Egyptian Environmental Policy Program
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Report on

Marine Turtles of

Wadi El Gemal-Hamata Park,

Southern Red Sea Coast, Egypt.

International Resources Group and partners:
Winrock International
PA Government Services, Inc.
Development Alternatives, Inc.
Environmental Quality International
Capacity Building International

September 2004

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Prepared by

Dr. Jeff Miller
The American University in Cairo

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EXECUTIVE SUMMARY

Marine turtles exhibit low-density, wide-spread nesting along the entire Egyptian Sea coast, from the islands at the Gulf of Suez to the southern boarder with Sudan. A significant proportion of that nesting occurs within the Wadi Gemal – Hamata Protected Area (WGHPA).

Marine turtles must come ashore to lay their eggs. The eggs incubate in the beach for 6 to 8 weeks before the hatchlings emerge and go to the sea. This requirement makes them particularly vulnerable to developmental encroachment of the nesting areas that are vital to their survival. Too often each development area is viewed in isolation and considered to be small in terms of the length of the coast line; because only a small number of turtles are impacted at a time, at any one place the view is that the turtles will adjust. However, the biology of marine turtles is constrained such that the ability of the populations to adjust to encroachment is limited. One of the limitations is that turtles return to the general area where they hatched; another is that they may be deterred from nesting by lights and activity on beaches. Along the Red Sea coast of Egypt there are few large areas remaining where marine turtles may nest without at least intermittent disturbance; one of the remaining areas is contained in the Wadi Gemal – Hamata Protected Area (WGHPA).

The value of the area derives from the complex mix of natural and cultural resources that can be utilized sustainability within the limitations of the abiotic and biotic parts, including marine turtles. However, if the use exceeds the limitations of the resource or compromises the biological constraints of the species, the value reduces. The goal must be to find the balance to maintain a high quality area that retains its value while facilitating sustainable use. Given that there is imperfect knowledge of the sensitivity of all species and habitats, the precautionary principle must be embraced as the guide for conservation and management decision making.

The general agreement on the value of the area and the need to maintain the quality is shown by the vision statements and objectives of the major stakeholders. The vision statement of the conservation management plan for the southern zone of the Red Sea (Rouphael 2003) foresees that “In the year 2008, the flora and fauna, habitats and water quality of the CMA [Coastal Management Area] will be in the same or better condition than in 2003.” The first objective of the Tourism Development Authority Red Sea sustainable tourism initiative land use plan for the area south of Marsa Alam is to “protect the wilderness character of the area south of Marsa Alam for use and enjoyment by present and future generations”. The first management objective of the Wadi Gemal – Hamata Protected Area (WGHPA) is “to maintain the natural resources and conditions of the PA” (Protected Area) (PSU 2003). Further, there is an adequate legal framework to protect the flora, fauna and

their supporting terrestrial and marine ecosystems from further erosion of quality. By giving emphasis to the biological, cultural and physiographic resources in the area, the sustainable use by Egyptians and international tourists can be achieved and the value of the resources can be maintained. However, if the emphasis is on use, rather that sustainability, the resource will be degraded and the value will decline.

Recommendations:

Having reviewed the planning documents and available data as well as having conducted an on-site visit to the area, the following recommendations are submitted with the view of maintaining the quality of the habitat and the number of marine turtles utilizing the WGHPA coast:

1. The designated areas for development within WGHPA should not be developed to avoid fragmenting the marine turtle nesting in the park.

2. Lighting on existing resorts and wharfs should be modified to prevent potential disruption of nesting turtles and disorientation of hatchlings.

3. Any new development along the WGHPA boundaries should comply with lighting requirements as if they were inside the park.

4. Rangers should be trained to monitor the marine turtle nesting activity in the WBHPA.

5. A program of training of local ‘turtle guides’ should be developed to provide some economic input to the existing local communities.

Terms of Reference

This report concerns the conservation management of the marine turtles nesting and resident in the Wadi El Gimal National Park. The terms of reference are outlined below.

Four tasks were identified, within each task a set of objectives were established:

1. Review on-ground situation
   - To review spatial relationships of beaches and known nesting sites
   - To collect current information on previous and current activities and use of the area
   - To collect information on developmental plans for the area
   - To obtain copies of existing data for development of a database
   - To talk with local Ranges and managers concerning local issues

2. Review existing data
   - To assess extent and quality of existing data
   - To estimate spatial nesting distribution
   - To estimate temporal nesting distribution

3. Prepare Management Recommendations report
   - To prepare a report containing Management Recommendations limited to marine turtle related issues from the material collected during steps 1 and 2 (above) and accessory information.
   - The plan will include:
     - Review of the identified developmental threats
     - Review of the existing data on temporal and spatial distribution of marine turtles
     - Recommendations for management

4. Prepare monitoring plan
   - To prepare a monitoring program
   - Plan will include:
     - Priority for data collection
     - Methods for data collection
     - Training and data quality control requirements
     - Data sheet pro forma
     - Lists of recommended equipment and suppliers
     - Biological synopsis for each species
     - Outline of interpretative program for use by Rangers

These terms of reference provide the context of the report.

PREFACE

The purpose of this document is to provide a biological basis for managing human activities that impact on the populations of marine turtles occurring in the Wadi El Gemal - Hamata Protected Area, Egypt, with a view to facilitate their conservation.

This document identifies the major known and potential impacts of human activities on marine turtles occurring in and around the Wadi El Gemal - Hamata Protected Area and along the southern Red Sea coast of Egypt.

The conclusions presented in this document are based on the current scientific understanding of marine turtles, a review of present and predicted future patterns of human activity in the Wadi El Gemal - Hamata Protected Area, and on prudent application of the precautionary principle.

Vision Statement

"Wadi El Gemal - Hamata PA and its invaluable natural and cultural resources will be established as a world class attraction and an important regional asset for sustainable economic growth; as a result of systematic, responsive and effective management and promotion of its resources" (PSU 2003b).

The main management objectives for WGHPA are (PSU 2003b):

1. To maintain the natural resources and conditions of the PA;
2. To protect cultural heritage resources of the PA;
3. To enhance the sustainable utility of natural resources in the PA through the establishment of appropriate management systems;
4. To promote WGHPA as a focal point for ecologically sensitive tourism, thus expanding and diversifying the economic activity base in the region;
5. To enhance the environmental quality of the WGHPA;
6. To optimize socio-economic benefits to the indigenous population from the region's natural heritage;
7. To promote public understanding and appreciation of Egypt's natural heritage.

SECTION I Marine Turtles

INTRODUCTION

Five of the world's seven species of marine turtle are found, at least occasionally, in the northern Red Sea: loggerhead (*Caretta caretta*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coricaeca*) and olive ridley (*Lepidochelys olivacea*) (Frazier and Salis 1984, Frazier *et al.* 1987, Gasperetti *et al.* 1993). The two most common species are the green turtle and the hawksbill turtle (Frazier *et al.* 1987).

The effective conservation of marine turtles requires management of two general areas: the protection of primary habitats and the control of human activity to be within the parameters of turtle biology. Primary habitats of marine turtles include feeding and migratory pathways as well as mating and nesting areas. An appreciation of the biological constraints which in part make these animals attractive to humans is necessary to control human activities in and adjacent to the primary habitats. Although most of the effort needs to be focused in the protected areas, many primary and secondary habitats occur outside the Wadi El Gemal - Hamata Protected Area (WGHPA). Future development of the Egyptian Red Sea Coast requires careful planning and environmentally appropriate construction to ensure that sustainable tourism does not destroy the biological resources of the region.

