FATE: The drifting Fish Aggregating device (dFAD) TrajEctory modeling tool for marine protected area management

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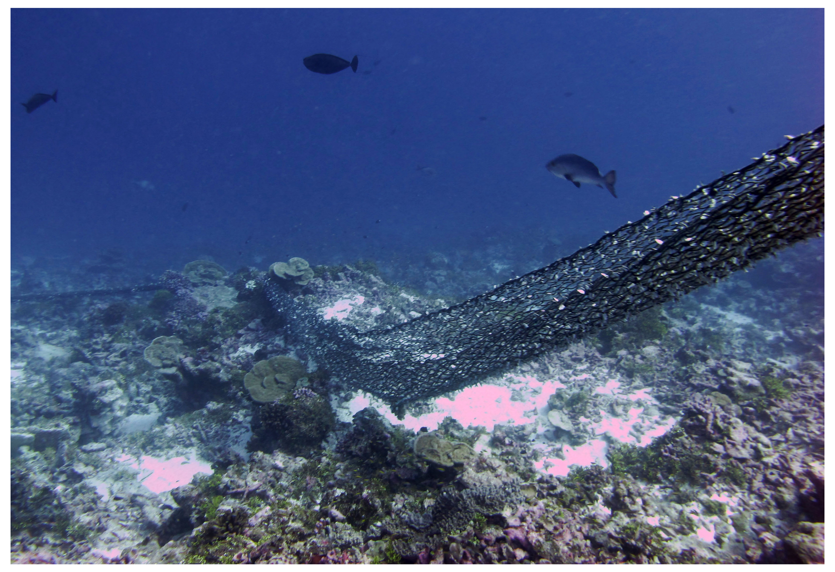
Introduction to the problem

- 30,000 dFADs deployed in Pacific each year [1]
- dFADs can ground on coral reefs causing damage (**Fig 1**)
- dFADs may remove biomass from protected areas [2]
- dFADs follow complex current trajectories, which are hard to predict
- Intercepting a dFAD can take up to 32 person-hours (**Fig 2**)



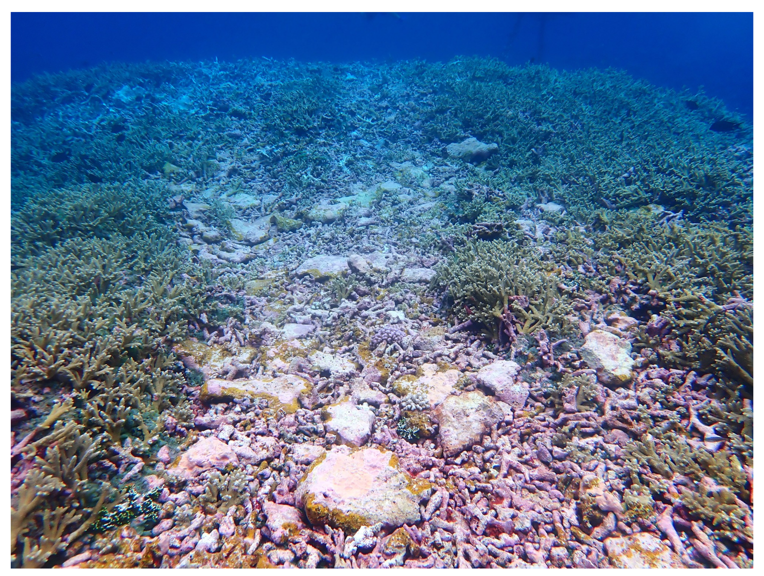


Figure 1: dFADs aggregate fishes in the open ocean (top left) but may get stuck on coral reefs closer to shore (top right), potentially destroying the reef (bottom left). Image credits: K.Pollock/TNC.

Decision Point

Whether to deploy tactical resources to intercept dFAD before it hits the reef

Figure 2: Tactical resources to intercept dFADs include boats (left) and snorkelers (bottom). **Successful dFAD interceptions may take up to 32 person hours**. Image credits: K.Pollock/TNC.

