005, respectively, (Kreb *et al*. 2005) with the majority of deaths (66%) attributed to gillnet entanglement (Kreb and Budiono 2005). Other threatening

factors include collisions and harassment from speedboats in core habitat areas, physical displacement by container barges operating in the narrow Kedang Pahu tributary, coal, mercury and cyanide pollution from mining operations, possibly prey depletion due to intensive fishing with gillnets, electricity and poisons, and past live captures to stock aquaria (Kreb and Budiono 2005).

4.4 Mekong River, Cambodia, Lao PDR and Vietnam

The effective range of Irrawaddy dolphins in the Mekong River is a 190 km segment located between Kratie, Cambodia (about 500 km upstream of the river mouth in Vietnam) and Khone Falls, which physically obstructs farther upstream movement and is located slightly upstream of the Lao PDR - Cambodia border (Beasley *et al.* 2003). Dolphins previously inhabited Tonle Sap (Great Lake) (Lloze, 1973) but apparently have been extirpated from there (Beasley *et al.* 2003). Preliminary mark-recapture estimates of abundance established that the population numbered at least 125 individuals (95% CI = 114 - 152) in April 2005. Anthropogenic factors, mostly gillnet entanglement, were implicated in the deaths of 15 adult and juvenile dolphins (62.5%, N = 24) and high mortality rates (5.4% based on the April 2005 minimum population estimate) suggest a population in decline (Beasley *et al.* this volume). The large number of recent calf mortalities is worrisome and may indicate a problem with environmental contaminants. Analyses of mercury as a possible threat indicated that levels were not high. Other potential threats include illegal dynamite and electric fishing, water pollution, and noise, collisions and harassment from dolphin watching and high speed transport vessels (Beasley *et al.* this volume).

4.5 Songkhla Lake, Thailand

Although the precise number of dolphins in Songkhla Lake is unknown, the population probably numbers in the low tens and there is strong qualitative evidence of declining size in recent years. During surveys in May 2000 and February 2001 covering 545 km in the inner and middle portions of the lake (Thale Luang) north of Papayurn Island, Beasley *et al.* (2002) recorded only four sightings of dolphin groups. In September 2003 Smith *et al.* (2005) conducted a line-transect survey covering 234 km in Thale Luang. The intention had been to search the entire lake, however, survey effort was effectively limited to the same area covered by Beasley *et al.* (2002) due to shallow water, thick sea grass and an extremely high density of fixed fishing gears. Sighting conditions were good but no dolphins were detected. A survey conducted in August 2004 by the Department of Marine and Coastal Resources using a microlite aircraft flying at an altitude of 300 feet estimated that the population probably did not exceed 20 individuals (Kittawattanawong, this volume). 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, imply 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 to the northern portion (Beasley *et al.* 2002; Smith *et al.* 2004). These fixed fishing gears, which number about 40,000 and equal more than 8000 km of linear barrier distributed in multiple rows, also physically exclude dolphins from inhabiting a major portion of the lake (Smith

et al. 2004). The large and increasing proportion of stranded calves recorded between January 1990 and December 2003 might be due to high toxic loads of bioaccumulating agrochemicals used intensively in fields along the shore of the lake (Smith *et al.* 2004).

5.0 CONSERVATION THREATS

5.1 Fisheries bycatch

Workshop participants agreed that incidental killing in gillnets is currently the most critical threat to freshwater populations of Irrawaddy dolphins. Possible exceptions are the Ayeyarwady River where electric fishing is now viewed as the most urgent threat, and Chilika Lake where vessel harassment and collisions from dolphin watching operations may threaten the animals to the same or greater degree.

The most detailed information on bycatch comes from the Mekong River where, of the 15 mortalities confirmed to be have been caused by humans in 2001-2005, 13 or 87% were due to gillnet entanglement (Beasley *et al.* this volume). This number almost certainly underestimates the number of deaths due to bycatch based on unreported kills and recovered carcasses where the cause of death was unclear – the condition of three additional adult dolphins was suggestive of human involvement, although this could not be confirmed.

Based on reports from local fishermen and the retrieval of eight carcasses between 1995 and 2005, Kreb *et al.* (this volume) documented 48 mortalities of which 66% died as a result of gillnet entanglement in large mesh (10 –17.5 cm) gillnets. One juvenile dolphin was killed by electric fishing and a calf died from entanglement in a hook and line. Using the most recent and precise abundance estimate of 70 individuals, (Kreb *et al.* 2005), yearly mortality and confirmed by-catch represented 6% and 4% of the total population size, respectively. Kreb and Budiono (2005) often observed dolphins feeding near these nets. Many gillnet fishermen claimed that dolphins actively guided fish into their nets, and that they use the dolphins' feeding patterns as indicators of the location and time to set their nets.

Except for anecdotal accounts, no direct information is available on gillnet entanglement in the Ayeyarwady River. However, the large and apparently increasing numbers of gillnets used within the current range of the species (66, 100, and 122 recorded during surveys in 2002-2004, respectively) and the increasing number of gill nets encountered as a 2002 all-river survey progressed downstream implies that these fishing gears may be at least partially responsible for the low population size and downstream range decline of the species (Smith *et al.* this volume).

Beasley *et al.* (2002) presented 28 records of dolphins that stranded in Songhkla Lake between January 1990 and April 2001. At least 13 of these were judged to have died from net entanglement, based upon the presence of net scars on the carcass or the reports of local fishermen. Of the total strandings, at least nine were calves (i.e., one meter in length or smaller). Since that report, 14 additional strandings have been recorded, including eight calves. At least two of those animals were believed to have been killed accidentally in gillnets set to catch sea bass (*Lates calcarifer*), including a pregnant female whose flukes had been cut off, probably to extract her body from the net (Smith *et al.* 2004).

