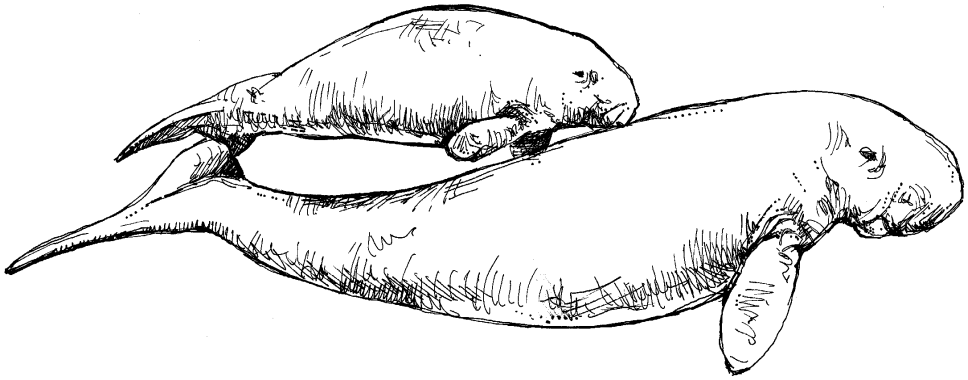
current status of knowledge of

# dugongs in palau:

## a review and project summary report




Prepared by

**Patricia Z.R. Davis**

**(Revised by Andrew Smith)**


For

**Palau Country Program**
**The Nature Conservancy**


**November 2003**
**(Revised August 2004)**

**TNC Pacific Island Countries Report No. 7/04**


The Nature Conservancy

**CONTENTS**

Table of Contents ..... i
Acknowledgements ..... ii
Terms of Reference ..... iii

EXECUTIVE SUMMARY ..... iv

1. INTRODUCTION ..... 1
   1.1 Background to Study ..... 1
   1.2 Palau Dugong Project ..... 3

2. AERIAL SURVEY ..... 4
   2.1 Objectives ..... 4
   2.2 Methods ..... 4
   2.3 Results ..... 7
   2.4 Additional Information ..... 14

3. LOCAL KNOWLEDGE ..... 14
   3.1 Objectives ..... 14
   3.2 Methods ..... 15
   3.3 Results ..... 15

4. SEAGRASS SURVEYS ..... 20
   4.1 Objectives ..... 20
   4.2 Methods ..... 21
   4.3 Results ..... 25
   4.4 Additional Information ..... 30

5. DISCUSSION ..... 30

6. RECOMMENDATIONS ..... 32
   6.1 Update on Management Actions ..... 32
   6.2 Recommendations ..... 33

7. REFERENCES ..... 36

8. ATTACHMENTS ..... 39
   8.1 Issues Concerning Estimating Palau's Dugong Population from Aerial Surveys ..... 39

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*Cover drawing:* © Donald Bason/TNC

**TERMS OF REFERENCE**

The contractor (Patricia Davis, Community Centered Conservation) will work under the direction of, and in collaboration with, Dr. Andrew Smith (TNC) to:

1. Analyze the dugong aerial survey data from the October 1998 and the March 2003 surveys, and compare the results to all the previous surveys.

2. Prepare an end of project report on the status of Palau's dugong population that includes, at a minimum, the following:
    - The results of all the aerial surveys
    - The results of the local knowledge documentation
    - The results of the seagrass surveys
    - Details of the incidental sightings system
    - The legislative situation
    - Past, present and proposed management actions
    - Future research priorities

## EXECUTIVE SUMMARY

This report summarizes the results of the dugong component of the multi-partner project—"Crocodile and Dugong Population Assessments and Management in the Republic of Palau"—conducted between September 2002 - September 2004. The results of these studies are summarized and assessed in relation to past studies of Palau's dugongs.

The dugong population in this archipelago is small and vulnerable to extinction although it still appears to be reproductively viable. Results from interviews with knowledgeable fishermen, an aerial survey and seagrass mapping has revealed that the dugong population travels throughout the coastal waters of Palau, concentrating in two major areas during the day time, idling close to reefs, presumably sheltering from boat traffic and predators. Dugongs appear to be site-specific in their movements, often being seen in the same locality on subsequent days. However, it appears that dugongs no longer visit some areas, possibly due to increased boat traffic in those areas.

Legislation increasing penalties for killing dugong to $5000-$20,000 has discouraged poachers from discussing hunting openly. In the past, interviews with knowledgeable fishermen, who once hunted dugong, revealed information about hunting rates and prime hunting areas and times. Interviews conducted in 2003 revealed that there is a great reluctance to discuss such issues with researchers, therefore it is difficult to determine any changes in levels of hunting or attitudes towards poaching. Some seagrass beds are included in no-entry areas in some States for the purpose of sustaining fish and invertebrate stocks. However, no protected areas exists to protect seagrass beds *per se* from anthropogenic impacts from land and/or sea-based activities. The new legislation does require any entity proposing a new development to include an Environmental Impact Statement considering the potential impact of such development on dugongs and their habitats.

The priorities for dugong conservation activities in Palau include:

1. Surveillance and Enforcement
    - Allocate additional support (personnel, training and funding) towards surveillance and enforcement efforts at both the national and state levels.
    - Investigate the legal and practical feasibility of establishing a reward system for reporting hunting or possession of dugong, and implement the system if proven feasible.
2. Education
    - Initiate a nationwide education and awareness program.
3. Habitat Protection
    - Continue targeted studies to better understanding the seagrass habitats to provide a basis for protection.
    - Provide increased protection to the key dugong feeding areas (seagrass beds).
4. Dugong Life History, Status and Management
    - The responsibility for dugong research, assessments and management should be progressively transferred to the Bureau of Marine Resources.
    - Information on dugong distributions and status should be continued.
    - Efforts should continue to collect information from dugong necropsies.

## 1. INTRODUCTION

### 1.1 Background

The dugong, *Dugong dugon*—also known as the sea cow in English, and *mesekiu* in Palauan—is an exceptional marine mammal, feeding solely on sub-aquatic vegetation, predominantly seagrass. Dugongs inhabit the shallow coastal waters of 43 countries, bordering the tropical and sub-tropical Indian and Western Pacific oceans (Figure 1). Despite their relatively extensive range, most dugong populations are small and in danger of becoming extinct due to increasing anthropogenic pressures such as poaching as well as indirect impacts on their habitat, such as pollution and development. They have been listed as vulnerable to extinction by the World Conservation Union (IUCN, 1990).

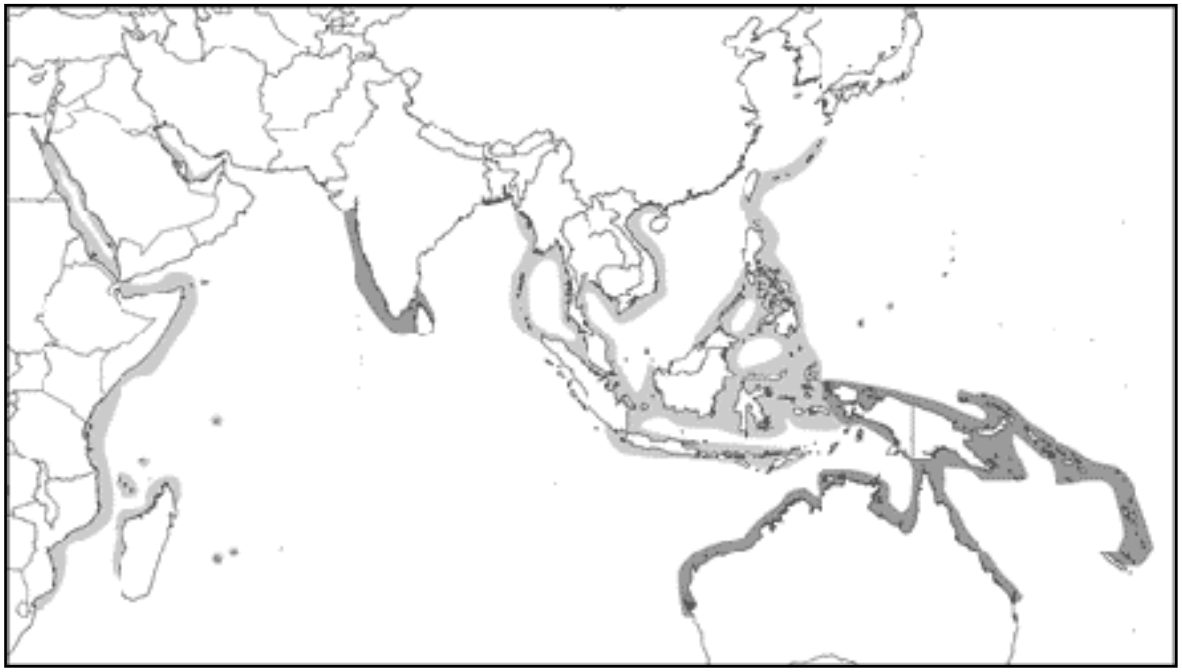


**Figure 1: The dugong's present range (UNEP, 2002)**

**Vulnerability to Extinction**

Dugong populations inhabiting isolated archipelagoes are particularly vulnerable to extinction, as their numbers are small and emigration or recruitment in the face of external pressures is unlikely or non-existent. Suspected or confirmed extinctions of dugongs have been reported from the Mascarenes, Laccadives, Maldives, Nicobars, Ryukus, Barren, Narcondom, Cocos (Keeling), Christmas, and lesser Sunda Islands, Mauritius, western Sri Lanka, Japan's Sakishima Shoto Islands and several islands in the Philippines. Dugongs have also already disappeared from the waters of Taiwan, Hong Kong's Pearl River estuary, and parts of Cambodia and Vietnam (Husar, 1975, Lawler *et al*., 2002).

In the Micronesian region, dugongs occur only in Palau (Figure 2), apart from occasional sightings of isolated animals around Yap and Guam (Nishiwaki *et al.,* 1979). It is believed that the Palauan dugong population is one of the most isolated in the world, with neighboring populations as far west as the Philippines (850 km) and as far south as west Papua (formerly Irian Jaya) (800 km) and thus the likelihood of recruitment after local extinction is extremely low (Nishiwaki and Marsh, 1985).

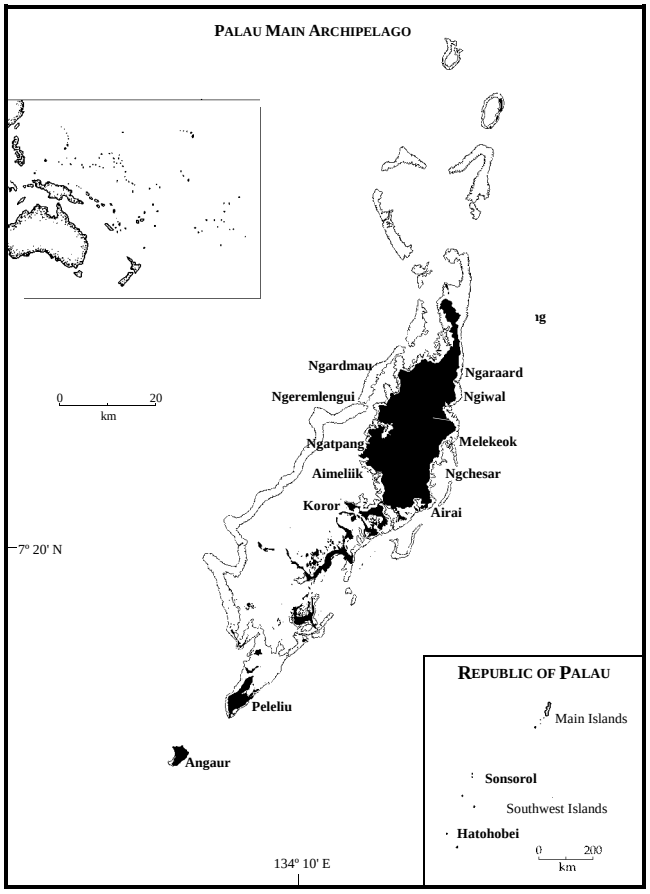



**Figure 2: Map of Palau with State names.**

The dugong's vulnerability to extinction arises from a combination of life history factors and its dependence on shallow coastal waters. Dugongs are slow-growing mammals, with females only reaching sexual maturity after 6 to 17 years and producing a single calf every 2.5 to 5 years (UNEP, 2002). Marsh's population models based on such life history parameters have revealed that a dugong population can only sustain a 5 % natural mortality rate, excluding human-induced deaths, before declining. The sustainable level of exploitation may be in the order of only two percent of females per year (Marsh, 1995). The dugong's food source, seagrass, is usually found in sheltered coastal waters less than 10 m in depth, however, deeper beds with feeding trails have been found to 24 m in Australia (Lee Long *et al.*, 1993, cited in Marsh and Lawler, 1998). In this environment, dugongs are inevitably brought into close contact with anthropogenic impacts such as boat traffic, poaching, coastal development and pollution, which may directly drive them away from once-utilized resources or indirectly result in the deterioration in the quality and/or abundance of important food sources.

In Palau, dugongs were traditionally hunted only on special occasions, when they were presented to high-ranking people, such as chiefs. Aside from this, natural causes of mortality are thought to have been low, with the only natural predators being sharks and crocodiles that may occasionally take calves. With the effects of several foreign administrations since the 1800s, the advent of World War II, traditional marine resources management and hunting practices have became eroded, and fast motorboats have replaced traditional canoes and rafts. During the 1970's, around 20 or more dugongs were estimated to be killed each year by poachers (Brownell *et al.* 1981). At the same time, a conservative, and subjective, population estimate of 50 individuals was calculated on the basis of interviews and aerial surveys. However, subsequent interviews with fishermen in the 1990's revealed that the poaching rate was still as high as 13 dugongs per year (Marsh *et al*, 1995), and taking into consideration the estimated maximum sustainable take of two percent of the female population, the estimate of 50 dugongs has proven to be much too low (otherwise dugongs would be locally extinct by now).While no population figure can be calculated based on any studies to date, the population is believed to be quite small, vulnerable to local extinction, and *any* hunting unsustainable (Marsh, *et al.*, 1995). It remains likely that dugongs could become extinct in Palau, as they have in so many other archipelagoes, unless poaching is stopped as a matter of urgency (Marsh and Lawler, 1998).

**Threats to Habitat**

No information existed on the extent or composition of the seagrass beds of Palau prior to this project. Since the Japanese administration (1915-45) the use of coral dredge materials for construction has been the norm. More recently, with the inception of the Compact Road project in November 1999 (the

construction of a 55-mile road around the main island of Babeldaob), many states in Palau have increased dredging activities in their coastal waters, with few environmental mitigation measures put in place. These increasing dredging activities, in association with increased erosion and sedimentation from road construction and agricultural activities on land, threaten to destroy or damage seagrass communities which dugong and other marine life depend on as a primary source of food.

