THE NATURE CONSERVANCY

Indonesia Coastal & Marine Program

KOMODO NATIONAL PARK CETACEAN SURVEYS

A RAPID ECOLOGICAL ASSESSMENT OF
CETACEAN DIVERSITY, ABUNDANCE & DISTRIBUTION.

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Benjamin Kahn, M.Sc.

APEX ENVIRONMENTAL

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

Indonesian waters have an exceptional cetacean diversity and at least thirty different cetacean species inhabit these waters. More than one third of all known whales and dolphins species worldwide can be found in the Indonesian Seas, including numerous rare and endangered species (Klinowska 1991, IUCN 1996). Cetacean habitats include major rivers, mangroves, 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 (e.g. Tomascik *et al*. 1997).

1.1 Focus on migratory corridors and other critical habitats for cetaceans.

In eastern Indonesia, a strictly limited number of deep inter-island channels are suspected to function as migration corridors for cetaceans (PHPA 1984). These passages have considerable ecological significance and conservation value:

- Indonesian island straits and passages form an important migration corridor network for large cetaceans travelling from the Pacific Ocean and eastern Indonesian seas to the Indian Ocean, and vice versa.
- In addition, residential whale and dolphin populations are also likely to use these corridors as part of their home range.
- Indonesia's straits and passages are also likely to function as sensitive bottlenecks to numerous other species of large migratory marine life such as green, hawksbill and leatherback sea turtles, tuna and billfishes, as well as elasmobranchs such as manta rays and (whale) sharks.
- Local activities such as destructive fishing practices and gill netting near these straits can result in regional environmental impacts on cetacean populations and affect large marine ecosystem dynamics (Agardi 1997).

Komodo National Park (KNP) is part of the Nusa Tenggara island chain and located between the islands of Sumbawa and Flores. Komodo National Park includes three inter-island straits and is of importance to the conservation of Indonesia's terrestrial as well as marine bio-diversity (Pet and Djohani 1996).

Our survey focus on migration corridors such as the Nusa Tengarra island passages in Indonesia is both practical and productive migratory species management. This is because simple conservation measures can be implemented here in the short term, which have a direct and very positive outcome for 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). This integrated approach also assists with leverage for management options for all marine resources which inhabit the same area, including pressing coral reef and fishery issues. For example, local anti-bombing measures and certain fishing regulations (i.e. controlling extensive gill-netting practices) in the vicinity of the migration corridors may be particularly important to:

a. Avoid habitat degradation and corridor avoidance (cetaceans are especially sensitive to loud acoustic disturbances underwater).
b. Drastically reduce migratory marine life (by) catch levels.

1.2 Relevance of cetacean surveys to Komodo National Park management.

The visual and acoustic surveys as conducted in Komodo National Park are a primary tool to census whales and dolphins, but the information gathered has many direct conservation applications. The direct outcomes or the "4 W's" are: What (species), Where (do they occur), When (seasonal trends) and Why (habitat use). These W's are the minimum baseline data needed to identify critical habitats for the numerous whales and dolphins in these waters - including rare and endangered species such as orcas, sperm, pygmy Bryde's and blue whales. So one of the major functions of the surveys is to assess the current and future threats in cetacean critical habitats and to recommend specific protective management options for each site.

The visual and acoustic surveys show that the Komodo National Park and World Heritage Area is an important habitat for whales and dolphins (Kahn *et al.* 2000), and its long-term protective management benefits from seasonal regular cetacean survey activities. As more data becomes available, the rapid ecological assessments on cetaceans are increasingly integrated with the multi-faceted TNC conservation program on KNP marine biological diversity, and aim to

a. identify critical habitats for cetaceans and increase the protection for these areas,
b. broaden the array of KNP conservation perspectives and Park management measures, and
c. provide an additional tool for environmental awareness and community related activities.

1.3 Additional benefits of whale and dolphin surveys in Indonesia.

1.3.1 Cetacean surveys increase the exposure for the area of concern.

An important aspect of whale and dolphin surveys in remote regions of Indonesia is that it focuses conservation attention to a wide and exceptionally diverse geographical area. This way cetacean research can build up a 'critical mass' of interest, exposure and political will for better protection for all marine life inhabiting a priority conservation site.

1.3.2 Survey outcomes can effect change in people's perspectives on nature conservation.

Indonesia has a poor environmental performance and at least part of this is due to a lack of environmental awareness programs. Whales and dolphins are the perfect 'flagship' species to spearhead thematic nature conservation campaigns and increase the understanding and appreciation of the Archipelago's marine resources and assets. Survey outcomes can be integrated with educational materials that feature Indonesia's whales and dolphins. Such educational materials will make for an important awareness campaign on the amazing diversity of marine life in Indonesia, underline the need for conservation as well as promote the sustainable use of these resources. Our experience in Komodo National Park has shown that in Indonesia, cetacean surveys and ecological research can be an important impetus for realizing conservation measures and mitigating threats in the Park.

1.3.3 Surveys provide baseline data for future marine resource management reference.

The current state of knowledge on Indonesia's cetaceans is extremely limited and this effectively restricts our capacity for ecologically based management. The Komodo cetacean surveys increase our ecological understanding of cetaceans in these waters. It will also obtain the baseline data needed to assess the effects of the increased direct and accidental pressures on Indonesia's cetaceans in the future. These may include additional fishery interactions through increased efforts or new fishing techniques; existing mining practices, such as submarine tailings placements; new off-shore activities, such as deep-sea mineral mining explorations; major land developments near critical habitats; accidental oil spills; increased marine tourism activities with cetaceans, or natural disturbances. In any event, the baseline data collected during the visual and acoustic cetacean surveys will be a valuable reference for marine resource management in the future. In order to protect these highly migratory animals we must know as much as possible about the locations of their critical habitats, how they use each habitat, when they travel between them and the routes they take. Currently, data on all these aspects of cetacean management and conservation are not available for most regions of Indonesia.

2. Survey Objectives.

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.

3. To identify critical habitats for cetaceans, including preferred feeding grounds, mating locations and migration corridors.

4. To identify regional marine environmental impacts affecting KNP cetaceans.

5. To provide site and species-specific information on KNP cetaceans for:

    i. Marine resource and park management purposes.
    ii. Environmental awareness and educational programs.

6. To establish community-based cetacean monitoring programs 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.

3. Survey Methods and Research Activities.

The methodologies involved in this program have been specifically designed to cause minimal disturbance to cetaceans while allowing for discrete and close observations for positive species identification and photographic tagging of individual cetaceans. These methods have been practiced in Indonesian waters as well as in other parts of the world where benign cetacean research is conducted.

3.1 Survey method I: TNC speedboats.

The majority of the visual and acoustic cetacean surveys were carried out from a 25-foot TNC Yamaha speedboat cruising at 16-18 knots. This survey focused on the coastal areas, bays and inter-island passages of Komodo National Park. 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.

Time, sea surface conditions, GPS location, species sighted, estimated abundance, group composition, the presence of newborn calves, minimum distance from vessel, direction of travel and selected behaviours and species associations were recorded on standardised, waterproof data sheets. Photo-identifications were made of individuals with distinctive colourations, marks or scars using a Nikon 601 SLR camera equipped with a Nikkor 70-300mm lens. 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 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 Burns Electronics custom VHLF hydrophone (30Hz-20kHz) and audio amplifier. Acoustic surveys were only conducted 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, Flores, Nusa Tenggara Timor 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 the local live-aboard vessel Ora Buana. 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 and are described in Section 3.1. 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 and spaced approximately 6 nm apart.

4. Survey results.

4.1 Visual survey effort.

Surveys were conducted from 10 April to 27 April 2001. In total, 11 cetacean species were identified. The survey effort comprised of 15 field days and totaled 116.5 active survey hours. The surveys covered an estimated 1218.5 nautical mile (nm). The 11 species observed during 79 encounters were all toothed whales and dolphins (Suborder Odontoceti). No rorqual whales *(Balaenoptera sp.*, Suborder Mysticeti) were observed frequenting the Loh Dasami, Nusa Kode area or elsewhere. This was the first absence of baleen whales in three consecutive survey periods. An estimated 2170 individual cetaceans were sighted during the visual survey effort (Table 1).

4.2 Acoustic survey effort.

The acoustic survey effort included 37 listening stations and 28 acoustic contacts. The estimated acoustic coverage was 2331 nm^2 (Table 2). The number of acoustic contacts during the April 2001 survey was exceptionally high (75.7 % of all listening stations). This indicates a significant increase in cetacean abundance during this survey, as in accordance with the sighting and abundance results of the visual survey.

We employed a new and improved hydrophone that was developed specifically for cetacean acoustic survey work with extensive input from APEX Environmental. The initial calibration of the hydrophone suggest a detection range of over 8 nm for sperm whale vocalisations. Cargo vessels may be heard when located well beyond the horizon. Interference from the coastline is weak but clearly audible when 5.5 nm from the nearest land. This is a considerable improvement over the previous unit (which is widely considered the best hydrophone model available for the VHLF ranges of cetacean vocalisations). Its sensitivity may have increased the listening range and signal to noise ratios during the stations, resulting in more cetacean contacts. Overlap in stations especially during the live-aboard survey may also have resulted in increased overall contacts. The hydrophone sensitivity will be further examined and listening station distances set to ensure minimal overlap. High and low pass filters will be incorporated in the amplifier. This will further increase the effectiveness of the listening stations made from different vessels and conditions, increasing the consistency of results.

4.3 Cetacean species diversity.

During this survey the relatively high species diversity of the region was again confirmed. The 11 species encountered include the bottlenose dolphin (*T. truncatus*), Indo-Pacific humpbacked dolphin (*S. chinensis*), long-nosed spinner dolphin (*S. longirostris*), pan-tropical spotted dolphin (*S. attenuata*), Fraser's dolphin (*L. hosei*), Risso's dolphin (*G. griseus*), melon-headed whale (*P. electra*), false killer whale (*P. crassidens*), short-finned pilot whale (*G. marcorhynus*), killer whale or orca (*O. orca*) and sperm whale (*P. macrocephalus*) (Table 3; Fig. 1a). Including the recently DNA assisted identification of the pygmy Bryde's whales or Eden's whale (*B. edeni*) further discussed in Section 5, the number of cetacean species sighted during the surveys in KNP or adjacent waters totals 18 species (Table 3).

4.3.1 New species observed.

Two new species were recorded during the survey - *G. marcorhynchus and S. chinensis.* The absence of these two species thus far has been noted previously as unexpected (Kahn 2000). *G. macrorhynchus* is one of the most abundant members of the oceanic odontocete community in other parts of Indonesia (Rudolph *et al.* 1997, Kahn 1999) and its apparent rarity in the oceanic waters north and south of KNP is remarkable. It is also relatively common in other oceanic regions throughout its (sub)tropical range (e.g. Jefferson *et al*. 1993, Bernard and Reilly 1999).

S. chinensis is a vulnerable coastal cetacean distributed throughout the shallow waters of the Indian and western Pacific Oceans. Its known distribution ranges throughout coastal Indonesia . Interestingly, *S. chinensis* populations east of Sumatra (e.g most of Indonesia, Philippines, Papua New Guinea and Australia) lack the distinctive dorsal hump that gives the species its name. This eastern form is also characterised by significant body colour variations between different populations, age classes and individuals. The Komodo individuals sighted to date have a uniform gray colouration. It may be that that the predominantly coastal *S. chinensis* is a residential KNP species that has so far eluded identification due to its elusive behaviour, as well as its similarity and close association with *T. truncatus.*

The absence thus far of the two remaining in-shore cetacean species that may occur in KNP waters is also noteworthy. The Finless porpoise (*Neophocaena phocanoides*) and the Irrawaddy dolphin (*Orcaella brevirostris*) may have a discontinuous distribution and genetically distinct Asian and Australian populations. The extend of overlap between these population ranges, if they overlap at all, is currently unknown. As KNP is situated right in the area of interest, any sightings (or continued absence of sightings) of these species in the region would be of importance to determine the degree of connectivity between the Asian and Australian populations.

Species diversity continues to be a priority for all surveys as seasonal patterns in cetacean distribution are likely to occur in Indonesian and KNP waters. The new species sighted during the current survey suggest that the species diversity continues to increase with additional survey efforts. The surveys have been successful in recording the majority of cetacean species that inhabit KNP waters relatively frequently. However, seasonal, rare or elusive species continue to be added to the overall species list. The extend of habitat use within KNP boundaries by these species is of importance for species management especially.

