Natural History and Conservation of Irrawaddy dolphins,

Orcaella brevirostris,

with special reference to the Mekong River, Lao P.D.R.

by

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We accept this thesis as conforming to the required standard

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ABSTRACT

Irrawaddy dolphins, (*Orcaella brevirostris*), are classified as insufficiently known by the World Conservation Union (IUCN). This thesis describes current knowledge and status of Irrawaddy dolphins, guidelines for conservation, and results of a field study in the Mekong River in southern Lao P.D.R. The field study was comprised of habitat description, shore observations and photo-identification. Sighting frequency decreased from dawn to dusk. Foraging was the principal behaviour, often observed at a tributary mouth. Mean group size was 3.02 and ranged from 1-7. Mean divetime increased significantly when boats were within 100m. Difficulty in obtaining good photographs may limit the use of photo-identification as a research tool.

Throughout the range of this species, populations appear to be declining. If problems of habitat degradation and incidental catch are not adequately addressed, long-term survival may be in jeopardy. Conservation hopes lie in habitat protection, a reduction in incidental catch, further research, and education of local people.

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Chapter One
INTRODUCTION

RESEARCH PURPOSE AND OVERVIEW

This thesis has three main components. The first is an overview of the current knowledge and status of Irrawaddy dolphins (Orcaella brevirostris). The second describes my field study of Irrawaddy dolphins in the Mekong River, Lao Peoples' Democratic Republic (Lao P.D.R.). The last section is a synthesis of practical and theoretical knowledge resulting in a conservation strategy for the species. The material in these chapters fulfills my goals of gathering information relevant to the conservation concerns of this little-known cetacean, contributing new knowledge about the species, and suggesting possible avenues towards the conservation of Irrawaddy dolphins.

In meeting the first goal, I first reviewed the published and unpublished literature for information pertaining to Irrawaddy dolphins. I also contacted biologists and other people working in, or knowledgable about, countries where Irrawaddy dolphins occur. In December, 1994, I attended the first Asian River Dolphin Meeting in Hong Kong, where I obtained further information during discussions with participants and from submitted papers. Field knowledge resulted from direct observations of Irrawaddy dolphins in the Mekong River in May and June, 1993 and March and April, 1994. A description of the habitat, and information on dolphin habitat use and behaviour, vessel use of the study area, and interactions between vessels and dolphins were recorded. The above information was then synthesized in a study for the conservation of the species throughout its range, and specifically in the Lao P.D.R. study area.

NEED FOR IRRAWADDY DOLPHIN CONSERVATION

Irrawaddy dolphins are distributed from the east coast of India in the Bay of Bengal, to Papua New Guinea, and from northern Australia through the coast of Indochina (Figure 1 - Leatherwood and Reeves 1983, Leatherwood et al. 1984, Marsh et al. 1989). The species is confined to shallow coastal waters and certain larger rivers within this area. Compared to many other small cetaceans, knowledge of this dolphin is limited. There are relatively few published studies, and no systematic surveys have been conducted specifically for this species. Largely anecdotal information is available documenting habitat parameters and behaviour in the wild. Irrawaddy dolphins are officially classified as

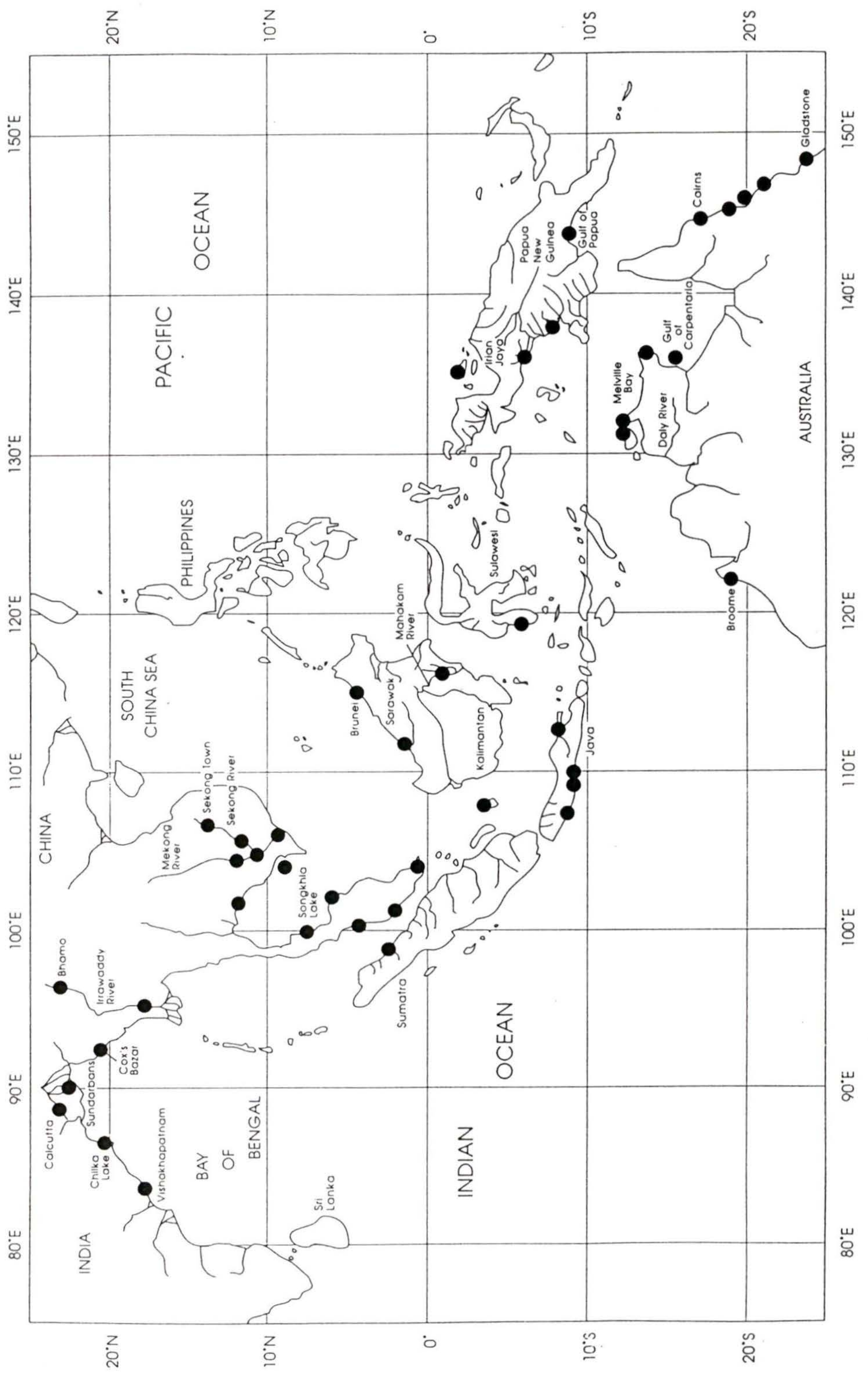

Figure 1. Map of global distribution of the Irrawaddy dolphin, showing representative locations of sightings and strandings.

insufficiently known by the World Conservation Union (IUCN).

Dolphins inhabiting rivers are among the most endangered of all cetaceans. In considering potential threats to river-dwelling Irrawaddy dolphins, it is helpful to look at other small cetaceans that inhabit similar habitats. Many of these threats were identified at the Workshop on Biology and Conservation of the Platanistid Dolphins, held in the People's Republic of China in 1986 (Perrin and Brownell 1989). In the Amazon, the boto (*Inia geoffrensis*) is in danger due to interactions with fisheries, hydroelectric development, deforestation, and pollution from agriculture, industry and mining (Best and da Silva 1989). The Ganges river dolphin (*Platanista gangetica*) inhabits the Ganges, Brahmaputra, Karnaphuli and Meghana rivers in India, Nepal and Bhutan, and there faces pollution, dams, mining, and directed and incidental catch (Mohan 1989, Shrestha 1989). The related Indus river dolphin (*Platanista minor*) has a restricted range in the Indus river in Pakistan, and is one of four cetaceans worldwide most vulnerable to becoming extinct (Reeves and Leatherwood 1994). The baiji, or Chinese river dolphin (*Lipotes vexillifer*), is the world's most endangered cetacean (Wang 1995), with only about 200 animals remaining (Ellis *et al*. 1993). Chen and Hua (1989) and Zhou and Lu (1989) state that the causes of drastic declines in abundance of the baiji are habitat degradation, harmful fishing gear and methods, and development of river traffic (especially injuries and deaths from boat propellers).

The combination of occupying a geographically restricted range and a relatively narrow ecological niche, along with a dependence on resources that are also used by humans, accounts for many of the problems river-dwelling dolphins are facing (Reeves and Leatherwood 1994). Their vulnerable habitat is being degraded on many fronts. The effects of deforestation, pollution, industrial and agricultural development and vessel traffic have taken their toll, and many regional populations of river dolphins are already extinct (Perrin and Brownell 1989). Avenues toward conserving river dolphins have included basic biological research, both in the wild and captivity, as well as the identification of threats and possible mitigating actions.

Irrawaddy dolphins, the subject of this study, are found in the Mekong River and some of its tributaries in Vietnam and Cambodia, and are the only species of cetacean recorded from the landlocked Lao P.D.R. There is little known about its historical distribution and abundance, or of its present status. However, Laotian villagers are reporting a decrease in the number of Irrawaddy dolphins seen in recent years, and are voicing concerns about activities they believe are impacting the dolphins and the ecosystem in general (Baird 1992).

RESEARCH SIGNIFICANCE

This research contributes to the understanding of Irrawaddy dolphin natural history and applied conservation management strategies. Observations of dolphin behaviour and habitat use contribute to a better understanding of the species, which in turn is essential for addressing conservation management. A foundation for future research is established, which will benefit conservation of not only this species, but also other species of cetaceans in similar situations. Some research techniques for studying river dolphins are evaluated in this thesis.

Dolphins, and cetaceans in general, are the basis for significant wildlife-viewing industries in many other parts of the world (e.g. Tilt 1987, Boynton 1989, Duffus and Dearden 1990, 1993, Hoyt 1992, Kendall 1993). The Lao P.D.R. is already targeting ecotourism in development plans (Laird 1993). In this study, the potential effects of vessel traffic on dolphin behaviour are analysed. This information is critical for sound development in the area of tourism and is important from a conservation perspective. It will establish a baseline against which future changes can be compared.

International organizations have recognized the need for this research. The International Whaling Commission's Sub-committee on Small Cetaceans recommended studies on Irrawaddy dolphins in Lao P.D.R., with particular emphasis on distribution, abundance, genetics and toxicology (IWC 1994). The IUCN's (World Conservation Union) Cetacean Specialist Group recommended research on the status and conservation of the Irrawaddy dolphin in southern Asia as a priority for attention and funding (Reeves and Leatherwood 1994).

Irrawaddy dolphins are, then, potentially at risk due to factors stemming from their habitation of coastal and riverine environments. Research to learn more about these dolphins and further identify the possible threats is warranted. In the next chapter, information is presented as a foundation for assessing the status of Irrawaddy dolphins, and for determining the research and conservation priorities.

Chapter Two
STATUS OF THE IRRAWADDY DOLPHIN: A REVIEW

INTRODUCTION

In this chapter, sighting records and reports of dead Irrawaddy dolphins have been compiled and are used to evaluate the distribution and abundance of this species. Information on ecology, biology and behaviour is reviewed, as are current and future potential threats to the Irrawaddy dolphin in all parts of its range. This information was obtained from the published and unpublished literature, and from personal communication with people in several countries who have experience with this species.

REVIEW OF CURRENT KNOWLEDGE

Distribution and Abundance

The earliest mention of Irrawaddy dolphins in the literature is by Owen (1869). He described a specimen found in 1852 at the mouth of the Vizagapatam (Vishakhapatnam) River along the east coast of India. The skull of this animal, the type specimen, collected by W. Elliot, is housed at the British Museum of Natural History (for specimen numbers, see Appendix I). Countries where this species has since been recorded are Australia, Bangladesh, Brunei, Burma (Myanmar), Cambodia (Kampuchea), India, Indonesia, Lao P.D.R. (Laos), Malaysia, Papua New Guinea, Singapore, Thailand and Vietnam (Figure 1). In the following section, records are reviewed by country (for ease of organization) to develop an understanding of the overall distribution and abundance of the species. For exact locations of the records, see Appendix I.

Records by country

Australia

Irrawaddy dolphin records from Australia are only known from as far back as 1948, when some skeletal remains were found at Melville Bay, Northern Territory (Johnson 1964). Although Marsh et al. (1989) regarded Irrawaddy dolphins as common in northern Australia, there are few published studies, or sighting or stranding records.

The principal exception is the results of an aerial survey conducted by Freeland and Bayliss (1989). The authors estimated the population in the Western Gulf of Carpentaria, Northern Territory, to be approximately 1,000 dolphins. They considered this population, the largest yet identified anywhere, to be of sufficient size to survive independent of other populations.

Between the Gulf of Carpentaria and the Daly River, another area surveyed in the Freeland and Bayliss (1989) study, 13 Irrawaddy dolphins were seen in 8 groups during 33 survey hours. Two sightings were between Melville and Bathurst Islands and two more were between Darwin and Point Blaze. These are the four western-most records published for Australia. However, there are three unpublished specimen records from Broome in Western Australia from 1948 and 1965 (G.J.B. Ross pers. comm.). The absence of records between the Darwin area and Broome may well reflect the remoteness of the area and lack of observers and reporting, rather than a break in distribution.

On the east coast of Australia, there are records from Cairns, to as far south as the Gladstone area (Marsh et al. 1989, J.G. Mead pers. comm., G.J.B. Ross pers. comm.). Dawbin (1972) mentioned that Irrawaddy dolphins can be found along the Queensland coast to south of Cairns.

There are at least 19 Australian specimens housed at the Museum of Tropical Queensland, 3 at the Queensland Museum (Paterson 1986, 1994), 3 at the Western Australian Museum, 1 at the Australian Museum (G.J.B. Ross pers. comm.), and 2 at the National Museum of Natural History, USA (J.G. Mead pers. comm.). There are no specimens in the Museum of Victoria, Australia, which has an extensive cetacean collection dating from last century (Dixon and Frigo 1994).

Bangladesh

There are three known sightings and three specimen records of Irrawaddy dolphins in Bangladesh. Morzer Bruyns (1971) reported that Irrawaddy dolphins have been seen 110km (70 miles) up the Pussur River in East Pakistan (Bangladesh). There are two sightings reported from the Sundarbans, one in 1969 and another in 1994 (Kasuya and Haque 1972, A.K.M. Aminul Haque pers. comm.). Three other records round out the known occurrence in this country. In 1960, an Irrawaddy dolphin was found dead at Cox's Bazar, and in 1976, three or four individuals of this species were among other cetaceans caught in fishing nets in the same area (Haque 1982, A.K.M. Aminul Haque pers. comm.). A decomposed cetacean, that I tentatively identified from photographs as an Irrawaddy dolphin, was found by B. Ahmed on Sonadia Island in southern Bangladesh in 1982.

Brunei

Gibson-Hill (1949, 1950) is the only author to report sightings of this species in Brunei. He reported seeing Irrawaddy dolphins at Muara Island and in "some numbers" off Brooketon (Muara) at the mouth of the Brunei River. There is also a skull in the British Museum (Natural History) that was collected at Muara Island, Brunei River (Pilleri and Gihr 1974).

Burma (Myanmar)

Irrawaddy dolphins have been recorded from the Irrawaddy River to at least 1300km (800 miles) from the sea (Morzer Bruyns 1971, U Tin Thein 1977, Lekagul and McNeely 1977, B.D. Smith pers. comm.). U Tin Thein (1977) mentioned three specific sighting records (one each at Katha, Kyauktonegyi, and Thayetmyo). In late March/early April 1996, Brian Smith (pers. comm.) recorded four sightings in the Irrawaddy River, between Mandalay and Ma U village. In early April, he also observed Irrawaddy dolphins eight times in the lower reaches of rivers along coastal Burma, north of Sandoway. There are four skeletal specimens from the Irrawaddy River in museums in Great Britain, Italy and India, the earliest from 1870 (Anderson 1871, Pilleri and Gihr 1974, M. Ghosh pers. comm., J.G. Mead pers. comm.). There are two or more additional specimen records, including at least one from Pagan (Leatherwood et al. 1984).

In 1983, fishers in Rangoon and Pagan were interviewed as to their knowledge of Irrawaddy dolphins (Leatherwood et al. 1984). In their opinion, the dolphins were most abundant in the lower river. At Pagan they apparently were seen very rarely, although reportedly up to 60 dolphins were once counted in the area by the local people. Irrawaddy dolphins are not known from the Salween and the Sittang, the other large rivers in Burma, perhaps because the Salween River is too turbulent, with many rapids, and the Sittang too shallow in the dry season (U Tin Thein 1977).

Cambodia (Kampuchea)

Lloze (1973) collected two Irrawaddy dolphins, in 1968 and 1969, near Kratie. He also reported sightings near the Cambodian/Vietnamese border, in the region of Tonle Sap, and along the Cambodian coast. A survey for dolphins along the Mekong River in North-eastern Cambodia in 1993 failed to locate any of these animals (Baird and Mounsouphom 1994). However, locals indicated that Irrawaddy dolphins did occur in that portion of the river, and identified five deep water pools where dolphins were frequently seen. Dolphins were also reported to be seen occasionally in the Tonle Sap River, but rarely south of Kratie. It appears that Irrawaddy dolphins navigate the Mekong River throughout

Cambodia, but are not as abundant as they once were. In coastal Cambodia, eight Irrawaddy dolphin were caught in late 1994 in fishing nets (S. Leatherwood pers. comm.).

India

There are twelve specimen records, one dating back to 1852 (Owen 1869), and four sighting records for India. They cover the area from Vishakhapatnam Harbour to the Calcutta area, the northern-most marine records of Irrawaddy dolphins. Only in the Irrawaddy River might the species be found further north. Besides coastal records, there are eight from Chilka Lake (Annandale 1915, Dhandapani 1992, M. Ghosh pers. comm., P.J.H. van Bree pers. comm.). At least six skeletons are preserved in museums (Owen 1869, Ellerman and Morrison-Scott 1951, M. Ghosh pers. comm., P.J.H. van Bree pers. comm.).

Chilka Lake, the largest brackish water body in Asia, with an area of 1100km^2 (Dhandapani 1992, Mohan 1994), historically has been an important habitat for Irrawaddy dolphins in India. Records from the lagoon date back to 1875 (M. Ghosh pers. comm., P.J.H. van Bree pers. comm.) At one time, Irrawaddy dolphins may have travelled between the lake and ocean; however, the river mouth has silted in, closing off that access (B.C. Choudhury pers. comm.).

Annandale's (1915) account of visits to Chilka Lake gives the impression that sightings were frequent at that time. More recently, only five live and two dead dolphins were seen in the lake during a 1985-87 study (Dhandapani 1992). A total population estimate of 20 animals for Chilka Lake has been suggested by the Fisheries Department of Orissa and the local fishers (Dhandapani 1992). Dhandapani sees this as a drastic reduction in the population from that at the time of Annandale's writings.

The status of Irrawaddy dolphins along the east coast of India, where there have been only occasional sightings over the years, is not known. There is little or no research effort and sightings are not likely to be reported (B.C. Choudhury pers. comm.).

Indonesia

Irrawaddy dolphins are (or were formerly) found in many areas of Indonesian coastal waters. Forty-two records of Irrawaddy dolphins in Indonesia have been compiled (Morzer Bruyns 1966, Pilleri and Gihr 1974, Tas'an and Leatherwood 1984, Wirawan 1989, Kartasantana and Suwelo 1994, J.G. Mead pers. comm., P.J.H. van Bree pers. comm.). Thirty-two of them are records of sightings and 10 of specimens. There are 12 records from the Belawan Deli River, and 1 from Labuhanruhu in Sumatra, 8 from Java, 1 from Sulawesi, 1 from Kumai Bay and 13 from the Mahakam River system in Kalimantan, and 6 from Irian Jaya. One specimen has no location associated with it. The majority of these records come from a single source, Morzer Bruyns (1966).

Irrawaddy dolphins traditionally occupied the waters around the mouth of the Mahakam River and upriver from the coast at least 200km (Tas'an and Leatherwood 1984). In 1978, approximately 100-150 Irrawaddy dolphins were estimated to be inhabiting Semayang Lake and Pela River, as well as the Mahakam River. Dolphins also occupied Melintang and Jempang lakes. Numbers have likely decreased in recent years (Tas'an and Leatherwood 1984, Wirawan 1989).

During a 1993 study in Lamalera, fishers were interviewed as to which cetaceans occupied the adjacent waters. Irrawaddy dolphins were not named, or identified from pictures (P. Rudolph pers. comm.). This is not surprising, given that waters off the island drop precipitously to depths of up to 2000m.

Lao P.D.R.

Numerous records of Irrawaddy dolphins have been compiled from Lao P.D.R. (Baird 1991, Baird 1992, Sluiter 1992, Baird and Mounsouphom 1994, Baird et al. 1994, Stacey unpublished). Surveys in 1991 and 1992 in the southern Lao provinces of Sekong, Attapeu and Champasak confirmed that Irrawaddy dolphins inhabit (or recently inhabited) parts of the Mekong and Sekong Rivers and some of their tributaries in this country (Baird et al. 1994). Villagers reported that Irrawaddy dolphins were once common in the Sekong River system but are now only seen in some years and even then only as far north as Sekong Town in the Sekong River, and in the Sekhamen, Sepian, and Sekampoh Rivers.

Irrawaddy dolphins are also distributed in the Mekong River in Lao P.D.R., but only in the 5km or so adjacent to the Cambodian border. A series of waterfalls, named Leepee or Khone Falls, is largely a barrier to further movement upriver. One record is known from above the falls; in the 1960s, a group of dolphins was seen for one month during the high-water season near the village of Don Dtan (Baird and Mounsouphom 1994). In the Mekong River, from the villages of Hang Khone and Hang Sadam, dolphins can be seen throughout the year; during the dry season they can be seen daily. Approximately 17 Irrawaddy dolphins were seen together at Hang Khone in May 1993 (Baird et al. 1994). This area is apparently the centre of Irrawaddy dolphin abundance in Lao P.D.R.

Malaysia

Eighteen records from Malaysia have been compiled: 12 of sightings and six of specimens (Gibson-Hill 1949, 1950, Morzer Bruyns 1966, 1971, Pilleri and Gihr 1974, J.G. Mead, pers. comm.). Five of the six specimens are in the British Museum (Natural History), Sarawak Museum, Museum of Comparative Zoology, Harvard, USA, and Field Museum, Chicago, USA.

The eight records from the Malay Peninsula include one from Perak, two from Penang, and five from the Klang River. Gibson-Hill (1950) found Irrawaddy dolphins to be fairly common in the estuaries of Sarawak rivers, especially in the lower waters of the Santubong branch of the Sarawak River. The other records from Malaysia consist of one from Buntai, three from Santubong and one with no specific location.

Gibson-Hill (1950) did not see any Irrawaddy dolphins along northern Sarawak, including Darvel Bay, and there are still no records from there or further north. He cited unsuitable habitat as a likely reason, with the possible exception of the upper portion of Sandakan Bay and Marudu Bay.

Papua New Guinea

Dawbin (1972) reported that some Irrawaddy dolphins were caught accidentally in fishing nets in the Gulf of Papua. To the best of his knowledge, there were no records from the north coast of New Guinea or further east of the Gulf of Papua at the time of his writing. Irrawaddy dolphins were also reported to travel approximately 16km (10 or more miles) up some rivers of Papua New Guinea (Mitchell 1975).

Singapore

A record was reported from Singapore by Pilleri and Gihr (1974). The stuffed skin of this specimen is held in the British Museum (Natural History).

Thailand

Records of Irrawaddy dolphins in Thailand date back to at least 1903 (Bonhote 1903). Numerous sighting records (Bonhote 1903, Kloss 1916, Andersen and Kinze 1993, M. Andersen pers. comm.) and 10 specimen records have been compiled (Pilleri and Gihr 1974, Andersen and Kinze 1993). Irrawaddy dolphins have been reported from Trat, near the Cambodian border, all along the coast of the Gulf of Thailand to Pattani, near the Malay border. There are no records from the Chao Phraya, Thailand's largest and busiest river. As yet, there are no known records from the Andaman Sea side of southern Thailand, although Irrawaddy dolphins likely occur there.

Andersen and Kinze (1993) have found that while Irrawaddy dolphins used to be common along the shores of the Gulf of Thailand, they are now seen infrequently. Their habitat has been reduced to waters 5km or more from shore along most of the Gulf, by pollution and habitat destruction (M. Andersen pers. comm.). The Laem Sing area currently has the highest concentration of Irrawaddy dolphins. Here they are found closer to shore than in other areas of the Gulf (M. Andersen pers. comm.).

Songkhla Lake is a brackish water body along the west coast of the Gulf of Thailand that has historically been home to Irrawaddy dolphins. M. Andersen (pers. comm.) estimated that in 1994 the lake contained 100-200 Irrawaddy dolphins. Unlike Chilka Lake, in India, the Songkhla dolphins have access to lake and ocean, but there is no information about movements between the two water bodies.

Vietnam

The only documentation of Irrawaddy dolphins in Vietnam is by Lloze (1973). Besides a few sighting and specimen records from the Mekong River, he reported on a skull from an island about 15km off the coast of Ha Tien, near the Vietnamese/Cambodian border. Neither surveys in the Nha Trang area, at the mouth of the Mekong River, and near Phu Quoe, nor searches of specimens in whale temples in South Central Vietnam and the Mekong delta in 1995 revealed any Irrawaddy dolphins (Jefferson et al. 1995). In late April 1996, surveys in the Mekong River, covering the majority of larger river channels between Can Tho and An Phu, in the Hau Giang distributary, and between Than Chau and Sa Dec, in the Tien Giang distributary, were conducted (B. Smith pers. comm.). No dolphins were seen; locals reported occasional sightings near Cho Moi, Chau Doc and in the estuarine area of Cua Cung Hau, a river mouth of the Tien Giang. Other local people believed that dolphins no longer inhabited the Mekong in Vietnam (B. Smith pers. comm.).

Discussion

The recurring themes relating to distribution and abundance are a lack of information, and a perception that numbers are declining throughout the dolphin's range. There is only one regional population estimate, and no overall estimates are reported.

