THE NEED FOR NEW CONSERVATION STRATEGIES AND POLICIES IN A HIGH CO₂ WORLD

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The CO$_2$ Problem

“...the current rate of...CO$_2$ release stands out as capable of driving a combination and magnitude of ocean geochemical changes potentially unparalleled in at least the last ~300 My of Earth history, raising the possibility that we are entering an unknown territory of marine ecosystem change.”

Hönisch, et al. 2012 Science 335, 1058-

“...warming and ocean acidification will intensify before they decline even with immediate reduction in emissions. There is an urgent need for immediate and decisive conservation action. Otherwise, another great mass extinction affecting all ocean ecosystems and comparable to the upheavals of the geological past appears inevitable.”

Jackson 2010. Phil. Trans. R. Soc. B 365:3765-
By 2100, the cost of damage [to the ocean] if we follow the high \([\text{CO}_2]\) emission pathway rises to USD 1,980 billion [/yr].... the amount that can be saved by lowering emissions, is well over a trillion dollars per year by 2100...”

Conclusions –

- The ongoing rapid changes to ocean temperature and chemistry seriously threaten the marine environment and the goods and services it provides.
- Planetary-scale actions are urgently needed to avoid these threats.

So what actions are currently advocated by ocean policy?
Sampling of GO and NGO policy/action statements

Suggested actions – 3 primary policy statements

1. Stabilize if not reduce atmospheric CO₂ concentration

2. Measure, monitor, model, and predict CO₂ effects on the marine environment.

3. Maximize resilience and adaptation potential of marine biota by minimizing non-CO₂ impacts using conventional conservation methods, e.g. MPA’s, pollution and overfishing reduction, etc.

*All are necessary, but are they achievable/sufficient to preserve marine ecosystems?*
1) Stabilize atmospheric CO₂:

Unrelenting increase in atmospheric CO₂ despite increasing awareness of risks and increasing efforts to reduce emissions -

- 1997 Kyoto Protocol
- 1992 Rio Convention “prevent dangerous anthropogenic interference”
- 2001 Marrakesh Accords
- 2009 COP 15 Copenhagen

1908 S. Arrenhius predicts CO₂ from fossil fuel burning will cause global warming

IPCC Reports: 1rst

2008-9 Economic downturn 7% reduction in US emissions
2) Measure, monitor, model, and predict effects

- Essential to understand nature and magnitude of the problem, and to inform marine conservation and management efforts

- But does not offer specific remedies to problem
3) Maximize resilience and adaptation using conventional conservation methods

“Climate change is likely to be the dominant driver of ecological change in the 21st century and removing local stressors may not be enough to maintain biological diversity. We believe that there is hope for the survival of natural ecosystems in a changing climate. However, the emphasis of the global conservation agenda needs to shift substantially from dealing with tractable, local stressors to tackling the more fundamental problem of curbing atmospheric CO$_2$ emissions.”

“It is clear from the on-going loss of biodiversity…that current conservation efforts, whether through PAs [protected areas] alone or in combination with other approaches, are not coping with the challenge. The data also indicate that the likelihood of success is small unless the conservation community radically rethinks the strategies needed.
3) Maximize resilience and adaptation using conventional conservation methods (cont.)

“It is likely that such an approach alone might not give corals enough time or space to survive in enough numbers to adapt..... We suggest taking a more aggressive approach to coral reef management and beginning to consider assisting corals in speeding up evolution. Without an aggressive, hands-on approach to wildlife management most big, charismatic mammals would today be extinct. We believe that coral reefs deserve similar attention and action.”

Riegl and Purkis 2011. in response to Pandolfi et al. 2011 Science 333: 418-
http://www.sciencemag.org/content/333/6041/418/reply#sci_el_15719

Conclusion: Reliance on conventional conservation methods appears risky if CO₂ continues to increase
Thus, an important policy question

If:
- we fail to stabilize CO$_2$ at levels below which serious marine consequences ensue, and
- conventionally managed marine ecosystems fail to adapt to the consequences,
what are our management and conservation options, if any?

Current answer - we don’t know.

Some unconventional physical, biological, chemical, and hybrid approaches have been proposed, but the safety and cost effectiveness of these have yet to be seriously evaluated.
Uncoventional conservation methods and possible effectiveness

<table>
<thead>
<tr>
<th>Conservation Method</th>
<th>Stressor addressed</th>
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<tbody>
<tr>
<td><strong>Unconventional -</strong></td>
<td>Temp.</td>
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<tr>
<td>Physical e.g. - sun shading, solar radiation management: increased upwelling</td>
<td>X</td>
</tr>
<tr>
<td>Biological e.g. - selective breeding, artificial selection, genetic engineering; creation of refugia; artificial preservation of genetic stock</td>
<td>X</td>
</tr>
<tr>
<td>Chemical e.g. – chemical, electrochemical, or geochemical modification of seawater (alkalinity addition, pH elevation)</td>
<td>(X)</td>
</tr>
<tr>
<td>Hybrid and other approaches – e.g., conversion of waste CO₂ to ocean alkalinity; storage of land crop waste in ocean; ocean fertilization</td>
<td>(X)</td>
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CO₂ acidification effects on carbonate saturation and marine biocalcification:

Mod. from McCulloch et al. 2012 Nature Climate Change DOI 101038/NCLIMATE1473
Effects of accelerate carbonate mineral weathering

\[ \text{CO}_2 + \text{H}_2\text{O} + \text{CaCO}_3 \text{s} \rightarrow \text{Ca(HCO}_3\text{)}_2 \text{aq} (+ \text{CaCO}_3 \text{aq}) \]

See: Rau, 2011
Environ. Sci. & Technol. 45: 1088-

Mod. from McCulloch et al. 2012 Nature Climate Change DOI 10.1038/NCLIMATE1473
Already used in seawater aquaria:

In-home CO₂+ carbonate reactors preserve/enhance marine organisms.
Arguments against unconventional approaches

- Too expensive - won’t be cost effective
- Can’t address large scale impacts/effects
- Potential for unintended, negative consequences
- Detracts from addressing core issue – rising CO₂ (moral hazard)

Rebuttal:
- We don’t yet know what scales, cost effectiveness, and safety might be possible, nor is it likely that all unconventional approaches have been identified.
- It looks increasingly risky to assume that we can can stabilize CO₂ at safe levels considering current lack of effective policy and technology
- Further solicitation of ideas and research are needed to address these issues
Policies needed to support the search and evaluation of new, unconventional marine management

1. Stabilize if not reduce atmospheric CO$_2$ concentration
2. Measure, monitor, model, and predict effects of elevated CO$_2$
3. Maximize resilience and adaptation of marine biota by minimizing non-CO$_2$ effects using conventional conservation methods, e.g. MPA’s, pollution and overfishing reductions, etc.

4. Actively solicit, evaluate, and test new marine management and conservation techniques in the (increasingly likely) event that policies 1-3 fail to adequately protect marine ecosystem
Suggested actions:

- Have GO’s and NGO’s insert policy language supporting an ongoing search for and evaluation of new management methods.

- Convene a workshop of stakeholders to explore alternative conservation methods and to roadmap how to best seek and evaluate these.

- Have such solicitation and evaluation an ongoing component of funded, ocean acidification research (e.g., national/international, NOAA, NSF, EPA, etc?)

- Include a session at OA meetings (like this one) that is devoted to discussing research on new, alternative marine management and conservation practices/policies
Further details: Rau et al. 2012 *Nature Climate Change*

Your comments and ideas?

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