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

Royer, S.J., Escalle, L., Scutt Phillips J., Lynch J., Lopez J., Swimmer Y., Murua H., Restrepo V., Moreno G.

INTER-AMERICAN TROPICAL TUNA COMMISSION WORKING GROUP ON dFADs, 12TH MEETING
12-13 May 2023

Modelling FADs backward trajectories arriving at essential habitats in Hawai‘i

Part 2 of Pacific Islands Regional Office (PIRO) - NOAA project (2020-2023), which aimed at defining guidelines and conservation recommendations to reduce the impact of lost and abandoned FADs on sea turtles in the Pacific Ocean

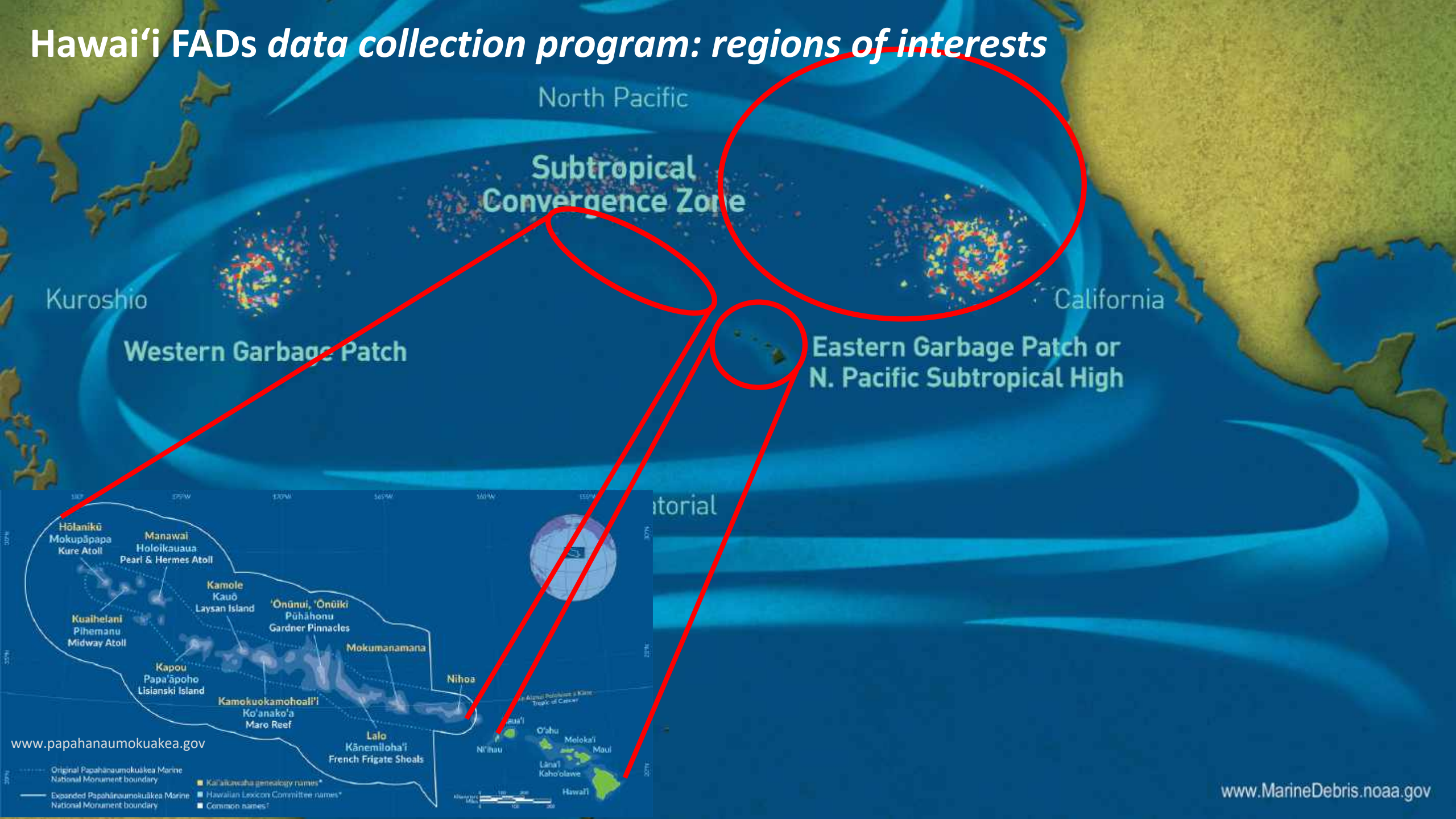
OBJECTIVES:

