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DUGONG AND SEAGRASS IN MALAKAL HARBOR, KOROR, REPUBLIC OF PALAU: Current status and management recommendations

Community Centered Conservation
2003

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DUGONG AND SEAGRASS IN MALAKAL HARBOR, KOROR, REPUBLIC OF PALAU: Current status and management recommendations

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Koror
2003

Palau Conservation Society

Coral Reef Research Foundation

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BELAU AIR

EXECUTIVE SUMMARY

Dugong *(Dugong dugon)* are the only herbivorous mammals that are strictly marine and they are listed as vulnerable to extinction. Palau's dugong population is the most isolated in the world and is therefore particularly at risk. Illegal hunting of dugong and anthropogenic threats to their seagrass habitat have been identified as issues that must be urgently addressed to ensure this species' future in Palau. This multi-disciplinary study gathered data on the status of the dugong and associated seagrass habitat in Koror State through: seagrass mapping, fisher interviews, incidental sighting records, necropsies and aerial surveys. An associated community awareness-raising program was also implemented. Seagrass surveys of Ngederrak reef indicated that this area was an important feeding ground for dugong, with dugong feeding trails and extensive *Thalassia hemprichii*, the dugong's preferred food species. The Malakal Harbor region was regularly frequented by dugong, according to incidental sighting data, and it is likely that the nearby Ngederrak reef provides a haven for dugong from the heavy boat traffic of the harbor. Decline in Palau's dugong population was widely reported by local fishers and therefore it is essential to ensure that the protected status of Ngederrak reef is maintained to help to ensure the continued survival of dugong in Koror. Promotion of the dugong as a flagship species and protection of seagrass habitat will also have positive repercussions for stocks of fish and other marine resources. Data collected from this study provide a baseline for further studies and a long-term incidental sighting program.

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1. INTRODUCTION

Dugong *(Dugong dugon),* or sea cows, are the only herbivorous mammals that are strictly marine and specialize in feeding on seagrass beds. They have a low reproductive rate with a maximum population increase rate of 5% per year, if there is low natural mortality and no human-induced mortality (Marsh 1986). They are listed as vulnerable to extinction on the IUCN (World Conservation Union) Red List (IUCN 1986). The Palauan dugong population is unique because it is the most isolated population in the world, 800km north of the Irian Jaya populations and 850km east of the Philippines populations (Nishiwaki and Marsh 1985). Thus the Palauan population is especially susceptible to extinction as numbers decline since re-population from other areas is unlikely (Marsh and Lawler 1998).

Seagrass is an important component of coastal and near shore environments and its ecological value has become increasingly recognized over the past 40 years. Seagrasses provides food for numerous fish species, waterfowl, marine turtles, and dugong (Short and Coles 2001). Seagrass habitats support complex food webs by virtue of their physical structure and primary production and are well known for their role as breeding grounds and nurseries for crustacean, finfish and shellfish species. Seagrass ranks with coral reefs and mangroves as one of the world's most productive coastal habitats. The loss of seagrass habitats is a significant aspect of the degradation of the world's oceans (Short and Coles 2001). The primary threat to the health of seagrass stems from land-based human activities. Increases in dredge and fill, coastal development, recreational boating and raised sediment and nutrient loading from run-off have dramatically reduced seagrass distribution (Short and Wyllie-Echeverria 1996).

It is illegal to kill a dugong in Palau, however poaching continues secretly. The animals are killed and consumed for special customs, but hunting at current levels has been deemed unsustainable (Marsh and Lawler 1998). Legislation is currently being implemented to increase the penalties for killing dugong in Palau, although the issue of surveillance and enforcement also needs to be addressed. Meanwhile the distribution and composition of dugong feeding grounds is unknown and the lack of information concerning their habitat is a major obstacle in furthering conservation efforts for both seagrass and the dugong it supports.

In Palau, the most significant threats to seagrass habitat are increased sedimentation of coastal waters from road-building and coastal development, sand-mining and dredging activities. Information is urgently required for proactive planning and conservation initiatives focused on conserving the valuable dugong

and seagrass beds of Palau. The current project aimed to address these gaps in knowledge by investigating the distribution and composition of dugong feeding grounds and establishing a long-term data collection system for dugong and associated seagrass habitat in Palau.

Previous studies of dugong in Palau employed aerial surveys with little, if any, in-water research. The high costs involved in aerial surveying and the limited information they provide for management efforts precludes repeated studies of this kind at less than 5 year intervals in Palau (Marsh and Lawler 1998). Mapping of seagrass habitats and identification of dugong feeding grounds is a research priority that urgently needs to be addressed (Marsh and Lawler 1998) and seagrass beds at depths of 7m or more may provide significant feeding grounds for dugong in Palauan waters (Marsh et al. 1992). The location and extent of these seagrass beds may not be apparent from aerial survey or photography and will only be discovered with extensive ground-truthing and consultation with dugong hunters who are aware of the animals' movements and locations of feeding grounds. This project addressed this need for information through identification of preferred dugong feeding grounds using a combination of interviews and in-water mapping.

2. AIMS AND OBJECTIVES

This study aimed to assess the distribution of dugong and associated habitat in Palau, using a multi-disciplinary array of techniques including:

- Seagrass Mapping
- Fisher Interviews
- Incidental Sighting Records
- Necropsies
- Aerial surveys
- Community Awareness

3. METHODS

3.1 STUDY SITE

Malakal Harbor (Figure 1) is a busy port in Palau, supporting the urban center of Koror (population 15,000). Dive and fishing boats travel in and out of the harbor daily through Lighthouse and Ngel Channels on either side of Ngederrak reef. Ngederrak Reef is located just south of Malakal Harbor in Koror State and covers an area of approximately 4km^2. It is flanked by two channels (15m – 30m deep); a major shipping channel to the Southeast and another narrower channel on its Northwest side. This reef displays a range of topography from spur and groove formations at the fore reef to a large inner lagoon and seagrass and algal beds on the reef flat. Ngederrak Reef was declared a marine protected area (no entry) in 2000 by Koror State Government after years of intensive fishing and invertebrate harvesting by local people led to concerns over depleted stocks.