4.4 Cetacean distribution in Komodo National Park.

All cetacean sighting coordinates of the April 2001 survey were transcribed to a GIS format and assigned species-specific data points (Figure 1a). 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	★
Dolphins - Family Delphinidae	▲
Globicephalinae - a Delphinidae subfamily of six species*	✚
Unidentified small cetacean (≤ 6 metre)	△
Unidentified large cetacean (> 6 metre)	○

* - The Globicephalinae subfamily is based on a systematic revision of the delphinidae and includes six species: *Feresa attenuata, Peponocephala electra, Globicephala marchorhynchus* 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.

The distribution patterns of the previous surveys (Kahn *et al.* 2000) have been largely confirmed (Figure 1a). The bottlenose dolphin, *T. truncatus*, continues to dominate the distribution of sightings within KNP borders, whereas the offshore areas adjacent to KNP have a more complex pattern. As expected, the species diversity in this zone consisted largely of oceanic odontocetes. Species-specific habitat use as identified in the April 2000 and October 2000 Monitoring Reports was consistent for the relevant species mentioned (see Kahn 2001), with the exception of *Balaenoptera edeni*, which was not sighted at all.

Species-specific sighting frequencies and estimated abundances were compiled for the April 2001 survey period (Figure 2a-b, Table 3). Overall, the KNP cetacean species assemblage was similar to the previous year (Kahn 2000, Kahn *et al*. 2000). 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. Additional species-specific patterns are discussed in Section 4.5.2.

4.5 Overview of cetacean diversity, abundance and distribution results - May 1999 to April 2001 survey periods.

4.5.1 Annual and seasonal comparisons - May 1999 to April 2001 survey periods.

The cetacean diversity and distribution within KNP and adjacent waters has been compiled for April 2001, as well as 1999 and 2000 (Figs 1a, 1b and 1c respectively). The 1999 survey results have been described in previous monitoring reports and have been incorporated in several park management recommendations (Kahn et al. 2000, Pet and Yeager 2000). The survey effort to date includes 71 survey days. On all but one KNP survey day (26/05/99) cetaceans were encountered. The total number of separate cetacean encounters is 299. This equates to an average for the April 1999 to April 2001 period of 4.2 encounters per survey day (range 1.7 - 5.3).

Yearly and seasonal trends are hard to determine with an overview of the survey efforts and results to date (Figures 3a-h). There is considerable variation in both the sightings and abundances between surveys, years and seasons (Figs 4a-b). This remains the case when the sighting data is corrected for survey effort such as active survey time and nautical miles surveyed (see Section 4.5.3).

A total estimated abundance of 7082 individual cetaceans were observed during the May 1999 - April 2001 period in KNP and adjacent waters. Estimated 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 (Figs 5a-b).

The abundance estimate must be considered with caution however. Large and possibly residential pods of highly social cetaceans (such as *S. attenuata* and P. *electra* as well as *S. longirostris* have been sighted numerous times during this period. Possible pod resightings are currently under investigation through photo-identification of pod members. Frequent encounters with the same pods indicate a residential population (which is of great interest by itself), but will inflate the estimated number of overall individuals in the region. On the other hand, the estimates for cetaceans present during each encounter are conservatively based on individuals sighted at the surface at any one time. This is a minimal number of the cetaceans encountered as large pods often stage their surface periods and only rarely are all members of a pod visible at the surface at the same time. This method results in a minimum estimate of cetaceans present during an encounter and will underestimate the overall abundance of cetaceans in the region. Additional data on regional abundance would necessitate long-term research and intense photo-identification studies (Mann *et al.* 2000). Nonetheless, rapid ecological assessment surveys, coupled with behavioural and ecological observations for each species, is most useful for meaningful recommendations on either research priorities or for conservation planning purposes (Mann *et al.* 2000).

The May 1999 - April 2001 Komodo surveys illustrate that even one-off visual and acoustic surveys are valuable tools to rapidly and reliably assess the diversity, abundance and an indication of habitat use of an area for migratory or highly mobile marine species such as cetaceans. In the majority of survey periods cetacean diversity is consistently high with over ten species regularly sighted in the relatively brief survey period (Fig 3). Thus, surveys similar to those implemented in KNP can be integrated with broader rapid ecological assessments of potential conservation sites. This is especially productive in areas where cetaceans are known to occur or where no base-line data exists.

4.5.2 Species-specific patterns: May 1999 to April 2001 survey periods.

The May 1999 - April 2001 data has also been analysed for seasonal and annual trends on the species level (Table 3, Figs 6a-b). Several species-specific patterns can be determined, relating to seasonality as well as habitat preference. These results confirm previous indications (e.g. Kahn 2000, Kahn 2001). The species-specific sighting frequencies continue to be dominated by *T. truncatus*, *S. longirostris* and *S. attenuata*. *P. electra* is also sighted with great regularity (Figs 1-c, Figs 6a-b, Fig 7).

The percentage of unidentified small cetaceans is relatively constant for all survey periods to date (averaging at 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.

Sighted throughout the May 1999 - April 2001 survey periods with similar frequencies are *T. truncatus*, *S. longirostris, S. attenuata*, *P. electra, L. hosei and P. crassidens* (Figs 7a). These sighting characteristics are expected for residential populations in KNP and adjacent waters especially.

When the data is analysed for species-specific sighting and abundance proportion for each survey, it becomes apparent which species are exclusively sighted during a particular survey season or year (Figs 8a-b, Table 3). These are *Z. cavirostris*, *F. attenuata* (both sighted exclusively in the October survey period) and the two *Kogia* species combined (both sighted exclusively in the April survey period. *B. edeni* was most frequently sighted in 2000, as was *S. bredanensis. P. macrocephalus* was most frequently sighted in 1999, not at all in 2000 and sighted again during the April 2001 survey). Rare species, known from less or equal than two sightings *are B. musculus, Kogia simus, O. orca, Z. cavirostris and D. delphis.* The relative abundance per survey for each species is of interest for the frequently seen species especially. *S. attenuata* abundance is extremely variable as opposed to *T. truncatus* and *S. longirostris*, which both have similar proportions for each survey to date (Fig 8a-b). *P. electra* sighting characteristics are in accordance with a residential population (see above), yet the abundance estimates thus far are substantially higher in the April survey periods.

4.5.3 Survey effort.

The cetacean survey results indicate there may not be a major seasonal influence on overall cetacean sightings and abundance, when corrected for both survey time (active survey hours; Figs 9a-b) and distance (nautical miles covered; Figs 10a-b). Instead the significant variation, both annual and seasonal, is in accordance with the likely large-scale movements of the many cetacean species observed in KNP waters. 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 distribution and abundance in the region.

For instance, the substantially reduced 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 are in turn likely to be related to favourable ecological and oceanographic conditions. Research into which environmental factors affect cetacean distribution and abundance in Indonesia, SE Asia (and indeed most regions of the world) is necessary for their effective management and conservation (e.g. Simmonds and Hutchinson 1996). The KNP cetacean surveys could be used for this purpose, especially when integrated with both regional fisheries statistics and remote ocean sensing.

4.5.4 Sighting conditions and survey methods.

During all cetacean encounters the sighting conditions are recorded. Sighting conditions range from 1 (excellent), 2 (fair), 3 (choppy), 4 (rough) and 5 (very rough). The categories are based on the Beaufort scale but are adjusted according to conditions particular to Komodo National Park. Of particular concern are current induced sea state and heavy rainsqualls. The percentage of sightings made under each condition per survey period indicate that most sightings are made in conditions 1-2 (Fig 11). This is largely expected as the fieldwork is scheduled during eastern

Indonesia's calm intermonsoon periods. However, even in unfavourable conditions (such as during the majority of May 1999 and parts of April 2001) substantial sightings are recorded in condition 4 and 5. The majority of sightings were recorded from the TNC speedboats (Fig 12). This is the major survey method in KNP and makes up for the majority of active survey hours and distance covered. However, the inclusion of a live-aboard vessel as part of each survey effort is an effective buffer against periods of inclement weather and also increases the range of the survey area. Due to the extreme weather changes in the Komodo region the surveys will always experience rapidly changing conditions, often within hours, and this will affect both survey routes and local sighting conditions. Overall, the sighting patterns between surveys have been relatively similar and characterised by largely favourable conditions.

5. Pygmy Bryde's whale *Balaenoptera edeni* identified by DNA biopsy sample analysis.

5.1 A collaborative and international approach to Indonesian cetacean research.

A rare and regionally distinct whale species has recently been identified in the waters of Komodo National Park - the pygmy Bryde's whale, *Balaenoptera edeni*. This interesting species, also called the Eden's whale or Sittang whale (Rice 1998) was initially sighted in KNP waters in 1999 and 2000 while conducting routine whale and dolphin surveys in the Park.

In previous reports (Kahn 2000) the whales were tentatively described as (pygmy or regionally distinct) Bryde's whales (*Balaenoptera edeni*), but the combination of features was, and remains, unusual. The closely related Bryde's whales (*B. brydei*) have a circumtropical distribution and have been caught in the subsistence whale fishery at Lamakera on Solor Island, located off eastern Flores (Barnes 1991and 1996), and have been sighted within KNP (Hoffmann 1998 as quoted in Rudolph *et al.* 1997), as well as in the waters adjacent to Bunaken National Park, northern Sulawesi (Kahn 1999). Some of these sightings may actually be *B. edeni* (see Section 5.2 on taxonomic issues).

The KNP whales could not be positively identified in the field because of their unusual morphology. This is not that surprising as there are only a few reports of 'normal' Bryde's whales in Southeast Asian waters published, let alone the pygmy species. Further examination of the photographic material available confirmed the Komodo whales looked very different from all likely whale candidates known to occur in SE Asian waters. There simply was no reference material available for comparison. In order to further the understanding of Indonesia's cetacean diversity and the ecological role of KNP, a joint proposal from Taman National Komodo, TNC-Indonesia Program and APEX Environmental was filed with LIPI and PKA, and subsequently approved. During the October 2000 survey, a small biopsy sample from one of the *Balaenoptera* whales in Loh Dasami was successfully taken for DNA analysis. A CITES sample exchange and transport permit was obtained in November 2000. Export of the sample was granted in June 2001 by the relevant Indonesian authorities.

The whale's DNA was recently analysed by the Molecular Ecology Lab, National Marine Fisheries Service, Southwest Fisheries Science Center in La Jolla, USA. This institution is a world leader in cetacean DNA complex analysis and specialises in *Balaenoptera* species. The analysis resulted in a complete match with a pygmy Bryde's whale sample from the Philippines (Perrin *et al.* 1996, Dizon *et al.* 2000).

This is a rare Balaenoptera species (IUCN 2000 Redlist Status is data deficient) and it may have variable morphologies. There are only a few reports of 'normal' Bryde's whales in Southeast Asian waters published, let alone the pygmy form. The huge regional gap in scientific knowledge on Indonesia's cetacean diversity, distribution and abundance - crucial information to identify critical habitats - can only be filled by cetacean programs such as those conducted in Komodo National Park by APEX Environmental and The Nature Conservancy Indonesia Program - Coastal and Marine Conservation Centre.

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). Thus the photos and video footage taken of this species in Komodo could provide an important benchmark for benign whale research in Indonesian waters. Ecological data obtained during the surveys to date suggests the KNP pygmy Bryde's whales inhabit inshore waters for extended periods. This habitat preference makes them highly sensitive to coastal fisheries interactions and destructive fishing practices like reef bombing.

The pygmy Bryde's whales observed in Komodo National Park waters have the following characteristics:

- Relatively pointed rostrum
- Prominent single ridge on rostrum
- Inconspicuous blow
- Relatively small for a baleen whale (most individuals are estimated between 7-10m)
- Prominent light grey/whitish pectoral fins (not present in the Philippine whales examined thus far)
- Extremely falcate dorsal fin
- Complex colour pattern including light grey chevron, nape streak and thorax patch (similar to a finback whale *B. physalus*).
- Active feeding, defecating, mating and other behaviours.

The identification is of importance as the Balaenoptera whale morphologies in the Indo-Pacific - and especially in SE Asia - are not well known and several species are not described in detail from this region. Other species in Australasia have been, or may be, separated into several (sub)species as more information comes to light (e.g. pygmy blue whale, dwarf minke whale, bottlenosed and common dolphins). Results of this finding have been widely circulated including scientific electronic news bulletin and professional marine mammal subscription lists (MARMAM) and received with considerable and worldwide interest.

5.2 Taxonomy issues - Balaenoptera edeni vs B. brydei.

The findings and scheduled Komodo Pygmy Bryde's whale focus research are also of taxonomic importance. This is because various populations of small rorquals in tropical oceans have been identified as B. edeni as well as B. brydei (Bryde's whale). The taxonomic relationships between these populations is not at all clear. In recent years most cetologists thought that *B. brydei* was a synonym of *B. edeni.* However, substantial size differences, recent molecular studies and increasing data on *B. edeni* morphology, distribution and geographical variation support the notion that at least two taxa are involved (Rice 1998).