It is not known whether this dolphin has a continuous distribution throughout its range. All locations of Irrawaddy dolphin records are connected by a continuous band of water less than 200m deep, other than a few small areas of deeper water between the Indonesian islands and Australia/New Guinea. Based only on the water depths and latitudes of known records, Irrawaddy dolphins could conceivably be found among the Philippine islands and along the coasts of Vietnam and China perhaps as far north as Taiwan. Further survey research might uncover records along this little-studied mainland coast, but it is unlikely Irrawaddy dolphins are other than rare visitors (at most) to the Philippines. They have not been represented among the many other small cetacean species seen or caught incidentally or directly in the numerous fisheries there (Leatherwood et al. 1992, 1994, Dolar et al. 1994, Dolar 1995).

Habitat

Dhandapani (1992) described the habitat of the Irrawaddy dolphin in India as rivers, estuaries, backwaters, brackishwater lagoons and mangrove creeks. This characterisation holds true for the rest of its range as well. While Irrawaddy dolphins are reported to remain within about 1.6km (1 mile) of the coast (Morzer Bruyns 1966, Dawbin 1972), they are also known from waters further than 5km from shore in the Gulf of Thailand (M. Andersen pers. comm.). Gibson-Hill (1950) reported that Irrawaddy dolphins were common in Sarawak waters in estuaries.

In the lower Mekong River, preferred habitats near sandbars were identified to be at the confluences of lakes, rivers and streams (Lloze 1973). Large, deep pools are inhabited by Irrawaddy dolphins further up the Mekong in Lao P.D.R. and Cambodia, especially in the dry season (Baird et al. 1994). Irrawaddy dolphins also occupy lakes in the Mahakam and Mekong river systems (Lloze 1973, Tas'an et al. 1980, Tas'an and Leatherwood 1984) and Songkhla and Chilka lakes in Thailand and India respectively (Annandale 1915, M. Andersen pers. comm.). In Australia there is a substantial population located adjacent to a shrimp breeding area of seagrass pastures (Freeland and Bayliss 1989).

In Northern Territory, Australia, Irrawaddy dolphins appeared to avoid waters outside the range of 2.5 - 18m depth (Freeland and Bayliss 1989). Morzer Bruyns (1966) found that they occurred mostly in depths of 6-18m (20-60 feet). In the Mahakam River, water depths where Irrawaddy dolphins have been sighted range from 3.5 - 12m (Tas'an et al. 1980). Morzer Bruyns (1971) reported that Irrawaddy dolphins can be found in waters of 25 to 30 C.

Although there are few studies documenting water temperature, depth, or other habitat parameters, it is apparent that Irrawaddy dolphins are a coastal and riverine species. These are the same habitats that are most quickly and dramatically affected by human activities.

Daily and Seasonal Movements

Only two accounts of daily movements were located. Irrawaddy dolphins were observed to travel from Semayang Lake to the Mahakam River in the early morning to feed, and to reverse their movements in the evening (Tas'an and Leatherwood 1984). Morzer Bruyns (1966) reported that Irrawaddy dolphins swam and fed against the tide, outward bound against the flood, and inward bound against the ebb.

Villagers in Lao P.D.R. reported seeing dolphins travelling up the river in pairs between February and April in Lao P.D.R. (Baird 1991). They believed the dolphins were following schools of fish that migrate upstream to spawn. At the beginning of the rainy season (June), when the river carries fish downriver, the dolphins are also seen heading downriver.

In the Irrawaddy River, the time of the highest water levels occurs from May through October, with a peak in August and September. At Pagan, dolphins reportedly were observed during northward migration in September and October and were seen moving south in July and August (Leatherwood et al. 1984). During the high water season, the dolphins are reported to prefer the delta of the river.

Annandale (1915) observed dolphin movements in Chilka Lake, corresponding to the seasonal rainy and dry periods, and attributed this to a seasonal change in the animals' food supply. He reported that in the outer channel, or lake-mouth, however, dolphins were present year-round and kept to the middle of the channel in the rainy season and ventured closer to the shores during the dry season. From 1985-1987, Chilka Lake was studied in all seasons but Irrawaddy dolphins were found only in the winter and summer (Dhandapani 1992).

There is no information on stock discreteness. It is probable there are genetically distinct populations, especially those in coastal versus riverine habitats. Tissue samples collected from Australia, Lao P.D.R. and Kalimantan are in the process of being analyzed for this purpose (see Appendix II for details).

Life History and Reproduction

Two calves have been born in captivity (Tas'an et al. 1980; illustrations in Tas'an and Leatherwood 1984). Gestation was estimated to be about 14 months; the size of one neonate was 96cm (Tas'an et al 1980). Morzer Bruyns (1971) observed calves half the length of adults in Malaysia and Borneo in September and remarked that newborns were 40% the length of the mother. Photographs in Tas'an and Leatherwood (1984) of a mother and neonate support this figure. A dead 105cm neonate with fetal folds was observed in Lao P.D.R. in May 1993 (Stacey unpublished). In Australia, a 217cm female carrying a near-term fetus of 91cm was caught in the month of August (Marsh et al. 1989).

The age of sexual maturity is unknown, but some animals may reach adult size of about 210cm at 4-6 years of age (Marsh et al. 1989). A

200cm female weighing 99.2kg, and a 176cm male weighing 54.4kg as of March 1995, are housed at Marine World, Fukuoka, Japan (S. Wakisaka pers. comm.). Evidence from dentinal layer counts of Irrawaddy dolphins from Australia suggest that Irrawaddy dolphin may live for at least 30 years or so (Marsh et al. 1989). No information is available on population dynamics.

Behaviour

Group Size

Only one quantitative report of group size is available. On aerial surveys in northern Australia, the mean group size in the Van Diemen Gulf area was 1.63 (n=8) while that in the western Gulf of Carpentaria, was 1.93 (n=27) in the dry season and 1.77 (n=43) in the wet season (Freeman and Bayliss 1989).

Other authors give estimates of similarly small group sizes: in Chilka Lake, Irrawaddy dolphins were usually observed in groups of three or four (Annandale 1915); in the lower Mahakam River system they were seen in groups of approximately 3-10 (Tas'an et al. 1980, Tas'an and Leatherwood 1984). Fishers at Pagan, Burma, reported seeing singles or small groups, although up to 60 reportedly have been counted by the local people in one area in the past (Leatherwood et al. 1984). Morzer Bruyns (1971) reported groups of 3 to 6, (usually 4), and Dawbin (1972) commented that Irrawaddy dolphins travel in small groups of about six or less.

Interactions with Humans

In Chilka Lake, Irrawaddy dolphins were observed swimming within a metre or two of small seine-net fishing activities and commonly followed boats (Annandale 1915). Dhandapani (1992) regarded Irrawaddy dolphins as "shy" animals. Lekagul and McNeely (1977) reported that Irrawaddy dolphins are thought by Thai fishers to guide fish into their nets.

In Kalimantan, in the lower Mahakam River system, Irrawaddy dolphins are recognized as a competitor for food and are chased away from nets by fishers (Tas'an et al. 1980). The dolphins are often observed with wounds on one or both pectoral fins; these are assumed by the fishers to be a result of entanglements with fishing nets.

Feeding

Annandale (1915) observed Irrawaddy dolphins feeding in Chilka Lake. He reported that they often swam quickly towards a rocky shore or outcropping, and at other times swam slowly along the surface in the same area, with the mouth open and the top of the head exposed. He speculated that in this latter case they were feeding on shoals of small crustaceans, Macropsis orientalis. At Pagan, Burma, fishers reported that catfish were the primary food of Irrawaddy dolphins (Leatherwood et al. 1984). The dolphins were reported to feed principally on carp (Cyprinidae) in the lower Mahakam River near Semayang Lake in Indonesia. These studies do not report on the evidence of such claims.

Marsh et al. (1989) and Lloze (1973) provided further information, by listing fish found in the stomachs of the following Irrawaddy dolphins. Two dolphins from the Mekong River in Cambodia were examined by Lloze and found to contain catfish (Pangasius sanitvongsei and Pangasius micronemus) and carp (Puntius javanicus, Cirrhinus auratus, Cirrhinus jullieni, Dangilas siamensis and Thynnichthys thynnoides). From ten Irrawaddy dolphins from the Townsville area, Australia, G. Heinsohn found remains of anchovy (Stolephorus sp.), perforated scale sardine (Sardinella perforata), wolf-herring (Chirocentrus dorab), garfish (Hemirhamphus sp.), Queensland halibut (Psettodes erumei), pony fish (Leiognathus equulus, Secutor insidiator and Leiognathus splendens), cardinal fish (Apogonichthyes sp.), butterfly bream (Nemipterus sp.), silver javelin fish (Pomadasys argyreus), spiny-cheeked grunter (Terapon puta), whiting (Sillago sp.), and flathead (Platycephalus sp.), as well as representatives from the Family Synodonotidae (grinner) and the Order Anguilliformes (eels - Marsh et al. 1989).

Other Behaviours

Surfacing behaviour is described by a few authors. Dawbin (1972) reported that Irrawaddy dolphins swim rather slowly, and Dhandapani (1992) stated that only the melon (top front of head) of the dolphins is visible when they surface quickly to breathe. Gibson-Hill (1950) observed them to be rather sluggish in their movements and to have noisy respirations. Morzer Bruyns (1971) described the dolphins as breathing two, three or five times every 10 seconds, following a deep dive of 20 to 70 seconds, or sometimes up to 3 minutes. He reported that they travel a few hundred metres to almost one kilometre (a few hundred yards to half a mile) per deep dive and are usually quiet, requiring vigilance to be seen. Two isolated individuals observed by S. Leatherwood in captivity at Safari Park, Chantaburi, Thailand, made long dives of 5 minutes 20 seconds and 4 minutes 45 seconds, and during the hour or so each was observed, repeated long dives with only a maximum of 4 quiescent breaths between. A group of eight Irrawaddy dolphins housed at the same facility tended to surface in rough synchrony after diving a maximum of 3 minutes and 20 seconds, although when chased and harassed by Indo-Pacific humpbacked dolphins (Sousa chinensis) sharing the tank, they once dived for five minutes (S. Leatherwood pers. comm.).

In Chilka Lake, Irrawaddy dolphins were frequently observed to swim onto a sand bar at the edge of the lake and to roll around in shallow water. They moved to deeper water if there was any disturbance on shore (Annandale 1915). Morzer Bruyns (1971) observed one Irrawaddy dolphin in a group jump clear of the water.

Morzer Bruyns (1966) has seen Irrawaddy dolphins in the same area with what he reported as Sotalia (now known as Sousa chinensis, Indo-Pacific humpbacked dolphin), but did not see any interactions between the two species. Where the two species are housed together in captivity, humpbacked dolphins are definitely dominant, using the entire pool, while the Irrawaddy dolphins are confined to a small portion (about 20%) of the pool and are frequently chased (S. Leatherwood pers. comm.).

Threats to Populations

Direct Takes

There are no organized fisheries for this species, but isolated instances of directed takes have been reported. Baird (1991) and Baird and Mounsouphom (1994) reported that four Irrawaddy dolphins in Lao P.D.R. were shot by soldiers between 1978 and 1990, in at least one case because the soldiers were apparently unfamiliar with dolphins. Another Irrawaddy dolphin was stoned to death by Lao villagers in 1983 (Baird 1991). In this case, the dolphin was killed in "self-defense" by swimmers who believed the dolphin to be dangerous. Annandale (1915) reported on a practice in Chilka Lake, whereby a man speared dolphins approaching his boat so as to obtain the oil; in India, as perhaps elsewhere, dolphin oil is regarded as a cure for rheumatism and is also used for other purposes (Reeves and Leatherwood 1994). Four or five dolphins still may be killed yearly by hand harpoons in Chilka Lake (Dhandapani 1992, Mohan 1994). B.C. Choudhury (pers. comm.) suggested that in recent years, few dolphins have been killed for their oil, but that dolphins found dead may be used for this purpose.

Overall, the incidence of directed takes is likely low, and would probably not pose a threat to healthy cetacean populations. However, in the case of the Irrawaddy dolphin, any directed takes may have significant damaging impacts.

Incidental Catch

Incidental catches seem to occur throughout the range of Irrawaddy dolphins where net fishing occurs. Andersen and Kinze (1993) reported circumstantial evidence of an increase of incidental catches of cetaceans in general in Thai waters. They determined that at least 15 Irrawaddy dolphins have been incidentally caught in Songkhla Lake, mainly in the shallower portions, in the last five years (Andersen and Kinze 1993).

In the Mekong River, along the Lao/Cambodian border, twenty-five Irrawaddy dolphins are known to have died between 1990 and 1995; at least 13 of these animals were incidentally caught in gillnets (Baird and Mounsouphom 1994, 1995). Occasional incidental catches are reported in gillnets in the Sekong River in Lao P.D.R. as well.

Leatherwood and colleagues conducted a study on cetaceans in the northern Indian Ocean area between 1980 and 1983 (Leatherwood et al. 1984). Besides using vessel surveys and observations, they conducted interviews with scientists and fishers to assess cetacean occurrence and interactions with humans. Dolphins were found to be incidentally caught in gillnets in several locations, including the Irrawaddy River. Irrawaddy dolphins are also occasionally entangled in fishing nets in Bangladesh (Haque 1982).

More than 50 gillnets of lengths up to 500m are used daily in Chilka Lake (Mohan 1994). Incidental catch is a concern (B.C. Choudhury pers. comm., Mohan 1994) but there is no information available on the severity of this problem. During recent boat surveys of the Mekong River in Vietnam, Jefferson et al. (1995) noted at least 250 gillnets, most extending across the entire navigable width of the river, in just 8km of one channel. The authors empathize that these nets, extending from the bottom to a metre from the surface, may be a threat to any dolphins which might still remain in the area.

Irrawaddy dolphins are not known to become caught in prawn nets in the Western Gulf of Carpentaria, despite the proximity of this fishery to the dolphins (Freeland and Bayliss 1989). In a report to the International Whaling Commission, Australia summarized incidental mortality of about 190 dolphins a year, including an unknown number of Irrawaddy dolphins, in barramundi and shark fisheries in its waters (IWC 1987). Irrawaddy dolphins were also taken accidentally in anti-shark nets at the northern end of the Great Barrier Reef (Mitchell 1975).

Other than nets, explosives may also be a hazard. In Lao P.D.R. and Cambodia, bombing raids during the Vietnam war undoubtedly affected the river, killing both fish and dolphins. The present-day Cambodian and Vietnamese practice of illegally fishing with explosives may be having an impact on Irrawaddy dolphins in the Mekong River and its tributaries (Baird and Mounsouphom 1993, Anonymous 1994, Baird et al. 1994, Jefferson et al. 1995) but the effects have not been quantified. Based on the above reports, incidental catch in gillnets is a concern for the conservation of Irrawaddy dolphins.

Live-Capture for Display

There are no Irrawaddy dolphins known to be in captivity in countries other than Thailand, Japan, and Indonesia. At least one was formerly held at Cairns Oceanarium in Australia (Mitchell 1975). To supply Gelanggand Saniudra (Jaya Ancol Oceanarium) in Jakarta, Indonesia, 16 Irrawaddy dolphins were removed from Semayang Lake, Kalimantan; six in 1974 and 10 in 1978 (Tas'an and Leatherwood 1984). One of these dolphins was subsequently housed at the Surabaya Zoo, Indonesia. In 1984, six more dolphins were captured in the Mahakam River system by the oceanarium (Wirawan 1989). As of 1 April 1995, only two of these animals were still alive (S. Leatherwood pers. comm.).

Thailand has two captive display facilities containing Irrawaddy dolphins, Oasis Seaworld in Laem Sing, and Safari World in Min Buri. Other Irrawaddy dolphins caught in nearby waters have been housed in abandoned shrimp farm ponds in Laem Ngop where they awaited sale to oceanaria. Dolphins held there became a profitable attraction for the broker, who charged people to view them. However, this illegal operation was closed down after complaints by local residents (Smith 1991, M. Andersen pers. comm.). Reportedly, as of 1 April 1995 only two dolphins remained at Laem Ngop (S. Leatherwood pers. comm.). Eight Irrawaddy dolphins caught during net fishery operations in late 1994 were removed from coastal waters of Cambodia and transported to Safari World in Thailand (S. Leatherwood pers. comm.). In March 1995, Safari World exported two Irrawaddy dolphins, a female and a male, to Marine World, Fukuoka, Japan (S. Wakisaka pers. comm.).

Habitat Degradation

The current or potential sources of habitat degradation that potentially affect Irrawaddy dolphins include: dams, declining food sources, pollution and sedimentation of lakes. There are no documented cases in which Irrawaddy dolphins have been affected by dams or barrages, but plans to construct hydro-electric dams in Lao P.D.R. and Cambodia could fragment populations and affect their habitats and food supply. Roberts (1993) has reported that fish stocks have declined since 1970 in the Hang Khone area of Lao P.D.R. These declines have been proceeding so rapidly in the 1990s, that the fishery is reportedly now only about 20% of what it was in 1970 (Roberts 1993). Fishers in the area believe that the reasons for this decline are an increase in number and quality of fish traps and gillnets in use and, most importantly, Cambodian fishers' use of explosives. A letter sent to Cambodian officials in 1993 by the Lao government, voicing concerns about fishing with explosives, resulted in the Cambodian Prime Minister's promising that efforts would be made to better enforce that country's laws prohibiting this practice (Baird and Mounsouphom 1993, Casey 1993). Upstream activities (such as dam construction, industrial waste disposal, and use of pesticides) that contribute to the deterioration of the Mekong basin may also play a role in the present condition of the fisheries of the area (Roberts 1993).

Villagers in Kalimantan reported that Irrawaddy dolphins had stopped moving towards the mouth of the Mahakam River, possibly because of increased industrial activity in the region (Tas'an et al. 1980, Tas'an and Leatherwood 1984), although this cause cannot be determined with certainty. In this same area in 1984-1985, dolphins were found with skin disease; all six of the Irrawaddy dolphins caught in August 1984 by Gelanggand Saniudra appeared to have been affected (Wirawan 1989), although no supporting evidence is given. Wirawan (1989) suggested that the outbreak may have been triggered by water chemistry changes in the lower Mahakam, following an extensive forest fire there in 1983. The lower Mahakam River area is becoming more densely populated, in part because of a federal program to translocate people from such heavily populated areas as Java (Wirawan 1989). Also, increased boat traffic and the potential for oil pollution due to oil exploration in the area are cited as possible threats to Irrawaddy dolphins (Wirawan 1989).

Dhandapani (1992) discussed the environmental changes that have taken place in Chilka Lake, possibly contributing to the decline of Irrawaddy dolphins there. Over the past decades, deposition of silt carried primarily by the Mandakini, Daya, Nuna and Bhargavi Rivers has transformed several hectares of the northern section of the lake into mudflats and wetlands, some of which is used for agriculture. The author also speculates that the other margins of Chilka Lake have become too shallow to be accessible to dolphins (Dhandapani 1992). In addition, the river mouth has silted in, possibly barring dolphins access to the ocean (B.C. Choudhury pers. comm.). The salinity of the lake is also increasing, as the flow of freshwater into it has decreased due to water diversions for agriculture (B.C. Choudhury pers. comm.). This is also the case at the mouth of the Ganges River, with the result that salinity in the Sundarbans in India and Bangladesh has increased (B.C. Choudhury pers. comm.). Songkhla Lake in Thailand is experiencing changes similar to those in Chilka Lake; a reduction has been seen in dolphins' access to the margins of the lake (M. Andersen pers. comm.).

Habitat destruction from trawling and depletion of food supplies are cited as potential problems in the Western Gulf of Carpentaria

(Freeland and Bayliss 1989). This is also a major problem in Thailand, where the coastal habitat throughout the Gulf of Thailand has been damaged by poor fishing practices, especially trawling, and destruction of mangrove forests (Woolman 1992). Many of these described habitat changes are qualitative observations, and while they may generally characterise the situation, care must be taken in drawing specific conclusions.

Protection Measures

Cultural

Irrawaddy dolphins are afforded some degree of protection from direct takes by cultural prohibitions against killing them in Bangladesh (Haque 1982), Lao P.D.R. and Cambodia (Baird et al. 1994), Thailand (Lekagul and McNeely 1977), Burma (U Tin Thein 1977), and Indonesia (Wirawan 1989). Cultural protection may also exist in Vietnam (Jefferson et al. 1995) and possibly other countries within the dolphin's range. Some people in these countries believe that dolphins rescue drowning people, and protect them from potentially dangerous river animals such as crocodiles. Stories exist of dolphins assisting fishers with their work.

Partly for these reasons, fishers are often willing to free Irrawaddy dolphins from their fishing nets, even at risk of damaging the nets. If the dolphins can't be released alive, however, the carcasses may be used to provide oil, bile and bones for medicinal purposes (Haque 1982, Leatherwood et al. 1984). In summary, intentional mortality appears minimal and most deaths in fisheries are accidental.

Legal Considerations

Several countries whose waters are home to Irrawaddy dolphins have legislation pertaining at least indirectly to this species. In Lao P.D.R., it is illegal to hunt, capture or trade Irrawaddy dolphins (TRAFFIC Southeast Asia 1993, Baird et al. 1994). In 1991, some citizens were arrested for an incident in Lao P.D.R. in which four dolphins were killed (TRAFFIC Southeast Asia 1993).

In India, the Irrawaddy dolphin is listed on Schedule I of the Indian Wildlife Act of 1972. The consequence of prosecution for killing or harming one of these animals is two months imprisonment and/or a fine (Mohan 1994). Apparently locals are afraid of fines associated with being caught with a dead dolphin, but in fact, the regulations do not include possession of dolphin oil (R.S. Lal Mohan pers. comm.). Incidental catch of marine mammals, including Irrawaddy dolphins, is recognized as a problem by the governments of Orissa and West Bengal in

India (James et al. 1989). Remedial measures aimed primarily at sea turtle conservation, such as hauling in fishing gear at frequent intervals, are also helpful to small cetaceans. Further management and conservation policies were being considered by India (James et al. 1989). The Zoological Survey of India has identified Chilka Lake as an area in need of conservation; accordingly surveys and inventories, including those for Irrawaddy dolphins, took place from 1985 through 1987 (Dhandapani 1992).

The Irrawaddy dolphin has been a protected species in Indonesia since 1975 (Wirawan 1989). Hunting and killing are prohibited. In Australia, Irrawaddy dolphins are covered by general protection of cetaceans, but live-captures have been allowed under permit (Klinowska 1991).

Protected Areas

There are no areas protected specifically for Irrawaddy dolphins, nor are there other protected areas that the species inhabits. Areas around Semayang Lake, Kalimantan, have been proposed for National Park status, for reasons including the protection of dolphins (Wirawan 1989), but as of 1995 no such parks had been established. Muara Kaman Nature Reserve, a swamp area adjacent to the Mahakam River, is reported to be a spawning area for Irrawaddy dolphin prey (Wirawan 1989).

The northern portion of Songkhla Lake in Thailand was scheduled to become a Ramsar site at the end of 1995. This official designation could be a vehicle for efforts to protect dolphin habitat. International pressure could be effective in Thailand to enforce the Ramsar requirements (M. Andersen pers. comm.). Chilka Lake in India is already a Ramsar site; nonetheless dolphin numbers are said to be declining (Mohan 1994). Protective designations for critical habitat will be an important component of any informed conservation strategy for Irrawaddy dolphins.

Captive Breeding

There has been no captive breeding of Irrawaddy dolphins specifically for the purposes of conservation. Wirawan (1989) concluded that the prospects of successful captive breeding at Gelanggand Saniudra were slim, but did not elaborate. Two Irrawaddy dolphin calves have been born at this institution. Of 22 dolphins captured between 1974 and 1984, six were still alive in 1985 (Wirawan 1989) and two in 1995 (S. Leatherwood pers. comm.). Despite these statistics, this profit-oriented enterprise has laid the groundwork for learning about Irrawaddy dolphins in captivity. This knowledge may be valuable for any efforts to use captive breeding as a conservation tool. Dhandapani (1992) suggested that captive breeding facilities be set up at Chilka Lake, to ensure the conservation of Irrawaddy dolphins at that location.

Tourism

Although listed here under protection measures, tourism could also be viewed as a possible threat to Irrawaddy dolphins. Wirawan (1989) mentioned the potential for including dolphin watching in existing tour packages that bring tourists to the Mahakam River. He also advocated the construction of an "oceanarium" along the Mahakam River, so that dolphin watching could supplement the current tourism experience. In his view, the oceanarium could also serve as a captive breeding centre for conservation and display purposes, and as a research unit. He also suggested that dolphins could be transported to this facility with less stress and therefore more success than to Jakarta. This proposal for removing dolphins from their natural habitats to oceanaria deserves very careful evaluation. The argument can be made that by removing animals from the wild removes some of the incentive for protecting the habitat, thereby rendering captive breeding ultimately futile.

Mohan (1994) suggested that Irrawaddy dolphins of Chilka Lake be promoted by the Tourism Department of India. He maintains that dolphin-based tourism would create a heightened awareness among the local people and encourage them to protect the dolphins if they benefited from the tourism. Villagers at Hang Khone, Lao P.D.R., have prepared for increasing tourism by establishing rules governing the number and behaviour of dolphin-watching boats.

SUMMARY

Five main areas of Irrawaddy dolphin concentration have been identified. In order of decreasing dolphin abundance, they are (estimated population size in parentheses): 1. Western Gulf of Carpentaria, Australia (1000+); 2. Songkhla Lake, Thailand (100-200); 3. Semayang Lake, Indonesia (100); 4. Mekong River between Hang Khone, Lao P.D.R. and Stung Treng, Cambodia (75); 5. Chilka Lake, India (20). Knowledge of distribution and abundance is far from complete, but this does suggest that the species' numbers are dangerously low. The most pressing conservation issues affecting the survival of Irrawaddy dolphins are habitat degradation and incidental catch. The species is fairly well protected, legally and culturally.

Research on Irrawaddy dolphins is not extensive, thus the animal remains relatively little known. The field study presented in the next chapter contributes significantly to the knowledge about the species.

Chapter Three

FIELD RESEARCH ON IRRAWADDY DOLPHINS IN THE MEKONG RIVER, Lao P.D.R.

INTRODUCTION

In the previous chapter, I reviewed what is known of Irrawaddy dolphin distribution, abundance, behaviour and biology and assessed the status of the animal in terms of threats and conservation concerns. I consider the field study described in this chapter valuable in contributing to this pool of knowledge about Irrawaddy dolphins. The study area, the Mekong River along the Lao/Cambodian border, was chosen for its history of reliable sightings during the dry season. In this chapter, I present information about the species based on this field study: details on surface and dive behaviours; habitat use; grouping characteristics; and diurnal behaviour. This study of Irrawaddy dolphins is comprised of observations from shore, a pilot photo-identification project, and habitat description.

