ASSESSMENT OF MORTALITY OF IRRAWADDY DOLPHINS IN THE MEKONG RIVER AND RECOMMENDATIONS FOR A POPULATION RECOVERY PLAN

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BACKGROUND

On 27-28 October 2009, the World Wide Fund for Nature (WWF) and the Cambodian Government convened the Workshop to Develop a Recovery Plan for the Irrawaddy Dolphin in the Mekong River. The immediate impetus for the workshop was the release by the WWF Cambodia Program of two technical reports. The first report (Dove *et al.* 2008) provided an abundance estimate for the population, based on a mark-recapture analysis, of 71 dolphins (95% CI = 66-86) in 2007. This estimate is substantially lower than the mark-recapture estimates previously reported by Isabel Beasley and colleagues, including: 136 ± S.E. 9.67 (CV = 0.07, 95% CI = 116-156) in 2004-05 (Beasley 2007, p 5-139) and a "minimum total population estimate" of 127 individuals (CV = 0.07; 95% CI = 108-146) as of April 2005 (Beasley et al. 2007, p 72). However, it is important to emphasize that different approaches were used in developing the two sets of estimates, and therefore the discrepancy between them appears larger than it probably is.

The second report, released in April 2009 (Dove 2009; also Dove 2008), provided information on 88 confirmed dolphin deaths between 2003 and 2008, of which 56 were described as involving calves. It suggested that disease associated with the infectious bacterium *Aeromonas hydrophila* was the principal cause of the exceptionally high mortality in the population, and that the dolphins were susceptible to such infection because of immunosuppression from persistent organic pollutants (POPs) and mercury, as well as genetic inbreeding. These reports led to discussions within WWF that an aggressive *ex-situ* conservation approach would be required to prevent the dolphin population from disappearing from the Mekong River in the near future. This approach would involve (1) live-capture of dolphins, (2) development of a vaccine and immunization of captured individuals to protect against *Aeromonas* infection, (3) keeping pregnant females and calves in a controlled environment until the young reach an age where their immune systems can resist infection from the bacteria, and (4) artificial insemination using semen collected from one or more other Irrawaddy dolphin populations as part of a captive breeding program.

Based on our review of available information, the discussions and presentations at the October 2009 workshop, and a brief trip upriver to observe the Mekong dolphins and fishing activities in the southern part of the population's current range, we, as international participants representing the IUCN Species Survival Commission's

Cetacean Specialist Group and Veterinary Specialist Group[1], offer the following assessment of the probable sources of mortality and recommendations for a recovery plan for the Mekong Irrawaddy dolphin population.

ASSESSMENT OF SOURCES OF MORTALITY IN THE MEKONG DOLPHIN POPULATION

Based on our review, the hypothesis of Dove (2009) that bacterial infections facilitated by the immunosuppressive effects of high contaminant loads and genetic inbreeding represent the principal threat to the population appears to be based on misinterpretations of available data. There are instead strong reasons to believe that interactions with fishing gear remain the primary source of human-caused mortality in the population despite the ban on gill netting in the nine deep-pool areas where the dolphins are most often found and in the areas of the river between these pools.

The high mortality rates of Irrawaddy dolphins in the Mekong River <u>cannot</u> be explained by infection from *Aeromonas* bacteria facilitated by immunosuppression from high contaminant loads and inbreeding (also see Appendix 1)

- Histological examinations of tissues from nine recovered carcasses (as reported by Dove 2009) revealed no evidence of inflammation or toxemia that would be expected if a bacterial disease had been responsible for the deaths.

- There appears be no relationship between the presence of neck lesions and the *Aeromonas* bacteria in the nine specimens cultured at the Pasteur Institute. Two dolphins with neck lesions (one adult and one juvenile) had no *Aeromonas* or other bacteria cultured, and one adult without a neck lesion had a pure culture of *Aeromonas*.

- If neonates were dying from a bacterial infection due to immunosuppression, the umbilical region and lungs would most likely be the first places to become infected – not the neck region where the lesions have been observed. In any event, bacteria require entry points and therefore determining the cause(s) of wounding must be a first priority of problem diagnosis.

- *Aeromonas* bacteria are ubiquitous in aquatic environments and they been found in normal, presumably healthy, free-ranging bottlenose dolphins *Tursiops truncatus* (Buck *et al.* 2006). Therefore, culturing the bacteria from dead dolphins does not mean that the animals were septicemic or died from the disease.

