

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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Abstract

During May and October 1999 visual and acoustic cetacean surveys were conducted in Komodo National Park (KNP), Indonesia and adjacent waters. The surveys were conducted as a rapid ecological assessment of KNP with the aim to 1. identify which cetacean species occur in these waters; 2. monitor seasonal patterns and identify sensitive marine areas for cetaceans; 3. identify marine environmental impacts affecting cetaceans; 4. provide site-specific information on cetaceans for educational and environmental awareness programs; 5. initiate a volunteer cetacean monitoring program for environmental staff and dive operations.

In total, 14 cetacean species were identified during 207 active survey hours conducted over 26 field days. The surveys covered an estimated 1443 nautical mile (nm). The 14 species encountered were predominantly toothed whales and dolphins, and included the long-nosed spinner dolphin (*Stenella longirostris*), bottlenosed dolphin (*Tursiops truncatus*), pan-tropical spotted dolphin (*S. attenuata*), melon-headed whale (*Peponocephala electra*), sperm whale (*Physeter macrocephalus*), Risso's dolphin (*Grampus griseus*), Fraser's dolphin (*Lagenodelphis hosei*), pygmy killer whale (*Feresa attenuata*), false killer whale (*Pseudorca crassidens*), rough-toothed dolphin (*Steno bredanensis*), common dolphin (*Delphinus sp.*), pygmy or dwarf sperm whale (*Kogia sp.*), Cuvier's beaked whale (*Ziphius cavirostris*) and a rorqual whale species (*Balaenoptera sp.*) with unusual morphological characteristics.

An estimated total of 2423 individual cetaceans were sighted during the 1999 survey periods. The acoustic surveys included 93 hydrophone listening stations. These covered an estimated 5912 nm². Acoustic contact with cetaceans was recorded during 29% of the listening stations. The sightings within KNP borders were dominated by members of the Family Delphinidae, especially *T. truncatus* and *S. longirostris*. The off-shore waters adjacent to KNP have a far more diverse pattern and high diversity of cetaceans, some rare and endangered. Three species were seen regularly throughout the survey period: *S. longirostris*, *T. truncatus* and *S. attenuata*. For eight species a relative abundance index was calculated using multiple species-specific visual search times. Species were assigned a local abundance category (abundant, common, uncommon and rare) according to their sighting frequency and visual search time. On six occasions species associations were observed, including one school comprising of four different dolphin species.

The presence of new-born calves was observed for seven dolphin species as well as the sperm whale, indicating the KNP area could be an important cetacean calving (and breeding) ground. Several environmental impacts were identified of relevance to cetaceans, which are especially sensitive to acoustic disturbances, such as reef bombing, as well as chemical pollution.

Responsible cetacean watching potential in the area has increased due to the survey results. However, this may not be an appropriate activity without strict permit and operational conditions, educational programs and adequate enforcement realised from the start. The survey's outreach activities include a volunteer cetacean monitoring program. The Nature Conservancy field staff and several dive tourism operators interested in cetacean ecology and ocean conservation have advanced their identification skills through workshops and field training. This program is currently active with staff recording cetacean sightings on standardised datasheets. This community involvement will increase the information available on KNP cetacean diversity and abundance during times other than the priority survey periods.

Komodo National Park and World Heritage Area has been identified as one of the richest marine diversity sites in the Indo-Pacific. The rapid ecological assessment for cetaceans shows that the Komodo region is also an important habitat for whales and dolphins, and would benefit from additional cetacean survey efforts to assist resource management plans, conservation measures and alternative livelihood options. Extensions of the Park and its buffer zones have been adopted by the management authorities in order to protect cetacean preferred habitats and migration routes and a 25 year management plan is currently being implemented.

The significance of cetacean surveys at Komodo National Park, Indonesia.

The waters of Komodo National Park (KNP) and adjacent areas include numerous coastal and marine habitats, and are characterised by strong currents, localised upwellings and a complex oceanography. KNP has exceptional tropical marine bio-diversity and recent coral reef and fish surveys conducted by The Nature Conservancy (TNC) have identified at least 250 species of scleractinian corals, 70 species of sponges, over 900 species of fish and several species of marine turtles and mammals (TNC, 1997). 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).

No detailed studies have been done in these waters on cetacean species diversity, abundance and distribution. A review of cetaceans sighted in Indonesian waters includes 29 species and regards the occurrence of three species as unconfirmed (Rudolph *et al.*, 1997). Data on cetacean species diversity, abundance and distribution is especially important when considering the region's complex oceanography. Indonesia is uniquely located as the only equatorial region worldwide where inter-oceanic exchange of marine flora and fauna occurs (e.g. Tomascik *et al.*, 1997). 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).

The ecological significance of these passages remains poorly understood, yet their importance as whale and dolphin migration corridors has been identified (PHPA, 1984). Migratory cetaceans which include these passages in their local or long-range movements are vulnerable to numerous regional and local environmental impacts such as habitat destruction, subsurface noise disturbances, net entanglement, marine pollution and over fishing of marine resources (Hofman, 1995). Most, if not all, of these impacts may occur in the waters of Komodo National Park. These impacts would affect residential populations as well as transient species that include these waters in their long-range movements.

Cetaceans are long-lived marine mammals dependent on the long-term health of marine resources. Their ecology, longevity, mobility and sensitivity to disturbances make cetaceans appropriate indicators for acute as well as chronic marine environmental impacts.

It is important to conduct periodic visual and acoustic cetacean surveys in Komodo National Park and adjacent waters in order to:

1. To provide data on cetacean diversity, distribution and abundance in all marine habitats of Komodo National Park (KNP). The survey's marine habitat foci include:
 - 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 sensitive marine areas 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.

Previous cetacean sightings in Komodo National Park and adjacent waters.

The oldest recorded sightings of cetaceans in the Komodo region were made during the 19th Century by the Yankee whalers who sailed through these waters to the Sulu and Celebes Sea whaling grounds. These records show that sperm whales (*Physeter macrocephalus*) were sighted year round and caught occasionally in the Komodo region (Townsend, 1935).

Recent reports on Komodo cetaceans are scarce. A review of Indonesian cetaceans (which included both historical information and more recent sightings) listed a total of five species (Rudolph *et al.*, 1997) for this region. Another noteworthy report mentions that the endangered blue whale (*Balaenoptera musculus*) has been sighted year round in Komodo waters, with a peak abundance in April-May (IUCN/UNEP, 1988).

The initial cetacean survey in May 1999 was the first of this kind in the area. The surveys identified additional rare species (e.g. *Kogia*, *Pseudorca*) which were not previously reported in the area (Kahn, 1999). The group composition of several of species sighted, such as the bottlenosed dolphin (*Tursiops truncatus*) and melon-headed whale (*Peponocephala electra*), included newborn calves. This initial survey indicated that the KNP area warranted additional attention as a relatively diverse cetacean habitat. The survey efforts during the October intermonsoon period were scheduled to provide

comparable data to the previous survey, maximise the probability of mysticete (baleen whale) sightings and obtain data on the area's ecological significance for both resident and migratory cetaceans.

