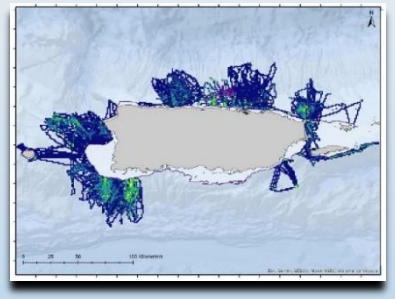
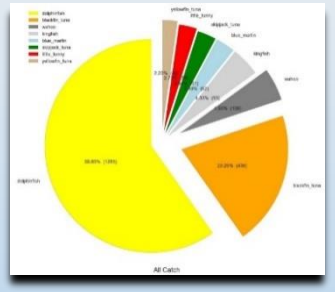
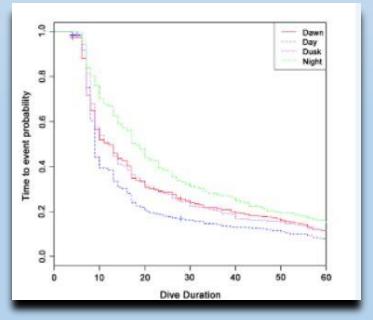
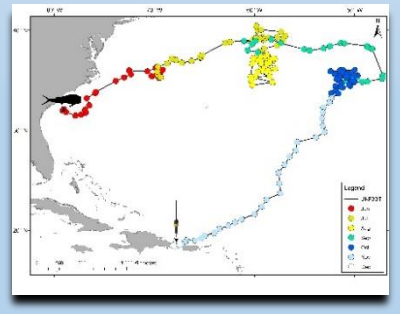
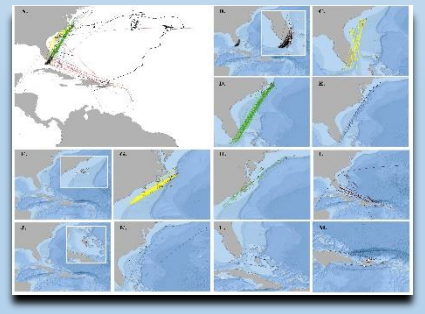
Dolphinfish Research Program



Dr. Wessley Merten, Director

SAFMC 9.16.2020

Beyond Our Shores Foundation

Dolphinfish Research Program

Newport, Rhode Island

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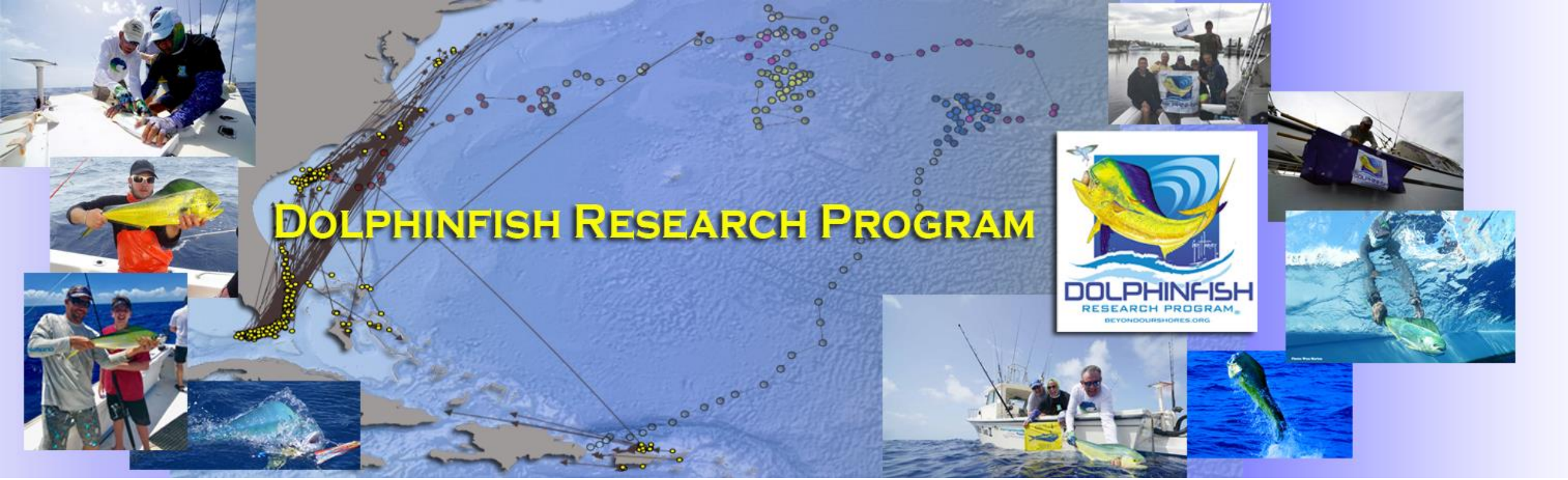

- **International citizen science mark and recapture program for dolphinfish**
- **Designed to collect data on movements, life history patterns, and population dynamics**
- **Started in 2002 – Now, in its 19th year**

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History of the Program

A.

State Funded

SC Dolphin Tagging Study

2002 Recaptures: FL to NY; Expansion: FL to NY

2003 Expansion: E BAH & MA

2004 Recapture : BAH; Expansion: GOM

2005 Recaptures: POR & CARIB MX

Privately Funded

Dolphin Tagging Pr

2006 Recapture: PR; Expansion: W BAH

2007 Recapture: CU; Expansion: CARIB MX

Dolphinfish Research Program (DRP)

2008 Recapture: VZ; Expansion: N PR & W PAC

2009 Recapture: N DR

2010 Recaptures: St. Kitts & Med; Expansion: MED

2011 Recapture: S DR; Expansion: S PR

2012 Recaptures: GOM to BAH; PR to SC & ANG

2013 Movement: PR to BAH; Expansion: GOO

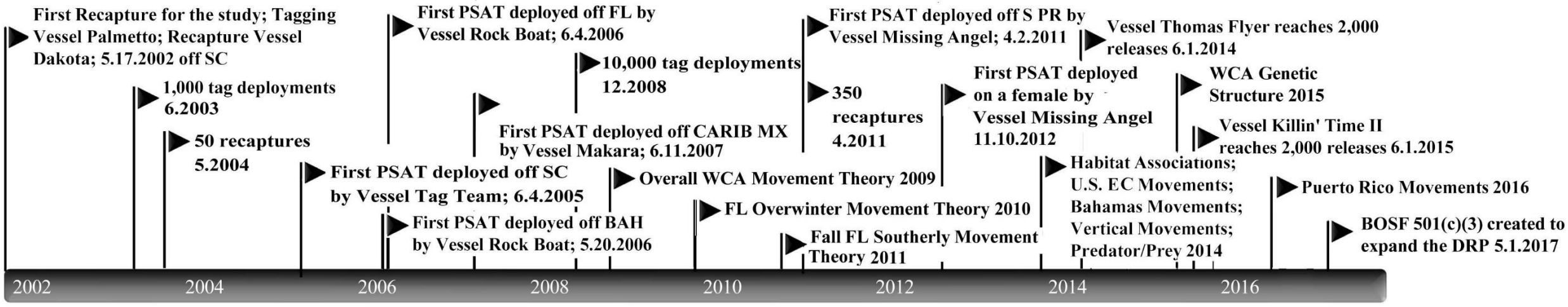
2014 Movement: SC to DR; Expansion: USVIs

2015 Recapture : CA; Expansion: CM & CA

2016 Expansion: BR & CU

2017 Expansion: GU

B.



Dolphinfish - Ideal Citizen Science Species Attributes:

- Wide distribution
- Ease of catch
- Low recreational expense to target
- Proximity to the coastline in comfortable marine settings
- Popularity (coloration and morphology)

Model species to engage the public in collecting biological and fishing activity data.

Pic: Wess Merten

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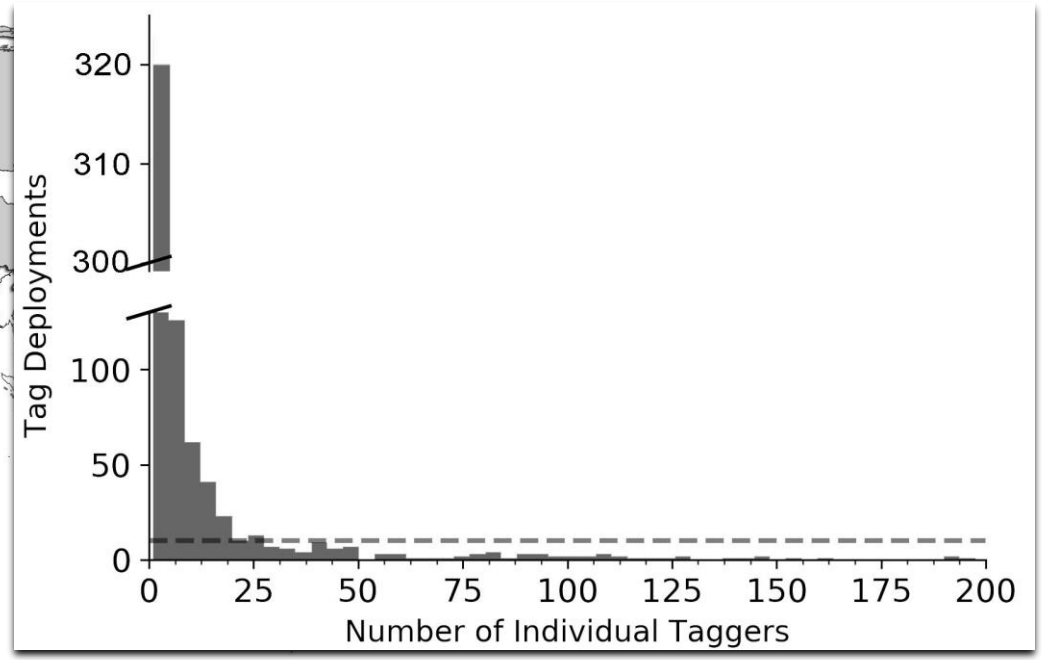
Angler Network



Totals as of 8.23.2020

1,623 Captains
1,642 Vessels
4,924 Participants
25 Countries
43 States

Angler Participation by:

Country | State | Zipcode

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DOLPHINFISH RESEARCH PROGRAM

Research Objectives

Table 1 Original scientific objectives of the Dolphinfish Research Program (DRP) and specific reference documenting evidence of science-based outcomes in scientific literature published using DRP data. Status (Partially Complete: PC; Incomplete: IC; UNK; Unknown;) and priorities (e.g., key word(s) describing priority topic(s) or locations) are included by region. MAB: Mid-Atlantic Bight; SNE: southern New England; DR: Dominican Republic; LA: Lesser Antilles; AC: Antilles Current; SS: Sargasso Sea; GS: Gulf Stream; AP: Anegada Passage; USC: United States Caribbean Sea; mFADs: moored fish aggregating device; N/A: not applicable)

Original Objectives	*Ref.*	*Status and Priorities by Region*				
		U.S East Coast	Mid-Atlantic Bight	Gulf of Mexico	Caribbean Sea	Eastern PO
Identify spring and fall migration routes	1,2,3	IC; Fall	IC; Climate Change	UNK	IC; Cayman Islands	IC; Climate Change
Document international range	2,5,6	IC; Azores	UNK	UNK	IC; GOM	UNK
Identify recreational fishing grounds	3	IC; MAB	IC; SNE	IC	IC; DR	UNK
Define temporal and spatial occurrence	3	IC: MAB	UNK	UNK	IC; LA	UNK
Identify winter grounds for U.S. dolphinfish	2	PC; AC	UNK	UNK	PC; SS	UNK
Identify routes dolphinfish use to enter U.S. waters	7	PC; AC	PC; GS	UNK	PC; AP	UNK
Collect data to define critical habitat	4, 5, 6	PC; Gender differences	UNK	UNK	IC; Gender differences; Outside USC	UNK
Define relevance of Sargassum	1, 3	PC; *Sargassum* events	IC	IC	IC; *Sargassum* events	N/A
Collect time-sensitive depth and temperature data	4	IC; SAB & MAB	UNK	UNK	IC; Outside USC	UNK
New Objectives		Florida Straits	Participation	Participation	mFADs	southern Panama

[1]Merten et al. 2014a; [2]Merten et al. 2014b; [3]Farrell et al. 2014; [4]Merten et al. 2014c; [5]Merten et al. 2014d; [6]Merten et al. 2015; [7]Me

*Note that a broad objective left out of this table is to generate population reference points on the WCA dolphin population – an assessment that should occur at the RFMO level like the work done in the ETP by IATTC

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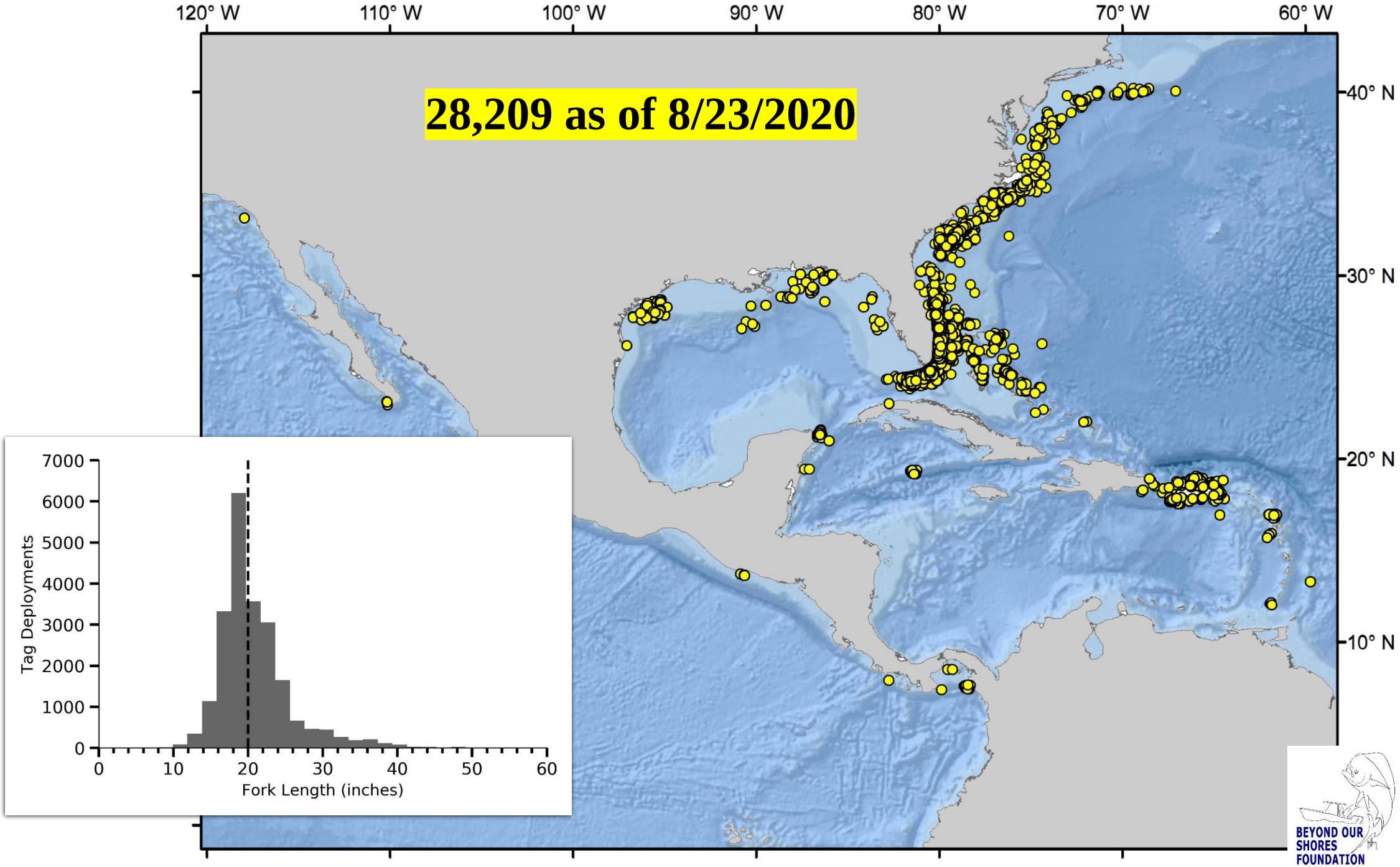
Overall Stats: Tag Deployments



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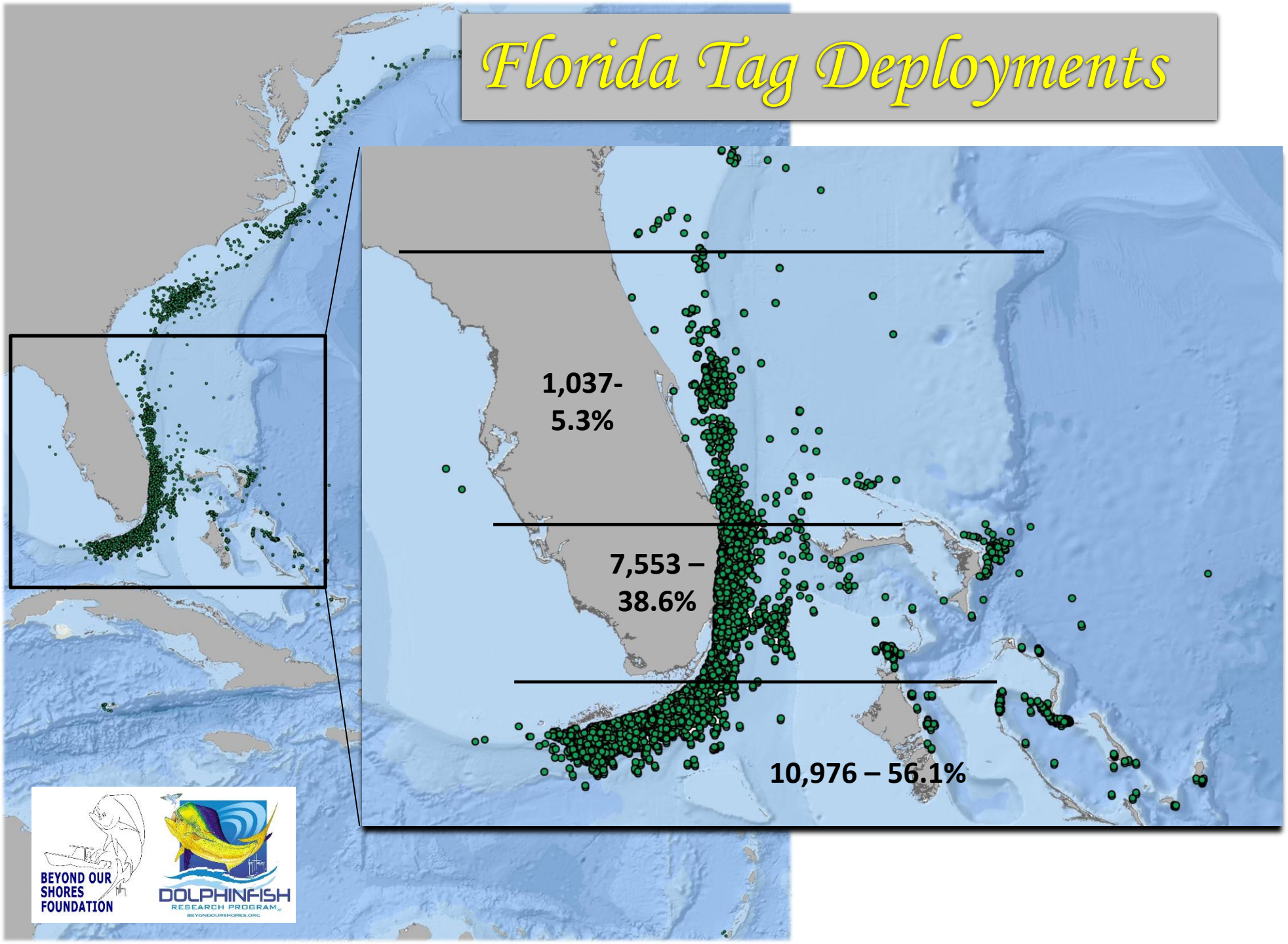
Florida Tag Deployments



Total as of 8.23.2020

19,566 – 69.3%

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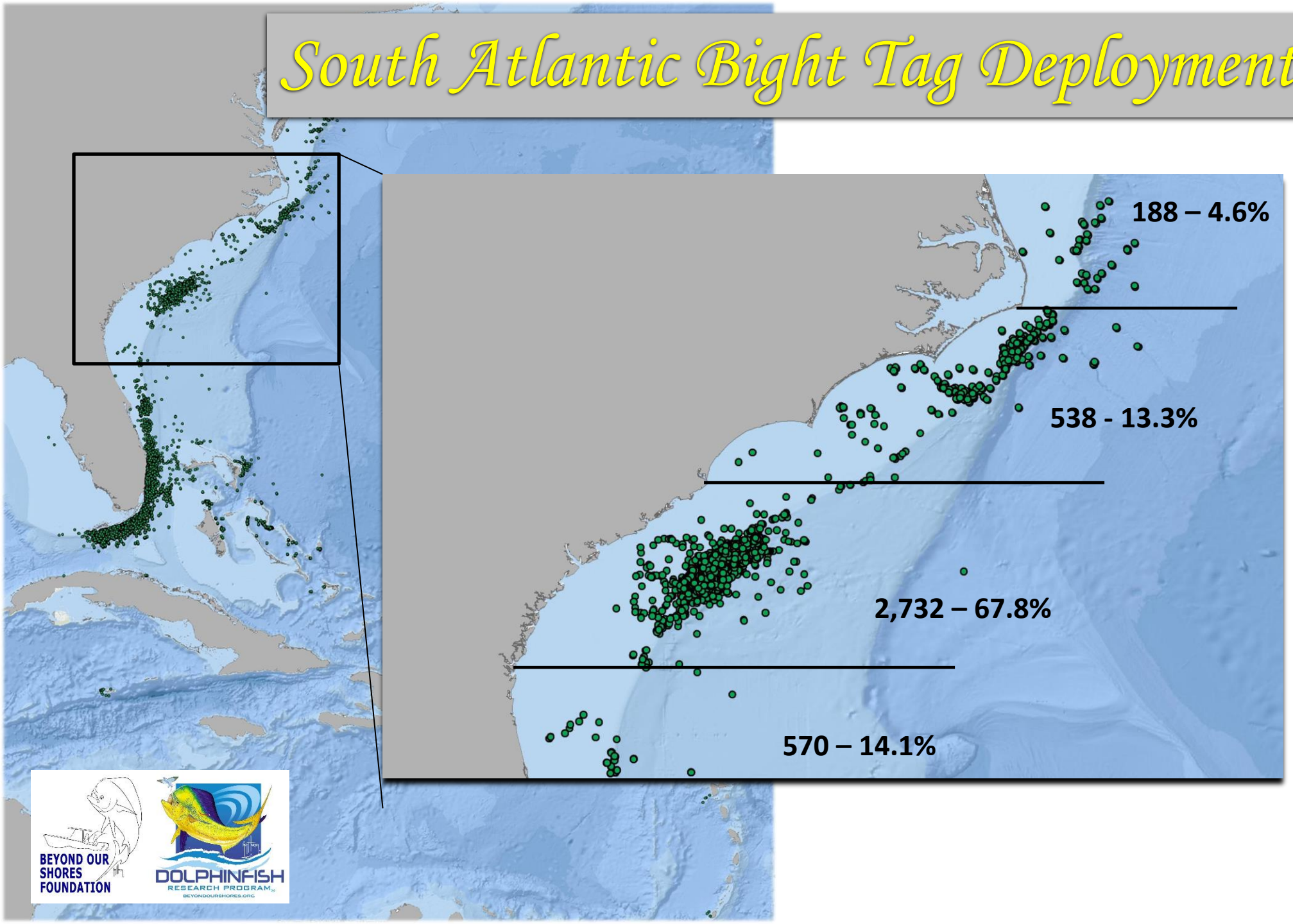
South Atlantic Bight Tag Deployments



