Marine Science Review – 177

Coral and coral reefs

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In this review:

A. Recent articles – no abstract available

Culter, J.K., Ritchie, K.B., Earle, S.A., Guggenheim, D.E., Halley, R.B., Ciembronowicz, K.T., Hine, A.C., Jarrett, B.D., Locker, S.D., and Jaap, W.C. **Pulley reef: a deep photosynthetic coral reef on the West Florida Shelf, USA.** *Coral Reefs* 25(2): 228, 2006.

Kahng, S.E. and Maragos, J.E. **The deepest, zooxanthellate scleractinian corals in the world?** *Coral Reefs* 25(2): 254, 2006.

B. Recent articles with abstracts

Graham, N.A.J., Wilson, S.K., Jennings, S., Polunin, N.V.C., Bijoux, J.P., and Robinson, J. **Dynamic fragility of oceanic coral reef ecosystems.** *Proceedings of the National Academy of Sciences [USA]* 103(22): 8425-8429, 2006.

Notes: As one of the most diverse and productive ecosystems known, and one of the first ecosystems to exhibit major climate-warming impacts (coral bleaching), coral reefs have drawn much scientific attention to what may prove to be their Achilles heel, the thermal sensitivity of reef-building corals. Here we show that climate change-driven loss of live coral, and ultimately structural complexity, in the Seychelles results in local extinctions, substantial reductions in species richness, reduced taxonomic distinctness, and a loss of species within key functional groups of reef fish. The importance of deteriorating physical structure to these patterns demonstrates the longer-term impacts of bleaching on reefs and raises questions over the potential for recovery. We suggest that isolated reef systems may be more susceptible to climate change, despite escaping many of the stressors impacting continental reefs.

Roberts, J.M., Wheeler, A.J., and Freiwald, A. **Reefs of the deep: The biology and geology of cold-water coral ecosystems.** *Science* 312(5773): 543-547, 2006.

Notes: Coral reefs are generally associated with shallow tropical seas; however, recent deep-ocean exploration using advanced acoustics and submersibles has revealed unexpectedly widespread and diverse coral ecosystems in deep waters on continental shelves, slopes, seamounts, and ridge systems around the world. Advances reviewed here include the use of corals as paleoclimatic archives and their biogeological functioning, biodiversity, and biogeography. Threats to these fragile, long-lived, and rich ecosystems are mounting: The impacts of deep-water trawling are already widespread, and effects of ocean acidification are potentially devastating.

Grottoli, A.G., Rodrigues, L.J., and Palardy, J.E. **Heterotrophic plasticity and resilience in bleached corals.** *Nature* 440(7088): 1186-1189, 2006.

Notes: Mass coral bleaching events caused by elevated seawater temperatures have resulted in extensive coral mortality throughout the tropics over the past few decades. With continued global warming, bleaching events are predicted to increase in frequency and severity, causing up to 60% coral mortality globally within the next few decades. Although some corals are able to recover and to survive bleaching, the mechanisms underlying such resilience are poorly understood. Here we show that the coral host has a significant role in recovery and resilience. Bleached and recovering *Montipora capitata* (branching) corals met more than 100% of their daily metabolic energy requirements by markedly increasing their feeding rates and CHAR (per cent contribution of heterotrophically acquired carbon to daily animal respiration), whereas *Porites compressa* (branching) and *Porites lobata* (mounding) corals did not. These findings suggest that coral species with high-CHAR capability during bleaching and recovery, irrespective of morphology, will be more resilient to bleaching events over the long term, could become the dominant coral species on reefs, and may help to safeguard affected reefs from potential local and global extinction.

Ries, J.B., Stanley, S.M., and Hardie, L.A. **Scleractinian corals produce calcite, and grow more slowly, in artificial Cretaceous seawater.** *Geology* 34(7): 525-528, 2006.

Notes: The mineralogies of most biotic and abiotic carbonates have alternated in synchroneity between the calcite (hexagonal) and aragonite (orthorhombic) polymorphs of CaCO3 throughout the Phanerozoic Eon. These intervals of calcite and aragonite production, or calcite seas and aragonite seas, are thought to be caused primarily by secular variation in the molar magnesium/calcium ratio of seawater (*m*Mg/Ca > 2 = aragonite + high-Mg calcite; *m*Mg/Ca < 2 = low-Mg calcite), a ratio that has oscillated between 1.0 and 5.2 throughout the Phanerozoic. In laboratory experiments, we show that three species of scleractinian corals, which produce aragonite in modern seawater and which have flourished as important reef builders primarily during aragonite seas of the past, began producing calcite in artificial seawater with an ambient *m*Mg/Ca ratio below that of modern seawater (5.2). The corals produced progressively higher percentages of calcite and calcified at lower rates with further reduction of the ambient *m*Mg/Ca ratio. In artificial seawater of imputed Late Cretaceous composition (*m*Mg/Ca = 1.0), which favors the precipitation of the calcite polymorph, scleractinian corals produced skeletons containing >30% low-Mg calcite (skeletal *m*Mg/Ca < 0.04). These results indicate that the skeletal mineral used by scleractinian corals is partially determined by seawater chemistry. Furthermore, slow calcification rates, resulting from the production of largely aragonitic skeletons in chemically unfavorable seawater (*m*Mg/Ca < 2), probably contributed to the scleractinians' diminished reef-building role in the calcite seas of Late Cretaceous and early Cenozoic time.