Specifically, three research questions direct this study: 1. What is the spatial distribution of the dolphins in the study area and how does this correspond with dominant habitat features; 2. How do dolphin behaviours correspond to habitat features and boat presence; and 3. Can Irrawaddy dolphins at this study site be individually identified through photo-identification.

In making land-based observations, I was able to avoid potential data bias originating from the presence of a research boat, and was able to compare dolphin behaviour with and without boats in the vicinity. Many researchers have questioned whether vessels have impacts on cetaceans (e.g. Würsig et al. 1985, Duffus 1988, Stone et al. 1992, Blane and Jaakson 1994), but no studies have been carried out with Irrawaddy dolphins. Other data I collected were on ventilation rate and surface behaviours. Cetacean ventilation rates have been the subject of many studies, for instance, to provide information for census surveys (Leatherwood et al. 1982, Zhou and Li 1989), on feeding (Dolphin 1988, Kopelman and Sadove 1995), and behavioural states (Chu 1988). Surface behaviours can also be indicative of behavioural states. Diurnal activities, which are an important consideration in population assessments, are discussed in Klinowska (1986) and Bräger (1993). Descriptions of habitat and habitat use as described in my study are particularly important for conservation purposes (Smith 1993).

Photo-identification has been used as a tool for individual recognition for many animal species including cetaceans (Würsig and Jefferson 1990). Photo-identification involves photographing animals to obtain a record of markings to individually identify the animal. Results can provide information on group structure, site fidelity, movement patterns, and population size, and, over the long term, descriptions of life history parameters (Würsig and Jefferson 1990).

The Study Area

Lao P.D.R. is a tropical, land-locked, mountainous country located almost entirely within the lower Mekong Basin. Natural resources such as forests, hydropower and minerals have a high potential for future industrial development (Inthavong et al. 1992). The country has a low population density, with a total of about four million people, more than 60% of whom live in the valleys of the Mekong River system (Inthavong et al. 1992). Eighty-five percent of the population lives outside of urban areas. Agricultural production, including fisheries, contributes nearly 60% to the GDP (Inthavong et al. 1992).

The Mekong River, which has its beginnings in the Tibetan plateau, flows 4200km through Southeast Asia before emptying into the South China Sea. On its journey, the river passes through China, Burma (Myanmar), Thailand, Lao P.D.R., Cambodia (Kampuchea) and Vietnam. The Mekong River is described as one of the cleanest in the world, due to the relatively "underdeveloped" state of most sub-basins in the lower Mekong basin, especially those located in Lao P.D.R. (Mekong Secretariat 1992). The water quality is described as "quite good" and not significantly affected by human activities (Inthavong et al. 1992), although this will likely change as development continues. Water from the Mekong River provides for household and municipal usage, and is economically important for fisheries, navigation, and to a lesser extent, hydropower (Inthavong et al. 1992). It is very likely that increasing investment will go into the production of hydro-electricity for export, particularly to Thailand where there is a large demand. There is little water used for agricultural irrigation in Lao P.D.R.

Lao P.D.R. is under the influence of the seasonal tropical monsoons, and is subject to the accompanying extreme variations in environmental conditions. The southwest monsoon occurs mainly between mid-May and mid-September or early October, and brings regular, heavy rainfall (Mekong Secretariat 1992). The northeast monsoon, characterized by dry conditions, occurs between mid-October or early November, and March. These two distinct seasons are separated by short transitional periods. My field study was undertaken in March and April, during the transition between the dry and wet seasons. The average annual amplitude of variation in water flow of the Mekong river is large, as seen at Kratie, Cambodia, where flow increases from 1,764m^3/sec in the dry season to 52,000m^3/sec during floods (Pantulu 1973). The continual scouring by floods has produced pools in many locations along the river, including one at my study site. Some pools reach several kilometres in length and depths of over 50m (Pantulu 1973).

As the Mekong River flows from Lao P.D.R. into Cambodia, it delineates the border between the two countries for a distance of approximately 10km before continuing through Cambodia towards the South China Sea. Along this 10km stretch of river are several villages, including the Lao villages of Hang Khone and Hang Sadam, situated at either end of a pool on one of the main channels of the Mekong. Hang Khone and Hang Sadam are small fishing villages located on adjacent islands. In 1993, Hang Khone had a population of about 222 people in 42 households; Hang Sadam's 76 families comprised about 386 people. About 90% of the families are engaged in fishing as their primary occupation (I.G. Baird pers. comm.). The widening of the river channel into a pool at this point, from, in the dry season, a width of 100m to approximately 600m, is locally called Boong Pa Gooang (13°56'N, 105°56'E) and comprises the study area (Figure 2). The Lao/Cambodian border runs through the middle of this pool. Due to the political situation in this border area, opportunities to travel up- and down-river or to venture across the border at the study site into Cambodia were limited during my field work. For this reason, much of the data was collected from the Lao shore.

About three kilometres upstream from Boong Pa Gooang, in Lao P.D.R., are the Lee Pee or Khone Falls. This series of waterfalls is about 8km wide and spans all of the numerous islands and river channels of the Mekong River at this point. Many fish species can travel past these falls (Roberts 1993). One record of Irrawaddy dolphins above Khone Falls is discussed in Baird and Mounsouphom (1994). According to residents of Don Dtan, a group of dolphins was seen daily near the village, just above the falls, for about one month during a high-water season in the 1960s. Irrawaddy dolphins are apparently not known by villagers living north of Don Dtan village.

Roberts (1993) discussed fishes and fishing methods in the Hang Khone area. He described the region as being one of the most important inland fisheries in Southeast Asia, supplying southern Lao P.D.R., and even northeastern Thailand from the markets in the Thai city of Ubon Ratchatani. The abundance of fish was attributed to the variety of habitats in the area, especially the rapids below the waterfalls. Roberts identified 93 fish species in a two-week study in June and July

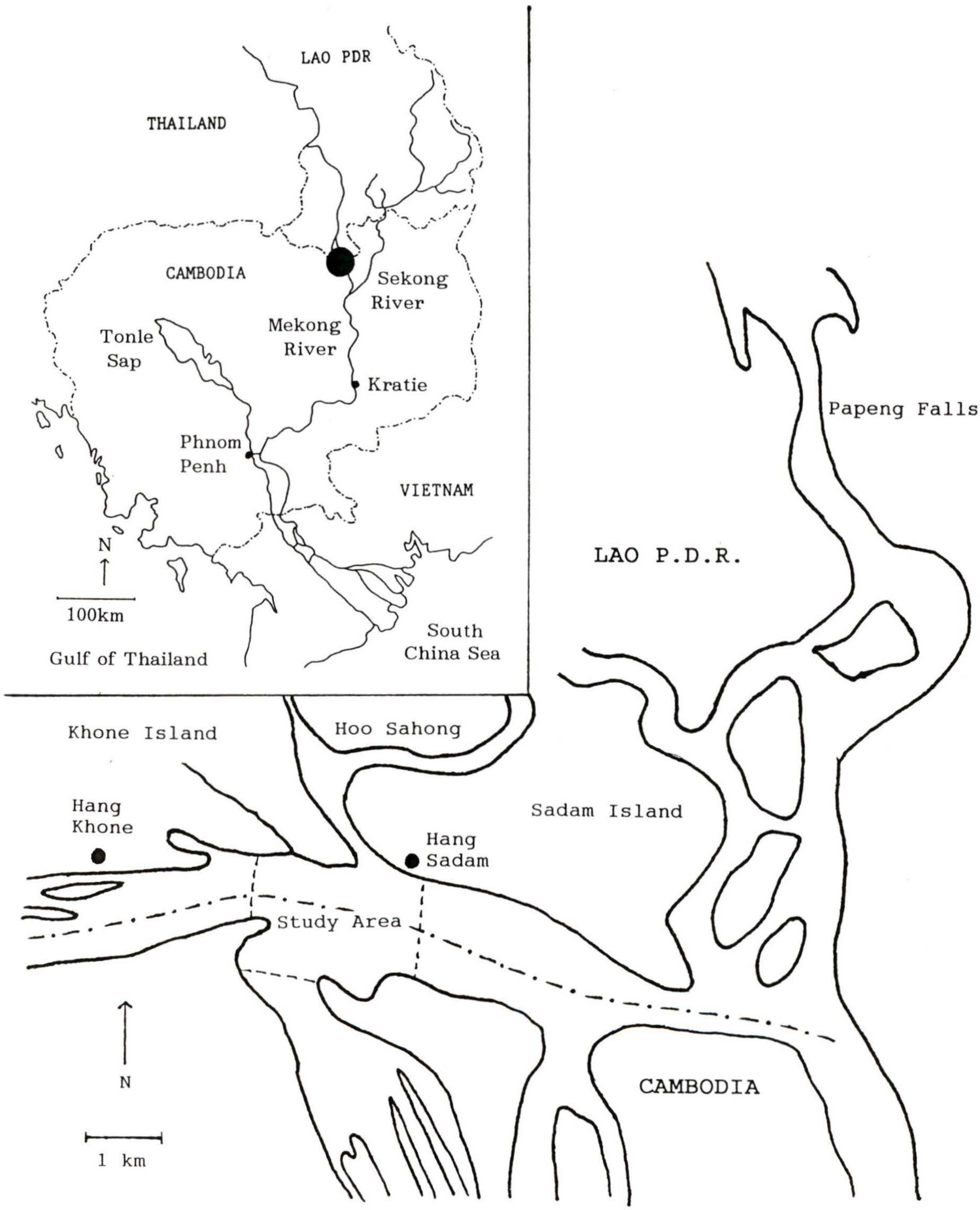

Figure 2. Map of study area with inset showing location within Indochina.

of 1993; he regarded this as perhaps less than one fourth of the total diversity in the local area. More than 850 fish species have been identified in the Lower Mekong Basin (Pantulu 1986). Three main fish migratory periods were identified based on interviews with locals: roughly late January-February; May-July; and November-December (Roberts 1993). In July-October, when water levels are high, many fish species move into the accessible forest, feeding on invertebrates, seeds, fruits and leaves. Fish were found to be caught by a variety of fixed and moveable traps, gillnets, hooks and spears depending on the target species and season (Roberts 1993).

METHODS

I made preliminary visits to the study site May 7-19 and June 21-25, 1993 to become familiar with the area, and assess the possibilities and limitations of the study. I collected the data used in the analyses from March 25 to April 21, 1994. To identify the location of dolphins and vessels, my field assistant and I made daily observations from shore using a field map of the study site, divided into 46, $100m^2$ quadrats, (Figure 3). The map was hand-drawn over a $100m^2$ grid; distances were estimated while scouting from shore and from a boat. A group of dolphins would typically surface within an area of this size, making it a good unit of analysis. Data collection was undertaken from the balcony of a house along the bank of the Mekong river, on the outskirts of the village of Hang Sadam. The house was approximately 15m above the water level and the main river channel about 100m from the bank during this low-water season. The main channel of the Mekong River flows through the study site from west to east from quadrats 23 and 30 to quadrats 1, 7 and 15 (Figure 3).

Habitat Parameters

I measured water depth, temperature, and flow rate of the water current in the study site. Fifty-six measurements of water depth were taken on March 30 and 31, in 29 quadrats. All the quadrats in Lao P.D.R. and a few in adjacent Cambodian waters were measured. Two measurements were taken in each quadrat, except in two quadrats where only one measurement was taken. A weighted line with marked 1m intervals was used; we made further measurements to the nearest cm with a tape measure at the time. While measuring water depth, we lowered a thermometer to a depth of 1m to determine water temperature. The water current in the study site was measured opportunistically by the rate of drift of a large tree stump on April 8. Other attempts using smaller objects, including the research boat, were unsuccessful due to the slow speed of

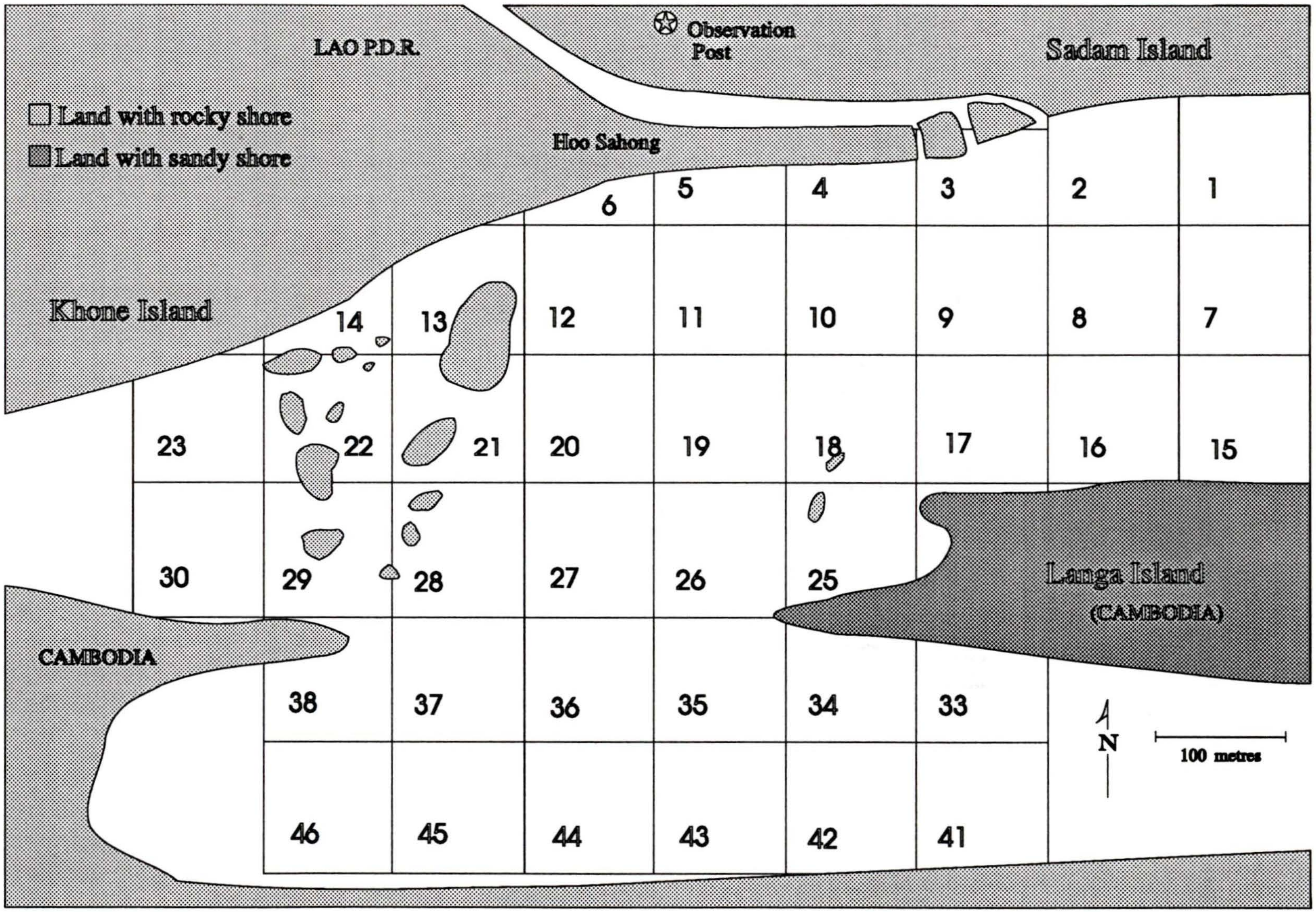

Figure 3. Field map of study site showing numbered quadrats and habitat description.

the current. We also measured current speeds in a narrow channel emptying into the river at the study area, and in a channel entering the main river below the study area. These measurements were obtained by repeated timing of sticks thrown into the centre of the channel travelling a set distance. We made notes on the physical and biotic features of the riverbank to provide a further description of habitat.

Dolphin Observations

One or two people scanned the water continuously for dolphins, every five minutes using binoculars to view the far reaches of the study site. Two binoculars were available, a Nikon 8 x 35 and a Swift 8.5 x 44. Village residents coming by to visit sometimes informally joined in the search. We recorded degree of cloud cover and water surface conditions, regardless of dolphin presence, at the beginning of the observation period, every hour on the hour thereafter, and when we noticed a marked change in conditions (Appendix III).

When dolphins were sighted, further information was collected. A group of dolphins was defined as those animals not more than 100m from another dolphin. At times, there was more than one group in the study area. If groups were too far apart to observe simultaneously, we collected detailed data on the closest group, and general information about the other(s). A new "group" was designated when the number of animals in the group changed, or when a group of animals reappeared after being out of sight for more than ten minutes. Dolphins typically surfaced two or more times in quick succession and then dove for a longer duration. The period between dives was defined as a surfacing run. The unit of analysis was a surfacing run followed by a dive. Since we could not distinguish one dolphin from another, and thus measure individual animal dive duration, we measured group dive duration, the time from the disappearance of the last dolphin to the emergence of the first after a dive.

When dolphins were detected, one person observed with binoculars and dictated while the second recorded the information onto a data sheet (Appendix III). The quadrat location (Q), was defined as the quadrat where the majority of the dolphins in the group surfaced. Using a digital watch, the time to the nearest second of each dolphin's surfacing was recorded. A typical surfacing involved the appearance of the top of the head and blowhole followed in a rolling motion by the back and dorsal fin. If an activity other than a typical surfacing occurred, this was noted. Appendix IV lists codes and definitions used in recording data. Also recorded were the direction of travel (D), total group size (T), cohesiveness (C) and whether all ventilations were accounted for (R) were recorded for each surfacing run. A line was drawn to connect (R) columns to indicate when ventilation times were continuous between surfacing runs and could later be used to measure dive time. At the beginning of each surfacing run, a new row on the data sheet was used. Additional comments were sometimes recorded on the data sheet. When only one person was available to collect data, only quadrat locations and the starting time of surfacing runs were recorded. If a vessel came within 100m of any dolphin, we recorded the time when the two were 100m apart, the boat type and estimated speed, and the time when the vessel was 100m away again. This distance was chosen arbitrarily.

After the field season, data were entered into SPSS for Windows 6.0, a software package for data management and statistical analysis. Variables entered were: record identification number; date; cloud cover; wind speed; group identification number; group size; time first animal in group surfaced after dive; quadrat; direction; cohesiveness; time last animal in group submerged for dive; number of surfacings during surfacing run; calculated dive length; boat type (if present); boat speed; whether or not dolphins surfaced within 100m of boat; and list of surface activities.

The information obtained from shore observations was employed to examine relationships between the dolphins and their environment. To examine these relationships, correlations between grouping characteristics, habitat parameters, vessel traffic, surface activities and diving were analyzed. Results of all statistical analyses were considered significant at $p < 0.05$.

Vessel Observations

To provide a picture of human activities, I recorded vessel traffic when dolphins were absent. For each vessel, I estimated the path taken through the study site, the time of entry, time of exit, type of boat, and speed. I also noted associated activities such as fishing or log transport.

Several types of boats were seen in the study area. Most common were narrow, native wooden boats, about 4-5m in length, some propelled by paddles (termed paddle boats) and some outfitted with 5, 8 or 11hp, long-tailed outboard engines (referred to as small motor boats). Many families had one of these types of boat for fishing and transportation. The other type of vessel in the area was larger, about 10-12m, and had an inboard engine (classified as large motor boats). This type of boat was used to tow logs or to ferry groups of people. Paddle boats were always classified as going slowly. Motor boats were judged to be going at a relative medium or fast pace.

Photo-identification

Photo-identification was conducted opportunistically on portions of 16 days when dolphins remained relatively stationary on the Lao side of the river. The shore-based research platform was abandoned in favour of a 4m native wooden boat, with no outboard engine. While the person in the rear of the craft used a paddle to attempt to gain a position near the dolphins, the person in front used a Canon EOS 630 SLR auto-advance camera with a date back and 100-300mm lens to photograph them with black and white Neopan 1600 ISO film. Photographs were taken of either side of the back and dorsal fin area. For analysis, contact sheets, and 4" X 6" prints of the more promising photographs, were examined for unique dolphin markings under an 8-power magnifying loupe, as suggested by Würsig and Jefferson (1990).

RESULTS

Habitat Description

Fifty-six measurements of water depth in the study area ranged from 5.0 to 35.4m (Figure 4) with a mean depth of 18.4m. Water temperature was consistently 31°C. The current speed measured in the main channel was 0.15m/s. Approximately two km downstream, a small tributary, Papeng Channel, about 60m wide, had a current speed of 1.66 m/s just above the main river. This location is approximately 8 km downstream of Papeng Falls (Figure 2). A small paddle boat was seen having difficulty navigating out of the channel. Whirlpools and back eddies were apparent. The current speed of the river channel near Hang Sadam, called Hoo Sahong, (Figure 2) was 0.75 m/s near its mouth.

Roughly 70% of the shoreline shown in Figure 3 (excluding the small islands) was solid rock with sparse vegetative cover in small pockets of sand. The remainder, Langa Island, was the exception, being sandy, with no vegetation along the present water-line. In both habitats at the height of the rainy season, the water level would extend up to or beyond the shrubs and trees growing higher along the river bank.

Dolphin Occurrence

We observed dolphins from the riverbank for 210 hours 58 minutes over 26 days and recorded 2,333 surfacing run/dive sequences by 251 groups of dolphins. Dolphins were present in the study area an average of 52% of each day (range = 16.2 - 96.2%). To determine sighting frequency, daylight hours were broken into 15-minute blocks, beginning at 0545 hours, with the last block ending at 1815 hours. Each block was

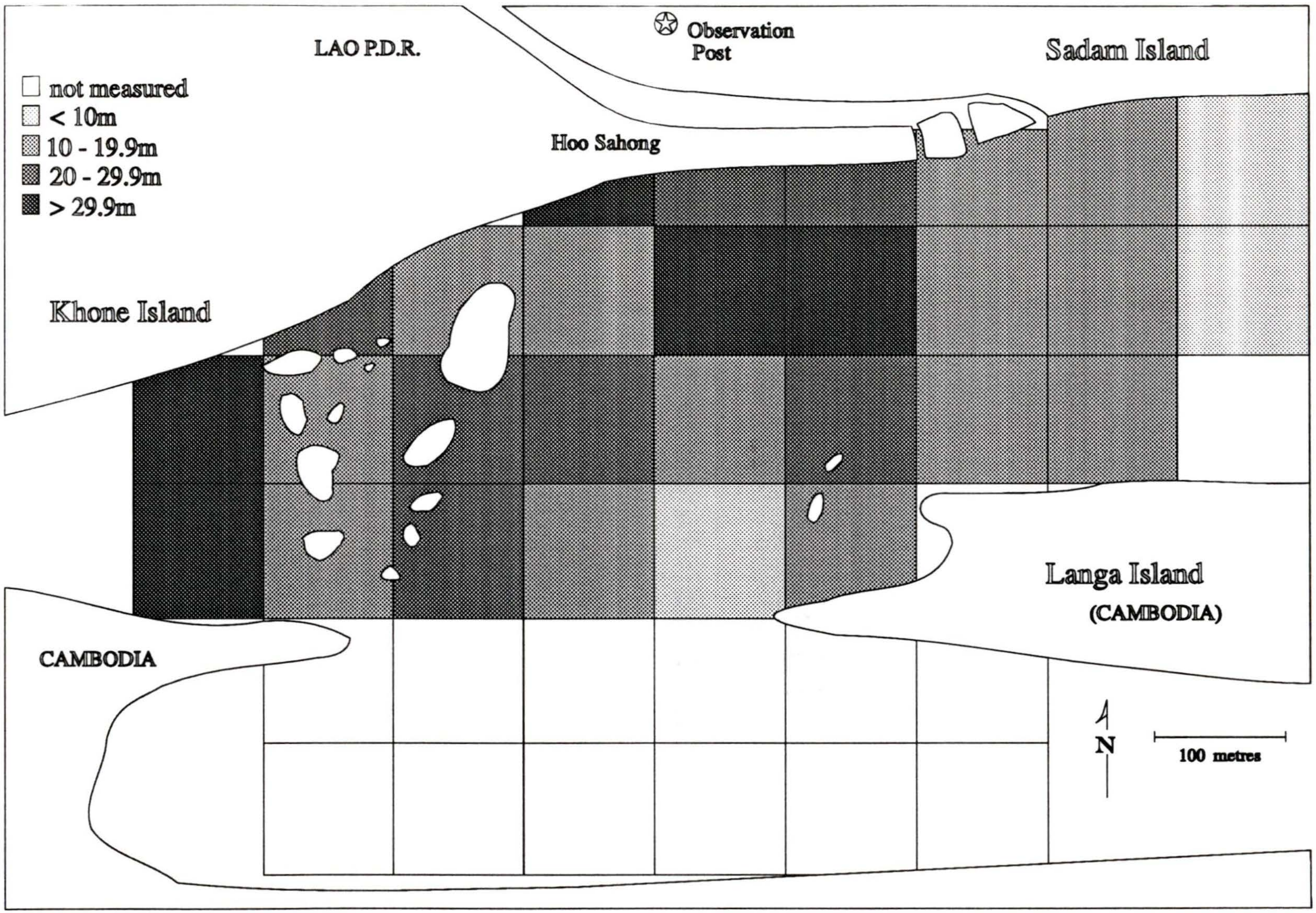

Figure 4. Map of mean water depth in the study area.

assigned to one of three categories: "1" dolphins present; "2" dolphins not present; or "3" not watching. A block was assigned a "1" if any dolphins were seen at all during that 15 minutes. Sighting frequency decreased from dawn to dusk (Spearman's rho = - 0.678, $p < 0.001$, $R=0.66$; Figure 5).

Habitat Use

On 44 occasions I was able to determine from which direction, upstream or downstream, dolphins entered the study site. They arrived from downstream in 39 instances (89%) and from upstream on five occasions (11%). On departing from the study area, dolphins were observed to leave swimming downstream on 21 occasions (55%) and upstream 17 times (45%). There were an additional 66 entrances and 53 departures where I could not determine direction. Upon entering, dolphins remained in the study area, rather than proceeding through. Only once did dolphins enter the study area from one direction (downstream) and continue steadily across the study site (disappearing upstream). On the two occasions when we observed dolphins in Hoo Sahong, they did not venture far up the channel, instead remaining within sight until they returned to the main river.