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. These procedures have been extensively trialed in Indonesian waters

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 KNP. While underway a minimum of two experienced observers conducted visual surveys of the surroundings waters. Once 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 also recorded. These were usually the result of unfavourable light conditions, sea state, lack of proximity or active avoidance behaviour.

Time, sea surface conditions, GPS location, group size and presence of newborn calves, minimum distance from vessel, direction of travel and eight selected behaviours were recorded on standardised, waterproof data sheets (Appendix I). After the ID and recordings, the vessel departed from the sighting area at reduced speed and resumed with the predetermined survey route.

During offshore routes the visual surveys were complimented by periodical acoustic listening stations using a directional Vemco custom VHLF hydrophone with audio amplifier. Acoustic surveys were only conducted if the vessel was located 4 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 off-shore conditions. The survey would commence in the early morning departing from The Nature Conservancy (TNC) Komodo Field Office in Labuan Bajo, Flores, Nusa Tenggara Timur and returned before sunset each day. On one occasion an overnight stop was made at Wenci Ranger Station, KNP, to increase the speed boat survey effort for Selat Linta and Selat Sape, which are the major deep-water passages between Sumbawa and Flores.

Survey method II - Local live-aboard vessels.

Visual and acoustic cetacean surveys were also carried out from two local live-aboard vessels, in order to increase coverage to remote areas and allow 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 and visual range was increased by the regular use of binoculars and increased observer height. The majority of

the acoustic surveys were conducted while on-board the live-aboard vessels. Listening stations were conducted more than 4 nautical miles (nm) off-shore to minimise disturbance and spaced approximately 6 nm apart. The live-aboard survey effort focused on the waters adjacent to KNP, such as the productive region north of Komodo, Banta and San Geang, as well as the Flores and Sumba Seas. Unseasonally strong southerly winds and high seas in May meant this last area was surveyed during the October period only.

Survey Results.

Because of the limited time scale of the cetacean rapid ecological assessment (REA) in Komodo waters and the challenging nature of studying living cetaceans, the results described in this report are largely descriptive. Comparative analyses will be conducted once the two intermonsoon KNP cetacean survey periods in 2000 have been completed and seasonal and annual variations in cetacean ecological parameters can be examined. Sensitive marine areas for cetaceans within KNP will also be evaluated upon completion of the 2000 surveys.

Visual survey effort.

The results of the visual and acoustic cetacean surveys conducted in KNP and adjacent waters can be found in Tables 1 and 2 respectively. Surveys were conducted from 16-26 May and 11-28 October 1999. In total, 14 cetacean species were identified (Table 2c). The survey effort comprised of 26 field days and totaled 207 active survey hours. The surveys covered an estimated 1443 nautical mile (nm). The 14 species positively identified during 92 encounters were predominantly toothed whales and dolphins (Suborder Odontoceti), although during the October period rorqual whales (*Balaenoptera* sp., Suborder Mysticeti) were observed frequenting the Gili Mota area on three occasions. This was the only area where baleen whales were encountered in 1999. An estimated total of 2423 individual cetaceans were sighted at sea. A detailed summary of survey effort for both methods and field periods is provided (Table 2).

Acoustic survey effort.

The acoustic survey included 93 hydrophone listening stations. It is estimated that a single station without any land interference and clear 360° reception realistically surveys $63 \text{ nm}^2 - \pi^2 \times$ the estimated acoustic radius of 6.5 nm. The acoustic survey covered an estimated 5912 nm^2 in all. Acoustic contact with cetaceans was recorded during 29% of the listening stations (Table 3). The acoustic radius has been estimated and calibrated numerous times by cross-checking audible underwater vessel noise and coastal interference with radar positions and GPS distances in various weather conditions.

The acoustic surveys confirm the relatively high abundance of cetaceans in these waters. Acoustic surveys are more effective than visual methods when detecting the presence of deep diving cetaceans with short surface intervals and often have an increased range when compared to visual surveys. The surveys have combined these methods where

possible, resulting in a comprehensive search effort. Subsequent acoustic survey data will also be valuable for comparisons between different regions and seasons.

Cetacean species diversity and distribution.

The species diversity of the region appears to be relatively high. By conducting a relatively limited survey effort in the two intermonsoon periods, close to half of all cetacean species known to occur in Indonesian waters have been positively identified. The species identified during the rapid ecological assessment are listed in Table 1, as well as their IUCN conservation status, Indonesian and regional (Flores) names.

To analyse the positions of cetacean encounters and identify potential sensitive marine areas for cetaceans, all GPS cetacean encounter coordinates were transcribed to a global information system (GIS) format and assigned species-specific data points (Figure 1). The distribution of cetaceans shows the colour-coded distribution of 14 cetacean species. Sightings were categorised and allocated the following symbols:

<i>Category</i>	<i>Symbol</i>
1. Sub-order Mysticeti - baleen whales	●
2. Families Physeteridea and Kogiidae - sperm whales	■
3. Family Ziphiidae - beaked whales	★
4. Blackfish - a historical name for six Globicephalid dolphin species.	+
5. Other dolphins - Family Delphinidae	▲
6. Unidentified small cetacean (≤ 6 metre)	△
7. Unidentified large cetacean (> 6 metre)	○

Members of the Family Delphinidae, especially the bottlenosed dolphin, *T.truncatus*, dominate the distribution of sightings within KNP borders. The offshore areas have a more diverse pattern. Numerous species of oceanic odontocetes are frequently encountered in this habitat, especially the long-nosed spinner dolphin, *S. longirostris* (Figure 1). The dominance in sighting frequencies and abundances of the two most common dolphins (*S.longirostris* and *T. truncatus*) shows that these species are able to adapt extremely well to a wide variety of marine environments, ranging from shallow turbid coastal waters to oceanic conditions. Other species may be more selective, or limited, in their preferred habitats and thus more vulnerable to disturbances and displacement.

During the extensive review of the high quality photographic slides and digital video images, field guides and literature, it became clear that the rorqual whales (*Balaenoptera sp.*) encountered off Gili Mota did not conform to any rorqual species' morphology

published thus far. Rorqual whale morphologies (*Balaenoptera sp.*) in the Indo-Pacific, and especially South East Asia, are not well known. Several cetacean species from this region are described from skulls and occasional strandings and not in living detail. Other cetacean species in Australasia are being reviewed taxonomically and re-classified with additional (sub) species (e.g. Perrin *et al.*, 1996). Subsequent encounters within KNP borders during the April 2000 cetacean surveys have confirmed the unusual external features of this balaenopterid. High quality slide images and digital footage have been reviewed by several cetacean experts world wide, yet a positive identification remains difficult without genetic samples and comparative DNA analysis (Kahn, 2000).

Species-specific data: Sighting frequencies, group sizes, calving rates and visual search times.

Sighting frequencies.

