

In this review:

- A. Recent articles – no abstract available
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O/A denotes an open access article or journal

A. Recent articles – no abstract available

Kruzic, P. and Pozar-Domac, A. **Impact of tuna farming on the banks of the coral *Cladocora caespitosa* in the Adriatic Sea.** *Coral Reefs* 26(3): 665, 2007.

Macintyre, I.G. and Toscano, M.A. **The Elkhorn Coral *Acropora palmata* is coming back to the Belize Barrier Reef.** *Coral Reefs* 26(4): 757, 2007.

Lam, K., Shin, P.K.S., and Hodgson, P. **Severe bioerosion caused by an outbreak of corallivorous *Drupella* and *Diadema* at Hoi Ha Wan Marine Park, Hong Kong.** *Coral Reefs* 26(4): 893, 2007.

Coles, S.L. and Bolick, H. **Invasive introduced sponge *Mycale grandis* overgrows reef corals in Kane'ohe Bay, O'ahu, Hawai'i.** *Coral Reefs* 26(4): 911, 2007.

Knowlton, N. and Jackson, J.B.C. **Shifting baselines, local impacts, and global change on coral reefs.** *PLoS Biology* 6(2): art. e54, 2008. O/A

Knowlton, N. **Coral reefs.** *Current Biology* 18(1): R18-R21, 2008. O/A

B. Recent publications available online

Lumsden, S.E., Hourigan, T.F., Bruckner, A.W., and Dorr, G. (eds.) 2007. **The State of Deep Coral Ecosystems of the United States.** *NOAA Technical Memorandum CRCP-3.* Silver Spring MD. 365pp.

Available at: www.nmfs.noaa.gov/habitat/dce.html

Notes: This NOAA report illustrates that deep corals, also known as “deep sea” or “cold-water” corals, are likely much more extensive and important to ocean ecosystems than previously known. Researchers have discovered multicolored sea fan corals in canyons and on seamounts in the Northeast Atlantic, complex reef-like stony coral structures on the continental shelf and slope in the Southeast U.S. and Gulf of Mexico, exceptionally rich coral gardens in the Aleutian Islands, and precious corals providing foraging habitat for endangered monk seals in Hawaii. The major threats to deep-sea corals highlighted include bottom trawling and dredging. Other potential threats include interactions with fishing gear such as longlines, traps or pots, and deep drop fishing, the harvest of precious corals for the jewelry trade, minerals resource exploration and extraction activities, invasive species, and climate change. Threats to deep-sea corals are highest in the waters off Alaska, the West Coast, and the Northeast and Southeast USA. This report also documents recent management actions by NOAA and the Regional

Fishery Management Councils to protect over one half million square miles of the seafloor in the Pacific, including unique deep coral habitats, from damage by bottom-trawling. There are many areas in U.S. waters that appear likely to harbor deep coral habitats but have not been surveyed. Effective conservation efforts will require additional mapping and research to identify the locations of deep coral habitats and better understand these unique resources. The Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006 (P.L. 109-479) calls on NOAA to develop a Deep Sea Coral Research and Technology Program, and provides new authorities to facilitate management efforts.

C. Recent articles with abstracts

Richmond, R.H., Rongo, T., Golbuu, Y., Victor, S., Idechong, N., Davis, G., Kostka, W., Neth, L., Hamnett, M., and Wolanski, E. **Watersheds and coral reefs: Conservation science, policy, and implementation.** *BioScience* 57(7): 598-607, 2007.

Notes: Coral reefs worldwide are being degraded by human-induced disturbances, resulting in ecological, economic, and cultural losses. Runoff and sedimentation are among the greatest threats to the coastal reefs surrounding high islands and adjacent to continental landmasses. Existing scientific data identify the key stressors, synergisms, and outcomes at the coral reef ecosystem, community, and population levels. These data demonstrate that marine protected areas alone may be insufficient for coral reef protection; integrated watershed management practices are also needed. Gaps in the effectiveness of environmental policy, legislation, and regulatory enforcement have resulted in the continued degradation of US and Australian reefs. Several Pacific islands, with intact resource stewardship and traditional leadership systems, have been able to apply research findings to coral reef management policies relatively quickly. Three case histories in Micronesia provide insight into how social sciences and biophysical data can be combined to manage human behaviors responsible for coral reef destruction.

Mumby, P.J., Hastings, A., and Edwards, H.J. **Thresholds and the resilience of Caribbean coral reefs.** *Nature* 450(7166): 98-101, 2007.

Notes: The deteriorating health of the world's coral reefs threatens global biodiversity, ecosystem function, and the livelihoods of millions of people living in tropical coastal regions. Reefs in the Caribbean are among the most heavily affected, having experienced mass disease-induced mortality of the herbivorous urchin *Diadema antillarum* in 1983 and two framework-building species of coral. Declining reef health is characterized by increases in macroalgae. A critical question is whether the observed macroalgal bloom on Caribbean reefs is easily reversible. To answer this question, we must resolve whether algal-dominated reefs are an alternative stable state of the ecosystem or simply the readily reversible result of a phase change along a gradient of some environmental or ecological parameter. Here, using a fully parameterized simulation model in combination with a simple analytical model, we show that Caribbean reefs became susceptible to alternative stable states once the urchin mortality event of 1983 confined the majority of grazing to parrotfishes. We reveal dramatic hysteresis in a natural system and define critical thresholds of grazing and coral cover beyond which resilience is lost. Most grazing thresholds lie near the upper level observed for parrotfishes in nature, suggesting that reefs are highly sensitive to parrotfish exploitation. Ecosystem thresholds can be combined with stochastic models of disturbance to identify targets for the restoration of ecosystem processes. We illustrate this principle by estimating the relationship between current reef state (coral cover and grazing) and the probability that the reef will withstand moderate hurricane intensity for two decades without becoming entrained in a shift towards a stable macroalgal-dominated state. Such targets may help reef managers face the challenge of addressing global disturbance at local scales.

