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STATUS AND CONSERVATION OF FACULTATIVE FRESHWATER CETACEANS IN ASIA

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ABSTRACT. **–** Irrawaddy dolphins *Orcaella brevirostris* and finless porpoises *Neophocaena phocaenoides* are referred to as facultative freshwater cetaceans because they occupy both fresh- and nearshore marine waters. In Asia, the especially rapid growth of human populations and their consequent resource demands have had profound impacts on these environments and the biodiversity that they sustain. Facultative freshwater cetaceans and other aquatic species inhabiting these waters are particularly threatened by intensive fishing with non-selective gear, vessel traffic, environmental degradation from water development (most notably dams), land reclamation, and the input of large quantities of toxic contaminants, especially those with bioaccumulative properties. Populations of finless porpoises in the Yangtze River and Inland Sea of Japan, and Irrawaddy dolphins in the Mahakam River, Malampaya Sound and Songkhla Lake, and probably the Mekong River and Chilkha Lake, are at risk of extirpation in the immediate future. The general absence of knowledge regarding the abundance and population structure (and even species occurrence in some areas) has prevented a comprehensive assessment of both species. To provide conservation guidance we liberally adapt a set of conservation principles developed for marine mammals (see Meffe et al., 1999) to the specific survival requirements (in the holistic sense) of facultative freshwater cetaceans in Asia and give practical advice for their implementation.

KEY WORDS. **–** Irrawaddy dolphin, *Orcaella brevirostris*, finless porpoise, *Neophocaena phocaenoides*, freshwater cetaceans, river dolphins, Asian cetaceans, marine biodiversity, freshwater biodiversity.

INTRODUCTION

Irrawaddy dolphins *Orcaella brevirostris* and finless porpoises *Neophocaena phocaenoides* are among the cetaceans at greatest risk to population extirpation and perhaps extinction. Their vulnerability stems from habitat requirements that are tied to marine and freshwater environments subjected to intensive human use and abuse. Finless porpoises occur in the Yangtze River system of China, and Irrawaddy dolphins in the Mahakam River system of Indonesia, Ayeyarwady (formerly Irrawaddy) River system of Myanmar and Mekong River system of Laos, Cambodia and Vietnam. Both species also inhabit nearshore marine waters, especially within semi-enclosed bays and in the vicinity of estuaries and mangrove forests. Finless porpoises range along the coasts of southern and eastern Asia, from the Persian Gulf east to Sendai Bay, Japan and south to at least northern Java. Irrawaddy dolphins range farther south, to northeastern Australia, and extend as far north as Malampaya Sound, Palawan, Philippines, and west to northeastern India. Irrawaddy dolphins also inhabit Chilkha Lake in east India and Songkhla Lake in southeastern Thailand, brackish or fresh-water bodies (depending upon the season) connected sporadically to the Bay of Bengal and Gulf of Thailand, respectively.

Irrawaddy dolphins and finless porpoises have been described as facultative river cetaceans, due to their ecological flexibility that allows them to inhabit marine and freshwater environments (Leatherwood and Reeves, 1994) – however, there may be obligate freshwater populations. These animals share this quality with only one other cetacean, the tucuxi *Sotalia fluviatilis*, which inhabits the Amazon and Orinoco river basins, and coastal marine waters of northeast South America (da Silva & Best, 1994).[1] This flexibility contrasts with the obligate freshwater cetaceans of Asia: the

1 Several other cetaceans, including the beluga *Delphinapterus leucas*, and bottlenose *Tursiops truncatus/T. aduncus* and Indo-Pacific humpback dolphins *Sousa chinensis* swim far up rivers, either occasionally or seasonally, but they are not year-round residents of freshwater environments (Leatherwood & Reeves, 1994).

baiji *Lipotes vexillifer*, which is sympatric with the Yangtze population of finless porpoises, and the South Asian or 'blind' river dolphins *Platanista gangetica gangetica* and *P.g. minor*. More is known about the status of these dolphins (see Reeves et al., 2000a), with the first classified as Critically Endangered and the other two classified as Endangered (Hilton-Taylor, 2000). As species, Irrawaddy dolphins and finless porpoises are classified as Data Deficient, but in the two river systems where they have been studied in detail, the Yangtze and Mahakam, populations have been classified as Endangered and Critically Endangered, respectively (Hilton-Taylor, 2000). Recent surveys of these cetaceans in other areas of their distribution (e.g. Irrawaddy dolphins in Malampaya Sound [Dolar et al., 2002; B.D. Smith, unpublished] and finless porpoises in the Inland Sea of Japan [Kasuya et al., 2002]) suggest that additional populations may become listed as Endangered or Critically Endangered as more becomes known regarding their status.

The objectives of this paper are to (1) review and evaluate the implications of recent information on the status and ecology of Irrawaddy dolphin and finless porpoise populations[2] and (2) recommend conservation actions based on new knowledge. For more comprehensive reviews of the species, readers are directed to Marsh et al. (1989), Stacey & Leatherwood (1997) and Stacey & Arnold (1999) for Irrawaddy dolphins, and Reeves et al. (1997) and Kasuya (1999) for finless porpoises.

Information on the ecology, abundance, life history, population structure and fine-scale distribution of Irrawaddy dolphins and finless porpoises is lacking for most of their range. The general absence of critical data on such things as basic as species range is evidenced by the fact that Irrawaddy dolphins were only recently confirmed to be present in the Philippines (Dolar et al., 2002), despite the fact that waters of Malampaya Sound, where they were found, are among the most intensively fished in the region and are located inshore of a multi-billion US dollar gas development project. The presence of finless porpoises was also only confirmed in the Vietnamese portion of the Gulf of Tonkin in April 2000, when the anterior portion of a floating carcass, which had apparently been cut loose from a nearby gillnet, was found during a dedicated cetacean survey (B.D. Smith, unpublished). The population accounts below generally include only areas where significant information has recently become available or where the persistence of the species is suspected to be at risk. The information varies greatly in terms of its usefulness for evaluating the status of populations and establishing conservation priorities.

REVIEW OF POPULATIONS

Irrawaddy Dolphin

Northern Australia – Irrawaddy dolphins range discontinuously in coastal waters across the northern rim of Australia from Broome to the Brisbane River (Stacey & Leatherwood, 1997; Stacey & Arnold, 1999). The dolphins are found in partially enclosed, shallow waters, particularly near the mouths of creeks and rivers (Parra et al., 2002). Although Paterson et al. (1998) reported Irrawaddy dolphins in the upper tidal reaches of the Brisbane River, they are not believed to generally occur in Australian rivers. Analysis of the skull morphology of Irrawaddy dolphins throughout much of their range indicates specific or sub-specific differences in the height of the temporal fossa, length of antorbital processes, and separation and width of nasal bones between animals of the Oriental and Australian zoological realms (Beasley et al., 2002a).

