LONG-TERM VISUAL AND ACOUSTIC CETACEAN SURVEYS IN KOMODO NATIONAL PARK, INDONESIA 1999-2001:

MANAGEMENT IMPLICATIONS FOR LARGE MIGRATORY MARINE LIFE.

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Abstract.

Komodo National Park and World Heritage Area (KNP) is located between the Indonesian islands of Sumbawa and Flores. To assess KNP's ecological significance for large migratory species of special concern, visual and acoustic cetacean surveys have been conducted twice yearly since 1999 and focus on several Park management and conservation priorities:

- Identify which species of cetaceans are present in KNP and adjacent waters and provide data on relative species abundance, seasonality, critical habitats of regional importance, tourism potential and environmental impacts.
- Involve government, industry and community stakeholders in cetacean monitoring programs.

Visual and acoustic surveys are carried out from an 8m half-cabin speedboat, as well as from live-aboard vessels. Time, location, sea state, species, abundance, group composition, distance, direction, behaviours and associations are recorded. Listening stations are conducted using a directional hydrophone. In the May 1999 - April 2001 survey periods a total of 18 cetacean species were identified during 207 survey hours over 71 field days during 5 intermonsoon field seasons. The surveys covered an estimated 4706 nautical miles. The species encountered were predominantly oceanic odontocetes, but also included several balaenopterid species. An estimated total of 7082 individual cetaceans were sighted during 299 encounters. Acoustic contact with cetaceans was recorded during 38.1% of the 217 listening stations. Temporal and spatial patterns are apparent on the species level. Major species-specific results include relative abundance indices, site preferences and calving rates. A regionally distinct baleen whale, the pygmy Bryde's whale *Balaenoptera edeni*, was positively identified using photographic and genetic profiling techniques. Critical habitats including regional migration corridors, have been identified. Major environmental impacts observed include reef bombing (acoustic habitat degradation, i.e. Kemp 1996, Gordon and Moscrop 1998) and other fisheries interactions. Cetacean watching potential has increased due to the survey results. However, this may not be an appropriate tourism activity without strict controls and enforcement in place first.

Significant extensions to KNP's legislative boundaries have been designed to include preferred habitats of the Park's cetaceans. These extensions are incorporated in the 25-year management plan and will increase the protective status of cetaceans, as well as other large migratory marine life, in KNP and Indonesia. The long-term cetacean surveys have resulted in major improvements in our knowledge of Indonesia's cetaceans and proved that the Komodo region is an important habitat for whales and dolphins. Overall, cetaceans are an important aspect of resource management plans as they allow a focus on large migratory marine life issues and are listed as vulnerable or endangered species by CITES. In addition, cetaceans can provide high-revenue alternative livelihood options through site promotion and environmentally sound cetacean watching (Hoyt 2000) for marine protected areas in eastern Indonesia. This is especially so when areas of consistent whale and/or dolphin sightings are considered in a strict tourism development and management plan. The experience in Komodo National Park has shown that in eastern Indonesia, cetacean surveys and ecological research can be an important impetus to realise cetacean conservation measures, assist with the mitigation of threats in protected areas and provide

input to national marine mammal conservation strategies. Lessons learned may be applicable to assist with potential site selection and design of additional marine protected areas for other eastern Indonesian island passages which function as Indo-Pacific marine migratory corridors. A recommended area for such an approach is the Alor region, one of the priority habitats for oceanic cetaceans in Indonesia, and possibly SE Asia.

Keywords: Komodo National Park, cetaceans, surveys, marine corridors, Indonesia.

The cetacean survey program in Komodo National Park and World Heritage Area.

Indonesia has an exceptional cetacean (the collective name for all whales and dolphins) diversity and a preliminary review of cetaceans sighted in Indonesian waters lists 29 species, while the occurrence of three other species was still unconfirmed (Rudolph *et al.* 1997). More than one-third of all known whale and dolphin species worldwide can be found in the Indonesian Seas, including numerous rare and endangered species (IUCN 1996). Cetacean habitats include major rivers and mangroves as well as coastal and open ocean environments. These diverse habitats are often in close proximity to one another because of Indonesia's narrow continental shelf, abundant oceanic islands and extreme depth gradients (Tomascik *et al*. 1997). Research on Indonesia's cetacean species diversity, abundance and distribution is especially important when considering the nation's complex geographical and oceanographic characteristics. Indonesia is uniquely located as the only equatorial region worldwide where inter-oceanic exchange of marine flora and fauna occurs. Cetacean movements between the tropical Pacific and Indian Oceans can occur through the passages between the Lesser Sunda Islands which span over 900 km between the Sunda and Sahul shelves (Klinowska 1991). In this region of eastern Indonesia, a strictly limited number of deep inter-island channels are known or suspected to function as migration corridors for cetaceans (PHPA 1984; Kahn 2002b). The ecological significance of these passages remains poorly understood, yet all Indonesia's cetacean populations, transient and resident, which include these passages in their local or long-range movements are vulnerable to numerous regional and local environmental impacts such as habitat destruction, net entanglement, marine pollution and over fishing of marine resources (Hofman 1995, Fair and Becker 2000), subsurface noise disturbances including reef bombing (Ketten 1998; Kahn *et al.* 2000), as well as directed catches for local consumption and bait for the shark long-line fishery (Barnes 1991, 1996; Kahn 2002a).

Komodo National Park (KNP) is part of the Lesser Sunda, or Nusa Tenggara, island chain and is located between the islands of Sumbawa and Flores. KNP includes three inter-island straits and is of importance to the conservation of Indonesia's terrestrial as well as marine biodiversity (Pet and Djohani 1996). Komodo National Park encompasses 603 km^2 of land and 1,214 km^2 of marine waters. It contains three large islands (Komodo, Rinca and Padar) and many smaller islands. The

Komodo area was established as a National Park in 1980 by the Government of Indonesia and declared a Man and Biosphere Reserve and a World Heritage Site in 1986. The region includes three major island passages which provide access for migratory marine life from the Indian Ocean and Sumba Sea to the other Indonesian Seas and the western Pacific. Its World Heritage Area status reiterates the importance to "ensure the identification, protection, conservation, presentation and transmission of world heritage values to future generations" (UNESCO 1972). The key survey objectives of the KNP cetacean rapid ecological assessment program are:

1. To provide base-line data on cetacean diversity, distribution and abundance in all marine habitats of Komodo National Park (KNP) including:
    i. Coastal habitats of KNP to monitor the presence of vulnerable coastal cetaceans.
    ii. Inter-island straits and deep channels of KNP to examine their significance as migration corridors for wide-ranging migratory cetaceans occurring in eastern Indonesian waters.
    iii. Oceanic areas to the north and south of KNP to monitor the presence of oceanic cetaceans.
2. To monitor seasonal patterns in KNP cetacean diversity, distribution and abundance to identify resident or transient populations.
3. To identify critical habitats for cetaceans, including preferred feeding grounds, mating locations and migration corridors.
4. To identify and assess the major local and regional environmental impacts that threaten eastern Indonesia's whales and dolphins.
5. To evaluate which protective measures can be implemented by Park management authorities to minimize the environmental impacts on cetacean habitats, including coral reefs, mangroves and the open ocean.
5. To establish community-based cetacean monitoring programs, as well as outreach activities, through the active participation of management agencies and stakeholders including:
    i. TNC-Komodo Field Office staff.
    ii. Balai Taman Nasional Komodo rangers.
    iii. Komodo National Park dive operators.
    iv. Local communities and fishermen.
7. To provide site and species-specific information on KNP cetaceans for:
    i. Marine resource and park management purposes.

ii. Environmental awareness and educational programs.

iii. Support to the Park's marine tourism and dive industry.

