15. Status of Coral Reefs in Hawai'i and United States Pacific Remote Island Areas (Baker, Howland, Palmyra, Kingman, Jarvis, Johnston, Wake) in 2008

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Abstract

Hawaiian Archipelago

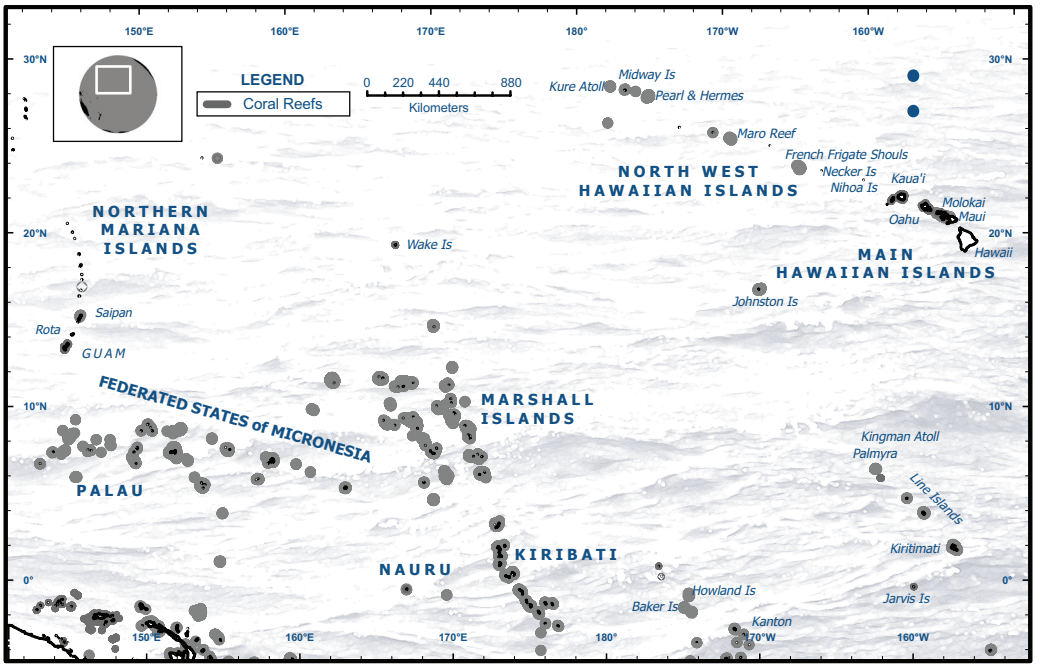
- Several urban areas and popular tourist destinations have suffered from pollution from the land, significant fishing pressure, recreational overuse, and alien species. Despite these pressures, many coral reefs in Hawai'i remain in fair to good condition, especially remote reefs;
- Most MPAs have proven to be highly effective in conserving biodiversity and fisheries resources. MPA size, habitat quality, and level of protection are the most important success factors, but several MPAs are too small to have significant effects outside their boundaries;
- Community-based management has been effective at several locations in Hawai'i and expansion of these efforts is being encouraged;
- Continued invasion and degradation of new habitats by alien species remains one of the most pressing threats to reefs in Hawai'i;
- The Papahānaumokuākea Marine National Monument (PMNM) is the largest fully protected marine conservation area in the world, with a unique predator-dominated trophic structure, many endemic species, and many threatened and endangered species. This is an important global biodiversity 'hot spot';
- Global impacts such as climate change (sea level rise, ocean warming and acidification) and marine debris threaten the unique ecosystem of the PMNM, and rapid international action is needed.

US Pacific Remote Island Areas (PRIAs)

- These are remote with limited human impacts, therefore they are nearly intact reefs with healthy coral communities, and predator-dominated fish assemblages with the highest fish biomass of all USA coral reefs (and near the highest recorded anywhere);
- Palmyra and Kingman are large atolls with higher coral biodiversity compared to other central Pacific islands: that may be due to being in the path of eastward flowing North Pacific Equatorial Countercurrent;
- Abandoned shipwrecks and associated fuel spills and degradation of reefs threatens these remote islands, including the rapid spread of an invasive corallimorph, *Rhodactis*, stimulated by dissolved iron at Palmyra and Baker;
- Residual World War II military construction and use continues to degrade habitats at Palmyra, Johnston, Wake, and Baker;
- The US Government is considering proposing the Central Pacific Islands Marine National Monument, which would create the world's largest MPA.