### 1.2 Palau Dugong Project

There is very limited information available concerning Palau's dugong population, as highlighted in the U.S. Marine Mammal Commission funded "Action Plan for the Management of the Dugong *Dugong dugon* in Palau" (Marsh and Lawler, 1998). Given the combined of lack of information about Palau's dugong population and the urgent need for additional management and conservation measures to maintain a viable population, a project was initiated by The Nature Conservancy (Palau Country Program) with financial support from the U.S. Fish and Wildlife Service (Crocodile and Dugong Population Assessments and Management in Palau. US FWS Agreement No. 122002G004).

The goal of this project was to provide information to be used to help maintain a viable population of dugongs in Palau. There were two specific objectives of this component of the project[1]:

1. To monitor the status and distribution of dugongs in Palau
2. To identify, classify and map the primary seagrass beds used by dugongs in Palau

The overall outputs of this project component were:

- A comprehensive report on past and current aerial survey results for dugongs in Palau, linked to local knowledge and primary seagrass habitats.
- An on-going system for recording incidental sightings and other reports of dugongs.
- Up-to-date information for use in environmental awareness campaigns and regulations development.
- Maps of critical dugong feeding habitat that will be used in MPA design for the Protected Areas Network, for inclusion in the National Biodiversity Strategy and Action Plan preparation, and provide the basis for developing a seagrass monitoring program.

This project was designed with the intent of involving all the relevant agencies and organizations in Palau, with the Conservancy primarily taking a coordinating role. The partners involved with the dugong component of this project have been:

- Palau Conservation Society (PCS)
- Palau International Coral Reef Center (PICRC)
- Bureau of Marine Resources (BMR)
- Community Centered Conservation (C3)

Those activities included:

***Aerial survey:*** An aerial survey based on the methodology used in the previous surveys (1977/78, 1983, 1991, 1998) was coordinated by the Conservancy, but involved observers from the project partners

[1] This project, "Crocodile and Dugong Population Assessments and Management in Palau. US FWS Agreement No. 122002G004", had two components, one focusing on dugongs, the other on saltwater crocodiles. The latter is covered by separate reports.

***Incidental sightings system:*** The Palau Conservation Society was contracted to develop a system for collecting and recording incidental sightings (live animals) and reporting (carcasses, poaching, etc.).

***Local knowledge:*** The Palau Conservation Society was contracted to conduct interviews with key knowledgeable people in Palau on the distribution and movements of dugongs, and any changes over time.

***Identification of the seagrass beds:*** The Palau International Coral Reef Center was contracted to identify and map potential areas of dugong habitat (seagrass beds with appropriate species) through the use of the recent and past dugong aerial survey data (distribution patterns of dugong sightings), local knowledge, past aerial photographs, and available remote sensing images.

The above activities are described in the next three sections of this report, detailing methodology and an analysis of results in the context of what has been learnt from previous studies. The information gained from all components is combined in the final discussion and provides the basis for recommended actions for the future protection of the dugongs in Palau.

## 2. AERIAL SURVEY

### 2.1 Objectives

1. To conduct an aerial survey based on the methodology used in the previous surveys (1977/78, 1983, 1991, 1998).

2. Analyze the results and compare them to the previous surveys.

3. Prepare a comprehensive report on past and current aerial survey results for dugongs in Palau, and discuss them in relation to the other project activities.

### 2.2 Methods

**Past Aerial Surveys**

There have been four previous aerial surveys of dugong conducted in Palau in 1977/8, 1983, 1991 and 1998 (Brownell *et al.*, 1981, Rathbun *et al.*, 1988, Marsh *et al.*, 1995, Smith, 1998 unpublished data). Surveys conducted in all years were essentially qualitative, therefore their primary uses were for determining areas of relatively high dugong density, and to compare the relative numbers of adults and calves between surveys. They were not designed to estimate the size of Palau's dugong population.[2] Anderson (1998) found that aerial surveys produced 'meaningful data on seasonal habitat use and group size' in Australia. Although the seasonal variation, in terms of water temperature, is negligible in Palau, information on group size is pertinent.

In all surveys, aside from the one in 1977, high-wing aircraft providing maximum visibility were used for surveying. The same flight paths were used in all cases, however, the results from the surveys are not directly comparable due to the variability in number of observers, total survey time, speed and altitude (Table 1). The survey in 1998 was not completed (one sector remained to be surveyed) due to the tragic

[2] See Attachment 8.1 for a discussion of why aerial surveys to estimate dugong population size in Palau are not feasible.

crash of the airplane on a commercial flight during the course of the study. In this section, the data from all five surveys are analyzed jointly in order to determine general patterns in distribution and habitat utilization by the Palauan dugong population, and to provide relative information on adult and calf numbers between surveys.

**2003 Aerial Survey**

The survey team consisted of a commercial pilot with previous dugong survey experience, a front-right survey leader, two mid-seat observers and two rear-seat observers. The survey leader[3] and one observer[4] had previous experience of dugong aerial surveys. All team members occupied the same seats during each flights, although their positions varied on consecutive survey days. On sighting a dugong, or group of dugongs, an observer called out to the survey leader, who would instruct the pilot to circle the location so that the sighting could be confirmed and number of individuals verified. Attempts were made to minimize the effects of glare by ensuring that all observers wore grey polarized sunglasses.

The survey took place on three consecutive days between 8th and 10th March 2003[5]. A Britten-Norman Islander high wing aircraft was used, flying at 185-204 km/hr (100-110 knots) at an altitude of 198 m (650 ft). The four flight routes (Figure 3) covered in previous surveys were completed, with an average survey time of 133 minutes (2 hours 14 minutes) per route. The total survey time was 535 minutes (8 hours 55 minutes).[6]

[3] Had participated in quantitative dugong aerial surveys on the Great Barrier Reef (Australia) in the 1980s, and led the 1998 Palau dugong aerial survey.
[4] Had participated in the 1998 Palau dugong aerial survey as an observer.
[5] In the following results and analysis, the term "survey day" is used for each separate flight sector/route. However, in 2003, due to very good survey conditions, two sectors/routes were flown on the last day (March 10, 2003). For the sake of consistency with previous survey analyses, each of the two sectors/routes on that day are considered separate "survey days" for analysis purposes.
[6] Observers were asked to also individually record turtle sightings (i.e. sightings were not called out to the survey leader for recording) in order to keep observers alert. However, this data was not recorded consistently by all observers, and so cannot provide any usable information

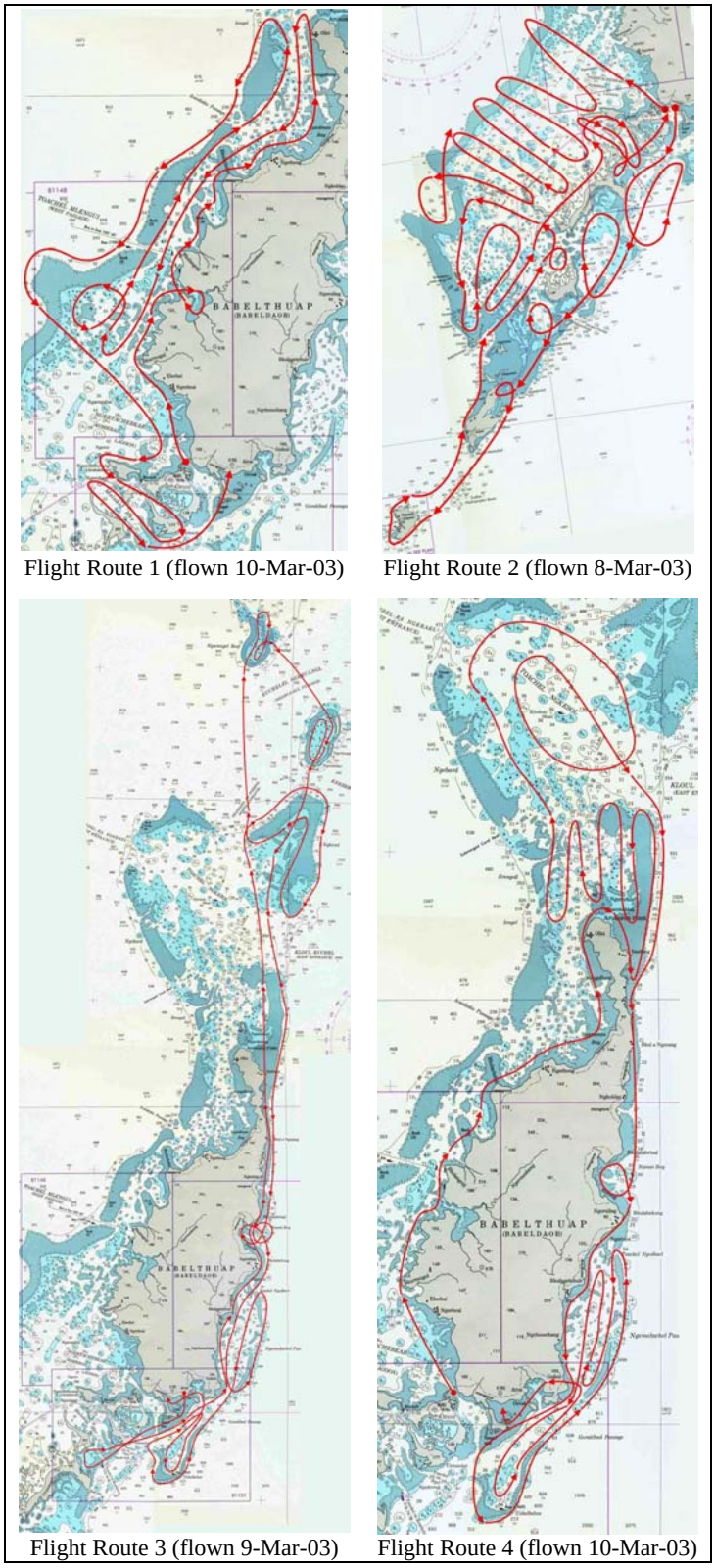



**Figure 3: The four flight routes flown in 2003 (based on the flight routes flown in 1991 and 1998)**

| Year: | 1977[1] | 1978[1] | 1983[2] | 1991[3] | 1998[4] | 2003[5] |
|---|---|---|---|---|---|---|
| **Dates** | Dec.<br>2-3 | Dec.<br>11-15, 17-18 | Aug.<br>19, 21-24, 26 | Aug.<br>5-8 | Oct.<br>26, 29-30 | Mar.<br>8-10 |
| **Tidal Phase** | Neap (decreasing)[6] | Spring | Spring | Spring (increasing) | Neap | Neap (decreasing) |
| **Type of Aircraft** | Low-wing | High wing | High wing | High wing | High wing | High wing |
| **No. of Observers** | 4 | Usually 3 | 3 | 4 | 3-6 | Usually 5 |
| **Observer Experience** | High? | High? | High? | Very high | Low | Low-med. |
| **Altitude (m)** | 275 | 275 | 150-300 | 275 | 244 | 198 |
| **Airspeed (km/hr)** | 120-130 | 115-145 | 170 | 200 | 204-213 | 185-204 |
| **Sea State** | N/A | Fair-excellent | Beaufort 0-2 | Beaufort 1-3.5 | Beaufort 2-3 | Beaufort 1-3 |
| **Cloud Cover** | N/A | <5-100% | 0-80% | Generally overcast | 30-75% | 25-75% |
| **Observation Time (mins)** | 304 | 1013 | 905 | 469 | 367 | 535 |

**Table 1: Comparison of flight details for all six aerial surveys.**
([1] Brownell, *et al.* (1981); [2] Rathbun, *et al.* (1988); [3] Marsh, *et al.* (1995); [4] Smith (1998, unpublished data); [5] Smith (2003, unpublished data); [6] Decreasing average tidal range.)

### 2.3 Results

In this section, the six aerial surveys are compared and contrasted in terms of type of aircraft used, observation times and other factors (Table 1). Where possible, a comparison has been made between the last three aerial surveys (1991, 1998 and 2003) as conditions were most similar for these years. However, the limitations of such a comparison must be stressed in light of the variable conditions for each survey. The overall picture is one of relative dugong distribution and numbers, rather than actual numbers. As noted above, this data cannot be extrapolated to estimate population size.

The total numbers of dugongs sighted are fairly similar across all survey years, except for the counts in 1977 which were particularly low (15 animals) (Table 2). This may have been due to a combination of decreased field of vision for observers in a low-wing aircraft, and a relatively short observation time (Table 1). Comparing numbers of dugongs seen per unit time per survey day (Table 2, and footnote 5) provides a more realistic comparison between results from the different survey years.

| Year: | 1977[1] | 1978[1] | 1983[2] | 1991[3] | 1998[4] | 2003[5] |
|---|---|---|---|---|---|---|
| **No. Dugongs Counted** | 15 | 34 | 38 | 26 | 33 | 27 |
| **% Calves** | 13.3 | 23.5 | 7.9 | 15.4 | 21.2 | 25.9 |
| **Dugongs/Min /Survey Day ± SE** | 0.069 | 0.086 ± 0.015 | 0.119 ± 0.020 | 0.042 ± 0.023 | 0.116 ± 0.064 | 0.051 ± 0.0 |
| **Mean Group Size ± SE** | N/A | 2.0 ± 0.30 | 1.38 ± 0.11 | 1.37 ± 0.16 | 2.1 ± 0.38 | 1.6 ± 0.19 |
| **Largest Group Seen** | N/A | 5(+) | 7 | 3 | 7 | 4 |
| **Total No. Seen in Malakal Area (Sect: I, II & VII)** | 9 | 13 | 2 | 9 | 20 | 15 |
| **% of Total Seen in Malakal Area** | 60 | 38.2 | 5.3 | 34.6 | 60.6 | 55.6 |

**Table 2: Comparison of numbers of dugongs seen, group size and calf abundance**
([1] Brownell, *et al.* (1981); [2] Rathbun, *et al.* (1988); [3] Marsh, *et al.* (1995); [4] Smith (1998, unpublished data); [5] Smith (2003, unpublished data)).

The rate of dugong sightings was highest in 1983 (0.119/min/day) and 1998 (0.116/min/day), although in 1998, Route 3 was not completed and this is the route with historically the least dugong sightings, and if completed would have most likely lowered the overall sighting rate.

The lowest sighting rates were in 1991 (0.042/min/day) and 2003 (0.051/min/day).