Total as of 8.23.2020

4,028 – 14.3%

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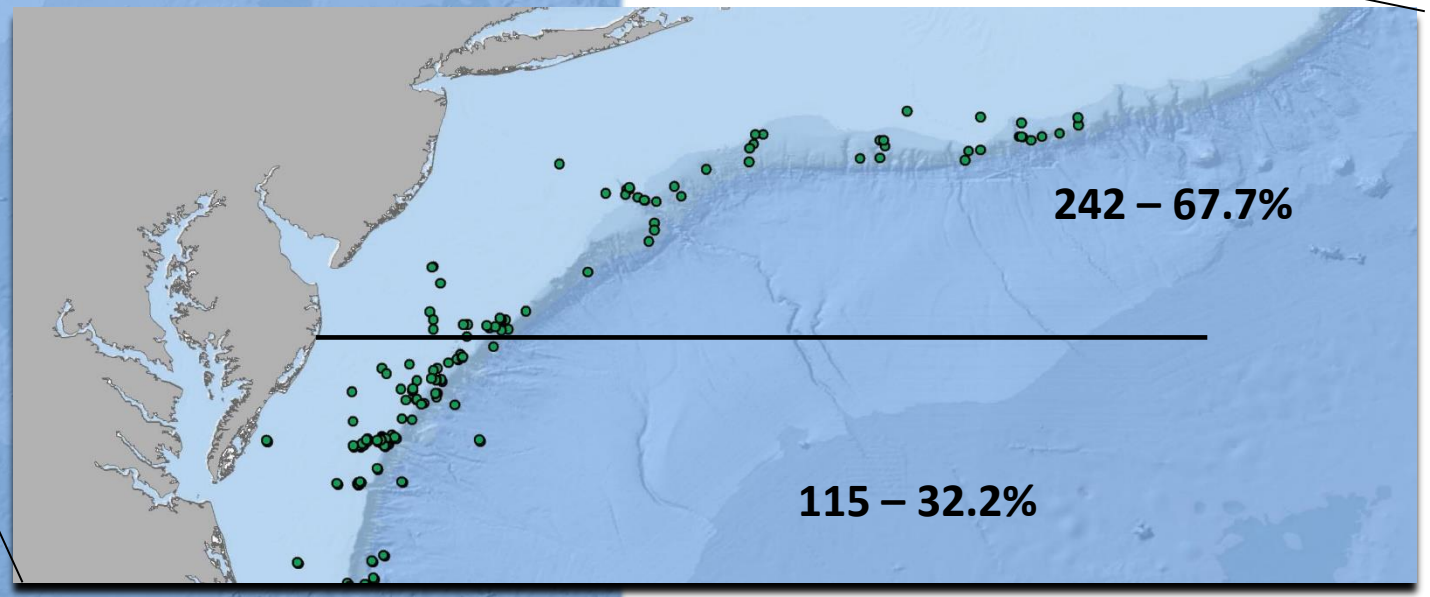
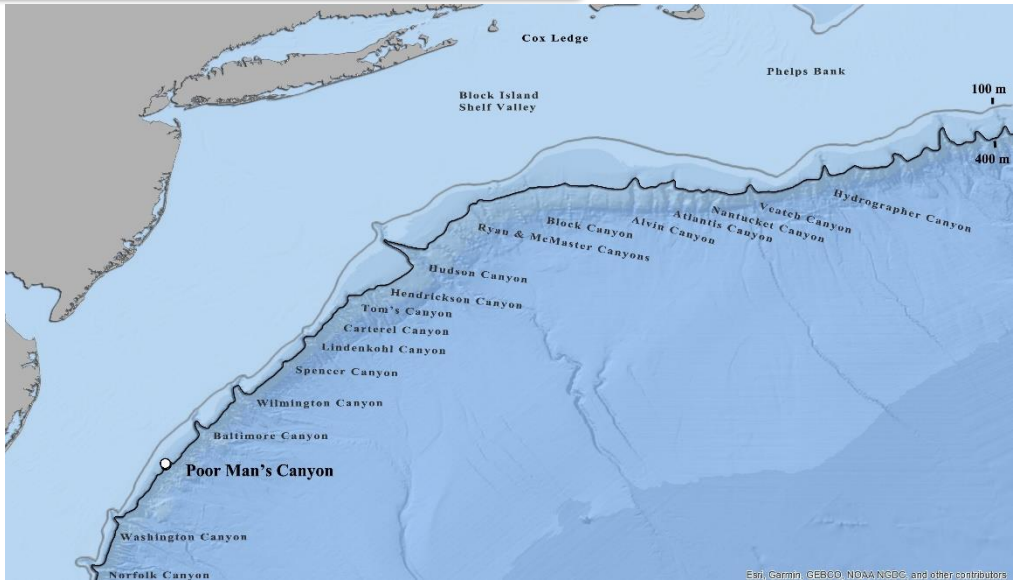
MAB Tag Deployments



Total as of 8.23.2020

357 – 1.3%



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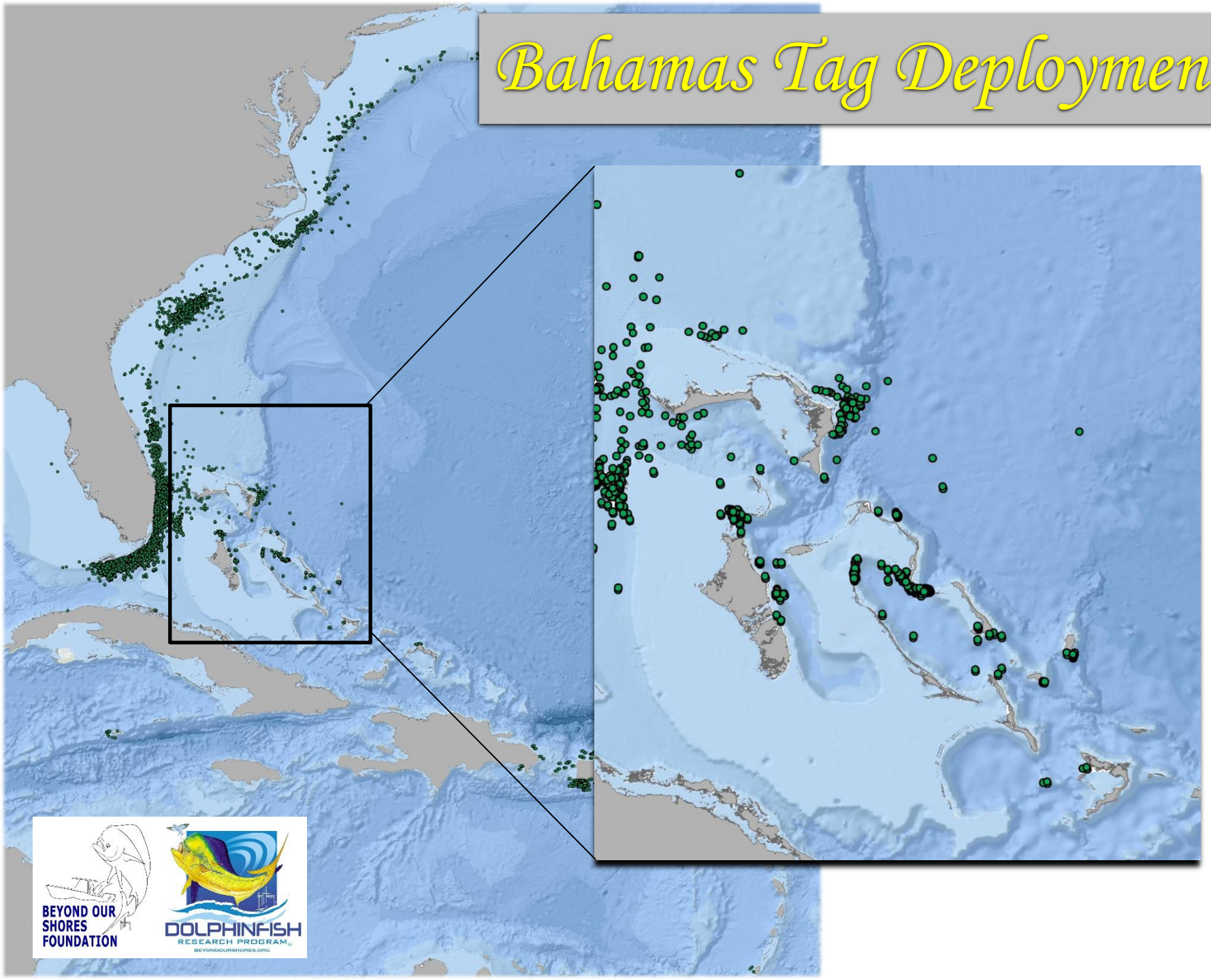
Bahamas Tag Deployments



Total as of 8.23.2020

1,319 – 4.6%

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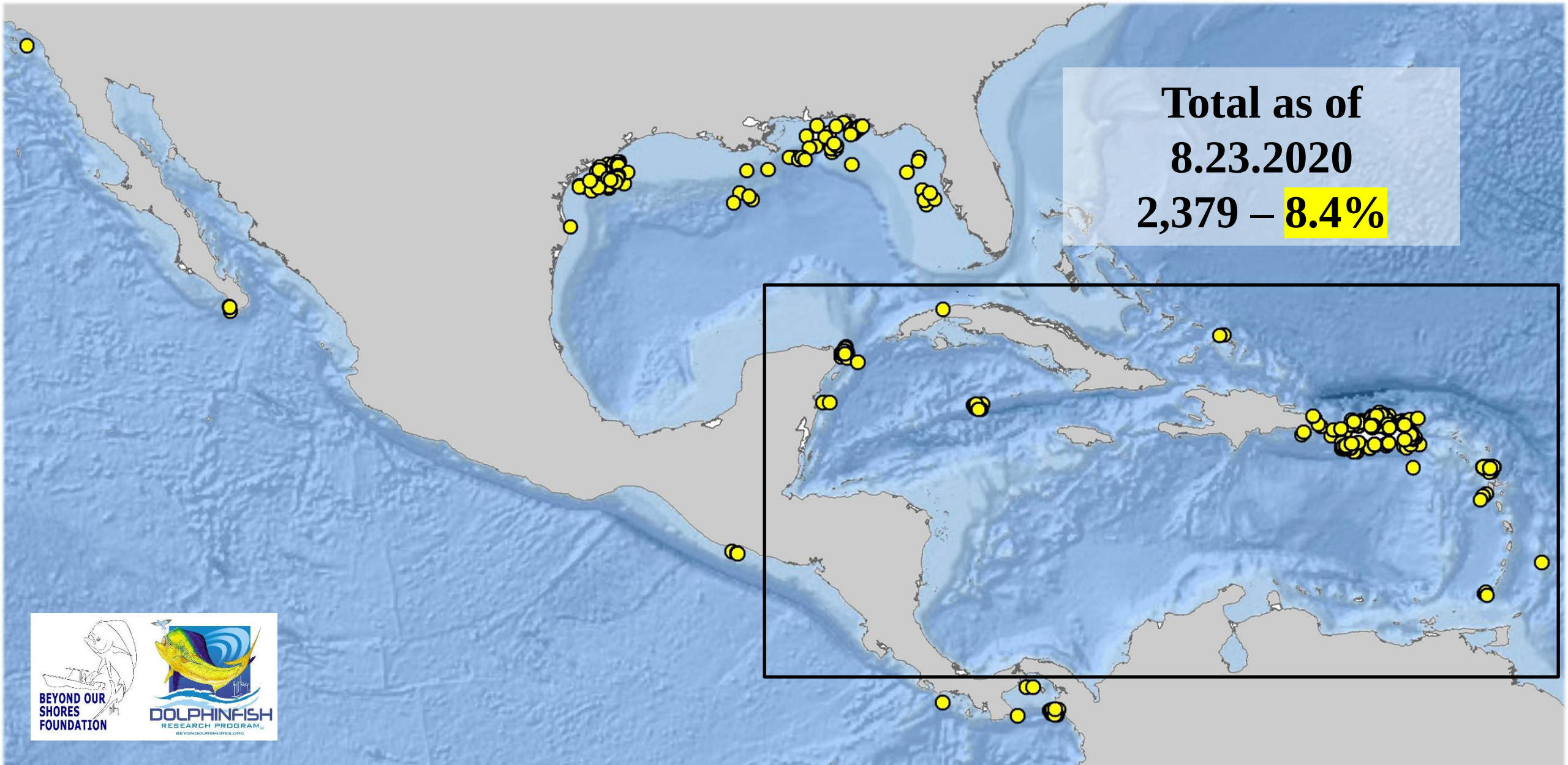
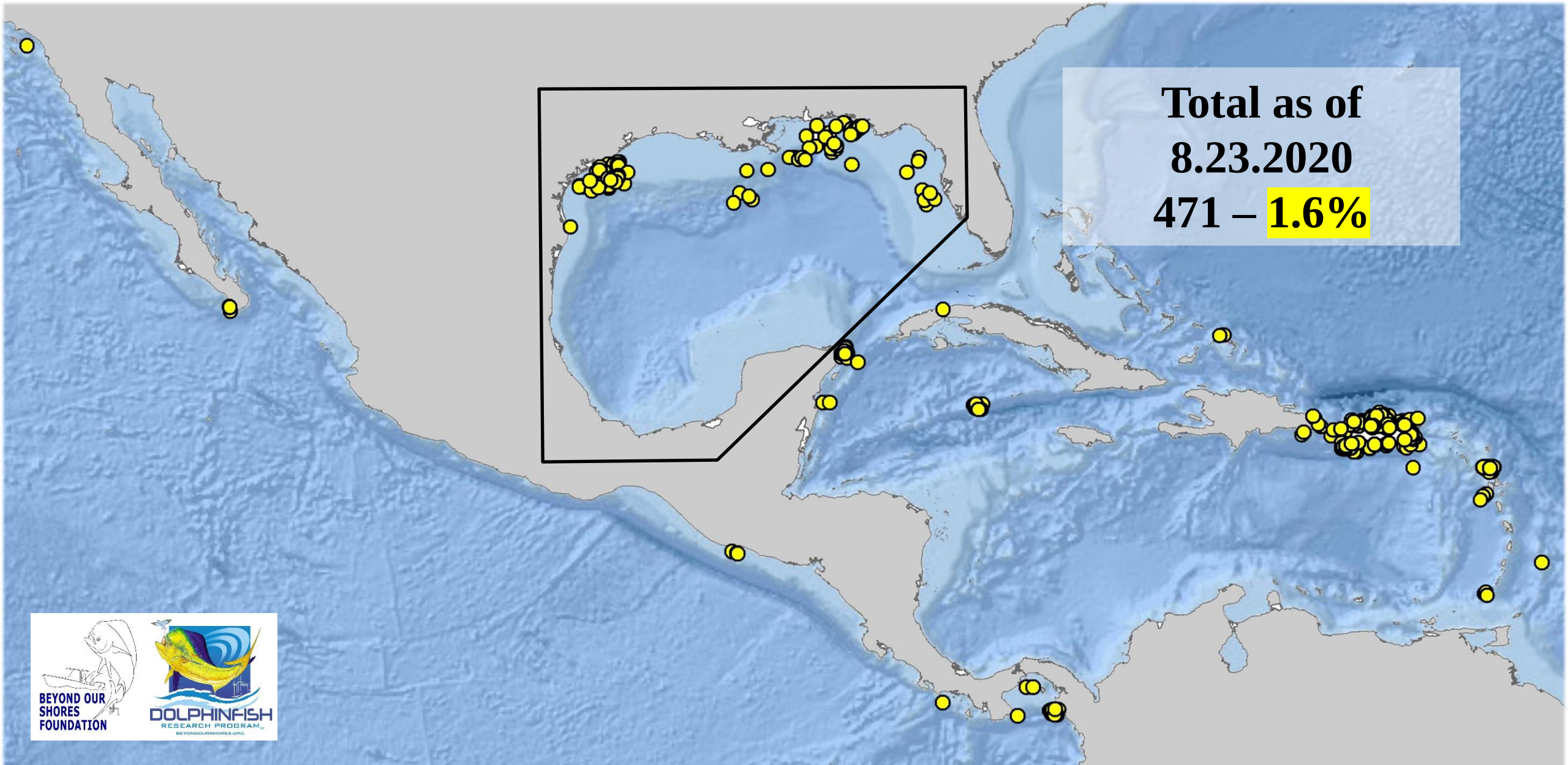
Caribbean Sea Tag Deployments



Gulf of Mexico Tag Deployments



Horizontal Movements

Tag Recoveries – 706 – As of 8.23.2020

Longest at liberty – 557 days
Tagged by Bouncer Smith
Reported by Raudrick Nazario of Guanica, PR
58 pounds.

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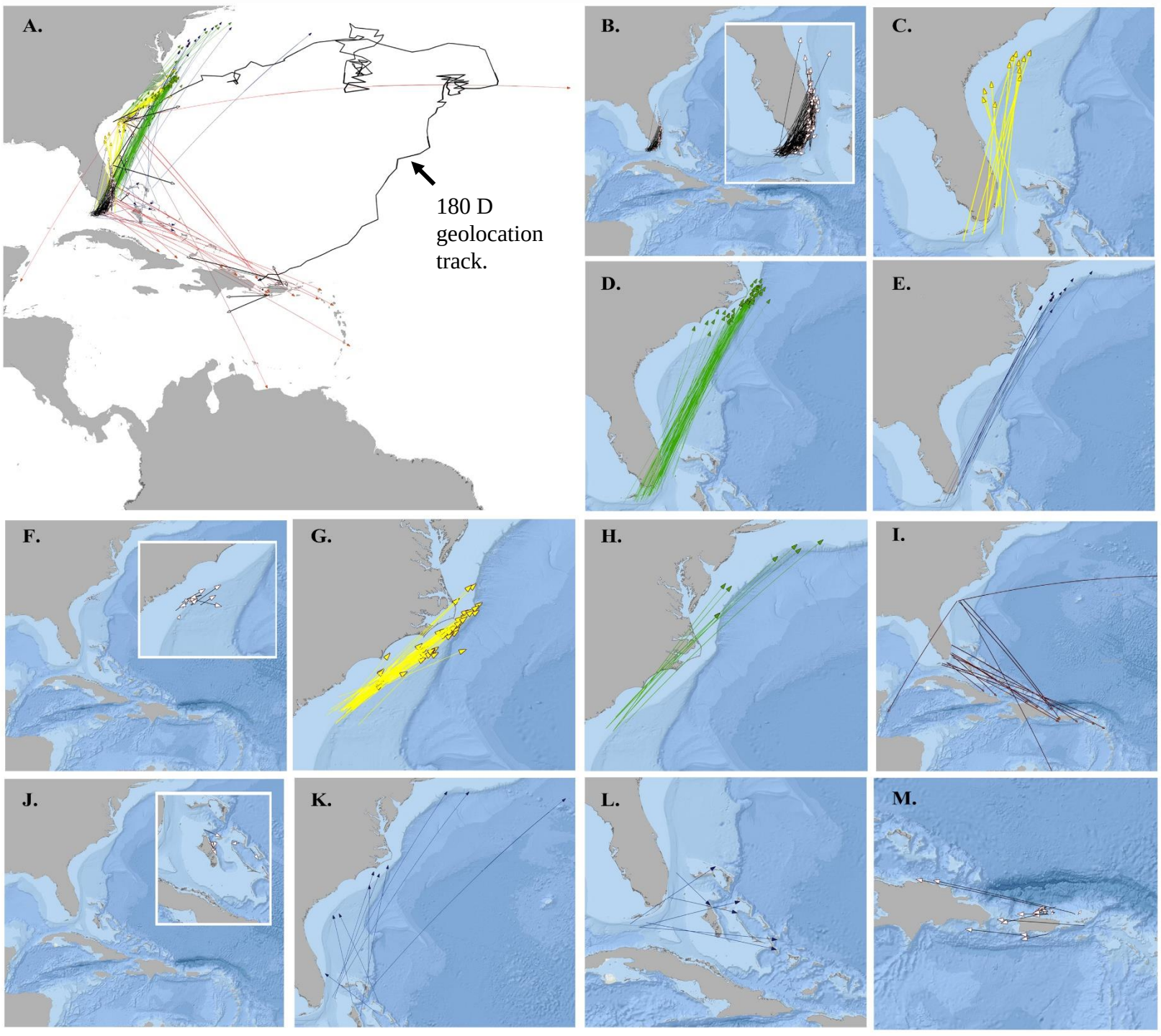
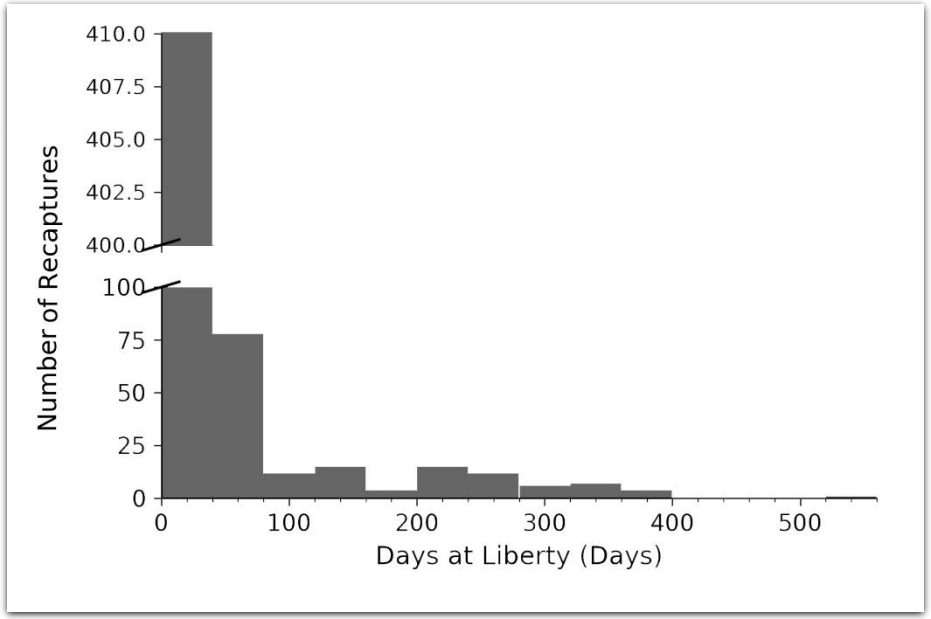
Table 3 Dolphinfish movement categories and established definitions generated by movements (n=706) from 2002 to 8.23.2020. FL: Florida; EC: United States East Coast; DAL: Days at Liberty; SC: South Carolina; SAB: South Atlantic Bight; NC: North Carolina; MAB: Mid-Atlantic Bight; GOM: Gulf of Mexico; BA: Bahamas; TA: Tropical Atlantic; CS: Caribbean Sea; Ref: in Figure 6; N/R: not reported.

Movement Categories	Description	Examples (#)	% of Total
FL Instate	Tagged and recovered off FL EC	306	43.34%
FL Short-term Revisit	Tagged and recovered off FL EC with DAL >60.	37	5.24%
SC Instate	Tagged and recovered off SC with DAL <90.	17	2.41%
SAB Short-term Revisit	Tagged north of FL and recovered south of its release site with DAL >120.	2	0.28%
NC Instate	Tagged and recovered off NC with DAL <60.	11	1.56%
MAB in region	Tagged and recovered in the MAB with DAL <60.	10	1.42%
MAB Short-term Revisit	Tagged in the MAB and recovered south of its release site with DAL >120.	1	0.14%
GOM in region	Tagged and recovered in the GOM with DAL <60.	1	0.14%
Inter-State Movements	Tagged off one EC state and recovered off another EC state north of its release site.	169	23.94%
FL to SAB Annual Revisit	Tagged off FL and recovered in the SAB in a year subsequent to when it was tagged.	8	1.13%
U.S. EC Dispersal	Tagged on the EC and recovered in the high seas, foreign or U.S. territorial waters.	19	2.69%
BA to U.S EC	Tagged within the BA and recovered along the EC.	10	1.42%
U.S. EC to BA	Tagged on U.S. EC and recovered in the BA	9	1.27%
BA Instate	Tagged and recovered in the BA	27	3.82%
U.S TA Instate North Coast	Tagged and recovered in the U.S. TA north of PR or the USVIs.	37	5.24%
U.S CS Instate South Coast	Tagged and recovered in the U.S. CS south of PR or the USVIs.	9	1.27%
U.S. TA or CS to BA or U.S. EC	Tagged in the U.S. TA or CS and recovered in the BA or along the U.S. EC.	4	0.56%
GOM to U.S. EC or BAH	Tagged in the GOM and recovered along the U.S. EC or BA	1	0.14%
EC Southerly Movement	Tagged along the U.S. EC and recovered south of its release site with DAL < 30.	17	2.41%
ETP Recovery	Tagged and recovered in the Eastern Tropical Pacific Ocean	11	1.56%





Pic: Charlene Brown

Dolphinfish movement
Types A = all movements
b-m = specific examples from Table 3 previous slide

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Florida Instate Movements

25.62 mpd
or 6.76 d
(n = 306)

Range:
0 – 57 DAL

Pic: Scott Kerrigan

Note: Participants in the DRP in Florida have reported a decrease in abundance of large gaffer size fish as well as a later start to the season with best months occurring now in August and September.