Introduction

This chapter summarises the status of the coral reefs of the main Hawaiian Islands (MHI), Northwestern Hawaiian Islands (NWHI), and the US Pacific Remote Island Areas (PRIAs). The coral reef habitat shallower than 18 m encompasses 1595 km^2 in the NWHI, 1231 km^2 in MHI, and 252 km^2 within the PRIAs (Baker, 5 km^2; Howland, 3 km^2; Palmyra, 47 km^2; Kingman, 21 km^2; Jarvis, 3 km^2; Johnson,150 km^2; Wake, 23 km^2). Complete details for each area appear in *The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States (SCRE): 2008* (http://ccma.nos.noaa.gov/stateofthereefs).



Hawai'i: The Hawaiian Archipelago spans over 2500 km from the island of Hawai'i in the south-east to Kure Atoll (the world's highest latitude atoll) in the north-west. These coral reefs in the central Pacific Ocean are exposed to large open ocean swells and strong trade winds that result in distinctive reef communities. The geographic isolation of Hawai'i has resulted in some of the highest endemism of any tropical marine ecosystem on earth. The archipelago consists of two regions: the populated main Hawaiian Islands (MHI); and the mostly uninhabited atolls, islands, and banks of the Northwestern Hawaiian Islands (NWHI). There are 8 high volcanic islands in the MHI, ranging in age from active lava flows on Hawai'i Island to Ni'ihau, formed 5.6 million years ago. The NWHI represent the older portion of the emergent Hawaiian Archipelago, beginning at Nihoa (7 mya) and extending to Midway and Kure Atolls (28 mya). The NWHI reefs are remote, nearly pristine and represent one of the last remaining intact large-scale predator-dominated coral reef ecosystems.

Coral reefs were important to the ancient Hawaiians for subsistence, culture, and survival and today provide commercial, recreational and subsistence fishing opportunities, world famous surfing and diving locations, and contribute US$800 million a year from marine tourism industry to the State's economy. The full economic value of Hawai'i's coral reefs was estimated at US$10 billion, with direct economic benefits of $360 million per year in 2002. However, several urban areas and popular tourist destinations have suffered from land-based sources of pollution, significant fishing pressure, recreational overuse, alien species, and coastal construction. Despite these human pressures, many of Hawai'i's coral reefs in remote areas are still in fair to good condition.

PRIAs: Pacific Remote Island Areas (PRIAs) are isolated US sovereign islands and atolls outside the jurisdiction of any specific State or Territory. The 7 islands and atolls are dispersed over a vast and remote area in the central Pacific Ocean and influenced by varying oceanographic and climatic conditions and processes; 6 of these are National Wildlife Refuges (NWR) under the jurisdiction of the US Fish and Wildlife Service (USFWS). Wake Atoll, the only one that is not a refuge, is under the control of the Department of the Interior and operated by the US Air Force, with a population of 150-250 Air Force personnel and contractors. The coral reefs of the PRIAs remain quite healthy and productive, with few impacts from unauthorized fishing, abandoned WWII materiel, and residual effects from guano mining, ship groundings, and climate change. These islands experience occasional tropical storms.

Main Hawaiian Islands – Status of Coral Reefs in 2008

Monitoring of Hawaiian coral reefs started in the 1960s and has documented numerous changes. Some communities are monitoring and managing their local resources in addition to State, Federal, university, non-profit, and NGO programs. Sediment is the leading land-based pollutant and is increasing as coastal areas are developed for agriculture and urban growth, including filling of floodplains, construction of storm drains, and stream channelisation. Most of the sewage treatment plants discharge secondary treated wastewater into the ground through 15–60 m deep injection wells. A recent tracer study on Maui identified the plume from such wells entering adjacent nearshore waters causing local overgrowth of marine algae near some popular beach areas.

The average annual sea surface temperatures (SSTs) in Hawai'i have increased 0.8°C since 1956; but there have only been 3 documented major bleaching events within the Hawaiian

Archipelago (MHI 1996, NWHI 2002 and 2004). Surveys in 2004 and 2005 revealed the presence of 8 coral diseases in the 3 major coral genera (*Porites, Montipora, Pocillopora*), but generally disease prevalence was low.

