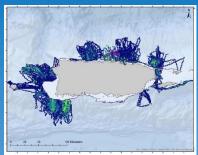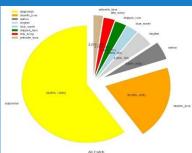# *Preliminary Results from 8 years of the Puerto Rico FAD System*
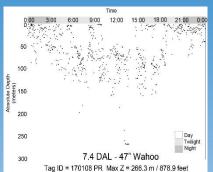


**Dr. Wessley Merten**

**CFMC 4.19.2022**

*Beyond Our Shores Foundation*

*FAD Research Program*

*Newport, Rhode Island*

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# Presentation Outline

**Presentation Objective:**

   **Provide a comprehensive update of research associated with the Puerto Rico FAD System.**

**Outline:**

1. Quick Program Statistics (5 mins)
2. Case Study 1: Catch and Effort (15 min)
3. Case Study 2: Vessel Census (7 min)
     Case Study 2a: Vessel Detections with Sound (4 min)
     Case Study 2b: Vessel and Marine life presence (4 mins)
4. Case Study 3: Tagging Studies (4 mins)
     1. Size-frequency tagged at FADs
     2. Wahoo vs. Dolphin
5. Acknowledgements and Questions: (2 min)

# Quick Program Statistics

**22**
Total de FAD Desplegados

**6**
FADs Activo

**2149**
Informes

**547**
Fish Tagged en FADs

16 Surface / 6 Subsurface

As of June 2019
**2,779** trips up to April 18th, 2022

As of 12.31.2021

1 Published
1 in review *Fisheries Science*
1 in prep

31 Satellite Tag Deployments
27 dolphin, 3 wahoo, 1 shark

34 Vessels Involved

Ultra-Light Vessel Tracking System (VTS)

350gr
(12.3oz)

29mm (1.1in)

PELAGIC

188mm
(7.4in)

81mm
(3.2in)

Table 1 FAD deployments (MM/DD/YYYY), damage or loss events, durations moored, total days moored, and number of deployment events for all surface FADs deployed in the Puerto Rico FAD System beginning June 2nd, 2015, to March 4, 2021.

| FAD ID | First Deployed | Estimated Depth (m) | Damaged or Lost | Days | Fixed or Deployed | Damaged or Lost | Days | Fixed or Deployed | Damaged or Lost | Days | Status | Total Days Moored | Number of Events |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E | 6/2/2015 | 550 | 2/19/2016 | 262 | 2/20/2016 | 11/28/2016 | 282 | 7/17/2017 | 9/20/2017 | 65 | Inactive | 609 | 3 |
| F | 6/3/2015 | 600 | 1/17/2017 | 594 | 5/15/2017 | 10/29/2017 | 167 | 7/21/2018 | 12/21/2021 | 1249 | Inactive | 2010 | 3 |
| G | 6/4/2015 | 598 | 9/20/2017 | 839 | | | | | | | Inactive | 839 | 1 |
| D | 6/8/2015 | 260 | 8/4/2017 | 788 | | | | | | | Inactive | 788 | 1 |
| A | 9/17/2015 | 305 | 12/10/2016 | 292 | | | | | | | Inactive | 292 | 1 |
| B | 9/18/2015 | 402 | 3/30/2016 | 291 | 7/17/2017 | 7/4/2018 | 352 | | | | Inactive | 643 | 2 |
| C | 9/19/2015 | 349 | 12/29/2017 | 832 | 7/21/2018 | 8/1/2018 | 11 | | | | Inactive | 843 | 2 |
| H | 2/10/2016 | 520 | 2/18/2018 | 739 | | | | | | | Inactive | 739 | 1 |
| K | 5/22/2017 | 500 | 6/4/2017 | 13 | | | | | | | Inactive | 13 | 1 |
| L | 5/22/2017 | 500 | 9/10/2018 | 476 | | | | | | | Inactive | 476 | 1 |

Maximum/Minimum longevity = 1249/12 days

Average longevity = 453

Average time to redeployment = 8.8 months

Case Study 1:
Catch and Effort:
Vessel Trip Histories

Picture: W. Merten

VTS Study Justification & Methods

# Database Management & Analysis

## Fishing Trips:

PDS Application Program Interface (API) combined with Google's data warehouse – BigQuery (PostgreSQL)