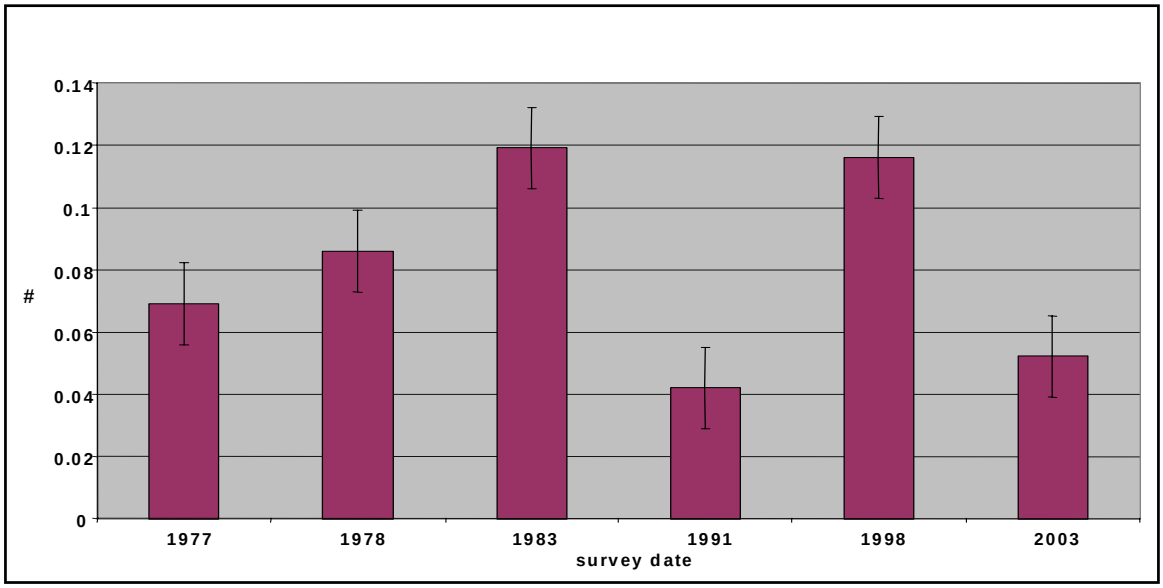



**Figure 4: Average number of dugongs seen per unit flight time for the six aerial surveys**

**Spatial distribution**

A total of 27 individuals were counted during the course of the 2003 survey, seven of which were calves. As in previous years, the highest concentration of dugongs was found in the Malakal Harbor area. Most sightings in the northern waters of Babeldaob occurred in the western lagoon, close to the states of Ngatpang and Ngardmau. Only one individual was seen on the eastern side of Babeldaob. In all previous aerial surveys, with the exception of 1983, the Malakal Harbor area (see segments I, II and VII on Figure 5) has been identified as an important habitat for dugongs, with the greatest concentrations of animals being observed here. Typically, 35-60% of the total animals recorded were seen in this area.

The earliest surveys (1977, 1978 and 1983) were not compared in Table 3 because of differences in aircraft, longer flight times (up to 2-3 times the length of later surveys) and/or number of times each segment was surveyed (between 1 and 9 times in earlier survey compared to 1-3 times in later surveys). Only 7.7 % of dugongs observed in the 2003 flight were in shallow water (where the bottom was visible) and this is consistent with Marsh's observations in the 1991 survey, when all but 8 % of dugongs were seen in deep water (Marsh *et al.*, 1995).

Most dugongs are found in segments I – II, (Malakal Harbor and north-east of Ngel Channel towards Airai) and V-VI (Ngardmau Bay and the western lagoon). No dugongs have been seen north of Ngerchelong except for a mother and calf pair sighted in Kossol Lagoon in 1998. Few dugongs have been seen south of the Malakal Harbor area, with no sightings recorded south of Mecherchar in the waters of Peleliu or Angaur. However, in 1978 and 1983, six individuals were seen in the southern sections of VIII, IX and X. These observations may have been due to increased flight times (up to twice as long). The aerial sightings for these three survey years are displayed in Figure 6.

| | **No. of Dugongs Adults—Calves** | | | **% of Total Dugongs Counted** | | |
|---|---|---|---|---|---|---|
| **Segment** | **1991** | **1998** | **2003** | **1991** | **1998** | **2003** |
| **I** | 3—1 | 3—1 | 3—1 | 15.4 | 12.1 | 14.8 |
| **II** | 1—1 | 13—2 | 9—3 | 7.7 | 45.5 | 44.4 |
| **III** | 2—0 | 0—0 | 1—0 | 7.7 | 0 | 3.7 |
| **IV** | 1—0 | 0—0 | 1—1 | 3.8 | 0 | 7.4 |
| **V** | 4—0 | 2—2 | 3—1 | 15.4 | 12.1 | 14.8 |
| **VI** | 10—2 | 5—0 | 1—0 | 46.2 | 15.2 | 3.7 |
| **VII** | 1—0 | 1—0 | 0—0 | 3.8 | 3 | 0 |
| **VIII** | 0—0 | 1—1 | 1—1 | 0 | 6.1 | 7.4 |
| **IX** | 0—0 | 0—0 | 0—0 | 0 | 0 | 0 |
| **X** | 0—0 | 0—0 | 1—0 | 0 | 0 | 3.8 |
| **XI** | 0—0 | 1—1 | 0—0 | 0 | 6.1 | 0 |
| **XII** | 0—0 | 0—0 | 0—0 | 0 | 0 | 0 |
| ***Sub-Totals*** | *22—4* | *26—7* | *20—7* | | | |
| **TOTAL** | **26** | **33** | **27** | | | |

**Table 3: Relative distribution of dugongs in aerial survey segments (Figure 5)**. Segments in which >10% of the total number of dugongs were sighted have been highlighted.

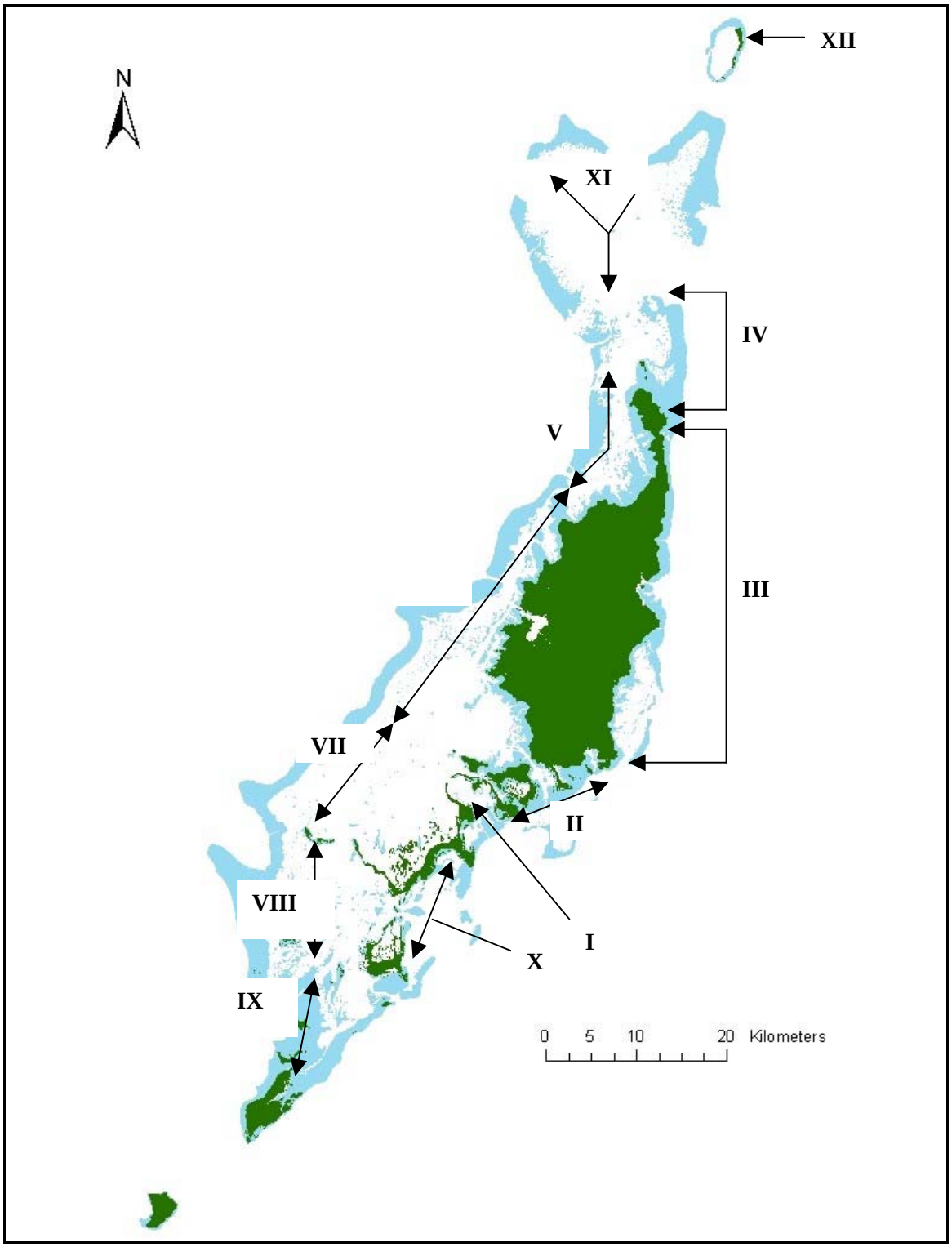



**Figure 5: Map showing the twelve aerial survey sections used for measuring dugong distribution in Palauan waters** (After Brownell et al., 1981)**.**

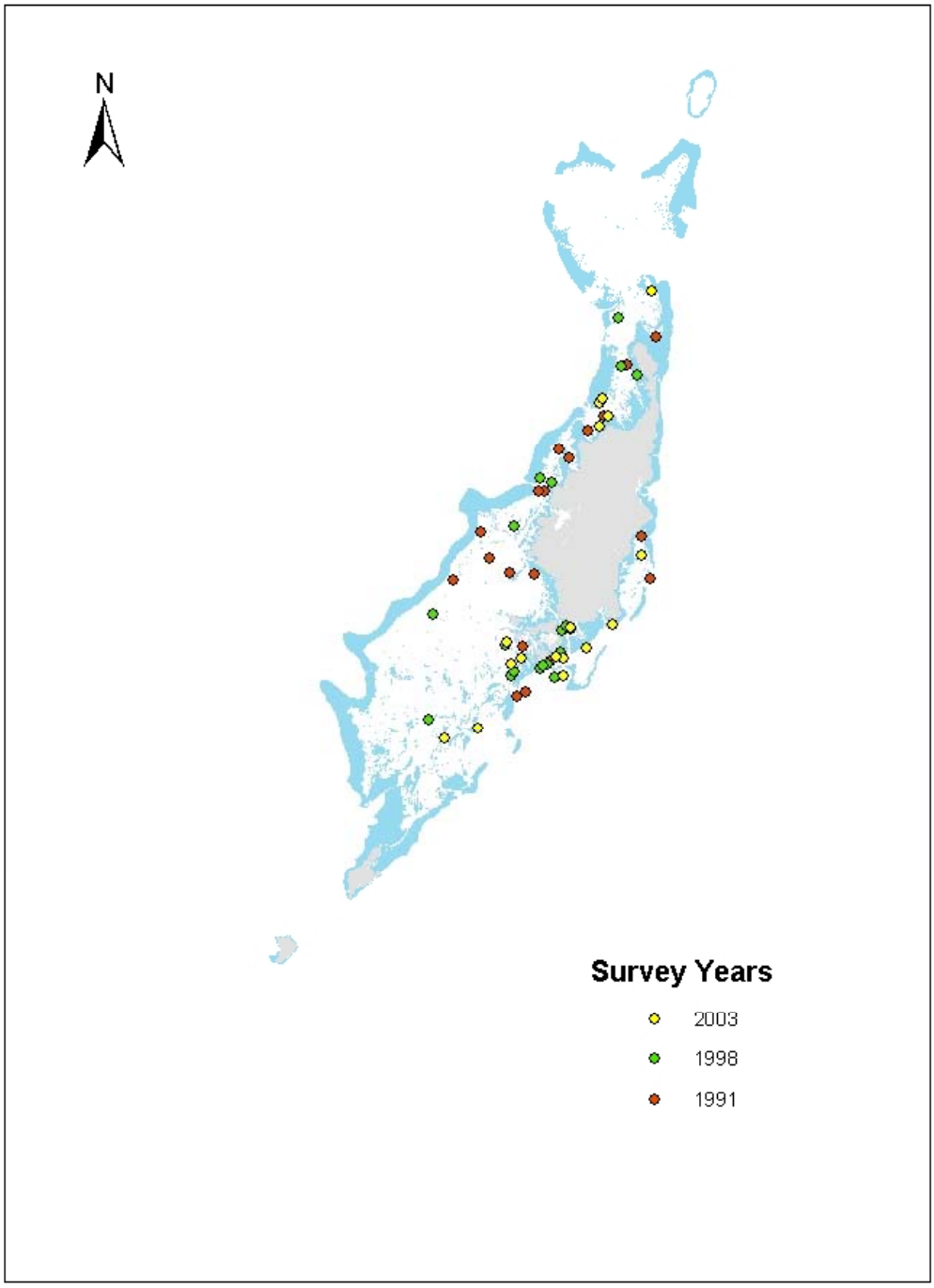



**Figure 6: Map showing location of sightings of dugongs from the past three aerial surveys.**

**Calves**

The percentage of calves seen is highly variable across the survey years (7.9 - 25.9 %), which could reflect fluctuations in calving rates, and/or be due to the difficulty in sighting calves from the air that may be swimming underneath their mothers, and/or possibly reflect the differing time of year of each survey (Figure 7). In 1978, 1998 and 2003 similar percentages of calves were observed so there do not appear to

have been any drastic changes in calving rates over the past 25 years. The average proportion of calves seen in Australian and Torres Straits surveys, varies from 9-14% (Anderson, 1986, Anderson, 1989, Marsh *et al.* 1984, Marsh, 1986, Marsh *et al.*, 1997). So in comparison, it appears that the proportion of calves see in Palau is high. The groups of dugongs observed in Australia were, however, larger and calves may be more easily overlooked when compared to the distinct lone female-calf pairs usually observed in Palau. Smaller groups are seen around Torres Strait but even so, the proportion of calves is, on average, much lower. It could be possible that the reproductive interval for females is on average lower for female dugongs in Palau, when compared to those in Australia. Factors that may contribute to possible higher calving rates in Palau might include:

- Less competition for food (abundant food resources and little competition due to low population size)
- Relative lack of seasonality (constant warm waters throughout the year)
- Limited potential migration distances relative to Australia (10s of km versus 100s of km).