For small cetaceans generally, it is recommended that yearly removals should not exceed 1–2% of their population size (Wade 1998) – the lower bound applicable to very small populations that are already vulnerable due to demographic and genetic factors. The high dolphin bycatch rates reported for the Mekong and Mahakam Rivers and suspected for Ayeyarwady River and Songkhla and Chilika Lakes (see above) are clearly unsustainable, especially given the small size of these populations.

5.2 Habitat Loss and Degradation

A workshop held in 1997 on the effects of water development on freshwater cetaceans in Asia emphasized that the complex hydrology and morphology of Asian rivers accounted for their ability to support cetaceans and that large-scale alterations in natural flow and barriers created by dams were having widespread and detrimental effects on these threatened species (Smith and Reeves 2000a). Discussions at the 1997 workshop were generally limited to the obligate freshwater cetaceans of Asia: Ganges and Indus river dolphins *Platanista gangetica gangetica* and *P.g. minor,* respectively, and the Yangtze river dolphin or baiji *Lipotes vexillifer*. Participants noted that water development structures affected freshwater bodies inhabited by Irrawaddy dolphins to a much lesser degree, but emphasized that there was a strong potential for projects in the planning stage to have severe impacts on the species.

Many dams have been proposed that may adversely affect the channels inhabited by Irrawaddy dolphins in the Mekong River Basin. It is difficult, however, to distinguish between projects that will probably never be built and those likely to be constructed in the near future. Of greatest concern are the large run-of-the-river dams (dams without a reservoir that generally preserve a relatively natural flow regime) proposed for the Mekong mainstem near Stung Treng and Sambor (Perrin *et al.* 1996; also see Mekong Secretariat 1995). In the Sekong River system, at least two dams have been proposed tens of kilometers below the reported upstream limit of the Irrawaddy dolphin. Dolphins are also threatened in the Sekong system by the proposed Xakaman and Xepian/Xenamnoi dam projects. This last project would divert almost all of the flow from the Xepian River to a reservoir behind another dam in the Xenamnoi River (Baird and Mounsouphom 1997). According to Öjendal *et al.* (2002) dams that will probably be constructed in the Se San/Sre Pok watershed, which comprises a network of tributaries that converge (together with the Sekong River) with the Mekong and provide about 10% of the total flow at Stung Treng, Cambodia, include the Se San 3 (located in Vietnam about 50 km from the Cambodian border and 20 km downstream of Yali Falls, and with a generating capacity of 260 MW at an estimated cost of US$ 320 million), Se San 4 (located in Vietnam about eight km from the Cambodian border with a generating capacity of 300 MW at an estimated cost of US $338 million) and the Upper Kontum (located in Vietnam in the Dak Nghe tributary of the Sesan River upstream of Yali Falls). In addition to dams in the Se San/Sre Pok of Vietnam, a number of projects have been proposed in this river basin downstream in Cambodia, including the Lower Se San 2 and Lower Sre Pok 2, but these are unlikely to be built in the near future (Öjendal *et al.* 2002). The only dam currently in place in the Se San/Sre Pok watershed is at Yali Falls, Vietnam. This dam was completed in 2001

and is 65 meters high with a 64.5 km^2 reservoir. It generates 720 MW of electricity and is believed to have cost about one billion US dollars (Öjendal *et al.* 2002). Serious declines in fisheries followed closure of the dam due to reduced and erratic flows during the dry season and changes in the overall morphology of the river downstream.

At the northern tip of Songkhla Lake a small connecting channel to the Gulf of Thailand previously existed but it was blocked by a dam constructed in 1955 to support irrigation of surrounding agricultural fields. The subsequent decline of salinity in the northern portion of the lake, which is the only area available for dolphins to inhabit due to habitat loss in the middle and southern portions (see below), dramatically affected the species composition and overall catches of fisheries in the lake with unknown effects on the dolphins and their prey. Blockage of the northern channel has also probably reduced freshwater flushing in the lake and therefore exacerbated already existing problems of sedimentation and high pollutant loads from expanding agriculture and aquaculture activities.

Deforestation and gold, sand and gravel mining introduce and redistribute large quantities of sediments causing major changes to the geomorphologic and hydraulic features of rivers and marine appended lakes that allow them to support dolphin populations. Smith (2003) recorded a total of 890 gold mining operations in the Ayeyarwady River during 2002, including 180 operations within the extent of dolphin occurrence. These operations, including large boat dredges (15.8%) and hydraulic land blasters (13.4%), were generally located in areas of reduced current, above and below defiles and near channel convergences – the same areas that constituted the preferred habitat of Irrawaddy dolphins (Smith *et al.* this volume). Although no large-scale gold mining operations occur in the Mekong mainstem, gold mining dredges operate in the Sekong River where dolphins have been reported to occasionally occur. Operations also exist on smaller tributaries, such as the Kampi River, which flows into the Mekong close to an area of core dolphin distribution (Beasley *et al.* this volume).

Increased sedimentation resulting from deforestation in surrounding watersheds has resulted in declining water depths in Songkhla, Chilika and Semayang Lakes. This latter water body is appended to the Mahakam River and previously supported dolphins throughout most of its breadth. Now it contains suitable habitat only in a small area near the channel connecting it with the mainstem (Kreb *et al.* this volume). Between 1992 and 1997 the maximum depth of Chilika Lake declined from 3.4 to 1.4 meters and the accumulation of sediments led to shrinkage of the opening channel and a dramatic decline in salinity. A new channel dredged in the northern portion of the lake in 2000 has apparently mitigated at least some of the problems caused by sedimentation (Pattnaik *et al.* this volume).