## Trip Catch:

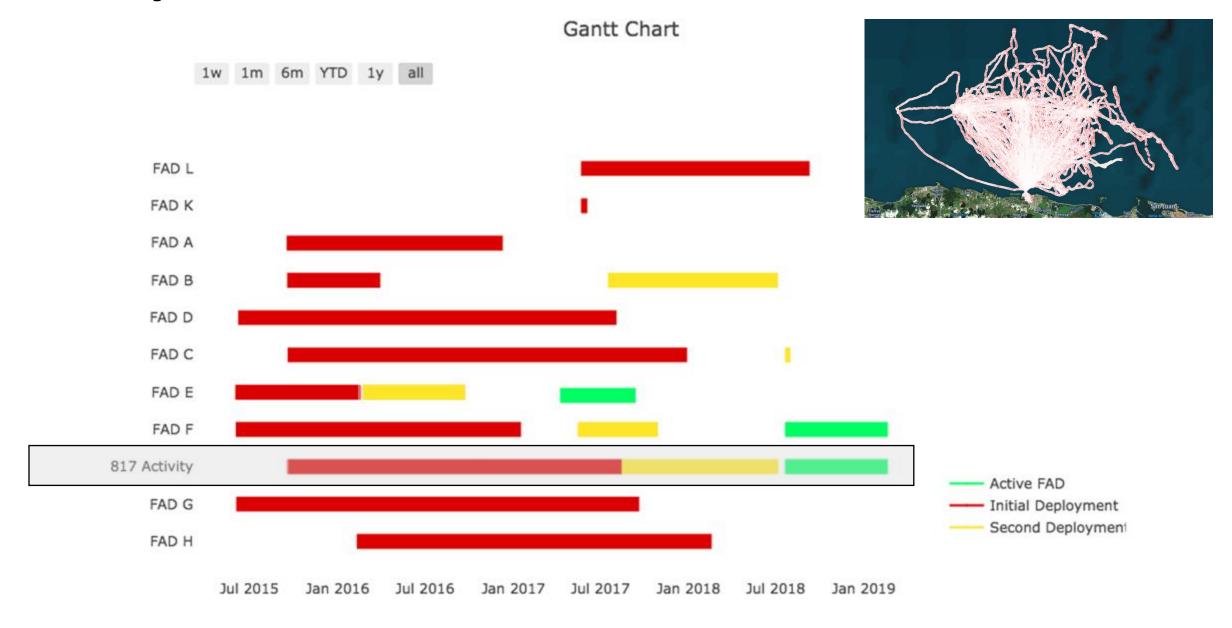Daily written surveys entered in BQ & joined to trips

## Data Cleaning & Analysis:

*SQL (updates/inserts/deletes)
*R with Matplotlib, CARTO for GIS

# Vessel Fishing Trip Histories: Charter Examples



Gantt Chart

Vessel Fishing Trip Histories: Charter Examples

Preliminary Results

Vessel Fishing Trip Histories: Charter Examples

Preliminary Results

Vessel Fishing Trip Histories: Charter Examples

# Preliminary Results

## Vessel Fishing Trip Histories: Charter Examples



January to May
44 Trips

**Legend**

**Fishing Hours/1.27 sq km**

**Value**

| | |
|---|---|
| 5.13 | Average time/trip = 5.14 hr |
| 4.62 | |
| 4.11 | |
| 3.59 | Average distance traveled/trip = 45.56 km |
| 3.08 | |
| 2.56 | |
| 2.05 | Average range from shore/trip = 13.41 km |
| 1.54 | |
| 1.02 | |
| 0.51 | Total Area covered = 322.28 sq km |
| 0 | |

○ FAD

municipios

── 40 meters

FAD G Associated Catch

White, 1   Wahoo, 1

Dorado, 32

NONFAD Associated Catch

Sail, 1
Blackfin, 1
Yellowfin, 1
Dorado, 8
Blue, 2

0   5   10   20 Kilometers

Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors

**Preliminary Results**

# Vessel Fishing Trip Histories: Charter Examples

**January to May**
**19 Trips Offshore**
**69 Trips Inshore**

**Legend**

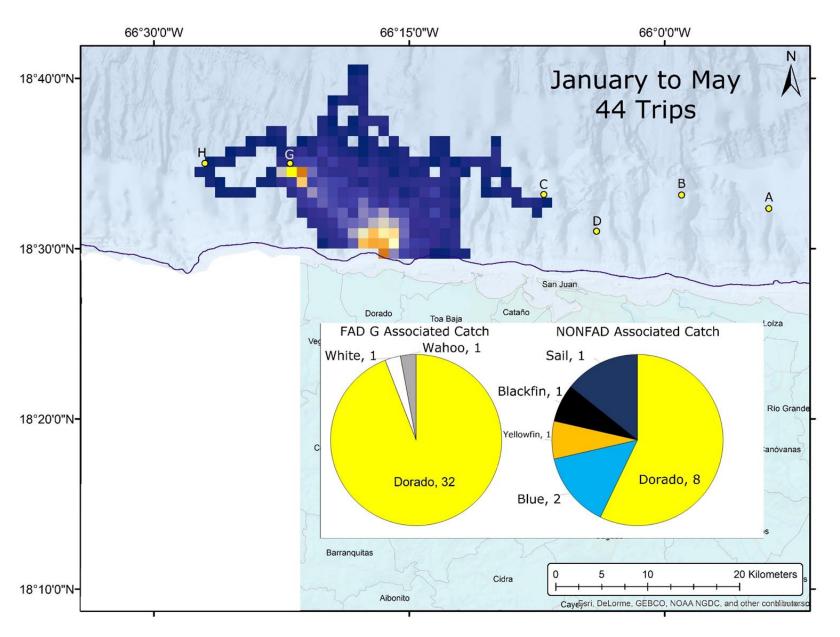**Offshore Fishing Hours/1.27 sq km**

Value

4.48528
4.03675
3.58822
3.1397
2.69117
2.24264
1.79411
1.34558
0.897056
0.448528
0