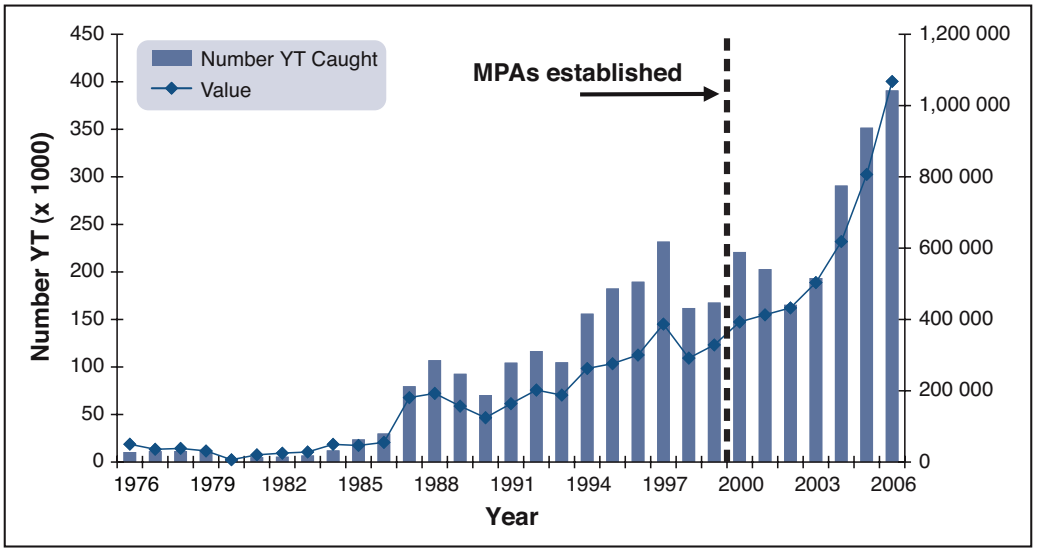
Most coastal waters are generally in good condition, but no comprehensive water quality monitoring program currently exists. Storm water runoff during high rain events cause many beaches to close for human health and safety reasons. A very large spill of more than 18 million litres of untreated wastewater occurred on March 24, 2006 into the Ala Wai canal and nearby Waikiki. The Hawai'i Department of Health 2006 list of polluted waters contains 93 streams and 219 coastal areas. The problem coastal waters are primarily harbours, semi-enclosed bays and protected shorelines, where mixing is reduced and resident time of pollutants is long compared to exposed coasts.

Coral cover across the MHI at 1682 sites averaged 19.9% with 7 coral species accounting for 96% of the total. Coral cover of hard-bottom habitats was highest in the southern portion of the MHI (Molokini, 45% and Kahoolawe, 49%) and lowest in the northern part (Ni'ihau, 4%). In general, coral cover decreased with increasing geologic age (i.e. from south-east to north-west; (R = –0.73). Coral cover at 27 long-term (more than 10 years) monitoring sites showed that cover at 70% of the sites had declined since monitoring started, with an average decline of 8%. Coral cover at 10 sites monitored for more than 30 years has declined by an average of 12%.

An assessment of 55 fish stocks in the MHI showed that 75% of the stocks examined were below typical over-fishing thresholds (25% of virgin stock biomass). Fish biomass data complied from 6 comprehensive studies at 188 locations (n = 1427 transects) was negatively correlated with human population density by island (R = –0.89). The remote island of Ni'ihau had the highest fish biomass while Oahu, with 72% of the state's population, had the lowest overall fish biomass among the MHI. At Oahu, apex predators were virtually absent, likely due to intense fishing pressure.

Alien species, particularly algae, continue to damage many nearshore marine environments around the MHI. The Hawai'i Marine Algae group (HIMAG) and interested community groups have developed methods to manage invasive species, especially algae. Since 2002, communities have removed over 150 tons of invasive algae in clean-up events with more than 2550 volunteers. HIMAG developed the 'super sucker,' an underwater vacuum, to remove large amounts of alien marine algae, especially in efforts to restore native reef habitats in Kāne'ohe Bay. The invasive soft coral, *Carijoa*, has spread over deeper reef areas and smothered some stands of black corals.

Socioeconomics: More than 82% of Hawai'i's tourists participate in some form of ocean recreation, generating almost $364 million each year; and 66% of 1600 local households surveyed participated in ocean swimming (28 times per year between 2004 and 2005). Other major uses of the coasts included recreational fishing (31% of households, 10 times per year), surfing (29% of households, 18 times per year), snorkelling (32% of households, 6 times per year) and subsistence fishing (10% of households, 5 times per year). The involvement of ethnic Hawaiians in ocean activities was 10–20% higher than other groups.



The number and value of yellow tang, the main aquarium target fish, caught in the west Hawai'i aquarium fishery from 1976 to 2006 has increased dramatically since 1987 and also since MPAs were established in 2000 (source: DLNR/DAR).

Status of Fisheries: Hawai'i's coastal fisheries resources are shared by subsistence, recreational, and small-scale commercial fishers. Seine nets have the highest catch rates per trip, followed by set gill nets, spear fishing, and handlines. The average catch per trip by seine nets, excluding coastal pelagic species, declined by 35% from 1966 to 2006: the catch also changed from jacks, bonefish, and threadfin being the dominant target species, to less valuable surgeonfishes and goatfishes. Total catch by handlines has also declined since the early 1990s; however the catch by spearfishing has increased during this same time. The Hawai'i Marine Recreational Fishing Survey in 2006 showed the recreational catch was dominated by goatfishes, surgeonfishes, and jacks (sampling limitations reduced the confidence in numeric estimates).

