Vessel Surveys and Visual Species Verifications at the Jacksonville Shallow Water Training Range: 2022 Annual Progress Report

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Cover Photo Credit:

Bottlenose dolphins (*Tursiops truncatus*). Photographed by Kate Sutherland (Duke University), taken under General Authorization Letter of Confirmation 19903 held by Andrew Read (Duke University).

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Acronyms and Abbreviations

π	nucleotide diversity
AFTT	Atlantic Fleet Training and Testing
AUTEC	Atlantic Undersea Test and Evaluation Center
BRS	Behavioral Response Study
CS-SVM	Class-Specific Support Vector Machine
DCL	detection, classification, and localization
JSWTR	Jacksonville Shallow Water Training Range
kb	kilobase
km	kilometer(s)
M3R	Marine Mammal Monitoring on Navy Ranges
OBIS-SEAMAP	Ocean Biodiversity Information System Spatial Ecological Analysis of Megavertebrate Populations
OPAREA	Operating Area
photo-ID	photo-identification
PMRF	Pacific Missile Range Facility
R/V	Research Vessel
SOAR	Southern California Tactical Training Range
U.S.	United States

1. Introduction

This report describes results from vessel surveys and visual species verifications conducted at the Jacksonville Shallow Water Training Range (JSWTR) in the Jacksonville Operating Area (OPAREA). This work continues from a multi-institutional monitoring program intended to provide information on the species composition, population identity, density, and baseline behavior of marine mammals and sea turtles present in United States (U.S.) Navy range complexes along the U.S. Atlantic Coast. This program began in 2007 with baseline aerial and vessel surveys as well as passive acoustic monitoring within Onslow Bay, North Carolina; it subsequently expanded to include study areas off the coast of Jacksonville, Florida, Cape Hatteras, North Carolina, and Virginia Beach, Virginia. In Onslow Bay, 6 years of monitoring yielded a comprehensive picture of the density, distribution, and abundance of marine mammals and sea turtles as well as provided new insights into residency patterns among pelagic delphinids within this region (Read et al. 2014). Dedicated survey effort within the Onslow Bay site concluded in 2013. More than 9 years of monitoring within the Jacksonville OPAREA have provided similar information on the density and distribution of marine mammals and sea turtles (Foley et al. 2019). Off the coast of Cape Hatteras and Virginia Beach, more than a decade of surveys and passive acoustic monitoring have also provided information on the complex distribution patterns as well as the marine mammal and sea turtle diversity within this highly productive area.

Although the original standardized line transect visual surveys and archival passive acoustic monitoring have been discontinued in the Atlantic Fleet Training and Testing (AFTT) OPAREAs, that foundational work has provided a robust baseline for several ongoing tagging and behavioral response projects (see Atlantic Behavioral Response Study, Mid-Atlantic Offshore Cetacean Monitoring, and Mid-Atlantic Nearshore & Mid-shelf Baleen Whale Monitoring). The Jacksonville Shallow Water Training Range was installed in 2018, and a dedicated passive acoustic marine mammal monitoring system (Marine Mammal Monitoring on Navy Ranges [M3R]) was integrated in 2019. Small vessel surveys were resumed on JSWTR in 2020 to support development and calibration of detection and classification algorithms for the M3R system through visual species verifications. This report describes vessel monitoring activities, including photo-identification (photo-ID), satellite tagging, biopsy sampling, and visual species verifications at the Jacksonville study area in 2022.

2. Methods

2.1 Study Area

The study area within the Jacksonville OPAREA is 5,786 square kilometers (km^2), surrounding the JSWTR, which is approximately 1,700 km^2 in area. The study area straddles the continental shelf break, including some of the Blake Plateau, and includes both shelf and pelagic waters (**Figure 1**).

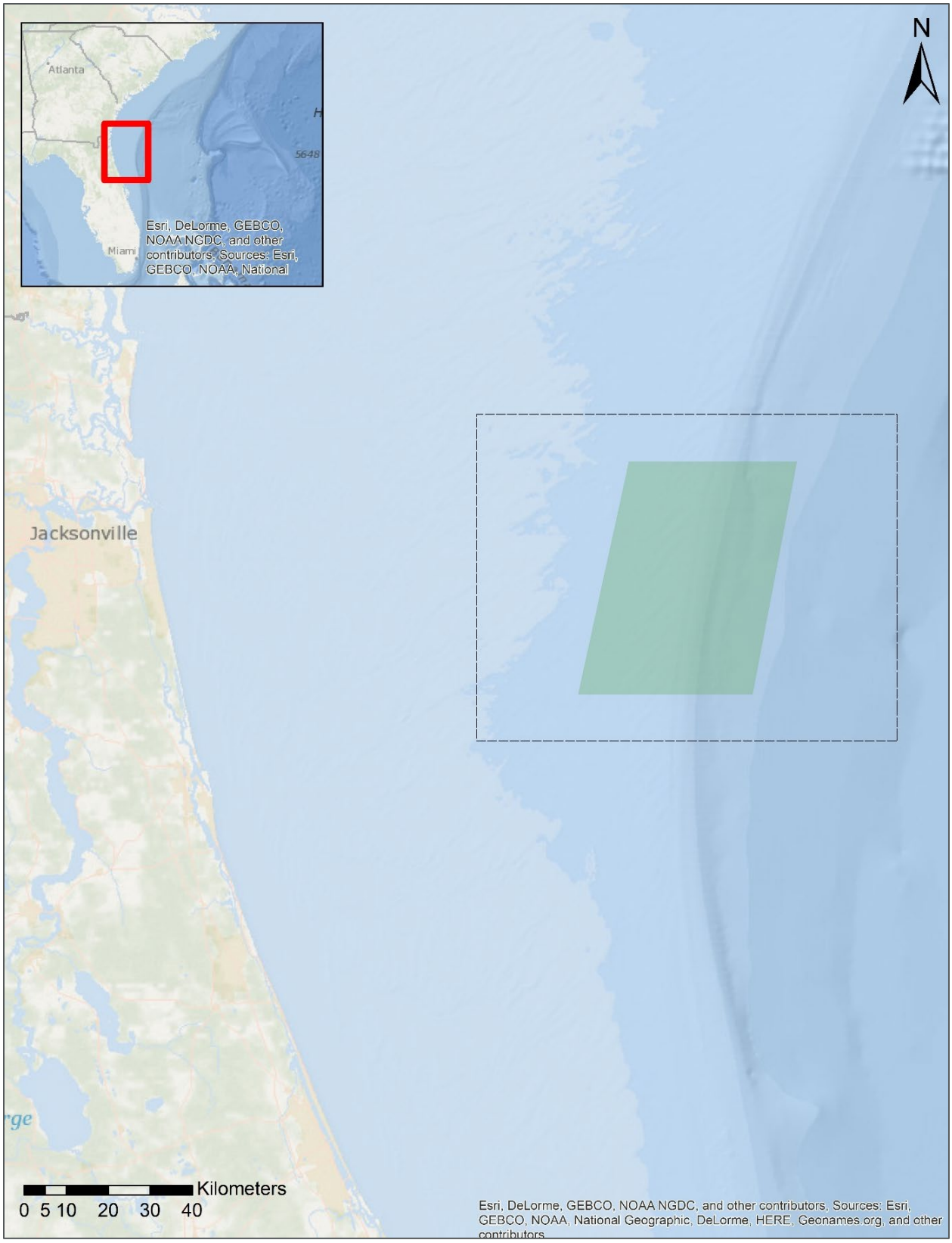

Figure 1. Map of the Jacksonville study area (dashed outline) and the JSWTR site (shaded box).

2.2 Data Collection

In May and December 2022, we employed visual survey methods to support species verification trials in conjunction with the M3R system in coordination with the Naval Undersea Warfare Center, Division Newport (see **Section 5**). We conducted surveys from Research Vessel (R/V) *Richard T. Barber* (May) (**Figure 2)** and R/V *Shearwater* (December) (**Figure 3**). The installation of hydrophones on the southern portion of the range was completed in November 2022; therefore, we focused our efforts within this region during the December 2022 surveys. When the M3R team relayed a possible cetacean location (see Jarvis et al. 2014 for M3R methods), the research vessel transited to the provided location coordinates, and two observers (one port and one starboard) scanned continuously from straight ahead to 90 degrees abeam either side of the trackline. We recorded the location, species, and behavior of every cetacean group observed as well as the location and species identity of all sea turtles. We collected environmental conditions (weather conditions, Beaufort sea state, depth, and sea-surface temperature) at each sighting and whenever survey conditions changed. Sighting and environmental data were logged on an iPad tablet linked to a Global Positioning System unit.