**Inshore Fishing Hours/1.27 sq km**

Value

48.18
43.36
38.54
33.72
28.91
24.09
19.27
14.45
9.63
4.81
0

○ FAD

municipios

40 meters

**FAD C & D Associated Catch**

Sail, 2
Marlin, 1
Dorado, 17

**NONFAD Associated Catch**

Yellowfin, 1
Dorado, 7

**Nearshore Associated Catch**

Remora, 1 — Smooth Hammerhead, 6 — Tripletail, 3 — Mutton Snapper, 1
Blue Runner, 1 — Jack, 2
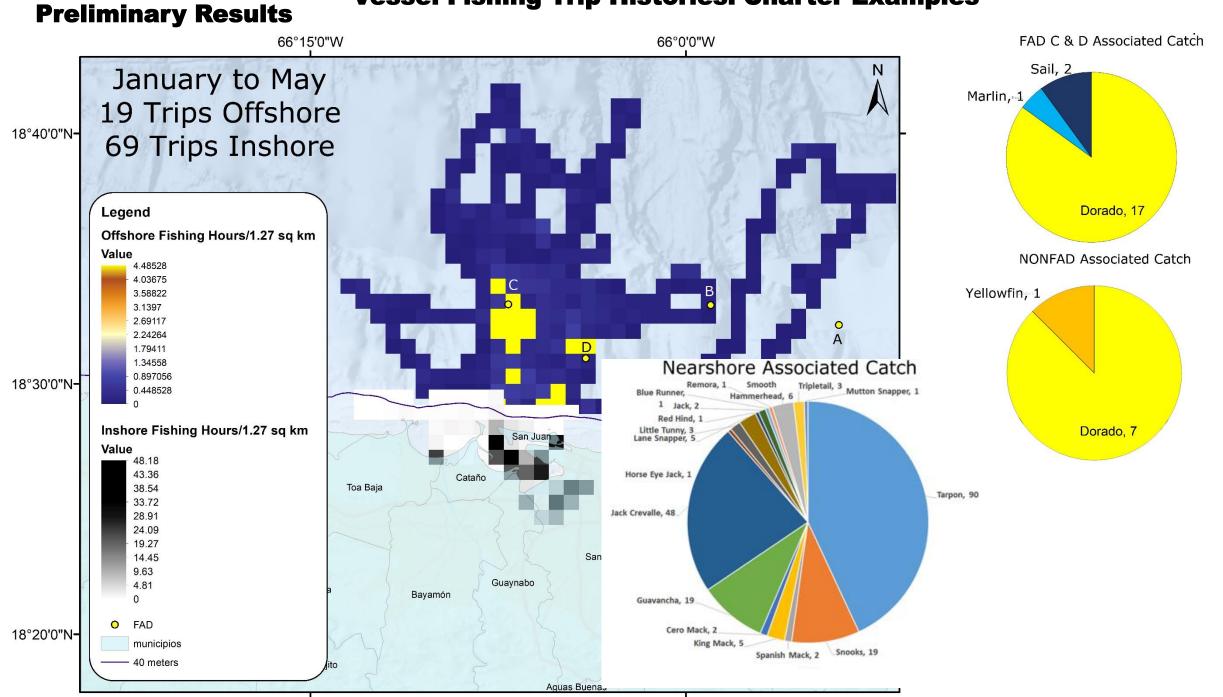Red Hind, 1
Little Tunny, 3
Lane Snapper, 5
Horse Eye Jack, 1
Jack Crevalle, 48
Tarpon, 90
Guavancha, 19
Cero Mack, 2
King Mack, 5
Spanish Mack, 2
Snooks, 19