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Florida to SC Movements

23.72 mpd
or 25.15 d
(n = 14)

Min: 8 d
Max: 67 d

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Florida to NC Movements

30.86 mpd
Or 32.63 d
(n = 73)

Min: 7 d
Max: 78 d

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Florida to MAB Movements

27.48 mpd
or 50.29 d
(n = 20)

Min: 10 d
Max: 85 d

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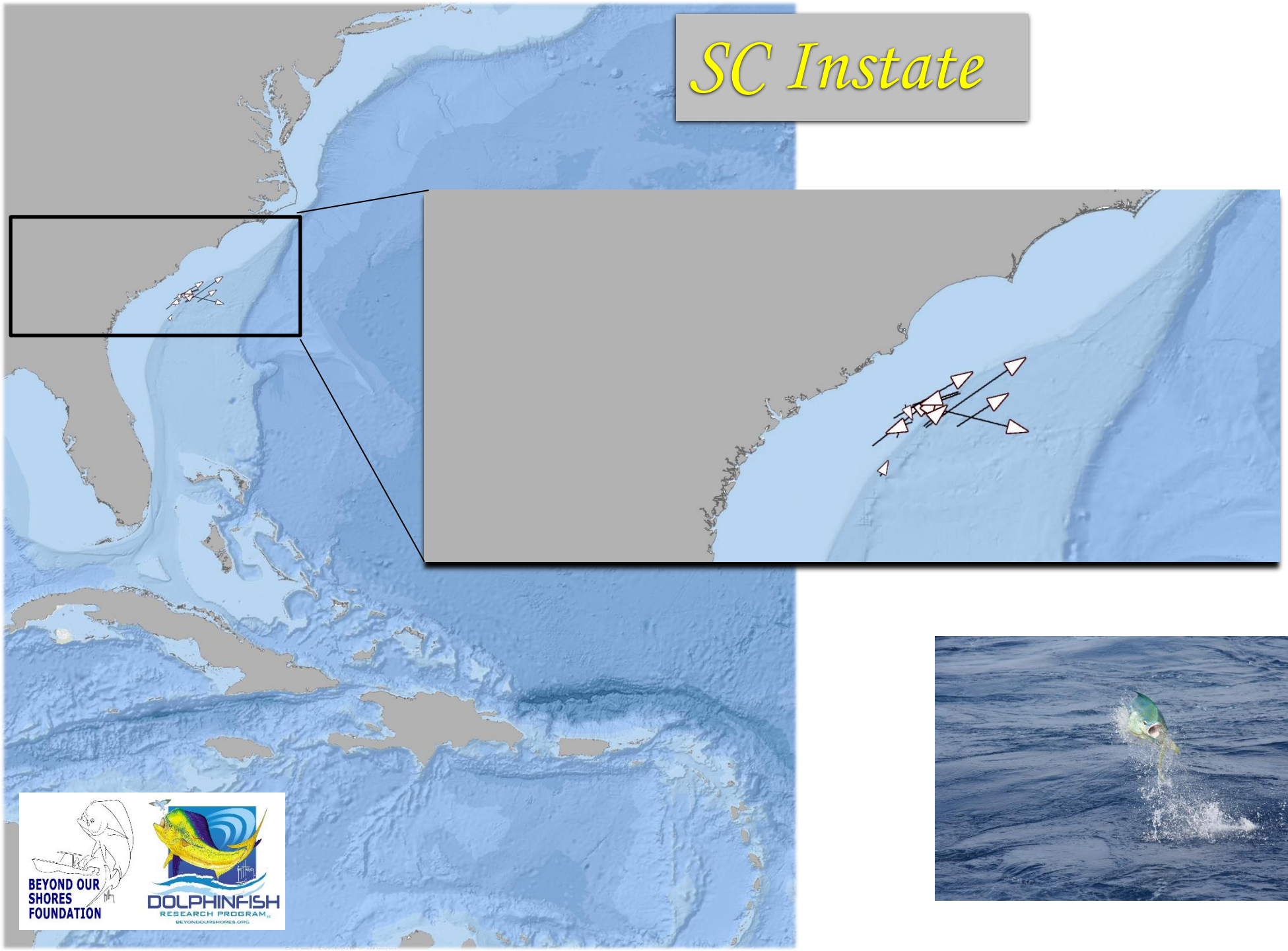
SC Instate

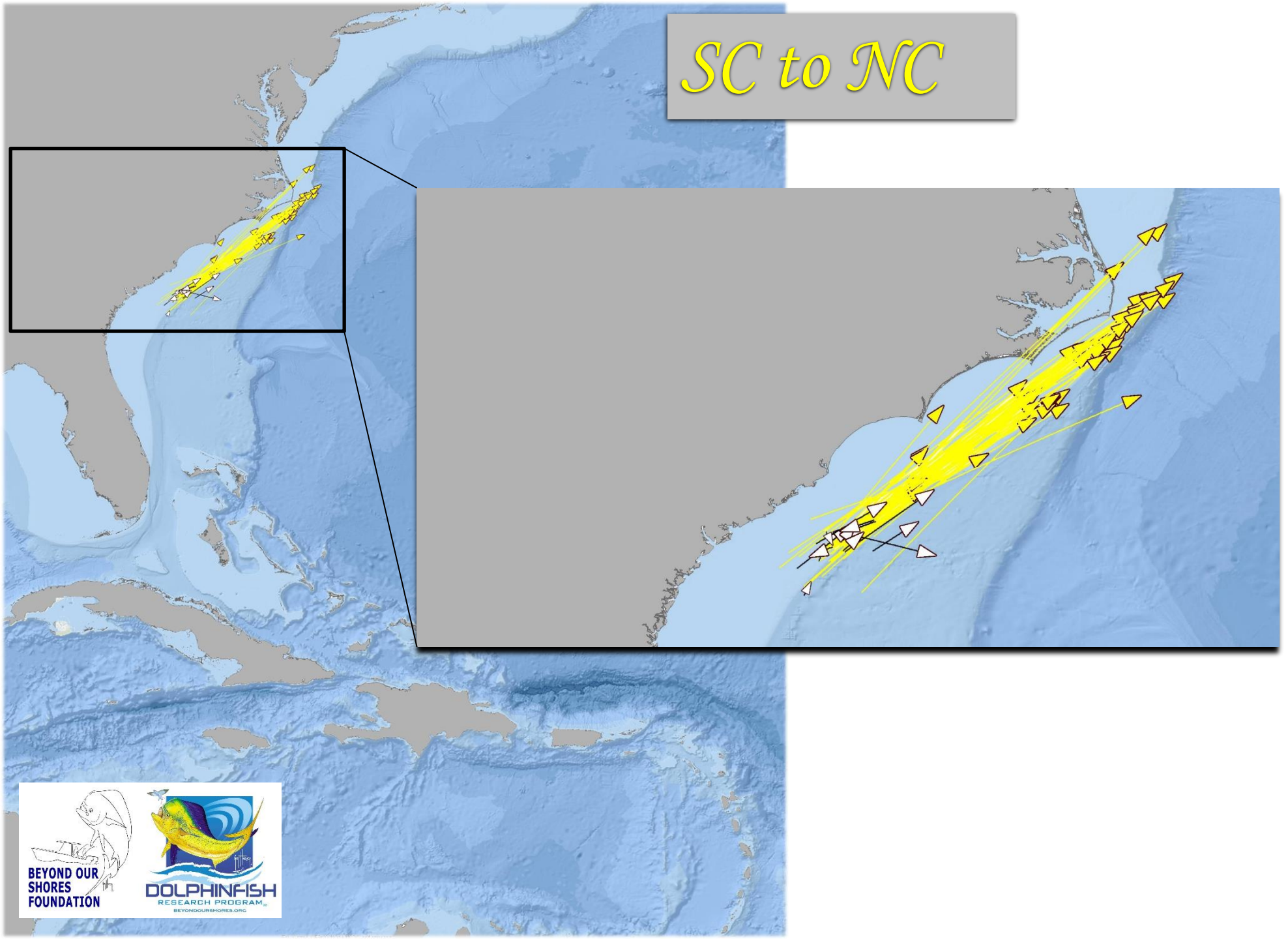


3.92 mpd
or 19.05 d
(n = 17)

Range:
0 to 76 DAL

Note: Participants in the DRP in South Carolina have reported a shortened season of dolphin over the last several years.

SC to NC



24.61 mpd
or 15.29 d
(n = 51)

Min: 3 d
Max: 69 d

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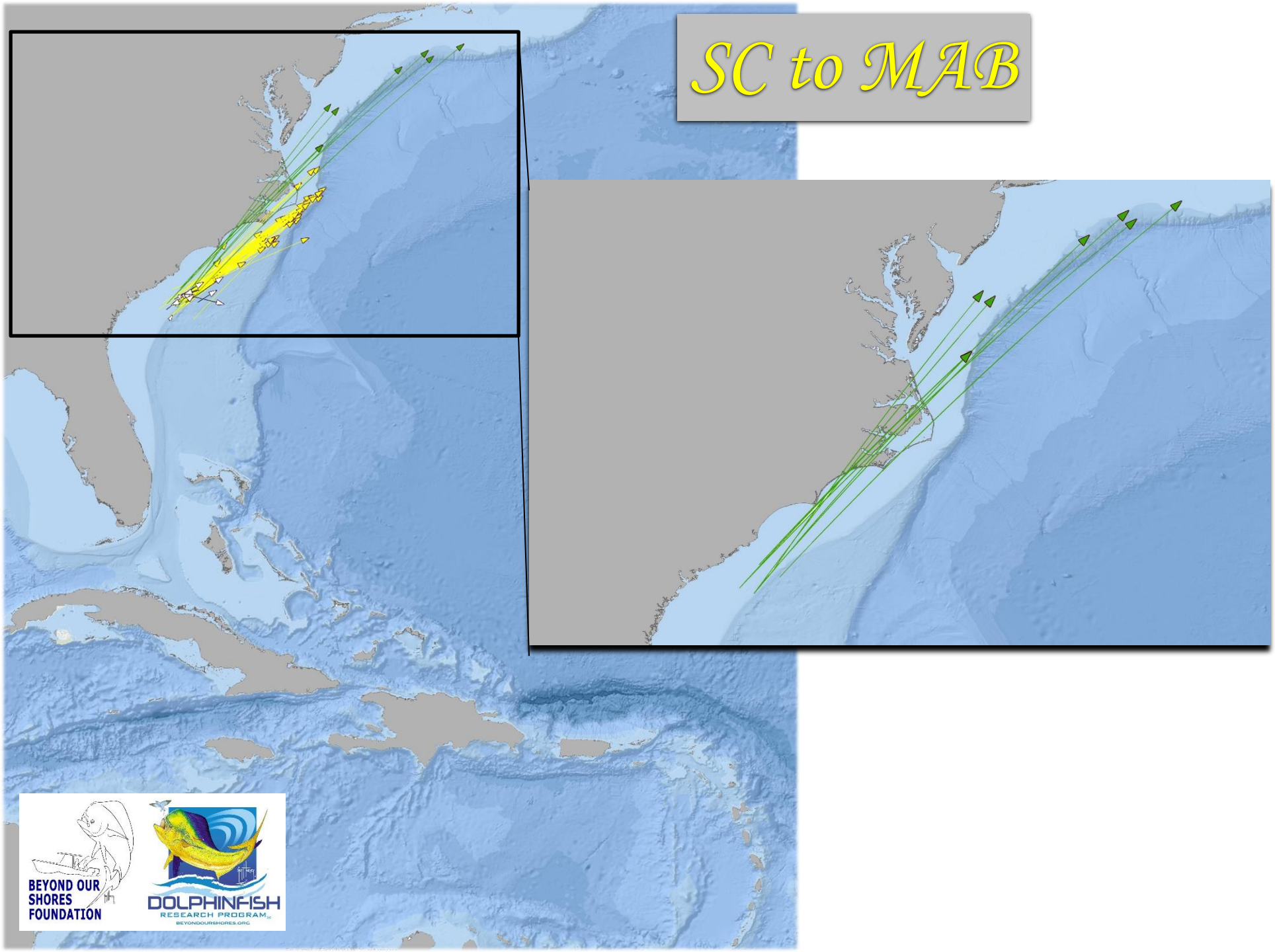
SC to MAB



9.32 mpd
or 83 d
(n = 8)

Min: 26 d
Max: 152 d

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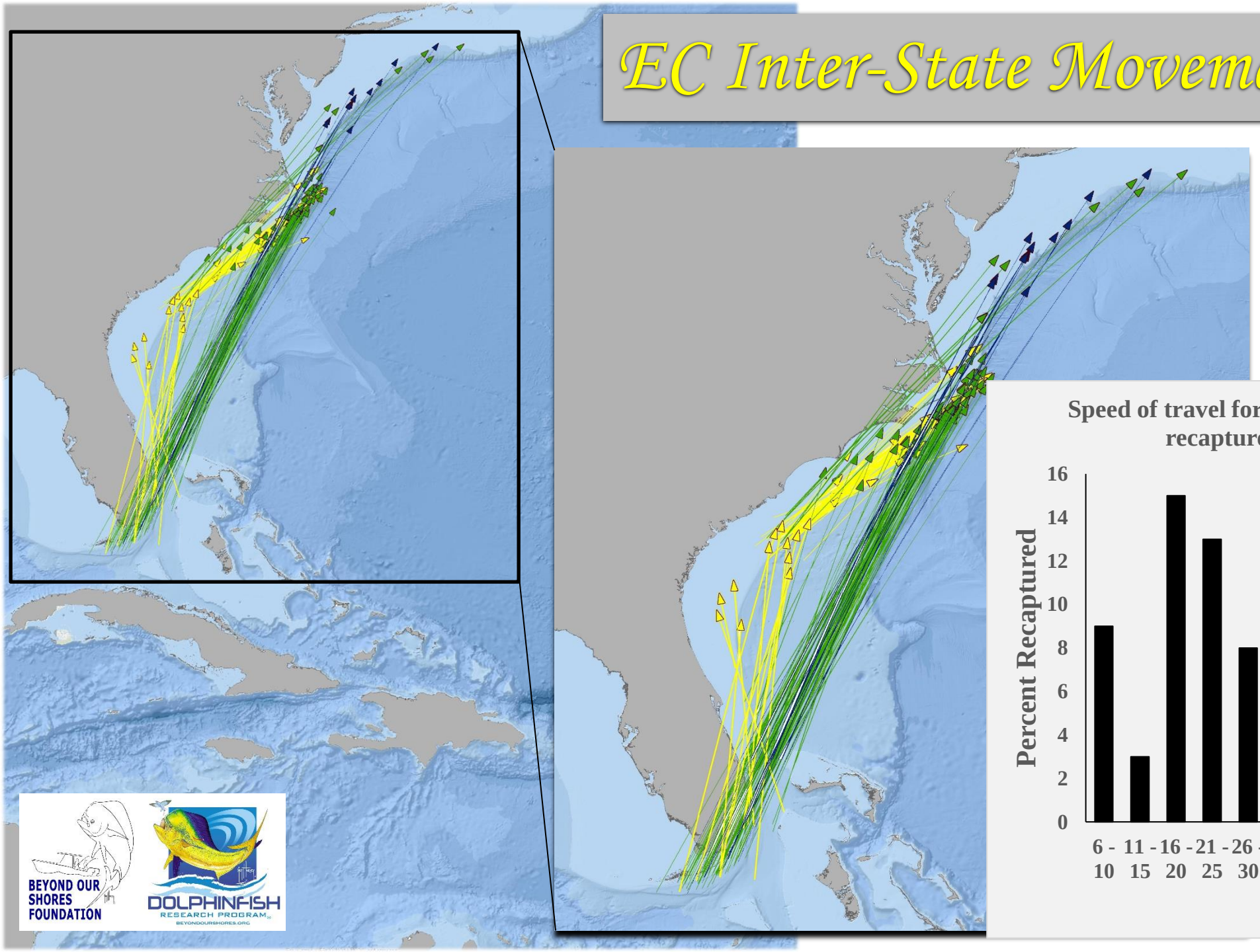
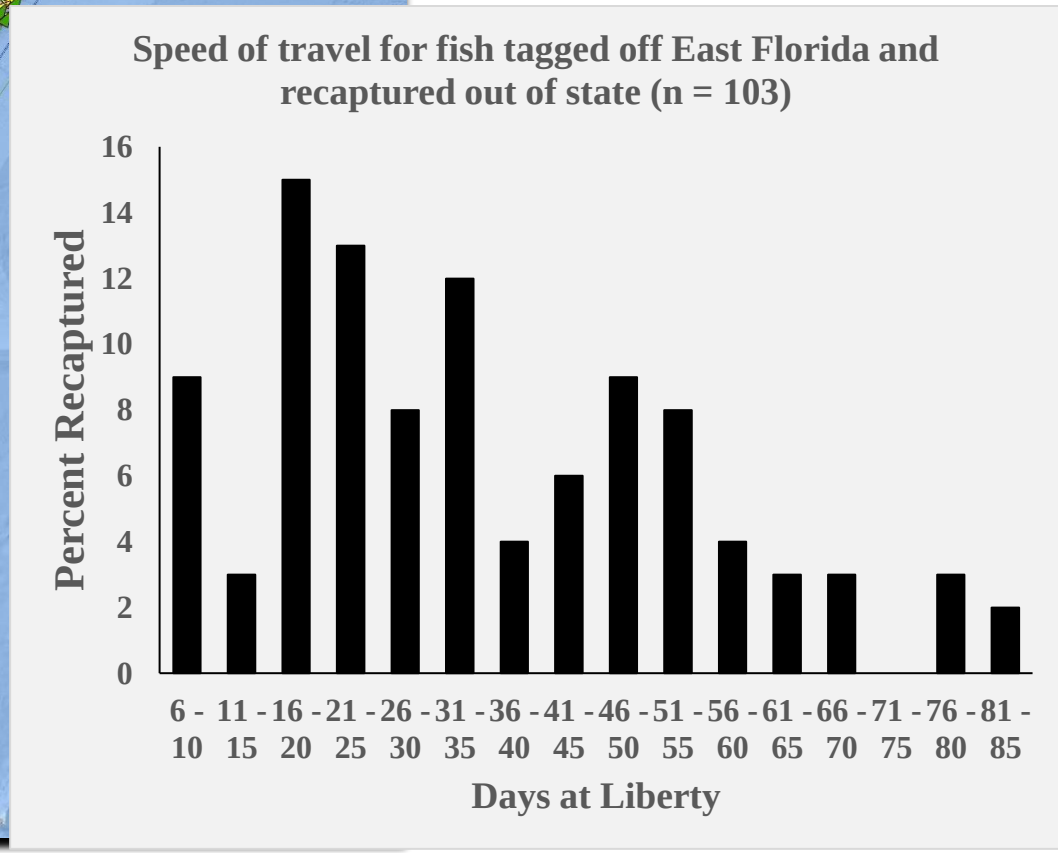
EC Inter-State Movements



35.18 d
(n = 169)



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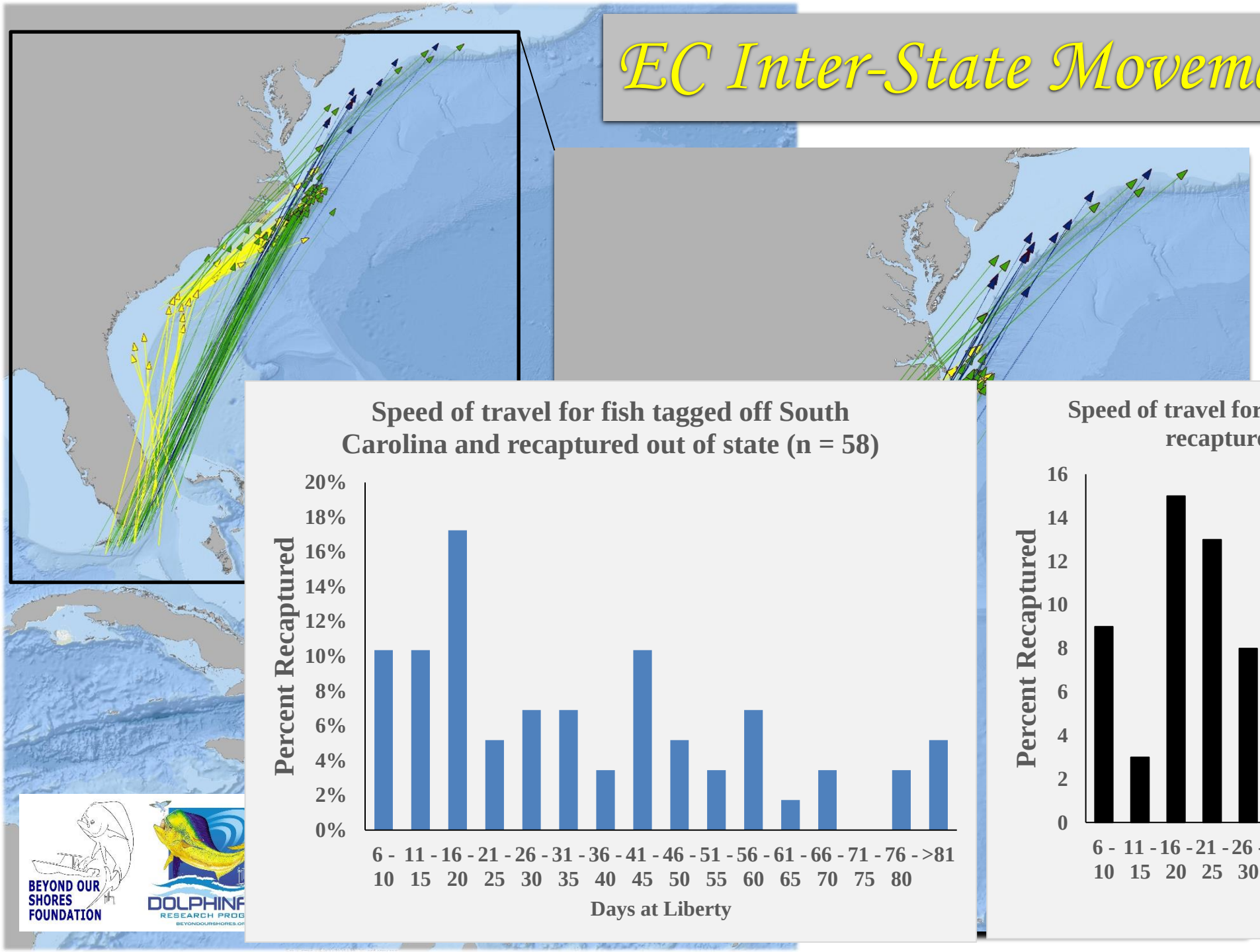
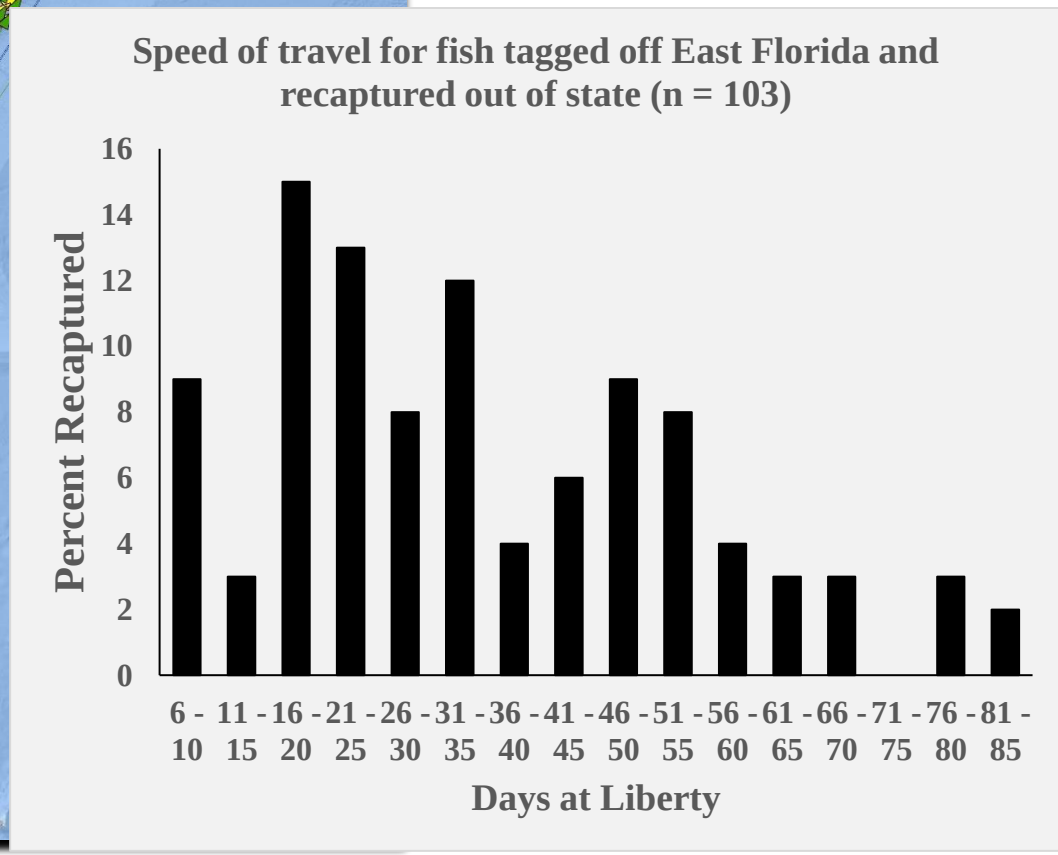
EC Inter-State Movements



35.18 d
(n = 169)



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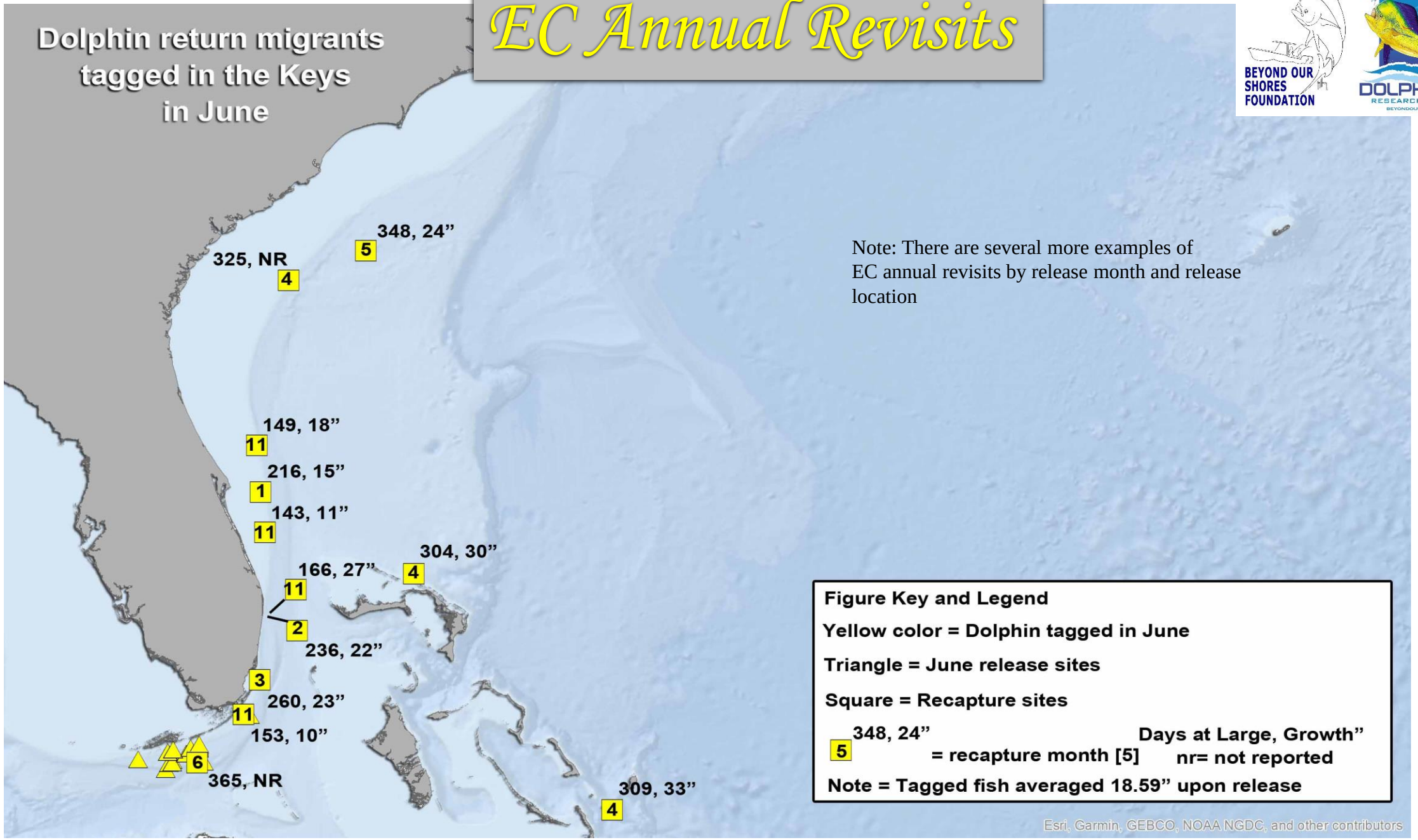
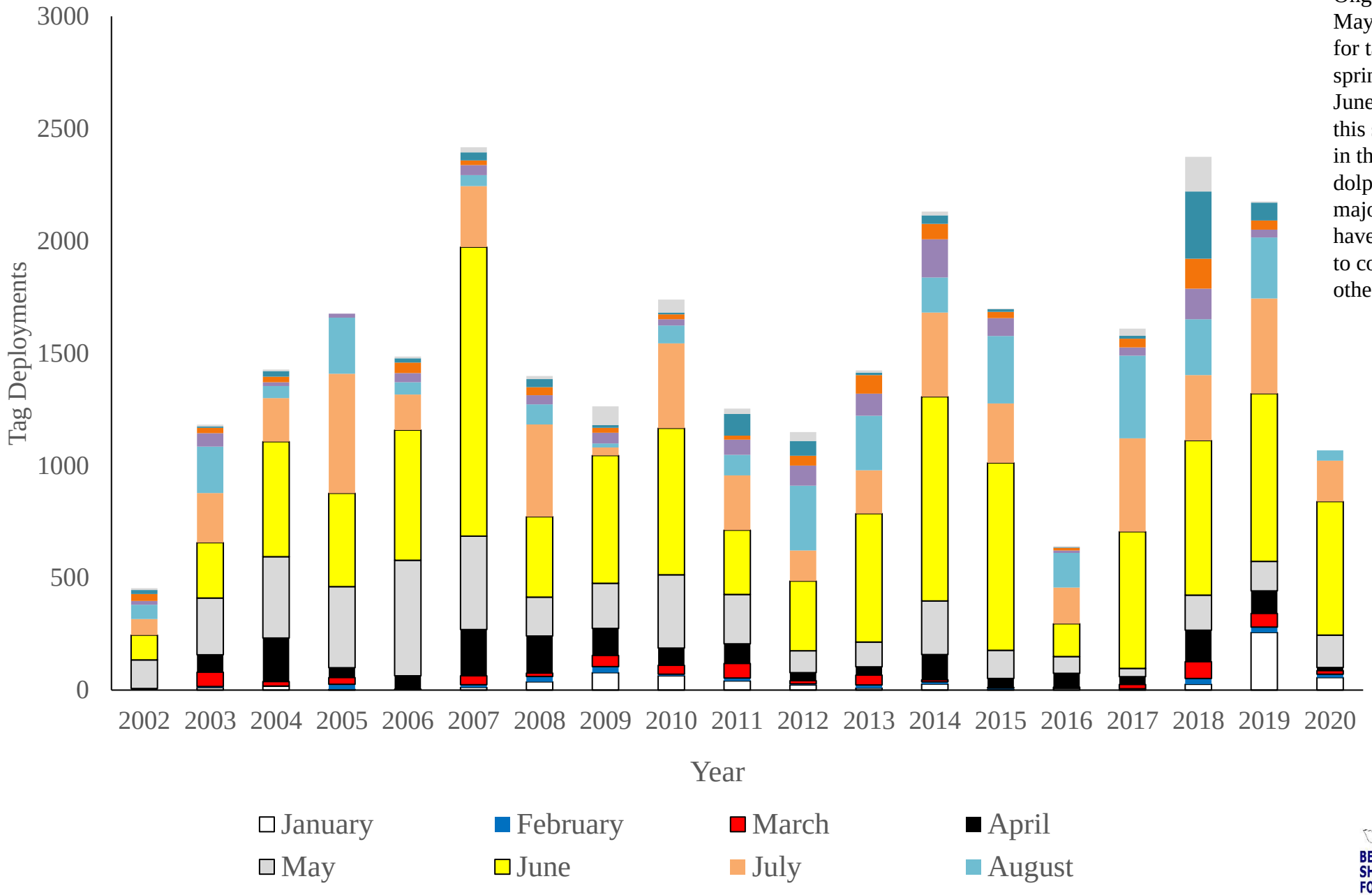
EC Annual Revisits



Note: There are several more examples of EC annual revisits by release month and release location

Tag Deployments by Year and Month from 2002 to 2020



Ongoing work - Historically, May was a more active month for tagging up to 2012 when spring activity decreased but June-August increased – does this show evidence of a shift in the seasonal prevalence of dolphin off Florida (given the majority of tag deployments have occurred there)? Need to compare this data with other data sources.