Rice (1998) summarizes that the whales that have been called Bryde's whales have two size groups. The smaller ones attain physical maturity at 9.0m and have a maximum length of

approximately 11.5m The smaller animals studied so far all come from the coastal and shelf waters of the eastern Indian Ocean, the Sunda Shelf and the western Pacific. The name *B. edeni* was based on one of these animals (the holotype is a skull and several baleen plates from Burma in 1871 and thus there is no morphological data available nor have there been DNA studies conducted on this sample). The larger Bryde's whale inhabits all tropical and warm temperate waters around the world. It does not even become sexually mature until it measures over 11.2 m in males, 11.7 m in females. The maximum length can be 14.6 m in males and 15.6 m in females. There is an offshore and coastal form of this larger Bryde's whale, which complicates the taxonomy (and field identifications) further. The offshore populations studied thus far fit the B. brydei descriptions, whereas the in-shore form (Japan, South Africa, elsewhere?) is still uncertain.

Because of the complex history of the taxonomy of these species, current researchers are focusing their efforts on osteological, genetic and morphological characteristics. Currently, the taxonomic classification for these species is still unresolved (e.g. *B. edeni* vs B. *brydei* 'coastal form'). This situation would benefit greatly from combined osteological, genetic and morphological studies, preferably from the same animal to expand the data on the species' holotypes. The absence of photographic and ecological data especially means that positive identifications of these fascinating whales in their natural habitat remains a challenge, particularly in regions where no baseline data exists

5.3 Initial ecological data on Balaenoptera edeni *in KNP waters.*

The Komodo baleen whales have been sighted during three survey periods in coastal waters off Gili Mota (October 1999) and Loh Dasami, Nusa Kode Strait (April and Oct 2000), as well as along the southeast coast of Rinca and in the vicinity of Loh Liang, Komodo (Oct 2000). The majority of these sightings occurred within Park boundaries. The whales have been most frequently sighted in Loh Dasami, Nusa Kode Strait. Feeding behaviours and social interactions have been observed here. Behaviours include repeated lunge feeding, defecation, breaching and aroused rolling resulting in a sex identification (male). The consistency of sightings and behaviours observed indicate a habitat preference for this area. Additional sightings of small unidentified baleen whales have been reported from Loh Liang (Pak Subijanto, pers. comm) as well as Selat Molo (J. Pet, pers. comm).

An ecological focus study is warranted to further investigate the potentially resident KNP *Balaenoptera edeni* whales. Important data for management consideration includes numerous population biology parameters, movement patterns, the extend and duration of KNP habitat use, as well as the assessment of environmental impacts and additional protective management measures (further discussed in Section 7.2)

6. Staff training, constituency building & community involvement.

6.1 Cetacean survey field staff training.

The field training of TNC-KFO staff expanded during the April 2001 surveys. The newly appointed TNC-KFO migratory marine life program assistant joined the surveys on all but two speedboat survey days and all the live-aboard survey. In addition, two Balai Taman Nasional Komodo rangers joined the surveys for a combined total of eight speedboat survey days as well.

The Program Assistant, Catharine K Winata was trained throughout the survey period in cetacean ecology, identifications at sea and data recording. A detailed position description with task lists

was produced with input from both the Monitoring Manager and Head of the Komodo Program. An APEX Environmental cetacean reference folder was produced and copies made available for both the Komodo Field Office as well as the TNC Bali Office - Coastal and Marine Program. The reference folder for each office included the following materials:

- Identification of cetaceans at sea brochure (Bahasa Indonesia and English versions).
- Cetacean observer techniques - What makes a good observer?
- Indonesian cetacean species list (incl. scientific and local names, conservation status of each species).
- Watching wild cetaceans with minimal disturbance in Indonesian waters (codes of conduct for responsible whale watching).
- Live cetacean stranding - Action guidelines.
- Marine mammal stranding report (adapted from NOAA's global form).
- Volunteer cetacean sighting data sheets.
- Info sheet - The Cetacean Surveys in Komodo National Park.
- Abstract in Bahasa Indonesia as well as English: Kahn, B., James, 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 - Jurnal Pesisir and Lautan August 3(2): 41-59.

6.2 Meeting on KNP cetacean surveys and Park management and expansion.

A management meeting on KNP cetacean survey results and its relevance to Park management was organised . This meeting was opened by a detailed presentation on survey outcomes to date and given at the TNC - Komodo Field Office in Labuan Bajo. The meeting was well attended by rangers and senior staff of both Taman National Komodo and TNC-KFO. Ir. Pak Novianto, Head of Balai Taman Nasional Park Komodo tabled several information requests. The issues concerned included:

- Possible resource competition between cetaceans and fishers in the Park. One of the main functions of Park management is to ensure that both these 'resource users' can co-exist. Cetaceans do compete with fishers occasionally. However, they are an integral component of KNP bio-diversity and increase the wilderness values of the Park's. This in turn is important for nature tourism demand and increased visitations.

- Importance of expanded boundaries of KNP to include important cetacean migration corridors such as Selat Sape. The status of the Park boundary expansions as adopted in the 25-year master plan (Pet and Yeager 2000) were discussed. This expansion would include Banta Isl. and Kelapa Isl., both situated at either entrance of Selat Sape) The proposed expansion of the Park would mean an additional major provincial stakeholder, Nusa Tenggara Barat (NTB), as the provincial boundary runs through Selat Sape itself and the two islands proposed for inclusion are under Sumbawa (NTB) jurisdiction. To assist with these developments detailed cetacean educational materials and slide duplicates were requested. These materials were delivered several days later for the joint TNC/Taman National presentations at the Nusa Tengarra Barat/Timor (Bima/Manggarai) provincial meeting where the Park's expansion will be officially discussed, and possibly finalised with mutual agreements.

The repeated sightings of highly migratory cetacean species at the entrances, or near vicinity of, this major corridor indicate that increased protection of Selat Sape would be of regional conservation significance (see Section 7.1.2).

7. Survey outcomes identify the need for increased protective management for KNP Cetaceans.

7.1 Selat Sape and adjacent islands.

This survey in particular included several sightings of importance to migratory marine corridor management. These sightings involved highly migratory species that were encountered at the Flores Sea entrance of Selat Sape. Importantly, these sightings were in the near vicinity of previous sightings of the same species.

7.1.1 Concentrated sightings of highly migratory cetacean species in the northern entrance of Selat Sape.

7.1.1.1 Orcas.

On 22/04/01 an orca pod (*O. orca*) of two individuals (a mature male and presumably a mature female) was encountered at 8° 15' 75" S and 119 ° 17' 75" E. The orcas were near a large mixed pod of oceanic dolphins, which were observed in the Flores Sea, north of Banta Island. The two orcas were photo-identified and no matches were found with the previous pod of October 2000. In fact, the orcas observed this survey both had very distinct and usual eye-patch colourations. These were a mottled light grey with unsharp borders as opposed to the normal crisp white eye-patch. No observations on other colour markings were made.

Interestingly, the location of this sighting is less than 2 nm from the previous orca pod of nine animals reported in October 2000 at 8° 14' 50" S and 119 ° 17' 50" E. Both pods travelled northeast. This area is at the junction of a migratory corridor between the Sumba Sea (Indian Ocean) and the Flores Sea. It is flanked by San Geang and Sumbawa in the west and Banta and Komodo Island in the east. The orca sightings, as well as the additional sightings mentioned below, strongly indicate this area could be a regular cetacean migratory passage.

7.1.1.2 Male sperm whales.

Socially mature male sperm whales (*P. macrocephalus*) may grow to 18 m in length and are the largest deep-sea predator. Sperm whales exhibit extreme sexual dimorphism. Males may be 1.6 times longer than their female counterparts (max. 11m) and mature bulls may weigh three times as much (45 tons). Selective whaling for larger individuals (males) has altered the sex ratio of this species and this is likely to have impacted on this long-lived species. Sperm whales have a complex social organisation whereby the males leave their nursery school in tropical waters upon adolescence and inhabit high latitude regions when mature (Whitehead and Kahn, 1992). Socially mature males are highly migratory and move between their cold water feeding grounds and the breeding grounds in the tropics. Thus encounters with mature male sperm whales in the tropics are of direct conservation significance.

The surveys have identified two solitary male sperm whales, once on 19/05/99 and once on 18/04/01. The length of the animals was estimated to be 13 m and 15 m respectively. These estimates were done by experienced sperm whale researchers, familiar with both visual and photographic length measurement techniques for sperm whales (Kahn 1991, Kahn *et al.* 1993). Again, both sightings where in relatively close proximity, just over 20 nm apart (8^0 15' 50" S, 119^0 26' 25" E and 8^0 20' 50" S, 119^0 05' 25" E). In addition, these sightings were in the same general

area as the orca sightings. In fact, the April 2001 sighting occurred only 6 nm east from Tg. Naru, on the northeastern tip of Sumbawa. Both animals were swimming in a straight and constant northeasterly direction throughout both observation periods. The diving patterns were regular, shallow (no flukes were observed at the end of each surface interval) and of short duration (less than 20 min). This also suggest the animals were passage making (i.e. actively migrating) and not actually feeding. It may well be that both of these mature male sperm whales recently entered the Indonesian Seas from the Indonesian Ocean through Selat Sape.

7.1.1.3 Blue whale.

A blue whale (*B. musculus*), estimated 24 m in length, was also sighted in this same area during the Oct 2000 survey. It was swimming in a constant westerly direction when first encountered north of Komodo Island and changed course toward Selat Sape as it approached Banta Island. It was last recorded at 8^0 17' 0" S and 119^0 20' 0" E before all contact was lost. The blue whale's behaviour may have been influenced by the nearby orcas (see Kahn 2000). This observation confirmed the only previous report on blue whales in the Komodo area (IUCN/UNEP 1988) and raises important questions on the ecological significance of the eastern Indonesian Seas (such as a possible breeding area) for this endangered and highly migratory species.

7.1.2 Threats to cetaceans in Selat Sape.

Over 16 small vessels anchored in the bays of northwest Kelapa Islands were observed at 18:15 on 18/04/01 when entering an overnight anchorage during the April 2001 live-aboard survey. The vessels were all reef bombers in the opinion of the researchers, as well as the captain and crew of the research vessel. Most likely, these vessels are primarily involved in destructive fishing practices such as reef blasting and cyanide fishing for the live coral reef fish trade. All but two larger ones made their exit upon our approach. Additional boats arrived upon sunset and passed close to our anchorage. Inspection with binoculars revealed that at least one of these has a large compressor on-board and two yellow Hookah lines set up at the aft deck. The whole set looked brand new and is routinely used to collect live reef fish using cyanide. The presence of such a fleet of destructive fishers is concerning. Kelapa Island is situated right on the southern entrance (Sumba Sea) of Selat Sape, between Sumbawa and Komodo Island.

In addition to its destructive impact on Indonesia's coral reef ecosystems, reef bombing is likely to affect Indonesia's cetaceans as well (see Ketten 1998 for a review on acoustic impacts on cetaceans and Kahn *et al.* 2000 for potential blasting impacts on Indonesia's cetacean corridors). Cetaceans are especially sensitive to acoustic disturbances (e.g. Hofman 1995; Simmonds and Hutchinson 1996; Kemp 1996, Gordon and Moscrop 1998) and frequent bombing activities near critical habitats such as corridors could result in numerous lethal and sub-lethal trauma effects such as:

- Fatal exposure to high pressure waves resulting from the blast.
- Permanently reduced sensory capabilities due to non-fatal exposure.
- Acoustic masking of environmental cues.
- Long-term abandonment of important habitats.
- Long-term alteration of migration routes.

Frequent bombing activities in the vicinity of Selat Sape will affect all of these impacts on both residential KNP whale and dolphin populations, as well as migratory cetaceans passing through the Strait on their long-range movements.

7.1.3 Short-term conservation opportunities for the Selat Sape migratory corridor area.

The fact that all these sightings of highly migratory oceanic cetaceans have occurred in a relatively small geographic area strongly indicates that the area is of ecological significance to migratory cetaceans. In addition, all sightings were of priority species under the TNC Indonesia Cetacean Action Plan. This warrants management attention and additional protection measures for this passage.

