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**Species conservation in a complex socio-ecological system:
Irrawaddy dolphins, *Orcaella brevirostris* in Chilika Lagoon,
India**

Thesis submitted by

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October 2009

for the degree of

Doctor of Philosophy

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ABSTRACT

Endangered species conservation requires many lines of inquiry to provide the evidence required for a holistic approach to conservation planning. The main aim of my research was to inform the conservation planning of endangered species found in developing countries. It is my thesis that species conservation in developing countries is a socio-ecological issue and that the role of conservation science is limited without the inquiry of human dimensions and their influence on conservation outcomes. I studied the Irrawaddy dolphin, *Orcaella brevirostris* in Chilika Lagoon, India, as a case study to exemplify this problem and to validate a solution.

The Irrawaddy dolphin has been assessed as 'Data Deficient' by the IUCN at a global scale, but five freshwater and brackish water subpopulations are Critically Endangered. The species is found in isolated, patchy populations and tends to occupy shallow, muddy coastal waters, enclosed bays and lagoons, or freshwater river systems. In the region of the Indian subcontinent, the species has been recorded from Chilika Lagoon on the east coast of India, and in the tributaries of the Sunderbans Delta, West Bengal. My thesis informs current knowledge regarding Irrawaddy dolphins and produces new results for the population in Chilika Lagoon. The absence of recent Irrawaddy dolphin carcasses along the coast of Orissa or of sightings of live Irrawaddy dolphins during a vessel based survey of the coast suggests that the population in Chilika Lagoon is isolated and should be treated as a conservation target.

Chilika Lagoon is a RAMSAR site supporting a population of more than 200,000 people. A preservationist strategy which completely excludes people from protected areas by relocation programs is neither feasible nor culturally advisable in the case of Chilika Lagoon. To incorporate dolphin conservation and sustainable use of resources into the daily lives of the people requires strategies that consider the social circumstance of the communities, and their perceptions. I interviewed fishers from 44 villages to collect local information and knowledge regarding Chilika and its dolphins. The results indicate a

significant decrease in the range of the dolphins within the Lagoon and suggest that the major causes for mortality in dolphins are fishing nets, habitat loss and motorized boats. I found that fishers' perception of dolphins differed primarily with the location of their village, suggesting that experience plays a role in developing affiliation. Local people in Chilika like to observe dolphins, like to have them in their vicinity when they go fishing and to an extent revere dolphins. These are good signs for conservation and for future dialogue in the fields of awareness building, innovative solutions and co-operation towards conservation aims. I also found that the economic well being of stakeholders is dependent on fish catch and there are conflicting perceptions towards the management of fishery resources in Chilika among local communities and between policy makers and local communities. These issues of common property management are likely to limit the success of social programs, including conservation initiatives.

I identified 80 individual dolphins using natural marks and variously estimated the abundance of the population using Mark-Recapture analysis as 109 to 112 individuals at $CV=0.07$ (closed models); and 140 at $CV=0.25$ (open models), based on surveys from November 2004 to December 2006. The power analysis indicated that a rate of 5% decrease per year would take 7 years to detect; even a decline of 20% would take 3 years to detect using the same survey protocols, by which time a population of 112 animals will have become reduced to 57 animals. It is thus critical that the monitoring of the population use a robust standard protocol which includes an assessment of uncertainty. I suggest that owing to the small population size, long-lasting natural marks, enclosed nature of the study area and already present photo-identification catalogue, the Mark-Recapture methodology would be feasible and appropriate for future monitoring of the population.

The total Extent of Occurrence for Irrawaddy dolphins in Chilika was $<330\text{km}^2$; and the Area of Occupancy was $<131\text{km}^2$, both of which are less than half of the available habitat. The dolphins concentrate their use in two core areas in the Lagoon: the Outer Channel (12km^2) and the South-Central Sector (49km^2). The site fidelity of individual dolphins is high with more than 80% of the individuals remaining within 10km of their mean centre. Home range estimates vary from 1.7km^2 to 186km^2 for individuals sighted more than nine

times between 2004 and 2006 with a large overlap in home ranges. The quality and carrying capacity of the habitat thus play an important role in the long term survival and health of dolphins in Chilika.

The analysis of group size and behavior suggested that average group sizes were small (3-4 dolphins) with 25% of the observations consisting of solitary individuals. Group size did not differ significantly among the behavioral states of feeding, milling and traveling, but were significantly larger when the dolphins were socializing and resting. The dolphins were found across the entire range of water depths and salinity, and group sizes varied little with changes in measured environmental variables. The core areas appear to be the major feeding grounds for Irrawaddy dolphins in Chilika Lagoon, with feeding, milling and socializing dominating the day-time activity budget.

A preliminary analysis of social structure for Irrawaddy dolphins suggested that the associations among dolphins in Chilika Lagoon were weaker and more fluid than those observed in other populations of *Orcaella*, which live in stable societies. Out of the 48 individuals analyzed, only 14 individuals showed an association index ≥ 0.5 . Few individuals did not associate with any other individuals, whereas most individuals associated loosely with all other individuals.

Based on all the data, both the conventional IUCN assessment and the RAMAS Red List assessment indicate that the population of Irrawaddy dolphins in Chilika Lagoon should be listed as Critically Endangered. This decision would be precautionary rather than evidentiary and not without uncertainty.

I investigated the locally run dolphin-watching industry, an established occupation in the Outer Channel, to assess ways in which the industry could help in conservation of dolphins. Ideally, the industry would strengthen conservation programs through local economic development and income generation. Interviews with tourists suggest that boat drivers turn their engines off in the presence of dolphins indicating that most boat drivers have gradually become aware that dolphins stay around their boats longer if the engines are

off. Results from a questionnaire survey of tourist operators show that local communities are aware of the risks faced by dolphins from the tourism operations, and could distinguish factors that cause disturbance and mortality. Respondents suggested that removal of obstructions to dolphin movements was the most effective conservation strategy, as it would increase the amount of space available to dolphins and ease their movement between the Outer Channel and South Central sectors. This strategy would also increase the free movement of roe and fish into the Lagoon. The strength of the tourism linkage is very similar to that of the fisheries with communities in the Outer Channel of Chilika but conservation outcomes from the linkage have not yet been realized and would require responsible social and ecological planning to make the industry sustainable. There are currently no set approach distance and no limits on the number of boats allowed around a group of dolphins, or on the number of boats allowed to go dolphin watching per day. Conservation practitioners need to increase awareness amongst local stakeholders to help recognize the benefits of conservation goals, and the linkage between tourism livelihood and dolphin persistence.

My research demonstrates that conservation planners require evidence from both ecological and socio-economic lines of inquiry. Biological information is necessary, but not sufficient to conserve Irrawaddy dolphins in Chilika. Dolphin conservation is inextricably linked to natural resource management and system-level management. One of the main limitations to successful conservation is the mismatch between top-down 'expert opinion' - based management decisions and the preferences of the stakeholders who actually operate at the scale of the system being managed. Given the Critically Endangered status of the Irrawaddy dolphin population of Chilika and the cultural and social importance of dolphins, a long term conservation program inclusive of social and ecological research using an action-research model should be the future goal of conservation practice in Chilika. I propose a conservation model which functions with the support of policy makers to reduce cross-scale conflict, rather than as a top-down enforcer of protection. Given the range of natural and induced ecological changes in Chilika over the past decades and the changes anticipated in this era of climate change, sustaining habitat quality remains the priority of conservation planning for the Chilika system.

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