We examined use of the survey area by individual cetaceans using photo-ID and collected biopsy samples for analysis of population structure. We obtained digital photographs to confirm species identification at each sighting. Photographs were taken with Canon or Nikon digital single-lens reflex cameras (equipped with 100- to 400-millimeter zoom lenses) in 24-bit color at a resolution of 6,016 × 4,016 pixels and saved in .jpg format. We used remote biopsy-sampling methods to collect small skin and blubber samples using a variety of 27- to 68-kilogram pull crossbows, depending on the species and sampling distance. Biopsy samples were collected with a specialized 2.5-centimeter stainless-steel biopsy tip attached to a modified bolt, typically fired from the survey vessel's bow.

Figure 2. The R/V *Richard T. Barber*.

Figure 3. The R/V *Shearwater*.

2.3 Data Analysis

Vessel survey effort and sighting data were mapped using ArcGIS Pro 3.02 (Esri, Redlands, California). All sighting data collected will be posted on the data archive Ocean Biodiversity Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP).

2.4 Data Storage

All acoustic, visual survey, and photographic data have been archived on digital media, and backed up on a Duke University network server.

3. Results

3.1 Vessel Survey Effort

We conducted 6 days of vessel surveys within the Jacksonville study area and 1 day of opportunistic survey during transits from and to Beaufort, North Carolina, in 2022, totaling 478 kilometers, or 78.25 hours, of survey effort (**Table 1**). These surveys were conducted in Beaufort sea state 1 to 6 and covered the JSWTR site (**Figure 4** and **Figure 5**), as well as shelf and pelagic waters between Florida and North Carolina (**Figure 6**).

Table 1. Dates, distances, and durations surveyed during vessel surveys within the Jacksonville survey area in 2022.

Date	Beaufort Sea State	Distance Surveyed (kilometers)	Survey Time (hours:minutes)	At-Sea Time (hours:minutes)	Platform
14-May-22	1–2	69	6:31	10:58	R/V *R.T. Barber*
15-May-22	2	54.7	6:22	12:00	R/V *R.T. Barber*
16-May-22	4	25	3:13	7:54	R/V *R.T. Barber*
18-May-22	3	74	6:29	11:11	R/V *R.T. Barber*
11-Dec-22	3–4	0	—	5:23	R/V *Shearwater*
12-Dec-22	3–4	101.1	9:15	24:00	R/V *Shearwater*
13-Dec-22	4–5	82	9:44	24:00	R/V *Shearwater*
14-Dec-22	4–5	72.2	9:35	24:00	R/V *Shearwater*
15-Dec-22	5–6	0	—	23:50	R/V *Shearwater*

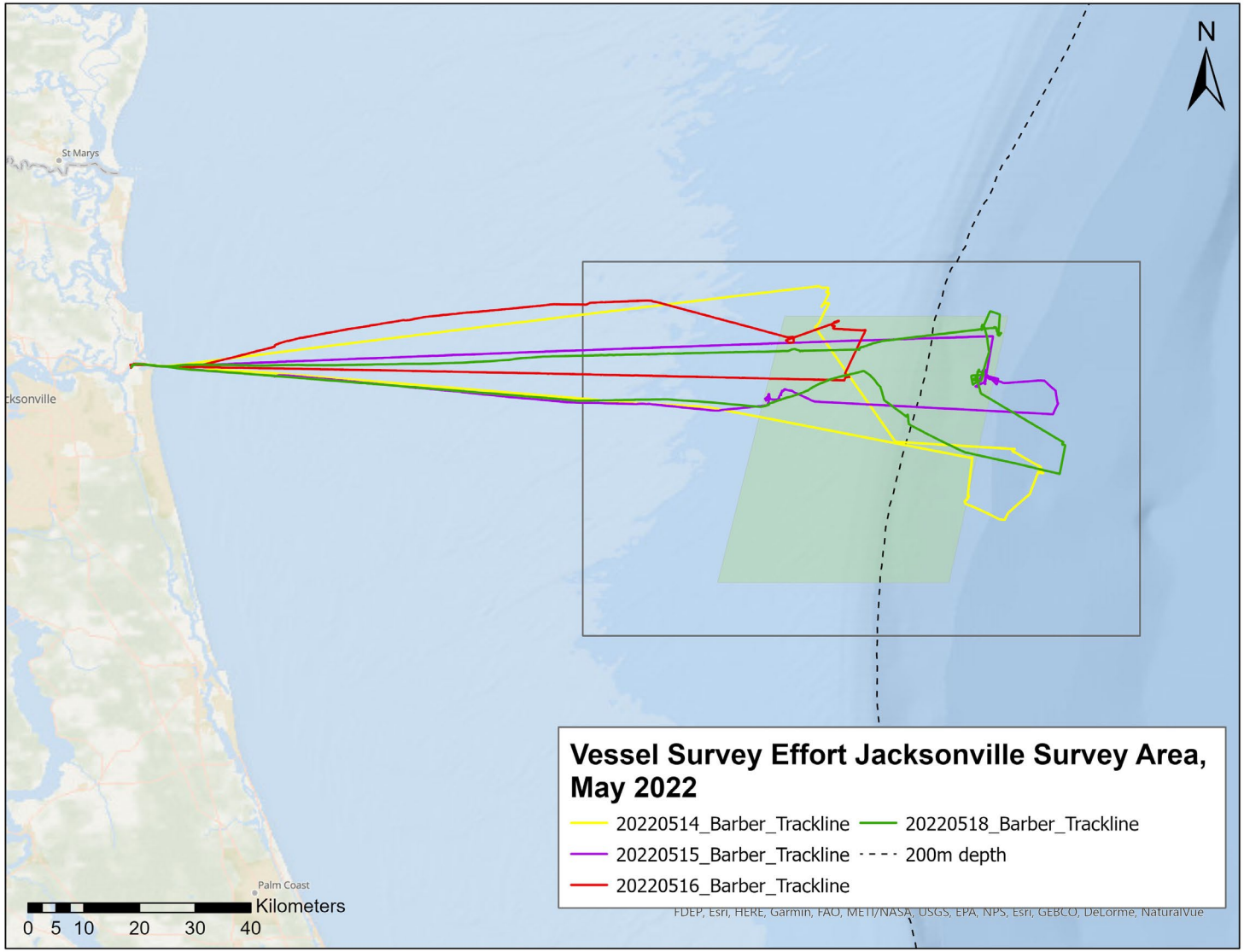

Figure 4. Effort during vessel surveys in the Jacksonville survey area in May 2022.

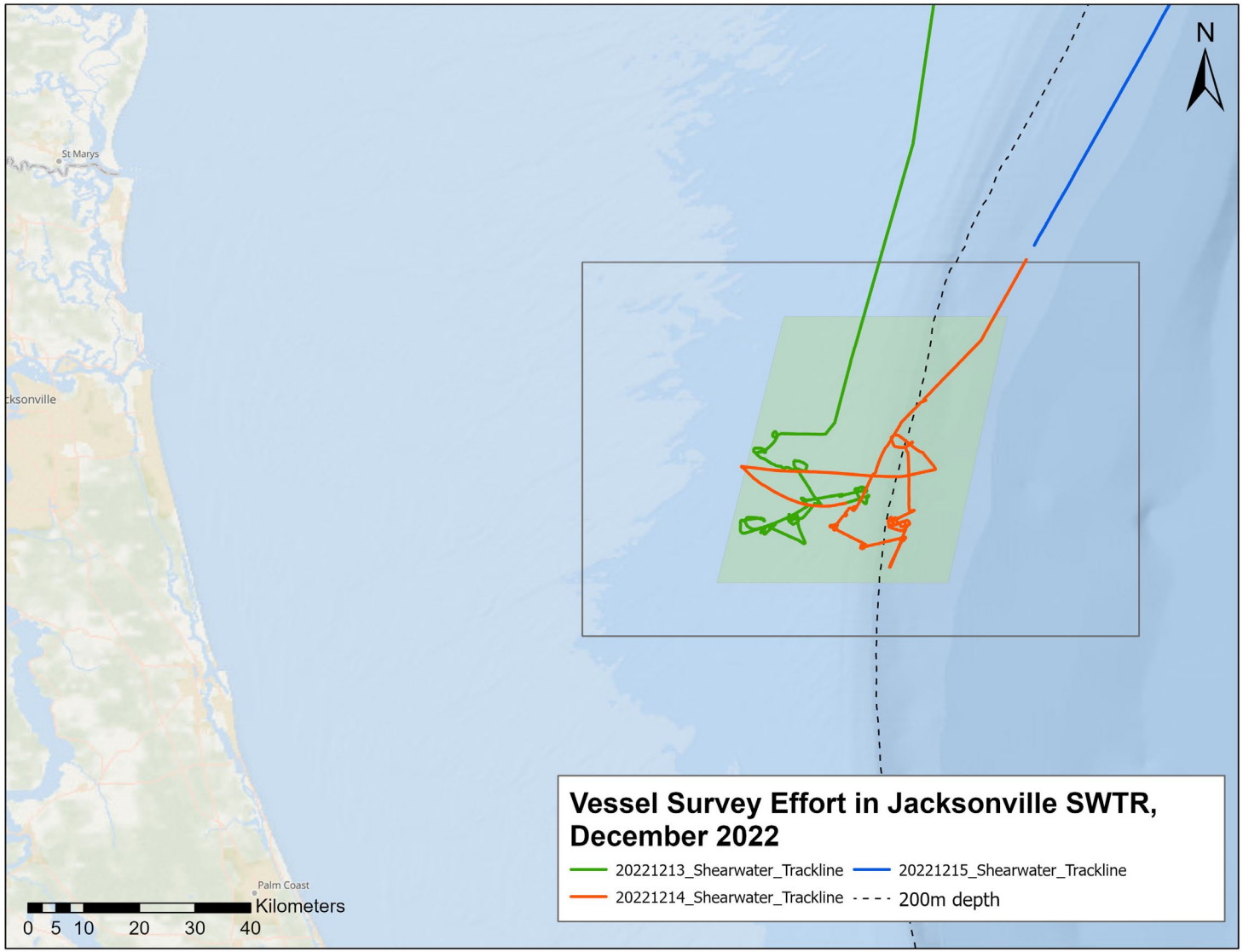

Figure 5. Effort during vessel surveys in the Jacksonville survey area in December 2022.

