

Marine Science Review - 172

Miscellaneous publications



In this review:

- A. Recent articles – no abstract available
- B. Recent publications available online
- C. Recent articles with abstracts

A. Recent articles – no abstract available

Solan, M., Raffaelli, D.G., Paterson, D.M., White, P.C.L., and Pierce, G.J. **Marine biodiversity and ecosystem function: empirical approaches and future research needs - Introduction.** *Marine Ecology Progress Series* 311: 175-178, 2006.

B. Recent publications available online

Greenwald, N. 2006. **The Bering Sea: A Biodiversity Assessment of Vertebrate Species.** Center for Biological Diversity, Portland, OR and Pacific Environment, San Francisco, CA. 63pp.

Available at: <http://www.biologicaldiversity.org/swcbd/programs/marine/bering/BeringSeaRpt.pdf>

Notes: In a comprehensive assessment of the status of and threats to Bering Sea vertebrate species, the Center for Biological Diversity reviewed nearly 500 references from published and grey literature, online databases, and other information. Based on this review, they determined that at least 549 vertebrate species live in the Bering Sea for all or part of the year, including 418 fish, 102 birds and 29 marine mammals. We classified species' status as non-imperiled, unknown or of conservation concern. Species of concern were further classified as critically imperiled, imperiled or vulnerable. Of the 549 vertebrate species in the Bering Sea, we determined that 335 (61%) have an unknown status, 148 (27%) appear to be non-imperiled and 66 (12%) are of conservation concern. Of the species of concern, 52 (79%) are vulnerable, nine (13.6%) are imperiled, and five (7.6%) are critically imperiled. The fact that most species of concern in the Bering Sea are listed as vulnerable, and thus may not be at immediate risk of extinction, is cause for hope. For many of these species, positive reforms in management could forestall further decline. Of the Bering Sea species of concern, 34 are birds, 21 are marine mammals and 11 are fish. Birds of concern include the critically imperiled Spoon-billed Sandpiper, Kittlitz's Murrelet and Short-tailed Albatross, and the imperiled Spectacled Eider, Steller's Eider, Common Eider and King Eider. Marine mammals of concern include the critically imperiled North Pacific Right Whale and Blue Whale, and the imperiled Steller's Sea Lion, Northern Sea Otter, Ringed Seal, Polar Bear and Pacific Walrus. All of the fish species of concern are listed as vulnerable, primarily due to the lack of detailed information on their status, including Sablefish, Softskin Slickhead, Greenland Turbot, Shortraker Rockfish, Rougheye Rockfish, Shortspine Thornyhead, Broadfin Thornyhead, Blue Lanternfish, Big Skate, Basking Shark and Big Mouth Manefish. Incidental to our search for information on Bering Sea vertebrate species, we also found information indicating six invertebrate species (five species of crab and one species of shrimp) are of concern, and have included these species in the report. We identified potential threats to 22% of all studied Bering Sea species. Commercial fishing, either through direct exploitation, bycatch or competition, potentially impacts the greatest number of Bering Sea species (71), affecting 56% of all species for which we found threat information. Pollution potentially affects the second highest number of species (60, 48%), followed by ecological factors (35, 28%), hunting (26, 20%), global climate change (25, 20%), habitat destruction (25, 20%), human disturbance (21, 17%) and exotic species (21, 17%). These threats are resulting in the decline of a number of Bering Sea wildlife species, placing them at risk of extinction.

C. Recent articles with abstracts

Cowen, R.K., Paris, C.B., and Srinivasan, A. **Scaling of connectivity in marine populations.** *Science* 311(5760): 522-527, 2006.

Notes: Defining the scale of connectivity, or exchange, among marine populations and determining the factors driving this exchange are pivotal to our understanding of the population dynamics, genetic structure, and biogeography of many coastal species. Using a high-resolution biophysical model for the Caribbean region, we report that typical larval dispersal distances of ecologically relevant magnitudes are on the scale of only 10 to 100 kilometers for a variety of reef fish species. We also show the importance of the early onset of active larval movement mediating the dispersal potential. In addition to self-recruitment, larval import from outside the local area is required to sustain most populations, although these population subsidies are very limited in particular systems. The results reveal distinct regions of population isolation based on larval dispersal that also correspond to genetic and morphological clines observed across a range of marine organisms.

Sinclair, A.R.E. and Byrom, A.E. **Understanding ecosystem dynamics for conservation of biota.** *Journal of Animal Ecology* 75(1): 64-79, 2006.