8. To share the survey results and research outcomes with the Indonesian National Park Authorities, environmental organisations and local communities.

Survey Methods and Research Activities.

Survey method I: TNC speedboats.

The majority of the periodic 15-day visual and acoustic cetacean surveys were carried out from a 25-foot TNC Yamaha speedboat cruising at 16-18 knots. The surveys focused on the coastal areas, bays and inter-island passages of Komodo National Park, as well as the adjacent offshore waters of the Flores and Sumba Seas. While underway, a minimum of two experienced observers conducted visual surveys of the surrounding waters. If cetaceans were sighted the vessel's course and speed were adjusted to allow for a discreet approach and close observation. Whenever possible a positive species identification (ID) was made. Unidentified cetacean encounters were recorded as such after a minimum of 10 minutes of visual survey efforts focused on obtaining a positive identification. Unidentified cetacean encounters were usually the result of unfavourable light conditions, sea state, lack of proximity, active avoidance behaviour or operational constraints. Standardised waterproof data sheets were used to record time, sea surface conditions, GPS location, species sighted, estimated abundance, group composition, the presence of newborn calves, minimum distance from vessel, direction of travel, species associations and a suite of selected behaviours. A Nikon 601 SLR camera equipped with a Nikkor 70-300mm lens was used to obtain multi-species photo-identifications of individual animals with distinctive colourations, marks or scars. In addition, a Sony PC-10 digital video camera was also frequently used to record the diversity of cetacean species and behaviours. After the ID and data recordings were completed, the vessel departed from the sighting area at a reduced speed and resumed the predetermined survey route. During offshore routes, the visual surveys were complimented by periodical acoustic listening stations using a directional Vemco VHLF hydrophone (20Hz-20KHz) or Burns Electronics custom hydrophone (30Hz-20kHz) with amplifier. Acoustic surveys were conducted only if the vessel was located four or more nautical miles offshore to minimise any coastal interference. Listening stations were conducted every 30 minutes, or approximately 7-8 nautical miles apart depending on offshore conditions. Acoustic contacts with priority species

were digitally recorded with a Sony Portable MiniDisc Recorder (MZ-R70). The survey commenced in the early morning departing from The Nature Conservancy - Komodo Field Office in Labuan Bajo, located on Flores Island in the Nusa Tenggara Timor province of eastern Indonesia and returned before sunset each day.

3.2 Survey method II: Local live-aboard vessels.

Visual and acoustic cetacean surveys were also carried out from local live-aboard vessels, usually for 5-day periods. Use of the live-aboard increased the coverage to remote areas and allowed the surveys to continue during less optimal weather conditions. The data collection procedures did not differ between survey methods. The vessel speed averaged 6-7 knots. Increased observer height and regular use of 40x8 marine binoculars increased the visual survey range. The majority of the acoustic surveys were conducted while on-board the live-aboard vessel. Listening stations were conducted on the hour for at least five minutes. Stations were only conducted when located more than 4 nautical miles (nm) offshore to minimise disturbance. Stations were spaced approximately 6 nm apart.

Survey results.

All cetacean sighting coordinates of the May 1999 - April 2001 survey periods were transcribed to a GIS format and assigned species-specific data points (Figure 1). Cetacean species were colour-coded and allocated the following symbols:

Category	*Symbol*
Sub-order Mysticeti - baleen whales	●
Families Physeteridea and Kogiidae - sperm whales	■
Family Ziphiidae - beaked whales	◈
Family Delphinidae - dolphins	▲
Globicephalinae - a Delphinidae subfamily of six species*	✚
Unidentified small cetacean (< 6 metre)	△
Unidentified large cetacean (> 6 metre)	□
Unidentified beaked whale (Fam. Ziphiidae)	◇

∗ - The Globicephalinae subfamily is based on a systematic revision of the Delphinidae and includes six species: *Feresa attenuata, Peponocephala electra, Globicephala macorhynchus* and *G. melas, Pseudorca crassidens* and *Griseus grampus* (LeDuc *et al*. 1999). It replaces the historical blackfish category that includes the majority of these species as well. For the Indonesia cetacean surveys, Globicephalinae sightings are recorded when sightings of members of the subfamily can not be identified to species. This occurs infrequently and is due to the similarities of *P. electra, F. attenuata* and juvenile *G. grampus,* in particular during unfavourable sighting conditions.

In the May 1999 - April 2001 survey periods a total of 18 cetacean species (Table 1) were identified during 207 survey hours over 71 field days during 5 inter-monsoon field seasons. The species encountered were predominantly oceanic odontocetes, but also included two balaenopterid whale species. The visual and acoustic survey results (Figures 2a-h) are summarized below. The surveys covered an estimated distance of 4706 nautical miles and 553.25 active survey hours. An estimated total of 7082 individual cetaceans were sighted during 299 encounters. Acoustic contact with cetaceans was recorded during 38.1% of the 217 listening stations. The mean number of sightings per survey day equaled 4.2 encounters (range 1.7 - 5.3) for the May 1999 to April 2001 period (Figure 3a). On all but one KNP survey day (26/05/99) cetaceans were encountered. Estimated mean abundance per sighting ranged from 17.9 to 27.8 individuals per encounter per survey and was calculated at 23.7 for the whole period (Figure 3b). *T. truncatus* and *S. longirostris* dominate the distribution of sightings within KNP borders (Figure 1). In the eastern part of KNP at the entrance of Selat Molo and near Nusa Kode, pods of *S. longirostris* are especially common (Figure 1). In the straits and offshore areas adjacent to KNP a more diverse pattern is becoming evident. Numerous species of oceanic delphinids are abundant in the deeper waters of Komodo National Park. The large and deep expanse of water within KNP borders between Nusa Kode, Padar and south Komodo is frequented by large pods of *S. attenuata*, numbering up to 350 individuals. This part of the Park also inhabits *G. griseus*, *P. crassidens* and occasionally *P. macrocephalus*. The San Geang area presents a marine environment significantly different to all other KNP regions surveyed. It is the only representative of an oceanic volcanic island within survey distance from Labuan Bajo, and records a relatively high number of sperm whale (*P. macrocephalus*), numerous 'blackfish' (Globicephalinae) and orca (*O. orca*) sightings. Ziphiids (*Z. cavirostris*) are regularly sighted in the vicinity of the island. During 1999 and 2000 pygmy Bryde's whales, *Balaenoptera edeni,* have been repeatedly sighted around Gili Mota, and in an inter-island passage between Nusa Kode and south Rinca. Unconfirmed reports from rangers