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Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

Dolphinfish (*Coryphaena hippurus*) distribution in relation to biophysical ocean conditions in the northwest Atlantic☆

Edward R. Farrell[a,b,*], Andre M. Boustany[b,1], Patrick N. Halpin[b,2], Donald L. Hammond[c,3]

[a] The University of Texas at Austin, Department of Marine Science, Marine Science Institute, 750 Channel View Drive, Port Aransas, TX 78373, USA
[b] Duke University, Nicholas School of the Environment, Marine Geospatial Ecology Lab, A328 Levine Science Research Center, 450 Research Drive, Durham, NC 27708, United States
[c] Dolphinfish Research Program, Cooperative Science Services, LLC, 961 Anchor Rd., Charleston, SC 29412, United States

Farrel et al. (2014) used the DRP dataset to compare recreational and commercial CPUE relative to biophysical properties as well as seasonal overlap of fisheries. The most obvious trend to note is the incidence of overlap of fisheries is highest both spatially and temporally from April through June off the SAB and OBX.

- Dolphinfish CPUE highest at 22-25°C with a peak at 24°C for LL data
- Recreational catches occurred in water as low as 19°C with peak catches at 27°C
- Dolphinfish CPUE was highest when chlorophyll-a concentration was <0.2 mg m−3, and the majority of recreational dolphinfish were captured in waters <0.1 mg m−3 with a peak at 0.02 mg m−3.
- Majority (73.26%) of recreational dolphinfish were caught in association with Sargassum spp., and larger dolphinfish (>82.3 cm FL) are caught more frequently outside of the floating mats.

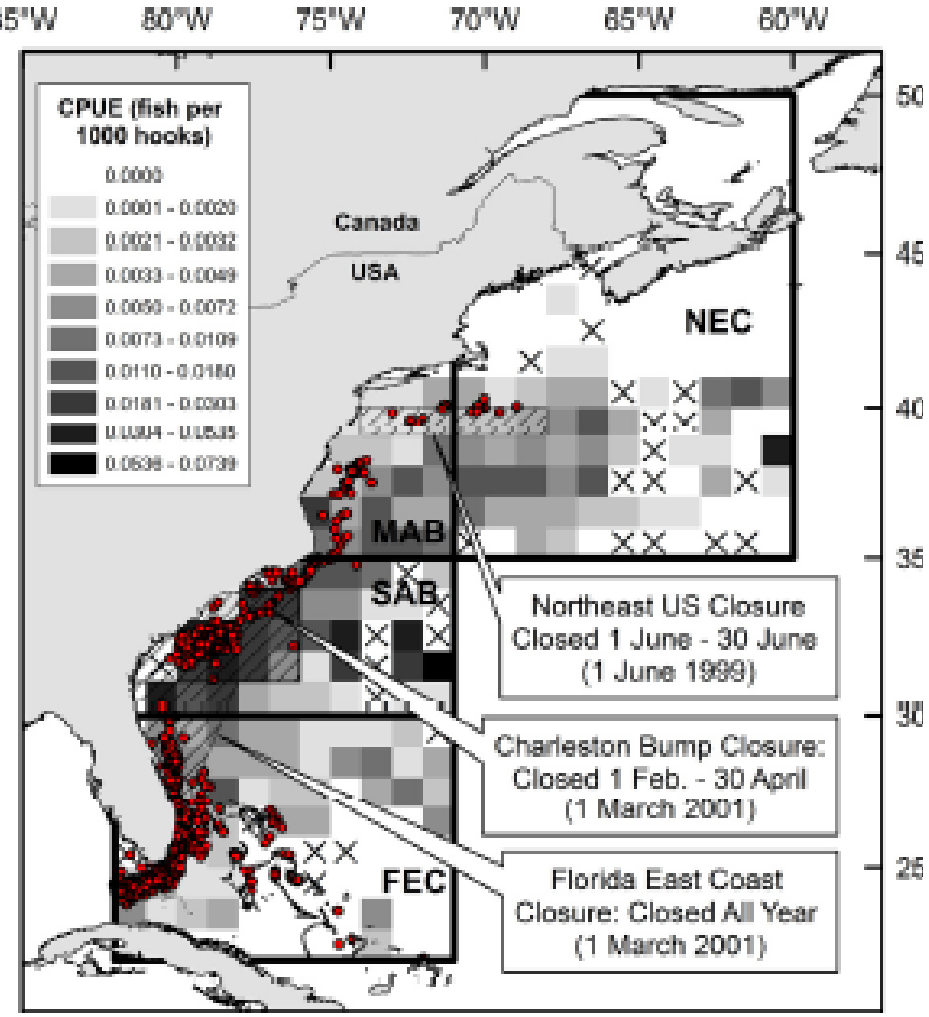

Fig. 1. Map of study area with statistical areas and pelagic longline closed a overlaid. See text for descriptions of statistical areas. Each square represents a 1° area where one or more longline sets (n = 36,325) were made during the study pe (individual set locations are not shown due to privacy concerns). An × indicates were one or more sets were made and no dolphinfish were captured. Individual release locations are represented as red dots (n = 8111).(For interpretation o references to color in this figure legend, the reader is referred to the web versi the article.)

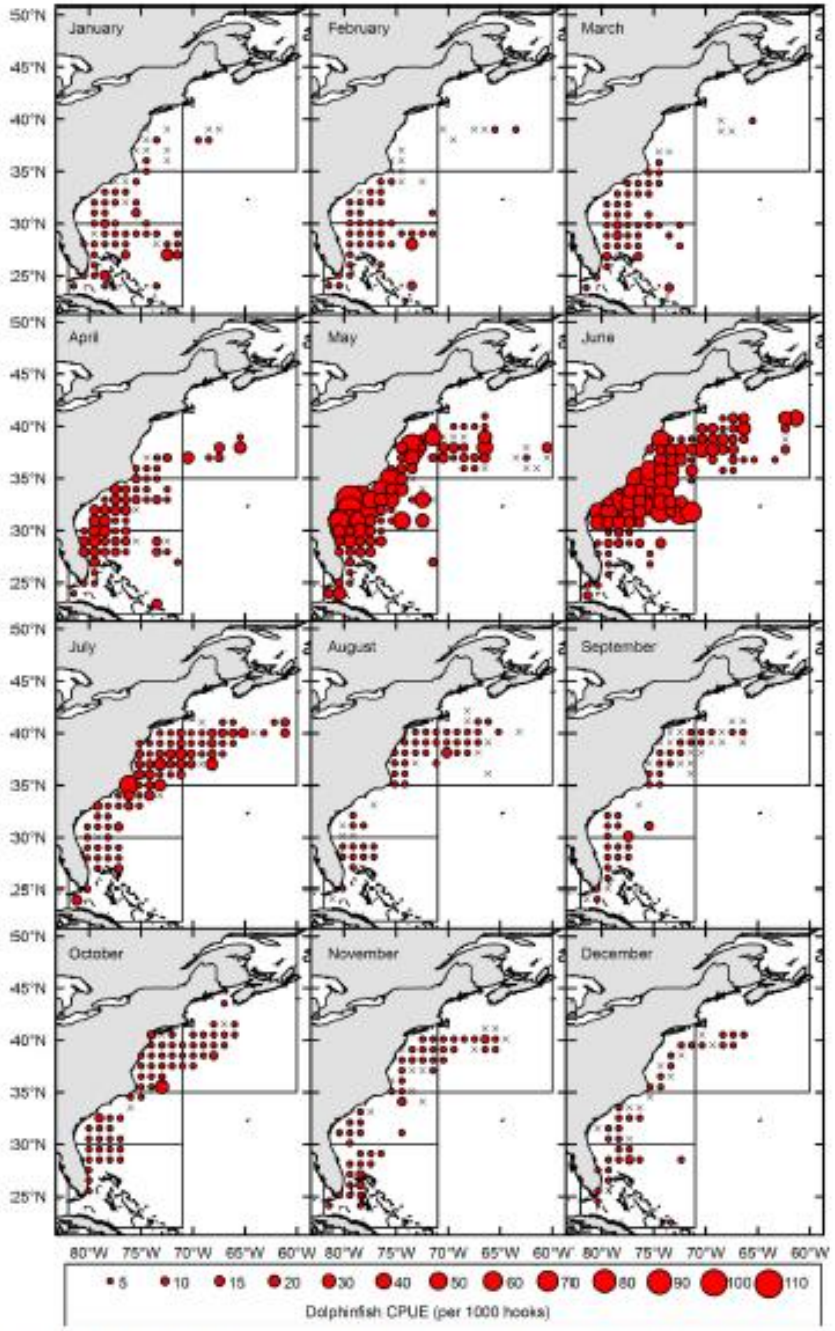

Fig. 4. Temporospatial variability of dolphinfish CPUE in 1° × 1° cells. Black × indicates areas where more than 1000 hooks were set but no dolphinfish were caught.

From Farrel et al. (2014), the most obvious trend to note is the incidence of overlap of fisheries is highest both spatially and temporally from April through June off the SAB and OBX.

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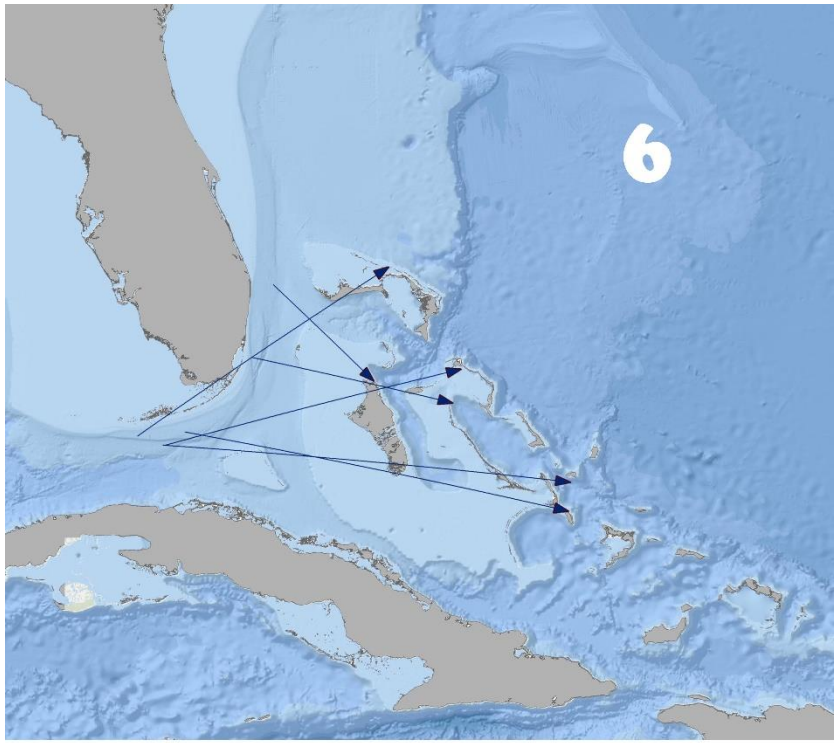
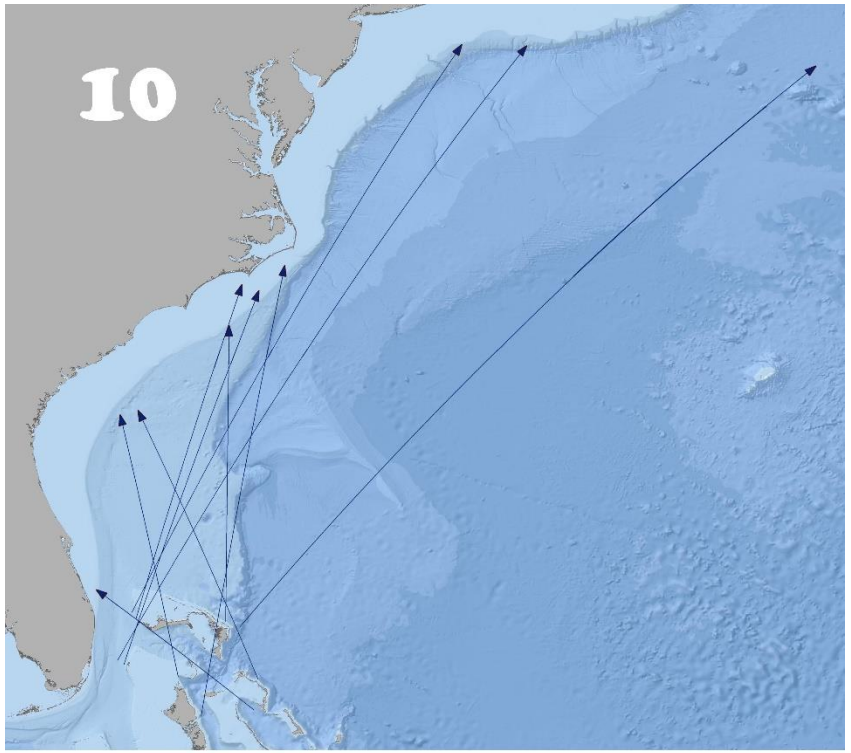
Bahamas



U.S East Coast to Bahamas

267 d

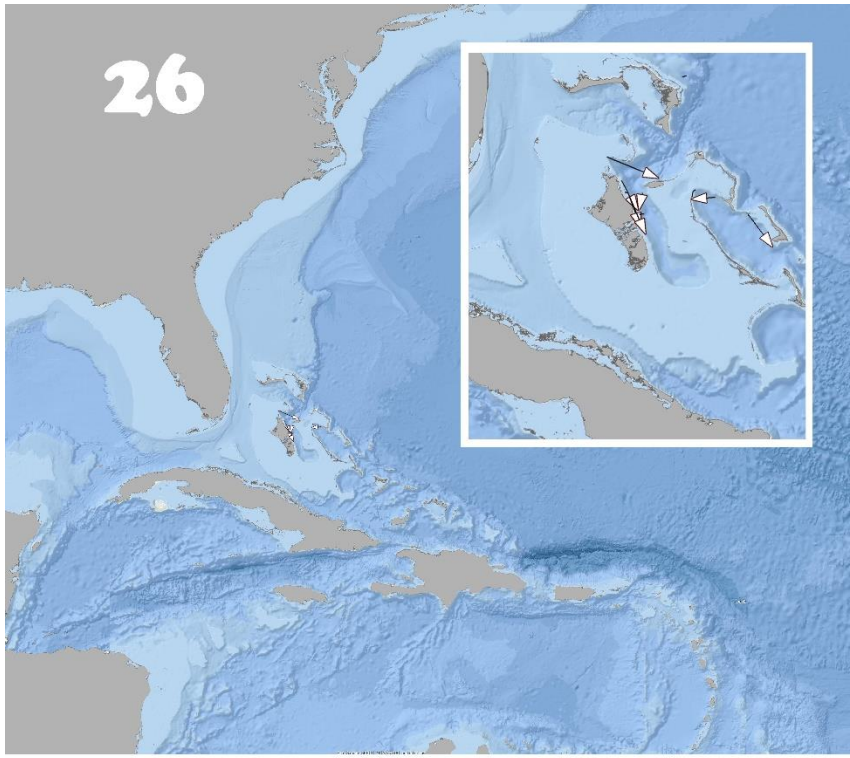
(n = 6)



Bahamas Dispersals

14.39 mpd or 57.77 d

(n = 10)



Bahamas In-Country

1.876 mpd

(n = 26)

Range: 0 to 77 DAL

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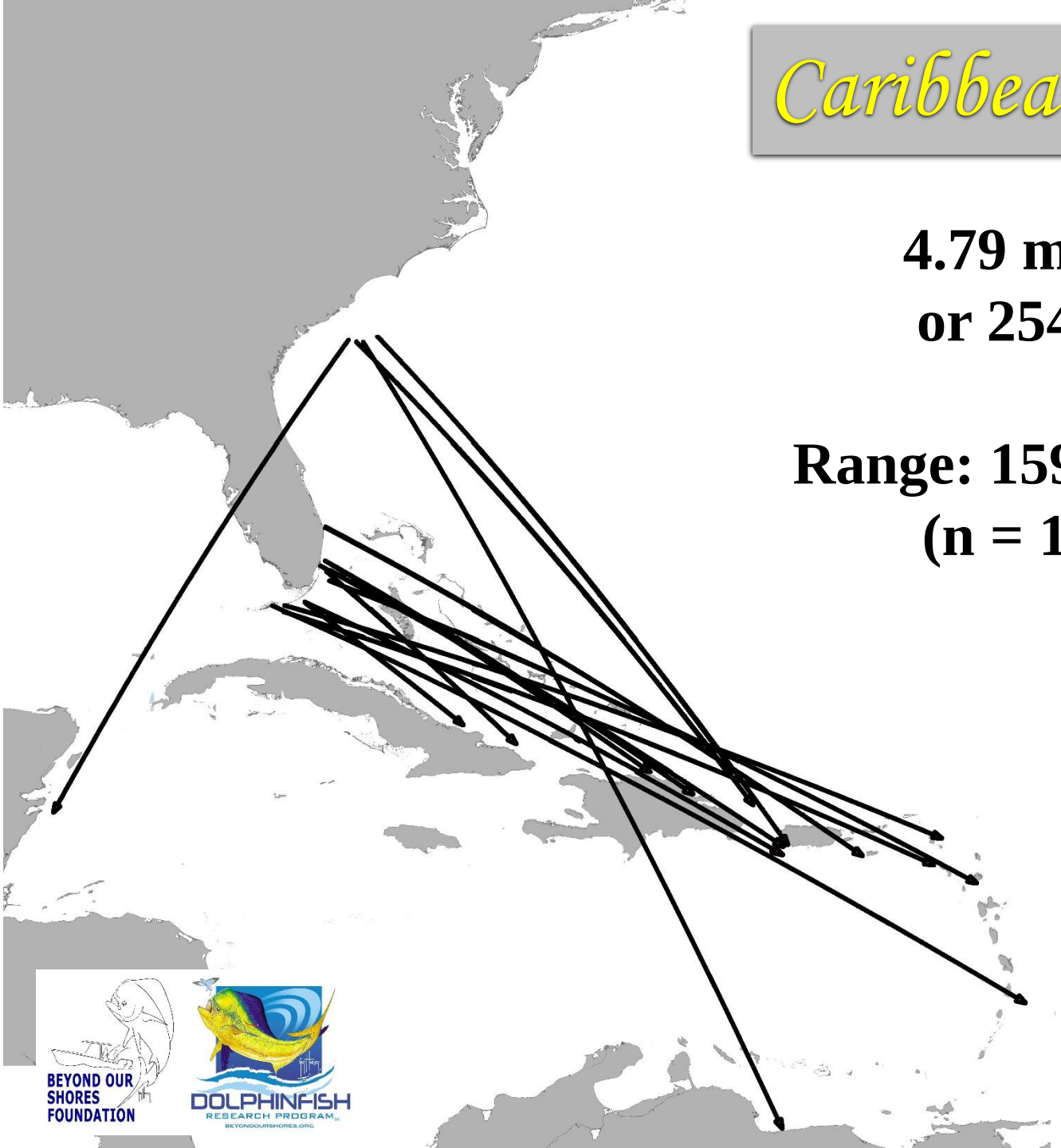
Caribbean Sea



4.79 mpd
or 254 d

Range: 159 to 557
(n = 19)

Fisheries Research 175 (2016) 24–34

Contents lists available at ScienceDirect

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journal homepage: www.elsevier.com/locate/fishres

Movement dynamics of dolphinfish (*Coryphaena hippurus*) in the northeastern Caribbean Sea: Evidence of seasonal re-entry into domestic and international fisheries throughout the western central Atlantic

Wessley Merten[a,b,*], Richard Appeldoorn[a], Donald Hammond[b]

[a] Department of Marine Sciences, University of Puerto Rico, Mayagüez, PO Box 9000, Mayagüez, PR 00681, United States
[b] Cooperative Science Services LLC, Dolphinfish Research Program, 983 Anchor Road, Charleston, SC 29412, United States

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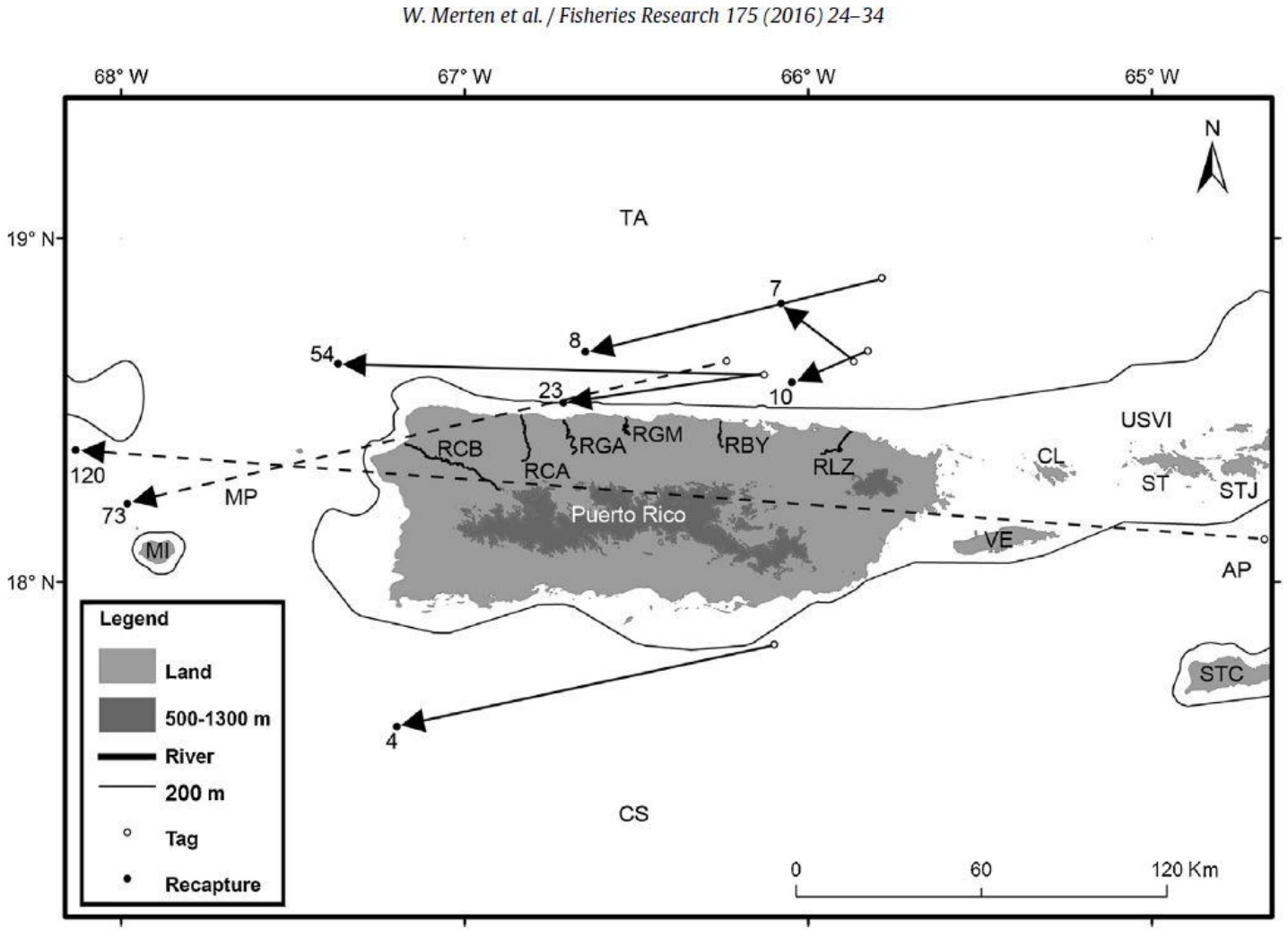

