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PREDICTED ORIGINS OF DRIFTING FISH AGGREGATING DEVICES (DFADS) INTO ENVIRONMENTALLY SENSITIVE HABITATS OF HAWAIʻI USING BACKWARDS SIMULATED DRIFT TRAJECTORIES

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BACKGROUND INFORMATION

Tropical tuna purse-seine fishing vessels contribute significantly to abandoned, lost, or discarded fishing gear by deploying large numbers of drifting Fish Aggregating Devices (dFADs, Escalle *et al.*, 2021a; Lopez *et al.*, 2021). These devices, when lost, or abandoned by fishers may reach areas far from their original tropical fishing grounds. In Hawaiʻi, in addition to contributing to the increasing issue of plastic pollution, they can also impact marine life by arming essential habitats such as coral reefs and showing an entanglement risk for several marine species. In particular, several species are protected by the Federal Endangered Species Act, such as the Hawaiian Monk Seal (*Neomonachus schauinslandi*), the Hawaiian Green Sea (*Chelonia mydas*), and the Hawksbill turtles (*Eretmochelys imbricata*), the Spinner Dolphins (*Stenella longirostris*), the Humpback Whale (*Megaptera novaeangliae*) and the Hawaiian Goose (*Branta sandvicensis*).

AIM

This study aims at identifying the origin areas of dFADs that can impact the marine environment by damaging fragile benthic habitats and entangling wildlife. The spatial extent of the simulations included the whole Pacific Ocean, from 120°E to 90°W and from 50°N to 30°S to cover both the Western and Central Pacific Fisheries Commission (WCPFC) and the Inter-American Tropical Tuna Commission (IATTC) convention areas and the Hawaiian Exclusive Economic Zone (EEZ) (Figure 1). We investigated the likely origin of dFADs stranding in Hawaiʻi coastal areas and their connectivity route with the equatorial region where dFADs are deployed and used by purse seiners. The potential origin zones in the equatorial areas were separated into Equatorial Zones (EZ) and dFAD Zone (FZ). This will help determine the probability of the origin of dFADs arriving in key essential habitats over a timescale of five years. We used backward simulated Lagrangian drift trajectories to assess these origin areas with a focus on essential Hawaiʻi coastal habitats and unique ecosystems defined as coastal zones (CZ). Results will also be compared, when possible, with actual reports of dFADs washing ashore in the MHI and the PMNM. The results presented in this report are preliminary.