No information is available on the range-wide abundance of the species in Australia. In the western Gulf of Carpenteria, on the basis of aerial surveys, Freeland & Bayliss (1989) estimated the abundance of Irrawaddy dolphins as 1000 individuals. However, this estimate is probably biased due to survey limitations (Parra et al., 2002). Substantial numbers of Irrawaddy dolphins in Australia have been killed in shark nets set to protect bathers (Paterson, 1990) and in gillnet fisheries for barramundi *Lates calcarifer* and threadfin salmon *Polynemus sheridani* and *Eleutheronema tetradactylum* (Anderson, 1995). Mortality of Irrawaddy dolphins (and other marine mammals) in shark nets has declined (from unknown but significant levels) along the Queensland coast to an estimated overall total of 1.3 individuals annually from 1992-1995 after the replacement of most shark nets with baited drumlins (Gribble et al., 1998). Regulations, including net attendance rules and gear modifications, have been introduced to reduce marine mammal bycatch but enforcement, especially in remote areas, has been poor (Hale, 1997).

Mahakam River – Irrawaddy dolphins in the Mahakam River of East Kalimantan, Indonesia, range in the mainstem from about 80 km to 600 km upstream of the mouth, seasonally inclusive of several tributaries and Semayang and Melintang Lakes (Kreb, 2002). The total population was roughly estimated to be about 34 individuals based upon eight sighting surveys covering their entire known range during February 1999 to July 2000 (Kreb, 2002). Sightings were confined to a 190 km segment in the middle reaches of the mainstem, starting from about 180 km above the mouth, inclusive of the Kedang Kepala, Kedang Rantau, Belayan and Kedang Pahu tributaries, and in the Ratah tributary of the upper reaches, which enters the Mahakam about 500 km upstream from the mouth (Kreb, 2002). The highest sighting rate was recorded during low water stage and was 0.14 dolphins/linear km. Dolphins were concentrated in deep

2 Our reference to populations in this context is based on geography, rather than, in most cases, biological evidence of demographic isolation.

pools located near confluences and meanders, and occasionally found in appended lakes and connecting tributaries. These areas were also primary fishing grounds and subjected to intensive motorized vessel traffic. During the five sighting surveys conducted of the entire river during high, low, and medium water stages, no sightings were made below 180 km upstream of the mouth. There are occasional reports of dolphins occurring as far downstream as 80 km above the river mouth, but not below this point (Kreb, 2002).

During 1997-99, 16 deaths were recorded (10 dolphins from gillnet entanglement, three probably from vessel strikes, and three deliberately killed for unknown reasons (Kreb, 2000). Sixteen Irrawaddy dolphins were captured from Semayang Lake (6 in 1974 and 10 in 1978) and taken to Jaya Ancol Oceanarium in Jarkata, Indonesia (Tas'an & Leatherwood, 1984). During 1997-98, at least seven dolphins were also illegally caught from the river and brought to oceanaria. Plans exist to capture more animals for a new oceanarium to be built in Tenggarong (Kreb, pers. comm.). Intensive fishing with gillnets, electricity and poison (Kreb, 2000), and the accidental introduction of an exotic piscivorous fish *Channa micropeltes*, locally known as *ikan toman* may have depleted their prey (Kreb, pers. comm.). The high density of gillnets used in Semayang and Melintang Lakes obstructs dolphin movements, thereby reducing available habitat. This problem, together with high sedimentation caused by deforestation of the surrounding shorelines, has probably resulted in the elimination of these lakes as primary areas of occupancy as reported by Tas'an & Leatherwood (1984). Leaks from dams in the upper reaches that retain chemical wastes from gold mining industries, including mercury and cyanide, occurred in 1997 and resulted in a massive fish kill (Kreb, pers. comm.). The Mahakam population was recently listed as Critically Endangered due to surveys indicating that there are less than 50 mature individuals remaining (Hilton-Taylor 2000).

Borneo (exclusive of the Mahakam River population) – The first evidence of Irrawaddy dolphins in Borneo was a report by Weber (1923) of sightings near Muara Island in the mouth of the Brunei River. In northern Borneo (Malaysian waters), Banks (1931) reported sightings and a specimen near the mouth of the Sarawak River. Gibson-Hill (1950) reported that the dolphins occurred in the mouth of the Brunei River and in the lower Santubong branch of the Sarawak River. Mörzer Bruyns (1966) reported their occurrence as far as 32 km upstream in the Rajang River, Sarawak. Pilleri & Gihr (1972, 1974) examined a skull from Muara Island. Elkin (1992) tentatively identified five Irrawaddy dolphins swimming in muddy water close to the shore in Brunei. Dolar et al. (1997) reported a group following a shrimp trawler about 20 km up the Kinabatangan River and one or more groups of 10-15 individuals in Sandakan Bay, Sabah. Beasley & Jefferson (1997) reported that Irrawaddy dolphins were consistently found near Kuching, Sarawak, as well as in Sandakan. The last authors recorded a total of 28 sightings (mean group size = 4.4, S.D. = 2.19, range = 1-10) during three visits and noted potential threats from intensive gillnetting, trawling, and degradation of coastal and riparian zones from intensive logging and conversion to palm oil plantations. These authors also speculated that Irrawaddy dolphins occupying the coastal and estuarine waters of Borneo might come from one or more populations, separate from those in the Mahakam River. Their reasoning was that the coloration of Irrawaddy dolphins in the Mahakam is much lighter than animals observed along the north coast of Borneo, and that the coastline between Sabah and the Mahakam has a narrow continental shelf, which implies a lack of suitable habitat and a range hiatus. Additional sighting records from northern Borneo are contained in an unpublished report of surveys conducted in July – October 1998 (Beasley, 1998). These include one from the Baram River mouth, two from the Batang River mouth, and 15 from in or near Kuching Bay. The only records from southern Borneo (Indonesian waters), outside of the Mahakam River (see above), are unpublished second- hand reports from the Kumay and Kendawangan River mouths, in southern and western Kalimantan, respectively (see Perrin et al., 1996; Rudolph et al., 1997). Dolar et al. (1997) noted that Irrawaddy dolphin distribution in Borneo was limited to shallow waters where turbidity was high (20-93 NTU – nephelometric turbidity units) and salinity was low (2-10 ppt).

Malampaya Sound – Irrawaddy dolphins in Malampaya Sound are the only known population of the species in the Philippines. They were first documented in Malampaya Sound during an investigation of dugongs in 1986 (Kataoka et al., 1995). During a dedicated cetacean survey of the sound in June-July 1999, Dolar et al. (2002) recorded 17 sightings during 230 linear km of search effort and calculated a mean encounter rate of 7.4 dolphins/100km (S.E.=2.9) and mean group size of 5.3 dolphins (S.E.=1.1). All sightings were made in shallow waters (76% less than 6 m deep) of the inner sound. A rough preliminary estimate from line-transect surveys conducted during April, August, and October 2001 indicated that the population numbers about 60 individuals (CV=0.257) confined to a 133.7 sq. km area of the inner sound. The same study found that incidental mortality, primarily due to entanglement in gill nets set on the bottom for crabs, is unsustainable (B.D. Smith, unpublished). Other threats include habitat degradation (both in the estuary and surrounding watershed) and possibly prey depletion from over-fishing and the destruction of fish spawning grounds (Dolar et al., 2002).

