REPORT OF THE FIRST WORKSHOP ON CONSERVATION AND RESEARCH NEEDS OF INDO-PACIFIC HUMPBACK DOLPHINS, *SOUSA CHINENSIS*, IN THE WATERS OF TAIWAN

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(Also available from this website are the: *Research Action Plan for the Humpback Dolphins of Western Taiwan* and *symposium program of the First Symposium and Workshop on the Conservation and Research of Indo-Pacific Humpback Dolphins,* Sousa chinensis*, of the Waters of Taiwan*)

Table of Contents

Introduction

A small population of Indo-Pacific humpback dolphins (*Sousa chinensis*) was discovered along the west coast of Taiwan in 2002 (Wang et al. 2004a; International Conservation Newsletter 2003). This discovery has evoked much scientific and conservation interest. It has also given Taiwan an unexpected opportunity to help conserve the diversity of life on Earth. However, this opportunity may not last long. Taiwan's humpback dolphins are threatened by a variety of factors, some of which are plainly evident and others of which are poorly understood. Many of the dolphins bear evidence of serious injuries, at least some of which were caused by human activities. Without a doubt, action is urgently needed to protect these animals and their habitat. (Note: Under the Wildlife Conservation Law of Taiwan, humpback dolphins are already included amongst the species requiring the highest level of protection).

Indo-Pacific humpback dolphins occur discontinuously in near-shore marine and estuarine waters from the Indian Ocean coast of Africa eastward to the Pacific coasts of China and Australia. In Southeast Asia, they have been studied in only a few areas, most notably Hong Kong. In addition to the population recently discovered off the west coast of Taiwan, several populations are known to inhabit specific portions of the mainland Chinese coast. The deeper portions of the Taiwan Strait appear to represent a barrier to dispersal for populations of these highly coastal animals. Therefore, based on the evidence currently available, Taiwan's humpback dolphins are considered to be a distinct and separate population of a globally vulnerable species.

The first international workshop on a cetacean conservation issue in Taiwan was conducted at the New Palace (Wuchi, Taichung County, Taiwan) on 25-27 February 2004. The overall aims of this workshop were to evaluate the status of the dolphin population, identify and rank threats, develop a research action plan, and suggest potential approaches to threat mitigation. The workshop was hosted by the National Museum of Marine Biology and Aquarium of Checheng (Pingtung County, Taiwan) and sponsored by the National Science Council of Taiwan, the Council of Agriculture of Taiwan and Ocean Park Conservation Foundation of Hong Kong. The workshop was convened and chaired by Dr. John Y. Wang (of the *FormosaCetus* Research and Conservation Group and National Museum of Marine Biology and Aquarium). He was assisted in preparing and editing this report by Dr. Randall R. Reeves (IUCN Cetacean Specialist Group Chair) and Miss Shih-Chu Yang (*FormosaCetus* Research and Conservation Group). Other participants included experts in cetacean science and conservation from Canada, the United States, Japan, Hong Kong, and New Zealand as well as representatives of the National Museum of Marine Biology and Aquarium and National Pingtung University of Science and Technology. Representatives of the Council of Agriculture had to cancel their plans to participate at the last minute so that they could deal with an environmental protest event. The agenda and list of participants (including observers) are given in Appendices 1 and 2, respectively.

Two field trips were arranged for participants during the workshop period. One was a boat trip from Wuchi Harbour to Dadu River to observe the coastline and search for dolphins. The other was to allow the participants to see the Wuchi Harbour fish market.

Immediately preceding the workshop, a one-day public symposium on humpback dolphins was hosted by the National Museum of Marine Biology and Aquarium. This symposium consisted of 13 invited presentations by Taiwanese and foreign speakers. The full texts of the presentations were printed in the symposium program (Wang and Yang 2004; see Appendix

3 for presentation abstracts). Readers of the present report are encouraged to consult that program for further background information on many of the issues discussed herein (available at: www.nmmba.gov.tw).

Contents and Organization of this Report

The main body of this report consists of five sections, as follows:

- Brief summaries of background information to define the problems related to humpback dolphins and their environment in Taiwan;
- Identification and ranking of threats to the dolphin population;
- Identification of conservation-related scientific uncertainties and approaches to resolve them;
- Options for conservation and management; and
- Research action plan.

The first four sections are intended to provide a record of the workshop findings and the rationales behind recommended research and conservation options. It was anticipated that the fifth section, the Research Action Plan, would be a stand-alone document that could be used by government agencies, nongovernmental organizations, researchers, funding institutions, and other stakeholders to inform the planning process and guide decision-making over the next few years. The Research Action Plan is presented separately as Appendix 4.

The workshop dealt only with the scientific aspects of humpback dolphin conservation. No attempt was made to address the social, economic, and administrative dimensions of the problem. It was expected that the workshop report and research action plan would provide a solid foundation for discussions at the county and national levels, and that necessary actions would be taken in a timely fashion by those responsible for wildlife conservation in Taiwan. While foreign scientists, conservationists, and non-governmental organizations can be expected to continue contributing to the efforts to conserve these dolphins, the primary responsibility for long-term support (i.e., financial, logistical, managerial, etc.) must come from all levels of government and private sources (including the industrial sector) within Taiwan.

1. Background

1.1. Indo-Pacific Humpback Dolphins – General

Jefferson briefly summarized the taxonomy, distribution, reproductive biology, ecology, and abundance of Indo-Pacific humpback dolphins (see Jefferson 2000; Jefferson and Karczmarski 2001; IWC 2003; Jefferson 2004). He called participants' attention to a forthcoming special issue of the journal *Aquatic Mammals* that will be devoted entirely to the genus *Sousa*.

Taxonomy of the genus *Sousa* is confused and controversial. The humpback dolphins in the eastern Atlantic Ocean are considered a separate species, *S. teuszii*, while those in the Indian and Pacific oceans will probably prove to consist of at least two species rather than the currently recognized single species, *S. chinensis*. Little is known about stock structure. At present, four distinct areas of occurrence within the South and East China Seas are known: Hong Kong/Pearl River Estuary (PRE), Xiamen (China)/Chinmen Islands (Taiwan), Beibu Gulf (=Gulf of Tonkin), and Taiwan proper. In the eastern part of the species' range, these dolphins tend to occur in isolated pockets centred on medium-sized to large estuaries.

Reproductive biology is largely inferred from studies in South Africa. Female Indo-Pacific humpback dolphins probably do not become sexually mature until about 9 or 10 years of age, males perhaps 12 or 13. Gestation may last 10-12 months, with most calves being born in the spring or summer (however, calving is not as seasonal as in some other species). The calving interval is likely 3 years, and calves probably remain dependent upon their mothers for at least 2 years.

In addition to being estuary-dependent, Indo-Pacific humpback dolphins exhibit a strong preference for shallow near-shore waters. They are rarely seen in water deeper than about 20m. Sightings within a kilometre of shore and in water less than 10m deep are common. Their diet in Asian waters consists mainly of fish. These dolphins usually occur in small, fluid groups of less than 10 individuals although 20 or more are sometimes seen together.

Numbers have been estimated for only a few parts of the species' distribution. The Hong Kong/PRE population is estimated at about 1500 animals, whereas the Xiamen/Chinmen Islands population is thought to consist of only 80-100. A general decline in abundance across the species' range is thought to have occurred as a result of several factors, including mortality in fisheries, destruction or degradation of habitat, and possibly toxic contamination and reduced availability of prey. Total range-wide numbers of Indo-Pacific humpback dolphins are likely in the 10,000s but probably not more than 100,000.

1.2. Hong Kong/PRE Population

Studies of humpback dolphins in Hong Kong waters since 1993 have provided important new insight on the species. Hung supplemented the information provided by Jefferson (above), noting that to date 321 individual humpback dolphins have been photo-identified in that population (see Hung 2004). Association patterns among individuals appear to be fluid, and estimates of home range vary from about 30km^2 to nearly 400km^2. The population is subject to great pressure from human activities, including coastal development, sewage and industrial discharge, intensive fishing, dredging, shipping, and recreational and other vessel traffic. In addition to full protection of the dolphins from deliberate harm, the Hong Kong government has established a marine park as a "dolphin sanctuary," and additional protected areas are under consideration (also see Lun 2004). Importantly, regional cooperation to protect dolphins has been established between the Hong Kong government and Guangdong Province authorities.

Within Hong Kong, the Environmental Impact Assessment Ordinance requires proponents of development projects to identify potential adverse effects on dolphins and to carry out mitigation measures to minimize such effects. The government and local nongovernmental organizations (e.g., Ocean Park Conservation Foundation, Hong Kong Dolphin Conservation Society, World Wildlife Fund) have extensive public awareness and education programs as well.

The Hong Kong government, through its Agriculture, Fisheries and Conservation Department, maintains a longstanding commitment to study and monitor the dolphin population. This has included sponsorship of line-transect surveys, photo-identification, stranding notification and response, and discrete projects to investigate potential impacts of marine traffic and bycatch (Lun 2004). A trial program to biopsy humpback dolphins will be conducted in the autumn of 2004. This and other efforts in Hong Kong provide opportunities to test and develop research methods that could (eventually) be applied in Taiwan and elsewhere.

1.3. Western Taiwan Population

Wang summarized the current state of knowledge on humpback dolphins in Taiwan (also see Wang et al. 2004a,b). Until recently, records within Taiwanese territory were mainly from the Chinmen Islands in western Taiwan Strait. Only two strandings and a few scattered photographs of humpback dolphins were available to document the species' presence along the west coast of Taiwan. The first dedicated surveys for cetaceans off western Taiwan were conducted in 2002, and additional survey work was conducted in 2003. A total of 16 sightings of humpback dolphin groups were recorded in 11 survey days. Analyses to generate an abundance estimate are still underway. To date, humpback dolphins have been confirmed to inhabit a stretch of coastal waters about 80 km long from Tungshiao (Miaoli County) southward to the mouth of the Juoshuei River (Changhua County). However, credible sightings that were reported just north of Waishanding Zhou (Chiayi County) and at the mouth of the Houlong River (Miaoli County), and a stranding in Taoyuan County, extend the distribution to a stretch of coastal waters about 200 km long. All sightings have been in water shallower than 15m and within 2km of shore. Hung described the apparent differences in pigmentation patterns between the animals seen off Taiwan and those from Hong Kong and Xiamen/Chinmen Islands. Given the proclivity of humpback dolphins to remain in shallow coastal waters, the animals in the waters of western Taiwan are provisionally considered an isolated population. Also, about a third of the 32 dolphins photo-identified to date exhibited large scars, mainly on their caudal peduncles. The causes of the injuries are uncertain but are likely to include entanglement in fishing gear and vessel collisions.