Mumby, P.J. **The impact of exploiting grazers (Scaridae) on the dynamics of Caribbean coral reefs.** *Ecological Applications* 16(2): 747-769, 2006.

Notes: Coral reefs provide a number of ecosystem services including coastal defense from storms, the generation of building materials, and fisheries. It is increasingly clear that the management of reef resources requires an ecosystem approach in which extractive activities are weighed against the needs of the ecosystem and its functions rather than solely those of the fishery. Here, I use a spatially explicit simulation model of a Caribbean coral reef to examine the ecosystem requirements for grazing which is primarily conducted by parrotfishes (Scaridae). The model allows the impact of fishing grazers to be assessed in the wider context of other ecosystem processes including coral-algal competition, hurricanes, and mass extinction of the herbivorous urchin *Diadema antillarum*. Using a new analytical model of scarid grazing, it is estimated that parrotfishes can only maintain between 10% and 30% of a structurally complex forereef in a grazed state. Predictions from this grazing model were then incorporated into a broader simulation model of the ecosystem. Simulations predict that scarid grazing is unable to maintain high levels of coral cover (≥ 30%) when severe hurricanes occur on a decadal basis, such as occurs in parts of the northern Caribbean. However, reefs can withstand such intense disturbance when grazing is undertaken by both scarids and the urchin *Diadema*. Scarid grazing is predicted to allow recovery from hurricanes when their incidence falls to 20 years or less (e.g., most of Central and South America). Sensitivity analyses revealed that scarid grazing had the most acute impact on model behavior, and depletion led to the emergence of a stable, algal-dominated community state. Under conditions of heavy grazer depletion, coral cover was predicted to decline rapidly from an initial level of 30% to less than 1% within 40 years, even when hurricane frequency was low at 60 years. Depleted grazers caused a population bottleneck in juvenile corals in which algal overgrowth caused elevated levels of postsettlement mortality and resulted in a bimodal distribution of coral sizes. Several new hypotheses were generated including a region-wide change in the spatial heterogeneity of coral reefs following extinction of *Diadema*. The management of parrotfishes on Caribbean reefs is usually approached implicitly through no-take marine reserves. The model predicts that depletion of grazers in nonreserve areas can severely limit coral accretion. Other studies have shown that low coral accretion can reduce the structural complexity and therefore quality of the reef habitat for many

organisms. A speculative yet rational inference from the model is that failure to manage scarid populations outside reserves will have a profoundly negative impact on the functioning of the reserve system and status of non-reserve reefs.

Nystrom, M. **Redundancy and response diversity of functional groups: Implications for the resilience of coral reefs.** *Ambio* 35(1): 30-35, 2006.

Notes: To improve coral reef management, a deeper understanding of biodiversity across scales in the context of functional groups is required. The focus of this paper is on the role of diversity within functional groups in securing important ecosystem processes that contribute to the resilience of coral-dominated reef states. Two important components of species biodiversity that confer ecosystem resilience are analyzed: redundancy and the diversity of responses within functional groups to change. Three critical functional groups are used to illustrate the interaction between these two components and their role in coral reef resilience: zooxanthellae (symbiotic microalgae in reef-building corals), reef-building corals, and herbivores. The paper further examines the consequences of undermining functional redundancy and response diversity and addresses strategies to secure ecological processes that are critical for coral reef resilience.

Mumby, P.J., Hedley, J.D., Zychaluk, K., Harborne, A.R., and Blackwell, P.G. **Revisiting the catastrophic die-off of the urchin *Diadema antillarum* on Caribbean coral reefs: Fresh insights on resilience from a simulation model.** *Ecological Modelling* 196(1-2): 131-148, 2006.

Notes: In 1983, the dominant urchin of Caribbean coral reefs (*Diadema antillarum*) experienced massive disease-induced mortality and its functional extinction persists to this day. Concurrently, reports of coral disease, coral bleaching and nutrification began to appear and many Caribbean reefs have deteriorated in the last two decades. Here, we describe a spatial simulation model of physical and ecological processes occurring on a dominant Caribbean for reef habitat, often referred to as *Montastraea* reef. The model uses a square lattice to simulate the dynamics of two types of hard coral (a brooder and spawner), cropped algal substrata and macroalgae. Grazing occurs independently by *Diadema* and parrotfishes and influences the competitive interactions between corals and macroalgae. Four important types of disturbance are simulated: loss of the urchin *Diadema*, hurricanes, fishing of parrotfishes and nutrification. We use the model to revisit the impact of losing the keystone herbivore, *Diadema*. The urchin imparted great resilience to Caribbean reefs in the face of severe disturbances including: high hurricane frequencies (once per decade), overfishing of scarids and a range of nutrification levels, including a doubling of the vertical growth rate, vegetative growth rate and colonisation rate of macroalgae. Parrotfishes are able to compensate for the loss of this urchin under a limited range of physical and ecological conditions. When not exploited, parrotfishes allow coral to persist at least at equilibrial levels when hurricane frequencies drop to around once every 20 years (e.g. those found in Central America). However, coral cover declined under decadal hurricane frequencies which may partly explain observations in regions of intense hurricane activity such as Florida. Parrotfish grazing is sufficiently intense to mitigate nutrification impacts providing that the cover of corals is not heavily depleted by other processes such as hurricanes and disease. Indeed, the cover of living coral exhibits a strong interaction with both grazing and nutrification in determining the survival of coral recruits. Reefs of higher coral cover have greater resilience for a given level of nutrification or grazing and therefore management efforts that arrest declines in coral cover will build greater natural resilience in the system. The model provides a strong case for conserving parrotfishes because reef decline is predicted to be inevitable when urchins are scarce and fishing of grazers is intense (e.g. to the levels seen in Jamaica). Lastly, the model provides a new perspective on the bottom-up versus top-down debate of macroalgal blooms in Jamaica. Nutrification impacts are predicted to be most important when urchins are scarce and parrotfishes are relatively lightly exploited. Therefore, a full understanding of the impact of nutrification will only occur if no-take marine reserves permit scarid biomass to reach unexploited levels. Under these conditions, coral cover is only predicted to increase if nutrification levels are low.