Mekong River – The range of Irrawaddy dolphins in the Mekong is probably limited upstream by Khone Falls (or Lee Pee), an approximately 8 km wide complex of waterfalls and islands, located about 350 km above the river mouth and slightly above the Lao/Cambodian border (Baird & Mounsouphom, 1994, 1997; Baird et al., 1994). About 3 km below the falls, the dolphins occur regularly in a large (about 600 m in diameter) and deep (over 50 m during high water season) pool, known locally as Boong Pa Gooang (meaning small croaker site, after the sciaenid fish *Boesmania microlepis* that vocalizes during its spawning season in February and March; Roberts & Baird [1995]). Dolphins were observed daily in the pool during the dry seasons of 1992-93, generally in groups of 2-10, but 17 were seen at least once (Baird et al., 1994). Using visual and acoustic methods, Borsani (1999) estimated that there were 8-10 dolphins present in Boong Pa Gooang in late March/ early April 1998.

During the flood season (June-October) dolphins in the Mekong enter smaller tributaries, probably following seasonal fish migrations. Anecdotal reports suggest that the dolphins ascend the Sekong River and its tributaries, the Houay Khaliang (only during high water), Xepian (until Xepha Falls about 50 km above the Sekong confluence), Xenamnoi (until Tatkhek Falls about 8 km above the Sekong confluence), and Xekaman (until about 50 km above the Sekong confluence and including the Houay Twai tributary and possibly the Xepian).[3] In the Sekong, the dolphins have been reported to range as far upstream as Kalaum Town, Laos, about 280 km above the Mekong confluence near Stung Treng, Cambodia (Baird & Mounsouphom, 1997).

Farther downstream in the Mekong, during March and May 1997, Baird (unpublished) sighted about 40 dolphins in northern Cambodia and estimated, on the basis of interviews, that the total population in the Mekong may be around 100 individuals. He also suggested that dolphins may have been extirpated or reduced to negligible levels in the Great Lake (Ton Le Sap) of Cambodia. Ton Le Sap was reported to have once been a major habitat, at least during the flood season. During the rule of the Khmer Rouge in the mid- to late-1970s, Irrawaddy dolphins were hunted in Ton Le Sap for their oil (reportedly for use in the motors of fishing boats), which probably greatly reduced their numbers. During March - June 1976, one group of hunters were reported to have killed 3-4 dolphins every day (Perrin et al., 1996).

The only documentation of Irrawaddy dolphins in the Mekong of Vietnam are a few records reported by Lloze (1973) and a single skull deposited in the Binh Thang Whale Temple near the river mouth (Smith et al., 1997a). Four Irrawaddy dolphin skulls were also examined by Smith et al. (1997a) at the Vung Tau Whale Temple, located in the mouth of the nearby Dong River. During a survey of almost the entire length (224 km) of the two main distributaries of the Mekong, Tien and Hau Giang, in April 1996, Smith et al. (1997a) were unable to find a single dolphin.

During December 1990 to May 1996, at least 23 dolphins were accidentally killed in the segment of the Mekong near the Laos/Cambodia border, 12 from entanglement in gillnets and most of the rest by explosives used for fishing in Cambodia (Baird & Mounsouphom, 1997). In the Sekong River, one dolphin died from gillnet entanglement in August 1993 and another was reported killed in a falling-door bamboo trap. Two dolphins were reported to have been released from gillnets by fishermen, one in the Mekong close to the border in April 1992 and one in the Sekong, near Sekong Town in February 1993 (Baird & Mounsouphom, 1997).

Smith et al. (1997a) noted the presence of several dozen stow nets in the Mekong River mouth, each one extending 200-400 m, followed upstream by more than 10 rows of nylon gillnets stretched across the entire channel, with only small openings to permit vessel traffic. They suggested that dolphin bycatch and habitat displacement caused by these nets might explain the absence of cetacean sightings during their survey of the lower Mekong in Vietnam during April 1996.

A large number of dams have been proposed for the Mekong River system, which, if built, would degrade essential habitat features and block the movements of dolphins and their prey. In the Sekong River system, at least two dams are proposed to be built tens of kilometers below the reported upstream range of the dolphins. Dolphins are also threatened in the Sekong system by the proposed Xakaman and Xepian/ Xenamnoi dam projects. This last project proposes to construct a dam for diverting almost all flow from the Xepian River to a reservoir contained behind another dam in the Xenamnoi River (Baird & Mounsouphom, 1997). Large run-of-the-river dams have also been proposed for the Mekong mainstem at Stung Treng and Sambor (Perrin et al., 1996)

Possible species-level differences were found between the cytochrome *b* gene sequence of an Irrawaddy dolphin from the Mekong River in Laos and others analyzed from northern Australia (Le Duc et al., 1999). Recent consideration was given to listing the Mekong population as Endangered or Critically Endangered, but the attempt was dropped due to insufficient information, especially regarding their status in Cambodia (B.D. Smith, unpublished).

Dolphins in the Mekong receive some degree of protection from the traditional respect they are afforded by local fishermen (Baird et al., 1994). Fishermen in Vietnam worship whales and dolphins because they believe that the animals will aid them if in distress at sea (Smith et al., 1997a). Most Cambodians and Laotians say that they do not hunt the dolphins and believe that bad luck will result from killing them (Baird et al., 1994). The Lao Community Fisheries and Dolphin Protection Project is working with local people to reduce incidental catches of dolphins in gillnets, stop explosive fishing, and manage aquatic resources in a sustainable manner (Perrin et al., 1996). One practical measure was the establishment of a fund so that fishermen who find a dolphin entangled in their nets and cut it free would be compensated for damages (Baird et al., 1994). A small-scale dolphin watching operation has also been established in Hangkhon and Hangsadam, which provides substantial income to local villagers (Borsani, 1999).

In Laos, dolphins are legally protected from hunting, capturing, and trading with fines of US$ 65-650 and imprisonment of three months to one year. As of 1995, there were no legal protections for cetaceans in Cambodia or Vietnam, but authorities reported that this would be changed soon (Perrin et al., 1996).

3 The Xeanamnoi, Xekaman, and Xekhaman affluents are spelled with an "s" for the first letter in some references.

Songkhla Lake – Irrawaddy dolphins were first recorded in Songkhla Lake by Pilleri & Gihr (1974), who examined three specimens from strandings in the middle portion of the lake. During 545.2 km of survey effort conducted in the inner and middle portions of the lake, north of Papayurn Island, Beasley et al. (2002b) recorded only four sightings and calculated a sighting rate of 0.03 dolphins/linear km (mean group size = 4.3 dolphins, S.D. = 2.9, range = 1-8). All sightings were made in the upper portion of Thale Luang, the deepest portion of the lake (2.1-2.5 m). Due to shallow water and the extremely high density of fixed fishing gear, these authors speculated that dolphins were probably absent from Thale Sap and the southern portion of Thale Luang, and therefore prevented from moving in and out of the shallow channel sporadically connecting the lake to the sea. The same authors also presented records of 28 dolphins that have stranded since 1990. At least 13 of these died from apparent net entanglement and at least nine were neonates (i.e., one meter in length or less). There seems little doubt that the status of this population is very precarious and that even low levels of mortality from incidental catches could quickly lead to its extirpation.