Of the estimated 2423 cetaceans seen and 14 species identified, only one dolphin species (*S.longirostris*) was classified as locally abundant (Table 4). Two species were considered common (*T. truncatus*; *S.attenuata*), five uncommon (*P.electra*; *Balaenoptera sp.*; *P. macrocephalus*; *G.griseus*; *L.hosei*), and the remaining six species were considered rare (*Kogia sp.*; *P. crassidens*; *F. attenuata*; *D. delphis*; *S. bredanensis*; *Z. cavirostris* - Table 4). The abundance categories were defined by sighting frequency:

Abundance category		Sighting frequency (n)
Abundant	(A)	$n \geq 20$
Common	(C)	$10 \leq n < 20$
Uncommon	(U)	$3 \leq n < 9$
Rare	(R)	$n \leq 2$

These estimated local abundances were also confirmed by the visual search times as calculated for eight cetacean species (Table 4). All species-specific sighting frequencies of positively identified cetacean encounters are shown in Figure 2. The relatively high sighting frequency of *S.longirostris*, *S. attenuata*, *T. truncatus* and *P. electra* during both 1999 survey periods indicates KNP may inhabit residential populations of these species at least.

Group sizes and composition.

The mean group size (and standard errors) was calculated for all cetacean species encountered (Figure 3, Table 4). This data accurately reflects the known sociality of the species most frequently encountered. More detailed group compositions are hard to examine without more intrusive techniques such as biopsy darting. The most realistic source for group composition data in the KNP area would be from a (mass) stranding event in the area.

Although strandings are a rare occurrence in KNP, with the additional Balai Nasional Park Rangers and TNC-KFO Monitoring Staff involved in the cetacean sighting program, any stranding would have a good chance of being recorded and sampled. Data on species identification, health status, individual sizes and sex should be recorded together with photographic material illustrating the external characteristics of the animals.

Calving rates.

The presence or absence of calves was recorded for most encounters. Calves are defined as newborn depending on their size and behaviour. Newborn calves are estimated to be less than 6-12 months old. Calves were observed for seven dolphin species and the sperm whale, indicating the KNP region may be an important cetacean calving and breeding ground. No mating was observed, but for most species this takes place shortly after the birth of a single calf (e.g. Simmonds and Hutchinson, 1996). The estimated calving rates should be considered preliminary and interpreted with caution (Table 5).

Initial visual search times (IVST).

For each field day, the active visual survey time (hours) prior to the first cetacean encountered was recorded as the initial visual search time (IVST). IVST sightings did not need to result in positive identifications. Mean IVST of both survey methods and seasons were compared (Table 6). IVST did not differ significantly between season (t-test, $p=0.08$) or survey method (t-test, $p=0.13$).

Species - specific visual search times (VST).

For those cetacean species encountered more than two times ($n \geq 3$), a species-specific visual search time (VST) was calculated. VST could be calculated by recording the search effort in hours between sightings of the same species. VST is defined as the mean of all species-specific sighting intervals as corrected for active survey hours and survey method. The equation is

$$VST = \frac{\sum \{ (\Delta t_{1-2 \text{ species A}}) - \text{inactive survey time } \Delta t_{1-2 \text{ species A}} \}}{n_{\text{species A}}}$$

- $\Delta t_{1-2 \text{ species A}}$ = the survey time (hrs) between two subsequent encounters with species A.
- inactive survey time $\Delta t_{1-2 \text{ species A}}$ = the time at sea spend (hrs) on other activities such as prolonged encounters with other species and operational pauses.
- $n_{\text{species A}}$ = the total number of encounters with species A over the survey period (VST could be calculated for species with $n \geq 3$ only)

To calculate VST, the data from different survey methods was pooled in order to obtain the maximum comparable observations. This calibration was equated by comparing the visual search times of the two methods on the two most common species - *S.longirostris* and *T.truncatus*. The VST for both species proved highly consistent between survey methods (Table 7). The search time calibration from survey method two (local live-aboard) to method one (TNC speedboat) was calculated to be 0.40 (± 0.03). Although the data allowed for only a limited number of calibration sets (n=4), the low variance between calibration sets indicated the data will remain robust once converted. In addition, the estimated speed ratio of the different survey methods very closely approximates this index ($6/16 = 0.38$).

Seasonality.

Information on the temporal and geographical variations in cetacean diversity and abundance are crucial to evaluating conservation measures, yet often require large data sets before any patterns can be identified (e.g Whitehead and Kahn, 1992). Seasonal fluctuations in KNP cetacean diversity distribution and abundance are especially difficult to quantify because of the absence of long-term observations. No detailed patterns were identified. Still, some general differences were evident for the two survey periods in 1999. Of the two periods, the October survey resulted in a marked increase in cetacean diversity, total encounters and overall estimated abundance (Table 2). This may be in part due to the increased survey effort, or the KNP area inhabited a more diverse cetacean community during this time. To what extent these results are confounded by search effort, or even short-term oceanographic fluctuations remains unclear. Additional survey efforts in 2000 will be necessary to further investigate these initial patterns in seasonality.

Species associations.

The survey results include numerous cetacean species associations. This is a fascinating aspect of cetacean ecology, yet the function of these associations remains poorly understood. A total of six odontocete cetacean associations have been recorded during the survey periods. The observations of these species association gives further indication that KNP is a valuable marine area for cetaceans.

Multi-species photo-identification of individual cetaceans.

One of the main long-term objectives of the rapid ecological assessment surveys is to investigate cetacean movements and habitat use within Komodo National Park and its adjacent waters. This is necessary in order to develop ecologically-based conservation measures for management plans relevant to cetaceans and other large migratory marine life.

Information on cetacean movement patterns and habitat use is normally obtained by conducting multi-day visual and acoustic tracking surveys of particular pods of echolocating odontocetes, or by placing radio or satellite transmitter tags on individual animals of selected species. Non-invasive tagging of individual whales and dolphins can

be best achieved by photographing the distinctive marks and colour patterns of numerous cetacean species. Reliable identification features for individual photo-identification studies have now been used for most baleen whales, sperm whales, pilot whales, several beaked whale species, as well as Risso's, spotted and bottlenose dolphins. Individual photo-identifications have been cataloged for the following KNP cetacean species: Bottlenose dolphin *T. truncatus*, Risso's dolphin *G. grampus*, rorqual whales *Balaenoptera sp.*, spotted dolphin *S. attenuata*, melon-headed whale *P. electra* and sperm whale *P. macrocephalus*.

These identifications are part of an Indonesian Cetacean Photographic Library, which includes cetaceans photographed in northern Sulawesi, the Sangihe-Talaud Archipelago, Bali, Lombok and Sumbawa. The long-term aim of the library is to confirm any re-sightings of previously photo-tagged individuals in the future. This will provide valuable resource management information on species' habitat preferences, local movement patterns and potential migration routes. In addition to the TNC Komodo Field Office staff and Balai Komodo National Park rangers, numerous dive operators have been approached to report cetacean sightings and assist with the photo-identification efforts of Indonesia's cetaceans. Interested individuals with possible identification photographs of Indonesian cetaceans are welcomed to contact the first author (BK).