- Although Dove (2009) considered the contamination levels measured in blubber from Mekong dolphins high, they were in fact low compared to the levels found

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in other small cetaceans sampled in other areas (see references in Appendix 1 and in O'Shea 1999).

- The comparison in Dove (2009) between toxic levels of organochlorines in blood and the levels measured in blubber is invalid because lipophilic contaminants are sequestered in the blubber. Contaminant levels would thus be expected to be much higher in lipid tissues. To be meaningful, comparisons need to be between like tissues – blood values to blood values, blubber values to blubber values.

- The fact that only a single haplotype was found in the portion of the mitochondrial control region sequenced for the nine Irrawaddy dolphin samples (see Dove 2009) does not lead directly to the conclusion that the population is suffering from inbreeding depression. In fact, at least two haplotypes have been reported from Mekong dolphins (Beasley *et al*. 2005). The hypothesis that inbreeding depression is compromising immune function is implausible given how recently the population has declined to its current small numbers (i.e. over the last 35-40 years). That said, there is no doubt that such a small population is at high risk from demographic and environmental stochasticity alone.

Fishery interactions remain the major source of human-caused mortality of Irrawaddy dolphins in the Mekong

- Photographs of at least five dolphins with neck lesions showed either impression marks or unhealed, narrow, linear lacerations or cuts penetrating the skin around the neck. Such impression marks and wounds are considered to be diagnostic of entanglement in monofilament gillnets (see Read and Murray 2000).

- Photographs used for identification purposes (see Appendix 5 of Dove *et al.* 2008) and observations made of dolphins during a field visit to Kratie indicated distinct marks and mutilations on the dorsal fin consistent with fishery interactions (see Kiszka *et al.* 2008). These types of marks have been reported on most species of small cetaceans from the largest to the smallest (the killer whale, *Orcinus orca*, and the vaquita, *Phocoena sinus*, respectively).

- Gillnet fishing has been banned since 2006 in the nine deep-pool areas where dolphins are most often found and in the segments of river between these pools. However, it was explicitly acknowledged – by fishery agency representatives at the Phnom Penh workshop and by riverside community residents during the field trip – that gillnet fishing continues in the inter-pool areas, possibly because relatively little enforcement occurs outside the pool areas. Evidence from photo-identification studies indicates that the dolphins often move between pools (Dove et al. 2008, p 18).

- Although all nine deep-pool areas are apparently well monitored during daytime hours, there is no monitoring effort during the night when illegal gillnet fishing may occur.

- The legal mesh size for gillnets in the Cambodian section of the Mekong River is 5-15 cm. The higher end of this range is about the perfect size to fit around the neck of a calf, and this could at least partly account for the skew in age distribution of the recorded mortality since 2006. Other small cetaceans are known to become entangled in small-mesh gillnets so this would also be expected for this species.

Additional considerations

This assessment and the recommendations below should be seen as works in progress and as initial steps rather than as a final outcome. One example of a subject that deserves further exploration is the heavy scarring on the body of the adult male that we examined in Kratie and on many live Mekong dolphins seen in photographs. This type and degree of scarring has not been observed (or at least has not been reported) for other riverine populations of *Orcaella*. Therefore, it will be important to investigate whether Mekong dolphins interact differently with one another and whether social or behavioral factors are playing some role in the high mortality in this population.

RECOMMENDATIONS FOR A RECOVERY PLAN

Abundance estimates for Irrawaddy dolphins in the Mekong River, regardless of the apparent discrepancies between those reported in Dove *et al.* (2008) and Beasley (2007), and the fact that at least 88 dolphins have died since 2003 (Dove 2009), indicate that the population will certainly go extinct in the near future without urgent conservation actions. Due to the urgency of the situation and the limited resources available to address dolphin conservation in Cambodia, it is vital that management and research actions focus on the most probable sources of mortality as indicated by a rigorous evaluation of all past and present scientific data. The recommendations below are prioritized according to immediate and long-term research and conservation needs.

Immediate research and conservation needs in rough order of priority

- All past and present data from photo-identification and mortality monitoring studies should be compiled so that appropriate analyses can be conducted for conservation management, including a prediction of how many years remain before this population could go extinct without significant reductions in human-caused mortality. This will require collaboration among past and present dolphin researchers, and that appropriate credit is given in terms of authorship of technical papers and reports.

