FORCE Management Brief #2 for Caribbean Reef Management

Factoring marine environments into resource management

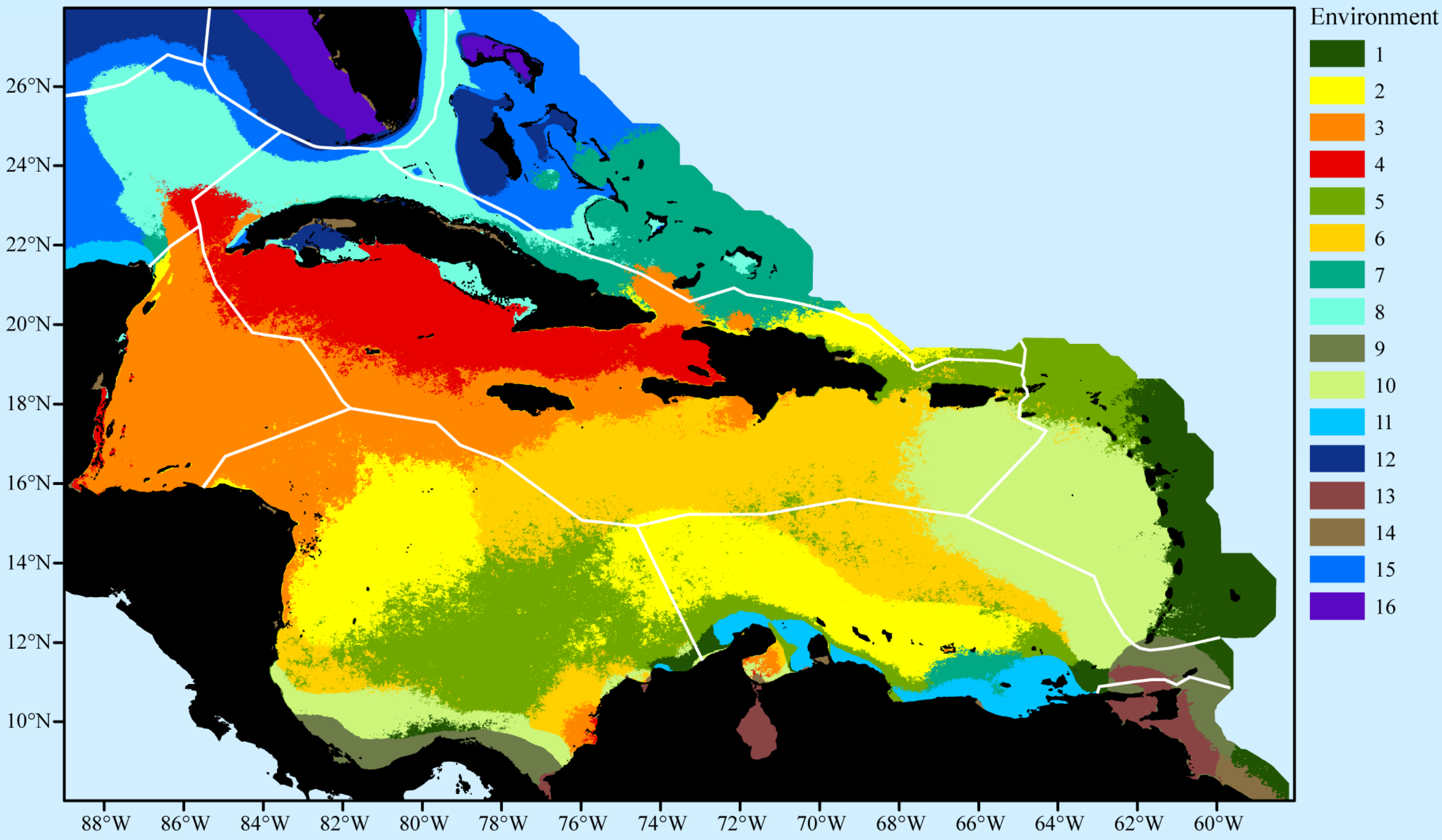
The issue

Marine ecosystems have long been exposed to the influence of diverse environmental forces such as extreme temperatures, upwelling, storms, river and runoff inputs, wave energy and hurricanes. These physical factors strongly influence reef biodiversity, the impact of disturbance, and recovery of marine ecosystems. However, data on physical environments have been difficult to acquire.

Recently, FORCE used a wide range of satellite and field data to create the most detailed characterization of Caribbean environments to date called *Physical Environments of the Caribbean Sea* (PECS, at a spatial detail of 1 km^2). These maps categorise the basin into distinct environmental provinces based on the characteristics of their waters. As many organisms, particularly those living in shallow coastal habitats, are strongly influenced by mechanical forces of wave action and hurricanes, we also mapped average wave energy and the number of hurricanes that have impacted each site. These maps will help managers plan their interventions and monitor their impacts.

The evidence

Many studies have looked at the physical environment and how it shapes the response of animals and plants. Some responses are very obvious, such as the impact of hurricanes damaging reefs and mangroves, or the effects of light on the availability of seagrass. Others are subtle, such as the differences in habitat types due to wave exposure from seagrass habitats found in very sheltered areas to reefs dominated by octocorals in exposed areas. At intermediate levels of wave exposure a larger diversity of habitats can coexist (e.g., seagrass beds and coral reefs). Wave exposure can also determine where major reefs are found. The most complex and biodiverse reef habitat in the Caribbean is built by large colonies of the mountainous star coral, *Montastraea* spp. and branching corals (*Acropora*) although the branching corals are now rare.