Short-term opportunities for improving the protective status of this area would be the approval of the proposed KNP boundary expansions and subsequent implementation of anti-bombing measures and gill- and driftnet fishing restrictions in the wider Selat Sape area. Although the actual area of interest is outside the proposed KNP boundaries, protective management implemented here will have a direct benefit to the migratory cetaceans sighted in KNP and adjacent waters. These measures would also be beneficial to other migratory marine life such as turtles, sharks and would assist with the conservation priorities of the KNP and World Heritage Site.

7.2 Threats to the Pygmy Bryde's whale and other cetaceans in KNP.

7.2.1 Fisheries interactions.

During each day of observations, the Pygmy Bryde's whales swam extremely close to the coastline of Gili Mota, Nusa Kode or Rinca for the majority of observation time. This behaviour increases the vulnerability of these whales to coastal fishing practices such as gill netting and reef blasting. It is noteworthy that bottlenose dolphins (*T. truncatus*), spinner dolphins (*S. longirostris*) as well as numerous large mantas (*Manta birostris*) were also frequently observed in the same area. The Rinca - Nusa Kode passage in particular does warrant extra attention as a sensitive marine area for cetaceans, and *B. edeni* in particular. Additional patrols to the area have been recommended to TNC- KFO and Balai Taman National Komodo in order to minimize any bombing activities or extensive gill net placements by the numerous fishing vessels in the passage (Kahn 2000). These measures would benefit all cetaceans inhabiting this part of KNP and can be integrated with reef conservation and sustainable fisheries programs.

7.2.2 Marine tourism interactions.

KNP is well known for its unique Komodo Dragon (*Varanus komodoensis*) as well as its exceptional marine biodiversity. The Park includes some of the best scuba diving in SE Asia. Several of the most spectacular dive sites are located in the scenic Loh Dasami area. This area is visited year-round by an increasing number of dive vessels and local charter boats, usually for several days at a time.

Impromptu whale watching and in-water interactions with tourists are frequent when the whales are sighted. These interactions are currently unregulated. In response to this possible threat by well meaning tourism attention, APEX Environmental has produced and distributed guidelines or codes of conduct for responsible whale watching (see also Kahn *et al.* 2000). This initiative would benefit from a more concentrated effort to inform and educate the vessels' crew. The short-term benefit would be an increased awareness of minimal disturbance boat handling techniques and other responsible whale watching practices. An official endorsement from the Komodo Dive

Association of these practices would ensure all members are in agreement and intend to follow the guidelines and management regulations that may stem from the continued monitoring of the pygmy Bryde's whales. The Association's members could also report any whale sightings in KNP.

The difficulties in identifying this KNP Balaenopterid whale species in the field illustrates how little is known on Indonesia's cetacean populations and presents yet another aspect of the exceptional marine diversity of the Indonesian Seas. The Komodo cetacean surveys would benefit from further integration with other marine conservation activities, including coastal and pelagic fisheries, community liaison and environmental awareness programs. The lessons learned in KNP are also important to ensure that effective conservation outcomes can be achieved in other prime cetacean habitats of the Indonesian Archipelago.

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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.

Bernard, H.J. and S.B. Reilly. 1999. Pilot Whales. *In*: Ridgway, S.H. and R. Harrison. Eds. Handbook of marine mammals. Volume 6: The second book of dolphins and the porpoises. Academic Press. London UK. 485p.

Dizon, A., C.S. Baker, F. Cipriano, G. Lento, P. Palsboll and R. Reeves (eds). 2000. Molecular genetic identification of whales, dolphins and porpoises: Proceedings of a workshop on the forensic use of molecular techniques to identify wildlife products in the marketplace. U.S. Department of Commerce. NOAA Technical Memorandum, NOAA-TM-NMFS-SWFSC-286. 52pp. + xi.

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

Hofman. R.J. 1995. The changing focus of marine mammal conservation. Trends Ecol. & Evol. Vol. 10. No. 11: 462-465

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

IUCN/UNEP. 1988. Coral reefs of the world. Vol. 2: Indian Ocean, Red Sea and Gulf. UNEP Regional Seas Directories and Bibliographies:1-389, maps 1-36. IUCN Gland, Switzerland.

Jefferson, T.A., Leatherwood, S. and M.A. Webber. 1993. FAO species identification guide - Marine mammals of the world. UNEP, Rome. 320p.

Kahn, B. 1991. The population biology and social organisation of sperm whales (Physeter macrocephalus) off the Seychelles: Indications of recent exploitation. M.Sc. thesis. Dalhousie University, Nove Scotia, Canada. 130 pp.

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. 226p.

Kahn, B. 2000. Komodo National Park cetacean surveys: A rapid ecological assessment of cetacean diversity, abundance and distribution. Interim monitoring report - April 2000. TNC Indonesia Program, Coastal and Marine Conservation Center, Bali. 24pp.

Kahn, B. 2001. Komodo National Park cetacean surveys - Monitoring Report October 2000. TNC Indonesia Program - Coastal and Marine Conservation Centre. 26pp.

Kahn, B. Whitehead, H. and M. Dillon. 1993. Indications of density-denpendent effects from comparisons of sperm whale populations. Mar. Ecol. Prog. Ser. 93: 1-7.

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.

Kemp, N.J. 1996. Habitat loss and degradation. *In*: The conservation of whales and dolphins: Science and practice. By M .Simmonds and J Hutchington (eds). Wiley and Sons. 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 for downloading at the NOAA web site.

Klinowska, M. 1991. Dolphins, porpoises and whales of the world. The IUCN red data book. IUCN, Gland Switzerland 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. Mar. Mam. Sci. 15: 619-48.

Mann, J. Connor, R.C., Tyack, P.L. and H. Whitehead. 2000. Cetacean societies - Field studies of dolphin and whales. 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. Rep. Int. Whal. Commn. 46:409-413.

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.

Rice. D. 1998. Marine mammals of the world - systematics and distribution. The Society for Marine Mammalogy. Special Publication 4

Simmonds, M.P. and J.D. Hutchinson. 1996. The conservation of whales and dolphins. John 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.

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

Whitehead. H. and B. Kahn. 1992. Temporal and geographical variation in the social structure of female sperm whale. Can. J. Zool. 70: 2145-2149.

Tables.

Table 1: KNP cetacean visual survey summary for the April 2000 period.

KNP cetacean visual survey effort 10 April - 27 April 2001	TNC Speedboat	Live-aboard	Survey April 2001
Total no. of days surveyed	10	5	15
Survey effort (hrs)	71.25	45.25	116.5
Estimated area surveyed (nm)	939.5	279	1218.5
Cetacean identification encounters	58	21	79
Estimated number of cetaceans surveyed	1651	519	2170
Cetacean species identified	7	8	11

Table 2: KNP cetacean acoustic survey summary for the April 2001 period.

KNP cetacean acoustic survey effort 19 April - 5 May 2000	
Listening stations	37
Cetacean contact	28
Acoustic encounter rate (%)	75.7
Area covered (nm2)	2331

Table 3: 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	*Kogia 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 1a: Cetacean species diversity and distribution in Komodo National Park and adjacent waters - April 2001 survey.

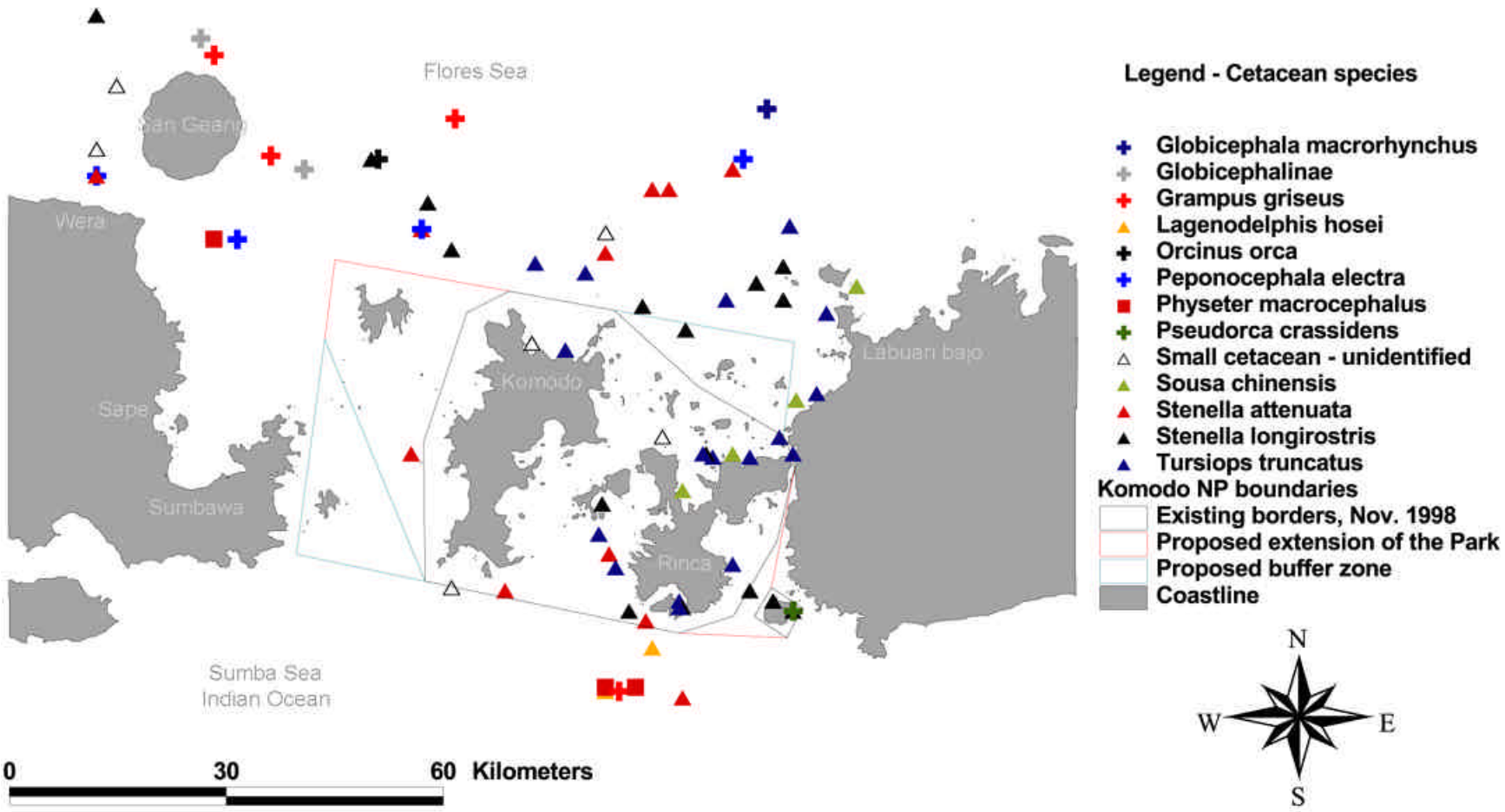


Figure 1b: Cetacean species diversity and distribution in Komodo National Park and adjacent waters - 1999 surveys.