A source of habitat loss and population fragmentation in several areas has been the proliferation of fixed fishing gears. In the middle and southern portions of Songkhla Lake about 27,000 *Sai nong* or sitting traps (two wings composed of small mesh nets suspended between bamboo poles, each about 100m long, deployed in a V-formation, with a large trap at the apex) and 13,000 *Sang sai* or barrier traps (closely spaced bamboo poles, sometimes with a net suspended in between, starting from the shore and extending 200-300 m out with

traps placed periodically along its length) create more than 8000 km of linear barrier in multiple rows. These fishing structures are left in place year-round and restrict dolphin movements such that their habitat is substantially reduced and the potential for demographic interaction with individuals in the Gulf of Thailand is eliminated (Smith *et al.* 2004). Fixed fishing gears also occupy most parts of Semayang Lake and limit dolphin movements to a narrow, dredged channel that is subject to intensive vessel traffic (Kreb *et al.* this volume)

During a survey in the Mekong Delta, Smith *et al.* (1997) observed several dozen stow nets, each one stretching 200-400 m, and over 10 rows of gillnets laid out so that they stretched across nearly the entire channel with only small openings to permit vessel traffic. These authors speculated that the effective blockage of the delta by these nets may at least partially explain the lack of dolphin sightings during a comprehensive survey in the Mekong River of Vietnam conducted in 1996.

5.3 Chemical and Noise Pollution

Irrawaddy dolphins are apex predators. This means that the biomagnification properties of persistent contaminants are a particular concern. The risk of toxic effects may be greater for dolphins inhabiting freshwater versus marine environments due to reduced flushing in lakes and the affinity of dolphins for countercurrents in rivers where entrained contaminants (especially heavy metals) may settle in higher concentrations than elsewhere. Despite the potential dangers of chemical toxicity, few studies have been undertaken on the levels of persistent contaminants in tissues of Irrawaddy dolphins or their prey.

Mercury is a potential problem in the Ayeyarwady River where the element is used to amalgamate gold during mining operations. During a 2004 survey of the Ayeyarwady between Mandalay and Bhamo 61 samples of fish muscle tissue were collected (51 of *Ompok* sp. and 10 of *Crossocheilus burmanicus*). The mean mercury concentration for the *Ompok* specimens was 182 ng/g (SD = 96, range = 82-684), and for the C. *burmanicus* samples 30 ng/g (SD = 18, range = 15-75). The measured concentrations were high enough to give reason for concern about their potential effects on piscivorous wildlife and humans (Smith *et al.* this volume).

Small-scale gold mining takes place in the Mekong River but some of these operations use cyanide instead of mercury to amalgamate the gold (Sotham and Middleton 2004). Mercury concentrations in the livers of nine Irrawaddy dolphin carcasses recovered from the Mekong River (two adults (2.8 and 3.7 ng/g) and seven calves (0.9 – 1.6 ng/g)) were relatively low (Beasley *et al.*, this volume).

Water samples collected during 1996-1999 in downstream sections of the Mahakam River found that mercury and cyanide were below the local allowable limit of 1.0 ug/l except for samples taken in 1997, which were nearly 2.5 ug/l, when a leak occurred in a dam that retains waste products from a large gold mine upstream. The leak caused a massive fish kill (Kreb *et al.* this volume).

No information is available on the effects of mercury on Irrawaddy dolphins, however, a causal link has been suggested between liver disease and high levels of the metal in bottlenose dolphins (*Tursiops truncatus*) and long-finned pilot whales (*Globicephala melas*) (Rawson *et al.* 1993; Bowles 1999).

A possible explanation for the recent high proportion of stranded calves recorded in Songkhla Lake may be that they 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 (Smith *et al.* 2004). Eutrophication in the lake is also a major problem causing toxic algal blooms and major fish kills during the dry season that potentially affect the dolphin population due to prey depletion. High levels of calcium carbonate and antibiotics used in shrimp farms may also be having deleterious effects on the ecology of the lake.

Fishing with poisons (e.g., cyanide, pesticides and chemical fertilizers) occurs widespread in the Mekong, Mahakam and Ayeyarwady rivers. Spillage of coal from transport barges, which results in high acidity and massive fish kills, may be a problem in certain areas of the Mahakam River, especially in the Kedang Pahu tributary, and may account for changes occasionally observed in the skin pigment of dolphins in this area (Kreb *et al.* this volume).

Irrawaddy dolphins have acute hearing and well developed echolocation abilities. Their dependency on sound to navigate, detect and catch their prey and possibly to communicate means that acoustical disturbance must be considered as a potential threat. Sounds of sufficient intensity and at frequencies used by the dolphins may interfere with their ability to detect biologically important sounds or displace them from preferred habitat. Dolphins may become disoriented due to intense acoustic disturbance, and possibly more vulnerable to injury or death from vessel collisions.

Gold mining operations (large boat dredges and hydraulic land blasting) produce extremely loud noises 24 hours a day in the Ayeyarwady River. Especially in the Mekong and Mahakam rivers, dolphins may also be affected by relatively high frequency sounds (about 5 kHz) produced by speed boats used for human transport in core areas of dolphin distribution. There is a lack of quantitative studies on the auditory threshold of Irrawaddy dolphins in freshwater environments and on the intensity and frequencies of noise sources, especially for speed boats and gold mining dredges.