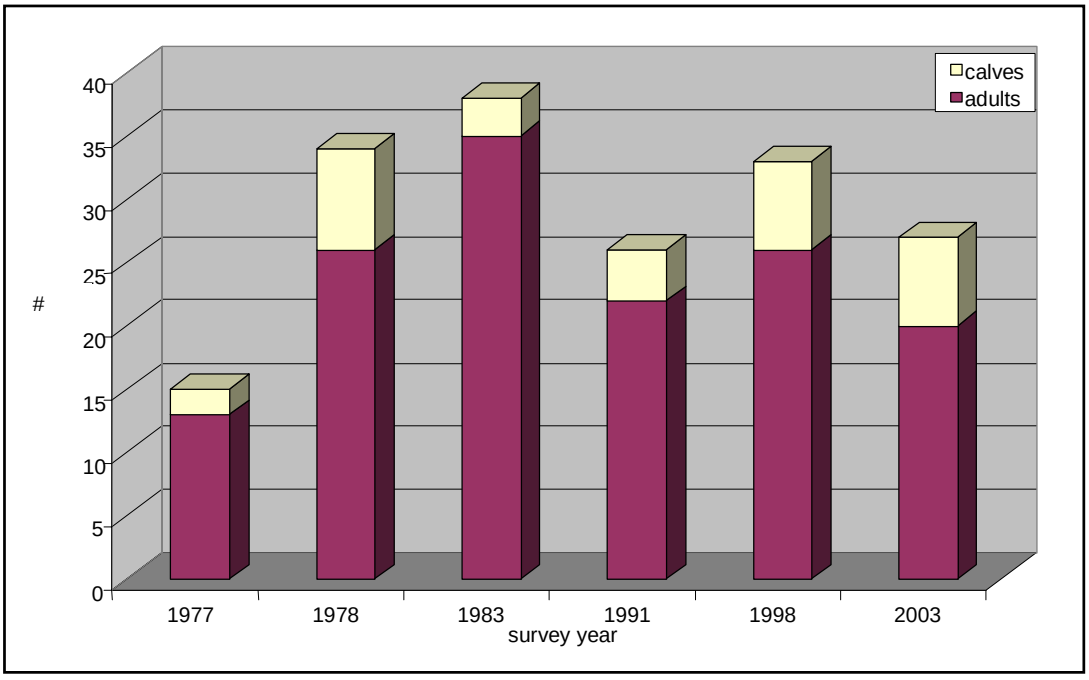



**Figure 7: Numbers of adults and calves seen on each aerial surveys**

All cow-calf pairs were seen on or very close to reefs in 1998 and 2003, most likely for the purpose of sheltering the calves from strong currents and possibly to allow a quick escape to shallow waters in the presence of predators. In 1998, three cow-calf pairs were seen in the Malakal Harbor area (I and II) three cows with calves in north and northeast Babeldaob areas (section V and XI), and one pair in the Rock Islands area (section VIII). In 2003, four pairs were observed close to reefs in the Malakal Harbor area (I and II), with two pairs in north Babeldaob (IV and V), and another pair within the Rock Islands (section VIII) (Table 3). There has been speculation that dugongs in Palau are restricted in their feeding habits by poaching and boat activity and thus rest by day and come into shallow waters to feed by night when these threats are lessened. However, cow-calf pairs are also likely to be in close proximity to high-quality resources at all times, not only during the night, as lactation makes heavy energy demands on females. Females with calves need to be feeding more often and/or on better quality resources than lone dugongs, thus it is possible to infer that high quality seagrasses are likely to be present in sections I, II and V (Malakal Harbor and the northwest lagoon). Although feeding or feeding plumes were not observed during the 2003 aerial survey, this does not mean that dugongs were not feeding. Flying at such altitude

and speed, it was unlikely that observers would see dugongs in the process of feeding, especially if this involved the animals diving to depths of up to 10 m or more.

**Group sizes**

The most common group size observed in all aerial surveys was 1 or 2 dugongs, usually a lone adult or a female with her calf. The mean group sizes seen across survey years ranges from 1.4 to 2.1 animals. The largest groups seen were seven dugongs in 1983 and 1998. Rathbun *et al.* (1988:268) note that the group observed in 1983 was swimming "with one animal in the lead and the rest following behind and to the sides in a compact group (within 1m of each other)." He compares this behavior with the 'mating herds' of manatees seen in Florida. These types of groups, consisting of males chasing a female have since been described in dugong studies by Anderson (1989) in Moreton Bay, Australia. Of the group of seven observed in 1998, initially four dugong were spotted 'idling', then another three surfaced while the plane circled (A. Smith, per comm.). The bottom of the lagoon was not always visible during the surveys, so there may have been more dugongs below the surface that could not be seen from the air.

In the Palau aerial surveys, occasionally three dugongs were seen together, one cow-calf pair and a third animal. The third adult may either be another female, or it may be the cow's previous calf that has reached adult size, but remains with the cow. In the cases where four adults have been observed, they may be females and sub-adults.

Herd sizes of 20 have been observed in Queensland and 100 or more in Moreton Bay (south-east Queensland, Australia), Shark Bay (Western Australia) and Cape York (north-east Australia) (Marsh and Saalfeld, 1989). Smaller maximum herd sizes and higher dispersion seems to be typical of tropical island ecosystems, when compared to Australia's continental shelf (De Iongh *et al.*, 1995). For example, the largest group size seen in aerial surveys of the Torres Strait populations in 1992 was eight, and over 75 % of animals were alone or in cow-calf pairs (Marsh *et al*., 1997). In the 1990 and 1992 aerial surveys of dugongs in the Lease Islands, Indonesia, the mean group size observed was 2.5 to 3.0 animals (De Iongh *et al*., 1995), only slightly higher than the mean observed in Palau (1.4 to 2.1 animals). De Iongh *et al.* (1995) describes dugongs as 'mildly social' and 'facultative herders' with groups representing feeding assemblages with loose social interactions rather than fixed herds with strong social bonds. This is confirmed in the case of dugongs in Palauan waters which, aside from cow-calf pairs, appear to be largely solitary.

There appears to be consistent grouping behavior close to Ngel Channel in the Malakal Harbor area. This 'Malakal herd' was identified by Brownell *et al.* (1981) and re-sighted in subsequent survey years. This grouping behavior could be anti-predatory in nature as the animals are in deeper, exposed waters and may be more vulnerable to shark attacks, however, in 1998 this group was observed to be diving, not only idling on the surface, so they may also have been feeding.

**Deepwater habitats**

Large herbivorous mammals such as dugongs need to feed continuously on large amounts of vegetation to satisfy their energy requirements. Mono-specific deepwater beds, consisting of *Halophila ovalis*, have been identified in both the Rock Islands southern lagoon and in channels in the western barrier reef at depths of up to 30 m (P. Colin, pers. comm., 2003, J. Kuartei pers. comm., 2003). Although dugongs are seen over deeper water away from extensive shallow seagrass beds during the day, they may be accessing these deeper resources before moving into shallower waters at night (see previous comments on energy demands of lactation). This behavior may also be related to past day-time hunting pressures and boat traffic in these shallow areas. Not sighting dugongs in shallow water during the aerial surveys may also be an artifact of the tidal phases.

### 2.4 Additional Information

The following information relates to dugong life history, but was not collected during the aerial survey.

**Reproduction**

Brownell (1981) observed neo-natal calves in December 1978 and Asano (1938) captured a calf that measured only 1.19 m in September 1937. Since dugongs measure approximately 1.1 m at birth (Marsh *et al.*, 1978), the animal captured in 1937 was a very young individual and we can infer that births occur at least from September to December in Palau (Brownell *et al.*, 1981). Marsh *et al.* (1984) conclude that breeding is diffusely seasonal in tropical Australian waters, occurring over several months, mostly August-September, through to December. Since the gestation period is approximately 13 months, it is likely that calving and mating occur at fairly similar times. Dugongs are likely to calve in shallow, sheltered waters, possibly in bays or close to the shore. Calving may occur prior to the new shoot growth of seagrasses off Townsville, Australia, which starts in August so that females and calves, which start feeding soon after birth, can take advantage of the highly nutritious new-growth plants (Marsh *et al.*, 1984). No studies have so far been conducted on the monthly fluctuations in seagrass biomass in Palau.

## 3. LOCAL KNOWLEDGE AND INCIDENTAL SIGHTINGS

This section summarizes the information on local knowledge about dugongs obtained by Palau Conservation Society (Matthews, 2003), and the development of an incidental sightings system for Palau.

### 3.1 Objectives

The contractor, Palau Conservation Society, was asked to:

1. *Incidental Sightings:* Develop a system for collecting and recording incidental sightings (live animals) and reporting (carcasses, poaching, etc.) of dugongs (*Dugong dugon*) in Palau. It was to include, at a minimum:
    - Designing, then producing and widely distributing sighting/reporting cards throughout Palau.
    - Establishing a process for retrieving cards that have been filled out.
    - Designing and establishing an incidental sightings/reporting database, with input, analysis, mapping, and reporting programs and associated instructional documentation for ease of use.
    - Arrangements to maintain the system after this contract.
    - Producing an annual summary report of sightings/reports for distribution to appropriate agencies in Palau.

2. *Local Knowledge:* Conduct structured and unstructured interviews with key Palauans knowledgeable of dugongs. Information collected should, at a minimum, include distribution, movements, habits, general behavior, perceived changes over time, and any other relevant information.

## 3.2 Methods

### Interviews

A total of 47 men from 14 of Palau's 16 states were interviewed between December 2002 and February 2003 by staff from the Palau Conservation Society (PCS). These men were fishermen who were identified by community members as being knowledgeable about dugongs. Interview questions related to the cultural significance of dugongs, past and present use and changes in behavior or distribution over time.

### Incidental Sighting System

A reporting system for incidental sightings of dugongs by local residents was established by PCS so that information on dugong locations and behavior could be stored over the long-term in a central database.

## 3.3 Results

### Interviews

#### *Sightings*

Informants were asked to mark areas where they had seen dugongs on topographic maps. The areas identified have been displayed below in Figure 8.

There is an obvious overlap between anecdotal sightings and aerial sightings, except for north-east Babeldaob which was identified by interviewees, although no dugongs were sighted here from the air. Dugongs may visit these areas at night or when waters are particularly calm as the coastline here, unlike on the western side of Babeldaob, does not benefit from the protection of a barrier reef. There may have been more difficulty sighting dugongs on the north east coast due to deeper waters in closer proximity to the coast. This contrasts with the shallow wide lagoon on the west coast, in which dugongs may be more visible from the survey plane.

Just over half of the men interviewed (53 %) thought that dugongs occupied the waters close to their State all year round and 43 % had seen dugongs more than five times in the past year in the following states:
Aimeliik
Koror
Melekeok
Ngaraard
Ngchesar
Ngiwal
Peleliu
Ngerchelong
Ngeremlengui
Ngatpang

Most had never seen dugong feeding (77 %). The 19 % of respondents who claimed to have seen dugong feeding, said they had been in the following states:
Airai
Koror
Melekeok
Ngaraard
Ngerchelong

Ngeremlengui
Ngchesar
Ngiwal

***Large groups***

Large groups of dugongs had only been seen by respondents in the following areas five years ago, although the number of dugongs that constituted a ‘large’ group was not specified in the questionnaires:
Ngederrak, Koror
Chesengel, Melekeok
Meteu a toachel, Melekeok
Peleliu

***Changes in numbers***

When asked whether they thought there were more or less dugongs than 5 years ago, 10 years ago, or 50 years ago, just over half of respondents thought there were less, but surprisingly, about one third thought there were more. Declines were attributed to increased boat traffic and hunting.

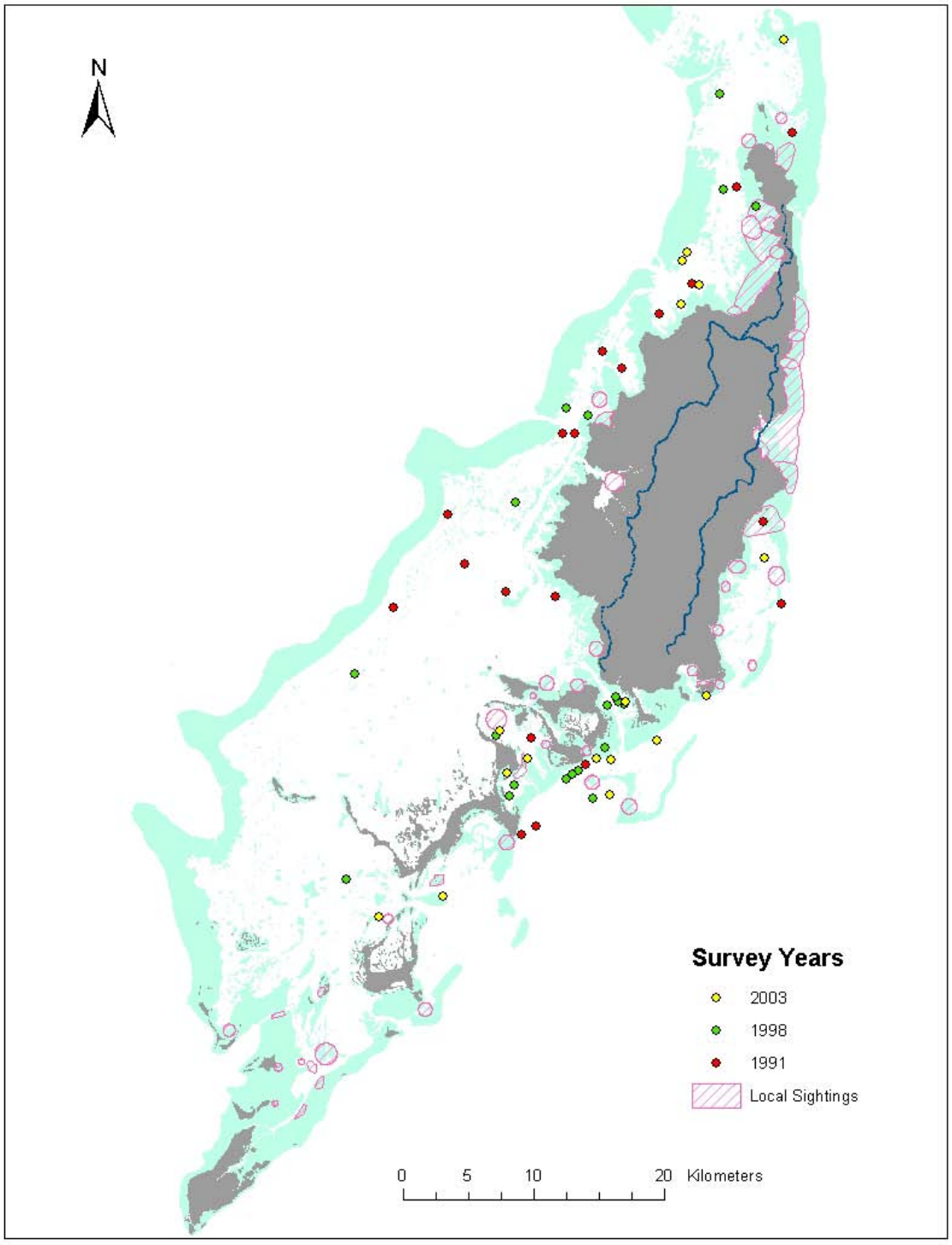



**Figure 8 : Map showing dugong habitats described from interviews (PCS) with fishermen overlaid with sightings from recent aerial surveys.** The Compact Road, currently in its fifth year of construction is shown in dark blue.