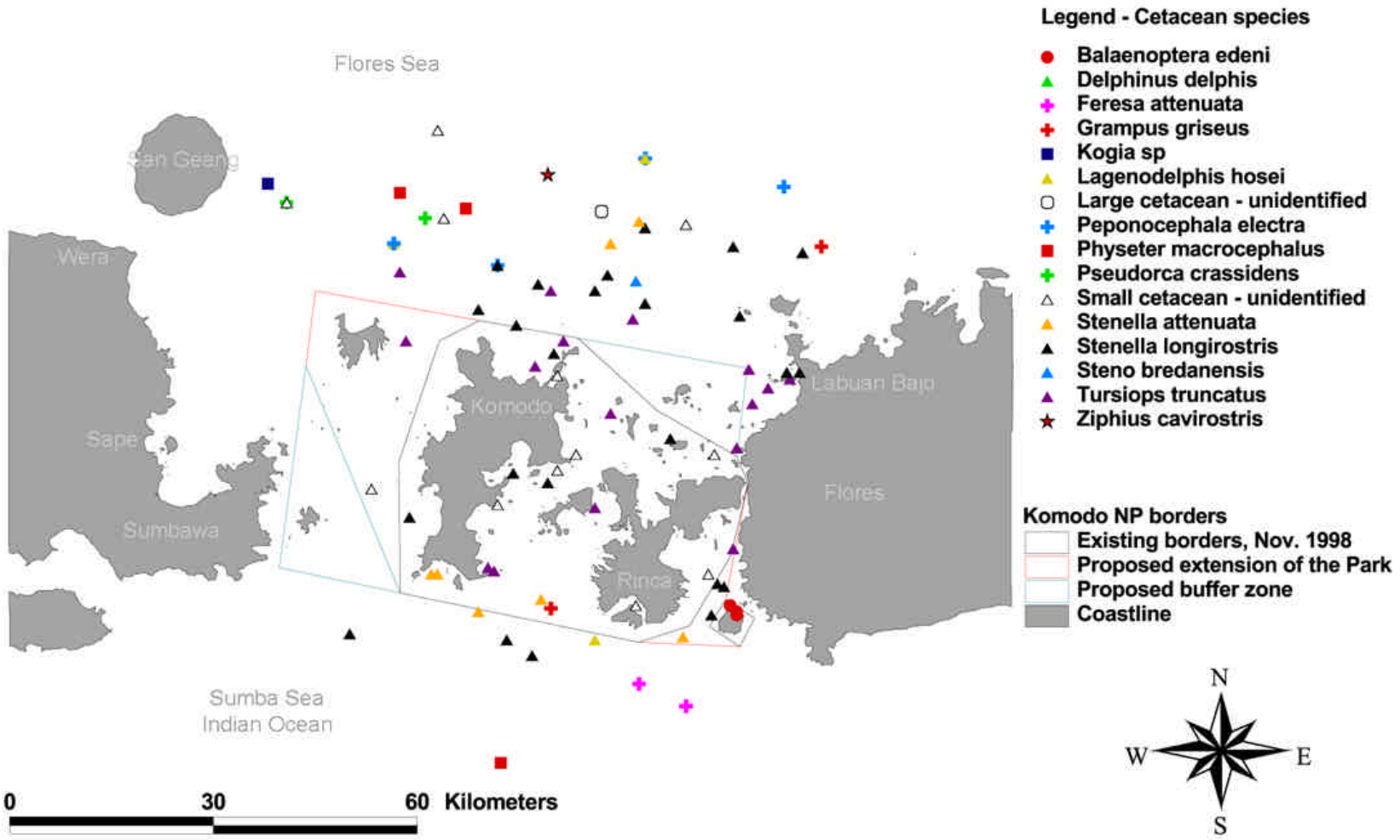


Figure 1c: Cetacean species diversity and distribution in Komodo National Park and adjacent waters - 2000 surveys.

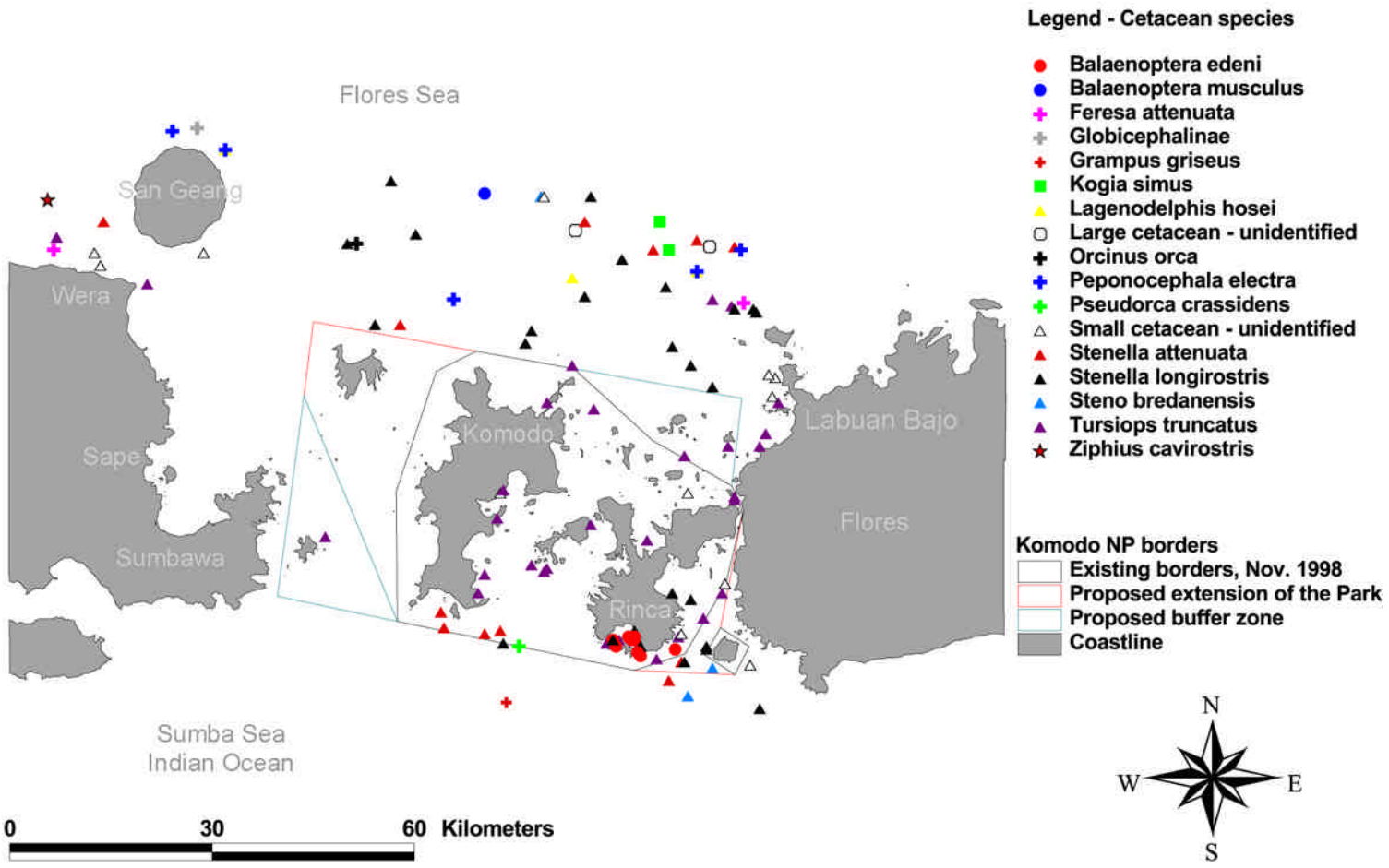


Figure 2a: Species-specific sighting frequency (%) during the April 2001 Komodo survey.

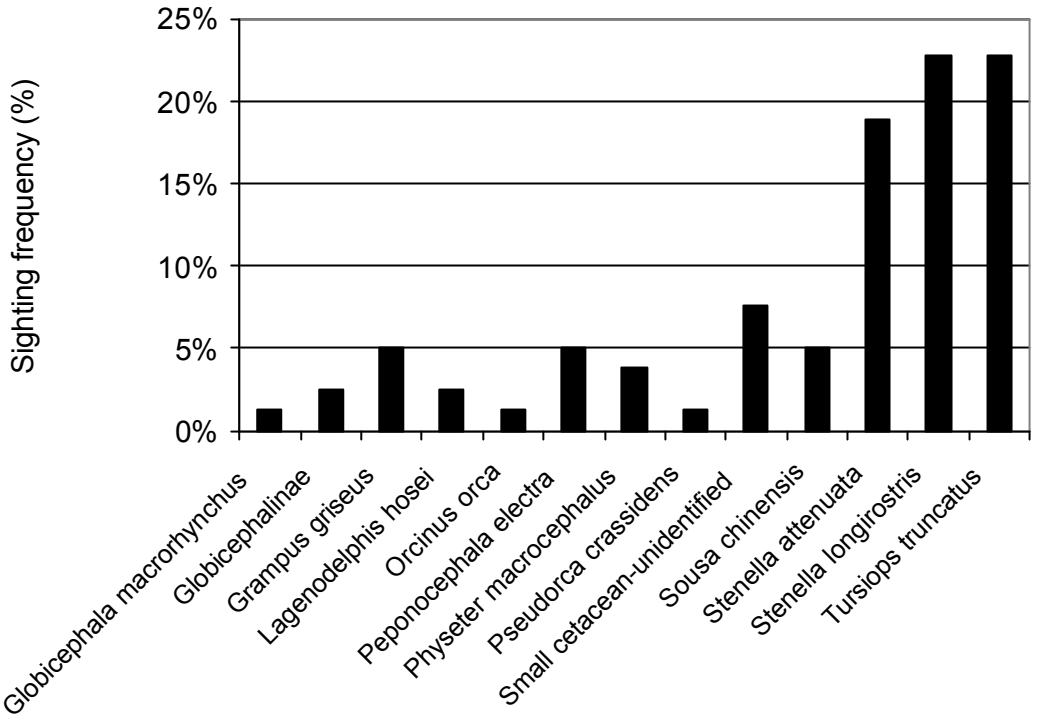


Figure 2b : Species-specific abundance (%) during the April 2001 Komodo survey

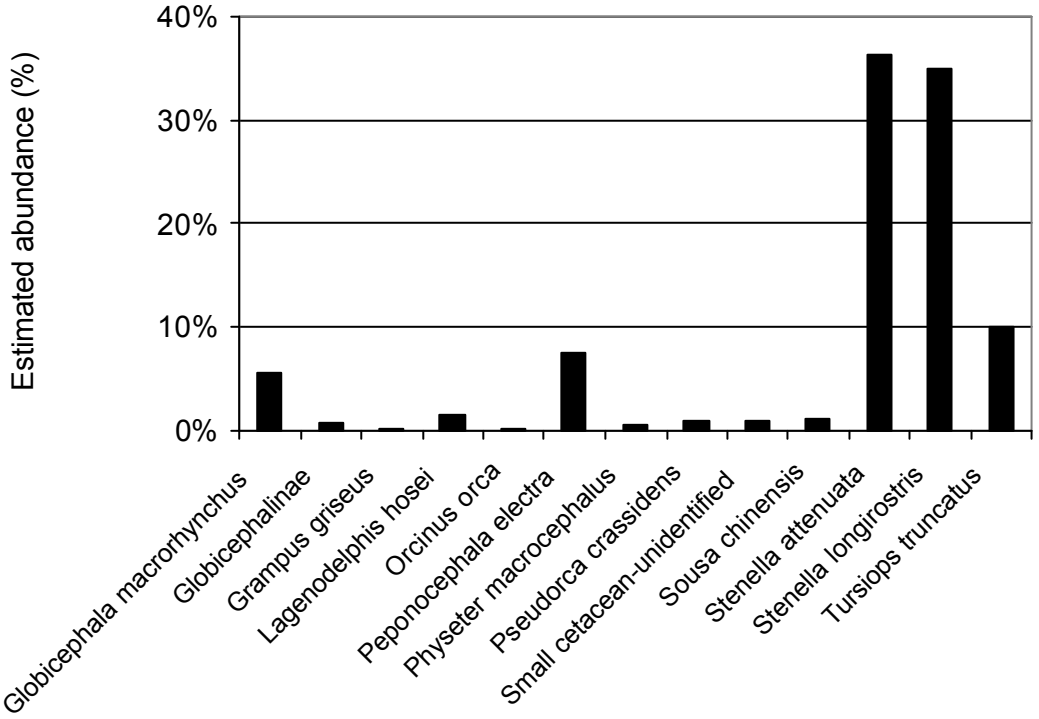


Figure 3a: Active survey days for each survey period.

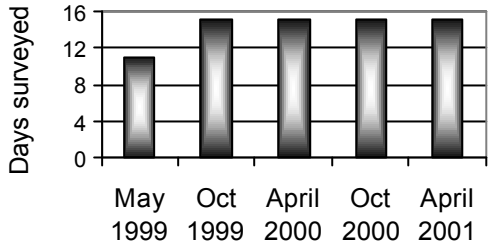


Figure 3b: Active survey hours for each survey period.

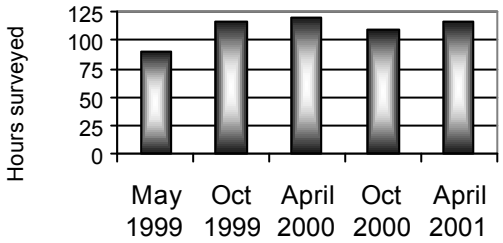


Figure 3c: Estimated area surveyed for each survey period.

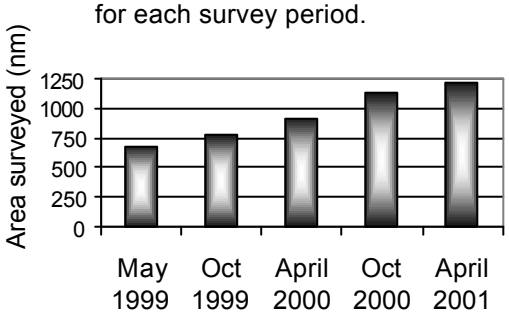


Figure 3d: Number of listening stations for each survey period

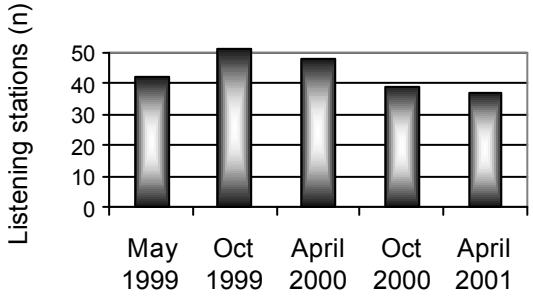


Figure 3e:Cetacean acoustic contact per listening station for each survey period.

