Marine Science Review – 167

Habitats and ecosystems

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In this review:

A. Recent articles – no abstract available

Ray, G.C. **The coastal realm's environmental debt.** *Aquatic Conservation: Marine and Freshwater Ecosystems* 16(1): 1-4, 2006.

Hoegh-Guldberg, O. **Complexities of coral reef recovery.** *Science* 311(5757): 42-43, 2006.

Chapman, P. and Reed, D. **Advances in coastal habitat restoration in the northern Gulf of Mexico.** *Ecological Engineering* 26(1): 1-5, 2006.

B. Recent articles with abstracts

Hindell, J.S. **Assessing the trophic link between seagrass habitats and piscivorous fishes.** *Marine and Freshwater Research* 57(1): 121-131, 2006.

Notes: Links between piscivorous fishes and seagrass habitat were investigated in Port Phillip Bay, Australia. Abundances of piscivorous fish were estimated, the contribution of fish to their diets was measured and the trophic link between these fish and seagrass beds was assessed with stable isotopes. Piscivorous fishes were common in seagrass and included eight species from seven families (33% by abundance). They consumed at least eight families of teleost prey, including juveniles of seagrass-associated taxa, such as monacanthids (e.g. *Meuschenia freycineti*) and syngnathids (*Stigmatopora argus*). No fish were exclusively piscivorous and contribution of fish to the diets of the most common species (*Arripis truttacea* and *Kestratherina esox*) varied strongly through time. Putative contributions of each source (primary producer-plant) to the nutrition of piscivorous fishes were: (1) fishes whose base for nutritional support was driven mostly (> 50%) by seagrass (e.g. *Platycephalus speculator* and *Platycephalus laevigatus*); and (2) fishes whose base for nutritional support was not driven by any particular primary producer (e.g. *Arripis truttacea* and *Pseudocaranx dentex*). The propensity for piscivorous fish to include seagrass-associated fish in their diets, their perennial presence in seagrass and the strong putative contribution by seagrass to their nutrition, suggest that seagrass habitats can be valuable habitat for piscivorous fishes.

Orth, R.J., Luckenbach, M.L., Marion, S.R., Moore, K.A., and Wilcox, D.J. **Seagrass recovery in the Delmarva Coastal Bays, USA.** *Aquatic Botany* 84(1): 26-36, 2006.

Notes: *Zostera marina* (eelgrass) in the coastal bays of the Delmarva Peninsula, USA, declined precipitously in the 1930s due to the pandemic wasting disease and a destructive hurricane in 1933. This resulted in major changes in many of the ecosystem services provided by this seagrass, such as loss of bay scallops (*Argopecten irradians*) and disappearance of brant (*Branta bernicla*). Natural recovery of *Z. marina*, possibly deriving from either small remnant stands or undocumented transplant projects after the demise of *Z. marina*, has been significant in four northern bays, with over 7319 ha reported through 2003 compared to 2129 ha in 1986, an average expansion rate of 305 ha year(-1). This rapid spread was likely due to seeds and seed dispersal from recovering beds. However, no recovery had occurred in the southern coastal bays prior to restoration efforts, possibly due to both their distance from potential donor beds, restricted entrances to the bays, and the narrow time period when seeds

are available for colonization via rafting reproductive shoots carrying viable seeds. Survival and expansion of small test plots (4 m^2) in these southern coastal bays between 1997 and 2000 demonstrated that propagule supply, rather than water quality, was limiting seagrass recovery in these bays. In 2001, we initiated a large-scale *Z. marina* restoration effort in the southern coastal bays utilizing seeds, while simultaneously monitoring water quality using spatially and temporally intensive water quality mapping techniques. Between 2001 and 2004, approximately 24 million seeds harvested from natural, dense beds in Chesapeake Bay were broadcast into experimental plots ranging in size from 0.2 to 2 ha in four coastal bays having no seagrass, totaling approximately 46 ha through 2004. Successful germination (estimated at 5-10% of seeds broadcast), growth and expansion of *Z. marina* in and around these plots over this 3-year test period, as well as water quality data, suggest conditions are appropriate for plant growth. Low-level aerial photographs in 2004 showed 38% of the bottom in 52-0.4 ha plots was covered by vegetation. Increasing *Z. marina* coverage will have important implications for fisheries and waterfowl but may potentially conflict with aquaculture, which is rapidly expanding in this region. Continued recovery will depend on maintaining good water quality to avoid the macro-algal accumulations and phytoplankton blooms that have characterized other coastal lagoons. The patterns of natural seagrass recovery and the results of restoration efforts we describe here, as well as seagrass recoveries from wasting disease outbreaks, anoxic events, hurricanes, and propeller scarring reported elsewhere, suggest that seeds and seed dispersal play an important role in the recovery and expansion of these beds.

Lee, S.C. **Habitat complexity and consumer-mediated positive feedbacks on a Caribbean coral reef.** *Oikos* 112(2): 442-447, 2006.