include additional sightings of this species along east Komodo Island, including Loh Namu and Loh Liang. The pygmy Bryde's whale *Balaenoptera edeni*, a regionally distinct baleen whale, was positively identified by photographic and genetic profiling techniques (Kahn *et al.* 2001). This is the first positive identification of a *living* pygmy Bryde's whale with matching photographic data in Indonesia, and possibly SE Asia (Philippine samples come from stranded or harpooned individuals; this species has also been hunted by Japanese whaling vessels in the Solomon Islands, Perrin *et al.* 1996). Thus, the photos and video footage taken of the pygmy Bryde's whales in Komodo could provide an important benchmark for future benign whale research on this data-deficient species in Indonesian waters and SE Asia. The percentage of unidentified small cetaceans is relatively constant for all survey periods to date (mean of 11.7 %) and reflects the challenging survey conditions at sea. Unidentified cetacean encounters can be contributed to unfavourable sighting conditions due to sea state or light conditions, active avoidance or operational difficulties. The summarized survey results indicate considerable variation in both the sightings and abundances between surveys, years and seasons (Figures 2a-h). This remains the case when the sighting data are corrected for survey effort such as active survey time or distance in nautical miles surveyed (Figures 4a-b). Other comparative results are not within the scope of this publication (see Kahn 2001b). The relative abundance estimates of the KNP cetacean species assemblage indicate that the bottlenose dolphin *T. truncatus* and long-nosed spinner dolphin *S. longirostris* are the most abundant KNP species, followed by the pan-tropical spotted dolphin *S. attenuata* and melon-headed whale *P. electra* respectively. Species-specific sighting frequencies and estimated abundances were compiled for the May 1999 - April 2001 survey periods (Figures 5a-b). During encounters with large migratory cetaceans, survey effort changed priority from rapid ecological assessment (Kahn 2001a, 2002a) to ecological focus research and detailed species-specific behavioural observations (i.e. Whitehead and Kahn 1992; Kahn 1999) by conducting 'group follows' (Mann *et al.* 2000). Such group follows may range from hours to days (visual and acoustic tracking). As these large cetacean species have a relatively low abundance in the survey area, and are often classified as vulnerable or endangered globally, it is considered justified to spend more time for additional data collection with these species of special concern. Ecological focus research provides a context for the initial sighting and habitat preferences of a priority species within the wider survey area. Additional information on (photographic) identification of individuals, local movements, dive profiles and other behavioural activities (indicative of feeding, mating, migrating) and genetic materials (sloughed skin or biopsy sampling)

was obtained during the group follows. The collection of genetic material depended on the appropriate species encounters, sea state and cetacean sensitivity to vessel approach. Additional sightings of other cetacean species continued to be recorded if such activities did not interfere with the group follows. The May 1999 – April 2001 surveys included several sightings of highly migratory cetacean species including female sperm whales and immatures of both sexes (also referred to as nursery schools; n=7), socially and sexually mature sperm whales *P. macrocephalus* (also referred to as bulls; n=2), orcas *O. orca* (n=2) and a blue whale, *B. musculus* (n=1); an additional blue whale was sighted in the same area during Oct 2001 (Kahn. pers.obs). These sightings are of importance to improved migratory marine life management in the Indonesian Seas. All sightings, except encounters with female sperm whale nursery schools in the Sumba Sea, were recorded at the junction of a migratory corridor (Selat Sape) between the Sumba Sea (Indian Ocean) and the Flores Sea (which is part of the Indonesian Seas connecting to the western Pacific). This area of interest is flanked by San Geang and Sumbawa in the west and Banta and Komodo Island in the east. Importantly, even though these sightings span more than two years of periodic survey efforts, the large migratory cetaceans were always sighted near a previous sighting of that same species, and directions of travel were either identical or similar.

Discussion

The current state of knowledge on Indonesia's cetaceans is extremely limited and this effectively restricts the capacity for their ecologically based management. The whale and dolphin surveys have greatly increased our understanding of Komodo National Park's significance as an important cetacean habitat (Kahn *et al.* 2000; Kahn 2001b). Newborn calves were observed for seven dolphin species as well as the sperm whale. This indicates that the KNP area could be an important cetacean calving ground. The relative abundance (abundant, common, uncommon and rare), group sizes, as well as habitat preferences have been investigated for eight cetacean species by use of survey encounter rates (Kahn *et al.* 2001) and 'group follows' (Mann *et al.* 2000). This is the first time this kind of species-specific and comparative data has been available for Indonesia.

The substantial variation in cetacean species diversity, distribution and abundance, and lack of annual and seasonal patterns is to be expected for such a relatively short period of data collection, and in accordance with the routine large-scale movements of the majority of the 18 cetacean

species observed in KNP waters (i.e. Kahn *et al.* 1993). Even small cetaceans are known to travel extensively within their home range, and often swim over 100km/day (Mann *et al.* 2000). In addition, factors such as prey availability and oceanographic conditions during each survey period will influence cetacean diversity, distribution and abundance in the region. The substantial reduction in sightings and abundance per survey effort for the initial May 1999 period is unclear, but may at least in part be caused by the significant multi-year El Nino Southern Oscillation (ENSO) active at that time. The 1998 La Nina effect could have been responsible for the severely reduced fish catches in the Komodo area in 1998 (Pet 1999), and a similar negative effect on cetacean prey species in this region seems likely. The high values recorded for Oct 1999 and April 2001 may be indicative of favourable ecological and oceanographic conditions for oceanic cetaceans. Additional research into which environmental factors affect cetacean diversity, distribution and abundance in Indonesia is necessary for their effective management and conservation (e.g. Simmonds and Hutchinson 1996). Preferred habitats in and adjacent to KNP waters have been identified for several species of small cetaceans, and the occurrence and behaviour of highly migratory whale and dolphin species in the waters of KNP is consistent with the identification of eastern Indonesia's island passages as migratory corridors of regional conservation significance (PHPA 1984; DKP/IPB 2001). The surveys to date have recorded concentrated sightings of highly migratory cetacean species in the northern entrance of Selat Sape. Although the sample size is still very limiting, blue whales and other highly migratory whale species, including orcas as well as socially and sexually mature sperm whales, or bulls, with an estimated lengths in excess of 16 meters, are repeatedly sighted within close proximity to Banta Island and the Flores Sea (northern) entrance of Selat Sape (the major migratory passage in the Komodo National Park research area). All these sightings of highly migratory oceanic cetaceans have occurred in a relatively small geographic area. This sighting pattern strongly indicates that the area is of importance to large migratory cetacean species and underlines the need for additional protection of this area, as proposed by the inclusion of Banta Island and Selat Sape within KNP borders. This management measure for migratory marine species of special concern has been incorporated in the Park's 25-year master plan (Pet and Yeager 2000).

Implications for management of migratory marine life of eastern Indonesia.

The Indo-Pacific migratory passages or 'marine bottlenecks' of Nusa Tengarra in eastern Indonesia may have regional ecological significance as multi-species critical habitats (UNEP/CMS. in press). The extent and intensity of marine exploitation and threats in Indonesia (such as reef bombing as well as numerous other fisheries interactions, see review by Kahn and Fauzi 2001), coupled with the exceptional diversity of cetaceans and other marine life, make it urgent that additional protective management is realized. Hence, the establishment of an Indonesia Marine Mammal Management Area (IMMMA) will be crucial (PHPA 1984; Salm 1984; Kahn 2002c), because for whales and dolphins the impacts on crucial aspects of their ecology often occur outside the current areas of protection. The implementation of an IMMMA with four different management zones is currently under consideration by the Government of Indonesia (Kahn 2002d). On-going cetacean survey and research focus on the Nusa Tengarra island passages in eastern Indonesia are also needed to support both practical and productive migratory species management. This is crucial, because relatively simple conservation measures can be implemented in the passages through site-based programs in the short term which would have a direct and very positive outcome for most of eastern Indonesia's migratory marine mammals. In addition, these outcomes are also beneficial for a myriad of other ocean wanderers sighted in the region (mantas, sharks, whale sharks, sunfish or mola mola, marine turtles, billfish). If such measures are integrated with other pressing coral reef and (coastal and pelagic) fishery issues, the approach also assists with leverage for management options for all marine resources in the same area. These, and other, measures are currently being implemented at Komodo National Park (Kahn and Pet 2001).

Migratory and oceanic habitat conservation opportunities for coastal MPAs.