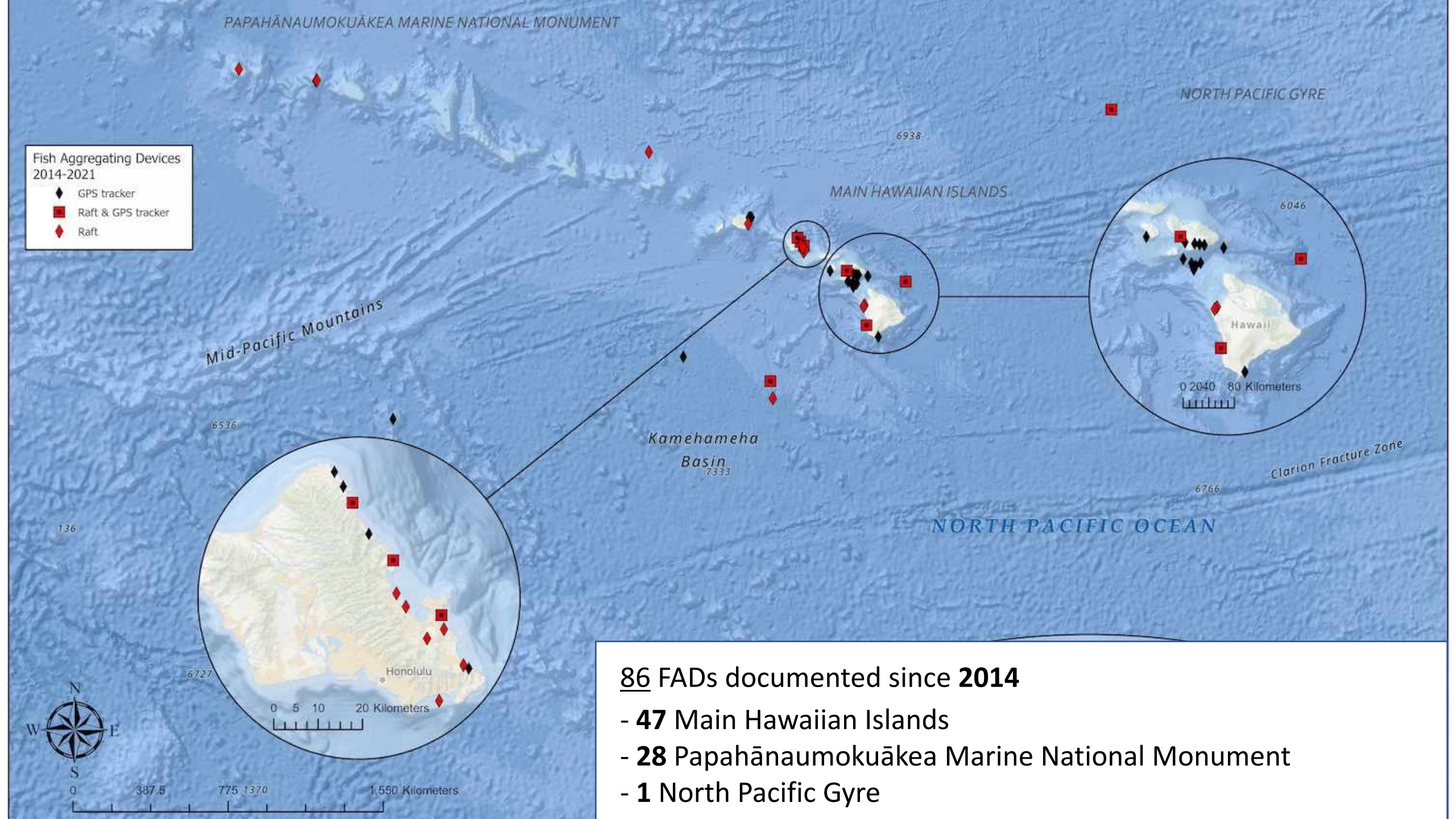
Using backward simulated Lagrangian drift trajectories, we aimed at evaluating the origin areas of dFADs stranding in Hawai‘i with a focus on essential coastal habitats and unique ecosystems defined as coastal zones (CZ).

