Scientists predict major shifts in Pacific ecosystems by 2100

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What if you woke up every day to find that the closest grocery store had moved several miles farther away from your home? Over time, you would have to travel hundreds of extra miles to find essential food for yourself and your family. This is potentially a scenario faced by thousands of marine animals affected by climate change.

A new study published in *Nature Climate Change* examines the distribution of various open ocean animals in the North Pacific and explores how that could change over the next century as global ocean temperatures increase and productivity levels shift. The researchers conclude that some critical ocean habitats could undergo significant changes in location, moving more than 600 miles from where they are now, while other habitats could remain relatively unchanged.

Among large animals, loggerhead turtles, some sharks and blue whales may face the harshest impacts of climate change while some seabirds may actually benefit. Not only are species at risk, but also coastal communities and industries could feel the impact since top predator habitat shifts can result in the displacement of fisheries and ecotourism, such as whale watching.

"For species already stressed by overfishing or other human impacts, increased migration time and loss of habitat could be a heavy blow," said Elliott Hazen, a National Oceanic and Atmospheric Administration researcher on the project who is affiliated with the Center for Ocean Solutions at Stanford. "But if we can build some plausible scenarios of how marine ecosystems may change, this may help efforts to prioritize and proactively manage them."

In order to carry out their study, the authors employed complex mathematical models with data from the decade-long "Tagging of Pacific Predators" (TOPP) project, in which 4,300 electronic tags placed on 23 species from 2000 to 2009 created unprecedented insight into migration patterns and hotspots of predator species in the northern Pacific.

Satellite measurements of sea surface temperature and chlorophyll-a (used to estimate surface productivity) were combined with the tracking data to identify "key habitat areas" for a variety of different ocean predators. The researchers then used climate models of ocean temperature and productivity to ascertain how those key habitat areas might change in the face of ocean warming.

One of these key habitat areas, known as the North Pacific Transition Zone, marks the interface between cold, nutrient-rich polar water to the north and warmer, nutrient-poor water to the south. This region is used by a variety of ocean predators, including marine mammals, tunas and

seabirds, as a corridor across the Pacific Ocean basin. The study suggests that this critical region could shift by as much as 600 miles, resulting in a 20 percent loss of species diversity in the region.

Other critical habitat areas, however, may experience little or no impact. The California Current, which runs along the west coast of North America, supports a variety of open ocean predators each year, when cold, nutrient-rich water creates regions of high productivity. This so-called upwelling cycle would likely continue despite ocean warming. "The fact that tagging indicates this is the number one lunch stop in town along the most populous coast in the nation – and stabilizes in a warming world – increases our opportunity to consider how to protect these hot spots," said Barbara Block, the Charles and Elizabeth Prothro Professor in Marine Sciences at Stanford, who is heavily involved in TOPP.

Among the Pacific's top predators, turtles, sharks and marine mammals such as whales appear to be most at risk from habitat shifts associated with Pacific warming. In some cases, predicted losses in essential habitat ranged as high as 35 percent.

But animals such as seabirds and tunas may benefit from climate-change-related shifts that could actually increase their potential habitat for foraging due to their broader tolerances to temperature.

"The differences from one species to another is their ability to adapt to temperatures and to use multiple ocean areas," said Hazen. "Having multiple sources of food, migration corridors and areas to call home provides a buffer against climate variability and change."

"Modeling of future scenarios is used in national security, financial investing and other critical areas," said Larry Crowder, the science director of the Center for Ocean Solutions, who was involved in the study.

"Here we use it to envision climate change impacts on large predators in the Pacific so that steps can be taken to better manage species that are important both commercially and for conservation goals," he said.

Based on these predictions, marine and coastal managers may alter fishing catches or revamp marine protected areas.

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