To examine the spatial patterns and habitat use, I calculated the total number of surfacing runs seen during the study for each quadrat. To compensate for unequal quadrat sizes, I multiplied the number of surfacing runs in partial quadrats by the percentage of the full quadrat area. Numbers were rounded to full integers. The results range from 0 to 300 surfacings per $100m^2$ (n=41, mean=58.2, median=20.0, mode=0). Figure 6 shows the relative use of each quadrat. The highest use quadrats span the main river from near the channel mouth (rocky shore) to Langa Island (sandy shore - Figure 3). Using the adjusted number of surfacings per quadrat, I calculated water depth preference in the 28 quadrats I had obtained such measurements by determining the number of surfacing runs per quadrat (Figure 7). Irrawaddy dolphins were seen most frequently in depths of 15-19.9m.

Dive Duration

I was able to calculate the duration of 277 group dives. The mean dive duration was 115.3 seconds (SD=59.1, minimum = 19, maximum = 430.8 [7.18 minutes]). To investigate whether dolphin groups of different sizes dove for varying lengths of time, I conducted a one-way analysis of variance (ANOVA) to test the null hypothesis that mean dive duration is the same for all groups. Although most assumptions required by this test (each group is a random sample from a normal population and the

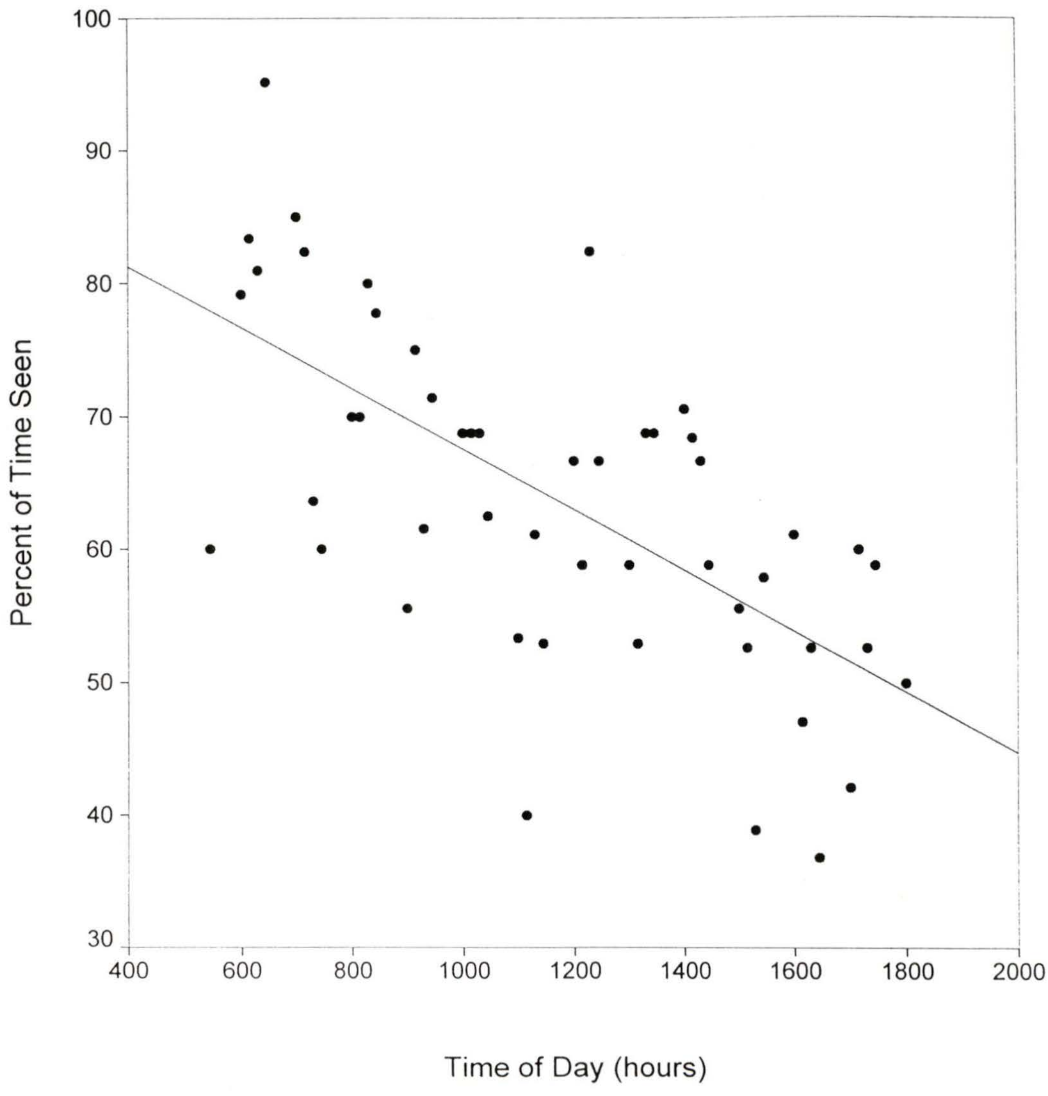

Figure 5. Scattergram showing that the sighting frequency of dolphins decreased from dawn to dusk.

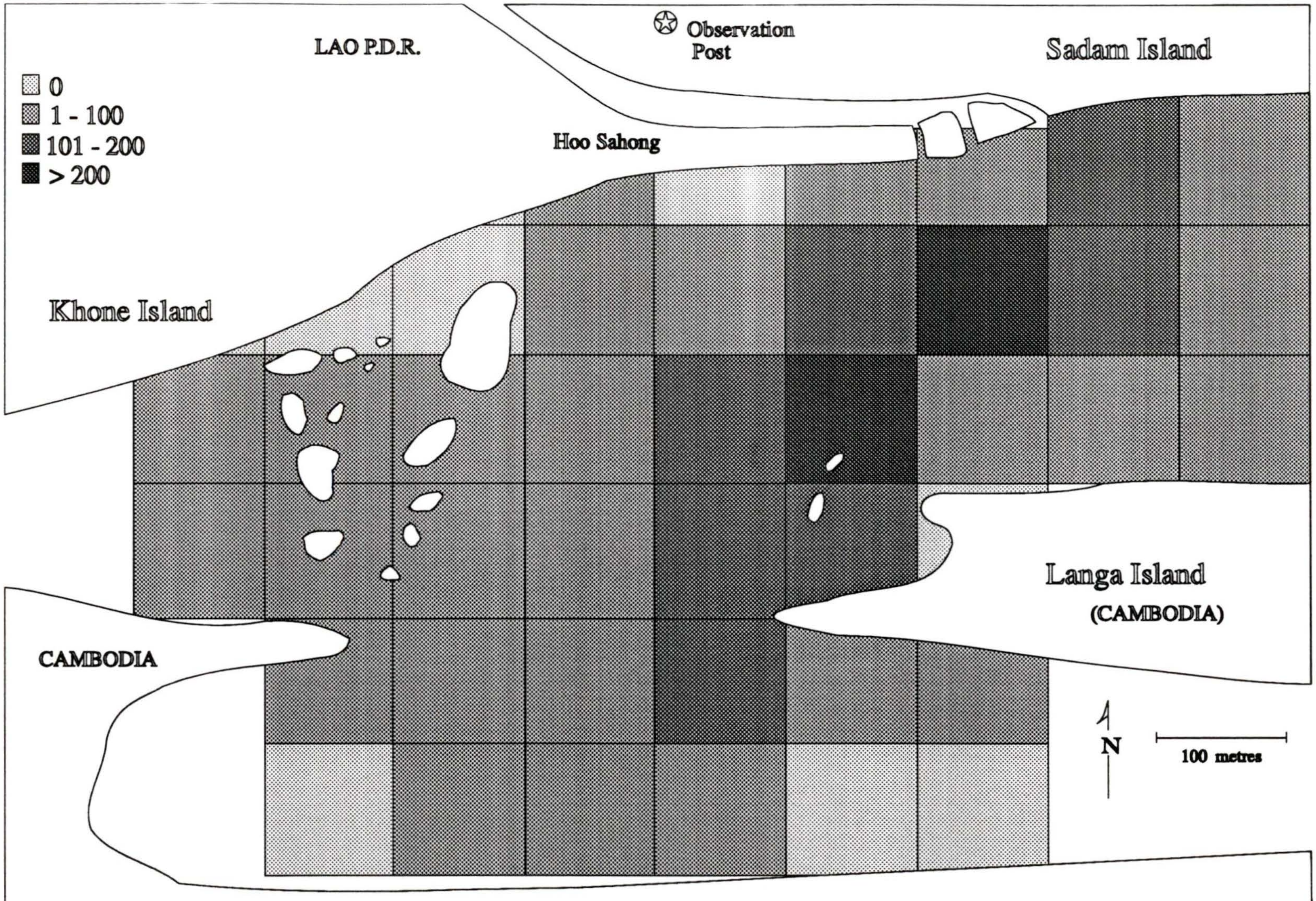

Figure 6. Map of dolphin usage of the study area showing number of surfacing runs.

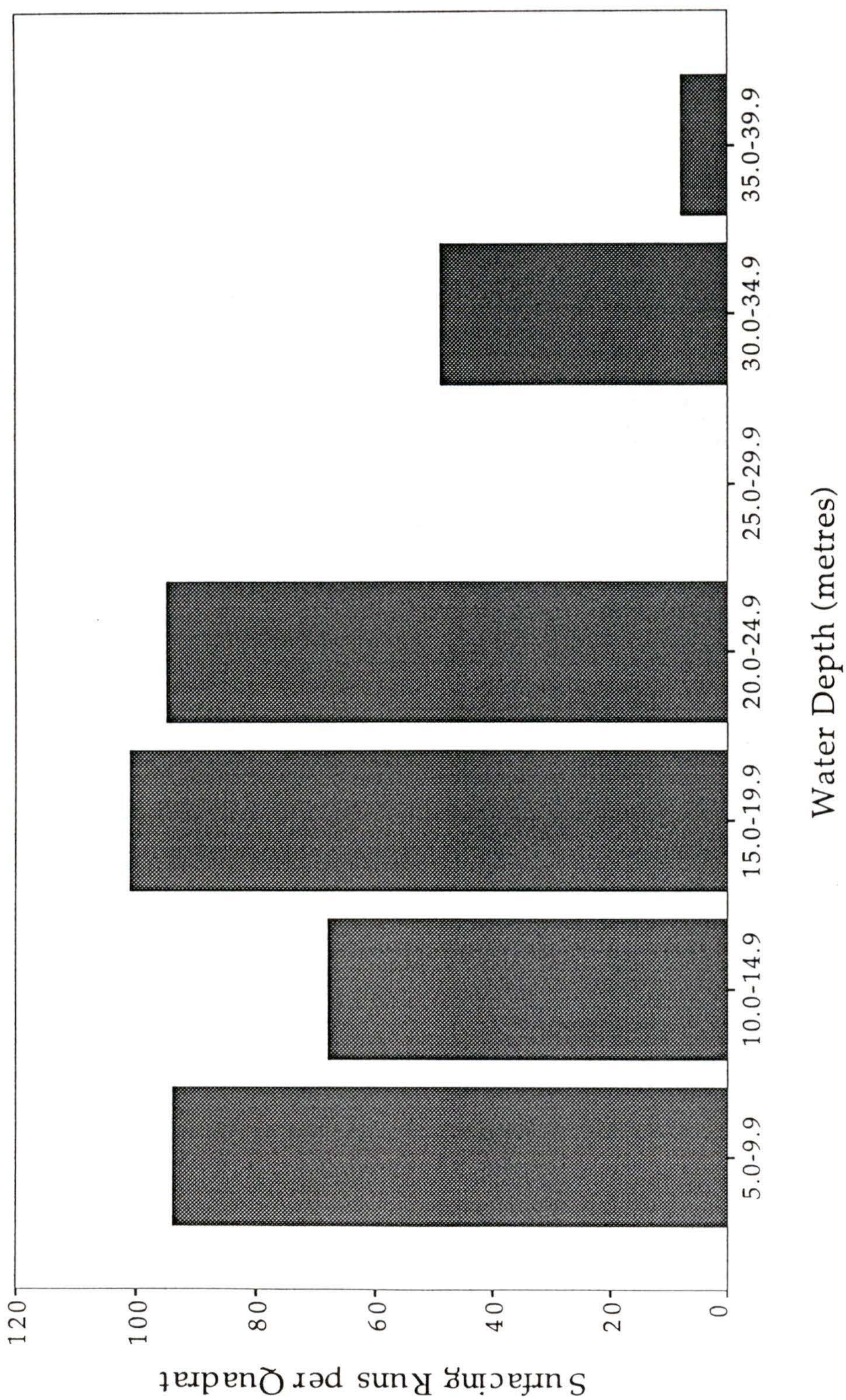

Figure 7. Histogram of number of surfacing runs per quadrat in water depths of 5-metre intervals.

variances of the groups are equal - Norusis 1993) are met, all samples are not independent. However, the F-test is robust enough withstand all but the most serious deviations from the assumptions (Zar 1984). To compensate for small sample sizes in some groups (Table 1), I combined group sizes of 1 and 2, and 5, 6 and 7. The test results indicate that the null hypothesis is accepted at the 95% probability level (F=2.53, df=3, p=0.057). I concluded that there is little difference in mean dive durations for different group sizes.

Table 1. Mean dive duration (seconds) in relation to group size.

Group Size	Mean	Number of Dives
1	133.6	11
2	115.7	42
3	127.3	78
4	112.8	77
5	96.5	62
6	165.7	3
7	128.5	4

Several studies have suggested that the presence of boats may affect the behaviour of cetaceans, particularly diving behaviour (e.g. Stone et al. 1992). I used a one-way ANOVA to test the null hypothesis that diving durations were similar regardless of boat presence. This hypothesis was rejected. When no boats were within 100m of dolphins, mean dive duration was significantly shorter than when boats were present (F=10.17, df=1, p=0.002: Table 2) Sample sizes were inadequate to test for differences between boat types or speeds.

Table 2. Mean dive duration (seconds) in relation to boat presence.

Category	Mean	Std Dev	No. of Cases
no boats present	110.6	59.2	236
boats within 100m	142.0	51.5	41

To analyze the relationship between dive duration and water depth, categories of <10m, 10-19.9m, 20-29.9m and >29.9m were established, and are used throughout the rest of the analysis. A significant relationship (F=2.66, df=3, p=0.049) was found with the use of a one-way ANOVA (Table 3). The longest dive times were in the shallowest and deepest waters. A Tukey's-B multiple comparison test finds a significant difference between water depths of < 10m and 20-29.9m.

Table 3. Mean dive duration (seconds) corresponding to water depth.

Category	Mean	Std Dev	Number of Dives
< 10 metres	136.7	81.17	42
10 - 19.9 metres	115.4	52.05	126
20 - 29.9 metres	103.4	52.38	46
> 29.9 metres	129.7	68.96	24

I also tested to see if surfacing direction (north, south, east, west or non-directional), and group cohesiveness (using the five classes used in data collection) had a significant bearing on dive duration. A one-way ANOVA did not reveal any relationships between these variables at the 95% significance level (Table 4).

Table 4. Summary statistics for dive duration correlated with surfacing direction or group cohesiveness.

Variable	F	df	p	Number of Dives
Surfacing Direction	1.718	4	0.147	245
Cohesiveness	0.682	4	0.605	252

Ventilation Rate

The mean number of ventilations per dolphin on each surfacing run was 1.96. I used a one-way ANOVA to test whether ventilation rate varied significantly with boat presence, the distance dolphins surfaced from boats (between 50-100m or <50m), or water depth (using the aforementioned categories). The null hypothesis that there was no difference in mean number of ventilations per surfacing was accepted in all cases (Table 5).

Table 5. Summary statistics for mean number of ventilations per surfacing for the conditions of boat presence, dolphin surface distance from boats and water depth.

Variable	F	df	p	Number of Ventilations
Boat presence	.0041	1	.949	717
Distance from boat	.0820	1	.781	12
Water depth	1.948	3	.121	614

Group Size and Cohesiveness

While dolphins were being observed, group size would often change. In determining a measure of group size, I based the calculation on only the initial size of groups seen, either at the beginning of an observation session, or groups that appeared in the study area during observation, to maintain independence within the data set. There were 128 groups meeting this criteria, ranging in size from 1 to 7. Mean group size was 3.02, the median was 3 and the modes were 2 and 3 (Figure 8).

The number of surfacing runs observed for groups of different sizes is shown in Figure 9. For this analysis, all groups sizes (n=251) were used, including those resulting from groups splitting or joining during data collection. We observed groups of three for over 600 surfacing runs, the most for any group size. There was no significant relationship between group cohesiveness and boat type (paddle, small motor or large motor) or speed (slow, medium or fast; Table 6) when tested using a one-way ANOVA.

Table 6. Summary statistics for correlation of group cohesiveness with boat type and speed.

Variable	F	df	p	Number of Cases
Boat type	0.424	2	0.655	135
Boat speed	0.077	2	0.926	128

Swimming and Foraging Behaviour

I believe the study site was used almost exclusively for foraging during daylight hours (no night observations were made). This assumption is based on the dolphins' pattern of spending extended periods of time in the relatively small area, repeated direction changes, and the lack of through travel. Dolphins surfaced parallel to the river flow (frequency: east=479, west=506) more often than perpendicular (frequency: north=19, south=50). They surfaced in more than one direction during a surfacing run 39% of the time (665 times out of 1719 surfacing runs). Groups were not always static, but were seen to dissolve and reform while in the study site. Since dolphins could not be identified individually, I could not determine the dynamics or composition of the groups over time.

On two occasions, fresh fish parts (a head and a swim bladder) were recovered from the vicinity of the dolphins. The fish head was identified by a local researcher as a carp, pha mak ban (Cosmochilus harmandi - I.G. Baird pers. comm.), a species found locally in a study

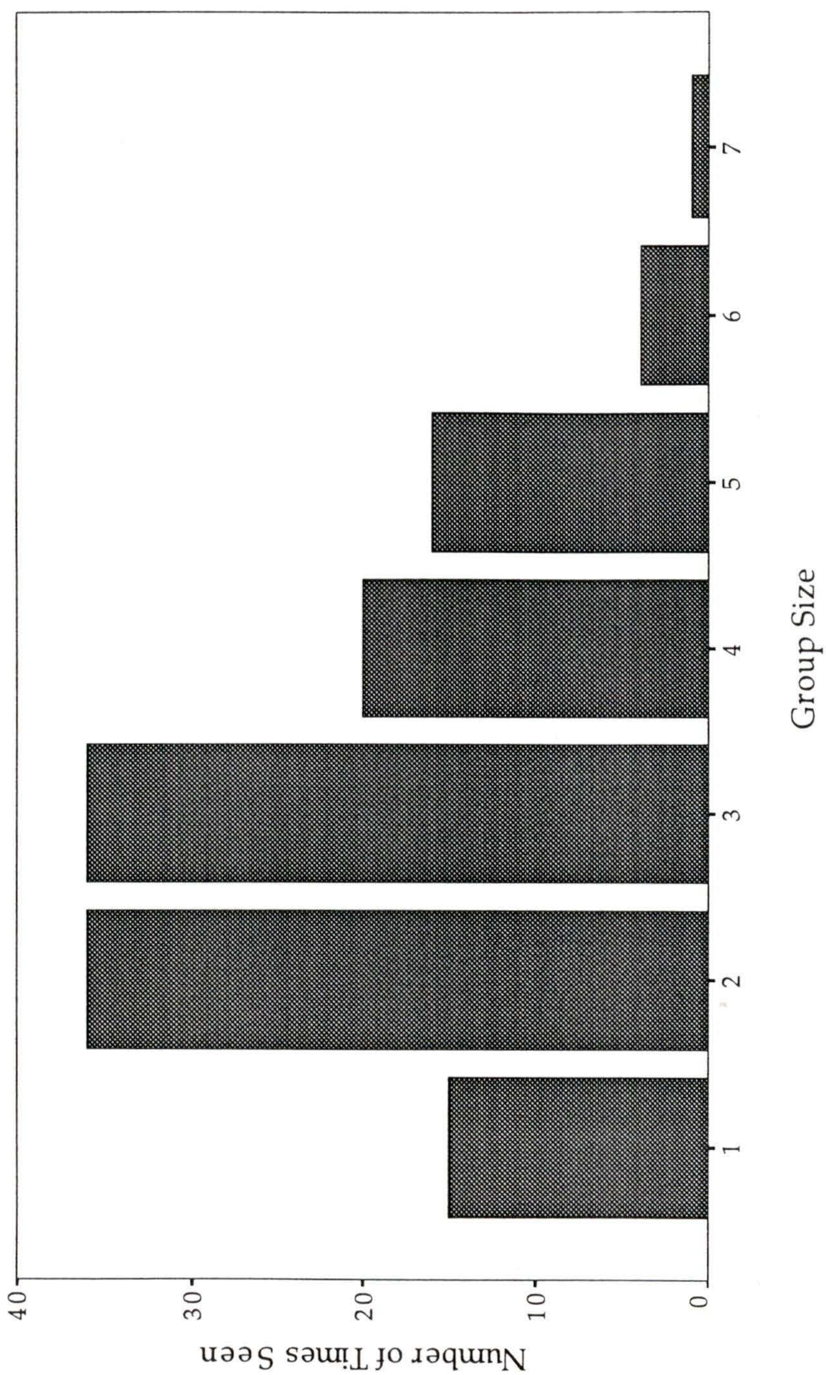

Figure 8. Histogram of group size.

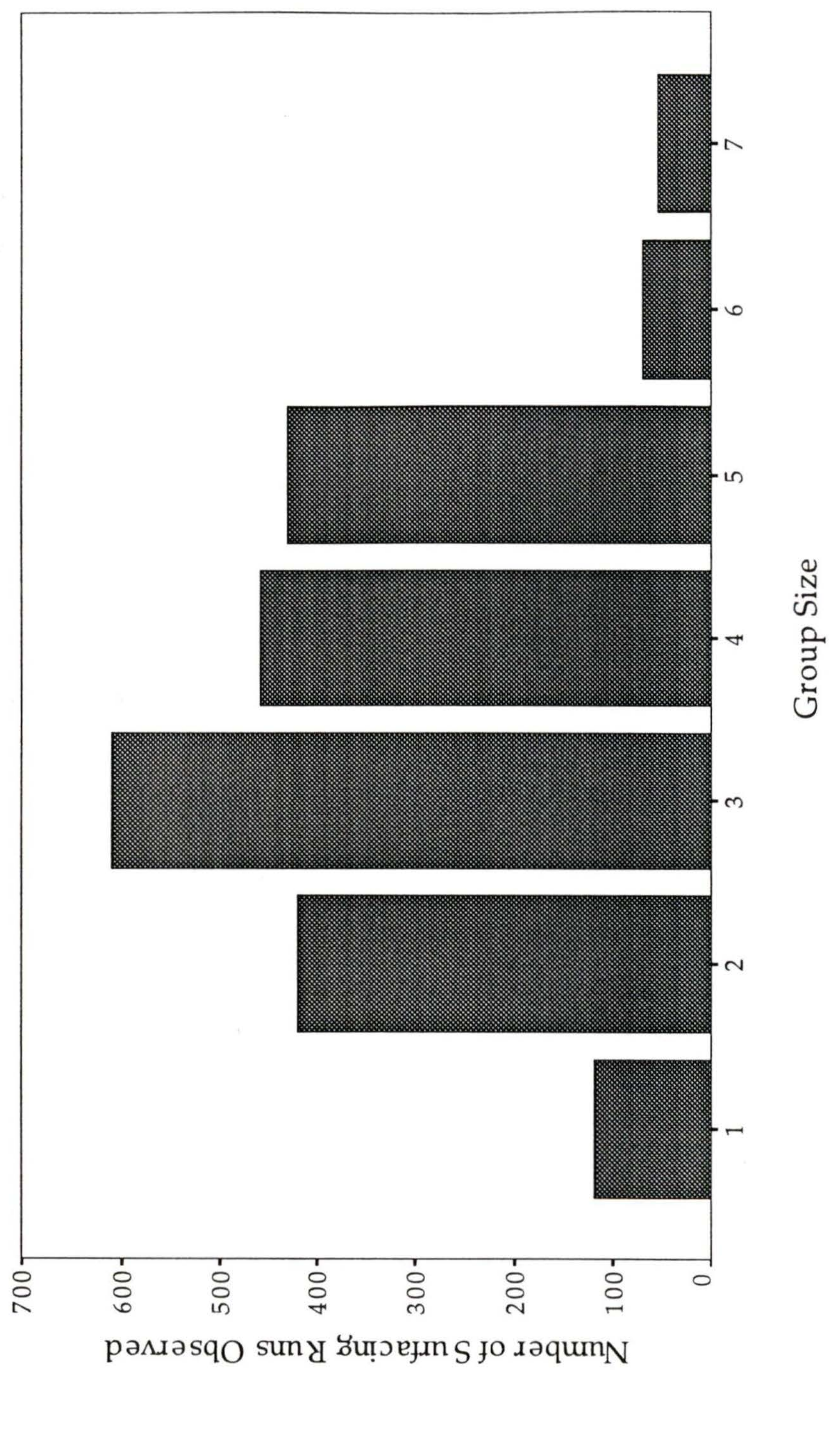

Figure 9. Histogram of amount of time (measured as number of surfacing runs) groups of various sizes were observed.

by Roberts (1993). Villagers said the species is common year-round. The fish head included the large dorsal spine and weighed 330 grams. Numerous fish heads of several species have been similarly retrieved by local residents (Baird and Mounsouphom 1994). The swim bladder was dragged around (intentionally or perhaps still attached to the fish being consumed) by the dolphin for several minutes before it was found floating freely. River terns (Sterna aurantia) were seen daily, hovering above the dolphins, sometimes swooping down to collect a scrap from the water surface. We saw no repeated pausing on the surface or slow swimming in a manner that would suggest resting. Only once did a group of dolphins travel directly through the study area. Feeding and foraging behaviour as described above was interspersed with discreet surface activities such as tail slapping, rolling sideways, splashing, and spitting water (see Table 7 for a complete list). These activities occurred on 14% of surfacing runs.

Table 7. Number of occurrences of surface activities.

Activity	Number of Occurrences
Pectoral fin wave	181
Unidentified splash	155
Spitting water	111
Tail wave	79
Surface with most of head showing	48
Pectoral fin slap	33
Leap partway out of water	32
Sideways roll	19
Pause at surface	16
Tail slap	15
Slow surfacing	15
Bubble blowing	12
Fast surfacing	10
Spyhop	4
Breach	3
Body contact with another dolphin	2

A Chi-Square test revealed that the occurrence of one or more activities during a surfacing run was not associated with the presence or absence of boats (X^2=.229, df=1, p=0.632). The same test revealed different from expected values with the presence of the three different boat types (X^2=11.69, df=2, p=0.003; Table 8). There were fewer than expected occurrences of surface activities when large motor boats were within 100m. There were more than expected surface activities when dolphins were in the company of paddle boats.

