STATUS OF CORAL REEFS OF THE PACIFIC – 2011 ADDENDUM:
United States Pacific Remote Islands Marine National Monument (Johnston, Howland, Baker, Jarvis, Palmyra, Kingman, Wake)

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Marine Area: 225,040 km^2 (1)
Coastline: unkn
Land Area: 15 km^2
Reef Area: 252.3 km^2 (2)
Total MPAs: 8
Mangrove area: 0 km^2
Percentage of reefs threatened: ??

Population (2011 est.): < 125
Population (2050 proj): <125
Population growth:
Urban population: 0
GDP: NA
GDP/Cap: NA

Data from NWRS Refuge Profiles database (https://rmis/fws.gov/Profiles) unless indicated with a reference number

Overview

The US Pacific Remote Islands (PRI) includes seven diverse and widely separated islands, atolls, and reefs in the Central Pacific that are under the jurisdiction of the United States. Baker, Howland, and Jarvis Islands; Johnston and Palmyra Atolls; and Kingman Reef all lie between Hawaii and American Samoa. Wake Atoll is located between the Northwestern Hawaiian Islands (NWHI) and Guam. All of the PRIS have been managed as National Wildlife Refuges by the US Fish and Wildlife Service (USFWS) since 1926 (Johnston), 1974 (Howland, Baker, Jarvis), 2001 (Palmyra and Kingman), or 2009 (Wake). The PRI are distant from human population centers; the least remote are Jarvis and Palmyra, which are both around 350 km from, respectively, Kiritimati and Tabuaeran in the Line Islands chain. Four of the PRIS (Howland, Baker, Jarvis, and Kingman) are unpopulated. A small field camp at Johnston maintained by the USFWS has supported a staff of 4-5 people since 2010 to control non-native invasive Yellow Crazy ants. Palmyra has a research station maintained by The Nature Conservancy of Hawai`i for the Palmyra Atoll Research Consortium (PARC) that supports a small staff, scientists, and visitors. The US Air Force installation at Wake Island is staffed by ~100 people. In 2009, all of the PRI were included within the Pacific Remote Islands Marine National Monument (PRIMNM). They represent one of the last frontiers and havens for wildlife in the world, and comprise the most widespread collection of coral reef, seabird, and shorebird protected areas on the planet under a single nation's jurisdiction. These reefs are ideal laboratories for monitoring the effects of global climate change, as other threats such as coastal pollution, disease, and overfishing are mostly absent.

Status, health, and resilience of coral reefs

Before 2000 few systematic surveys of the reefs were accomplished. Since 2000, biennial reef assessment and monitoring surveys have been conducted at Howland, Baker, Kingman, Palmyra, and Jarvis by the US National Oceanic and Atmospheric Administration (NOAA) Pacific Islands Fisheries Science Center (PIFSC) Coral Reef Ecosystem Division (CRED), the USFWS, and other partners; biennial surveys at Johnston were initiated in 2004 and at Wake in 2005. NOAA CRED and partners collect data on benthic cover, coral stress, and fish communities as well as environmental data such as temperature, nutrients, and currents. Since 2005 scientists from PARC, a collaborative partnership of research institutions, museums, and conservation organizations, have undertaken integrative research into biodiversity and ecosystem function, as well as ocean and climate systems, at Palmyra and Kingman. USFWS National Wildlife Refuge System (NWRS) staff conducts targeted monitoring at Palmyra and Kingman focusing on threats to reef resources and their impacts.

The cooperative NOAA/USFWS monitoring surveys have dramatically increased knowledge of the biodiversity of the coral reef ecosystems in the PRI [(3)] (Table 1). While the fish fauna was the best known of the reef biota before 2000, with close to 300 shore-fish species reported from each of Johnston, Palmyra, and Wake, records of stony corals and benthic algae were more impoverished. For Kingman there were no records of any stony coral or benthic algal species before 2000; for Jarvis, only 5 species of marine algae had been reported but no stony coral species. Of the seven islands/atolls within the PRI, the greatest collective increase in these 3 groups by 2010 was at Kingman (843%), where records of stony corals increased from 0 to 182 species, benthic algae from 0 to 95 species, and inshore fishes from 58 to 270 species. More than a 250% increase in the collective number of species was reported at each of Jarvis (103 to 423 species, 311%) and Baker (124 to 458 species, 269%) by 2010. Smaller collective increases were reported at Howland (144%) and Palmyra Atoll (50%). The smallest collective increases were found at Johnston (464 to 539 species, 16%) and Wake (378 to 541 species, 43%). At Johnston and Wake, where the Department of Defense has historically maintained facilities and defensive areas, biological inventories previous to those initiated by NOAA/USFWS in 2004/2005 had been conducted in response to issues such as dredging and contaminants; consequently, the cooperative marine surveys generated the smallest collective increases in biodiversity records at those locations.