Ayeyarwady River – In the Ayeyarwady River of Myanmar (formerly known as Burma), Irrawaddy dolphins were reported by Anderson (1879) to range no farther downstream than Prome (about 360 km from the sea) during the low-water season and Yenanyoung (about 540 km from the sea) during the high-water season. Leatherwood et al. (1984) interviewed fishermen in Yangon (formerly Rangoon) and Bagan (formerly Pagan), who reported that Irrawaddy dolphins were most abundant in the lower reaches of the river and that, although the animals sometimes became entangled in their fishing nets, they released them if found still alive. The fishermen regarded the dolphins as a good omen and credited them with saving the lives of drowning people. Stranded or accidentally killed dolphins were reportedly rendered for their oil, which was used for medicinal purposes.

During a survey conducted in March-April 1996, Smith et al. (1997b) searched along 248 km of non-continuous trackline in the upper reaches between the Sagaing (Ava) Bridge and Ma U Village, concentrating mostly in the approximately 27-km segment between Mandalay and Shin Hla, and observed three dolphin groups (estimated 12 individuals). The same researchers returned in December 1999 and conducted a continuous survey divided into three components: (1) upstream from Mandalay to the Shweli confluence (206 km), (2) downstream from the Shweli confluence to Mandalay (192.6 km), and (3) downstream survey from Mandalay to Bagan (99 km). During the entire survey, they recorded 11 dolphin groups (estimated 37 individuals). On the basis of sightings made during the upstream survey, 16 dolphins were estimated as the minimum count for the Mandalay to Shweli confluence segment. During February 1998, Smith & Hobbs (2002) surveyed 360 km from Bhamo to Mandalay. They observed 14 dolphin groups and estimated the minimum population size as 59 individuals.

During the above-mentioned surveys, sightings were concentrated in geomorphologically complex reaches upstream and downstream of channel convergences, islands, and defiles (where an alluvial channel becomes abruptly narrow and deep as it cuts through a mountain range). The researchers identified accidental entanglement in gillnets and poisoning from mercury, which enters the river via gold-mining operations, as potential threats to the population.

During most sightings recorded during these surveys, the researchers followed the dolphins in a small canoe with local fishermen who tapped a wooden pin on the side of their vessel to "summon" the animals. On three different occasions, they observed what they interpreted as occurrences of cooperative fishing between the dolphins and fishermen (Smith et al., 1997b; B. D. Smith & L. Hobbs, unpublished.). During these occasions, the dolphins swam in concentric circles to herd a fish school into a concentrated mass against the shore. In this manner, the fishermen were sometimes able to catch more fish in a single cast than in an entire day of fishing without the dolphins. Observations of dolphin behavior supported the fishermen's explanation that the animals benefited from the activity by preying on fish that were 1) confused by the net cast, 2) pinned beneath and partially sticking outside of the net lead line, and 3) momentarily stuck in the mud after the fishermen pulled the net.

The 19th century naturalist John Anderson described Irrawaddy dolphins in the Ayeyarwady River as distinct from *O. brevirostris* and classified them as a separate species, *Orcella* [sic.] *fluminalis* (Anderson, 1879). Although Anderson's observations were exhaustive (see Appendix 1 in Smith & Hobbs, 2002), many of the features he described are variable among individuals and his comparisons were limited to two adult males from the Ayeyarwady and two females, one immature and one pregnant, presumably from the Bay of Bengal. Subsequent authors have reported no consistent differences among riverine and marine populations of Asia (Thomas, 1892; Weber, 1923; Lloze, 1973; Pilleri & Gihr, 1974; Beasley et al., 2002a), although these findings were apparently based on no additional specimens from the Ayeyarwady.

Bay of Bengal (exclusive of Chilka Lake) – Published records of Irrawaddy dolphins along the Indian coast of the Bay of Bengal range from Vishakhapatnam (the western-most record for the species and where the neotype specimen was obtained) north to Calcutta (Owen, 1869; Cobbold, 1876; Ellerman & Morrison-Scott, 1951; James et al., 1989). In Bangladesh, Mörzer Bruyns (1971) reported observing Irrawaddy dolphins 110 km upstream in the Pussur River of the Sundarbans Delta. Although Stacey and Leatherwood (1997) considered this record to be tentative, during a casual visit, B.D. Smith (unpublished) observed the species throughout the river downstream of Khulna (about 110 km from the mouth) and occurring sympatric with Ganges River dolphins in the upper portion. Kasuya & Haque (1972) also reported seeing Irrawaddy dolphins on five occasions in the Sundarbans of Bangladesh (one near Mongla, in the Pussur River below Khulna). A few specimens were also reported in Haque (1982). These animals were caught incidentally in fishing nets or found dead along the beach near Cox's Bazaar. During a survey along the coast between Cox's Bazaar and Chittagong (94 km) in January 1999, Smith et al. (2001) observed two Irrawaddy dolphins groups (totaling 4-6 individuals), occurring less than 2 km offshore of mangrove forests and in the vicinity of bottom-set gillnets. During the same survey, the researchers also recovered the floating carcass of a neonate Irrawaddy dolphin. In Myanmar, the only records of Irrawaddy dolphins in the Bay of Bengal are from a survey conducted by Smith et al. (1997b) of the Rakhine (Arakan) coast, in the far north of the country, during April 1996. These researchers observed eight dolphin groups (mean size = 2.4, SD = 1.5, range = 1-6) while searching along 205 km of trackline in river delta habitat, including the lower reaches and estuaries of the Myebone, Kalidan, and Kyaukpyu Rivers. It should be noted that the same researchers did not have any sightings of this species while searching along 567 km of trackline in adjacent coastal waters between Andrew Bay and Sittwe (Akyab).

Chilka Lake – Irrawaddy dolphins were first reported from Chilka Lake, India, by Annandale (1915) on the basis of a recovered specimen and observations of the animals in the outer channel throughout the year. They are now rarely observed due to exploitation for their oil (hence their local name *Bashiyya Magar* – oil yielding dolphin) and increasing siltation in the northern-most portion of the lake. The dolphins also die in gillnets and dragnets set for catching mullets and prawns (Dhandapani, 1992, 1997). Sahu et al. (1998) examined seven carcasses found floating in the lake: three from the northern sector near Nalaban, and four in the central sector near Balugaon, Parikud Jetty, and Kalijai Island. The same researchers also reported that the dolphins were observed less often in the southern portion of the lake during the summer months [wet season] in comparison to the winter months [dry season], while sightings in the northern portion remained similar throughout the year. It should be noted that the main freshwater inputs, the Daya, Nuna, and Bhargavi Rivers, empty into the northern portion. Sahu et al. (1998) also identified intensive gillnetting, eutrophication, siltation, the increasing use of mechanized boats, and pollution from sewage and industry as the primary threats facing the population.

