THE SKIMMER ON MARINE ECOSYSTEMS AND MANAGEMENT

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The Skimmer: Managing and conserving ocean ecosystems in a rapidly changing climate

Editor's note: The Skimmer is a MEAM feature where we briefly review the latest news and research on a topic. This Skimmer features new research and insights presented at the 4th International Symposium on Effects of Climate Change on the World's Oceans (ECCWO), held in June 2018 in Washington, DC. In last month's MEAM, we covered new research on how weather and climate extremes are impacting marine ecosystems, as well as some climate change tools and resources, presented at the symposium. This month we examine what practitioners can do about it.

Marine species just are not where they used to be: Managing and conserving species on the move

- The problem: Much of current conservation action is based on maintaining species in the same places they have been located historically and at roughly the same levels of abundance. Marine resource management, likewise, is based on historical assumptions about where species are and in what numbers. But we are currently seeing big geographical shifts in marine populations in response to climate change, sometimes across political and management boundaries. How in the world can we deal with this?

Takeaway Message #1: Marine resource management and conservation needs to look forward, not back – or, why modeling is even more critical to management than it used to be

- Speakers at the ECCWO symposium provided a tremendous amount of insight into how managers and conservation practitioners could start to address these issues. One of the most important messages was that **we need to manage and conserve based on projections of the future, not past history.** The future under climate change will just not look like the past.
- What should management and conservation-relevant projections look like? They will undoubtedly take many forms, but the OceanAdapt website offers an early example. This tool tracks historical shifts in the spatial distribution and models the future thermal habitats of more than 650 North American marine fish and invertebrate species. These projections can help managers identify where traditional fisheries may decline and where new fisheries may emerge.
- Another example are earth systems model (ESM) projections that integrate atmosphere, ocean, land, ice, and biosphere dynamics to project regional and global climate under a wide variety of conditions. These models could provide a variety of information critical for national security decision making. For example, the US Department of Energy's Energy Exascale Earth System Model (E3SM) forecasts:
  - That global sea level will rise 0.3-1.2 m by 2100. Furthermore, there is a possibility of a rise as high as 2.4 m if the ice shelves that support the Antarctic ice sheet

collapse. The model can keep decision makers up to date on the likelihood of this happening.
- What maritime operating conditions will be like under new ice-free and reduced-ice conditions, including typical patterns for the annual openings and closings of shipping routes and the types of support/rescue resources needed for maritime safety.

Are US national security decision makers using these capabilities? No – they are using static IPCC reports (referred to as "tombs of data products" by one speaker). Relationships between the environmental prediction and natural security communities need to be built for these capabilities to be fully utilized. [Ringler et al., pg. 175]

- For more on how models that incorporate human and natural systems can help us figure out what factors are driving the changes we are seeing in the ocean and what outcomes we might see from different climate scenarios and management choices, check out this plenary talk by Eric Galbraith of Universitat Autònoma de Barcelona.

Insight: Make modeling an inclusive process

In another plenary talk about ecosystem-based management of marine ecosystems in the face of climate change, Sarah Cooley of The Ocean Conservancy emphasized that policy development needs to be an inclusive process with repeated interaction between modelers, managers, and resource users. (Watch a recording of the plenary.) She cited the Oyster Futures project that developed recommendations for oyster policies and management for the Choptank and Little Choptank rivers, tributaries of the Chesapeake Bay on the east coast of the US, as a great example of this. For this initiative, industry, manager, social scientists, and natural scientists all sat around a table (literally, they had assigned seating which changed periodically) and discussed management actions with the assistance of expert facilitators. The group used simulations and projections to examine how management measures (e.g., season length, sanctuaries, gear types) and restoration practices would impact oyster populations, harvests, and water quality. Results? A package of recommendations approved by all sent to the Maryland Department of Natural Resources in March 2018.