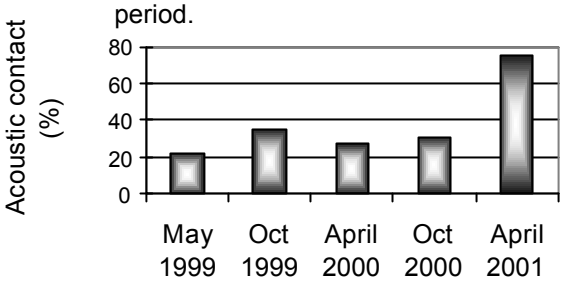


Figure 3f: Number of species positively identified for each survey period.

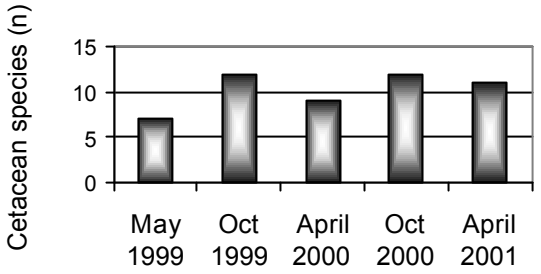


Figure 3g: Cetacean sighting frequencies for each survey period.

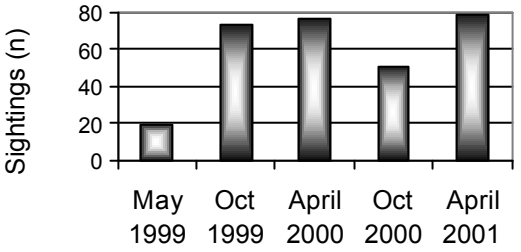


Figure 3h: Estimated cetacean adbundance each survey period.

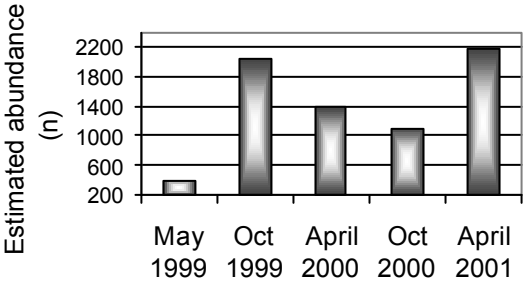


Figure 4a: Percentage of total cetacean sightings per survey.

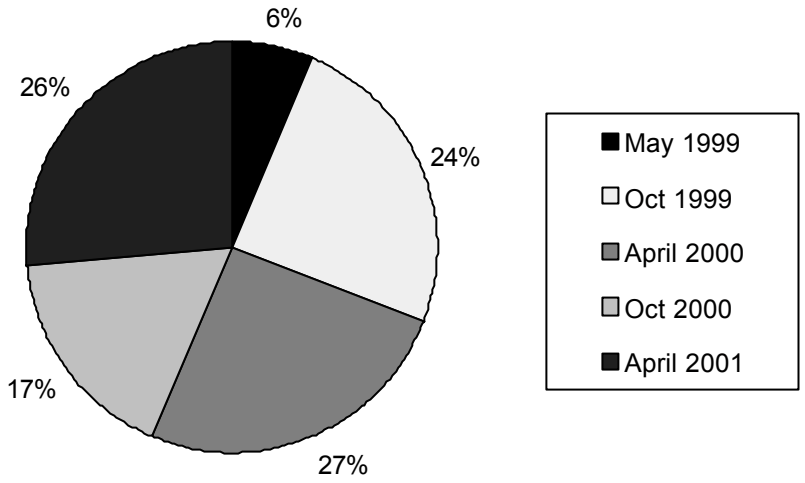


Figure 4b: Percentage of total estimated cetacean abundance per survey.

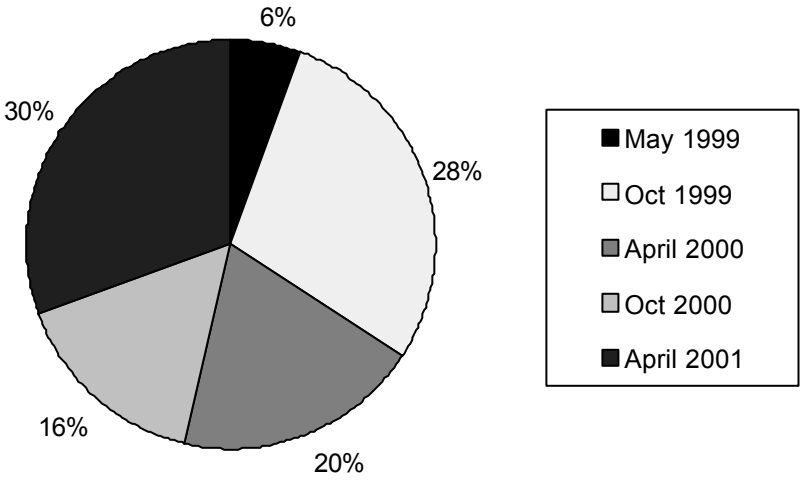


Figure 5a: Average cetacean sightings (n) per survey day.

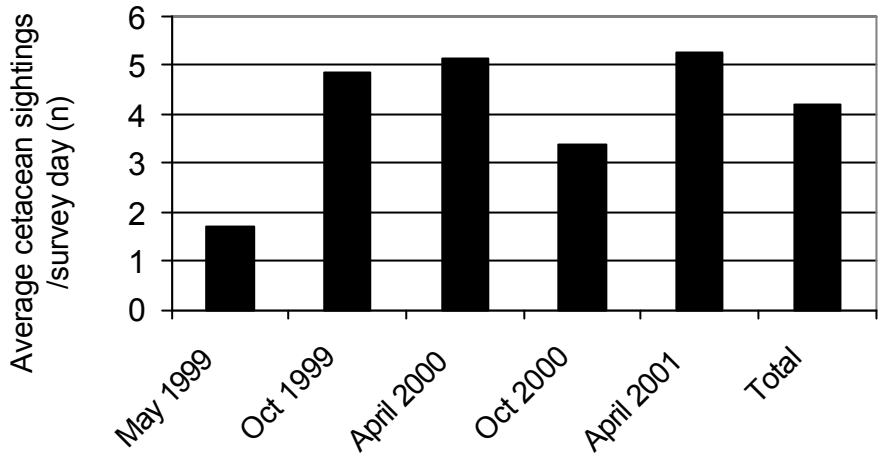


Figure 5b: Average cetacean abundance (n) per sighting.

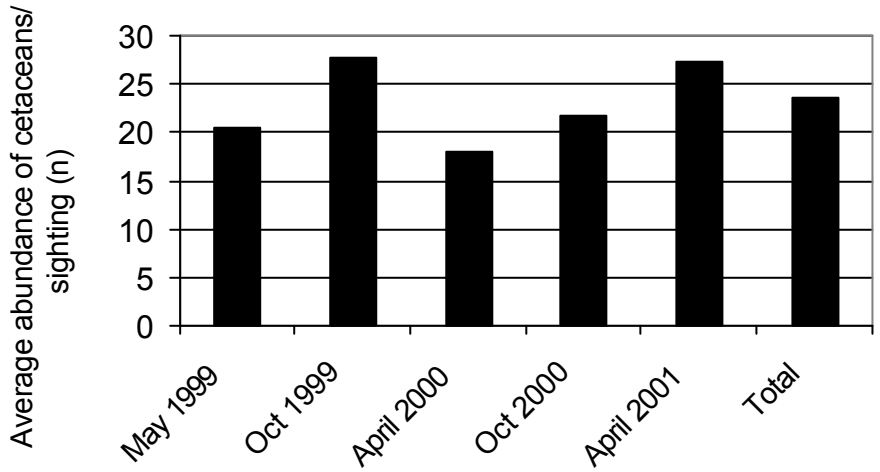


Figure 6a: Species-specific cetacean sightings (n = 299) for all Komodo survey days to date (n=71).

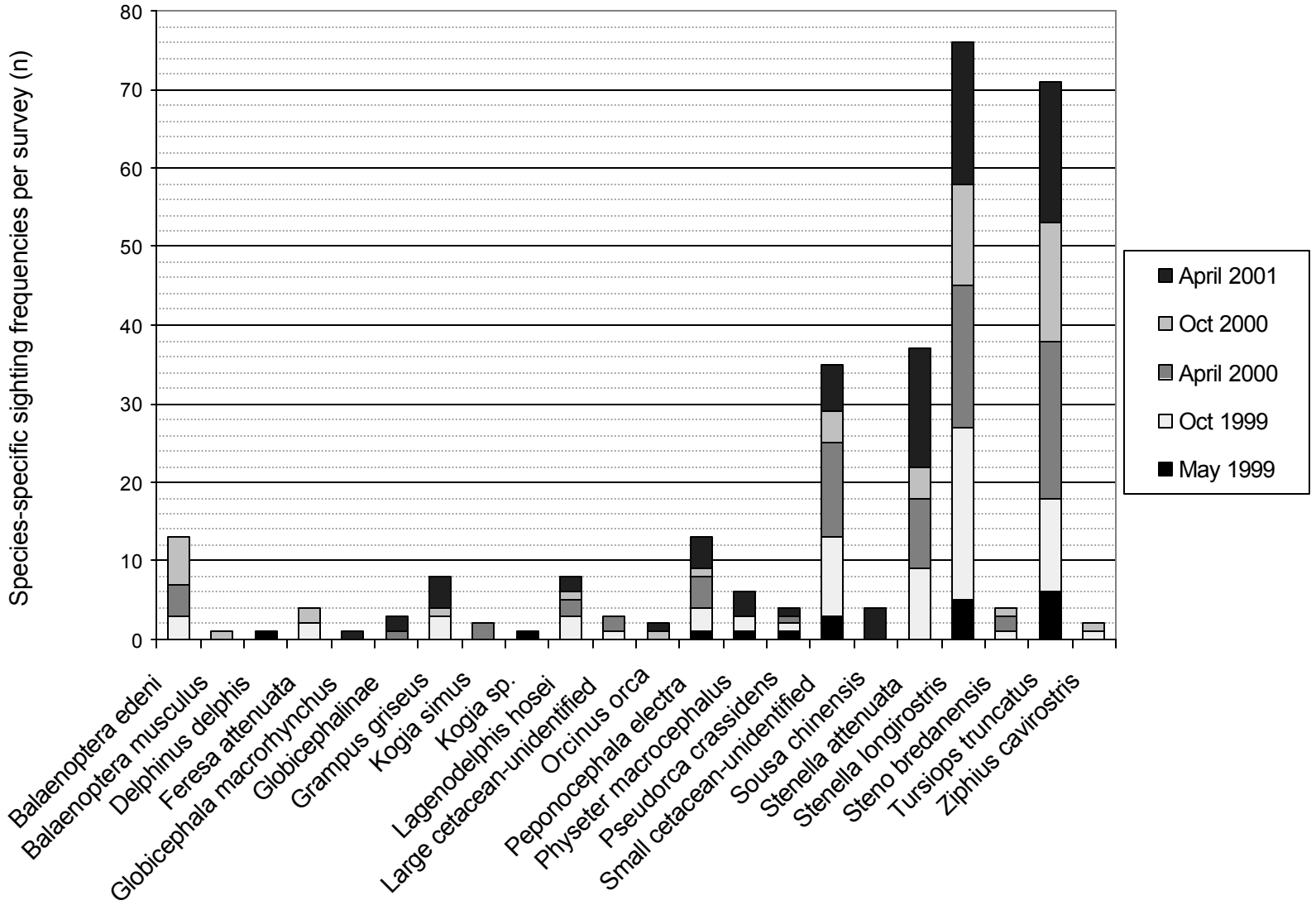


Figure 6b: Species-specific cetacean abundance (n=7082) for all Komodo surveys days to date (n=71)