Although much is known about marine turtle biology in general (Miller 1997), little is known about several critical aspects of their biology in Egypt, including (1) distribution of nesting, (2) amount of nesting and (3) species contribution to the total nesting. Other unknown but necessary information includes: the relative and absolute population sizes of each species occurring in WGHPA; estimates of the numbers breeding and/or foraging at particular sites; estimates of the proportion of turtles breeding in any one season; population structure (ratio of males to females; immature to adult turtles); hatching and emergence success. Further, nesting habitats are poorly documented along the Egyptian Red Sea Coast. Similarly, primary and secondary foraging habitats for each turtle species remain largely unknown; although most reefs and coastal waters host populations of marine turtles, numbers and seasonality of use are not well documented.

These gaps in the scientific knowledge concerning marine turtles in Egypt hinder the formulation of precise conservation management guidelines and policies. Whilst information gaps must be addressed for management to be successful over the long term, the precautionary principle must be applied in the absence of this information.

METHODOLOGY

Sources of data included unpublished reports and management documents. These documents provided information on development plans and provided a context for interpreting the local situation.

The on-site visit during 8-11 April 2004 allowed a brief assessment of the spatial relationships of most of the beaches and known nesting areas on the mainland coast and Wadi El Gemal Island. Other information was obtained verbally from local rangers and fishermen. Copies of existing data were supplied by the local rangers.

Positional field data were obtained using a GPS. Positions of locations not specified by the original source were estimated by finding the location on a rectified map of the area and extracting the latitude and longitude using ArcGIS. Data obtained were organized into a GIS compatible database and plotted on a rectified image of the WGHPA area supplied by EEPP-PSU.

PHYSICAL DESCRIPTION

The following description of the WGHPA is derived from a variety of sources, including an on-site visit (April 8-11, 2004) and management documents (Rouphael 2003, PSU 2003a) as well as published literature. To avoid repeating information that is already available to managers and decision makers, the extracted material presented below is directly relevant to marine turtles. This approach excludes much of the contextual information about the physical and biological resources of the area.

Physical Area

The Egyptian Red Sea coast angles about 30 degrees west of North along an axis of approximately 330 degrees. The coast line has a well developed fringing reef. Six types of fringing reef have been described in the general area of WGHPA (Kotb *et al.* 2001). These include: (1) wide rocky reef flat (> 100 wide) with gently sloping reef face, (2) narrow reef flat (<50m wide) with deep lagoons and with or without a distinct reef edge and/or steep reef face, (3) moderately wide reef flat (100-200m wide) with steep reef face (Kotb *et al.* 2001).

The coastal margin of WGHPA extends more than 110 km long the shore. The coastal park area is supported by a large landward area in the middle portion but the landward side of the coast is not under EEAA management at the northern and southern ends (Fig. 1). The coastal area includes several distinct habitat types: Coastal desert, Raised headlands, Gravel and sandy plains, and Wadis that open to the sea. The Wadis provide beaches that are a mixture of sand and gravel.

Figure 1. General map of Wadi El Gemal – Hamata Protected Area. Inset shows the location of WGHPA in the context of Egypt. Numbered (buff colored) polygons are the two areas proposed for development within the park boundaries.

Wadi El Gemal National Park contains 5 islands: (1) Wadi El Gemal Island located approximately 5 km off Ras Baghdadi and (2) the Qulan Archipelago (Hamata Islands) which contains 4 islands (Siyul, Showarit, Umm Ladid and Mahabis). These low-lying islands are from 3 to 5 km off shore; they are comprised of raised fossil reefs with sandy beaches. Other coastal and off-shore islands exist to the south of the WCPA.

Coastal Geomorphology

The landward portion of the coastal margin of WGHPA varies from wide sabkhas through alluvial (sand and gravel) plains to sandy beaches interspersed with rocky headlands (TDA/RSSTI 2003). The generalized slope of the coastal margin is less than 5% but there are cliffs (up to about 5 m) at the headlands. Wadis provide a gentle sandy slope to the sea. Details of the geomorphology, slope analysis, under lying rock and shoreline classification are contained in planning documents (TDA/RSSTI 2003).

Oceanography

The surface ocean currents that move along the Egyptian Red Sea coast follow the prevailing wind (North-North-West), i.e. north to south along the coast (Rouphael 2003). Some localized disruption in surface flow occurs as a result of storms and near-shore islands.

Tidal cycles are semidiurnal with a typical spring tidal range of 0.6 to 1.2m; there is little difference in the timing of high water and low water at separated points along the northern Red Sea coast (Davies and Morgan 1995).

Water temperatures in the northern Red Sea vary from lows near 17C in winter (February) to highs near 27C in late summer (August) (Davies and Morgan 1995). Water temperatures in enclosed areas and in shallow areas near the coast typically exhibit a greater range (Davies and Morgan 1995).

Climate/Weather

The dominate wind direction throughout the year is North-North-West with occasional southerly winds blowing during the winter. Average wind velocities vary little between summer and winter (22 km/hr, 19 km/hr, respectively, Rouphael 2003); daytime wind velocity is generally higher than nighttime velocity (Rouphael 2003).

Seasonal weather patterns divide the annual cycle into hot dry summers and cool dry winters. Seasonal extreme air temperatures range between about 9 and 39 C in the northern and 13.5 and 42 C in the southern coastal areas.

Based on data obtained from Ras Banas (located to the south of WGHPA) summer extends from April until Mid October, during which the mean daily temperatures are in the low 30s C (Fig. 2). Maximum air temperatures approach 40C, while minimum temperatures are typically in the range of 20 to 25 C. Diurnal variations in air temperature may exceed 10 C. Humidity is lowest in summer; the mean for any summer month does not go above about 40%. Evaporation rates are highest in summer (range 16.5-28 mm) (TDA/RSSTI 2003).

Mean daily temperatures in winter are in the range of 18.3 to 19.7C. Maximum air temperatures are typically below 26, while minimum temperatures are typically in the range of 12.4 to 15 C. Diurnal variation in air temperature may exceed 10 C (TDA/RSSTI 2003).

Humidity is highest in winter (Fig. 3); the mean for any winter month is typically above 45%, with some monthly averages reaching 59%. Evaporation rates are lowest in winter (range 8.7 to 13.1 mm) (TDA/RSSTI 2003).

Rainfall in the area of WGHPA is generally sparse, intermittent and often localized. Most rain falls during October through December with lesser amounts falling during February through May (Fig. 3) (TDA/RSSTI 2003). Evaporation is highest during the summer months and lowest during the winter period.

The transitional periods between the primary seasons are short, being about one month in autumn (mid October through mid November) and about six weeks to two months in spring (during March and April) (TDA/RSSTI 2003).

Coastal Ecosystem

Reefal ecosystems of the Red Sea have been described and the coastal ecosystems of WGHPA have been described in general terms (Sheppard *et al.* 1992, Rouphael 2003). Only information relevant to turtles has been included here.

Most of the fringing reefs host seagrasses (Sheppard *et al.* 1992), albeit in varying density. Most species live in areas of unconsolidated soft sediment material in less than 10 m of water depth (Rouphael 2003). Seven species of sea grass have been reported from 15 sites sampled in the WGHPA (Rouphael 2003); the percent cover varied within and between sites (Rouphael 2003). The most wide spread species was *Halophila stipulacea*; it was found innumerous monospecific meadows in subtidal areas (Rouphael 2003).