Overview of FATE objectives

1. Create a decision-making tool to help decide whether to deploy tactical resources to intercept dFADs (**Fig 3A**)
2. Use NASA Earth data and models to predict dFAD trajectories
3. Understand how important fishes interact with dFADs (**Fig 3B**)
4. Use FATE operationally in the Palmyra NWR

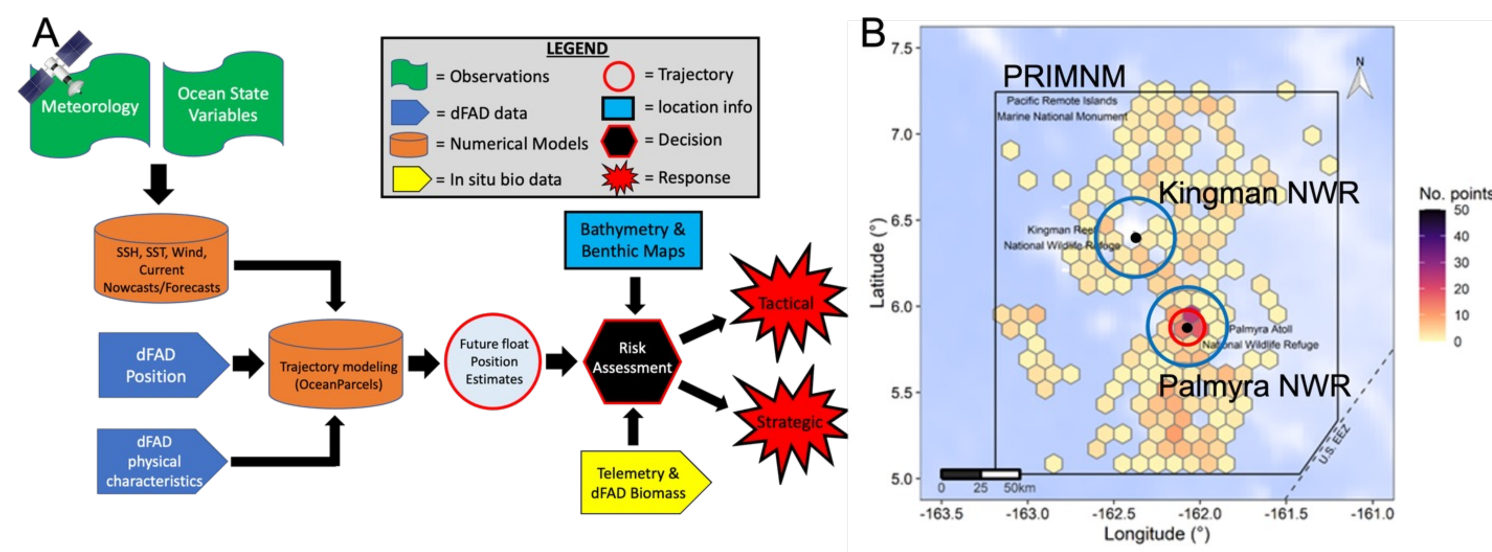


Figure 3: A) Flow chart indicating high level steps of the FATE tool. B)Yellowfin tuna (*Thunnus albacares*) density from geolocation telemetry tags within the Pacific Remote Islands Marine National Monument (solid black line) and the Palmyra Atoll National Wildlife Refuge (solid blue line) in 2022–2023 [3]. Dashed line indicates the U.S. exclusive economic zone (EEZ). Hexagons are filled with a scale of light-dark colors that correspond to increasingly larger numbers of points. Red line around Palmyra indicates the 6-nautical mile radius within which the Palmyra FAD Watch program currently intercepts dFADs.