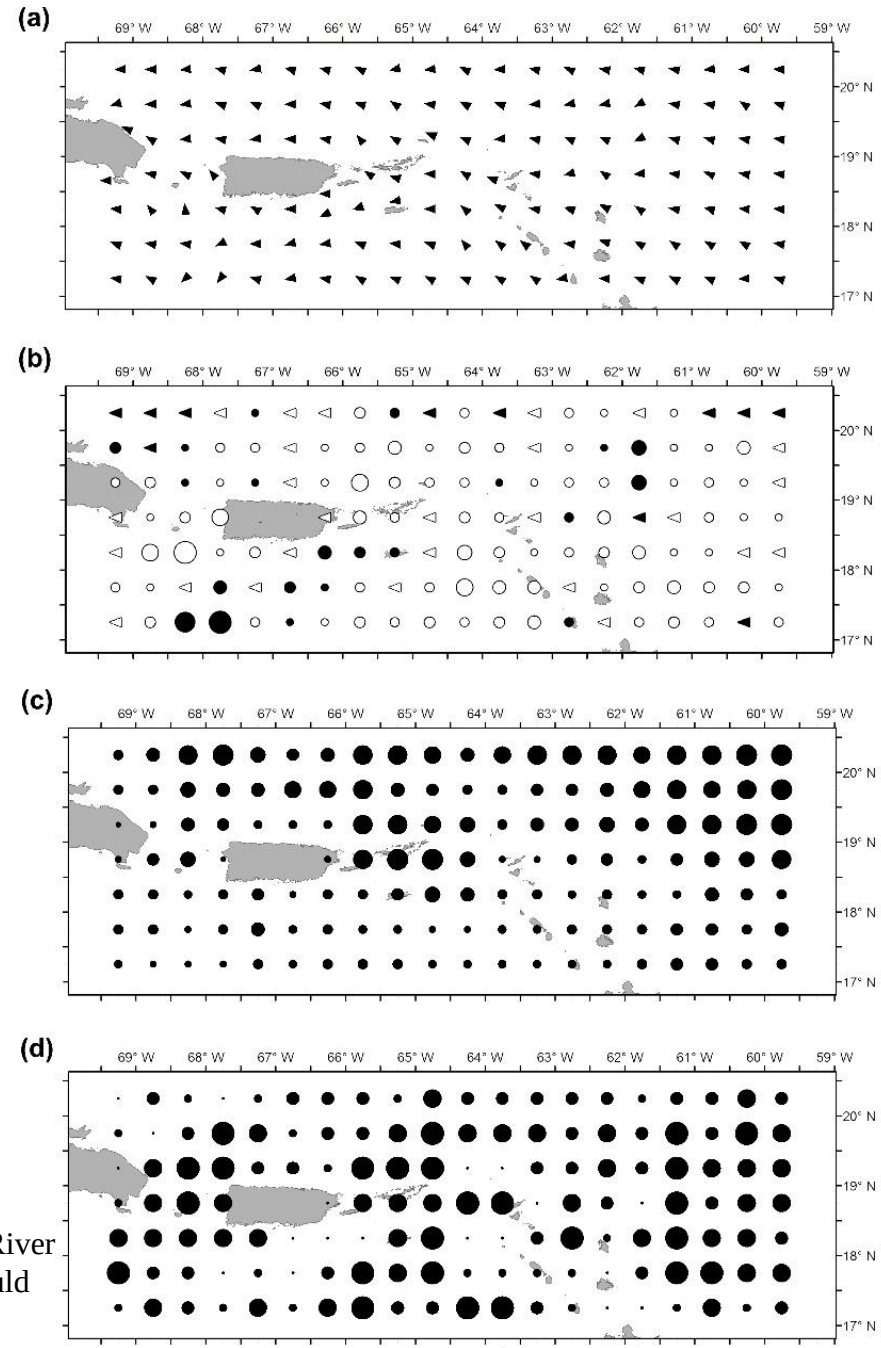

Ongoing work – Describe movement dynamics between tropical Atlantic and Caribbean Sea via the Mona and Anegada Passages. Intrusion of Orinoco River water could affect interannual abundance. Same could apply elsewhere where/when “green water” occurs.

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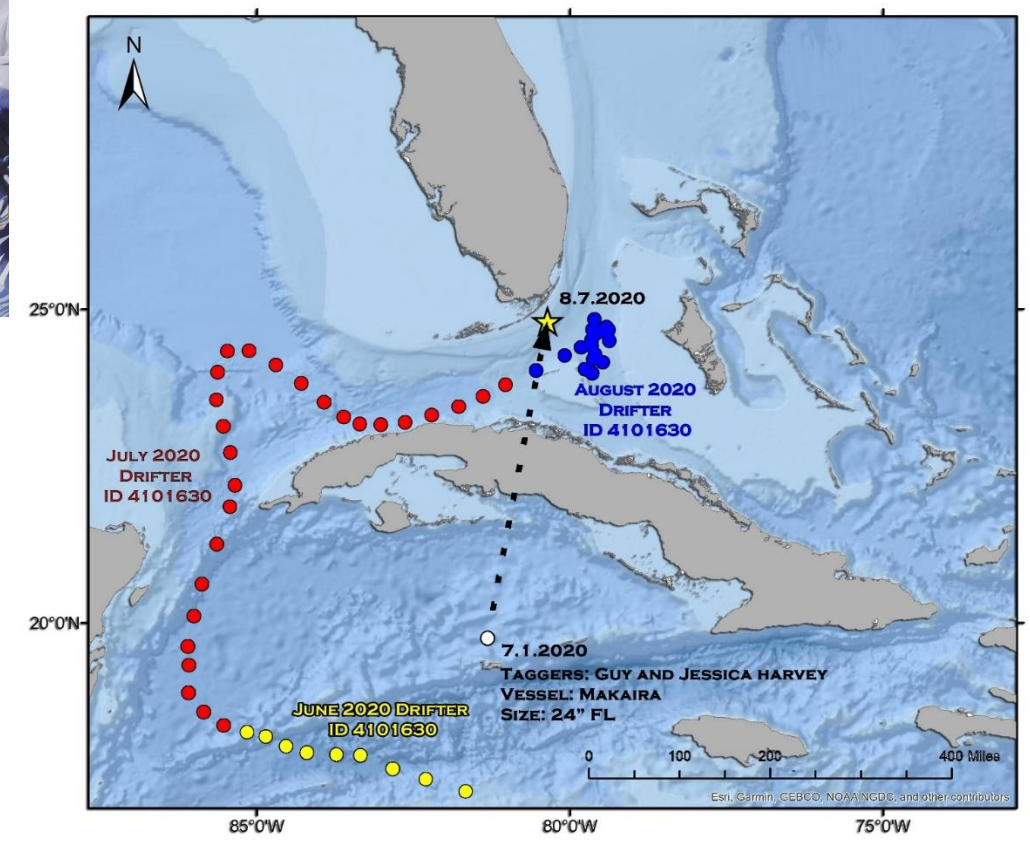
Caribbean Sea

August 2020 – Cayman to Key Largo dolphin recovery



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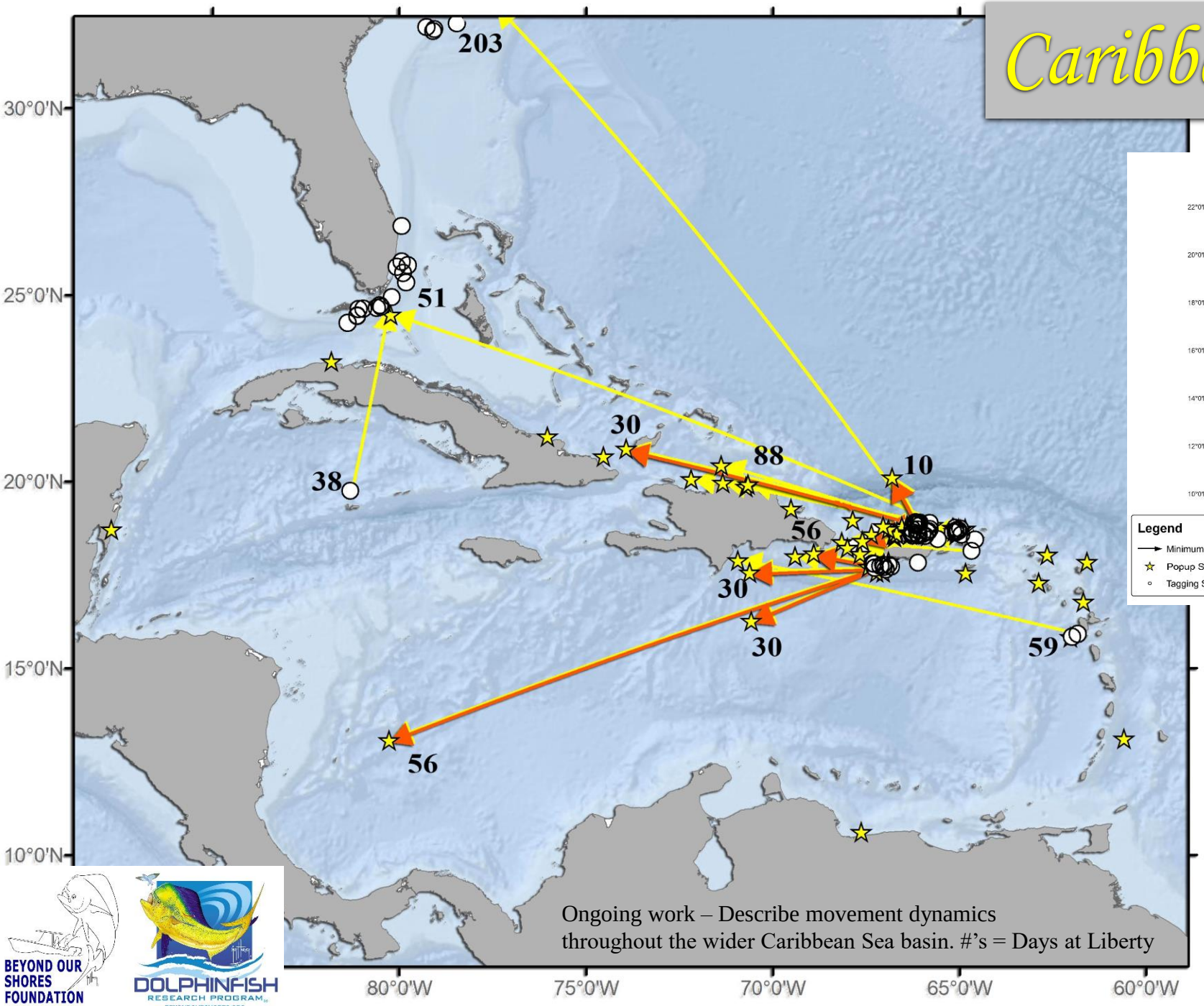
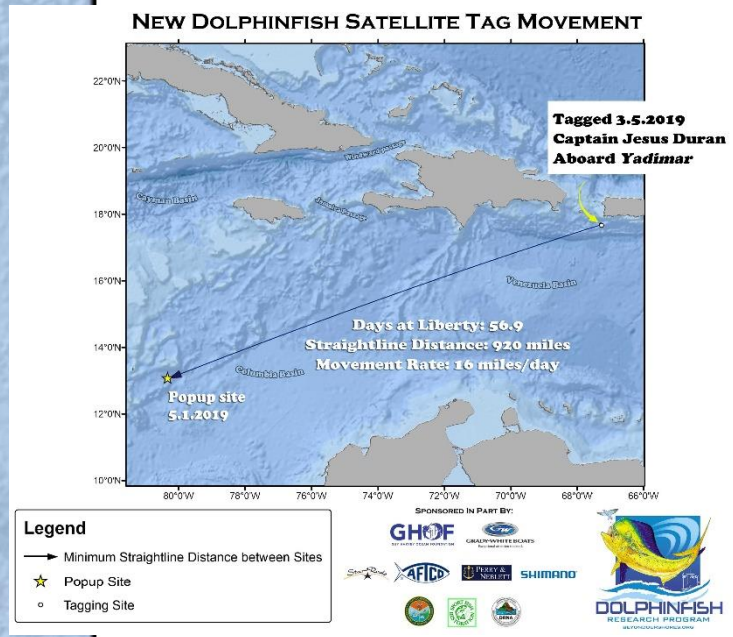
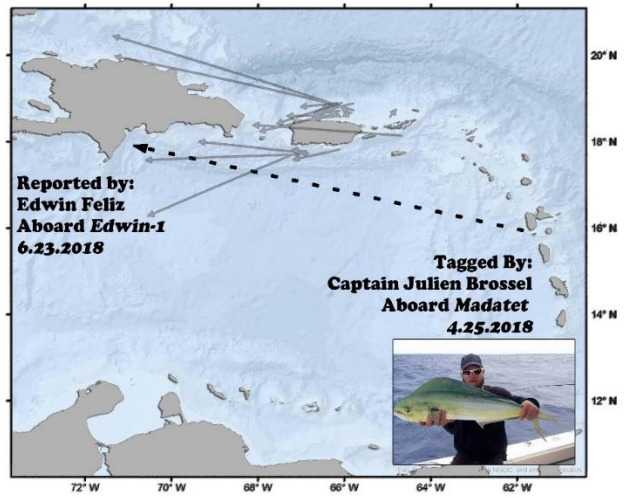
Caribbean Sea



Ongoing work – Describe movement dynamics throughout the wider Caribbean Sea basin. #'s = Days at Liberty

New Dolphinfish Satellite Tag Movement





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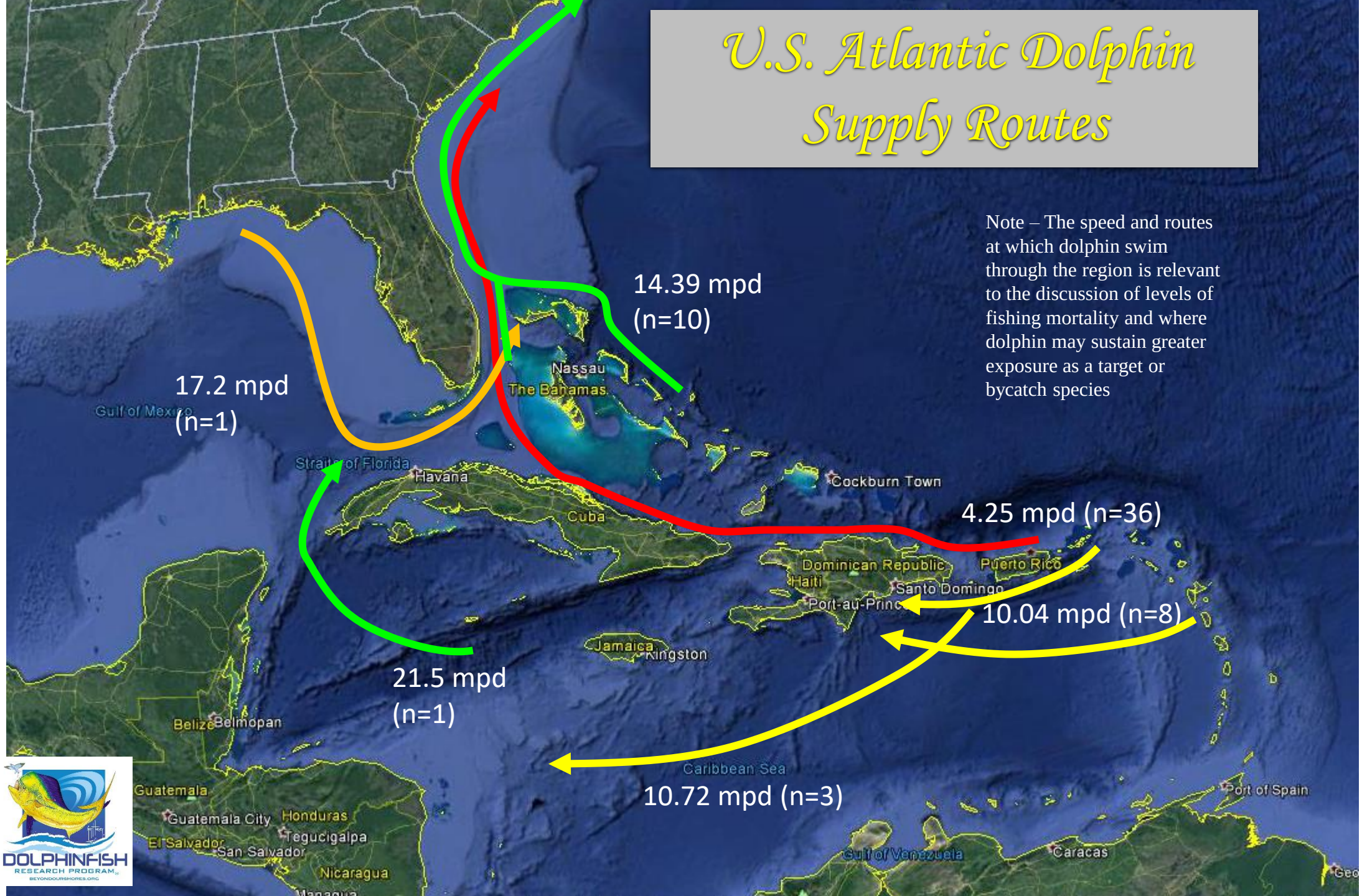
U.S. Atlantic Dolphin Supply Routes

Pic: Jeff Brehm

U.S. Atlantic Dolphin Supply Routes



Note – The speed and routes at which dolphin swim through the region is relevant to the discussion of levels of fishing mortality and where dolphin may sustain greater exposure as a target or bycatch species

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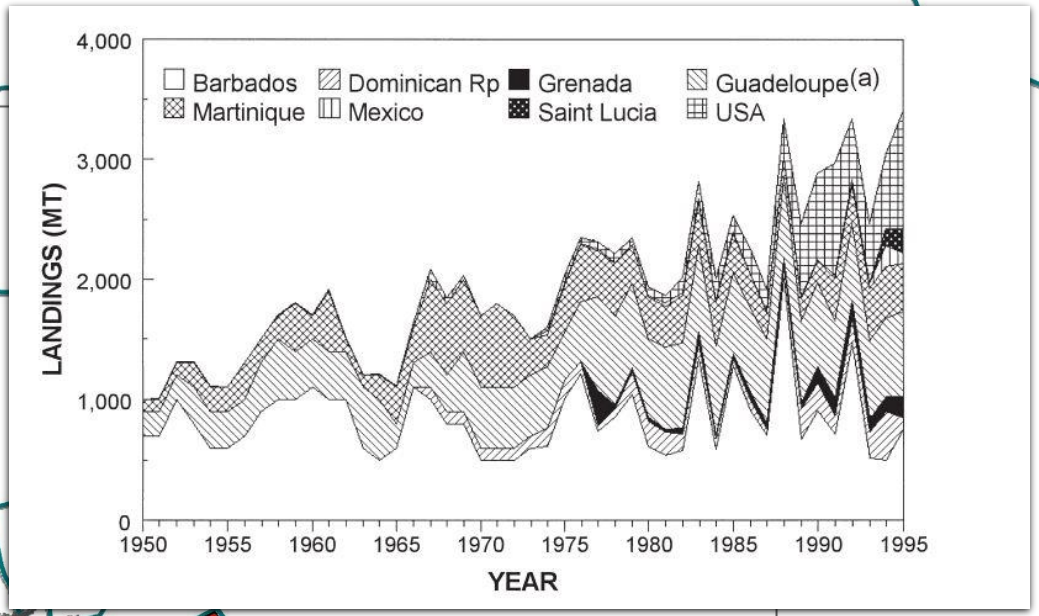
Caribbean Sea (WECAFC) Dolphin Landings



Reference:
Mahon, R. 1999. Dolphinfish Fisheries in the Caribbean Region. Scientia Marina, 63(3-4), 411-420.

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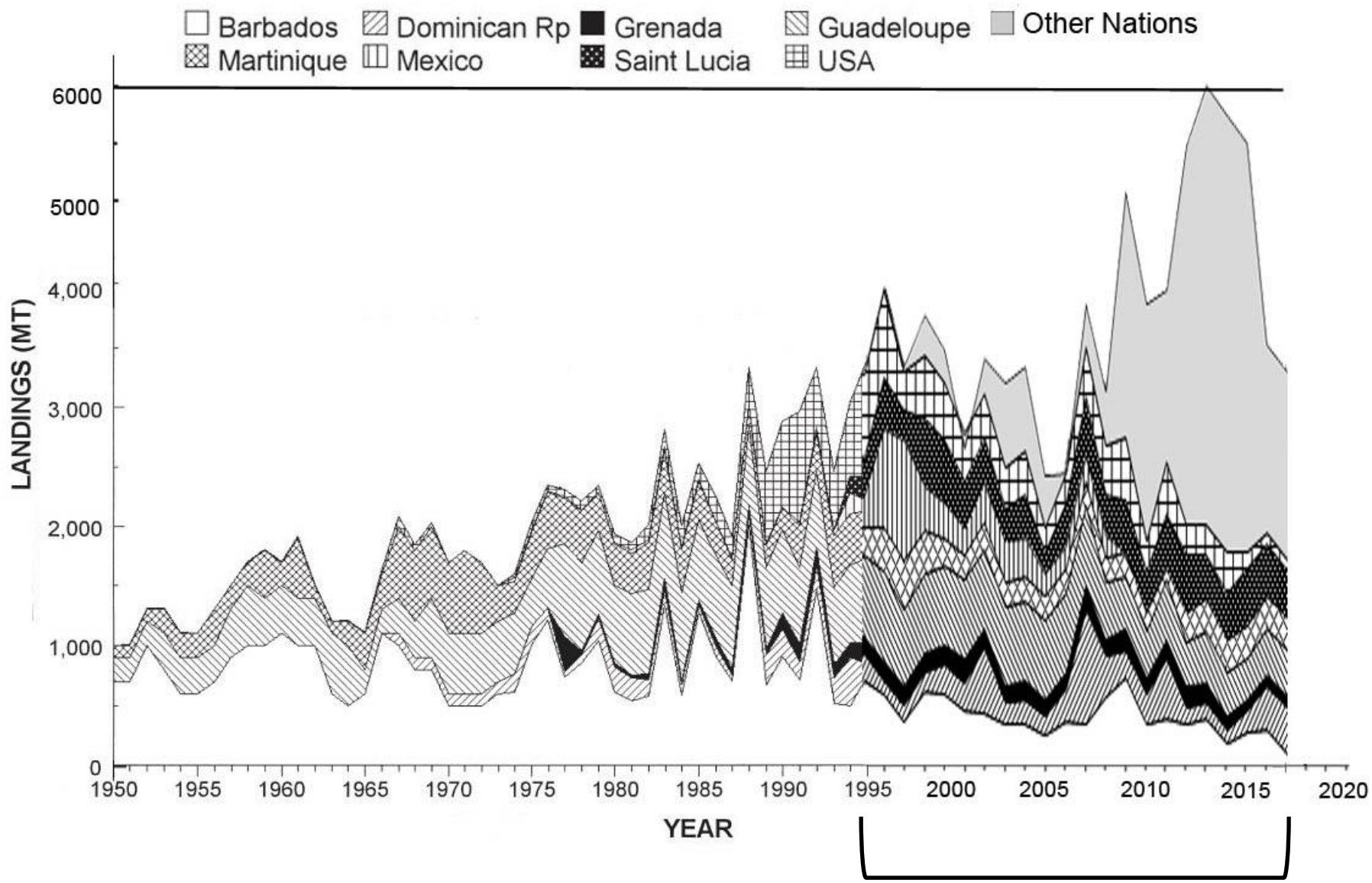
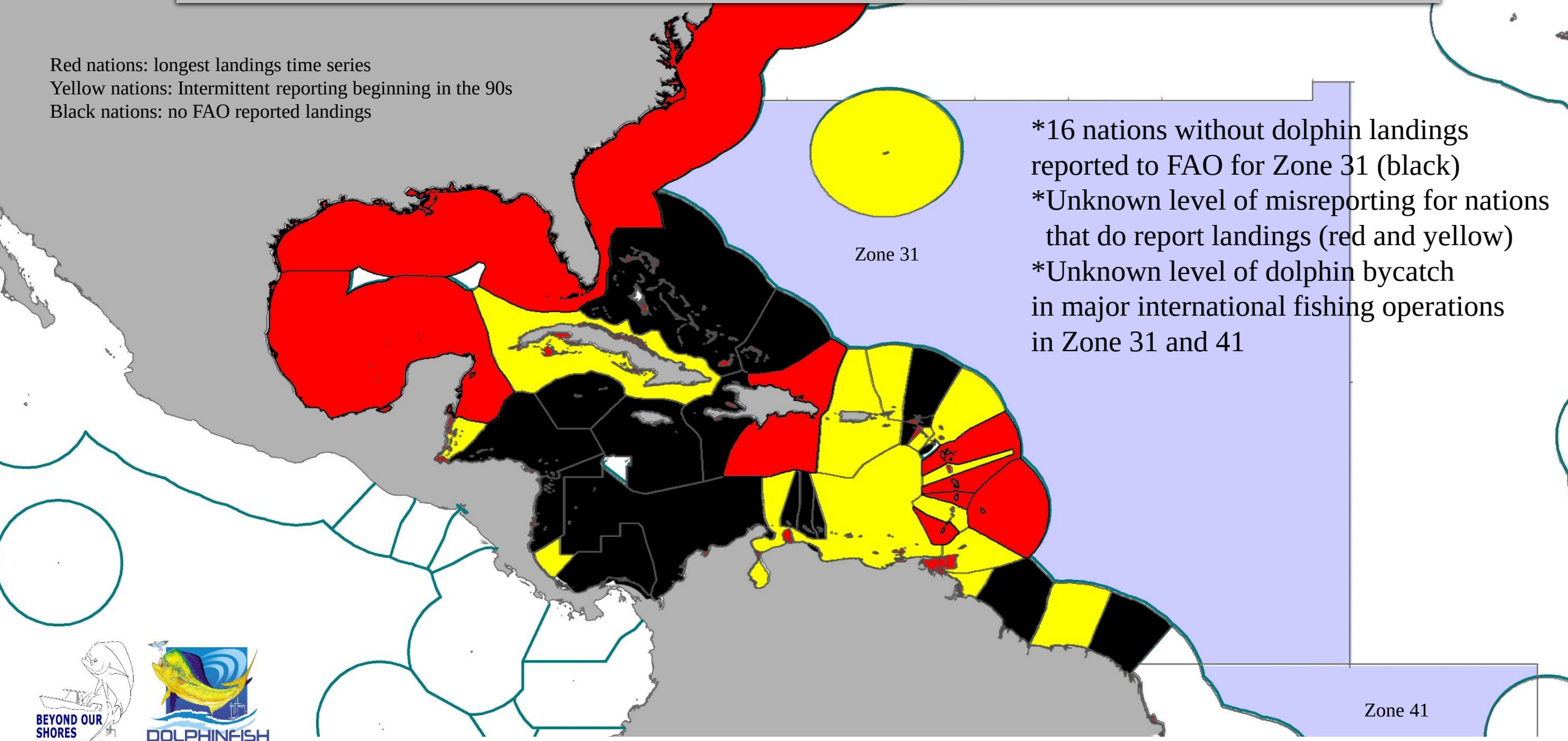


Reference:
Mahon, R. 1999. Dolphinfish Fisheries in the Caribbean Region. Scientia Marina, 63(3-4), 411-420.

