# Globally endangered sea turtles of the

# Palmyra Atoll National Wildlife Refuge:

# A Focus on Scientific Analysis

Exercise

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## Overview

Little is known about sea turtles and their habitats at the remote Palmyra Atoll National Wildlife Refuge (PANWR) in the Central Pacific. This lack of knowledge may hinder management and conservation efforts. To help provide insights into protection strategies, in this exercise you will make suggestions for designing a comprehensive research program on globally endangered sea turtles of the Palmyra Atoll National Wildlife Refuge. You will then use existing survey data to answer questions about the relative abundance of endangered sea turtles along the atoll, and critically analyze your results. Finally, you will carry out research to devise your own methods for studying sea turtles at the PANWR.

## Introduction

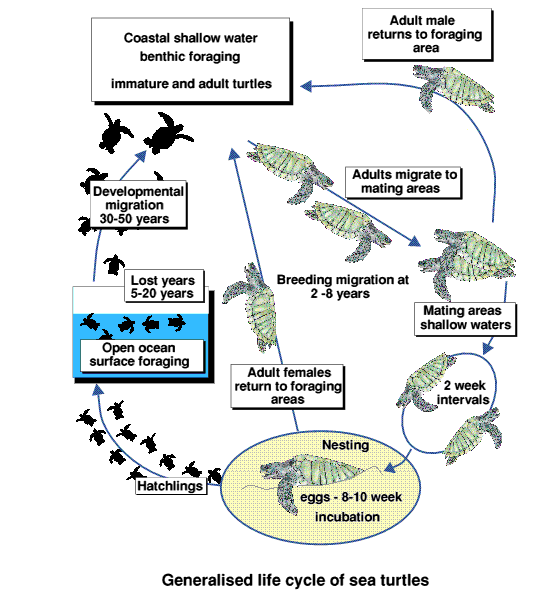
The world’s oceans and seas, which span about three quarters of the earth’s surface and contain a substantial part of the planet’s biodiversity, are under threat. Systems are strained by unsustainable fishing practices, habitat degradation, coastal development, climate change, and other factors. Over the course of their lives, sea turtles play important ecological roles in many marine systems. These charismatic animals have long been important elements of diverse cultures, and their conservation can benefit humans as well through, for example, ecotourism or environmental employment. Even so, many of these ancient reptiles are now endangered worldwide due to harvest, fisheries interaction, habitat loss, pollution and disease, climate change, and other threats. Sea turtles are flagship species, whose conservation can also protect the vast, diverse, and often threatened habitats they utilize.

Sea turtles, also known as marine turtles, have inhabited the earth for over 100 million years, since the Cretaceous Period (Hirayama 1998). The fossil record reveals that four families were established during this period, two of which have survived into the present (Pritchard 1996). The family Dermochelyidae contains only the leatherback turtle, *Dermochelys* *coriacea*, while the second family, the Cheloniidae, is commonly thought to include six species classified into five genera. These include the critically endangered hawksbill turtle, *Eretmochelys* *imbricata*, a tropical species and one of the few animals known to feed on sponges. Also in this family are the primarily herbivorous green sea turtle (*Chelonia* *mydas*), and the carnivorous loggerhead (*Caretta* *caretta*), found in tropical and temperate areas worldwide. The flatback (*Natator* *depressus*) has a restricted distribution, nesting mainly in Australia. Another species with a restricted distribution is the Kemp’s ridley (*Lepidochelys kempii*), found only in the Atlantic Ocean. Although they may look similar, many studies support recognition of the Kemp's ridley, *L. kempii*, and the olive ridley, *Lepidochelys olivacea*, as separate species (Bowen et al. 1991; Bowen et al. 1993; Dutton et al. 1996).

Throughout their highly migratory life cycles, sea turtles are known to serve as prey for some species such as sharks, as consumers and habitat modifiers, and as nutrient transporters (Bjorndal and Jackson 2003). In the latter capacity, turtles carry nutrients (elements needed for survival, growth, or metabolism) between different ecosystems by, for example, laying eggs. After hatching from eggs on nesting beaches, young sea turtles disperse into the ocean. As juveniles, some species, including green and hawksbill sea turtles, leave the pelagic environment and move to coastal feeding grounds (Musick and Limpus 1997). Adults undertake breeding migrations that may span thousands of kilometers between feeding grounds and nesting areas. Many females return to nest in the vicinity of their natal beach (Carr 1967; Figure 1). Although there is much information about sea turtles, scientific knowledge about some topics and populations remains scarce.