The commercial aquarium fishery is now Hawai'i's major inshore fishery, with landings reported as more than 990 000 specimens, valued for collectors at US$1.93 million in 2006 (75.6% coming from the island of Hawai'i). In 2000, 9 Fish Replenishment Areas (FRAs) which prohibit aquarium collecting were established in West Hawai'i to conserve aquarium reef fishes and reduce conflict among resource users. These FRAs cover 35.2% of the West Hawai'i coastline and designations were based on substantial community input. Despite this reduction in aquarium collecting area, there are now many more collectors, and the total number of fish caught and their value have approximately doubled to that prior to the creation of the FRAs. Aquarium fish density has increased in the FRAs, especially the density of the primary target species (yellow tang, *Zebrasoma flavescens*). This indicates that FRAs are effective at replenishing aquarium fish stocks in West Hawai'i after 7 years. Total fish biomass and the number of large fishes (>20 cm) was greater in 12 MPAs than in adjacent areas open to fishing by more than 200% and 150%, respectively.

Conclusions and Recommendations: Food, recreation, culture, commerce, aesthetics, and shoreline protection are a few of the ecosystem services provided by Hawai'i's coral reefs. These reefs also have extremely high biodiversity and conservation value due to large proportions of endemic species. The coral reefs are valued at more than US$10 billion, thus are an important component of the economy especially for leisure pursuits and the Hawaiian way of life. However, the 1.2 million residents (70% live on Oahu) and more than 7 million tourists visit each year put increasing pressures on Hawai'i's coral reefs.

As coastal development continues to expand in the MHI, focus should be given to the implementation, maintenance, and enforcement of best management practices that reduce sediment runoff and prevent further damage to coral reefs. Management should be ecosystem-based to include the entire watershed from ridge to reef. The continued invasion and damage by alien species remains a major threat to Hawai'i's reefs and mechanical and hand removal of invading algae has proven to be effective at a small scale: large scale removal should be implemented.

The effects of intensive fishing pressure must be mitigated and stocks and ecosystems rebuilt through co-ordinated measures including: increasing restrictions on very efficient fishing gear such as gillnets and scuba fishing (particularly at night); bag limits; and larger closed areas. For example, in 2006 set (lay) nets were banned around Maui and parts of Oahu, and now all lay nets must be registered with limits on mesh size, times and location. There are no recreational fishing licenses in Hawai'i and the non-commercial catch is enormous, therefore more emphasis is needed to assess these fisheries and manage them.

MPAs are highly successful in Hawai'i at conserving biodiversity and fish resources, as well as increasing fish yields nearby, such as aquarium fish. However, less than 1% of the reefs around the MHI are in no-take MPAs: increasing the number and size of MPAs in Hawai'i will greatly improve fish stocks and help preserve biodiversity.

A network of more than 28 communities meets twice a year to discuss local resource management issues. In some areas, community planning and active participation in management is a direct response to growing concerns about over use of resources or perceived changes to lifestyle. Locally-managed marine areas that incorporate traditional concepts of customary marine stewardship into MPA management are helping to increase the effectiveness of decision making and helping with rules and regulations compliance. An ecosystem-based management will require comprehensive ocean zoning to resolve the mismatches between the spatial and temporal scales of governance and ecosystems.

Northwestern Hawaiian Islands – Status of Coral Reefs 2008

In 2006, the Government of USA designated the Northwestern Hawaiian Islands Marine National Monument (later renamed Papahānaumokuākea Marine National Monument, PMNM) as one of the world's largest conservation areas (362 600 km^2). The management of the PMNM is shared by 3 co-trustee agencies: State of Hawai'i; United States Department of the Interior, Fish and Wildlife Service; and Department of Commerce, NOAA. A number of government and non-government organizations conduct research and monitoring of the coral reefs in the NWHI. Scientific expeditions in the NWHI since 2000 have reported many new records and some new

species. For example, a coral species cannot be identified to the genus or family level, so it may be a relic (or 'fossil') species. The live coral cover on the islands and atolls ranged from <1% at Gardner Pinnacles to 37% at Lisianski-Neva Shoal (average 19.9%). There was no significant difference in coral cover at 27 permanent stations in 2000–2002 (16.6%) and 2006 (14.0%; $p>0.05$). Cover of macroalgae, turf algae, crustose coralline algae and coral populations at 8 US islands across the Pacific, showed that the NWHI have the highest algal cover and the lowest coral cover. This is probably due to the subtropical location of the NWHI where there are often cool water temperatures and a high frequency of large waves during winter.