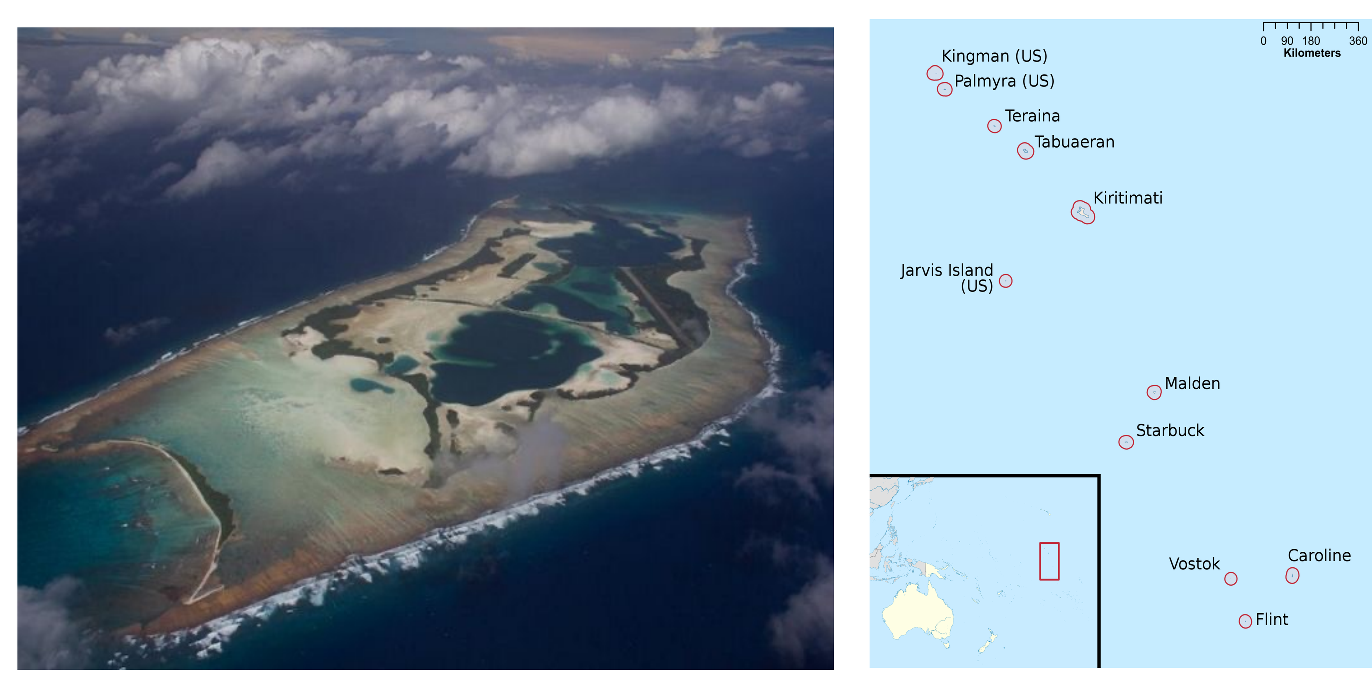


Figure 4: Map of the Line Islands including Palmyra Atoll (right) and its overhead image (left, credit the Nature Conservancy).

Open software for use in a remote environment

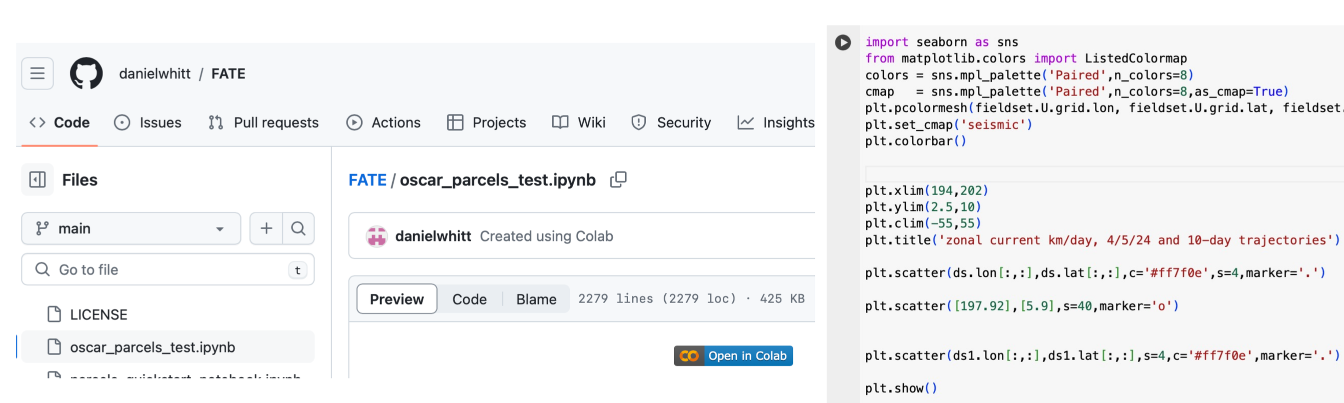
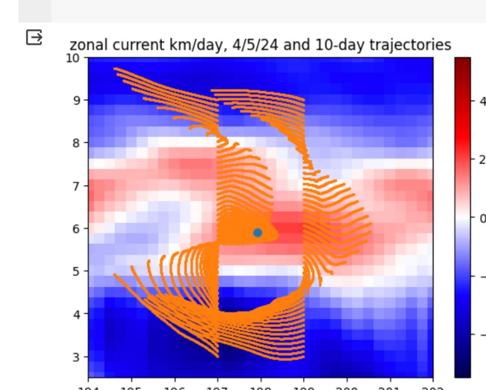


Figure 5: The software will be developed as a Jupyter notebook in Google Colab and version controlled and shared using Github, so that the end user can run the FATE tool from any personal computer with an internet connection sufficient to work with a web browser. The tool will automatically retrieve and install all relevant software packages and data in an on-demand cloud instance and conduct all processing remotely with text inputs from the user and visualizations delivered by web browser. An initial notebook with a visualization of virtual Lagrangian particle trajectories simulated using the OceanParcels package [4] and NASA OSCAR ocean surface currents [5] during April 2024 is shown at the right.