Notes: Theoretical and empirical evidence suggest that positive feedbacks can increase resilience in ecological communities. On Caribbean coral reefs, there have been striking shifts from physically complex communities with high coral cover to relatively homogenous communities dominated by macroalgae, which have persisted for decades. However, little is known about positive feedbacks that may maintain coral reef community states. Here, I explore a potential consumer-mediated feedback on a Jamaican reef by examining how grazing by a keystone herbivore (*Diadema antillarum*) is enhanced by physical structure, which offer refugia from predation. Surveys revealed that habitat complexity and *Diadema* density were positively related. Increasing habitat complexity by adding physical structure significantly decreased macroalgal cover and increased the proportion of urchins in algal habitats in field manipulations. Experimental increases in urchin density also decreased macroalgal cover, but did not affect the proportion of urchins in algal habitats. These results suggest that the low habitat complexity of macroalgal-dominated reefs may inhibit an urchin-mediated shift to coral dominance and that positive feedbacks must be considered in reef restoration efforts.

Inagaki, F., Nunoura, T., Nakagawa, S., Teske, A., Lever, M., Lauer, A., Suzuki, M., Takai, K., Delwiche, M., Colwell, F.S., Nealson, K.H., Horikoshi, K., D'Hondt, S., and Jørgensen, B.B. **Biogeographical distribution and diversity of microbes in methane hydrate-bearing deep marine sediments on the Pacific Ocean Margin.** *Proceedings of the National Academy of Sciences [USA]* 103(8): 2815-2820, 2006.

Notes: The deep subseafloor biosphere is among the least-understood habitats on Earth, even though the huge microbial biomass therein plays an important role for potential long-term controls on global biogeochemical cycles. We report here the vertical and geographical distribution of microbes and their phylogenetic diversities in deeply buried marine sediments of the Pacific Ocean Margins. During the Ocean Drilling Program Legs 201 and 204, we obtained sediment cores from the Peru and Cascadia Margins that varied with respect to the presence of dissolved methane and methane hydrate. To examine differences in prokaryotic distribution patterns in sediments with or without methane hydrates, we studied >2,800 clones possessing partial sequences (400-500 bp) of the 16S rRNA gene and 348 representative clone sequences (~1 kbp) from the two geographically separated subseafloor environments. Archaea of the uncultivated Deep-Sea Archaeal Group were consistently the dominant phylotype in sediments associated with methane hydrate. Sediment cores lacking methane hydrates displayed few or no Deep-Sea Archaeal Group phylotypes. Bacterial communities in the methane hydrate-bearing sediments were dominated by members of the JS1 group, Planctomycetes, and Chloroflexi. Results from cluster and principal component analyses, which include previously reported data from the West and East Pacific Margins, suggest that, for these locations in the Pacific Ocean, prokaryotic communities from methane hydrate-bearing sediment cores are distinct from those in hydrate-free cores. The recognition of which microbial groups prevail under distinctive subseafloor environments is a significant step toward determining the role these communities play in Earth's essential biogeochemical processes.

Bromberg, K.D. and Bertness, M.D. **Reconstructing New England salt marsh losses using historical maps.** *Estuaries* 28(6): 823-832, 2005.

Notes: Analyses of habitat loss are often restricted to the past 75 years by the relative youth of aerial photography and remote sensing technologies. Although photographic techniques are highly accurate, they are unable to provide measurements of habitat loss prior to the 1950s. In this study, historical maps from the late 1700s and early 1800s covering portions of Rhode Island, Massachusetts, New Hampshire, and Maine were used to approximate naturally occurring salt marsh cover in New England. Historical data was compared to current salt marsh coverage available in public geographic information system (GIS) data sets. The average loss in New England is estimated at 37% using this technique. Rhode Island has lost the largest proportion of salt marshes by state, a staggering 53% loss since 1832. Massachusetts has also experienced large losses, amounting to a 41% loss of salt marsh since 1777. The Boston area alone has lost 81% of its salt marshes. Salt marsh loss was highly correlated with urban growth. Restoration and preservation efforts have resulted in the retention of salt marsh in less populated areas of New England. Although historical maps are difficult to verify, they represent an extremely valuable and underused data repository. Using historical maps to trace land use practices is an effective way to overcome the short-term nature of many ecological studies. This technique could be applied to other habitats and other regions, wherever accurate historical maps are available. Analysis of historic conditions of habitats can help conservation managers determine appropriate goals for restoration and management

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Jantz, P., Goetz, S., and Jantz, C. **Urbanization and the loss of resource lands in the Chesapeake Bay watershed.** *Environmental Management* 36(6): 808-825, 2005.

Notes: We made use of land cover maps, and land use change associated with urbanization, to provide estimates of the loss of natural resource lands (forest, agriculture, and wetland areas) across the 168,000 km² Chesapeake Bay watershed. We conducted extensive accuracy assessments of the satellite-derived maps, most of which were produced by us using widely available multitemporal Landsat imagery.The change in urbanization was derived from impervious surface area maps (the built environment) for 1990 and 2000, from which we estimated the loss of resource lands that occurred during this decade.Within the watershed, we observed a 61% increase in developed land (from 5,177 to 8,363 km²). Most of this new development (64%) occurred on agricultural and grasslands, whereas 33% occurred on forested land.Some smaller municipalities lost as much as 17% of their forest lands and 36% of their agricultural lands to development, although in the outlying counties losses ranged from 0% to 1.4% for forests and 0% to 2.6% for agriculture. Fast-growing urban areas surrounded by forested land experienced the most loss of forest to impervious surfaces. These estimates could be used for the monitoring of the impacts of development across the Chesapeake Bay watershed, and the approach has utility for other regions nationwide. In turn, the results and the approach can help jurisdictions set goals for resource land protection and acquisition that are consistent with regional restoration goals.