Finless Porpoise

Japanese Waters - Finless porpoises in Japanese waters are mainly distributed in five largely-inshore areas: 1) Tokyo to Sendai bays, 2) Ise-Mikawa bays, 3) Seto Inland Sea, 4) Omura Bay, and 5) Araike Sound/Tachibana Bay (Shirakihara et al., 1992; Yoshida, 2002). Based on morphometric and molecular genetic studies, these five areas appear to each contain separate populations, apparently with little or no mixing (Yoshida et al., 1995, 2001; Yoshida, 2002). The Inland Sea population occupies the largest range (Yamada & Okamoto, 2000). Estimates of abundance are available for most of the stocks: 1,952 porpoises in Ise-Mikawa bays (Miyashita et al., 1995), 187 porpoises in Omura Bay (Yoshida et al., 1998), and 3,093 porpoises in Araike Sound/Tachibana Bay (Yoshida et al., 1997). The Seto Inland Sea population was estimated to contain 4,900 animals in the mid- to late-1970s (Kasuya & Kureha, 1979). Recent surveys suggest that abundance there has declined to only 4% of that size in the eastern and southern portions of the sea, and 60% in the western portion (Kasuya et al., 2002), however, a range shift may partially explain these findings (International Whaling Commission, 2001). Abundance has not been estimated for the Tokyo to Sendai bays population. Finless porpoise habitat in Japanese waters is generally less than 50 m deep and 4-6 km from the coast (Shirakihara et al., 1994).

Changes in porpoise density have been interpreted to indicate seasonal movements in some areas. Kasuya & Kureha (1979) suggested that there is a movement of porpoises during summer from the Inland Sea to the Pacific coast of Japan through two eastern passes. Density in the mid-Ariake Sound increases from September through April, and then decreases to a minimum during August. These observations, together with evidence of increased densities at the mouths of Araike Sound and Tachibana Bay in summer months, suggest an offshore movement during summer for that population (Shirakihara et al., 1994).

The life history of finless porpoises has been studied in some detail in the Inland Sea of Japan (Kasuya & Kureha, 1979), Ise Bay (Furuta et al., 1989), and in the coastal waters of western Kyushu (Shirakihara et al., 1993). Sexual maturity occurs at ages of 3-6 years for males and at about 4-5 for females, with some apparent geographical variation (Kasuya & Kureha, 1979; Shirakihara et al., 1993; Kasuya, 1999). Calving has been estimated to occur in April to August in the Inland Sea (Kasuya & Kureha, 1979), April in Ise Bay (Furuta et al., 1989), November to December in the western Kyushu populations (Shirakihara et al., 1993), and late August to early September for the Tachibana Bay population (Mizue et al., 1965).

Directed killing of finless porpoises does not appear to have been undertaken in any major or organized fashion in Japanese waters. This is somewhat surprising, since the Japanese have a strong tradition of eating cetacean meat. However, there is some evidence that finless porpoise flesh causes diarrhea, which may explain why they seem to have escaped this form of exploitation (Kasuya, 1999). The animals are also typically elusive and would probably be difficult to catch. Recent discoveries of finless porpoise meat for sale at Korean fish markets are thought to have come from bycatches in Korean waters, rather than from direct hunts in Japan (International Whaling Commission, 2001). All five Japanese populations are apparently subjected to incidental catches (International Whaling Commission, 2001). Finless porpoises were captured by trap-net fishermen in Tachibana Bay (Mizue et al., 1965) but this operation has now ceased (Kasuya & Kureha, 1979). Porpoises in the southern waters of Japan (waters around southern Honshu and Kyushu) are taken in gill nets, set nets, and trawls (Shirakihara et al., 1992).

In addition, to incidental catches in fishing nets, the finless porpoise population in the Seto Inland Sea is subjected to land reclamation, environmental contamination, high levels of vessel traffic, red tides, and probably prey depletion (Yamada & Okamoto, 2000; International Whaling Commission, 2001; Kasuya et al., 2002). Butyltin levels in specimens from the Inland Sea were high, as compared to conspecifics from other areas (Tanabe et al., 1998). Due to a belief that finless porpoises assist hook and line fishermen, they have been protected since 1930 in waters off Takehara (Kasuya et al., 2002). Legislation has been introduced to reduce chemical contamination in the Inland Sea.

Yangtze River – Finless porpoises in the Yangtze River make up the only known freshwater population of the species. The population is generally regarded as a subspecies, *N. phocaenoides asiaeorientalis* (Rice, 1998), and its status is considered Endangered (Hilton-Taylor, 2000). It has received relatively greater attention, in comparison to other finless porpoise populations in China, largely as an artifact of its shared distribution with the baiji (*Lipotes vexillifer*), the world's most endangered cetacean (see Reeves et al., 2000b).

Finless porpoise distribution extends from Yichang (about 1,700 km upriver from the mouth) downstream to the estuary, and includes the Yangtze mainstem and its two largest appended water bodies: Dong Ting Lake and its affluent the Xiang River, and Poyang Lake and its affluent the Gan River (Zhang et al., 1993; Wang et al., 2000; Zhou et al., 1998, 2000). In the Gan River, porpoises historically occurred as far upstream as the convergence of the Gongshui and Zhangshui Rivers. The actual population size is unknown, due to the lack of systematic surveys. However, Zhang et al. (1993) roughly estimated its size at 2,700 from surveys conducted mostly in the 1980s. Recently, 700 were estimated to occur in the lower reaches between Nanjing and Hukou, and Wang et al. (2000) suggested that the total population size may now be lower than 2,000.

Although porpoise habitat in the Yangtze frequently changes in size and location, in response to fluctuations in water and sediment flows, density is particularly high at the mouths of Poyang and Dongting Lakes. The animals occur primarily within several hundred meters of shore, and concentrate in counter-currents near sandbars (Wang et al., 2000). Zhang et al. (1993) stated that density appeared to be highest in winter and lowest in summer. They suggested that at least some porpoises in the Yangtze migrate to the ocean. However, recent genetic studies have supported the idea that the Yangtze population is separate from those in marine waters (Yang & Zhou, 2000). Sexual maturity occurs at ages of 5-6 years for both males and females, and calves are born in spring months of March to May (Chang & Zhou, 1995).

