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Perspective: Building environmental change into spatial closures to reduce sea turtle bycatch

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In the early 2000s, the dataset from (US) federal fisheries observers for California's drift gillnet fishery was examined and a concerning pattern emerged. During warm-water years, endangered juvenile loggerhead turtles were coming closer to shore in southern California, which occasionally resulted in bycatch in drift gillnets. These were relatively rare events, which meant there was not enough distribution data to understand the underlying mechanisms, but the relationship between turtles and temperature was strong enough to warrant action. In 2003, NOAA Fisheries (the US federal fisheries agency) established the Loggerhead Conservation Area – a seasonal fisheries closure off southern California that is enacted for months between June and August when El Niño conditions are declared or forecasted to occur, or simply when sea surface temperatures are warmer than normal.

Since its establishment, the closure has been enacted during three periods: August 2014, June-August 2015, and June-August 2016. And it has been largely effective: only one loggerhead turtle has been caught (and released alive) by the drift gillnet fishery since it was established.

However, the productivity of the drift gillnet fishery has been steadily decreasing. Our team was interested in using additional loggerhead distribution data collected since 2003 to re-examine the relationship between turtles and temperature to consider refining the closure rule to reduce bycatch likelihood while also reducing fishery opportunity costs. In a newly published paper in Ecological Indicators, we present our findings, excerpted below.

Understanding the relationship between turtles and temperature

Relationships between species and environmental conditions can operate across many different spatial and temporal scales. For example, species may respond to broad-scale climate forcing, such as El Niño, or local mechanisms such as increased nearshore temperatures. Species may react to these environmental changes immediately, or there may be delays in response, caused for example by the transiting time it takes for highly migratory species to move between areas, or the time it takes for prey to aggregate.

Because we were unsure of the underlying temperature-based mechanisms that cause loggerheads to enter nearshore waters and interact with the fishery, we explored multiple spatial and temporal scales. Spatially, we tested broad-scale climate forcing from El Niño, intermediate mechanisms that operate over hundreds of kilometers, and local mechanisms (tens of kilometers). Temporally, we accounted for immediate (one month), intermediate (two-three months), and long-period (six months) response lags.

We found that a local temperature mechanism with a long-period response lag was best able to explain turtle presence in nearshore waters off southern California. This translated into a rule to implement the closure when local temperature anomalies averaged over the preceding six months (the long-period response lag) exceeded a threshold of 0.77 °C. Importantly, when we examined how this rule would have performed if it had been implemented in the past, a closure rule based on this mechanism had low opportunity costs to the fishing fleet, and a high ability to avoid historical bycatch events.

Based on this result, we postulate that turtles are responding to local temperature events that are not necessarily caused by broad-scale climate forcing. For example, turtle presence in nearshore waters coincided with a warm-water anomaly event commonly known as "The Blob", which was unrelated to El Niño. Additionally, the long-period response lag likely accounts for the transiting time it takes turtles to reach nearshore waters, or the time it takes turtles to aggregate in high-enough densities to be detected in the distribution datasets.

Looking forward

Under conditions of increasing extreme climatic events, we can expect to see more cases of species shifting beyond their normal distribution patterns. This presents an interesting challenge for marine spatial management: how can we accommodate these atypical biological states without incurring undue opportunity costs to resource users?

The field of dynamic management is one possible solution. Dynamic management strategies are flexible in space and/or time, allowing them to track the variability of the features they are designed to protect. These strategies can be regulated similarly to static marine protected areas, with strict boundaries delineating when and where activities can occur. For example, Hobday and Hartmann (2006) developed a dynamic management strategy to avoid bycatch of southern bluefin tuna using core, buffer, and open zones.

Alternatively, dynamic management strategies may inform activities using risk surfaces that show the relative suitability of activities between areas. Examples of dynamic risk surface include TurtleWatch and EcoCast, both of which help fishers avoid the bycatch of protected species. Incorporating environmental dynamism into management plans can help ensure spatial management strategies don't lose ecological relevance – for example, when a species shifts outside of the managed area designed to offer it protection. In a time of increasing climate variability and change, it is important that our approach to management can change, too.

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