The prevalence of coral disease is low in the NWHI; 10 diseases have been reported affecting the 4 major genera (*Porites, Montipora, Pocillopora, Acropora*) with *Porites trematodiasis* disease being the most common. Levels of disease appear to be stable through time, with the exception of *Acropora* white syndrome at French Frigate Shoals. This disease kills *Acropora* and there was partial to total mortality in 97.6% of the 41 marked colonies after one year. Only 5 introduced invertebrate species have been found in the NWHI; much less than the 287 introduced species in the MHI.

Total fish biomass assessed in 2000–2002 (1400 kg per hectare) did not differ significantly ($p>0.05$) from estimates made in 2005 (1200 kg per hectare) and there were no differences in the fish trophic structure. Apex predators accounted for 36% of total biomass, followed by herbivores (34%), secondary carnivores (24%), and plankton eaters (6%); 55% of the total biomass on the fore-reef was apex predators, with a lower proportion in sheltered sites where there are usually fewer predators.

The NOAA Coral Reef Conservation Program and Marine Debris Program, and the Pacific Islands Fisheries Science Center removed 511 tons of historical debris from the reefs of the NWHI between 2001 and 2005. It is estimated that the annual accumulation rate of debris is more than 52 tons, which indicates that the current level of removal is not sufficient to keep up with accumulation. More effort will be required to negotiate with potential East Asian source countries for a reduction of debris, especially abandoned fishing nets.

There are contrasting trends with endangered megafauna in the NWHI; the Hawaiian monk seal *(Monachus schauinslandi)* is the only endangered pinniped entirely within US waters and the only seal dependent on coral reefs. The current population is about 1100 seals, a decrease of about 60% since the 1950s. Counts declined by 5% per year from 1985 to 1993, were relatively stable through 2000 and have declined after 2001, with lowest abundance recorded in 2005. The Hawaiian green turtle population is a single genetic stock that is endemic to the Hawaiian Archipelago. The principal rookery is at French Frigate Shoals where more than 90% of all nesting occurs. When protection and management started in the 1970s, the green turtle population was about 20% of pre-exploitation stock; now it is estimated to be about 83% of pre-exploitation stock with a population growth of approximately 5.4% per year. However, the critical nesting beaches on Eastern Island, French Frigate Shoals continue to shrink due to local sea level rise and heavy wave action. Similarly, the beach habitat for the Hawaiian monk seal is also declining in the NWHI.

Status of Fisheries: Recent fishing and other resource extraction in the NWHI has been mostly limited to two commercial fisheries: the on-going NWHI bottom fish fishery; and the now-closed NWHI lobster trap fishery. All fishing activity in the NWHI is declining with the designation of the PMNM. The bottom fishery can continue until mid-2011, and current monitoring will provide crucial information on the abundance and distribution of target species for management of stocks in the MHI. There is no trade in coral and live fish in the PMNM.

Conclusions and recommendations: The NWHI is one of the few regions in the world where monitoring and research can be conducted in virtual absence of human pressures. This allows extrapolations about subtropical reefs in the past, and what might occur in the future if larger and more effective no-take marine reserves were to be established elsewhere. The co-trustees of the PMNM are committed to preserving the ecological integrity of the monument and perpetuation of NWHI ecosystems, native Hawaiian culture, and other historic resources. The final regulations for the PMNM spell out the management scope and purpose, boundary, definitions, prohibitions and regulated activities. The co-trustees developed and signed a Memorandum of Agreement in 2006 to establish roles and responsibilities, and co-ordination bodies and mechanisms for management; as well as developing a research plan to provide direction for future research in the NWHI. The most pressing management concern in the NWHI is the introduction of alien and invasive species; thus the Aquatic Invasive Species Response Team at the State of Hawai'i Division of Aquatic Resources has recently started inspecting the hulls of all vessels travelling to the NWHI from the MHI to prevent or reduce the introduction of alien species. Another management recommendation is to increase marine debris removal at local and international levels.