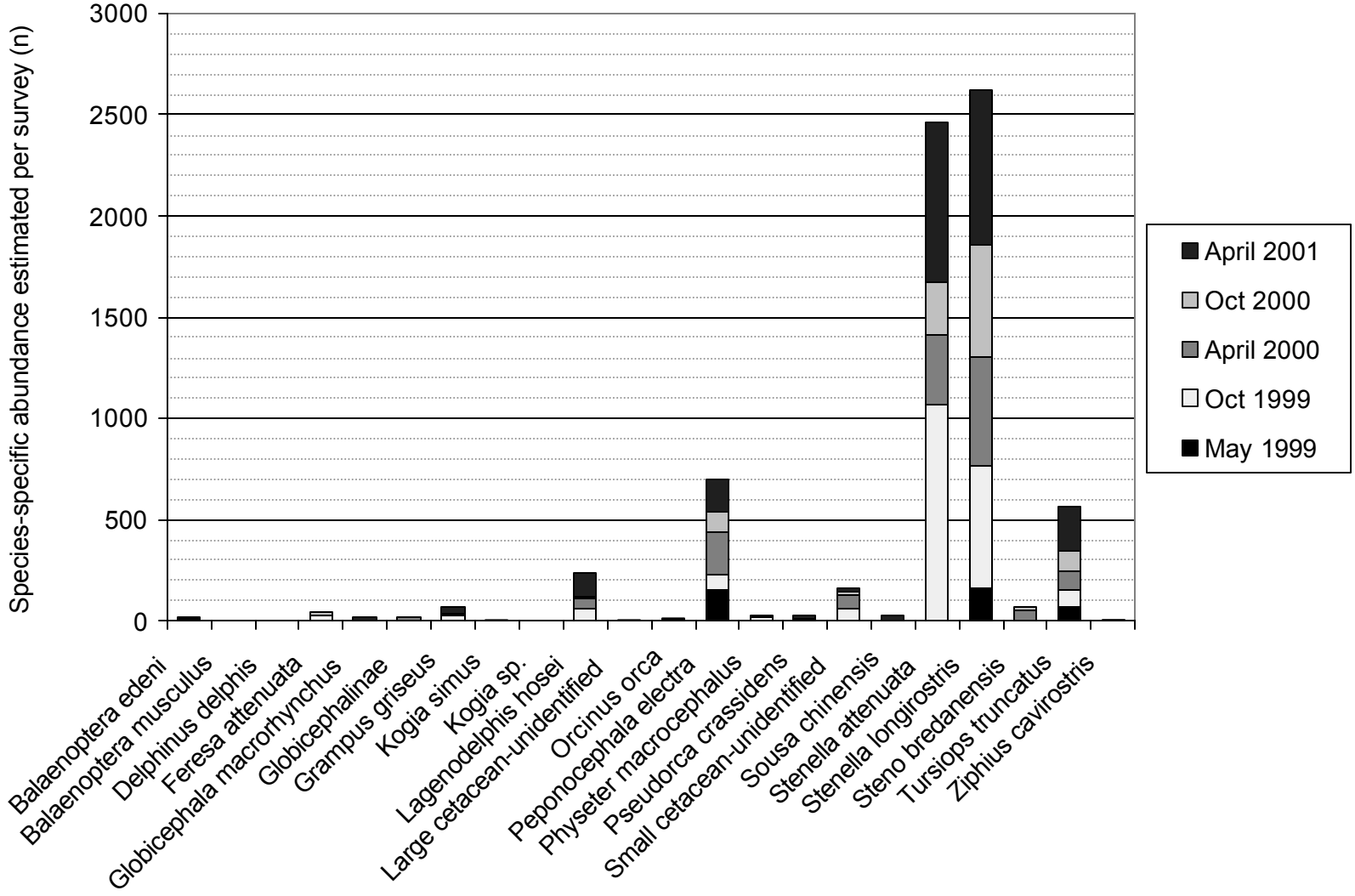


Fig 7. Species-specific sighting frequencies (%) per survey period.

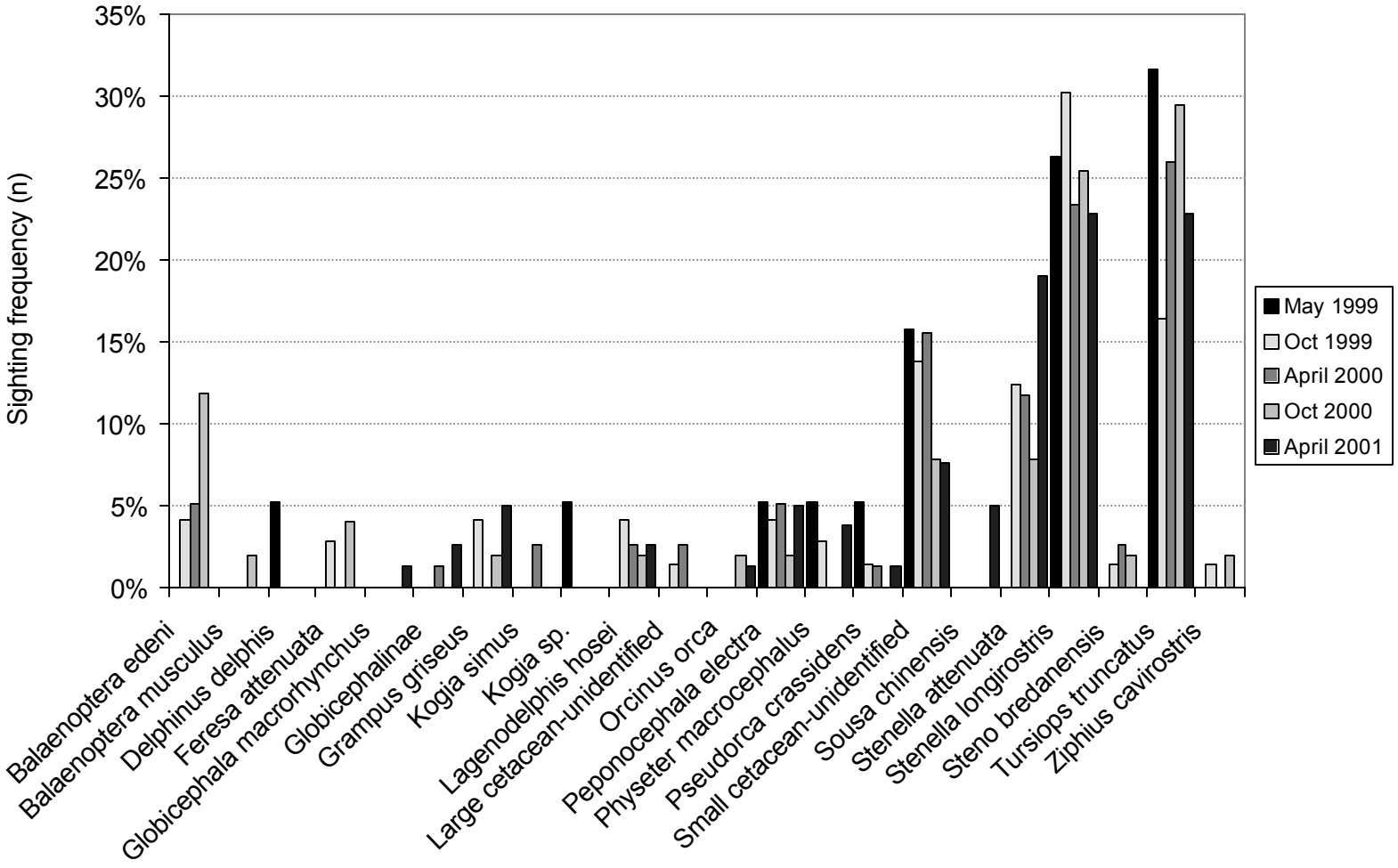


Figure 8a:Percentage of species-specific cetacean sightings for each Komodo survey.

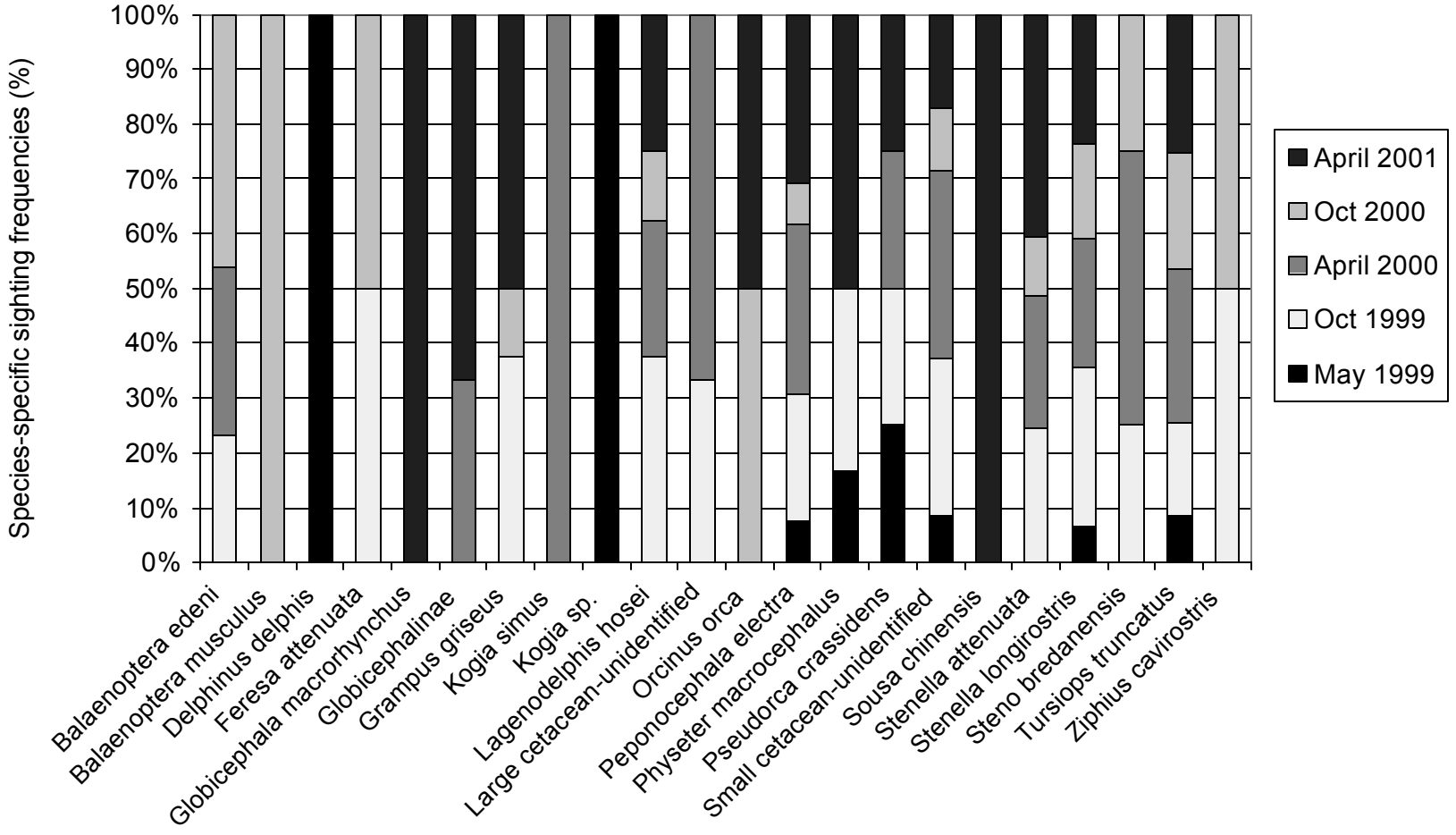


Figure 8b: Percentage of species-specific cetacean abundance for each Komodo survey.