Explore and quantify their connectivity route between Hawai’I CZ and the equatorial region where dFADs are known to be deployed and used by purse seiners.

For more details about this project please also see the following talks that were presented at the Bycatch and FAD WGs:
Bycatch WG: 5c1. Escalle et al., (ISSF/SPC) Drifting fish aggregating devices (dFAD) & sea turtle interactions in the open ocean.
FAD WG: FAD-07-4. Gala et al., (ISSF) Guidelines to reduce the impact of FADs on sea turtles.

Hawai‘i FADs *data collection program: regions of interests*





86 FADs documented since **2014**

- **47** Main Hawaiian Islands
- **28** Papahānaumokuākea Marine National Monument
- **1** North Pacific Gyre

Data collection

Pacific Community
Communauté du Pacifique

B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
OLD ENTRY NUMBER (associated w	Double with Entry #	HPU CMDR Event number	TO BE USED IN PAPER #1	ENTERED BY	CONTACT EMAIL	CONTACT PH	DATE ENTER	FOUND BY/SOURCE	FAD RAFT PRESENT	BUOY PRESENT	RAFT/BUOY PRESENT	RAFT/BUOY PRESE	BUOY MAKE	BUOY MODEL	BUOY ID #
1	-	-	Yes	Sarah-Jeanne Royer	sjroyer@hawaii.edu	808-218-3556	-	-	No	Yes	GPS tracker	No	Zunibal	-	-
2	-	-	Yes	-	-	-	-	Sustainable Coastlines Hawa	No	Yes	GPS tracker	No	Satlink	-	-
3	-	-	Yes	-	-	-	-	Sustainable Coastlines Hawa	No	Yes	GPS tracker	No	Zunibal	Zuni-7	-
4	-	-	Yes	Sarah-Jeanne Royer	sjroyer@hawaii.edu	808-218-3556	-	Sustainable Coastlines Hawa	No	Yes	GPS tracker	No	Zunibal	Zuni-7	-
5	-	-	Yes	-	-	-	-	Joanna Fletchall	No	Yes	GPS tracker	No	Marine Instruments	-	-
6	-	-	Yes	-	-	-	-	Sustainable Coastlines Hawa	No	Yes	GPS tracker	No	Zunibal	Zuni-7	-
7	-	-	Yes	-	-	-	-	Sustainable Coastlines Hawa	No	Yes	GPS tracker	No	Zunibal	Zuni-7	-
8	-	-	Yes	-	-	-	-	-	No	Yes	GPS tracker	No	Zunibal	Zuni-7	-
9	-	-	Yes	-	-	-	-	Anthony Burris	No	Yes	GPS tracker	No	Marine Instruments	-	-
10	-	-	Yes	-	-	-	-	Maui Diamond II	Yes	Yes	GPS tracker and raft	Yes	Marine Instruments	M3++	M3++ 500978
11	-	-	Yes	-	-	-	-	Sustainable Coastlines Hawa	No	Yes	GPS tracker	No	Satlink	ELB3010 DSL	-
12	-	pre-NREP, dont know where h	Yes	Hank Lynch	lynch.hank@gmail.com	808-721-4223	-	Hank Lynch	Yes	Yes	GPS tracker and raft	Yes	Marine Instruments	something 502322	502322
13	-	-	Yes	-	-	-	-	Kallie Burns	No	Yes	GPS tracker	No	OrbBuoy/MI	-	-
14	-	-	Yes	-	-	-	-	Shawn Zenor	Yes	Yes	GPS tracker and raft	Yes	Marine Instruments	M3++	M3++ 503572
15	-	-	Yes	-	-	-	-	Sustainable Coastlines Hawa	No	Yes	GPS tracker	No	Marine Instruments	-	2582
16	-	-	Yes	Sarah-Jeanne Royer	sjroyer@hawaii.edu	808-218-3556	-	-	No	Yes	GPS tracker	No	-	-	72260
17	-	-	Yes	Sarah-Jeanne Royer	sjroyer@hawaii.edu	808-218-3556	-	-	No	Yes	GPS tracker	No	Marine Instruments	M3i	M3i 229051
18	-	-	Yes	Sarah-Jeanne Royer	sjroyer@hawaii.edu	808-218-3556	-	-	No	Yes	GPS tracker	No	Marine Instruments	M3i	M3i 232959
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20	-	-	Yes	-	-	-	-	Sustainable Coastlines Hawa	No	Yes	GPS tracker	No	Marine Instruments	M3i	M3i 103209
21	-	-	Yes	-	-	-	-	Noni and Ron Sanford	No	Yes	GPS tracker	No	Marine Instruments	M8i	M8i 55641
22	-	-	Yes	-	-	-	-	Noni and Ron Sanford	No	Yes	GPS tracker	No	Zunibal	Tuna e7	-