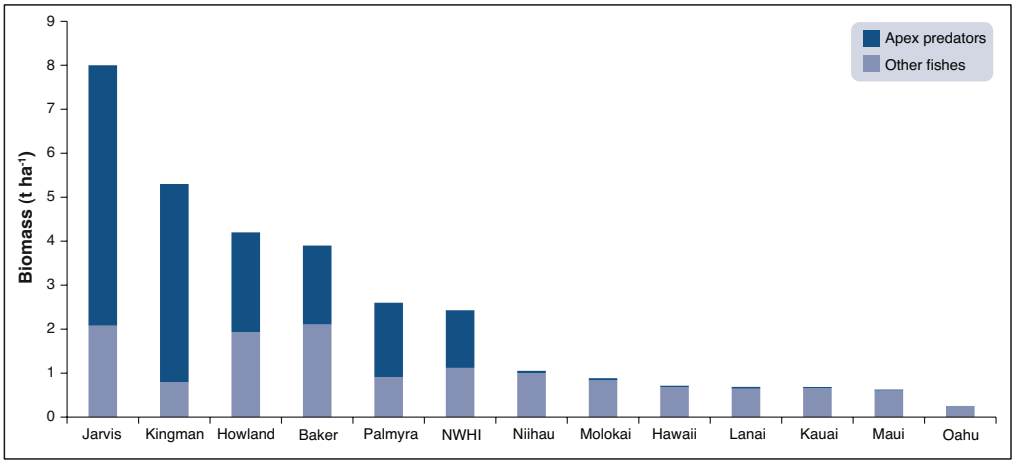
Pacific Remote Island Areas (PRIAs): Status of Coral Reefs 2008

To survey these remote US Pacific Island Areas requires large vessels and interagency collaboration. NOAA has conducted biennial Pacific Rapid Assessment and Monitoring Program (RAMP) cruises since 2000 at all 7 locations with scientists from the Pacific Islands Fisheries Science Center's Coral Reef Ecosystem Division (PIFSC-CRED), the USFWS, and collaborating institutions. The Scripps Institution of Oceanography (SIO) also sponsored surveys at Palmyra and Kingman in August 2005, Palmyra in August 2006 and Kingman in August 2007. The PRIAs are part of 3 central Pacific archipelagos: Wake Atoll at the north end of the Marshall Islands; Baker and Howland Islands at the north end of the Phoenix Islands; Johnston Atoll, Kingman Reef and Palmyra Atoll at the north end, and Jarvis Island at the middle, of the Line Islands. In 2006 tropical cyclone Ioke, one of the strongest storms seen in the Central Pacific, struck Johnston Atoll as a Category 2 hurricane and Wake Atoll as a Category 4 typhoon.

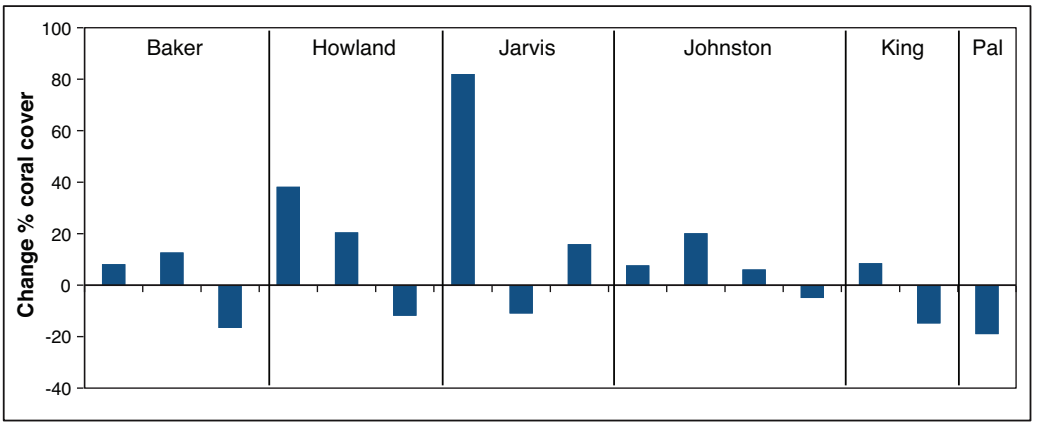
Although there are 264 total species in 52 hard coral genera and 22 other cnidarian genera reported in the PRIAs, the individual totals range from 50 species and 20 genera at Jarvis and Johnston to approximately 190 species and 50 genera at Kingman and Palmyra. These numbers are consistent with other Central Pacific reefs and reflect the role of habitat size, diversity, proximity to neighbouring reefs in determining the diversity at each reef. Two of the largest atolls (Palmyra and Kingman) have substantially higher coral diversity compared to Kanton, Tabuaeran and Kiritimati Atolls and may benefit from the North Pacific Countercurrent which carries larvae of species from the western Pacific where there are many more species. There has not been any recent severe or chronic coral bleaching at the PRIAs to date, probably because these reefs are in a healthy and resilient state; Palmyra may be an exception due to lagoon

degradation from WWII military construction. Live coral cover of more than 40% is common in protected, leeward, and lagoon habitats, whereas coral cover generally does not exceed 20% in wave-exposed habitats. Recent towed-diver surveys showed that cover of hard and soft corals combined was highest on Palmyra (44%), followed by Kingman (41%), Baker (38%), Howland (36%), Jarvis (24%), Johnston (25%), and Wake (28%).