5.4 Vessel Harassment and Collisions

The potential for vessel collisions is high in Chilika Lake due to the large number of dolphin-watching boats (more than 350), the small area where the vessels operate (about 25 km^2), and the close distance that the vessels approach the animals due to pressure from tourists who want to view and photograph the animals at close range. Although the number of dolphin deaths caused by vessel collisions in Chilika Lake is unknown, several animals are believed to have been killed as a result of interactions with dolphin-watching boats (Pattnaik *et al.* this volume). Two records exist of dolphin deaths from vessel collisions in the Mekong River, one near the Lao PDR-Cambodia border and another in Kampi pool where the dolphin was apparently hit by a large barge (Beasley *et al.* this volume). Three incidents of fatal vessel collisions are known from the Mahakam River. All were apparently caused by speed boats (Kreb *et al.* 2005).

In addition to deaths and injuries caused by vessel collisions there is the potential for vessel harassment to affect dolphin populations due to stress and disturbance during their normal foraging, resting and socializing behavior. Stacey (1996) found that Irrawaddy dolphins in the Lao PDR- Cambodia bor-

der pool of the Mekong River dived longer when large motor boats approached to within 100m. Kreb and Rahadi (2004) reported that Irrawaddy dolphins in the Mahakam River exhibited significantly longer dives in the presence of container tugboats (>1000 hp), speedboats (40-200 hp) and motorized canoes (<40 hp), listed in order of increasing dive durations elicited by the different types. Longer dives require more energy to initiate, complete, and recover from, and repeated exposure to these vessels could be a source of chronic biophysical stress for affected individuals. Active avoidance of tugboats was recorded at low water levels in the narrow and shallow Kedang Pahu tributary. Dolphins produced higher frequency, longer duration and more frequent whistles in the presence of speedboats. Irrawaddy dolphins in the Mahakam also reacted to the presence of vessels at longer distances (about 250 m) compared to members of the species in the adjoining coastal marine environment (about 50 m). The difference between behavioral responses to vessels in these environments may be related to the more restricted habitat of riverine dwelling dolphins in deep pools compared to the more open environment of coastal waters (Kreb 2004).

6.0 CONSERVATION SOLUTIONS

6.1 Bycatch Mitigation

A particular challenge for mitigating Irrawaddy dolphin bycatch in freshwater systems is that gillnet fisheries tend to be small-scale, noncommercial and widely dispersed. Mitigation approaches discussed during the workshop included (1) establishing core conservation areas where gillnetting would be banned or severely restricted; (2) promoting net attendance rules and providing training on the safe release of entangled dolphins; (3) initiating a program to compensate fishermen for damage caused to their nets by safely releasing an entangled dolphin; (4) providing alternative or diversified employment options for gillnet fishermen; (5) encouraging the use of fishing gear that does not harm dolphins by altering or establishing fee structures for fishing permits to make gillnetting more expensive while decreasing the fees for fishing practices that do not directly threaten dolphins (e.g., cast-net fishing); and (6) experimenting with and potentially employing acoustical deterrents and acoustically reflective gillnets.

Most participants agreed that net attendance rules established in conjunction with training for gillnet fishermen on how to safely release entangled dolphins and a compensation program to reimburse them for nets damaged in the rescue process would be a useful mitigation approach outside of core conservation areas where gillnetting would be strictly prohibited. Issues that would need to be addressed include (1) the reluctance of part-time fishermen who pursue other occupations such as farming to attend their nets; (2) the fact that full-time fishermen may deploy nets in multiple locations; (3) guaranteeing that there are adequate funds to compensate fishermen for lost or damaged nets; (4) guarding against false claims of net loss or damage; and (5) ensuring an adequate capacity (human and financial) to monitor and enforce the regulations.

Participants agreed that it would be unacceptable to prohibit gillnet fishing without providing employment alternatives that ensure an equal or greater income for gillnet fishermen. They also agreed that gillnet fishing bans should be established in an incremental fashion such that additional areas become

closed to gillnetting as more gillnet fishermen are diverted into other occupations or fisheries. The success of this type of approach would depend on the close cooperation of regulatory authorities, conservation organizations and local fishing communities, and strict enforcement to ensure that everyone abides by the same rules. Generally, alternative livelihoods for gillnet fishermen should be a closely related profession such as aquaculture or cast-net or trap fishing. However, in some cases where gillnet fishing is only a part-time occupation practiced along with other employment activities such as farming, it may be possible to successfully emphasize completely different options. In a few cases it may also be possible to employ former gillnet fishermen as boatmen and guides for dolphin-watching tourism.

In the Mekong River, a program is currently being implemented by WWF, WCS and the Cambodian Rural Development Team that provides diversified employment opportunities such as mushroom farming and pond aquaculture for gillnet fishermen. In the Ayeyarwady River, the Department of Fisheries of Myanmar is planning to conduct certification courses for cast-net fishermen to take small groups of tourists with them while searching for the dolphins and engaging in cooperative fishing activities (see Smith *et al.* 1997b; Smith *et al.* this volume). Funds raised from this activity would be an enormous help to these generally impoverished fishermen and may also be an option to partially compensate local fishery departments for lost revenue from permits no longer sold for gillnetting concessions as these are eliminated on an incremental basis.

Participants agreed that technical solutions, such as acoustical deterrents (i.e., pingers), were of limited feasibility for mitigating gillnet entanglement due to the high costs of the devices (ca. $100 each) and the extreme difficulties of monitoring their effectiveness. From a monitoring perspective the "critically endangered" status of most populations ensures that a likely scenario would be extirpation before significant differences could be detected in bycatch rates between nets deployed with pingers and those deployed without them (see Dawson *et al.* 1998). Nevertheless some participants thought that it would be useful to test behavioral responses of the animals to pingers (see Stone *et al.* 2000; Culik *et al.* 2001) and acoustically reflective nets, and that these devices or net modifications could be appropriate for deployment in areas outside of core conservation zones where gillnetting would be prohibited. Key issues that will need to be considered are whether or not the dolphins become habituated (see Cox *et al.* 2001) or even attracted to nets with pingers (the so-called "dinner bell effect") and whether or not the acoustic output could have detrimental effects on the hearing of the animals (see Ketten 1998). Smith mentioned that one local solution sometimes employed by local fishermen to deter Irrawaddy dolphins in the Ayeyarwady River from stealing fish from their nets was to strike two iron bars together underwater. In view of the drawbacks on employing high-tech acoustical deterrents, the efficacy of this "home-grown" solution could be investigated further.