Photo: Stakeholders participating in OysterFutures meeting. Image from www.oysterfutures.wordpress.com

Takeaway Message #2: Even when governments are not adapting to climate change impacts, stakeholders are – we need to understand and plan for this

- A second takeaway message from the conference is that **stakeholder response to climate change is understudied and can dramatically impact the effectiveness of management systems, health of marine ecosystems, and well-being of maritime communities and industries** [e.g., Burden et al., pg. 121].

- In her plenary presentation, Gretta Pecl of the Center for Marine Socioecology and the Institute for Marine and Antarctic Studies in Tasmania, Australia, discussed how species shifts are making Tasmanian ecosystems look substantially different, but response from the government has been limited. In the absence of governmental directives, stakeholders are adapting to these changes autonomously. For example, charters are advertising trips for new species and the fishing industry is changing the way it lands and handles products. New research (Pecl et al., In review) finds that half of these autonomous adaptations may be antithetical to planned government-led adaptations. (To learn more, watch a recording of the plenary and join MEAM in September for a webinar on this topic.)

- Studies of fishing communities in the US Northeast demonstrate the complex dynamics of human adaptations to climate change. Fish distributions in the Northwest Atlantic have already undergone significant shifts as a result of climate change. Fishing communities for summer flounder 'fluke' and red and silver hake (pictured is a red hake) in the US Northeast are adapting to these changes in a variety of ways including switching target species, traveling farther to fish, switching ports, and leaving fishing altogether. The most common adaptation strategy is changing target species, but many factors (such as the availability of fishing quota and out-of-state fishing permits, distance to fishing grounds, vessel size, and level of fisher specialization) determine which adaptation strategies fishers chose. For instance:
  - Generalist trawlers are particularly successful at switching to catch newly-arrived species, provided they are permitted to catch those species
  - Relatively few fishers actually shift their fishing grounds, and the ones that do generally have larger vessels that can range farther from their home port. Not many fishers are willing (or can afford) to steam three days north to start fishing then steam three days south to land their catch when they are done fishing
  - Larger (> 20 m) specialist trawlers (e.g., fluke trawlers) near their species' southern range limit do tend to follow their target species north. [Papaioannou et al., pg. 163 and Selden et al., pg. 119]
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- Another factor in determining how fishers respond to shifts in fish distribution is their own perception of those shifts. Some fishers view the changes as cyclical (i.e., not permanent) while others see the changes as range expansions (i.e., the fish may be in new locations, but they are still where they used to be as well). These beliefs dampen adaptation, whereas fishers that view the changes as long-term range shifts tend to take more adaptive actions. [Papaioannou et al., pg. 163]

- Existing regulations can also influence fisher behavior in unintended ways. As an example, the distribution of summer flounder (fluke) has shifted north in recent years, and fluke boats from Beaufort, North Carolina, are traveling north to New Jersey to fish then returning to North Carolina to land the fish because state quotas reflect where the fish used to be rather than were they are now. North Carolina has the allocated catch, but the fish are further north. Fisheries management hasn't kept up with species shifts, and one result has been that politicians are involved and, in at least one instance, scientific processes are being bypassed.

- And at least this fishery is managed by a regional body. Even bigger problems arise when species shift across political boundaries where there is little cooperation. A posterchild for this type of conflict was the Mackerel War between Iceland and Great Britain (backed by the EU) a decade ago. The bulk of the regional mackerel population used to be in EU waters but started shifting into Icelandic waters. There was no cooperative management arrangement, so everyone fished, and stocks declined. This was such a big deal that it was an important factor in Iceland dropping its bid to join the EU.

- New research shows that the potential for conflicts like these are going to increase dramatically in the future. A brand new study by ECCWO presenter Malin Pinsky of Rutgers University and colleagues looked at projected future shifts of 892 commercially important fish and invertebrate species relative to 261 EEZs under two greenhouse gas emissions scenarios. They found that dozens of EEZs would have new stocks by 2060 even under a strong greenhouse gas mitigation (reduced global warming) scenario, and even more EEZs would have new stocks under a 'business-as-usual' emissions scenario (greater global warming). These trends will increase over time as the oceans continue to warm. They will likely be especially problematic for regions that are dependent on seafood protein and where international relations are already strained (e.g., South China Sea).