Reef Area	Stony Corals		Benthic Algae		Inshore Fishes	
	pre-2000	2010	pre-2000	2010	pre-2000	2010
Howland	25	109	11	47	162	328
Baker	28	104	16	86	80	268
Jarvis	0	70	5	79	98	274
Palmyra	72	177	90	93	282	395
Kingman	0	182	0	95	58	270
Johnston	38	49	141	189	285	301
Wake	52	97	5	121	321	323

Table 1. Number of species of stony corals, benthic algae, and inshore fishes known at each of the seven islands/atolls in the PRI. Table modified from Kenyon et al. 2012

Results from standardized surveys of corals, algae, and fish by NOAA CRED at 40 or more different islands, atolls, and banks throughout the US Pacific highlight the importance of the remote reefs contained within the PRI as ecological reference areas. Mean prevalence of coral disease at 6 of the 7 PRI was the lowest (1.2%) of the five main geographical regions in the US Pacific, which include the main Hawaiian Islands, NWHI, American Samoa, and Guam-Commonwealth of the Northern Mariana Islands [(4).] Coral disease hotspots were found at Johnston (prevalence 8.7%) and at French Frigate Shoals in the NWHI due in part to white syndrome, which can result in severe and rapid tissue loss, particularly on the tabular *Acropora cytherea.* No diseases of crustose coralline algae (CCA) were found at Johnston, Baker, or Wake, and of the 7 PRI, prevalence of CCA disease was highest at Palmyra (1.4%) [(5)]. Remote reef areas including the PRI supported, on average, four times more fish biomass than reefs in populated areas [(6)]. Large-bodied piscivores such as sharks and jacks made up a substantial portion of fish biomass at many of the remote reef areas but were rarely encountered around populated islands. For example, sharks were recorded during 101 of the 231 surveys in the PRI, but on only two of the 232 surveys at the four most densely populated islands (Oahu, Guam, Saipan, and Tutuila). Among the reef areas, estimated mean total fish biomass ranged from <20 g m^{-2} at heavily populated islands in the Marianas (Guam, Saipan, and Tinian) to around 250 g m^{-2} and above at the unpopulated reef areas of Jarvis and Kingman in the PRI; total fish biomass was higher only at Kure in the NWHI [(6)].

The US Pacific-wide surveys also underscore the role of the PRI in supporting populations of species that are considered threatened. Of the 59 Pacific coral species/species complexes proposed for listing as Threatened under the US Endangered Species Act (ESA) in response to a petition in 2009 from the Center for Biological Diversity [(7)] , 21 species have been reported from the PRI [(8,9)] (Table 2). The number reported from Kingman (17) and Palmyra (15) is exceeded in federally-protected waters only at the Ofu Unit of the National Park of American Samoa (21). If listed under the ESA, these corals would receive legal protection. Of the 45 species of coral reef fishes listed on the IUCN Red List of Threatened Species that were observed across the US Pacific, the greatest diversity of listed fishes were recorded in the PRI (39) [(10)]. At the island level, the greatest number was observed at Howland (26 species), followed by Jarvis (25), Palmyra (24), and Baker (20). The greatest densities of IUCN-listed fish species were also observed in the PRI, where the overall mean was 33 individuals km^{-2}. Sharks, groupers, humphead wrasse (*Cheilinus undulatus*), and bumphead parrotfish (*Bolbometopon muricatum*) accounted for more than 80% of the IUCN-listed fish species observed in the US Pacific. These species are important in structuring fish and benthic communities through their roles as influential competitors and predators on coral reefs. Most conspicuous large-bodied species of sharks and groupers were observed only at remote and uninhabited islands. Bumphead parrotfish, listed as Vulnerable by the IUCN and a NOAA Species of Concern, were rare or absent in the US Pacific except at Wake Atoll where their mean density was 297 individuals km^{-2}. Bumphead parrotfish were also observed at Palmyra, where their mean density was five fish km^{-2}. Only 4 other Bumphead parrotfish individuals were observed elsewhere in the US Pacific during NOAA CRED surveys between 2000 and 2009 [(6,11)]. The greatest densities of humphead wrasse, listed as Endangered by the IUCN and also a NOAA Species of Concern, were observed in the PRI, with a regional mean of 0.26 individuals observed km^{-2}. Within the PRI, the greatest density was recorded at Wake Atoll with 114 individuals observed km^{-2}. Palmyra Atoll had the second greatest density with 63 individuals observed km^{-2}. Collectively these US Pacific-wide surveys highlight the importance of these remote habitats for sustaining healthy and diverse populations of corals, algae, and fish.

Species/Species Complex	Johnston	Howland	Baker	Jarvis	Palmyra	Kingman	Wake
Acropora aculeus					X	X	X
Acropora acuminata		X	X		X	X	X
Acropora aspera			X		X	X	
Acropora globiceps					X	X	
Acropora microclados			X	X	X	X	
Acropora palmerae							X
Acropora paniculata	X				X	X	
Acropora polystoma		X	X		X		
Acropora retusa	X	X				X	
Acropora speciosa						X	
Acropora striata						X	
Acropora vaughani		X	X		X	X	
Acropora verweyi			X	X	X	X	
Alveopora verrilliana					X	X	
Isopora cuneata		X			X		
Montipora caliculata		X	X	X	X	X	
Montipora dilatata/flabellata/turgescer	X				X	X	
Montipora lobulata							X
Montipora patula/verrilli	X				X	X	
Pocillopora danae		X	X	X	X	X	
Pocillopora elegans (Indo-Pacific)	X	X	X	X	X	X	X
Number of species:	5	8	8	5	15	17	5

Table 2. Known occurrence in the PRI of coral species/species complexes proposed for listing as Threatened under the U.S. Endangered Species Act (Note: this table can be omitted and the numbers summarized in the text if it adds unnecessarily to the length of the chapter)

Although Johnston Atoll is currently uninhabited except for a small terrestrial field crew, it previously had a relatively large population associated with military facilities, which generated anthropogenic pressures impacting the surrounding ecosystems. NOAA CRED surveys report the coral reef ecosystem at Johnston is still relatively intact with a fairly large population of apex fish predators when compared to heavily populated areas in the Pacific, but large-fish biomass and density are lower than at other areas in the PRI[(6,12)]. Of the seven PRI reef systems, average coral cover at Johnston (18%) is the lowest [(13)] (Fig. 1) and prevalence of coral disease (8.7%) is the highest [(4,14)] .