6.2 Protected Areas and Core Conservation Zones

Participants noted that multiple-use protected areas will play a key role for conserving freshwater populations of Irrawaddy dolphins. Protected areas could be a particularly effective conservation tool due to the fidelity of the spe-

cies in freshwater systems to relatively circumscribed areas (see above) which aids effective management. Priority areas for protected area status include: (1) in the Mekong River, nine deep pool areas between Kratie and the Lao PDR-Cambodia border totaling 5,632 ha; (2) 10-20 km segments in the Mahakam River, at the Kedang Pahu tributary mouth at Muara Pahu Town, the mouths of the Kedang Kepala and Kedang Rantau, and the Pela tributary including the southern portion of Semayang Lake; (3) in the Ayeyarwady River, segments between the Taping river confluence at Bhamo to the upstream end of the second river defile at Sinkan (36 linear km), the downstream end of the second river defile to Tagaung (165 linear km), and the downstream end of the third river defile at Kyaukmyaung to Mingun (74 linear km); (4) in Songkhla Lake, the middle portion of upper Thale Luang; and (5) in Chilika Lake, the area between Magamukh and the outer mouth.

Although additional biological data would be helpful on the fine-scale distribution and movement patterns of the dolphins and the nature of threats they face, sufficient information currently exists to designate scientifically appropriate protected areas for all five populations in the areas summarized above. Key considerations for the establishment of protected areas include (1) developing a management plan in collaboration with local communities and local and national government agencies; (2) clarifying responsibilities among relevant agencies and NGOs; and (3) demarcating clear boundaries where protected area regulations and guidelines apply. The need to conduct socio-economic surveys to assess potential impacts and opportunities prior to the establishment of protected areas was also stressed.

An example of how a protected area might be established in Songkhla Lake is the current network of fishing reserves for protecting fish reproduction in the lake. This network currently consists of 11 reserves (not including one in Thale Noi, a small lake north of Thale Luang) covering a total of 16 km^2. The largest one is located in upper Thale Luang surrounding the Ko Yai peninsula and covers 7 km^2. Another reserve in an area close to where dolphins have been observed covers 0.6 km^2 along the shoreline near Lampan. These reserves were established after extensive consultations with local fishermen and violators are apparently reported to the Fisheries Department by community guards (Smith *et al.* 2004). Evidence from 24 sighting records made in Songkhla Lake during 2000-2004 suggests that a reserve would need to cover 26 km^2 in the middle portion of upper Thale Luang to encompass 50% of the locations where dolphins were previously sighted (Kittiwattanawong *et al.* this volume).

6.3 Education and Community Involvement

Participants stressed the importance of involving local communities in the development and implementation of conservation plans for Irrawaddy dolphins. This will require a major effort to provide appropriate information to people on the status of the dolphin populations and on opportunities for implementing protective measures. Important considerations include (1) choosing the most effective target audience for educational activities; (2) ensuring that the potential benefits of dolphin-watching tourism are equitably shared with local stakeholders, especially fishermen; (3) establishing the close connection between

dolphin conservation and sustainable use of freshwater resources (see Flagship species below); and (4) promoting traditional fishing methods that do not directly harm dolphins.

6.4 Flagship Species

Irrawaddy dolphins make particularly appropriate flagship species for the rivers and marine appended lakes where they occur because the animals are generally revered by local people. Flagship species mobilize support for broader biodiversity conservation issues. For Irrawaddy dolphins these issues include the importance of (1) using selective fishing techniques and protecting fish broodstock in deep pools and fish spawning areas located adjacent to dolphin habitat; (2) maintaining natural geomorphic and hydrologic processes that may be affected by the construction of dams and embankments, and dredging and hydraulic blasting for mining gold; (3) ensuring adequate freshwater supplies so that dolphins can move freely among the deep pools that constitute their core habitat; and (4) promoting transboundary cooperation among national administrative units (e.g., provinces, districts, townships, etc.) and countries for the Mekong population (Cambodia, Lao PDR and Vietnam.).

Participants stressed the importance of distinguishing between Irrawaddy dolphins as "flagship" versus "indicator" species. These terms are often erroneously used interchangeably. Irrawaddy dolphins make poor indicator species due to their position at the top of the food chain, low reproductive rates and flexible foraging behavior. Significant and irreversible damage to freshwater systems can occur well before population level effects can be detected in such species.

Dolphins receive traditional protection in the Ayeyarwady River by virtue of the positive role they play in a cooperative fishery with cast-net fishermen. The fishermen summon the dolphins by tapping the sides of their boat with a conical wooden pin called a *Labai Kway*. If the dolphins "agree" to help the fishermen, one animal slaps the water surface with its tail flukes. One or two lead dolphins then swim in smaller and smaller semi-circles, corralling the fish towards the shore, while the other animals remain outside to guard against escapees. With a wave of their half-submerged flukes, the dolphins then deliver a concentrated mass of fish to the fishermen and "signal" them to cast their net. Using this technique the fishermen can catch as many fish in a single net cast as they normally do during a whole day of fishing without the dolphins. The dolphins benefit from the activity by preying on fish whose movements are confused by the sinking net and those that are momentarily stuck on the mud bottom after the net is pulled up (Smith *et al.* 1997b).