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3	-	-	Yes	-	-	-	-	Sustainable Coastlines Hawai	No	Yes	GPS tracker	No	Zunibal	Zuni-7	-
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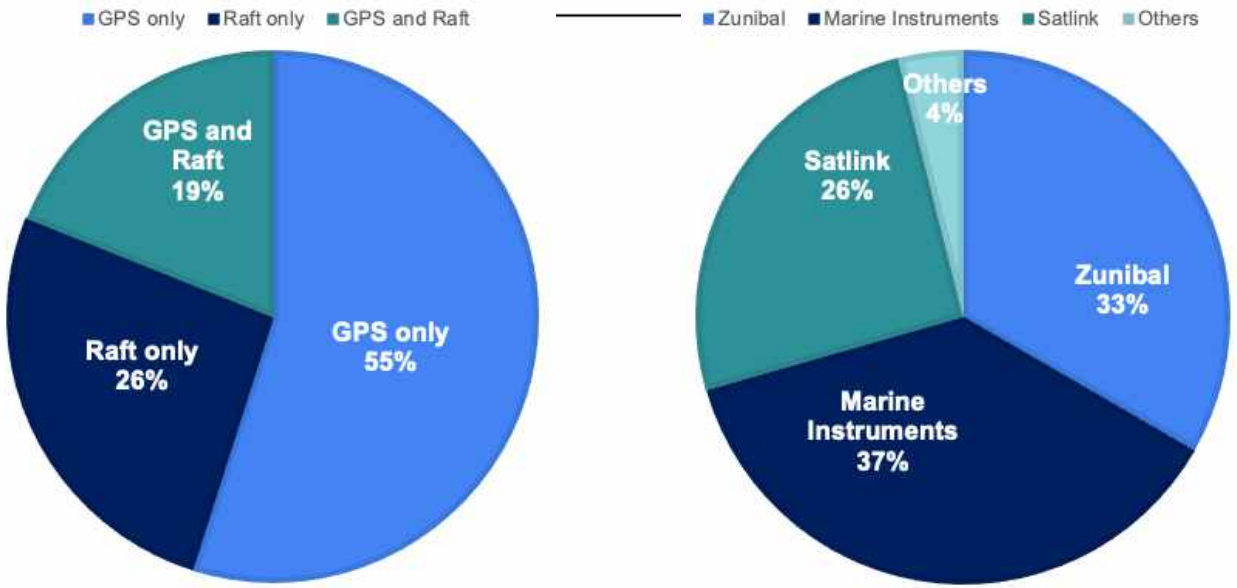

Overall, 55% of the dFADs were the GPS buoy only while 26% were the raft only and 19% were the GPS buoy and raft only.

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*).

In order, Marine Istruments, Zunibal and Satlink were the most common GPS buyos found.

Credit: HPU, CMDR

Credit: Sustainable Coastlines Hawai'i

Credit: HPU, CMDR

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SCH6
SCH6
SCH6

Credit: HPU, CMDR


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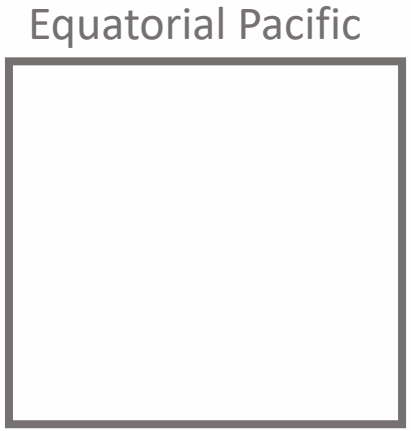
Passive drift simulation