Notes: 1. Ecosystems have higher-order emerging properties that can affect the conservation of species. We identify some of these properties in order to facilitate a better understanding of them. 2. Nonlinear, indirect effects of food web interactions among species can produce counterintuitive changes in populations. 3. Species differ in their roles and linkages with other species in the system. These roles are a property of the system. Such differences in roles influence how we conserve individual species. 4. Ecosystems operate at a multitude of interacting spatial and temporal scales, which together structure the system and affect the dynamics of individual populations. 5. Disturbance also structures an ecosystem, producing both long-term slow changes and sudden shifts in ecosystem dynamics. 6. Ecosystems therefore can have multiple states, determined both by disturbance regimes and biotic interactions. Conservation should recognize a possible multiplicity of natural states while avoiding aberrant (human-induced) states. 7. Ecosystem processes are influenced by the composition of the biota they contain. Disturbances to the biota can distort processes and functions, which in turn can endanger individual species. 8. The goal of ecosystem conservation is the long-term persistence of the biota in the system. There are two paradigms: community-based conservation (CBC) and protected area conservation. Both have their advantages but neither is sufficient to protect the biota on its own. 9. CBC is required to conserve the majority of the world's biota not included in protected areas. However, current CBC methods favour a few idiosyncratic species, distort the species complex, and ignore the majority. More comprehensive methods are required for this approach to meet the goal of ecosystem conservation. 10. Protected areas are essential to conserve species unable to coexist with humans. They also function as ecological baselines to monitor the effects of humans on their own ecosystems. 11. However, protected areas suffer from loss of habitat through attrition of critical areas. Thus, renewal (addition) of habitat is required in order to achieve the long-term persistence of biota in functioning ecosystems. Identification of minimum habitat areas and restoration of ecosystems become two major priorities for future research.

Gruenthal, K.M. and Burton, R.S. **Genetic diversity and species identification in the endangered white abalone (*Haliotis sorenseni*).** *Conservation Genetics* 6(6): 929-939, 2005.

Notes: In 2001, the white abalone *Haliotis sorenseni* became the first marine invertebrate in United States waters to receive federal protection as an endangered species. Prior to the endangered species listing, 20 abalone were collected as potential broodstock for a captive rearing program. Using DNA from these animals, we have developed genetic markers, including five nuclear microsatellite loci and partial sequences of one nuclear (VERL) and two mitochondrial (COI and CytB) genes, to assess genetic variability in the species, aid in species identification, and potentially track the success of future outplanting of captive-reared animals. All five microsatellite loci were polymorphic and followed expectations of simple Mendelian inheritance in laboratory crosses. Each of the wild-caught adult abalone exhibited a unique composite microsatellite genotype, suggesting that significant genetic variation remains in natural populations. A combination of nuclear and mitochondrial gene sequencing demonstrated that one of the original wild-caught animals was, in fact, not a white abalone, but *H. kamtschatkana* (possibly subspecies *assimilis*). Similarly, another animal of uncertain identity accidentally collected by dredging was also shown to be *H. kamtschatkana*. Inclusion of these two animals as broodstock could have resulted in unintentional hybridizations

detrimental to the white abalone recovery program. Molecular genetic identifications will be useful both in preventing broodstock contamination and as markers for future restocking operations.

Patten, B.C. **Network perspectives on ecological indicators and actuators: Enfolding, observability, and controllability.** *Ecological Indicators* 6(1): 6-23, 2006.

Notes: The subject of ecological indicators is both complex and technical. Indicators are low signal/noise read-outs from systems reflecting deeply embedded processes. Informal, single factor indicators reflect superficial properties. Complex systems require formal, multifactorial measures. Conceptual basis, importance and bandwidth of variables, reliability and statistical properties, data and skill requirements, data quality and archiving, robustness under technology change, and cost/benefit issues are factors in indicator design. Network models enable formalism to be brought to the indicator problem. Networks are oriented in time-forward and reverse directions, giving rise to environs. Output environs span network flows derived from inputs, and input environs encompass flows leading to outputs. Both have mathematical descriptions. Variable embedding is a key difficulty in defining and interpreting indicators. Formally, all system energy and matter flows are enfolded within each empirical stock and flow. Embedding in output flows is the source of low signal/noise ratios of indicators. Network enfolding is a powerful expression of systemic holism and the source of what is termed the "indicator problem". Observability and controllability are formal system properties related, respectively, to indication and its reciprocal, actuation. These are defined and illustrated for simple cases. Composite systems have mixed controllable (c), observable (o), uncontrollable (c'), or unobservable (o') elements, in four possible combinations - (c, o), (c, o'), (c', o), and (c', o'). To exert control based on indicators, what available indicators indicate must be matched to what available actuators actuate. That is, (c, o) sectors must jointly be in output environs of manipulated inputs and input environs of indicator outputs - the relevant environs must intersect. If S-a is a linear system to be controlled and S-b a linear controller, theory gives that if S-a and S-b are individually controllable (c) or observable (o), then any uncontrollable (c') or unobservable (o') elements of the control system SaSbSa ... will always be in S-b, never in S-a. This means the system to be controlled can be ignored as a source of c' or o', and improved control can be sought exclusively within the management system, S-b. Though this is limited to linear systems, it illustrates how formal theory can help structure the indicator problem and its relationship to management. A wildlife management (deer) example is discussed both without and with modeling incorporated into S-b. Application of ecological indicators to monitor and manage complex systems is a difficult technical problem. Guidance from formal theory can help clarify its technical dimensions.

Lovejoy, C., Massana, R., and Pedros-Alio, C. **Diversity and distribution of marine microbial eukaryotes in the Arctic Ocean and adjacent seas.** *Applied and Environmental Microbiology* 72(5): 3085-3095, 2006.