Graham, N.A.J., Wilson, S.K., Jennings, S., Polunin, N.V.C., Robinson, J., Bijoux, J.P., and Daw, T.M. **Lag effects in the impacts of mass coral bleaching on coral reef fish, fisheries, and ecosystems.** *Conservation Biology* 21(5): 1291-1300, 2007.

Notes: Recent episodes of coral bleaching have led to wide-scale loss of reef corals and raised concerns over the effectiveness of existing conservation and management efforts. The 1998 bleaching event was most severe in the western Indian Ocean, where coral declined by up to 90% in some locations. Using fisheries-independent data, we assessed the long-term impacts of this event on fishery target species in the Seychelles, the overall size structure of the fish, assemblage, and the effectiveness of

two marine protected areas (MPAs) in protecting fish communities. The biomass of fished species above the size retained in fish traps changed little between 1994 and 2005, indicating no current effect on fishery yields. Biomass remained higher in MPAs, indicating they were effective in protecting fish stocks. Nevertheless, the size structure of the fish communities, as described with size-spectra analysis, changed in both fished areas and MPAs, with a decline in smaller fish (<30 cm) and an increase in larger fish (>45 cm). We believe this represents a time-lag response to a reduction in reef structural complexity brought about because fishes are being lost through natural mortality and fishing, and are not being replaced by juveniles. This effect is expected to be greater in terms of fisheries productivity and, because congruent patterns are observed for herbivores, suggests that MPAs do not offer coral reefs long-term resilience to bleaching events. Corallivores and planktivores declined strikingly in abundance, particularly in MPAs, and this decline was associated with a similar pattern of decline in their preferred corals. We suggest that climate-mediated disturbances, such as coral bleaching, be at the fore of conservation planning for coral reefs.

Tsounis, G., Rossi, S., Gili, J.M., and Arntz, W. **Red coral fishery at the Costa Brava (NW Mediterranean): Case study of an overharvested precious coral.** *Ecosystems* 10(6): 975-986, 2007.

Notes: The Mediterranean red coral (*Corallium rubrum*, L. 1758) is a slow-growing longevous gorgonian that produces a red calcium carbonate skeleton, which is in high demand by the jewellery industry. Its long history of intensive commercial harvesting has resulted in a well-documented decline of its stocks throughout the Mediterranean, becoming especially apparent during the last two decades. Based on the extensive ecological data from the Costa Brava (NE Spain) stocks, this study reviews, for the first time, socioeconomic aspects and the impact of current fishing practices on the red coral population structure and reproductive biology. A comparison of the intensively harvested populations in shallow water with that of the infrequently harvested ones in deep water, along with a population in a marine reserve as well, reveals that 98% of all shallow water colonies show a juvenile size and branching pattern as a result of harvesting. Recent data on the reproductive biology of the species show that 91% of the colonies in shallow water populations (<60 m depth) are not 100% sexually mature. These populations are clearly at the limit of their recoverability potential. The maximum sustainable yield (estimated using the Beverton-Holt model) is reached at an age of first capture of 98 years, although the current regulations allow harvesting of approximately 11-year-old colonies (corresponding to a basal diameter of 7 mm). The presented data reveal how this renewable resource is being exploited in a clearly non-sustainable and inefficient way, changing significantly the underwater landscape of the Mediterranean coast. The review of all available data suggests that the shallow water stocks are depleted. Furthermore, recent trends in poaching of juvenile colonies and mass mortality events threaten the survival of the shallow water populations. A ban on reconstituted coral from the market appears to be the only option to control this form of poaching.

McClanahan, T.R., Ateweberhan, M., Muhando, C.A., Maina, J., and Mohammed, M.S. **Effects of climate and seawater temperature variation on coral bleaching and mortality.** *Ecological Monographs* 77(4): 503-525, 2007.

Notes: Coral bleaching due to thermal and environmental stress threatens coral reefs and possibly people who rely on their resources. Here we explore patterns of coral bleaching and mortality in East Africa in 1998 and 2005 in a region where the equatorial current and the island effect of Madagascar interact to create different thermal and physicochemical environments. A variety of temperature statistics were calculated, and their relationships with the degree-heating months (DHM), a good predictor of coral bleaching, determined. Changes in coral cover were analyzed from 29 sites that span >1000 km of coastline from Kenya to the Comoros Islands. Temperature patterns are influenced by the island effect, and there are three main temperature environments based on the rise in temperature over 52 years, measures of temperature variation, and DHM. Offshore sites north of Madagascar that included the Comoros had low temperature rises, low DHM, high standard deviations (SD), and the lowest relative coral mortality. Coastal sites in Kenya had moderate temperature rises, the lowest temperature SD, high DHM, and the highest relative coral mortality. Coastal sites in the south had the highest temperature rises, moderate SD and DHM, and low relative coral mortality. Consequently, the rate of temperature rise was less important than background variation, as reflected by SD and kurtosis measures of sea surface water temperature (SST), in predicting coral survival across 1998. Coral bleaching responses to a warm-water anomaly in 2005 were also negatively related to temperature variation, but positively correlated with the speed of water flow. Separating these effects is difficult; however, both factors will be associated with current environments on the opposite sides of reefs and islands. Reefs in current shadows may represent refugia where corals acclimate and adapt to environmental variation, which better prepares them for rising temperature and anomalies, even though these sites are likely to experience the fastest rates of temperature rise. We suggest that these sites are a conservation

priority and should be targeted for management and further ecological research in order to understand acclimation, adaptation, and resilience to climate change.