Table 8. Expected and observed frequencies of dolphin surface activity in relation to types of boats within 100m.

Boat Type	Surface Activities Present	
	Expected Value	Observed Value
Paddle Boats	7.8	14
Small Motor Boats	16.9	16
Large Motor Boats	5.3	0

Neither boat speed (slow, medium or fast; X^2=4.55, df=2, p=0.103) nor the distance dolphins surfaced from boats (<50m or between 50 and 100m; X^2=.09, df=1, p=0.764) were associated with the presence of surface activities. Further Chi-Square tests revealed that there were significantly more occasions of surface activity after shorter dives than longer ones (using five categories of dive time; X^2=18.37, df=4, p=0.001). There were also significantly more surface activities exhibited in shallow water compared to deeper water (X^2=16.32, df=3, p<0.001). More activities than expected occurred in water up to 10m deep than in water greater than 10m deep. To examine the spatial distribution of where surface activities occurred, only those quadrats where more than five surfacing runs were recorded were used in the analysis.

The percentage of surfacing runs where surface activities were displayed was calculated and the results are shown in Figure 10. The quadrats with the highest percentage were in adjoining quadrats 33, 34 and 43, where 30-47% of surfacing runs contained one or more associated activities.

Surface Distance from Boats

The distance that dolphins surfaced from boats (divided into categories of <50m or between 50-100m) differed significantly with the speed and type of boat when analyzed using a one-way ANOVA. Dolphins tended to surface closer to slow boats more often than fast ones (X^2=9.98, df=2, p=0.007) and also closer to paddle boats than to large motor boats (X^2=3.2, df=1, p=0.074), though this latter difference was not significant.

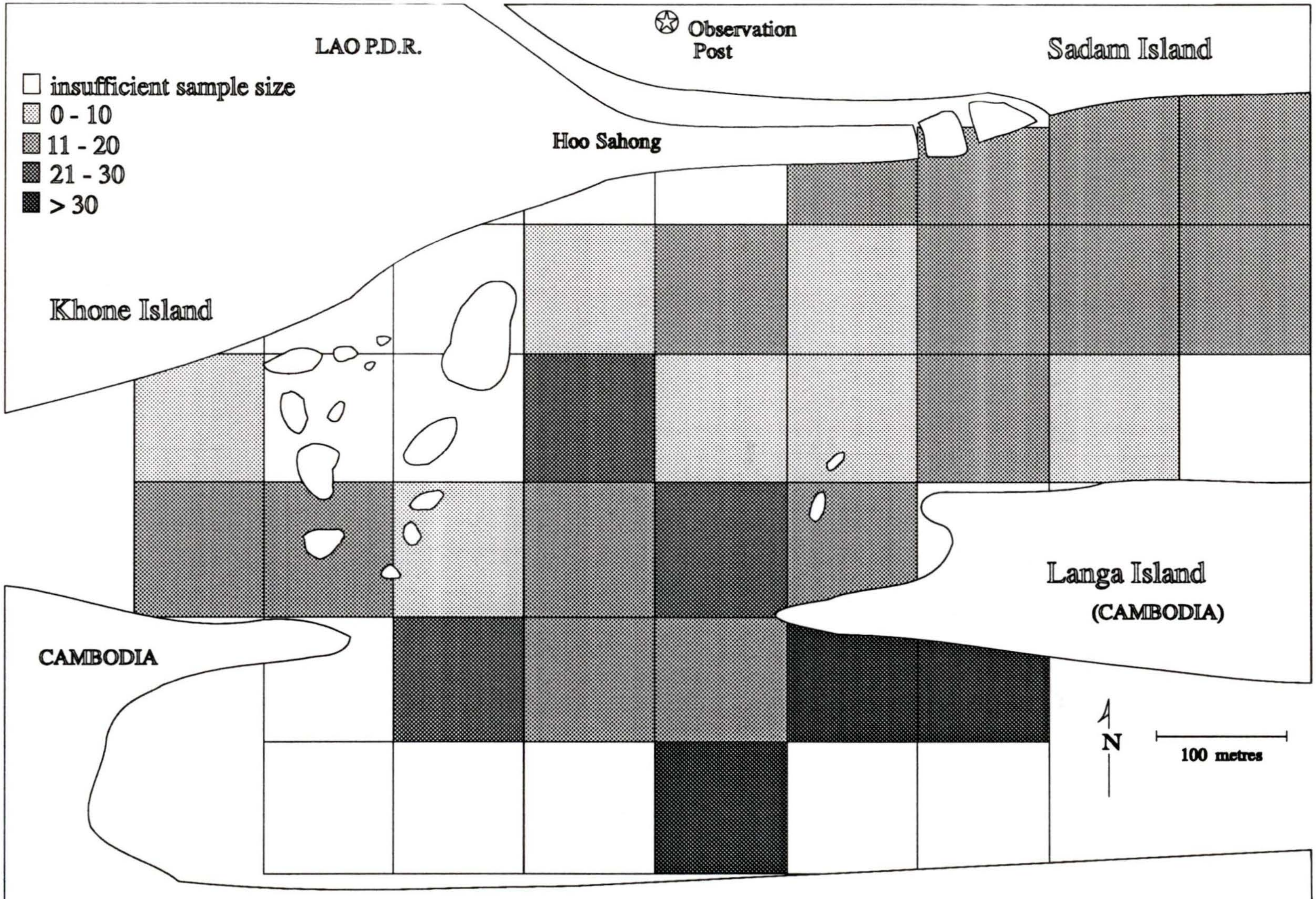

Figure 10. Percentage of surfacing runs during which surface activities were displayed.

Vessel Observations

Forty-eight hours of boat traffic data were recorded over 12 days. Paddle boats and small motor boats were sighted daily; large motor boats were recorded mostly on April 2 (19 occurrences) and once on each of three other days. On April 2, the large motor boats were being used to drag logs downstream from the bay west of quadrats 38 and 46. The other three days this type of boat was used as a passenger ferry. There were slightly more small motor boats than paddle boats utilizing the study area in the 48 hours of observation, but paddle boats were present for much longer than small motor boats due to their slower speed (Table 9). This time spent in the study area was calculated based on the number of boats we were able to time, which is different than the total number of boats counted. Paddle boats were within the study area a mean of 12.03 minutes, compared to only 2.47 minutes for small motor boats. On average, paddle boats are almost always likely to be present in the study area (54 minutes of every hour), while small motor boats pass by more quickly, resulting in an average presence of 14 minutes every hour.

Table 9. Characteristics of paddle boat and small motor boat use of the study area over 48 hours of observation time.

Boat Type	Total Number of Boats	Boats per Hour	Time Spent in Study Area	Mean Time per Boat	Time in Study Area per Hour
Paddle Boats	214	4.46	1864.02 (n=155)	12.03	53.65 (89.4%)
Small Motor Boats	264	5.50	588.95 (n=238)	2.47	13.61 (22.7%)

Photo-identification

Six hundred twenty-nine photographs of dolphins were taken in an attempt to photo-identify individuals. I could distinguish relatively large nicks (greater than about 5cm) and the general shape of the fin in 47 (7.5%) of these photographs. Other photographs were too distant, out of focus, portrayed an angled view, or did not show the dorsal fin. Only 11 photographs were good enough to identify potential characteristics of relatively smaller nicks or any scars, scratches or pock marks. These 11 represent six encounters and at least two different animals; possibly up to six. One animal has a large nick on the trailing edge of the fin (Dolphin #1 - Figure 11). This dolphin was identified on two days, April 12 and April 16. According to field notes and photographs, this dolphin was accompanied by at least two others on both days. The other nine photographs show dolphins with no identifying characteristics to positively distinguish one from the other. None were photographed on the

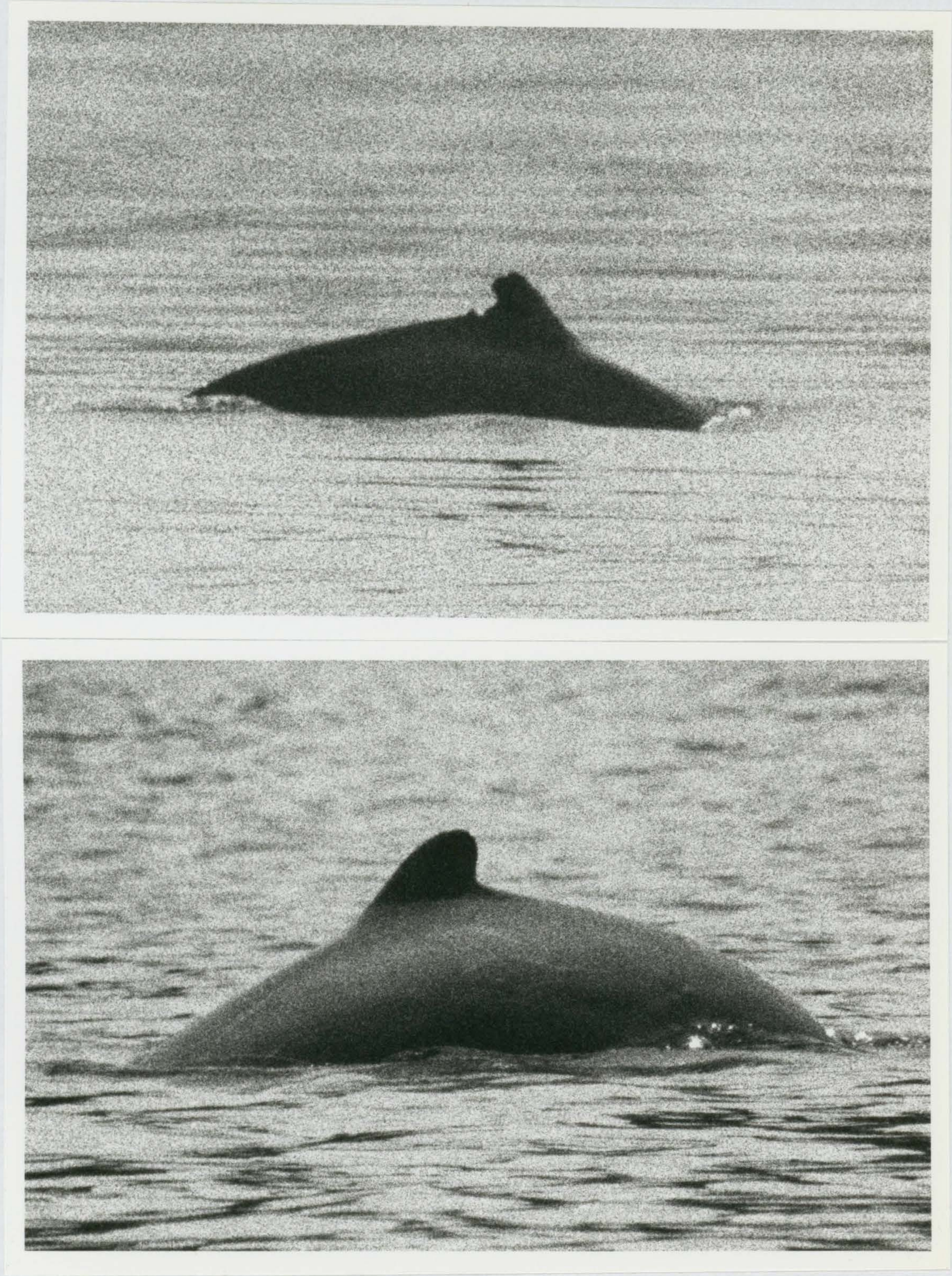

Figure 11. Photograph of Dolphin #1 (showing large notch on the trailing edge of the dorsal fin) and another dolphin with no distinctive markings.

same day as Dolphin #1.

DISCUSSION

Daily and Seasonal Movements

Irrawaddy dolphins were seen daily in this study, most often in the early hours, with a decrease in their presence towards evening. Cetaceans have been noted to exhibit diurnal movements and behaviours, although the extent to which these are regulated internally or by their prey species, which also may have marked diurnal rhythms, is unclear (Klinowska 1986). Several cetacean studies revealed that diurnal feeding patterns varied with differences in species, season, habitat and prey type. In the Amazon, boto were noted to move from rivers into lakes in the early morning and again in late afternoon, movements presumed to relate to feeding (Layne 1958). In the same river, boto were observed to feed predominantly from 0600-0900h and again from 1500-1600h (Best and da Silva 1989). Hua et al. (1989) concluded from their studies that baiji had diurnal behaviours, generally being active during the day and relatively inactive after feeding and at night. From June to August, bottlenose dolphins in the Gulf of Mexico fed mainly in the morning with a secondary smaller peak in late afternoon (Bräger 1993). Diurnal patterns were not apparent the rest of the year. Klinowska (1986) suggested that there is little difference in the occurrence of diurnal activity patterns between freshwater and marine cetaceans.

If the study area is important for foraging, the pattern of use of the area may then be evidence of diurnal feeding. Whether the pattern observed is a result of prey being available selectively in the morning, or whether there is another reason for this feeding pattern (for instance, other behaviours taking precedence in the afternoon), is not known. While the effects of observer fatigue as the day progressed cannot be ruled out as an explanation for this decrease, dolphins were easy enough to spot that I believe this to have had negligible impact. As is typical with cetacean studies, only a portion of the dolphins' daily range was able to be surveyed, limiting conclusions on their full scope of behaviours and movement patterns. Resting, travelling and social behaviour may have taken place in habitats up- or downstream, that were utilized preferentially later in the day.

There is little known of seasonal movements of Irrawaddy dolphins, but there are several reports in the literature of other river-dwelling dolphins. Boto may occupy the same range for over a year, and although fluctuations in their range corresponding to the dry and wet seasons may occur, long distance migrations are unlikely (Best and da Silva 1989). In the wet season, river-dwelling dolphins in the Amazon utilized the previously unavailable habitats: flooded forests and small tributaries and lakes (Best and da Silva 1989). Baiji have been known to travel as far as 200km (Hua et al. 1989). These animals apparently move long distances in response to seasonal changes that cause their habitats of sandbars and banks to change locations (Hua et al. 1989). In a study of the boto in the Amazon River, 25 animals have been captured and marked with freeze-brands and plastic numbered tags, and 17 outfitted with VHF radios (da Silva and Martin 1995). Monthly surveys show the dolphins to be resident year-round. Daily movements of up to 20km are common; trips of 100km have been documented. Animals may remain within a small area for days or weeks at a time.

Irrawaddy dolphins are apparently present year-round in the Mekong River, and become less common at the study site during the rainy season, although their presence in other locations may increase (Baird and Mounsouphom 1994). For example, these authors suggested that some dolphins generally move into the Sekong River during the high-water season, returning to the Mekong in the dry season. During my visit in June of 1993, the water had risen considerably from the lowest levels the previous month. Casual observations on this preliminary visit lead me to believe that while still occupying the study site on a daily basis, dolphins were harder to locate, and were probably not present as often as during the low-water season. Irrawaddy dolphins appear to spread out over a larger area during high water, making use of the new habitat available, and possibly following prey species into larger tributaries, as discussed in Baird and Mounsouphom (1994). Whether long-distance or long-term movements take place is unknown. Both daily and seasonal movement patterns are important to consider in designing sighting surveys and comparing research results. Because of diurnal and seasonal movements dolphins may be more easily seen (or missed) at different times, and research results could vary significantly at different times of the day or year.

Habitat Use

Water depth and temperature were two habitat parameters measured during this study. The maximum depth measured at the study site, 35.4m, is surprisingly deep for a river, especially at the height of the dry season, yet is in line with the depths suggested by Tana (1995) and Pantulu (1973), both of whom suggest that Mekong pools can reach depths of 50m. Baird and Mounsouphom (1994) reported that villagers in Lao P.D.R. and Cambodia have identified five deep-water pools between Kratie and the Lao border, where dolphins are said to live in considerable numbers, especially in the dry season. The Amazon River is also up to

50m deep in areas frequented by boto (Hurtado and Vidal 1995). The water temperature determined in my study, 31°C, is slightly higher than the only other water temperature reported for Irrawaddy dolphins, of 25 to 30°C (Morzer Bruyns 1971).

There are a few reports of Irrawaddy dolphin presence in waters of specific depth. Depths of 2.5-18m were preferred in the Bay of Carpentaria, Australia (Freeland and Bayliss 1989), 3.5-12m in the Mahakam River (Tas'an et al. 1980), and 6-18m in other unspecified areas (Morzer Bruyns 1966). These are all considerably shallower than the depths recorded at Mekong study site. Two studies on boto and tucuxi (Sotalia fluviatilis) in the Amazon River examined habitat use based on water depth. Hurtado and Vidal (1995) found that while the boto was found in depths that varied from 1-50m, 94% of sightings were in water less than 15m. In the same area, Ojeda and Vidal (1995) found that 86% of tucuxi were in less than 15m of water. In my study, 12% of surfacing runs were in water less than 10m and 48% were in depths of 10-20m. Water depth preference likely differs considerably with the specific habitat and environmental conditions.

Dolphin habitat use in general has been examined in many studies, for example that of the ubiquitous bottlenose dolphin (Tursiops truncatus). Ballance (1992) found that bottlenose dolphins in the Gulf of California were sighted frequently, usually feeding, close to estuaries. The high concentration of nutrients in estuaries, as well as lagoons, and bays with mangroves, kelp or seagrass, is thought to provide productive feeding grounds for bottlenose dolphins off California and in the Gulf of Mexico (Ballance 1992). Preferred habitats of river-dwelling dolphins have been identified for most species. The Ganges river dolphin was noted to congregate at river narrowings and confluences, and downstream of shallow areas (Kasuya and Haque 1972). In the Mahakali, Karnali, Narayani and Sapta Kosi Rivers in India and Nepal, alluvial braided channels and high velocity flows were characteristic of Ganges river dolphin habitats (Smith et al. 1994), quite different from the slow-moving Mekong River at my study site. Smith (1993) studied Ganges river dolphin habitat in further detail in the Karnali River and concluded that primary habitats occurred where physiographic and hydrologic features combined to produce complex and diverse conditions, specifically, counter-current eddy systems. These systems provide a diverse source of nutrients (from accumulated woody debris and the associated communities of algae, fungus, bacteria, insects and fish) and encourage their release and cycling (Smith 1993). Features of primary habitat were: a single channel slightly downstream from a faster flowing stream branch or tributary; mean surface flow velocity of 0.8m/s; bottom substrates of cobbles or silt, sediment deposition where the stream branch or tributary enters the main river, creating a counter-current eddy that traps and deposits woody debris along the shore (Smith 1993).

Baiji also favour counter-current eddies, and their activities are closely tied with sandbars and banks (Hua et al. 1989). In fact, the authors found that baiji were difficult to locate in areas that did not have these features. Lloze (1973) found that Irrawaddy dolphins in the lower Mekong also preferred areas around sandbars near the confluences of lakes, rivers and streams. Indus river dolphins are also seen frequently at confluences (Khan and Niazi 1989). Botos congregate at river mouths and just below rapids, where there is more fish movement and where they are possibly disoriented and thus easier to catch (Best and da Silva 1989). Layne (1958) mentioned the often large quantities of debris, such as branches and rafts of vegetation, drifting down the Amazon, sometimes accumulating in current eddies or against shore. This phenomenon was not noted in the Mekong during the study, but is an example of a potential component of the dynamic tropical habitat.

While collecting data, I noticed a high level of use off the tributary mouth, especially around a floating marker signifying one end of a fixed gillnet. Figure 6 shows this pattern of relatively high levels of use off the mouth of the river channel compared to the rest of the study area. This is likely an area of high productivity due to water mixing as discussed above. This area of high use extends across the river to the tip of the sandy Langa Island; perhaps a similar environment to the sandbars mentioned in other studies. Dolphins used to be seen more often near the channel mouths, according to the headman of Hang Sadam.

The three primary Ganges river dolphin habitats identified on the Geruwa branch of the Karnali River had current velocities of 0.71, 0.90, and 0.82m/s (Smith 1993). These are similar to the measurement of 0.75m/s taken in the tributary at the Mekong study site. The other two measurements of current flow in the study area varied widely on either side of this: 0.15m/s in the deep water pool, and 1.66m/s at a tributary two kilometres downstream. Irrawaddy dolphins made extensive use of the deep pool, and made forays into the adjoining tributary twice. No observations were undertaken at the third site. Although there are a wide range of habitats available, no generalizations of primary dolphin habitat in the Mekong River can be made based on current velocity due to the limited spatial and temporal scope of my study.

Habitats are dynamic, changing over days, months and years. This study took place over a short time period, and presents only a snapshot of the widely varying conditions of this landscape. As the study was concluding, the rains were beginning and water levels were rising accordingly. This would bring changing current flows and patterns, water depth, temperature and turbidity. Vessel and dolphin use of the area would soon change in response to the availability of new habitat. Irrawaddy dolphin prey species would be responding to this change as well, with migrations or other habitat use alterations (Baird and Mounsouphom 1994). Eventually the water would reach the banks, and both fish and dolphins would likely venture into the flooded riparian forest, as Lao villagers suggest they do, similar to the situation in the Amazon (Best and da Silva 1989). It is important to keep in mind the dynamic nature of the habitat and that the measurements taken during this study are temporally specific, as are dolphin behaviours and patterns of dolphin and vessel use of the area.

Group Size

Group size is important in most animal species. There are several advantages of group living, including more efficient foraging, feeding and predator avoidance, and access to breeding opportunities and social relationships. Being a member of a group has costs as well as benefits, both which vary according to group size (Bertram 1978). In those species that practice group hunting, an optimal foraging group size may exist, as for killer whales, Orcinus orca (Baird and Dill 1996). Group sizes may differ between seasons, depending on the prey being pursued (Würsig and Würsig 1979).

We might expect dolphins in different habitats to structure their group organization in different ways, as outlined by Würsig et al. (1989) for dusky dolphins (Lagenorhynchus obscurus). These authors believe that, at least for nearshore marine dolphins, species has less to do with group size and behaviours than habitat and food availability. Because of environmental similarities and constraints, group sizes of Irrawaddy dolphins in this study may be more similar to other river-dwelling dolphins than marine cetaceans, whose groups can number in the hundreds or thousands. Large aggregations of schooling fish might be more efficiently captured with the cooperation of such large groups, whereas smaller schools, or solitary fish, may be more suited to predation by single or small groups of dolphins (Würsig 1991).

Several studies of river dolphins have found that they occur in relatively small group sizes. In the Amazon River, for example, Best and da Silva (1989) reported that solitary boto are most typical. In Ecuador, Utreras (1995) found that 31.5% of sightings were of one animal and 24% were of two animals. Group sizes ranged from 1-13, with aggregations of up to 50 dolphins, in a study by Hurtado and Vidal (1995) in the Amazon River bordering Colombia, Perú and Brazil. Groups of 1-2 made up 85% of these groups. da Silva and Martin (1995) found that boto group size in the central Amazon was typically 1-2, with larger aggregations of up to 20 lasting several hours or days. McGuire (1995) found that in the Cinaruco River, Venezuela, boto group size varied with season and location. The tucuxi is also found in relatively small groups; in groups of 1-20, 85% were of groups of 1-4 in the Amazon bordering Colombia, Perú and Brazil (Ojeda and Vidal 1995). Aggregations of up to 50 dolphins were also seen.

In a study of baiji, Zhou and Li (1989) found that group size ranged from 1-10 with a mean of 3.36 animals; the most common group size was 3-4. Other researchers found that baiji formed groups of 5-7 most commonly; 1-2 animals were seldom seen together (Hua et al. 1989). These relatively small groups are believed to aggregate periodically into larger groups of 10 or more, occasionally as many as 17 (Hua et al. 1989, Zhou and Li 1989). These larger groups were often seen feeding during periods of local prey abundance (Zhou and Li 1989).

Irrawaddy dolphins in the Mahakam River, Chilka Lake, Gulf of Carpentaria and Irrawaddy River have been reported in small groups of less than 10, and usually 1-4, as reviewed in Chapter Two (Annandale 1915, Tas'an et al. 1980, Freeman and Bayliss 1989). In my study, mean group size was 3.02 with a range of 1-7. Groups of two and three were most common. I also saw one group of about 17 dolphins at the study area on my initial visit. This information is comparable with the patterns reported in the literature. Relatively small group sizes are the norm, while aggregations occur periodically, likely in response to environmental changes such as prey density or social factors.

The groups sizes reported for my study do not imply a social grouping, as group size was defined spatially, by the observed distance between dolphins. The group size and function from the point of view of the dolphins cannot be ascertained, as vocalizations or other interactions may have occurred that were not detected during this study.

Diving Characteristics

Dive time is likely dependent on behavioural state and environmental conditions, and is difficult to compare between studies without knowledge of these variables. There are no previous field studies documenting Irrawaddy dolphin dive durations. S. Leatherwood (pers. comm.), on a visit to a Thai oceanarium, recorded Irrawaddy dolphins diving for up to 5 minutes 20 seconds. The longest dive duration in this study was recorded for the group and was 7 minutes, 11 seconds. Individual dive duration may be slightly longer than this. A few other dive durations are available for river-dwelling dolphins. Zhou and Li (1989) studied baiji diving behaviour and found that mean long dives were 51.47 seconds, somewhat shorter than the 115.3 seconds found in this study. Hua et al. (1989) reported average dives of 40-60 seconds for baiji with lengths of up to 6-7 minutes.

One behavioural variable that likely influences dive time is foraging. Foraging activities (searching for, pursuing and capturing prey) of aquatic mammals are largely carried out while diving. In general, long dives are often associated with foraging, and shorter dives with resting, or other activities (Würsig and Würsig 1979). In deep water, cetacean foraging dives can be limited by the breath-holding capability of the animal. Group size, which may relate to foraging activities, as discussed earlier, did not correlate with length of dives.

I hypothesised that dolphins' dive duration might be longer in quadrats with the largest mean depth, because of the increased energetic cost of travelling to and from the surface, but this is not reflected in the results of the study. Würsig et al. (1986) found in a study of gray whales in the Bering Sea that dive duration did not show a consistent increase with increasing depth in July, but did in September. In that study, researchers assumed that the whales were bottom feeding. Even though I have a rough idea of the depth of the Lao study site, I do not know the depth at which dolphins were feeding.

Dive durations, or more precisely, the number of surfacings in a given time period, are an important component in calculating cetacean population estimates based on sighting surveys, and can vary with time of day, season, location, environmental conditions, group size and composition, and presence of vessels (Leatherwood et al. 1982). Ventilation patterns may also vary with activities and may be used to categorize behavioural states. For instance, Kopelman and Sadove (1995) found that there were significant differences in ventilatory and dive parameters between surface-feeding and non-surface-feeding fin whales. The information I have gathered on dive durations and surfacing patterns will be valuable baseline information for use during sighting surveys, until more site-specific information can be obtained in areas under investigation.