3.2 SEAGRASS MAPPING

Seagrass beds on Ngederrak Reef were mapped between October 2002 and April 2003 by a team of four divers. An aerial photograph of the study site was provided courtesy of Dr Patrick Colin (Coral Reef Research Foundation) and this was geo-referenced by PALARIS (Palau Automated Land Resource Information Service). Firstly, manta tows were conducted in parallel lines approximately 50-100m apart, from the reef crest to the back of the reef. The observer held onto a short rope and was towed adjacent to the side of a boat. The boat was stopped at one-minute intervals, substrate type noted and the position marked with a hand-held GPS unit. Whenever possible, species composition and density of seagrass beds was approximated as and when they were encountered. This information was entered into <Arc View 3.2> as a set of coded dots, to reveal areas where seagrass occurred across the reef flat. Using the GPS positions that marked the extent of these seagrass areas, the sites were revisited and the species composition mapped in detail by haphazard sampling within each site using 0.5m^2 quadrats and recording percentage cover of all species present. The blades of seagrasses, in particular large *Enhalus acoroides* plants, were pulled up through the mesh on the quadrats, so that they stood vertically rather than horizontally, in order to produce a more accurate estimate of percentage cover.

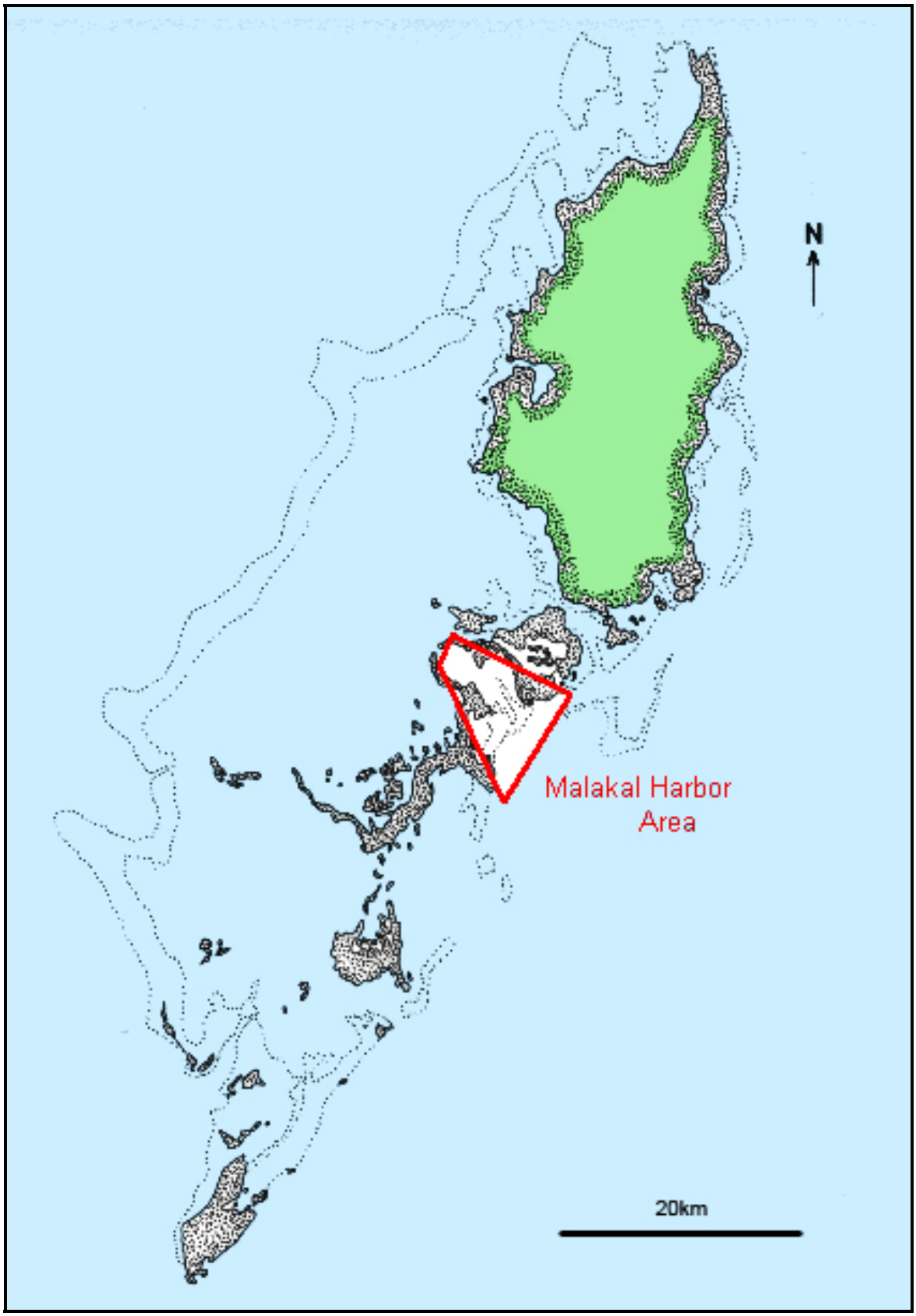


Figure 1: Palau, showing primary study site

The lagoon was too deep to map by snorkel, so four divers descended at seven randomly-selected sites (S1 to S7) between the entrance and the closed end of the lagoon to record seagrasses present. A different technique was used for mapping here as seagrass density was relatively low compared to the reef flat but covered a large area. At each site, the divers descended along the boat's anchor line to which they attached the end of their transect lines and proceeded to swim out 50m following bearings of 120°N, 240°N and 0°N. At 10m intervals along the transect, a 0.5m² quadrat was laid on the substrate within which seagrass species composition and percentage cover, was estimated. After completing surveys at two sites, the estimates of each surveyor were verified to ensure accuracy, through comparison of their estimates with actual counts of seagrass blades within a given quadrat (Appendix 1).



Seagrass survey

3.3 INTERVIEWS

Nine interviews were conducted in Palauan and English between August 2002 and July 2003 with ex-hunters and a pilot from Belau Air. The interviews were unstructured, informal discussions which lasted approximately one hour. General questions were asked regarding perceived changes in dugong locations and behavior. More specific questions were asked about methods of hunting and attitudes towards poaching. Notes were taken by interviewers and respondents were encouraged to mark locations where dugong were consistently sighted on a marine chart of Palau.