Ongoing work – update Mahon's 1999 analysis by extending out the time series Here – 1996 to 2017. *Other Nations include those now reporting dolphin landings to the FAO since Mahon's analysis

Caribbean Sea and WECAFC Dolphin Landings

Red nations: longest landings time series
Yellow nations: Intermittent reporting beginning in the 90s
Black nations: no FAO reported landings



*16 nations without dolphin landings reported to FAO for Zone 31 (black)
*Unknown level of misreporting for nations that do report landings (red and yellow)
*Unknown level of dolphin bycatch in major international fishing operations in Zone 31 and 41

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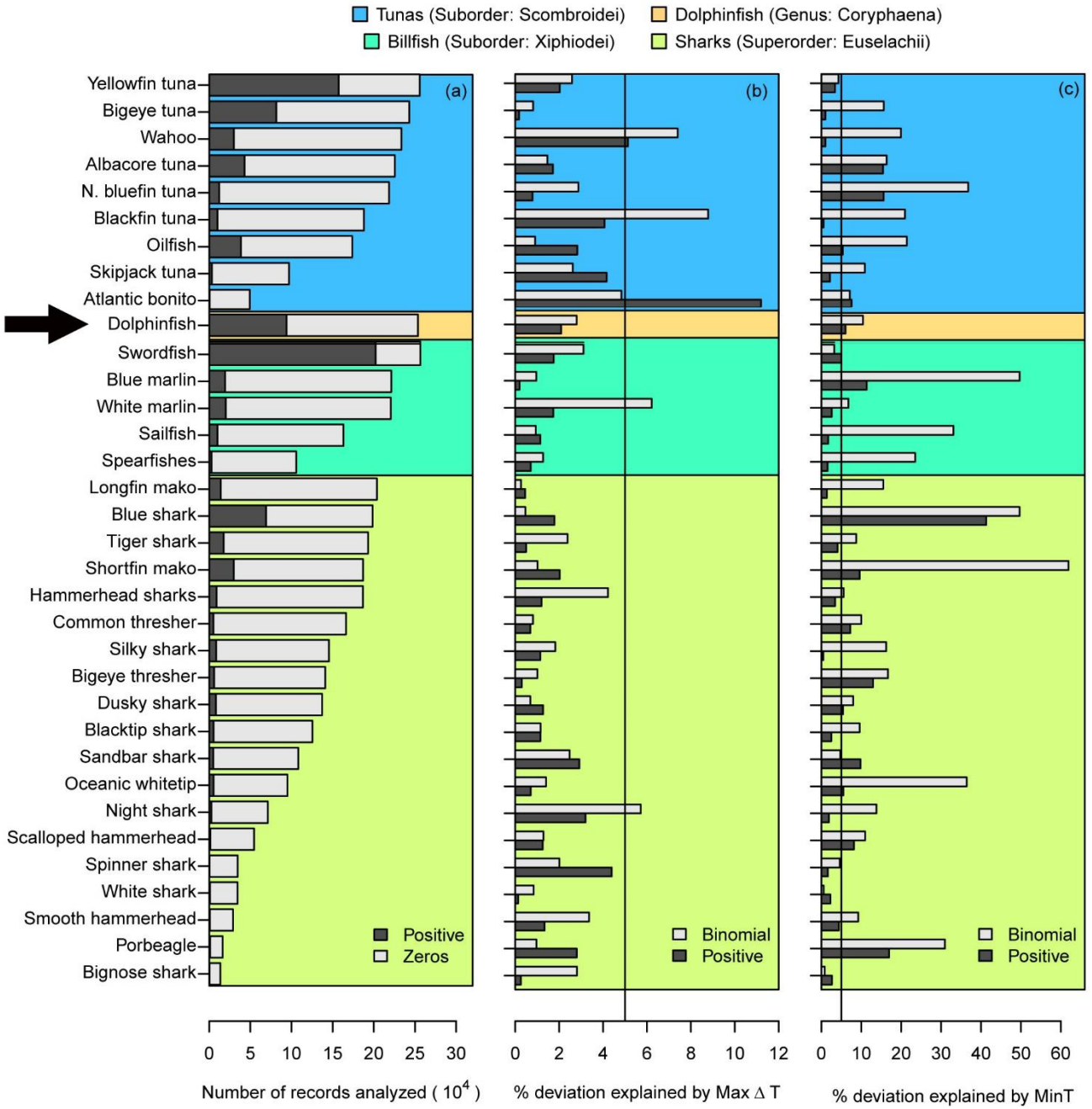
Lynch et al. (2018) Abundance trends of highly migratory species in the Atlantic Ocean: Accounting for water temperature profiles. ICES Journal of Marine Science.

In this study, the top three species encountered in Atlantic U.S. longline operations were swordfish, yellowfin tuna, and dolphinfish (left panel). Dolphinfish, indicated with the black arrow, are bycatch, yet are encountered higher than bigeye tuna, a target species. The far-right panel shows that dolphinfish were neither encountered nor caught in high rates when vessels set in cold water.



Given the findings of this study, dolphinfish bycatch among longline operations under vessels of different flag states could be high. Whatever the level may be, where is longlining the most prevalent throughout the WCA and Caribbean Sea? A question that set off the following analysis (slides 44-48).

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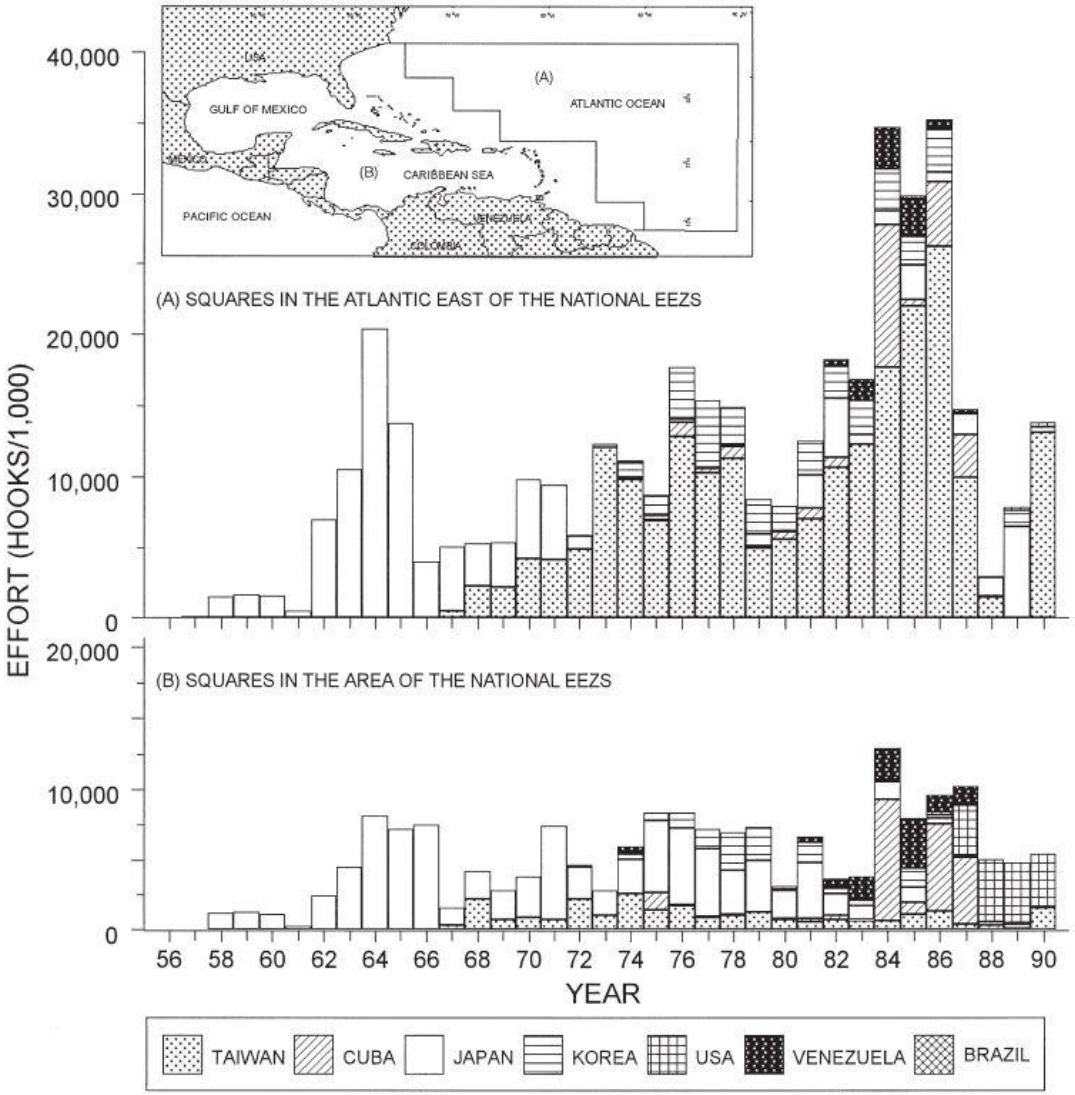
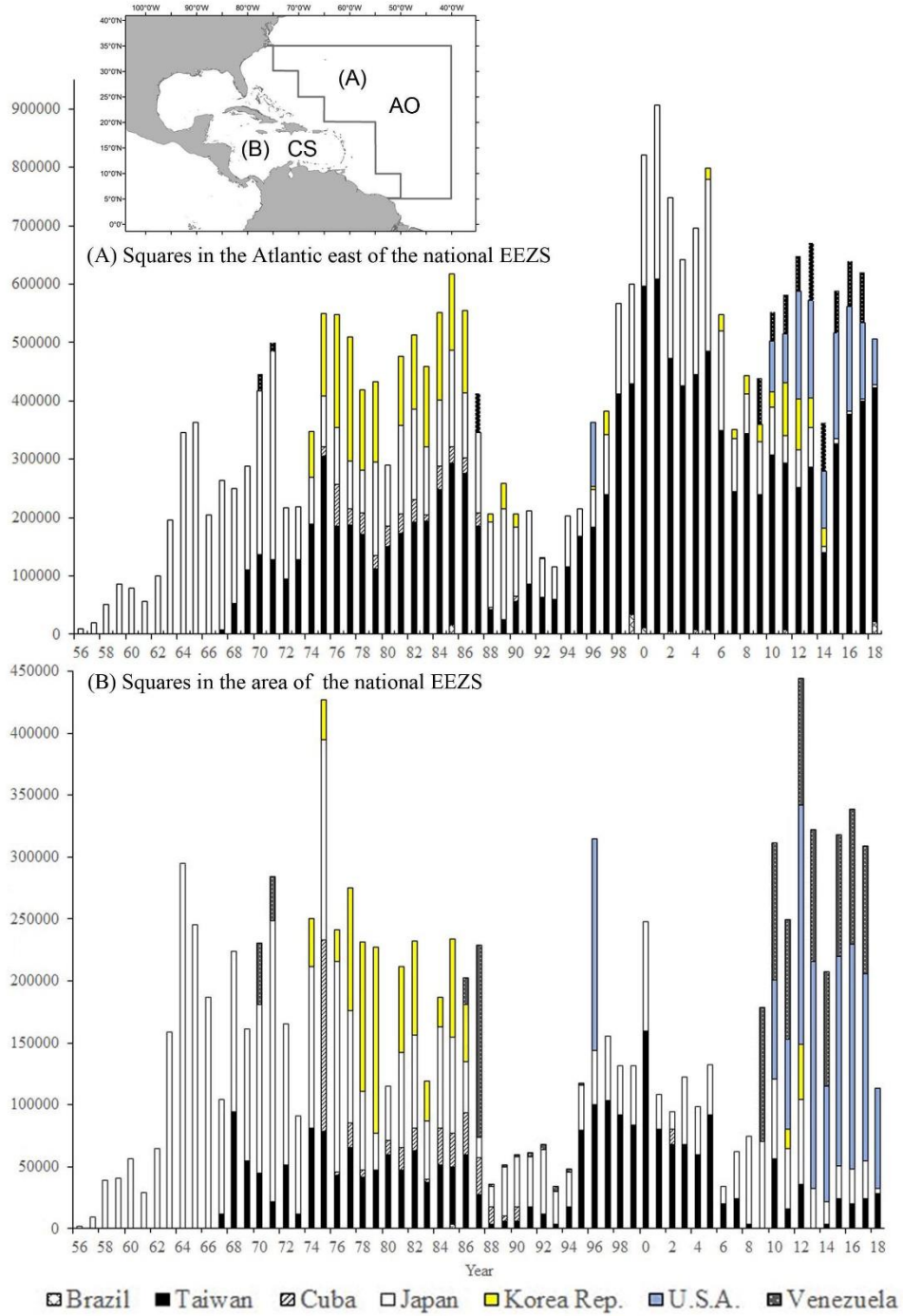
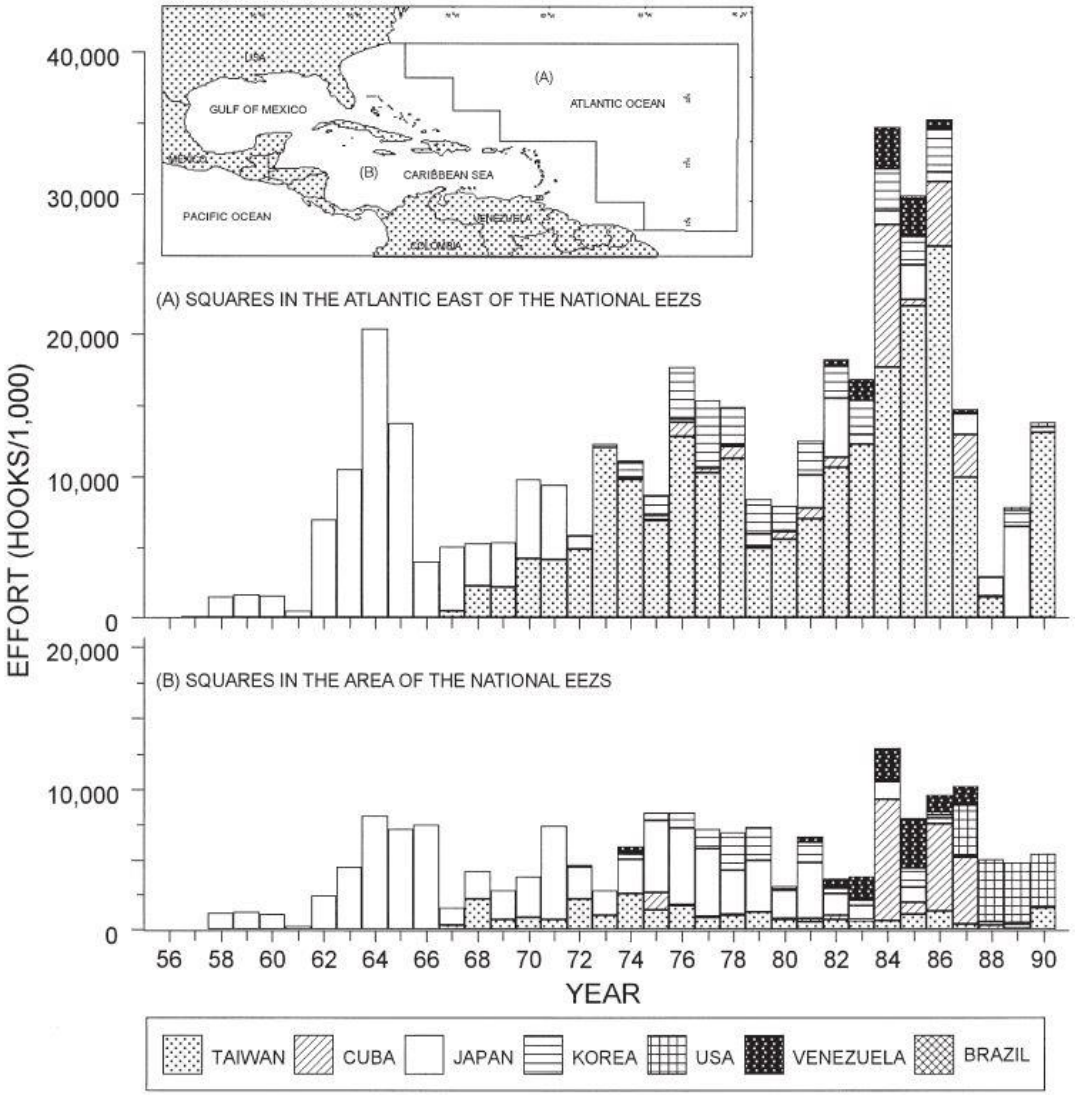


FIG. 2. – Trends in longline fishing effort by countries reporting landings in the WECAFC area. The data are shown for two areas: (A) data reporting squares in the Atlantic east of national EEZs; and (B) squares in the area of national EEZs.



Reference:
Mahon, R. 1999. Dolphinfish Fisheries in the Caribbean Region. Scientia Marina, 63(3-4), 411-420.

Ongoing work – update Mahon's 1999 Analysis by extending out the time series Here – 1956 to 2018. *These countries have the longest and most consistent record for annual dolphin landings in the WECAFC region.



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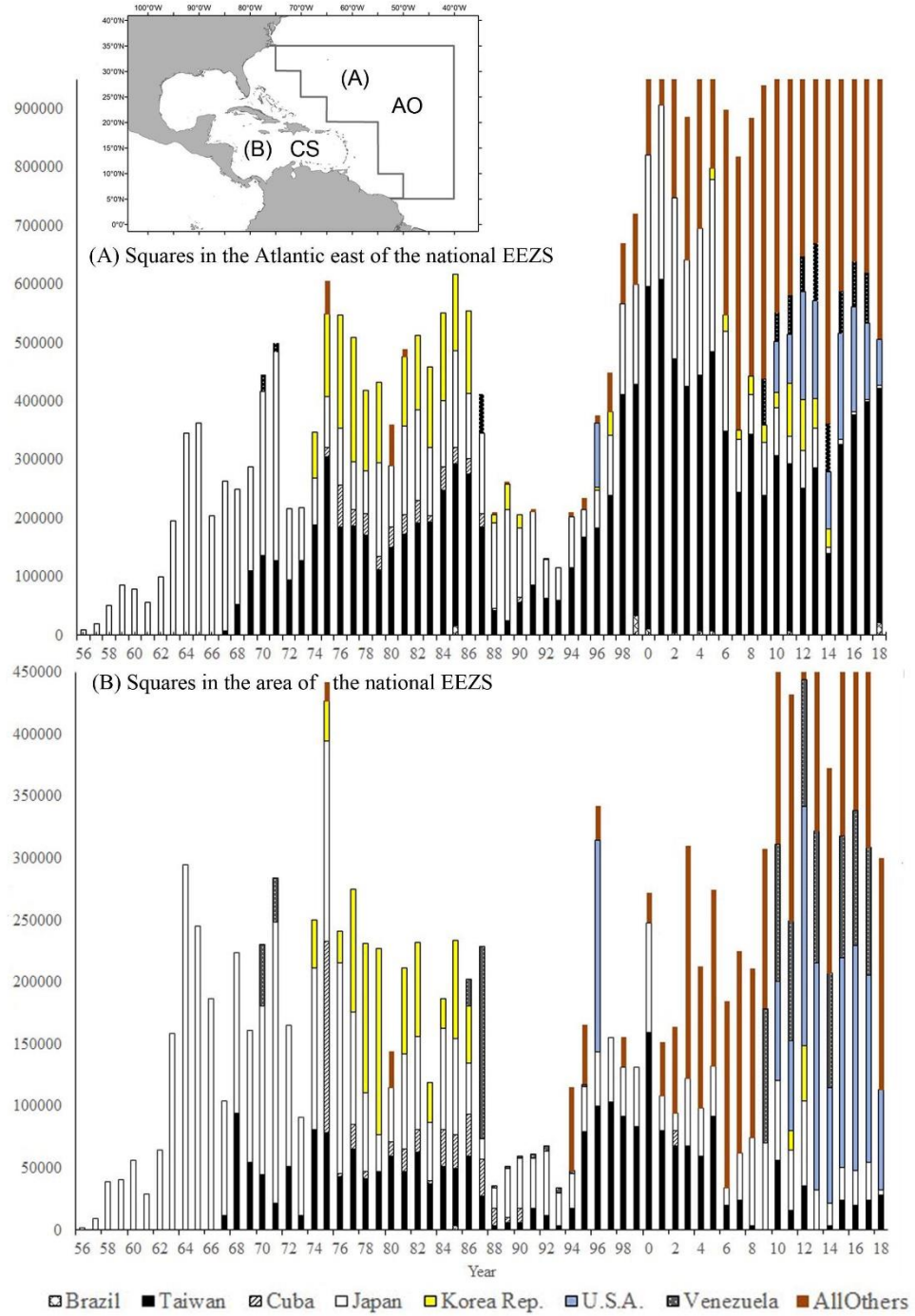
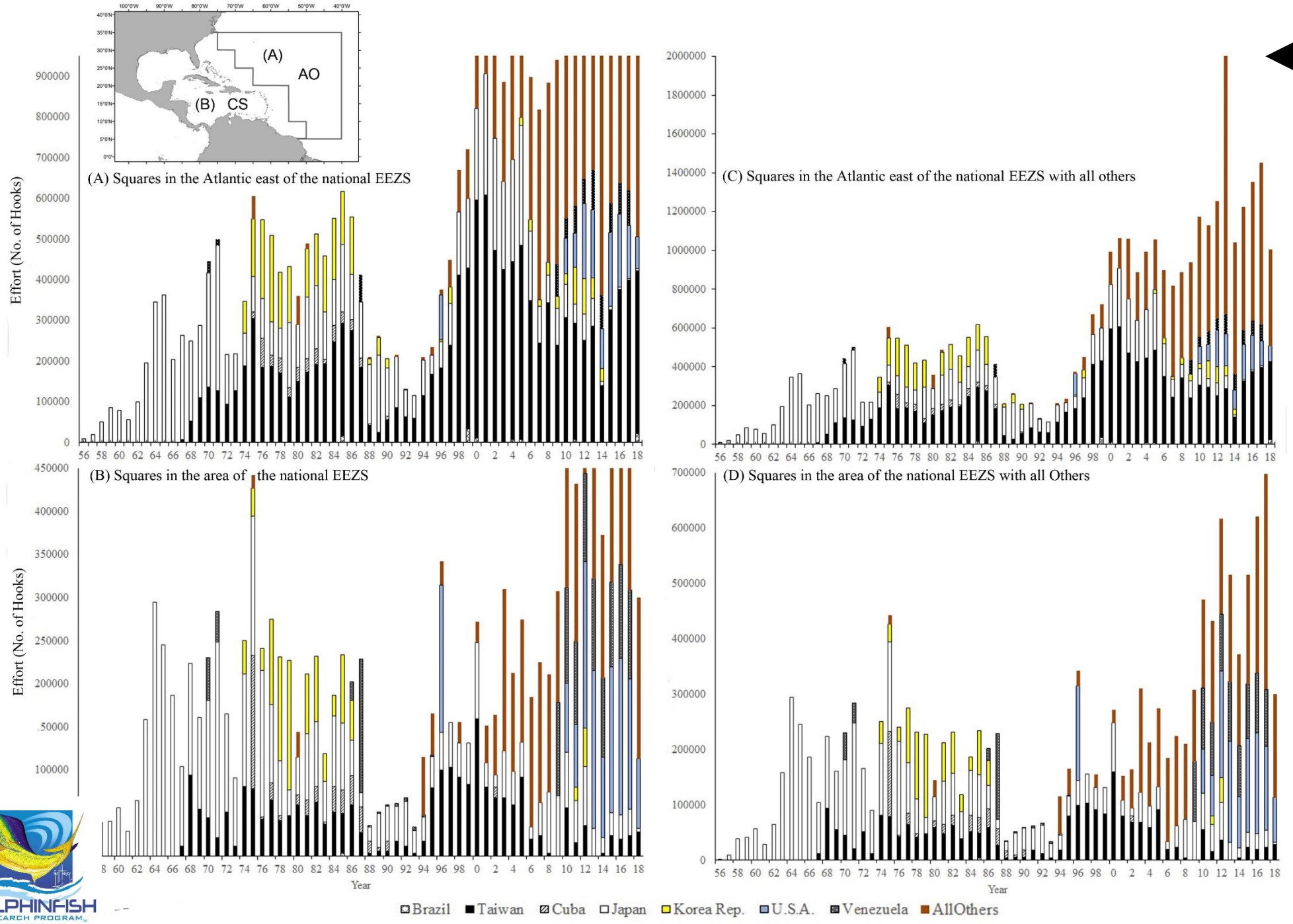


Reference:
Mahon, R. 1999. Dolphinfish Fisheries in the Caribbean Region. Scientia Marina, 63(3-4), 411-420.