Notes: We analyzed microbial eukaryote diversity in perennially cold arctic marine waters by using 18S rRNA gene clone libraries. Samples were collected during concurrent oceanographic missions to opposite sides of the Arctic Ocean Basin and encompassed five distinct water masses. Two deep water Arctic Ocean sites and the convergence of the Greenland, Norwegian, and Barents Seas were sampled from 28 August to 2 September 2002. An additional sample was obtained from the Beaufort Sea (Canada) in early October 2002. The ribotypes were diverse, with different communities among sites and between the upper mixed layer and just below the halocline. Eukaryotes from the remote Canada Basin contained new phylotypes belonging to the radiolarian orders Acantharea, Polycystinea, and Taxopodida. A novel group within the photosynthetic stramenopiles was also identified. One sample closest to the interior of the Canada Basin yielded only four major taxa, and all but two of the sequences recovered belonged to the polar diatom *Fragilariopsis* and a radiolarian. Overall, 42% of the sequences were < 98% similar to any sequences in GenBank. Moreover, 15% of these were < 95% similar to previously recovered sequences, which is indicative of endemic or undersampled taxa in the North Polar environment. The cold, stable Arctic Ocean is a threatened environment, and climate change could result in significant loss of global microbial biodiversity.

Bhadury, P., Mohammad, B.T., and Wright, P.C. **The current status of natural products from marine fungi and their potential as anti-infective agents.** *Journal of Industrial Microbiology and Biotechnology* 33(5): 325-337, 2006.

Notes: A growing number of marine fungi are the sources of novel and potentially life-saving bioactive secondary metabolites. Here, we have discussed some of these novel antibacterial, antiviral, antiprotozoal compounds isolated from marine-derived fungi and their possible roles in disease eradication. We have also discussed the future commercial exploitation of these compounds for possible drug development using metabolic engineering and post-genomics approaches.

Paola, C., Foufoula-Georgiou, E., Dietrich, W. E., Hondzo, M., Mohrig, D., Parker, G., Power, M. E., Rodriguez-Iturbe, I., Voller, V., and Wilcock, P. **Toward a unified science of the Earth's surface: Opportunities for synthesis among hydrology, geomorphology, geochemistry, and ecology.** *Water Resources Research* 42(3): art. W03S10, 2006.

Notes: The Earth's surface is shaped by the interaction of tectonics, water, sediment, solutes, and biota over a wide range of spatial and temporal scales and across diverse environments. Development of a predictive science of Earth surface dynamics integrates many disciplines and approaches, including hydrology, geomorphology, ocean and atmospheric science, sedimentary and structural geology, geochemistry, and ecology. This paper discusses challenges, opportunities, and a few example problems that can serve as pathways toward this integration.

Xu, J.P. **Microbial ecology in the age of genomics and metagenomics: concepts, tools, and recent advances.** *Molecular Ecology* 15(7): 1713-1731, 2006.

Notes: Microbial ecology examines the diversity and activity of micro-organisms in Earth's biosphere. In the last 20 years, the application of genomics tools have revolutionized microbial ecological studies and drastically expanded our view on the previously underappreciated microbial world. This review first introduces the basic concepts in microbial ecology and the main genomics methods that have been used to examine natural microbial populations and communities. In the ensuing three specific sections, the applications of the genomics in microbial ecological research are highlighted. The first describes the widespread application of multilocus sequence typing and representational difference analysis in studying genetic variation within microbial species. Such investigations have identified that migration, horizontal gene transfer and recombination are common in natural microbial populations and that microbial strains can be highly variable in genome size and gene content. The second section highlights and summarizes the use of four specific genomics methods (phylogenetic analysis of ribosomal RNA, DNA-DNA re-association kinetics, metagenomics, and micro-arrays) in analysing the diversity and potential activity of microbial populations and communities from a variety of terrestrial and aquatic environments. Such analyses have identified many unexpected phylogenetic lineages in viruses, bacteria, archaea, and microbial eukaryotes. Functional analyses of environmental DNA also revealed highly prevalent, but previously unknown, metabolic processes in natural microbial communities. In the third section, the ecological implications of sequenced microbial genomes are briefly discussed. Comparative analyses of prokaryotic genomic sequences suggest the importance of ecology in determining microbial genome size and gene content. The significant variability in genome size and gene content among strains and species of prokaryotes indicate the highly fluid nature of prokaryotic genomes, a result consistent with those from multilocus sequence typing and representational difference analyses. The integration of various levels of ecological analyses coupled to the application and further development of high throughput technologies are accelerating the pace of discovery in microbial ecology.

McDonald, M.A., Hildebrand, J.A., and Wiggins, S.M. **Increases in deep ocean ambient noise in the Northeast Pacific west of San Nicolas Island, California.** *Journal of the Acoustical Society of America* 120(2): 711-718, 2006.

Notes: Recent measurement at a previously studied location illustrates the magnitude of increases in ocean ambient noise in the Northeast Pacific over the past four decades. Continuous measurements west of San Nicolas Island, California, over 138 days, spanning 2003-2004 are compared to measurements made during the 1960s at the same site. Ambient noise levels at 30-50Hz were 10-12dB higher (95% CI=2.6dB) in 2003-2004 than in 1964-1966, suggesting an average noise increase rate of 2.5-3dB per decade. Above 50Hz the noise level differences between recording periods gradually diminished to only 1-3dB at 100-300Hz. Above 300Hz the 1964-1966 ambient noise levels were higher than in 2003-2004, owing to a diel component which was absent in the more recent data. Low frequency (10-50Hz) ocean ambient noise levels are closely related to shipping vessel traffic. The number of commercial vessels plying the world's oceans approximately doubled between 1965 and 2003 and the gross tonnage quadrupled, with a corresponding increase in horsepower. Increases in commercial shipping are believed to account for the observed low-frequency ambient noise increase.