Swimming and Foraging Behaviour

Cetacean research can be very limited, given that many of the animals' activities take place unseen underwater. Activities that take place on the surface are thus important to help interpret the animals' overall behavioural state. In overview, groups of dolphins tended not to travel through the study area, but were more likely to spend extended time in the pool area, changing direction repeatedly, either during surfacing runs or over several surfacing runs. Repeated dives in varying directions in one general location such as this have been attributed as foraging in other studies (e.g. Shane 1990). Some dolphins exhibit considerable surface and aerial behaviours in conjunction with feeding. Particular among this group are dusky dolphins, where such behaviours have been associated with surface feeding (Würsig and Würsig 1979). These types of behaviours after feeding have been termed socializing or playing, and may in part function to reaffirm social bonds (Würsig and Würsig 1979, Norris and Dohl 1980).

In my study, dolphins showed more instances of surface activity after short dives, rather than long dives, when they may have been feeding. As seen by examining Figures 4 and 10, surface activities were seen in the shallower quadrats. It was my subjective opinion during data collection that quadrats 33 and 34 (relatively shallow water) were favoured for surface activities. Whether shallow water was preferred for socializing, or whether socializing would take place when feeding was relatively unproductive (as perhaps is the case in shallow water) can not be determined from this study.

In the dry season, small migratory cyprinid fish are caught in abundance by villagers at the study site (Baird and Mounsouphom 1994). Villagers think that these are important in the diet of Irrawaddy dolphins. Baird and Mounsouphom (1994) suggested that Irrawaddy dolphins follow the cyprinids as the fish swim downstream at the beginning of the wet season. Other suspected prey items are fish whose heads are found floating in the area, such as the one I found of Cosmochilus harmandi. Other species represented are Bagarius yarrelli, Kryptopterus apogon, Pangasius hypophthalmus and Mystus microphthalmus, all types of catfish (Baird and Mounsouphom 1994). Lao villagers believe that dolphins usually only eat the lower portions of larger fish, leaving the dorsal and pectoral spines behind. Villagers reported that fish leave the tributaries and return to the mainstream Mekong when the water levels begin to go down, at the same time that dolphin sightings in the main river become more frequent (Baird and Mounsouphom 1994). We saw dolphins in Hoo Sahong for the first time on April 16, 1994, which according to Hang Sadam's headman is the day that the migration of Pangasius sp. began.

Besides the fish head and swim bladder, I saw one other incident that strongly suggests foraging. In proximity to where two dolphins had been surfacing, a fish approximately 30cm in length jumped through the air in an arc. Several seconds later, one dolphin surfaced very quickly where the fish had landed. The headman of Hang Sadam suggested that dolphins could not feed successfully on their own, and therefore were usually seen in groups. He believes that spitting water, as we frequently observed during the study, is associated with feeding. Marsh et al. (1989) report that Irrawaddy dolphins and beluga whales (Delphinapterus leucas) can similarly expel water from their mouths in a coherent column, unlike the more diffuse spitting by other odontocetes. Villagers also suggest that Irrawaddy dolphins chase fish into nets, and thus help the fishers. There seems to be no concern about the potential competition between people and dolphins for the same food supply.

Dolphin/Vessel Interactions

There is a growing body of literature addressing the area of cetacean/human interactions, especially with regard to vessels. Blane and Jaakson (1994) summarize several cetacean responses to boats that have been reported in the literature: reduced feeding; loss of pod integrity; shortened surfacings and displacement from feeding areas; disruption of social groupings; and avoidance of high speed fishing boats. Several interactions specific to river dolphins have been documented. Smith (1993) reported that Ganges river dolphins are no longer sighted in two locations where motorized ferries have begun operations, but believed dolphins to be relatively unaffected by human-powered vessels. High noise levels also appear to disturb Ganges river dolphins; usual habitats were vacated when noisy grass-cutting was underway along the shores (Smith 1993). Baiji generally made longer dives and changed direction underwater when approached by boats, and tended not to surface within 50m of them (Zhou and Li 1989). This species also was found to vacate an area that became polluted from a nearby refinery, and avoided other areas at times when human activity was at a peak (Hua et al. 1989).

Cetacean dive duration has been used in other studies as an indicator of potential disturbance from boats. For instance, Stone et al. (1992), in a study of fin whales, found that blow intervals were shorter in the presence of boats (within 0.25nm) than when boats were absent. In my study, when boats were within 100m of dolphins, mean dive durations were significantly longer than when boats were absent. Blane and Jaakson (1994) though, found that beluga dive time was longer in the presence of boats. While collecting data, it was my subjective opinion that when motor boats were travelling towards surfacing dolphins, dolphins would submerge prematurely. However, as I reported earlier, the data did not support this observation.

There were fewer than expected occurrences of surface activities when large motor boats were within 100m, and more than expected in the presence of paddle boats. This difference though is likely a reflection of the speed differential of the two boat types; paddle boats are slower and thus spend more time in the presence of dolphins. Dolphins tended to surface closer to paddle boats than to large motor boats; this was also correlated with speed. Blane and Jaakson (1994) reported that belugas avoid high speed boats, but did not elaborate on the methods used to reach this conclusion. My observations lead me to believe that large motor boats, used to tow logs and ferry people, were the most disruptive to dolphin behaviour patterns. These boats were not seen often, but there is potential for increased traffic related to logging activities. Potential vessel disturbance of dolphins may have a seasonal component, if dolphins, as suspected, spend more of their time in the rainy season in smaller tributaries and in the flooded forest, presumably away from heavy vessel traffic. Dedicated dolphin watching trips would likely not be undertaken during the rainy season, when dolphins are harder to find and the increased current flow makes navigating difficult.

I determined from villagers that the first small motorized boat in my study area appeared in 1987, and these boats were common after 1989. In the village of Hang Khone there are presently 10 motor boats and about 30 paddle boats. Villagers explained that dolphins used to come close to paddle boats, but have become scarcer in general since the arrival of power boats, and do not generally surface near them. According to the headman of Hang Sadam, Irrawaddy dolphins will only enter Hoo Sahong to feed if there are few boats present, especially motor boats. He added that motor boats have negatively affected dolphins, but generally, dolphins seem to stay out of their way.

Quantifying cause and effect relationships between the presence of boats and cetacean behaviour is difficult under the best of circumstances. Several limitations specific to this study, especially with the temporal and spatial scope of the data collection, further add to the challenge. The study area appears to be used primarily for foraging and perhaps socializing; vessel impacts may be different when dolphins are resting, travelling or utilizing a different foraging habitat. Seasonal differences may exist, especially given the dynamic nature of this habitat, that could not be addressed within the limited time period of this study. The methods of data collection also had shortcomings. Boats were only recorded as being present if they were within 100m, dive durations could not be measured for individuals, and because boats, especially motor boats, travelled quickly through the study area and were not stopping to watch dolphins, there was little time to ascertain the interactions. In some cases, dolphins dove as motor boats were approaching, and did not appear again until the boat was out of sight several minutes later, putting into question the value of vessel correlations with ensuing behaviours. It can be easy to interpret vessel/dolphin interactions from the observer's perspective, instead of the dolphins'. Cetaceans utilize a three-dimensional space that includes a depth component that may be overlooked, an element that provides cetaceans with additional habitat, physically if not acoustically, separate from the plane in which vessels operate. This is especially true in open marine environments, and perhaps vessel impacts may be amplified in rivers, as the depth and width parameters are usually more restricted. If dolphins are indeed being disturbed by vessels, the long-term consequences may be difficult to predict and observe. Results may be relatively easy to determine, such as habitat displacement, or more subtle, such as a decrease in reproductive rate. Even if such occurrences were documented, implicating vessel or other human impacts as the cause would be difficult without detailed long-term studies, preferably experimental.

Photo-identification

Photo-identification can contribute substantially to studies of cetacean social structure, survival rates, feeding and reproductive behaviour, seasonal and short-term movement patterns, and abundance estimates (e.g. Würsig and Würsig 1979, Slooten and Dawson 1992, Trujillo Gonzales 1994). While photo-identification has been a useful technique in many marine cetacean applications (Würsig and Jefferson 1990), it may be less useful with some river dwelling dolphins, due in part to their behaviour. Two dolphins inhabiting the Amazon River system, the boto and tucuxi, have been studied using photo-identification. T. Henningsen (pers. comm.) outlined the behaviours that made it difficult to photo-identify these two dolphins in the Peruvian Amazon (see also Henningsen et al. 1995). The main obstacle was that the dolphins would often surface without showing much of the back and dorsal fin. These behaviours contributed to the difficulty in anticipating their movements and taking well-focused photographs. These behaviours also characterize the Irrawaddy dolphins encountered during my study. Certainly their habits of generally surfacing unpredictably, staying low in the water, and only surfacing once or twice at a time were factors in the lack of success in obtaining quality photographs.

Despite problems, the boto and tucuxi have been photo-identified successfully in the long-term. Trujillo et al. (1993) suggested that photo-identification could be used as an index to estimate abundance, as an estimated 71.4% of the boto population in their study area was identified using this technique. The boto has also been studied by Hurtado and Vidal (1995), along 120 km of the Amazon River. From a total of 5,000 photographs, 70 individual dolphins were identified, based on scars and colorations. Boto have pigmentation patterns of varying pink and gray coloration. Colour film is therefore important to document these patterns (Trujillo Gonzalez 1994), and likely increases the success of photo-identification compared to cetaceans with a dominant uniform coloration such as Irrawaddy dolphins. Twenty five percent of botos displayed cuts believed to have been inflicted by fishers as "punishment" when dolphins become entangled in gillnets (Hurtado and Vidal 1995). These markings also likely increase the ability to distinguish individuals. Utreras (1995), also using nicks and pigmentation patterns, found photo-identification to be a useful tool for movement and behaviour studies of the boto.

Despite their apparent evasive behaviour, tucuxi are being individually identified through the use of photographs. Ojeda and Vidal (1995) found that an analysis of 1,000 photographs of tucuxi in the Amazon River revealed at least 25 individual dolphins, based on observations of notches and scars. Pizzorno et al. (1995) also studied the tucuxi, specifically to outline an adequate methodology for photo-identification of this species. They found that about 19% of their exposures were suitable for individual identification of this dolphin. This is somewhat higher than the percentage of 7.5% of usable photographs found in my study.

A possible explanation for the differences seen between these studies and mine is that I was utilizing a paddled boat, while other studies were undertaken using slow-moving motorized vessels. A motorized boat would enable researchers to maintain a closer distance to the dolphin surfacings. Much of the time on the water in Lao P.D.R. was spent paddling to get close to the animals. By the time we were nearby, they often had moved on to a different site. Conversely, a motor boat may have made it difficult to approach the dolphins closely. Other factors, such as width or depth of the river, season, or behavioural state may also have played a role. Irrawaddy dolphins would have likely been easier to photograph when resting or travelling, activities which were not observed (resting) or seen infrequently (travelling). Differences between the abilities of the photographers must also be considered. Because nicks and other markings are generally small relative to those on larger cetaceans, I recommend the use of a finer-grain film (slower than 1600 as used here as suggested by Würsig and Jefferson 1990) for any future photo-identification studies of Irrawaddy dolphins.

CONCLUSION

This field study touches on a wide range of topics, including diving behaviour, foraging ecology, habitat use, social behaviour, factors affecting group size, and diurnal movements. I attempted to provide enough background to put the findings from this study into context. I found that Irrawaddy dolphins were present in the study site predominantly in the early part of the day. This is perhaps indicative of diurnal feeding, given the probable foraging suggested by repeated direction changes and lack of through travel. Habitat use was highest off the tributary mouth and adjacent sandy island. Mean water depth at the study site was 18.4m, current speed was 0.15m/s and water temperature was 31°C. Mean dive duration was 115.3 seconds, similar for all group sizes. When no boats were within 100m of dolphins, mean dive duration was significantly shorter than when boats were present. The longest dive times occurred in the shallowest and the deepest water. There was no significant relationship between surfacing direction or group cohesiveness and dive duration. The mean number of ventilations per dolphin on each surfacing run was 1.96, and did not change with boat presence. Group size ranged from 1-7, with a mean of 3. There was no significant relationship between group cohesiveness and boat type or speed. Discreet surface activities occurred on 14% of surfacing runs and neither boat speed nor the distance dolphins surfaced from boats were associated with the presence of these surface activities. These activities occurred most frequently in shallower water, especially in one area away from the tributary mouth. Dolphins tended to surface closer to paddle boats than to large boats. Of over six hundred photographs taken, only 11 were of quality sufficient to attempt to identify individuals. Two animals, and tentatively up to six, could be identified.

The conclusions of this study must be placed into the context of the limited time and space over which the research was conducted. As discussed previously, the Irrawaddy dolphin behaviours and environmental interactions observed are likely site- and time-specific, especially in this dynamic habitat. This study provides a portrait of Irrawaddy dolphins that is far from complete, but is an example of the baseline research that is needed before being able to progress to question-oriented studies. Long-term, in-depth observations over a larger area are needed next, and are discussed in the next chapter. In summary, this study contributes significantly to the collective knowledge about Irrawaddy dolphins, and provides a basis for further research questions.

This information, while not abundant, is what is available to work with to design a conservation plan, which is the thrust of the next chapter.

Chapter Four
PRACTICAL AND THEORETICAL CONSIDERATIONS OF IRRAWADDY DOLPHIN CONSERVATION

CURRENT STATUS OF IRRAWADDY DOLPHINS

Global Situation

Based on the information presented in Chapter Two, it is apparent that the status of the Irrawaddy dolphin is unclear due to insufficient data. However, the information that is available suggests declining numbers and a decreased use of some habitats. Helene Marsh, in an address to the Society for Marine Mammalogy in 1995, predicted, based on her extensive field studies, that coastal tropical marine mammals, including Irrawaddy dolphins, had little chance of long-term survival. The impacts of rapid growth in human demands, habitat degradation and high fishing efforts are at the root of this concern. Even in Australia, where there is a relatively high degree of habitat protection and low human population levels, dugong (*Dugong dugong*) numbers are nonetheless declining (Marsh 1995). Thus, there is every reason to be concerned for the long-term survival of Irrawaddy dolphins.

The most pressing conservation issues affecting the survival of this species are habitat degradation and incidental catch. The general lack of information about Irrawaddy dolphins (Chapter Two) is a concern as well, insofar as this leads to delaying vital action and making incorrect decisions, if and when such actions are taken. More hopefully, there is a general positive attitude towards Irrawaddy dolphins in some countries such as Lao P.D.R., Burma, and Indonesia, as discussed in Chapter Two. However, there is a danger that economics may take precedence over traditional attitudes if people have access to a market for Irrawaddy dolphin specimens or products. A case in point is the recent live-capture industry in Thailand (Smith 1991). Direct take is apparently minimal, unlike the situation with some other small cetaceans in countries such as the Philippines (Dolar 1995, Alave and Dolar 1995) and Perú (Vidal 1993).

Situation at the Lao P.D.R. Study Site

The situation at the Lao study site appears to have worsened in recent years. Twenty-five animals are known to have died in this area between 1990 and 1995, 13 of which became entangled in gillnets (Baird and Mounsouphom 1994, 1995). At least one other was caught in a large fish trap (Baird and Mounsouphom 1995). The headman of Hang Sadam informed me that over the last 20 years, about 2 or 3 dolphins have been found dead each year. Gillnet use began in the early 1970s and explosives were first used in 1979.

Gillnets are used when water currents are lowest, between November and June (Baird and Mounsouphom 1994). During May and June, and from November to January, these nets are set near the surface, and apparently pose more of a threat to dolphins than those set deeper in February through March (Baird and Mounsouphom 1994). I determined that the mesh size of the gillnets ranged from 2.5 to 25cm, but that nets of 12 and 14cm were most common. Baird and Mounsouphom (1994) reported that dolphins appear to become entangled primarily in larger-meshed nets, from 12-25cm, set on the surface in deep water. I was told that these nets have become more common since 1990. All dolphins caught in gillnets since then have become entangled by the tail in large-mesh, multi-filament nets (Baird and Mounsouphom 1995).

In my opinion, the number of dolphins becoming caught in nets is alarming. There is no population estimate for the Mekong River, or the local area, but based on villagers' reports, dolphins have never been abundant, and numbers are declining. One villager feels that there are only about half as many dolphins now as 20 years ago, a change that has happened gradually over those years.

Fish catches appear to have declined drastically; in 1993 the catch reported by villagers was only 20% of what it had been in 1970 (Roberts 1993). Although illegal, Cambodians periodically explode charges in the river to catch the fish that are stunned or die as a result. I observed this twice during my stay. This practise kills fish indiscriminately and may potentially cause injury to Irrawaddy dolphins as well.

There are plans to construct a large tourist facility on an adjacent section of river, only a few kilometres away from the study site (McEachern 1993). This will result in some increase in boat traffic. However, large boats may never become too numerous in this area, as Khone Falls, a few kilometres up-river, is a barrier to navigation, although large vessels were previously transported across Khone Island on a railtrack to continue their journey down-river (Mekong Secretariat 1990). This system has now been abandoned and the railway largely removed.

The rivers inhabited by Irrawaddy dolphins are, as yet, in better condition than the rivers occupied by the platanistid dolphins of Asia, the Ganges and Indus river dolphins. These two dolphins have to contend with extensive water development projects that have fragmented their populations (Reeves and Leatherwood 1994). But Irrawaddy dolphins may soon be faced with similar conditions. There have long been plans for extensive development of the Mekong River, in the form of hydro-electric dams, both on the mainstream and the tributaries. These plans were conceived by the Mekong Committee, currently known as the Interim Committee for Coordination of Investigations of the Lower Mekong Basin. This intergovernmental organization was created in 1957 and is supported by the United Nations and many bilateral aid agencies (Lohmann 1990, Jacobs 1995). The original plan of the Committee was to alleviate poverty in mainland Southeast Asia by initiating socio-economic development through hydro-power, irrigation and flood control projects, through a series of immense dams along the lower Mekong in Lao P.D.R. and Cambodia, aided by nearly 100 tributary dams (Lohmann 1990, Jacobs 1995). This "biggest, most ambitious and expensive development project of all time" would have forced hundreds of thousands of people to leave their villages, and would have resulted in thousands of square kilometres of river valley and forest being flooded (Lohmann 1990:61).

In this one respect, the wars and political turmoil in Indochina in the 60s, 70s and 80s were beneficial (Jacobs 1995). Due to the impossibility of ground surveys or construction during these years, and because Cambodia withdrew from the Committee due to the hostilities, most of these ambitious plans were put on hold (Jacobs 1995). However, the pace of planning has been increasing in recent years. Cambodia is making moves to re-join the Committee and the political situations in Lao P.D.R., Cambodia and Vietnam are now such that plans are being re-examined. Both mainstream and tributary dams could have serious effects on Irrawaddy dolphins, through population fragmentation, habitat destruction and disruption of prey migrations. Jacobs (1995) points out that, on a positive note, dam construction plans will likely be revised, taking into consideration more recent knowledge of environmental and social impacts of these types of projects. In addition, concerned organizations and citizens, world-wide and locally (especially in Thailand where environmental activism is rapidly developing [Sluiter 1992]), may demand evaluations of these impacts, or question the validity of dam construction in the first place. These viewpoints, however, may be overly optimistic. Environmental destruction and social disaster are current realities with the implementation of the handful of dams already constructed (Sluiter 1992).

The Lao government established the Lao Community Fisheries and Dolphin Protection Project in January 1993 to deal with environmental and social concerns (Baird and Mounsouphom 1993). The geographic mandate of this group covers all areas in Lao P.D.R. inhabited by Irrawaddy dolphins, with a focus on the Lao/Cambodian border area of the Mekong River near Hang Khone. The Community Fisheries and Dolphin Protection Project espouses community involvement and education. Numerous community meetings have been held as a forum for exchange of information and ideas between the project workers and the local people (Baird and Mounsouphom 1993). The project aims to help communities have more control over environmental and political issues by providing relevant information, and giving local people opportunities to communicate their opinions and concerns to other communities and government agencies. Major issues being dealt with include declining fish stocks, explosives fishing by Cambodians, dam projects, tourism development, and incidental catches of dolphins in gillnets (Baird and Mounsouphom 1993). A government-funded program compensates fishers for net damage resulting from releasing dolphins (Baird et al. 1994). Through the Project, the communities of Hang Khone and Hang Sadam were also able to petition the government to make a formal request to Cambodia for more stringent enforcement of laws prohibiting the use of explosives in fishing (I.G. Baird pers. comm.). Another initiative was the designation of certain areas as reserves, which are off limits for fishing. Each village in the area has designated one such reserve, based on habitat considered important for fish; the reserve controlled by Hang Khone is a narrow strip along the shoreline in quadrats 13, 14 and 23 (Figure 3). The Lao Community Fisheries and Dolphin Protection Project is a type of community-based conservation effort that may be effective, and should be examined more closely as a model throughout the dolphin's range.

RECOMMENDATIONS FOR FURTHER RESEARCH

Considerations on a Global Scale

Finding and implementing solutions to the conservation problems identified in Chapter Two is important. Specifically, addressing habitat degradation and incidental catch are priorities. Some action towards these problems can be initiated immediately, one of which is research. Efforts should be made to obtain further information about Irrawaddy dolphins in the entirety of their range. There are likely more areas where Irrawaddy dolphins can be found which have not yet been identified. Knowing where these populations exist, and their size, will put conservation priorities into perspective and determine the best locations for establishing conservation programs, such as protected areas. This can be accomplished by creating a network with biologists, conservationists, farmers, fishers and other interested people, some of whom were identified and contacted during research for this thesis, and are listed in Appendix II.

Although my attempts to determine abundance of Irrawaddy dolphins at the Lao study site through photo-identification were not successful, modifications to the methods used (Chapter Three) could make this technique worthwhile. Determining and monitoring abundance and distribution remains an important research goal. Monitoring programs should commence in all areas of Irrawaddy dolphin concentration, and other locations as they become known. Surveys should use robust estimation techniques such as carefully designed line and strip transects (e.g. Utreras 1995) and mark-recapture studies. Surveys in all locations should be carried out in such a manner that they can be replicated over the years to monitor trends in abundance. However, Irrawaddy dolphins may not be numerous enough in many places for quantitative surveys to be viable.

It is important to gather further information on Irrawaddy dolphin biology and ecology, and to monitor the animals' response to local human activities and developments. The population of an estimated one thousand Irrawaddy dolphins in Australia's western Gulf of Carpentaria is a prime candidate for this type of research. This area appears to have been little disturbed by human activities and habitat degradation. Conditions and responses could be quite different between populations, especially coastal and inland groups, so a comparative study also would be useful.

Research should investigate the genetic structure of stocks of Irrawaddy dolphins especially between marine and freshwater populations. Information on stock differentiation is needed for conservation and should be treated as a research priority. To help with establishing these studies, a directory of those researchers desiring Irrawaddy dolphin tissue samples for genetic studies or skeletal material for taxonomic studies should be compiled. Information about tissue collection needs and protocols should also be distributed to appropriate people throughout the range of the dolphin, and opportunistic tissue collection and distribution encouraged. Morphological and certain physiological data are also useful in taxonomic studies, so they too can be collected as appropriate.

Given the situation of Irrawaddy dolphins in all other locations, great care should be taken to prevent a decline in dolphin numbers in the seemingly strong population of the Western Gulf of Carpentaria. Given the pressures on, and resulting status of, river dolphins world-wide, Irrawaddy dolphins living in riverine and estuarine habitats should be given special consideration. Pollution, dams, vessel traffic and fishing nets could quickly spell disaster for dolphins in these environments. Programs could explore carefully-planned, small-scale tourism as a way of promoting conservation and increasing awareness, with a financial benefit accruing preferably to the entire local community. Irrawaddy dolphins appear to be locally common, at least seasonally, in several relatively confined locations. This condition is conducive to reliable sightings, but also means that dolphins may be susceptible to disturbance, especially given the results in Chapter Three of the increase in dive duration and surface activities in proximity to vessels at the Lao study site.

Given the fact that Irrawaddy dolphins are at least currently concentrated in lakes, estuaries, river pools, and discrete coastal areas, the establishment of protected areas has the potential of being an effective conservation strategy. Protected areas should be established with as much involvement by local people as possible and designed with features to maximize their social and economic benefits. Doing so will be the best chance that those affected by the protected areas will comply with the regulations put in place. It is clear that dolphins cannot be protected in isolation, but only if dedicated, all-encompassing programs are initiated to protect and rehabilitate important dolphin habitat, which is also critical to many other species.

Recommendations for Research in Lao P.D.R.

Several findings from Chapter Three are discussed here that may be beneficial for the continued conservation efforts of the Lao Community Fisheries and Dolphin Protection Project. The Project will receive a copy of the results with the prospect that they can integrate the information into the framework of community knowledge and ongoing actions for the benefit of the dolphins, environment and community. Results from the field study will also benefit studies of Irrawaddy dolphins, and other river-dwelling dolphins world-wide.

Information about water depth and the relative dolphin use of the habitat could possibly help the community in enhancing their conservation plans. The community may decide that the no-fishing areas already set aside are sufficient, or that perhaps changes to the boundaries or further reserves would be beneficial. As dolphin use of the current reserve is low, this reserve may not contribute to minimizing dolphin incidental catch. The findings on dolphin behaviour in proximity to boats may contribute to guidelines on suitable dolphin-boat co-existence, including plans for dolphin-watching. The knowledge of diurnal use of the study area by the dolphins (declining as the day progresses) is also informative for plans for small-scale tourism. Given that dolphins tend to surface closer to paddle boats than power boats, perhaps dolphin watching would be better carried out in paddle boats.

Many of the results, such as vessel traffic levels, dolphin group size, dive time, habitat use and behaviour, can be used as baseline data to measure changes over time. Monitoring and recording of dolphin mortalities should continue. At a minimum, gender and size of the dead animals should be recorded. Also important are stomach content and reproductive tract analyses. Dedicated observations, as time permits throughout the year, of group size, habitat use, time of day and behaviour would be valuable. My study was quite limited spatially and temporally, covering just a small area during the transition from the dry to wet season. Much could be learned if the study was expanded to other areas of the Mekong river system and across the seasons. Important research questions for the future include:

1. Are there areas with similar physiographic and habitat features in areas of the lower Mekong River and its tributaries, and if so, where are they?