Ongoing work – update Mahon's 1999 Analysis by extending out the time series Here – 1956 to 2018. *All Others (red) include those now reporting dolphin longline effort to the FAO since Mahon's analysis



Ongoing work – update Mahon's 1999 Analysis by extending out the time series Here – 1956 to 2018. *All Others include those now reporting dolphin longline effort to the FAO since Mahon's analysis.

Nearly 3x the number of hooks set nowadays than during Mahon's analysis in both the Atlantic east of national EEZS and within National EEZs

Less effort within National EEZs than outside – a trend noted by Mahon (1999)

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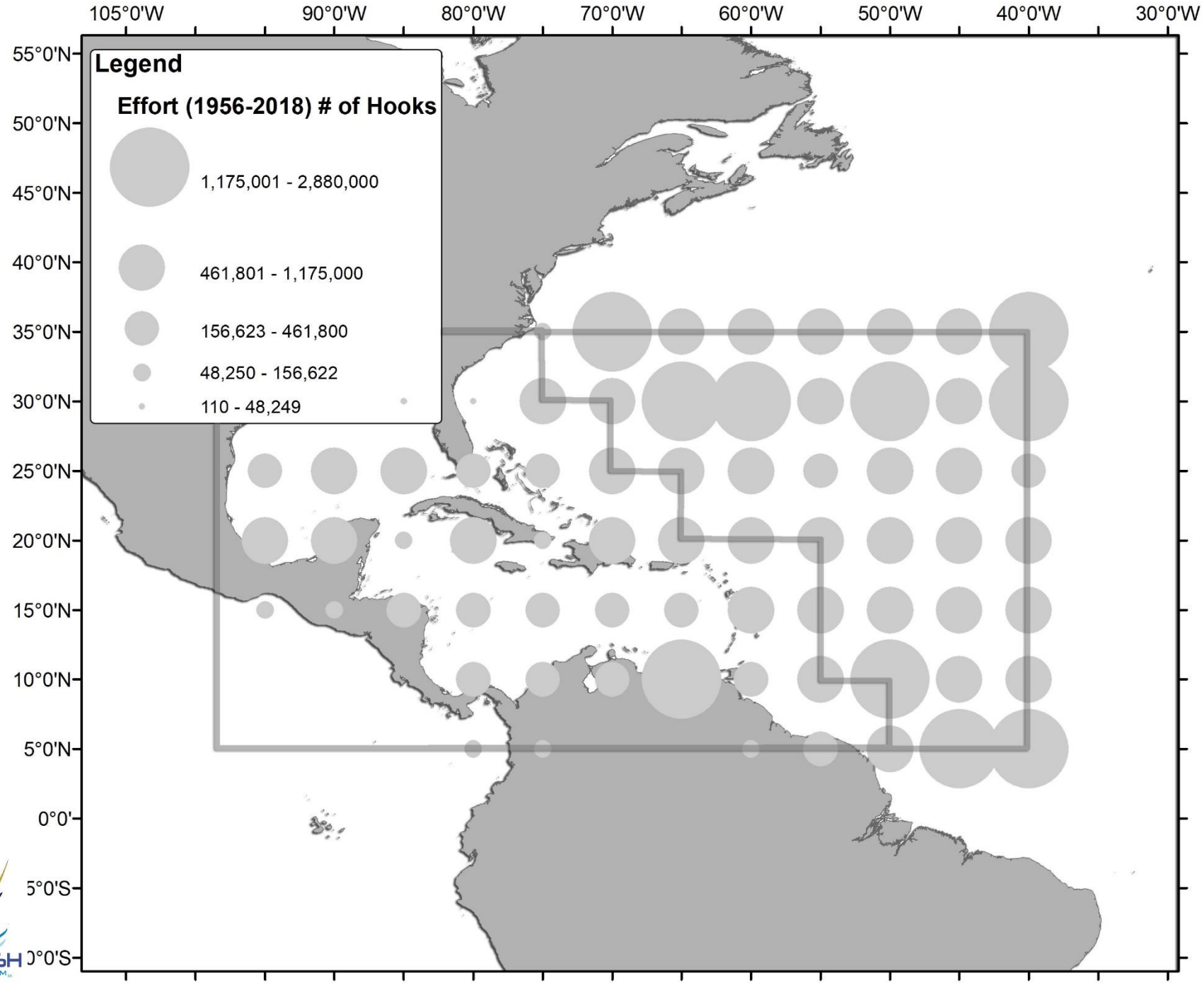

Ongoing work – update Mahon's 1999 Analysis by extending out the time series Here – 1956 to 2018 spatial distribution of LL effort. *This includes the major reporting countries and "All Others" now reporting longline effort to ICCAT since Mahon's analysis in the WECAFC area (bounding box).

West and south of Bermuda are among the main hotspots plus northeast of Suriname and Brazil – entering zone 41.

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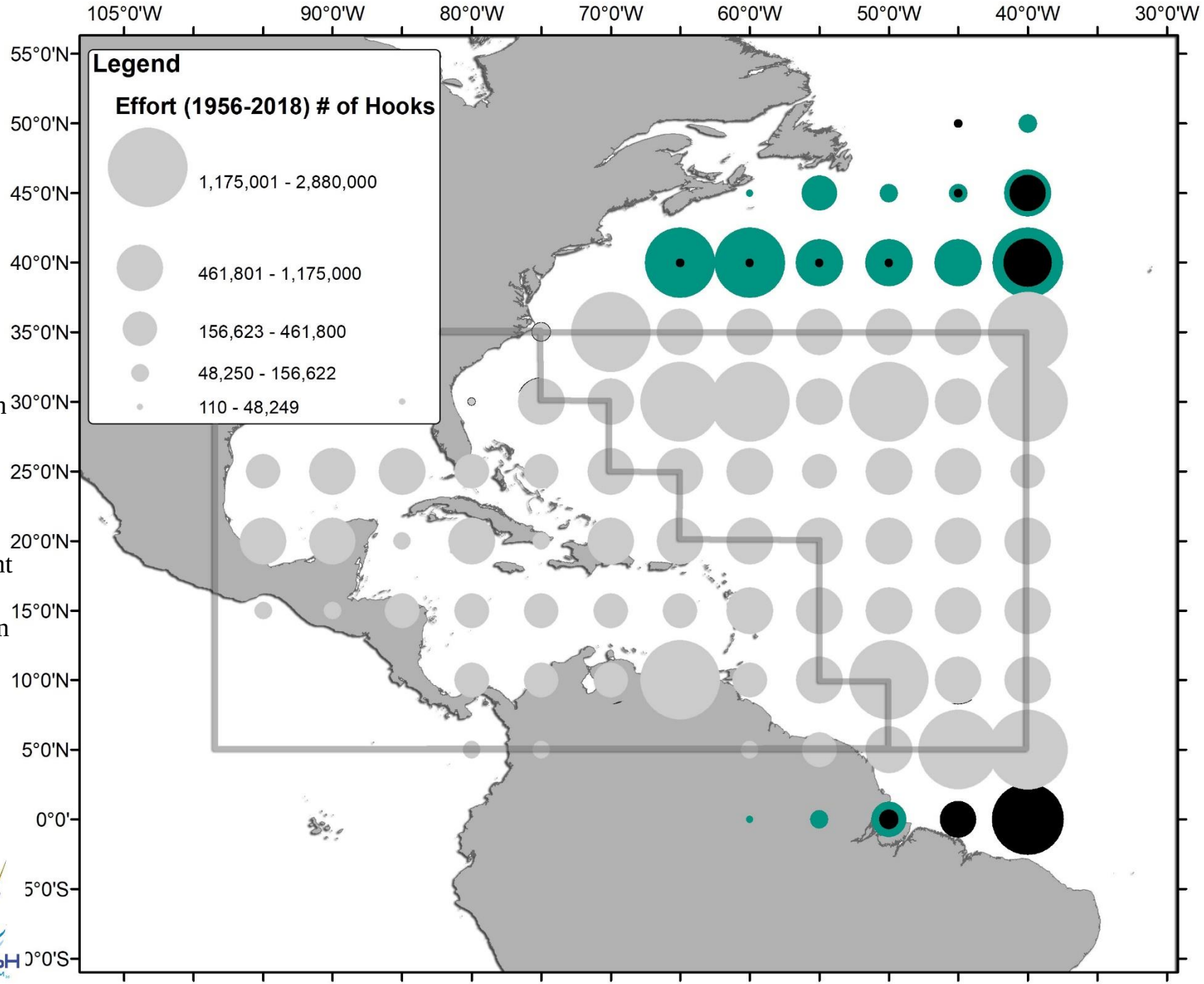
Note – We have received reports of dolphin being caught by Canadian longliners off Nova Scotia, bycatch that seldom happened in the past. Expanding this figure to include longline effort in the North Atlantic is relevant to the discussion of whether range expansion is occurring for dolphin in the WCA.



Ongoing work – update Mahon's 1999 Analysis by extending out the time series Here – 1956 to 2018 spatial distribution of LL effort. *This includes the major reporting countries and "All Others" now reporting longline effort to ICCAT since Mahon's analysis in the WECAFC area (bounding box) plus areas outside.

"All other" nations have more effort east of the MAB but top nations more active in north central Atlantic and off Brazil zone 41.

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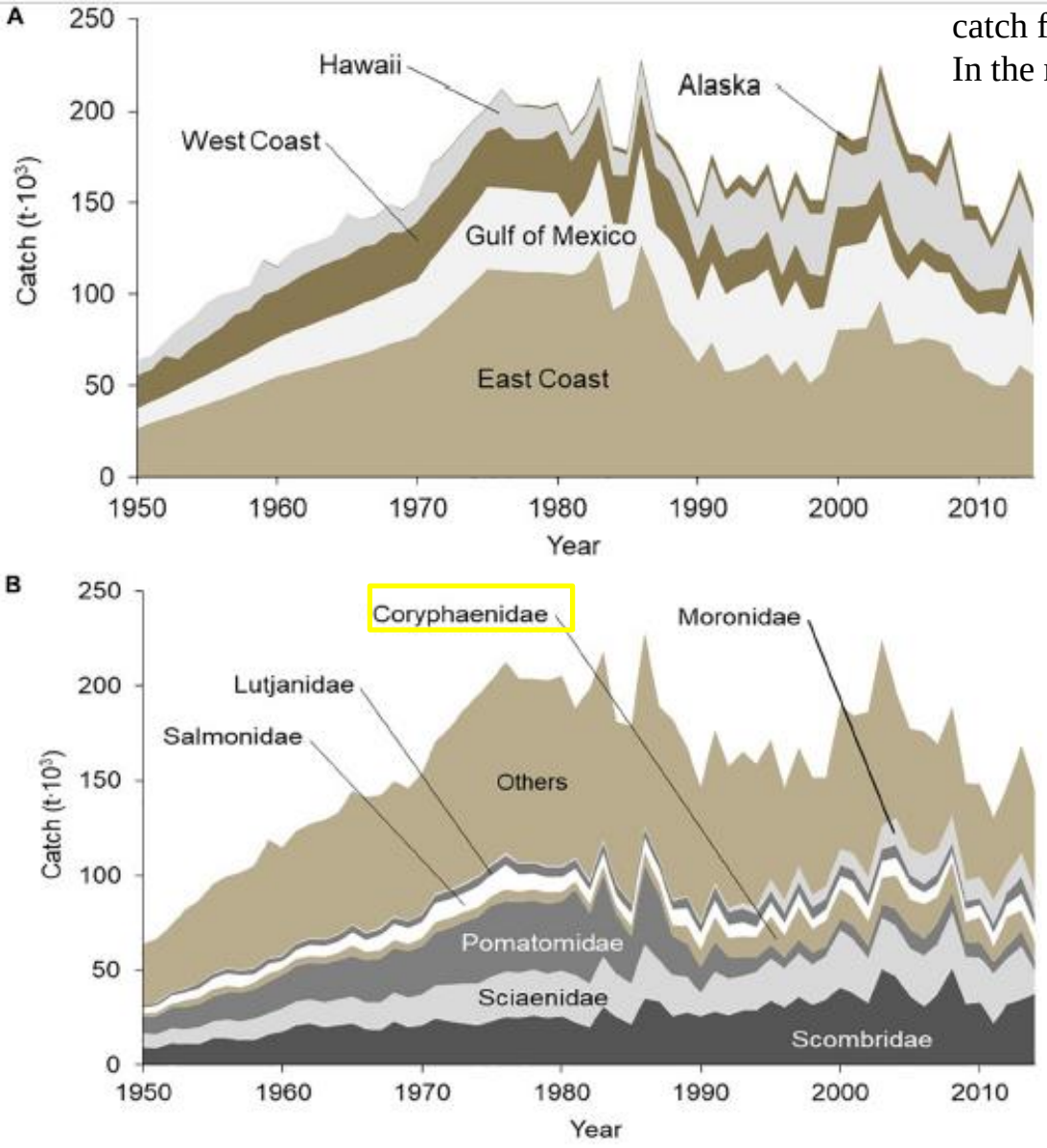
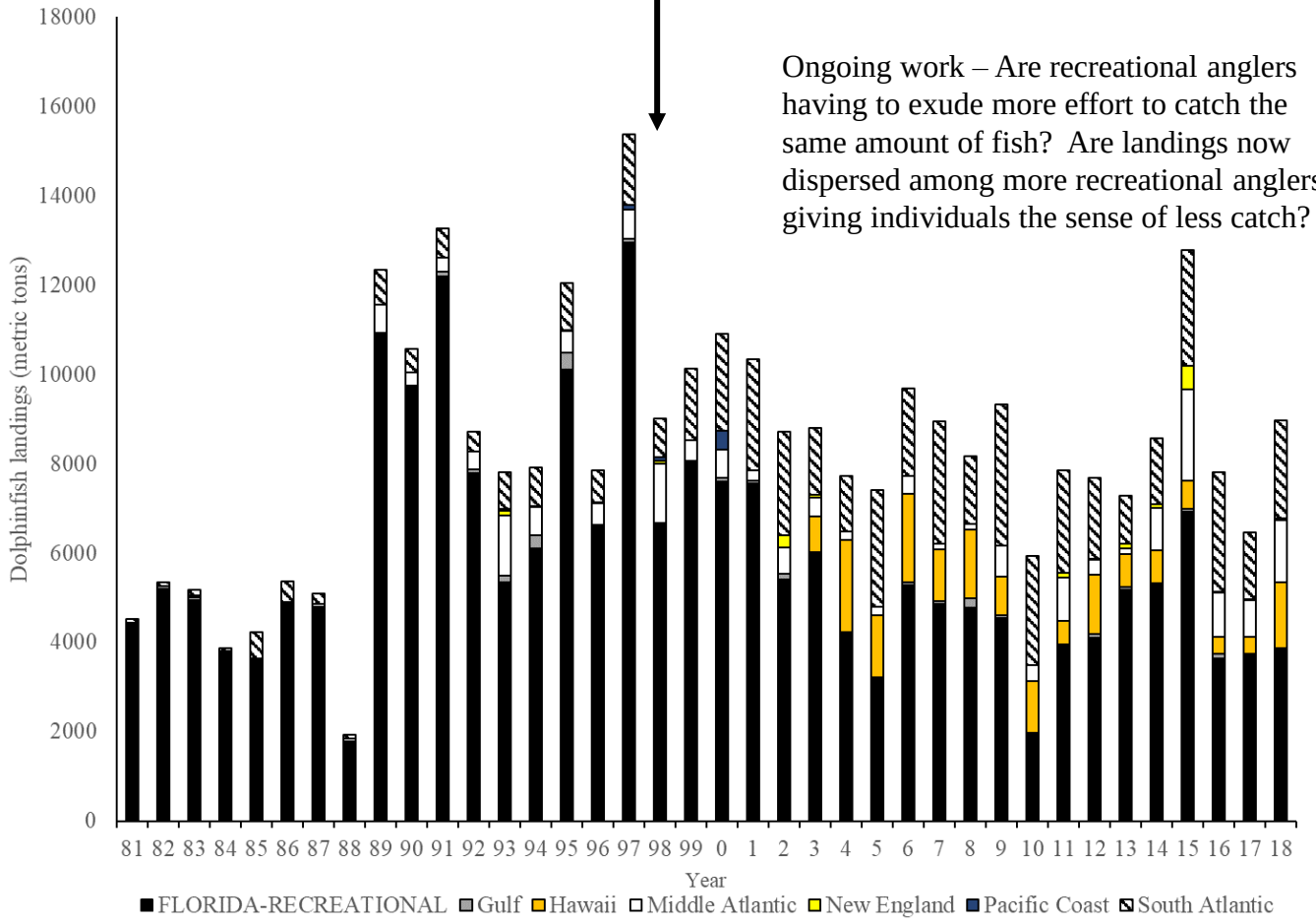
Freire KMF et al. (2020) Estimating Global Catches of Marine Recreational Fisheries.
Front. Mar. Sci. 7:12. doi: 10.3389/fmars.2020.00012

Freire et al. (2020) note an increase in global recreational catch for dolphin beginning In the mid-1990s.



U.S. recreational dolphin landings in metric tons from NOAA (https://foss.nmfs.noaa.gov/) from 1981 to 2018 by region plus "Florida Rec" as a standalone region.

Ongoing work – Are recreational anglers having to exude more effort to catch the same amount of fish? Are landings now dispersed among more recreational anglers giving individuals the sense of less catch?



Recreational average annual in metric tons = 8262.64; Max: 15,367.35
Commercial average annual in metric tons = 52.90; Max: 1006.9

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Vertical Movements

6 adult males: 3 Florida, 2 South Carolina, 1 Puerto Rico

97.5-120 cm FL

23,166 depth fixes

1,869 dives

83.37 days or 2,000.88 hours

Maximum depth: 255.5 m

Mean depth range: 2.7 – 35.0 m

Temperature Range °C: 16-30°C

Average Temperature Range °C: 24.65-28.44°C

Mar Biol (2014) 161:1823–1834
DOI 10.1007/s00227-014-2464-0

ORIGINAL PAPER

Diel vertical movements of adult male dolphinfish (*Coryphaena hippurus*) in the western central Atlantic as determined by use of pop-up satellite archival transmitters

Wessley Merten · Richard Appeldoorn · Roberto Rivera · Donald Hammond

Received: 4 February 2014 / Accepted: 14 May 2014 / Published online: 7 June 2014

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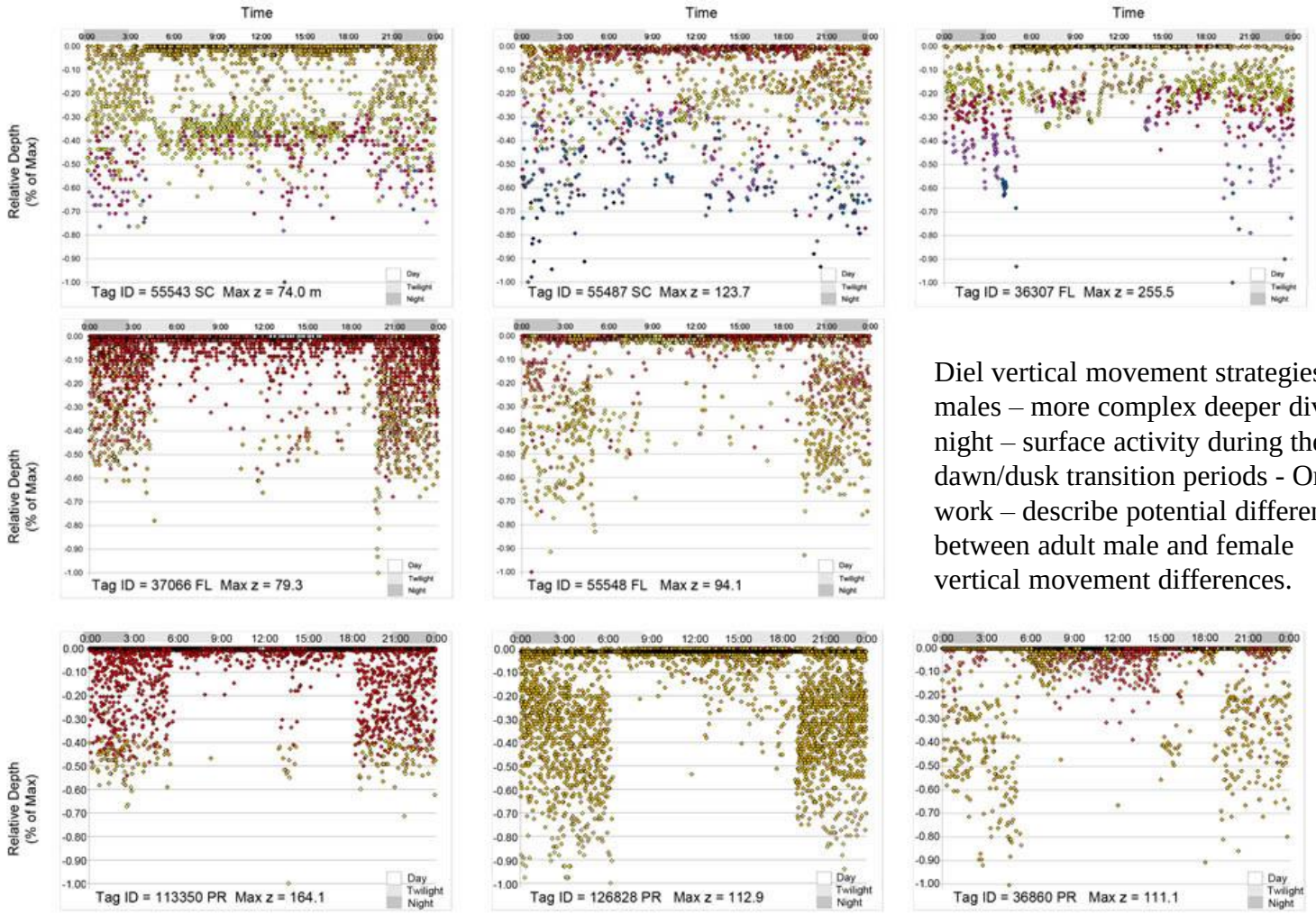
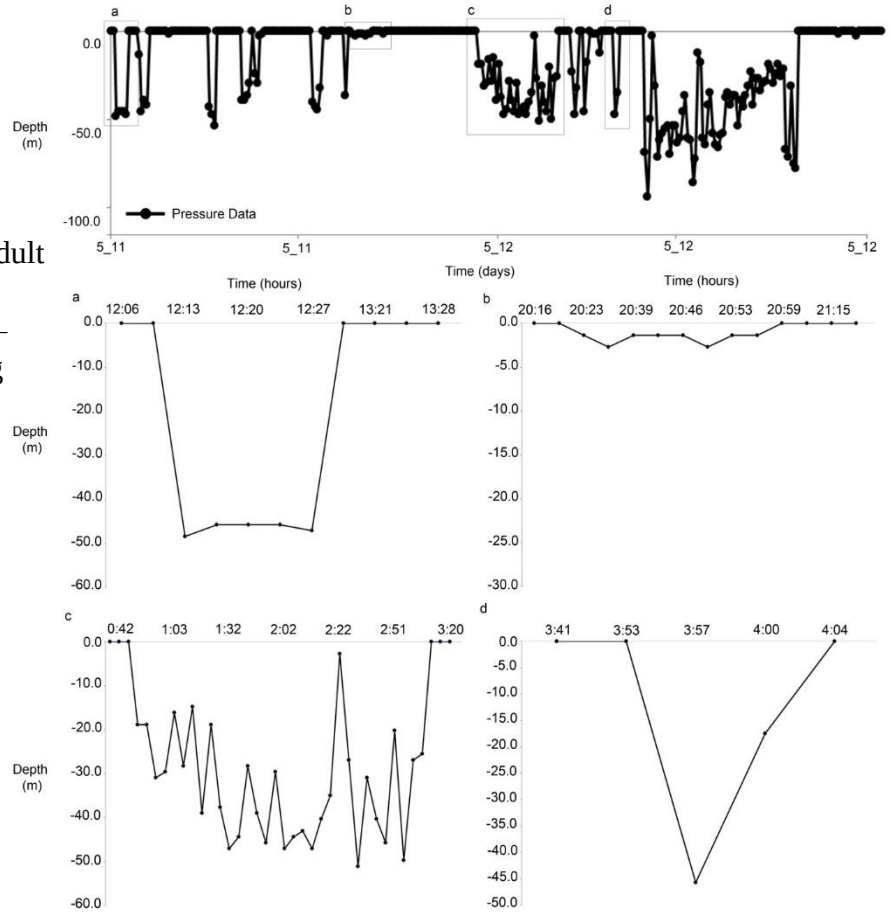
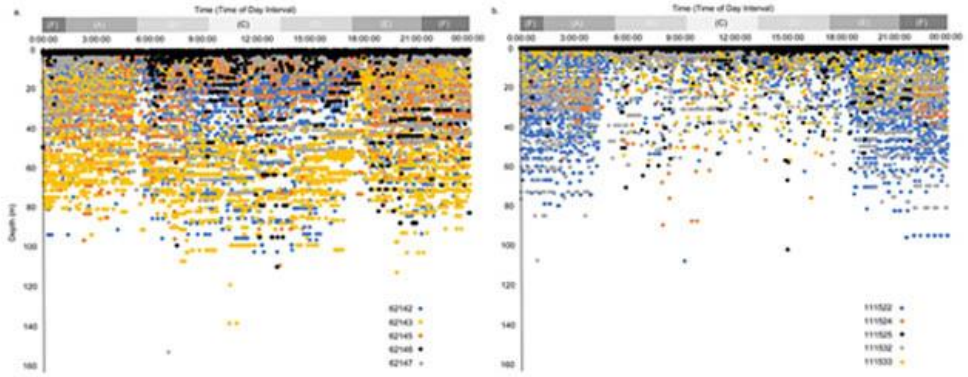
Vertical Dive Patterns



Diel vertical movement strategies for adult males – more complex deeper dives at night – surface activity during the day – dawn/dusk transition periods - Ongoing work – describe potential differences between adult male and female vertical movement differences.