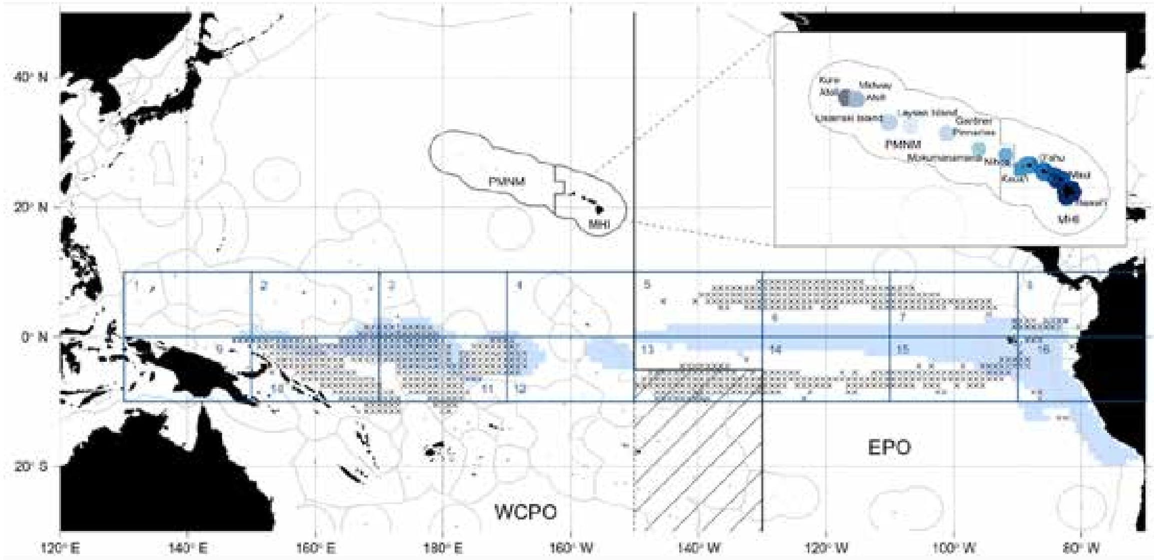

FIGURE 1. Map of the Pacific Ocean with the main areas considered in the simulations. The black line indicates the WCPFC and IATTC convention areas, with the striped area being included in both convention areas. Blue rectangles correspond to the Equatorial Zones (EZ) used in the simulations to identify areas of release of virtual dFADs throughout the equatorial Pacific in the simulations. DFAD Zones (FZ) in the simulations are indicated as 1° cells included in the main dFAD deployments areas (blue) and main dFAD densities areas (black crosses). Magnification of the main Hawaiian Islands (MHI) and the Papahanamukakea National Marine Monument (PMNM) with a special focus on the coastal zones (CZ) used in the simulations.

PRELIMINARY RESULTS

The Hawaiian Archipelago receives a generous amount of abandoned, lost, and derelict fishing gear (ALDFG), including dFADs, each year. Throughout 2014 to 2021, a total amount of 86 dFADs were documented with 47 from the Main Hawaiian Islands, 28 from Papahānaumokuākea Marine National Monument, and 1 from the North Pacific Gyre (Figure 2). Overall, 55% of the dFADs were the GPS buoy only while 26% were the raft only and 19% were the GPS buoy and raft. Rarely the tail is still connected to the raft, which is the result of having the tail lost before stranding or entangled in a coral reef before beaching along the shoreline (Royer et al., *in preparation*). The windward (east) sides of the islands are known to receive large amounts of floating plastic debris that do not originate from Hawaiʻi. Instead, debris is thought to come from the GPGP and is caught by the islands' windward shorelines.

Using backward simulated drift trajectories, preliminary results showed that all Hawaiian coastal zones (CZ) showed at least some level of potential connectivity with the equatorial pacific, where dFADs are deployed and used, although with high variability ending on the area considered and the drift time (Figure 3). Connectivity will be studied for both summer (May to October) and winter (November to April) season's arrival, as well as for different ENSO periods.