San Juan
Cataño
Toa Baja
Guaynabo
Bayamón
Aguas Buenas

Preliminary Results

Vessel Fishing Trip Histories: Commercial Example

# Preliminary Results

# Vessel Fishing Trip Histories: Commercial Example
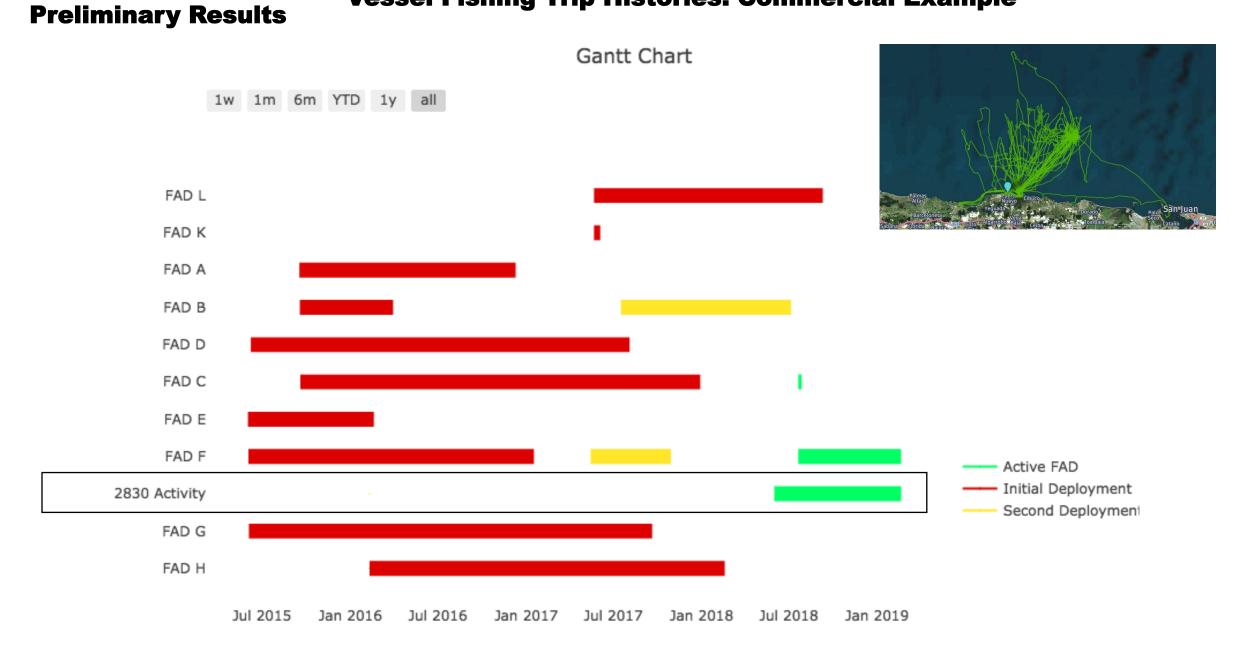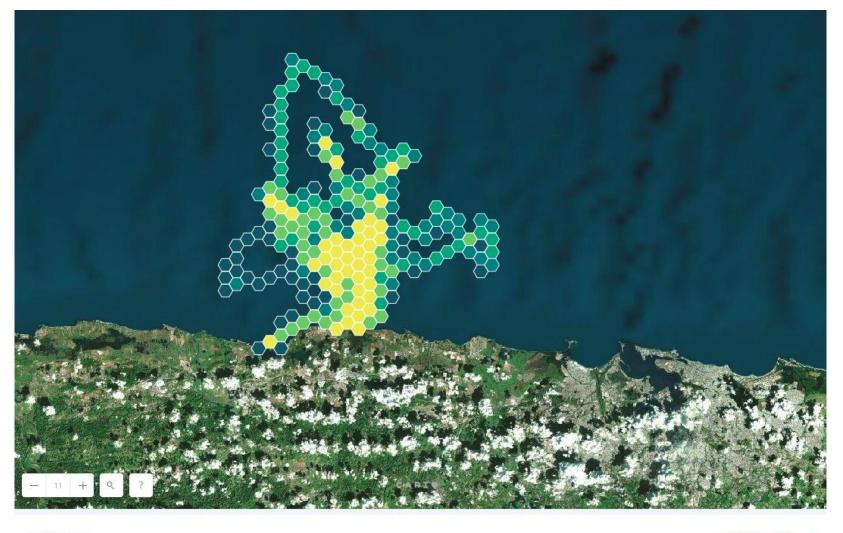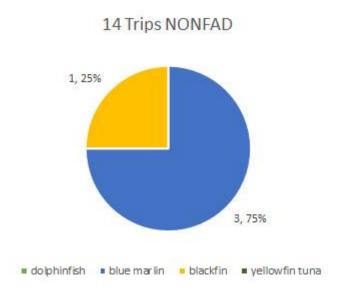
Preliminary Results

Vessel Fishing Trip Histories: Commercial Example

# Vessel Fishing Trip Histories: Commercial Example

# Vessel Fishing Trip Histories: Commercial Example

## Preliminary Results

**Preliminary Results**

**Vessel Fishing Trip Histories: Recreational Example**

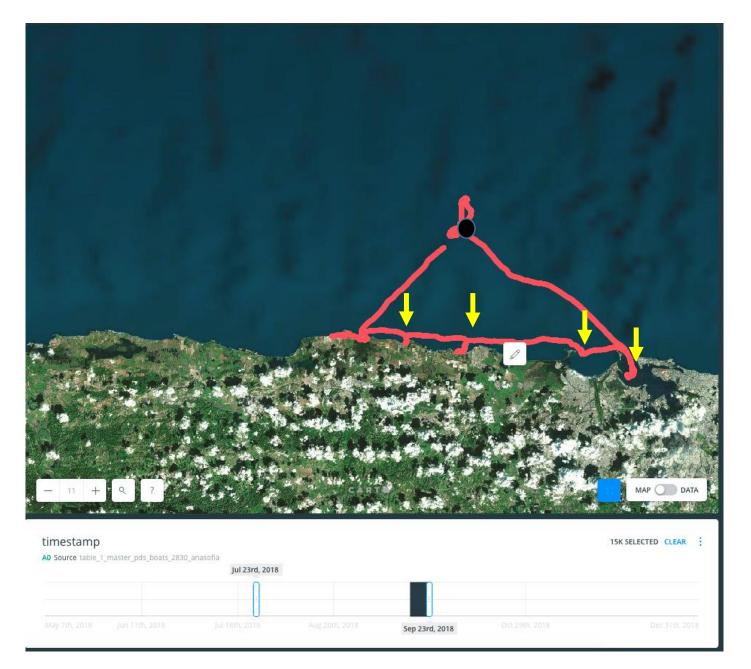| Vessel Type | Vessel ID | Trip Departure Time | Space | Gear & Method | Catch |
|---|---|---|---|---|---|
| Nearshore Charter | 871 |  | Shifts effort offshore to fish FADs | Pole and Troll<br>Live Bait | Dorado 139; YFT 10; Wahoo 2 |
| Offshore Charter | 817 |  | Shifts effort toward nearest FAD | Pole and Troll | Dorado 144; BUM 11; YFT 3 |
| Commercial | 2830 |  | Targets live bait nearshore then shifts effort offshore; shifts effort away from the FADs October-January | Live Bait<br>Chum<br>Jig<br>Pole and Troll | Dorado 310; YFT 19; Wahoo 12 |
| Recreational | 1968 |  | FADs 20 miles east are out of reach | Pole and Troll | Dorado 557; Wahoo 21; BUM 14 |