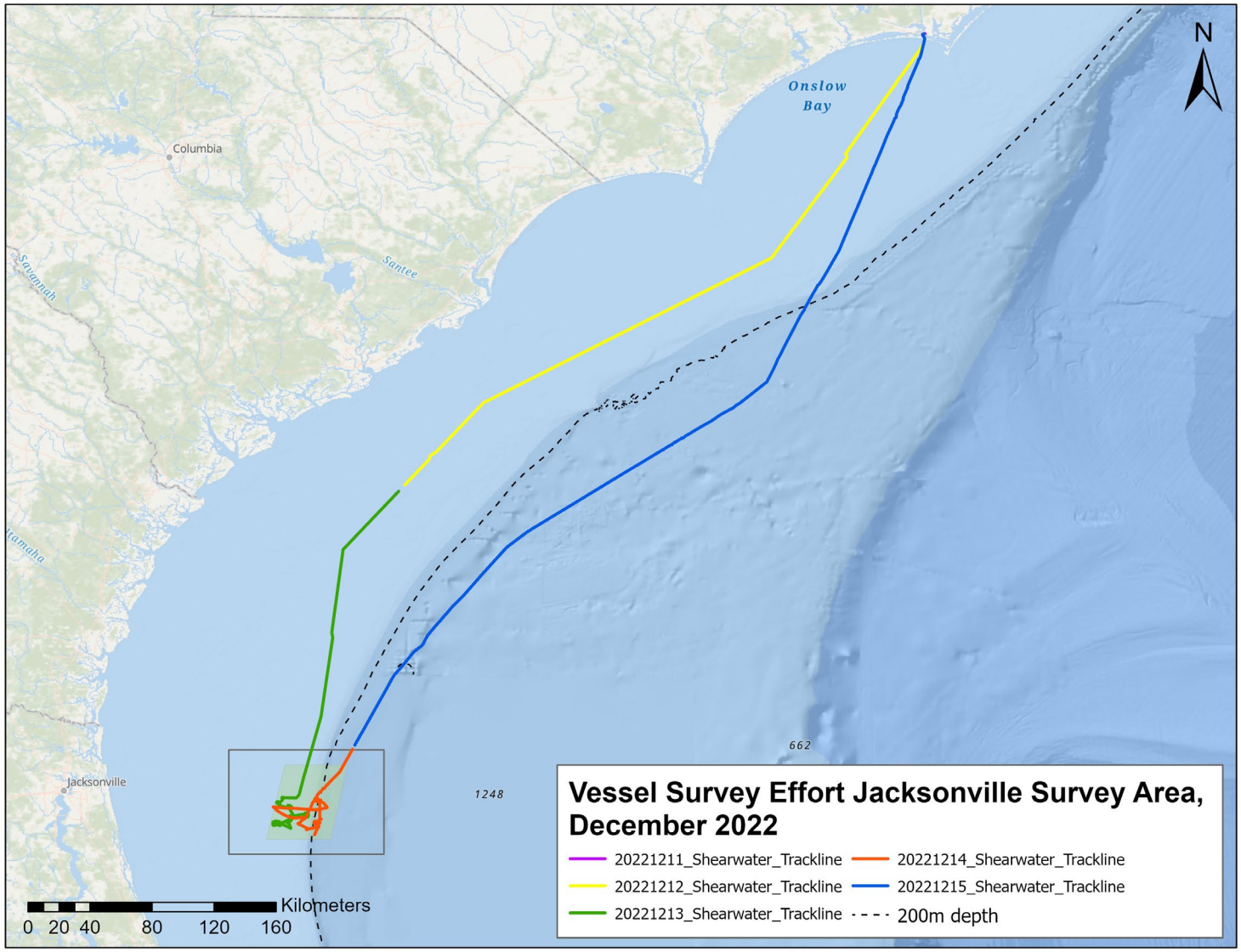

Figure 6. Survey effort during vessel transits and surveys in the Jacksonville survey area in December 2022.

3.2 Marine Mammal and Sea Turtle Sightings

We recorded 34 cetacean sightings during these vessel surveys. Atlantic spotted dolphins (*Stenella frontalis*) (n=8) and bottlenose dolphins (*Tursiops truncatus)* (n=21) dominated the marine mammal fauna. We also observed five unidentified dolphins (**Table 2** and **Table 3**). Loggerhead sea turtles (*Carreta caretta*) (n=7) were also seen in the survey area during 2022 (**Table 4)**.

3.3 Distributions and Habitat Associations of Cetaceans

The distribution of marine mammal sightings from North Carolina to Florida and within the Jacksonville survey area are presented in **Figure 7** and **Figure 8,** respectively. Similar to our observations in previous years, Atlantic spotted dolphins were restricted to shallow shelf waters, but bottlenose dolphins were found both in shelf waters and offshore of the continental shelf break.

3.4 Biopsy Sampling and Genetic Analyses

We collected five biopsy samples within the Jacksonville survey area during 2022. All samples were obtained from bottlenose dolphins (**Table 5** and **Figure 9**). Voucher specimens of these samples are archived at the Duke University Marine Laboratory in Beaufort, North Carolina.

Building on Shintaku (2021), we expanded on prior population genetic analyses of bottlenose dolphins by analyzing diversity at the gene level (Campbell and Schultz 2022). We used the results from the genome-wide scan previously conducted with the RADseq data using PCAdapt. This revealed an overlap of 68 outlier loci after an inshore-offshore and coastal-offshore comparison. From these data, we identified 225 genes within 200 kilobase (kb) of the outlier loci. We retained 11 genes related to metabolic/hypoxia-related processes for further investigation.

To understand the mechanisms driving population structure, we performed whole-genome resequencing (approximately 10x coverage) on four individuals from each of the three populations (inshore, coastal, and offshore) identified by Shintaku (2021), significantly increasing genetic resolution at the gene level. We used Analysis of Next Generation Sequencing Data to calculate nucleotide diversity (π) for sliding windows of 5 kb at 1-kb intervals, providing a genome-wide view of genetic diversity at incredibly high resolution. First, we determined if offshore populations were the most genetically diverse, as the literature suggests (Hoelzel et al. 1998; Natoli et al. 2004). Second, we scanned the genome for regions where inshore populations contained more variation than offshore populations, indicating potential targets of positive selection. Lastly, we visualized nucleotide diversity in windows around candidate genes from our genome-wide scan for outlier genes related to hypoxia.

As expected, nucleotide diversity was highest in offshore populations and lowest in inshore populations (**Figure 10A**). Windows of high nucleotide diversity exist across all three populations, but the highest distribution and lowest density is found offshore. Nucleotide diversity in the X chromosome is unique and approximately half as large as the average nucleotide diversity of the autosomal genome (**Figure 10B**).

Plotting nucleotide diversity across the entire genome was uninformative. Using individual chromosomes allowed us to visualize differential regions of variation, but our capacity to interpret the data was greatly improved by zooming into the gene and its surroundings. A spike in offshore π is present in the 250-kb window upstream of the genes DDIT4 and PFKFB4 (**Figure 11A, B**). This is also present in the genes CASP8 and RAPGEFL1 with the inshore population instead (**Figure 11C, D**). These spikes in diversity comprise more than one window**,** so loci adjacent to the highest diversity window are similarly diverse. This suggests that selection is acting on regions greater than 5 kb (the size of one window). Regions exist where nucleotide diversity spikes in a population, indicating a shift in the environmental conditions the population faces. These regions of high diversity may be evolving at a faster rate than other regions of the genome.

Table 2. Cetacean sightings from vessel surveys in 2022.