- Furthermore, mass migration (of people) and increases in piracy, terrorism, and trafficking may also be adaptive behaviors for climate change. A new report from the American Security Project finds that coastal communities of Southeast Asia – Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Thailand, and Vietnam – will face some of the worst impacts of climate change. Sea surface temperatures in the region could increase by 6° C by 2100, and sea level rise is predicted to endanger two-thirds of Asian cities. Fisheries are the primary source of food and income for millions in the region and are threatened by overfishing and climate change. People will adapt by migrating, shifting economic activities, and/or engaging in illicit activities such as piracy, terrorism, or trafficking. The report finds that to improve security outcomes, governments need to increase intelligence sharing and coordination between countries to combat piracy, terrorism, and radicalization; develop processes to manage increased migration, both internally and internationally; bolster community resilience to threats; and respond to climate change.

A glimpse into our 'no-analog future': How "the Blob" led to a record number of whale entanglements along the California coast in 2015 and 2016

The story of how the large marine heatwave off the North American West Coast in 2015-2016 ("The Blob") led to humpback whales getting tangled in crab pots off the California coast is a perfect example of how climate change will set off chains of events with unanticipated and often severe consequences. In 2015, warm waters off the coast of California led to pelagic forage fish such as anchovy – that is, humpback whale food – being compressed into a relatively narrow band close to shore, in the same areas where Dungeness crab fishers set their pots. This wouldn't normally be a problem because Dungeness crab fishers have usually picked up their gear and moved on to salmon fishing by the April-June period when humpback whales migrate through the region. But in 2015 and 2016, the continued presence of domoic acid from a harmful algal bloom in the region (related to the large marine heatwave) led to a delay in opening the Dungeness crab season; at the same time, poor salmon catches (also related to the large marine heatwave) failed to draw fishers away from the Dungeness crab fishery. So Dungeness crab landings actually peaked in the April-June timeframe, leading to numerous entanglements between Dungeness crab gear and migrating humpback whales. A working group of fishery stakeholders, resource managers, and conservationists convened in 2015 to address the entanglement problem and developed best practices and voluntary recommendations, but many mitigation activities didn't start until 2017, highlighting the need for more responsive and nimble management processes. Welcome to the "no-analog future" as climate change forces ocean states beyond historical envelopes. [Santora and Mantua, pg. 42]

Takeaway Message #3: Don't give up! Even in the face of climate change, marine resource management matters

- Another takeaway message from the symposium was that **management matters, even in times of rapid climate change.** In fact, in times of rapid climate change, management really matters.

- Why? In short, it is because fishing can impact fish stocks as much as or even more than climate change. For example, global harvest of wild marine fish stocks quadrupled between 1950 and the end of the 20th century. 'Hindcasts' from coupled human-ocean models show that the vast majority of this change was due to technology, not climate change. And while climate change will have profound impacts on fish populations (e.g., fish biomass is expected to decrease by the end of this century due to temperature-driven changes to fish metabolism), these models forecast that, in the absence of effective regulation of fishing effort, future changes in technology and management will probably be even more important than climate change in determining future global harvests. [Watch the plenary by Eric Galbraith of Universitat Autònoma de Barcelona for more information.]

- This goes for the deep ocean as well. Temperatures in the deep ocean are expected to increase by as much as 1°C by 2100, and significant decreases in oxygen concentrations and particulate organic matter as well as increases in acidity are also expected. Most assessments of the vulnerability of marine species to climate change focus on coastal species, but a new analysis found that deep-sea fish are just as vulnerable to climate change as coastal fish and that 49% of exploited deep-sea fish could be threatened by 2060 under 'business as usual' climate and fisheries management scenarios. The good news? Good fisheries management could dramatically reduce the number of species at risk to 9%. [Cheung et al., pg. 89]

Thinking about marine protected areas in a changing climate

For marine protected areas (MPAs), climate change could change the quality, composition, and even existence of species, communities, and habitats (aka features) within the areas. In his ECCWO talk, Paul Buckley with the Cefas Marine Climate Change Centre in the UK discussed management implications of climate change for UK MPAs. Some possibilities:

- If features are lost for a multipurpose MPA, designation orders may need to be revised
- If the target feature is lost for a sole purpose MPA, the MPA may need to be abandoned
- If the quality of a feature or features within an MPA changes, adaptive management needs to be considered
- If a species moves out of an MPA but still exists in UK waters, features may need to be added to existing MPAs or alternative MPAs may need to be designated.