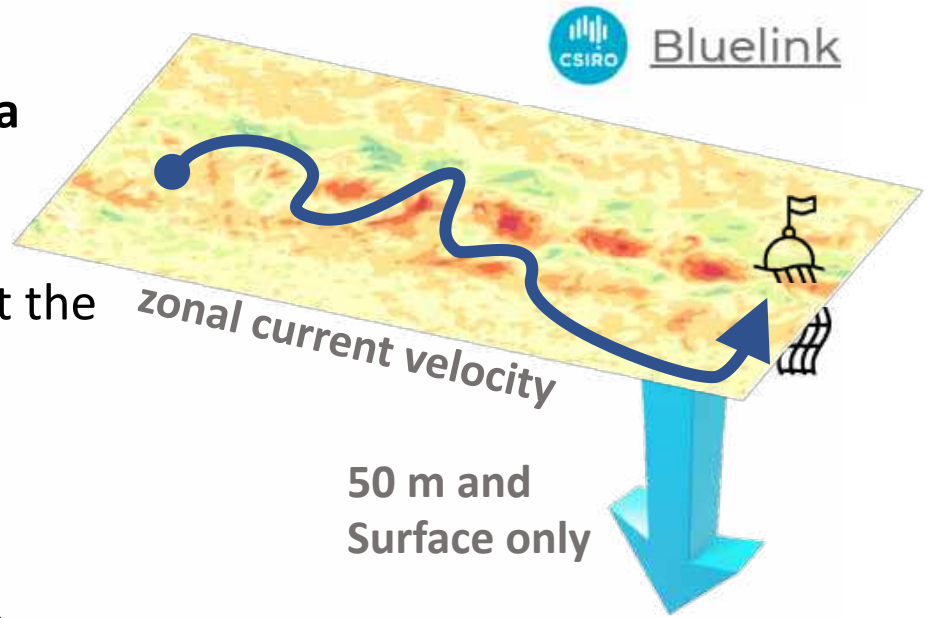
- **Limited availability of observed dFAD trajectory data**
- **Use knowledge of ocean currents to predict the pathways of passively drifting objects**
- **Virtual ‘particles’ are moved around by current velocity forcings, across depths corresponding to dFAD drift profile**
- **Seed particles randomly across areas of interest and repeatedly through time**



Zone of interest,
seeding area
(HI coastal zones)