Irrawaddy dolphins have been adopted as the mascot of the Phattalung Province in Thailand, and a Royal proclamation from Her Majesty Queen Sirikit of Thailand signed on 3 October 2001 designated Irrawaddy dolphins in Songkhla Lake as a Royal Protected Species. Irrawaddy dolphins are used as the mascot and logo for the East Kalimantan Province (Mahakam), Chilika Lake Management Authority, and Yayasan Konservasi RASI (Conservation Foundation for Protection of Rare Aquatic Species of Indonesia), and the species has been designated as a flagship of the WWF Living Mekong Programme and the Mekong Wetlands Biodiversity and Sustainable Use Program.

6.5 Dolphin Watching Tourism

Collisions and harassment from dolphin watching vessels potentially threaten freshwater populations of Irrawaddy dolphins. However, participants noted that, if judiciously managed, the activity could also confer substantial conservation benefits by giving economic value to the animals as a living resource, providing a platform of opportunity for research and monitoring, and helping to spread awareness about the conservation value and needs of the species.

Commercial dolphin watching activities currently exist only in the Mekong River and Chilika Lake. In the Mekong, operations first started in the Lao PDR–Cambodia transboundary pool in the 1990s, with local boats taking tourists to a rock island near the center of the pool to observe the animals. As dolphin-watching tourism became more popular, pressure from the tourists to get close to the animals resulted in a shift from land-based to vessel-based operations and a rapid increase in the number of vessels involved. There are currently 25-30 dolphin-watching vessels on the Lao PDR side of the border with 2-3 vessels operating in close vicinity of the dolphins at any one time during daylight hours. Most of these vessels are long-tail boats, which are particularly hazardous to dolphins because the propeller is located several meters behind the boat hull. This increases the potential for fatal lacerations to the animals because the dolphins may attempt to evade the vessel only to collide with a revolving propeller.

Approximately 85% of the tourists visiting the Lao PDR–Cambodia pool are foreigners, with the remainder made up of Laotians. Tourism started several years later in Kampi Pool (Cambodia) and grew rapidly. In 1997, the provincial governor prohibited fishing which has forced some local people to fish illegally. Currently at least seven tourism boats operate in the pool. Fees are US$2 per person (Cambodians are free) for watching dolphins from a shoreline view point and US$5 per person for dolphin watching from a long-tailed boat. An agreement was signed in November 2004 to share shore-based entrance fees at the Kampi viewing site between the Cambodia's provincial Department of Tourism, the Village Development Committee of the local community, and the provincial Department of Fisheries. This agreement, however, does not extend to the funds collected from the tourism boats.

In Chilika Lake about 100,000 tourists, almost entirely Indian nationals, engage in vessel-based dolphin-watching activities each year, with the peak month in December. Three villages currently hold a monopoly on dolphin-watching tourism and do not allow others to become involved in the activity. More than 350 boats are involved. A relatively small area near the mouth of the lake is used for dolphin watching tourism. When the animals are spotted, a large number of boats converge on the group. The cost of a dolphin-watching tour is US$9 per boat.

Participants agreed that formal guidelines should be adopted for dolphin watching activities. Guidelines being promoted for use in Chilika Lake and the Mekong and Mahakam Rivers are contained in Annex 4.

6.6 Research and Monitoring

Conventional density sampling techniques used for marine cetaceans cannot generally be applied to riverine populations of Irrawaddy dolphins because the

complex geomorphology and hydrology of the floodplain rivers where the species occurs prevents vessel-based surveys from following transect lines placed randomly relative to the animals' distribution. Most surveys in these environments have used relatively simple direct count techniques which generally suffer from negative biases related to observer perception (e.g., all surfacings are not necessarily noted because observers may be inattentive, distracted, fatigued, or focused on a different location) or dolphin availability (most animals are underwater at any given time, and, when they are at the surface, they generally show little of their body; see Marsh and Sinclair 1989; Smith and Reeves 2000b). During direct count surveys of Irrawaddy dolphins, measures have been taken in the field to reduce these biases. These include conducting simultaneous land-based counts (Beasley *et al.* 2003), incorporating the use of a rear observer to expand the area of visual coverage, and surveying at a slow speed to increase the probability of detecting animals that dive for extended periods of time (Kreb 2002; Smith and Hobbs 2002). Independent concurrent counts were successfully used to statistically quantify and develop correction factors for perception bias during a survey of Irrawaddy dolphins in the mangrove channels of the Sundarbans in Bangladesh (Smith *et al.* 2006).

Mark-recapture analysis of photo-identified individuals has been used to estimate the population of Irrawaddy dolphins in the Mahakam (Kreb 2005) and Mekong (Beasley *et al.* this volume) Rivers, and this technique is currently being applied to the population in Chilika Lake. An examination of photographs of animals from the Ayeyarwady River revealed few nicks, scars, scratches, deformities and pigmentation features in the region of the dorsal fin that could be used to identify individuals (B. Smith, unpublished), thereby implying possible differences in the availability of these marks among different populations. A similar paucity of identifying marks was documented for a small isolated population of Irrawaddy dolphins in Malampaya Sound, Philippines (Smith *et al.* 2004)