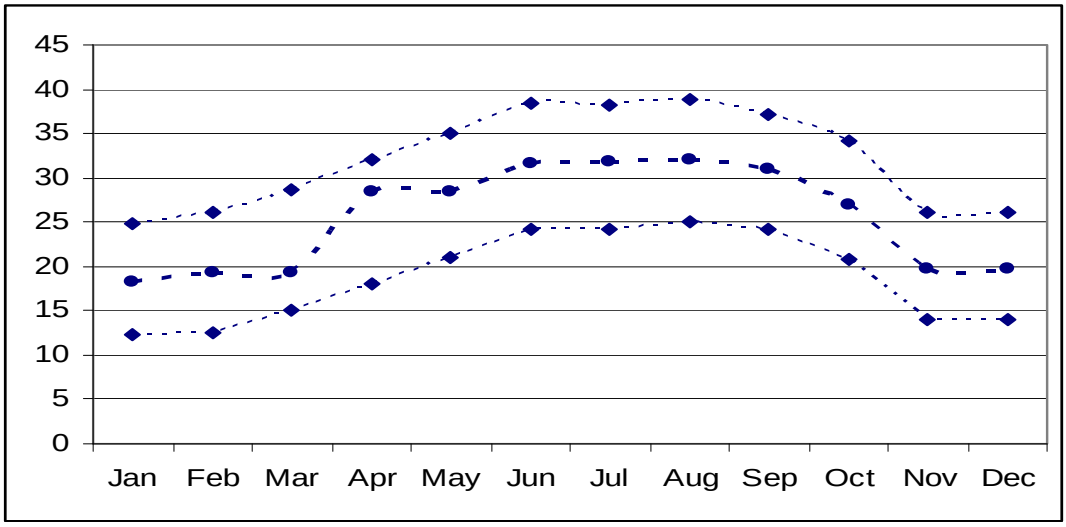

Figure 2. Seasonal temperature variation recorded at Ras Banas Station and averaged monthly over a 10 year period. Upper line = Maximum Temperature; Middle line = Mean Temperature; Lower line = Minimum Temperature. Source: TDA/RSSTI 2003

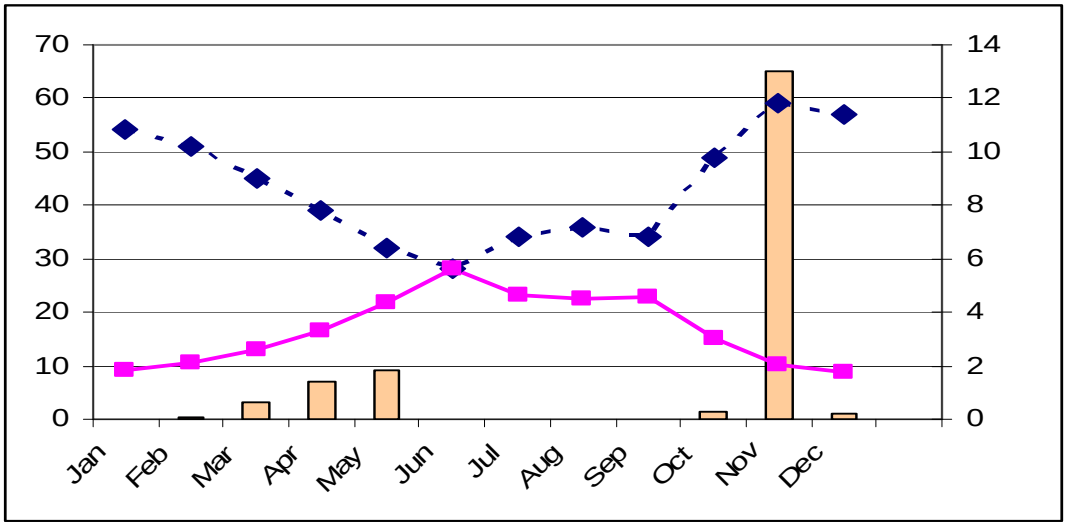

Figure 3. Seasonal variation in relative humidity, evaporation and rainfall recorded at Ras Banas Station and averaged monthly over a 10 year period. Dashed line = Relative Humidity; solid line = Evaporation (mm); Vertical bars = Rainfall (mm). Source: TDA/RSSTI 2003

The majority of the fringing reef flats are exposed, at least during the neap tides; these intertidal areas contain pavements (more or less consolidated material) and soft sediment areas (including sandy areas). These intertidal pavements and soft sediment

areas host an array of algae, including *Turbinaria, Padina, Sargassum, and Halimeda*, and other organisms (Jones *et al.* 1987).

Although specific information concerning the sponges of the WGHPA is not available, the Red Sea supports numerous species living on the reef face and reef slope regions of the fringing reefs. The complexity of the potential habitat and the known diversity of other organisms that are typically associated with species-rich marine ecosystems (jellyfish, crustaceans, mollusks, bryozoans, echinoderms etc.) support the inference of a diverse poripheraian fauna (JICA 2000, GEF 1997).

BIOLOGICAL DESCRIPTION OF MARINE TURTLES

Five of the world's seven species of marine turtle are found in Red Sea (Table 1). Some species are frequently seen, such as the green turtle and the hawksbill turtle. Others, such as the loggerhead, olive ridley and leatherback, are known to occur but are seldom seen.

The conservation status of marine turtle species at a global level was assessed by IUCN and classified into one of the following categories: extinct, extinct in the wild, critically endangered, endangered, vulnerable, lower risk, or data deficient (Redlist 2004). All five marine turtle species in the Egyptian Red Sea area are listed as either critically endangered (hawksbill turtle), or endangered (green, loggerhead, olive ridley, leatherback turtle) on a global scale (Table 1). The cumulative affects of various anthropogenic impacts have caused declines in the global populations and it is expected that current impacts are likely to cause them to continue to decline.

Although the specific biological characteristics differ among the species of marine turtles, they share a set of common characteristics that allow the construction of a general life history pattern (Table 2; Fig. 4).

Females of all species of marine turtles lay multiple (typically 2-7) clutches during their reproductive season (Miller 1997); each cultch of eggs contains from 50-200 eggs, depending on the species (Dodd 1988, Hirth 1997, Miller 1997, Witzell 1983, Pritchard 1971, Marquez 1994). At the end of her nesting season, a female returns to her foraging area; typically she will not reproduce for at least two and perhaps as many as eight years (Carr 1984, Limpus *et al.* 1992, Miller 1997).

Table 1. Marine turtle species occurring in the Red Sea and their conservation status as assessed by IUCN (the World Conservation Union).

Common Name	Scientific Name	IUCN Classification category
Family: Cheloniidae		
Green	*Chelonia mydas*	Endangered
Hawksbill	*Eretmochelys imbricata*	Critically Endangered
Loggerhead	*Caretta caretta*	Endangered
Olive ridley	*Lepidochelys olivacea*	Endangered
Family: Dermochelidae		
Leatherback	*Dermochelys coriacea*	Critically Endangered

The duration of incubation depends on the temperature of the surrounding sand; warmer temperatures speed incubation whereas cooler temperatures retard incubation duration. The sex of the hatchling turtle is determined by incubation temperature (Mrosovsky and Yntema 1982, Miller and Limpus 1981, Ackerman 1997); females are produced from eggs incubated at warmer temperatures and males are produced from eggs incubated at cooler temperatures. Developmental of the embryos follows a series of predictable, sequential stages (Miller 1985).

Approximately 60 days after egg deposition hatchlings emerge at night when the sand temperature drops in relation to the cooler night air. Hatchlings use the topography of the surrounding terrain to orient towards the brightest low horizon to find the sea (Limpus 1971, Mrosovsky and Shettleworth 1968).

Hatchlings are subject to some depredation while crossing the beach. Once in the water, hatchlings use a combination of wave direction, current, and magnetic fields to orient themselves to swim away from the shore toward deeper offshore areas (Lohmann and Lohmann 1998). During this time the hatchlings are believed to imprint with the cues to necessary to allow them to find their way back to their natal beaches. Hatchlings are believed to associate with floating seaweed mats driven by surface currents (Carr 1986, 1987a).