Dizon, R.T. and Yap, H.T. **Understanding coral reefs as complex systems: degradation and prospects for recovery.** *Scientia Marina* 70(2): 219-226, 2006.

Notes: The present century is witness to unprecedented levels of coral reef degradation worldwide. Current understanding based on traditional ideas is unlikely to capture adequately the dynamics of phenomena accompanying this trend. In this regard, the ideas of complexity are reviewed. Some applications to coral reefs as complex systems have already been discussed

in the literature although further progress is warranted as the search for new and more effective management tools continues, and the direction towards more holistic, integrative and large scale approaches gains wider acceptance. We distinguish between the concepts of robustness and resilience in the face of disturbance, highlight the various mechanisms that foster these stability properties and provide some coral reef examples. We identify some of the driving forces behind succession that are critical for community assembly and possible reef recovery. Finally, we consider how self-organization arises out of apparently random and chaotic processes and interactions to exhibit certain regularities and patterns especially when moving up on the scale of space and/or time.

Cinner, J., Marnane, M.J., McClanahan, T.R., and Almany, G.R. **Periodic closures as adaptive coral reef management in the Indo-Pacific.** *Ecology and Society* 11(1): U244-U277, 2006.

Notes: This study explores the social, economic, and ecological context within which communities in Papua New Guinea and Indonesia use adaptive coral reef management. We tested whether periodic closures had positive effects on reef resources, and found that both the biomass and the average size of fishes commonly caught in Indo-Pacific subsistence fisheries were greater inside areas subject to periodic closures compared to sites with year-round open access. Surprisingly, both long-lived and short-lived species benefited from periodic closures. Our study sites were remote communities that shared many socioeconomic characteristics; these may be crucial to the effectiveness of adaptive management of reef resources through periodic closures. Some of these factors include exclusive tenure over marine resources, a body of traditional ecological knowledge that allows for the rapid assessment of resource conditions, social customs that facilitate compliance with closures, relatively small human populations, negligible migration, and a relatively low dependence on fisheries. This dynamic adaptive management system, in which communities manage their resources among multiple social and ecological baselines, contrasts with western fisheries management practices, centered on maintaining exploited populations at stable levels in which net production is maximized.

Rotjan, R.D. and Lewis, S.M. **Parrotfish abundance and selective corallivory on a Belizean coral reef.** *Journal of Experimental Marine Biology and Ecology* 335(2): 292-301, 2006.

Notes: Parrotfish are important members of coral reef communities because they consume macroalgae that would otherwise outcompete reef-building corals for space. However, some Caribbean parrotfish species also feed directly on live corals, and thus have the potential to negatively impact coral fitness and survival. This study investigates selective grazing by parrotfish on particular coral species, differences in grazing incidence among reef habitats and intraspecific discrimination among colonies of several coral species. We also investigate spatial and temporal patterns of parrotfish species abundance across habitats on the Belize barrier reef, and examine correlations between parrotfish abundance and grazing intensity across reef habitats. We found that members of the *Montastraea annularis* species complex, major builders of Caribbean reefs, were preferred targets of parrotfish grazing across all reef habitats, while *M. cavernosa*, *Agaricia agaricites*, *Diploria strigosa*, *Porites astreoides* and *Porites porites* were not preferred; *Siderastrea siderea* was preferentially grazed only in the spur and groove habitats. Parrotfish grazing preferences varied across habitats; *M. annularis* was grazed most often in shallow habitats, whereas *M. franksi* was consumed more at depth. Although it was not possible to directly observe parrotfish grazing on corals, we did find a positive correlation between *Sparisoma aurofrenatum* abundance and *M. franksi* grazing incidence across habitats. Finally, when we compared our results to parrotfish abundances measured by a previous study, we found that *Sparisoma viride* and *Sp. aurofrenatum*, two species known to be corallivorous, had increased abundances between 1982 and 2004. In light of escalating threats on Caribbean reef corals, it would be important for future studies to evaluate the impact of parrotfish corallivory on coral survival.

Weber, M., Lott, C., and Fabricius, K.E. **Sedimentation stress in a scleractinian coral exposed to terrestrial and marine sediments with contrasting physical, organic and geochemical properties.** *Journal of Experimental Marine Biology and Ecology* 336(1): 18-32, 2006.