Since our 2014 paper, we have acquired 16 additional high-rate vertical movement time series for dolphin along the U.S. east coast, U.S. Caribbean Sea, and in the ETP off Panama and Baja California (the latter in collaboration with Monterey Bay Aq.) – ongoing work – describe regional vertical movement differences/similarities

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Growth

Ongoing work – Describe growth potential as observed through tagging data for long-term recaptures. Compare these growth rates to those observed from studies of dolphin growth using scales and otoliths.

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Wess Mercer

Caribbean Sea Recaptures

Days Liberty	Release Size (FL in mm)	Recapture Size (FL in mm)	Growth Rate (mm/d)	Recapture Location
230	560 e	1040 e	2.09	Antigua, West indies
231	480 e	1020 e	2.34	La Parguera, Puerto Rico
246	510 m	1220 m	2.89	La Parguera, Puerto Rico
256	640 e	970 e	1.29	St. Barthelemy - F.W.I.
263	610 e	1270 e	2.51	Choroni, Venezuala
330	610 m	1040 e	1.30	Majahaul, Mexico
341	460 m	1070 m	1.79	Bassaterre, St. Kitts
557	640 e	1250 e	1.10	La Parguera, Puerto Rico
	e-estimated m-measured	e-estimated m-measured		

Western and Central North Atlantic Recaptures

Days Liberty	Release Size (FL in mm)	Recapture Size (FL in mm)	Growth Rate (mm/d)	Recapture Location
45	460 m	530 m	1.56	Freeport, BA
159	460 e	900 m	2.77	Bahia de Baracoa, Cuba
192	460 e	710 e	1.30	Puerto Plata, D.R.
223	480 e	1070 e	2.65	N. Exuma Sound, BA
229	530 m	1150 m	2.71	Santa Cruz Del Norte, Cuba
241	640 m	1200 m	2.32	534 miles SW of Azores
252	410 m	1250 m	3.33	Bahia De Gibara, Cuba
309	510 m	1350 m	2.72	Rum Cay, BA
318	430 m	990 m	1.76	Long Island, BA
	e-estimated m-measured	e-estimated m-measured		

Captured Dolphinfish Growth Rates				
Data Source	Growth Rate (mm/d)	No. of Fish	Location	Aging Method
This study	**2.14 FL**	**17**	**Transient WCA and Caribbean Sea**	**Tagging Data**
Beardsley (1967)	1.99 FL	121	Florida Current	Scale annuli
Rose and Hassler (1968)	1.56 FL	593	North Carolina	Scale annuli
Oxenford and Hunte (1983)	1.43 SL	25	Barbados	Daily otolith checks
Oxenford and Hunte (1983)	1.53 SL	1084	Barbados	Daily otolith checks
Oxenford and Hunte (1983)	4.71 SL	50	Barbados	Daily otolith checks
Murray (1985)	1.78 FL	2953	St. Lucia	Progression in size frequency
Bentivoglio (1988)	0.49 SL	19	Gulf of Mexico	Daily otolith checks
Bentivoglio (1988)	3.88 SL	81	Gulf of Mexico	Daily otolith checks
Uchiyama et al. (1986)	3.19 SL	11	Hawaii	Daily otolith checks
Rivera Betancourt (1994)	2.52 FL	121	Puerto Rico	Daily otolith checks
Rivera and Appeldoorn (2000)	3.31 SL	121	Puerto Rico	Daily otolith checks
Schwenke and Buckel (2007)	3.78 FL	107	North Carolina	Daily otolith checks

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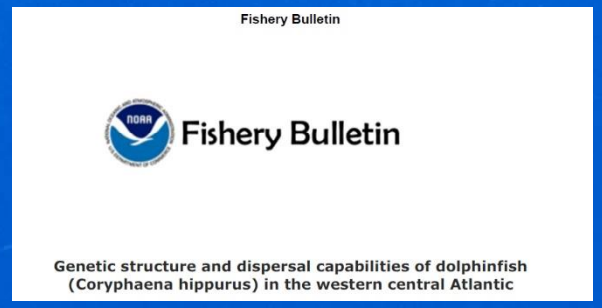
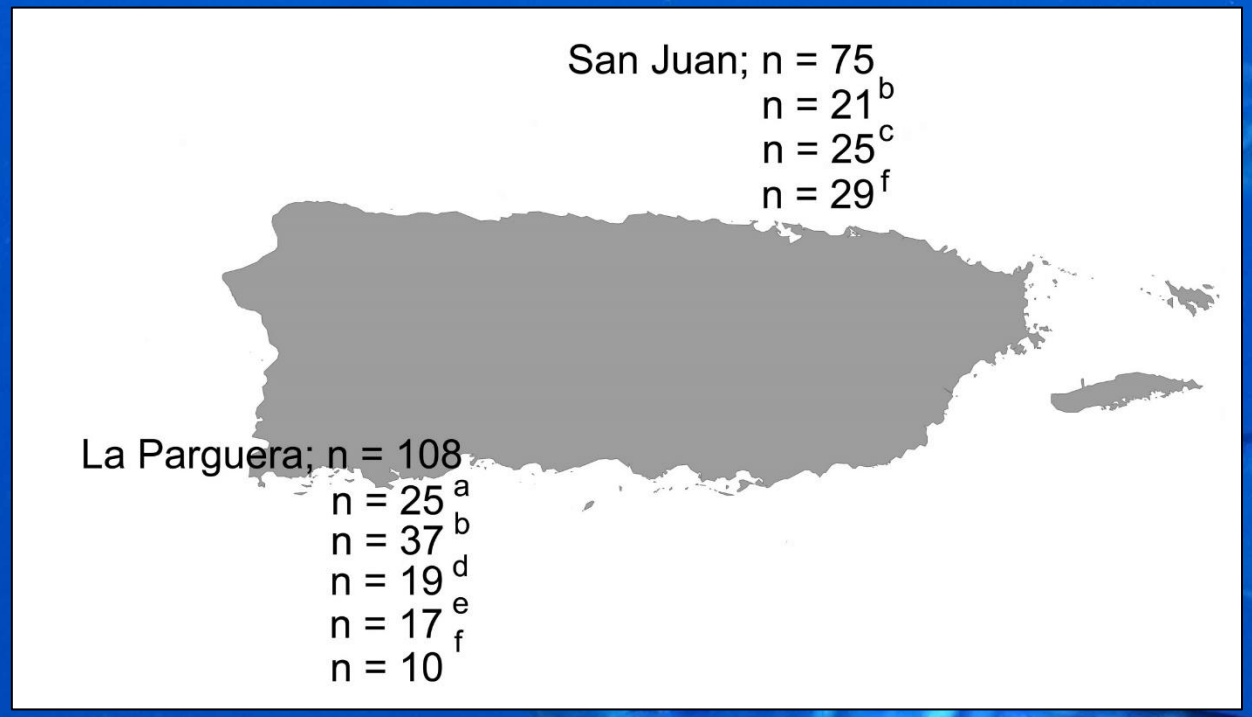
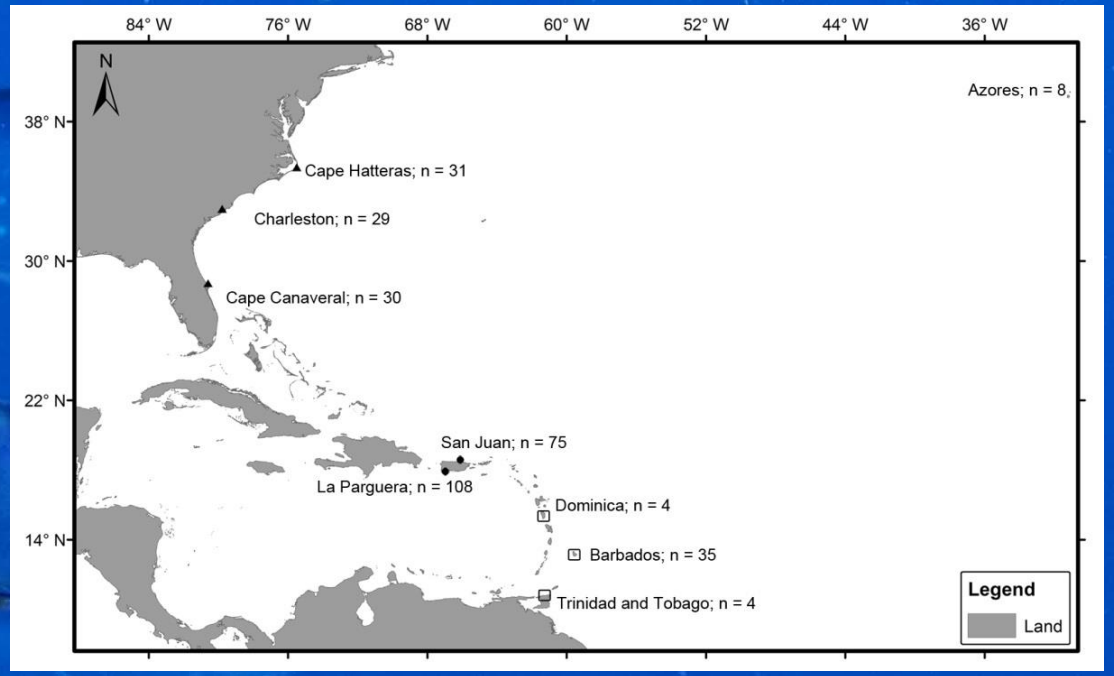


Population Structure

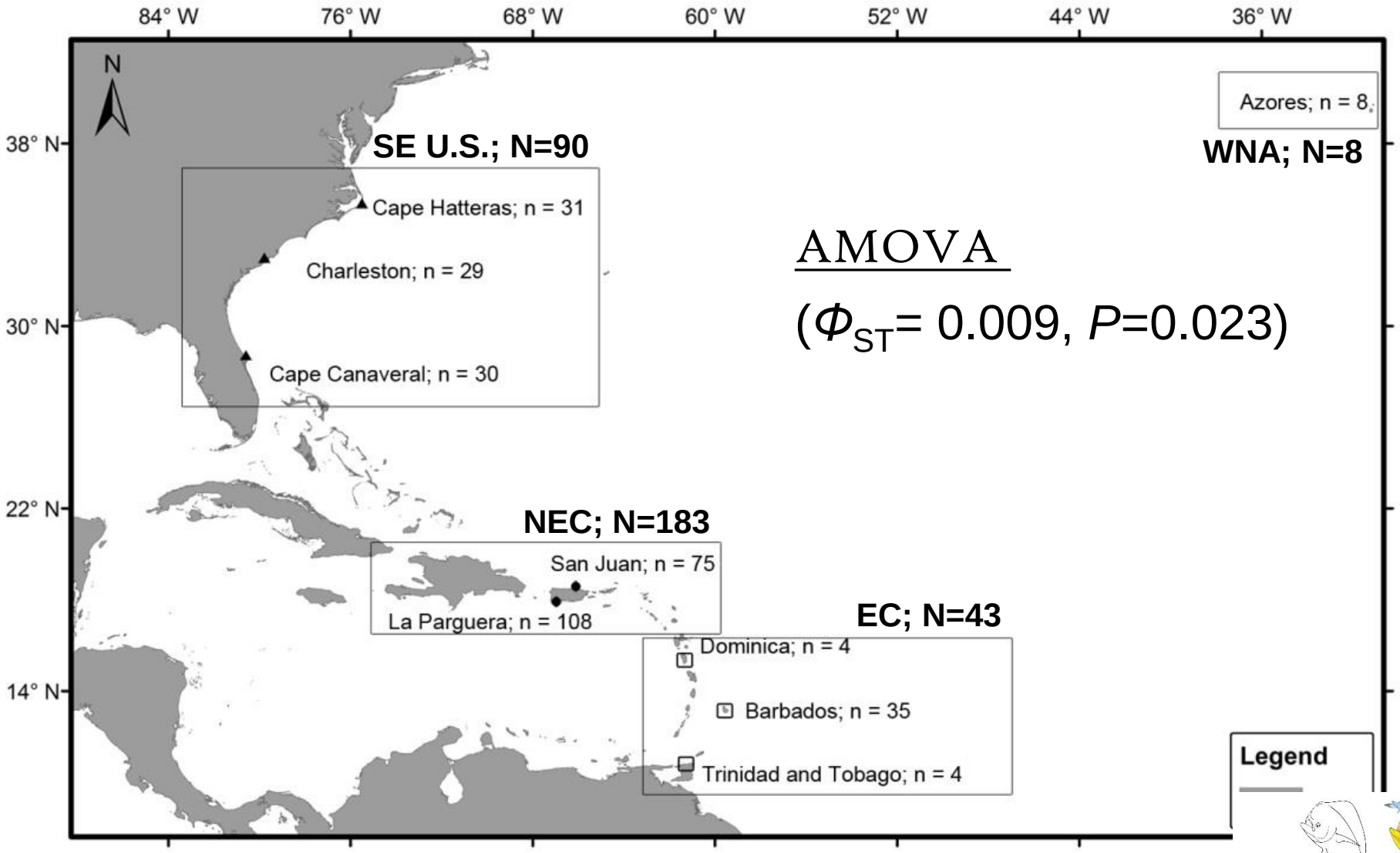
Ancedotal reports and landings data around Puerto Rico showed the timing and arrival of dolphin off the north coast of Puerto Rico differed from off the south coast. A long standing question in Puerto Rico was whether these pulses of fish represented different dolphin stocks. This set off an analysis of 324 samples collected around the WCA with an emphasis between San Juan and La Parguera, PR, with samples collected over a four-year period around the island and on consecutive days between coasts in those years.





Western Central Atlantic:

In a comparison of 183 specimens of dolphinfish between the north and south coasts of Puerto Rico no genetic differentiation was detected (ΦST= −0.002, *P*=0.640). On a broader scale, patterns of genetic variation of ND1 were compared for samples collected throughout the western central Atlantic identified 199 haplotypes from all of the regions combined. Analysis of all samples revealed shallow genetic structure (ΦST=0.009, *P*=0.023), but pairwise regional comparisons did not, indicating low population differentiation of dolphinfish throughout the western central Atlantic.



AMOVA

(Φ_{ST}= 0.009, *P*=0.023)

Take Home – Genetically, the WCA population is the same stock, but there could be different fishery stocks based on differences in regional movements by season and year and which nations target those fish.

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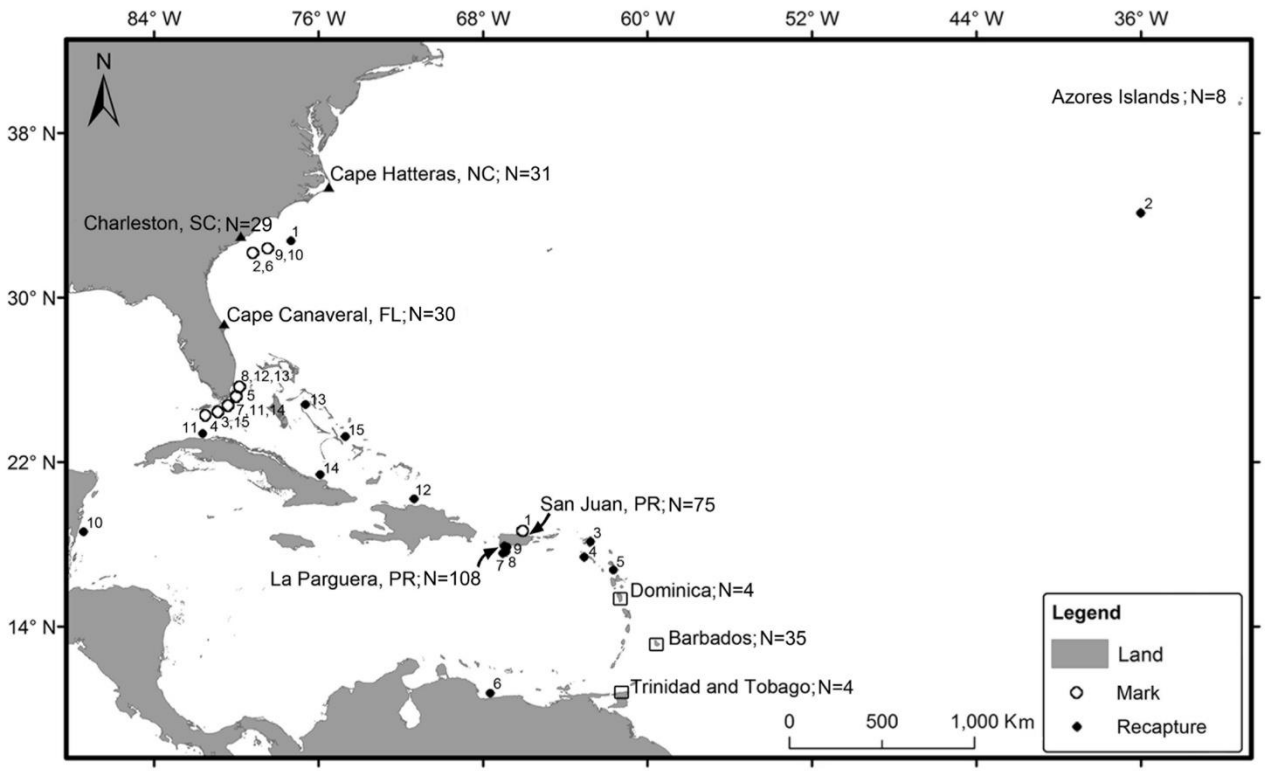

Figure 1

Tissue sample distribution and conventional tagging movements of dolphinfish (*Coryphaena hippurus*) in the western central and central North Atlantic. Tissue samples were taken from fish collected at different landing sites in each of the 3 regions in the western central Atlantic, including the southeastern United States in 2012 (triangles), northeastern Caribbean Sea during 2010–2013 (arrows), and eastern Caribbean Sea (open squares) during 1998 and 2014; samples from fish collected in the central North Atlantic (Azores Islands) were taken in 1998. The numbers adjacent to open circles (fish release locations) and closed circles (fish recapture locations) correspond to the tagging information in Table 4.

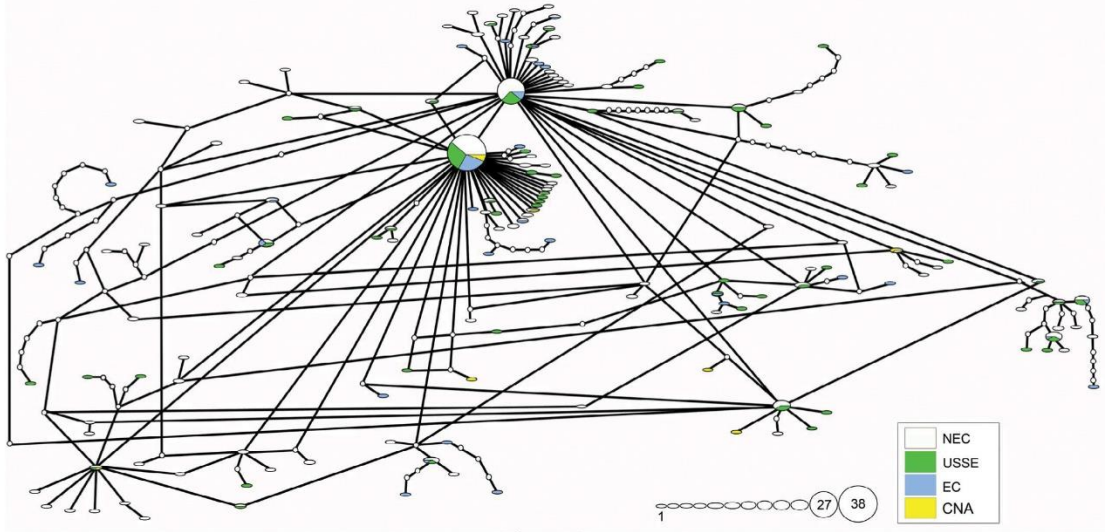

Figure 2

Statistical parsimony network for dolphinfish (*Coryphaena hippurus*) based on mitochondrial nicotinamide adenine dinucleotide (NADH) dehydrogenase subunit 1 (ND1) sequences. The size of circles is proportional to the number of shared haplotypes represented as pie charts. The small white circles on the connecting lines indicate the number of mutations among haplotypes and internal nodes. The color of a section in pie charts indicates a region: northeastern Caribbean Sea (NEC); southeastern United States (USSE); eastern Caribbean Sea (EC); central North Atlantic (CNA). The circles next to the legend indicate the proportionality of the number of haplotypes to the size of the circles (1–10, 27, and 38).

Statistical parsimony network showing no grouping of distinct haplotypes by region, an observation that would suggest greater genetic differences between sampling sites.

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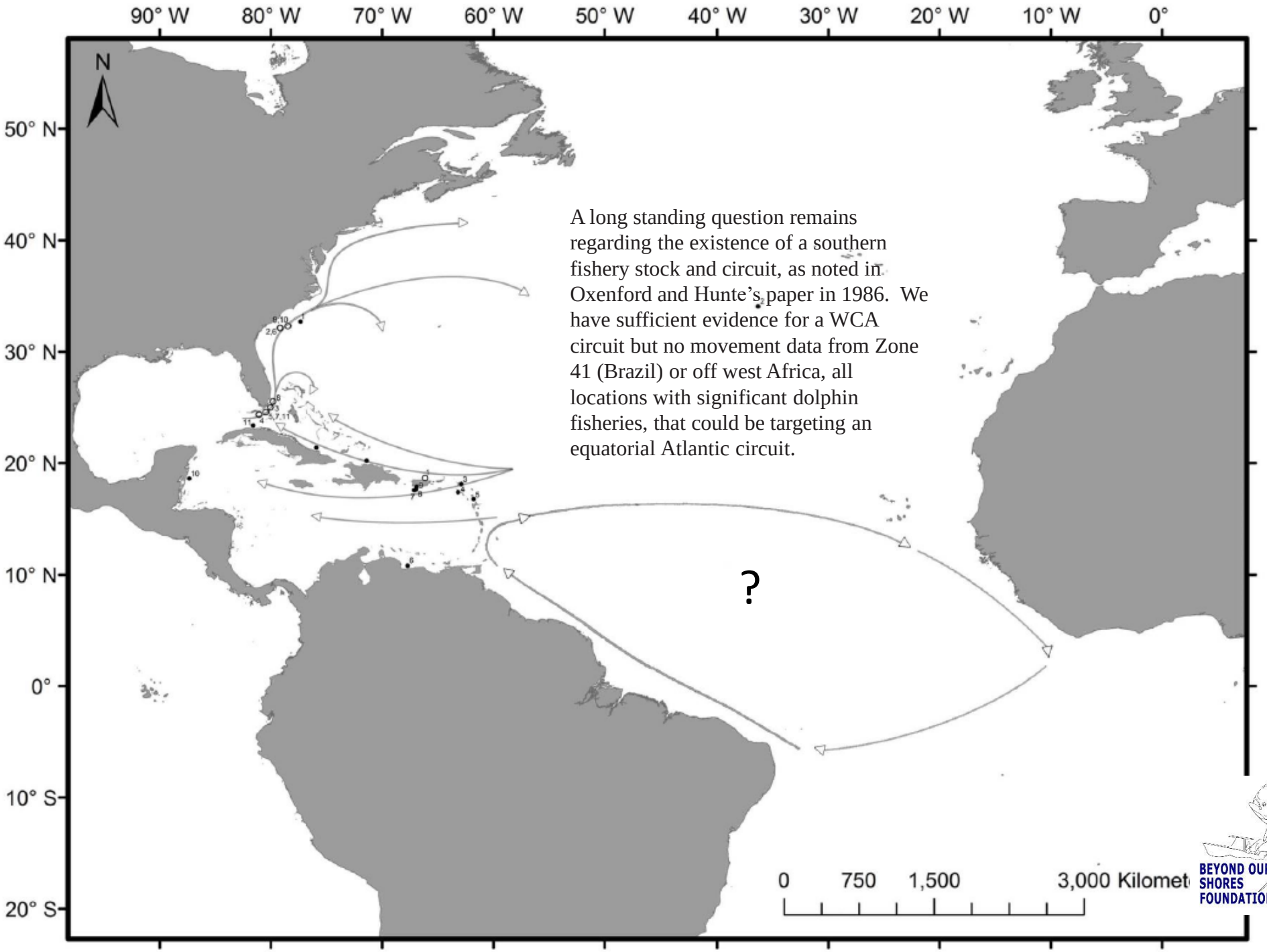

A long standing question remains regarding the existence of a southern fishery stock and circuit, as noted in Oxenford and Hunte's paper in 1986. We have sufficient evidence for a WCA circuit but no movement data from Zone 41 (Brazil) or off west Africa, all locations with significant dolphin fisheries, that could be targeting an equatorial Atlantic circuit.

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Conclusion: Issues Facing WCA Dolphin Stock

- Changing movement patterns (shortened seasons; size frequency changes; range expansion (WNA?) – Noted from anecdotal and quantitative data sources
- Magnitude of unknowns relative to movement ecology in/from the GOM and MAB
  - What proportion of the seasonal influx of dolphin enter the U.S. Atlantic fishery from the GOM, Caribbean, Bahamas, or Antilles Current?
  - How do fish in these regions connect with other U.S. regions or international locations?
- No population reference points
- 16 nations in the WCA not reporting dolphin commercial landings
- Unknown level of mis- or under-reporting for nations that do submit commercial landings
- Quality data on the recreational fishery yet increase in the global fishery (Freire et al. 2020)
  - Lack of estimates of recreational effort throughout WCA – Increase in effort to get same or less fish?
- Indirect harvest in purse seine and longline fisheries (Hall and Roman 2013; Lynch 2018)
  - Prevalence/Expansion of longlining around Bermuda, western North Atlantic, off Suriname and Brazil, Cuba, DR, VZ
- Lack of data on/at FADs in Caribbean Sea as it pertains to dolphin landings/effort
- Increasing demand in major seafood markets (MSA 2016)
- High discard mortality (Rudershausen et al. 2019) and lack of use of circle hooks by recreational anglers targeting dolphin
- Inconsistent regulations on same stock despite transient evidence
  - On average dolphin can move through the U.S. East Coast system in 35 days which represents 10% of an annual cycle. Focusing management and conservation on where fish spend 90% of their annual cycle needs to occur.
- Underappreciate of multinational distribution which fragments data collection and management
- Perception of resistance to overfishing

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The Salvation of Dolphinfish