Educational activities and the TNC Cetacean Monitoring Program.

Educational activities.

The survey's outreach activities include a Cetacean Monitoring Program for The Nature Conservancy (TNC) field staff, Balai Taman Nasional Komodo rangers and dive tourism operators interested in cetacean ecology and ocean conservation.

This community involvement will ensure the program remains active between priority cetacean survey periods with continuous, real-time data recordings. This also facilitates information exchange between interested parties and fosters environmental awareness with TNC staff, KNP rangers, the nature-based tourism industry and local guides.

The education and environmental awareness activities conducted during the survey periods include:

- i. Cetacean ecology and species identification slide seminars and videos for TNC staff, Komodo National Park rangers and interested parties.
- ii. In-field cetacean identification training for TNC staff, Komodo National Park rangers and interested parties.
- iii. Interviews with TNC staff and KNP Rangers to record details on previous cetacean sightings.
- iv. Implementation of a voluntary cetacean sighting and monitoring program to TNC staff, as well as two interested live-aboard dive operations which frequent KNP and various remote marine areas of Nusa Tenggara.
- v. The distribution of information sheets, educational videos and illustrated reference books on the identification of cetaceans at sea.

- vi. Additional training on data recording and use of standardised datasheets (Appendix I). These datasheets are also in use at other locations in Indonesia.

Cetacean sightings by TNC Komodo Field Office Staff and KNP Rangers.

Interviews with TNC personnel and KNP Rangers revealed that mysticetes (baleen whales) have been sighted within KNP, albeit infrequently. In some instances the same whales remained within KNP waters for several weeks, others were sighted only once. Most sightings occurred during the September-October inter monsoon period. No positive identifications were made by KNP Rangers. TNC staff also sighted numerous large cetaceans between 1995-1998, including rorqual whales (*Balaenoptera sp.*) in Selat Molo; sperm whales (*P. macrocephalus*) in Selat Sape; and a stranding of a large 15-20m unidentified mysticete at Rinca (J.Pet and A. Mulyadi pers.comm.).

The TNC Cetacean Monitoring Program is currently active. Sightings are to be reported to the cetacean monitoring coordinator of the Komodo Field Office in Labuan Bajo. The coordinator is to verify any positive identifications using the check lists, reference books and educational materials provided or by contacting the program's principal investigators. If there are *any* uncertainties on the positive species identification, then the encounter must be recorded as 'unidentified cetacean'. Any guesswork, although done with the best of intentions, will greatly affect the accuracy of the data collected. This should be avoided at all costs. We hope that these monitoring activities will become incorporated into the daily routine of all marine monitoring personnel and boat crew interested. The enthusiasm shown thus far, and the growing experience of the staff involved, will surely result in valuable data on Indonesia's cetaceans throughout the year.

Cetacean survey contributions by the dive community.

Numerous dive operators have expressed interest in cetacean identification and are actively involved in a regional cetacean sighting program. The majority of operators have been briefed to identify those cetaceans frequently encountered at sea and to record this information on datasheets. Importantly, most contact persons responsible for data entry have experience with identifying cetaceans at sea. We are indeed fortunate that these motivated persons continue to monitor an extensive coastal area during their daily routes to and from dive sites. Once completed, the data sheets are faxed or e-mailed to the APEX Environmental office. Data are then verified, processed and become part of an Indonesian cetacean database. Numerous sightings have been reported covering an extensive marine area from Bali to Alor, northern Sulawesi, Papua Barat and Papua New Guinea. Operators or individuals with cetacean identification photographs or other relevant information are encouraged to contact the authors.

Increased marine education and environmental awareness, together with the conservation and enforcement measures currently implemented in KNP, are crucial for the future of Komodo's marine and terrestrial bio-diversity and the development of alternative, sustainable livelihoods alike.

Environmental threats to KNP cetaceans.

An overview of direct and indirect environmental threats to cetaceans can be found in numerous reviews (e.g. Hofman 1995) and include:

- Marine debris
- By-catch in commercial fisheries
- Noise pollution
- Food chain effects
- Diseases
- Oil and chemical spills

Of these the following are of particular relevance to cetaceans occurring in KNP and adjacent waters:

Marine debris and net entanglement.

On May 21, 1999 the survey identified a large marine area polluted with high concentrations of discarded plastics. The area affected was estimated to be 5-10 nm² and was located between 8°13 S/119°24 E and 8°11 S/119°31 E. Large quantities of plastic objects were seen, ranging from household wares to pellets, ropes, drums, large containers and bags. These items were distributed between the surface and approximately 20 metres deep.

Depending on the prevailing currents, this significant accumulation of plastic waste could have seriously affected KNP marine life and its remote beaches and coastal areas. At present, no effective waste disposal system for the KNP region including Labuan Bajo and Sape is available (Pet & Djohani, 1996), so it seems likely that at least part of the waste was locally produced.

On October 28, 1999, a 100m section of discarded long-line equipment was retrieved in open ocean south of Komodo Isl. (at approximately 8°53 S/119°25 E). Hooks and buoys were present and although this type of ghost net is relatively benign when compared to discarded gillnets, these nets continue to pose a serious threat to all large migratory marine life (e.g. Read, 1998). On all other survey routes the occurrence of marine debris was minimal.

Noise pollution related to destructive fishing practices.

On May 22, 1999 a total of seven bomb blasts were heard north of Labuan Bajo during two morning hydrophone listening stations of six minutes each (located at 8°16S/119°47E and 8°16S/119°53E respectively). No acoustic contact with cetaceans was recorded during these stations. The nearest point of land was eight nautical mile from these locations and no other vessels were sighted. Additional blasts, both within KNP borders, as along the southeast coast of Sumbawa, have been witnessed in 2000.

No direct studies on the effect of reef bombing on cetaceans have been published so far. However, research on effects of seismic and military tests indicate that the potential impact of bombing on these acoustically sensitive marine mammals could be extensive (Ketten, 1998).

Blasts or rapid onset sources are capable of inducing broad hearing losses in virtually all cetacean species. Blast injuries usually result from a single exposure with an explosive shock wave which has a sudden, massive pressure increase above ambient followed by a pressure decrease to well below ambient. Overpressures between 30 and 50 kPa are enough for a high incidence of severe blast injury. Acoustic traumas, at any one frequency, are highly species dependent and are a complex interaction of exposure time, signal characteristics, and intensity for a particular species at that frequency (Ketten, 1998). Generally, the smaller species are most sensitive to high frequency disturbances, whereas the larger whales are most disturbed by low frequency noise (Gordon and Moscrop, 1998).

Non-lethal reef blasting effects on cetaceans in the vicinity of the explosion site include:

- the permanent reduction of sensory capabilities
- the masking of important signals (including echolocation, intra-species communication, predator-prey interactions and other environmental cues)
- the disruption of important behaviours through startle and repulsion
- the long-term abandonment of important habitats and
- the alteration of migration patterns.