Glenn, E.P., Nagler, P.L., Brusca, R.C., and Hinojosa-Huerta, O. **Coastal wetlands of the northern Gulf of California: inventory and conservation status.** *Aquatic Conservation: Marine and Freshwater Ecosystems* 16(1): 5-28, 2006.

Notes: 1. Above 28ºN, the coastline of the northern Gulf of California is indented at frequent intervals by negative or inverse estuaries that are saltier at their backs than at their mouths due to the lack of freshwater inflow. These 'esteros' total over 215000 ha in area and encompass mangrove marshes below 29ºN and saltgrass (*Distichlis palmeri*) marshes north of 29ºN. An additional 6000 ha of freshwater and brackish wetlands are found in the Colorado River delta where fresh water enters the intertidal zone. 2. The mangrove marshes in the Gulf of California have been afforded some degree of protected status in Mexico, but the northern saltgrass esteros do not have priority conservation status and are increasingly becoming development targets for resorts, vacation homes and aquaculture sites. 3. We conducted an inventory of the marshes using aerial photography and satellite images, and evaluated the extent and type of development on each marsh. We reviewed the available literature on the marshes to document their vegetation types, and ecological functions in the adjacent marine and terrestrial ecosystems. 4. Over 95% of the mangrove marshes have been developed for shrimp farming. However, the farms are built adjacent to, rather than in, the marshes, and the mangrove stands are still mostly intact. 5. The majority of saltgrass marshes above the mangrove line are still relatively unspoiled. However, resort and vacation home development is taking place on land surrounding them. 6. We recommend a system of protected reserves incorporating the pristine wetlands, along with water quality management and buffer zones for the more developed esteros. The saltgrass marshes should be considered for

conservation protection, similar to the protection given to the southern mangrove marshes whose value has already been recognized.

Compton, J.E., Andersen, C.P., Phillips, D.L., Brooks, J.R., Johnson, M.G., Church, M.R., Hogsett, W.E., Cairns, M.A., Rygiewicz, P.T., McComb, B.C., and Shaff, C.D. **Ecological and water quality consequences of nutrient addition for salmon restoration in the Pacific Northwest.** *Frontiers in Ecology and Environment* 4(1): 18-26, 2006.

Notes: Salmon runs have declined over the past two centuries in the Pacific Northwest region of North America. Reduced inputs of salmon-derived organic matter and nutrients (SDN) may limit freshwater production and thus establish a negative feedback loop affecting future generations of fish. Restoration efforts use the rationale of declining SDN to justify artificial nutrient additions, with the goal of reversing salmon decline. The forms of nutrient addition include introducing salmon carcasses, carcass analogs (processed fish cakes), or inorganic fertilizers. While evidence suggests that fish and wildlife may benefit from increases in food availability as a result of carcass additions, stream ecosystems vary in their ability to use nutrients to benefit salmon. Moreover, the practice may introduce excess nutrients, disease, and toxic substances to streams that may already exceed proposed water quality standards. Restoration efforts involving nutrient addition must balance the potential benefits of increased food resources with the possible harm caused by increased nutrient and toxin loads.

Yang, S.L., Li, M., Dai, S.B., Liu, Z., Zhang, J., and Ding, P.X. **Drastic decrease in sediment supply from the Yangtze River and its challenge to coastal wetland management.** *Geophysical Research Letters* 33(6): art. L06408, 2006.

Notes: The 1951-2004 time series of annual sediment supply from the Yangtze were analyzed using the wavelet method. Coastal bathymetric data were processed using the Arc-GIS software. A typical intertidal flat was measured from May 2002 to August 2005 for comparison of bed levels before and after the Three Gorges Dam (TGD). There is a significant decreasing trend in riverine sediment supply since late 1960s, which is attributed mainly to the dam constructions. TGD reduced the sediment load to147 mt/yr in 2004, only 35% of the average. In response to this drastic decrease, the deltaic coast is turning from progradation to recession. We predict that the Yangtze sediment supply will further decrease and coastal erosion will be intensified in the coming decades, which poses a great challenge to coastal management.

Duarte, C.M., Middelburg, J.J., and Caraco, N. **Major role of marine vegetation on the oceanic carbon cycle.** *Biogeosciences* 2(1): 1-8, 2005.