It is important to note that because of the coastal-pelagic habitat proximity for much of eastern Indonesia (as well as Papua New Guinea, the Solomon Islands and other South Pacific island nations), MPA initiatives on migratory marine life, including large whales, can be realistically incorporated into (eco)regional planning. The lack of a significant continental shelf and presence of extreme depth gradients in the majority of this region provide an opportunity to include 'oceanic zones' in future MPA site selection and design for this region, even if the primary aim of

those protected areas is to manage reef ecosystems or/and coastal fisheries. Such 'oceanic zones' may include oceanic habitats such as seamounts, oceanic islands and even deep-sea trenches, which may be near the (routinely coastal) management focus of MPAs. This approach would yield major benefits for the management of oceanic protected areas and would by-pass several key challenges associated with (oceanic) MPA establishment and management (e.g. Hyrenbach *et al.* 2000; Roberts *et al.* 2001). For eastern Indonesia's migratory corridors this would be a practical and effective site-based approach to the conservation and management of migratory marine species of special concern – a strategy similar to (and complementary with) protecting the major nesting beaches of marine turtle species – and would provide a field basis in SE Asia to address trans-boundary marine species conservation. This approach is highly recommended for another important cetacean habitat in eastern Indonesia, the Alor region.

The need for protective marine resource management in the Alor region

The east Flores – west Alor region can be considered one of the prime (oceanic) cetacean habitats in the Indonesian Seas (Barnes 1996; Rudolph *et al.* 1997; Kahn 2002b), and possibly even in SE Asia as a whole. Of special interest is not only the high diversity and relative abundance of blue whales and sperm whales and at least 18 other species of oceanic cetaceans in the east Flores – west Alor region; it also includes four major Indo-Pacific migratory passages, between the islands of Flores, Solor, Adonara, Lembata, Pantar and Alor. The region has a complex oceanography resulting from productive currents of the Indonesian flowthrough and deep-water upwellings of the Savu Sea (Gordon and Fine 1996; Bray *et al.* 1997). Another important aspect of the area is the traditional (sperm) whaling heritage of the Lamalera coastal community, and the continued work with (and research contribution by) this and other coastal communities (Kahn 2002a). The east Flores – west Alor region is not only an exceptional cetacean habitat in the Indonesian Seas. It also has an exceptional abundance of a wide array of other large marine life, including manta rays, (leatherback) marine turtles, bill fish, tuna, mola mola, (whale) sharks and other pelagics. Therefore, an increase in the protective management for marine corridors and other habitats in Alor is also likely to be of regional significance. However, the concentration of marine resources also makes the region highly vulnerable to increasingly modern and extensive fisheries activities that specifically target mantas, marine turtles, small cetaceans, whales and (whale) sharks. The substantial landings of most target species are of major concern and likely to result in rapid

overexploitation of large migratory marine life passing through the area. Hence, continued and expanded conservation efforts are needed urgently in Alor to a) conserve the exceptional marine life and coastal and marine ecosystems in this remote part of eastern Indonesia and b) assist with the identification and implementation of options for sustainable development and c) promote environmentally sound economic diversification for remote regions of eastern Indonesia. The most effective approach to realise these goals is through the establishment of a Marine Protected Area (MPA). An Alor MPA could specifically incorporate protective management measures for migratory and resident cetacean populations and other large migratory marine life, as well as coastal resource management and fisheries considerations. Because of the exceptional localized diversity and abundance of large marine life, the establishment of such a MPA in the Alor region would substantially improve migratory marine life management in the Indonesian Seas. In addition, the establishment of a MPA in the Alor region would strengthen and complement Indonesia's national conservation and management policy on migratory marine species (DKP/IPB 2001). Such a specific MPA with conservation priorities for migratory marine life incorporated in its management objectives will also act as a catalyst for increased surveys, research and community outreach. In order to protect these highly migratory animals we must know as much as possible about their ecology, population status and dynamics, the locations of their critical habitats, how they use each habitat, when they travel between them and the routes they take. Because of the lack of knowledge on most, if not all, of Indonesia's migratory marine life populations, a habitat focus is considered the most effective approach in providing guidance to short-term conservation and management goals. At the same time, it is important that additional biological research on these species can be conducted in order to address ecological questions of importance to long-term management. The results of the KNP cetacean surveys, as well as those initiated in Alor more recently (Kahn 2002a) confirm that straits and passages should be considered as '*priority management units for species of special concern'* (Agardy 1997). Site-based marine conservation programs and improved protective management measures for Alor's and other Nusa Tenggara migratory passages are crucial to the conservation of Indonesia's, and indeed SE Asia's, migratory marine biodiversity.

Conclusion

The Komodo cetacean surveys have made a significant contribution to the knowledge of Indonesia's cetacean diversity, distribution and relative abundance. The long-term cetacean surveys have shown that the Komodo region is an important habitat for whales and dolphins, and are an important aspect of resource management plans, conservation measures and alternative livelihood options for marine protected areas in eastern Indonesia. Significant extensions to KNP's legislative boundaries have been designed to include preferred habitats of the Park's cetaceans. These extensions are incorporated in the 25-year management plan and will increase the protective status of cetaceans in KNP and Indonesia. In addition, the positive identification of the pygmy Bryde's whale, a new species for these waters, further increased the exceptional marine bio-diversity of the Indonesian Seas. The experience in Komodo National Park has shown that in eastern Indonesia, cetacean surveys and ecological research can be an important impetus to realise conservation measures, assist with the mitigation of threats in protected areas and provide input to national marine mammal conservation strategies.

The lessons learned in KNP are also important to ensure that effective conservation outcomes can be achieved in other priority cetacean habitats of the Indonesian Archipelago, and may assist with potential site selection and design of additional marine protected areas in eastern Indonesia such as the Alor region (Barnes 1996, Kahn 2002c) as well as other sites of the so-called Flores-Banda ecoregion. This region has an exceptionally high diversity and abundance of large marine life including cetaceans, and numerous vulnerable migratory species are currently under intense fisheries pressure. Improved protective management could be effected in the Alor region through the establishment of a MPA with a large migratory marine life conservation focus, and include strong coastal resource management and community development components.

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References.

Agardy, T.S. 1997. *Marine protected areas and ocean conservation*. Academic Press Limited, London UK. 244pp.

Barnes, R.H. 1991. Indigenous whaling and porpoise hunting in Indonesia. *In: Cetaceans and cetacean research in the Indian Ocean Sanctuary* (eds. S. Leatherwood and G.P. Donovan). pp 99-106. Marine Mammal Technical Report Nr.3. United Nations Environment Program, Nairobi.

Barnes, R.H. 1996. *Sea Hunters of Indonesia, Fishers and Weavers of Lamalera*. Clarenford Press. Oxford. England. 362pp.

Bray, N.A., S.E. Wijffels, J.C. Chong, M. Fieux, S. Hautala, G. Meyers and W.M.L. Morawitz. 1997. Characteristics of the Indo-Pacific throughflow in the eastern Indian Ocean. *Geophysiscal Research Letters* **24**(21), 2569-2572.

DKP/IPB. 2001. *Penyusunan draft akademik kebijaken dan strategi national konservasi hidupan liar biota laut migrasi. Laporan Akhir, Proyek pengembangan konservasi kawasan dan sumberdaya pesisir.* Directorat Kelautan dan Perikanan & Institut Pertanian Bogor. 63pp.

Fair, P.A. and P.R. Becker. 2000. Review of stress in marine mammals. *Journal of Aquatic Ecosystem Stress and Recovery* **7**, 335-354.

Gordon, A.L. and R.A. Fine. 1996. Pathways of water between the Pacific and Indian Oceans in the Indonesian Seas. *Nature* **379**, 146-149.

Gordon, J. and A. Moscrop. 1998. Underwater noise pollution and its significance for whales and dolphins. Pp 281-320 *in: The conservation of whales and dolphins: Science and practice.* (eds M. Simmonds and J. Hutchington). Wiley and Sons. Chichester, England.

Hofman, R.J. 1995. The changing focus of marine mammal conservation. *Trends in Ecoology and Evolution* **10**(11), 462-465.

Hoyt, E. 2000. *Whale Watching 2000: Worldwide tourism numbers, expenditures, and expanding socioeconomic benefits.* The International Fund for Animal Welfare (IFAW). Crowborough, UK. 157pp.

