

## The Palmyra Atoll Research Consortium



White tern (*Gygis alba*)

*Palmyra Atoll in the tropical Pacific is the site of some exciting work by scientists from a diverse collection of research institutions. The Palmyra Atoll Research Consortium (PARC) fosters collaborative multi- and inter-disciplinary research by U.S. Department of the Interior (DOI) agencies (USGS and U.S. Fish and Wildlife Service–USFWS), academic institutions (for example, Stanford University, University of California, University of Hawaii, and Victoria University of Wellington in New Zealand) and non-governmental organizations (for example, American Museum of Natural History and The Nature Conservancy) on the terrestrial and marine ecosystems at Palmyra Atoll. USGS has been a member of PARC since its inception in 2004.*

Palmyra has a complex history of private ownership and use except during World War II when it was under U.S. military control as a Naval Air Station. In 2000, most of the atoll's emergent lands were purchased by The Nature Conservancy (TNC). TNC retained the largest island as a preserve and research station but later sold most of the atoll to the U.S. for Refuge lands. In 2001, Palmyra Atoll and its surrounding waters (to the 12-mile limit) were transferred to the USFWS and are now designated as the *Palmyra Atoll National Wildlife Refuge* and a *Marine National Monument*. For more details about the Refuge, see U.S. Fish and Wildlife Service (2011).

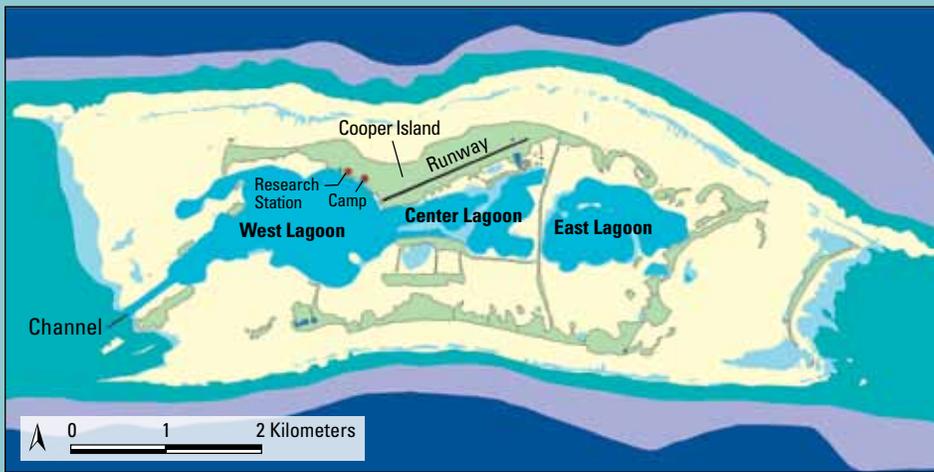


**Figure 1.** Location of Palmyra and other U.S. Pacific Island territories that comprise the U.S. Minor Outlying Areas in the Pacific.

Palmyra functions as a living laboratory. It is a low-lying coral atoll located about 1,800 kilometers south/southwest of Hawaii near the equator in the central Pacific Ocean (latitude 5°53'N, longitude 162°05'W). Palmyra Atoll and nearby Kingman Reef are U.S. territories and represent the northern atolls/reefs of the U.S. Line Islands. Palmyra also is one of the nine sovereign territories of the United States recognized as U.S. Minor Outlying Areas (fig. 1). Palmyra Atoll and nearby Kingman Reef are National Wildlife Refuges and were included as part of the seven units that comprise the *Pacific Remote Islands Marine National Monument* set aside by President Bush in 2009 (Proclamation 8336).



Mimic goatfish (*Mulloidichthys mimicus*)



**Figure 2.** Main geographic features of Palmyra Atoll.

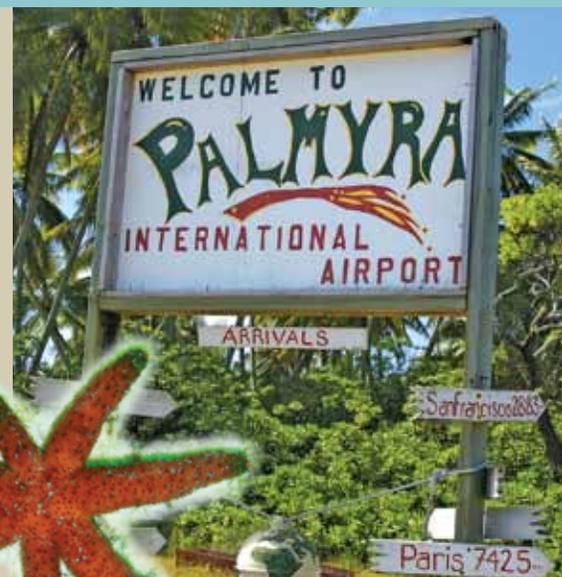
### EXPLANATION

- Land
- Shallow channel / deep reef
- Deep channel
- Shallow / exposed reef
- Extent of underwater land features
- Depth 10–100 fathoms