**Figure 1**. The sea turtle life cycle spans diverse ecosystems sometimes separated by thousands of miles. Palmyra Atoll is a foraging area for green and hawksbill sea turtles.

Source: http://www.euroturtle.org/biology/lifec.htm



### Sea turtles at Palmyra Atoll

Little is known about threatened sea turtles and their habitats at the remote Palmyra Atoll National Wildlife Refuge (PANWR), located in the Central Pacific about halfway between Hawaii and American Samoa (5°53′N 162°05′W, Figure 2). It is known that the two species found to date at Palmyra (Figure 3) are listed under the US Endangered Species Act. The green sea turtle (*Chelonia mydas*) is listed as Threatened except where Endangered (nesting colonies in Florida and Pacific Mexico), and the hawksbill sea turtle (*Eretmochelys imbricata*) is listed as Endangered. In addition, these species, along with all other marine turtles, are included on the World Conservation Union’s IUCN Red List of Threatened Species. Preliminary reports by government personnel and our research team have underscored the paucity of knowledge about sea turtles and their ecosystems at Palmyra. This dearth of information hinders effective conservation, recovery and management.

**Figure 2**. Map showing the location of Palmyra Atoll, Central Pacific (Credit: Peter Ersts, CBC).



**Figure 3**. Satellite image of Palmyra Atoll, Central Pacific (center; credit: IKONOS), with green (left; credit: Dan Brumbaugh, CBC) and hawksbill (right; credit: Palmyra Atoll National Wildlife Refuge) sea turtles found there.



Protected areas such as Palmyra form the cornerstone for biological conservation and can safeguard biodiversity from genes to ecosystems. However, protection of an area does not automatically ensure the well being of its organisms or habitats, particularly of migratory species such as sea turtles. It is necessary to understand species biology and ecological processes within a protected area, as well as the links among populations that may move across area boundaries. Highly migratory sea turtles, for example, may face serious threats when they depart protected borders, including those of the PANWR, on their breeding or developmental migrations. These migrations may be as far as several thousand kilometers from their feeding grounds. Significantly, Palmyra

Atoll is thought not to be a major nesting area, but rather, a year-round feeding ground for both adults and juveniles, meaning that the departure of turtles from its waters can place them in endangerment from outside factors.

The Refuge offers unique opportunities for sea turtle conservation research because of the interdisciplinary research efforts of the Palmyra Atoll Research Consortium (PARC), and its unusual history. Palmyra Atoll is an incorporated territory of the United States. Portions of the terrestrial areas of the atoll are privately owned by The Nature Conservancy and managed as a nature reserve. The neighboring islets and surrounding waters, out to the 12-mile limit, were transferred to the United States Fish and Wildlife Service and designated as the Palmyra Atoll National Wildlife Refuge in 2001. The Refuge was established by the Department of the Interior and is managed by the FWS. During World War II, however, Palmyra Atoll was heavily altered as a result of the US Government occupation. Extensive dredging, and connection of the islets that made up the atoll into causeways changed the hydrological and oceanographic features of the atoll. Efforts to restore the original hydrodynamic flow, which are currently being considered for the lagoon system (Figure 3), could involve breaching these causeways. However, these restoration efforts may release toxic plumes and other pollutants left behind by the US government occupation into the marine environment, potentially negatively impacting sea turtle feeding grounds and other habitats.

In recent years, the atoll has been uninhabited except for management or research personnel, including members of the multi-institutional PARC, which carries out integrative studies of biodiversity and environmental physics along the Atoll. Relatively few sea turtle studies are carried out in marine systems under as intense scientific attention as Palmyra, and this broader research context should help address priority questions about the ecological roles of sea turtles and ecosystem approaches to sea turtle conservation and management. Because sea turtles at Palmyra forage in a unique environment currently removed from direct, pervasive human influence, this research can expand our knowledge of these reptiles where they are relatively unaffected by people, providing an essential baseline for understanding natural processes, ecological roles, and human impacts.