1.4. Environmental Context

Information on the environment of humpback dolphins off western Taiwan was obtained primarily from direct personal observations (see Wang et al. 2004a), website searches by Yang and Wang, and from a presentation to the workshop by Hsiao. Categories of known or potential threats to the animals include:

- Entanglement in trammel, drift, and sink gillnets.
- Large-scale alteration of the coastline through land reclamation, harbour construction, breakwaters, sand mining, etc.
- Major alterations and reductions in freshwater flow in estuaries.
- Depletion of local fish stocks through over-fishing and habitat degradation (e.g., mangrove deforestation).
- Discharge of large volumes of untreated municipal sewage, industrial effluent, and contaminated wastewater (e.g., from aquaculture) into the marine environment.
- Agricultural runoff laden with pesticides, herbicides, and fertilizers (e.g., nitrogen, phosphorous).
- Marine debris that includes large volumes of plastic and other synthetic materials.

Plans exist for major expansion of the Mailiao industrial area of the Formosa Plastics Group (Yunlin County). Large-scale land reclamation is also planned to expand the present Mailiao site southward. Among other large land reclamation projects planned for the west coast of Taiwan is the Chinese Petroleum Company's new petrochemical plant project slated for either Yunlin or Chiayi County. Environmental impact assessment, to date, has focused primarily on concerns about air and water quality, noise, solid waste management, safety, and effects on aquaculture operations or commercially valuable species. No attention has been paid to broader issues of habitat modification or loss, and the potential effects on dolphins have been completely ignored.

The rivers of western Taiwan and their watersheds have a long and dismal history of over-use and misuse. Local aquifers have been depleted by fish culture operations, land subsidence and salinization are widespread problems, and severe flooding occurs during typhoons. Land reclamation is justified in part as a way of controlling flooding by the sea. Also, as industries need large expanses of land, confining new construction to reclaimed land has been seen as a way of reducing the impact of industrial expansion on local agricultural and residential properties. Most of the annual flow of the Juoshuei River is already diverted by upstream dams, with approximately two-thirds of the water going to irrigation for agriculture and the rest to industries. Only a limited amount of fresh water reaches the sea during the rainy season. The Formosa Plastics Group expansion plans mentioned above will also include a reservoir at or near the mouth of the Juoshuei River to capture and store any excess water for use during times of water shortage. The Juoshuei River is currently the largest river (by flow volume) in Taiwan and its estuary appears to be an important habitat for humpback dolphins.

Historical problems of heavy metal contamination were associated with electroplating (traditionally pursued at the household level), especially in Changhua County. Recent centralization of the industries has resulted in better control of heavy metal waste, but the previous metal contaminants are still present in the environment.

Taichung is a major chemical shipping port, and factory waste is at least occasionally pumped directly into the harbour, a practice implicated in large fish kills. The stretch of coastline of Changhua County (between the Dadu River mouth and the Mailiao industrial area near the Juoshuei River estuary) may be less affected by direct discharges.

Although no large oil spills have occurred along the west coast of Taiwan, there is a very high volume of tanker traffic associated with the many petrochemical plants in the region. Small spills are not uncommon (e.g., in Yunlin County on 25 February 2004).

Mariculture in the region is dominated by oyster and clam farming. The oyster cages tend to serve as artificial reefs and therefore attract large numbers of small fish. There is some recreational fishing around the cages but no immediate prospect of commercial fisheries developing. A dolphin observed during the June 2002 survey off central western Taiwan had what appeared to be a 15-20cm black sea bream (*Acanthopagrus schlegelii*) in its jaws. Such fish are known to be common around the oyster cages.

A recent (winter 2002/2003) massive die-off of the endangered black-faced spoonbill (*Platalea minor*) in southwestern Taiwan was attributed to botulism poisoning (see http://www.birdlife.org/news/news/2003/01/b-fspoonbill.html). The botulism outbreak, thought to have been responsible for killing about 8% of the spoonbill population, was apparently stimulated by a large kill of fish and shrimp in aquaculture ponds that resulted from dramatic temperature changes and possibly poisoning by fish farmers (to rid their impoundments of undesirable species). This event may be symptomatic of an aquaculture industry that is inadequately regulated and therefore capable of having devastating impacts on wildlife (quite apart from its depletion of local aquifers).

The fisheries off the west coast of Taiwan include a large artisanal coastal gillnet fleet that uses trammel nets, surface drift nets, and sink gillnets (totalling about 7500 vessels, nationwide, in the mid-1990s). More than 4600 PVC sampans using gillnets were registered along the west coast in 2002. In addition, some portion of the nationwide total of about 1450 non-sampan gillnetting boats were operating on the west coast. About a third of Taiwan's total fish landings come from one or another kind of gillnetting. Gray mullet (*Mugil cephalus*) is one of the most prized target fish species of western Taiwan. Drift nets are sometimes used to "seine" mullet in shallow water (<10m). Most coastal gillnet fishermen fish part-time. They spend part of their time catching larvae for "grow-out" ponds or engaged in small-scale agriculture and other occupations. Although bottom trawling is prohibited within 3nmi of shore, some illegal trawling does occur. A Taiwanese fisherman reported in 2003 that a humpback dolphin had been taken in a trawl net several years previously, so it must be assumed that there is potential for problematic interactions between the dolphin population and trawl fishing in local waters. For further information on Taiwan's fisheries, see http://www.fa.gov.tw/eindex.htm.

Although the open marketing of cetacean meat in Taiwan has ceased in view of its illegality, clandestine marketing still occurs routinely. However, there is no evidence suggesting that humpback dolphins are deliberately taken by local fishermen. Also, the traditional dislike of eating "white" animals may discourage the use or exchange of those that are bycaught in fishing gear. Furthermore, humpback dolphins are considered by some to be the "fish" of Matsu, the sea goddess, and by others to be the reincarnation of drowning victims. Occasional takes may nevertheless occur because fishermen from other ports also fish in these waters at least seasonally (e.g., for gray mullet).

Finally, there is concern about plans to deploy two U.S.-made low-frequency active sonar units (one in northern and one in southern Taiwan) for submarine detection in the Taiwan Strait (Taipei Times, 16 February 2004, p. 2). Use of powerful military sonar was the most plausible cause of cetacean mass mortality events in the Bahamas and elsewhere (e.g., Evans and England 2001), so this planned deployment in Taiwan could put all cetaceans along the west coast at serious risk.

1.5. Vulnerability of Humpback Dolphin Populations

While humpback dolphins appear to have a relatively high degree of behavioural and ecological flexibility, other aspects of their biology and ecology make them particularly vulnerable. Those in Asia have a coastal distribution and seem to be almost completely reliant upon estuaries for suitable feeding habitat. The fact that estuaries are among the most heavily used regions for fishing, shipping, dumping and discharge, aquaculture, and industrial development means that the habitat of humpback dolphins is at risk. In addition, these animals are long-lived and slow to reproduce, which means that populations have low potential growth rates. Because humpback dolphins occur most commonly in small, localized populations that are non-migratory, they have little opportunity to avoid or escape from disturbances. Finally, like other small cetaceans, humpback dolphins can become entangled in fishing gear, especially gillnets, and this is a serious source of mortality. Together, these characteristics mean that humpback dolphins are likely to suffer heavily from their close proximity to human population centers. Conservation and management therefore need to be especially precautionary and take this exceptional vulnerability into account.

2. Threats

Known, likely, and potential threats to humpback dolphins in western Taiwan were identified and ranked by the workshop according to the severity of their impacts (Table 1). An attempt was also made to identify the types of information needed to better understand or address those threats, assess the feasibility of obtaining such information, and estimate the time needed to acquire it (Table 1). The threats fall into five broad categories: decreased/degraded habitat, direct removals of individual dolphins, decreased prey availability, noise/disturbance, and chemical pollution.

It is important to emphasize that the list of threats and their rankings are based upon what is known at present, and that things are likely to change as more is learned about the dolphin population and its environment.

The threats identified as having the greatest impact on the humpback dolphins of Taiwan were:
1) Reduction of freshwater flow
2) Habitat loss
3) Fishery bycatch
4) Industrial and municipal discharge

The following comments were made to clarify certain items in Table 1:

- Gillnet fishing is a lethal threat to small cetaceans of all species throughout the world (e.g., Perrin et al. 1994) and it is almost certain that humpback dolphins in Taiwan are subject to bycatch mortality, living as they do in waters that are heavily infested with gillnets. The reason for a very low reported bycatch rate could be that there are so few surviving animals in the population, inevitably making bycatch a rare event. It should not be surprising, therefore, when fishermen report that they *never* catch these dolphins in their nets. Also, the lack of reported dolphin bycatch in coastal fisheries of western Taiwan maybe the result of relying on fishermen to report their bycatch to government authorities or interviewers. The only reliable way to obtain quantitative estimates of bycatch is to place independent observers on fishing boats or patrol vessels (e.g. coastguard or fisheries) to record the catch. Given the small size of the humpback dolphin population, catches of even a few animals over several years may not be sustainable.
- In regard to Depletion of Prey, the Information Needed was ranked 1-3 because it is contingent upon feeding ecology. Only after one knows what prey are important to the dolphins does it become important (or possible) to know the status of that prey.
- Authoritative information on pesticide use and the constituents of industrial discharge was not available to the workshop, and this partly explains the uncertainty about the importance of these potential threat factors. The use of DDT is presumed to have stopped in Taiwan, but it is suspected that some use of this toxic pesticide continues in mainland China. A review of the types of contaminants known to be present in the aquatic environment of western Taiwan (preferably including their sources when known) could assist in identifying likely problem chemicals in the dolphins' food web. An example comes from the northeastern Pacific where, following reports of heavy PCB contamination in killer whales (*Orcinus orca*) (Ross et al. 2000), a review of the literature (peer-reviewed scientific articles and less accessible technical reports) was compiled to help identify local sources of contaminants in British Columbia and Washington (Grant and Ross 2002).