On Palmyra, about 25 heavily vegetated islets with 250 hectares of emergent land are surrounded by about 6,300 hectares of coral reefs and lagoons (fig. 2). The largest islet is Cooper Island, where a small runway and the research station are located. It was the center of operations during the U.S. military occupation when as many as 6,000 troops were stationed on the atoll.

With several unique ecosystems, both terrestrial and marine, Palmyra supports a variety of native as well as introduced species. The atoll exhibits moderate to high species diversity and an abundance of fishes, corals, snails, and lobsters, and maintains a predator-dominated marine ecosystem. Palmyra has limited historical and current resident human populations with most changes in the structure and population on the atoll occurring during U.S. military occupation. Importantly, Palmyra represents a protected site where controlled research can be conducted where it is relatively free from contemporary local human impacts.

Palmyra is characterized as a low-lying equatorial atoll without documented mangroves or seagrasses. Preliminary data suggest that Palmyra reefs support about three times the amount of fish biomass than nearby inhabited Christmas and Fanning Islands with large apex predators (for example, groupers, snappers, jacks, and sharks) accounting for 56 percent of the atoll's total fish biomass. Because of its remote location and current protection, Palmyra can serve as a baseline relative to areas with heavy fishing pressures, such as the main Hawaiian Islands.



Luzon sea star (*Echinaster luzonicus*)

## Research

PARC was created in 2004 to develop research opportunities to address potential threats to Palmyra and similarly healthy sites from local, regional, and global environmental threats, including climate change, invasive species, contaminants, and other stressors. Currently (2012), each institution's membership in PARC includes annual round-trip airfare from Honolulu to Palmyra for 7 individuals and 180 island-days of food, lodging, laboratory use, SCUBA resources, boat use, etc. while on the atoll. A Special Use Permit (SUP) from the USFWS is required to conduct research on the atoll. As of 2012, PARC affiliated authors have published more than 85 peer-reviewed journal articles and/or dissertations on Palmyra research, primarily on three overarching themes: (1) biodiversity studies and the structure and function of the coral reef ecosystems and quantitative measures of anthropogenic changes to the atoll; (2) effects of climate change, oceanographic drivers, and biogeochemical variability of the waters surrounding Palmyra; and (3) ecosystem management and conservation—specifically the result of habitat modifications, contaminants, and invasive species on the atoll.

USGS scientists are actively engaged in several research projects at Palmyra Atoll that also relate to other atoll systems in the Pacific and worldwide. Palmyra is an ideal “laboratory” for assessing and forecasting change brought about by sea level rise and other impacts of anthropogenic global change, including ocean heating, acidification, and shifts in storm frequency and intensity, without the difficult task of filtering out local anthropogenic impacts.

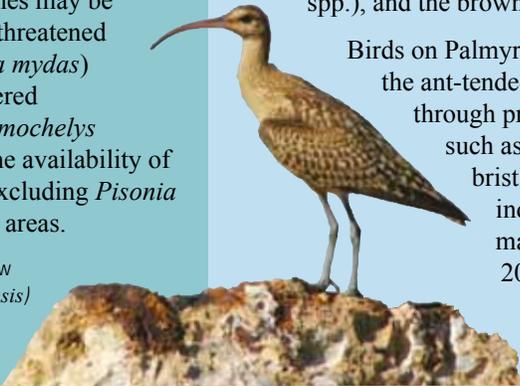
Another advantage of Palmyra is its rich history of ecological census data (for example, migratory birds, fish, corals, and other invertebrates)—some collected by the USFWS, others by the National Oceanic and Atmospheric Administration (NOAA) and several academic institutions with protocols comparable to those used at other remote Pacific Refuges, atolls, and island systems. Thus, Palmyra can serve as an important site for monitoring and research in coming decades and the resulting data will be broadly applicable to other DOI trust responsibilities, such as coastal national parks and wildlife refuges. Such data can provide valuable tools for resource managers, particularly with respect to understanding the status and relative health of coral reefs, coasts, and implementation of the U.S. Ocean Action Plan (2004). The USGS Western Ecological Research Center also is developing protocols for an intensive monitoring and assessment program at Palmyra for both the terrestrial (island) and marine (lagoon and reef) environments that can serve as a baseline from which to monitor future changes.