Support decision making by pairing trajectory forecasts with risk

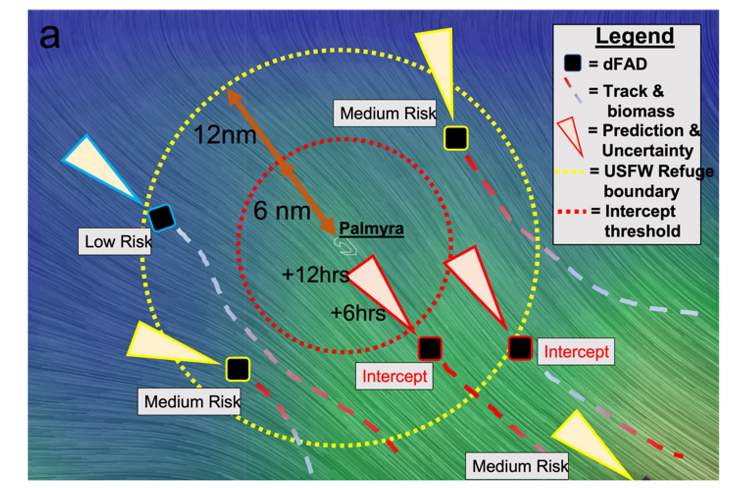
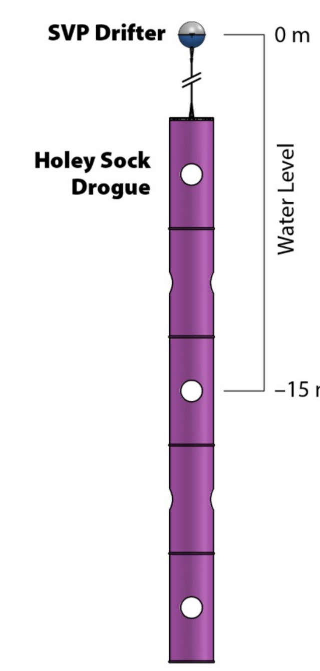


Figure 6: Hypothetical visualization of regional surface currents from OSCAR, with incoming dFAD tracks and fish biomass index represented by warm/cool colors. Cone represents a crude example of predicted locations in time using Lagrangian simulations, where color of the dFAD represents risk level.

Field Work to Evaluate FATE & Build Understanding

1. Drifting buoy deployments to evaluate satellite currents around Palmyra and compare with dFAD movement (**Fig 7**).
2. Animal telemetry of yellowfin tuna to quantify fishes' movements in relation to dFADs within protected area



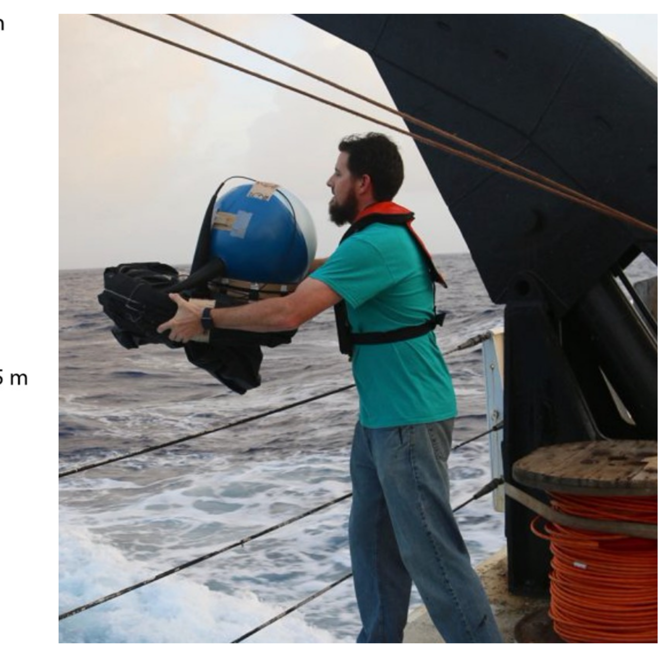


Figure 7: The study will involve field campaigns to tag 50 tuna and release 24 SVP drifters near Palmyra to understand dFAD activity and its relation to currents and fish. Drifter images from Scripps Drifter Laboratory and NOAA Global Drifter Program Websites.

Expected FATE outcomes

1. Reduced time searching for and recovering dFADs
2. Reduced number of dFADs grounded on coral reefs
3. Better understanding of how tuna interact with dFADs

Additional anticipated benefits

1. Transferability of tool/concept to other Pacific islands that experience high numbers of dFAD intrusions or groundings

References

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