Hoegh-Guldberg, O., Mumby, P.J., Hooten, A.J., Steneck, R.S., Greenfield, P., Gomez, E., Harvell, C.D., Sale, P.F., Edwards, A.J., Caldeira, K., Knowlton, N., Eakin, C.M., Iglesias-Prieto, R., Muthiga, N., Bradbury, R.H., Dubi, A., and Hatziolos, M.E. **Coral reefs under rapid climate change and ocean acidification.** *Science* 318(5857): 1737-1742, 2007.

Notes: Atmospheric carbon dioxide concentration is expected to exceed 500 parts per million and global temperatures to rise by at least 2°C by 2050 to 2100, values that significantly exceed those of at least the past 420,000 years during which most extant marine organisms evolved. Under conditions expected in the 21st century, global warming and ocean acidification will compromise carbonate accretion, with corals becoming increasingly rare on reef systems. The result will be less diverse reef communities and carbonate reef structures that fail to be maintained. Climate change also exacerbates local stresses from declining water quality and overexploitation of key species, driving reefs increasingly toward the tipping point for functional collapse. This review presents future scenarios for coral reefs that predict increasingly serious consequences for reef-associated fisheries, tourism, coastal protection, and people. As the International Year of the Reef 2008 begins, scaled-up management intervention and decisive action on global emissions are required if the loss of coral-dominated ecosystems is to be avoided.

Kleypas, J.A., Danabasoglu, G., and Lough, J.M. **Potential role of the ocean thermostat in determining regional differences in coral reef bleaching events.** *Geophysical Research Letters* 35(3): art. L03613, 2008.

Notes: Several negative feedback mechanisms have been proposed by others to explain the stability of maximum sea surface temperature (SST) in the western Pacific warm pool (WPWP). If these "ocean thermostat" mechanisms effectively suppress warming in the future, then coral reefs in this region should be less exposed to conditions that favor coral reef bleaching. In this study we look for regional differences in reef exposure and sensitivity to increasing SSTs by comparing reported coral reef bleaching events with observed and modeled SSTs of the last fifty years. Coral reefs within or near the WPWP have had fewer reported bleaching events relative to reefs in other regions. Analysis of SST data indicate that the warmest parts of the WPWP have warmed less than elsewhere in the tropical oceans, which supports the existence of thermostat mechanisms that act to depress warming beyond certain temperature thresholds.

Burkepile, D.E. and Hay, M.E. **Predator release of the gastropod *Cyphoma gibbosum* increases predation on gorgonian corals.** *Oecologia* 154(1): 167-173, 2007.

Notes: When large, predatory fishes and invertebrates were excluded from areas of a coral reef in the Florida Keys, USA, densities of the normally rare gastropod *Cyphoma gibbosum*, a principal predator of gorgonian corals, increased 19-fold. Gorgonians in predator enclosures were grazed more frequently and extensively by *C. gibbosum* than were gorgonians in uncaged areas. In enclosures, 14% of all gorgonians showed recent predation by *C. gibbosum*, with 62% of the entire colony surface being removed from these attacked individuals. In areas where predators of *C. Gibbosum* were not excluded, only 5% of gorgonians exhibited recent damage, with only 26% of the colony surface being removed from these few damaged individuals. Thus, the increases in both frequency and extent of attack combined to produce an 8x increase in gorgonian damage following removal of large predators. These patterns suggest that predators typically suppress *C. Gibbosum* populations, that overfishing of these predators could release *C. Gibbosum* from top-down control, and that this release will allow increased damage to gorgonian corals.

Menza, C., Kendall, M., Rogers, C., and Miller, J. **A deep reef in deep trouble.** *Continental Shelf Research* 27(17): 2224-2230, 2007.

Notes: The well-documented degradation of shallower reefs which are often closer to land and more vulnerable to pollution, sewage and other human-related stressors has led to the suggestion that deeper, more remote offshore reefs could possibly serve as sources of coral and fish larvae to replenish the shallower reefs. Yet, the distribution, status, and ecological roles of

deep (>30 m) Caribbean reefs are not well known. In this report, an observation of a deep reef which has undergone a recent extensive loss of coral cover is presented. In stark contrast to the typical pattern of coral loss in shallow reefs, the deeper corals were most affected. This report is the first description of such a pattern of coral loss on a deep reef.

Pante, E., King, A., and Dustan, P. **Short-term decline of a Bahamian patch reef coral community: Rainbow Gardens Reef 1991-2004.** *Hydrobiologia* 596: 121-132, 2008.