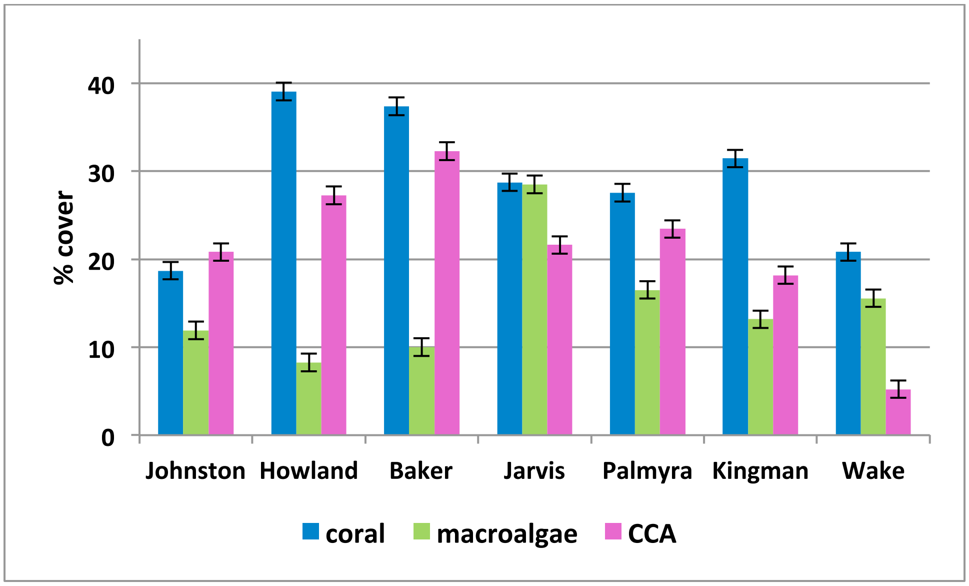


Figure 1. Average percent cover of live coral, macroalgae, and crustose coralline algae (CCA) from towed-diver surveys conducted from 2000 to 2009. Figure modified from Vroom 2011

Howland and Baker Islands have both been inhabited briefly in the past, in the mid-1800s for guano mining and before WWII by colonists from Hawai`i, but they have been uninhabited for the past 70 years and have relatively pristine coral reef ecosystems [(16)]. Both islands are affected by highly variable oceanographic conditions near the Equator, including upwelling from the Equatorial Undercurrent and the periodic effects of the El Niño-Southern Oscillation. Marine monitoring visits to these islands since 2000 have helped to document the biodiversity, structure, and oceanographic variability characterizing their coral reef ecosystems. Live coral cover at both islands is the highest of the PRI (37-39%) as is CCA cover (27-32%, Fig. 1) [(13)], while prevalence of coral disease is among the lowest (<0.5%) [(14)]. Although Howland and Baker Islands are geographically proximate (60 km apart), of comparable size, and geomorphically similar [(12,16)], a comparison of benthic and fish communities between the two islands revealed them to be biologically distinct from each other [(15)] . Generally, reef slope regions around Baker Island supported a much larger abundance of upright branched acroporid corals, while reef communities at Howland Island exhibited a higher abundance of smaller, more compact coral species and CCA. Algal communities also differed with nearly twice as many algal species known from Baker (86) as from Howland (47) (Table 1) [(17)]. The fish communities of Howland and Baker were rich in carnivores and top predators, with the biomass of these types of fish similar to biomass estimates from the NWHI and the US Line Islands [(18)]. With no apparent boundaries preventing dispersal of organisms between Howland and Baker, coral reef community differences are likely attributable to finer-scale geomorphology, physical forcing, or disturbance history [(15)].

Surveys conducted during a February 2010 monitoring cruise dramatically underlined the strong effect that the 2009 El Niño event had on corals at Howland and Baker Islands. *In situ* subsurface loggers indicated that seawater temperatures increased steadily throughout 2009, peaking at 31.2 °C in early November, and remained above the coral bleaching threshold (29.7 °C) beyond the time when instruments were recovered in early February 2010. Nearly 35% of colonies belonging to 17 coral genera surveyed within belt transects exhibited bleaching, predominantly within the 10–18 m isobaths along east Howland Island and east and northeast Baker Island [(19)]. Bleaching conditions differed among coral taxa, with *Pocillopora*, *Acropora*, and *Fungia* exhibiting the greatest percentage of affected colonies, followed by *Pavona*, *Porites*, and *Psammocora*; *Montipora* was the most resistant to bleaching with <2.5% of colonies affected. Lesser incidences of bleaching were observed along the western reefs, where upwelling normally occurs. This is the first documented mass bleaching episode at Howland and Baker Islands; however, anecdotal evidence suggests recurrent, widespread bleaching may be a principal source of disturbance, affecting coral reef species composition and structural dynamics at Howland and Baker over multi-year timescales [(19)].

At Jarvis, Palmyra, and Kingman, a general warming pattern was observed in ocean temperatures recorded by *in situ* subsurface temperature loggers beginning early in 2009, with water temperatures slowly rising 2.5°C–6°C throughout the year. Temperatures peaked in January 2010, a warming trend attributed to the relatively strong El Niño in 2009 [(20)]. Despite the anomalously warm temperatures in 2009 and 2010, widespread coral bleaching was not observed at any of these three locations [(20)], though mild bleaching (9.2% prevalence) was observed at Palmyra Atoll where mean water temperature reached 30.1^{o} C [(21)]. Following this mild bleaching event an outbreak of *Acropora* white syndrome disease was identified on the shallow western reef terrace and northern backreef at Palmyra [(22)].