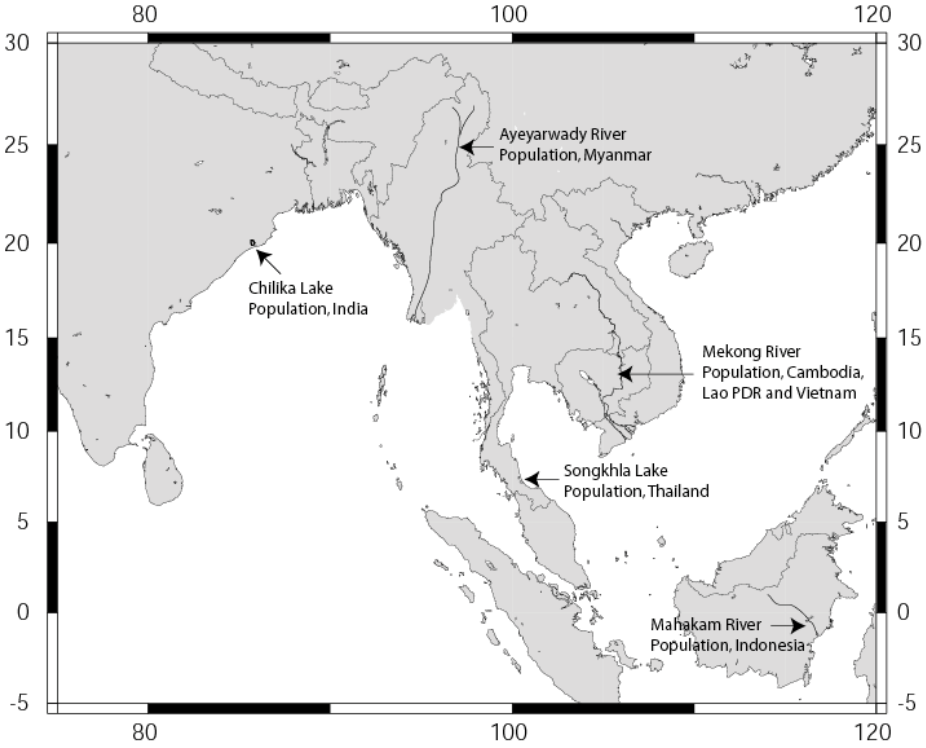
The value of interview surveys was discussed as an indirect approach for assessing bycatch. While this technique has been used by researchers for most of the freshwater populations of Irrawaddy dolphins, participants agreed that it had limited value as a stand alone method. Participants stressed the importance of carcass recovery programs as a direct approach for evaluating the specific circumstances of Irrawaddy dolphin bycatch, and recommended that a necropsy protocol be developed so that the full research value of recovered carcasses could be realized. One difficulty of implementing a carcass recovery program is that, especially as awareness raising programs communicate the importance of protecting the species, local people may be reluctant to report mortalities due to fear of getting into trouble with authorities or the belief that a perceived increase in the number of deaths could lead to restrictions on fishing or dolphin tourism activities. Participants recommended that regulations be put into place and communicated to river stakeholders which require them to turn over carcasses to local authorities, but that no actions should be taken to punish people who report dolphin kills. Another indirect method used to monitor the potential for incidental kills was direct counts of gillnetting operations made during surveys conducted to assess dolphin populations. In the Ayeyarwady River information on gillnet and dolphin encounter rates was used to prioritize river segments for

focal conservation attention and to make inferences about the probable cause of the species' range decline (Smith *et al.* this volume).

7.0 CONCLUSION

Freshwater populations of Irrawaddy dolphins are at a crossroads. Extinction is likely in the near future unless strong conservation measures, based on sound science and extensive input from local human communities, are urgently implemented. The Action Plan for the Conservation of Freshwater Populations of Irrawaddy Dolphins, developed on the basis of discussions detailed above, offers clear and practical guidance on a potential way forward. The challenge is to work assiduously on implementing recommendations of the plan so that these animals, which represent a rare adaptation within the order Cetacea and play strong positive roles in the lives of local people, are given the best possible chance for long-term survival.

Figure 1. Map showing the locations of the five freshwater population of Irrawaddy dolphins.



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ANNEX 2.

LIST OF WORKSHOP PARTICIPANTS

Isabel Beasley, Ph.D. Candidate, School of Tropical Studies and Geography, James Cook University

Or Channy, Team Leader, Cambodian Rural Development Team, Kratie

Kongkiat Kittawattanawong, Research Biologist, Phuket Marine Biological Center, Department of Marine and Coastal Resources, Thailand

Danielle Kreb, Principal Investigator, Pesut Mahakam Conservation Program

Alvin Lopez, Wetlands Ecologist, IUCN, Mekong Wetlands Biodiversity Conservation and Sustainable Use Programme

Hari Moelyono, Community Education Staff, Yayasan Konservasi RASI

Ajit Pattnaik, Director, Chilika Development Authority

Chanthone Phothitay, Staff Officer, Department of Fisheries, Lao PDR

Robert Shore, Officer – Species, Habitats, and Ecosystems, WWF Living Mekong Programme

Brian D. Smith, Associate Conservation Biologist, Wildlife Conservation Society

Kim Sokha, Field Coordinator, Cambodian Mekong Dolphin Conservation Project

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Tint Tun, Associate Marine Biologist, Wildlife Conservation Society

Martin Gilbert, Field Veterinarian, Wildlife Conservation Society

ANNEX 3.