Notes: Temporal changes in the stony coral assemblages of Rainbow Gardens Reef (Iguana Cay, Exumas, Bahamas), were revealed by comparing quantitative community descriptors recorded in 1991 and 2004. Mean percent live cover significantly dropped from 13% to 3% between 1991 and 2004 (-77%, $P < 0.01$). During that period, coral abundance (number of colonies) decreased from 295 to 240 (-18.6%, $P < 0.01$). The community was less rich, equally diverse, more even, and the spatial structure of the reef had become more homogeneous. Most large *Montastrea annularis*, *Agaricia agaricites*, *Porites porites*, and *Porites astreoides* colonies were absent in 2004. Colonies were also more prone to stress related to algal smothering, excess sediment, and endolithic boring. No disease was recorded on stony corals in 2004. Examination of *M. annularis* skeletons revealed intense bioerosion and a bright yellow skeletal band that corresponded to 1998-1999. Reefs worldwide suffered an unprecedented period of coral bleaching during the 1998 El Nino event, which is likely to have played a role in the decline of Rainbow Gardens. Evidence suggests that the synergistic actions of bleaching, bioerosion, and storm action reduced Rainbow's formerly discrete coral patches to rubble. These results attest to the state of crisis of Caribbean coral reefs: even shallow, and presumably eurythermic communities in remote localities can be sensitive to change. Other patch reefs in the vicinity of Rainbow Gardens do not seem as degraded suggesting that local, small-scale differences may be important components of reef resilience.

Kuffner, I.B., Andersson, A.J., Jokiel, P.L., Rodgers, K.S., and Mackenzie, F.T. **Decreased abundance of crustose coralline algae due to ocean acidification.** *Nature Geoscience* 1(2): 114-117, 2008.

Notes: Owing to anthropogenic emissions, atmospheric concentrations of carbon dioxide could almost double between 2006 and 2100 according to business-as-usual carbon dioxide emission scenarios. Because the ocean absorbs carbon dioxide from the atmosphere, increasing atmospheric carbon dioxide concentrations will lead to increasing dissolved inorganic carbon and carbon dioxide in surface ocean waters, and hence acidification and lower carbonate saturation states. As a consequence, it has been suggested that marine calcifying organisms, for example corals, coralline algae, molluscs and foraminifera, will have difficulties producing their skeletons and shells at current rates, with potentially severe implications for marine ecosystems, including coral reefs. Here we report a seven-week experiment exploring the effects of ocean acidification on crustose coralline algae, a cosmopolitan group of calcifying algae that is ecologically important in most shallowwater habitats. Six outdoor mesocosms were continuously supplied with sea water from the adjacent reef and manipulated to simulate conditions of either ambient or elevated seawater carbon dioxide concentrations. The recruitment rate and growth of crustose coralline algae were severely inhibited in the elevated carbon dioxide mesocosms. Our findings suggest that ocean acidification due to human activities could cause significant change to benthic community structure in shallow-warm-water carbonate ecosystems.

Mora, C. **A clear human footprint in the coral reefs of the Caribbean.** *Proceedings of the Royal Society of London [B]* 275(1636): 767-773, 2008.

Notes: The recent degradation of coral reefs worldwide is increasingly well documented, yet the underlying causes remain debated. In this study, we used a large-scale database on the status of coral reef communities in the Caribbean and analysed it in combination with a comprehensive set of socioeconomic and environmental databases to decouple confounding factors and identify the drivers of change in coral reef communities. Our results indicated that human activities related to agricultural land use, coastal development, overfishing and climate change had created independent and overwhelming responses in fishes, corals and macroalgae. While the effective implementation of marine protected areas (MPAs) increased the biomass of fish populations, coral reef builders and macroalgae followed patterns of change independent of MPAs. However, we also found significant ecological links among all these groups of organisms suggesting that the long-term stability of coral reefs as a whole requires a holistic and regional approach to the control of human-related stressors in addition to the improvement and establishment of new MPAs.

Ainsworth, T., Fine, M., Roff, G., and Hoegh-Guldberg, O. **Bacteria are not the primary cause of bleaching in the Mediterranean coral *Oculina patagonica*.** *ISME Journal* 2(1): 67-73, 2008. O/A

Notes: Coral bleaching occurs when the endosymbiosis between corals and their symbionts disintegrates during stress. Mass coral bleaching events have increased over the past 20 years and are directly correlated with periods of warm sea temperatures. However, some hypotheses have suggested that reef-building corals bleach due to infection by bacterial pathogens. The 'Bacterial Bleaching' hypothesis is based on laboratory studies of the Mediterranean invading coral, *Oculina patagonica*, and has further generated conclusions such as the coral probiotic hypothesis and coral hologenome theory of evolution. We aimed to investigate the natural microbial ecology of *O. patagonica* during the annual bleaching using fluorescence in situ hybridization to map bacterial populations within the coral tissue layers, and found that the coral bleaches on the temperate rocky reefs of the Israeli coastline without the presence of *Vibrio shiloi* or bacterial penetration of its tissue layers. Bacterial communities were found associated with the endolithic layer of bleached coral regions, and a community dominance shift from an apparent cyanobacterial-dominated endolithic layer to an algal-dominated layer was found in bleached coral samples. While bacterial communities certainly play important roles in coral stasis and health, we suggest environmental stressors, such as those documented with reef-building corals, are the primary triggers leading to bleaching of *O. patagonica* and suggest that bacterial involvement in patterns of bleaching is that of opportunistic colonization.