Sogin, M.L., Morrison, H.G., Huber, J.A., Welch, D.M., Huse, S.M., Neal, P.R., Arrieta, J.M., and Herndl, G.J. **Microbial diversity in the deep sea and the underexplored "rare biosphere"**. *Proceedings of the National Academy of Sciences [USA]* 103(32): 12115-12120, 2006.

Notes: The evolution of marine microbes over billions of years predicts that the composition of microbial communities should be much greater than the published estimates of a few thousand distinct kinds of microbes per liter of seawater. By adopting a massively parallel tag sequencing strategy, we show that bacterial communities of deep water masses of the North Atlantic and diffuse flow hydrothermal vents are one to two orders of magnitude more complex than previously reported for any microbial environment. A relatively small number of different populations dominate all samples, but thousands of low-abundance populations account for most of the observed phylogenetic diversity. This "rare biosphere" is very ancient and may represent a nearly inexhaustible source of genomic innovation. Members of the rare biosphere are highly divergent from each other and, at different times in earth's history, may have had a profound impact on shaping planetary processes.

Schlesinger, W.H. **Global change ecology**. *Trends in Ecology and Evolution* 21(6): 348-351, 2006.

Notes: Ecology has expanded from its traditional focus on organisms to include studies of the Earth as an integrated ecosystem. Aided by satellite technologies and computer models of the climate of the Earth, global change ecology now records basic parameters of our planet, including its net primary productivity, biogeochemical cycling and effects of humans on it. As I discuss here, this new perspective shows us what must be done to transform human behaviors to enable the persistence of life on Earth under human stewardship

Briggs, J.C. **Proximate sources of marine biodiversity**. *Journal of Biogeography* 33(1): 1-10, 2006.

Notes: When temperature and other kinds of barrier divide formerly continuous populations and confine them to more restricted geographical areas, there is an evolutionary reaction that will, over time, result in the formation of endemic species. In such cases, an allopatric speciation process is considered to have taken place because reproductive isolation was caused by physical means instead of by natural selection. In contrast, when populations exist in a very high-diversity area and remain undivided by physical events, they exhibit a tendency to speciate by means of sympatry (or parapatry). This process, sometimes called competitive or ecological speciation, does involve reproductive isolation by means of natural selection. Populations that exist in geographical provinces bounded by physical barriers add to the overall diversity through the production of endemic species. This increase by species packing is relatively slow due to the very gradual tempo of the allopatric speciation process. Populations existing in centres of origin add to the general diversity through the production of species that are dominant in terms of their ability to spread over large parts of the world. It is proposed that such species are usually formed by sympatric speciation, a process that can be c. 20 times faster than species formation by allopatry. It is not suggested that sympatry is exclusive to centres of origin, nor that allopatry is confined to peripheral provinces. Both processes are widespread, but there do appear to be distinctive geographical concentrations. Considering that numbers of widespread species produced by centres of origin may eventually become subdivided by barriers, and thus give rise to descendants by allopatry, it is difficult to say how much of our present species diversity has come from one source or the other. Both speciation by sympatry from centres of origin and speciation by allopatry in peripheral provinces appear to be important sources of marine biodiversity.

Deredec, A. and Courchamp, F. **Combined impacts of Allee effects and parasitism**. *Oikos* 112(3): 667-679, 2006.

Notes: Despite their individual importance for population dynamics and conservation biology, the combined impacts of Allee effects and parasitism have received little attention. We built a mathematical model to compare the dynamics of populations with or without Allee effects when infected by microparasites. We show that the influence of an Allee effect takes the form of a tradeoff. The presence of an Allee effect in host populations may protect them, by reducing the range of population sizes that allow parasite spread. Yet if infection spreads, the Allee effect weakens host populations by reducing their size and by widening the range of parasite species that lead them to extinction. These results have important implications for predicting

the survival of threatened populations or the success of reintroductions, and may help define size ranges within which given populations should be maintained to prevent both epidemics and Allee effects driven extinctions.

Groffman, P., Baron, J., Blett, T., Gold, A., Goodman, I., Gunderson, L., Levinson, B., Palmer, M., Paerl, H., Peterson, G., Poff, N., Rejeski, D., Reynolds, J., Turner, M., Weathers, K., and Wiens, J. **Ecological thresholds: The key to successful environmental management or an important concept with no practical application?** *Ecosystems* 9(1): 1-13, 2006.

Notes: An ecological threshold is the point at which there is an abrupt change in an ecosystem quality, property or phenomenon, or where small changes in an environmental driver produce large responses in the ecosystem. Analysis of thresholds is complicated by nonlinear dynamics and by multiple factor controls that operate at diverse spatial and temporal scales. These complexities have challenged the use and utility of threshold concepts in environmental management despite great concern about preventing dramatic state changes in valued ecosystems, the need for determining critical pollutant loads and the ubiquity of other threshold-based environmental problems. In this paper we define the scope of the thresholds concept in ecological science and discuss methods for identifying and investigating thresholds using a variety of examples from terrestrial and aquatic environments, at ecosystem, landscape and regional scales. We end with a discussion of key research needs in this area.