## Exercise

### A) Asking questions about sea turtle research at Palmyra Atoll

Why study sea turtles at Palmyra? Based on the information above, can you formulate three scientific or management/conservation questions that can be addressed through research at the PANWR? In a group or as part of a classroom discussion, organize the various questions raised by your class into overarching research themes.

### B) Identifying objectives for sea turtle research at the PANWR

Next, please identify three to five priority objectives for sea turtle research at the PANWR. Include a justification of why meeting each objective is important to science or conservation.

### C) Methods and results: focus on sea turtle surveys at Palmyra Atoll

To advance the research and conservation of sea turtles at Palmyra Atoll, studies began there in 2005. One major objective of the early research at Palmyra was to gain some understanding of sea turtle distribution and abundance there. To this end, surveys were carried out to document the occurrence of sea turtles along the atoll about every three months from August 2005 to September 2006, and approximately annually thereafter. Survey counts were conducted by 5 to 10 researchers who simultaneously traveled by kayak and boat along non-linear transects, each counting the number of turtles that they encountered on the transect. The total number of turtles counted was influenced by weather and visibility conditions, and as many as 120 turtles were seen during the roughly 2-hour survey period.

To help provide insights into conservation and management, you will use data from the first survey to investigate the abundance of endangered sea turtles along the atoll. The coordinates of sea turtle sightings were recorded in this survey using Global Positioning System (GPS) technology and overlaid with satellite images to investigate ecological interactions. Below are the results of this survey, which took place in August 2005 (Appendix 1: Figures 4-8). Use these data to reply to the following questions. For each question, also consider what some limitations might be in only using these survey data to formulate your answers.

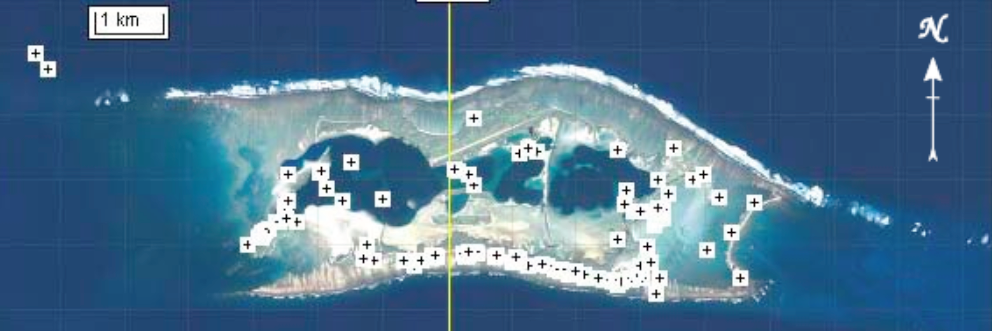
1. Which species appears to be most common along the atoll?
2. Are sea turtles found randomly throughout the atoll? If not, identify areas where sea turtles are most commonly seen.
3. Assuming the data are correct, what might be some explanations to account for their distribution?
4. Identify strengths and weaknesses of using this survey to assess turtle distribution at the PANWR.
5. How would you carry out future surveys to improve the quality of conclusions drawn from these data?
6. Now look at the results of additional surveys, which followed a more defined survey design (Appendix 2: Figures 9-11). Do they confirm the conclusions based on the first survey? Are these data sufficient to estimate distribution and relative abundance of sea turtles along the atoll? Based on these data, design three testable hypotheses for future studies investigating distribution and abundance.