Notes: The carbon burial in vegetated sediments, ignored in past assessments of carbon burial in the ocean, was evaluated using a bottom-up approach derived from upscaling a compilation of published individual estimates of carbon burial in vegetated habitats (seagrass meadows, salt marshes and mangrove forests) to the global level and a top-down approach derived from considerations of global sediment balance and a compilation of the organic carbon content of vegetated sediments. Up-scaling of individual burial estimates values yielded a total carbon burial in vegetated habitats of 111 Tmol C y(-1). The total burial in unvegetated sediments was estimated to be 126 Tg C y(-1), resulting in a bottom-up estimate of total burial in the ocean of about 244 Tg C y(-1), two-fold higher than estimates of oceanic carbon burial that presently enter global carbon budgets. The organic carbon concentrations in vegetated marine sediments exceeds by 2 to 10-fold those in shelf/deltaic sediments. Top-down recalculation of ocean sediment budgets to account for these, previously neglected, organic-rich sediments, yields a top-down carbon burial estimate of 216 Tg C y(-1), with vegetated coastal habitats contributing about 50%. Even though vegetated carbon burial contributes about half of the total carbon burial in the ocean, burial represents a small fraction of the net production of these ecosystems, estimated at about 3388 Tg C y(- 1), suggesting that bulk of the benthic net ecosystem production must support excess respiration in other compartments, such as unvegetated sediments and the coastal pelagic compartment. The total excess organic carbon available to be exported to the ocean is estimated at between 1126 to 3534 Tg C y(-1), the bulk of which must be respired in the open ocean. Widespread loss of vegetated coastal habitats must have reduced carbon burial in the ocean by about 30 Tg Cy-1, identifying the destruction of these ecosystems as an important loss of CO2 sink capacity in the biosphere.

Ravindran, J. and Raghukumar, C. **Histological observations on the scleractinian coral *Porites lutea* affected by pink-line syndrome.** *Current Science* 90(5): 720-724, 2006.

Notes: A pink-line syndrome (PLS) was reported in the reef building coral *Porites lutea* in Kavaratti island of the Lakshadweep archipelago. The affected corals had dead patches colonized by a cyanobacterium *Phormidium valderianum* and the bordering coral tissue was pink. We examined the histological changes associated with the PLS-affected tissue. Results showed that the zooxanthellae were released from the gastrodermal cells into the coelenteron. Gastrodermal cells undergo necrosis and detachment from the basal membrane. The basic staining of the cytoplasm in the gastrodermal cells bordering the calicoblastic layer suggests accumulation of calcium ions. The ectodermal epithelium and calicoblastic cells showed destruction through 'apoptosis-like' processes. Cell swelling and vacuolation were observed in the gastrodermal and ectodermal cells. In this communication we discuss how the presence of the cyanobacterium adjacent to the PLS-affected tissue could cause the observed damage, bring about imbalance and a shift in the coral-zooxanthellae symbiosis.

Ellis, J.C., Farina, J.M., and Witman, J.D. **Nutrient transfer from sea to land: the case of gulls and cormorants in the Gulf of Maine.** *Journal of Animal Ecology* 75(2): 565-574, 2006.

Notes: The structure of communities is influenced by the transport of resources across ecosystem boundaries. Seabirds are capable of introducing large amounts of marine-derived nutrients to land, thereby modifying resource availability to terrestrial species. In this study we investigated the hypothesis that variation in nesting densities of great black-backed gulls *Larus marinus* and double-crested cormorants *Phalacrocorax auritus* would modify the effect of these species on soil nutrients and plant species composition on offshore islands in the Gulf of Maine, USA. Our results showed a significant positive correlation between nest density and concentrations of ammonia and nitrate in soils, but no significant relationship between nest density and phosphate. Ammonia and phosphate concentrations were good predictors of plant species composition; there were more annual forbs than perennial grasses in the abandoned cormorant colony compared with the gull colonies. Extremely high concentrations of ammonia in the highest density colony (active cormorant) may have been the main factor inhibiting plant germination at this site. All of the plant species in gull and cormorant colonies showed enriched dN-15 signatures, indicating substantial input of marine-derived nitrogen from seabirds. Our study demonstrated that gulls and cormorants are effective vectors for the transport of marine nutrients to terrestrial ecosystems. However, transported nutrients occurred in particularly high concentrations in areas with nesting cormorants. Nesting densities and species-specific variation in resource transport should be considered when predicting the effects of seabirds and other biogenic vectors of allochthonous resources.

Martin, D., Bertasi, F., Colangelo, M.A., de Vries, M., Frost, M., Hawkins, S.J., Macpherson, E., Moschella, P.S., Satta, M.P., Thompson, R.C., and Ceccherelli, V.U. **Ecological impact of coastal defence structures on sediment and mobile fauna: Evaluating and forecasting consequences of unavoidable modifications of native habitats.** *Coastal Engineering* 52(10-11): 1027-1051, 2005.

Notes: We analyse the effects of coastal defence structures, mainly low crested (LCS), on the surrounding intertidal and subtidal infaunal assemblages and mobile fauna. The results summarise joint studies within the DELOS project in Spain (Mediterranean Sea), Italy (Adriatic Sea) and UK (English Channel and Atlantic Ocean). We demonstrate that univariate analysis did not generally identify LCS impacts, but multivariate analyses did, this being a general trend across all locations and countries. Changes in sediment and infauna seem to be inevitable and usually tend to induce negative changes, particularly on the landward side and in the presence of additional structures or after beach nourishment. The consequences of LCS construction always depend on the response of the assemblages inhabiting a given region. However, to assess the ecological importance of the induced changes and to provide additional monitoring criteria, likely indicator species should be taken into account. The presence of species either coming from the new hard bottoms or associated to physical disturbances is viewed as a negative impact, while the potential nursery role of LCS is a positive one. The combined use of monitoring and forecast models allows to identify these impacts and may play a relevant role in mitigation protocols. Finally, our work supports the feasibility of introducing design criteria tending to facilitate a positive evolution of the assemblages surrounding the structures once the changes due to the presence of the LCS are completed and the new situation tends to become more stable.