Notes: Terrestrial runoff increases siltation and nutrient availability on coastal coral reefs worldwide. However the factors determining stress in corals when exposed to short-term sedimentation, including the interactions between sediments and nutrients, are little understood. We exposed corals to ten different sediment types at environmentally relevant concentrations (33 to 160 mg DW cm^2) and exposure times (12 to 60 h) in laboratory and field experiments. The sediments originated from 2

estuaries, 2 nearshore and one offshore locations and also included ground-up aragonite. For two of these sediments, three grain size fractions were used (silt < 63 mm, fine sand: 63- 250 mm, medium sand: 250-500 mm). Sediments were characterised by 19 parameters grouped into "physical", "organic and nutrient-related" and "geochemical" parameters. Changes in the photosynthetic yield of the coral *Montipora peltiformis* was measured by pulse-amplitude modulated chlorophyll fluorometry (PAM) as proxy for photophysiological stress from exposure, and to determine rates of recovery. Different sediments exerted greatly contrasting levels of stress in the corals. Our results show that grain size and organic and nutrient-related sediment properties are key factors determining sedimentation stress in corals after short-term exposure. Photophysiological stress was measurable after 36 h of exposure to most of the silt-sized sediments, and coral recovery was incomplete after 48 to 96 h recovery time. The four sandy sediment types caused no measurable stress at the same concentration for the same exposure time. Stress levels were strongly related to the values of organic and nutrient-related parameters in the sediment, weakly related to the physical parameters and unrelated to the geochemical parameters measured. *M. peltiformis* removed the sandy grain size classes more easily than the silt, and nutrient-poor sediments were removed more easily than nutrient-rich sediments. Anoxia developed on the sediment surfaces of the nutrient-rich silts, which had become slimy and smelled of hydrogen sulphide, suggesting increased bacterial activity. Our finding that silt-sized and nutrient-rich sediments can stress corals after short exposure, while sandy sediments or nutrient-poor silts affect corals to a lesser extent, will help refining predictions of sedimentation threats to coral reefs at given environmental conditions.

Franklin, D.J., Cedres, C.M.M., and Hoegh-Guldberg, O. **Increased mortality and photoinhibition in the symbiotic dinoflagellates of the Indo-Pacific coral *Stylophora pistillata* (Esper) after summer bleaching.** *Marine Biology* 149(3): 633-642, 2006.

Notes: Coral bleaching (the loss of symbiotic dinoflagellates from reef-building corals) is most frequently caused by high light and temperature conditions. We exposed the explants of the hermatypic coral *Stylophora pistillata* to four combinations of light and temperature in late spring and also in late summer. During mid-summer, two NOAA bleaching warnings were issued for Heron Island reef (Southern Great Barrier Reef, Australia) when sea temperature exceeded the NOAA bleaching threshold, and a 'mild' (in terms of the whole coral community) bleaching event occurred, resulting in widespread *S. pistillata* bleaching and mortality. Symbiotic dinoflagellate biomass decreased by more than half from late spring to late summer (from 2.5x10(6) to 0.8x10(6) dinoflagellates cm(2) coral tissue), and those dinoflagellates that remained after summer became photoinhibited more readily (dark-adapted F(V) : F(M) decreased to (0.3 compared with 0.4 in spring), and died in greater numbers (up to 17% dinoflagellate mortality compared with 5% in the spring) when exposed to artificially elevated light and temperature. Adding exogenous antioxidants (D-mannitol and L-ascorbic acid) to the water surrounding the coral had no clear effect on either photoinhibition or symbiont mortality. These data show that light and temperature stress cause mortality of the dinoflagellate symbionts within the coral, and that susceptibility to light and temperature stress is strongly related to coral condition. Photoinhibitory mechanisms are clearly involved, and will increase through a positive feedback mechanism: symbiont loss promotes further symbiont loss as the light microenvironment becomes progressively harsher.

Tsounis, G., Rossi, S., Gili, J.M., and Arntz, W. **Population structure of an exploited benthic cnidarian: the case study of red coral (*Corallium rubrum* L.).** *Marine Biology* 149(5): 1059-1070, 2006.

Notes: Octocorals are an important part of many ecosystems as they add three-dimensional complexity to the benthos and thereby increase biodiversity. The Mediterranean red coral (*Corallium rubrum*, L. 1758) is a longevous octocoral that is harvested commercially, yet natural and anthropogenic influences on its population size structure are little understood. This study found that some harvested red coral populations had a significantly different size structure when compared to populations at the nearby Marine Protected Area (MPA) of Medas Islands at the Spanish Costa Brava (NW Mediterranean). Eighty- nine percent of the red corals in the harvested Costa Brava area are less than 10 years old and 96% of all colonies have not yet grown more than second- order branches. The size/age distribution of the harvested population is notably skewed towards younger and smaller colonies. Thus, although red coral is still abundant, its population structure is strongly distorted by harvesting. The results confirm that MPAs are useful to distinguish between anthropogenic and natural influences on population structure. However, 14 years of protection appears to be an insufficient recovery time for a longevous octocoral population such as red coral.

Pandolfi, J.M. and Jackson, J.B.C. **Ecological persistence interrupted in Caribbean coral reefs.** *Ecology Letters* 9(7): 818-826, 2006.