2. What are the characteristics of other areas in the Mekong system where Irrawaddy dolphins congregate?

3. Are tributary mouths an important component of Irrawaddy dolphin habitat?

4. Are there times of the year or locations where photo-identification would be more feasible?

5. Are there times or places where other types of population surveys would be feasible?

6. Are there seasonal differences in Irrawaddy dolphin behaviours and distribution patterns?

7. What locations, times and in what types of nets are Irrawaddy dolphins becoming entangled? Can these variables be modified to reduce dolphin mortalities?

Incidental catch in nets is obviously the biggest immediate threat to Irrawaddy dolphins in the study area and likely the surrounding area. If the situation does not change, I believe there is little hope for the long-term survival of the Irrawaddy dolphin in the Mekong River system. Villagers near the study area also believe that dolphins are rapidly nearing extinction (Baird and Mounsouphom 1994). They believe that dolphins are friends of humans and relate stories of how dolphins have saved people who have fallen into the water or who have been attacked by crocodiles (Baird and Mounsouphom 1994). A common desire of Lao villagers is for their children and grandchildren to grow up in an environment that still includes dolphins.

GENERAL CONSIDERATIONS FOR CONSERVATION

Cultural Sensitivity in Conservation Programs

Conservation programs, whether for remote rural areas in distant countries, or in our own cities, must be sensitive to the local people and culture. Before designing and implementing a conservation program, conservationists must first determine the goals and values of the local people (Jordan 1995), and not just impose formula solutions for the problems, whether they be perceived or real. Within this framework, conservation programs should seek to provide financial, logistical and/or social support, as needed, to local people as they establish communication with governments and organise community groups to tackle broad-scale or local issues. Solutions must be worked out in cooperation with the local citizens; conservation must be in their best interests, and be workable within the social setting. Education is one key component in a culturally sensitive conservation program, where the local community is informed of the issues and encouraged to participate in finding and implementing solutions. The Lao Community Fisheries and Dolphin Protection Project is one good example of where this is working. Another is an education program in the Columbian Amazon, which is thought to be responsible for reducing dolphin mortality related to human activities through talks, school visits, workshops, exchange programs, youth group training, publications and field trips (Kendall et al. 1995).

Conservation and Uncertainty

One problem with conservation plans is the considerable uncertainly present within the many different spheres of knowledge needed to make the plans work. Even basic biological knowledge of the species may be lacking. Life-history data are often incomplete due to technical and logistical problems, especially if the population is already at low levels, and if the species under consideration, such as a marine mammal, is long-lived (Congdon et al. 1993). Incomplete knowledge of biogeographical patterns is also common. For instance, we do not know if there is a continuous distribution of Irrawaddy dolphins from the Mekong River to the South China Sea, and if so, we do not know the extent of interbreeding. This lack of information makes it difficult to evaluate the situation and to plan and implement programs accordingly. Other information, pertaining to the social issues, may also be lacking. As an example, the history of the relationship between the local people and the environment may not be fully understood. In general, the more information that can be gathered, the greater the chance of a robust, workable conservation plan. A conservative plan must be fashioned taking into consideration the unknowns. Such a plan would err on the side of caution, especially where populations are suspected of being threatened or endangered. Finally, conservation plans must recognize that the risks of uncertainly may be compounded over time and may be unrecognized. Congdon et al. (1993) concluded, from a study of sea turtles, that long-lived species are extremely limited in their ability to withstand chronic disturbances. Therefore, initial uncertainty (such as where chronic disturbances are undetected) may lead to catastrophic results, which may not be apparent for many years in the case of long-lived species. This has definite implications for cetaceans, including Irrawaddy dolphins.

Integration of Natural and Social Sciences

As McNeely and Wachtel (1988) pointed out, conservation projects are often more a social than a biological challenge. They suggested that traditional (and indigenous) cultural approaches to conservation be employed where they still exist, or renewed where they have been abandoned, as the day-to-day existence of rural people depends on a close affinity and understanding of nature. Jacobson and Robinson (1990) considered current environmental problems to be largely due to a failure to address the underlying socio-political causes. With this in mind, a sound management program for conservation, either in rural or urban areas, will consider a variety of information, both social and biological. Accordingly, data from both the natural and social science disciplines will be gathered and integrated. Natural science information would ideally consist of complete knowledge of reproductive biology, population dynamics, social structure, behaviour, physiology and distribution. Social science data would include consideration of economic, political, cultural, and sociological factors pertaining to the area under investigation, as well as the human influences on the habitat and species. Conservation sometimes involves modifying people's behaviour, whether through excluding them from an area, or suggesting changes in behaviours. Knowing something about the social and political setting helps to create a conservation plan that has the best chance of working, given the potential problems that can arise.

Programs that address the social well-being and political stability of the community are important for conservation success. Socio-economic and political difficulties can lead to a lack of biological data collection, as well as limited environmental awareness and education, and commitment to conservation, as seen in Latin America (Vidal 1993). A foundation in statute is also important. Laws and guidelines that promote the goals of a conservation plan can play an important role. Domestic and international agreements between jurisdictions are sometimes necessary to afford the most protection. An example is the Comisión Permanente del Pacifico Sur/Programa de las Naciones Unidas para el Medio Ambiente 1992, an agreement between the governments of Panamá, Colombia, Ecuador, Perú and Chile regarding the conservation of aquatic mammals in those regions (Vidal 1993). These considerations involve many people working together, dealing with information spanning many disciplines and countries. This idea goes beyond the traditional role of the biologist collecting field data only to be published in an academic journal, as discussed in the next section.

The Role of Scientists in Conservation

There has been much discussion in the literature recently as to scientists' responsibility to become involved with conservation or environmental activism (e.g. Haupt 1995, Salzman 1995). Hagan (1995) discussed the differences between conservation biologists and environmentalists and concluded that the two are not synonymous. Conservation biologists, as other scientists, are expected to design unbiased experiments and to evaluate data objectively (Hagan 1995). Conclusions are assumed to be independent of values. An environmentalist, on the other hand, "pursues conservation of the natural world according to a value system" (Hagan 1995:975). Hagan put forth this dichotomy to point out that the question of values is an important one to be answered in addressing the role that scientists play in conservation. Perhaps because of this dilemma, many scientists have been reluctant to become involved in environmental activism, even though a love and concern for the environment may have initially attracted them to their field.

I believe that there must be people who can bridge the gap between science and the practicalities of conservation. A growing number of biologists agree with this, as evidenced by the volumes of journals such as Conservation Biology and Biological Conservation. A look through these journals reveals biologists addressing their research within the larger sphere of culture, politics, and economics, to deal with the pressing conservation dilemmas with which they are faced. But providing scientific evidence may not be enough to persuade policymakers to make the needed conservation decisions (Salzman 1995). Haupt (1995) suggested that scientists will be needed in the political arena, where many of the decisions will be made that influence conservation. Salzman (1995) asserted that some decision-makers admit they simply do not care about the environmental crises, instead being of the opinion that the immediate human needs should be considered before the long-term consequences. I believe that scientists must provide input to the decisions being made, and, perhaps most importantly, impart their passion and values for the natural world to the people with the power to make these decisions. For if this schism cannot be bridged, no amount of scientific evidence will be sufficient to bring about the needed changes in policy.

The quest to maintain biological diversity, as Aplet et al. (1992) suggested, requires participation by those with diverse educational backgrounds. Others agree that close attention should be paid to interdisciplinary cooperation to further the conservation agenda (e.g. Temple 1992). Jacobson and Robinson (1990) lamented the fact that appropriate cross-disciplinary training (in ecology, economics, politics and social studies) to address our environmental problems, is lacking. Geography as a discipline has the potential to meet this challenge, and to provide the necessary education through a cross-disciplinary curriculum. Many geographers already have a knowledge of both the natural and social sciences, and experience with integration of the two, qualities needed in the field of conservation. Reeves (1995) pointed out that in the conservation arena, a major challenge is for biologists to converse with engineers, hydrologists and planners in the conservation efforts of river dolphins. Geographers could fill this role very well. Other examples of people with whom interdisciplinary communication might be important within the conservation field are politicians, government workers, teachers and lawyers. The strength of geographers may be in their understanding of, and experience with, interdisciplinary studies and their skills of integrating information.

Conclusion

The fact remains that if the death rate of a population is higher than the birth rate over the long term, extinction is inevitable (disregarding the possible influence of immigration and emigration). Continued dam construction, incidental catch and other environmental disturbances may result in just that for the Irrawaddy dolphin. There are many different ways of approaching conservation, including species and ecosystem perspectives, but common to all must be a cultural sensitivity, an appreciation for the pitfalls of uncertainty, and interdisciplinary studies. There must also be scientists who feel a responsibility to the planet's living things, and who are willing to move beyond their academic duty to protect them.

Chapter Five
SUMMARY AND CONCLUSION

This research was undertaken to gather together the scattered information about Irrawaddy dolphins throughout their range, to learn more about the species through a field study, and to examine the conservation status and challenges. Together this knowledge adds to that literature previously available. In Chapter One I give an overview of the thesis, and discuss the need for, and significance of, increased information and strategies for Irrawaddy dolphin conservation. River-dwelling dolphins the world over, generally living in close proximity to humans, are especially vulnerable to the effects of habitat degradation, incidental catch and other impacts.

Chapter Two provides an overview of Irrawaddy dolphin distribution and abundance in each country where the species is found, and details on habitat use, daily and seasonal movements, group size, biology and feeding and swimming behaviours. A general trend was noted of declining numbers in many historical habitats. One missing piece of information is stock discreteness, which is needed for a good conservation program. It is critical to identify populations that are genetically distinct, especially without adequate knowledge of spatial behaviour.
Although there is little direct hunting for Irrawaddy dolphins throughout their range, habitat degradation and incidental catch are taking their toll. The information in this chapter provides a context for a discussion of the results of the field study, and for an examination of conservation recommendations.

The field study in the Mekong River, southern Lao P.D.R., comprises Chapter Three. There were three components to this part of the research: shore-based observations of habitat use and behaviour, boat-based photo-identification and a description of the habitat. This research was descriptive, rather than question-based, as I felt that this was the best method of inquiry given the lack of knowledge of Irrawaddy dolphins and the study site. This has resulted in a larger knowledge base than if focused questions had been the target of investigation.

I found that Irrawaddy dolphins were present daily at the Hang Sadam study site. They were seen most frequently in the early morning and sightings decreased over the rest of the day. Their behaviours of repeated direction changes and lack of through travel were characteristic of foraging and feeding. There was preferential use of the habitat off the channel mouth and the adjacent sandy island, similar to river dolphin habitat use reported in the literature. Group size was generally small (mean of three animals), but flexible, with frequent changes in size during foraging, likely in response to the prey being pursued. Irrawaddy dolphins were found to display an array of surface activities, but were not as acrobatic as some other small cetaceans are reported to be. Long-term movements are not well documented, but it appears that the dolphins are present year-round at the study area, but are most often seen during the dry season. There is potential for disturbance from vessels, as several changes in behaviour were associated with boat presence. The most pronounced was an increase in dive duration when boats were within 100m. This vessel interaction data must be treated carefully, as direct cause and effects relationships cannot be assumed. The final component of this study was to determine if photo-identification is a feasible research tool to help determine abundance estimates, and to learn more about social structure, as it has been for many cetacean species. The Irrawaddy dolphins at Hang Sadam study site displayed elusive behaviours that resulted in obtaining few good photographs that might be used for this purpose. Overall, this field study provides baseline information about Irrawaddy dolphins and their riverine habitat, but it must be viewed within the temporal and spatial limitations of the study.

Based on the findings of the review and field study, Chapter Four provides recommendations for Irrawaddy dolphin conservation at the Mekong River study site, and throughout the range of this dolphin. The over-riding concern is that conservation be integrated with the social, political and economic realities of the local culture. This may be accomplished by integrating natural and social science data so as to maximize the chances of success and minimize the risks of uncertainty that come with the lack of knowledge we are faced with. I suggest that many geographers are well situated to contribute significantly in the conservation field, with knowledge of both natural and social sciences, and experience with discipline integration.

In conclusion, the long-term prospect of the continued existence of Irrawaddy dolphins is in question. Conservation measures may be too late for the baiji, but I believe there is still time to derail the same fate for Irrawaddy dolphins. We will always be confronted with incomplete knowledge with which to base conservation decisions, but by careful consideration of the available social data along with the traditional scientific knowledge we can maximize the chances that constructive measures are taken. The communities that co-exist with

Irrawaddy dolphins must know that the existence of both is dependent on a healthy ecosystem. Education is one key to obtaining this goal, as is the appropriate financial, social and logistical support so they are able to address the environmental issues at hand. Further research, as outlined in Chapter Four, is required, as is appropriate legislation and enforcement. The level of incidental catch in gillnets must be reduced significantly.

Irrawaddy dolphins are but a small part of the larger framework of environmental conservation. As a visible, tangible and respected component of the coastal and inland waters of the Indo-Pacific, Irrawaddy dolphins can perhaps be an incentive for people to protect an adequate habitat for all species that make their home in these waters.

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APPENDIX I

Irrawaddy Dolphin Records: Sightings, Direct and Incidental Takes, Museum Specimens and Strandings.

	country	date	location	lat_long	type
1	Australia		North Cairns, QL	17 S 146 E	incidental catch
2	Australia	1948 07 16	Melville Bay, NT	12 S 131 E	specimen
3	Australia	1948 07 16	Melville Bay, NT	12 S 131 E	found dead
4	Australia	1965 05 14	Cable Beach, Broome	18 S 122 E	specimen
5	Australia	1965 06 25	Crab Creek, Broome	18 S 122 E	specimen
6	Australia	1965 06 25	Crab Creek, Broome	18 S 122 E	incidental catch
7	Australia	1966 07 12	Townsville	19 16'S 149 49'E	incidental catch
8	Australia	1968 09	Cairns, QL	17 S 146 E	specimen
9	Australia	1969 09 23	Pallarenda, Townsville	19 12'S 146 46'E	specimen
10	Australia	1970 04 23	Horseshoe Bay, Magnetic Is.	19 07'S 146 51'E	specimen
11	Australia	1970 04 23	Horseshoe Bay, Magnetic Is.	19 07'S 146 51'E	specimen
12	Australia	1970 10 03	Pallarenda, Townsville	19 12'S 146 46'E	specimen
13	Australia	1970 12 13	Horseshoe Bay, Magnetic Is.	19 07'S 146 51'E	specimen
14	Australia	1971 03 18	Horseshoe Bay, Magnetic Is.	19 07'S 146 51'E	specimen
15	Australia	1971 04 23	Horseshoe Bay, Magnetic Is.	19 07'S 146 51'E	specimen
16	Australia	1971 06 10	Pallarenda, Townsville	19 12'S 146 46'E	specimen
17	Australia	1972 03 18	Kissing Point, Townsville	19 14'S 146 48'E	specimen
18	Australia	1972 04 21	Horseshoe Bay, Magnetic Is.	19 07'S 146 51'E	specimen
19	Australia	1974 08 18	Pallarenda, Townsville	19 12'S 146 46'E	specimen
20	Australia	1974 08 18	Pallarenda, Townsville	19 12'S 146 46'E	specimen
21	Australia	1974 09 27	Mackay	21 09'S 149 11'E	incidental catch
22	Australia	1975 03 28	The Strand, Townsville	19 16'S 146 48'E	specimen

	number	sex	length	person	material	museum
1						
2				D. Johnson	part of skeleton	National Museum of Natural History, USA
3				D. Johnson	miscellaneous skeletal	National Museum of Natural History, USA
4				Baird	skull	Western Australian Museum
5			218.0 cm	W. Butler	skull, mandibles, teeth	Western Australian Museum
6			152.0 cm	W. Butler	skull	Western Australian Museum
7				R.K. Bryson	skull and skeleton	Queensland Museum
8					skull	Australian Museum
9						Museum of Tropical Queensland
10						Museum of Tropical Queensland
11						Museum of Tropical Queensland
12						Museum of Tropical Queensland
13						Museum of Tropical Queensland
14						Museum of Tropical Queensland
15						Museum of Tropical Queensland
16						Museum of Tropical Queensland
17						Museum of Tropical Queensland
18						Museum of Tropical Queensland
19						Museum of Tropical Queensland
20						Museum of Tropical Queensland
21				S. Adams	skull and skeleton	Queensland Museum
22						Museum of Tropical Queensland

	reg_no	ref
1		J. Mead pers. comm.
2	00284429	J. Mead pers. comm.
3	00284430	J. Mead pers. comm.
4	WAM1823	G. Ross pers. comm.
5	WAM1824	G. Ross pers. comm.
6	WAM1823	G. Ross pers. comm.
7	J14263	Paterson (1986)
8	AMM12359	G. Ross pers. comm.
9	JM4700	Paterson (1994)
10	JM4705	Paterson (1994)
11	JM4706	Paterson (1994)
12	JM4707	Paterson (1994)
13	JM4708	Paterson (1994)
14	JM4709	Paterson (1994)
15	JM4704	Paterson (1994)
16	JM4741	Paterson (1994)
17	JM4720	Paterson (1994)
18	JM4721	Paterson (1994)
19	JM4722	Paterson (1994)
20	JM4723	Paterson (1994)
21	JM511	Paterson (1986)
22	JM4727	Paterson (1994)

	country	date	location	lat_long	type
23	Australia	1975 08 27	Kissing Point, Townsville	19 14'S 146 48'E	specimen
24	Australia	1976 07 30	Pallarenda, Townsville	19 12'S 146 46'E	specimen
25	Australia	1976 09 10	Rowe's Bay, Townsville	19 13'S 146 47'E	specimen
26	Australia	1976 09 10	Rowe's Bay, Townsville	19 13'S 146 47'E	specimen
27	Australia	1983 12 10-30	between Daly River and Milingimbi	12 S 132 E	sighting
28	Australia	1984 08	Western Gulf of Carpentaria	15 S 135 E	sighting
29	Australia	1984 08 09	Ross River mouth, Townsville	19 16'S 146 50'E	specimen
30	Australia	1984 09 30	Tolakea, Townsville	19 09'S 146 35'E	specimen
31	Australia	1985 01 22	Main Beach, Cape Hillsborough	20 55'S 149 00'E	beachcast
32	Australia	1985 02	Western Gulf of Carpentaria	15 S 135 E	sighting
33	Australia	1987 06 18	Saunders Beach, QL	19 11'S 146 41'E	found dead
34	Bangladesh	1960 02	Cox's Bazar	21 30'N 92 E	found dead
35	Bangladesh	1969	Sundarbans and Mongla	22 N 90 E	sighting
36	Bangladesh	pre 1971	70 miles up the Pussur River		sighting
37	Bangladesh	1976 02	off Cox's Bazar	21 30'N 92 E	direct catch
38	Bangladesh	1982 12	South tip of Sonadia Island	21 30' N 92 E	found dead
39	Bangladesh	1994 08	below Khulna, Sundarbans	22 N 90 E	sighting
40	Brunei		Buara Island	5 N 115 E	sighting
41	Brunei		off Brooketon (Muara)	5 N 115 E	sighting
42	Brunei		Muara Island, Brunei River	5 N 115 E	specimen
43	Burma		Irrawaddy River		specimen
44	Burma		Irrawaddy River		specimen

	number	sex	length	person	material	museum
23						Museum of Tropical Queensland
24						Museum of Tropical Queensland
25						Museum of Tropical Queensland
26						Museum of Tropical Queensland
27	13					
28	numerous sightings					
29						Museum of Tropical Queensland
30						Museum of Tropical Queensland
31				R. Thompson	skull and mandible	Queensland Museum
32	numerous sightings					
33			185 cm	JCUNQ		
34				A. Haque		
35	6					
36						
37	3 or 4				oil	
38						
39	3					
40						
41						
42					skull (no mandibles)	British Museum (Natural History)
43					skeleton (no skull)	British Museum (Natural History)
44					skull	Museum of Genova, Italy

	reg_no	ref
23	JM 4729	Paterson (1994)
24	JM4734	Paterson (1994)
25	JM4735	Paterson (1994)
26	JM4736	Paterson (1994)
27		Freeland and Bayliss (1989)
28		Freeland and Bayliss (1989)
29	JM4739	Paterson (1994)
30	JM4740	Paterson (1994)
31	JM4937	Paterson (1994)
32		Freeland and Bayliss (1989)
33		J. Mead pers. comm.
34		Haque (1982)
35		Kasuya and Haque (1972)
36		Morzer Bruyns (1971)
37		Haque (1982), pers. comm.
38		B. Ahmed pers. comm.
39		A. Haque, pers. comm.
40		Gibson-Hill (1949)
41		Gibson-Hill (1950)
42	1888.5.28.1	Pilleri and Gihr (1974)
43	1877.12.10.17	Andersen (1871), Pilleri and Gihr (1974)
44		Pilleri and Gihr (1974)

	country	date	location	lat_long	type
45	Burma	1870 03 08	Bhamo, Irrawaddy River	24 15'N 97 15'E	collected
46	Burma	1886	near Bhamo, Irrawaddy River	24 15'E 97 15'E	collected
47	Burma	mid 1970s	Pagan, Irrawaddy River	21 N 95 E	found dead
48	Burma	pre 1971	Irrawaddy River		sighting
49	Burma	pre 1977	above Bhamo, Irrawaddy River	24 30'N 97 15'E	sighting
50	Burma	pre 1977	Katha, Irrawaddy River	24 30'N 96 30'E	sighting
51	Burma	pre 1977	Kyauktonegyi, Irrawaddy River		sighting
52	Burma	pre 1977	Thayetmyo, Irrawaddy River	19 N 95 E	sighting
53	Burma	1982 11	Irrawaddy River		found dead
54	Burma	1996 03	north of Mandalay, Irrawaddy River	22 24.3'N 96 00.1'E	sighting
55	Burma	1996 03	north of Mandalay, Irrawaddy River	22 09.4'N 96 00.9'E	sighting
56	Burma	1996 03	north of Mandalaly, Irrawaddy River	22 02.9'N 96 01.9'E	sighting
57	Burma	1996 03	north of Mandalay, Irrawaddy River	22 09.4'N 96 00.9'E	sighting
58	Burma	1996 04	north of Sandoway	19 25.5'N 93 35.7'E	sighting
59	Burma	1996 04	north of Sandoway	20 04.9'N 93 23.7'E	sighting
60	Burma	1996 04	north of Sandoway	20 18.5'N 93 01.1'E	sighting
61	Burma	1996 04	north of Sandoway	20 21.8'N 93 01.3'E	sighting
62	Burma	1996 04	north of Sandoway	20 18.5'N 93 01.0'E	sighting
63	Burma	1996 04	north of Sandoway	20 17.1'N 93 00.4'E	sighting
64	Burma	1996 04	north of Sandoway	20 14.4'N 92 59.2'E	sighting
65	Burma	1996 04	north of Sandoway	20 13.4'N 92 59.0'E	sighting
66	Cambodia	1964 12	Peam Ro, Prey Veng Province	11 15'N 105 15'E	incidental catch

	number	sex	length	person	material	museum
45		M	7'1"	Bowers	skull and skeleton	Zoological Survey of India
46				L. Fea	skeleton	Museo di Storia Naturale de Genova, Italy
47			approx 7 ft			
48						
49						
50	1					
51	1					
52	2 or 3					
53					oil	
54	2			B. Smith		
55	4			B. Smith		
56	1			B. Smith		
57	7			B. Smith		
58	2			B. Smith		
59	3			B. Smith		
60	1			B. Smith		
61	1			B. Smith		
62	2			B. Smith		
63	2			B. Smith		
64	2			B. Smith		
65	6			B. Smith		
66		F				

	reg_no	ref
45	13030	M. Ghosh pers. comm.
46	MS003776	Pilleri and Gihr (1974)
47		Leatherwood et al. (1984)
48		Morzer Bruyns (1971)
49		Lekagul and McNeely (1977)
50		U Tin Thein (1977)
51		U Tin Thein (1977)
52		U Tin Thein (1977)
53		Leatherwood et al. (1984)
54		B. Smith pers. comm.
55		B. Smith pers. comm.
56		B. Smith pers. comm.
57		B. Smith pers. comm.
58		B. Smith pers. comm.
59		B. Smith pers. comm.
60		B. Smith pers. comm.
61		B. Smith pers. comm.
62		B. Smith pers. comm.
63		B. Smith pers. comm.
64		B. Smith pers. comm.
65		B. Smith pers. comm.
66		Tana (1995)

	country	date	location	lat_long	type
67	Cambodia	1964 12	Banteay Dek, Kandal Province	11 15'N 105 E	incidental catch
68	Cambodia	1968 02 28	near Kratie	11 30'N 105 E	collected
69	Cambodia	1969 02 18	near Kratie	11 30'N 105 E	collected
70	Cambodia	pre 1973	Mekong River		sighting
71	Cambodia	1976	Tonle Sap	13 N 104 E	direct take
72	Cambodia	1980 01	Chong Khneas, Siem Reap Province	13 15'N 104 E	incidental catch
73	Cambodia	1983 12	Bak Dai Stream, near Cambodian/Vietnam border	11 N 105 E	sighting
74	Cambodia	1992 07	Cambodian/Vietnam border	11 N 105 E	incidental catch
75	Cambodia	1993 12 13	Bak Kheng, Muk Kampul District, Kandal Province	11 15'N 105 E	incidental catch
76	Cambodia	pre 1994	Tonlesap River	12 N 105 E	sighting
77	Cambodia	1994	Chong Khneas, Siem Reap Province	13 15' N 104 E	specimen
78	Cambodia	1995 04	At the rapids system in Stung Treng Province	13 N 106 E	found dead
79	India				specimen
80	India		Cicular Canal, Calcutta	22 N 88 E	collected
81	India	1852 08	Mouth of Vishakhapatnam River	17 25'N 83 14'E	found dead
82	India	1859	Calcutta vicinity	22 N 88 E	specimen
83	India	1873 01 03	"Northeastern Province"		collected
84	India	1875 07 09	Chilka Lake	19 30'N 85 30'E	specimen
85	India	1875	Chilka Lake	19 30'N 85 30'E	collected
86	India	1879	Hughli River, Calcutta	22 N 88 E	specimen
87	India	1914 02	Kalidai Is., Chilka Lake	19 30'N 85 30'E	found dead
88	India	1915 (approx)	outer channel, Chilka Lake	19 30'N 85 30'E	sighting

	number	sex	length	person	material	museum
67						
68		F	190 cm	R. Lloze	skeleton and organs	Phnom Penh University, Cambodia
69		F	200 cm	R. Lloze	skeleton and organs	Phnom Penh University, Cambodia
70						
71	many				oil	
72						
73	about two dozen					
74						
75			about 2 m			
76						
77					skull	
78			about 2 m			
79		M			skull	Zoological Survey of India
80				J. Barckley	skull	Zoological Survey of India
81				W. Elliot	skull	British Museum (Natural History)
82		F	4'0"		skull and skeleton	Zoological Survey of India
83				J. Anderson	liver fluke	
84					skull	Zoologisch Museum Amsterdam
85				L. Schwendler	skull	Zoological Survey of India
86		M		Anderson	skeleton	Museum National d'Histoire Naturelle, France
87		M			skeleton	
88	usually 3-4					