As recently as the 1970s, directed hunting for meat and oil occurred, but it is thought that protective measures have put an end to this practice (Liu, 1991; Reeves et al., 1997). Current threats include incidental catches in gillnets and rolling hooks (a specialized type of longline used in the Yangtze) and kills from electric fishing, vessel collisions, and explosions used to modify channels. Environmental degradation and habitat loss, caused in particular by the damming of the Yangtze and its tributaries, has probably also played a role in causing a population decline. Water development projects of concern include: 1) the Gezhouba Dam (completed in 1989) near Yichang, 2) about 1,300 small dams built in the connecting channels of appended lakes, and 3) the construction of the Three Gorges Dam (began in 1994 and scheduled to be completed in 2009), which is located about 38 km upstream of the Gezhouba Dam (Liu et al., 2000). These structures have degraded cetacean habitat by altering water flow and sediment transport regimes (Reeves et al., 2000b). It should be noted, however, that finless porpoises still occupy waters just downstream of the Gezhouba Dam, which raises interesting questions about their ability to adapt to the altered conditions downstream of a large run-of-the-river dam, in contrast to the baiji, whose range declined by about 150 km after its construction (Wang et al., 2000).

Limited research on concentrations of DDTs in finless porpoises found that levels were not especially high when compared to animals from Japan and Hong Kong (Yang et al., 1988; Jefferson et al., 2002a). Heavy metal concentrations were also found to be low, but tissues were only analyzed from muscle (Lui et al., 1983). However, the liver is the organ that accumulates these compounds in the greatest concentrations.

Several dozen individuals have been live-captured from the river for use in captive research and for a captive-breeding program at the semi-natural reserve at Shi Shou (see Wang et al., 2000; Wei et al., 2002). There is currently much controversy as to the likelihood of success of captive breeding and its contribution to finless porpoise conservation, especially in view of the fact that there are no plans for subsequent re-introductions and few measures have been taken for protecting remaining habitat in the wild (Reeves et al., 2000b).

Hong Kong – Although the presence of finless porpoises in Hong Kong waters has been known for some time (see Parsons et al., 1995), the population remained largely unstudied until 1998, when an intensive, detailed study of its population biology was undertaken (Jefferson & Braulik, 1999). Much was learned of the population's status, and most of these results are reported in this volume (see Barros et al., 2002; Beasely & Jefferson, 2002; Goold & Jefferson, 2002; Jefferson et al., 2002a, b, c).

The population ranges throughout Hong Kong's southern and eastern waters (only avoiding the northwest, estuarine-influenced waters), and also extends some unknown distance into Chinese waters of Guangdong Province to the south (and probably east) of Hong Kong (Jefferson et al., 2002b). Waters around the southwest portion of Lamma Island support a particularly high density of finless porpoises in the winter and spring seasons. The overall population size is unknown, but line transect estimates indicate a minimum of 217 individuals. Because coverage was limited to only a portion of the overall population range, the actual size could be much larger. During the peak season (spring), about 150 porpoises occur within the Hong Kong Special Administrative Region (SAR) (Jefferson et al., 2002b). There are no reliable indications of a decreasing population trend at present.

Sighting surveys suggest that there is a general offshore movement in the summer and an inshore movement in winter (Jefferson et al., 2002b). Stomach content analyses of 31 porpoises found that they fed on a variety of benthic and pelagic fish species, several species of cephalopods, and occasionally shrimps (Barros et al., 2002). From a sample of 86 specimens from southern China (mostly from Hong Kong), Jefferson et al. (2002c) found that male and female finless porpoises reach sexual maturity at ages of about 4-5 and 5-6 years, respectively. Males grow somewhat larger than females, and the asymptotic length of both sexes pooled was 161 cm. The oldest individual in the sample was 33 years (the oldest known for any phocoenid). Calving occurred throughout the year, but there was a large peak during November through January.

Directed killing of finless porpoises in Hong Kong water has not been reported. Known causes of death include incidental catches in fishing nets and vessel collisions, as well as parasitic infections, reproductive abnormalities, and shark attack (Parsons & Jefferson, 2000; Jefferson et al., 2002a). The effects of environmental contaminants on the health of the animals are not known, but levels of organochlorines (especially DDTs) and some heavy metals (in particular, mercury) have been found to be high and possibly health-threatening (Parsons, 1997; Parsons & Chan, 1998; Parsons, 1999; Minh et al., 1999; Jefferson et al., 2002a). Raw or barely treated sewage is released into Hong Kong waters, and the potential for introduction of pathogenic bacteria appears high. The Hong Kong Government is currently developing a Strategic Sewage Disposal Strategy, which is expected to include primary treatment and possibly disinfection. Coastal reclamation may have already eliminated some areas of porpoise habitat. Porpoises may have also been displaced or their behavior altered by intensive shipping and high-speed vessel traffic. Overfishing is well known in Hong Kong (ERM-Hong Kong, 1997), and the abundance and composition of porpoise prey may have been affected.

The Agriculture, Fisheries and Conservation Department (AFCD) of the Hong Kong Government is actively managing the population, and is continuing to co-fund (with OPCF) conservation-related studies, including long-term monitoring. The Wild Animals Protection Ordinance provides protection in Hong Kong SAR waters, and legislation also provides some measure of protection in mainland Chinese waters. However, plans to upgrade the status of finless porpoises to a Grade One Protected Species in China have not yet been successful. Several marine parks are being established in important habitat for the species in Hong Kong, and the AFCD plans to develop a conservation plan similar to that recently produced for the local population of humpback dolphins.

Pakistan – Because Pakistan is the only area in the Indian Ocean where finless porpoises have been studied, we will summarize available information here. Porpoises occur along the coast of Pakistan from the mouths of the Indus River, west to at least Karachi (Pilleri & Gihr, 1972), and possibly as far as the Iranian border (Roberts, 1977). Porpoises inhabit the mouth of the Indus River, including Kudi, Mull, Khai, and Dubla channels (Pilleri & Gihr, 1972; Roberts, 1977).

Finless porpoises are found in the Indus River mouth in the winter and summer monsoon months. Before the monsoon season, near the end of April, they move offshore, and then return at the end of the monsoon, usually in October (Pilleri & Gihr, 1972; Roberts, 1977). These movements are generally associated with the presence of prawns, and some animals have apparently been temporarily stranded in estuarine pools when the tide becomes low (Pilleri & Gihr, 1972). Finless porpoises have also been seen along the Mekran coast from late September to April (Roberts, 1977).

Finless porpoises in Pakistan feed on a variety of fishes, squids, and shrimps (Pilleri & Gihr, 1972). Little else is known of the their ecology. Directed killing has not been reported. Some porpoises are probably killed incidentally in coastal gillnet operations, but bycatch rates are unknown. Fishermen in Pakistan claim that the abundance of finless porpoises has declined in recent decades, probably due to the effects of fishing (Pilleri & Gihr, 1972; Roberts, 1977). Protection measures for finless porpoises in Pakistan (if any) are not known.

RECOMMENDATIONS FOR CONSERVATION

Conservation is an ongoing process that requires hard work, constant evaluation and innovative responses.[4] Holistic solutions are needed to integrate ecological, sociological, political, and administrative considerations. After exhaustive review, a set of principles for the conservation of marine mammals was developed to initiate a discussion of priority issues (see Meffe et al., 1999). We have used this as a starting point for developing our own priorities to address the specific challenges of conserving facultative freshwater cetacean populations in Asia. These are summarized in bold with details following on their justification and translation into protective measures.