- Oil and Chemical Spills were rated Low-High impact because although they are unlikely to happen (= Low), the impact if/when they do occur could be catastrophic (= High). (The main effects of oil spills are likely to be from breathing toxic fumes at the air/water interface and/or from ingesting oil-contaminated prey.). The effects of chemical spills will depend upon the amount and type of chemical spilled.
- The basis for ranking Aquaculture as Low impact was that so little of it occurs in the coastal waters of western Taiwan. Among other things, the clearing of mangroves, the use of large quantities of fresh water from rivers and their watersheds, and the release into the environment of tributyltins from soaked nets (nets are often soaked with tributyltins to retard bio-fouling) can be associated with aquaculture operations. Investigation of the history of aquaculture development in western Taiwan could be informative if it were possible to correlate the occurrence of dolphins with aquaculture presence or practices.
- Similar reasoning applies to Introduced Diseases (i.e., those from humans or domestic animals), which are also rated Low-High impact. Although there is no immediate reason to expect an epizootic, if there were one, it would be catastrophic for this small dolphin population. Humans may inadvertently transmit pathogens to humpback dolphins by i) releasing pathogen-containing biological wastes from humans, domestic animals, and livestock; ii) introducing non-native species to dolphin habitat, which in turn may transfer pathogens to dolphins; or iii) releasing chemical contaminants that reduce the effectiveness of normal host (immune) response by dolphins in the face of naturally-occurring pathogens (Ross 2002).
- Noise from vessel traffic was ranked Low impact because large commercial vessels generally remain well offshore except when entering and exiting port directly.
- With regard to Noise, the need for information on construction plans and methods is in relation to percussive pile driving, which causes extremely loud and potentially damaging noise underwater (Würsig et al. 2000).
- The Vessel Collision threat was ranked as Low-Medium potential impact primarily because of the possibility that high-speed ferries could eventually be used in western Taiwan (they are not at present) and the fact that recreational use of personal water craft (e.g., jet-skis, Sea-Doos, etc.) is increasing. It is relevant to note that there is some evidence of mortality from collisions in Hong Kong (Jefferson 2000), and also that some of the scarring on the animals in Taiwan is suggestive of collision injuries.
- Vessel-based Ecotourism was ranked as Low-High impact due to concern about the potentially very intensive dolphin-watching that could develop quickly in the area, as evidenced by similar activities along eastern Taiwan. If managed properly, dolphin-watching could be low-impact; if not, the impact could be significant for a small population with a restricted distribution.
- Military Activities were ranked as Low-High impact because few details were available concerning the future purchase and deployment of land-based, low-frequency active sonar units in Taiwan (see Taipei Times, 16 February 2004). Depending upon those details, such deployment could represent a serious or a relatively low risk to humpback dolphins. The question marks in the Logistical Feasibility column for this item refer to the fact that it may not be possible to obtain information on frequencies and operating schedule for the military sonars. Also, although large military exercises are generally well publicized in Taiwan, details about the ordnance etc. involved are not.

In addition to the threats from human activities identified in Table 1, this small dolphin population is potentially at risk from the effects of its small size (reduced genetic and demographic variability), disease (epizootic events leading to catastrophic die-offs), and climate change (e.g., increased frequency and severity of typhoons, drier conditions in watersheds leading to further reductions of freshwater flow in estuaries).

Although it may never be possible to determine the historical extent of the humpback dolphin's range in Taiwan, or to even crudely estimate its past abundance, it is reasonable to assume that the species was much more widespread and abundant in the past and that at least some (possibly much) of its habitat in this region has already been lost. That assumption must be borne in mind as decisions are made about present and future activities that would further reduce the amount of suitable habitat available for this species in Taiwan.

3. Scientific Uncertainties

Not surprisingly, given the recentness of the discovery of humpback dolphins off western Taiwan and the limited research that has been conducted on them to date (Wang et al. 2004a,b), there are many scientific uncertainties about the dolphin population. These were identified and ranked according to their relative importance for guiding conservation action (Table 2). Also, methods for resolving the uncertainties were identified, logistical feasibility of the use of given methods in western Taiwan was determined, and the number of years needed to obtain a meaningful result (if resources were available) was estimated (Table 2).

As in the case of threats (Section II, above), workshop participants provided a series of comments to clarify items in the table, as follows:

3.1. Abundance and Distribution

The surveys of coastal waters off western Taiwan were not conducted according to strict line-transect principles. Nevertheless, as long as certain conditions are met, it is possible to produce an abundance estimate by using a line-transect approach with the survey data. Data collected in Taiwanese waters would be used to estimate most parameters of the line-transect equation, but "surrogate data" from extensive surveys of the Hong Kong/PRE population, which has similar sighting characteristics, can be used to estimate the probability density function [f(0)]. Jefferson, Hung, Wang, and Yang are collaborating to produce an abundance estimate based on surveys conducted in 2002 and 2003.

Abundance can also be estimated by applying a mark-recapture analysis to the photo-ID data of individual dolphins. As long as certain assumptions are met, the photo-ID dataset can be used to model population size, using either a closed or open population model (presently, this population is assumed to be closed). However, a fairly large sample of individual dolphin identifications over a discrete period (or periods) will be required.

In order to determine the abundance and distribution of dolphins in the very shallow coastal strip inside sand bars, dedicated surveys of this area using shallow-draft vessels (such as an inflatable boat with a small outboard engine) will be needed. These surveys may use a different technique than the further-offshore line-transect surveys, and may employ, for instance, strip-transect or point-transect sampling approaches.

Aerial surveys should be considered, especially as a way of covering the near-shore waters that are difficult to navigate by boat. Aerial line-transect surveys of this population should be scientifically feasible. However, it was anticipated that the cost and difficulty of obtaining permission to fly in sensitive areas would be prohibitive, unless an arrangement could be made to use military aircraft. Wang noted that no high-wing, fixed-wing small planes have been seen in Taiwan and therefore helicopters would be the only acceptable type of aircraft potentially available for such surveys. Even if formal aerial line-transect surveys prove impossible to arrange, reconnaissance-type surveys of the near-shore strip (inside the sandbars) should be considered.

In regard to distribution, it would be interesting to know how the dolphins cope with typhoons, when the sea conditions near shore are extreme. Do they move to sheltered areas inshore of sandbars, relocate offshore, or simply endure such storms *in situ*? Also, consideration should be given to periodically extending the line-transect surveys beyond the study area, as was done in 2003. This provides opportunities to further investigate the limits of the population's total range.

3.2. Trends

Despite the importance of obtaining trend data, it was acknowledged that this could prove impractical in the near term. Given the low number of sightings expected per survey, and the consequent imprecision of the abundance estimates, it would take a long time series of survey estimates to detect any but a very dramatic change in numbers (see Taylor and Gerrodette 1993).

Population models provide an alternative approach to estimating trends (e.g., Martien et al. 1999; Slooten et al. 2000), but modeling would be contingent upon having a good estimate of absolute abundance.

Interviews of elderly fishermen in coastal regions not presently occupied by the species may yield information on contraction in range. A contraction in range would indicate that the population has declined in abundance. A formal, rigorously designed interview program would be preferable to an informal, *ad hoc* approach. Many such formal programs exist in Canada, Australia, the United States, and northern Europe where social scientists and biologists have sought to tap the "traditional ecological knowledge" of aboriginal people engaged in "subsistence" use of natural resources (e.g., Huntington et al. 1999).

3.3. Habitat Requirements

Habitat requirements are clearly linked to feeding ecology. It is important not only to know where the dolphins encounter their prey, but also to understand where, when, and under what conditions the prey populations themselves originate and grow. In a broad sense, the habitat of the dolphins must encompass the habitat of their prey. Given what is known about humpback dolphins in Hong Kong, and considering that the animals off western Taiwan appear to concentrate in or near estuaries, research emphasis should focus at least initially on estuaries.

3.4. Population Discreteness

Preliminary evidence indicates that colour patterns and their development differ in humpback dolphins from Hong Kong and Taiwan. A quantitative analysis is needed to compare the colour and spotting patterns of different age classes of dolphins from the two areas (as well as between Taiwan animals and those found along the mainland Chinese coast). Judging by other cetacean species, spotting can be considered a stable and informative character for stock discrimination.

Comparison of genotypes at 20-40 microsatellite loci of the two available samples from Taiwan and the 60-70 animals from Hong Kong/PRE and Xiamen/Chinmen Islands is expected to provide useful information on gene flow across the Taiwan Strait. Data will be analyzed using assignment methods such as Pritchard's Structure and Probability of Identity.

Information from surveys may strengthen the case for isolation if that information shows a sharp edge to the distribution of humpback dolphins off western Taiwan as well as the population(s) in the western Taiwan Strait.

3.5. Movement Patterns

Movement patterns can be examined using photo-ID data, and then compared with information from nearby areas (e.g., Xiamen/Chinmen Islands and Hong Kong/PRE) to examine population discreteness. In this approach, the catalogue of identified individuals from Taiwan would be compared for matches to the 321 individuals currently identified in Hong Kong/PRE and the 11 known from Xiamen/Chinmen Islands. Any matches would indicate movements of animals (and thus potential gene flow) across the Taiwan Strait and among the three areas.

3.6. Health Status

It is possible to use photographs of live animals taken at sea to analyze the occurrence and prevalence of several factors that may be indicative of health status. These include skin problems (e.g., lesions, skin diseases, fungus), body scarring/injuries (e.g., net marks, rope scars, propeller cuts, ship-strike injuries), and general body condition (e.g., nutritional state).

3.7. Precautionary approach to research methods

In considering how to address scientific uncertainties, the workshop noted the small population size and range of humpback dolphins in Taiwan, and thus the importance of taking a precautionary approach when choosing research methods as well as when developing management options. Specifically, both taking biopsies and attaching telemetry devices involve some level of risk to the animals (e.g., Bearzi 2000; Kraus et al. 2000). When deciding whether to use these "invasive" approaches, it becomes necessary to weigh the level of such risks against the quality and importance of the information that can be obtained. Participants agreed that at the present time, the use of invasive research techniques, such as biopsy and tagging, should be avoided. This is especially true given that alternative non-invasive research methods are available to address most if not all of the key research and management questions. It was further noted that the much larger humpback dolphin population in Hong Kong's waters can provide a potential surrogate for addressing some of these questions and testing some of the invasive methods first, if any of the key research questions cannot be answered using non-invasive methods.

3.8. Importance of carcass salvage and necropsy

A number of scientific and management issues would be informed by examination of carcasses of stranded or bycaught humpback dolphins. Again, Hong Kong provides a good example. There, an aggressive program to ensure that stranded cetaceans are promptly reported and salvaged has provided opportunities to evaluate anthropogenic causes of mortality and morbidity (e.g., fishery interactions, vessel collisions), shark predation, parasite burdens, and toxicology (Minh et al. 1999; Jefferson 2000; Parsons and Jefferson 2000). In Taiwan, it is important that any carcasses of humpback dolphins from any source, regardless of their condition, be collected and sent to humpback dolphin researchers.

A proper necropsy should involve as much of the following as possible, depending upon the condition of the carcass: (1) external examination for any signs of injury or trauma and abnormal lesions such as net marks or skin diseases; (2) internal examination of the body cavities, organs, muscles and bones for any gross abnormalities and/or the presence of macroparasites (a provisional diagnosis of the cause of death may be possible from such examination); and (3) collection of standard data/samples for ongoing biological studies (e.g., skin or other tissue sample for genetic analyses, skull, teeth, stomach, reproductive organs, tissues for contaminant analyses, etc.).