Day, T., Nagel, L., van Oppen, M.J.H., and Caley, M.J. **Factors affecting the evolution of bleaching resistance in corals.** *American Naturalist* 171(2): E72-E88, 2008.

Notes: We present a mathematical model of coevolutionary interactions between partners in a coral-algae mutualistic symbiosis. Our goal is to better understand factors affecting the potential evolution of bleaching resistance in corals in response to increased average sea temperatures. We explore the evolutionary consequences of four factors: (i) trade-offs among fitness components, (ii) different proximate mechanisms of coral bleaching, (iii) the genetic determination of bleaching resistance, and (iv) the mode of sexual reproduction. We show that traits in mutualistic symbioses, such as thermal tolerance in corals, are potentially subject to novel kinds of evolutionary constraints and that these constraints are mediated by ecological dynamics. We also show that some proximate mechanisms of bleaching yield faster evolutionary responses to temperature stress and that the nature of interspecific control of bleaching resistance and the mode of sexual reproduction interact to strongly influence the rate of spread of resistance alleles. These qualitative theoretical results highlight important future directions for empirical research in order to quantify the potential for coral reefs to evolve resistance to thermal stress.

Cairns, S.D. **Deep-water corals: An overview with special reference to diversity and distribution of deep-water Scleractinian corals.** *Bulletin of Marine Science* 81(3): 311-322, 2007.

Notes: The polyphyletic term *coral* is defined as those Cnidaria having continuous or discontinuous calcium carbonate or horn-like skeletal elements. So defined, the group consists of seven taxa (Scleractinia, Antipatharia, Octocorallia, Stylasteridae, and Milleporidae, two zoanthids, and three calcified hydractiniids) constituting about 5080 species, 66% of which occur in water deeper than 50 m, i.e., deep water as defined in this paper. Although the number of newly described species of deep-water scleractinian corals appears to be increasing at an exponential rate, it is suggested that this rate will plateau in the near future. The majority of azooxanthellate Scleractinia is solitary in form, firmly attached to a substrate, most abundant at 200-1000 m, and consist of caryophylliids. Literature helpful for the identification of deep-water Scleractinia is listed according to 16 geographic regions of the world. A species diversity contour map is presented for the azooxanthellate scleractinian species, showing centers of high diversity in the Philippine region, the western Atlantic Antilles, and the northwest Indian Ocean, and is remarkably similar to high diversity regions for shallow-water zooxanthellate Scleractinia. As suggested for shallow-water corals, the cause for the high diversity of deep-water scleractinian diversity is thought to be the result of the availability of large contiguous stable substrate, in the case of deep-water corals at depths of 200-1000 m (the area effect), whereas regions of low biodiversity appear to be correlated with a shallow depth of the aragonite saturation horizon.

Reed, J.K., Koenig, C.C., and Shepard, A.N. **Impacts of bottom trawling on a deep-water *Oculina* coral ecosystem off Florida.** *Bulletin of Marine Science* 81(3): 481-496, 2007.

Notes: In 1984, a portion of the deep-water *Oculina* coral reef ecosystem off eastern Florida was protected as the *Oculina* Habitat Area of Particular Concern (OHAPC), prohibiting bottom trawls, longlines, dredges, and anchors. Unfortunately, the northern two thirds of the reef system remained open to these gear until 2000 when the OHAPC boundaries were expanded to 1029 km². In the 1970s, the *Oculina* reefs were teeming with large spawning aggregations of grouper and snapper. By the early 1990s, commercial and recreational fishing had decimated the fish populations, and the coral had been severely impacted by bottom trawling for rock shrimp. Historical photographic transects, taken in the 1970s with the JOHNSON-SEA-LINK submersibles, provide crucial evidence of the status and health of the reefs prior to heavy fishing and trawling activities. Quantitative analyses of photographic images by point count reveal drastic loss of live coral cover between 1975 and 2001. Six coral reef sites had nearly 100% loss of live coral, whereas only two reefs which were within the boundaries of the original OHAPC since 1984 survived and were not impacted by trawling. Management and conservation plans for deep-sea coral reef ecosystems worldwide must be based on sound scientific understanding as well as adequate surveillance and enforcement; this study will help build a foundation for this understanding.

Lipp, E.K., Futch, I.C., and Griffin, D.W. **Analysis of multiple enteric viral targets as sewage markers in coral reefs.** *Marine Pollution Bulletin* 54(12): 1897-1902, 2007.

Notes: Water and coral mucus samples were collected from throughout the Florida Keys National Marine Sanctuary and the Dry Tortugas for three years and were analyzed for human enteric viruses (enteroviruses, noroviruses, hepatitis A virus and adenoviruses) as conservative markers of human sewage using molecular methods. Of the 100 coral and water samples collected, 40 contained genetic material from one or more human enteric viruses. DNA-based adenoviruses were detected widely, in 37.8% of samples and at 91% of stations, including 'pristine' reefs in the Dry Tortugas; however, the detection rate was $\leq 12\%$ for, the RNA-based enteroviruses and noroviruses (hepatitis A virus was never detected). The disparity between the prevalence of RNA- and DNA-based viruses suggests the need for additional work to determine the utility of adenovirus as marker of human sewage.

Manzello, D.P., Berkelmans, R., and Hendee, J.C. **Coral bleaching indices and thresholds for the Florida Reef Tract, Bahamas, and St. Croix, US Virgin Islands.** *Marine Pollution Bulletin* 54(12): 1923-1931, 2007.