# Conclusion

- Vessel fishing trip histories provide quantitative estimates of FAD and Non-FAD use on different temporal and spatial scales

- This method can be used to assess FAD use and performance by sector

- VTS systems can die which require daily assessments of device health and status

- Results are only representative of when vessel captains report catch and trip data

- Results can be used to examine other socioeconomic trends in fishing activity

- VTS represents a relatively cost-effective approach to assess FAD fishing activity

- ~$500/device for 2 years of data service (additional costs for data management + analysis)

# Case Study 2: Use of video monitoring to quantify spatial and temporal patterns in fishing effort across sectors at moored FADs off Puerto Rico

Wessley Merten[1], Roberto Rivera[2], Richard Appeldoorn[3],
Kelvin Serrano[4], Omar Collazo[4], Nilda Jimenez[4]

Published 2018 by the
Beyond Our Shores Foundation

Study Justification & Methods

Results & Discussion

# Results – Temporal Variation
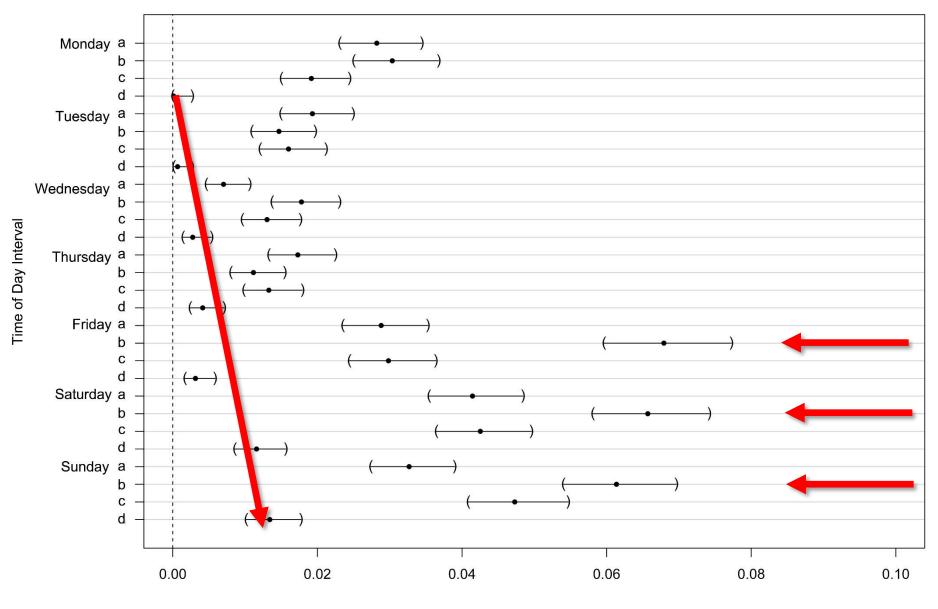
$$logit(y_{i,j,p}) = \beta_o + \beta_1 TOD_{i,t} + \beta_2 DOW_{j,t} + \beta_3 (TOD * DOW)_{i,j,t}$$

Found significant differences by time of day and
day of week.

Table 2 Results of a two-way analysis of variance comparing vessel effort by time of day and day of week off San Juan, Puerto Rico.

| Source of Variation | Degrees of Freedom | Sums of Squares | Mean Square | F Value | P Value |
|---|---|---|---|---|---|
| TOD | 3 | 35 | 11.64 | 498.05 | <0.001 |
| Day | 6 | 36 | 5.96 | 255.03 | <0.001 |
| Interaction | 18 | 16 | 0.86 | 36.93 | <0.001 |
| Error | 233492 | 5458 | 0.023 | | |

# Results – Temporal Variation in Vessel Activity

# Results – Cost-Benefit Analysis

Table 4 Costs and benefits of video versus traditional survey techniques for one three-week camera deployment in the study region from Loiza to Manati, Puerto Rico; No.= number; $F = field; $D = desk.