Table 2. Biological Characteristics of Marine Turtles Relevant to Management

CHARACTERISTIC	REFERENCE
High Fecundity	Dodd 1988, Hirth 1997, Miller 1997, Witzell 1983, Pritchard 1971, Marquez 1994
Sex Determined by Incubation Temperature	Mrosovsky and Yntema 1982, Miller and Limpus 1981
Hatchlings Disperse to Oceanic Planktonic Life	Musick and Limpus 1997
High Mortality before Adulthood	Chaloupka and Limpus 1997
Several Decades to Sexual Maturity	Balazs 1980, Limpus 1992, Limpus and Walter 1980
Long Breeding Life (inferred)	Limpus *et al.* 1992
Individual does not Breed Every Year	Miller 1997
Migratory – Foraging areas are Far from Nesting Areas	Limpus *et al.* 1992
Limited Number of Nesting Sites	Dodd 1988, Hirth 1997, Miller 1997, Witzell 1983, Pritchard 1971, Marquez 1994
High Fidelity to Foraging Area	Limpus *et al.* 1992, Limpus *et al.* 1994 a b, Spring 1999
High Fidelity to Nesting Area	Allard *et al.* 1994, Meylan *et al.* 1990
High Fidelity to Internesting Area	Limpus *et al.* 1992, Miller 1997

Immature turtles may spend 5 to 20 years (Limpus 1992) in the pelagic phase before they migrate to inshore foraging areas. After an estimated period of 20-50 years (Balazs 1980, Limpus 1992, Limpus and Walter 1980), during which they have matured, turtles migrate from their foraging areas (possibly 100 or 1000's of kilometers away) to a nesting location close to their natal (place of birth) beach (Allard *et al.* 1994, Meylan *et al.* 1990). Mating takes place in the water approximately 30 days prior to the first nesting (Owens 1980); it may occur offshore of the natal beaches or it may occur at considerable distance from the nesting beach. Each female receives sperm from multiple males and each male will inseminate multiple females. Males leave the breeding area once females commence fortnightly trips to the beach to lay eggs (Limpus 1993).

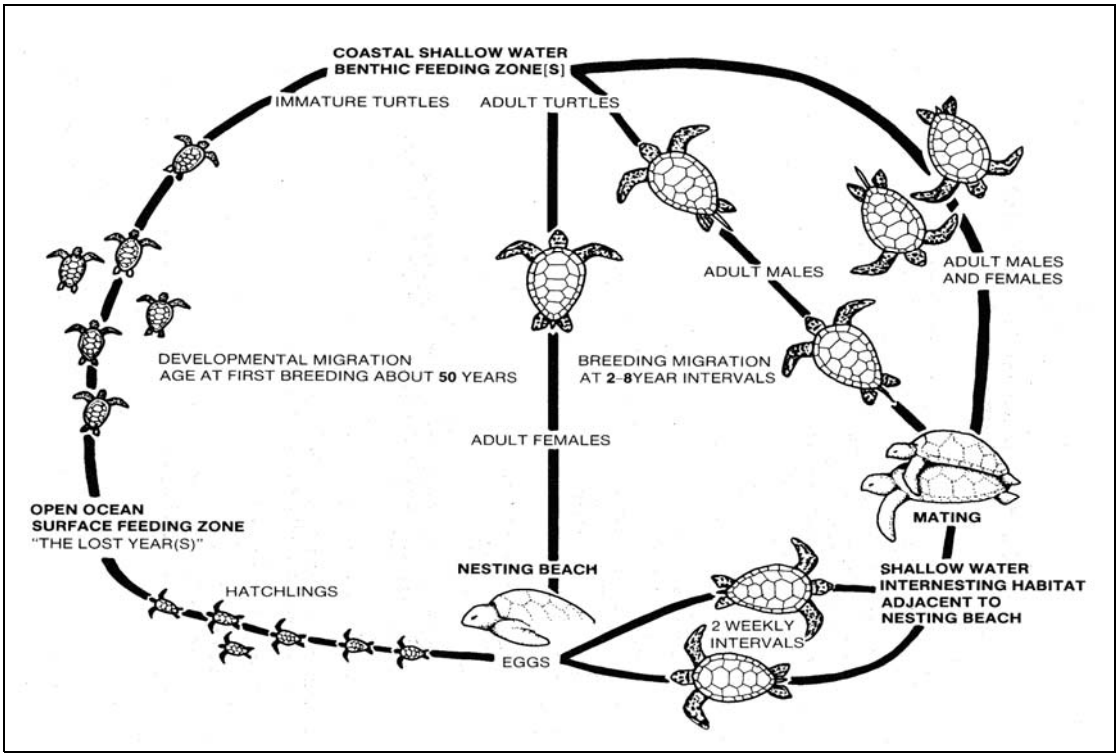

Figure 4. General life history of a marine turtle. This schematic is based primarily on data for the green turtle and species specific differences do occur. See text for details; see also Dodd 1988, Hirth 1997, Witzell 1983, Pritchard 1971, Marquez 1994 for biological information). From: Miller 1997

Within the generalized life cycle (Fig. 4), there are particular biological characteristics that are relevant to management (explained in the following paragraphs).

The smaller (younger) size classes experience high mortality resulting from a variety of natural and anthropogenic causes.

Although marine turtles exhibit high fecundity (producing several hundred eggs during a nesting season), not all eggs produce hatchlings to the beach surface. Not all hatchlings that emerge onto the beach survive to enter the sea. Not all hatchlings survive crossing the reef flat (Gyuris 1994) and not all hatchlings that reach deep water survive to adulthood. In addition, marine turtles do not reproduce every year, further reducing the individual reproductive out-put.

All life phases of marine turtles (eggs, hatchlings, immature, adult) are affected by environmental cues and conditions, such as temperature, humidity, light horizon, food supply.

Normal embryonic development occurs when the temperature of the incubation environment is between 24C and 33C; as the temperature extends outside this range, malformation and mortality rates increase (Miller 1985). Within this range, the temperature in marine turtle nests determines the sex of the hatchlings (Ackerman 1997), warmer incubation temperatures produce female hatchlings while cooler incubation temperatures produce male hatchlings.

Hatchlings use low-angle, light horizons to find the sea; they also use wave and current patterns to disperse from the nesting beaches and to reach deepwater offshore (Limpus 1971, Lohmann and Lohmann 1998). Hatchlings do not actively swim against current: on the larger scale they float and drift passively, on the small scale they swim to feed and survive.

There number of nesting sites (natal beaches exhibiting regular, high hatching success) appears to be limited. Nesting beaches share a general set of characteristics, including: (1) being accessible from sea; (2) having sand that has low salinity, high humidity, good ventilation and good drainage; (3) having a stable temperature range (i.e. 25-33C at least seasonally for approximately 16 weeks); (4) being stable for digging of nest chambers; (5) being stable through time for subsequent nesting; (6) being adjacent to currents for hatchling dispersal; and (6) being close to inter-nesting habitat.

Marine turtles exhibit high fidelity to a nesting site, to an inter-nesting area (the habitat used between sequential nesting attempts within one breeding season) and to a foraging area (the habitat wherein the turtle spends the majority of its adult life feeding). During successive breeding seasons, marine turtles return to the same geographic region (rookery region, typically the same or adjacent beaches or islands) to nest. Because marine turtles return to the region of their birth (Allard *et al.* 1994), beaches where the nesting population has been destroyed will not be 'colonized' by other turtles.At the end of their breeding season, the turtles return to the foraging areas from whence they came. Turtles usually do not relocate to 'new' areas (Limpus *et al.* 1992, Limpus *et al.* 1994a b, Spring 1999).

The number of marine turtles nesting each year is variable. The number of green turtles nesting may vary as much as an order of magnitude (Limpus and Nicholls 1988); this variation is linked to weather phenomena that influences primary productivity in littoral seagrass pastures (Limpus and Nicholls 1988, Bjorndal 1997). This correlation has been demonstrated green turtles. The reasons for the inter-annual fluctuations in the numbers of nesting marine turtles of other species remains unspecified but are probably related to the quality and quantity of food.