Notes: The recent mass mortality of Caribbean reef corals dramatically altered reef community structure and begs the question of the past stability and persistence of coral assemblages before human disturbance began. We report within habitat stability in coral community composition in the Pleistocene fossil record of Barbados for at least 95 000 years despite marked variability in global sea level and climate. Results were consistent for surveys of both common and rare taxa. Comparison of Pleistocene and modern community structure shows that recent human impacts have changed coral community structure in ways not observed in the preceding 220 000 years.

Smith, J.E., Shaw, M., Edwards, R.A., Obura, D., Pantos, O., Sala, E., Sandin, S.A., Smriga, S., Hatay, M., and Rohwer, F.L. **Indirect effects of algae on coral: algae-mediated, microbe-induced coral mortality.** *Ecology Letters* 9(7): 835-845, 2006.

Notes: Declines in coral cover are generally associated with increases in the abundance of fleshy algae. In many cases, it remains unclear whether algae are responsible, directly or indirectly, for coral death or whether they simply settle on dead coral surfaces. Here, we show that algae can indirectly cause coral mortality by enhancing microbial activity via the release of dissolved compounds. When coral and algae were placed in chambers together but separated by a 0.02 μm filter, corals suffered 100% mortality. With the addition of the broad-spectrum antibiotic ampicillin, mortality was completely prevented. Physiological measurements showed complementary patterns of increasing coral stress with proximity to algae. Our results suggest that as human impacts increase and algae become more abundant on reefs a positive feedback loop may be created whereby compounds released by algae enhance microbial activity on live coral surfaces causing mortality of corals and further algal growth.

Fabricius, K.E. **Effects of irradiance, flow, and colony pigmentation on the temperature microenvironment around corals: Implications for coral bleaching?** *Limnology and Oceanography* 51(1): 30-37, 2006.

Notes: Experiments were conducted to determine the effects of colony pigmentation, irradiance, and flow on the temperature microenvironment that corals experience in shallow water. The warming of colony surfaces increased with increasing colony pigmentation (darker surfaces) and at high irradiance but was alleviated by higher water flow. Dark colonies were up to 1.5ºC warmer than ambient seawater at high irradiance and slow flow. In contrast, very light colonies were similar in temperature to ambient water at all levels of flow and irradiance. The darkness of corals progressively increased along a gradient of decreasing water clarity from oligotrophic offshore reefs toward turbid high-nutrient reefs near the coast. The surface temperature of these darkly pigmented turbid-water corals was significantly greater than that of the paler corals in the clear-water environments at comparable seawater temperatures, light, and current conditions. The surface warming of darkly pigmented colonies in coastal environments is sufficiently high to exceed their bleaching threshold during warm, calm, and clear seawater conditions.

Schneider, K. and Erez, J. **The effect of carbonate chemistry on calcification and photosynthesis in the hermatypic coral *Acropora eurystoma*.** *Limnology and Oceanography* 51(3): 1284-1293, 2006.

Notes: The rise in atmospheric CO2 has caused significant decrease in sea surface pH and carbonate ion (CO3((-2)) concentration. This decrease has a negative effect on calcification in hermatypic corals and other calcifying organisms. We report the results of three laboratory experiments designed specifically to separate the effects of the different carbonate chemistry parameters (pH, CO3(-2), CO2 [aq], total alkalinity [A(T)], and total inorganic carbon [CT]) on the calcification, photosynthesis, and respiration of the hermatypic coral *Acropora eurystoma*. The carbonate system was varied to change pH (7.9-8.5), without changing CT; CT was changed keeping the pH constant, and CT was changed keeping the PCO2 constant. In all of these experiments, calcification (both light and dark) was positively correlated with CO3(-2) concentration, suggesting that the corals are not sensitive to pH or CT but to the CO3(-2) concentration. A decrease of ~ 30% in the CO3(-2) concentration (which is equivalent to a decrease of about 0.2 pH units in seawater) caused a calcification decrease of about 50%. These results suggest that calcification in today's ocean (pCO2 = 370 ppm) is lower by ~ 20% compared with preindustrial time (pCO2 = 280 ppm). An additional decrease of ~ 35% is expected if atmospheric CO2 concentration doubles (pCO(2) = 560

ppm). In all of these experiments, photosynthesis and respiration did not show any significant response to changes in the carbonate chemistry of seawater. Based on this observation, we propose a mechanism by which the photosynthesis of symbionts is enhanced by coral calcification at high pH when CO2(aq) is low. Overall it seems that photosynthesis and calcification support each other mainly through internal pH regulation, which provides CO3-(2) ions for calcification and CO2(aq) for photosynthesis.

Reed, J.K., Weaver, D.C., and Pomponi, S.A. **Habitat and fauna of deep-water *Lophelia pertusa* coral reefs off the southeastern US: Blake Plateau, Straits of Florida, and Gulf of Mexico.** *Bulletin of Marine Science* 78(2): 343-375, 2006.