### D) Developing methods for sea turtle research

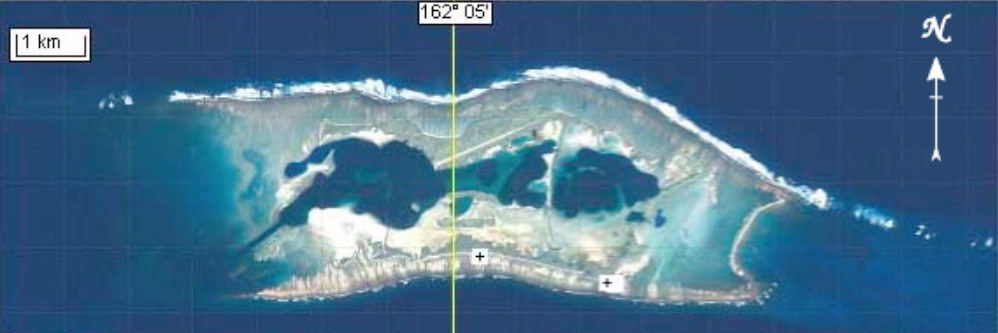
Now, consider the following research questions currently being investigated at Palmyra: a) diet; b) health; c) local movements at the refuge; d) migratory connections to other sites outside the Refuge. Choose one of these areas, and carry out library research to identify methods you would use if you were carrying out the research. Report your findings by writing two to three paragraphs in a format suitable for publication in the Introduction or Methods section of a scientific journal article.

## Appendix 1.

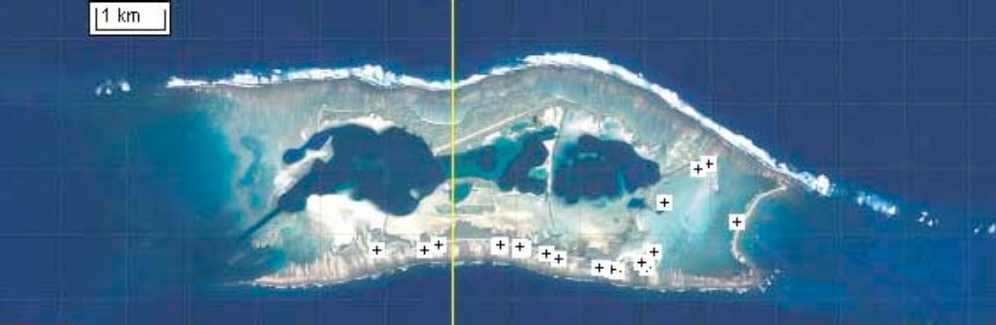
**Figure** **4**. GPS locations of sea turtle sightings (+) from the August 2005 survey (number of turtle sightings (n) = 224). Note: For many of these turtles, it was not possible to assign a size or species classification, although all individuals captured in subsequent studies were green sea turtles.



**Figure 5**. GPS location of confirmed or possible hawksbill sea turtle sightings (+) observed during the August 2005 survey. The sightings in the southeast consist of multiple turtle observations, while the one along the central south flats was one possible hawksbill.



**Figure 6**. Locations where algae, the likely main diet of green sea turtles, were observed. These sites were noted opportunistically during the 2005 sea turtle survey, which was not directed specifically at identifying locations of algal growth. In later years, researchers again surveyed the habitat along the algal-covered, shallow-water reef flats where sea turtles were most commonly observed, in order to investigate sea turtle habitat associations. It is important to keep in mind that the presence of the animals in a particular habitat does not necessarily mean they prefer that habitat. Algae sampling was conducted on these flats to explore the distribution, abundance and dominance of this key diet item for green sea turtles. Results from this study documented various genera of algae, including items often ingested by green turtles.



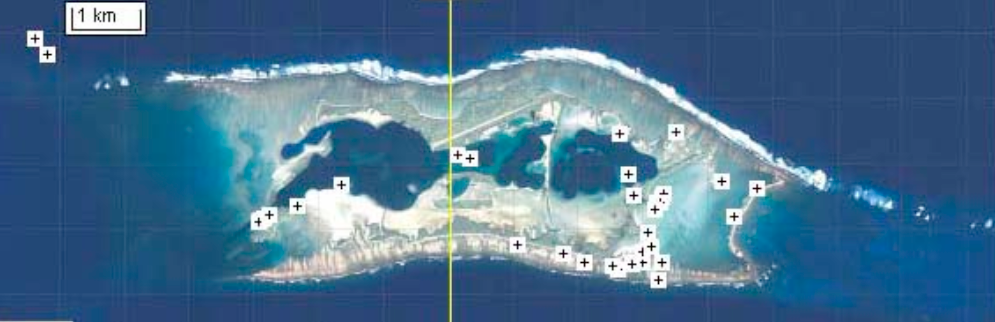
**Figure 7**. GPS location of sea turtle sightings (+) at high and low tides. Note: For many of these turtles, it was not possible to assign a size or species classification. Tide classifications were based on computer generated tide charts for Palmyra Atoll provided by the station staff, with height in feet rounded to integers to account for site-specific variability.