	reg_no	ref
67		Tana (1995)
68	OBKMC 1	Lloze (1973)
69	OBKMC 2	Lloze (1973)
70		Lloze (1973)
71		Tana (1995)
72		Tana (1995)
73		Tana (1995)
74		Tana (1995)
75		Tana (1995)
76		Baird et al. (1994)
77		Tana (1995)
78		Tana (1995)
79	19122	M. Ghosh pers. comm.
80	19123	M. Ghosh pers. comm.
81	1454A	Owen (1869), Ellerman and Morrison-Scott (1951)
82	19382	M. Ghosh pers. comm.
83		Cobbold (1876)
84	ZMA 5071	P. van Bree pers. comm.
85	19379	M. Ghosh pers. comm.
86	1880-18	
87		Annandale (1915)
88		Annandale (1915)

	country	date	location	lat_long	type
89	India	1915 (approx)	Satpara, Chilka Lake	19 30'N 85 30'E	sighting
90	India	1915 (approx)	Chilka Lake	19 30'N 85 30'E	sighting
91	India	1985-1987	Chilka Lake	19 30'N 85 30'E	sighting
92	India	1985 12 03	northern Chilka Lake	19 30'N 85 30'E	found dead
93	India	1985 11	Chilka Lake	19 30'N 85 30'E	found dead
94	India	1987 03	Gahirmatha Beach		found dead
95	India	1989	Biterkamika Sanctuary		incidental catch
96	Indonesia				specimen
97	Indonesia		Kumay River, Kalimantan		sighting
98	Indonesia	1888	Kalimantan		unknown
99	Indonesia	1900 09	Long Iram, Mahakam River		specimen
100	Indonesia	1902	Long Iram, Mahakam River		sighting
101	Indonesia	1914 05	Mahakam River, Kalimantan		specimen
102	Indonesia	1955 04 11-16	Tjilitjap, Java		sighting
103	Indonesia	1956 02 28	Belawan Deli River, Sumatra	4 N 98 E	sighting
104	Indonesia	1956 03 05	Belawan Deli River, Sumatra	4 N 98 E	sighting
105	Indonesia	1956 07 23-25	Surabaya, Java	8 S 113 E	sighting
106	Indonesia	1956 07 31	Makassar, Celebes (Sulawesi)		sighting
107	Indonesia	1956 08 10-13	Surabaya, Java	8 S 113 E	sighting
108	Indonesia	1956 08 30	Belawan Deli River, Sumatra	4 N 98 E	sighting
109	Indonesia	1956 09 04	Belawan Deli River, Sumatra	4 N 98 E	sighting
110	Indonesia	1956 12 19	Belawan Deli River, Sumatra	4 N 98 E	sighting

	number	sex	length	person	material	museum
89						
90						
91	about 20					
92		F	140 cm	P. Dhandapani		
93						
94			201 cm			
95						
96					skull	Museum Zoologicun Bogoriense
97						
98						British Museum (Natural History)
99				Nieuwenhuis	skull (no mandibles)	Zoological Museum Amsterdam
100						
101		F		H. Raven	tail, skull, flippers	National Museum of Natural History, USA
102						
103						
104						
105						
106						
107						
108						
109						
110						

	reg_no	ref
89		Annandale (1915)
90		Annandale (1915)
91		Dhandapani (1992)
92		Dhandapani (1992)
93		Dhandapani (1992)
94		James et al. (1989)
95		L. Mohan pers. comm.
96		Leatherwood unpublished data
97		Priyono (1995)
98	1888.5.28.1	Pilleri and Gihr (1974)
99	ZMA 5070	P. van Bree pers. comm., Morzer Bruyns (1966)
100		Morzer Bruyns (1966)
101	00199743	
102		Morzer Bruyns (1966)
103		Morzer Bruyns (1966)
104		Morzer Bruyns (1966)
105		Morzer Bruyns (1966)
106		Morzer Bruyns (1966)
107		Morzer Bruyns (1966)
108		Morzer Bruyns (1966)
109		Morzer Bruyns (1966)
110		Morzer Bruyns (1966)

	country	date	location	lat_long	type
111	Indonesia	1957 01 16-21	Surabaya, Java	8 S 113 E	sighting
112	Indonesia	1957 02 15	Belawan Deli River, Sumatra	4 N 98 E	sighting
113	Indonesia	1957 06 02	Belawan Deli River, Sumatra	4 N 98 E	sighting
114	Indonesia	1957 06 20-22	Surabaya, Java	8 S 113 E	sighting
115	Indonesia	1957 07 22	Belawan Deli River, Sumatra	4 N 98 E	sighting
116	Indonesia	1957 12 19	Belawan Deli River, Sumatra	4 N 98 E	sighting
117	Indonesia	1958	Pulo Supiori to Pulo Biak, Irian Jaya		sighting
118	Indonesia	1958	Southwest coast, Irian Jaya		sighting
119	Indonesia	1958 05 18	Belawan Deli River, Sumatra	4 N 98 E	sighting
120	Indonesia	1959	Pulo Supiori to Pulo Biak, Irian Jaya		sighting
121	Indonesia	1959 03 02	Belawan Deli River, Sumatra	4 N 98 E	sighting
122	Indonesia	1959 03 28	Surabaya, Java	8 S 113 E	sighting
123	Indonesia	1959 04 29	Belawan Deli River, Sumatra	4 N 98 E	sighting
124	Indonesia	1959 10 07/08	Tandjong Pandan, Biliton	3 S 108 E	sighting
125	Indonesia	1960	southwest coast Irian Jaya		sighting
126	Indonesia	pre 1971	S New Guinea (Irian Jaya)		sighting
127	Indonesia	pre 1972	north coast Irian Jaya		sighting
128	Indonesia	1972 06	Labuhanruhu, Sumatra	3 12'N 99 33'E	found dead
129	Indonesia	1974	Mahakam River, Kalimantan		specimen
130	Indonesia	1974 10 15	Semayang Lake, Mahakam River, Kalimantan	0.5 N 116 E	sighting
131	Indonesia	1978	Mahakam River and vicinity		population estimate
132	Indonesia	1978	Mahakam River, Kalimantan		specimen

	number	sex	length	person	material	museum
111						
112						
113						
114						
115						
116						
117						
118						
119						
120						
121						
122						
123						
124						
125						
126						
127						
128				P. Van Peenen	skull	National Museum of Natural History, USA
129				Jaya Ancol	body cast	Jaya Ancol Oceanarium, Jakarta, Indonesia
130	2					
131	100-150					
132				Jaya Ancol	skull and skeleton	Jaya Ancol Oceanarium, Jakarta, Indonesia

	reg_no	ref
111		Morzer Bruyns (1966)
112		Morzer Bruyns (1966)
113		Morzer Bruyns (1966)
114		Morzer Bruyns (1966)
115		Morzer Bruyns (1966)
116		Morzer Bruyns (1966)
117		Morzer Bruyns (1966)
118		Morzer Bruyns (1966)
119		Morzer Bruyns (1966)
120		Morzer Bruyns (1966)
121		Morzer Bruyns (1966)
122		Morzer Bruyns (1966)
123		Morzer Bruyns (1966)
124		Morzer Bruyns (1966)
125		Morzer Bruyns (1966)
126		Morzer Bruyns (1971)
127		Dawbin (1972)
128	00486170	J. Mead pers. comm.
129		Tas'an and Leatherwood (1984)
130		Tas'an and Leatherwood (1984)
131		Tas'an and Leatherwood (1984)
132		Tas'an and Leatherwood (1984)

	country	date	location	lat_long	type
133	Indonesia	1978 09 24	Semayang Lake, Mahakam River, Kalimantan	0.5 N 116 E	sighting
134	Indonesia	1980	Seribu Archipelago, Javan Sea		specimen
135	Indonesia	1982	Muara Kaman		incidental catch
136	Indonesia	1985 06	Muara Pahu, Mahakam River		incidental catch
137	Indonesia	1985 09	near Senoni, Mahakam River		found dead
138	Indonesia	1990	Segara Anakan Bay, Java		population estimate
139	Indonesia	1993	Mahakam River and vicinity		population estimate
140	Lao PDR	1960s	Don Dtan Village, above Khone Falls	13 58'N 105 56'E	sighting
141	Lao PDR	1978 03	confluence of the Sekong and Sekhamen Rivers	15 N 106 45'E	sighting
142	Lao PDR	1978 03	Sekhamen River	15 30'N 107 E	direct take
143	Lao PDR	1984	Kung village		direct take
144	Lao PDR	1989 (approx)	upstream of Banphon, Sekong Province	15 30'N 107 E	sighting
145	Lao PDR	pre 1989	Wang Deeow		sighting
146	Lao PDR	1989	Sanamsai, Sekong River		incidental catch
147	Lao PDR	late 1980s	Houay Twai Stream		found dead
148	Lao PDR	1990	Sompoy, Sekong River		sighting
149	Lao PDR	1990	Sekong River, Sekong Province		direct take
150	Lao PDR	1990	Sekong River, Sekong Province		direct take
151	Lao PDR	1991	Gaeng Luang, Sekong River		sighting
152	Lao PDR	1991	Talan village, Sekong River		sighting
153	Lao PDR	1991	Hatnyai, mouth of Sepian River	14 30'N 106 30'E	sighting
154	Lao PDR	1991	Bahn Mai, Sepian River		sighting

	number	sex	length	person	material	museum
133	7					
134				A. Soemarto	skull	Museum Zoologicun Bogoriense
135						
136						
137						
138	30					
139	68					
140						
141	2					
142						
143						
144	2					
145	up to 20					
146						
147						
148	2					
149						
150						
151	2					
152	seen every year					
153	3					
154	10					

	reg_no	ref
133		Tas'an and Leatherwood (1984)
134		Tas'an and Leatherwood (1984)
135		Wirawan (1989)
136		Wirawan (1989)
137		Wirawan (1989)
138		Gelanggang Samudera Jaya Ancol (1990)
139		Priyono (1995)
140		Baird and Mounsouphom (1994)
141		Baird (1991)
142		Baird (1991)
143		Baird (1991)
144		Baird (1991)
145		Baird (1991)
146		Baird (1992), Baird et al. (1994)
147		Baird and Mounsouphom (1995)
148		Baird (1992)
149		Baird et al. (1994)
150		Baird et al. (1994)
151		Baird (1992)
152		Baird (1992)
153		Baird (1992)
154		Baird (1992)

	country	date	location	lat_long	type
155	Lao PDR	1991 12	Hang Khone	13 56'N 105 56'E	sighting
156	Lao PDR	1991 12	near Sekong Town	15 45'N 107 E	specimen
157	Lao PDR	1991 12	Hang Khone, Mekong River	13 56'N 105 56'E	incidental catch
158	Lao PDR	1991 12	Hang Khone, Mekong River	13 56'N 105 56'E	incidental catch
159	Lao PDR	pre 1992	Sekong River		sighting
160	Lao PDR	1992	Hang Khone, Mekong River	13 56'N 105 56'E	incidental catch
161	Lao PDR	1992	Sepian River	14 30'N 106 30'E	sighting
162	Lao PDR	1992 01	Hang Khone, Mekong River	13 56'N 105 56'E	incidental catch
163	Lao PDR	1992 02-03	Hang Khone, Mekong River	13 56'N 105 56'E	incidental catch
164	Lao PDR	1992 03	Hang Khone, Mekong River	13 56'N 105 56'E	incidental catch
165	Lao PDR	1992 03	Hang Khone, Mekong River	13 56'N 105 56'E	incidental catch
166	Lao PDR	1992 03-04	Hang Khone	13 56'N 105 56'E	sighting
167	Lao PDR	1992 04	near Sekong Town	15 45'N 107 E	sighting
168	Lao PDR	1992 04 08	Hang Khone, Mekong River	13 56'N 105 56'E	incidental catch
169	Lao PDR	1992 07-10	Sekong River, Attapeu Province		sighting
170	Lao PDR	1992 07-10	Sekong River, Attapeu Province		sighting
171	Lao PDR	1993 01-05	Hang Khone	13 56'N 105 56'E	sighting
172	Lao PDR	1993 02	Hang Khone, Mekong River	13 56'N 105 56'E	incidental catch
173	Lao PDR	1993 05 13	Hang Khone	13 56'N 105 56'E	sighting
174	Lao PDR	1993 05 14	Hang Khone, Mekong River	13 56'N 105 56'E	found dead
175	Lao PDR	1993 05 17	Hang Khone, Mekong River	13 56'N 105 56'E	found dead
176	Lao PDR	1993 05 22	Hang Khone, Mekong River	13 56'N 105 56'E	incidental catch

	number	sex	length	person	material	museum
155	20-30					
156					skull	
157				I. Baird	skull and teeth	Forestry Department, Vientiane, Lao PDR
158						
159						
160						
161	2					
162						
163				I. Baird		
164				I. Baird		
165			219 cm	I. Baird		
166	up to 15					
167	1					
168		M	190 cm	I. Baird		
169	6					
170	2					
171	groups of 1-17					
172						
173	approx 17					
174		M	105.0 cm	P. Stacey	skeleton, skull, teeth, tissue	
175		M	179.2 cm	P. Stacey	teeth, tissue	
176		F	230 cm	I. Baird	tissue	

	reg_no	ref
155		Baird et al. (1994), Baird (1991)
156		Baird et al. (1994)
157		Baird (1991)
158		Baird (1992), Baird et al. (1994)
159		Baird (1992)
160		Baird (1992), Baird et al. (1994)
161		Baird et al. (1994)
162		Baird (1992), Baird et al. (1994)
163		Baird (1992), Baird et al. (1994)
164		Baird (1992), Baird et al. (1994)
165		Baird (1992), Baird et al. (1994)
166		Baird et al. (1994), Baird (1992)
167		Baird et al. (1994)
168		Baird (1992), Baird et al. (1994), Sluiter (1992)
169		Baird et al. (1994)
170		Baird et al. (1994)
171		Baird et al. (1994), Stacey unpublished
172		Baird et al. (1994)
173		Baird et al. (1994), Stacey unpublished
174		Baird et al. (1994), Stacey unpublished
175		Stacey unpublished
176		Baird et al. (1994)

	country	date	location	lat_long	type
177	Lao PDR	1993 08	15 km south of Sekong Town	15 45'N 107 E	incidental catch
178	Lao PDR	pre 1994	Sekong, Sekhamen, Sepian, and Sekampoh Rivers		sighting
179	Lao PDR	1994 03/04	Hang Khone	13 56'N 105 56'E	sighting
180	Lao PDR	1994 04	Lao/Cambodian border		live stranding
181	Lao PDR	1994 08	Near Attapeu Town, Sekong River	15 N 107 E	sighting
182	Lao PDR	1994 09	Houay Kaliang Stream		sighting
183	Lao PDR	1994 12	Lao/Cambodian border		incidental catch
184	Lao PDR	1994 12	Houay Talat Stream, near Lao/Cambodian border		incidental catch
185	Lao PDR	early 1995	Lao/Cambodian border		found dead
186	Lao PDR	early 1995	Lao/Cambodian border		found dead
187	Lao PDR	early 1995	Lao/Cambodian border		incidental catch
188	Lao PDR	early 1995	Lao/Cambodian border		incidental catch
189	Malaysia		Buntai, Sarawak		sighting
190	Malaysia		Bantang, Perak		sighting
191	Malaysia		lower Santubong River	1 30'N 105 15'E	sighting
192	Malaysia		Bato Maung, Penang	5 N 100 E	specimen
193	Malaysia		Santubong, Sarawak	1 30'N 105 15'E	specimen
194	Malaysia		Baram River, Sarawak	3 N 115 E	specimen
195	Malaysia	1892	Sarawak		specimen
196	Malaysia	1959 03 04	Klang River, Port Swettenham		sighting
197	Malaysia	1959 04 27	Klang River, Port Swettenham		sighting
198	Malaysia	1959 09 24-26	Rajang River, Sarawak		sighting

	number	sex	length	person	material	museum
177						
178						
179	1-15					
180			juvenile			
181						
182						
183			juvenile			
184						
185			juvenile			
186			juvenile			
187		F	adult			
188			calf			
189						
190						
191						
192				O. Sin	skull and skeleton	British Museum (Natural History)
193					mounted specimen	Sarawak Museum, Malaysia
194					skull	Zoological Museum
195				C. Hose	skeleton	Museum of Comparative Zoology, Harvard, USA
196						
197						
198						

	reg_no	ref
177		Baird et al. (1994)
178		Baird et al. (1994)
179		Stacey unpublished
180		Baird and Mounsouphom (1995)
181		Baird and Mounsouphom (1995)
182		Baird and Mounsouphom (1995)
183		Baird and Mounsouphom (1995)
184		Baird and Mounsouphom (1995)
185		Baird and Mounsouphom (1995)
186		Baird and Mounsouphom (1995)
187		Baird and Mounsouphom (1995)
188		Baird and Mounsouphom (1995)
189		Gibson-Hill (1949)
190		Gibson-Hill (1949)
191		Gibson-Hill (1950)
192	1964.2.24.1	Pilleri and Gihr (1974)
193		
194		Pilleri and Gihr (1974)
195	MC021929	J. Mead pers. comm.
196		Morzer Bruyns (1966)
197		Morzer Bruyns (1966)
198		Morzer Bruyns (1966)

	country	date	location	lat_long	type
199	Malaysia	1959 10 12	Klang River, Port Swettenham		sighting
200	Malaysia	1960 02 20	Klang River, Port Swettenham		sighting
201	Malaysia	1960 04 17-19	Rajang River, Sarawak		sighting
202	Malaysia	1963 05 14-17	Rajang River, Sarawak		sighting
203	Malaysia	1964 07 29	Santubong, Sarawak		specimen
204	Malaysia	1966 07	Santubong, Sarawak		specimen
205	Malaysia	pre 1971	Klang River, Malaya		sighting
206	Malaysia	pre 1971	Penang	5 N 100 E	sighting
207	Papua New Guinea	pre 1972	Gulf of Papua	8 S 145 E	incidental catch
208	Papua New Guinea	pre 1975	rivers of Papua New Guinea		sighting
209	Singapore				specimen
210	Thailand		Laem Ngop	12 15'N 102 30'E	sighting
211	Thailand		Laem Sing		sighting
212	Thailand		Ban Phe	12 45'N 101 15'E	sighting
213	Thailand		Rayong	12 45'N 101 15'E	sighting
214	Thailand		Songkhla	7 N 100 30'E	specimen
215	Thailand				specimen
216	Thailand		Trat	12 15'N 102 30'E	sighting
217	Thailand	1903	Tanjong, Patani	7 N 101 E	collected
218	Thailand	1903	Tanjong, Patani	7 N 101 E	collected
219	Thailand	pre 1916	Chanthaburi	12 30'N 102 E	sighting
220	Thailand	pre 1937	Chanthaburn coast		sighting

	number	sex	length	person	material	museum
199						
200						
201						
202						
203				T. Harrison		Field Museum, Chicago, USA
204				T. Harrison		Field Museum, Chicago, USA
205	Regularly seen					
206						
207						
208						
209					stuffed skin	British Museum (Natural History)
210						
211						
212						
213						
214					skull	Private collection of G. Pilleri
215					mounted skeleton	Bang Saen Marine Science Center, Thailand
216						
217		M	220.0 cm			
218		M	275.2 cm			
219						
220						

	reg_no	ref
199		Morzer Bruyns (1966)
200		Morzer Bruyns (1966)
201		Morzer Bruyns (1966)
202		Morzer Bruyns (1966)
203	FM099610	J. Mead pers. comm.
204	FM099613	J. Mead pers. comm.
205		Morzer Bruyns (1971)
206		Morzer Bruyns (1971)
207		Dawbin (1972)
208		Mitchell (1975)
209	1883.11.20.2	Pilleri and Gihr (1974)
210		Andersen and Kinze (1993)
211		Andersen and Kinze (1993)
212		Andersen and Kinze (1993)
213		Andersen and Kinze (1993)
214	T-563	Pilleri and Gihr (1974)
215		Andersen and Kinze (1993)
216		Andersen and Kinze (1993)
217	specimen A	Bonhote (1903) in Pilleri and Gihr (1974)
218	specimen B	Bonhote (1903) in Pilleri and Gihr (1974)
219		Kloss (1916)
220		Gibson-Hill (1949)

	country	date	location	lat_long	type
221	Thailand	1956 12 15	Kra River		sighting
222	Thailand	1958 05 20	Kra River		sighting
223	Thailand	1971	Songkhla Lake	7 N 100 30'E	live stranding
224	Thailand	1971	Songkhla Lake	7 N 100 30'E	live stranding
225	Thailand	1971	Songkhla Lake	7 N 100 30'E	live stranding
226	Thailand	1985 02 02	Naklua		stranding
227	Thailand	1990	Songkhla Lake	7 N 100 30'E	specimen
228	Thailand	1990 01 18	Songkhla Lake	7 N 100 30'E	specimen
229	Thailand	1990 05	Bang Saen		incidental catch
230	Thailand	1992 10 21	Naklua		stranding
231	Vietnam	1967 12 31	Iles des Pirates	10 15'N 104 30'E	found dead
232	Vietnam	1968	Mekong River		sighting

	number	sex	length	person	material	museum
221						
222						
223			193 cm		stuffed specimen	Songkhla Teachers College, Thailand
224					skeleton	Songkhla Teachers College, Thailand
225					skeleton	Collection of G. Pilleri
226						
227			219 cm		skeleton	Nat Institute of Coastal Aquaculture, Thailand
228			219 cm		stuffed specimen	National Institute of Coastal Aquaculture, Thailand
229		F	207 cm			Bang Saen Marine Science Center, Thailand
230						
231					skull	
232						

	reg_no	ref
221		Morzer Bruyns (1966)
222		Morzer Bruyns (1966)
223		Pilleri and Gihr (1974)
224	Exp. No. 17	Pilleri and Gihr (1974)
225	T 563	Pilleri and Gihr (1974)
226		Andersen and Kinze (1993)
227		Andersen and Kinze (1993)
228		Andersen and Kinze (1993)
229		Andersen and Kinze (1993)
230		Andersen and Kinze (1993)
231		Lloze (1973)
232		Lloze (1973)

APPENDIX II

People Involved in Irrawaddy Dolphin Research

Name and Address	Activities
Michael Andersen/Carl Kinze SCIGTAS Institute of Marine Science Burapha University Saen Suk, 20131 Chonburi THAILAND	Surveys for Irrawaddy dolphins in Thailand.
Peter Arnold Museum of Tropical Queensland 70-84 Flinders Street Townsville, Queensland 4810 AUSTRALIA	Colour patterns of Irrawaddy dolphins in Queensland; anatomic, taxonomic and phylogenetic descriptions (with George Heinsohn).
Ian Baird/ Bounhong Mounsouphom Lao Community Fisheries and Dolphin Protection Project Box 860, Pakse LAO P.D.R.	Studies of Irrawaddy dolphin distribution, feeding and natural history in Lao P.D.R. and Cambodia.
Barb Curry/ Andy Dizon/ Richard LeDuc National Marine Fisheries Service Southwest Fisheries Science Center P.O. Box 271 La Jolla, CA 92038 U.S.A.	Genetic studies of Irrawaddy dolphins.
P. Dhandapani Marine Biological Station Zoological Survey of India 100 Santhome High Road Madras 600 028 INDIA	Status of Irrawaddy dolphins in Chilka Lake, India.
George Heinsohn School of Biological Sciences Department of Zoology James Cook University Townsville, Queensland 4811 AUSTRALIA	Colour patterns of Irrawaddy dolphins in Queensland; anatomic, taxonomic and phylogenetic descriptions (with Peter Arnold).
Stephen Leatherwood Ocean Park Conservation Foundation Ocean Park, Aberdeen HONG KONG	Overall status of Irrawaddy dolphins; conservation.

Helene Marsh Department of Environmental Studies James Cook University Townsville, Queensland 4811 AUSTRALIA	Field surveys for Irrawaddy dolphins in conjunction with dugong studies.
R.S. Lal Mohan Conservation of Nature Trust B/24 Gandhinagar Calicut - 673 005 Kerala, INDIA	Studies of Irrawaddy dolphins in Chilka Lake, India

APPENDIX III

Sample Field Data Sheet

Date:

Q								D	T	C	R

APPENDIX IV
Codes Used in Shore-Based Observations

Environment Codes

Cloud Cover
- 0 = clear
- 1 = up to 10%
- 2 = up to 20%
- 3 = up to 30% etc.

Water Surface
- 1 = calm
- 2 = slight ripple
- 3 = moderate ripple
- 4 = chop

Dolphin Group Behaviour Codes

Directionality (D on data sheet)
- N = generally north
- S = generally south
- E = generally east
- W = generally west
- ND = non-directional

Cohesiveness (C on data sheet)
- 1 = not more than 1m between any dolphins
- 2 = 1-3m between any dolphins
- 3 = 3-10m between any dolphins
- 4 = 10-50m between any dolphins
- 5 = more than 50m between any dolphins

Individual Dolphin Behaviour Codes

- 1 = unidentified splash
- 2 = tail slap
- 3 = tail wave
- 4 = pectoral fin slap
- 5 = sideways roll
- 6 = touching
- 7 = leap partway out of water
- 8 = fish seen in mouth
- 9 = spyhop
- 10 = leap completely out of water
- 11 = pause at surface for x (specify) seconds
- 12 = other behaviour (specify)
- 13 = spit water
- 14 = head lift
- 15 = pectoral fin wave
- 16 = going slowly
- 17 = going quickly
- 18 = bubble blowing
- HA = high arch dive

Vessel Codes

Vessel Type
- B1 = paddle boat
- B2 = small motor boat
- B3 = large motor boat

Vessel Speed
- BS1 = slow
- BS2 = medium
- BS3 = fast

VITA

Surname: Stacey Given Names: Pam Joyce

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Educational Institutions Attended:

University of Victoria	1991 to 1996
University of Victoria	1983 to 1987
Camosun College	1981 to 1983

Degrees Awarded:

B.Sc. (Biology)	University of Victoria	1987

Honours and Awards:

Canada-ASEAN Centre/Asia Pacific Foundation of Canada-Student Travel Award	1994

Publications:

Peer-reviewed publications

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Author [redacted]

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June 12, 1996