3.4 INCIDENTAL SIGHTING REPORTS

In August 2002, Dugong Incidental Sighting datasheets (Appendix 2) and marine charts were distributed to various dive tour operators, government conservation officers and marine research facilities. Participants were asked to fill out the datasheets with details of dugong sightings and to mark locations on the marine chart using labeled pins. Every month, a volunteer collected the sighting records from participating organizations and entered the information into a database. These data were given to Palau Conservation Society (PCS) for an official Incidental Sighting System for the general public in September 2003. Deep-water seagrass beds were also reported by local research scientists (Pat Colin and Jason Kuartei pers. comm.).

3.5 NECROPSIES

C3 requested the Division of Fish & Wildlife to inform them if dugong carcasses were found, so that necropsy data could be obtained. A basic examination was conducted of carcasses and samples of tissue, stomach contents and reproductive organs were removed where possible. Rangers from the Division of Marine Resources and Division of Fish & Wildlife assisted with necropsies. Necropsies were conducted following guidelines from Eros et al. (2000).

3.5 AERIAL SURVEYS

An aerial survey of dugong in Palau was coordinated by The Nature Conservancy in March 2003 and funded by the US Fish & Wildlife Foundation. The survey route was the same as in previous years and surveys were carried out on 4 consecutive days, with observers from PCS, Division of Marine Resources, Koror State Rangers, Palau International Coral Reef Center and C3. A review of the findings from this and previous aerial surveys will be published separately (Davis in prep).



Aerial survey

2.7 COMMUNITY AWARENESS

C3 publicized findings from this study on a local radio show in September 2003 in conjunction with the Division of Marine Resources. Two high school students and two college students accompanied C3 on field trips to map seagrass and one university student conducted interviews with fishers and participated in an overnight stay at the Dolphins Pacific facility and kayaking trips to search for dugong. A public lecture was given in August 2003 about C3's dugong and seagrass work in Palau in order to raise awareness about the project and the need for further conservation efforts for the species to survive in Palau. C3 also produced press releases about the dugong necropsies for local newspapers, urging local people to drive boats with due caution in the Malakal Harbor area, particularly at low tide and at night time and provided information for an article in the regional 'Pacific' magazine.

3. RESULTS

3.1 SEAGRASS MAPPING

3.1.1 Reef Flat

Four major seagrass sites were identified after mapping of manta-tow data on a geo-referenced aerial photograph of Ngederrak Reef (Figure 3) and determination of the largest continuous areas of dense seagrass. Figure 2 shows the percentage composition of these sites as estimated by quadrat sampling.

Seagrass species abbreviations are as follows:

Ea – Enhalus acoroides

Th – Thalassia hemprichii

Cr – Cymodocea rotundata

Cs – Cymodocea serrulata

Si – Syringodium ioesitifolium

Ho – Halophila ovalis

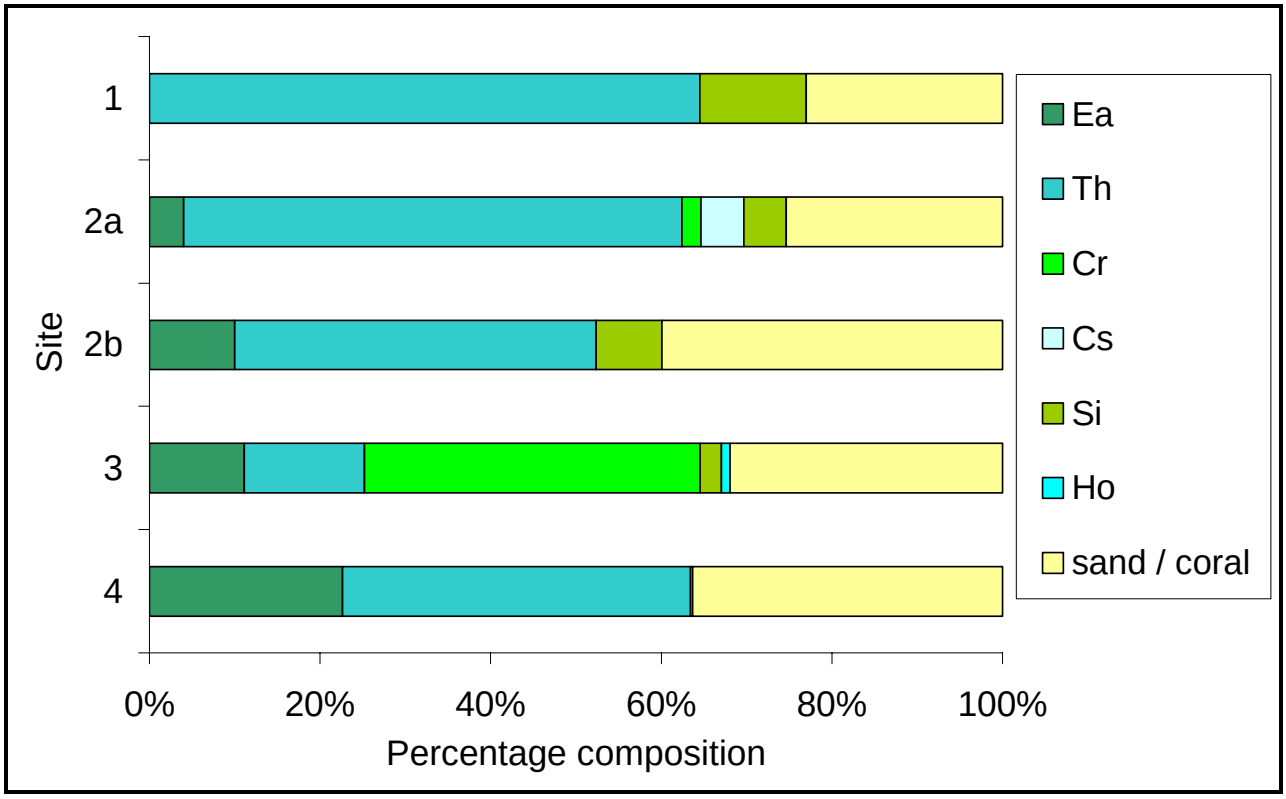


Figure 2: Species composition of seagrass beds on Ngerderrak reef flat

Between two and five species of seagrass were found at each site. *Th* was present at all sites, *En* and *Si* in all but one. *Cr* and *Cs* were only found in two sites and *Ho* in just one. *Ho* was out-competed by taller-growing seagrasses. All sites predominantly consisted of *Th* (41-65% cover), except for site 3, where *Cr* was dominant (39% cover). In the *Th* – dominated beds, *Ea* was the second most abundant species. Two sites were sampled within site 2 in order to better represent the large area. The percent compositions of *Ea, Th* and *Si* were fairly similar for both 2a and 2b, but a small amount of *Cr* and *Cs* was recorded in 2a but not 2b.