**Present use**

The majority of interviewees (60 %) agreed that hunting still occurs in Palau. 44 % of respondents said that dugong was still eaten in their State, although 43 % said it was not. One-third said dugong was eaten less than once a year, whilst the remainder gave no response. There was much reluctance to discuss the issue of hunting compared with previous interviews (Rathbun *et al.*, 1988, Marsh *et al*., 1992), most likely due to new legislation passed in 2002 to increase penalties for killing dugong from $100 to $5,000-10,000. One-third of the men said that calves were the preferred target of hunting and methods used to kill dugong included spear (46 %), speargun (17 %), boat (11 %) and/or dynamite (9 %). It was interesting to note that the majority of men questioned (74 %) felt that dugong were no longer a valuable part of Palauan culture.

***Past use and cultural significance***

70 % of respondents said that bracelets were made in their State from dugong vertebrae in the past and 70 % believed this no longer occurred. Most stated that dugong had been eaten less than once a year in the past. There was a great difference in answers pertaining to who could catch dugong and eat it in the past. 75% of the men said anyone could hunt dugong in the past and about half said that the meat could be eaten by anyone, whereas a quarter said that it could not. The period of time in question was not specified in the interviews, so there may have been variation in the interpretation of 'past', with some respondents talking about the distant past (50-100 years ago) and others describing the more recent past (10-20 years ago). 60 % said that dugong was eaten at any time with only 4 % claiming it was eaten only at special occasions. In this case, the 'past' may have been interpreted by the respondents as more recent than intended by the questionnaire or knowledge of past ceremonial traditions has been lost.

***Comparison with past interviews***

*Reported deaths*
Due to the tougher legislation pertaining to poaching of dugong and the concurrent reluctance to talk about hunting issues, it is difficult to determine approximate numbers of dugong that are being hunted annually in Palau. However, it appears that poaching continues despite the new law and there appears to be ubiquitous preference for the meat of calves. During a three month period, between December 2002 and March 2003, there were three reported deaths of dugongs (pers. obs.), two of which were found floating close to Koror, a juvenile male which may have been hit by a boat and a mature female that may have been killed by explosives. In the latter case, it is likely that a calf and/or another female were taken by the poachers. Both of these animals were feeding when they died and it is likely that they were killed at night. The third animal was killed in Melekeok by a poacher and the meat frozen for home consumption. There was an additional rumored killing of a calf in Koror over the Christmas period, 2002. This makes a possible death toll of four dugongs within a three month period.

Interviews in 1983 focused on hunting methods and estimates of dugongs killed per year (Rathbun *et al.*, 1988). At least seven dugongs had been killed in 1982 and several in 1983. In 1991, dugongs were still being poached regularly with four to seven dugong hunting teams, consisting of at least two men, operating out of Koror. One informant estimated 11 dugongs had been killed between 1990 and 1991 off the west coast of Babeldaob. It seemed from the interviews that dugong hunting was carried out deliberately rather than opportunistically and timed to obtain meat for special occasions. It was often home frozen and served to guests without their knowledge (as women and children usually disapproved of poaching). Hunters affirmed that they preferred the meat of females and juvenile dugongs. In 1991, Marsh *et al.*(1992:88) noted that "[Palauans] appreciate dugongs as part of their fauna and natural heritage." It seems to be the case that most women and children certainly care about the future of the

dugong in Palau (pers. obs), but the majority of fishermen interviewed in 2003 were either indifferent towards dugongs or no longer considered these animals valuable to Palauan culture (Matthews, 2003).

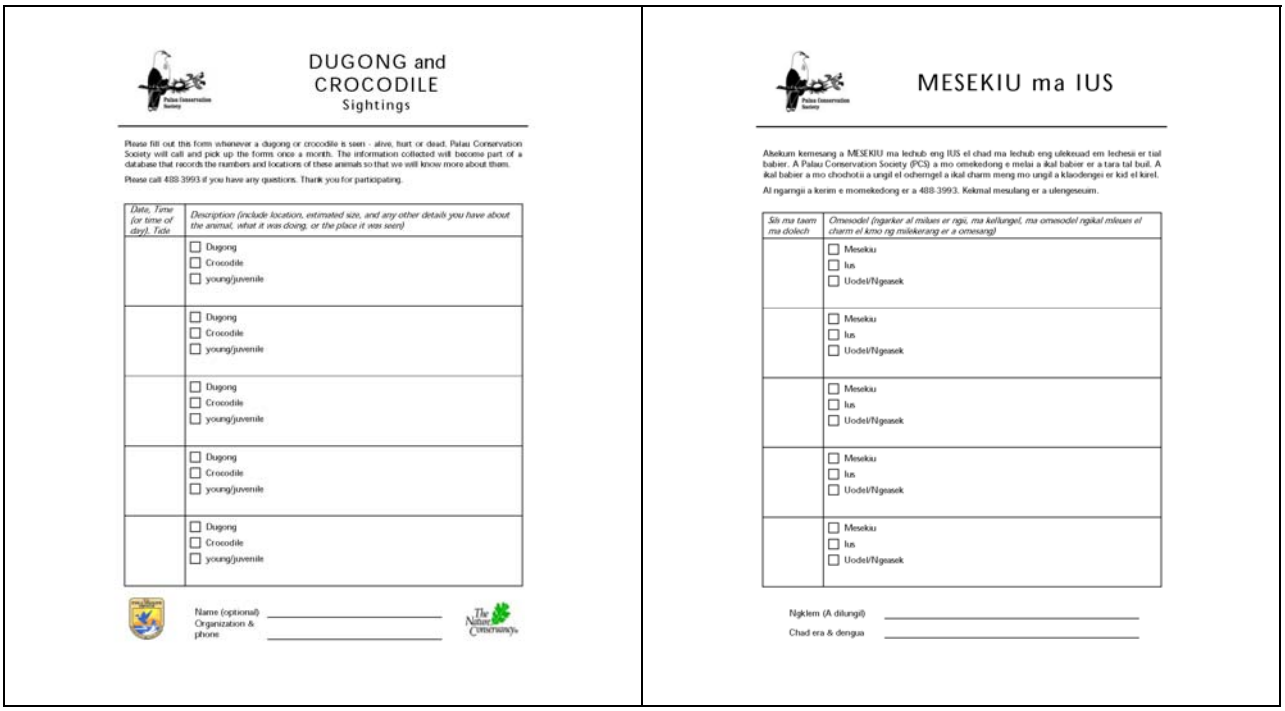
*Jewelry*
In 1991, locally-made jewellery carved from dugong ribs was found at four stores in Koror. By 1996, all forms of jewelry made from dugong bones had been confiscated from stores in Koror and to date, there have been no further reports of such sales. (K. Chin, pers. comm., 2003). With the introduction of new legislation for the protection of dugongs in 2002, owners of dugong bracelets are required to register their pieces with the Bureau of Marine Resources and any unregistered items will be confiscated after a certain date. Registration was due to begin in late 2003, however, by mid-2004 this had not been completed.

*Changes in behavior*
From additional interviews with eight fishermen conducted by Community Centered Conservation (C3) in 2002 and 2003, it appears that dugongs are now hunted opportunistically rather than deliberately, possibly due to the new legislation acting as a deterrent. Poachers often hide a heavy spear used for killing dugong in their boat when they go out at night to hunt for turtles, just in case they come across dugongs feeding in the seagrass beds. The largest group of dugongs seen by respondents was a group of seven and this was led by a large individual (possibly a mating herd). Respondents had noticed a change in habitat use by dugong from the mid to late-1990's. Some individual animals used to be predictable in their movements, often seen on consecutive days and months in a particular area, but due to boat traffic and possibly hunting pressure, they are no longer seen at these specific locations. Three informants mentioned that dugongs like to feed on '*yoad*' or floating seagrasses, and this has been confirmed off Ngederrak through observations during a number of flights (these observations were not during the aerial survey) (Davis and Edward, unpublished data, 2003).

**Incidental Sightings System**

Palau Conservation Society has developed a reporting system for local sightings of dugongs. Sighting cards have been distributed to all dive shops and State offices in Palau from where they will be distributed to the general public. These cards can be returned to the distributing outlet or PCS on completion and the information will be entered into a central database at the office of the latter. As of mid-2004, there have been some reported sightings—three reports, totaling eight dugongs—most have been called in, not reported on the forms. The reporting form is currently being reviewed and revised in light of feedback to date. More effort will be required to ensure that the relevant agencies, the public and tour operators are better informed of the sightings system.

Below is a copy of the current incidental reporting card.



DUGONG and CROCODILE Sightings

Please fill out this form whenever a dugong or crocodile is seen - alive, hurt or dead. Palau Conservation Society will call and pick up the forms once a month. The information collected will become part of a database that records the numbers and locations of these animals so that we will know more about them.

Please call 488 3993 if you have any questions. Thank you for participating.

| Date, Time (or time of day), Tide | Description (include location, estimated size, and any other details you have about the animal, what it was doing, or the place it was seen) |
|---|---|
| | ☐ Dugong ☐ Crocodile ☐ young/juvenile |
| | ☐ Dugong ☐ Crocodile ☐ young/juvenile |
| | ☐ Dugong ☐ Crocodile ☐ young/juvenile |
| | ☐ Dugong ☐ Crocodile ☐ young/juvenile |
| | ☐ Dugong ☐ Crocodile ☐ young/juvenile |

Name (optional) _____

Organization & phone _____

The Nature Conservancy

MESEKIU ma IUS

Afsekum kemesang a MESEKIU ma lechub eng IUS el chad ma lechub eng ulekeuad em lechesii er tial babier. A Palau Conservation Society (PCS) a mo omekedong e melai a ikal babier er a tara tal buil. A ikal babier a mo chodhotii a ungil el odhemgel a ikal charm meng mo ungil a klaodengei er kid el kirel.

Al ngarngii a kerim e momekedong er a 488-3993. Kekmal mesulang er a ulengeseuim.

| Sils ma taem ma dolech | Omnsodel (ngarker al milues er ngii, ma kellungel, ma omnsodel ngikal mileues el charm el kmo ng milekerang er a omesang) |
|---|---|
| | ☐ Mesekau ☐ Ius ☐ Uodel/Ngeasek |
| | ☐ Mesekau ☐ Ius ☐ Uodel/Ngeasek |
| | ☐ Mesekau ☐ Ius ☐ Uodel/Ngeasek |
| | ☐ Mesekau ☐ Ius ☐ Uodel/Ngeasek |
| | ☐ Mesekau ☐ Ius ☐ Uodel/Ngeasek |

Ngklem (A dilungil) _____

Chad era & dengua _____

**Reported sightings**

Prior to the establishment of the PCS-based incidental sightings system, an informal incidental reporting system was established Community Centered Conservation (C3) in July 2002, with participation from dive shops, researchers and individuals. Most sightings were reported in July-September and also in January, with few sightings in the interim months. The south-west winds are strong in the former months, which may account for more dugongs being seen in the sheltered areas close to the Rock Islands during these months.

Aragones (1994) notes that in Palawan (Philippines) more dugongs were sighted during the summer (March-April) and wet season months (May-June) of 1989. This coincides with the bimodal biomass peaking of seagrasses in the Philippines (Fortes, 1984). No studies have yet been conducted on biomass fluctuations of seagrass beds in Palau, but the biomass may also peak during the wetter months of July-September.

## 4. SEAGRASS SURVEYS

This section summarizes the results of the seagrass surveys undertaken by the Palau International Coral Reef Center (Idip, 2003).

### 4.1 Objectives

The contractor, Palau International Coral Reef Center (PICRC), was asked to:

1. Use a range of sources—such as: past aerial photographs, any available remote sensing images, the past distribution patterns of dugong sightings (combining all previous aerial surveys), and local knowledge—to identify potential areas of dugong feeding habitat, that is, seagrass beds with appropriate species.

2. After identifying likely areas of dugong feeding habitat, conduct extensive ground-truthing by snorkeling and/or diving these areas to determine the extent (with GPS) of the seagrass beds and the basic species composition. The results were to be mapped for incorporation into Palau's national GIS system.

3. Prepare a report documenting the methods used, results and recommended future research and monitoring needs. Include maps of the identified seagrass beds (in hard and digital formats – GIS layers in ArcView® format).

## 4.2 Methods

### Study Sites

Four survey sites were identified, based on dugong distribution observed during all the aerial surveys undertaken to date, information from PCS's interviews in 2003, and by using remotely sensed images.

The selected survey sites were Ngederrak reef (Koror), Ngesekesau (Koror), Bkul Omelochel (Airai),) and the seagrass bed stretching from Ngardmau (Btaoat reef) to the Ollei dock in Ngerchelong. (Figure 9).