Palmyra Atoll represents a near-pristine oceanic reef environment, with some of the highest coral diversity [3,23] and greatest concentrations of large-bodied marine predators [6,24] in the central Pacific. The relative lack of persistent human pressures has made Palmyra a unique location for a wide range of research pertaining to ecosystem structure and function. Nonetheless, ecosystem consequences of human interventions exist. Researchers have continued to record the invasive expansion of the native corallimorph *Rhodactis howesii* associated with a long line vessel that shipwrecked on the western terrace in 1991 [25]. Surveys in 2011 indicate that the corallimorph has spread more than 2 km from the wreck location and is present in large monotypic stands, carpeting the substrate in areas that were once dominated by reef-building corals. High densities are also found around several buoys installed on the atoll in 2001, demonstrating an association with man-made structures. The USFWS has received funding to remove the shipwreck at Palmyra, with complete removal of the wreck and surrounding debris field by the end of 2013. Along with the wreckage removal, restoration efforts will target removing 70% of the corallimorph in the distribution field mapped in 2011 within 5 years. Experimental plots have demonstrated that the corallimorph can be successfully removed from large areas of monotypic cover by *in situ* tarping and inserting chlorine tablets beneath the tarps. Smaller patches in coral-rich areas can be controlled by covering corallimorph polyps with calcium carbonate slurry. While *R. howesii* is native to Palmyra, introductions of non-indigenous species have even greater potential to cause dramatic economic and ecological damage. Five non-indigenous invertebrate and algal introductions have been described at Palmyra, including two sponges (*Haliclona (Sigmadocia) caerulea* and *Gelliodes fibrosa),* one bryozoan (*Zoobotryon verticillatum)*, one hydroid (*Pennaria disticha*) and one macroalga (*Acanthophora spicifera)* [26]. The Hawaiian Archipelago is thought to be the most likely source of the introductions via shipping or yachting activity to the Atoll. Currently, the impacts of these introductions remain unknown although future monitoring will assess the influence of these non-indigenous species on this remote system.

Kingman Reef was among the last of the remote locations in the US Pacific to be scientifically explored underwater due to the absence of habitable emergent land, coupled with its distance from human population centers. Coral diversity at Kingman is similar to that at Palmyra (Table 1) but is high compared to other adjacent atolls and reef islands to the south and west (Phoenix and Line Islands) where data are available [27]. Structural patterns of the undisturbed fish assemblage are a baseline reflecting natural ecological processes that are not influenced by fishing or other anthropogenic factors. The most striking feature of the fish assemblage is the inverted biomass pyramid (more predator than prey biomass) with dominance by apex predators, primarily sharks and large snappers, across all depths and habitat strata surveyed by divers [24,28]. Reef communities with relatively intact food webs such as those at Kingman are considered the best available baselines for Pacific reefs [24]. In late 2007 a wrecked ship went aground off the northern windward side of Kingman. Scientists suspect the ship was burned by fire, abandoned, and then floated several thousand miles to Kingman. Observations in 2010 indicate the wreck had been pushed farther on top of the reef's crest and was deteriorating as it moved westward into the lagoon. As a result of this westward movement, a large metal well from the vessel was found in the lagoon, in addition to timbers, fiberglass sections, and miscellaneous pipework scattered along the forereef, reef crest, and backreef. High density of cyanobacteria growing in the area of the wreckage is presumed to be stimulated by dissolved iron from the corroded metal on the ship. USFWS has committed funds to removal of the wreck along with that at Palmyra by the end of 2013.

Wake Atoll supports at least 97 species of stony corals, based on spatially limited surveys conducted between 1979 and 2005 (Table 2). Scleractinian species richness at Wake is lower than in the northern Marshall Islands (168 species) and Mariana Islands (377 species), but exceeds that in the Hawaiian Islands (65 species) [29]. Zoogeographic analysis of the fish fauna at Wake indicated the greatest species overlap occurred with the northern Mariana Islands (87%) and the Marshall Islands (82%), and lower species overlap occurred with the southern Mariana Islands (66%) and Hawaiian Islands (40%) [30]. Zoogeographic analysis of Wake corals also indicates greatest overlap with the Mariana (82.5%) and the northern Marshall Islands (72.5%) and lesser overlap with the Hawaiian Archipelago (23.8%) [29]. The coral fauna at both Wake and the northern Marshall Islands remain poorly studied, however, compared to the Mariana Islands and the Hawaiian Islands. Greater search effort on the deeper fore reef, reef flat, and lagoon patch reefs will likely yield additional coral species at Wake and modify estimates of biogeographic affinities. Average coral cover along the fore reef is 21%, with coral cover along the northeast side more than twice as high as along the southwest side [29]. A number of wrecks, anchors, and other ground tackle are found around the atoll particularly in the vicinity of the harbor entrance on the southwest side; a large cyanobacteria bloom was noted by towed divers near a shallow wreck (*R/C Stoner*) outside the harbor entrance during 2007 surveys but was not observed in either 2005 or 2011 [12,31].

Status of coral reefs – STABLE (medium confidence) Trends in coral cover are mostly stable, with some sites showing increases or decreases. There were no signs of widespread, long-term, persistent changes; however, quantitative data have been recorded at most locations for only a decade or less, reducing the confidence of this assessment. Increase in knowledge of biodiversity since 2000 derives from increased survey effort at locations that previously were poorly explored.

Coral reef health and resilience – STABLE (high confidence) While there are several problem-specific hotspots (e.g., coral disease prevalence at Johnston, bleaching event at Howland and Baker, corallimorph spread at Palmyra), overall the reefs of the PRI are in good condition and continue to serve as ecological baselines of the structure and function of coral reefs without major anthropogenic influence.