4. Management Goals and Options for Mitigation

Based on their experiences in other parts of the world, in most cases working with other species of small cetaceans, the participants sought to identify various alternative management goals as well as options for mitigation that might be used by concerned parties to begin addressing threats to the humpback dolphins of Taiwan. Although a wide array of management options are indicated in Table 3, only those related to the four highest-priority threats were discussed in detail: freshwater input, habitat loss, bycatch in fisheries, and contaminants.

The workshop's intent was to identify a range of options, while recognizing that some would be impractical or inappropriate in the Taiwan context. Participants did not intend for their lists of options to be exhaustive, nor did they intend them to be prescriptive. Once the authorities and stakeholders in Taiwan become engaged in their own scoping processes, they may identify additional options tailored to the local situation.

The management options identified below are not necessarily mutually exclusive. It may prove desirable to implement several, or even all, options under a given threat category.

4.1. Management Goals

Establishment of management goals is a critical initial step in developing a conservation action plan. These goals can be short-, medium-, or long-term, but they need to be stated clearly and be acceptable to most (preferably all) major stakeholders. Broad-based, inclusive participation in the development of management goals can cause conflict and intense debate, but it greatly increases the likelihood that any ensuing management measures will be implemented successfully.

The following series of alternative management-goal options illustrates one way of choosing management goals. The long-term management goal could be to:

- Ensure the continued survival of this dolphin population off the west coast of Taiwan;
- Prevent further reduction of the geographic range of the population;
- Enable the population to reoccupy the full extent of its original geographic range; or
- Prevent harm of any kind to the humpback dolphins off the west coast of Taiwan.

The foregoing options are listed in ascending order from the least to the most stringent, in terms of how much restriction on human activities might be required to achieve them. In most cases, all stakeholders would probably readily accept the first option, while some would wish to implement the strongest possible protection implied in the last option. In between those two extremes, advocates of conservation and sustainable development may be able to reach a consensus on management goals.

The stated goals of the dolphin conservation program of the Hong Kong Agriculture, Fisheries and Conservation Department are to allow humpback dolphins to continue to use Hong Kong's waters and to enhance the long-term survival of the Pearl River Estuary humpback dolphin population (Lun 2004; Agriculture, Fisheries and Conservation Department 2000). Hong Kong has about ten years of experience in the development of their program, and it would be prudent for Taiwan to take advantage of lessons learned there, recognizing that the situation in Taiwan is urgent and no time should be wasted on “trial-and-error” approaches.

4.2. Options for Mitigation

4.2.1. Reduced Freshwater Flow into Estuaries

- Include potential effects on dolphins in Environmental Impact Assessments (EIAs) for future water diversion/impoundment projects.
- Allocate minimum water flow to estuaries within range of dolphins.
- Compensate industries/communities for loss of water due to allocation to estuaries.
- Create economic incentives to reduce the consumption of fresh water and encourage water recycling.
- Halt construction of and plans for further water diversion/impoundment projects on rivers flowing into estuaries within range of dolphins.
- Restore freshwater flow to the rivers of western Taiwan or reverse river diversions.

4.2.2. Habitat Loss

- Include potential loss or modification of dolphin habitat as a factor to be considered in environmental impact assessments of new land reclamation projects.
- Minimize impacts of land reclamation within areas used by dolphins.
- Declare the portion of coastline inhabited by humpback dolphins as a reclamation-free zone (i.e., no further land reclamation allowed).
- Restore dolphin habitat by reversing land reclamation in and near estuaries.

4.2.3. Bycatch in Fisheries

- Establish one or more dolphin protection areas (in the range of the humpback dolphin population) within which use of gillnets and other high-risk fishing gear is prohibited.
- Prohibit use of gillnets and other high-risk gear in areas/seasons of known frequent occurrence of humpback dolphins.
- Prohibit types of gillnets most likely to entangle dolphins.
- Require that gillnets be tended so that any entangled dolphins can be released alive quickly.
- Compensate fishermen for reductions in catches as a result of not using gillnets (i.e., buy-out program).
- Develop modifications to gillnets to make them less hazardous (and less often lethal) for dolphins (e.g., lighter twine, breakaway connections, modified net stiffness; IWC 2003:371).
- Require use and maintenance of pingers to scare dolphins away from nets with noise. (**Note:** The effectiveness of using pingers in reducing bycatch has not been demonstrated for humpback dolphins, and this option should not be attempted without serious, careful advance planning and deliberation (see IWC 2000:235-243). This caution also applies to gear modification. Given the cost and time needed to conduct scientifically credible experiments (such as those by Kraus et al. 1997 and Gearin et al. 2000) and the difficulties associated with implementation even if effectiveness could be demonstrated, neither the use of pingers nor gear modification is likely to be a practical option for reducing the bycatch of humpback dolphins in Taiwan in the near future).

4.2.4. Environmental Contaminants

The workshop addressed this issue from the premise that pollution of rivers and coastal waters continues to be a serious problem in Taiwan and that it is not being addressed adequately under existing laws and regulations. If it is found that certain of the contaminants identified here are not in the local environment, or that effective measures are already in place and enforced, then the corresponding management options may not be necessary.

- Broadly, reduce contaminant inputs to rivers, estuaries, and the marine environment.
- Improve regulations on chemical design, use, transport, handling, and disposal, especially for chemicals with persistent, bio-accumulative, and toxic properties (e.g., PCBs, DDT, tributyltins).
- Implement improved source control measures that target specific sectors.
- Reclaim and recycle potentially useful constituents from production wastes and sewage (e.g., metals).
- Upgrade effluent treatment to remove chemicals from sewage or in some cases degrade them to inert products (sludge will likely require treatment or disposal as hazardous waste).
- Separate municipal and industrial liquid waste grids to improve source control and waste treatment options.
- Introduce “buffer zones,” integrated pest management, and other practices to prevent/reduce runoff of pesticides from agricultural zones.
- Once contaminants have been released into the aquatic environment, measures such as sediment capping or the dredging (removal) of contaminated sediments or adjacent soils can be carried out, but these are generally costly and less effective than the proactive approaches listed above.

The Stockholm Convention, which recently came into force, provides a global framework for controlling or eliminating some of the most harmful environmental toxins (Appendix 5). Taiwan’s conformity with the terms of this convention would obviously be a step toward improving the health of marine food webs generally.

4.2.5. Area-based Approaches

Some management measures are amenable to an area-based approach, which can be especially effective with non-migratory populations. In effect, any effort to reduce spatial overlap between the dolphins and the various threat factors should aid conservation. For example, regulations to set minimum levels of river flow could be effective in maintaining or restoring the estuarine habitat of humpback dolphins. Likewise, gillnet fishing and further land reclamation could be discouraged in areas where the dolphins are most common.

Although measures that apply throughout the range of the population would be most effective, it is important to begin by introducing mitigation efforts in areas where dolphins are most common, and then seeking to expand protection as more is learned about their ranging patterns and ecology. In Hong Kong, for instance, designation of the Sha Chau and Lung Kwu Chau Marine Park has provided a model for developing the necessary management infrastructure and protecting the integrity of a segment of dolphin habitat. Meanwhile, ongoing research has identified additional areas of particular importance to the dolphins, and one or more additional protected areas may be designated in the near future (Agriculture, Fisheries and Conservation Department 2000).

4.2.6. Captive Breeding for Conservation

Because it has been applied successfully in some instances with species other than marine mammals, the concept of using captive breeding to improve the survival prospects of wild cetacean populations is often raised. The workshop did not address this issue in detail. However, it was noted that there is no evidence to suggest that captive breeding of humpback dolphins would be a realistic option for reintroduction, restocking, or some other kind of population enhancement. Even if animals taken from the wild were to breed successfully in captivity, problems associated with the release of captive-born dolphins into the wild would be severe. For a detailed discussion of the pros and cons of this approach, see Reeves and Mead (1999).

4.3. Beneficial Effects on Other Species, Including Humans

Efforts to improve the prospects for survival of Taiwan's humpback dolphin population will have ancillary beneficial effects on the natural environment more generally. For example, bycatch reduction measures can lead to improved fishery management, with positive implications for reduced wastage and improved stock assessment, stock monitoring, and stock recovery. Further, healthy and productive rivers, estuaries, and coastal waters are needed to maintain, enhance, and restore populations of a wide range of indigenous flora and fauna. These, in turn, would enrich and improve the health of human communities. As the people of Taiwan seek to achieve a better balance between their economic aspirations and environmental sustainability (for reasons unrelated to dolphins – e.g., human health concerns, socio-economic equity, compliance with international agreements), measures taken to restore natural rivers and estuaries, enhance marine productivity, and reduce pollution should be politically popular. Interest in conserving humpback dolphins may reinforce the appeal of such measures and thus lead to a healthier environment for both people and wildlife.

4.4. General Recommendations

Three key general recommendations emerged from the workshop, as follows:

- Humpback dolphins and their habitat requirements should be routinely considered in EIAs for development along the west coast of Taiwan. The impacts of inland developments (even many kilometres from the ocean) on watersheds, and in turn the potential indirect impacts on humpback dolphins, must also be considered in EIAs.
- Consideration should be given to establishing a multi-stakeholder body in Taiwan similar to Hong Kong's Marine Mammal Conservation Working Group (Agriculture, Fisheries and Conservation Department 2000) to oversee and monitor conservation action and research on behalf of humpback dolphins.
- Further workshops to review progress and plan next steps for research and mitigation should occur at regular intervals; it is suggested that the second humpback dolphin workshop should take place in 2007.

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Table 1. Threats and information needed to better understand or address them.