## BIODIVERSITY

### Forests

Until the early 21st century, Palmyra had one of the largest and most intact stands of *Pisonia* forest throughout the entire Pacific, with two of the most abundant native tree species in this forest being *P. grandis* and the beach heliotrope (*Tournefortia argentea*). The emergent land area on Palmyra is occupied primarily by non-native invasive coconut palms (*Cocos nucifera*) with about 43 percent coverage on the islands. The introduction of *Cocos* occurred as early as 1885, when 200 coconut trees were planted, which bore more than 25,000 trees by 1913. *Cocos* will be managed as an invasive species, because their coverage on Palmyra's sandy beaches may be inhibiting nesting by the threatened green sea turtle (*Chelonia mydas*) and the federally endangered hawksbill sea turtle (*Eretmochelys imbricata*) and impacts the availability of seabird nesting sites by excluding *Pisonia* and *Tournefortia* in some areas.

Bristle-thighed curlew  
(*Numenius tahitiensis*)



### Birds

Palmyra hosts a variety of breeding, wintering, and visiting seabirds and shorebirds. The atoll provides habitat for more than 1 million nesting seabirds whose distributions within the atoll are or have been determined by plant community distributions, species' nesting habits, trade wind exposure, and introduced rats (*Rattus exulans*). Several bird species, such as the black noddy (*Anous minutus*) and the red-footed booby (*Sula sula*), are dependent or have preference toward particular tree species for nesting. Due to the extent of *Pisonia grandis* trees on the atoll, a 1995 report identified Palmyra as the site with the largest black noddy colony in the central Pacific, which included 20,000 out of 46,000 individuals nesting in the Line Islands. *Tournefortia* at Palmyra also supports one of the largest red-footed booby colonies in the world, with around 25,000 pairs at the height of the nesting season, second only to the Galapagos Islands. Other common nesting bird species on Palmyra include the great frigatebird (*Fregata minor*), sooty tern (*Sterna fuscata*), tropic birds (*Phaethon* spp.), and the brown booby (*Sula leucogaster*).



Brown booby (*Sula leucogaster*)

Birds on Palmyra face many threats from invasive species such as rats and the ant-tended scale insect *Pulvinaria urbicola*. Rats cause nest failure through predation and pose major problems for surface-nesting species such as the sooty tern and the brown booby. In addition, endangered bristle-thighed curlews (*Numenius tahitiensis*) undergo a molt-induced flightless period while over-wintering on Palmyra, making this species especially susceptible to predation. In 2011, USFWS, TNC, and Island Conservation conducted a comprehensive project to eradicate rats at Palmyra, which may have removed this threat.

### Corals

Palmyra's coral reefs support about 170 coral species (compared to about 50 species in the Hawaiian Islands and about 700 species in the Indo-Pacific region). The total number of stony coral genera observed in 2004 was 36, and the 3 genera with the greatest abundance on Palmyra were *Pocillopora*, *Porites*, and *Pavona*. In addition, Palmyra Atoll and Kingman Reef had the highest coral and anemone species diversity of all areas surveyed in the Phoenix and Line Islands. Researchers speculate that this high species diversity is because both sites are in the path of the Equatorial Counter Current (ECC) and the sites may act as stepping stones for dispersal to other central Pacific Islands.

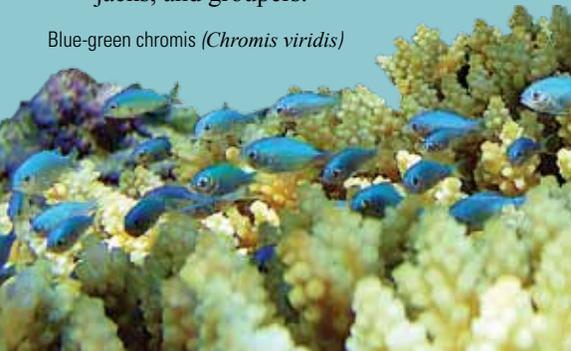


Mushroom coral (*Fungia fungites*)

### Coral Reef Fishes

From 2000 to 2004, qualitative field assessments of Palmyra reef fishes documented 343 fish species. As the largest apex predators on Palmyra, sharks account for 44 percent of the total fish biomass with the remaining apex predators consisting of snappers, sharks, jacks, and groupers.