These sub-lethal effects of reef blasting can have a profound impact on residential and migratory cetacean populations patterns (Ketten, 1998).

Apart from the negative effects on cetaceans, reef bombing is one of the major threats to reef ecosystems and sustainable reef fishing practices in Indonesia (e.g Djohani *et al.*, 1999). The acoustic detection of reef bombing activities may indicate that large scale monitoring of this illegal fishing activity in KNP can be done effectively by installing several hydrophone recorder units at strategic locations.

A constant acoustic monitoring presence in KNP could:

- a) Quantify the practice of reef bombing in KNP and adjacent waters.
- b) Effect a rapid enforcement response once a relay system to a shore-based monitoring station is operational.
- c) Act as a deterrent by increasing the risk for fishermen to be caught while bombing KNP reefs.

Gill netting activities.

The apparent increase in the use of monofilament gill nets in the KNP area (J.Pet pers. comm.) could have a major impact on KNP cetaceans through entanglements in active and discarded fishing gear. This is likely to result in higher accidental cetacean deaths (Read, 1998). KNP cetaceans, as well as other large marine life in these waters, are

especially vulnerable to net placements along the numerous inter-island passages and possible migration corridors. Such gill net placements could quickly result in high cetacean by-catch rates.

Potential long-term effects of destructive fishing activities near Nusa Tenggara migratory straits and passages.

The number of inter-island channels along the Nusa Tenggara island chain have been previously identified as important cetacean migration routes for numerous whale species, some rare and endangered (PHPA 1984). These passages are strictly limited in number. Displacement of migratory marine animals from a preferred passage would result in lengthy and unfamiliar alternative routes. For instance, if the KNP passages (Selat Sape, Selat Linta and Selat Molo) are avoided then the alternative migratory passages are several hundred kilometers away (i.e. the Sumbawa-Lombok Strait or the Flores-Alor passages). If these alternative passages are also subjected to similar levels of acoustic disturbance then the options for migratory cetaceans are even further diminished.

Ultimately, high levels of acoustic disturbance and inappropriate fishing methods (including gill and drift netting) in or near Indonesia's major passages could lead to the effective blockage of migratory routes, and the extirpation of vulnerable large migratory cetacean species. This would impact on the feeding ecology and mating systems of these long-lived marine mammals in eastern Indonesian seas. Such activities could even affect regional Indo-Pacific waters, as 'large scale biotic linkages mean that impacts can reverberate through geographically vast areas' (Agardy 1997) and is of special relevance to migratory cetaceans (e.g. Kahn *et al.*, 1993).

Increased protective management measures for KNP straits, and indeed all of Nusa Tenggara's major island passages, are crucial to the conservation of Indonesia's marine bio-diversity. Straits and passages should be considered as priority management units for species of special concern, such as those threatened or endangered, have important ecological roles, and those of cultural or commercial importance (Agardy, 1997).

Alternative livelihood options.

Responsible cetacean watching potential in KNP.

To provide for sustainable alternative livelihoods is one of the main challenges to tropical marine conservation and an integral part of Indonesia's environmental issues. Environmentally sensitive marine tourism is widely viewed as a viable option to create economic and environmental sustainability as an alternative to resource depleting activities.

It appears likely that the current cetacean surveys and rapid ecological assessment will increase interest in commercial cetacean watching ventures in KNP. It is thus of interest that numerous international examples have illustrated that initial permit requests should be carefully considered; and if found appropriate for KNP, these activities should be

strictly controlled with adequate management policies and enforcement measures in place from the start.

The basic prerequisites for responsible cetacean watching activities are:

1. Long-term consistency of cetacean sightings.
2. Controlled access to the targeted cetacean habitat.
3. High standards of environmental awareness of operators with a commitment to:
 - i. Minimal disturbance boat handling techniques.
 - ii. Periodic rest periods for target species.
 - iii. Specific training programs for staff.
 - iv. Educational commentaries and materials for clients.
4. Adequate management and enforcement of rules and regulations. Management issues to be addressed include but are not limited to:
 - i. Licensing and evaluation of permit requirements.
 - ii. The limit of the number of operators.
 - iii. The maximum number of vessels.
 - iv. The maximum number of clients per vessel.
 - v. Minimal approach distances and other strict operational guidelines and industry codes of conduct.
 - vi. Educational programs in cetacean ecology and species identification for park managers, rangers and enforcement field staff.
 - vii. Environmental management charges or other initiatives to integrate marine conservation and tourism.
 - viii. Enforcement measures against the entry of illegal operators and regulatory breaches by permit holders.
 - ix. Logistics and economic costs of management requirements.
5. Marine environmental monitoring and cetacean research
 - i. Monitoring of cetacean diversity, distribution and abundance, behaviours and responses to cetacean watching activities.
 - ii. On-going surveys and ecological research on KNP cetaceans.

Relevance of regional cetacean surveys to coastal resource management and marine protected areas in Indonesia.

Cetaceans, as a guild of common species with a relatively high localised abundance, are increasingly recognised as a useful tool for marine conservation programs. Cetaceans have been identified as focal species for marine resource management and conservation (Lambert, 1997). In eastern Canada, for example, results from cetacean surveys have been instrumental in the establishment of a new marine protected area (Hooker *et al.*, 1999).

The on-going rapid ecological assessments of Komodo National Park cetaceans have identified a relative high cetacean diversity, abundance and extensive distribution within KNP borders and the adjacent waters of the Flores and Sumba Seas. The 1999 assessments indicate that the survey area supports a diverse community of whales and dolphins throughout the year. Sensitive marine areas for Indonesia's cetaceans are

increasingly apparent as more data on resident and migratory species becomes available in 2000.

The cetacean survey program in Komodo National Park and adjacent waters has been implemented as an integral component of the current marine resources management strategy. Such a program is of direct relevance and broadens the protective management perspective for Komodo National Park and World Heritage Area.

The KNP protective measures for cetaceans as incorporated in the 25 year management plan include extensions of Park boundaries and cetacean migration buffer zones (Pet and Yeager, 2000). This is an important cetacean conservation strategy for Komodo National Park, but also when viewed from a regional perspective.

The Indo-Pacific, and the Eastern Indonesian region in particular, is considered the most bio-diverse ocean realm in the world. Indonesia's cetaceans, as highly effective and specialised predators, are an important component of this diversity and inhabit river, coastal and oceanic habitats. However, there is a considerable lack of scientific knowledge of relevance to marine resource management on the ecology of Indonesia's living cetaceans and this situation can only be improved by regional cetacean surveys.

Obtaining additional data on cetacean species diversity, distribution and abundance is especially important when considering Indonesia's location and complex regional oceanography. Indonesia is uniquely located as the only equatorial island nation where inter-oceanic exchange of marine flora and fauna occurs (e.g Tomascik *et al.*, 1997). Cetacean movements between the tropical Pacific and Indian Oceans can occur through the Nusa Tenggara passages (PHPA, 1984; Klinowska, 1991; Kahn 2000). Because of this significant geographical location, there is an urgent need for additional protective measures for cetaceans in all seas under Indonesian jurisdiction.