Because marine turtles are primary or secondary consumers (Table 3), they are

vulnerable to the impact of bioaccumulation of toxins and contaminants through their food.

Table 3. Primary foods of marine turtles.

Species	Primary Food	Reference
Chelonia mydas	Sea grass, algae	Hirth 1997
Eretmochelys imbricata	Sponges	Witzell 1983
Caretta caretta	Mollusks	Dodd 1988
Lepidochelys olivacea	Crustaceans	Marquez 1994
Dermochelys coriacea	Jelly fish	Pritchard 1971

Marine turtles are marine reptiles that breathe air. They spend the majority of their time under water, coming to the surface only to breathe and occasionally to bask. They can hold their breath for long periods of time while foraging or resting on the bottom. However, turtles captured incidentally in fishing gear can deplete oxygen stores within 15 minutes and drown (see references in Lutcavage and Lutz 1997).

The implications of these characteristics are important for management of nesting sites and foraging areas. Turtles are susceptible to both short-term (acute) impacts and to cumulative (chronic) impacts. As a result, events that appear of no consequence in isolation or in the short term may contribute to dire outcomes for the individual and the population when combined with other impacts and accrued over the lifetime of the animal. Management must seek adopt an integrated approach that considers the potential impact of specific actions as well as the cumulative impact of a wide array of human activities while acknowledging the non-negotiable biological characteristics of marine turtles.

Because turtles are migratory, management efforts must be coordinated at local, regional, national, and international levels to ensure that marine turtles are protected throughout their ranges.

As a result of the biological characteristics of marine turtles (Table 2), determining whether populations are stable, increasing, or declining and determining the effectiveness of management strategies is difficult. It must be realized that turtles nesting and foraging along the Egyptian Red Sea coast have survived the accumulated impact of human activities and natural events that occurred during the last 20-50 years; the effectiveness of management strategies initiated today will impact on the turtle populations for the next 20-50 years and through the life span of the turtles.

REVIEW OF SEA TURTLES IN THE EGYPTIAN RED SEA

Until relatively recently there have been few studies on marine turtles in the Red Sea (Frazier *et al.* 1987). Although Rüppell (1835) and Steindachner (1912) presented observations on marine turtles before 1920, marine turtles of the Red Sea were ignored until the late 1970s (Urban 1970, Moore and Blazarotti 1977, Walczak 1979, Hirth and Abdel-Latif 1980, Sella 1982, Frazier and Salas 1984). Most of these reports focus on specific sites (e.g. Hirth and Abdel-Latif 1980) or small scale surveys (e.g. Walczak 1979). Miller (1989) presented the results of a survey along the Saudi Arabian Red Sea coast. Gasperitti *et al.* (1993) reviewed the literature concerning turtles of the Arabian Peninsula, including the sea turtles of the Red Sea but did not include distributional data from the western side.

In 1984, Frazier and Salas reviewed the status of marine turtles in the Egyptian Red Sea. They found that of the five species of marine turtles known to inhabit the area. Three (hawksbill, green and leatherback) turtles were recognized by local fishermen and had distinctive local names; the other two were not. Frazier *et al.* (1987) put this information into the context of other two species.

Relative Abundance

Hawksbill turtles are considered most common marine turtle in the Egyptian Red Sea (Frazier *et al.* (1987). This consideration was based on both interviews with local people and divers, as well as examination of beaches (Frazier and Salas 1984, Frazier *et al.* 1987).

The green turtle is the second most common marine turtle in the Red Sea (Frazier and Salas 1984, Frazier *et al.* (1987). They speculated that the smaller numbers of green turtles was the result of the “scarcity of feeding habitat”.

The presence of the olive ridley turtle and the loggerhead turtle in the Red sea is supported by only a few records. There are two records of olive ridley turtles and only “three or four” records of loggerhead turtles from southern Sinai (Frazier *et al.* 1987, p297). These species (loggerhead and olive ridley) were thought to be “waifs” (Frazier and Salas 1984, Frazier *et al.* 1987).

The leatherback turtle is seen infrequently in the vicinity of Sinai at the northern end, but there are no records of nesting of leatherback turtles nesting in all of the Red Sea (Frazier *et al.* 1987, p298). The leatherback turtles were considered to be vagrants (Frazier and Salas 1984, Frazier *et al.* (1987).

The current status of these species is not known; nor is assessment of any change possible because no data were presented by the earlier authors.

Nesting

The northern Red Sea hosts nesting populations of hawksbill and green turtles (Fig.5). Frazier *et al.* (1987, p291) noted that nesting by hawksbill turtles along the Egyptian Red Sea coast occurred from "Ras Banas to islands at the mouths of the Gulfs of Suez and Aqaba"; they gave Gulbal el Kebir and Tiran islands as specific examples. They estimated that approximately 500 hawksbill turtles nest mainly on the offshore islands (Frazier and Salas 1984, Frazier *et al.* 1987).

Neither the olive ridley turtle nor the loggerhead turtle has been recorded nesting anywhere in the Red Sea; the leatherback turtle has not been recorded nesting in the northern Red Sea region (Frazier and Salas 1984, Frazier *et al.* 1987).

Distribution of Nesting

Small numbers (50 -100) of green turtles nest in concentrations along the northern Saudi Arabian coast (Miller 1989, Al Merghani *et al*. 2000). Green turtle tracks and nest pits have "been seen on Egyptian islands" (Frazier *et al.* 1987, p294) and along the Egyptian mainland (Frazier and Salas 1984).

Based on incomplete survey data, there are three concentrations of sea turtles nesting along the Egyptian Red Sea coast (Fig 5). One concentration is focused on the off-shore Shadwan Islands group and near-shore Gifton Islands group located in the area where the Gulf of Suez joins the Red Sea. The next concentration of nesting is located in WGHPA. The third concentration is located at the Zabargad Islands off-shore and south-east of Ras Banas. Each of these locations hosts nesting green and hawksbill turtles. None of these sites has been surveyed repeatedly to determine the timing of nesting or the species ratio in the annual nesting. Elsewhere along the coast nesting occurs at low-density, mostly be green turtles but also by the occasional hawksbill turtle (Frazier and Salas 1984, Frazier *et al.* 1987). The paucity of records of coastal nesting may reflect the real intensity or be an artifact of the lack of surveys to determine the distribution of nesting.

In WGHPA, green turtles are reported to nest on the mainland at Umm El Abas and Ras Baghdadi, and on Wadi El Gemal Island and Siyul Island, in the Qulan Archipelago (Frazier and Salas 1984, Salam 2001, AM El Ghani 2002). M. Hanfay, PSU Hurghada, (pers. comm. April 2003 cited by Rouphael 2003) recorded five old nests approximately one km north of Shams Alam Resort. Frazier and Salas (1984)

Figure 5. Distribution of marine turtle nesting in the northern Red Sea. Large red circles indicate the three areas of concentrated nesting. Species: green plus = hawksbill; yellow circle with dot = green turtle; small red dot = unidentified species; loggerhead, leatherback and ridley = dark & purple small circles.

reported 50 hawksbill nests on Wadi El Gemal Island. In August 2001, Salam reported nesting on beaches in Hankorb, Ras Bagdadi, Wadi El Gemal Island and other sites along the coast but did not report the species involved; they are presumed to be green turtles but it is recognized that some proportion (albeit unknown) were hawksbill turtles, especially on Wadi El Gemal Island.

The recent (April 2004) survey of beaches in WGHPA did not include all beaches; only known (or suspected) nesting areas were examined. However, a total of 439 nest sites were located (177 green turtle nests, 192 hawksbill turtle nests and 70 with no species identification) (Fig. 6). These data (Appendix I) provide a picture of low-density, wide-spread nesting on the islands and along the entire coast of the WGHPA, where surveys have been conducted. Given that the recent survey was conducted in April, before the coming nesting season and several months after the previous season, the season in which the nests had been established cannot be determined accurately. Storm surges that wash over nests make them appear older as does wind erosion of dry surface sand. Several seasons of regular monitoring must be conducted to gather data on the distribution and intensity of nesting. Intense nesting was found in both of the areas designated for future development, as well as in between them. Nesting on Wadi El Gemal Island was also wide spread with a concentration on the southern extension of the island. Older records from the Hamata Islands (Qulan Islands) show that both green and hawksbill turtles nest there as well.