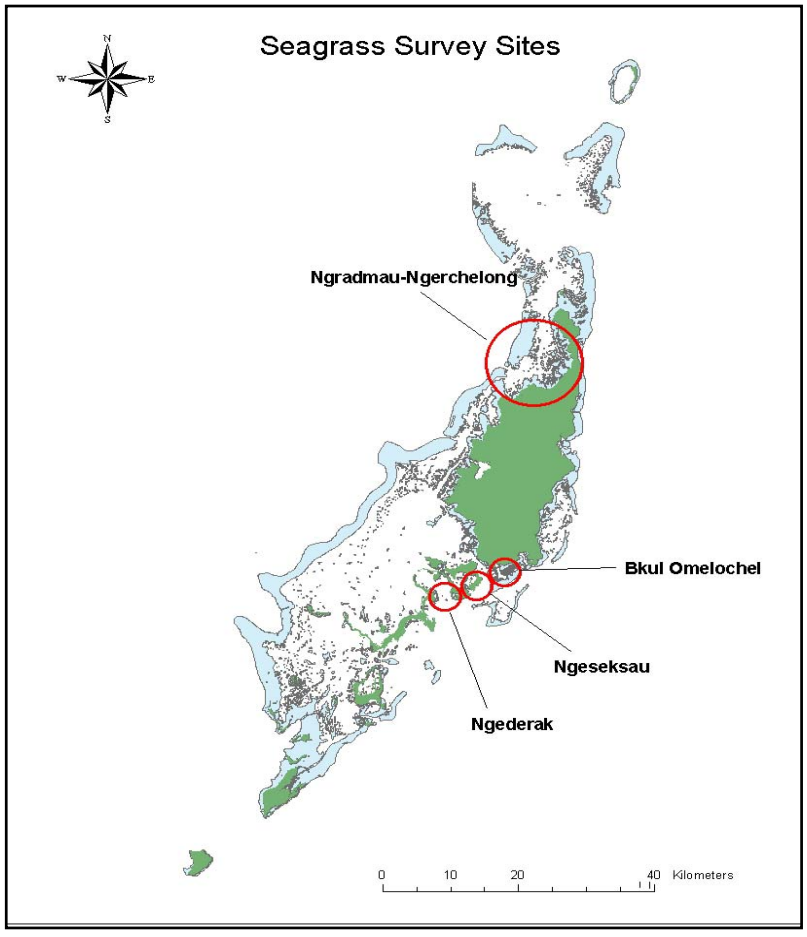



**Figure 9: Seagrass survey sites**

**Preliminary surveys**

The selected sites were visited and preliminary surveys were done to determine the overall composition of the area. These surveys were very quick qualitative surveys. The techniques involved in the survey were fairly simple. At the site, random points were chosen and the GPS coordinates were noted. At each random point a diver swam around for about five or ten minutes and noted down observations such as bottom character, visibility and the absence or presence of seagrass. If there was seagrass present, the estimated abundance and species was recorded. The information collected along with the satellite imagery was then used later to determine the position and number of transects at the sites and also was used in the classification of seagrass meadows.

**Imagery used**

The images used for the survey were IKONOS imagery. IKONOS is a satellite-based platform operated by Space Imaging Inc. that captures digital images in four spectral bands as well as panchromatic images. The four spectral bands are Red, Green, Blue and Near Infrared. Resolution for the spectral bands is 4 meters while the panchromatic band offers a resolution of 1 meter. The images were taken by the satellite in November of 2000. Mainly because of their availability and their high resolution, IKONOS imagery was used for this survey.

When provided, the images were already ortho-rectified and projected using the Universal Trans Mercator (UTM) method with WGS84 datum. Therefore, preprocessing of the images was very limited. The only processing needed was to subset the images of the selected sites and the conversion of the coordinate system from UTM WGS84 to Lat/Long WGS84.

**Transects**

There are a variety of techniques and methods that can be used for ground-truthing. The techniques differ according to the locality features, depth and mapping objectives. For this survey it was decided that a combination of transects and points for the shallow areas (5 meters or less) would be used and GPS tracking for deeper zones (greater than 6 meters).

A total of six transects were used on Ngederrak reef. These transects ran from east to west across the entire extent of the reef with an approximate distance of 300 m between each. Deep-water surveys were also conducted using SCUBA and GPS tracking along the inner channel and along the eastern and western end of the reef flat (Figure 10).



**Figure 10: Transects surveyed on Ngederrak Reef.** Red lines indicate shallow water-transect. White lines represent deep-water survey lines.

Thirteen transects were used at Ngesekesau reef. Seven transects on the northern end of the seagrass bed ran in an east/west direction. The other six transects ran in a north/south direction. Distance between the transects was again approximately 300 meters. One deep-water survey was conducted along the western border of the reef (Figure 11).

At Bkul ra Omelochel a total of 12 transects were used. All transects ran parallel to each other and ran in a north/south direction. Distances between transects were approximately 300 meters. One deep-water survey was conducted along the western end of the reef and another was conducted along the eastern end (Figure 11).

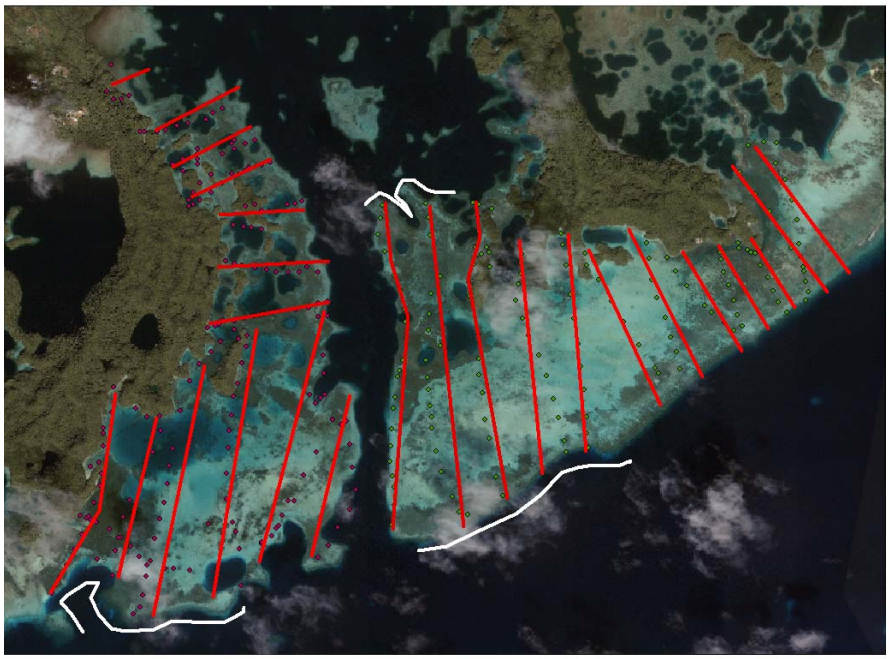


**Figure 11: Transects for Ngesekesau reef and Bkul ra Omelochel.** Red lines indicate shallow water transect. White lines represent deep-water survey lines

A total of 31 transects were used for the survey in Ngardmau, Ngaraard and Ngarchelong (Figure 12). Due to the extent of the seagrass bed transects were placed further apart from each other, between 500 meters and 1,000 meters apart. Most transects ran from the coast out towards the barrier reef. Deep-water surveys were done at three sites.

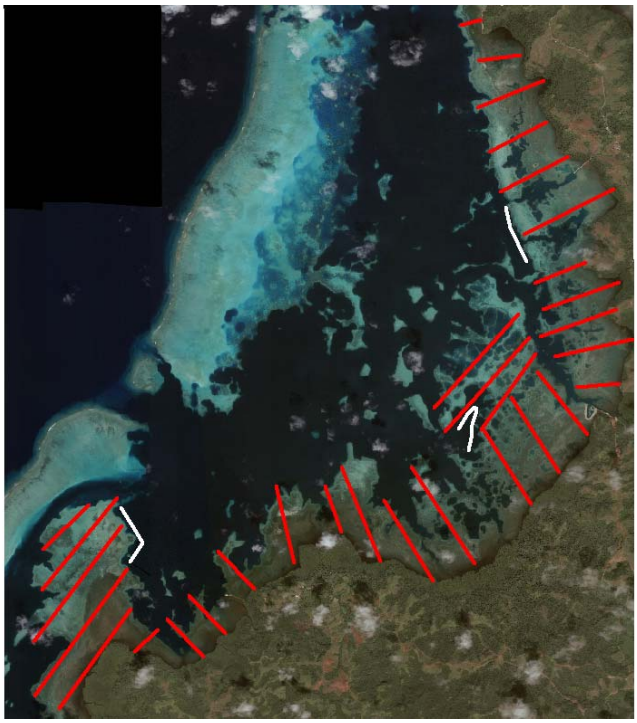


**Figure 12: Transects for Ngardmau/Ngaraard/Ngerchelong reef flat.** Red lines indicate shallow water transect. White lines represent deep-water survey lines

**Ground-truthing**

Prior to the actual field surveys the GPS coordinates of each transect end point was noted. Upon reaching the site, the transects were located by finding either endpoint by GPS or by using land references. Stops were made approximately every 100 meters along the transect. At each stop the GPS was recorded and a diver would enter the water to note the presence or absence of seagrass. If there was seagrass present, the diver would determine the species composition by placing three random 0.25$m^2$ quadrats in the area. This information along with substrate description and depth were recorded onto the data sheet. If no seagrass was present the diver would note this along with substrate composition.

The deep-water surveys were similar to the transect surveys in some cases. Using SCUBA, the diver swam along a predetermined course while the boat slowly followed. Upon reaching a seagrass bed the diver released a float to the surface, signaling to the people on the boat to record the GPS coordinates. The diver then followed the edge of the seagrass bed, making sure to release the float every 50 meters or so to get GPS coordinates. The diver recorded seagrass composition, seagrass percent cover, substrate, and depth at each signaling interval.

**GIS Mapping**

Initially, all data was entered into a MS Excel database and processed. The data was then transferred to ArcView® where it was converted to point shape files and layered onto the respective site images. All images and shape files were projected using Lat/Long WGS84.

The boundaries for the seagrass habitats were determined using data from the field surveys in conjunction with IKONOS imagery of the site and general seagrass characteristics. The boundaries were drawn manually as polygon layers in ArcView® with information about seagrass composition and the extent of the seagrass area attached.

**4.3 Results**

**Definition of a Seagrass Bed**

When mapping seagrass habitats it is important to identify what is considered a seagrass meadow and whether the 'extent' of the seagrass bed consists of only dense areas or includes patchy continuous segments. For this survey, the 'extent' of the seagrass bed includes all portions of the continuous seagrass bed.

**Classification**

The classification schemes for all the sites are based on species composition. With the use of the ground-truthing data and the IKONOS imagery it was possible to classify portions of the entire seagrass bed by seagrass species combination. The species combination classes were site dependent, therefore each site has a different classification scheme.

**Ngederrak Reef**

Figure 13 shows the results of the Ngederrak reef survey. The seagrass distribution on Ngederrak reef is fairly complex. With the mapping scale used, the determination of species community was not possible except for a few areas. Therefore, most of the reef flat was classified as a single area comprised of *Enhalus acoroides, Thalassia hemprichii, Cymodocea rotundata, Cymodocea serrulata, Halophila ovalis,*

*Syringodium isoetifolium*, and *Halodule uninervis.* A sizeable seagrass bed at the southwestern tip of the reef, consisting of *T. hemprichii, C. rotundata, C. serrulata and S. isoetifolium*, was classified into another group. The northeastern end next to Ngel channel was also classified into a separate group consisting of *E. acoroides, T. hemprichii* and *H. ovalis.*

The deep-water survey of Ngederrak reef was the only one that produced positive results. Using the results of this survey, combined with some of the transect data, it was possible to estimate the boundaries for the deeper water area, which was classified into a separate group. The seagrass species in this group are *E. acoroides, T. hemprichii, C. rotundata, C. serrulata, and H. ovalis.*

The total seagrass coverage for the site is approximately 260 hectares or 2.6 $km^2$.

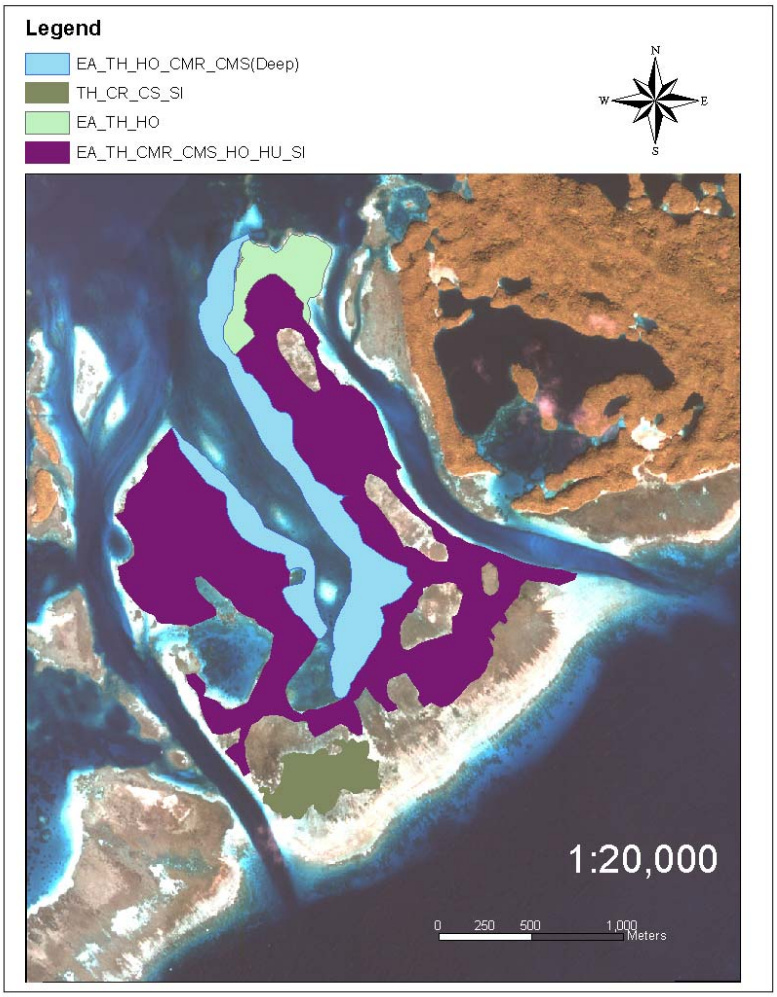



**Figure 13: Ngederrak Reef beds classified by species combinations.**

**Bkul ra Omelochel**

Figure 14 shows the survey result of Bkul ra Omelochel. Species diversity was low at this site in comparison to the other surveyed sites, consisting of only five species, which are *E. acoroides, T. hemprichii, C. rotundata, C. serrulata,* and *H. ovalis.*

The northeastern extent of the surveyed area consists of a dense seagrass bed containing *E. acroides, T. hemprichii, C. rotundata, and C. serrulata*. Seagrass distribution along the reef edge was patchy and consisted of only two seagrasses, *E. acoroides* and *T. hemprichii*. The sandy region in the middle of the seagrass bed consisted of five seagrass species but distribution was very patchy in most parts. Due to the similar species composition, the classification used for this region was also used for the dense seagrass bed located close to Omelochel Island.