Helfield, J.M. and Naiman, R.J. **Keystone interactions: Salmon and bear in riparian forests of Alaska.** *Ecosystems* 9(2): 167-180, 2006.

Notes: The term "keystone species" is used to describe organisms that exert a disproportionately important influence on the ecosystems in which they live. Analogous concepts such as "keystone mutualism" and "mobile links" illustrate how, in many cases, the interactions of two or more species produce an effect greater than that of any one species individually. Because of their role in transporting nutrients from the ocean to river and riparian ecosystems, Pacific salmon (*Oncorhynchus* spp.) and brown bear (*Ursus arctos*) have been described as keystone species and mobile links, although few data are available to quantify the importance of this interaction relative to other nutrient vectors. Application of a mass balance model to data from a southwestern Alaskan stream suggests that nitrogen (N) influx to the riparian forest is significantly increased in the presence of both salmon and bear, but not by either species individually. The interactions of salmon and bear may provide up to 24% of riparian N budgets, but this percentage varies in time and space according to variations in salmon escapement, channel morphology and watershed vegetation characteristics, suggesting interdependence and functional redundancy among N sources. These findings illustrate the complexity of interspecific interactions, the importance of linkages across ecosystem boundaries and the necessity of examining the processes and interactions that shape ecological communities, rather than their specific component parts.

Lees, K., Pitois, S., Scott, C., Frid, C., and Mackinson, S. **Characterizing regime shifts in the marine environment.** *Fish and Fisheries* 7(2): 104-127, 2006.

Notes: Recent years have seen a plethora of studies reporting that 'regime shifts' have occurred in the North Atlantic and Pacific Oceans during the last century. In many cases, the criteria used to distinguish a regime shift have not been explicitly stated. In other cases, a formal definition has been proposed and the data set assessed against it. Developing a universal quantitative definition for identifying and distinguishing between purported climatic and ecological regime shifts has proved problematic as many authors have developed criteria that seem unique to the system under study. Consequently, they throw little light on the drivers of ecological regime shifts. Criteria used to define regime shifts are reviewed and on the basis of evidence from purported regime shifts, common characteristics in the speed and amplitude of the changes and the duration of quasi-stable states are used to propose a more clearly defined set of criteria for defining climatic and ecological regime shifts. Causal drivers of regime shifts are explored using correlation analysis. Limitations of these methods are discussed.

Saenz-Arroyo, A., Roberts, C.M., Torre, J., Carino-Olvera, M., and Hawkins, J.P. **The value of evidence about past abundance: marine fauna of the Gulf of California through the eyes of 16th to 19th century travellers.** *Fish and Fisheries*

Notes: Eyewitness accounts written by early travellers to 'the new worlds' provide valuable insights into how seascapes once looked. Although this kind of information has been widely used to chart human impacts on terrestrial ecosystems, it has been greatly overlooked in the marine realm. Here we present a synthesis of 16th to 19th century travellers' descriptions of the Gulf of California and its marine wildlife. The diaries written by conquerors, pirates, missionaries and naturalists described a place in which whales were 'innumerable,' turtles were 'covering the sea' and large fish were so abundant that they could be taken by hand. Beds of pearl oysters that are described had disappeared by 1940 and only historical documents reveal the existence of large, widespread, deep pearl oyster reefs, whose ecology and past functions we know little about. Disqualifying the testimonies of early visitors to a region as 'anecdotal' is dangerous; it may lead to setting inappropriate management targets that could lead to the extinction of species that are rare today but were once much more abundant. Moreover, it represents unfair historical judgement on the work of early natural historians, scholars and scientists. We suggest that the review and analytical synthesis of reports made by early travellers should become part of the pre-requisites for deciding how to manage marine ecosystems today.

Wright, J.P. and Jones, C.G. **The concept of organisms as ecosystem engineers ten years on: Progress, limitations, and challenges.** *BioScience* 56(3): 203-209, 2006.

Notes: The modification of the physical environment by organisms is a critical interaction in most ecosystems. The concept of ecosystem engineering acknowledges this fact and allows ecologists to develop the conceptual tools for uncovering general patterns and building broadly applicable models. Although the concept has occasioned some controversy during its development, it is quickly gaining acceptance among ecologists. We outline the nature of some of these controversies and describe some of the major insights gained by viewing ecological systems through the lens of ecosystem engineering. We close by discussing areas of research where we believe the concept of organisms as ecosystem engineers will be most likely to lead to significant insights into the structure and function of ecological systems.

Crain, C.M. and Bertness, M.D. **Ecosystem engineering across environmental gradients: Implications for conservation and management.** *BioScience* 56(3): 211-218, 2006.