Grebmeier, J.M., Overland, J.E., Moore, S.E., Farley, E.V., Carmack, E.C., Cooper, L.W., Frey, K.E., Helle, J.H., McLaughlin, F.A., and McNutt, S.L. **A major ecosystem shift in the northern Bering Sea.** *Science* 311(5766): 1461-1464, 2006.

Notes: Until recently, northern Bering Sea ecosystems were characterized by extensive seasonal sea ice cover, high water column and sediment carbon production, and tight pelagic-benthic coupling of organic production. Here, we show that these ecosystems are shifting away from these characteristics. Changes in biological communities are contemporaneous with shifts in regional atmospheric and hydrographic forcing. In the past decade, geographic displacement of marine mammal population distributions has coincided with a reduction of benthic prey populations, an increase in pelagic fish, a reduction in sea ice, and an increase in air and ocean temperatures. These changes now observed on the shallow shelf of the northern Bering Sea should be expected to affect a much broader portion of the Pacific-influenced sector of the Arctic Ocean.

Carpenter, R.C. and Edmunds, P.J. **Local and regional scale recovery of *Diadema* promotes recruitment of scleractinian corals.** *Ecology Letters* 9(3): 268-277, 2006.

Notes: The phase change from coral to macroalgal dominance on many Caribbean reefs was exacerbated by the mortality of the echinoid *Diadema antillarum* in 1983-1984, and until recently, this sea urchin has remained rare on reefs throughout the western Atlantic. By the late 1990s, *Diadema* started to reappear in large numbers on some Jamaican reefs, and by 2000, the high densities were correlated with significantly greater abundances of juvenile corals. Here, we show that dense populations of *Diadema* now occur over a multi-kilometre-wide scale at six locations scattered along a 4100 km arc across the entire Caribbean. In all cases, these dense populations are found in shallow water (< 6 m depth) on outer reef communities and are associated with reduced macroalgal cover and enhanced coral recruitment. We conclude that population recovery of *Diadema* is occurring at both local and regional scales, and that grazing by this echinoid is creating conditions favouring the recruitment of corals.

Moran, K.L. and Bjorndal, K.A. **Simulated green turtle grazing affects structure and productivity of seagrass pastures.** *Marine Ecology Progress Series* 305: 235-247, 2005.

Notes: The seagrass *Thalassia testudinum* evolved under much greater grazing pressure than exists today because overexploitation by humans caused the severe decline of green turtles *Chelonia mydas*, the major seagrass herbivore in the Caribbean. Understanding the effects of grazing on the structure and function of seagrass ecosystems is critical to evaluating how ecosystem processes have changed since the major herbivore was essentially removed from modern Caribbean seagrass systems. We evaluated effects of grazing on the structure and productivity of *T. testudinum* pastures by simulating green turtle grazing in 3 x 3 m plots for 16 mo in the central Bahamas and comparing these clipped plots to adjacent control (unclipped) plots. Simulated grazing affected the physical structure of *T. testudinum* plots, resulting in a system with reduced structural complexity. Simulated grazing resulted in compensatory growth in *T. testudinum*. Clipped plots maintained levels of growth comparable to unclipped plots over the 1.6 mo clipping trial, and specific mass growth was significantly elevated in clipped plots, even without simulating the nutrient return from green turtle feces and urine. The green turtle grazing pattern of re-cropping *T. testudinum* plots is sustainable for long periods -- at least 16 mo. We estimated a range of carrying capacities of *T. testudinum* for green turtles of 1567 to 3748 kg turtle ha(-1). Our study provides a foundation for reconstruction models and restoration plans for Caribbean seagrass ecosystems.

Linares, C., Coma, R., Diaz, D., Zabala, M., Hereu, B., and Dantart, L. **Immediate and delayed effects of a mass mortality event on gorgonian population dynamics and benthic community structure in the NW Mediterranean Sea.** *Marine Ecology Progress Series* 305: 127-137, 2005.

Notes: In the boreal summer of 1999, many invertebrates of hard-bottom communities in the NW Mediterranean Sea suffered mass mortality. Our study assessed the population of the temperate octocoral *Paramuricea clavata* before the event and monitored the population over the following 4 yr. Spatial patterns showed decreasing mortality with increasing depth between 0 and 50 m, as well as high local variability. The temporal pattern was characterized by a sharp decrease in biomass (58%) shortly after the event caused by the combined effect of colony death (9% of the population) and an increase in the extent of colony injury (from 9% before the event to 52%, shortly after it). After 4 yr of monitoring, our results indicated a large delayed

effect of the event. Population density decreased continuously after November 1999, and by the completion of the study in November 2003 the accumulated density decrease was 48% of the initial population. This decrease was mainly due to the death of colonies subjected to extensive injury, and because recruitment did not offset mortality. After November 1999, biomass continued to decrease at a slow rate, becoming almost constant after November 2001. Overall, the delayed effect of the event accounted for a 70% loss in *P. clavata* biomass. The fact that a stabilization of the density and biomass of this species was observed during the last year of our study suggests that the delayed impact of the 1999 mass mortality event may be nearing its end. Nevertheless, given the low dynamics of *P. clavata* and its role as a habitat former, the delayed effect of the mass mortality event indicates the relevant role that disturbance can play on the population dynamics of this species and as a community structuring force on the coralligenous community.