- All available photographs of dead Mekong dolphins should be examined in detail by experts with experience in determining signs of bycatch on stranded or salvaged carcasses of small cetaceans.

- Night patrols should be implemented immediately to enforce the ban on gillnet fishing in the nine deep-pool areas where the dolphins are most frequently found. Such patrols in inter-pool areas are also desirable although they may not always be feasible and safe, especially at low water levels due to the presence of rocks and rapids.

- It is clear (judging by promotional material at the Phnom Penh airport, on CNN travel advertisements, etc.) that the continued existence of a dolphin population in the Mekong River is a national priority in Cambodia for a combination of cultural, economic, and political reasons. However, there should be no illusions about the compatibility of the dolphins' survival and the continued presence of gillnets in their range. The authorities responsible for ensuring that a viable population of dolphins persists in the Mekong need to make every effort to eliminate entangling nets from the river segment starting just downstream of Kratie and continuing upstream to the Cambodia-Lao PDR border. Such elimination will need to be accompanied by a sustained effort to provide alternative livelihoods for affected fishermen and ensure that the subsistence needs of local communities are met.

- Effective implementation of regulations on gillnet fishing, whether those already in place or additional ones introduced, requires extensive educational outreach using culturally appropriate media materials in the Cambodian language and frequent, systematic patrols during both day and night to guarantee compliance.

- The existing mortality monitoring network should be modified to emphasize thorough, on-site examination and photography of animals (see Read and Murray 2000, Barco and Touhey 2006) as soon as possible after discovery of the carcasses and before they are transferred to Kratie. Photographs should be taken of the entire body including dorsal and ventral surfaces, dorsal fin, flukes, and flippers, and of any marks or lesions. To the extent possible, community members should be engaged in all aspects of the investigations so that they will become more likely to report future deaths as soon as they are aware of them.

- During dolphin surveys, or as a dedicated effort, a systematic census should be made of fishing gears according to type (Deap et al. 2003) during both high- and low-water seasons in all channels between Kratie and the Cambodia-Lao PDR border. The resultant data should be used to estimate the seasonal density of fishing gears and assess the risks of dolphin entanglement or entrapment according to the spatial and temporal overlap. This assessment should then be used as the basis for implementing additional management measures to reduce the risk of incidental catches.

- An expert on riverine fisheries in Southeast Asia should be contracted to conduct a thorough inventory of other fishing gears (besides gill nets) that may be entangling or otherwise injuring and killing dolphins in the Mekong River. This inventory should be carried out in collaboration with a cetacean bycatch expert

and used as a basis for the development of additional management recommendations.

- Although it should go without saying, we wish to re-emphasize the importance of having WWF-Cambodia work even more closely than it already does with the Cambodian Fisheries Administration and the Commission on Dolphin Conservation and Ecotourism Development. Only through such cooperation and collaboration will it be possible to improve understanding of mortality and stress factors in a short period of time and to begin managing the human activities are contributing to the population's rapid decline.

Long-term research and conservation needs in rough order of priority

- Fishery regulations needed to protect Irrawaddy dolphins (see above) should be formally adopted under legislation according to Cambodian law so that their benefits are sustained in the long term within the management framework of relevant governmental agencies.

- The current photo-identification study should be strengthened and surveys carried out annually, with an emphasis on the use of the data to estimate abundance and survivorship, to describe movement patterns, and to monitor body scars and dorsal fin disfigurements as indicators of interactions with fisheries.

- A systematic program for monitoring fishing practices and fish catches should be implemented throughout the river segment from Kratie to the Cambodia-Lao PDR border. This program should include the fishing gear census mentioned above, systematic interviews with local fishermen, regular visits to fish landing sites to investigate fish catch sizes and composition, and direct observations and sampling of fisheries to quantify effort and catch and to identify locations where entangling gear is set. One possibility to consider (given the high calf mortality rate) is that mother-calf pairs spend more time close to the river banks where the current is weaker. If fishermen place their nets in the same areas, this could help explain why calves appear to be so exceptionally vulnerable to entanglement. The primary goal of the overall monitoring effort should be to provide science-based knowledge for the adaptive management of riverine fisheries with respect to dolphin conservation and the subsistence needs of local fishing communities.