Date	Time (local)	Latitude (°N)	Longitude (°W)	Species	Common Name	Group Size	Biopsy Samples	Photo-ID Images
14-May-22	9:43:20	30.25119	80.07264	*Tursiops truncatus*	Bottlenose dolphin	2	—	14
14-May-22	10:20:17	30.19678	80.07899	*Tursiops truncatus*	Bottlenose dolphin	5	ZTS-22-002	43
14-May-22	11:49:36	30.22752	79.96303	Unidentified dolphin	Unidentified dolphin	1	—	73
14-May-22	12:12:58	30.26231	80.00652	*Tursiops truncatus*	Bottlenose dolphin	14	ZTS-22-003	33
14-May-22	14:41:28	30.52251	80.30508	Unidentified dolphin	Unidentified dolphin	1	—	0
15-May-22	9:10:30	30.34670	80.40201	Unidentified dolphin	Unidentified dolphin	—	—	0
15-May-22	9:13:33	30.34663	80.38520	*Tursiops truncatus*	Bottlenose dolphin	4	ZTS-22-004	30
15-May-22	12:26:53	30.38684	80.05409	*Tursiops truncatus*	Bottlenose dolphin	6	ZTS-22-005	36
15-May-22	13:33:44	30.38885	80.05237	*Tursiops truncatus*	Bottlenose dolphin	3	—	4
16-May-22	11:20:45	30.46762	80.29800	*Stenella frontalis*	Atlantic spotted dolphin	10	—	67
16-May-22	12:45:53	30.38744	80.27753	*Tursiops truncatus*	Bottlenose dolphin	2	—	0
18-May-22	10:36:21	30.27260	79.92427	*Tursiops truncatus*	Bottlenose dolphin	13	ZTS-22-006	51
18-May-22	11:31:18	30.38029	80.06748	Unidentified dolphin	Unidentified dolphin	1	—	29
18-May-22	14:53:18	30.42351	80.34619	*Stenella frontalis*	Atlantic spotted dolphin	9	—	169
12-Dec-22	8:07:40	33.11618	78.15589	*Stenella frontalis*	Atlantic spotted dolphin	2	—	0
12-Dec-22	8:27:18	33.08889	78.21021	*Tursiops truncatus*	Bottlenose dolphin	5	—	0
12-Dec-22	9:47:37	32.98967	78.40801	*Stenella frontalis*	Atlantic spotted dolphin	2	—	0
12-Dec-22	16:03:02	32.44284	79.35527	*Stenella frontalis*	Atlantic spotted dolphin	3	—	10
13-Dec-22	7:36:29	30.29066	80.35536	*Stenella frontalis*	Atlantic spotted dolphin	13	—	111
13-Dec-22	7:49:36	30.28945	80.38357	*Tursiops truncatus*	Bottlenose dolphin	2	—	26
13-Dec-22	8:07:22	30.28263	80.38822	*Tursiops truncatus*	Bottlenose dolphin	3	—	14
13-Dec-22	10:45:16	30.15499	80.34557	*Tursiops truncatus*	Bottlenose dolphin	8	—	213
13-Dec-22	11:53:08	30.13584	80.39834	*Tursiops truncatus*	Bottlenose dolphin	1	—	8
13-Dec-22	12:07:46	30.14177	80.40383	*Tursiops truncatus*	Bottlenose dolphin	10	—	74
13-Dec-22	13:36:03	30.13882	80.41324	*Tursiops truncatus*	Bottlenose dolphin	3	—	24

Date	Time (local)	Latitude (°N)	Longitude (°W)	Species	Common Name	Group Size	Biopsy Samples	Photo-ID Images
13-Dec-22	14:26:09	30.15836	80.36721	*Stenella frontalis*	Atlantic spotted dolphin	3	—	0
13-Dec-22	14:43:00	30.17598	80.33659	*Tursiops truncatus*	Bottlenose dolphin	4	—	47
13-Dec-22	15:04:57	30.19163	80.28045	*Tursiops truncatus*	Bottlenose dolphin	11	—	33
13-Dec-22	15:14:57	30.19109	80.28487	*Tursiops truncatus*	Bottlenose dolphin	4	—	0
13-Dec-22	15:53:51	30.20120	80.25643	*Tursiops truncatus*	Bottlenose dolphin	1	—	0
14-Dec-22	11:07:40	30.13523	80.18987	*Tursiops truncatus*	Bottlenose dolphin	15	—	275
14-Dec-22	15:02:40	30.15841	80.27896	*Tursiops truncatus*	Bottlenose dolphin	2	—	4
14-Dec-22	16:05:27	30.22472	80.23202	*Stenella frontalis*	Atlantic spotted dolphin	2	—	135
15-Dec-22	9:55:11	32.53311	77.80725	Unidentified dolphin	Unidentified dolphin	5	—	0

Key: °N = degrees north; °W = degrees west

Table 3. Numbers of cetacean sightings for each species observed during vessel surveys in 2022.

Species	Sightings 2022
Grampus griseus	0
Stenella frontalis	8
Steno bredanensis	0
Tursiops truncatus	21
Unidentified	5
Total	**34**

Table 4. Sea turtle sightings from vessel surveys in 2022.

Date	Time (local)	Latitude (°N)	Longitude (°W)	Species	Common Name	Group Size
16-May-22	11:27:50	30.47244	80.28761	*Caretta caretta*	Loggerhead sea turtle	1
12-Dec-22	8:34:14	33.07953	78.22892	*Caretta caretta*	Loggerhead sea turtle	1
13-Dec-22	10:57:02	30.15347	80.36372	*Caretta caretta*	Loggerhead sea turtle	1

Key: °N = degrees north; °W = degrees west

Table 5. Biopsy samples collected within the Jacksonville survey area in 2022.

Date	Time (local)	Latitude (°N)	Longitude (°W)	Species	Sample #
14-May-22	10:20:17	30.18196	80.08333	*Tursiops truncatus*	ZTS-22-002
14-May-22	12:12:58	30.26456	80.00558	*Tursiops truncatus*	ZTS-22-003
15-May-22	9:13:33	30.35925	80.37955	*Tursiops truncatus*	ZTS-22-004
15-May-22	12:26:53	30.38264	80.05657	*Tursiops truncatus*	ZTS-22-005
18-May-22	10:36:21	30.27307	79.92559	*Tursiops truncatus*	ZTS-22-006