| Survey Method | Personnel | | | | Method | | Data Size (gb) | Technique | |
|---|---|---|---|---|---|---|---|---|---|
| | No. (#) | Salary[A] (USD/hr) | Field[1] (hrs) | Desk[2] (hrs) | Cost | Resources | | Pros | Cons |
| Video | 2F 1D | $45F[X] $45D[X] | 3 | 40 | $2070[C] ($5000)[D] | Boat; FAD; Camera; SD card; Batteries | 7 | *in situ*; Programmable; Potential for automation; Potential for web streaming; Easily comparable to other locations with FADs | Potential lens obstruction or field of view issues; Need batteries or power source; Need demographic data from other data sources |
| Port | 11F 3D | $35F $60D | 880[B] | 520 | $70000[C] ($15000)[D] | Forms; Clipboards; Pens; Transportation | 1 | Obtain more information about trip profiles and boats | Only public access sites are sampled; No data from boats at private docks |
| Phone | 4D | $60D | N/A | 260[E] | $18000[C] ($8000)[D] | Phone service; Office space | 2 | Easy for domestic calls; Reach people at private access sites and those that fish odd hours | Difficult and expensive to call internationally; Low response rates without pre-notification |
| Mail | 3D | $60D | 0 | 270[F] | $24750[C] ($8000)[D] | Printer; Postage | 3 | Reach people at private access sites; No valid phone number or email needed | Printing and mailing surveys is expensive; Need valid addresses |
| Web | 1D | $100D | 0 | 170 | $18000[J] ($11000)[D] | Web domain; Web server; Email license | 2 | Can target entire study group; Once developed, reused for little cost | No contact or data without valid emails |

# Conclusion

- Conducted a fishery independent assessment of multi-sector fishing effort using video monitoring

- Video monitoring represents a cost-effective approach to assess in situ fishing activity

- Results serve as baseline estimates of FAD use

- Results are only representative of daytime fishing effort

- Need to match fishery-dependent port surveys with in situ FADCAM data

- Need to increase recording time and automate vessel detection through image recognition