In general, in response to climate change, features and areas that may be most affected by climate change need to be identified, and conservation targets and objectives need to be reviewed more regularly. [Buckley et al., pg. 158]

Other insights from the ECCWO symposium:

- While many, if not most, of our current conservation laws and mandates do not explicitly address climate change, some do contain provisions that could be used to address climate change impacts. For example, a recent study reviewed 21 obligations relevant to marine biodiversity in the UK and how they account for climate change. Very few specifically reference climate change, but 10 of the obligations reference natural variability/environmental change. In addition, all of them include formal review and reporting cycles and secondary legislation/complementary policy development where climate change impacts could be considered.

- Extreme events such as marine heatwaves can be teachable moments. They can catch people off guard and can motivate adaptation. [Pershing et al., pg. 48]

Credit: Eric Oliver/Dalhousie University

- Some fishing communities are giving management a lot of flexibility right now because they are so worried about what is going on with marine ecosystems. Managers need to take advantage of this opportunity to innovate and incorporate new information. [Haynie et al., pg. 164]

- Fisheries managers need to take advantage of structures that bring flexibility into the system and need to consider the ways that highly specialized permit programs may constrain adaptation. Examples of mechanisms that add flexibility include quota transfer and side payment mechanisms [Burden et al., pg. 121 and Selden et al., pg. 119]. In addition, co-management arrangements allow communities (which see climate change impacts first) to incorporate changes into management sooner than purely top-down management structures.

Climate change in the Arctic is a big deal for everyone for many reasons, or "What happens in the Arctic does not stay in the Arctic"

- It can't be stressed enough how much what is going on at the poles matters to those of us at lower latitudes. As the chair of the US Arctic Research Commission Frances Ulmer likes to say, "The Arctic is the world's air conditioner, and it's breaking down." A quick perusal of a map of potential policy-relevant tipping points for the Earth's climate system shows that a disproportionate number of tipping points are near the poles.

- If you read the MEAM Skimmer on the Arctic from several months ago, you know that the Arctic is warming twice as fast as the rest of the world and this is leading to a

host of other changes in the Arctic. For instance, land ice is retreating, there is a lot less sea ice than there used to be, Arctic marine ecosystems are changing, permafrost is thawing, ocean chemistry is changing (e.g., acidity is increasing), sea levels are rising, and ice-dependent Arctic species are at risk. All of this is impacting the health, safety, food security, culture, and infrastructure of Arctic peoples.

- And as we also covered in that Skimmer, this is a big deal for everyone on the planet because these factors are destabilizing the mid-latitude jet stream, leading to more frequent and intense mid-latitude storms, the release of marine methane hydrates is increasing the level of greenhouse gases in the atmosphere, the formation of Atlantic deep water is being interrupted leading to changes in global circulation, and the melting of the Greenland ice sheet is leading to sea level rise and ocean and current alterations (just to name a few).

- In addition, the decrease in the extent of sea ice in the Arctic is essentially opening up another ocean. The decrease in the extent of sea ice in the Arctic is increasing access to and creating major opportunities for increased use and exploitation of the region – think shipping, fisheries, mining, and oil and gas. Arctic development is attracting global attention and investment from traditional Arctic maritime nations (e.g., Russia, Norway) and some new ones (e.g., China, South Korea, Japan). [Ulmer, pg. 174 and Brigham, pg 174]

Illustration credit: Bas Kohler for the 4th International Symposium on the Effects of Climate Change on the World's Oceans. See more Kohler illustrations from the conference (available for use in science communications).