Key: °N = degrees north; °W = degrees west

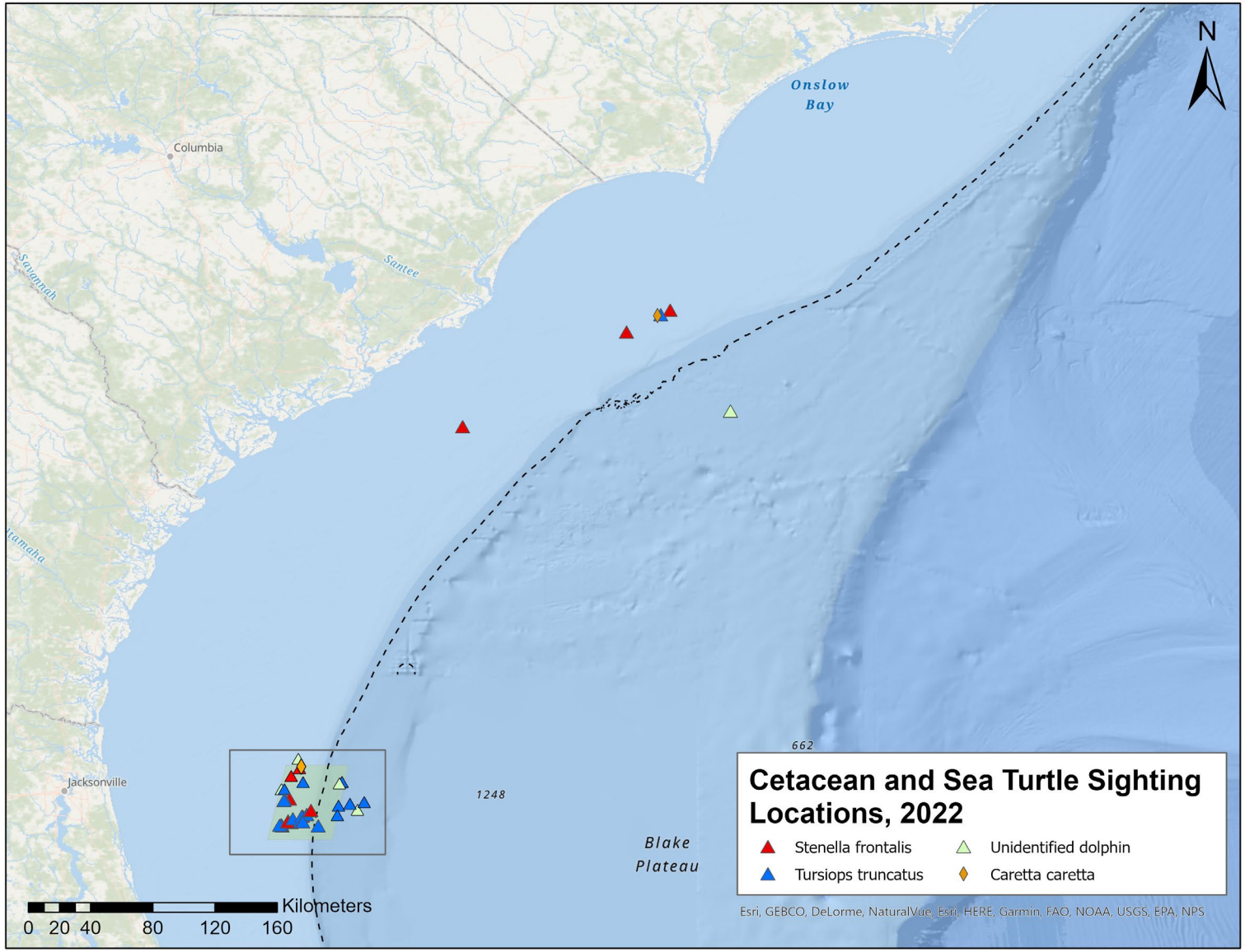

Figure 7. Distribution of all cetacean and sea turtle sightings during vessel surveys in 2022.

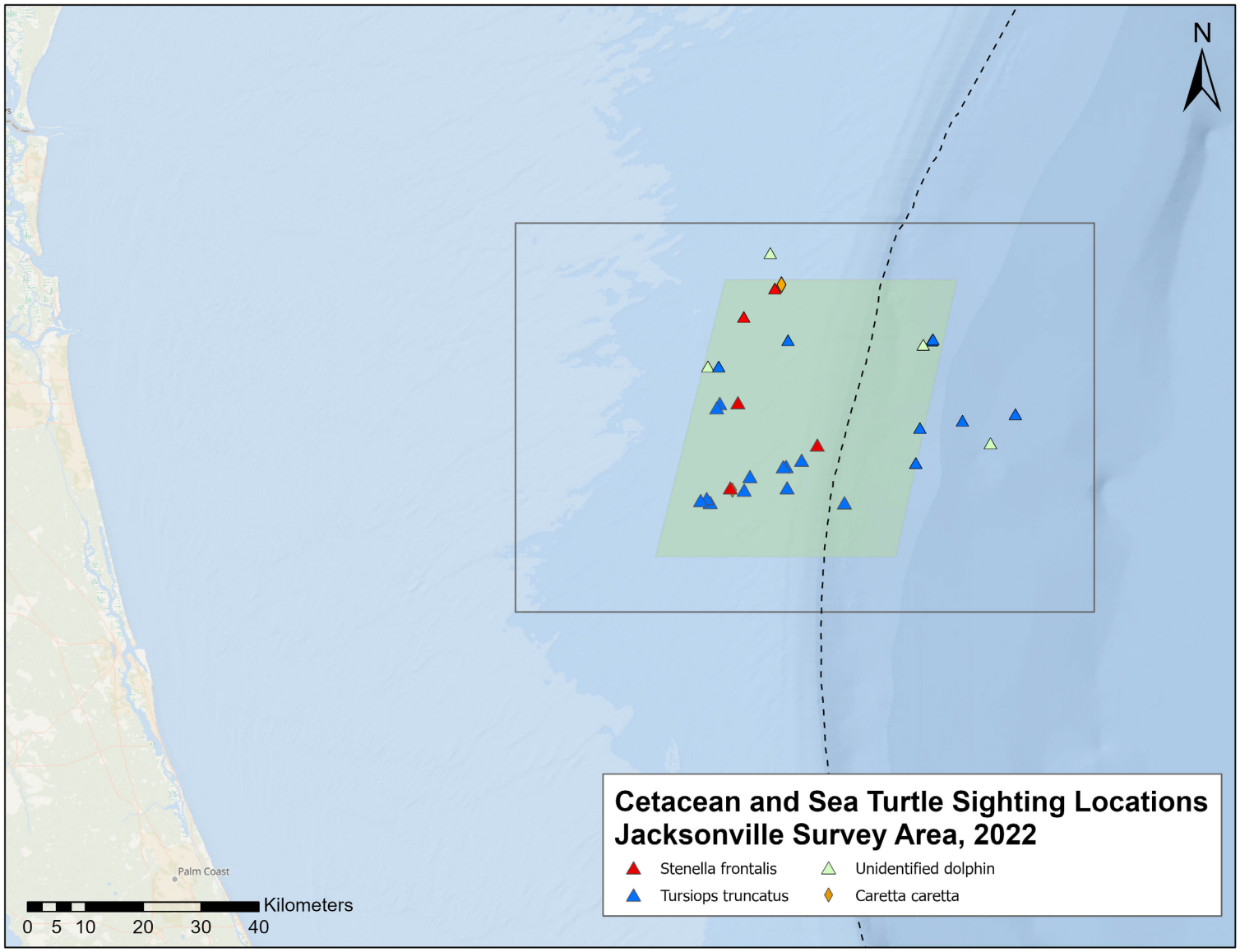

Figure 8. Distribution of all cetacean and sea turtle sightings during vessel surveys in the Jacksonville survey area in 2022.

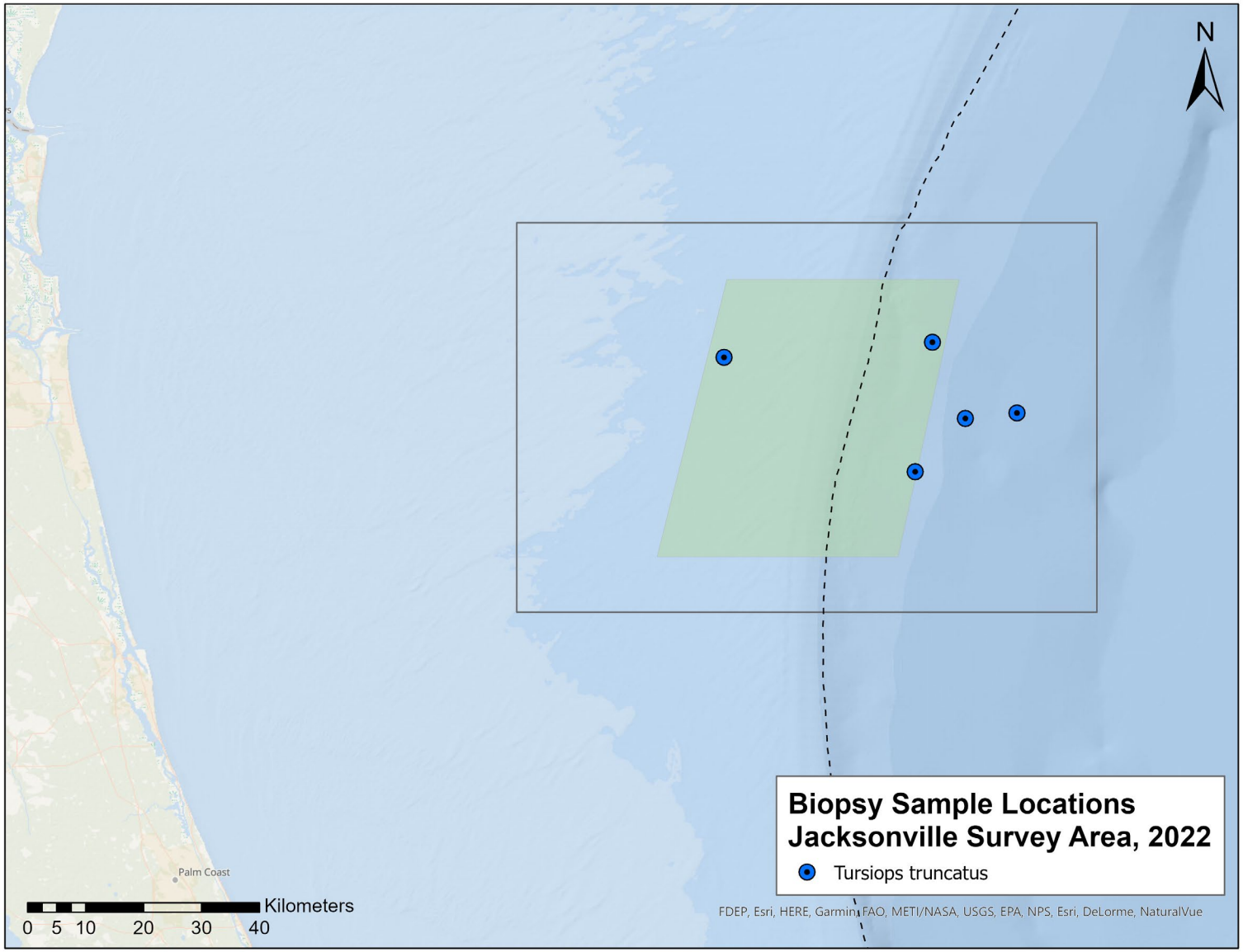

Figure 9. Locations of biopsy samples collected in the Jacksonville survey area in 2022.