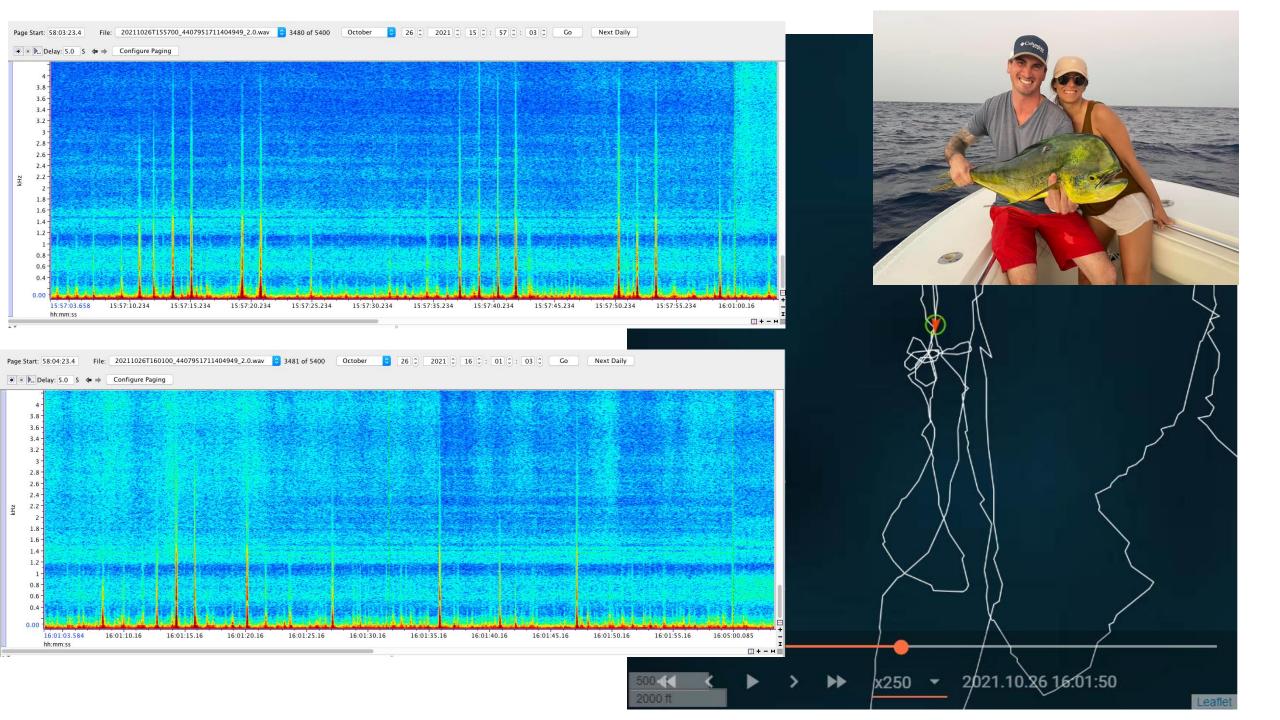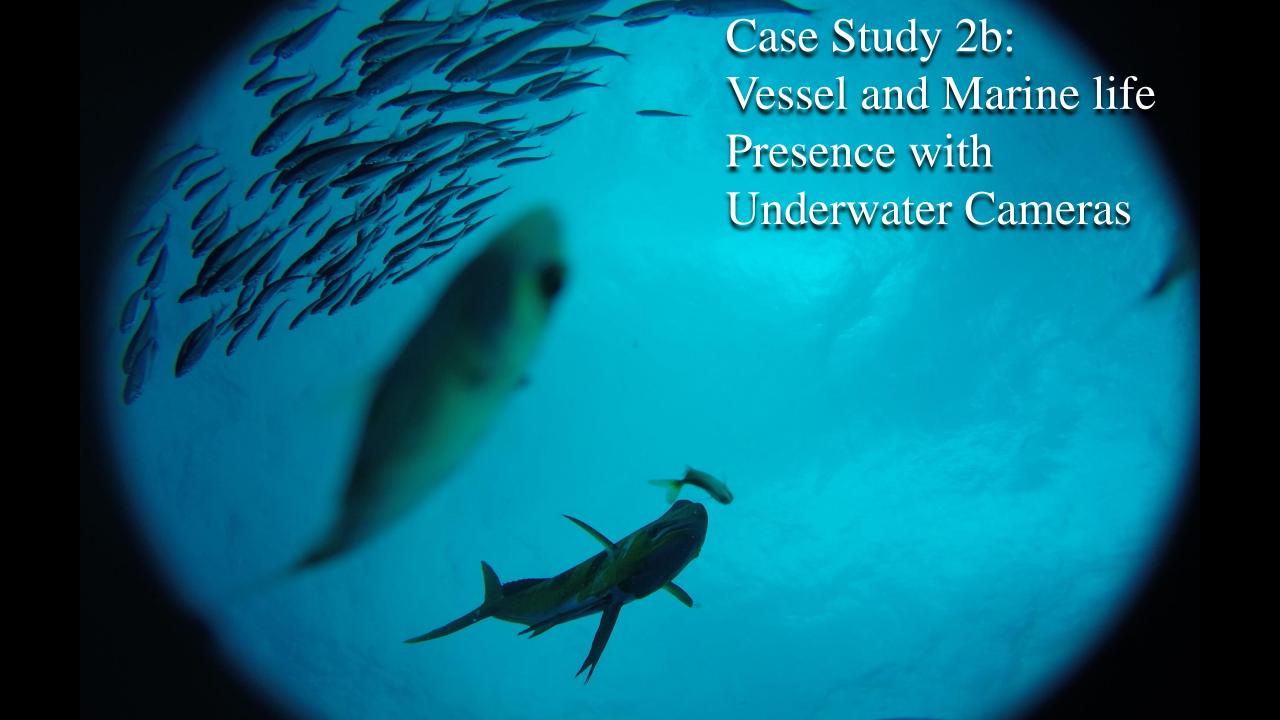Case Study 2b:
Vessel Detection using Sound
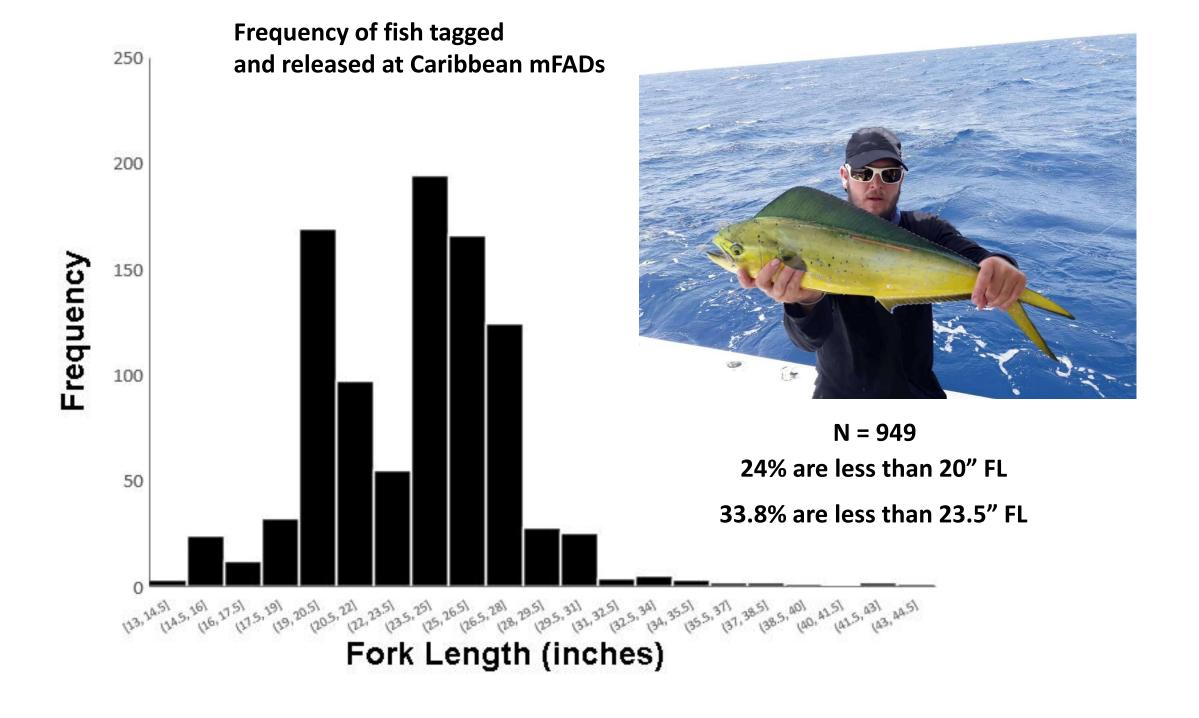
# FAD POSICIONES