Hyrenbach K.D., K. A. Forney and P. K. Dayton A. 2000. Viewpoint: Marine protected areas and ocean basin management. *Aquatic Conservation: Marine and Freshwater Ecosystems* **10**, 437–458.

IUCN. 1996. *IUCN Red List of Threatened Animals* (eds. J. Baillie, and B. Groomridge). The World Conservation Union, Gland, Switzerland. 488p.

Kahn, B. 2002a. *Alor Rapid Ecological Assessment – Visual and acoustic cetacean surveys and evaluation of traditional whaling practices, fisheries interactions and nature-based tourism potential: October*

2001 and May 2002 survey periods. Alor Rapid Ecological Assessment Report for WWF - Wallacea and TNC Coastal and Marine Program/Indonesia. 36pp.

Kahn, B. 2002b. *Indonesia's migratory corridors for large marine life: Scientific and management perspectives. Keynote presentation: Session on Sustainable Fisheries Management in Transboundary Areas.* Konferensi Nasional III. Pengelolaan Sumberdaya Pesisir dan Lautan Indonesia Bali, 21-24 May 2002 (National Coastal and Ocean Conference). Proceedings in press.

Kahn, B. 2002c. *Discussion paper on the establishment of a Protected Marine Mammal Fisheries Area in Indonesia's national and EEZ waters.* TNC Indonesia Technical Report prepared for the Government of the Republic of Indonesia - Ministry of Marine Affairs and Fisheries. 55pp.

Kahn, B. 2002d. *Status of Marine Mammals of Indonesia – UNEP/CMS Technical Report*. Final Draft submitted to the United Nations Environment Programme – Convention on the Conservation of Migratory Species of Wild Animals (UNEP/CMS) Second International Conference on the Marine Mammals of Southeast Asia. July 24-26, 2002. Demaguette, Philippines. 13pp.

Kahn, B. 2001a. *Rapid ecological assessment in the Sangihe-Talaud Archipelago, North Sulawesi, Indonesia: Visual and acoustic cetacean survey component.* Technical Report - TNC Coastal and Marine Program Indonesia. 16pp.

Kahn, B. 2001b. *Komodo National Park Cetacean Surveys: April 2001 and 1999-2001 survey synopsis.* Presented working paper CMS/SEAMAMSII/24. United Nations Environment Programme – Convention on the Conservation of Migratory Species of Wild Animals (UNEP/CMS) Second International Conference on the Marine Mammals of Southeast Asia. July 22-23, 2002. Demaguette, Philippines. 39pp.

Kahn, B. 1999. Oceanic cetacean surveys and sperm whale (*Physeter macrocephalus*) research of Northern Sulawesi, Indonesia. *In: Proceedings of the 13th Biennial Conference on the Biology of Marine Mammals,* Hawaii Nov.28 - Dec. 3 1999. p226.

Kahn, B. and A. Fauzi. 2001. *Fisheries in the Sulu Sulawesi Seas - Indonesian Country Report: Assessment of the state of biophysical, socio-economic, and institutional aspects of coastal and pelagic fisheries in the Indonesian part of the Sulu-Sulawesi Seas.* Technical Report for the Sulu-Sulawesi Marine Ecoregion Conservation Program. WWF Indonesia - Wallacea Program. 148pp.

Kahn, B and J. S. Pet. 2001. Cetacean surveys and Marine Protected Area management: Komodo National Park & World Heritage Area, Indonesia. *In: Proceedings of the 14th Biennial Conference on the Biology of Marine Mammals,* Vancouver, BC, Canada Nov.28 - Dec. 3, 2001. p110.

Kahn B., Wawandono N. B. and Subijanto, J. 2001. *Protecting the cetaceans of Komodo National Park, Indonesia : Positive identification of the rare Pygmy Bryde's whale* (Balaenoptera edeni) *with the assistance of genetic profiling.* Final Report to the Indonesian Institute of Sciences (LIPI). 11pp.

Kahn, B., James-Kahn, Y. and J.Pet. 2000. Komodo National Park cetacean surveys - A rapid ecological assessment of cetacean diversity, distribution and abundance. *Indonesian Journal of Coastal and Marine Resources* **3**(2), 41-59.

Kahn, B. Whitehead, H. and M. Dillon. 1993. Indications of density-dependent effects from comparisons of sperm whale populations. Marine Ecology Progress Series **93**, 1-7.

Kahn, B. 1999. Oceanic cetacean surveys and sperm whale (*Physeter macrocephalus*) ecology research off northern Sulawesi, Indonesia. *In: Abstracts of the 13th Biennial Conference on the Biology of Marine Mammals*. Hawaii, USA. p226.

Kemp, N.J. 1996. Habitat loss and degradation. *In*: *The conservation of whales and dolphins: Science and practice* (eds M .Simmonds and J Hutchington). Wiley and Sons. Chichester, England.

Ketten, D. 1998. *Marine mammal auditory systems: a summary of audiometric and anatomical data and its implications for underwater acoustic impacts.* NOAA-TM-NMFS-SWFSC-256. 74p (available at www.noaa.gov).

Klinowska, M. 1991. *Dolphins, porpoises and whales of the world. The IUCN Red Data Book.* IUCN, Gland Switserland and Cambridge, UK. viii + 429pp.

LeDuc, R.G., Perrin, W.F. and Dizon, A.E. 1999. Phylogenetic relationships among the delphinid cetaceans based on full cytochrome b sequences. *Marine Mammal Science* **15**, 619-48.

Mann, J. Connor, R.C., Tyack, P.L. and H. Whitehead. 2000. *Cetacean societies - Field studies of dolphin and whales.* University of Chicago Press, Chicago USA. 433pp.

Perrin, W.F., Dolar, M .L. L. and E. Ortega. 1996. Osteological comparison of Bryde's whales from the Philippines with specimens from other regions. *Reports of the International Whaling Commission* 4**6**, 409-413.

Pet, J.S. 1999. *Marine resource Utilization in Komodo National Park.* Monitoring Report 1997-1998 for The Nature Conservancy Indonesia Program. 38pp.

Pet, J. and R. Djohani. 1996. *A framework for the management of the marine resources of Komodo National Park and surrounding marine areas in Eastern Indonesia.* The Nature Conservancy - Indonesia Program Report. 41pp.

Pet, J.S. and Yeager, C. (eds), 2000. *25-year master plan for management, Komodo National Park* (Book 1-3). Department of Nature Protection and Conservation, Ministry of Forestry, Jakarta.

PHPA. 1984. *Marine Conservation Data Atlas*. Dit. Jen. PHPA Dep. Kehutanan. Jakarta, Indonesia.

Roberts, CM, Halpern, B., Palumi, S.R and R.R. Warner. 2001. Designing Marine Reserve Networks: Why small isolated areas are not enough. *Conservation Biology in Practice* **2**(3), 10-17.

Rudolph, P., C. Smeenk and S. Leatherwood. 1997. Preliminary checklist of cetacea in the Indonesian Archipelago and adjacent waters. *Zoologische Verhandelingen* **312**, 1-48.

Salm, R.V. 1984. *The Seas Must Live*. Volume 5. Conservation of marine species in Indonesia. IUCN/WWF Report for the Directorate General of Forest Protection and Nature Conservation: 76pp.

Simmonds, M.P. and J.D. Hutchinson. 1996. *The conservation of whales and dolphins*. Wiley & Sons Ltd., Chichester, England.

Tomascik, T. Mah, A.J. Nontji and M.K. Moosa. 1997. *The ecology of the Indonesian Seas.* Part 1-2. Periplus Editions HK) Ltd. 1354pp.