Notes: It is well established that elevated sea temperatures cause widespread coral bleaching, yet confusion lingers as to what facet of extreme temperatures is most important. Utilizing long-term in situ datasets, we calculated nine thermal stress indices and tested their effectiveness at segregating bleaching years a posteriori for multiple reefs on the Florida Reef Tract. The indices examined represent three aspects of thermal stress: (1) short-term, acute temperature stress; (2) cumulative temperature stress; and (3) temperature variability. Maximum monthly sea surface temperature (SST) and the number of days $>30.5^{\circ}\text{C}$ were the most significant; indicating that cumulative exposure to temperature extremes characterized bleaching years. Bleaching thresholds were warmer for Florida than the Bahamas and St. Croix, US Virgin Islands reflecting differences in seasonal maximum SST. Hind-casts showed that monthly mean SST above a local threshold explained all bleaching years in Florida, the Bahamas, and US Virgin Islands.

Bruno, J.F and Selig, E.R. **Regional decline of coral cover in the Indo-Pacific: Timing, extent, and subregional comparisons.** *PLoS ONE* 2(8): art. e711, 2007. [O/A](#)

Notes: *Background.* A number of factors have recently caused mass coral mortality events in all of the world's tropical oceans. However, little is known about the timing, rate or spatial variability of the loss of reef-building corals, especially in the Indo-Pacific, which contains 75% of the world's coral reefs. *Methodology/Principle Findings.* We compiled and analyzed a coral cover database of 6001 quantitative surveys of 2667 Indo-Pacific coral reefs performed between 1968 and 2004. Surveys conducted during 2003 indicated that coral cover averaged only 22.1% (95% CI: 20.7, 23.4) and just 7 of 390 reefs surveyed that year had coral cover $>60\%$. Estimated yearly coral cover loss based on annually pooled survey data was approximately 1% over the last twenty years and 2% between 1997 and 2003 (or 3,168 km² per year). The annual loss based on repeated measures regression

analysis of a subset of reefs that were monitored for multiple years from 1997 to 2004 was 0.72 % ($n = 476$ reefs, 95% CI: 0.36, 1.08). *Conclusions/Significance.* The rate and extent of coral loss in the Indo-Pacific are greater than expected. Coral cover was also surprisingly uniform among subregions and declined decades earlier than previously assumed, even on some of the Pacific's most intensely managed reefs. These results have significant implications for policy makers and resource managers as they search for successful models to reverse coral loss.

Sandin, S.A. *et al.* **Baselines and degradation of coral reefs in the northern Line Islands.** *PLoS ONE* 3(2): art. e1548, 2008. [O/A](#)

Notes: Effective conservation requires rigorous baselines of pristine conditions to assess the impacts of human activities and to evaluate the efficacy of management. Most coral reefs are moderately to severely degraded by local human activities such as fishing and pollution as well as global change, hence it is difficult to separate local from global effects. To this end, we surveyed coral reefs on uninhabited atolls in the northern Line Islands to provide a baseline of reef community structure, and on increasingly populated atolls to document changes associated with human activities. We found that top predators and reef-building organisms dominated unpopulated Kingman and Palmyra, while small planktivorous fishes and fleshy algae dominated the populated atolls of Tabuaeran and Kiritimati. Sharks and other top predators overwhelmed the fish assemblages on Kingman and Palmyra so that the biomass pyramid was inverted (top-heavy). In contrast, the biomass pyramid at Tabuaeran and Kiritimati exhibited the typical bottom-heavy pattern. Reefs without people exhibited less coral disease and greater coral recruitment relative to more inhabited reefs. Thus, protection from overfishing and pollution appears to increase the resilience of reef ecosystems to the effects of global warming.

Edmunds, P.J. **Evidence for a decadal-scale decline in the growth rates of juvenile scleractinian corals.** *Marine Ecology Progress Series* 341: 1-13, 2007.

Notes: Juvenile life stages play critical roles in the population dynamics of virtually all organisms, and therefore precise estimates of juvenile growth and survival are important for accurate demographic analyses. For tropical reef corals, the contribution of juveniles to population dynamics is strongly determined by their growth rates, which are inversely proportional to the duration of this life stage and the risks of mortality, yet empirical estimates of this important trait are surprisingly rare. Based largely on results published before 1990, it is often assumed that juvenile corals ≤ 50 mm diameter grow ~ 10 to 34 mm yr^{-1} , and therefore are ~ 1.5 to 5.0 yr old. In contrast, results presented here show that juvenile corals (≤ 40 mm diameter) in St. John, US Virgin Islands, have grown at much slower rates on shallow reefs (< 9 m depth) where annual censuses have been completed for 9 yr (1996 to 2005). For nearly a decade, juvenile corals in this location have maintained overall mean growth rates of only 3 mm yr^{-1} , or 6 mm yr^{-1} for the subset of colonies that grew ≥ 0 mm yr^{-1} . Therefore, most of these juvenile corals have grown at rates consistent with an upper age estimate of 7 to 13 yr, which is 1.4 to 8.7 times older than estimates derived from often-cited growth rates. This discrepancy has important implications, because it suggests that the recruitment dynamics of coral populations may function over time scales longer than are usually considered. Conceivably, these time scales may now extend over lengthier periods than once was the case, at least as can be determined from sparse results distributed through > 32 yr of peer-reviewed studies that reveal a gradual decline in the growth rates of juvenile corals. The correspondence of this decline with rising seawater temperature and depressed aragonite saturation state raises the possibility that the effects of global climate change have already reduced the growth of juvenile corals.