- Future plans that can cause major habitat problems, like the construction of dams in the river mainstem and its tributaries, must continue to be monitored and examined carefully. The impacts of planned dam projects on the dolphins and other megafauna (e.g. giant catfish and Siamese crocodile) should be a key consideration in environmental impact assessments and a long-term priority should be to compile and maintain an inventory of proposed and planned dam projects in the Mekong river system, including information on their location, technical specifications, hydrology and geomorphology of upstream and downstream waters, and status of proposals or plans.

- More effort should be made to develop collaborations with researchers and institutions in southern and eastern Asia (e.g. China, Japan) in order to take advantage of existing regional expertise and facilities and to reduce the turnaround time for analyses. International experts outside the region should also continue to be used to assist in analyses and recovery efforts.

REFERENCES

Barco, S. and Touhey, K. 2006. Handbook for Recognizing, Evaluating, and Documenting Human Interaction in Stranded Cetaceans and Pinnipeds. Unpublished report from the Virginia Aquarium Stranding Program and Cape Cod Stranding Network, Inc.

Beasley, I.L. 2007. Conservation of the Irrawaddy dolphin, *Orcaella brevirostris* (Owen in Gray, 1866) in the Mekong River: biological and social considerations influencing management. Ph.D. thesis, James Cook University.

Beasley, I., Phay, S., Gilbert, M., Chanthone, P., Yim, S., Lor, K.S. and Kim, S. 2007. Review of the status and conservation of Irrawaddy dolphins *Orcaella brevirostris* in the Mekong River of Cambodia, Lao PDR and Vietnam. Pp. 67-82 in B.D. Smith, R.G. Shore and A. Lopez, editors, Status and conservation of freshwater populations of Irrawaddy dolphins. Wildlife Conservation Society Working Paper No. 31.

Beasley , I., Robertson , K. and Arnold, P. 2005. Description of a new dolphin, the Australian snubfin dolphin *Orcaella heinsohni* sp. n. (Cetacea, Delphinidae). *Mar. Mamm. Sci.* 21(3):365-400.

Buck, J.D., Wells, R.S., Rhinehart, H.L. and Hansen, L.J. 2006. Aerobic microorganisms associated with free-ranging bottlenose dolphins in coastal Gulf of Mexico and Atlantic Ocean waters. Journal of Wildlife Diseases 42(3):536–544.

Deap, L., Degen, P. and Van Zalinge, N. 2003. Fishing gears of the Cambodian Mekong. Inland Fisheries Research and Development Institute of Cambodia (IFReDI), Danida & MRC, Phnom Penh, Cambodia. Fisheries Technical Paper Series, Volume IV, 269 p.

Dove, V. 2008. Investigating neonatal mortalities in the Mekong River Irrawaddy dolphin population (*Orcaella brevirostris*). M. VSc. Thesis, Faculty of Veterinary Science, Murdoch University, Perth. 232 p.

Dove, V. 2009. Mortality investigation of the Mekong Irrawaddy River dolphin *(Orcaella brevirostris)* in Cambodia based on necropsy sample analysis. WWF Cambodia Technical Report.

Dove, V., Dove, D., Trujillo, F., Zanre, R. 2008. Abundance estimation of the Mekong Irrawaddy dolphin *Orcaella brevirostris* based on mark-recapture analysis of photo-identified individuals. WWF Cambodia Technical Report.

Kiszka, J., Pelourdeau, D. and Ridoux, V. 2008. Body scars and dorsal fin disfigurements as indicators of interaction between small cetaceans and fisheries around the Mozambique channel island of Mayotte. Western Indian Ocean J. Mar. Sci. 7:185–193.

O'Shea, T.J. 1999. Environmental contaminants and marine mammals. Pages 485-564 in J.E. Reynolds, III and S.A. Rommel, editors, Biology of Marine Mammals. Smithsonian Institution Press. Washington and London.

Read, A.J. and Murray, K.T. 2000. Gross Evidence of Human-induced Mortality in Small Cetaceans. U.S. Dep. Commerce. NOAA Tech. Memo. NMFS-OPR-15, 21 p.

