THE SKIMMER ON MARINE ECOSYSTEMS AND MANAGEMENT

Published on *Marine Ecosystems and Management (MEAM)* (https://meam.openchannels.org)

Estimating the vulnerability of ocean planning and blue economy to climate change

Climate-related drivers of change – such as ocean warming, acidification, and deoxygenation – will alter ocean conditions and lead to changes in marine ecosystem structure and functioning, as well as the redistribution of the services that the oceans provide (see Figure 1). As a consequence, human uses that rely on these services – fisheries, aquaculture, and tourism for example – will also undergo spatial and temporal changes at multiple scales. These changes will include local increases and decreases in intensity of uses and relocation of uses. Marine spatial planning (MSP) informs the distribution of ocean uses in space and time, and it will undoubtedly be affected by climate change at all scales ranging from global to local.

MEAM discussed this with Catarina Frazão Santos, a research scientist with the Marine and Environmental Sciences Centre at the University of Lisbon. She is currently leading the research project OCEANPLAN to understand how marine spatial planning may be affected by and adapt to global climate change. She can be contacted at cfsantos@fc.ul.pt.

MEAM: Can you describe a few examples of how climate change can influence the distribution of ocean uses?

Frazão Santos: One example of how climate change is changing the distribution of ocean uses is the Arctic. The reduction of sea ice cover in the Arctic Ocean is opening up new areas for potential economic exploitation. New shipping routes (e.g., the Northern Sea Route), hydrocarbon exploitation, commercial fishing, and aquaculture are among the ocean uses that will become possible in previously inaccessible and unexploited areas. Competition for this new ocean space can lead to increased conflict among blue economy-related sectors. In addition, the occurrence of ocean uses at new locations may have significant negative effects on key species and habitats as well as the human communities that rely on them.

It is important to keep in mind, however, that the effects of climate change on MSP will vary regionally because some ocean uses are more sensitive to climate change-related effects than others and different ocean uses have different socioeconomic importance across nations and regions.

MEAM: How can we assess the vulnerability of ocean planning processes to climate change?

Frazão Santos: We developed an index – the Ocean Planning Vulnerability Index – to assess this. The index uses the combined vulnerability to climate change of seven main ocean uses –fisheries, marine conservation, aquaculture, marine and coastal tourism, shipping, renewable energy, and seabed mining – as a proxy for MSP vulnerability. Vulnerability is characterized in the same way it is for the IPCC model – that is, as a function of a system's exposure, sensitivity, and adaptive capacity.

For *exposure* (i.e., what can be affected by climate change, the presence of goods and services), we consider the intensity and importance of the seven main ocean uses for a country. For *sensitivity* (i.e., how much can be affected by climate change or impact level), we consider how much the main drivers of ocean change (e.g., ocean warming, acidification, and deoxygenation) impact each ocean use. For *adaptive capacity* (i.e., the ability to adjust and respond), we consider variables related to a country's capacity to adapt to climate change – assets, flexibility, organization, learning, and agency. We integrate variables from each of the three dimensions of vulnerability (exposure, sensitivity, and adaptive capacity) into our index to get our preliminary MSP vulnerability values.

MEAM: Where has the index been applied so far, and what have you found?

Frazão Santos: We applied the index to 24 European coastal states (23 EU member states and Norway). The results are still preliminary (see Figure 2), but it is interesting to see that vulnerability varied significantly according to how we considered exposure. For vulnerability based on intensity (presence) of ocean uses, most vulnerable countries were located in Southern and Western Europe (e.g., Spain, Italy, France, and the UK). In contrast, vulnerability based on the importance (a country's dependence) on ocean uses, the most vulnerable countries were in Northern Europe and the eastern Mediterranean (e.g., Greece, Cyprus, and Norway). We also noticed that results were predominantly explained by variations in exposure because adaptive capacity did not vary considerably among European countries which generally have a high level of human development and we used global sensitivity. We also looked for variations between the vulnerability of blue economy sectors (all sectors except marine conservation) and the vulnerability of all ocean uses but did not find significant differences. I would stress, though, that these are only preliminary results. We will be applying the index to a variety of other case studies next year, as part of the new research project OCEANPLAN that we are launching.

MEAM: How can MSP processes plan for climate change impacts?

Frazão Santos: Planning for a changing ocean will require increasingly flexible and adaptive MSP approaches, as well as the proper recognition of climate change as a real (and increasing) challenge. MSP will not be able to anticipate every potential future climate-related scenario and plan for all potential cases because this would be a massive use of resources with no guarantee of success. Instead, MSP must have the mechanisms to adapt to an uncertain and dynamic future. There are a number of operational approaches that can be incorporated into MSP to foster this flexibility and increase adaptive capacity. These approaches include adaptive management, dynamic ocean management, dynamic ocean zoning, anticipatory zoning, and just-in-time planning. A key challenge, however, will be finding the right balance between legal predictability and stability for ocean users with flexibility. And since management needs and contexts vary from place to place, a one-size-fits-all solution will almost never be appropriate.