Threats	Threat Impact (High/Medium/ Low)	Known, Likely, Potential, Unlikely	Information Needed	Importance* (High/Medium/ Low)	Logistically Feasible	Schedule (within X years)**
Reduction of freshwater flow (dams, flood control, other river alterations, climate change, aquaculture)	High	Known	Existing water use	High	YES	1
			Planned water use	High	YES	1
Habitat loss (land reclamation, breakwalls, dredging, climate change)	High	Likely	Plans for further coastal industrial development	High	YES	1
			Future reclamation projects	High	YES***	1
Fishery bycatch (gillnets, trawls)	High	Likely	Occurrence of bycatch	High	YES****	2
			Level of bycatch	High	NO	-
			Fishing practices	Medium	YES	1
Industrial discharge	Medium-High	Likely	Contaminant levels in prey	Medium	YES	3
			Contaminant types and sources	Medium	YES	1
			Eutrophication – level	Low	YES	2
			Contaminants in dolphins	Low	NO	-
Municipal sewage discharge	Medium-High	Likely	Contaminant levels in prey	Medium	YES	3
			Contaminant types and sources	Medium	YES	1
			Eutrophication – level	Low	YES	2
			Contaminants in dolphins	Low	NO	-
Agricultural run-off (pesticides/phosphates/ nitrates)	Medium	Likely	Contaminant levels in prey	Medium	YES	3
			Contaminant types and sources	Medium	YES	1
			Eutrophication – level	Low	YES	2
			Contaminants in dolphins	Low	NO	-
Depletion of prey (e.g., over-fishing, loss of prey habitat, die-offs)	Medium	Potential	Status of fish stocks	Low-High	YES	2
			Status of prey habitat	Low	YES	2
Vessel-based eco-tourism (dolphin-watch, "scenic" tours, recreational fishing)	Low-High	Potential	Future cetacean-watch plans and regulations	Medium	YES	?
Military activities	Low-High	Potential	Plans for deployment of new military sonar (specifics of frequencies involved)	Medium	YES?	2-3
			Other military activities (shelling, torpedoes, traditional sonars)	Low	YES?	?
Oil and chemical spills, discharges (intentional and accidental)	Low-High	Potential	Number and types of ships visiting ports or transiting	Low	YES	1
			Risk assessments available?	Low	?	?

Introduced diseases	Low-High	Potential	Water and shellfish quality (coliforms)	Low	YES	3
			Microbes/antibodies in dolphins	Low	NO	-
Collisions with vessels	Low-Medium	Potential	Boat traffic information	Low	YES	1
			Occurrence of collision (including sampans, jet-skis, etc.)	Low	YES	-
			Plans for fast ferries	Low	YES	?
Noise (vessel traffic, construction, percussive piling)	Low	Likely	Construction plans and methods (esp. percussive piling)	Medium	?	?
			Vessel noise profile	Low	YES	3
			Boat traffic information	Low	YES	1
Aquaculture practices (land, oyster cages, pollution, eutrophication, physical obstruction, poisons, antibiotic-resistant microbes, botulism [e.g., black-faced spoonbill die-offs])	Low	Potential	Past and present patterns of aquaculture	Low	YES	1
			Past and present aquaculture practices	Low	YES	1
Direct catches (food, live display)	Low	Potential	Number of animals being caught (past and present)	Low	NO	-
Offshore oil and other developments / pipelines, etc.	Low	Potential		Low	-	-
Toxic blooms (red tides, domoic acid)	Low	Unlikely		Low	NO	-

*Refers to how important it is to obtain the information.
**This column presupposes that the necessary resources (money and manpower) are available to carry out the work.
***It is feasible to obtain this information only if the environmental impact assessment process in Taiwan is closely monitored.
****From interviews with fishermen (simply to verify that bycatch occurs).

Table 2. Priority biological knowledge related to conservation goals. For elaboration on many of the items, see text.

Information On:	Importance (High/Medium/ Low)	Methods	Logistically Feasible*	Schedule (within X years)*
Abundance	High	Reanalysis of available data	YES	1
		Ship-board line transect surveys	YES	1
		Photo-ID (mark-recapture)	YES	3
		Surveys inshore of sandbars	YES	1
		Aerial line transect surveys	NO?***	1
		Genetic recapture	NO**	3
Population trends	High	Historical research	YES	2
		Repeated surveys	?	>>5
		Population modelling	NO	-
Distribution (seasonal, typhoon)	High	Ship-board surveys	YES	2
		Reports of sightings (interviews)	YES	1-2
		Aerial surveys	NO?***	2
		Satellite tagging	NO**	-
Habitat requirements	High	Collection of oceanographic data (salinity, clarity, depth, substrate, SST)	YES	1-3
		Multivariate habitat analyses (e.g., GIS)	YES	3-5
		Prey density	NO	-
Demography / life history	High	Age/sex structure of schools	YES	3
		Longitudinal study using photo-ID	YES	>5
		Carcass analyses	NO**	-
Population discreteness	Medium-High	Morphology	YES (only pigmentation)**	1
		Genetics (with existing samples)	YES (microsatellites)**	1
		Movement (photo-ID)	Yes	3
		Movement (satellite tagging)	NO**	-
		Parasite loads	NO**	-
		Contaminant patterns	NO**	-
		Distribution	YES	2
Feeding ecology	Medium-High	Stomach contents	YES**	?
		Direct observations of feeding	YES	?
		Prey density	NO	-
		Stable isotope/fatty acid analyses	NO**	-

Pathology	Medium-High	Necropsy examination (gross) on all carcasses	YES**	?
		Further laboratory investigation on fresh carcasses/tissues	NO**	-
Health status (body condition, scars, bio-markers, skin conditions)	Medium-High	Longitudinal analysis of prevalence of skin problems (photos/photo ID/index)	YES	3
		Longitudinal analysis of injuries and scars (photos/photo ID/index)	YES	3
		Longitudinal analysis of body condition (photos/photo ID/index)	YES	3
Individual movements (daily, seasonal)	Medium	Photo ID; ranging pattern analysis	YES	3
		Telemetry	NO**	-
Behavioral ecology (e.g., acoustic)	Low	Ethological studies	YES	1
		Acoustic studies	YES	1
		Behavioural sampling	YES	1
		Telemetry	NO**	-
Population genetics (e.g., level of inbreeding)	Low	Biopsy	NO**	-

*These columns are intended to indicate how easy (or difficult) it is expected to be to get the required information.
**These items are affected by the general lack of fresh beach-cast specimens (only two badly decomposed carcasses have become available over the last decade) and/or the fact that "invasive" research (e.g., biopsy darting, telemetry) on this small and vulnerable population is contraindicated (see text). Some methods were determined to be feasible even with limited carcasses because even single specimens can provide important information.
***Logistically difficult – depends on aircraft availability and permission to fly through potentially sensitive, military airspace.

Table 3. Mitigation/management options for the four main threats (see Table 1). (Key to abbreviations: EIA = Environmental Impact Assessment; PBT = Persistent, Bioaccumulative, Toxic).

Threats	Mitigation / Management Options
Reduction of freshwater flow (dams, flood control, other river alterations)	Add humpback dolphins to EIAs (general recommendation)
	Allocate minimum water flow to rivers and estuaries (e.g., via compensation to industries / communities for their losses, incentives to reduce usage, water purification and recycling, desalination projects)
	Halt construction of and plans for further water diversion or impoundment
	Restore flow to rivers of western Taiwan
Habitat loss (land reclamation, breakwalls, dredging, alterations of estuaries)	Include consideration of potential dolphin and prey habitat loss in EIAs for new land reclamation and other industrial projects
	Minimize land reclamation in remaining areas of dolphin habitat
	Establish dolphin protection area (within range of dolphin) where no further land reclamation is allowed
	Restore habitat by reversing land reclamation and other developments
Fishery bycatch (gillnets, trawls)	Establish dolphin protection area where gillnets and trawls are banned
	Prohibit use of gillnets and trawls in area/season of high dolphin occurrence
	Prohibit certain types of gillnets (e.g., trammel, large-mesh)
	Gear modification (with provisos, see text)
	Use of “pingers” (with provisos, see text)
	Modify fishing practices (e.g., tending nets constantly)
	Compensate fishermen for losses (e.g., ”buy-out” program)
Industrial, municipal, and agricultural Discharge	Regulate chemical design, use, handling, disposal, and transport of PBT compounds (e.g., PCBs, dioxin)
	Implement source control measures that target sectors
	Reclaim and recycle potentially useful constituents of sewage (e.g., metals)
	Upgrade effluent treatment to remove chemicals from sewage or degrade them to inert products (sludge should likely be treated as hazardous waste)
	Introduce buffer zones, integrated pest management (IPM) and other practices to prevent or reduce runoff of pesticides
	Separate municipal and industrial liquid waste grids to improve source control and waste treatment options
	Remove contaminated sediments or soils

APPENDIX 1

WORKSHOP AGENDA

(26 February 2004)

VENUE: 6th floor meeting room in the New Palace building (Wuchi, Taichung County, Taiwan)

Chairman: J.Y. Wang
English Rapporteur: R.R. Reeves
Chinese Rapporteur: S.-C. Yang

1. WELCOME

2. ACKNOWLEDGEMENTS OF THE FUNDING SOURCES

3. INTRODUCTION OF THE PARTICIPANTS

4. REVIEW AND ADOPTION OF THE *AGENDA*

5. DEFINING THE PROBLEM (SCOPING)

5.1. Is there a problem (i.e., high risk of extinction/extirpation)?

5.1.1. What is known about humpback dolphins? – T.A. Jefferson
- 5.1.1.1. Taxonomy
- 5.1.1.2. Distribution
- 5.1.1.3. Reproduction
- 5.1.1.4. Ecology
- 5.1.1.5. Abundance
- 5.1.1.6. Threats and conservation status

5.1.2. What is known about humpback dolphins of western Taiwan? – J.Y. Wang
- 5.1.2.1. Records
- 5.1.2.2. Distinct and isolated population (see 5.1.2.8. below)
- 5.1.2.3. Distribution
- 5.1.2.4. Abundance
- 5.1.2.5. Injuries (and mortality?)
- 5.1.2.6. Potential existing and new threats
- 5.1.2.7. Conservation status
  - 5.1.2.7.1. Cultural beliefs
  - 5.1.2.7.2. Legal protection
  - 5.1.2.7.3. Public awareness
- 5.1.2.8. Distinct and isolated population – S.K. Hung

5.2. The state of the environment inhabited by this population

5.2.1. Hydrology of western Taiwan (past, present, future plans) – T.-M. Hsiao
5.2.2. Net fisheries of western Taiwan (past, present, future) – S.-C. Yang
5.2.3. Case study of killer whale in British Columbia – P.S. Ross

5.3. Identify and prioritize known, likely and potential threats

6. IDENTIFYING AREAS OF UNCERTAINTIES

6.1. Identify and prioritize biological information needed for conservation

6.2. Identify and prioritize other information (i.e., about threats) needed to better understand the problem(s)

7. CREATING A PLAN TO ADDRESS THE UNCERTAINTIES

7.1. Methods for obtaining the needed information

7.2. Schedule (within 1, 2, 3, 5, 10 years, etc.)

7.3. Funding needs and sources

8. CONSERVATION/MANAGEMENT ACTIONS AND POSSIBLE OPTIONS

8.1. Management infrastructure, relevant legislation, enforcement capacity, agency responsibilities/jurisdictions, etc.

8.1.1. Hong Kong (example) **–** J.C.Y. Lun

8.1.2. Taiwan **–** Y.-T. Day

8.2. Possible long-term goal(s) – E. Slooten/J.C.Y. Lun

8.3. Some short-term goals – E. Slooten/J.C.Y. Lun

8.4. Possible management options for the most serious threats – W.F. Perrin

9. MONITORING: DOLPHINS; AND PERFORMANCE ON REDUCING UNCERTAINTIES AND ON THE INITIAL CONSERVATION PLANS

9.1. Future meetings

9.2. Marine Mammal Conservation Working Group of Hong Kong

10. RESEARCH ACTION PLAN AND WORKSHOP REPORT

10.1. *The Research Action Plan*

10.1.1. Main elements and structure

10.1.2. Review process

Possible items to include:

1) General and short introduction describing: the reason (background) for the workshop, the scope of the workshop and the participants involved.
2) Agreement by all that there is a high risk of extinction of this population?
3) The main long-term goal identified by the participants
4) The main threats identified
5) Priority research needs
6) Priority conservation needs
7) The plan to resolve uncertainties in knowledge
8) The plan for conservation actions based on available knowledge
9) Recommendations (for research and conservation and schedules)
10) A concluding statement about the urgency for immediate action

10.2. ***Report of the First Workshop on the Conservation and Research of Indo-Pacific Humpback Dolphins, Sousa chinensis, of the waters of Taiwan***

10.2.1. Main elements and structure

10.2.2. Post-workshop review process

10.3. Drafting of an Open Letter to the President of the NMMBA

10.4. Review the Workshop Report (to be continued post-workshop)

APPENDIX 2

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APPENDIX 3

ABSTRACTS OF PRESENTATIONS AT THE FIRST SYMPOSIUM ON THE CONSERVATION AND RESEARCH OF INDO-PACIFIC HUMPBACK DOLPHINS, *SOUSA CHINENSIS*, OF THE WATERS OF TAIWAN

(23 February 2004)

Conservation of small cetaceans: global to local perspectives - Randall R. Reeves
This presentation attempts to place the small cetaceans that inhabit Taiwan's coastal waters into a broad geographic and management context. It also stresses the importance of being able to provide the general public, and of course policy makers, with a convincing argument as to why a small population of small cetaceans should command their attention and resources. Approximately 70 currently recognized species in the order Cetacea, suborder Odontoceti (toothed whales, dolphins, and porpoises), are classified (informally) as small cetaceans. In general, people are sympathetic toward them, and the threat of deliberate exploitation (harpooning or driving ashore) is much less acute than it was in the past. However, new threats, including incidental mortality in fishing gear and habitat degradation (e.g., chemical pollution and noise), continue to threaten many species and populations. No single international convention exists with a mandate to conserve the world's species and populations of small cetaceans, nor is there any bilateral or multilateral agreement in the western North Pacific that would provide a conservation regime for small cetaceans at the regional level. This means, for the moment at least, that national governments and local authorities are on their own to develop and pursue appropriate conservation policies. In the case of the Indo-Pacific humpbacked dolphin (*Sousa chinensis*), Taiwan can benefit from the major advances in scientific knowledge about this species achieved as a result of research in Hong Kong and nearby waters of China over the past decade. It will be important over the coming years for the results of research on humpbacked dolphins in Taiwan to be conveyed to regional and international audiences, and thereby integrated into a wider view of the species' biology and status. It will also be important for Taiwan to take advantage of what has been accomplished and learned in Hong Kong and other jurisdictions (e.g., New Zealand, western Europe, and North America) concerning the management of human activities to conserve small cetaceans.

A review of the biology of the Indo-Pacific humpback dolphin *Sousa chinensis* (Osbeck, 1765) - Thomas A. Jefferson
The Indo-Pacific humpback dolphin (*Sousa chinensis*) is one of two species of humpback dolphins currently recognized by most marine mammal biologists. The taxonomy is unresolved, and there are probably multiple species in the Indo-Pacific. It is a moderate-sized dolphin, with a robust body and a distinct dorsal hump in the western portion of its range. Coloration is highly variable, both geographically and by sex and age. The species is found in a coastal band from South Africa to central China and northern Australia. Reproduction has been poorly-studied, but calving generally appears to occur year-round, and sexual maturity is reached at ages of about 9-13 years. They occur in nearshore waters, especially in estuaries and around reefs. The animals feed on a variety of nearshore fish and cephalopod species (and occasionally crustaceans). Predation by sharks is known for some areas. Behavior patterns are similar to those of other coastal dolphins, but humpback dolphins generally do not bowride. Group sizes tend to be small (<10) in most areas, and group composition is fluid. Abundance or density has only been estimated for only a few areas, and most populations are thought to be small (tens to low hundreds). The Hong Kong and Pearl

River Estuary population is the largest known, with over 1,500 dolphins estimated. Threats include a variety of human activities, including incidental catches in fisheries and shark nets, vessel collisions, habitat loss, and detrimental effects of environmental contaminants. Several populations are thought be declining, although the status of most remains completely unknown. Clearly, humpback dolphins are highly vulnerable to the effects of human activities, and much more attention is needed to ensure the health and viability of populations in developed areas, such as Taiwan.

The Indo-Pacific humpback dolphins, *Sousa chinensis*, in the waters of western Taiwan - John Y. Wang, Shih-Chu Yang and Samuel K. Hung (presented by Shih-Chu Yang)
Little is known about Indo-Pacific humpback dolphins in Taiwanese waters. Prior to surveys in 2002and 2003, Indo-Pacific humpback dolphins were thought, incorrectly, to occur sporadically in these waters. Almost the entire coastal waters of western Taiwan were surveyed and humpback dolphins were found regularly with the main concentration of dolphins being found in a thin strip of shallow, coastal water of Miaoli, Taichung and Changhua counties (sightings have also been reported from the waters of Yunlin and Chiayi counties). All dolphin sightings were made in or near estuarine waters that were less than 3 km from shore and less than 15 m deep (usually much shallower). Furthermore, based on the unique pigmentation patterns exhibited by the humpback dolphins of western Taiwan, they appear to comprise a population that is distinct from those of neighbouring waters. Preliminary estimates of population size indicate there are at least 30 but not more than 200 individuals. Being restricted to a more or less **one dimensional** distribution along the coastal and estuarine waters of western Taiwan, this population is highly vulnerable to numerous existing anthropogenic threats. Furthermore, two recent industrial development projects are adding more concern for the future existence of this population: 1) the damming of the Juoshuei River by the Formosan Plastics Group (construction is underway after an environmental impact assessment, which did not consider these dolphins, was approved); and 2) the construction of a new petrochemical plant by the Chinese Petroleum Corporation in Yunlin or Chiayi County. To conserve this unique population, it is critical to immediately assess: 1) the population's status; and 2) the main threats to the population. With so few dolphins remaining, it is urgent to reduce or eliminate the impacts of the main threats.

Genetic and biological consequences of isolated small populations of cetaceans - Bradley N. White
The amount of genetic variation that a population can hold and the rate of loss of that genetic variation are related to the effective size of the population. The effective size (Ne) of a population is related to the number of breeding individuals, which can be substantially smaller than the census population. The higher the effective population size the slower the loss of that genetic variation. Reproductive connectivity with another population can slow the rate of loss and help maintain a higher level of genetic variation. Genetic variation can be described and measured in terms of allelic diversity, the number of different forms of a gene and heterozygosity, the presence of two different forms of a gene in individuals. Low genetic variation leads to bringing together of deleterious recessive alleles at genes and reduces the evolutionary potential of the population to adapt to environmental change including disease. An important group of genes that are the most genetically variable in mammals is found at the Major Histocompatibility Complex (MHC). These genes are involved in the immune response to pathogens and parasites and reproduction. The North Atlantic right whale presently numbers about 320 individuals. It produces about 11 calves per year from 100 adult females. This is only one third the production of the South Atlantic right whale. Some North Atlantic right whale mature females have never had a calf and others only one and there is a

long inter-calf interval for those with multiple calves. As a result of over 20 years of field work led by the New England Aquarium in Boston most of the individuals have been photo-identified and most of the mother calf pairs identified. DNA has been isolated from biopsy samples from about 75% of the individuals in the catalogue. All individuals have been genetically analysed at 35 microsatellite loci and the North Atlantic right whale shows only one half the allelic diversity and hetrozygosity of the South Atlantic right whale. The integration of the extensive photo-identification catalogue and the DNA profiles allows paternities to be assigned and accurate estimates of the effective population size. Parentage assignments allow examination of the effects of inbreeding (related individuals mating) and the reproductive success of individuals. We are presently genotyping animals at a number of genes in the MHC to examine whether limited genetic diversity at these loci is related to poor reproductive success and poor health. The data base contains a health assessment of individuals based on skin lesions and other indicators. We are also assessing the level of genetic variation in the species from the 16th century from DNA extracted from bones from whaling sites. The North Atlantic right whale therefore serves as model species to examine the effects of low population size on the genetics, reproduction and health.

Can anything be done about bycatch of cetaceans in fisheries? - William F. Perrin
Bycatch in fisheries is the most important conservation threat to small cetaceans. Examples of fishery bycatches that have caused or likely caused population declines in small cetaceans include kills of dolphins in the tuna purse-seine fishery in the eastern tropical Pacific, in various fisheries in the Philippine eastern Sulu Sea and in the Taiwanese shark gillnet fishery in the waters of Australia, Indonesia and Papua New Guinea. In Southeast Asia, where exploratory surveys have been carried out problems of bycatch have emerged in almost every case. Bycatch can evolve into directed catch and has done so in several places globally. Bycatch problems can be solved, providing adequate legal framework and resources are available. In the U.S., fisheries are classified into high-risk, medium-risk and low-risk categories, and where bycatch exceeds a limit based on population and reproductive capacity, bycatch-reduction teams work at reducing the kill. Population survey need not always involve use of very large vessels. Numerous ways exist to reduce bycatch. Before launching a bycatch-reduction program, explicit goals should be agreed by all stakeholders, who should subsequently be involved in the mitigation efforts. Bycatch-reduction efforts should be monitored to ensure sustained success. Economic damage to the fishery should be mitigated. In the situation of lack of adequate legal framework and resources needed to begin a bycatch-reduction program, several initial steps not requiring massive resources can be carried out, the most important of which is identify and increase public awareness of potentially unsustainable bycatches.