Appendix 1

Review of Necropsy Information

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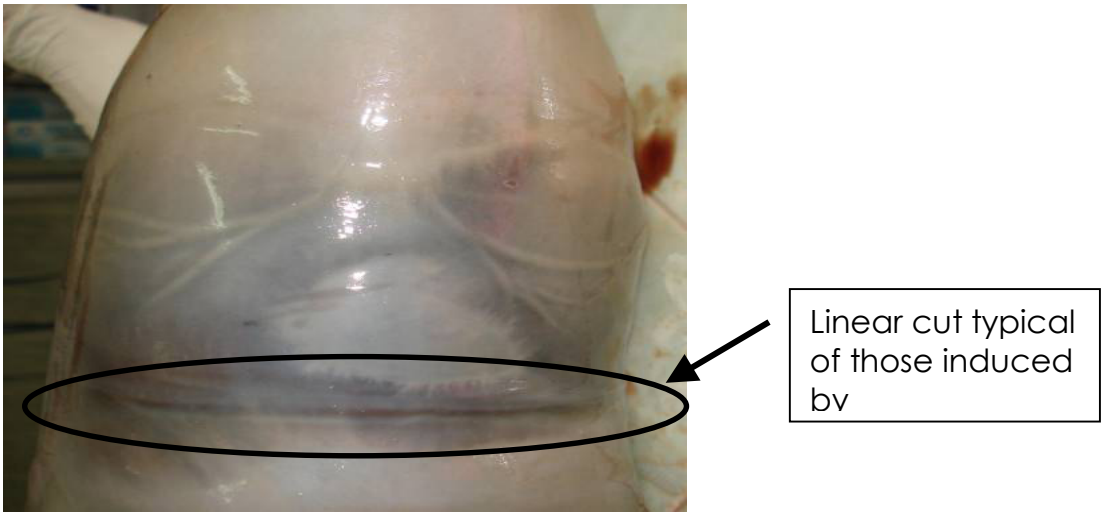
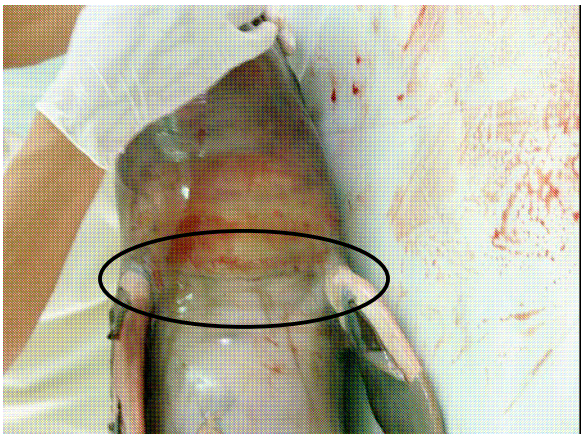
In reviewing the necropsy information provided in Dove 2009, it appears that cause of death of the carcasses examined is likely due to interactions with fishing nets in many cases, although some carcasses were severely decomposed and thus hard to determine cause of death reliably.

A number of carcasses have marked circumferential lesions around the neck with either impression marks or narrow cuts extending through the skin into the underlying blubber, surrounded by bruising which indicates the trauma occurred in the live animal rather than after death. Examples of these are shown below. In some cases, the carcasses were so decomposed that the skin has been sloughed and only underlying blubber is observed. In these cases, it is difficult to assess the integrity of the skin and adjacent tissues and draw any meaningful conclusions.

Carcass 08-001





Carcass 06-0912

07-001

07-12

07-13

These lesions suggest these animals had their necks encircled by monofilament of some type before death. Such lesions are typical of small cetaceans dying following entanglement in gillnets (Read and Murray 2000). Interestingly, many live adult animals have dorsal fin scars typical of dolphins previously entangled in fishing line as described in Kiska et al. (2008).

Nine of the carcasses examined recently had samples of skin lesions cultured by the Institute Pasteur. A variety of bacteria typical of warm freshwater environments were isolated from dolphin tissues, including *Aeromonas hydrophila*, a bacteria commonly isolated from both live healthy and dead dolphins in other parts of the world (Buck et al). The isolation of a range of bacteria from dead dolphin carcasses is to be expected, especially in cases that are several days dead. To determine whether or not a bacteria has caused death requires histopathology to determine whether or not there is evidence of inflammation associated with bacteria, as well as a statistical approach to examine the strength of association between presence of bacteria and lesions. The report indicates that no inflammation was observed by histopathology in dolphin tissues, although decomposition would have made interpretation difficult. There does not appear to be a significant association between presence of pure culture of *Aeromonas hydrophila* and the neck lesions, see table below. Thus, it is unlikely that bacterial infection played a significant role in dolphin deaths, but isolates were secondary invaders of traumatic wounds around the time of death.