Blue-green chromis (*Chromis viridis*)



### Marine Turtles and Marine Mammals

Two species of marine turtles use the atoll, including the threatened green sea turtle and the critically endangered hawksbill sea turtle. Palmyra Atoll provides an important stepping stone along these turtle species' migratory routes, especially because of its remote location in the Central Pacific. Bottlenose dolphins (*Tursiops truncatus*), spinner dolphins (*Stenella longirostris*), melonheaded whales (*Peponocephala electra*), and pilot whales (*Globicephala macrorhynchus*) are the most common marine mammal species sighted although the endangered Hawaiian monk seal (*Monachus schauinslandi*) also has been recorded near Palmyra.

Green sea turtle  
(*Chelonia mydas*)





## Invertebrates

To date (2012), only a limited number of studies have been conducted on Palmyra's non-coral invertebrates. Some studies have focused on single macroinvertebrates, such as giant clams (*Tridacna maxima*), crown-of-thorns sea stars (*Acanthaster planci*), and the coconut crab (*Birgus latro*), which is the largest known terrestrial arthropod with a body length up to 40 centimeters. However, six other species of terrestrial crabs also inhabit the atoll.



Coconut crab (*Birgus latro*)

## Historical Proxies

Coral cores extracted from Palmyra reefs in 2005 documented regional atmospheric signatures of <sup>14</sup>C dated before and after the era of Pacific nuclear testing that peaked immediately before the international atmospheric nuclear test ban treaty in 1963. Thus, Palmyra's coral records provide a valuable baseline time stamp for other events that may have affected Pacific region habitats and can be used as a dating proxy for other studies on the atoll.

## Acknowledgments

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## References Cited

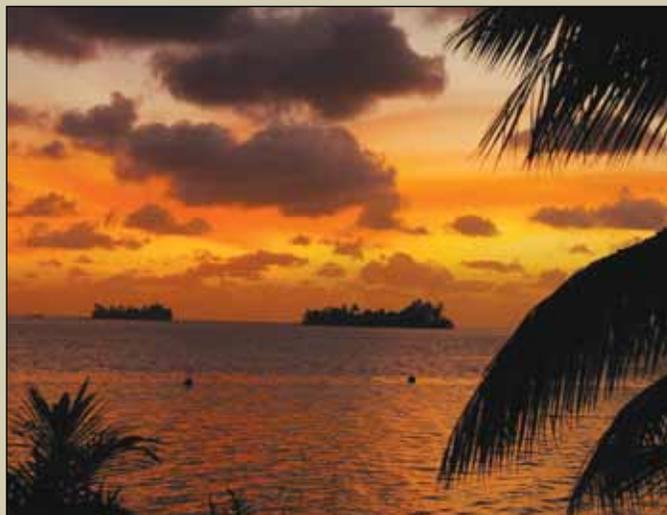
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### Photographic credits:

Kevin Lafferty—All fish, all corals, sea star, sea turtle.  
Tom Suchanek—All birds, coconut crab, airport sign, sunset.  
The Nature Conservancy—Geographic features of Palmyra.

## Climate Change

Palmyra's location in the central Pacific places it at the eastern edge of the Southern Oscillation, which exposes its coral reefs to sudden climatic changes. Palmyra's climate typically is warm and wet during El Niño events and cool and dry during La Niña events—the Intertropical Convergence Zone shifts to the east of Palmyra during El Niños and to the west of Palmyra during La Niñas. Palmyra also experiences variable salinity levels—warm, less saline water pools to the west and cold, more saline water pools to the east—which are likely dictated by El Niño/La Niña processes. Thus, as a mostly uninhabited atoll, Palmyra can be useful as a sentinel site for scientists and managers in the detection of the impacts from changes in ocean temperature, winds, salinity, and pH on Pacific marine and terrestrial ecosystems.



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### For more information:

Additional information and links about Palmyra, including history, wildlife, current research, publications and news articles, can be found at <http://www.palmyraresearch.org>.

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