Possible effects of habitat degradation on the declining finless porpoise population in the Inland Sea of Japan - Toshio Kasuya
Two sets of sighting surveys repeated with a 22 year interval showed a decline of finless porpoises in the Inland Sea for all the 18 tracks compared, 11 of which were statistically significant. The decline occurred both in the near shore (<1 nm) and intermediate (1-3 nm) strata, but it was unclear for the offshore stratum (>3 nm) due to extreme low density. The average sighting rate and size of the stratum suggest approximate population decline of 12% (central and eastern region), 56% (western region), and 31% (for both regions combined). The last figure is equal to an annual decline of about 5%, which can result from a technically undetectable level of change in demographic rates. Incidental mortality in fishing nets and accumulation of pollutant such as PCB, DDT, butyl tins and dioxins are possible causal

factors, but habitat degradation due to oil spills, reclamation and extraction of sand could have also contributed to the changes.

Characterizing the risk of contaminant-related health impacts in cetaceans - Peter S. Ross

Environmental pollution ranks high on the list of threats to the world's marine mammals. While such endocrine-disrupting compounds as the polychlorinated biphenyls (PCBs) and the pesticide DDT represent well-documented concerns in wildlife, a wide range of other, often poorly understood, contaminants can be found in cetaceans, their habitat, and their prey. Many whale, dolphin and porpoise species can be considered as particularly vulnerable to the effects of contaminants because of characteristics such as their: 1) often high position in aquatic food chains which can lead to biomagnification of persistent chemicals; 2) long lifespan which can allow for bioaccumulation of persistent chemicals; 3) reliance on the water-air interface where some pollutants may concentrate; 4) reliance on lipids (fat) for energy storage and the provision of nutrition to nursing calves, with these lipids serving as the route by which many chemicals are stored (blubber) or transferred (milk); 5) relative inability to metabolically eliminate some contaminants; and 6) specialized breeding, feeding and socializing strategies, which can predispose individuals or populations to being exposed to certain types of contaminants. Understanding the basic biology, life history and habitat use of a given cetacean population therefore represents a foundation for characterizing the risks associated with exposure to environmental contaminants. Understanding the nature of the different types of contaminants to which a given population is exposed represents another key component of assessing contaminant-related health risks to a population. Important considerations that must be included in a characterization of contaminant risks include a chemical's i) persistence, volatility, solubility in water, and degradation products; ii) history of design, manufacture, use and disposal in local, national and global terms; iii) behaviour and fate in the environment, including aquatic food webs; and iv) toxicity to the marine mammal in question. Measuring the effects of contaminants on marine mammals can involve: i) a risk-based assessment by measuring the levels and patterns of chemicals in the marine mammal and/or its prey; ii) mechanistic studies using simple or complex contaminant exposures in laboratory animal studies; and/or iii) biomarker-based (biopsy) approaches to measuring health effects in free-ranging individuals. Ultimately, a 'weight of evidence' which combines the three strategies may offer the best guidance to scientists, conservationists and managers. Addressing contaminant risks can involve regulations on chemical design and/or on source control, engineering strategies such as dredging or capping, or habitat remediation. However, effective conservation strategies must also consider contaminant risks in the context of the many other human–associated threats to vulnerable cetacean populations, such as fishing interactions, climate change, diminished prey availability, and noise, all of which may contribute to a reduction in habitat quality and/or population viability.

Environmental implications on the health and diseases of free-ranging dolphins - Reimi E. Kinoshita

A complex interaction of multiple factors lead to the diseased state and an important component in this equation is the environment. There appears to be an appreciable increase in the diseases of marine life worldwide over the past one to two decades, including events leading to the mass mortalities of cetaceans. Emerging diseases are of special concern as they can cause significant mortality and morbidity of animals. This increase might be related to climatic changes and anthropogenic activities, which may result in: animal/host shifts making them more susceptible to infection; facilitating pathogen transmission through changes in its prevalence and distribution; introduction of (novel) pathogens or toxins into the marine environment; a decrease in host resistance; and degradation of habitat. Cetacean disease and mortalities are not only important in the conservation and welfare of their species but cetaceans can act as sentinels of the ocean, reflecting changes that might impact the marine ecosystem and potential effects on human and other marine life health. Some important and recently identified diseases of free-ranging cetaceans include morbilliviruses, which are believed to have been primarily responsible for several epizootics, since 1987, in populations of dolphins and porpoises in the United States and Europe. Brucellosis has only been first reported in cetaceans in 1994, caused by novel species of the bacterium. It can potentially cause reproductive disorders in its host and also may pose a public health risk. Human–related activities might have played a part in the apparent increase in frequency of toxic algal blooms. Brevetoxin, saxitoxin and domoic acid are examples of toxins produced by these algae, which have been implicated in cetacean die-offs. Contaminants such as organochlorines can have multiple effects on the health of wild cetaceans. The impact of a single outbreak event of these pathogens or toxins may be sufficient to threaten the newly discovered population of Indo-Pacific humpback dolphins (*Sousa chinensis*) in the waters of western Taiwan, given their small size and restricted distribution. Continuous surveillance and a multidisciplinary approach are essential to understand and identify factors affecting cetacean health and disease. Thorough necropsies and investigations of stranded cetaceans are an invaluable source of information. Vigilance and awareness of potential zoonoses are required.

Management of Hector's dolphins in New Zealand: achievements to date and action plan to achieve sustainability - Elisabeth Slooten

Hector's dolphin *Cephalorhynchus hectori* is endemic to New Zealand waters. There are at least four genetically distinct populations, off the east, west and south coasts of the South Island and off the west coast of the North Island. The North Island population has recently been designated a separate subspecies *Cephalorhynchus hectori maui* (also known as Maui's dolphin). All four populations have been subject to entanglement in gillnet fisheries for more than 30 years, and have been depleted during that time. Hector's dolphin is listed on the IUCN Red List as Endangered, with the North Island population listed as Critically Endangered. The first management action to reduce the impact of gillnet entanglement was the creation in 1988 of a Marine Mammal Sanctuary around Banks Peninsula (east of Christchurch on the South Island east coast). This sanctuary was created by the Minister of Conservation, under the Marine Mammals Protection Act. A second protected area, off the west coast of the North Island, was created in 2003 by the Minister of Fisheries, under the Fisheries Act. A long-term research project around Banks Peninsula (started in 1984) indicates that this population is still declining. Recent aerial surveys show that the local dolphin population is well protected in summer, when 80-95% of the local population is found within the sanctuary boundaries. However, in winter the dolphin population is more widely dispersed and less than 35% of the population is protected. Extensions of the sanctuary boundaries offshore, as well as north and south, would be required to reduce bycatch to sustainable levels. This case study shows the importance of carefully choosing the boundaries of protected areas. In the Banks Peninsula case, fishing effort shifted to areas immediately north, south and offshore of the sanctuary, where dolphin densities are still relatively high. As a consequence, the bycatch problem has been partly solved and partly shifted. The overall level of bycatch in the Banks Peninsula area has been reduced from approximately 50 dolphins per year to approximately half that level (last estimate of bycatch in the commercial gillnet fleet alone = 16 in one fishing season). The Potential Biological Removal (PBR) rate for the local population would be <1 individual per year for the areas north and south of the Banks Peninsula Marine Mammal Sanctuary. The North Island protected area includes a much higher proportion of the local Hector's dolphin population. However, there are concerns about the southern boundary of the protected area and the fact that harbours and bays are not included.

Research and conservation efforts to protect Indo-Pacific humpback dolphins (Chinese white dolphins) in Hong Kong - Samuel K. Hung

Sixteen cetacean species have been recorded in Hong Kong waters, but only the Indo-Pacific humpback dolphin (*Sousa chinensis*) and finless porpoise (*Neophocaena phocaenoides*) can be found year-round and considered residents. Since 1993, the Hong Kong Government funded several cetacean research studies, in which systematic research techniques (e.g. line-transect vessel survey and photo-identification) and a stranding recovery programme were carried out to study the status and biology of the humpback dolphins. As a result, a great deal of information has been collected in the past eight years, including the distribution, abundance, social organization, ranging patterns, behaviour, life history and mortality causes of humpback dolphins in Hong Kong. The information has been used by the government to formulate conservation programmes to effectively protect the humpback dolphins in the long term. In Hong Kong, humpback dolphins are facing various threats related to human activities. These include water pollution, habitat loss, seabed dredging, incidental catch by fishermen, vessel collision and underwater noises. To deal with the threats facing local cetaceans, the Hong Kong government has taken various actions to protect them and their habitat. The government has established several conservation regulations and marine protected areas for the dolphins and their habitat. The government also continues to provide research funding to monitor the status of humpback dolphins in Hong Kong waters, and has established regional cooperation with the Guangdong authority to protect the dolphins throughout the Pearl River Estuary. Both local NGOs and the government have launched various public awareness programmes and produced educational material to increase the awareness of the conservation of local dolphins, porpoises and the marine environment.

Status and Conservation of Indo-Pacific humpback dolphins (Chinese white dolphins) in the People's Republic of China - Samuel K. Hung

Currently the status of Indo-Pacific humpback dolphin along the coast of the People's Republic of China is poorly known. Stranding records indicate that humpback dolphins occur along the coastal waters from Beibu Gulf in the south to Yangtze River to the north. Studies on the status of humpback dolphins have only been conducted in the Pearl River Estuary of Guangdong Province and Xiamen Harbour of Fujian Province. Several threats are faced by humpback dolphins in the coastal waters of China, including direct and incidental catch, habitat loss, vessel collision, water pollution, destructive fishing practices and underwater blasting involved in coastal construction projects. Some conservation measures are in place to protect the humpback dolphins in China. This species is listed as a Grade 1 National Protected Species in the List of Wildlife Under National Key Protection and receives protection from various legislations in the People's Republic of China. Two national nature reserves were established in Xiamen and the Pearl River Estuary in 2000 and 2003 respectively. However, law enforcement has not been effective so far. Several suggestions for conservation measures were made in the "Action Plan for Conservation of Chinese White Dolphins in China", which includes strict enforcement to prohibit sewage discharge, banning destructive fishing practices, reviving fisheries resources, strict regulation on seabed dredging, reclamation projects and mariculture in coastal waters, and strengthening scientific research on the population biology of humpback dolphins.

Conservation Programme for the Chinese White Dolphin Adopted by the Hong Kong Government - Janice C.Y. Lun (presented by Samuel K. Hung)

Since the early 1990s, the Hong Kong Government has commissioned several studies to examine the status of Chinese white dolphins in Hong Kong and a conservation programme was formulated in 2000 based on the studies' findings. The goal of the conservation programme was to enable the humpback dolphins to use Hong Kong's waters and to enhance their survival in the Pearl River Estuary. The government identified several human activities that were threatening the humpback dolphins and a four-pronged approach was adopted in order to provide effective measures to reduce the impacts of these activities and to conserve the dolphins. This approach involved management (i.e., improving dolphin habitat, minimizing impacts using an EIA process and protecting core dolphin areas), public education to arouse interest in dolphin conservation, research to provide accurate and update information of the dolphins, and cross-boundary cooperation with relevant authorities to facilitate information exchange and a coordinated approach for conserving the dolphin population.