Timing of nesting

Nests of green turtles have been found between July and November in Sinai (Frazier *et al.* 1987). Frazier *et al.* (1987) reported that hawksbill nested from April to July in Egypt. Green turtles nest at Ras Baridi, northern Saudi Arabian coast, between August and December with most green turtles nesting during October (Al Merghani *et al.* 2000). In contrast, green turtles nest in Egypt from May to November (Ali Salam, EEAA Hurghada, pers. comm. cited by Rouphael 2003). Nests of green turtles have been reported from Wadi El Gemal Island in June 2002 (S. Balm El Din, PSU Hurgbada (pers. comm. cited by Rouphael 2003). A small number nests were reported on Ras Bagbdadi (A. Salain, EEAA Hurghada pers. comm. March 2003, cited by Rouphael 2003).

The beach survey conducted in April 2004 did not find any fresh signs of nesting for either species; however, old nest pits of both species were found on Wadi El Gemal Island and on mainland beaches. At the present time the nesting season is thought to extend from May through November. The duration of the nesting season can be better defined through a monitoring program.

Figure 6. Distribution of known nesting by marine turtles in Wadi El Gemal – Hamata Protected Area. Species: green plus = hawksbill; yellow circle with dot = green turtle; small red dot = unidentified species. Numbered (buff colored) polygons are the two areas proposed for development within the park boundaries.

Genetic Stocks
There is no information on the composition of the genetic stocks of marine turtles nesting and/or foraging along the Egyptian Red Sea coast. Given the size of the northern portion of the Red Sea and the proximity of nesting areas in Saudi Arabia (Miller 1989, Al Merghani *et al.* 2000), it is a reasonable working assumption that the northern Red Sea hosts a single genetic nesting stock for each species. This assumption can be tested by current genetic analysis techniques. This information would aid current and future management decision making.

Population Status
Any decline in the population combined with the long maturation and low reproductive rate, increases the risk to the viability of the population from any increases in mortality (see Chaloupka and Limpus 1997). Sustained losses of adult and subadult turtles from anthropogenic sources may result local extinction (see Heppell *et al.* 1996b). It must be remembered that long term monitoring is required to detect significant changes in marine turtle populations; even 20-25 years of monitoring does not contain a single generation for green turtles.

There is no direct evidence available concerning the status of marine turtle population in the Egyptian portion of the Red Sea; nor is there any known data on population trends for any population of marine turtles in the Red Sea.

Effective management of human impacts on marine turtles requires information concerning the general and specific biology of the turtles. For all the species of marine turtle found in Egyptian waters, there is inadequate knowledge of the sizes of their populations, distributions, or the location of nesting areas as well as foraging habitats.

OVERVIEW OF IMPACTS, EFFECTS AND THREATS

Human activities affect marine turtles in many different ways and over different temporal and spatial scales (Table 4). Impacts and their effects may be acute (short-term), chronic (long-term) or permanent. For example, being struck by a boat may injure or kill a marine turtle, whereas development at a nesting beach may deflect nesting to suboptimal areas and thereby reduce the success of the reproductive effort. More subtle impacts occur as well (i.e. light and physical interaction can disrupt nesting efforts).

An isolated incidence involving one individual turtle can be accepted as having only minor short-term, restricted impact, but repeated, long-term interactions involving many individuals can have a cumulative, negative impact on the behavior of individual turtles and, hence on the functioning of the population.

Table 4. Major threats to short and long term survival of marine turtles.

Major Threats to Survival	Reference
Harvest (Eggs, Meat, Shell)	Campbell 2003
Degradation of Foraging Areas	Lutcavage *et al.* 1997
Degradation of Nesting Areas	Lutcavage *et al.* 1997
Development and inappropriate use	Witherington and Fraser 2003
International Trade	Mack *et al.* 1995, Groombridge and Luxmoore 1989
Marine Pollution (Oil, Debris, Plastics)	Lutcavage *et al.* 1997
Fishing Bycatch (Trawling, Netting)	Campbell 2003, Epperly 2003

At certain times in their lives (e.g. very young, during breeding seasons, or when engaged in mating or foraging), turtles are may be more sensitive to (or tolerant of) specific impacts. Different species may also show more or less response to specific stimuli because of physiological or other factors.

As a result it is extremely difficult to assess the extent to which a particular impact will affect, or is affecting, individual animals or a population; assessment can only be made using long term data. Prudent conservation management dictates that the precautionary principle must be invoked to minimize serious or irreversible effects. Predictions of effects of human activities on sea turtles must be included in management decisions, while acknowledging the need for more supporting scientific evidence (Dobbs 2001).

Identified Threats

Among the problems threatening the continued survival of marine turtles in the Red Sea and along the Egyptian coast noted by Frazier *et al.* (1987) were the taking of green turtles for meat, the taking of their eggs for food, and the specific killing of hawksbill turtles for the scales (tortoise-shell). The present levels of exploitation of marine turtles along the Red Sea coast are thought to be low. Petroleum was considered to be a major threat stemming from spilt oil contaminating the water (floating oil and tar balls) and many beaches (fouling both adults and hatchlings crossing the beach) and the process of blasting during exploration for oil reserves. Frazier *et al.* (1987, p291) noted that some islands exhibited “signs of ancient and incredibly heavy exploitation of sea turtles on several Red Sea Islands”.

Frazier *et al.* (1987, p294) commented that "most nests [of hawksbill turtles were] about 5 m inland of the crest of the beach" and speculated that hawksbill turtle "nests are often tucked under small bushes, which may provide some shade" to reduce thermal stress on the eggs. Miller (1989) noted that hawksbill turtles nesting on the Arabian Gulf Islands did not seek vegetation for nesting; the idea of hawksbill turtles selecting to nest in association with vegetation persists in the literature without the support of experimental data.

Although the relative importance of threats depends on the species and the locality, all marine turtles face a general set of threats, including predation of nests; incidental capture in fisheries gear; ingestion of synthetic materials (e.g. plastic bags, discarded fishing line, tar balls); vessel strike; coastal development; unregulated tourism; increased incidence of disease; and entanglement in discarded and lost nets (see Lutcavage *et al.* 1997, Epperly 2003, Milton and Lutz 2003 for detailed discussions).

The main categories of impacts and resulting effects upon marine turtles within the WGPA include:

1. Coastal Debris

Marine turtles may die if they ingest or become entrapped in marine debris. If ingested debris prevents the turtle from surfacing to breathe it will drown; if the material disrupts normal digestion, the turtle will suffer a lingering death.

Hatchling sea turtles are particularly at risk because they congregate where oceanic debris concentrates. Small turtles feed capriciously on items of appropriate size (e.g. pieces of plastic bags, plastic beads and tar balls) (Carr 1987). Debris on beaches may interfere with nesting activities such as digging a chamber in which to deposit eggs; debris may interfere with hatchlings reaching the sea (Hutchinson and Simmonds 1991).

The beaches of WGHPA are littered with debris. Material ranging from plastic water containers, plastic bags and sheets of plastic, general litter and rubbish, light bulbs, wood and tar-coated debris was seen on every beach visited, beginning just outside the boundaries of the resorts. The potential for disruption of nesting activity and reduce hatching success seems high.

This material should be removed from the beaches, but this is a huge task. This task could not be accomplished quickly but could be done in stages. The priority areas would be the five islands within the park and all areas where turtles are currently recorded to nest. Removing debris from other beaches could be done as a second level task.