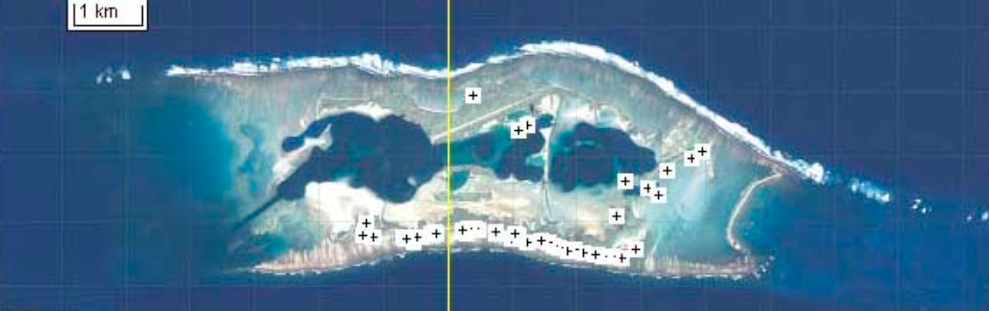
1. Tide height 0 feet, rising and falling (n=18)



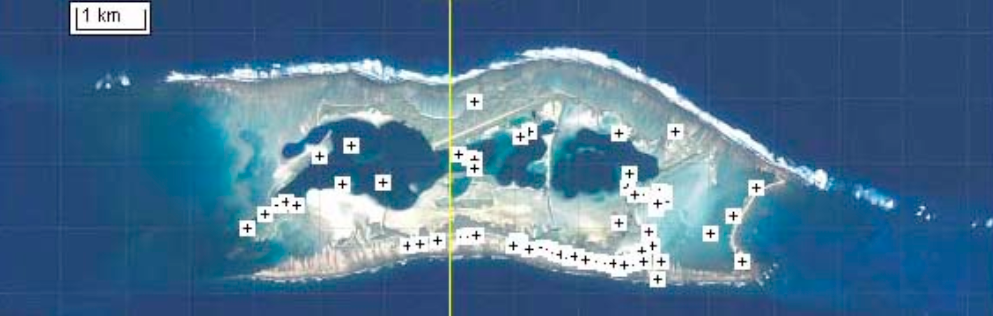
1. Tide height 1 foot, rising and falling (n=56).



1. Tide height 2 feet, rising and falling (n=56).



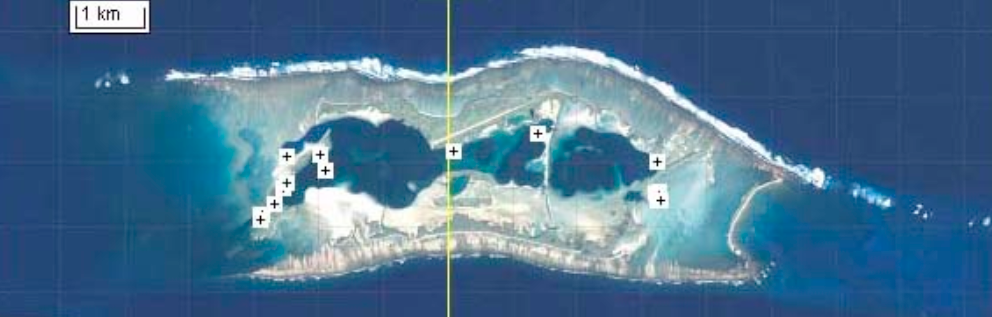
1. Tide height 3 feet, rising and falling (n=99).



