In a new paper in the journal One Earth, an international task force of experts developed a framework to assess the abundance and distribution of marine biodiversity, and applied it to U.S. waters from the near coast to the borders of Exclusive Economic Zone (EEZ).

**Why Assess Biodiversity at the National Level?**

The astounding array of biodiversity and habitats in our oceans are at the heart of ecosystem health, sustaining a range of essential services to people, from shoreline protection to commercial and recreational fishing, carbon sequestration, and more. However, climate change, extractive industries and other stressors are threatening marine biodiversity. Stemming its loss is essential across management priorities, including the president’s commitment to protect 30% of coastal and marine waters by 2030, the White House Ocean Climate Action Plan, and the National Ocean Biodiversity Strategy. But just putting in place more marine protected areas (MPAs) will not make them more effective. The U.S. needs a network of MPAs that are more than the sum of their parts. They should be ecologically representative, foster connectivity between habitats, and consider the dynamic nature of coastal and marine systems.

The biodiversity assessment framework is the basis by which managers and communities can ground regional and local actions in a nationwide knowledge of marine biodiversity distribution. It could be used to continually assess biodiversity over time and at multiple spatial scales to strategically expand protections, evaluate management effectiveness, and foster climate adaptation. The framework is able to inform any mandate or policy that involves area-based management and has the potential to link climate resilience and biodiversity by incorporating improved future species distributions.

**Key takeaways from the framework’s first application to U.S. waters**

- **U.S. protected areas fail to meet network criteria**, despite 26% of U.S. marine waters being in some form of protection.
- **MPAs vary widely in success across ecoregions**. There are no fully protected areas (FPAs) that are both large and well-connected, and less than two-thirds are in some form of protection.
- **Balancing multiple network criteria is key**. Some regions have lower area coverage but more effective MPAs because they better balance representativity, replication, and connectivity.
- **We likely overestimate protection because of data gaps**, including sparse information from outside of MPAs, oceanic waters (vs. coastal systems), and invertebrate species (vs. vertebrates).
Applying the Biodiversity Assessment Framework to U.S. Waters

The framework quantifies indicators of biodiversity (i.e., habitat-forming species, species of conservation concern, harmful organisms, and supporting organisms) across 24 distinct U.S. marine ecoregions, then compares them to the Convention on Biological Diversity’s (CBD) five criteria of an effective MPA network.

24 distinct ecoregions

5 criteria of an effective MPA network

- Important areas for specific animals or plants
- Representativity of a region’s biodiversity and habitat types
- Connectivity among MPAs
- Replication of sites with particular biodiversity components
- Viability and Adequacy of the size and condition of an MPA to maintain ecosystem integrity

Figure 1

The Marine Biodiversity Assessment Framework

Walk through the main steps of the framework to assess the distribution and abundance of marine biodiversity

1. Identify biodiversity components
   Including habitat-forming species, species of conservation concern, harmful organisms, and supporting organisms

2. Develop metrics
   Including occurrence, abundance, distribution, and diversity

3. Create biodiversity indicators
   By applying metrics to components

4. Assemble indicator data
   Across ecoregions

5. Assemble location data
   Of protected areas

6. Overlay indicators and protection
   To assess the key criteria of an effective MPA network
Currently, 26% of U.S. waters are in an MPA or FPA, seemingly close to the 30% target. However, this 26% obscures large spatial variations and substantial gaps in which species and habitat types are protected. This underscores the importance of evaluating protections using data on biodiversity and a more comprehensive network criteria.

Figure 2
Snapshots from the Framework
Examples from its first application assessing MPA effectiveness against network criteria

While the Alaska region has some large MPAs, it lags other regions because they score low on representativity, replication of habitat-formers, and important areas.

The Pacific Islands come closest to meeting network criteria, including for habitat formers such as reef corals, deep-water corals, mangroves and red-listed species.

The Southern Florida/Bahamian Atlantic and the Montereyan Pacific Transition are the only two regions that meet criteria for adequacy and connectivity.

1 Acadian Atlantic
2 Alaskan/Fjordland Pacific
3 Aleutian Archipelago
4 American Samoa
5 Arctic Basin
6 Beaufort/Chukchi Seas
7 Bering Sea
8 Caribbean Sea
9 Carolinian Atlantic
10 Columbian Pacific
11 Guam and Marianas
12 Gulf Stream
13 Hawaiian Archipelago
14 Howland and Baker Islands
15 Jarvis Island
16 Montereyan Pacific Transition
17 Northern Gulf of Mexico
18 Northern Gulf Stream Transition
19 Palmyra Atoll
20 South Florida/Bahamian Atlantic
21 Southern Californian Pacific
22 Southern Gulf of Mexico
23 Virginian Atlantic
24 Wake Island
Figure 3
The U.S. MPA Network Falls Short of Effective Protection
Indicators of U.S. marine biodiversity protection assessed across all regions

**Adequacy**
- Most protected areas are below size threshold
- Adequately sized protected areas

**Coverage**

**Viability**
- Data are insufficient
- Climate

**Representivity**
- Best for reef corals but poor for deep-water coral
- Mangroves
- Seagrasses

**Important areas**
- Poor coverage for marine mammals
- Biologically important areas (mammals)
- Important bird areas

Protection of important areas for birds and mammals is inconsistent

Across the 24 ecoregions, percentage that are in protected waters:

- About 60% of important bird areas (IBAs)
- <10% of biologically important areas (BIAs) for marine mammals

**South Florida/Bahamian Atlantic**
Important areas for both seabirds and marine mammals are best covered by MPAs in the South Florida/Bahamian Atlantic ecoregion, but still have low coverage by FPAs.