Dugong feeding trails

A total of 6 dugong feeding trails were identified on the reef flat during seagrass surveys (Figure 3). These were typically less than 1m in length and approximately 25cm in width. Confirmation of the existence of feeding trails was provided by Warren Lee Long, a seagrass expert from Australia, who was present during mapping work in October 2002. The composition of the beds in which feeding trails were recorded included a number of species combinations; most were combinations of two or three species:

- *Ea, Th, Ho*
- *Ea, Th, Cr*
- *Ea, Th*
- *Ea, Cs, Ho*
- *Ea, Ho*
- *Ho*

Most trails appeared to have removed all species except for *Ea* and often *Th* was cropped rather than removed in full, so that the leaf sheaths and rhizomes remained buried in the sand. This was not surprising as mature *Enhalus sp.* and *Thalassia sp.* have thick fibrous leaves and their rhizomes often proved impossible to remove from the substrate using bare hands. Dugong prefer tender young shoots and do not waste energy digging out tough rhizomes from the substrate as these are harder to digest and yield less nutritional benefits in relation to the energy expended. Note on Figure 3 that all feeding trails occurred within 'sparse' rather than 'dense' seagrass stands. This again reflects the animals' preference for younger tender plants typically found in these stands. Feeding trails along with signs of turtle 'cropping' were also observed nearby at Ngeremuangel, where dugong have been spotted during aerial surveys.

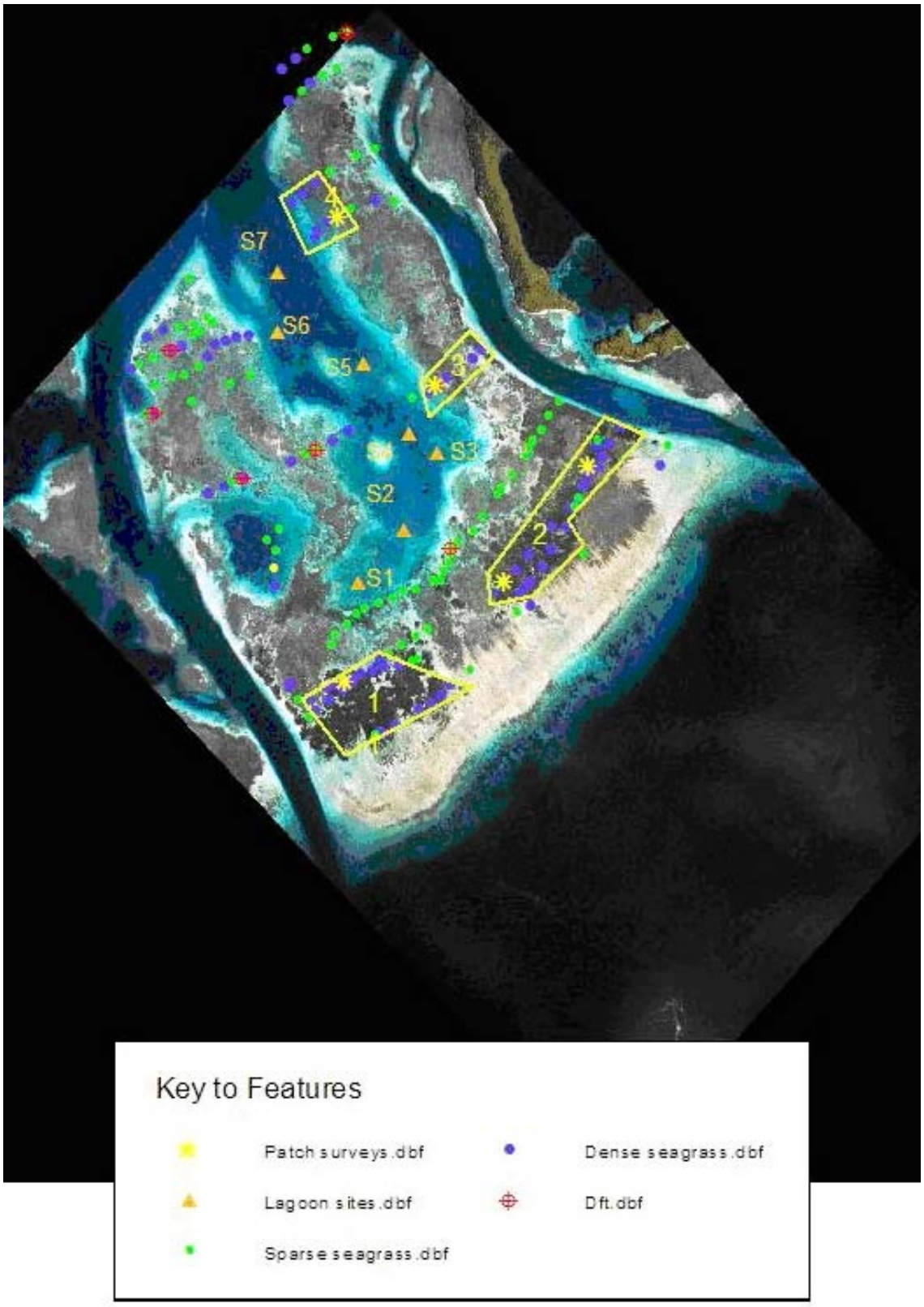


Figure 3: Aerial photo of Ngederrak Reef showing survey sites Note : DFT = Dugong Feeding Trail. (Aerial photograph taken by Dr.Patrick Colin, September 2002)

3.1.2 Lagoon

The average depth of sites surveyed in the lagoon was 9m. The lagoon was deeper towards its mouth, as would be expected because of tidal movement; the shallowest area was at S1 (6m) and the deepest at S7 (12m) (Figure 3). Strong currents occurred near the mouth of the lagoon as the water rushed in and out with tides. Several informants had reported dugong sightings in the lagoon during daylight hours, where they may seek refuge from the heavy boat traffic present in the channels that flank the reef. No evidence of feeding was recorded in the lagoon, although circular depressions (20-25cm diameter, 20cm deep) were seen, which may be indicative of dugong activity.