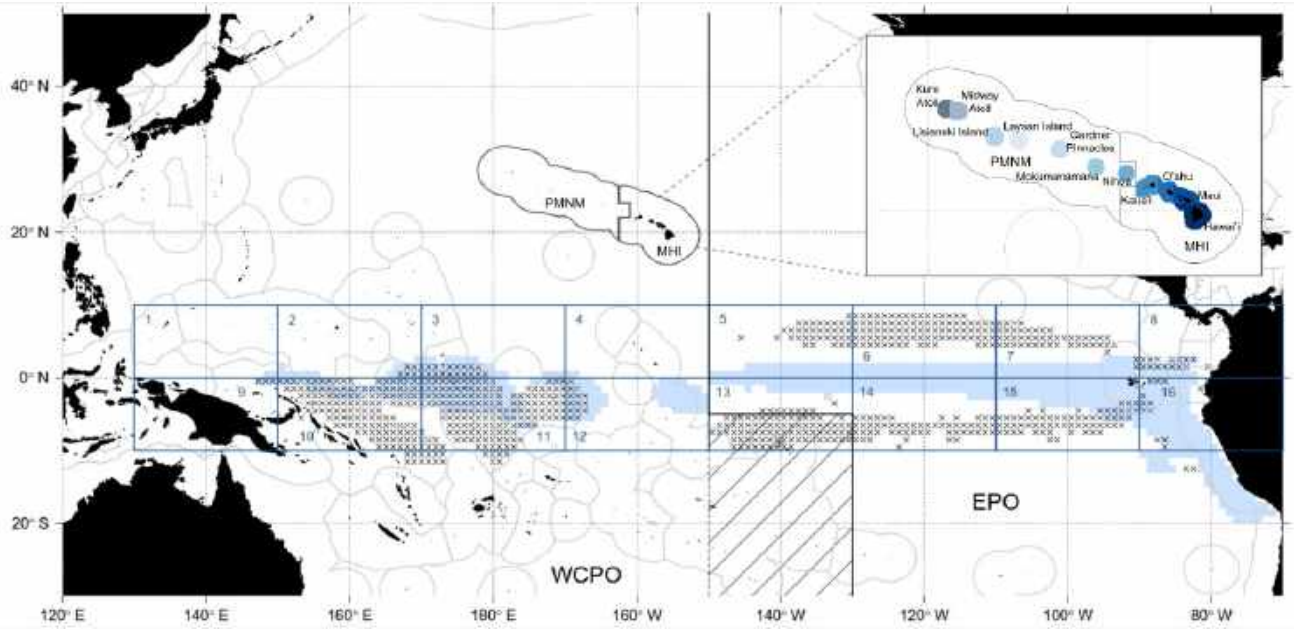
Backward Lagrangian Simulation Overview

- Ocean circulation model: **Bluelink Reanalysis physical ocean data** Current **velocity flow fields at 1/10°, daily** resolution
- Mean **velocity integrated across top 50m** of water column and at the **surface** given that most FADs arriving in Hawai‘i do not have tail.
- Domain bounded by **120°E to 70°W, and 50°N to 30°S**
- Virtual dFAD particles (**vFADs**) advected using a **6-hour time-step,** with positions **saved at weekly intervals**
- New v**FAD seeding at weekly intervals** during deployment periods
- Drift-trajectories simulated backwards up to five years prior to stranding events

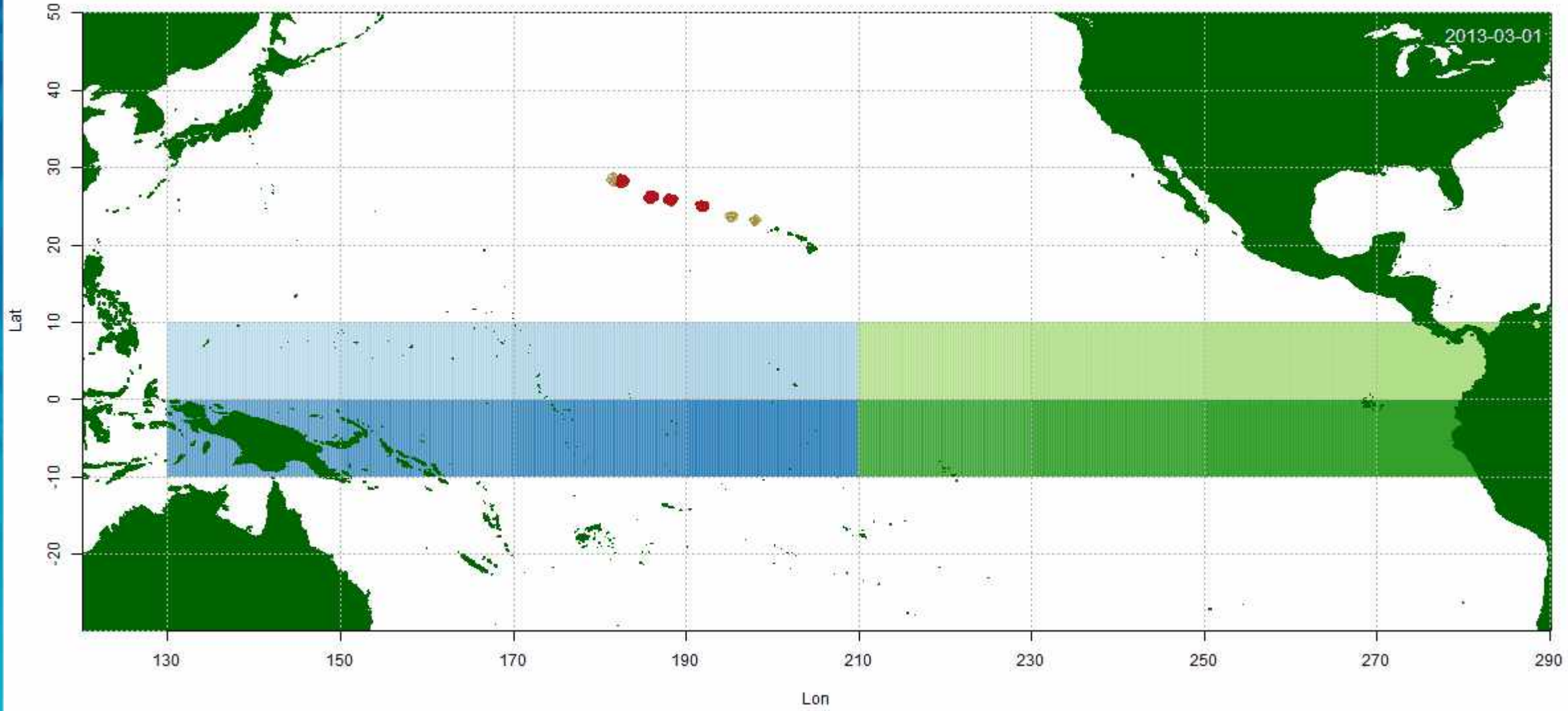


Origin Zones (EZ and FZ)