Coral cover at 16 selected permanently marked transect sites, representing 7 of the PRIAs (except Wake), has increased at 10 sites and decreased at 6 sites between 2000 and 2008 in all PRIAs, with first measures of mean coral cover being 36% and latest surveys at 48%. This



This graph clearly shows the difference in fish biomass, especially for apex predators, between the remote US Pacific Remote Island Areas (left, Jarvis to Palmyra), the Northwestern Hawaiian Islands and the main Hawaiian Islands (right, Nihau to Oahu) with almost no apex predators in the last 7 island reefs.



This figure summarises changes in percent cover of corals and other cnidarians between the earliest and latest surveys at 16 permanent transect sites in the 6 US Line & Phoenix Islands National Wildlife Refuges between 2000-2008. Coral cover has increased at 10 sites, and decreased at 6 sites (Pal = Palmyra).

overall increasing trend is probably due to coral recovery after bleaching in the late 1990s. Coral declines at the boat anchorages at Baker and Howland appear to be due to competition between corals and invasive blue-green algae, stimulated by dissolved iron from wrecks and other scrap metal. A decline at Jarvis may be from wave damage, and declines in *Acropora* species at Johnston are likely related to coral diseases and residual damage from military construction. Coral declines at one Kingman site are related to crown-of-thorn starfish (COTS, *Acanthaster planci*) predation, but the high abundance of prey corals elsewhere around Kingman indicates that these are serving to maintain COTS at high levels since 2002; this is not reported on less healthy reefs. *Acropora* corals are a sensitive indicator of environmental stress: because they continue to flourish on many PRIA sites, it shows that coral populations are predominantly in excellent condition. There are about 200 species of turf and macroalgae in the PRIAs; the Line Islands (Palmyra, Kingman, and Jarvis) have higher algal diversity than the Phoenix Islands (Howland and Baker) despite being similar in size.

Surveys in 2006 indicate that the overall prevalence of coral disease across the region is very low compared to reefs near populated areas, affecting between 0.01 and 2.8% of colonies at the 80 survey sites; 39 sites (48.8%) showed some disease, with Johnston Atoll (a former military base) having the highest occurrence of coral disease (at 78% of sites) and the highest mean prevalence (0.7 ± 0.2%; mean ± SE).

The abundance of reef sharks, large groupers, jacks, and humphead wrasses are much higher on the PRIA reefs than on other reefs in the region where there has been fishing pressure. These reefs are among the most predator-dominated and biomass-rich reefs and atolls in the Pacific. Fish assemblages at Howland, Baker, Palmyra, Kingman, and especially Jarvis rank among the highest biomass (3000–8000 kg/ha) and most predator-dominated (54–74%) reefs ever surveyed.

Commercial fishing has been prohibited within the Natural Wildlife Refuges by the government but the NOAA Fisheries Pacific Regional Office issues commercial bottom fishing and lobster fishing permits in the PRIAs. Some unauthorized fishing within NWR boundaries is suspected at several PRIAs where surveillance and monitoring efforts are presently inadequate.

Conclusions and Recommendations: The PRIA reefs represent some of the most intact and healthy ecosystems remaining anywhere with high biodiversity, coral cover and reef fish biomass, as well as predator-dominance. These reefs provide a unique opportunity to examine and understand ecosystem function and resilience to climate change in the absence of direct human impacts. Thus they deserve the highest levels of protection and conservation. Most of the islands are uninhabited with no coastal development and runoff, however, there are residual impacts from military use on Johnston, Palmyra and Wake Atolls and Baker Island. An emerging threat is the potential for increased commercial fishing, especially illegal, unauthorized and unreported shark finning and bottom and lobster fishing, mostly by foreign fishers on uninhabited reefs.

Palmyra was purchased by The Nature Conservancy in 2000 and the USFWS purchased all of Palmyra from TNC in 2001 except for the main island (Cooper) to establish the Palmyra Atoll NWR. Now the USFWS oversees conservation management and research in cooperation with TNC, which manages the research station on Cooper Island constructed by TNC in 2006.

Members of the research consortium include Stanford University; SIO; American Museum of Natural History; California Academy of Sciences; the University of California at Santa Barbara and Irvine; University of Hawai'i; US Geological Survey; TNC; and Victoria University of Wellington, New Zealand. The station cost $1.5 million and is funded by the Gordon and Betty Moore Foundation for up to 20 researchers. These National Wildlife Refuges will help protect against human impacts, and the new proposed Marine National Monument covering all 7 PRIAs could result in reducing commercial fishing inside refuge boundaries, and provide improve surveillance, enforcement, removal of existing shipwrecks at Kingman, Palmyra and possibly Wake, and support for other restoration initiatives in the ocean and on land, at Kingman, Palmyra, Baker, Johnston and Wake.