Notes: Ecosystem engineers are organisms whose presence or activity alters their physical surroundings or changes the flow of resources, thereby creating or modifying habitats. Because ecosystem engineers affect communities through environmentally mediated interactions, their impact and importance are likely to shift across environmental stress gradients. We hypothesize that in extreme physical environments, ecosystem engineers that ameliorate physical stress are essential for ecosystem function, whereas in physically benign environments where competitor and consumer pressure is typically high, engineers support ecosystem processes by providing competitor- or predator-free space. Important ecosystem engineers alleviate limiting abiotic and biotic stresses, expanding distributional limits for numerous species, and often form the foundation for community development. Because managing important engineers can protect numerous associated species and functions, we advocate using these organisms as conservation targets, harnessing the benefits of ecosystem engineers in various environments. Developing a predictive understanding of engineering across environmental gradients is important for furthering our conceptual understanding of ecosystem structure and function, and could aid in directing limited management resources to critical ecosystem engineers.

Brook, B.W., Traill, L.W., and Bradshaw, C.J.A. **Minimum viable population sizes and global extinction risk are unrelated.** *Ecology Letters* 9(4): 375-382, 2006.

Notes: Theoretical and empirical work has shown that once reduced in size and geographical range, species face a considerably elevated risk of extinction. We predict minimum viable population sizes (MVP) for 1198 species based on long-term time-series data and model-averaged population dynamics simulations. The median MVP estimate was 1377 individuals (90% probability of persistence over 100 years) but the overall distribution was wide and strongly positively skewed. Factors commonly cited as correlating with extinction risk failed to predict MVP but were able to predict successfully the probability of World Conservation Union Listing. MVPs were most strongly related to local environmental variation rather than a species'

intrinsic ecological and life history attributes. Further, the large variation in MVP across species is unrelated to (or at least dwarfed by) the anthropogenic threats that drive the global biodiversity crisis by causing once-abundant species to decline.

Borrvall, C. and Ebenman, B. **Early onset of secondary extinctions in ecological communities following the loss of top predators.** *Ecology Letters* 9(4): 435-442, 2006.

Notes: The large vulnerability of top predators to human-induced disturbances on ecosystems is a matter of growing concern. Because top predators often exert strong influence on their prey populations their extinction can have far-reaching consequences for the structure and functioning of ecosystems. It has, for example, been observed that the local loss of a predator can trigger a cascade of secondary extinctions. However, the time lags involved in such secondary extinctions remain unexplored. Here we show that the loss of a top predator leads to a significantly earlier onset of secondary extinctions in model communities than does the loss of a species from other trophic levels. Moreover, in most cases time to secondary extinction increases with increasing species richness. If local secondary extinctions occur early they are less likely to be balanced by immigration of species from local communities nearby. The implications of these results for community persistence and conservation priorities are discussed.

Petchey, O.L. and Gaston, K.J. **Functional diversity: back to basics and looking forward.** *Ecology Letters* 9(6): 741-758, 2006.

Notes: Functional diversity is a component of biodiversity that generally concerns the range of things that organisms do in communities and ecosystems. Here, we review how functional diversity can explain and predict the impact of organisms on ecosystems and thereby provide a mechanistic link between the two. Critical points in developing predictive measures of functional diversity are the choice of functional traits with which organisms are distinguished, how the diversity of that trait information is summarized into a measure of functional diversity, and that the measures of functional diversity are validated through quantitative analyses and experimental tests. There is a vast amount of trait information available for plant species and a substantial amount for animals. Choosing which traits to include in a particular measure of functional diversity will depend on the specific aims of a particular study. Quantitative methods for choosing traits and for assigning weighting to traits are being developed, but need much more work before we can be confident about trait choice. The number of ways of measuring functional diversity is growing rapidly. We divide them into four main groups. The first, the number of functional groups or types, has significant problems and researchers are more frequently using measures that do not require species to be grouped. Of these, some measure diversity by summarizing distances between species in trait space, some by estimating the size of the dendrogram required to describe the difference, and some include information about species' abundances. We show some new and important differences between these, as well as what they indicate about the responses of assemblages to loss of individuals. There is good experimental and analytical evidence that functional diversity can provide a link between organisms and ecosystems but greater validation of measures is required. We suggest that non-significant results have a range of alternate explanations that do not necessarily contradict positive effects of functional diversity. Finally, we suggest areas for development of techniques used to measure functional diversity, highlight some exciting questions that are being addressed using ideas about functional diversity, and suggest some directions for novel research.

McLoughlin, P.D., Taylor, M.K., and Messier, F. **Conservation risks of male-selective harvest for mammals with low reproductive potential.** *Journal of Wildlife Management* 69(4): 1592-1600, 2005.

Notes: We used harvested, stochastic population models for grizzly bears (*Ursus arctos*) and polar bears (*U. maritimus*) to illustrate the propensity for male-biased harvesting to reduce mean male age and numbers of sexually mature males for species with relatively low reproductive potential. We compared our results with those obtained from caribou (*Rangifer tarandus*), an annually reproducing species with relatively high reproductive potential. Differences in the rate at which mean ages and numbers of sexually mature males were reduced by harvesting was a function of differences in species life history of species, but also the extent to which young animals were protected from hunting. For example, the length of each species' reproductive cycle (we modeled 1 year for caribou, 2 years for bears) determined the degree to which sex-biased harvest was also age-biased. Proportionately more young bears were protected from harvest than young caribou due to the multiannual, rather than annual, parental care afforded young bears (we assumed all females with accompanying offspring were invulnerable

to harvest). This additional age-bias in the hunt served to direct offtake toward adult males; consequently, as male selectivity in the kill increased, mean ages of bears declined at rates that were higher than for caribou. For species with low reproductive potential, we believe there is a real possibility that persistence probabilities may be overestimated if, after prolonged sex-selective harvest, lack of sexually mature males in the population impairs fecundity. We encourage further development of population models that incorporate potentially negative, hunting-induced impacts on reproduction. In particular, we support the development of models that link the mean age of males or frequency of adult males in a population to the rate at which females are successfully mated.