Davenport, J. and Davenport, J.L. **The impact of tourism and personal leisure transport on coastal environments: A review.** *Estuarine, Coastal and Shelf Science* 67(1-2): 280-292, 2006.

Notes: Coastal tourism started in the 19th Century and has increased in non-linear fashion ever since, stimulated by a combination of developments in transport technology and rising prosperity. Initially, mainly national in character, the introduction of roll-on, roll-off ferries and inexpensive air transport caused an exponential 28-fold rise in international tourism between 1950 and the start of the 21st Century. This review considers the impact of tourism at two levels: (1) that created by the sheer numbers of tourists and their demands ('mass tourism and transport') and (2) that resulting from individual, often novel, forms of transport ('personal leisure transport'). Under (1), the consequences of the construction of coastal resorts and roads, marinas and jetties for habitat fragmentation and reduced biodiversity are described. Next, the effects of large cruise ships (now some 250 in number) are considered, particularly in relation to unregulated pollution and the delivery of substantial numbers of tourists to remote destinations. Thirdly, the literature related to disturbance caused by interfidal trampling by tourists on rocky/sandy shores is reviewed, followed by a section devoted to the unappreciated effects of beach 'cleaning' (i.e. removal of natural strandlines as well as litter) that is practiced throughout the world's sandy beach resorts. Finally, the potentially positive area of coastal ecotourism is considered, but evidence is assembled to highlight the problems associated with too high a demand. Under (2), the impact of a range of personal leisure transport modes is considered. These range from relatively innocuous pursuits (e.g. swimming, surfing, sailboarding and dinghy sailing), to an extremely popular sport (SCUBA diving) that is marketed for its environmentally-friendly nature, yet causes measurable deterioration in the world's coral ecosystems despite good management practices. The impact of motorboats is considered, particularly in the context of transmission of non-native species, while the highly polluting and disturbing technology of 'personal watercraft' is evaluated. Finally, the uncontrolled emergence of new, extreme sports' (e.g. 'coasteering', kitesurfing) is identified as a future problem.

Pihl, L., Baden, S., Kautsky, N., Ronnback, P., Soderqvist, T., Troell, M., and Wennhage, H. **Shift in fish assemblage structure due to loss of seagrass *Zostera marina* habitats in Sweden.** *Estuarine, Coastal and Shelf Science* 67(1-2): 123-132, 2006.

Notes: The areal extent of *Zostera marina* in the archipelago of the Swedish Skagerrak has decreased by 60% over two decades. To investigate the effects of *Z. marina* loss on the local fish assemblages, the fish fauna was compared between existing seagrass beds and sites where seagrass had vanished. A field study was carried out at four shallow locations in the outer archipelago of the coast in June 2004. Within each location two sites were sampled, one with an existing *Z. marina* bed and another where *Z. marina* had disappeared. Fish were sampled semi-quantitatively with a beach seine. Samples were taken during both day and night and captured fish were examined to species, enumerated and measured in the field, and released thereafter. The number of fish species was found to be significantly higher in *Z. marina* habitats compared to areas where seagrass was missing, and density and biomass of fish were generally lower in areas dominated by bare sediment compared to those in the seagrass habitats. Several species and groups of fishes (i.e., gadoids, labrids, syngnathids) were absent or occurred in low densities at sites where *Z. marina* was missing. For example, juvenile 0-group cod density was reduced by 96% at sites where *Z. marina* had disappeared. Such a reduction in recruitment of cod is in the same order of magnitude as the combined effect of seal predation and mortality due to by-catches in the eel fyke-net fishery estimated for the archipelago of the Swedish Skagerrak. Hence, the results clearly indicate a shift in the fish assemblage, including a loss of taxa at the family level as a result of degradation in habitat-forming vegetation.

Downs, C.A., Fauth, J.E., Robinson, C.E., Curry, R., Lanzendorf, B., Halas, J.C., Halas, J., and Woodley, C.M. **Cellular diagnostics and coral health: Declining coral health in the Florida Keys.** *Marine Pollution Bulletin* 51(5-7): 558-569, 2005.

Notes: Coral reefs within the Florida Keys are disappearing at an alarming rate. Coral cover in the Florida Keys National Marine Sanctuary declined by 38% from 1996 to 2000. In 2000, populations of *Montastraea annularis* at four sites near Molasses Reef within the Florida Keys National Marine Sanctuary and one reef within Biscayne National Park were sampled on a quarterly basis. Anecdotal observations showed corals at Alina's Reef in Biscayne National Park appeared healthy in March, but experienced an acute loss of coral cover by August. Cellular Diagnostic analysis indicated that Alina's Reef corals were in distress: they had been afflicted with a severe oxidative damaging and protein-denaturing stress that affected both the corals and their symbiotic zooxanthellae. This condition was associated with a significant xenobiotic detoxification response in both species, reflecting probable chemical contaminant exposure. These results demonstrate that applying a Cellular Diagnostic approach can be effective in helping to identify stress and its underlying causes, providing diagnostic and prognostic biomarkers of coral health.