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References

Friedlander A, Aeby G, Brainard R and 8 others (2008).The state of the coral reef ecosystems of the Main Hawaiian Islands. In: State of the coral reefs of the United States and the Freely Associated States: 2008. Waddell J, Clark AM eds, NOAA Technical Memorandum NOS NCCOS, Silver Spring, MD, pp 219–261.

Friedlander A, Aeby G, Balwani S and 8 others (2008). State of the Coral Reef Ecosystems of the Northwestern Hawaiian Islands. In: State of the coral reefs of the United States and the Freely Associated States: 2008. Waddell J, Clark AM eds, NOAA Technical Memorandum NOS NCCOS, Silver Spring, MD, pp 263–306.

Maragos J, Miller J, Gove J and 20 others (2008). U.S. coral reefs in the Line and Phoenix Islands, Central Pacific Ocean: History, Geology, Oceanography, and Biology. In: Riegl B, Dodge RE (eds) Coral Reefs of the USA. Coral Reefs of the World, Volume 1, Springer-Verlag, pp 595–641.

Maragos J, Friedlander AM, Godwin S and 10 others (2008). U.S. coral reefs in the Line and Phoenix Islands, Central Pacific Ocean: Status, Threats and Significance. In: Riegl B, Dodge RE (eds) Coral Reefs of the USA. Coral Reefs of the World, Volume 1, Springer–Verlag, pp 643–654.

Miller J, Maragos J, Brainard R, and 17 others (2008). The State of Coral Reef Ecosystems of the Pacific Remote Island Areas. In: State of the coral reefs of the United States and the Freely Associated States: 2008. Waddell J, Clark AM eds, NOAA Technical Memorandum NOS NCCOS, Silver Spring, MD, pp 353–386.

PAPAHĀNAUMOKUĀKEA MARINE NATIONAL MONUMENT

On June 15, 2006, the President of the USA, George W. Bush designated the North-western Hawaiian Islands (NWHI) as a Marine National Monument, one of the world's largest conservation areas. The Monument encompasses nearly 362,600 km^2 of ocean and includes all the islands, atolls, shoals and banks from Nihoa Island to Kure Atoll. In March 2007, the NWHI was renamed as the Papahānaumokuākea Marine National Monument (PMNM) by the President's wife, Laura Bush. Native Hawaiians consider the NWHI as a sacred place where life begins and spirits return after death.

The unique predator-dominated trophic structure, the large numbers of endemic species, and the occurrence of threatened and endangered species makes the PMNM an ecosystem of global significance. These reefs and islands offer a rare glimpse into how a large-scale coral reef ecosystem should appear and function without damaging human impacts. The region contains the critically endangered Hawaiian monk seal (Box p. 24), contains one of the largest and most important assemblages of seabirds in the world, and supports 90% of sea turtles found in the whole Hawaiian Archipelago. Approximately 25% of all species examined are endemic to the Hawaiian Archipelago making this region an important biodiversity 'hot spot'.

Management of the PMNM is the responsibility of the State of Hawai'i, the United States Department of the Interior, Fish and Wildlife Service, and the Department of Commerce, NOAA: these co-trustees are committed to preserving the ecological integrity and perpetuation of the ecosystems, native Hawaiian culture, and other historic resources. Management of the PMNM will be comprehensive and based on integrated ecosystem-based management that seeks to conserve this valuable and irreplaceable ecosystem well into the future via an integrated management structure that ensures continued co-operation among all partners. The most significant long-term threats will be from diseases, ocean acidification, sea level rise and bleaching associated with climate change. The large number of endemic species and the unique ecosystem dynamics make the region particularly susceptible to alien and invasive species. Also, this area is increasingly susceptible to poaching from the many distant-water fishing fleets, and enforcement will require improved surveillance technologies.

The PMNM will serve as a key sentinel for monitoring and deciphering short- and long-term responses to local, regional, and global environmental and human stressors because it is remote, uninhabited, and relatively pristine compared to other reefs in the world. On-going research, monitoring, habitat restoration and conservation management of the PMNM will provide significant insights to benefit management for all islands and coral reefs. The PMNM represents a natural and cultural treasure of high scientific, conservation and aesthetic value, and the wise stewardship of this unique ecosystem is the responsibility of us all (from Alan Friedlander alan.friedlander@noaa.gov).