WORKSHOP AGENDA

Day One – 21 March

8:30-8:45	Registration
8:45-9:00	Welcoming speech by Mr. Ing Try, Deputy Director, Cambodia Department of Fisheries
9:00-9:15	Speech by Mr. Brian Smith, Associate Conservation Biologist, WCS and Asian Coordinator, IUCN Species Survival Commission Cetacean Specialist Group
9:15-9:30	Opening Speech by H.E. Por Try, Secretary of State of the Cambodia Ministry of Agriculture, Forestry and Fisheries
9:30-11:00	Review of the status and conservation plans for the Mekong population (60 minute presentation; 30 minutes for questions - Isabel Beasley, Phay Somany, Kim Sokha, Alvin Lopez and Rob Shore)
11:00-11:30	Coffee break
11:30-1:00	Review of the status and conservation plans for the Mahakam population (60 minute presentation; 30 minutes for questions – Danielle Kreb and Hari Moelyono)
1:00-2:00	Lunch
2:00-3:30	Review of the status and conservation plans for the Ayeyarwady population (60 minute presentation; 30 minutes for questions – Brian Smith, Mya Than Tun, and Tint Tun)
3:30-4:00	Coffee break
4:00-5:30	Review of the status and conservation plans for the Chilika Lake population (60 minute presentation; 30 minutes for questions - Ajit Pattnaik and Dipani Sutaria)

Day Two – 22 March

8:30-10:00	Review of the status and conservation plans for the Songkhla Lake population (60 minute presentation; 30 minutes for questions – Kongkiat Kittawattanawong)
10:00-10:30	Coffee break
10:30-12:00	Discussion on research and monitoring (Chair: Brian Smith; Rapporteur: Isabel Beasley)
12:30-1:30	Lunch
1:30-3:00	Discussion on bycatch assessment and mitigation (Chair: Isabel Beasley; Rapporteur: Brian Smith)
3:00-3:30	Coffee break
3:30-5:00	Discussion on water development and other sources of habitat degradation (Chair: Brian Smith; Rapporteur: Alvin Lopez)
5:00-6:00	Discussion on vessel collisions (Chair: Danielle Kreb; Rapporteur: Isabel Beasley)

Day Three – 23 March

8:30 –9:30	Discussion on chemical and noise pollution (Chair: Danielle Kreb; Rapporteur: Brian Smith)
9:30-10:30	Discussion on the role of protected or core conservation areas (Chair: Phay Somany, Rapporteur: Daniel Kreb)
10:30-11:00	Coffee break
11:00-12:30	Discussion on dolphin tourism as a contributing factor for conservation and guidelines to prevent harmful interactions (Chair: Isabel Beasley; Rapporteur: Rob Shore)
12:30-1:30	Lunch
1:30-2:30	Evidence for population discreteness and evolutionary uniqueness of freshwater populations of Irrawaddy dolphins (Chair: Danielle Kreb; Rapporteur: Isabel Beasley)
2:30-3:30	Discussion on the role of Irrawaddy dolphins as flagship species for biodiversity conservation in freshwater systems (Chair: Alvin Lopez; Rapporteur: Rob Shore)
3:30-4:00	Coffee break
4:00-5:30	Discussion on community involvement in dolphin conservation (Chair: Rob Shore; Rapporteur: Alvin Lopez)
5:30-6:00	Discussion on the outline for the action plan (Chair: Brian Smith; Rapporteur: Daniel Kreb)

Day Four – 24 March

8:30-09:30	Distribute and read draft conservation action plan
9:30-10:30	Discussion of the draft plan: general recommendations
10:30-11:00	Coffee break
11:00-12:00	Discussion of draft plan: Recommendations for Mekong population
12:00-01:00	Discussion of draft plan: Recommendations for Mahakam population
1:00-02:00	Lunch
2:00-03:00	Discussion of draft plan: Recommendations for Ayeyarwady population
3:00-04:00	Discussion of draft plan: Recommendations for Chilika Lagoon population
4:00-04:30	Coffee Break
4:30-05:30	Discussion of draft plan: Recommendations for Songkhla Lake population
5:30-5:40	Closing Ceremony by H.E. Pao Try, Pao Try, Secretary of State of Ministry of Agriculture, Forestry and Fisheries

Day Five and Six – 25-26 March

Field Trip to Kratie Pool

25 March evening: Roundtable discussion: Turning conservation plans into conservation action

ANNEX 4.

DOLPHIN WATCHING GUIDELINES

Kampi Pool, Mekong River, Cambodia

- Motorized vessels should not approach dolphin groups closer than 100 m. If dolphins are within 100 m when the motor is turned off, the boat operator should paddle the boat to outside this distance before starting the motor.
- No rubbish is to be thrown into the dolphin area.
- Tourists must be quiet and not yell and hit the boat when the dolphins come near.
- Tourism boats are not allowed to use the boat motor within the dolphin-watching area – only paddling is allowed.
- The dolphin-watching area will be demarcated by plastic buoys which the boat operators must take care of and not move.
- No dolphin-watching boats are to enter Chroy Banteay Pool to view dolphins.
- No other motorized boats from outside the area are allowed to take tourists to view the dolphins – all must take the authorized dolphin-watching boats from Kampi viewing site.
- Exceptions to the above rule include research groups, authorized in writing by the Department of Fisheries to conserve and manage the dolphin population.
- All other boats must travel through the area slowly, at no-wake speed.

Chilika Lake, Orissa State, India

- Please ask your boatman not to speed into a group of dolphins.
- Approach them slowly at no wake speed and keep the boat parallel to the animals.
- Put off the boat engine in the presence of dolphins.
- Please do not chase dolphins, this scares them away and disrupts their normal activities.
- Dolphins are valuable to the ecosystem, valuable to the tourist and valuable to the boat operator.
- Do not litter plastic and paper. Keep Chilika clean.

Mahakam River, East Kalimantan, Indonesia

- Do not use a speedboat as the sound will harass dolphins, and you will definitely not see any dolphins.
- Ask the boatsmen to maintain a steady, slow speed and keep parallel to the dolphins with a 30 m distance as a general rule while your engine is on.
- Do not suddenly change your boat speed or try to chase a dolphin.
- Do never cut a dolphin's swimming path or move in between individuals.
- Do not try to feed or swim with a dolphin.

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