Use of reef resources

Coral reefs of the PRI occur within the boundaries of the seven National Wildlife Refuges contained within the PRIMNM. These refuges are closed to all activities except as allowed through a Special Use Permit (SUP). An SUP enables the public to engage in wildlife-related activities on a Refuge that would otherwise be prohibited, balancing use and conservation. Marine activities may include recreational fishing, wildlife observation and photography through diving and snorkeling, environmental education and interpretation, research, monitoring surveys, and scientific collections. In evaluating an SUP application, the Refuge System mission emphasizes that the needs of fish, wildlife, and plants must be of primary consideration. Commercial fishing is prohibited. Recreational fishing, when permitted, is subject to restrictions on the use of gear such as traps, nets, and automated spear guns that may be injurious to reef resources, as well as prohibitions on the take of sharks, rays, bumphead parrotfishes (*Bolbometopon muricatum*) and humphead wrasse (*Cheilinus undulatus*). Trespass and poaching by unauthorized users, particularly foreign fishing boats, is difficult to quantify given the distances separating the reefs and their remote locations.

Use of reef resources – STABLE (high confidence)

The National Wildlife Refuge System regulates human activities affecting reef resources through conditions specified in Special Use Permits. While the level of illegal trespass and poaching is unknown, the high fish biomass and abundance of large-bodied predators such as sharks and jacks suggest illicit exploitation of this resource, if any, is low.

Factors affecting reef health and condition

Coral reefs of the PRI are variably affected by a number of drivers and processes. Oceanographic factors include El Niño warming, localized upwelling, and severe wave events. Human-related factors include the residual effects of WWII-era military construction and deteriorating shipwrecks. The ecological consequences of non-native marine species documented at Palmyra remain unknown. Present-day direct anthropogenic impacts are minimal.

Howland and Baker were utilized by the US military during WWII, with anchors, chains, and other unwanted military material discarded on the reef. Surveys near the anchorage off the western leeward side of Baker during 2000-2006 revealed increased levels of cyanobacteria and corallimorphs that appeared to be stimulated by dissolved iron from discarded metallic debris [(12)]. At Palmyra, the lagoon was subject to major military modifications during WWII and now the dominant fauna on the lagoon's hard substrate are sponges, not corals [(32)]. Altered water circulation in the lagoon is thought to generate sedimentation pressure contributing to recent declines in coral cover in a southeast back reef area ('Coral Gardens') renowned for its high coral cover and diversity, particularly within the genus *Acropora*. [(32)]. A proposal has been put forward to remove a small portion of a military causeway to increase westward flow of water and reduce sedimentation stress on this important pocket of coral biodiversity.

Hurricanes are uncommon in the PRI. Since 2000 only 2 hurricanes have passed within 50 nautical miles of the PRI [(33)]. In 2002 Hurricane Huko, a Category 1 storm, passed north of Wake. In August 2006 Ioke passed south of Johnston as a Category 2 hurricane and north of Wake as a Category 4 storm. Surveys at Wake in May 2007 showed a 37% decrease in live coral cover at sites on the northeast side of Wake, but less damage than expected to the reef elsewhere [(12)]. In December 2008 Wake Island was inundated by a surge of water up to a meter high from the north; the exceptionally large waves were likely generated by distant storms to the north [(34)]. Damage to Wake Island facilities was extensive, exceeding that of Typhoon Ioke. The large amounts of sand and calcifying invertebrate organisms that were carried inland suggest damage likely occurred to benthic reef communities.

As for all Pacific reefs, climate change may cause significant damage through changing temperature regimes, increasing ocean acidity, and stronger storms and cyclones. Topographic upwelling of the Equatorial Undercurrent, which results in a vigorous supply of cold, nutrient-rich water to the euphotic zone, may locally mitigate the surface warming associated with greenhouse-gas forcing at equatorial islands including Howland, Baker, and Jarvis, which could become refuges for coral reef communities from anticipated climate changes of the 21st century [35].

Factors affecting coral reefs –EVIDENCE OF CHANGE (medium confidence)

The available information indicates that altered hydrography from past military construction, deteriorating shipwrecks, discarded metallic debris, severe wave events, and the potential for future impacts from strong El Niño and climate change can or already are affecting coral reefs in the PRI. The infrequency of *in situ* monitoring at most locations (every two years) makes it difficult to firmly establish linkages between observed states and their causal factors, which moderates the confidence level of this assessment.

Governance and management

Each of the islands, atolls, and reefs of the PRI is managed by the US Fish and Wildlife Service as a National Wildlife Refuge and is part of the Pacific Remote Islands Marine National Monument. The islands of Johnston and Wake Atolls are under the administrative jurisdiction of the US Air Force pursuant to agreements with the Department of the Interior. Inland waters surrounding the islands, atolls, and reefs are administered by the US Fish and Wildlife Service as National Wildlife Refuges. All of the refuges are overlaid by the Pacific Remote Islands Marine National Monument. The refuges include the emergent lands, and the submerged lands and waters extending seaward 12 nautical miles from the mean low water lines. Protection of these refuges is directed by the National Wildlife Refuge System Administration Act of 1966. These refuges are closed to all activities, except those allowed through a Special Use Permit.

