E-Letter responses to:

reports:
Ann F. Budd and John M. Pandolfi
Evolutionary Novelty Is Concentrated at the Edge of Coral Species Distributions
Science 2010; 328: 1558-1561 [Abstract] [Full text] [PDF]

E-Letters: Submit a response to this article

PUBLISHED E-LETTER RESPONSES:

Response to C. Klein *et al*.'s E-Letter

24 September 2010

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Respond to this E-Letter:
Re: Response to C. Klein *et al*.'s E-Letter

We are delighted that the conservation community is so quickly developing ways to implement practical solutions to spatial reserve design integrating studies of the fossil record. Quantitative methods in conservation science have advanced substantially in recent years, especially in the area of spatial conservation prioritization (*1*). The new methods include species distribution modeling, metapopulation modeling, population viability modeling and uncertainty analysis, as well as integrating economic costs (*2*, *3*). However, as C. Klein *et al*. admit, the primary biological data for most of the new spatial analyses involve species-level compositional information (*1*), including modern species occurrences and population sizes, and the primary metrics for identifying biodiversity centers or hotspots involve species richness, endemics, and rare or threatened species (*4*). Methods for analyzing other aspects of biodiversity, such as genetic and phylogenetic information and evolutionary processes, are still under development and have not been widely used in practice.

Klein *et al*.'s interest in our Report ("Evolutionary novelty is concentrated at the edge of coral species distributions," A. F. Budd, J. M. Pandolfi, 18 June 2010, p. 1558) underscores the importance of including evolutionary processes in conservation prioritization. Our approach advocates the use of fossil data in examining the role of long-term processes such as speciation, extinction, and the creation of evolutionary novelty in conservation science. Although conservation biologists make token mention of mass extinction events in Earth's history, fossil data have not been used to establish conservation priorities, and may provide a critical, yet heretofore untapped, long-term perspective to address management strategies (*5*–*9*), especially in the face of global phenomena such as climate change. As K. J. Willis *et al*. argue (*6*), "without an understanding of past variability, it is impossible to manage for the present or future." Our morphometric analyses agree with inferences based on molecular data, and add a longer time dimension than can be had by studying only modern species distributions and habitats. We applaud the inclusion of these and other evolutionary measures in the practical application of conservation priorities.

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Conserving Evolutionary Novelty on the Edge 24 September 2010

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Respond to this E-Letter:
Re: Conserving Evolutionary Novelty on the Edge

In their Report ("Evolutionary novelty is concentrated at the edge of coral species distributions," 18 June 2010, p. 1558), A. F. Budd and J. M. Pandolfi state that conservation priorities are determined based on species richness, endemism, and threats, but they misrepresent how spatial priorities are actually determined (*1*). These older approaches have been criticized (*2, 3*) and replaced by alternative spatial prioritization approaches (*1*) and are commonly used to design marine reserves [such as Great Barrier Reef (*4*), Kimbe Bay (*5*), and California (*6*)].

Budd and Pandolfi found that coral evolutionary novelty is concentrated at the edge of species distributions for one coral complex. They concluded that edge areas, along with population connectivity, should play a role in conservation prioritization. Several approaches for incorporating evolutionary processes into conservation prioritization exist, using data on phylogenetic diversity, evolutionary significant units, phylogeography, and evolutionary innovation (*7–13*). Given the paucity of data on spatial processes, this remains mostly a theoretical exercise (*13*). Proposing practical solutions to implement this idea into standard reserve design approaches is the next step.

The simplest way of including species distribution edges is to represent a fraction of the periphery of each species' distribution in a reserve network. Given the lack of marine species distribution data, it may be necessary to include the edges of commonly used biodiversity surrogates, such as habitats. Although this approach can be readily applied to any marine planning process, it's not without caveats: (i) Decisions about which of all important edges and how much of each to include are necessary; and (ii) where range limits of many species do not coincide, their incorporation may result in a larger reserve network than is feasible. These problems could be magnified if connectivity data were added.

Protecting peripheral areas will help promote the long-term persistence of biodiversity despite these challenges. Making decisions about the inevitable trade-offs between other conservation objectives (such as resilience and socioeconomics) remains one of the greatest unsolved problems in conservation planning that requires future work.

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Evolutionary Novelty at Range Edges for Coral Reef Organisms 8 September 2010

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Respond to this E-Letter:
Re: Evolutionary Novelty at Range Edges for Coral Reef Organisms

A. F. Budd and J. M. Pandolfi recently concluded that edge zones and peripheral locations represent areas of evolutionary novelty where species fuse (hybridization) or split (peripatric or parapatric speciation) ("Evolutionary novelty is concentrated at the edge of coral species distributions," Reports, 18 June 2010, p. 1558). Their study was limited to corals in the Caribbean, but accumulating evidence from other recent studies indicates that this is a global pattern for coral reef organisms in general.

Reef fishes are the most diverse vertebrate assemblages on earth, and the greatest number of hybrids occur at two isolated Indian Ocean locations that represent the range edge for both Indian and Pacific Ocean species (*1*). Similarly, in the Pacific Ocean, reef fish hybridization is concentrated at peripheral range-edge locations (*2*). For a variety of coral reef organisms, these peripheral locations also represent concentrations of genetically unique populations and centers of endemicity that are indicative of peripatric speciation (*3–5*).

Coral reefs support the greatest diversity of marine life, but this diversity is under threat from escalating anthropogenic impacts. While conservation efforts aim to minimize biodiversity loss, protecting the processes that generate evolutionary novelty and biodiversity at peripheral range-edge locations should be a priority.

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Conserve Unique Arabian Gulf Corals 10 August 2010

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Respond to this E-Letter:
Re: Conserve Unique Arabian Gulf Corals

A. F. Budd and J. M. Pandolfi ("Evolutionary novelty is concentrated at the edge of coral species distributions," Reports, 18 June 2010, p. 1558) use Pleistocene Caribbean examples to show increased novelty in speciation and adaptation at the edges of coral distribution. In modern corals, stressful environments with lower connectivity also caused novel speciation, environmental tolerance and niche exploitation in the Indian Ocean (IO). Budd and Pandolfi also stress the importance of peripheral areas for conservation, but these very areas are under grave threat.

The Arabian Gulf in the extreme northwest of the IO reef belt has two endemic species (*Acropora downingi, Porites harrisoni*) as its most common corals. A fairly recent flooding history (*1*), isolation due to the narrow Straits of Hormuz, and repeated mass mortality (*2*) have led to variably depressed and isolated coral populations with a strong likelihood of introgression. Arabian Gulf corals have unusual temperature resistance with the highest known bleaching thresholds. Regular temperature variability (14 to 35.5ºC with extremes of 12 to 37.5ºC on coral reefs) exceeds predictions for thermal death for most tropical corals. Morphological and ecological novelty is also expressed at the southeast extreme of the IO reef belt (Mozambique, South Africa) where endemic Acropora (*A. branchi, A. mossambica*) occur exclusively in the intertidal (*3*) and are also adapted to extremely high temperatures and desiccation.

Despite their obvious biological importance, Arabian Gulf coral reefs are among the most threatened in the world. Rampant construction rapidly alters the coastal and offshore systems and some Gulf states have lost most of their natural coastlines and with it all of their formerly rich coral reefs (*1*). Climate change has already led to increasingly frequent temperature extremes compromising many communities and threatening the endemics (*2*). Budd and Pandolfi's Report should serve as a call for increased conservation and research efforts in these peripheral coral systems.

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