The total estimated seagrass area was 249.5 hectares or 2.5 $km^2$ .No seagrass beds were sighted during the deep-water survey.

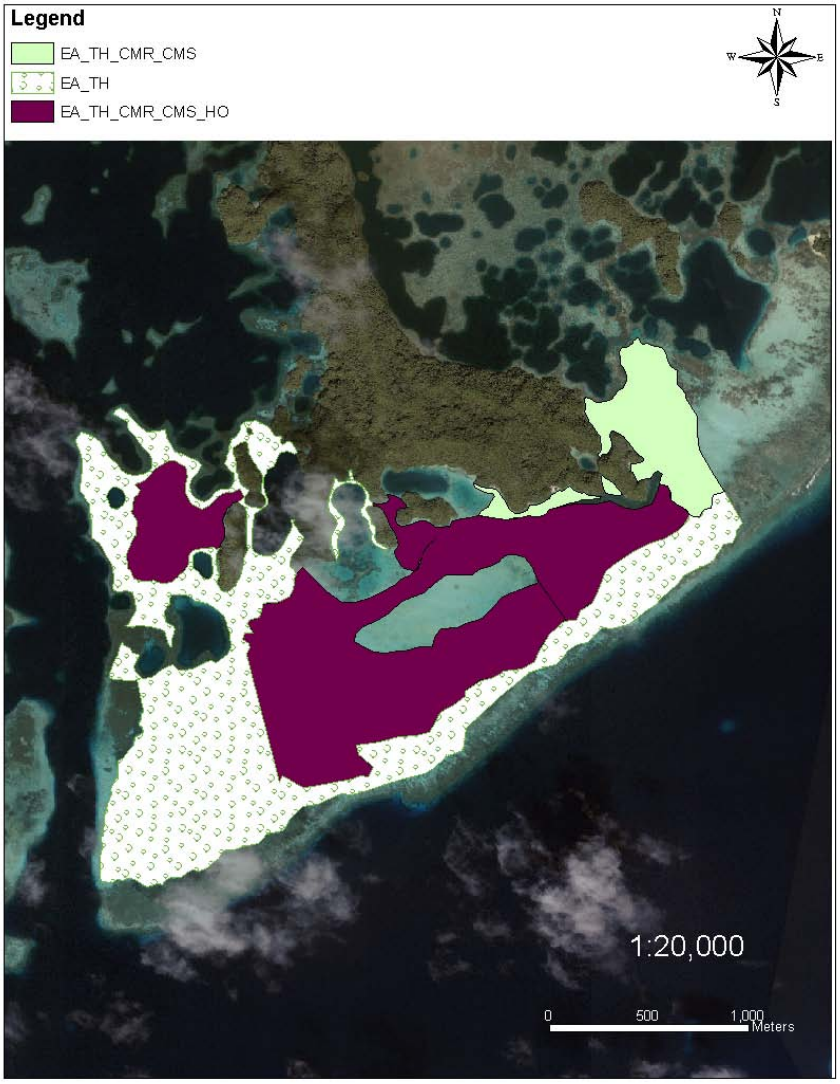



**Figure 14: Bkul ra Omelochel seagrass beds classified by species combination.**

**(3) Ngesekesau Reef (Koror)**

Figure 15 displays the results of the survey at Ngesekesau reef. The dense seagrass bed next to Ucheliungs (southwestern extent of map) was classified as one class. The dense bed consists of seven species of seagrass and they are *E. acoroides,* T. *hemprichii, C. rotundata, C. serrulata, H. ovalis, S.*

*isoetifolium*, and *H. uninervis.* The sandy area to the east was classified as a separate group. This area was dominated by *T. hemprichii* but did also contain *E. acoroides, C. rotundata,* and *H. ovalis.* The northern extent of the seagrass bed consisted mostly of *E. acoroides* and *T. hemprichii*, with *C. rotundata, C. serrulata* occurring in a few areas

No seagrass beds were encountered during the deep-water survey.

The total extent of this seagrass bed is estimated to be 259.4 hectares or 2.59 $km^{2.}$

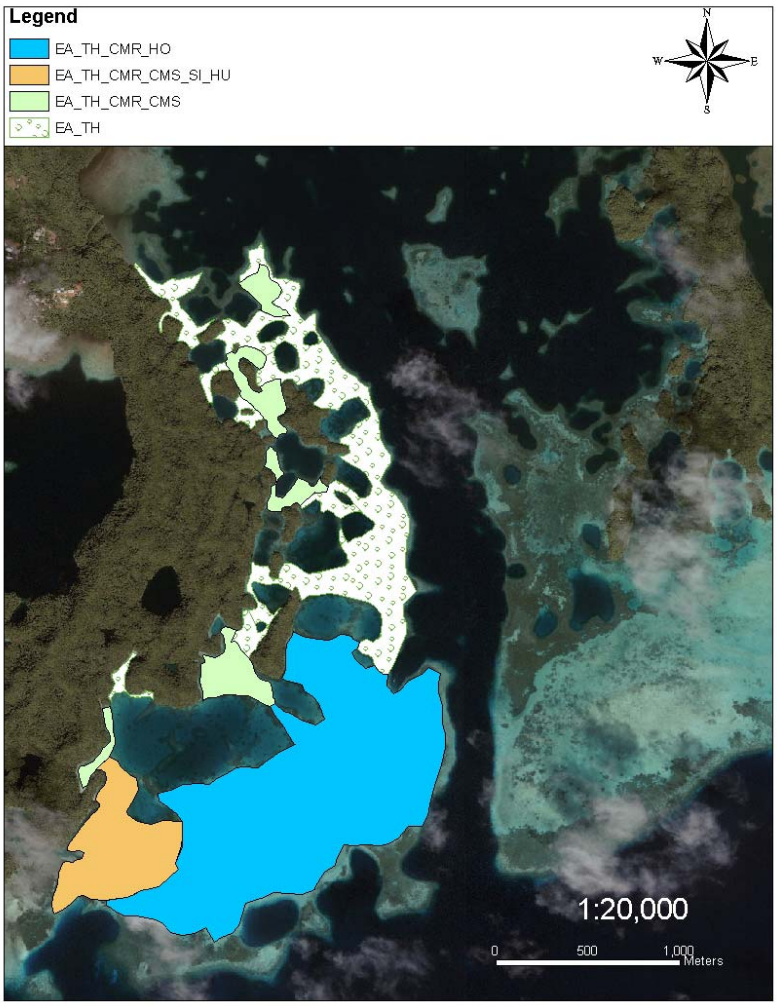



**Figure 15: Ngesekesau Reef (Koror) seagrass beds classified by species combinations.**

**Ngardmau/Ngaraard/Ngerchelong**

Figure 16 displays the results of the Ngardmau/Ngaraard/Ngerchelong seagrass survey. The site was classified into 10 different groups. A total of 1675 hectares or 16.75 $km^2$ of seagrass was estimated for the site.

As expected *Enhalus acoroides*, with its high tolerance for mud and sediment, was the only species recorded in the inner regions of flats next to mangroves. In the southern extent of the mapped area, west of the new Ngeremlengui dock, seagrass composition is comprised of *Enhalus acoroides, Thalassia*

*hemprichii, Cymodocea rotundata* and *Cymodocea serrulata. E. acoroides* is the dominant species next to the mangroves but is eventually taken over by *T. hemprichii , C. rotundata* which form a thick dense bed in the middle of the Btaot reef flat. *C. serrulata* was also found in the dense bed but abundance was fairly low. Outside of the dense seagrass bed all four seagrass species were still found but distribution was moderate to patchy. On the eastern side of the new Ngeremlengui dock, seagrass composition was more diverse. Species found included: *E. acoroides, T. hemprichii, C. rotundata, C. serrulata, H. ovalis, S. isoetifolium*, and *H. uninervis.* Moving eastwards towards the Ngaraard dock there was a drop in species diversity from 7 species to 5 species. With the exception of a species-rich portion to the west of the Ollei dock, the seagrass bed extending from the Ollei dock to the Ngaraard dock is comprised of only 3 species of seagrass. The three species are *E. acoroides, T. hemprichii*, and *H. ovalis.* The seagrass species found in the species-rich portion include *E. acoroides*, T. *hemprichii, C. rotundata, C. serrulata, H. ovalis, S. isoetifolium*, and *H. uninervis.*

During the Deep-water surveys no seagrass beds were identified.

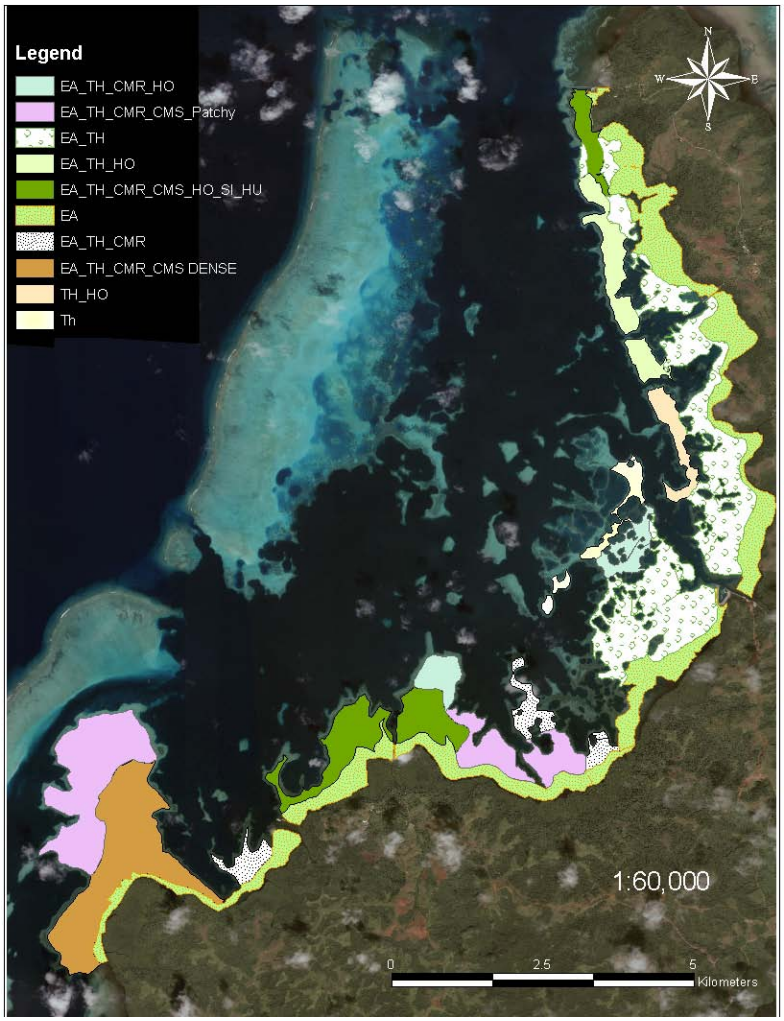



**Figure 16: Ngardmau/Ngaraard/Ngerchelong seagrass beds classified by species combinations.**

### 4.4 Additional Information

**Diet**

In Palau, feeding trails have been seen in both monospecific seagrass beds composed of *Halophila ovalis* and mixed beds of *Cymodocea serrulata, Cymodocea rotundata, Enhalus acoroides, Thalassia hemprichii* and *Halophila ovalis* (Davis, unpublished data, 2002). Analyses of stomach contents from two carcasses has revealed that dugongs feed on at least five of the nine species of seagrass found in Palau – *Halophila ovalis, Thalassia hemprichii, Syringodium isoetifolium, Cymodocea rotundata, Halodule uninervis* and *Enhalus acoroides* (Davis *et al.*, unpublished data, 2003). Circular 'crater-like' feeding trails, 25 to 30 cm in diameter and 8 to 10 cm deep, as described by Aragones in the Philippines (Aragones, 1994) have also been observed in sparse seagrass beds comprised predominantly of *Halophila ovalis* (Davis, unpublished data, 2002).

## 5. DISCUSSION

The distribution of dugongs observed during aerial surveys and locations identified by fishers and hunters show a great degree of overlap. The most important day time feeding and/or resting areas appear to be in, and to the east of, the Malakal Harbor area, and the lagoon off the north-west coast of Babeldaob. The majority of dugongs appear to be idling over deeper water adjacent to reefs, in calm water, where they can avoid boat traffic and possibly predators. They may be utilizing deep water seagrass beds during the day and then moving into the shallows to feed at night. Satellite telemetry studies in Australia have shown that individual dugongs should be capable of moving more than 140 km in two days (Marsh and Rathbun, 1990). Studies in the Molluccas Province, Indonesia, in the 1990's confirmed journeys of up to 65 km in just two days (unpublished information, cited in De Iongh *et al.,* 1995).

Combined aerial sightings and sightings by fishers show that dugongs can be found throughout the coastal waters of Palau. Such a mobile species requires protection throughout its range and, in Palau's case, throughout the coastal waters of all states (except the Southwest Islands).

The six previous aerial surveys do not provide information on possible changes in population numbers over time. The fact that the number of animals counted per unit flight time has not changed drastically over the past 25 years does not necessarily mean that dugong numbers are stable. The probability of detecting change is dependent on the difference between the estimates as well as the variability in the data and sampling design (Caughley and Gunn, 1996), and observer experience. As populations become smaller, the precision of estimates decreases and the likelihood of detecting a change in size also declines (Taylor and Gerodette, 1993). As explained in Attachment 1, it is not feasible to undertake aerial surveys as the primary method for monitoring dugong status. However, aerial surveys can also provide information on the percentages of cow-calf pairs observed, which is important in a small population of animals to ensure that reproduction is still occurring successfully. Comparing the relative number of sightings between surveys, while it does not indicate population status, should there be a significant decrease or increase in the population that change should be discernable, as long as the flight routes and methodologies are kept as similar as possible. Such survey results would need to be validated through other additional assessment methods as well (such as the incidental sighting rates; interviews; and so on). Finally, the aerial surveys do allow a rough check on the habitat through both the distribution of the sightings (a lack of dugongs being seen where that have always been seen would be cause for concern), and by observation of the habitat directly (changes in habitat over larger areas can more often be more easily detected from the air, than the ground). Having said that, it is recommended that aerial surveys not be conducted any more frequently than once every ten years, and only if additional funding is provided to

undertake the surveys that does not take away from other dugong conservation priorities (see Recommendations).