2. Harassment

Harassment of turtles involves disturbing normal patterns of their behavior. This may be deliberate or inadvertent, but the result is a change in behavior. Examples of such disruption include: shining a bright lights on nesting turtles, having a campfire at a nesting beach which disorients nesting females and/or hatchlings, lighted buildings situated on the coastal margin can alter natural lighting and disorient nesting females and/or hatchlings (Ehrenfeld 1968, Limpus 1971, Lohmann and Lohmann 1998, Mann 1977, Witherington 1992). The impact on nesting may be evident in the short term. The disturbed females may shift to other, sub optimal nesting locations and encounter problems with beach conditions; the eggs may not have the same hatching success when oviposited on sub-optimal beach conditions. Both of these situations may not appear to impact on the population but both may reduce the number of turtles into the future. Only long term monitoring of the number of turtles using the nesting beaches and the distribution of the nesting effort can detect such changes.

3. Habitat Disruption

Habitat disruption may impact on marine turtles indirectly via (1) high-rise buildings shading nesting beaches and altering sex ratios, (Mrosovsky *et al.* 1995), (2) sand replenishment may alter salinity, beach compaction, slope (Crain *et al.* 1995), (3) cement factory dust may solidify and prevent hatchlings from emerging (Pilcher 1999), (4) use of spiked beach umbrellas may penetrate into clutches and destroy eggs and other beach structures may compact sand above the eggs, (5) modified shorelines change hydrodynamics, thus affecting inshore currents and sediment rates which may in turn change the abundance and/or distribution of food.

The impacts of habitat degradation or destruction on marine turtles depend on several factors, including (1) whether the degraded areas are primary habitats, (2) the size of the degraded area, and (3) the degree and persistence of the degradation.

Disruption of the physical characteristics of the nesting beach may have serious consequences for a population, because activities at or near turtle nesting beaches could cause turtles to lay their eggs in sub-optimal habitats (Mann 1977). The impact of disturbance of the nesting beach depends on several factors, including (1) whether nesting turtles are displaced from primary habitats, (2) the frequency of disruption, (3) the duration of disruption, (4) the size of the area from which the animals are displaced, and (5) the number of turtles in a population.

Lights on vessels anchored offshore of nesting beaches may disorient nesting turtles; these lights also attract hatchlings and increase their risk of predation by reef fish and sharks (see below). The use of breakwater walls to stabilize beaches decreases nesting activity (Bouchard *et al.* 1998).

4. Incidental Catch in Fishing Gear

Fishing gear (active, lost or discarded) may entangle marine turtles (Hutchinson and Simmonds 1991). Turtle caught in fishing gear may be physiologically stressed and drown in less than 30 minutes (Lutcavage and Lutz 1997). Fishing gear does not have to be in the water to entrap turtles. Nets that have washed ashore may entangle nesting turtles and/or hatchlings.

5. Pollution

Marine pollution can affected marine turtles both directly and indirectly. Toxic chemicals in the marine environment may eventually pass through the food chain into turtles (Gladstone 1996, Gordon *et al.* 1998) and their eggs (Clark and Krynitsky 1980). Oil pollution may have both direct and indirect impacts on marine turtles. Toxic vapors may damage respiratory tissues floating oil may coat eyes, mouth, nasal passages and/or skin. If oil washes onto a nesting beach and does not weather before turtles begin nesting, increased mortality may occur (e.g. Fritts and McGehee 1989).

Even small discharges of oil into the sea (e.g. from outboard motors) may accumulate and may impact on a turtle that is already suffering some stress. The additive effect cannot be ignored (Lutcavage *et al.* 1997 and included references).

Oil pollution is not currently an important issue, although some tar was found on Wadi el Gemal island. There was little tar on the beaches. The potential is present, however, as the result of shipping past WGHPA that passes through the Suez Canal.

During a response to an oil spill, protective measures may impact on nesting turtles through traffic on the beach and vessel traffic offshore. While such events are infrequent, the impact of an oil spill clean up can add to other anthropogenic impacts affecting the survival of the population (Lutcavage *et al.* 1997). As part of Oil Spill Response Contingency planning for the Egyptian coastal area, the needs of the turtles should be considered. The known nesting beaches (nesting habitat) and the fringing reefs (foraging habitat) of the islands and coast should be considered in the contingency planning. The use of booms and other containment equipment must be judged in the context of the potential fouling of the habitat and the turtles (adults, hatchlings and eggs). Information on the duration of the nesting season and the distribution of nesting sites and the distribution of foraging areas is essential to good planning and action.

6. Vessel Strikes

Increasing the number of vessels operating in areas used by marine turtles increases the risk of turtles being struck by boats (Dobbs 2001). A collision with a boat may kill a turtle, or cause substantial injury that leads to death. Turtle-vessel collisions add to the cumulative anthropogenic mortalities which together may become a

significant threat to the population.

7. Deliberate or Reckless Killing and Injuring

The deliberate killing of turtles is prohibited in Egypt. No direct evidence indicating deliberate killing or injuring was found during the April 2004 inspections. However, there was comment made during discussion that turtle carcasses have been found with indications that suggest they may have been deliberately killed.

Deliberate or reckless killing or injuring of turtles probably occurs at a low frequency; however, the cumulative impact of injuries and mortalities from all anthropogenic sources can cause population declines.

Even such seemingly unobtrusive activity as taking pictures of a nesting turtle may disrupt the nesting effort or cause an egg chamber to collapse (possibly killing the eggs). This kind of uninformed and unintentional disruption of nesting turtles can be controlled by knowledgeable rangers and guides interacting with beach visitors.

8. Food Reduction

Marine turtles eat a variety of different foods during their lives; some of the variety is related to the life phase (hatchling, immature, adult) and some related to availability and possibly even individual learning/preference (Bjorndal 1997, Table 3).

Although much is known about general the food preferences of green and hawksbill turtles (Hirth 1997, Witzell 1983, Bjorndal 1997, Table 3), little is known of actual food selection in the Red Sea and Egyptian waters.

Significant changes in food abundance, quality and distribution can result from natural causes, or more directly from human disruption of habitat (Bjorndal 1997). The effects of food reduction on marine turtles depends on (1) the extent and magnitude of the reduction; (2) the duration of the reduction, (3) whether alternative food is available, and (4) whether the turtles can access alternative food items, among other causes. The impact may not be direct; anthropogenic effects on water quality or clarity may cause losses of seagrass habitat (Abal and Dennison 1996, Devlin 1999), thereby impacting on the local marine food web.

9. Disease

George (1997 and included references) discuss numerous disease scenarios that impact on marine turtles, some of which are enhanced by human activity. Necropsy of dead turtles can assist in identifying causes of death. Unfortunately, identifying diseases that cause death in marine turtles is difficult. By the time a turtle carcass washes ashore, it is usually too decomposed to determine the contribution of disease as the cause of death. For example, a dead female hawksbill turtle (Curved Carapace Length: 72 cm) was found on the Hertway beach (24.17481, 35.44217) on 10 April

2004. A subsequent field necropsy did not establish the cause of death; the animal may have died of natural causes or in unnatural circumstances.

10. Explosions

The effects of underwater explosions on marine turtles depend on the size and type of the explosive, the location relative to the turtle, the topography around the blast site, the location the blast site (e.g. water depth), and other factors (Ketten 1995).

There is very little information about the behavioral responses of marine turtles to underwater explosions turtles (see Klima *et al.* 1988, Minerals Management Service 1997). Unless the turtle is very close to the blast cite or that blasting occurs over a long period, especially during nesting season, underwater explosions are likely to have little long term impact on behavior or survivorship.