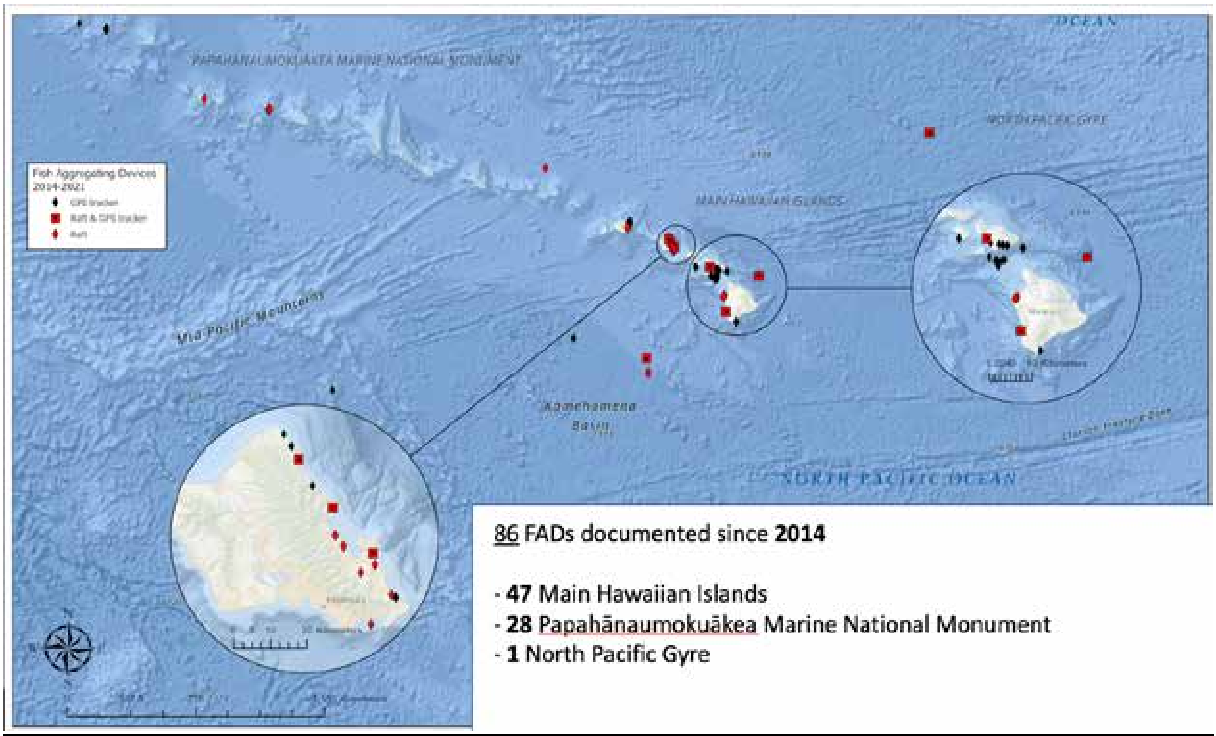

FIGURE 2. Map of dFADs arrival events that had location coordinates and were recovered as marine debris from 2014 to 2021 in the main Hawaiian Islands, Papahānaumokuākea Marine National Monument, and the North Pacific Gyre Region, The different combinations of dFADs components are represented by different symbols.

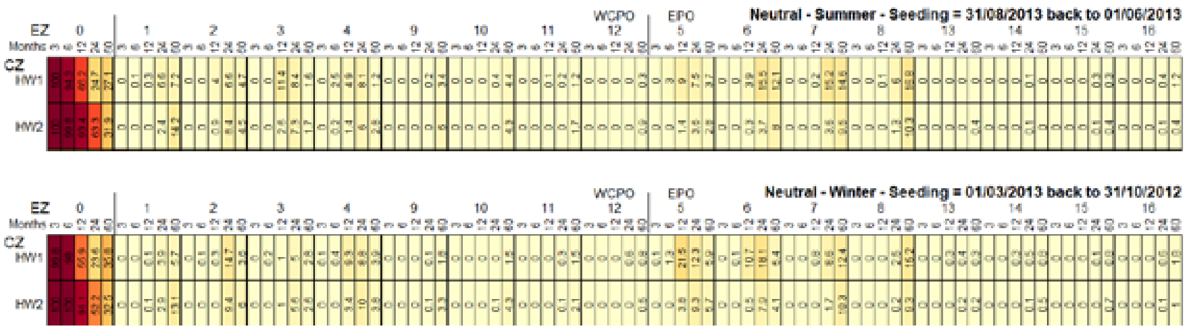

FIGURE 3. Percentage connectivity matrix of virtual particles in the time-backward simulation during an ENSO Neutral period by Equatorial Zones (EZ; from 1 to 16; 0 representing to rest of the Pacific Ocean) against seeding in turtles Coastal Zones (CZ) habitats and separated by drift time in months. Particles are seeded during the summer (top) or winter (bottom) period. Cells are coloured by the proportion of simulated particles arriving in each TZ by drift time. HW1 = main Hawaiian Islands; HW2 = Papahānaumokuākea Marine National Monument.

PERSPECTIVE

The adoption of new designs, such as biodegradable dFAD designs that would remain intact for a period no longer than 9 to 12 months could therefore highly reduce the number of dFAD reaching non-equatorial zones, such as Hawai'i, after long drift times. In addition, given the fact that dFADs freely drift from one convention area to the other and the lack of specific direct binding management measures related to dFAD loss and abandonment in the EPO such studies are important in helping to predict the fate of these dFADs and how to address these issues related to the potential high distance between the source and stranding areas.

This work is in progress and further analysis will be conducted. This includes looking at differences between the summer (May to October) and the winter months (November to April), in addition to simulations to reflect the main temporal variability for the Pacific Ocean (El Niño–Southern Oscillation (ENSO)) and La Niña period. Some more analysis will also be conducted to assess the contribution of the windward versus the leeward sides of the islands.

ACKNOWLEDGEMENTS

In the EPO, FAD density and deployment hotspots were identified using the IATTC buoy database (information reported to the IATTC under Resolution C-17-02) and the IATTC observer database. In the WCPO, hotspots of FAD deployments and FAD densities are derived from Escalle *et al.* (2021b), which are based on the Parties to the Nauru Agreement (PNA) FAD tracking database. Passive drift simulations were run on resources and services from the National Computational Infrastructure (NCI), which is supported by the Australian Government. The authors thank Scott Benson, Maxime Lalire, Bryan Wallace, and Irene Kelly for their participation in the Lagrangian simulation preparatory workshops; their expertise and advice helped design the experiment presented in this report. This project received funding under award NA20NMF4540142 from NOAA Fisheries Pacific Islands Regional Office. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of NOAA.

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