DeYoung, R.W. and Honeycutt, R.L. **The molecular toolbox: Genetic techniques in wildlife ecology and management.** *Journal of Wildlife Management* 69(4): 1362-1384, 2005.

Notes: Genetic data can provide a powerful tool for those interested in the ecology and management of wildlife, especially when it is combined with behavioral, demographic, or spatial information. Although the full potential of genetic approaches to the study of wildlife populations has yet to be realized, the application of genetic analyses is becoming increasingly feasible and cost-effective. This is due primarily to recent advances in the number and types of genetic markers available, the development of sophisticated data analysis methods, and increased automation of laboratory instrumentation. These technological advances have broadened the list of questions that can be answered with genetic data, allowing inference at multiple levels of resolution (inter-individual to inter-specific) and temporal and spatial scales. Genetic data can be used to assess mating systems, hybridization, gene flow, effective population size, and population viability. Genetic data can also be used to define management units; identify individuals, sex, and species; and to provide insights into demographic patterns associated with the reduction and expansion of populations. All of these factors are either related to a species' ecology or provide important information for management and conservation. We describe some applications of genetic data, discuss processes affecting genetic variation within and among populations, and provide an overview of genetic terminology and how genetic variation is measured. As genetic methods become progressively more accessible and adaptable to an ever-widening array of questions, it is expected that they will play an increasingly important role in the ecology and management of wildlife.

Leberg, P. **Genetic approaches for estimating the effective size of populations.** *Journal of Wildlife Management* 69(4): 1385-1399, 2005.

Notes: The effective population size (N_e) provides information on how fast genetic variation is being lost, or relatedness is increasing, in a population of interest. This parameter is often considered to be related to population viability. Genetic approaches offer several avenues for estimating N_e ; recent developments have helped relax assumptions of closed populations and stable population sizes that have hindered the estimation of N_e in many wildlife populations. The most promising areas of development are in the assessment of temporal changes in genetic composition for the estimation of contemporary N_e and the application of coalescent theory for estimation of historical N_e . Application of most estimators still requires making some questionable assumptions about wildlife populations. In general, these methods will be most beneficial when used in conjunction with current and historical demographic information.

Duffy, J.E. and Stachowicz, J.J. **Why biodiversity is important to oceanography: potential roles of genetic, species, and trophic diversity in pelagic ecosystem processes.** *Marine Ecology Progress Series* 311: 179-189, 2006.

Notes: The functioning of the global ecosystem is mediated in large part by pelagic marine organisms through their influence on biomass production, elemental cycling, and atmospheric composition. Growing theoretical and empirical evidence suggests that the stability and functioning of this complex system may depend, not only on aggregate biomass and production of pelagic producers and consumers, but also on the composition and richness of taxa within those compartments, yet rigorous experimental tests of relationships between diversity and these aspects of pelagic ecosystem functioning are virtually unknown. Here, we argue for more attention to such research, and we marshal preliminary evidence that several mechanisms underlying diversity effects on ecosystem processes in marine benthic and terrestrial systems also may operate in pelagic systems. We review selected examples of how genetic, species, and functional group diversity may affect ocean ecosystem processes. We consider 3 types of examples that detail how (1) producer richness or composition can directly affect ecosystem processes, (2) consumer diversity can directly and indirectly affect these same processes, and (3) diversity at and below the species level can

reduce variation of communities through time and enhance their resistance to perturbations. We suggest several promising avenues for assessing the role of biodiversity in pelagic ecosystems. Understanding and predicting responses of the global ocean ecosystem to accelerating climate and environmental change will be enhanced by more explicit and systematic attention to the functional diversity of microbial and macroscopic marine life.

Stachowicz, J.J. and Byrnes, J.E. **Species diversity, invasion success, and ecosystem functioning: disentangling the influence of resource competition, facilitation, and extrinsic factors.** *Marine Ecology Progress Series* 311: 251-262, 2006.

Notes: Experimental manipulations and observational surveys often produce conflicting conclusions regarding the effects of native species diversity on community susceptibility to invasion. Both provide useful pieces of information, but typically each asks fundamentally different questions. Surveys tell us that locations with species-rich native communities are characterized by conditions that promote exotic species richness, whereas experiments tell us that, within a location, the loss of resident species increases the likelihood of the establishment of new species. In the present study, we apply observational data to a study of the consequences of species loss for invasion in order to assess the generality across scales and the relative importance of experimental results. We begin by using long-term recruitment data to explore how small-scale mechanisms of biotic resistance could operate on a landscape scale. We find that individual species have complementary seasonal recruitment patterns such that more diverse communities might be able to more consistently fill space that opens throughout the season, leading to reduced invasion success. However, field surveys of native and invader richness show that the slope of the relationship between native and invader diversity changes with the availability of resources (space) and the presence of habitat-forming foundation species. In these systems, biotic resistance appears to be important only when resources are scarce and foundation species are rare. Thus, we conclude that biotic resistance, as identified in experiments, is a consistent effect of diversity that can be explained mechanistically at even a landscape scale, but that it plays a dominant role only when total diversity is constrained by resource limitation. This situation is common in experimentally constructed communities, but may be less so in nature.