DEVELOPMENT ISSUES

Tourism associated development is expected to increase in the WGHPA and in the surrounding area in the near future and planning for the impact is underway (TDA RSTI 2003). As a direct result, there will be increased pressure on the park (both physically and conceptually) to allow development within the boundaries. There is currently some development with in the park. To protect the resources of the park, these businesses must conform to the best conservation practice for all their activities, including waste disposal, guest activities and buildings (lighting, location).

Although good for broad-scale identification of important natural assets, when applied to portions of larger regions identification of environmentally sensitive areas (ESAs) overlooks the complexity and interrelatedness of the biological and physical resources in the regional and local context. This is particularly true when dealing with migratory species and species that function on different temporal and spatial scales; marine turtles fit both of these criteria.

Unfortunately when specific (albeit incomplete) data are known about the use of areas by species (e.g. nesting beaches used by sea turtles), there is a tendency to focus concern on those locations without putting the full range of requirements of the species into the consideration. For example, turtle nesting beaches were identified in the planning document; however, this was done with limited data. A more complete data set shows that marine turtle nesting in the area is low-density, wide-spread. The approach of identifying specific locations that are in reality only part of the required habitat to support the species puts the species at risk of being granted only part of what it requires to maintain a healthy population. In other words, the broad scale analysis must be reviewed according to the biological requirements of multiple species and adjusted according to their spatial and temporal

needs through application of the precautionary principle to ensure the sustainability of the resource.

Lighting

Light pollution is a major problem on many sea turtle nesting beaches; females may be discouraged from nesting (Witherington 1992) and spatial nesting patterns can be altered (Salmon *et al.* 2000); hatchling orientation can be disrupted (Witherington 1997). In most of these situations development occurred before the impact on the nesting turtles was recognized. As a result there have been numerous problems (economic, structural, and social) identified that restrict or prevent the proper addressing of the issue. Along the Red Sea coast of Egypt, some places are highly developed and others are still undeveloped. Although there are economic arguments in favor of development, it must be remembered that the availability of a high quality resource (the Red Sea, the marine biota including corals, fishes, turtles, marine mammals, etc.) is what makes the area valuable for tourism, the major economic force in the area. It seems obvious that the best strategy is to maintain the highest quality resource base in order to keep the value in the region. This translates to putting the priority on protecting the marine and coastal environments rather than continued uncontrolled or misplaced development.

Given the constraints imposed on marine turtles by their biology (Table 2), the argument for continued development based solely on economic grounds is unsustainable in the medium and long term. The turtles cannot change their behavior to suit human desires. Marine turtles need places where they can nest and places where they can forage without disruption. Along the Red Sea coast, green and hawksbill turtles nest in the low-density and their nesting areas are wide-spread; their foraging areas are also wide-spread along the coast.

WGHPA provides a unique refuge for nesting and foraging that is currently not heavily encumbered by development. Further north along the coast the number of potential refugia and their size is restricted by existing tourist facilities, local communities, factories and harbors; this increases the importance of WGHPA as a refuge for marine turtles and other wildlife.

Lighting and other aspects of existing development must be modified to restore the beach and coastal areas to meet the needs of the turtles both for nesting and foraging. Any new development must meet strict requirements to ensure that the required habitats are not degraded. Planned developments must be excluded from the remaining undisturbed areas to ensure refugia for the turtles and other marine biota.

This does not mean that people or recreational and/or commercial activities should be excluded; however it does mean that the priority in use of the park is granted to the wildlife (both terrestrial and marine). To achieve the balance required to protect

the resources and to facilitate sustainable use in the region requires conservation management to restrict detrimental activities while providing opportunities for utilization within limits.

The simplest way in which to determine if light is a problem at a nesting beach is to stand on the beach looking landward; if any light source can be seen, that source is a potential problem (see Witherington and Martin1996). The more subtle impact of the cumulative glow in the sky around resorts and other human habitation may also distract nesting turtles and hatchlings (see Witherington and Martin1996); reduction of the glow is a matter of turning off unnecessary lights, even if they cannot be seen directly from the beach.

Light shining on and near nesting beaches can be managed relatively simply by using one or more of the following techniques:

- Turing off all unnecessary lighting
- Using timing restrictions during the nesting season
- Limiting the duration a light is on by utilizing motion detectors
- Using good light control (i.e. lowering, shielding, recessing, and redirecting lights)
- Planting and maintaining native and decorative vegetation to form light screens
- Using physical barriers (e.g. creating artificial dunes well landward of the nesting area and between the nesting area and light sources.
- Modifying the color of light by using filters, long wave length light sources
- Modifying the light that is emitted from accommodation (i.e. closing curtains and/or blinds at night, moving lamps away from windows, applying tinting to windows)

Social and Economic Aspects

Tourists interact with marine turtles on nesting beaches around the world (e.g. Hawaii. Balazs1995, Johnson *et al.* 1996; central America Campbell 1999, Campbell 2002b; south America, Marcovaldi and Marcovaldi 1999; the Caribbean Fournillier 1994; south East Asia, Cheng 1995; Australia, Wilson and Tisdell 2001; the Mediterranean Dimopoulos 2001, Yerli and Canbolat 1998, Venizelos, L. 2001).

The importance of not consumptive tourism that includes turtles should not be underestimated (Witherington and Frasier 2003). Properly managed ecotourism involving marine turtles is sustainable and economically viable (Tisdell and Wilson, 2001 a, b, Wilson and Tisdell 2001). Further, the style tourism is important in determining the value of the experience; cultural presentation and tourist expectation play contributing roles in maintaining the vale of the experience of seeking, finding, and watching turtles nest on the beach at night.

Tourism is very important in the region and to WGHPA. The economic benefit at the local contributes to the economy of Egypt. It must be acknowledged that tourism in the region depends on the quality of the regional resources; further, it must be acknowledged that in order for this benefit to be sustainable, the tourism industry of the region must behave in a manner that does not degrade or destroy the resource. Specifically, tourist facilities near and within the park must not damage the resource; this would be contrary to the purpose of the park and not be sustainable.

The park was designated to have northern and southern sections that are marine, including the coast, but not terrestrial. Development in these two areas can be allowed under restrictions so that the marine habitat is not degraded. One of the issues in this area is lighting. The inappropriate use of lighting in and on wharfs as well as inappropriate activities (e.g. fires on beaches), especially during the turtle nesting season, must be prevented to maintain the current quality of the turtle nesting.

Interpretative Program

As noted in the land use management plan, an interpretative program is an important part of the management of the WGHPA area. With specific reference to the marine turtles of the area, an interpretative program conducted by rangers and locals for resort guests would enhance the overall experience of the visitor. An outline of an interpretative program is presented in Section II.

The basic idea is that Park Rangers would be trained to train local residents to guide tourists along beaches at night with an anticipation of finding nesting turtles. The role of the Rangers would be to monitor the quality of the interpretative program and to monitor the interactions of the 'turtle guides' and the tourists with the turtles. If developed properly, an Arabian Desert experience would include a visit to a turtle nesting beach thus providing a unique experience for tourists and income for locals.

SUMMARY

The marine turtles of the Egyptian Red Sea are a special component of the biodiversity of the coastal ecosystem. They have a set of non-negotiable requirements that cannot be compromised, if they are to survive in the long term. WGHPA provides a unique refuge for marine turtles (and other marine and terrestrial flora and fauna) along the southern Egyptian Red Sea coast. With proper conservation management of human development and behavior in the area, marine turtles can contribute to the economic viability of the region.

To achieve the sustainable interactions several actions should occur:

A. The designated areas for development within WGHPA should not be developed to avoid fragmenting the marine turtle nesting in the park.

B. Lighting on existing resorts and wharfs should be modified to prevent potential disruption of nesting turtles and disorientation of hatchlings.

C. Rangers should be trained to monitor the marine turtle nesting activity in the WBHPA

D. A program of training of local ‘turtle guides’ should be developed to provide some economic input to the existing local communities.

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