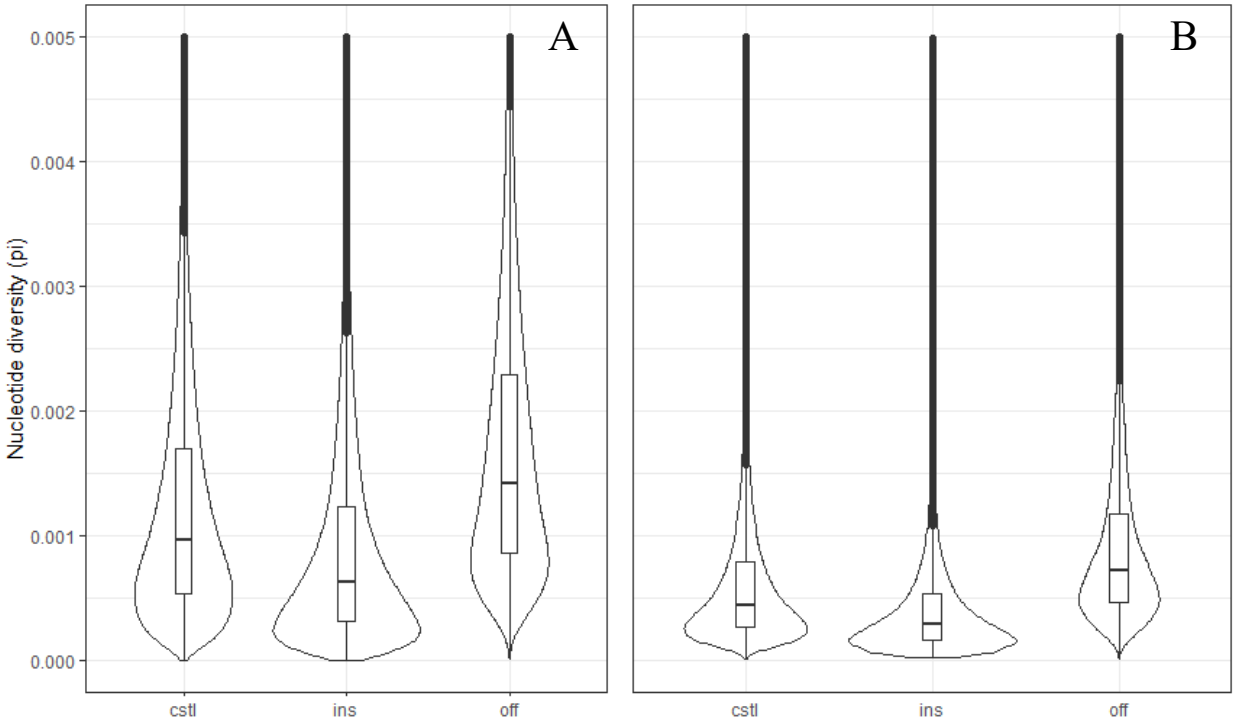

Figure 10. Violin plots of nucleotide diversity: (A) across the entire genome (197,025 outlier windows with nucleotide diversity greater than 0.005 are removed for clarity), and (B) with respect to the X chromosome (1,923 outlier windows with nucleotide diversity greater than 0.005 are removed for clarity).

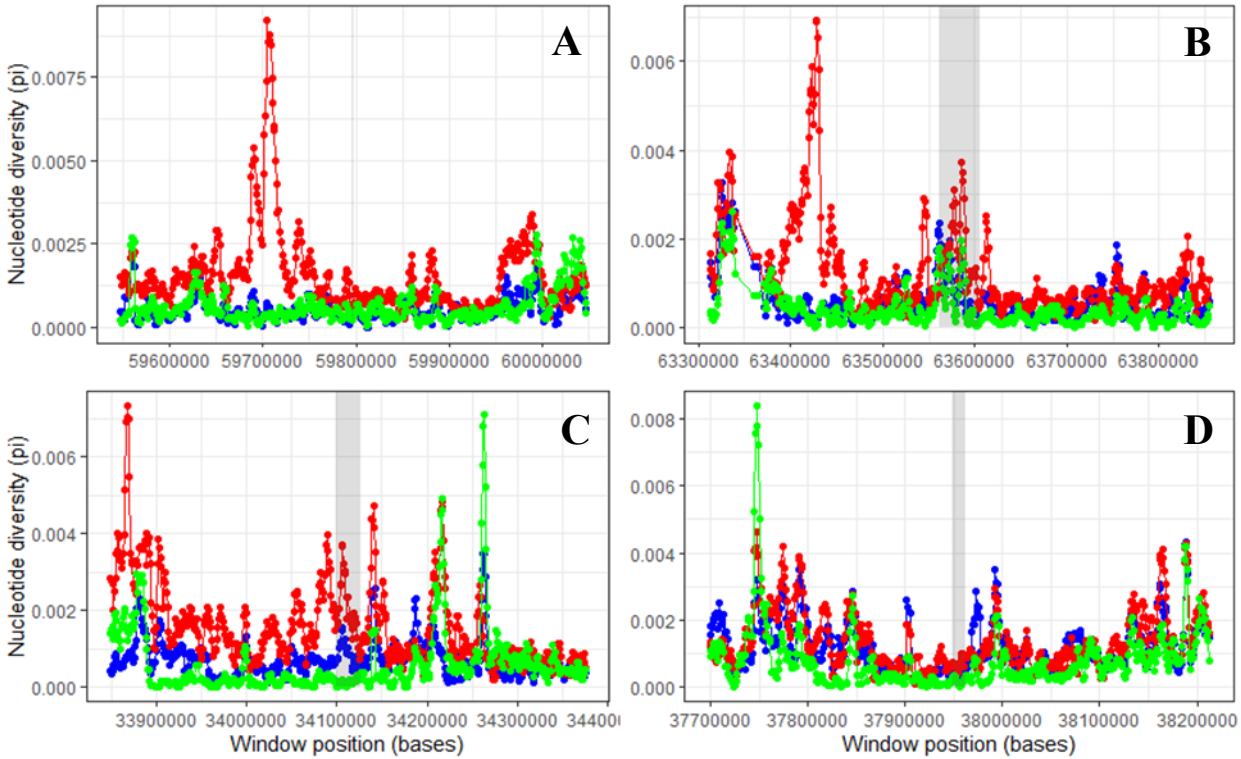

Figure 11. Nucleotide diversity in a 500-kb window for (A) DDIT4 in NC_047049.1, (B) PFKFB4 in NC_047043.1, (C) CASP8 in NC_047040.1, and (D) RAPGEFL1 in NC_047053.1 (green is inshore, red is offshore, blue is coastal, and the shaded region represents the gene).

3.5 Satellite Tagging

In May 2022, we attempted to deploy satellite tags in collaboration with Jessica Aschettino from HDR, Inc., but we did not encounter any target species during this trip.

3.6 Photographic Effort

More than 1,500 digital images were collected for species confirmation and individual identification during 2022. All images have been coded and graded for distinctiveness and photographic quality. Photo-ID analysis has identified 9 new Atlantic spotted dolphins and 33 new bottlenose dolphins, and these individuals have been added to our existing catalogs (**Table 6**).

Table 6. Summary of photographs taken of animals within the Jacksonville survey area in 2022, with photo-ID catalog sizes and total number of matches within the catalog to date.

Species	Common Name	Images 2022	Catalog Size	Matches to Date
Globicephala macrorhynchus	Short-finned pilot whale	0	52	0
Grampus griseus	Risso's dolphin	0	73	1
Stenella frontalis	Atlantic spotted dolphin	492	265	27
Tursiops truncatus	Bottlenose dolphin	929	219	29
Steno bredanensis	Rough-toothed dolphin	0	78	10

To date, 27 individual Atlantic spotted dolphins, or 10 percent of the catalogued individuals, have been re-sighted within the Jacksonville survey area (**Figure 12**). Two individuals, Sfr 1-022 and Sfr 7-040, first observed in 2021, were re-sighted in 2022, 18 months and 13 months later, respectively. Our longest match of a pair of Atlantic spotted dolphins was made in 2021. First observed together in October 2014, Sfr 8-027 and Sfr 1-008 were seen together again in 2021 within the Jacksonville survey area after 6 years and 7 months. Another pair, Sfr 7-008 and Sfr 9-011 were first observed together in 2013. In 2016, Sfr 7-008 was observed without Sfr 9-011, but they were again photographed together in July 2017. Eight Atlantic spotted dolphins were observed on consecutive days in July 2017 (**Table 7**). Three of these eight individuals were observed together in July 2014. One pair of Atlantic spotted dolphins (Sfr 8-037 and Sfr DU 8-014) was seen together in consecutive months of 2017. One trio (Sfr 6-024, Sfr 7-035, and Sfr 9-040) match has been documented, photographed together in 2016 and 2017. Sfr 8-052, an Atlantic spotted dolphin identified in 2021, was observed on both 22 and 24 May 2021, with different individuals at each sighting (**Table 7**).