The seagrass surveys conducted through this survey were designed to only provide a preliminary assessment and to assist with identifying priority sites and topics for future applied seagrass studies. Prior to these surveys, virtually nothing was known about Palau's seagrass beds. While the study has provided some information on some key feeding areas known to be frequented by dugongs, the sampling was not intensive enough to provide a baseline on composition for on-going monitoring. More intensive work over a much longer time frame (all seasons) will be needed to obtain full details of the extent and composition of all the key seagrass beds, and to confirm the presence of dugong feeding trails. Seagrass 'beds' can be just a few meters in diameter and distinct beds of different species composition can occur within a few meters of one another. Due to the large-scale mapping in this survey, many individual beds may have been missed and in other places, they may in fact, be patchy rather than continuous beds (as shown on the GIS maps). There is a need in Palau to both better understand the country's seagrass beds in general (including for fisheries purposes), as well as more specifically as dugong feeding habitat. For dugong conservation, it will be important to monitor selected individual beds for feeding trails and changes in biomass over the course of a year or more to reveal information on species preferences, volume ingested and fluctuations in resource availability.

The major threat to the survival of Palau's dugongs, as in previous years, is poaching. Although the introduction of a new dugong protection law with stiffer penalties (raised from $100 to $5,000-$20,000) may have deterred many poachers from continuing to kill dugongs, increased surveillance and enforcement is needed at both the national and the state levels.[7] Education and awareness about the threats to dugongs and seagrass beds needs to be promoted throughout the country. Although there appear to be vast areas of seagrass beds in Palau's shallow coastal waters, increased dredging activities related to construction—especially due to the construction of the 'Compact Road' around the island of Babeldaob, and the secondary roads connecting to it—are posing threats to their health. It is vital that communities and their leaders are informed of the importance of these nearshore seagrass beds to the sustenance of not only dugongs and turtles, but the important subsistence and commercial species of fish and invertebrates. There have been concerns voiced country-wide about perceived declines in marine invertebrates which were once plentiful in nearshore seagrass beds (PCS interviews for the National Biodiversity Strategy and Action Plan, unpublished information, 2003). Further research on seagrass beds should focus on the impacts of dredging and the impacts of sedimentation on the health of the seagrass beds and the fish and invertebrate populations that they support. In this way, the need for protection of seagrass beds from anthropogenic activities can be presented to local communities and hopefully encourage their leaders to implement legislation to protect these vital habitats. The future for Palau's dugongs rests entirely with the people of Palau and the choices that they make concerning their coastal environment in the coming decade. Even if poaching is eradicated today, this small population is still vulnerable to extinction. Its dwindling numbers and associated loss of genetic variation, makes it even more susceptible to decimation through environmental and demographic stochasticity.

Palau is one of the few small archipelagoes that still has a population of dugong inhabiting its waters and therefore it has an international responsibility to put in place measures to protect its small but unique population.

[7] Currently, dugong laws are national laws and can only be enforced by state authorities if the state Conservation Officer/Ranger has been endorsed to do so by the Ministry of Justice; otherwise state enforcement officers can only inform their national counterparts of an infringement and request they make an arrest. While some of the states have had their enforcement officers endorsed by the Ministry of Justice, there is still some uncertainty as to its legality. This will only be settled through being challenged in court.

## 6. RECOMMENDATIONS

### 6.1 Update on Management Actions

The following recommendations were made by Marsh and Lawler in the 1998 U.S. Marine Mammal Commission Action Plan for the Management of the Dugong, *Dugong dugon* in Palau. The goal of the Action Plan is:

- To maintain a viable population of dugongs in Palau.

The current status of each Objective of the Action Plan is provided below (numbers refer to the numbers in the Action Plan).

***1. To encourage Palauans to value dugongs as a significant feature of their marine environment and as a 'flagship' species for marine conservation initiatives.***

- Palau Conservation Society ran a public awareness campaign focusing on the dugong from 1996-1997.
- The dugong is the sporting 'mascot' for the Palau Community College, and for a socio-cultural NGO called Belau Cares, Inc.

***2. To identify and minimize causes of dugong disturbance and mortality in Palauan waters.***

- The fines incurred for killing, capturing, trapping, wounding, possessing, transporting, restraining or otherwise having under one's control a dugong or any part of one, was $50 for a first time offence and $100 for further offences until 2002 when this legislation was updated. In November 2002, RPPL No.6-28 was passed by the President, raising the penalty to $5000-10,000 for first-time offenders and $10,000-20,000 for repeat offences. The law also mandates the Minister of Natural Resources & Development and the Minister of Education to promulgate regulations establishing educational programs for Palauan citizens and the general public about the dugong. The education program requirement has is yet to be implemented.
- Division of Fish and Wildlife Protection searched all souvenir stores in Koror during 1995-1996 and confiscated all jewelry made from dugong parts. There have been no reported sales of such goods since (K. Chin, pers comm., 2003).
- Public reporting of dugong carcasses now occurs and during 2002-2003, two carcasses were reported to the Division of Fish and Wildlife Protection, who subsequently retrieved the bodies so that samples could be removed for DNA and stomach content analyses. The carcasses were inspected using the methods outlined in GBRMPA Necropsy Manual (Eros *et al.*, 2000). Palau Conservation Society has a copy of this manual for any future necropsies.
- So far, no restrictions have been placed on boat traffic speed in dugong feeding areas. Such regulations should be considered by each State in addition to no-entry zones in shallow seagrass areas.

***3. To protect dugong habitats throughout the Palauan archipelago.***

- Seagrass surveys have been conducted in four areas known to be frequented by dugongs. Photographic documentation of feeding trails is still needed. Studies on the impacts of dredging and other coastal activities on the health of seagrass beds and their associated fish and invertebrate assemblages are necessary in order to convince local communities of their value and importance for protection.
- An analysis of past aerial photographs of seagrass beds would help to determine natural and human-induced changes in the extent of these habitats over time.

- Mapping land and sea-based threats to seagrass beds on the GIS maps included in this report begin to identify vulnerable areas which need immediate protection.
- Environmental Impact Assessments (EIAs) usually address potential impacts of developments on seagrass beds, but do not identify their importance as dugong feeding areas. The new legislation RPPL No. 6-28 mandates the Minister of Resources and Development to promulgate regulations requiring any entity proposing new development to include an Environmental Impact Statement considering the potential impact of such development on dugongs and their habitats.
- Dugong feeding habitat is being included as one of the design criteria for the Protected Areas Network currently being implemented in Palau.

***4. To monitor the status of dugongs and their habitats in Palauan waters in a cost-effective manner.***

- The status and distribution of dugongs has been addressed in this report, with a comparison of past data.
- PCS has implemented an incidental sighting program for the general public and carcasses are routinely reported to the Division of Fish and Wildlife Protection.
- Future aerial surveys should be undertaken, but limited to a maximum of once every tens years, and only if specific funding is identified for the surveys that does not detract from other higher priority conservation activities.

***5. To coordinate activities, monitor and evaluate progress and update/revise the 1998 Action Plan.***

- The Nature Conservancy, with financial assistance from the U.S. Fish and Wildlife Service, has been responsible for coordinating the current round of dugong-related research (1998-2004).
- Future dugong management–related activities should be coordinated through the Bureau of Marine Resources, linked to the current turtle and proposed crocodile programs within the Bureau.
- Palau Conservation Society has been responsible for dugong and other environmental awareness activities since 1996.
- The recommendations provided within this report constitute an update of the 1998 Action Plan. These recommendations should be presented to the relevant government and non-government organizations and incorporated into future research and management projects.
- An updated version of this report should be prepared in 2006, incorporating findings from the Incidental Sighting Program and other research relating to dugongs and seagrasses.

## 6.2 Recommendations

### Surveillance and Enforcement

**1. Allocate additional support (personnel, training and funding) towards surveillance and enforcement efforts at both the national and state levels.**
(*Responsible agency:* Ministry of Justice and State enforcement programs)

- Areas requiring particular attention include in the Malakal Harbor area and the north-west coast of Babeldaob, especially between dusk and dawn.
- The legal issues associated with state enforcement officers' being endorsed to enforce specific national laws (such as the dugong law (RPPL No. 6-28) need to be clearly resolved, and if necessary, tested in court.
- Additional training of enforcement officers on dugong laws, understanding life history, and the need for protection is required.

**2. Investigate the legal and practical feasibility of establishing a reward system for reporting hunting or possession of dugong, and implement the system if proven feasible.**
(*Responsible agency:* Ministry of Justice)

- Through a reward system, members of the public should be offered cash rewards for reporting hunting or possession of dugong, that leads to a conviction. Currently, RPPL No. 6-28 for dugong conservation states that 50% of the penalty (which could range from $2,500 - $10,000) could be offered to informants on successful prosecution of offenders). Once such a system is established, it will need to be widely publicized.

**Education**

**3. Initiate a nationwide education and awareness program.**
(*Responsible agency:* Ministry of Education, Ministry of Resources and Development, and Palau Conservation Society)

- The Ministry of Education and the Palau Conservation Society should jointly coordinate a nationwide education and awareness program focusing on raising awareness of the plight of dugongs, increasing the publics' "pride" in being the only Micronesian country that has dugongs, and making people aware of the law changes. The last campaign was undertaken by PCS 1996-97, and focused on schoolchildren, most of whom disapprove of the killing of dugongs. Future campaigns should build on those school initiatives and focus key sectors of the public, including traditional and elected leaders, and the poachers. Under the current law, the Minister of Resources and Development and the Minister of Education are mandated to initiate and education campaign.

**Habitat Protection**

**4. Continue targeted studies to better understanding the seagrass habitats to provide a basis for protection.**
(*Responsible agency:* Palau International Coral Reef Center, in collaboration with the Bureau of Marine Resources and NGOs)

- The identification of important dugong feeding areas (seagrass beds) should be continued, with the highest priority being given to the broader Malakal Harbor area and the north-west coast of Babeldaob.
- Continue mapping of all seagrass bed in Palau to determine current seagrass species distribution and abundance. Along with the mapping project efforts must be made to identify new seagrass communities, especially deeper water communities.
- Implement a biological seagrass monitoring program around Palau to determine physical changes to seagrass beds. The Palau International Coral Reef Center is currently involved in a seagrass monitoring program (SeagrassNet and SeagrassWatch), which could be used as a basis for a seagrass monitoring program. The monitoring program should include measuring physical parameters such as light, temperature, salinity and nutrient levels.

**5. Provide increased protection to the key dugong feeding areas (seagrass beds).**
(*Responsible agency:* Ministry of Resources and Development (PAN and Bureau of Marine Resources) and the Environmental Quality Protection Board)

- These areas need to be provided with increased levels of protection under both state and national legislation. The recently passed (Nov. 2003) Protected Areas Network Act (PAN) has the dual objectives of local level resources management and national biodiversity conservation. The design criteria will include areas of biological and ecological significance, such as seagrass beds, and especially seagrass beds of importance to dugongs. As the PAN includes both terrestrial and marine areas, land based sources of impact will also be addressed in management of these areas.

The National Biodiversity Strategy and Action Plan (NBSAP) development has recently re-started after being stalled for over a year. The results of this project will feed into that planning process.

- Criteria for considering the impacts of proposed development projects need to be developed and all relevant project Environmental Impact Statements must address potential impacts on dugong habitat, as required by RPPL No. 6-28.
- Koror State should consider controls on boat traffic speed in and outside Ngel Channel (adjacent to Ngedererrak Reef).

**Dugong Life History, Status and Management**

6. **The responsibility for dugong research, assessments and management should be progressively transferred to the Bureau of Marine Resources.**
   - As the capacity of the BMR's current turtle project, and proposed crocodile project are developed, these projects (turtle, crocodile) should be combined and a dugong component added, and the projects should be progressively integrated into a "vulnerable species" program. Support (personnel, training and funding) will need to be provided to BMR.
   - A coordinating committee, with representatives from the key national and state government agencies and the NGOs, should be established to coordinate activities related to dugongs, turtles, and crocodiles. BMR should be the secretariat for this committee.

7. **Information on dugong distributions and status should be continued.**
   (*Responsible agency:* Bureau of Marine Resources, with support from Palau Conservation Society)

   - The incidental sightings system should be continued and progressively transferred to the Bureau of Marine Resources. The incidental sightings form is currently under review and may require revising as soon as the review is completed.
   - Future aerial surveys should be undertaken, but limited to a maximum of once every tens years (next survey in 2013), and only if specific funding is identified for the surveys that does not detract from other higher priority conservation activities. The methods should be as close as possible to those undertaken in 1991, 1998, and 2003.

8. **Efforts should continue to collect information from dugong necropsies**.
   (*Responsible agency:* Bureau of Marine Resources, with support from Division of Fish and Wildlife Protection and Palau Conservation Society)

   - Morphological measurements, stomach and DNA samples should be collected from all dead dugongs. When and wherever possible, reproductive organs should be removed from carcasses and sent for analysis (currently James Cook University is willing to accept samples for analysis).
   - Training of BMR staff, and supporting agencies, will be required, as there are currently very few people in Palau with the knowledge required to conduct dugong necropsies.

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## 8. ATTACHMENTS

### 8.1 Issues Concerning Estimating Palau's Dugong Population from Aerial Surveys

The following is taken from Marsh and Lawler (1998:12-13):

> Frequent aerial surveys of dugongs will be of limited use and are not recommended as the primary method for monitoring dugong status. Statistical models developed by Taylor and Gerrodette (1993) and modified for dugongs by Marsh (1995b) show that for populations comprising a few hundred animals the power to detect changes in abundance is extremely weak even with frequent repeat surveys (Table below).
>
> Assuming a population of 100 dugongs, Table 1 indicates that it would be necessary to conduct bimonthly surveys for 13 years to prove that a 5% per annum decline was in fact occurring. By this time there would be only 48 left.
>
> **Table**: Years required to detect a significant decline in hypothetical dugong populations of various sizes which are declining at 5% p.a. using aerial surveys conducted every one or two months. The estimates assume that $\alpha$-$\beta$-0.1. The coefficients of variation of the population estimate at the time of the first survey have been calculated from empirical data.

| Population size | Years to detect a decline using monthly surveys | Years to detect a decline using bimonthly surveys |
|---|---|---|
| 100 | 10.1 | 12.8 |
| 200 | 8.1 | 10.3 |
| 500 | 6.0 | 7.7 |
| 1000 | 4.8 | 6.0 |

> The optimum frequency of aerial surveys is a tradeoff between information and cost. We recommend that a survey similar to those conducted in 1978, 1983 and 1991 be carried out once every five years. Such surveys will not provide statistical proof that dugong numbers have declined. However, they will provide a qualitative indication of trends in abundance and in changes in the areas used by dugongs. The major reason for advocating a five year interval is that the funds for more frequent surveys could be better spent on education initiatives. A survey interval of more than five years reduces the likelihood of maintaining consistency in survey methodology because of the difficulty in maintaining any continuity of personnel between surveys.

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