1. Rising tide (all heights)



1. Falling tide (all heights)



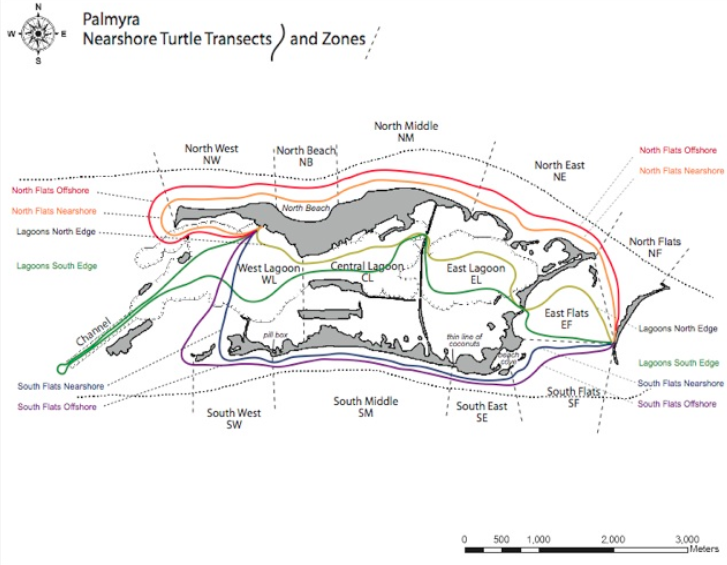
1. Falling tide (0-1 feet)

**Figure 8**. Tracks showing the path of survey vessels during the August 2005 survey.

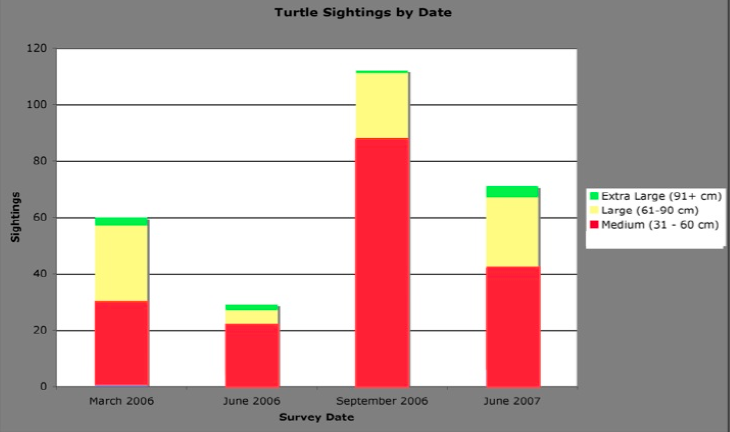


## Appendix 2.

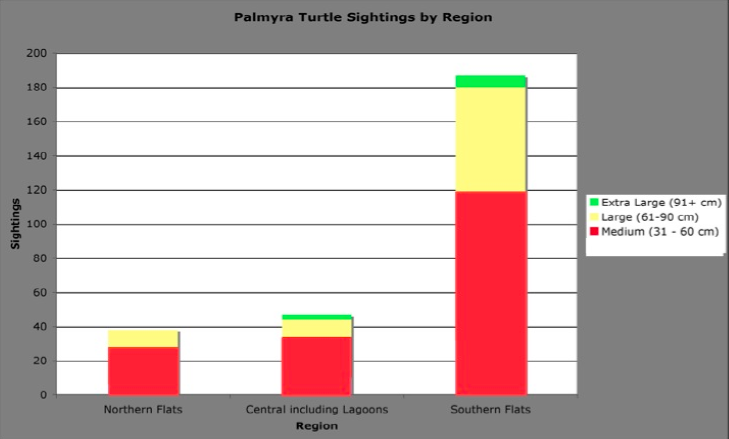
**Figure 9**. Search paths defined for the surveys (2006 to present).



**Figure 10.** Summary of survey results – turtle sightings by date. *Note*: For many of these turtles, it was not possible to assign a species classification, and all size categories are estimates since the turtles were not measured.



**Figure 11**. Summary of survey results – turtle sightings by region on the atoll.



## Additional resources

* Palmyra Atoll National Wildlife Refuge: <https://www.fws.gov/refuge/palmyra_atoll/>
* Palmyra Atoll Research Consortium: <http://www.palmyraresearch.org/about/what-is-parc>
* Sea Turtle Research at Palmyra: <https://www.amnh.org/our-research/center-for-biodiversity-conservation/research-and-conservation/biodiversity-exploration-and-monitoring/sea-turtles-of-palmyra-atoll>
* See real sea turtle satellite tracks worldwide, download sea turtle images, and learn about sea turtles: [http://www.seaturtle.org](http://www.seaturtle.org/)

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