- Based on area of **tropical tuna fishing ground**
- Divided into **WCPO and EPO** origin zones
- Zoning into **16 equatorial deployment areas**, spread across both convention areas **(EZs)**
- Alternatively, zones of dense, **observed FAD operations (FZs)**, divided into deployment (depl) and density hotspots (dens)
- Special focus on the **coastal zones (CZ)** of the main Hawaiian Islands (MHI) and the Papahanamukakea Marine National Monument (PMNM)



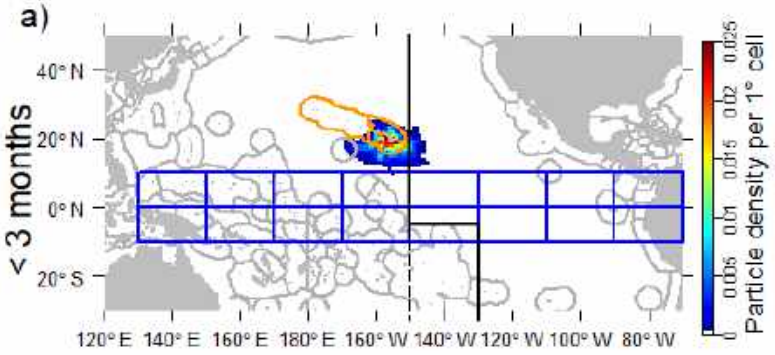
FAD seeding in the N. Hawaiian Islands



Quantifying Connectivity

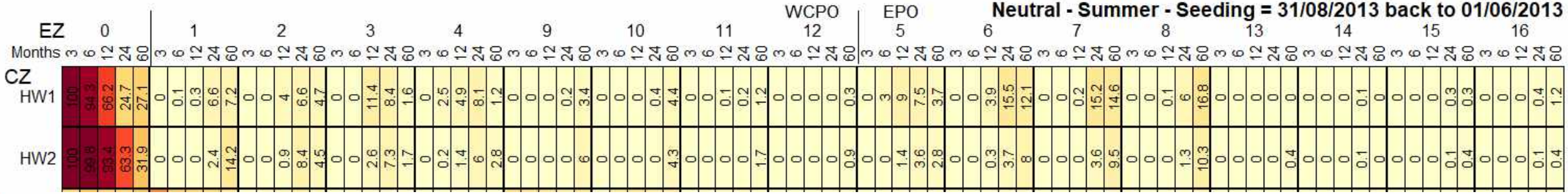
- Connectivity based on tracking vFADs between zones
- Structured on each vFAD relative time and deployment/arrival zone
- Combine for all vFADs:
  - released in an origin zone
  - arriving in a destination zone
  - having drifted for a certain time
- Connectivity matrices and particle density plots

FAD seeding in the Main Hawaiian Islands



Quantifying Connectivity

- Preliminary results showed that all Hawaiian coastal zones (CZ) showed at least some level of potential connectivity with the equatorial pacific (EZ), where dFADs are deployed and used, although with high variability ending on the area considered and the drift time.