UNESCO. 1972. T*he Convention Concerning the Protection of the World Cultural and Natural Heritage - Article 4*. UNESCO General Conference. Paris.

UNEP/CMS. In press. *Report of the workshop on the biology and conservation of small cetaceans and dugong of Southeast Asia*. United Nations Environment Programme – Convention on the Conservation of Migratory Species of Wild Animals (UNEP/CMS). July 24-26, 2002. Demaguette, Philippines. 39pp.

Whitehead. H. and B. Kahn. 1992. Temporal and geographical variation in the social structure of female sperm whale. *Canadian Journal of Zoology* **70,** 2145-2149.

Tables.

Table 1: Cetacean species positively identified in Komodo National Park and adjacent waters for the 1999 - 2001 survey periods.

Cetacean species		May 1999	Oct 1999	April 2000	Oct 2000	April 2001
1. Long-nosed spinner dolphin	*S. longirostris*	◆	◆	◆	◆	◆
2. Bottlenose dolphin	*T. truncatus*	■	■	■	■	■
3. Pan-tropical spotted dolphin	*S. attenuata*		■	■	■	■
4. Melon-headed whale	*P. electra*	●	●	●	●	●
5. Pygmy Bryde's whale	*B. edeni*		●	●	●	
6. Sperm whale	*P. macrocephalus*	●	●			●
7. Fraser's dolphin	*L. hosei*		●	●	●	●
8. Risso's dolphin	*G. griseus*		●		●	●
9. Pygmy killer whale	*F. attenuata*		○		○	
10. Dwarf sperm whale	*K. simus*			○		
10. Pygmy/dwarf sperm whale	*Kogia sp.*	○				
11. False killer whale	*P. crassidens*	○	○	○		○
12. Common dolphin	*Delphinus sp.*	○				
13. Rough-toothed dolphin	*S. bredanensis*		○	○	○	
14. Cuvier's beaked whale	*Z. cavirostris*		○		○	
15. Blue whale	*B. musculus*				○	
16. Orca	*O. orca*				○	○
17. Short-finned pilot whale	*G. macrorhynchus*					○
18. Indo-Pacific humpbacked dolphin	*S. chinensis*					○

◆ = Abundant; ■ = Common; ● = Uncommon; ○ = Rare (Categories based on Kahn *et al.* 2000). The *Kogia sp.* sighting is included for completeness but not counted as a positive species identification.

Figures.

Figure 1: Cetacean species diversity and distribution in Komodo National Park and adjacent waters May 1999 - April 2001 survey.

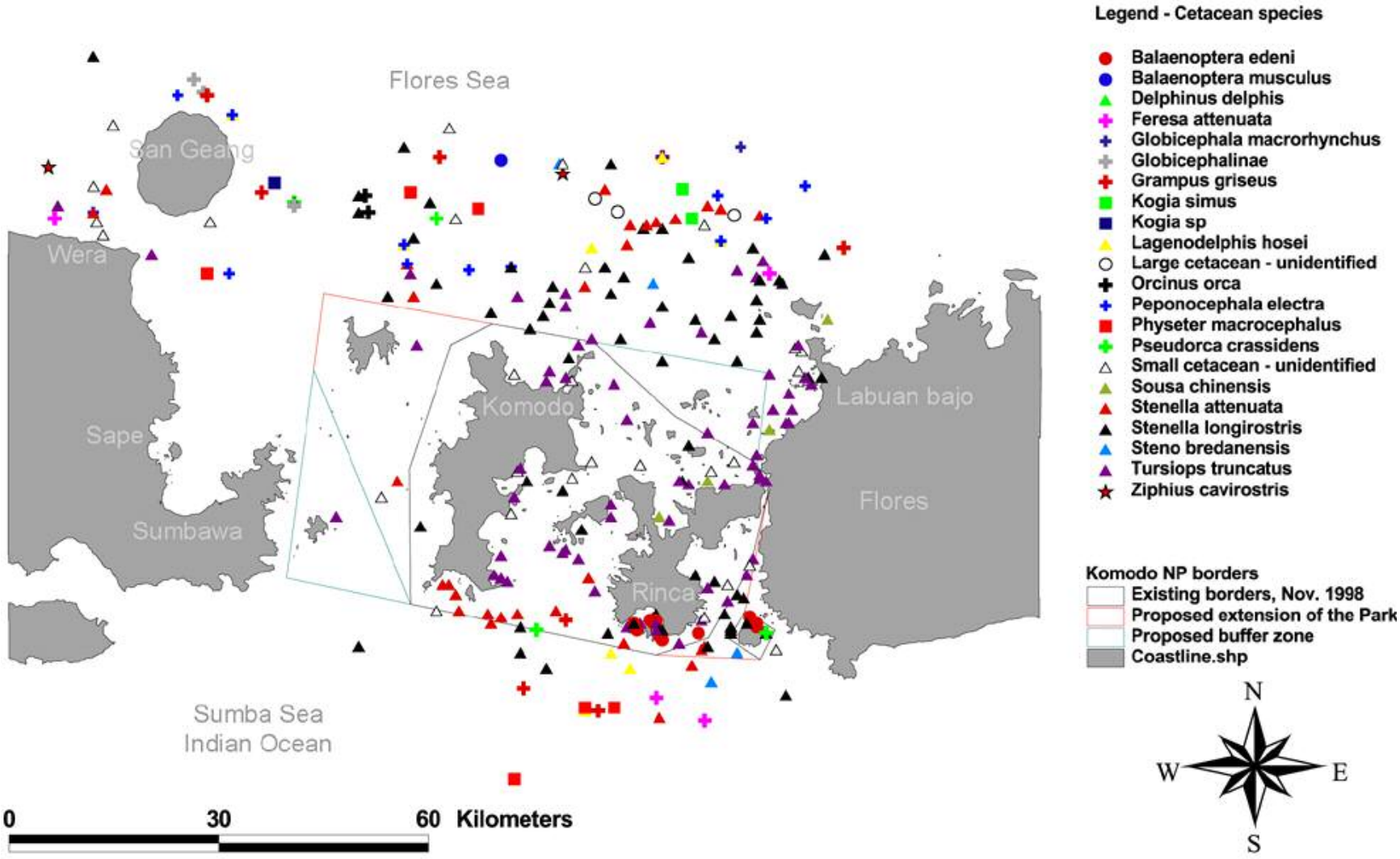

Figure 2a: Active survey days for each survey period.

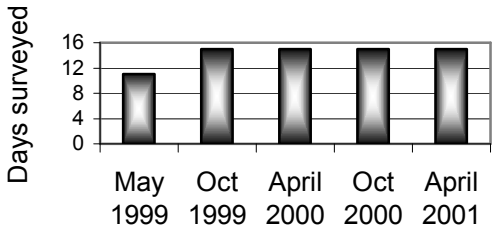

Figure 2b: Active survey hours for each survey period.

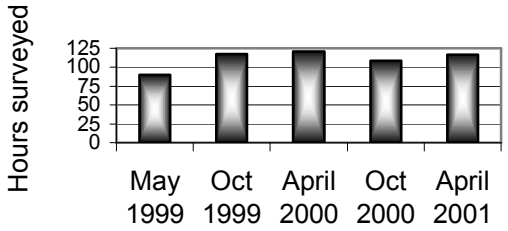

Figure 2c: Estimated area surveyed for each survey period.