4 We consider it self-evident that facultative freshwater cetaceans should be conserved (for both ethical and ecological reasons; see Katona & Whitehead, 1988; Ehrlich & Ehrlich, 1992) and believe that the more important question is "whether we as a species have the sense and self-control to carry out the task" (Kunin & Lawton, 1996).

I. The maintenance of healthy cetacean populations is inconsistent with the ever-growing human use of marine and freshwater resources.

Within the range of aquatic environments occupied by cetaceans, humans disproportionately affect rivers, lakes and neritic waters. The most important steps that should be taken in the long term to slow or reverse the increasing degradation of these environments are to reduce human birthrates and demands on natural resources. From the perspective of conserving facultative freshwater cetaceans, a few practical measures should be taken immediately. The guiding premise behind these measures is that the environmental requirements of freshwater cetaceans closely reflect at least two critical requirements of sustainable human communities – reasonably clean water and readily available sources of high quality food – and that by addressing these requirements we also promote our own sustainability.

There is an urgent need to reduce or eliminate contaminants at their sources. Persistent toxic elements (primarily lead, cadmium, mercury), organochlorines (primarily polychlorinated biphenyls (PCBs), organotins, and pesticides, such toxaphene, cyclodienes (aldrin, endrin and dieldrin) and DDTs are particularly insidious, due to their bioaccumulative properties - over time in individuals and from one generation to the next as females 'dump' much of their chemical burden to their young across the placenta and during nursing. Although aromatic and polycyclic hydrocarbons (primarily associated with the manufacture and use of petroleum products) do not biomagnify in food chains (Hellou et al., 1990; Law & Whinnett, 1992), they contain well-known carcinogens that have been associated with the development of tumors in belugas (Martineau et al., 1988; but also see Geraci et al., 1987). Environmental contaminant levels have been measured for finless porpoises from Japan, the Yangtze River, Yellow Sea, Bohai Sea, East China Sea, and Hong Kong. Organochlorines (especially DDT and PCBs) in finless porpoise tissues have been recorded as high throughout much of their range (see review in Jefferson et al., this volume c), and there is concern about the high levels of mercury in some areas, such as Hong Kong. Only recently have butyltins been recognized as among the most toxic chemicals known (Tanabe, 1999; Tanabe et al., 1998), and there is concern about how these contaminants may be affecting finless porpoise populations. There is an urgent need to develop better techniques for assessing the impacts of the high levels of pollutants that facultative freshwater cetaceans are routinely exposed to in many areas. Collaborations should be pursued among biologists responsible for arranging and conducting necropsies, and veterinarians and pathologists working with aquatic mammals.

The sustainability of coastal and riverine fish stocks is vital to the food security of humans and cetaceans. Despite this fact, our knowledge of fishery dynamics in the marine and fresh waters occupied by facultative freshwater cetaceans remains poor, and management programs are absent or severely inadequate. From a research perspective, fish market surveys and onboard observer programs are required to monitor fish catches and fishing effort. There is also a need for better information on the species composition of dolphin and porpoise prey so scientists can evaluate relationships between species abundance and prey availability. In areas where fish or cetacean stocks are threatened, time/area closures or gear restrictions should be considered. The support of local fishermen will be critical for ensuring compliance. Traditional knowledge should be incorporated into fisheries management policy whenever possible. This will require extensive consultations among fishermen, management authorities, and scientists.

The establishment of protected areas should be considered for areas where facultative freshwater cetaceans occur in particularly high densities or where they are especially vulnerable (e.g., calving and nursing areas), and where there is a reasonable chance of providing effective protection from habitat degradation, and accidental and deliberate killing. Ideally, these areas should be designed to encompass the entire range of seasonal movements and life stages of the populations they are intended to protect. This may not always be feasible, so in some cases initial designations should be viewed as a catalyst for research on the efficacy of the protected area and possible redesign or expansion at a later date.

II. Without protection from deliberate and accidental removals the conservation prospects for facultative freshwater cetaceans are poor.

The sustainable use of resources has become a prevalent (or perhaps the dominant) theme of the conservation/development lexicon (see United Nations Conference on Environment and Development, 1992). Small cetaceans make very poor candidates for exercising this option, due to their low rates of natural increase and difficulties in monitoring population trends at scales useful for management (Perrin, 1999). While incidental mortality during fishing operations may be impossible to eliminate altogether, regulations prohibiting deliberate killing and the sale of cetacean products should be strictly enforced. Vigilance is required to ensure that markets created by accidental kills do not encourage subsequent directed hunts.

Monitoring is required to ensure that accidental kills are sustainable. Information on cetacean bycatch should be systematically collected as a regular component of fisheries investigations. Onboard observers are by far the most effective approach for obtaining credible information on cetacean bycatch, but these programs are expensive and often not appropriate for the small artisanal fisheries that characterize many areas inhabited by Irrawaddy dolphins and finless porpoises. Land-based observations conducted from vantage points overlooking intensively fished areas and examination of specimens obtained from stranding networks and from fisheries bycatch, can also provide valuable information on temporal and spatial patterns of cetacean kills. In some areas, it is illegal for fishermen to possess cetacean carcasses. This has resulted in a loss of knowledge on genetics, life history, pollutant levels, and the causes and rates of accidental kills. Existing regulations should be modified so that fishermen are encouraged to report incidental catches and recover carcasses for examination and necropsy by scientists.

From a conservation perspective, removals of cetaceans for oceanaria have the same effects on wild populations as deliberate killing. Such removals may have already contributed to a decline of Irrawaddy dolphins in the Mahakam River (it is worth repeating here that this population was recently listed as Critically Endangered [Hilton-Taylor, 2000]). A strong argument can be made, however, for the educational value of these facilities and how an increase in awareness (and perhaps sentimental attachment) may translate into an increased commitment towards effective conservation (see Reeves & Mead, 1999). Any plans for removals of finless porpoises or Irrawaddy dolphins from the wild should be preceded by statistically defensible estimates of abundance that ensure the numbers taken will not adversely affect source populations. In no areas where populations have been assessed has there been found a sufficient 'surplus' of animals to justify removals. It should be self evident that the capture, transport, and care of cetaceans must proceed only in the most humane manner possible. Sufficient resources must be available for the construction and maintenance of suitable facilities, and for providing up-to-date veterinary care. Rarely have these standards been met in existing oceanaria.

III. Conserving cetaceans must be based on an understanding of the dynamics of the ecosystems in which they live.

Knowledge of even the most basic features of cetacean ecology is lacking for much of the region occupied by Irrawaddy dolphins and finless porpoises. A similar absence of information exists for most other environmental components, a situation that prevents any rational attempt at managing resources in ways that preserve the integrity of ecosystems while accommodating human use. Detailed guidance on the types of research necessary for developing ecosystem-based management strategies is beyond the scope of this paper, but a few significant gaps in knowledge related to the animals themselves are population structure (see below), abundance, and the environmental requirements necessary for supporting healthy populations.