Age class	**Neck lesion**	**Pure culture *Aeromonas hydrophila***	**Mixed culture with *Aeromonas hydrophila***	**No *Aeromonas*. Other bacteria cultured**

Adult	Present		08-008	07-011
	Absent	09-002		
Juvenile	Present			09-001
	Absent			
Calf	Present	07-007, 09-003	07-009, 07-012, 08-002	
	Absent			

Tissues submitted for toxicological analyses revealed blubber levels of organochlorine levels typical, yet in the lower range, of small cetaceans in the region (see table below). Liver levels of mercury were also measured and although comparable data for small cetaceans in the area are not readily available, there are abundant data from cetaceans elsewhere. Liver mercury levels are hard to interpret as mercury is detoxified in marine mammal livers where it is combined with selenium in storage granules. High levels have been reported in a variety of odontocetes, especially in areas such as the Mediterranean with high background mercury of geological origin, yet its impact on marine mammal health is unclear. Liver levels in the Mekong river dolphin calves (0.86 – 1.54 ppm) are lower than the range reported for other cetaceans, such as 626 ppm in pilot whales, 5,400 ppm in striped dolphins and 13,000 ppm in bottlenose dolphins (O'Hara and O'Shea 2001).

Species	Sum PCBs (ng/g) in blubber	Sum DDTs (ng/g) in blubber	Reference
Orcaella brevirostris	210-660	4,100-12,000	Dove 2009
Platanista gangetica	1,100 - 13,000	21,000- 64,000	Senthilkumar et al 1999
Neophocoena phocanoides	744,000-370,000	19,000-27,000	Kajiwara et al 2006
Neophocoena phocanoides	610,000-48,000,000		Jefferson et al 2002

Pseudorca crassidens	1,000 -33,000	1,200 – 83,000	Ylitalo et al 2009

Thus the combination of obvious traumatic lesions in these dolphin carcasses, combined with the lack of any significant neonatal infections typical of immunosuppressed neonates, such as umbilical infections or pneumonia, suggests that these calves died of fisheries interactions.

References

Buck, J. D., R. S. Wells, H. Rhinehart, L. Hansen. 2006. Aerobic microorganisms associated with free-ranging bottlenose dolphins in coastal Gulf of Mexico and Atlantic ocean waters. Journal of Wildlife Disease 42(3), 2006, pp. 536–544

Jefferson, T. A., B. E. Curry, and R. Kinoshita. 2002. Mortality and morbidity of Hong Kong finless porpoises, with emphasis on the role of environmental contaminants. The Raffles Bulletin of Zoology 10:161-171.

Kajiwara, N., S. Kamikawa, K. Ramu, D. Ueno, T. K. Yamada, A. Subramanian, P. K. S. Lam, T. A. Jefferson, M. Prudente, K.-H. C., and S. Tanabe. 2006. Geographical distribution of polybrominated diphenyl ethers (PBDEs) and organochlorines in small cetaceans from Asian waters. Chemosphere 64:287-295.

Kiszka, J., D. Pelourdeau and V. Ridoux. 2008. Body scars and dorsal fin disfigurements as indicators of interaction between small cetaceans and fisheries around the Mozambique channel island of Mayotte. Western Indian Ocean J. Mar. Sci 7: 185–193.

O'Hara, T. and T. O'Shea 2001. Toxicology. Pages 471-520 *in* L. Dierauf and F. Gulland, Editors, CRC Handbook of Marine Mammal Medicine. CRC Press, Boca Raton Florida.

Read, A. and K. T. Murray. 2000. Gross Evidence of Human-Induced Mortality in Small Cetaceans. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-OPR-15, 21 p.

Senthilkumar, K. K. Kannan, R. K. Sinha, S. Tanabe, and J. P. Giesy.1999. Bioaccumulation profiles of polychlorinated biphenyl congeners and organochlorine pesticides in Ganges river dolphins. Environmental Toxicology and Chemistry 18(7):1511-1520.

Ylitalo, G. M., R. W. Baird, G. K. Yanagida, D. L. Webster, S. J. Chivers, J. L. Bolton, G. S. Schorr, and D. J. McSweeney. 2009. High levels of persistent organic pollutants measured in blubber of island-associated false killer whales (*Pseudorca crassidens*) around the main Hawaiian Islands. Marine Pollution Bulletin doi:10.1016/j.marpolbul.2009.08.029