Note: Two other presentations were given in Chinese but no abstracts were provided. Please consult the symposium program of *The First Symposium and Workshop on the Conservation of Research of Indo-Pacific Humpback Dolphins,* Sousa chinensis*, of the Waters of Taiwan* (Wang and Yang 2004) for the contents (in Chinese) of the presentation on: *Conservation of Cetaceans in Taiwan: Past, Present and Future* written by Kuo-Yun Fang (Resources Conservation Section, Council of Agriculture) but presented by Shou-Ming Wang (Resources Conservation Section, Council of Agriculture). The other presentation was on *Local Perspectives on the Conservation of Chinese White Dolphins and the Local Coastal Environment* by Yuan-Chuan Lin (Member of Parliament, Yunlin County).

APPENDIX 4

RESEARCH ACTION PLAN FOR THE HUMPBACK DOLPHINS OF WESTERN TAIWAN

A small population of Indo-Pacific humpback dolphins (*Sousa chinensis*) was discovered along the west coast of Taiwan in 2002. This discovery has evoked much scientific and conservation interest. It has also given Taiwan an unexpected opportunity to help conserve the diversity of life on Earth. However, this opportunity may not last long. Taiwan's humpback dolphins are threatened by a variety of things, some of which are plainly evident and others of which are poorly understood. Many of the dolphins bear evidence of serious injuries, at least some of which were caused by human activities. Without a doubt, action is urgently needed to protect these animals and their habitat.

Indo-Pacific humpback dolphins occur discontinuously in near-shore marine and estuarine waters from the Indian Ocean coast of Africa eastward to the Pacific coasts of China and Australia. In Southeast Asia, they have been studied in only a few areas, most notably Hong Kong. In addition to the population recently discovered off the west coast of Taiwan, several populations are known to inhabit specific portions of the mainland Chinese coast.

The first international workshop on a cetacean conservation issue in Taiwan was conducted at the New Palace (Wuchi, Taichung County, Taiwan) on 25-27 February 2004. The overall aims of this workshop were to evaluate the status of the dolphin population, identify and rank threats, develop a research action plan, and suggest potential approaches to threat mitigation. The workshop was hosted by the National Museum of Marine Biology and Aquarium of Checheng (Pingtung County, Taiwan) and sponsored by the National Science Council of Taiwan, the Council of Agriculture of Taiwan and Ocean Park Conservation Foundation of Hong Kong. The workshop was convened and chaired by Dr. John Y. Wang (of the *FormosaCetus* Research and Conservation Group and National Museum of Marine Biology and Aquarium). He was assisted in preparing and editing this report by Dr. Randall R. Reeves (IUCN Cetacean Specialist Group Chair) and Miss Shih-Chu Yang (*FormosaCetus* Research and Conservation Group). Other participants included experts in cetacean science and conservation from Canada, the United States, Japan, Hong Kong, and New Zealand as well as representatives of the National Museum of Marine Biology and Aquarium and National Pingtung University of Science and Technology. Representatives of the Council of Agriculture had to cancel their plans to participate at the last minute so that they could deal with an environmental protest event.

Basic Information about Humpback Dolphins

Two species of humpback dolphins are currently recognized: Atlantic (*S. teuszii*) and Indo-Pacific (*S. chinensis*). It is likely that further research on systematics of the genus will result in the latter's being split into at least two species. The colouration of humpback dolphins varies dramatically with age. In Asia, they are born dark grey and gradually become lighter in colour, with dark spotting developing as they age. The spotting diminishes as they approach adulthood, at which time at least the females have few spots and appear pinkish white overall. In general, humpback dolphins are found in small groups (<10 individuals) and in shallow coastal waters (usually <20m deep), especially in regions associated with estuaries. They appear to have small home ranges and do not appear to migrate or to have pronounced seasonality in reproduction.

Although no rigorous abundance estimates exist for the vast majority of the species' range, it is likely that aggregate numbers are in the 10,000s and probably not more than 100,000. Also, it is likely that in many areas where fishing with gillnets has been intensive and where estuarine habitat has been degraded by human activities (e.g., chemical contamination, mangrove deforestation, river impoundment and diversion, extensive land reclamation), local humpback dolphin populations have been seriously reduced.

Humpback Dolphins in Taiwan

During ship-based surveys conducted in 2002 and 2003, humpback dolphins were observed only in the coastal waters of Miaoli, Taichung, and Changhua counties in western Taiwan. There is also a stranding record from Taoyuan and credible sightings have been reported in the waters of Yunlin and Chiayi counties. Humpback dolphins have not been observed in water deeper than about 15m. They generally appear to be confined to a narrow strip within several kilometres of shore, and they are frequently found in waters <5m deep. Although group sizes tend to be small, one group of about 20 animals was seen in 2002. Like the humpback dolphins on the western side of the Taiwan Strait, those on the eastern side are usually found in or near estuaries.

Humpback dolphins in Taiwan's waters appear to have a consistently different color pattern from the dolphins in mainland Chinese waters. Also, the deeper portions of the Taiwan Strait appear to represent a barrier to dispersal for populations of this highly coastal species. Therefore, at least provisionally, the humpback dolphins in Taiwan's waters should be regarded as a separate, isolated population. Early indications from surveys in 2002 and 2003 suggest that the total abundance is at least 30 and possibly in the low hundreds of individuals.

It is not possible to make even a crude estimate of historical abundance. For a number of reasons, however, it must be assumed that the present-day population is a relatively small remnant that occupies only a fraction of its historical range in Taiwan. This assumption is based on the belief that the widespread and intensive use of gillnets, large-scale modification of the shoreline by industrial development, and, perhaps most importantly, the near-total elimination of freshwater discharge from the rivers of western Taiwan, have had a devastating effect on the dolphin population.

Threats

The workshop participants identified numerous known or suspected threats to humpback dolphins off western Taiwan. These included:

- **Loss of freshwater discharge from rivers.** Because this species is closely associated with, and presumably reliant upon, estuarine habitat, the near-total elimination of freshwater input to estuaries must severely limit the amount of suitable habitat available.
- **Large-scale modification of shoreline habitat** by land reclamation, industrial development, seawall construction, and sand mining. Effects on the dolphins are uncertain, but possibly important.
- **Incidental mortality in fishing gear.** Wherever gillnets are used and dolphins are present, dolphins die from entanglement.

- **Toxic contamination** from industrial, agricultural, and municipal discharge. Both the dolphins and their prey are likely to experience impaired health (e.g., reproductive disorders, compromised immune systems) as a result of chemical pollution of estuarine and nearshore waters.
- **Prey depletion** from over-fishing and habitat degradation. Although formal stock assessment is lacking for most coastal fish species in western Taiwan waters, there is reason to believe that many populations have been depleted (e.g., the scarcity of locally caught fish in local fish markets such as Wuchi Harbour). Again, effects on the dolphins are uncertain, but the quantity and quality of their prey base may be reduced.

In addition to threats from ongoing human activities, the dolphins are potentially at risk from the effects of small population size (reduced genetic and demographic variability), disease (epizootic events that can lead to massive die-offs), single catastrophic events (e.g., large oil or chemical spills), and climate change (e.g., increased frequency and severity of typhoons, drier conditions in watersheds leading to further reductions of freshwater flow in estuaries).

Research Priorities

The workshop participants identified the highest-priority research of immediate importance to the conservation of humpback dolphins in Taiwan, notably:

- Abundance estimation.
- Determination of total distribution, seasonal movements, and habitat preferences of this population.
- Improved understanding of the nature, distribution, and scale of threats, such as:
    - fishing effort (by gear type, number of vessels, days at sea).
    - development projects that will affect the freshwater regime and shoreline integrity.
- Improved understanding of point-source pollution in western Taiwan in order to identify potentially high risks of exposure to toxins

The first two items are needed to better characterize the status of this dolphin population and its habitat requirements, while the last two items are needed to improve the abilities of conservationists and resource managers to provide advice on environmental impact assessment and mitigation planning.

Approaches to Conservation

In the immediate term, it is crucial to provide as much protection as possible to the surviving animals in this population. To ensure effectiveness, the design and implementation of mitigation measures needs to involve stakeholder participation at the individual, municipal, county, and national levels. The process should involve individuals representing a wide range of interests, e.g., regulatory agencies, scientific institutions, nongovernmental organizations, fishery organizations, industry, trade associations, tour-boat operators, humpback dolphin scientists, and the general public. One approach to achieving the goals of effectiveness and inclusiveness would be to establish a multi-stakeholder oversight body, e.g., a "Humpback Dolphin Advisory Group," to initiate and monitor mitigation and research efforts. As is true of all action plans, this one will require close monitoring to ensure implementation and track progress. In this regard, the workshop recommended that the second workshop on Taiwan's humpback dolphins should be held in 2007.

Summary

Although only limited information is available for the Taiwanese population of the Indo-Pacific humpback dolphin, rough estimates of abundance and distribution suggest that immediate mitigation measures are needed to prevent its extinction/extirpation. Several serious and growing threats to these small cetaceans, their prey, and their habitat are apparent, and highlight the urgency of a threat-directed conservation action plan. This workshop drew on local and international knowledge to characterize: 1) humpback dolphin biology in Taiwanese coastal waters; 2) humpback dolphin ecology (habitat needs, feeding ecology) in Taiwanese coastal waters; 3) the major direct and indirect threats to these dolphins, their prey, and their habitat; and 4) knowledge gaps and research needed to refine conservation goals and identify mitigation measures that are applicable to the Taiwanese situation.

APPENDIX 5

THE STOCKHOLM CONVENTION
(Peter S. Ross)

The Stockholm Convention, sponsored by the United Nations Environment Programme, provides a global framework for phasing out the 12 highest-priority persistent organic pollutants of current concern. These chemicals (including the polychlorinated biphenyls, or PCBs and DDT) have persistent, bioaccumulative, and toxic (PBT) properties. While they are of greatest concern in and adjacent to areas where industrial, urban, and agricultural activities are concentrated, PBT compounds can move quickly and easily into remote regions of the world. They are known to pose health risks to people and animals (including marine mammals and seabirds) that rely heavily upon fish or other marine resources as food. All of these chemicals have endocrine-disrupting properties, and exposure can lead to developmental toxicities to the reproductive, immune, and nervous systems. The consequent long-term reduction in individual fitness can lead to population-level impacts on vulnerable populations. For example, effects can be manifest in reduced reproductive output or increased susceptibility to diseases. The full text of this convention can be found at: http://www.pops.int/