PECS classification of physicochemical regions. Each colour represents a distinct environment. White lines indicate the Marine Ecoregions of the World (Spalding et al. 2007, BioScience 57), previously the most detailed classification available for the area.

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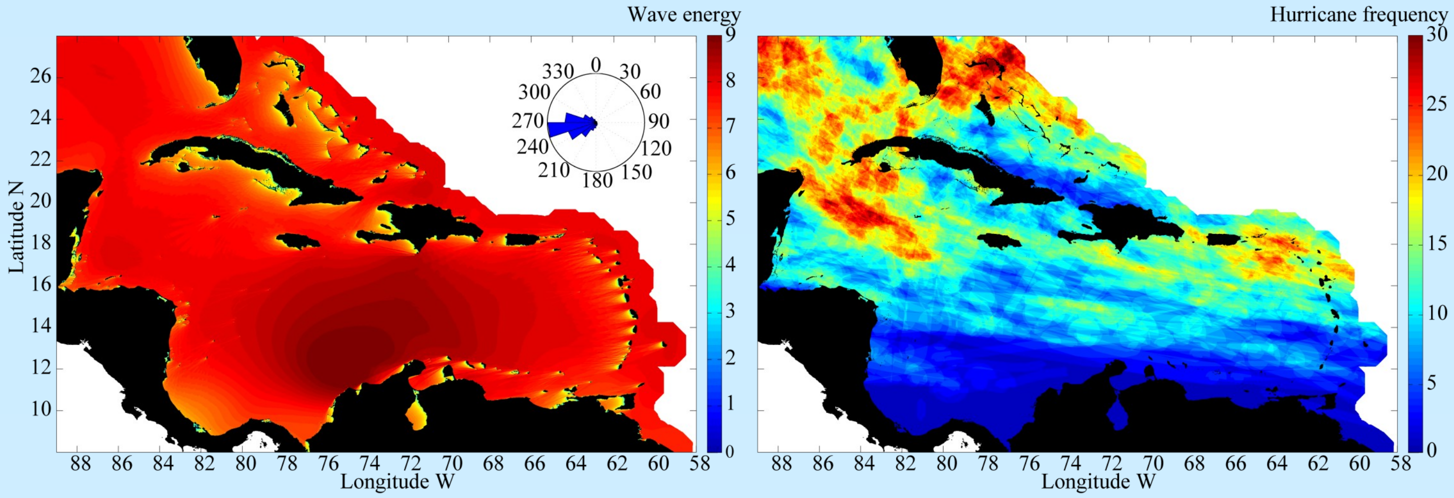

PECS disturbance regimes, showing average wave energy (left, inset showing general wind patterns for the entire Caribbean) and hurricane incidence in the last 157 years (right).

Management uses

By defining physical environments, PECS can be used for a variety of purposes within resource management:

(1) *Mapping biodiversity proxies*: Good-quality data on marine biodiversity are scarce. Habitat maps are a common proxy for biodiversity assessments; however, they assume that species living in each habitat are the same everywhere. In reality, marine communities vary according to physical environment even within a single habitat type. Habitat maps can now be stratified by physical environment to provide better proxies of biodiversity.

(2) *Building ecologically representative marine protected area (MPA) networks*: the Convention on Biological Diversity emphasizes importance of including a representative range of diversity within an MPA network. A good way to do this is attempt to represent each habitat type in each of its physical environments.

(3) *Assessing transferability of management approaches and setting realistic expectations for management outcomes*: areas of the same environment are likely to respond similarly to management interventions (e.g., reserve impacts should be similar in comparable environments). PECS can help explain why some areas respond well to management and other areas (in different environments) respond differently.

(4) *Setting priorities for rapid assessment/monitoring activities:* stratifying field surveys by physical environment would facilitate a cost-effective, comprehensive appraisal of biodiversity within an area.

(5) *Identifying potentially valuable or vulnerable marine ecosystems*: PECS can be used, for example, to identify areas where upwelling occurs, which might be particularly productive and valuable form a fisheries perspective. PECS can also identify areas under river influences, which might be heavily impacted by pollution.

(6) *Mapping potential fishing access*: areas with high wave energy tend to be too rough so receive less fishing.

(7) *Mapping potential algal growth*: Much of the Caribbean has very weak tides and wind-driven waves play an important role in delivering fresh nutrients to algae which help them grow. Areas of high wave exposure tend to have faster-growing algae than sheltered areas. This information might identify areas that are more susceptible to algal overgrowth if herbivores are heavily depleted. Essentially, an algal bloom is more likely in exposed areas rather than in sheltered areas if parrotfish are removed .

Further information

www.force-project.eu (follow this link to get access to PECS maps, freely available in the FORCE webGIS)

Chollett I, Mumby PJ, Müller-Karger FE, Hu C. 2012. Physical environments of the Caribbean Sea. Limnology and Oceanography 57: 1233-1244.

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