Ieno, E.N., Solan, M., Batty, P., and Pierce, G.J. **How biodiversity affects ecosystem functioning: roles of infaunal species richness, identity and density in the marine benthos.** *Marine Ecology Progress Series* 311: 263-271, 2006.

Notes: The extent to which changes in biodiversity are causally linked to key ecosystem processes is a primary focus of contemporary ecological research. Highly controlled manipulative experiments have revealed significant and positive effects of increased diversity on ecosystem functioning, but uncertainties in experimental design have made it difficult to determine whether such effects are related to the number of species or to effects associated with species identity and density. Using infaunal marine invertebrates, we established 2 parallel laboratory experiments to examine the hypothesis that changes in the composition of benthic macrofauna alter the biogeochemistry of coastal intertidal mudflats. Our study identified clear effects of increased infaunal species diversity on nutrient generation. However, significant species identity and density effects underpin the observed response, reflecting species-specific traits associated with bioturbation. Post-hoc examination of our conclusions using power analysis revealed that, given our experimental design, the probability of finding a correct significant effect, the minimum detectable difference necessary to detect a significant effect, and the minimum number of replicates necessary in order to achieve an acceptable power, all differed between species. Our study has important implications for the design of biodiversity-ecosystem function experiments because the disparity between the contributions that individual species make to ecosystem function demands the use of different levels of replication for each species within an experiment.

Raffaelli, D.G. **Biodiversity and ecosystem functioning: issues of scale and trophic complexity.** *Marine Ecology Progress Series* 311: 285-294, 2006.

Notes: Research on the relationship between biodiversity and ecosystem functioning is entering a new phase. The main driver behind this is an awareness that biodiversity loss operates at large spatial scales and generally involves reductions and changes in species at different trophic levels simultaneously. Evaluating how ecosystem processes are likely to change following species loss at multiple trophic levels will be difficult because of the feedbacks between levels and between levels and the ecosystem processes of interest. Similarly, carrying out manipulative experiments designed to accommodate multiple trophic levels at the landscape scales in which society is interested will be extremely challenging. Novel approaches, such as the BioMERGE

(Biotic Mechanisms of Ecosystem Regulation in the Global Environment) initiative, are needed. In addition, future work should be more services-oriented, rather than process-oriented, if effects of biodiversity change on services are to be properly assessed. Finally, the application of mainstream ecosystem ecology to biodiversity-ecosystem functioning research seems to have been neglected to date. In this respect, there is potential for the mass-balance approach to contribute to the debate.

Naeem, S. **Expanding scales in biodiversity-based research: challenges and solutions for marine systems.** *Marine Ecology Progress Series* 311: 273-283, 2006.

Notes: As in terrestrial biodiversity, human influences over marine biodiversity will alter the way ecosystems contribute to biogeochemical or ecosystem processes. While many studies have documented how alterations of terrestrial biology affect ecosystem functioning, few studies have examined marine systems. The main challenge faced by biodiversity and ecosystem functioning (BEF) research in marine ecology is dealing with the large scales of marine systems and the logistical difficulties of attempting to conduct the kinds of complex, combinatorial experiments that have been done in terrestrial ecology. BioMERGE (Biotic Mechanisms of Ecosystem Regulation in the Global Environment) has developed a framework for relating biodiversity, via biomass, to ecosystem functioning and for employing extinction scenarios to explore the realm of possible changes in ecosystem functioning that biodiversity loss could create. This approach may find much utility in marine BEF research because it obviates the need for complex experiments. I provide an overview of the issues, the framework, and some directions marine ecology could take to further our understanding of the ecosystem consequences of marine biodiversity loss.

Bulling, M.T., White, P.C.L., Raffaelli, D.G., and Pierce, G.J. **Using model systems to address the biodiversity-ecosystem functioning process.** *Marine Ecology Progress Series* 311: 295-309, 2006.

Notes: Declines in biodiversity resulting from anthropogenic disturbance to ecosystems have focused attention on the role of biodiversity in ecosystem functioning. However, the high level of complexity of ecosystems has made this a difficult topic to investigate. Much simpler model systems incorporating small-scale, spatially delimited, artificial assemblages of species have been widely used recently to address the link between biodiversity and ecosystem functioning (BEF). Their simplicity lends tractability to these systems, but has also resulted in much criticism in the literature over their relevance. Here, we examine the strengths and limitations of model systems and examine how useful these systems might be in addressing several issues that are likely to represent future challenges to understanding BEF: spatial scale, multiple trophic levels, variation, environmental stochasticity and the choice of representative combinations of species. We find that model systems have already played an important role in enhancing our understanding of BEF and are likely to continue this role in the future. However, they do have important limitations, and it is essential to take these into account when putting results into the broader context of ecosystems and to improve the level of integration of results with those from other methodologies.