In 2022, three bottlenose dolphins were re-sighted from previous years. Ttr 7-010, identified in March 2012, was re-sighted for the first time in December 2022. This re-sighting interval is the longest in the Jacksonville bottlenose dolphin catalog at 10 years and 8 months. Another multi-year re-sighting was made for Ttr 6-029, who was seen first in February 2016, then seen again in December 2022. Three bottlenose dolphins were first catalogued in 2022, then re-sighted within the same month. In May 2021, 15 bottlenose dolphins were first catalogued, and then

resighted on the same day or the day following initial identification. The remaining eight bottlenose dolphin matches have been from re-sightings within the Jacksonville survey area across 2 or more years. Two pairs of bottlenose dolphins have been re-sighted together. Ttr 6-010 and Ttr 6-036 were observed together in January 2012, and again in July 2013. Ttr 6-037 and Ttr 6-038 were observed together first in September 2013, and again in February 2017. Ttr 6-007, the first cataloged individual in 2013, was re-sighted in 2017. One bottlenose dolphin trio (Ttr 7-022, Ttr 7-030, and Ttr 7-031) has been re-sighted within the Jacksonville survey area, seen together first in 2015, and again in 2017 (**Table 7** and **Figure 12**). One individual from this trio (Ttr 7-030) was also observed in April 2015, before the trio was first documented; however, photograph quality prevented us from determining if the two other individuals were part of the initial sighting.

One Risso's dolphin was re-sighted in May 2021 within the Jacksonville survey area, the only re-sighting for this catalog. Ggr 1-013 was observed first in June 2017, and again 3 years and 11 months later.

Ten individual rough-toothed dolphins have been re-sighted. Two individuals were re-sighted in 2021, after several years. Sbr 7-007 was observed originally in September 2016, and again in April 2021. Sbr 7-019 was originally observed in July 2017 and re-sighted in April 2021 (**Table 7**). Additionally, eight rough-toothed dolphins were seen on consecutive days in September 2016.

We have not yet identified any re-sightings for the short-finned pilot whale. Despite no matches within the Jacksonville short-finned pilot whale catalogs, short-finned pilot whale matches have been made to multiple adjacent study areas, as detailed below.

We have previously compared the Jacksonville short-finned pilot whale photo-ID catalog to both the Onslow Bay and Cape Hatteras catalogs, but no matches have been identified. However, as reported in Foley et al. (2017), seven short-finned pilot whales were observed in the Bahamas in 2007, then within the Jacksonville survey area in 2009. Three of these seven individuals were re-sighted again in the Bahamas in 2015. Additionally, five short-finned pilot whales first photographed together in the Bahamas in June 2009 were re-sighted within Onslow Bay 2 months later.

Table 7. Photo-ID matches of delphinids observed within the Jacksonville survey area.

ID[a]	Year											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2021	2022
Ttr 1-017											X[m]	
Ttr 1-018											X[m]	
Ttr 1-023											X[m]	
Ttr 6-007					X				X			
Ttr 6-010[b]				X	X							
Ttr 6-029								X				X
Ttr 6-036[b]				X	X							
Ttr 6-037[b]					X				X			

ID[a]	Year											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2021	2022
Ttr 6-038[b]					X				X			
Ttr 6-043											X	X
Ttr 6-047											X[m]	
Ttr 6-048											X[m]	
Ttr 6-050											X[m]	
Ttr 6-051											X[m]	
Ttr 7-010				X								X
Ttr 7-022[b]							X		X			
Ttr 7-030[b]							X[y]		X			
Ttr 7-031[b]							X		X			
Ttr 7-042											X[m]	
Ttr 7-043											X[m]	
Ttr 7-047											X[m]	
Ttr 7-051												X[m]
Ttr 7-053												X[m]
Ttr 8-018											X[m]	
Ttr 9-025											X[m]	
Ttr 9-028												X[m]
Ttr DU 1-001											X[m]	
Ttr DU 7-028											X[m]	
Ttr DU 8-011											X[m]	
Sfr 1-008						X					X	
Sfr 1-022											X	X
Sfr 2-002		X							X			
Sfr 2-006				X				X				
Sfr 3-001		X	X									
Sfr 6-024[b]								X	X			
Sfr 6-006[b]						X			X[m]			
Sfr 6-010		X							X			
Sfr 7-008[b]					X			X	X			
Sfr 7-010					X				X			
Sfr 7-013[b]						X			X[m]			
Sfr 7-014[b]						X			X[m]			
Sfr 7-015						X			X			
Sfr 7-035[b]								X	X			
Sfr 7-040											X	X
Sfr 8-005			X[m]									
Sfr 8-027						X					X	
Sfr 8-037[b]									X[y]			

ID[a]	Year											
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2021**	**2022**
Sfr 8-038[b]									X[m]			
Sfr 8-052											X[m]	
Sfr 9-011[b]					X				X			
Sfr 9-037[b]									X[m]			
Sfr 9-040[b]								X	X			
Sfr DU 1-003[b]									X[m]			
Sfr DU 6-010[b]									X[m]			
Sfr DU 7-008[b]									X[m]			
Sfr DU 8-014[b]									X[y]			
Sbr 1-001								X[m]				
Sbr 1-002								X[m]				
Sbr 6-001								X[m]				
Sbr 6-002								X[m]				
Sbr 7-001								X[m]				
Sbr 7-002								X[m]				
Sbr 7-003								X[m]				
Sbr 7-004								X[m]				
Sbr 7-007								X			X	
Sbr 7-019									X		X	
Ggr 1-013									X		X	

[a] Sfr = *Stenella frontalis* (Atlantic spotted dolphin); Ttr = *Tursiops truncatus* (bottlenose dolphin); Sbr = *Steno bredanensis* (rough-toothed dolphin); Ggr = *Grampus griseus* (Risso's dolphin)