Corals

Small patches of corals were found throughout the lagoon and hundreds of juvenile fish (especially *Lutjanus gibbus*) were observed to aggregate in such areas. Soft corals, including sea whips, were prevalent at S5 and S7, where currents could be strong as water rushed in and out of the lagoon mouth. Substantial areas of coral rubble were noted at S6.

Filamentous algae

Dark green and red filamentous algae was seen throughout the lagoon, often epiphytic on *Ho*, in particular. At S1 and S2, it was noted that dark green filamentous algae covered 50-75% of *Ho*.

Seagrass

Seagrass cover was much lower in the lagoon than on the reef flat. Overall, there appeared to be a higher density of seagrass in the enclosed, more sheltered parts of the lagoon, especially at S1-S3, relative to the sites near the entrance (S4-S7). There did not appear to be any concurrent change in seagrass species diversity between the enclosed end and the entrance. *Ho* dominated in the lagoon (7-40% cover) although *Cs* was more prevalent at S1 (16% cover) (Figure 4).

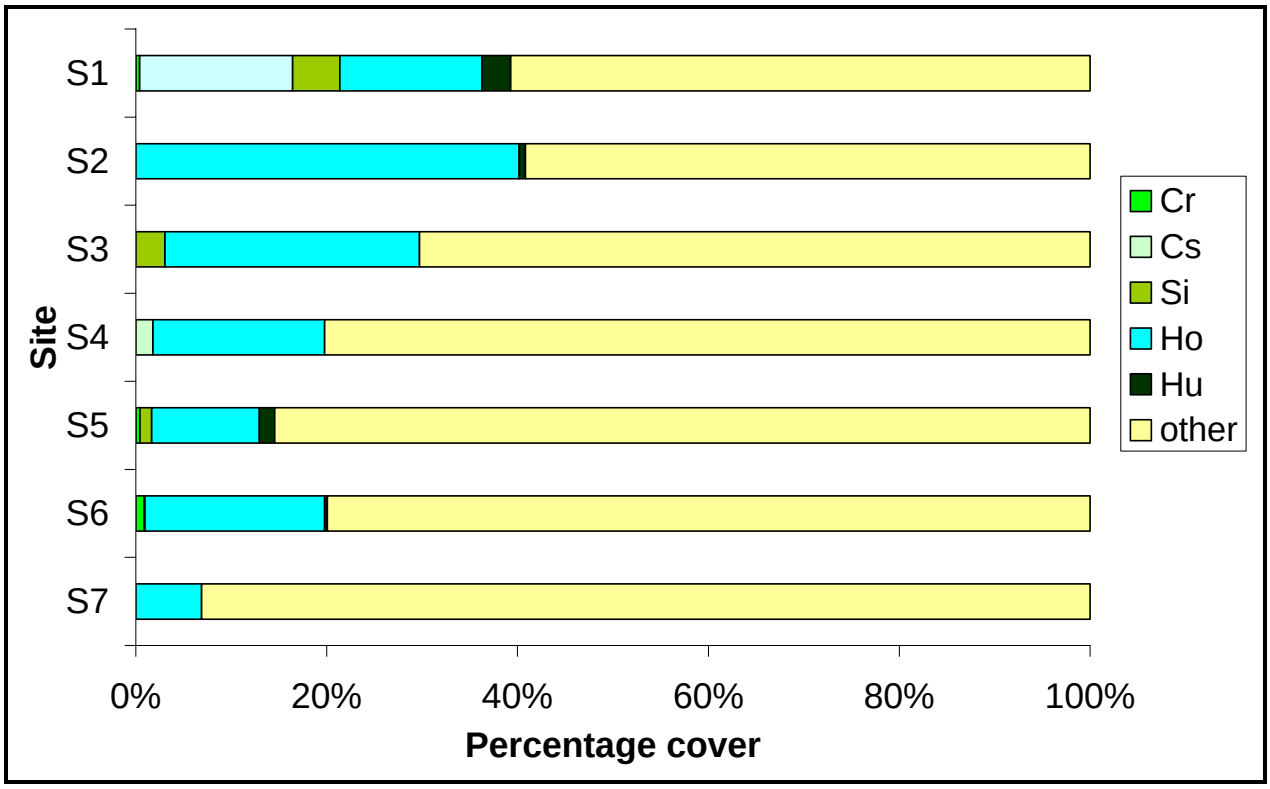


Figure 4: Species composition of seagrass beds in Ngederrak Lagoon

3.2 INTERVIEWS

Interviews were conducted with 8 individuals; 7 fishers and 1 pilot. The fishers were identified from 25 people interviewed about dugong in 1996 by Palau Conservation Society (PCS). The best times suggested for observing dugong in nearshore waters were consistent amongst interviewees. Most respondents felt that there had been changes in dugong behavior in the past 5 years: including disappearance from areas where they had been sighted regularly in the past and fewer sightings in shallow waters in the daytime; both of which were attributed as a response to increased boat traffic. It was rare to see a group of dugong, the largest reported consisting of seven animals. Three respondents said that they had seen dugong feeding on *yaod*, seagrass floating on the surface of the water. It was widely believed that dugong sleep or rest in deep water, often under rocks, protected from strong currents, during the day time and then move into shallow waters as night falls (when they are less likely to be spotted by poachers and boat traffic is reduced). Interviewees provided specific locations at which they had seen dugong feeding and/or resting in the distant and recent past. This information will be kept confidential to prevent it being accessed by poachers.