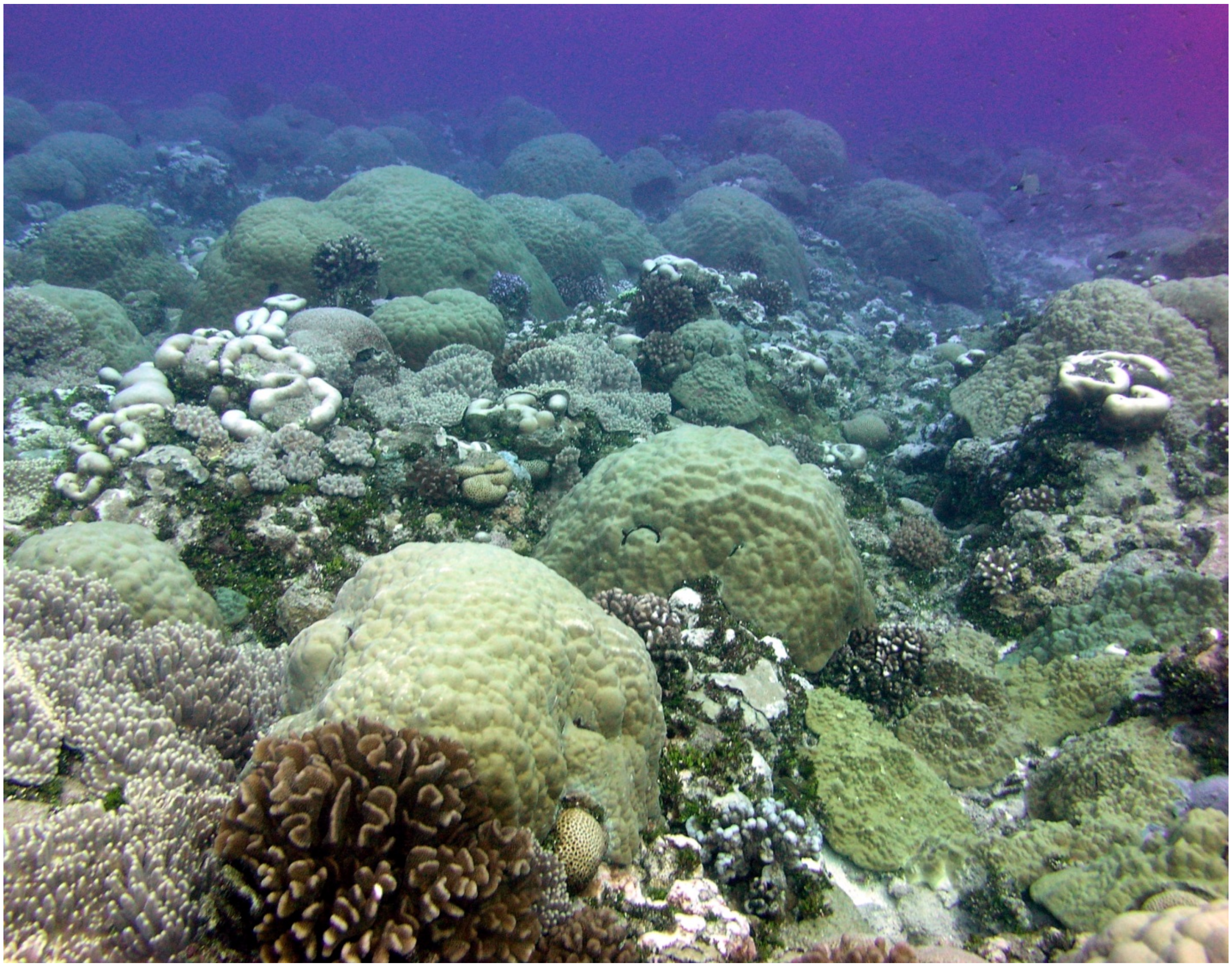
The Pacific Remote Islands Marine National Monument was established by President George W. Bush on January 6, 2009 under the authority of the Antiquities Act of 1906 by Presidential Proclamation 8336 (74 FR 1565, 12 January 2009) [1]. The Monument includes the emergent lands, and the submerged lands and waters extending seaward 50 nautical miles from the mean low water lines of Baker, Howland, and Jarvis Islands, Johnston, Palmyra, and Wake Atolls, and Kingman Reef. The US Fish and Wildlife Service has management responsibility for the Monument, including the National Wildlife Refuges in the PRI. The National Oceanic and Atmospheric Administration has primary management responsibility for fishery-related activities 12-50 nautical miles from the mean low water lines of Baker, Howland, and Jarvis Islands, Johnston, Palmyra, and Wake Atolls, and Kingman Reef. The Proclamation directs the Secretaries of the Interior and Commerce to prohibit commercial fishing in the Monument and to prohibit appropriation, injury, destruction, or removal of any feature of the Monument pursuant to their respective authorities. The Secretaries may permit noncommercial fishing upon request and shall provide a process to ensure that recreational fishing is managed as a sustainable activity.

A planning process was initiated in 2011 to develop a Monument Management Plan (MMP) for the PRIMNM to guide the management of the monument's resources [36]. USFWS and NOAA are working together in the development of the MMP, in a manner that will provide participation opportunities for the public, Federal agencies, and other interested parties. Additionally, the USFWS intends to prepare new or revised comprehensive conservations plans (CCPs) for each of the seven NWRs. A CCP provides refuge managers with a 15-year direction for achieving refuge purposes and contributing toward the mission of the NWRS consistent with sound principles of fish and wildlife management, conservation, legal mandates, and applicable policies. A CCP was completed for each of the Howland, Baker, and Jarvis NWRs in 2008. Development of a CCP for each of the Palmyra and Kingman NWRs was initiated in 2011. No previous CCP planning has occurred for the Johnston and Wake Refuges.