Scientifically defensible abundance estimates for Irrawaddy dolphins and finless porpoises are needed to establish conservation priorities. For coastal areas, lakes, and sounds existing line-transect sampling techniques can be used for both species. Attempts should be made to correct for sighting biases using information from acoustics and/or data on surfacing patterns (see Jefferson et al., 2002b; Beasley & Jefferson, 2002). Areas of riverine distribution present special challenges that will require substantial adaptations to existing techniques or new approaches altogether (see Smith & Reeves, 2000a).

Special attention should be made to investigate the environmental requirements of facultative freshwater cetaceans and to identify areas where the animals occur in high densities or engage in critical activities, such as those related to reproduction. For the foreseeable future, region-wide surveys for marine populations will be difficult to design, fund and implement. The development of scientifically tested habitat profiles could provide a valuable tool for identifying "hotspots" for follow-up surveys and to recommend for protected area status.

IV. The goal of conservation should be to maintain biological diversity at all levels.

An understanding of the demographic uniqueness of cetacean populations is essential. Wherever adequate data exist to permit a rigorous evaluation, geographic populations and, in some cases, new species have been identified (Perrin & Brownell, 1994). Preliminary information on finless porpoises and Irrawaddy dolphins suggests that recognition of a large number of populations is warranted, and that there may be species or subspecies level differences among these (see Yoshida, 2002; Beasley et al., 2002a; Jefferson, 2002). Further research is needed on genetics and morphometrics to clarify taxonomic and demographic relationships.

For genetic studies, a small piece of skin should be collected from recovered carcasses and stored in a glass or plastic vial filled with 20% dimethyl sulfoxide (DMSO) and saturated sodium chloride (NaCl). The vials should be refrigerated or frozen as soon as possible after collection and clearly labeled with the species, collection date and location, sex if known, and name of the collector. Cross-contamination must be avoided by using only sterilized instruments (i.e. washed in soapy water and rinsed in ethanol). For morphological studies standard measurements of available carcasses and skeletal materials should be taken, ideally by a single researcher in order to reduce variability. Information from bioacoustics, organochlorine levels, parasite species, and, in some cases, telemetry can also be used

The lack of information on the genetic relatedness of populations should not inhibit recognition of provisional units for conservation. These should be based on common sense boundaries and be as small as possible, given practical constraints (Wade & Angless, 1997). These populations may harbor critical genetic variation necessary for responding to natural or human-induced environmental change. Special attention should be given to populations isolated by natural (e.g., islands and deep or rough water) or anthropogenic (e.g., extirpation zones or densely concentrated fixed fishing nets) barriers. Examples of small populations that are at least partially isolated from other members of their species include Irrawaddy dolphins in Malampaya Sound, Chilka and Songkhla Lakes, and the Mekong, Mahakam, and probably Ayeyarwady Rivers, and finless porpoises in the Yangtze River and in the five areas of Japan summarized by Yoshida (2002).

V. Environmental assessments of coastal and riverine development projects should consider the needs of cetaceans during planning and management.

Implementation of this principle requires independent evaluation, extensive information on pre-development environmental conditions, consideration of cumulative and synergistic impacts, and long-term monitoring of environmental effects, should the development proceed (see Smith & Reeves, 2000b). The option of not proceeding with the development must be considered if the impacts are found to be severe and cannot be reduced to acceptable levels. Post-development empirical studies will be required to monitor mitigation and the realized effects on cetacean populations and their habitats.

The proposed construction of dams in the Mekong River system, both in the upstream reaches in Laos, and in the channel leading to Ton Le Sap, are of particular concern for Irrawaddy dolphins. Continuing reclamation and coastal development threatens finless porpoises (and Indo-Pacific humpback dolphins *Sousa chinensis*) in Hong Kong, and the proposed Kra Canal (connecting the Andaman Sea with the Gulf of Thailand) threatens both species in Thailand. In all cases, the burden of proof for demonstrating that developments will not harm cetaceans should lie squarely with the proponents and financiers of the projects.

VI. All stakeholders must be included in the process of determining conservation strategies and their implementation.

It is axiomatic that conservation cannot succeed in the long-term without the support of people affected by management decisions. Ensuring that stakeholders understand the problems and the potential results of alternative courses of action requires communication that is interactive, reciprocal, and continuous. In addition to the expertise of natural scientists, input from social scientists, fishermen, developers, and policy-makers should be incorporated.

VII. Scientists and resource managers from the region where facultative cetaceans live can most effectively implement research and conservation initiatives.

Education and infrastructure development are required so that local scientists and resource managers can provide the stimulus and expertise for cetacean conservation efforts in their own countries. Existing programs for collaborative research and professional development need to be expanded and strengthened. Whenever possible, training should incorporate the production of useful outputs, such as a formal population or habitat assessment, or a management plan for an area or population. Training programmes should always be tailored to the circumstances of those being trained, with the expectation that these people will become involved in research and conservation at local or regional levels.

VIII. Biodiversity approaches offer the most promising alternatives for conserving facultative freshwater cetaceans and their habitats.

The breadth of habitat encompassed by facultative river cetaceans and their occurrence in regions that are among the most biotically diverse worldwide, means that they share habitat with a large number of other threatened megafauna species. For instance, the Yangtze River finless porpoise shares habitat with the baiji *Lipotes vexillifer* (CR)[5], smooth-coated otter *Lutra gale perspicillata* (VU), Yangtze sturgeon *Acipenser dabryanus* (CR) and Chinese paddlefish *Psephurus gladius* (CR), while the Chinese alligator *Alligator sinensis* (CR) has already been extirpated from the river. In the Mekong River, Irrawaddy dolphins share habitat with the Siamese Crocodile *Crocodylus siamensis* (CR) and Asiatic softshell turtle *Amyda cartilaginea* (VU). Both species are sympatric with dugongs *Dugong dugon* (VU) over much of their range in marine waters.

Biodiversity approaches use information on the interdependencies within ecosystems to guide adaptive management. For instance, information on fish and invertebrate diversity could be used to assess the impact of coastal and riverine developments on cetacean habitat. From a practical viewpoint, researchers working on different taxa groups or investigating more basic environmental parameters (e.g., biological productivity, oceanography, hydrology, etc.) can often "piggy-back" on each others' research platforms and learn a great deal about their own topic from cross-disciplinary interaction. These considerations, and the fact that a large portion of the world's human population depends on biodiversity resources provided by waters inhabited by Asia's facultative freshwater cetaceans (especially in the Yangtze and Mekong Basins and coastal areas surrounding Japan and Hong Kong) imply that multi-taxa approaches will be essential for ensuring the long-term persistence of finless porpoise and Irrawaddy dolphin populations.

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5 CR= Critically Endangered, EN = Endangered , VU = Vulnerable: Classifications according to Hilton-Taylor (2000).

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