3.3 INCIDENTAL SIGHTINGS

Twenty sightings (30 individuals) were recorded and submitted between August 2002 and September 2003. These comprised 16 lone adults; three cow-calf pairs; one group of two cows and two calves and a group of two adults with one calf and a single calf (whose mother may have been submerged). Most of the sightings were from boats and only the dorsal surface of the dugong was seen as it surfaced to breathe. One incident involved a collision with a dive boat in shallow water over seagrass beds (approximately 1m deep). Fortunately the animal appeared unharmed and swam away. Two individuals observed dugong in the water while snorkeling and they noted that the animals did not appear afraid. In one case, the dugong actually approached the snorkeler.

Dugong sightings were most frequent from July to September and in January (at least 4 sightings per month). Seventeen out of the 20 sightings were in the Malakal Harbor area. Palauan seas tend to be rougher during July to September due to the trade winds and dugong may be more concentrated in sheltered, inshore waters during the daytime throughout these months. Almost all sightings were in the afternoon between 12pm and 5pm, with only three sightings recorded between 9am and 11am in the morning.

In September 2003, PCS established an Incidental Sighting Program for the general public, focusing on dugong, turtles and crocodiles. The information gathered by C3 during this project was passed onto PCS for inclusion in their sightings database. It is expected that in the future consistent sightings in certain locations will be apparent and therefore more patterns relating to habitat usage may emerge.

3.4 NECROPSIES

Two dead dugong were reported by members of the public in December 2002 and March 2003. The animals were removed from the water by Division of Fish and Wildlife and C3 had the opportunity to take measurements and tissue and stomach samples from the carcasses.

Dugong Necropsy 1 - Female

Date : 13th December 2002

Location: Division of Marine Resources (DMR)

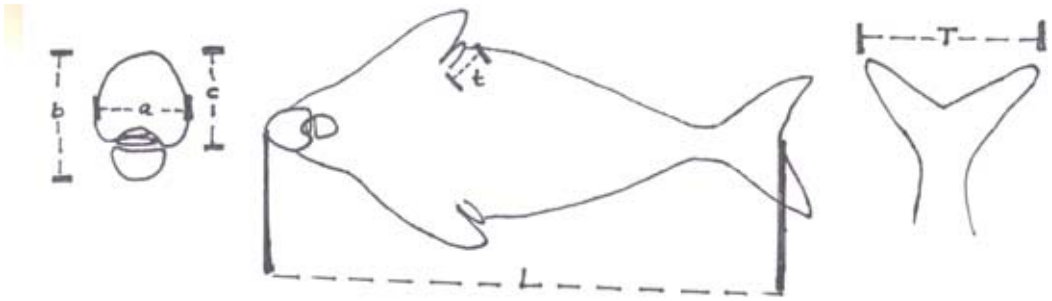
Time: 1400-1730

Participants: Rangers from Division of Fish & Wildlife, Patricia Davis (C3), Colby Kearns (Palau Community College Science Instructor), Tomoko Yamada (Vet, Dolphins Pacific) and Mitsuhiro Aoyama (JICA volunteer for DMR).

Location of carcass: The carcass was found floating ventral side up off the island of Meyuns, Koror, close to the hospital by rangers from the Division of Fish & Wildlife, following a call from a member of the public. It was found at approximately 10am and dragged to shore using ropes fastened around the head and tail.

Estimated time of death: It is estimated that the dugong had been dead for 24-48 hours prior to the necropsy. The carcass was in fair condition. Only a small amount of gas was released when incisions were made through the body wall and although the carcass had a strong odor, the internal organs looked fairly fresh and pink; the stomach was full of recently consumed seagrass and had only a slight smell.

Dimensions:



a = 33cm ; b = 48cm ; c=25cm L = 302cm ; t = 10cm ; T = 95cm

Figure 6 : Dimensions of Dugong 1 - Female

External Examination:

- Numerous soft blisters (vesicles) approximately 2.5cm in diameter on the ventral surface
- Usual scratches found on dorsal side (mating scars, incidental marks) but no obvious injuries
- Skin was sloughing off the face due to ropes tied around the head when moving carcass
- Animal was apparently bleeding from both nares when found (Kammen Chin, pers comm)
- Both eyes extremely distorted and protruding from the sockets
- Measurement of the genital opening-anus distance could not be obtained as the carcass had split during transport to the autopsy site.
- 2.5cm outer blubber layer*, 2.5cm cutaneous trunci layer*, 2.5cm inner blubber layer; these layers were particularly soft near the anus with a greenish tinge. The outer blubber layer was thinner in the abdominal region (1.25cm) in comparison to the thorax region.

Mammary glands: Teats were both approximately the same size, 10cm, and bloody and swollen. Palpation of the teats did not result in pus or milk being exuded. The mammary gland was cut and found to be dark red in color, soft but no milk was present.

Intestines: Hemorrhaging was present on parts of the surface of the jejunum. The membrane of the (descending?) colon appeared pale and bubbly in parts. Contents of duodenum were fluid as expected, and feces close to anus was dark green and compact*****.

Stomach: Appeared healthy and full of finely macerated seagrass***** (13.83kg) No foul odors and only a tiny amount of gas on incision. No sediment present. No seagrass found in mouth or esophagus.

Lungs: According to Tomoko Yamada, the lungs had much water and showed clear signs of drowning.

Ovaries: Approximately 7.5cm x 5cm, flattened and ovoid in shape*.

Possible cause of death: Based on the results of the necropsy it was difficult to determine whether the animal died of natural or unnatural causes. There were no obvious signs of disease either internally or externally, although pathological examinations of the tissues samples taken may reveal otherwise. The animal appeared to have eaten well prior to its death and there is a possibility that dynamite had been used by poachers to kill the animal, which may have lost consciousness and drowned as a result of the explosion. The bleeding observed from both nares and the fact that the eyes were out of their sockets

would certainly be indicative of dynamiting. However, since there was no rupturing of organs or detailed examination of the head of the animal, it is not possible to establish this as the cause of death.