Governance and management – EVIDENCE OF CHANGE (high confidence) +

The PRIMNM was established by Presidential Proclamation in 2009. Extending 50 nautical miles from the mean low water lines of its component islands and atolls, this Monument, compared to the Refuges, provides more inclusive protection of the marine ecosystems that sustain the terrestrial, nearshore, and pelagic bionetworks. Coordinated management by more than a single agency, while challenging, enables pooling of resources for improvements in planning, management, research, monitoring, and law enforcement.

Note re: Reefs at Risk Revisited page at the end of other country chapters: The Reefs at Risk Revisited report has little to say about the PRIs, except, "the Pacific also contains most of the world's largest marine protected areas, including the Phoenix Islands Protected Area in Kiribati, several sites around U.S. territories (Papahānaumokuākea, Rose Atoll, the Mariana Trench, and the Pacific Remote Islands Marine National Monuments), and the Galapagos Marine Park. Despite their size (combined, they are over 1.3 million sq km), these sites incorporate less than 5 percent of the region's reefs. Designated around remote places with few or no resident local populations, these MPAs provide only limited benefits to current reef health, but are an important safeguard against future threats, and may contribute to longer-term regional reef resilience."



Wake Atoll. Photo by Jean Kenyon

References (PRI):

1. Code of Federal Regulations, title 3 (January 1, 2010) Establishment of the Pacific Remote Islands Marine National Monument Proclamation 8336 of January 9, 2009. http://www.gpo.gov/fdsys/pkg/CFR-2010-title3-vol1/xml/CFR-2010-title3-vol1-proc8336.xml
2. Rohmann SO, Hayes JJ, Newhall RC *et al*. (2005*). The Area of Potential Shallow-Water Tropical and Subtropical Coral Ecosystems in the United States*. Coral Reefs 24(3):370-383. http://link.springer.com/article/10.1007/s00338-005-0014-4#page-1
3. Kenyon J, Maragos J, Vroom P (2012). *Monitoring Supports Establishment of Pacific Remote Islands Marine National Monument*. Proceedings of the 12th International Coral Reef Symposium, Cairns, Australia, 9-13 July 2012, Session 18F, 5 pp. http://www.icrs2012.com/Proceedings.htm
4. Vargas-Ángel B, Wheeler B (2009). *Coral Health and Disease Assessment in the US Pacific Territories and Affiliated States.* Proceedings of the 11th International Coral Reef Symposium, Ft. Lauderdale, Florida, 7–11 July 2008, Session 7, 5 pp. http://www.reefbase.org/resource_center/publication/icrs.aspx

5. Vargas-Ángel B (2010). *Crustose Coralline Algal Diseases in the US-Affiliated Pacific Islands.* Coral Reefs 9:943–956. http://link.springer.com/article/10.1007/s00338-010-0646-x#page-1
6. Williams ID, Richards BL, Sandin SA *et al*. (2011). *Differences in Reef Fish Assemblages between Populated and Remote Reefs Spanning Multiple Archipelagos Across the Central and Western Pacific.* Journal of Marine Biology 14 pp. http://www.hindawi.com/journals/jmb/2011/826234/
7. Brown E, Wolf S (2009*). Petition to List 83 Coral Species under the Endangered Species Act*. Center for Biological Diversity, San Francisco, 198 pp. http://www.biologicaldiversity.org/campaigns/coral_conservation/
8. Kenyon J, Maragos J, Vroom P (2011). *The Occurrence of Coral Species Reported as Threatened in Federally Protected Waters of the US Pacific.* Journal of Marine Biology 12 pp. http://www.hindawi.com/journals/jmb/2011/358687/
9. NOAA National Marine Fisheries Service Southeast and Pacific Islands Regional Offices (2012). *Supplemental Information Report on Status Review Report and Draft Management Report for 82 Coral Candidate Species*, 158 pp. http://www.nmfs.noaa.gov/stories/2012/11/82corals.html
10. Zgliczynski BJ, Williams ID, Schroeder RE *et al.* (2013). *The IUCN Red List of Threatened Species: An Assessment of Coral Reef Fishes in the US Pacific Islands*. Coral Reefs DOI 10.1007/s00338-013-1018-0. http://www.pifsc.noaa.gov/pubs/credpub.php
11. Kobayashi D, Friedlander A, Grimes C *et al*. (2011). Bumphead Parrotfish (*Bolbometopon muricatum*) Status Review. US Department of Commerce. NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-26, 113 pp. http://www.pifsc.noaa.gov/pubs/techpub_alpha.php
12. Miller J, Maragos J, Brainard R *et al*. (2008). *The State of Coral Reef Ecosystems of the Pacific Remote Island Areas*, in *The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2008. NOAA Technical Memorandum NOS NCCOS 73*, JE Waddell, AM Clarke, (eds), NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team: Silver Spring, MD 569 pp. http://ccma.nos.noaa.gov/ecosystems/coralreef/coral2008/
13. Vroom PS (2011). *'Coral Dominance': A Dangerous Ecosystem Misnomer*? Journal of Marine Biology p 8. http://www.hindawi.com/journals/jmb/2011/164127/
14. Vargas-Ángel B (2009). *Coral Health and Disease Assessment in the US Pacific Remote Island Areas.* Bulletin of Marine Science 84(2): 211–227. http://www.ingentaconnect.com/content/umrsmas/bullmar/2009/00000084/00000002/art00006
15. Vroom PS, Musburger CA, Cooper SW *et al.* (2010). *Marine Biological Community Baselines in Unimpacted Tropical Ecosystems: Spatial and Temporal Analysis of Reefs at Howland and Baker Islands.* Biodiversity Conservation 19:797–812. http://link.springer.com/article/10.1007/s10531-009-9735-y#page-1
16. Maragos J, Miller J, Gove J *et al.* (2008). *US Coral Reefs in the Line and Phoenix Islands, Central Pacific Ocean: History, Geology, Oceanography, and Biology*, in Coral Reefs of the USA, Vol 1. B Riegl, RE Dodge, (eds), Springer, Berlin pp 595-642. http://link.springer.com/chapter/10.1007/978-1-4020-6847-8_15#
17. Tsuda RT, Vroom PS, Abbott IA *et al.* (2008). *Additional Marine Benthic Algae from Howland and Baker Islands, Central Pacific.* Pacific Science 62:271–290. http://hdl.handle.net/10125/22698
18. Brainard R, Maragos J, Schroeder R *et al.* (2005). *The State of Coral Reef Ecosystems of the US Pacific Remote Island Areas,* in *The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2005.* NOAA Technical Memorandum NOS NCCOS 11, JE Waddell (ed), NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team: Silver Spring, MD, 522 pp . http://ccma.nos.noaa.gov/ecosystems/coralreef/coral_report_2005
19. Vargas-Ángel B, Looney EE, Vetter OJ *et al.* (2011). *Severe, Widespread El Niño-Associated Coral Bleaching in the US Phoenix Islands.* Bulletin of Marine Science 87(3): 623-638. http://www.ingentaconnect.com/content/umrsmas/bullmar/2011/00000087/00000003/art00020
20. Pacific Islands Fisheries Science Center (2010). Cruise Report, NOAA Ship *Hi`ialakai*, Cruise HA-10-01, Leg 3, 27 March–24 April 2010, 69 pp. http://www.pifsc.noaa.gov/library/hiialakai.php
21. Williams GJ, Knapp IS, Maragos JE *et al.* (2010). *Modeling Patterns of Coral Bleaching at a Remote Central Pacific Atoll.* Marine Pollution Bulletin 60:1467-1476. http://www.sciencedirect.com/science/article/pii/S0025326X10002109