Cantin, N.E., Negri, A.P., and Willis, B.L. **Photoinhibition from chronic herbicide exposure reduces reproductive output of reef-building corals.** *Marine Ecology Progress Series* 344: 81-93, 2007.

Notes: The photosystem II (PSII) herbicide diuron is commonly used within catchments that drain into the Great Barrier Reef lagoon, where it potentially reduces photosynthesis in *Symbiodinium*, the dinoflagellate symbiont associated with reef corals. Here we examine the importance of energy (carbohydrates) derived from photosynthesis to the gametogenesis of corals following long-term, experimental exposures to diuron. Two broadcast spawning corals, *Acropora tenuis* and *A. valida*, and a brooding coral, *Pocillopora damicornis*, were exposed to 0 (controls), 1.0 (low) and 10 (moderate) $\mu\text{g l}^{-1}$ diuron treatments for 2 to 3 mo prior to spawning or planulation. Diuron caused photoinhibition in each species, with pulse amplitude modulation (PAM) fluorometry recording consistent declines in effective quantum yields of 20% at $1.0 \mu\text{g l}^{-1}$ and 75 % at $10 \mu\text{g l}^{-1}$

diuron compared to control corals. *A. valida* and *P. damicornis* were both sensitive to chronic diuron-induced photoinhibition, becoming severely bleached (loss of *Symbiodinium* spp. and/or reductions in light-harvesting pigments), especially at 10 $\mu\text{g l}^{-1}$ diuron. At this moderate concentration, *A. valida* sustained both partial and full colony mortality. *A. tenuis* was more resistant to these concentrations of diuron, and neither bleached nor sustained partial mortality in any of the treatments. We found 2.5- to 5-fold reductions in total lipid content (coral tissue, oocytes and planulae) for the 3 species in the presence of diuron, indicating significant use of storage lipid to meet nutritional demands under conditions of chronic photoinhibition. Polyp fecundity was reduced by 6-fold in *A. valida* and both *A. valida* and *R. damicornis* were unable to spawn or planulate following long-term exposures to 10 $\mu\text{g l}^{-1}$ diuron. This is the first study to investigate the sub-lethal effects of chronic herbicide-induced photoinhibition on symbiotic corals and provides evidence of a link between reduced energy acquisition due to PSII photoinhibition and reduced reproductive output in zooxanthellate corals.

Rocha, L.A., Craig, M.T., and Bowen, B.W. **Phylogeography and the conservation of coral reef fishes.** *Coral Reefs* 26(3): 501-512, 2007.

Notes: Here we present a review of how the study of the geographic distribution of genetic lineages (phylogeography) has helped identify management units, evolutionary significant units, cryptic species, and areas of endemism, and how this information can help efforts to achieve effective conservation of coral reefs. These studies have confirmed the major biogeographic barriers that were originally identified by tropical species distributions. Ancient separations, identified primarily with mtDNA sequence comparisons, became apparent between populations on each side of the barriers. The general lack of correlation between pelagic larval duration and genetic connectivity across barriers indicates that life history and ecology can be as influential as oceanography and geography in shaping evolutionary partitions within ocean basins. Hence, conservation strategies require a recognition of ecological hotspots, those areas where habitat heterogeneity promotes speciation, in addition to more traditional approaches based on biogeography. Finally, the emerging field of genomics will add a new dimension to phylogeography, allowing the study of genes that are pertinent to recent and ongoing differentiation, and ultimately providing higher resolution to detect evolutionary significant units that have diverged in an ecological time scale.

Negri, A.P., Marshall, P.A., and Heyward, A.J. **Differing effects of thermal stress on coral fertilization and early embryogenesis in four Indo Pacific species.** *Coral Reefs* 26(4): 759-763, 2007.

Notes: Coral reefs are expected to be severely impacted by rising seawater temperatures associated with climate change. The fertilization and early embryogenesis of four reef-building coral species representing three Indo-Pacific families were examined in a series of laboratory experiments where temperatures were increased up to 5-6°C at ambient. High levels of fertilization and normal embryogenesis were observed for *Favites abdita*, *Favites chinensis* and *Mycedium elephantotus* at temperatures to 32°C (+5°C) and embryos developed normally until the 5th cell cleavage. *Acropora millepora* was the only species to be affected by higher temperatures, exhibiting significantly reduced fertilization and a higher frequency of embryonic abnormalities at 32°C (+4°C), and fertilization ceased altogether at 34°C (+6°C). Early cell cleavage rates increased with temperature up to 32°C for all species.

Macintyre, I.G., Glynn, P.W., and Toscano, M.A. **The demise of a major *Acropora palmata* bank-barrier reef off the southeast coast of Barbados, West Indies.** *Coral Reefs* 26(4): 765-773, 2007.