Flemer, D.A. and Champ, M.A. **What is the future fate of estuaries given nutrient over-enrichment, freshwater diversion and low flows?** *Marine Pollution Bulletin* 52(3): 247-258, 2006.

Notes: Freshwater inflow is central to the definition of estuaries and if we lose control of the quantity of freshwater flow or discharge (including seasonal timing) to estuaries then freshwater water quality has the potential to become a moot issue in estuarine ecosystems (Definition of estuaries: estuaries (aestus = tide) are physico-chemically, geomorphically, and biotically diverse ecosystems. Although numerous definitions of estuaries exist, we prefer the following: an estuary is a partially enclosed coastal water body in which freshwater runoff, often seasonally and episodically pulsed, dilutes salty ocean water and the biotic structure is influenced by dynamic tidal action and associated salinty gradients and reef building organisms and wetlands influence development and evolution of ecological structure and function (see Kjerfve, B., 1989. Estuarine geomorphology and physical oceanography. In: Day, J.W. Jr., Hall, C.A.S., Kemp, W.M., Yanez-Aranciba, A. (Eds.), Estuarine Ecology. John Wiley, for expanded definition)).

Thomsen, M.S. and McGlathery, K. **Effects of accumulations of sediments and drift algae on recruitment of sessile organisms associated with oyster reefs.** *Journal of Experimental Marine Biology and Ecology* 328(1): 22-34, 2006.

Notes: Increases in sediment and drift algae accumulations have caused degradation of coastal lagoons worldwide. It is well known that these factors are stressors of seagrass beds, sediment fauna and coral reefs. However, little is known about the impacts on temperate hard-bottom assemblages within soft-bottom lagoons. To test if accumulations of sediment and drift algae (stress) affected recruitment of sessile oyster reef organisms, we constructed cages in Hog Island Bay, Virginia that trapped drifting macroalgae (approximate to 2.7 kg WW m^2) and facilitated sedimentation (~ 7 mm per 2-3 month). The stress treatments and unstressed controls were placed in front, between, and behind reefs (position) to represent wave exposed (approximate to 0.3 m, windy conditions), current exposed (approximate to 0.2 m s(-1), peak tide) and protected (approximate to 0 m, 0.0 m s(-1)) habitats. The percentage cover of recruited taxa onto bricks was mapped 4 times during a 1-year period. There were strong significant effects of stress on the total assemblage, plant (but not animal) richness, total plant and animal cover, and cover of the most common taxa. Unstressed bricks had high plant richness, high animal and plant cover, and high cover of the oyster *Crassostrea virginica*, the alien algae *Gracilaria vermiculophylla* and *Codium fragile*, the alga *Agardhiella subulata*, and high to medium cover of the opportunistic algae *Ulva curvata* and *Enteromorpha* spp. In comparison, sediment-stressed bricks had low plant richness, low animal and plant cover, and low cover of *C. virginica*, *G. vermiculophylla*, *C. fragile*, *A. subulata*, *U. curvata* and *Enteromorpha* spp. Similarly, algae-stressed bricks also had low cover of animals, *C. virginica*, *G. vermiculophylla*, *C. fragile*, and *A. subulata*, but intermediate plant richness and plant cover and high cover of *U. curvata* and *Enteromorpha* spp. Although reef position caused significant multivariate results, this factor was clearly less important than the stress factor. Our study shows that accumulations of sediments and drift algae have an adverse impact on sessile temperate reef organisms, reducing richness and abundance, but favoring a few small opportunistic taxa. As the reef-generating oysters themselves performed poorly under these stressors, the long-term impact of the causes of these stressors, eutrophication and urbanization, is likely to be diminished reefs with cascading adverse effects on sessile reef organisms.

Ray, G.C., McCormick-Ray, J., Berg, P., and Epstein, H.E. **Pacific walrus: Benthic bioturbator of Beringia.** *Journal of Experimental Marine Biology and Ecology* 330(1): 403-419, 2006.

Notes: The dependency of walruses on sea ice as habitat, the extent of their feeding, their benthic bioturbation and consequent nutrient flux suggest that walruses play a major ecological role in Beringia. This suggestion is supported by several lines of evidence, accumulated during more than three decades of enquiry and leading to the hypothesis that positive feedbacks of walrus feeding strongly influence productivity and ecological function via benthic bioturbation and nutrient flux. Walruses annually consume an estimated 3 million metric tons of benthic biomass. Walrus prey species inhabit patches across the shelf according to sediment type and structure. Side-scan sonar and our calculations indicate that the area affected by walrus feeding is in the order of thousands of square kilometers per year. Annual to long-term walrus bioturbation results in significant, large-scale changes in sediment and biological-community structure, and magnifies nutrient flux from sediment pore water to the water column by about two orders of magnitude over wide areas. The combined effects of walrus feeding must be placed in the context of long-term, regional climate changes and responses. Should sea ice continue to move northward as a result of climate change, the walrus' ecological role could be diminished or lost, the benthic ecosystem could be fundamentally altered and native subsistence hunters would be deprived of important resources.

Dittmar, T., Hertkorn, N., Kattner, G., and Lara, R.J. **Mangroves, a major source of dissolved organic carbon to the oceans.** *Global Biogeochemical Cycles* 20(1): art. GB1012, 2006.