22. Williams GJ, Knapp IS, Work TM *et al*. (2011.) *Outbreak of Acropora White Syndrome Following a Mild Bleaching Event at Palmyra Atoll, Northern Line Islands, Central Pacific*. Coral Reefs 30:62. http://link.springer.com/article/10.1007%2Fs00338-011-0762-2?LI=true
23. Williams GJ, Maragos JE, Davy SK (2008). *Characterization of Coral Communities at Palmyra Atoll in the Remote Central Pacific Ocean.* Atoll Research Bulletin 557:1-32. http://www.sil.si.edu/digitalcollections/atollresearchbulletin/
24. Sandin SA, Smith JE, DeMartini EE *et al.* (2008). *Baselines and Degradation of Coral Reefs in the Northern Line Islands.* PLoS ONE 3(2):e1548. http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0001548
25. Work TM, Aeby GS, Maragos JE (2008). *Phase Shift from a Coral to a Corallimorph-Dominated Reef Associated With a Shipwreck on Palmyra Atoll*. PLoS ONE 3(8): e2989. http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0002989
26. Knapp IS, Godwin LS, Smith JE *et al.* (2011). *Records of Non-Indigenous Marine Species at Palmyra Atoll in the US Line Islands.* Marine Biodiversity Records 4:1-7. http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=8258742
27. Kenyon J, Maragos JE, Wilkinson CB (2010). *Characterization of Coral Communities at Kingman Reef in the Remote Central Pacific Ocean*. Atoll Research Bulletin 584: 1-31. http://www.sil.si.edu/digitalcollections/atollresearchbulletin/
28. Friedlander AM, Sandin SA, DeMartini EE *et al*. (2010). *Spatial Patterns of the Structure of Reef Fish Assemblages at a Pristine Atoll in the Central Pacific*. Marine Ecology Progress Series 410:219-231.
29. Kenyon JC, Bonito V, Wilkinson CB*. Characterization of Coral Communities at Wake Atoll in the Remote Central Pacific Ocean.* In press, Atoll Research Bulletin, 25 pp.
30. Lobel PS, Lobel LK (2004). *Annotated Checklist of the Fishes of Wake Atoll.* Pacific Science 58(1):65-90. http://muse.jhu.edu/journals/pacific_science/summary/v058/58.1lobel.html
31. Pacific Islands Fisheries Science Center. (2011). Cruise Report, NOAA Ship *Hi`ialakai*, Cruise HA-11-01, Leg 1, 10 March–2 April 2011, 35 pp. http://www.pifsc.noaa.gov/library/hiialakai.php
32. Williams GJ, Knapp IS, Maragos JE *et al.* (2011). *Proximate Environmental Drivers of Coral Communities at Palmyra Atoll: Establishing Baselines Prior to Removing a WWII Military Causeway.* Marine Pollution Bulletin 62:1842-1851. http://www.sciencedirect.com/science/article/pii/S0025326X11002529
33. NOAA Coastal Services Center Digital Coast, Historical Hurricane Tracks. http://www.csc.noaa.gov/digitalcoast/tools/hurricanes/
34. Pacific Islands Fisheries Science Center (2009). Cruise Report, NOAA Ship *Hi`ialakai*, Cruise HI-09-01, 12 March–1 April 2009, 61 pp. http://www.pifsc.noaa.gov/library/hiialakai.php
35. Karnauskas KB, Cohen AE (2012). *Equatorial Refuge Amid Tropical Warming*. Nature Climate Change 2:530-534. http://www.nature.com/nclimate/journal/v2/n7/full/nclimate1499.html
36. Federal Register Volume 76 Number 65, April 5, 2011. FR Doc No. 201-7960. pp 18775-18777. http://www.gpo.gov/fdsys/pkg/FR-2011-04-05/html/2011-7960.htm