**Staying ahead of the wave: predicting the distribution of global fishing effort**

Throughout history, oceanic waters beyond the jurisdiction of coastal and island nations (also known as the high seas) were sheltered from harvesting by commercial fisheries due to their geographic distance and scale. As commercial exploitation began depleting coastal resources in the mid-20th century, and fishing technologies advanced, fishermen started venturing deeper and further offshore. Today, commercial fisheries have a global and dynamic footprint. Fisheries policy deficiencies and loopholes allow for much of the pelagic fishing fleet in the high seas to operate unmonitored; the depth of their footprint has remained unknown for many decades. This gap in understanding about the spatiotemporal distribution of vessels in the open-ocean limits our ability to quantify and manage their impact on oceanic ecosystems. In recent years, there has been an increase in the use of vessel tracking technologies, such as Vessel Monitoring System (VMS) or Automatic Identification System (AIS). These systems, which were originally designed to prevent vessel-to-vessel collisions, are being used to study the distribution and behavior of the global fishing fleet. Global Fishing Watch (GFW) is a consortium of institutions which analyzes AIS signals to identify and map the distribution of the global fishing fleet; this study is the result of a collaboration between GFW and various academic groups lead by Duke University.

Like any other species, humans adjust their patterns of distribution based on their surroundings to maximize overlap with areas of suitable habitat and the resources critical to their survival. For several decades ecologists have used computer models and data on environmental conditions to define and predict areas of suitable habitat for terrestrial and marine species. Could these same tools be used to describe and predict where humans are expected to fish in the open-ocean?

Through our study we use information on the distribution of fishing vessels derived from AIS, machine learning and a broad range of oceanographic variables to create spatial models of fishing effort. More specifically, we focused on pelagic longliners, which are the most widespread form of fishing in the world. This form of fishing is typically used to catch tuna, swordfish and other pelagic fish that live in the upper depths of the sea, however, the baited hooks used to attract these commercially valuable fish also attracts non-targeted marine species such as sharks and seabirds, this is known as bycatch. Understanding where and when longliners may overlap with target and non-target biodiversity is very useful information that could help inform spatial forms of fisheries management.

In our study we used longline fishing effort estimates for the top five longline fishing nations in the high seas (China, Japan, South Korea, Spain and Taiwan) and statistically linked them to a set of 14 static and dynamic variables. The static variables included distance to the continental shelf break or oceanic seamount, which are physical features known to attracts pelagic predators. The dynamic predictors were extracted on a monthly basis and included sea surface temperature, dissolved oxygen concentration or net primary productivity. This information was used to fit monthly boosted regression tree models. Boosted regression trees iteratively classify presence and absence observations by partitioning explanatory variables, which can then be classified based on their importance. We built the models using portions of the observations and validated them by testing their ability to predict new observations. We also projected the models in time by testing how well monthly models were able to predict the distribution of fishing effort one, six and twelve months into the future.

The results demonstrate that the global pelagic longline fleet not only shows distinct monthly oceanographic preferences, but that these are dynamic over time and can be predicted through spatial models. The main correlates of fishing effort (surface temperature, oxygen and distance to continental shelf) are also known to be important for explaining the patterns of distribution of target species. While physiological limits are one of the main factors shaping the distribution of marine life, physiology has no leverage on the distribution of fishermen, who trace areas of suitable habitat for their ‘prey’. The environmental niche of humans in the open-ocean is therefore shaped by the preferences of their many target species.

As we grapple with rapidly changing oceans and ocean uses, advancements in predictive modeling, aided by new technologies, will help us move away from reliance on retrospective tactics in area-based management and towards more dynamic predictive approaches capable of delivering ecosystem-based management. This use of habitat models may allow managers to predict future areas of fishing effort and account for and prevent the overlap of fleets with non-target biodiversity. Future research includes the creation of fleet-specific and region-specific models as well as analyses of overlap with target and non-target species.