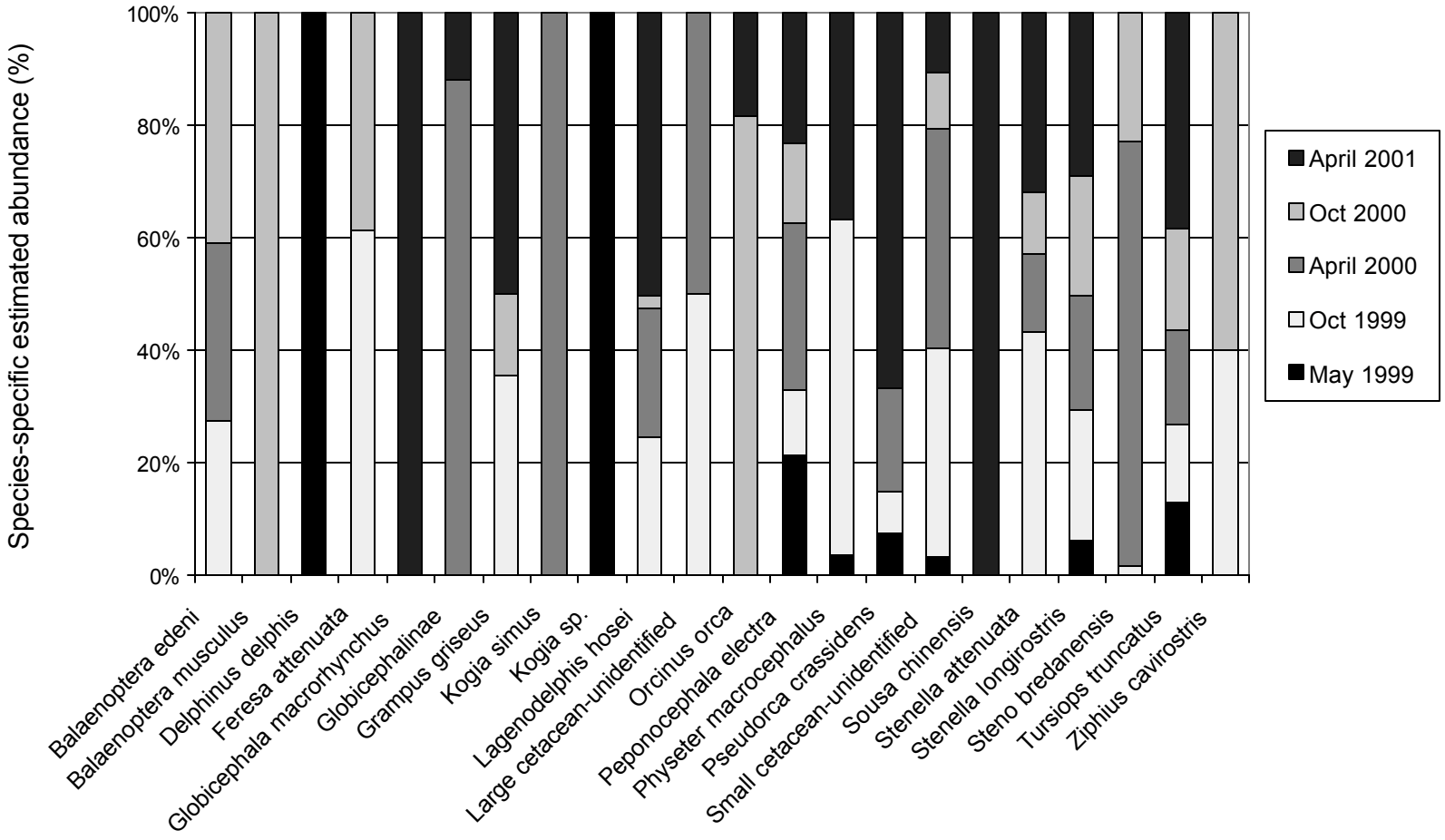
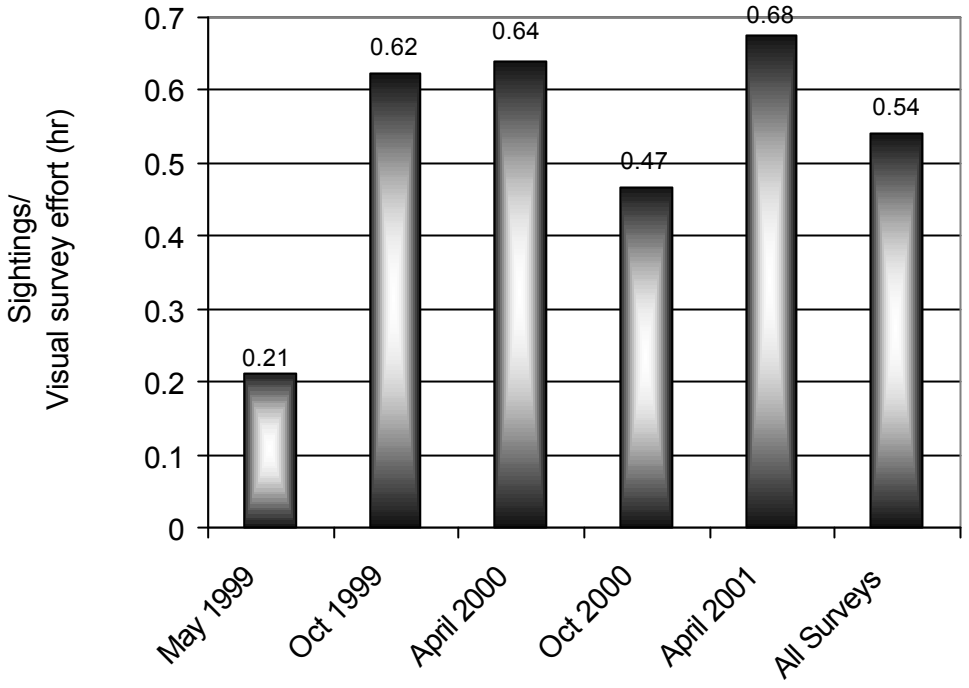


Figure 9a: Cetacean sightings per visual survey time (hr) for each survey period.



9b: Estimated cetacean abundance per visual survey time (hr) for each survey period.

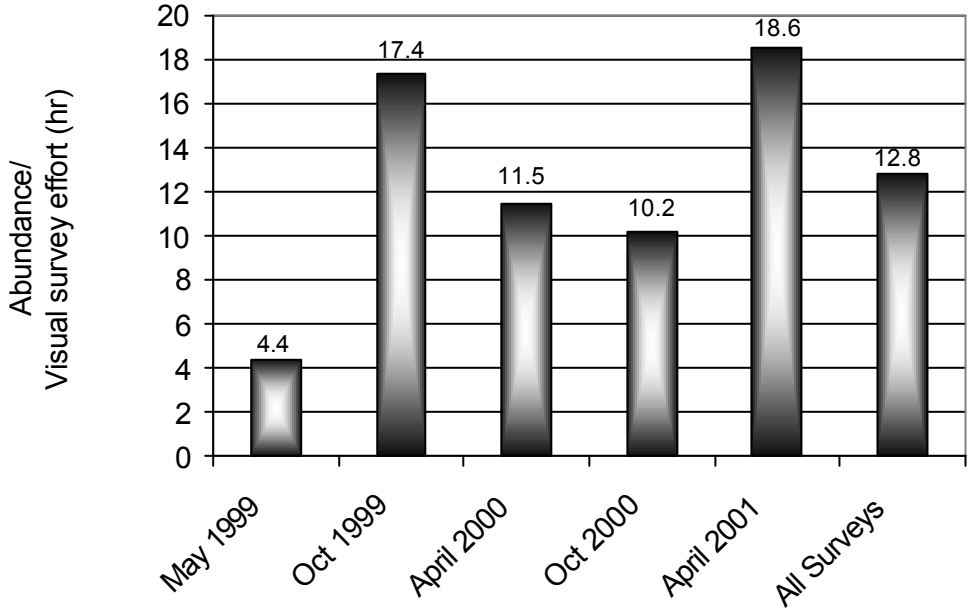


Figure 10a: Cetacean sightings per visual survey distance (nm) for each survey period.

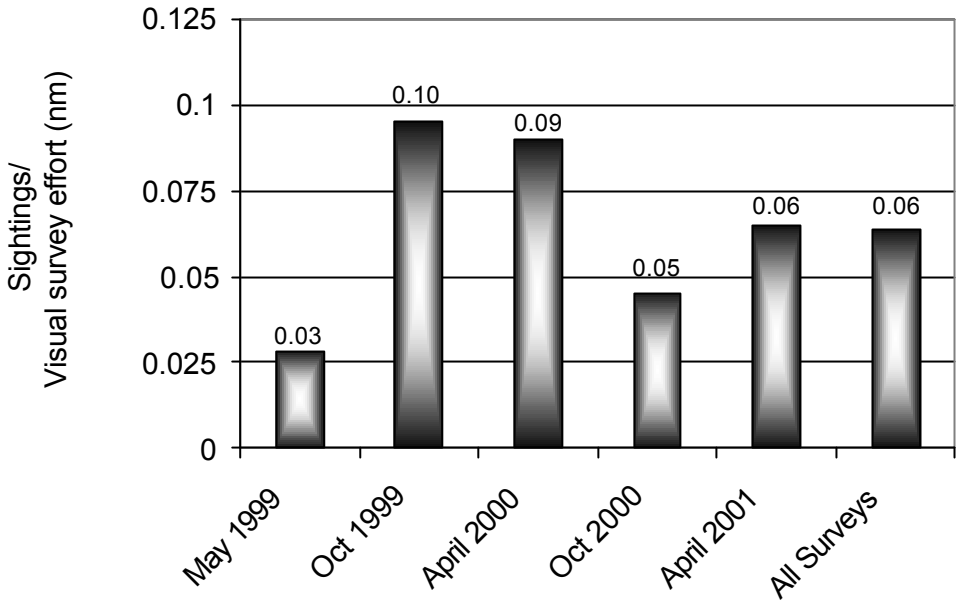


Figure 10b: Estimated cetacean abundance per visual survey distance (nm) for each survey period.

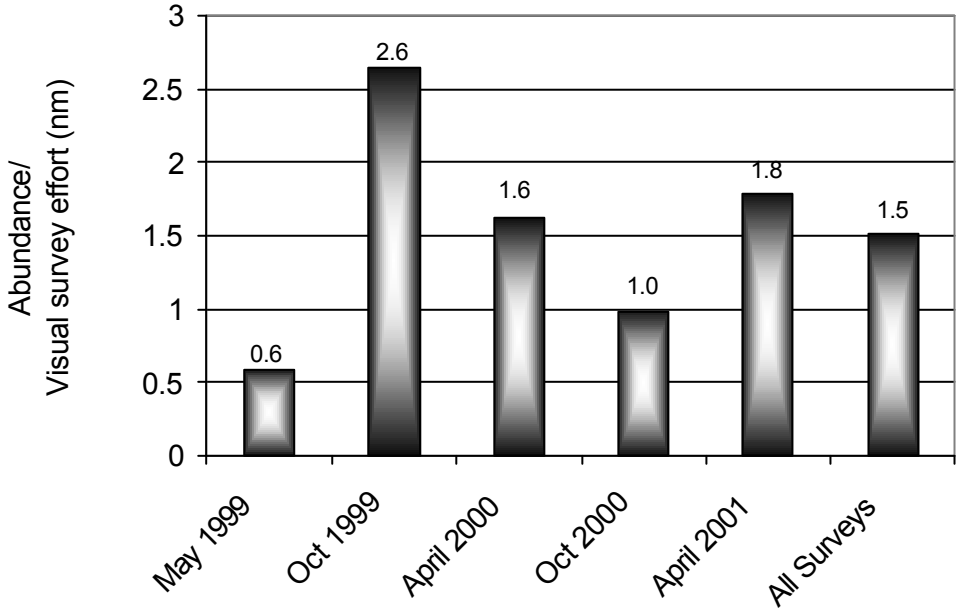


Figure 11: Cetacean sightings (%) for all categorised weather conditions (see text for explanation).

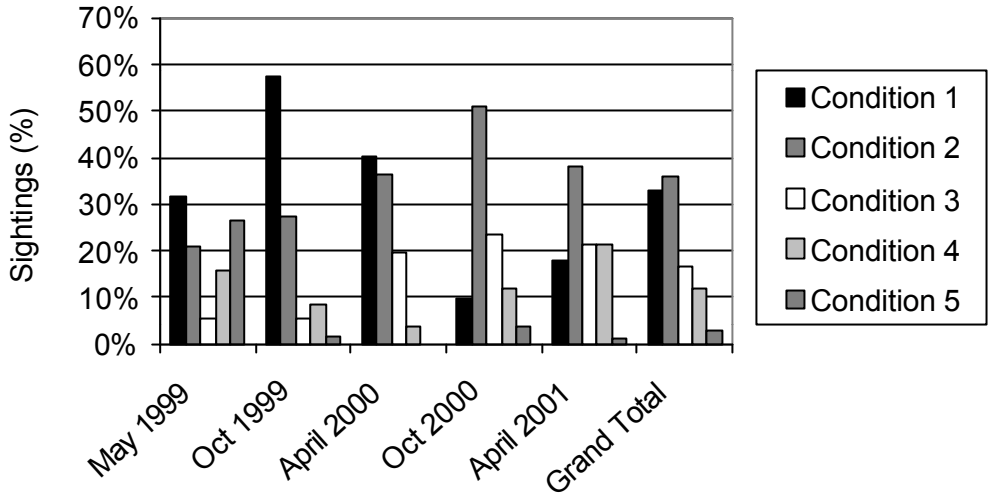


Figure 12: Cetacean sightings (%) for both survey methods.