* indicates that a sample was taken and preserved for further analysis. Mitsuhiro Aoyama also took a sample from the **liver, lung and kidney** for histological studies. The animal was buried by Kammen Chin and the skeleton will be displayed for educational purposes at the Department of Fish & Wildlife in 2003. If possible, the tusks, which had not yet descended, will be removed and used to estimate age.





Vesicles on skin



Head



Teat



Intestines



Lungs

Figure 6 : Photographs of Dugong 1 - Female

Dugong Necropsy 2 - Male

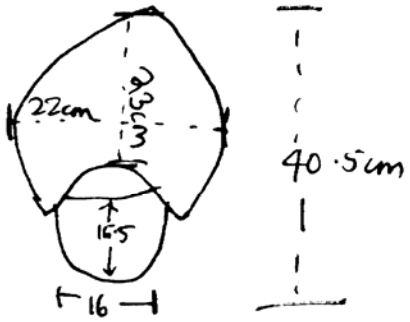
Date : 24th March 2003

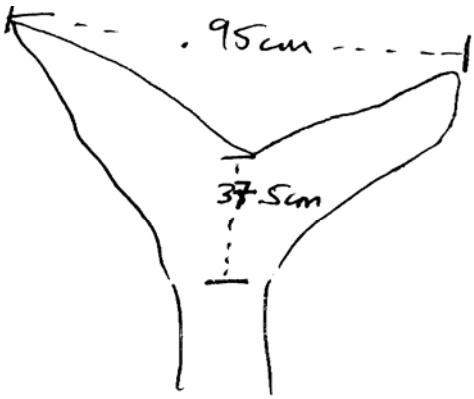
Location: Ngerbeched dock

Time: 1015

Location of carcass: During Saturday night, a returning fishing boat hit something floating on the surface of the water near Ngederrak reef (one report says near Ngel Channel, the other says near the Rock islands adjacent to Ngederrak). When it was realized that it was a dugong the carcass was taken back to Echang hamlet, where someone removed both tusks from the animal (unless these had already been removed from the carcass immediately after the collision). Fish & Wildlife rangers were called on Monday morning and the carcass was subsequently towed behind a boat to the Ngerbeched dock, where it could be examined.

Dimensions:





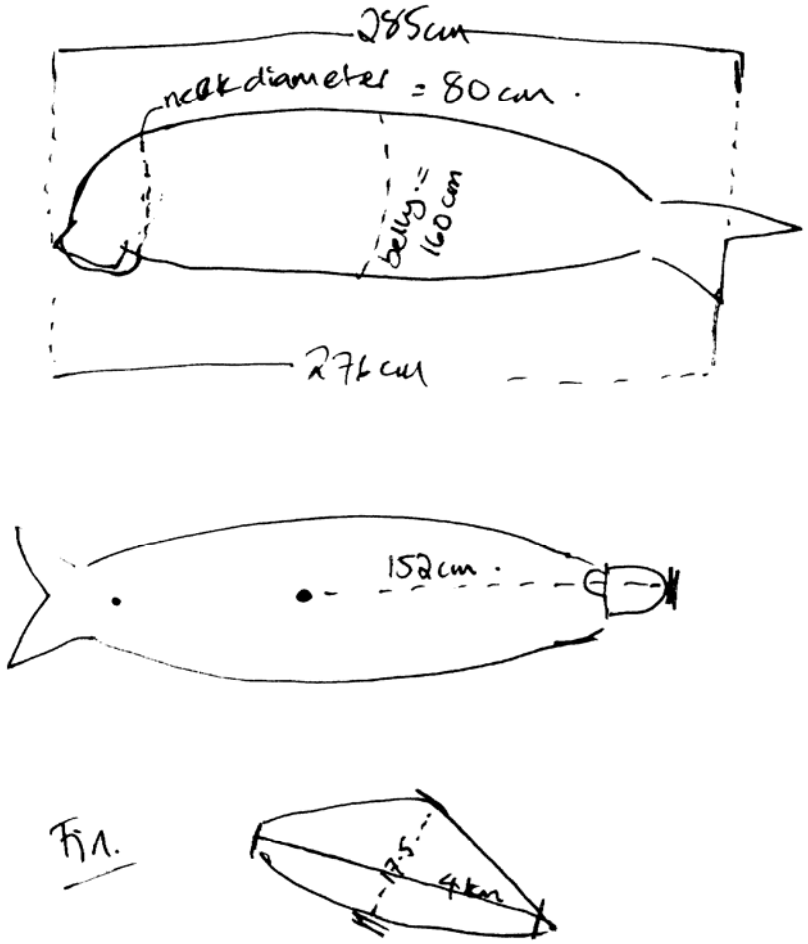


Figure 7 : Dimensions of Dugong 2 - Male

External Examination:

- Much skin around head and neck sloughed off
- Fins gnawed on by fish
- Young male
- Stomach contents, blood, skin and red muscle samples taken
- Tusks missing, jaw broken probably in order to remove tusks
- Stomach contents (to be analyzed)- fresh, many large nematodes, wt=1.79kg
- No obvious spear mark – may have been hit accidentally.
- Numerous scratches on dorsal surface








Tusks removed

Scratches on dorsal side

Figure 8 : Photographs of Dugong 2 - Male

DNA Analysis

Samples of red tissue were sent to Brenda McDonald, PhD student at James Cook University, Townsville Australia for genetic analyses. Miss McDonald was analyzing the genetics of dugong populations throughout the world to investigate evolutionary linkages between sub-populations.

3.4.2 Stomach Contents' Analysis

Stomach contents from the female dugong were analyzed by C3 and also sent to Karen Arthur, PhD student at University of Queensland, Brisbane, Australia to determine the species composition of seagrasses present. The analysis in Table 1 was provided by Karen Arthur in April 2003. However, following analysis of the same sample by C3, it seems *T.hemprichii* may have been mistaken under the microscope for *C.rotundata*; Miss Arthur informed us she had not seen *T.hemprichii* before so this supposition may indeed be true. In this case, her results would compare to ours of approximately 60% *T.hemprichii*, found in the female dugong's stomach. This would also make more sense, considering the far greater availability of *T. hemprichii,* compared to *C. rotundata*, in seagrass beds surveyed in Koror.