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Table 1: Cetacean species positively identified in Komodo National Park (KNP) and adjacent waters of the Flores Sea and Sumba Strait, Indonesia.

	Species	Status ¹	Indonesian name	Flores name ²	
1.	Sperm whale	<i>Physeter macrocephalus</i>	V	Paus sperma	Kote kelema
2.	Pygmy of dwarf sperm whale ³	<i>Kogia sp.</i>	N	Paus sperma kerdil or cebol	Fefa kumu
3.	False killer whale	<i>Pseudorca crassidens</i>	N	Paus pembunuh palsu	Temu blā
4.	Pygmy killer whale	<i>Feresa attenuata</i>	D	Paus pembunuh kerdil	Temu kebung
5.	Melon-headed whale	<i>Peponocephala electra</i>	N	Paus kepala semngka	Temu kebong
6.	Spinner dolphin	<i>Stenella longirostris</i>	L	Lumba-lumba paruh panjang	Temu kirā
7.	Pan-tropical spotted dolphin	<i>Stenella attenuata</i>	L	Lumba-lumba total	Temu kirā
8.	Rough-toothed dolphin	<i>Steno bredanensis</i>	D	Lumba-lumba gigi kasar	n/a
9.	Risso's dolphin	<i>Grampus griseus</i>	D	Lumba-lumba abu-abu	Temu bura
10.	Bottlenose dolphin	<i>Tursiops truncatus</i>	D	Lumba-lumba hidung botol	n/a
11.	Common dolphin ³	<i>Delphinus sp.</i>	N	n/a	n/a
12.	Fraser's dolphin	<i>Lagenodelphis hosei</i>	D	Lumba-lumba Fraser	Temu notong
13.	Cuvier's beaked whale	<i>Ziphius cavirostris</i>	D	Paus paruh Cuvier	Ika mea
14.	Rorqual whale ³	<i>Balaenoptera sp.</i>	D	n/a	n/a
15.	Bryde's whale ⁴	<i>Balaenoptera edeni</i>	D	Paus Bryde	n/a
16.	Sei whale ⁴	<i>Balaenoptera borealis</i>	E	Paus Sei	n/a
17.	Blue whale ⁵	<i>Balaenoptera musculus</i>	E	Paus biru	Lelanggaji

1. Status - IUCN status categories of threat. (Ex-Extinct; E-Endangered; V-Vulnerable; R-Rare; I-Intermediate; L-Lower Risk; D-Data Deficient; N-Not Evaluated; as defined in IUCN, 1996)
2. Flores ID - As reported by Rudolph *et al.* (1997).
3. Cetacean species sighted during the TNC cetacean surveys for which no positive identification could be made. The two *Kogia sp.*, as well as two of the three *Delphinus sp.*, have similar appearances, distribution and behaviours and are difficult to distinguish at sea under most circumstances. These species are, however, very distinct from all other cetaceans and are therefore included in the cetacean species list.
4. Additional cetacean species positively identified by Rudolph *et al.* (1997) in Komodo waters.
5. Additional cetacean species positively identified by IUCN/UNEP (1988) in Komodo waters.

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Table 2a: KNP cetacean visual survey summary for the May 1999 period.

KNP Cetacean Visual Survey - 16-26 May 1999	Survey method 1	Survey method 2	Survey May
Total no. of days surveyed	6	5	11
Survey effort (hrs)	42	48	90
Estimated area surveyed (nm)	450	225	675
Cetacean identification encounters	7	12	19
Estimated number of cetaceans surveyed	174	218	392
Cetacean species identified	2	6	7

Table 2b: KNP cetacean visual survey summary for the October 1999 period.

KNP Cetacean Visual Survey - 11-28 October 1999	Survey method 1	Survey method 2	Survey October
Total no. of days surveyed	8	7	15
Survey effort (hrs)	57	60	117
Estimated area surveyed (nm)	518	250	768
Cetacean identification encounters	47	26	73
Estimated number of cetaceans surveyed	1563	468	2031
Cetacean species identified	10	9	12

Table 2c: KNP cetacean visual survey summary for the May - October 1999 periods combined.

KNP Cetacean Visual Survey - May-October 1999 combined	May-99	Oct-99	Total 1999
Total no. of days surveyed	11	15	26
Survey effort (hrs)	90	117	207
Estimated area surveyed (nm)	675	768	1443
Cetacean identification encounters	19	73	92
Estimated number of cetaceans surveyed	392	2031	2423
Cetacean species identified	7	12	14

Survey method 1 - The Nature Conservancy speedboats

Survey method 2 - Local live-aboard vessels

Table 3: KNP Cetacean Acoustic Survey summary for the May - October 1999 periods combined.

KNP Cetacean Acoustic Survey	May-99	Oct-99	Total 1999
Listening stations	42	51	93
Cetacean acoustic contacts	9	18	27
Acoustic encounter rate (%)	21.5	35.3	29.0
Area covered (nm ²)	2670	3242	5912

Table 4: Species-specific data: Sighting frequencies, group sizes and visual search times (VST).

Species	Sightings (n)	Abundance category ¹	Estimated group size (SE)	VST (SE)
Long-nosed spinner dolphin <i>S. longirostris</i>	27	A	28.4(3.8)	3.50 (0.63)
Bottlenose dolphin <i>T. truncatus</i>	18	C	8.4 (3.2)	5.57 (0.91)
Pan-tropical spotted dolphin <i>S. attenuata</i>	11	C	100 (29.7)	8.29 (2.80)
Melon-headed whale <i>P. electra</i>	4	U	57.5 (43.7)	7.13 (4.14)
Rorqual whale <i>Balaenoptera sp.</i>	3	U	2 (--)	12.25 (4.26)
Sperm whale <i>P. macrocephalus</i>	3	U	6.3 (2.7)	13.63 (8.52)
Risso's dolphin <i>G. griseus</i>	3	U	8 (1.2)	14.54 (2.11)
Fraser's dolphin <i>L. hosei</i>	3	U	19.3 (3.1)	18.93 (7.55)
Pygmy killer whale <i>F. attenuata</i>	2	R	13.5 (2.1)	n/a
Pygmy/dwarf sperm whale <i>Kogia sp.</i>	1	R	1 (--)	n/a
False killer whale <i>P. crassidens</i>	2	R	2 (--)	n/a
Common dolphin <i>D. delphis</i>	1	R	1 (--)	n/a
Rough-toothed dolphin <i>S. bredanensis</i>	1	R	1 (--)	n/a
Cuvier's beaked whale <i>Z. cavirostris</i>	1	R	2 (--)	n/a

1. Abundance category definitions: **A**bundant $n \geq 20$; **C**ommon $10 \leq n < 20$; **U**ncommon $3 \leq n < 10$; **R**are $n \leq 2$

Table 5: Estimated calving rates for eight Komodo National Park cetacean species.