Notes: Formerly attributed to human activity, the demise of a bank-barrier reef off southeastern Barbados known as Cobbler's Reef is now thought to be largely the result of late Holocene, millennial-scale storm damage. Eleven surface samples of the reef crest coral *Acropora palmata* from nine sites along its 15-km length plot above the western Atlantic sea-level curve from 3,000 to 4,500 cal years ago (calibrated, calendar ¹⁴C years). These elevated clusters suggest that the reef complex suffered extensive storm damage during this period. The constant heavy wave action typical of this area and consequent low herbivory maintain conditions favoring algal growth, thereby limiting the reestablishment of post-storm reef framework. Site descriptions and detailed line surveys show a surface now composed mainly of reworked fragments of *A. palmata* covered with algal turf, macroalgae and crustose coralline algae. The reef contains no live *A. palmata* and only a few scattered coral colonies consisting primarily of *Diploria* spp. and *Porites astreoides*, along with the hydrocoral *Millepora complanata*. A few in situ framework dates plot at expected depths for normal coral growth below the sea-level curve during and after the period of intense storm activity. The

most recent of these in situ samples are 320 and 400 cal years old. Corals of this late period likely succumbed to high turbidity associated with land clearance for sugarcane agriculture in the mid-1600s.

Done, T., Turak, E., Wakeford, M., DeVantier, L., McDonald, A., and Fisk, D. **Decadal changes in turbid-water coral communities at Pandora Reef: loss of resilience or too soon to tell?** *Coral Reefs* 26(4): 789-805, 2007.

Notes: Coral communities were monitored at Pandora Reef, nearshore Great Barrier Reef from 1981 to 2005 using photography and videography. In the 1980s, regional elevation of land-based nutrients in coastal waters (ca. 2-6 times pre-European levels of early 1800s) did not prevent overall recovery of coral cover and diversity following a sequence of environmental disturbances in the 1970s. However, prospects for a repeat of such resilience following catastrophic mortality from high-temperature bleaching in 1998 and a cyclone in 2000 are not clear. Different coral communities around the reef varied greatly in relation to impacts and recovery. Fore-reef communities dominated by acroporids (fast growing branching and tabular *Acropora* and foliose *Montipora*) recovered strongly in the 1980s following apparently severe impacts by cyclone, flood and heat wave disturbances in the 1970s, attaining 60-90% cover by stabilizing rubble and outgrowing macro-algae in <10 years. In the back-reef, by contrast, poritid-dominated communities (massive and finger *Porites* and columnar *Goniopora* and *Alveopora*) had more stable trajectories and smaller impact from recent disturbances: recovery was well underway in 2005. The contrasting trajectories of different parts of the reef reflect differential survival of more persistent versus more ephemeral taxa, notably poritids and acroporids, respectively, both major contributors to framework and cover on reefs globally. A repeat of earlier resilience appears possible in the shallow fore-reef, but unlikely in the deeper fore-reef, which had few viable fragments or recruits in 2005. The main limits on recovery may be (1) reduced supply of coral larvae due to widespread regional losses of coral brood stock and (2) the reduced intervals between disturbances associated with global climate change. The presence of a high abundance of Acroporidae is a major pre-disposing risk factor for climate change impacts.

Fitzpatrick, S.M. and Donaldson, T.J. **Anthropogenic impacts to coral reefs in Palau, western Micronesia during the Late Holocene.** *Coral Reefs* 26(4): 915-930, 2007.

Notes: The Palauan archipelago contains one of the most ecologically diverse coral reef systems in the Indo-Pacific that was as attractive for humans prehistorically as it is today. New evidence is emerging that during the past few thousand years there has been increasing exploitation of coral reef resources, particularly finfish and mollusks, leading to a decline in taxa numbers, richness, and diversity in various locales. This paper examines the historical interactions between human populations and coral reef ecologies in Palau by combining known archaeological data and results from modern biological data of different reef fauna. The integration of these data sources provides a framework for attempting to explain variations in taxa composition between islands in the archipelago and how this may relate to human exploitation or other phenomena through time. By using this perspective to link past events with present-day conditions, we can gain a better sense of the extent to which anthropogenic changes may have affected island environments in western Micronesia during the Late Holocene. The study also illustrates the many difficulties researchers face in attempting to synthesize and explain past and present human predation behavior when using disparate sources of data.

Smith, L.D., Gilmour, J.P., and Heyward, A.J. **Resilience of coral communities on an isolated system of reefs following catastrophic mass-bleaching.** *Coral Reefs* 27(1): 197-205, 2008.

Notes: As a result of climate change, sea-water temperatures around the world are expected to increase, potentially causing more frequent and severe episodes of coral bleaching. In this study, the impact of elevated water temperatures at an isolated system of reefs was assessed by quantifying the changes in benthic communities over almost 10 years. Mass-coral bleaching in 1998 dramatically altered the community structure of the reefs, including a >80% relative decrease in the cover of hard and soft corals and a twofold increase in the cover of algae, but which did not include macroalgae. The magnitude of the impact varied among the different sites according to their initial cover and community structure, largely due to the differing susceptibilities of the dominant groups of hard corals. Subsequent increase in the cover of these groups varied according to their life history traits, such as modes of reproduction and rates of growth. Additionally, the increase in cover was strongly correlated with the magnitude of the impact at the different sites, suggesting that recovery was driven by processes acting over local scales. Six years after the bleaching, the hard corals had returned to approximately 40% of their pre-bleaching cover, but

there was little change in the cover of soft corals, and the structure of most hard coral communities remained very different to that prior to the bleaching. These data provides insights into the degree to which coral communities are resilient to catastrophic disturbances, when they are isolated from other reef systems but not exposed to some of the chronic stressors affecting many reefs around the world.