## prfadsystem.org/map



U.S. Caribbean Sea FADs

SUBMERGED FADS
●

Past FAD Locations

U.S. CARIBBEAN SEA PAST FAD LOCATIONS
✕ HISTORIC FAD LOCATIONS

**SPONSORED IN PART BY:**

DRNA

SPORT FISH RESTORATION

Camino Del Mar

El Morro

Hotel Cluster Central Point
18' 31.980' N
X -66' 3.996'W

Hotel 5 Southwest Point
18' 31.653'N
X -66' 4.672'W

Map by Wessley Merten

Delay: 5.0  S    Configure Paging

kHz

4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.00

15:57:03.658    15:57:10.234    15:57:15.234    15:57:20.234    15:57:25.234    15:57:30.234    15:57:35.234    15:57:40.234    15:57:45.234    15:57:50.234    15:57:55.234    16:01:00.16
hh:mm:ss

Delay: 5.0  S    Configure Paging

kHz

4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.00

16:01:03.584    16:01:10.16    16:01:15.16    16:01:20.16    16:01:25.16    16:01:30.16    16:01:35.16    16:01:40.16    16:01:45.16    16:01:50.16    16:01:55.16    16:05:00.085
hh:mm:ss

500
2000 ft

x250    2021.10.26 16:01:50

Leaflet

Case Study 2b:
Vessel and Marine life
Presence with
Underwater Cameras

Case Study 3:
Tagging Studies

Picture: W. Merten

Frequency of fish tagged and released at Caribbean mFADs

N = 949

24% are less than 20" FL

33.8% are less than 23.5" FL

# Wahoo Tagging





7.4 DAL - 47" Wahoo

Tag ID = 170108 PR  Max Z = 266.3 m / 878.9 feet

# Comparisons to Dolphin



30 DAL - Male 51"
Tag ID = 126828 PR   Max z = 113.0

30.25 DAL - Female 43"
Tag ID = 113350 PR Max z = 164.1

55.83 DAL - Male 47"
Tag ID = 175815 PR   Max z = 149.3

7.4 DAL - 47" Wahoo
Tag ID = 170108 PR  Max Z = 266.3 m / 878.9 feet

Legend

- March UKFSST Positions
- April
- May
- 5 KM Position Uncertainty
- Most Probable Track

San Pedro De Macoris

La Romana

Punta Cana

El Cabo

Isla Saona

Recaptured May 20th, 2019

#3

El Pichincho

Mona

Rincon

Mayaguez

Boqueron
La Parguera

#2

#1

#4

Tagged March 25th, 2019

# Acknowledgements

Captain Luis Lagradier (Puerto Rico Sportfishing Charters)
Captain Luis Burgos-Roviera (Caribbean Fishing Academy)
Captain Rafa Terraza (Billfish)
Captain Luis Iglesias (Bill Wraps)
Captain Humberto Morales (Double Hook)
Captain Marcos Hanke (LTP3)
Captain Irving Rivera (La Robalo)
Captain Hector Pesquero (Don Polo)
Captain Cedric Taquin (Menta)
Captain Robi Birriel (Nuri)
Captain Tylor Penfield (Ana Sofia)
Captain Jonathan Prices (Cono Azul)
Captain Kristian Tsotoros (Pinchona)
Captain Bradley Dray  (Mireya)

Captain Alex Oben (Seaborn Fishing Charters)
Captain Carlos Andres (Chispa)
Captain Jesus Duran (Lalooli)
Captain Emmanuel Markham (La Calankita)
Captain Milton Char (Phantomas)
Captain Cheo Volvo (Yadimar)
Captain Richard Delizza (Rock Boat)
Captain Julien Brossel (Madatet Lures)
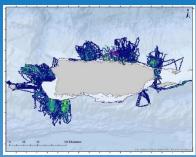Captain Ron Teke (Colorado Magic)
Captain David Neblett (Hit That)
Captain Hunter Stokes (Painkiller)
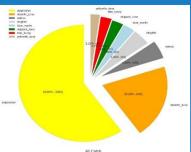Captain Chris Jobes (Pair of Docs)
Captain Rick Perrson (Swamphopper)
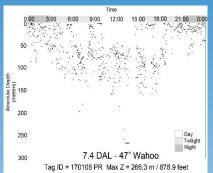Captain Dan Gates (No Name)

# QUESTIONS?



**Dr. Wessley Merten**

**CFMC 4.19.2022**

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