Notes: Expeditions from 1999 to 2004 for biomedical research explored various deep-sea coral ecosystems (DSCE) off the southeastern U.S. (Blake Plateau, Straits of Florida, and eastern Gulf of Mexico). Habitat and benthos were documented from 57 dives with human occupied submersibles and three with a remotely operated vehicle (ROV), and resulted in similar to 100 hrs of videotapes, 259 in situ digital images, 621 museum specimens, and > 400 microbial isolates. These were the first dives to document the habitat, benthic fauna, and fish diversity of some of these poorly known deep-water reefs. Fifty-eight fish species and 142 benthic invertebrate taxa were identified. High-definition topographic SEABEAM maps and echosounder profiles were also produced. Sites included in this report range from South Carolina on the Blake Plateau to the southwestern Florida slope: 1) Stetson *Lophelia* reefs along the eastern Blake Plateau off South Carolina; 2) Savannah *Lophelia* lithoherms along the western Blake Plateau off Georgia; 3) east Florida *Lophelia* reefs, 4) Miami Terrace escarpment in the Straits of Florida; 5) Pourtales Terrace off the Florida Keys; and 6) west Florida *Lophelia* lithoherms off the southwestern Florida shelf in the Gulf of Mexico. These are contrasted with the azooxanthellate deep-water *Oculina* reefs at the shelf-edge off central eastern Florida. The fisheries and biopharmaceutical resource potential of these deep-water habitats remain relatively unknown. Although these habitats are not currently designated as marine protected areas (MPAs) or coral habitat areas of particular concern (HAPCs), they are ecologically diverse, vulnerable to physical destruction, and irreplaceable resources. Activities involving bottom trawling, pipelines, or oil/gas production could negatively impact these reefs. National Oceanic and Atmospheric Administration (NOAA) Fisheries and the South Atlantic Fishery Management Council are currently developing priority mapping sites of the DSCEs within this region, and these data may provide potential targets for new MPAs and HAPCs.

Wielgus, J., Glassom, D., and Chadwick, N.E. **Patterns of polychaete worm infestation of stony corals in the northern Red Sea and relationships to water chemistry.** *Bulletin of Marine Science* 78(2): 377-388, 2006.

Notes: Coral reefs of the northern Red Sea are biodiverse and rich in endemisms, but also fragile and susceptible to stress by natural and anthropogenic disturbances. Colonies of several genera of reef-building stony corals at Eilat (Israeli Red Sea) recently have become infested with boring spionid polychaete worms, the presence of which has induced skeletal aberrations on corals. Of 656 corals examined, 218 (33.2%) were infested with boring spionid worms. The percent of infested coral colonies in the coral genera *Leptastrea* and *Porites* was significantly correlated with the concentration of total oxidized nitrogen (TON, NO2 + NO3) in the water column. TON levels also significantly predicted the likelihood of colony infestation in the corals *Leptastrea*, *Pavona*, and *Porites*, and the likelihood of skeletal aberration in *Porites*. High abundances of coral-boring polychaetes have been reported in other reef areas close to organic waste discharges. We conclude that anthropogenic nitrogen enrichment of waters surrounding coral reefs at Eilat may have caused corals to become vulnerable to infestation by boring spionid polychaetes, resulting in coral skeleton aberrations and increased susceptibility to damage by storms.

Rogers, C.S. and Miller, J. **Permanent 'phase shifts' or reversible declines in coral cover? Lack of recovery of two coral reefs in St. John, US Virgin Islands.** *Marine Ecology Progress Series* 306: 103-114, 2006.

Notes: Caribbean coral reefs have changed dramatically in the last 3 to 4 decades, with significant loss of coral cover and increases in algae. Here we present trends in benthic cover from 1989 to 2003 at 2 reefs (Lameshur Reef and Newfound Reef) off St. John, US Virgin Islands (USVI). Coral cover has declined in the fore-reef zones at both sites, and no recovery is evident. At Lameshur Reef, Hurricane Hugo (1989) caused significant physical damage and loss of coral. We suggest that macroalgae rapidly colonized new substrate made available by this storm and have hindered or prevented growth of adult corals, as well as settlement and survival of new coral recruits. Overfishing of herbivorous fishes in the USVI and loss of

shelter for these fishes because of major storms has presumably reduced the levels of herbivory that formerly controlled algal abundance. Coral cover declined at Newfound Reef from 1999 to 2000, most likely because of coral diseases. The trends that we have documented, loss of coral followed by no evidence of recovery, appear similar to findings from other studies in the Caribbean. We need to focus on functional shifts in the resilience of coral reefs that result in their inability to recover from natural and human-caused stressors.

Kline, D.I., Kuntz, N.M., Breitbart, M., Knowlton, N., and Rohwer, F. **Role of elevated organic carbon levels and microbial activity in coral mortality.** *Marine Ecology Progress Series* 314: 119-125, 2006.

Notes: Coral reefs are suffering a long-term global decline, yet the causes remain contentious. The role of poor water quality in this decline is particularly unclear, with most previous studies providing only weak correlations between elevated nutrient levels and coral mortality. Here we experimentally show that routinely measured components of water quality (nitrate, phosphate, ammonia) do not cause substantial coral mortality. In contrast, dissolved organic carbon (DOC), which is rarely measured on reefs, does. Elevated DOC levels also accelerate the growth rate of microbes living in the corals' surface mucopolysaccharide layer by an order of magnitude, suggesting that mortality occurs due to a disruption of the balance between the coral and its associated microbiota. We propose a model by which elevated DOC levels cause Caribbean reefs to shift further from coral to macroalgal dominance. Increasing DOC levels on coral reefs should be recognized as a threat and routinely monitored.