**Alaska**
In contrast, less than 10% of important areas are in MPAs across the five Alaska ecoregions—a major gap given the region’s importance to migrating whales and birds, and its vulnerability to climate change.
Indicators of marine biodiversity in MPAs and FPAs reveal how size, adequacy, and connectivity work together, creating opportunities for improvement.

Figure 4

**Opportunities for Strategic Expansion of Protected Areas**

Indicators of marine biodiversity in MPAs and FPAs reveal how size, adequacy, and connectivity work together, creating opportunities for improvement.

**KEY**

- **MPA**
- **FPA**
- Alaska
- East Coast
- Gulf of Mexico/Caribbean
- Pacific Islands
- West Coast

Expand existing protections where protected areas are well-connected but inadequately sized.

Prioritize regions where protected areas are neither adequately sized nor well-connected.

Ideal MPAs are well-connected and adequately sized.

Add protected areas where protected areas are poorly connected but adequately sized.

Improving effectiveness by increasing network size and connectivity

In U.S. waters, % of adequately sized protected areas:

- MPAs: 6%
- FPAs: 7%

**Alaska**

Alaskan MPAs are the least well connected, reinforcing the vulnerability of MPAs in this region. In Alaska, connectivity could be increased by designating new intermediate MPAs that decrease the distance between protected areas.

Large gaps between protected areas

In contrast, West Coast MPAs are both adequately sized and well-connected, although FPAs could stand to increase in size.

West Coast

- California
- Bering Sea
- Alaska

Large gaps between protected areas
PARTICIPATING EXPERTS

Research Leads
- J. Emmett Duffy, Co-Chair, Smithsonian Environmental Research Center
- Daniel Dunn, Co-Chair, University of Queensland
- Sarah Gignoux-Wolfsohn, Smithsonian Environmental Research Center and University of Massachusetts Lowell

Expert Group 1
- Clarissa Anderson, Southern California Coastal Ocean Observing System
- Nic Bax, CSIRO
- Gabrielle Canonico, NOAA Integrated Ocean Observing System
- Peter Chaniotis, Joint Nature Conservation Committee
- Steven Gaines, University of California Santa Barbara
- David Johnson, Seascape
- Lisa Levin, Scripps Institution of Oceanography
- Carolyn Lundquist, National Institute of Water and Atmospheric Research
- Eleonora Manca, Joint Nature Conservation Committee
- Anna Metaxas, Dalhousie University
- Peter Mumby, University of Queensland
- Jan Newton, University of Washington
- Dina Nisthar, University of Queensland
- Malin Pinsky, Rutgers University
- Marta Ribera, The Nature Conservancy
- Ryan Stanley, Fisheries and Oceans Canada
- Tracey Sutton, Nova Southeastern University
- Derek Tittensor, Dalhousie University
- Lauren Weatherdon, United Nations Environment Programme

Expert Group 2
- Abigail Benson, U.S. Geological Survey
- John Christensen, NOAA National Centers for Coastal Ocean Science
- Mimi Diorio, NOAA National Marine Protected Areas Center
- Kirsten Grorud-Colvert, Oregon State University
- Jeffery Leirness, NOAA National Centers for Coastal Ocean Science
- Russell Moffitt, Marine Conservation Institute
- Lance Morgan, Marine Conservation Institute
- Mark Monaco, NOAA National Centers for Coastal Ocean Science
- Beth Pike, Marine Conservation Institute
- Matthew Poti, NOAA National Centers for Coastal Ocean Science
- Jenna Sullivan-Stack, Oregon State University
- Lauren Wenzel, NOAA National Marine Protected Areas Center
- Arliss Winship, NOAA National Centers for Coastal Ocean Science

Geospatial Ecology Experts
- Jesse Cleary, Duke University, Marine Geospatial Ecology Lab
- Corrie Curtice, Duke University, Marine Geospatial Ecology Lab
- Sarah Deland, Duke University, Marine Geospatial Ecology Lab
- Patrick Halpin, Duke University, Marine Geospatial Ecology Lab
- Brittany Pashkow, Duke University, Marine Geospatial Ecology Lab

CITATIONS

KEY CONTACTS
J. Emmett Duffy, Smithsonian Institution, DuffyE@si.edu
Daniel Dunn, University of Queensland, daniel.dunn@uq.edu.au
Sarah Gignoux-Wolfsohn, University of Massachusetts Lowell, Sarah_GignouxWolfsohn@uml.edu
Kris Sarri, Go Blue Strategies, krissarri@gmail.com
Jason Landrum, Lenfest Ocean Program, jlandrum@lenfestocean.org
Emily Knight, Lenfest Ocean Program, eknight@lenfestocean.org

This effort was supported by the Lenfest Ocean Program and the National Marine Sanctuary Foundation, including funds from the Gordon and Betty Moore Foundation.