	Species	Number of calves (C)	Total estimated abundance (A)	Calving rate ¹
1	Pan-tropical spotted dolphin <i>S. attenuata</i>	20	1100	0.019
2	Long-nosed spinner dolphin <i>S. longirostris</i>	15	768	0.020
3	Bottlenosed dolphin <i>T. truncatus</i>	4	151	0.027
4	Fraser's dolphin <i>L. hosei</i>	3	58	0.055
5	Sperm whale <i>P. macrocephalus</i>	3	19	0.188
6	Melon-headed whale <i>P. electra</i>	3	230	0.013
7	Risso's dolphin <i>G. griseus</i>	2	24	0.091
8	Pygmy killer whale <i>F. attenuata</i>	1	27	0.038

1 - The estimated calving rate is calculated as $C/(A-C)$.

Table 6: t-Test results for seasonality and survey method (SM) in visual search times for the initial cetacean sighting made each survey day (IVST).

	May-99	Oct-99	SM1	SM2
IVST (hrs)	2.47	1.29	1.38	2.80
Observations (n)	11	15	14	12
Variance	5.68	2.17	2.11	5.7
p		0.08		0.13
Significance ($p < 0.05$)		No		No

Table 7: Visual search time conversion factor for the two most common cetaceans sighted in KNP and adjacent waters.

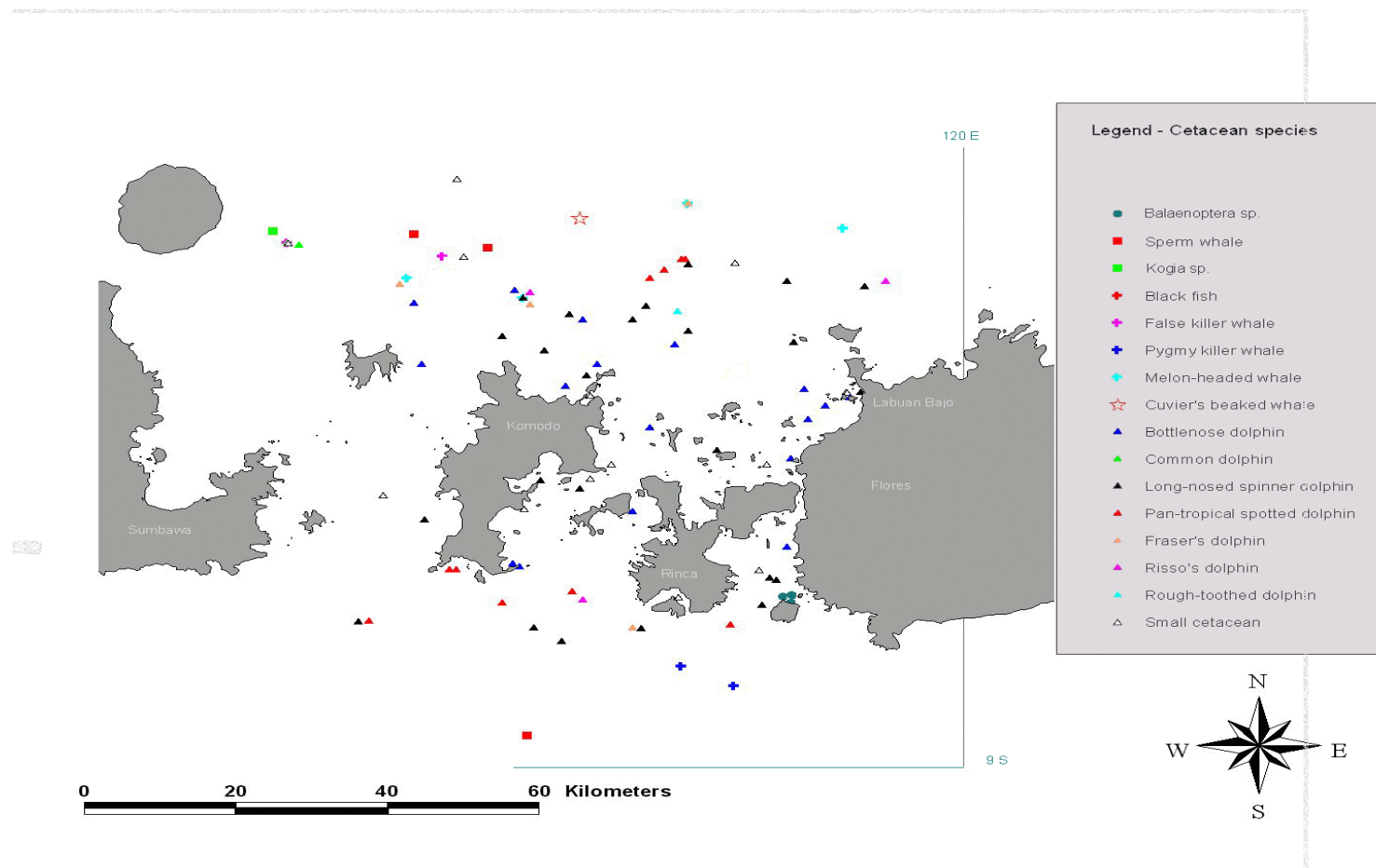
Species	Survey Period	SM1	SM2	Conversion Factor SM2-1
<i>T. truncatus</i>	Oct 1999	6.78	13.88	0.488473
<i>T. truncatus</i>	May-Oct 1999	6.37	15.61	0.408072
<i>S. longirostris</i>	Oct 1999	3.39	10.05	0.338308
<i>S. longirostris</i>	May-Oct 1999	3.42	9.07	0.374862
Mean SM2-1 (SE):				0.40 (0.03)

SM1 - Survey method 1 (The Nature Conservancy speedboats)

SM2 - Survey method 2 (Local live-aboard vessels)

Figures

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



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Figure 2: Species-specific sighting frequencies of cetaceans encountered in Komodo National Park and adjacent waters.