Nugues, M.M. and Bak, R.P.M. **Differential competitive abilities between Caribbean coral species and a brown alga: a year of experiments and a long-term perspective.** *Marine Ecology Progress Series* 315: 75-86, 2006.

Notes: The competitive replacement of corals by benthic algae is considered key to reef degradation. Such replacement could originate from direct competitive overgrowth of corals by algae or death of corals from other disturbances, followed by an increase in algal abundance. To assess the relative importance of these processes, this study experimentally tested the competitiveness of 6 Caribbean coral species against the brown alga *Lobophora variegata* on a fringing reef in Curacao, Netherlands Antilles. This alga has a widespread distribution and is considered particularly aggressive towards corals due to its creeping growth form. We compared the growth of transplanted algae over living and dead coral, as well as coral tissue mortality in the presence and absence of transplanted algae over a 1 yr period. Competitive trends were also related to changes in species abundance from 1973 to 2002 on the same reef. The results indicated that only 1 species, *Agaricia agaricites*, was competitively inferior to *L. variegata* and suffered more tissue mortality when exposed to the algae. Surveys of naturally occurring interactions showed that less competitive species were generally more overgrown by *L. variegata*, further reinforcing our results. Importantly, *A. agaricites* experienced the greatest decline in percent cover from 1973 to 2002 among the studied species. A large proportion of this decline occurred following the die-off of *Diadema antillarum* in 1983, which generally marks the onset of increased algal abundance on Caribbean reefs. We concluded that Caribbean corals have different competitive abilities against algae, highlighting the complexity and species-specific nature of coral-algal interactions. Although our data supports that prior death of corals may be generally required for algae to become established, competition with algae could play a significant role in structuring coral communities by reducing the abundance of poor competitive species. We suggest that a species-by-species approach is needed to understand the factors influencing transitions from coral to algal dominance on Caribbean reefs.

Garpe, K.C., Yahya, S.A.S., Lindahl, U., and Ohman, M.C. **Long-term effects of the 1998 coral bleaching event on reef fish assemblages.** *Marine Ecology Progress Series* 315: 237-247, 2006.

Notes: Coral bleaching events constitute compound disturbances often resulting in coral death as well as successive degradation of the reef framework. The 1997/1998 El Nino Southern Oscillation (ENSO) was the most severe on record and affected coral reefs worldwide. The present study examined the response of fish assemblages in plots of transplanted coral before and after the 1998 bleaching. Multidimensional scaling ordinations (MDS) demonstrate significant changes in assemblage composition related to habitat alteration. Within-site variability increased with disturbance, the increase being most apparent following substrate erosion. The differences in long-term responses as opposed to short-term responses were striking. Six mo after coral death, total abundance as well as taxonomic richness had increased at one of the sites, but not the

other, whereas 6 yr later, both measures had decreased significantly at both sites. Functional groups, with documented affiliations with coral, were significantly influenced by the habitat alteration. Herbivore abundance increased as an immediate response to bleaching, but was subsequently decimated in eroded habitat. The loss of structural complexity had major detrimental effects on the entire fish community. In conclusion, we present evidence of severe and long-lasting secondary impacts of a catastrophic bleaching event, with no apparent recovery. The discrepancies between short-term and long-term responses underline the importance of long-term monitoring of fish assemblages following habitat alteration.

Croquer, A., Bastidas, C., Lipscomp, D., Rodriguez-Martinez, R.E., Jordan-Dahlgren, E., and Guzman, H.M. **First report of folliculinid ciliates affecting Caribbean scleractinian corals.** *Coral Reefs* 25(2): 187-191, 2006.

Notes: This is the first report of a ciliate of the genus *Halofolliculina* infecting hard coral species of six families (Acroporidae, Agaricidae, Astrocoeniidae, Faviidae, Meandrinidae and Poritidae) and milleporids in the Caribbean. Surveys conducted during 2004-2005 in Venezuela, Panama and Mexico confirmed that this ciliate affects up to 25 scleractinian species. The prevalence of this ciliate at the coral community level was variable across sites, being most commonly found at Los Roques, Venezuela, and at Bocas del Toro, Panama (prevalence 0.2-2.5%), but rarely observed in the Mexican Caribbean. Ciliates were more prevalent within populations of acroporids (*Acropora palmata*, *Acropora cervicornis* and *Acropora prolifera*) in Los Roques. Recent observations also corroborate the presence of these ciliates in Curacao and Puerto Rico. Our observations indicate that ciliates affecting corals have a wider distribution than previously thought, and are no longer exclusively found in the Indo-Pacific and Red Sea.

Idjadi, J.A., Lee, S.C., Bruno, J.F., Precht, W.F., Allen-Requa, L., and Edmunds, P.J. **Rapid phase-shift reversal on a Jamaican coral reef.** *Coral Reefs* 25(2): 209-211, 2006.