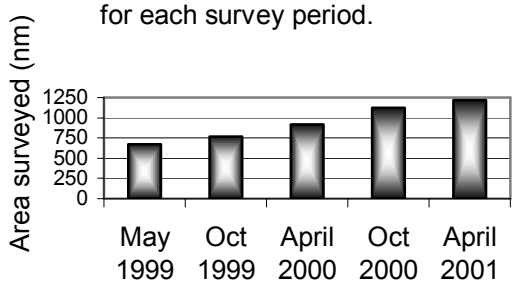

Figure 2d: Number of listening stations for each survey period

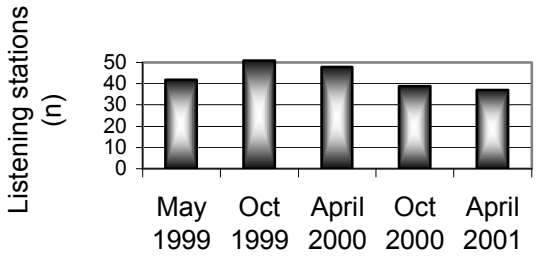

Figure 2e:Cetacean acoustic contact per listening station for each survey period.

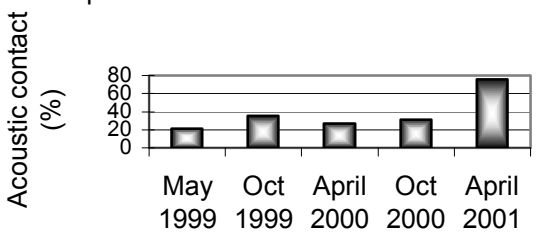

Figure 2f: Number of species positively identified for each survey period.

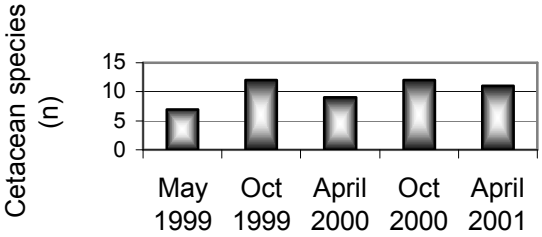

Figure 2g: Cetacean sighting frequencies for each survey period.

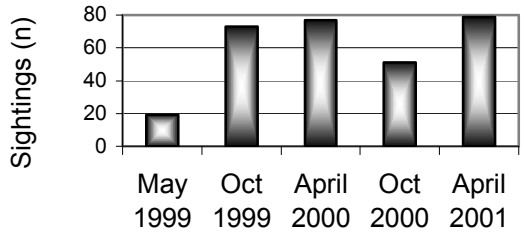

Figure 2h: Estimated cetacean abundance for each survey period.

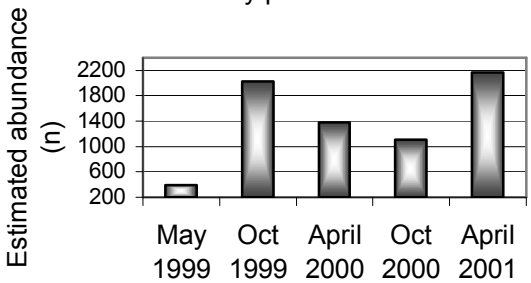

Figure 3a: Mean cetacean sightings (n) per survey day.

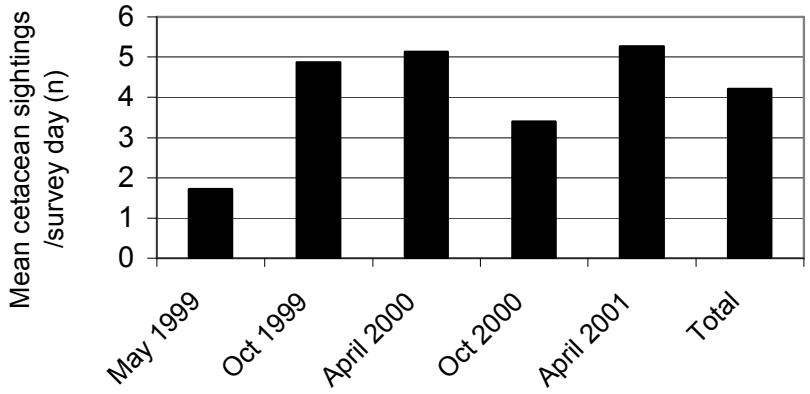

Figure 3b: Mean cetacean estimated abundance per sighting (n) per survey day.

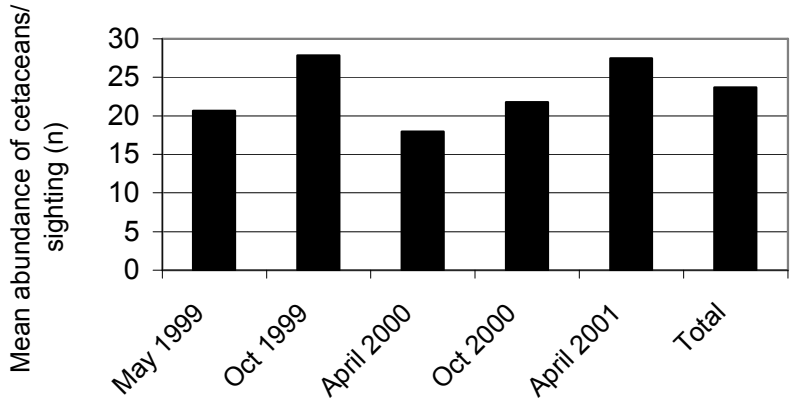

Figure 4a: Species-specific cetacean sightings (n = 299) for all Komodo survey days to date (n=71).