Notes: Organic matter, which is dissolved in low concentrations in the vast waters of the oceans, contains a total amount of carbon similar to atmospheric carbon dioxide. To understand global biogeochemical cycles, it is crucial to quantify the sources of marine dissolved organic carbon (DOC). We investigated the impact of mangroves, the dominant intertidal vegetation of the tropics, on marine DOC inventories. Stable carbon isotopes and proton nuclear magnetic resonance spectroscopy showed that mangroves are the main source of terrigenous DOC in the open ocean off northern Brazil. Sunlight efficiently destroyed aromatic molecules during transport offshore, removing about one third of mangrove-derived DOC. The remainder was refractory and may thus be distributed over the oceans. On a global scale, we estimate that mangroves account for >10% of the terrestrially derived, refractory DOC transported to the ocean, while they cover only <0.1% of the continents' surface.

Meybeck, M., Dürr, H.H., and Vörösmarty, C.J. **Global coastal segmentation and its river catchment contributors: A new look at land-ocean linkage.** *Global Biogeochemical Cycles* 20(1): art. GB1S90, 2006.

Notes: Here we present the COSCATs global database of 151 catchments in exorheic areas. The catchments connect to oceans through coastal segments according to three sets of criteria: natural limits (continents, oceans, regional seas, major capes, and bays), continental shelf topography (sills, basins, island chains), and geophysical dynamics (climate, ocean currents and tectonics). The COSCATs segmentation scheme is designed to improve Earth System analysis and to harmonize reporting of global riverine transfers from land to oceans. Each COSCAT is characterized by its coastal segment limits and length (median 2 400 km), by its catchment characteristics, including area (median 0.45 M km^2), width, latitudinal range, runoff average value and direction, including its related physiographic units (n = 500). We apply the COSCAT segmentation to all 151 basins to estimate water discharge and total nitrogen impacts to oceans and find that the average runoff (mm/yr) and N yields (YN in kg km-2 yr-1) range over more than 3 orders of magnitude at this coarse resolution, and that their average population density ranges over 2 orders of magnitude. Hyperactive regions, defined as segments with 5 to 10 times the world average yield (river transfers per unit area of land), are differentially placed for water runoff and total contemporary nitrogen. COSCATs have been designed to facilitate the budget reporting and the analysis of global scale heterogeneity for riverine fluxes and can be applied to other material, such as suspended solids, carbon species or other nutrients, particularly for areas draining into regional seas.

Boesch, D.F. **Scientific requirements for ecosystem-based management in the restoration of Chesapeake Bay and Coastal Louisiana.** *Ecological Engineering* 26(1): 6-26, 2006.

Notes: Ecosystem-based management requires integration of multiple system components and uses, identifying and striving for sustainable outcomes, precaution in avoiding deleterious actions, and adaptation based on experience to achieve effective

solutions. Efforts underway or in planning to restore and manage two major coastal ecosystems, the Chesapeake Bay (Chesapeake Bay Program) and coastal Louisiana (Louisiana Coastal Area Plan and Gulf Hypoxia Action Plan), are examined with respect to these four principles. These multifaceted restoration programs represent among the foremost challenges for science and coastal management in the United States and, thereby, have important implications for addressing the coastal environmental crises being experienced throughout the world. Although frameworks exist for integration of management objectives in both regions, the technical ability for the quantitatively integrated assessment of multiple stressors and strategies is still in an early stage of development. Science is also being challenged to identify sustainable futures, but emerging concepts of ecosystem resilience offer some promising approaches. Precautionary management is best conceived with regard to fisheries, but should become a more explicit consideration for managing risks and avoiding unanticipated consequences of restoration activities. Adaptive management is embraced as a central process in coastal Louisiana ecosystem restoration, but has not formally been implemented in the more mature Chesapeake Bay restoration. Based on these experiences, ecosystem-based management could be advanced by: (1) orienting more scientific activity to providing the solutions needed for ecosystem restoration; (2) building bridges crossing scientific and management barriers to more effectively integrate science and management; (3) directing more attention to understanding and predicting achievable restoration outcomes that consider possible state changes and ecosystem resilience; (4) improving the capacity of science to characterize and effectively communicate uncertainty; and (5) fully integrating modeling, observations, and research to facilitate more adaptive management.

Simenstad, C., Reed, D., and Ford, M. **When is restoration not? Incorporating landscape-scale processes to restore self-sustaining ecosystems in coastal wetland restoration.** *Ecological Engineering* 26(1): 27-39, 2006.

Notes: With increasing restoration initiatives for coastal wetlands, the question of 'What are we restoring to?' becomes more pressing. The goal of this paper is to explore restoration concepts, examples, and challenges from the Pacific and Gulf coasts. One of the fundamental concepts explored is change over time - either in the controlling processes or the restoration structure - and how such changes can be meshed with the goals of various restoration efforts. We subsequently review the concepts of ecosystem trajectories, alternative restoration approaches, and the ideal attributes of functional self-sustaining restoration in the context of realities of restoration planning, design, and implementation. These realities include the dynamics of the ecosystems being restored, very real constraints that are imposed by the contemporary physical and human landscape, and the need to plan for the long term development of restoration sites recognizing that both project performance and expectations may change over time.