Notes: Many Caribbean reefs have experienced a phase-shift in community structure, the principle features being a decline in coral cover and an increase in macroalgal biomass. However, one Jamaican reef - Dairy Bull on the north shore near Discovery Bay - is once again dominated by scleractinian corals and several key species have returned. Living coral cover at 6-8 m depth at Dairy Bull has doubled over the past 9 years and is now ~ 54%. The absolute cover of *Acropora cervicornis* was < 1% in 1995, but increased to ~ 11% by January 2004. During this time the cover of macroalgae decreased by 90%, from 45 to 6%. We speculate that long-lived colonies of *Montastraea annularis* may have facilitated the recovery of this reef by providing structural refugia.

Shenkar, N., Fine, M., Kramarsky-Winter, E., and Loya, Y. **Population dynamics of zooxanthellae during a bacterial bleaching event.** *Coral Reefs* 25(2): 223-227, 2006.

Notes: Each summer 80-90% of the colonies of *Oculina patagonica* undergo bleaching off the Mediterranean coast of Israel. To investigate fluctuations through a yearly bleaching cycle, monthly measurements of zooxanthella density, mitotic index and chlorophyll-*a* concentration were conducted. Results showed (1) a significant negative correlation between sea surface temperature (SST) and zooxanthella density; (2) both significantly lower zooxanthella mitotic index and higher chlorophyll-*a* per zooxanthella content during the bleaching season compared with the non-bleaching period; (3) prior to bleaching, a lag between the peak of zooxanthella density and chlorophyll-*a* concentration followed by a similar lag during recovery. Zooxanthella density declined significantly between March and May while chlorophyll-*a* concentration peaked in April, and then declined. Zooxanthella density increased significantly in November while chlorophyll-*a* concentration increased significantly in January. We conclude that during bacterial bleaching events, zooxanthellae are severely damaged. However, by the time of the following bleaching event the coral tissues regain their "normal" (pre-bleaching) zooxanthella population density.

Stone, R.P. **Coral habitat in the Aleutian Islands of Alaska: depth distribution, fine-scale species associations, and fisheries interactions.** *Coral Reefs* 25(2): 229-238, 2006.

Notes: The first in situ exploration of Aleutian Island coral habitat was completed in 2002 to determine the distribution of corals, to examine fine-scale associations between targeted fish species and corals, and to investigate the interaction between the areas' diverse fisheries and coral habitat. Corals, mostly gorgonians and hydrocorals, were present on all 25 seafloor transects and at depths between 27 and 363 m, but were most abundant between 100 and 200 m depth. Mean coral abundance (1.23 colonies m^2) far exceeded that reported for other high-latitude ecosystems and high-density coral gardens (3.85 colonies m^2) were observed at seven locations. Slope and offshore pinnacle habitats characterized by exposed bedrock, boulders, and cobbles generally supported the highest abundances of coral and fish. Overall, 85% of the economically important fish species observed on transects were associated with corals and other emergent epifauna. Disturbance to the seafloor from bottom-contact fishing gear was evident on 88% of the transects, and approximately 39% of the total area of the seafloor observed had been disturbed. Since cold-water corals appear to be a ubiquitous feature of seafloor habitats in the Aleutian Islands, fisheries managers face clear challenges integrating coral conservation into an ecosystem approach to fisheries management.

Mayor, P.A., Rogers, C.S., and Hillis-Starr, Z.M. **Distribution and abundance of elkhorn coral, *Acropora palmata*, and prevalence of white-band disease at Buck Island Reef National Monument, St. Croix, US Virgin Islands.** *Coral Reefs* 25(2): 239-242, 2006.

Notes: In the 1970s and 1980s elkhorn coral, *Acropora palmata*, declined dramatically throughout the Caribbean primarily due to white-band disease (WBD). In 2005, elkhorn coral was proposed for listing as threatened under the US Endangered Species Act. WBD was first documented at Buck Island Reef National Monument (BIRNM). Together with hurricanes WBD reduced live elkhorn coral coverage by probably over 90%. In the past decade some recovery has been observed at BIRNM. This study assessed the distribution and abundance of elkhorn coral and estimated the prevalence of WBD at the monument. Within an area of 795 ha, we estimated 97,232-134,371 (95% confidence limits) elkhorn coral colonies with any dimension of connected live tissue greater than one meter, about 3% of which were infected by WBD. Despite some recovery, the elkhorn coral density remains low and WBD may continue to present a threat to the elkhorn coral population.

Herren, L.W., Walters, L.J., and Beach, K.S. **Fragment generation, survival, and attachment of *Dictyota* spp. at Conch Reef in the Florida Keys, USA.** *Coral Reefs* 25(2): 287-295, 2006.

Notes: During the past decade, the relative abundance of the brown macroalgae *Dictyota* spp. has been high in the Florida Keys. Recent studies have shown that members of this genus successfully reproduce via vegetative fragmentation. To investigate the importance of fragmentation on the reef community, this study examined: (1) the degree of epiphytism on benthic organisms, (2) the rate of fragment production through fish foraging activities, (3) the likelihood of fragment entanglement, and (4) the fragment attachment and success rate. It was found that reef fish contributed substantially to the fragment pool; furthermore, most fish-produced fragments produced rhizoids and attached to sand grains within 24 h in the field. Fragments of *Dictyota* spp. most commonly became entangled around and then attached themselves to the green alga *Halimeda tuna*, and other *Dictyota* spp. These results suggest that vegetative fragmentation of *Dictyota* spp. plays an important role in the changing community structure on the Florida Keys reef tract.