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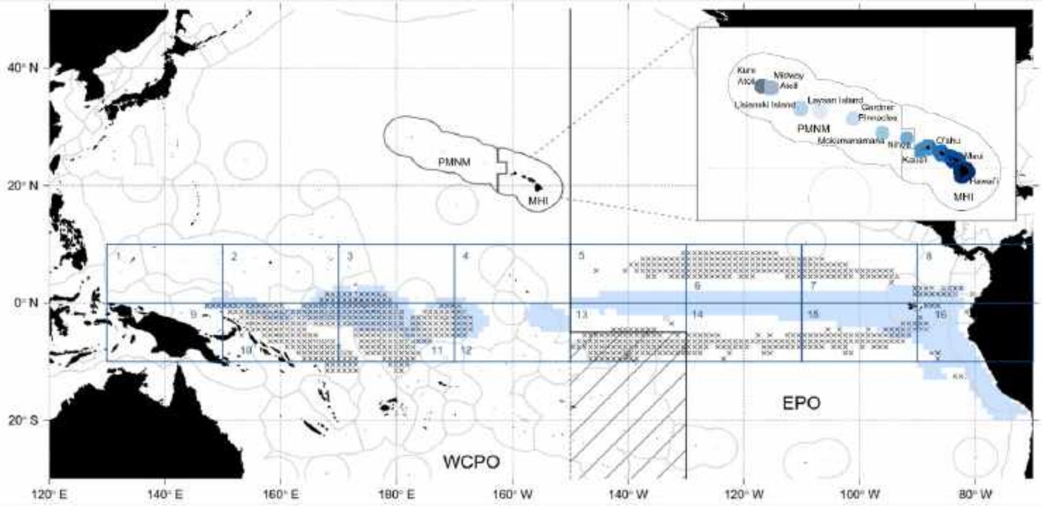

Neutral - Summer - Seeding = 31/08/2013 back to 01/06/2013

CZ \ EZ	0: 3	0: 6	0: 12	0: 24	0: 60	1: 3	1: 6	1: 12	1: 24	1: 60	2: 3	2: 6	2: 12	2: 24	2: 60	3: 3	3: 6	3: 12	3: 24	3: 60	4: 3	4: 6	4: 12	4: 24	4: 60
HW1	100	94.3	66.2	24.7	27.1	0	0.1	0.3	6.6	7.2	0	0	4	6.6	4.7	0	0	11.4	8.4	1.6	0	2.5	4.9	8.1	1.2
HW2	100	99.8	93.4	63.3	31.9	0	0	0	2.4	14.2	0	0	0.9	8.4	4.5	0	0	2.6	7.3	1.7	0	0.2	1.4	6	2.8

CZ \ EZ (WCPO)	9: 3	9: 6	9: 12	9: 24	9: 60	10: 3	10: 6	10: 12	10: 24	10: 60	11: 3	11: 6	11: 12	11: 24	11: 60	12: 3	12: 6	12: 12	12: 24	12: 60
HW1	0	0	0	0.2	3.4	0	0	0	0.4	4.4	0	0	0.1	0.2	1.2	0	0	0	0	0.3
HW2	0	0	0	0	6	0	0	0	0	4.3	0	0	0	0	1.7	0	0	0	0	0.9

CZ \ EZ (EPO)	5: 3	5: 6	5: 12	5: 24	5: 60	6: 3	6: 6	6: 12	6: 24	6: 60	7: 3	7: 6	7: 12	7: 24	7: 60	8: 3	8: 6	8: 12	8: 24	8: 60
HW1	0	3	9	7.5	3.7	0	0	3.9	15.5	12.1	0	0	0.2	15.2	14.6	0	0	0.1	6	16.8
HW2	0	0	1.4	3.6	2.8	0	0	0.3	3.7	8	0	0	0	3.6	9.5	0	0	0	1.3	10.3

CZ \ EZ (EPO)	13: 3	13: 6	13: 12	13: 24	13: 60	14: 3	14: 6	14: 12	14: 24	14: 60	15: 3	15: 6	15: 12	15: 24	15: 60	16: 3	16: 6	16: 12	16: 24	16: 60
HW1	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0.3	0.3	0	0	0	0.4	1.2
HW2	0	0	0	0	0.4	0	0	0	0.1	0	0	0	0	0.1	0.4	0	0	0	0.1	0.4

Next steps

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).

- Running simulations using surface currents.

- Running simulations to reflect the main temporal variability for the Pacific Ocean (El Niño–Southern Oscillation (ENSO)) with arrival during a Neutral; El Niño and La Niña periods, separately.

- Analysis to be conducted to assess the contribution of the wind-ward versus the lee-ward sides of the Hawaiin Islands.

Acknowledgements

- Volunteers that helped recovering the FADs and reporting them.

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Mahalo!

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Questions ?

Acknowledgments

In the EPO, dFAD 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 dFAD deployments and dFAD densities are derived from Escalle et al. (2021b), which are based on the Parties to the Nauru Agreement (PNA) dFAD 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 to 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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