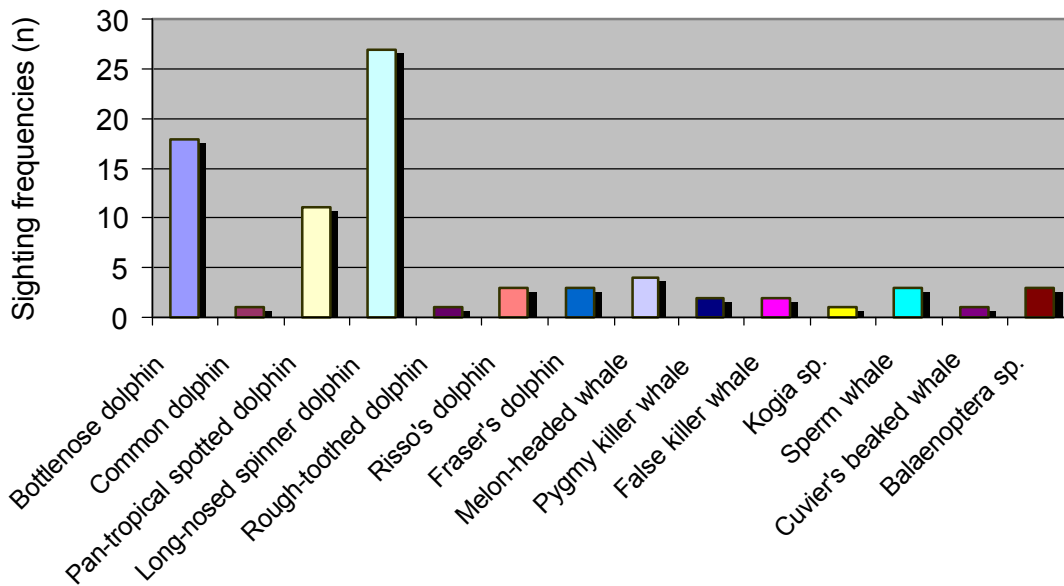


Figure 3: Average group sizes of cetacean species identified in Komodo National Park and adjacent waters.

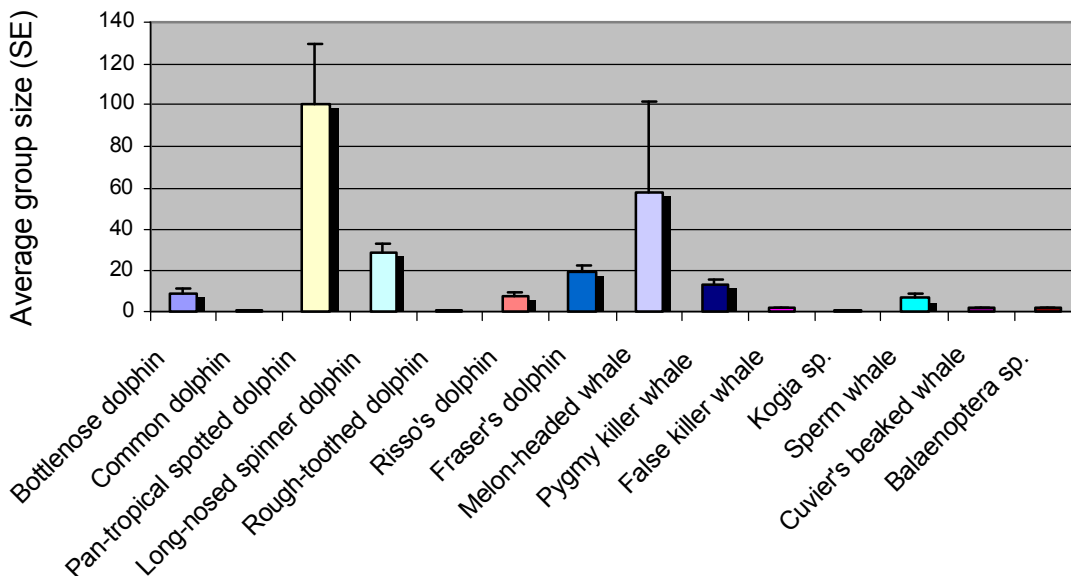


Figure 4: Species-specific visual search times (SE) for Komodo National Park and adjacent waters - 1999 surveys.

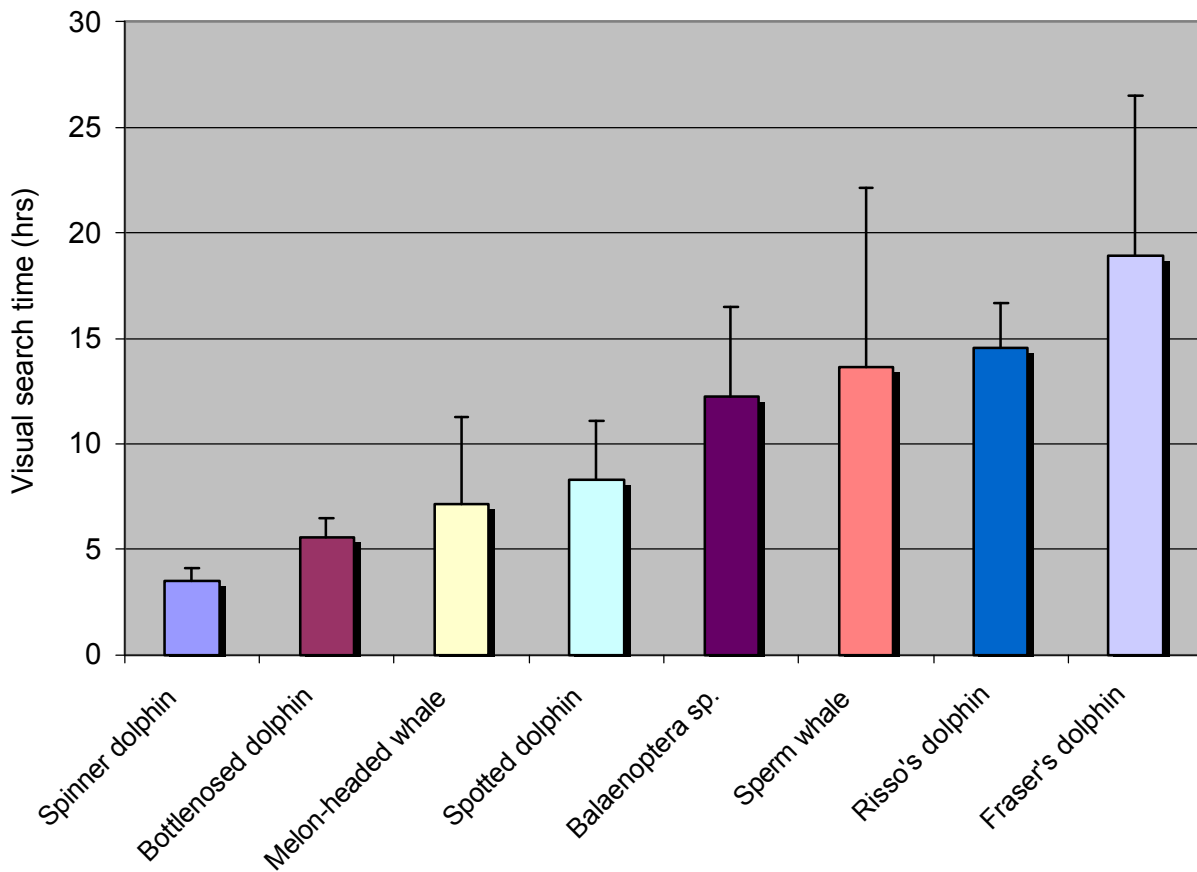


Figure 5: Examples of Komodo National Park cetacean diversity - *T. truncatus*, *Balaenoptera* sp., *P. macrocephalus* fluke up and dive.