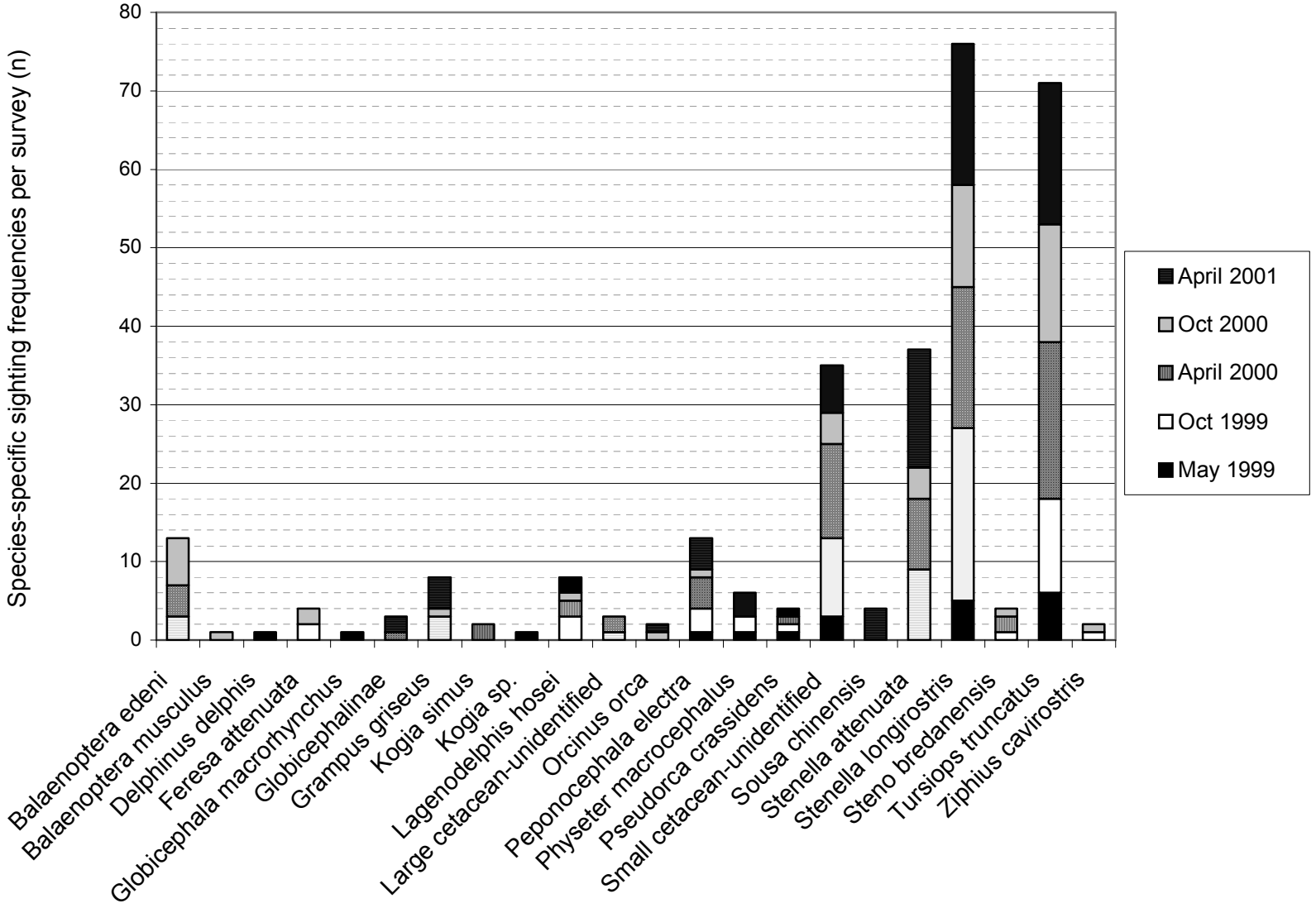

Figure 4b: Species-specific cetacean abundance (n=7082) for all Komodo surveys days to date (n=71).

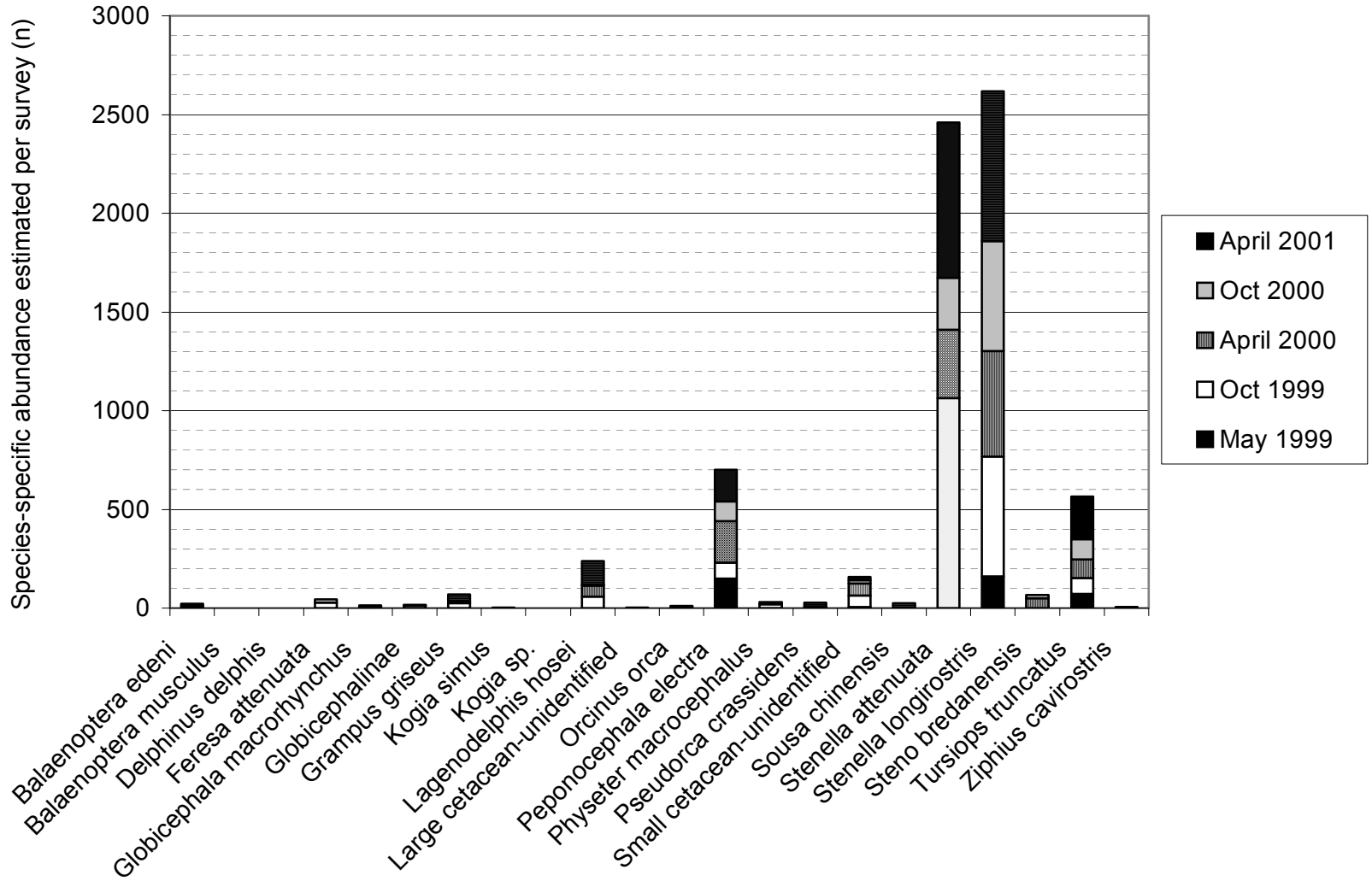

Figure 5a: Cetacean sightings per visual survey time (hr) for each survey period.

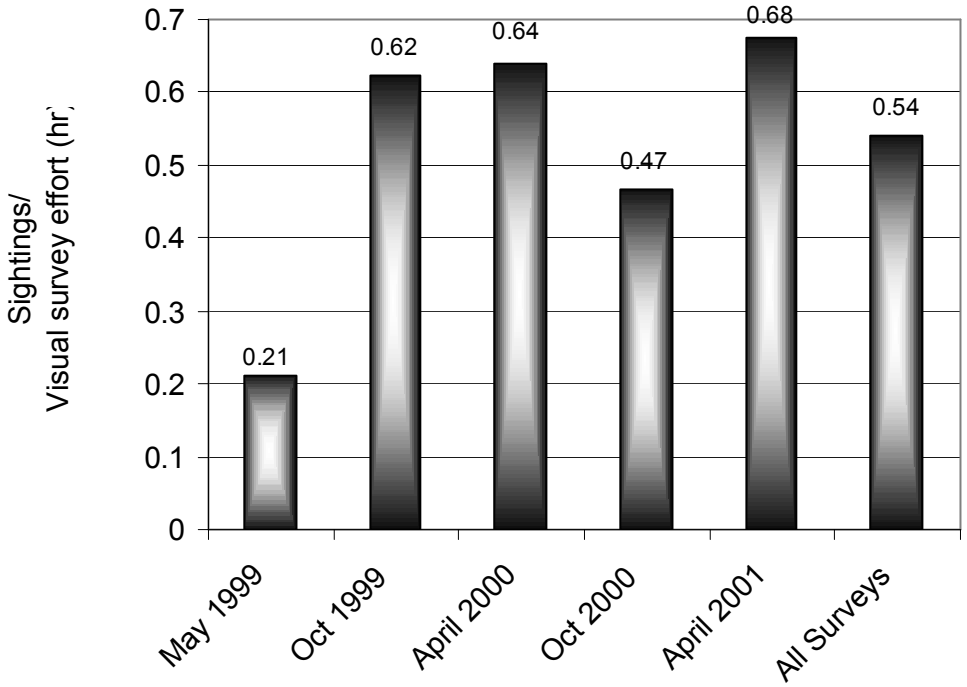

Figure 5b: Estimated cetacean abundance per visual survey distance (nm) for each survey period.