The male's stomach contents are yet to be analyzed.

Table 1: Stomach contents' analysis of female dugong

***Cymodocea** rotundata*	59%
Halophila ovalis	17%
Various rhizome material	14%
Halodule uninervis	4%
***Thalassia** hemprichii*	3%
Seagrass (not identified)	2%
Enhalus acroides	1%

3.4.3 Reproductive organs

An ovary was removed from one carcass and has been preserved but not yet examined.

4. CONCLUSIONS AND RECOMMENDATIONS

Ngederrak Reef was found to contain important dugong feeding habitat, confirmed by seagrass surveys, incidental reports, interviews, aerial surveys and feeding trails. *Thalassia hemprichii* was widespread on Ngederrak Reef flat and appeared to be the preferred food species for dugong according to data from feeding trails and stomach contents' analysis. As a protected area, with no boats entering its waters, Ngederrak Reef provides a haven for dugong amidst the heavy boat traffic of Malakal Harbor during the daytime. The reef hosts a variety of habitats, from deep channels, to a sheltered lagoon, shallow seagrass beds, reef flats and algal beds which support juvenile fish and invertebrate populations. These resources are of considerable subsistence and/or economic worth in Palau and the proximity of the reef to the urban center of Koror makes this area particularly vulnerable to overexploitation. The continued protection of Ngederrak Reef is therefore mandatory to protect not only the dugong, but other valuable marine resources.

The dugong, as one of Palau's few resident mammals, capturing the public's enthusiasm, should be promoted as a flagship species to protect the wealth of natural resources supported by seagrass beds. In Australia, publicity campaigns have raised awareness about these endangered animals and 'Dugong Protection Areas' have been introduced to provide safe areas for dugong to feed and rest undisturbed. Feeding areas already identified through research and local knowledge should be protected through State and National legislation. The construction of the Compact Road and the anticipated development throughout Babeldaob make it imperative that governments are proactive in protecting seagrass habitats on which not only the dugong, but the livelihoods of local populations depend. Suitable protective measures could include a protected network of seagrass beds throughout Babeldaob and Koror, and protection of adjacent coastline from unsuitable development. Protection of 'buffer zones' of mangroves and other vegetation on the land adjacent to seagrass could help to prevent overloading of sediments which can smother and kill seagrass.

Much of the information collected during the course of this study has been distributed to other Palauan organizations so that it may be used as a baseline for further studies and guarded from those who may seek to exploit it for the wrong purposes. The protocols developed and tested for mapping seagrass beds may be used by other researchers in the future. A long-term dugong incidental sighting program and future necropsies will continue under the supervision of Palau Conservation Society.

5. REFERENCES

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6. APPENDICES

6.1 PRECISION OF SEAGRASS PERCENTAGE COVER ESTIMATES

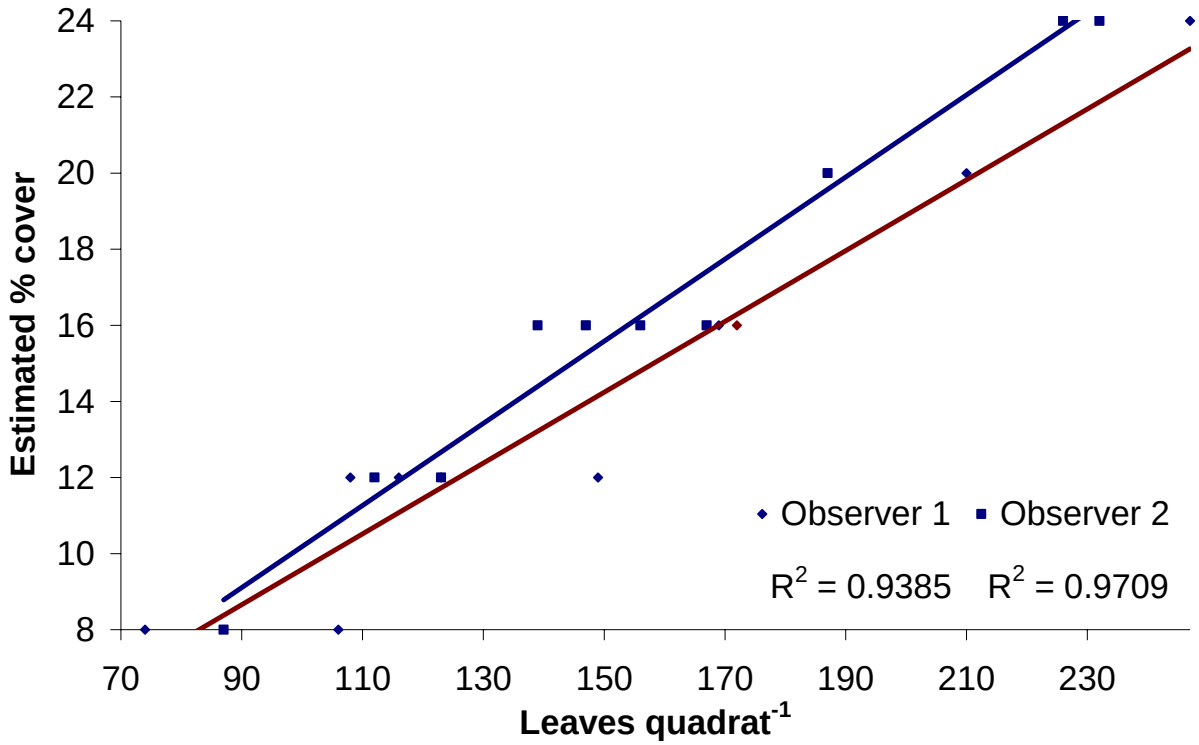


Figure 9: % cover estimates of observers correlated with actual density (number of leaves) of seagrass in surveyed quadrats

6.2 INCIDENTAL SIGHTING DATA SHEET

Record no. *	
Name of Observer:	
Date:	
Location :	
Time :	
Tide :	
Weather :	
No. of dugong :	
Length of dugong :	
Depth :	
Habitat :	
Behavior :	
Other observations :	

*The Record no. should correspond with the pin number showing the dugong's position on the map.