[b] Observed together in multiple sightings

[m] Re-sighted within same month

[y] Re-sighted within same year

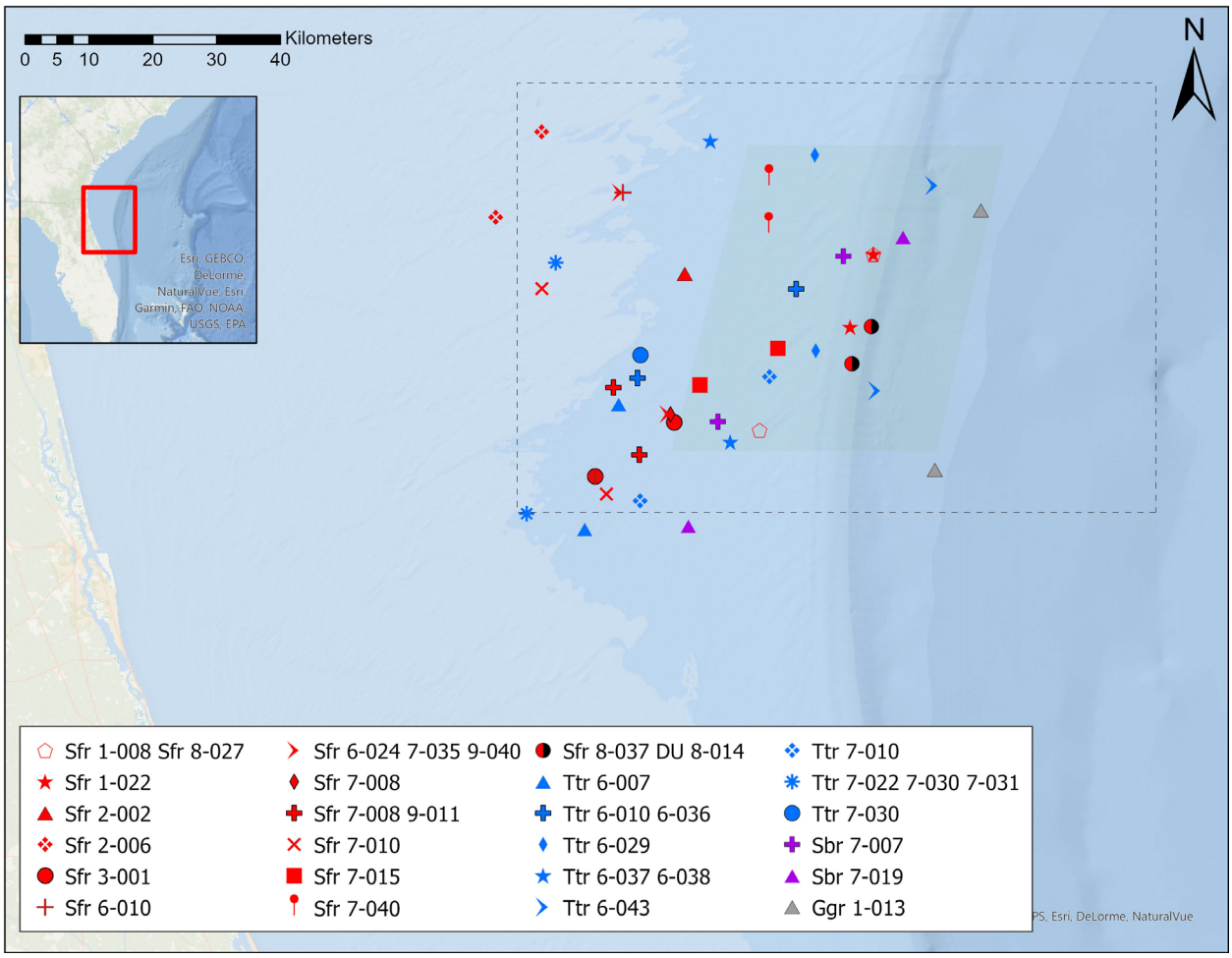

Figure 12. Locations of photo-matched dolphins within the Jacksonville survey area, excluding same-day or next-day re-sightings.

4. Summary: 2009–2022

Total survey effort conducted since the beginning of the monitoring program within the Jacksonville study area, including all AFTT protected species monitoring and tagging effort, is reported in **Table 8**. The annual numbers of sightings by species for both cetaceans and sea turtles within the Jacksonville survey area are presented in **Table 9** and **Table 10**. A summary of biopsy samples collected to date is reported in **Table 11**. **Table 12** summarizes the photo-ID catalog sizes and matches by species to date and images taken during the reporting period within the Jacksonville survey area.

Table 8. Vessel survey effort from July 2009 through December 2022 within the Jacksonville survey area.

	2009–2010	2011	2012	2013	2014	2015	2016	2017	2018	2021	2022	Total
Survey Hours	127.1	20.9	58.6	58.7	66.8	44.2	130.7	66.1	15.3	123.6	78.3	**790.3**
Survey Distance (km)	2,073.5	345.7	937.4	1,021.7	1,227.4	858.2	2,135.5	1,424.2	315.0	3,941.6	475	**14,755.2**

Table 9. Cetacean sightings by species from July 2009 through December 2022 during vessel surveys within the Jacksonville survey area.

Species	Sightings										
	2009–2010	2011	2012	2013	2014	2015	2016	2017	2018	2021	2022
Eubalaena glacialis	0	0	0	0	1	0	0	0	0	0	0
Globicephala macrorhynchus	3	0	0	0	0	0	5	0	1	0	0
Grampus griseus	2	0	0	1	1	1	0	2	0	3	0
Stenella attenuata	0	0	0	0	0	0	2	0	0	0	0
Stenella frontalis	35	6	14	9	20	10	10	18	4	41	8
Steno bredanensis	0	0	0	0	0	0	2	1	0	2	0
Tursiops truncatus	19	6	23	15	18	10	18	16	0	38	21
Tursiops/Stenella mix	0	0	0	0	1	0	0	0	0	0	0
Unidentified delphinid	13	0	4	3	4	0	5	0	0	1	5
Total	**72**	**12**	**41**	**28**	**45**	**21**	**42**	**37**	**5**	**85**	**34**

Table 10. Sea turtle sightings by species from July 2009 through December 2022 during surveys within the Jacksonville survey area.

Species	Sightings										
	2009–2010	2011	2012	2013	2014	2015	2016	2017	2018	2021	2022
Caretta caretta	52	20	41	33	31	22	22	24	0	7	3
Dermochelys coriacea	8	3	4	1	3	2	4	2	0	0	0
Lepidochelys kempii	1	0	1	0	0	0	0	0	0	0	0
Unidentified sea turtle	8	3	3	1	0	0	0	3	0	1	0
Total	**69**	**26**	**49**	**35**	**34**	**24**	**26**	**29**	**0**	**8**	**3**

Table 11. Biopsy samples collected from July 2009 through December 2022 during vessel surveys in the Jacksonville survey area.

Species	2009–2010	2011	2012	2013	2014	2015	2016	2017	2018	2021	2022	Total
Globicephala macrorhynchus	0	0	0	0	0	0	5	0	1	0	0	**6**
Grampus griseus	0	0	0	1	2	0	0	0	0	0	0	**3**
Stenella attenuata	0	0	0	0	0	0	1	0	0	0	0	**1**
Stenella frontalis	0	0	19	6	19	3	7	8	0	1	0	**63**
Steno bredanensis	0	0	0	0	0	0	4	2	0	0	0	**6**
Tursiops truncatus	0	0	12	5	10	5	5	2	0	12	5	**56**
Total	**0**	**0**	**31**	**12**	**31**	**8**	**22**	**12**	**1**	**13**	**5**	**135**

Table 12. Summary of images collected during all vessel surveys in the Jacksonville survey area from 2009 through 2022, with photo-identification catalog sizes and matches to date.

Species	2009–2010		2011		2012		2013		2014		2015		2016		2017		2018		2021		2022	
	Catalog Size	Matches	Catalog Size	Matches	Catalog Size	Matches	Catalog Size	Matches	Catalog Size	Matches	Catalog Size	Matches	Catalog Size	Matches	Catalog Size	Matches	Catalog Size	Matches	Catalog Size	Matches	Catalog Size	Matches
Globicephala macrorhynchus	0	0	0	0	0	0	12	0	12	0	12	0	12	0	29	0	29	0	52	0	52	0
Grampus griseus	1	0	1	0	1	0	7	0	22	0	73	1	36	0	36	0	56	0	56	0	56	0
Stenella frontalis	0	0	41	0	60	2	77	2	111	2	256	25	118	2	154	3	199	20	204	22	213	2
Tursiops truncatus	0	0	21	0	41	0	52	2	80	2	186	23	100	2	114	2	132	8	132	8	165	6
Steno bredanensis	0	0	0	0	0	0	0	0	0	0	78	10	0	0	43	8	54	8	54	8	54	0

5. Marine Mammal Monitoring on Navy Ranges Species Verification Trials

The M3R program began in 2000, with the development of a system to use the bottom-mounted hydrophones of the U.S. Navy's test and training ranges to detect, classify, localize, and monitor marine mammals in real-time by listening for their vocalizations. Each of the ranges has 100 to 200-plus widely spaced hydrophones, and the systems consist of rack-mounted computer nodes and monitoring displays connected with Gigabit networks. The M3R system is currently installed at the Atlantic Undersea Test and Evaluation Center (AUTEC), Southern California Tactical Training Range (SOAR), Pacific Missile Range Facility (PMRF), Jacksonville Shallow Water Training Range, and Canadian Forces Maritime Experimental and Test Ranges Nanoose Range. The M3R program collects continuous archive data and periodic recordings from each of these ranges and uses these data, along with field tests, for collaborative studies on marine mammal behavior, distribution, abundance, foraging, and habitat use. These data are useful for understanding the effects of U.S. Navy activities and the long-term health of the populations as well as for the development of detection, classification, localization, and density estimation algorithms.

JSWTR has 223 active hydrophones mounted at depths ranging from 35 to 355 meters over a span of 2,000 km^2 (**Figure 13**), making it the largest M3R system to date. In contrast to the AUTEC, PMRF, and SOAR deep-water ranges on which the M3R system is deployed, JSWTR is a shallow-water range that is likely to have different species present than those typically found on the deep-water ranges. The M3R system runs nearly continuously year-round, archiving data from all range hydrophones simultaneously in real-time, when no range activities would preclude its operation. Detection, classification, and localization (DCL) reports are stored to binary archive files for later playback and analysis. The M3R system employs three detector/classifiers: a Fast Fourier Transform (FFT)-based detector, a Class-Specific Support Vector Machine (CS-SVM) detector/classifier, and a Blainville's beaked whale foraging click matched filter (Jarvis et al. 2008). The CS-SVM classifier currently has six classes at JSWTR: Blainville's beaked whale foraging and buzz clicks, Cuvier's beaked whale foraging and buzz clicks, sperm whale clicks, and "generalized dolphin" clicks.

The M3R team conducted two species-verification trials in 2022 in collaboration with Duke University and HDR, Inc.: 14 through 18 May, and 13 and 14 December. During these trials, M3R personnel used the system's passive acoustic monitoring displays to look for species of interest, and direct the on-water team to the location of the animals via satellite-phone text messages. Upon finding the animals, the vessel survey crew verified the species, collected behavioral and environmental data, and took photographs for photo-ID catalogs; sampling also included collecting biopsy samples when possible.

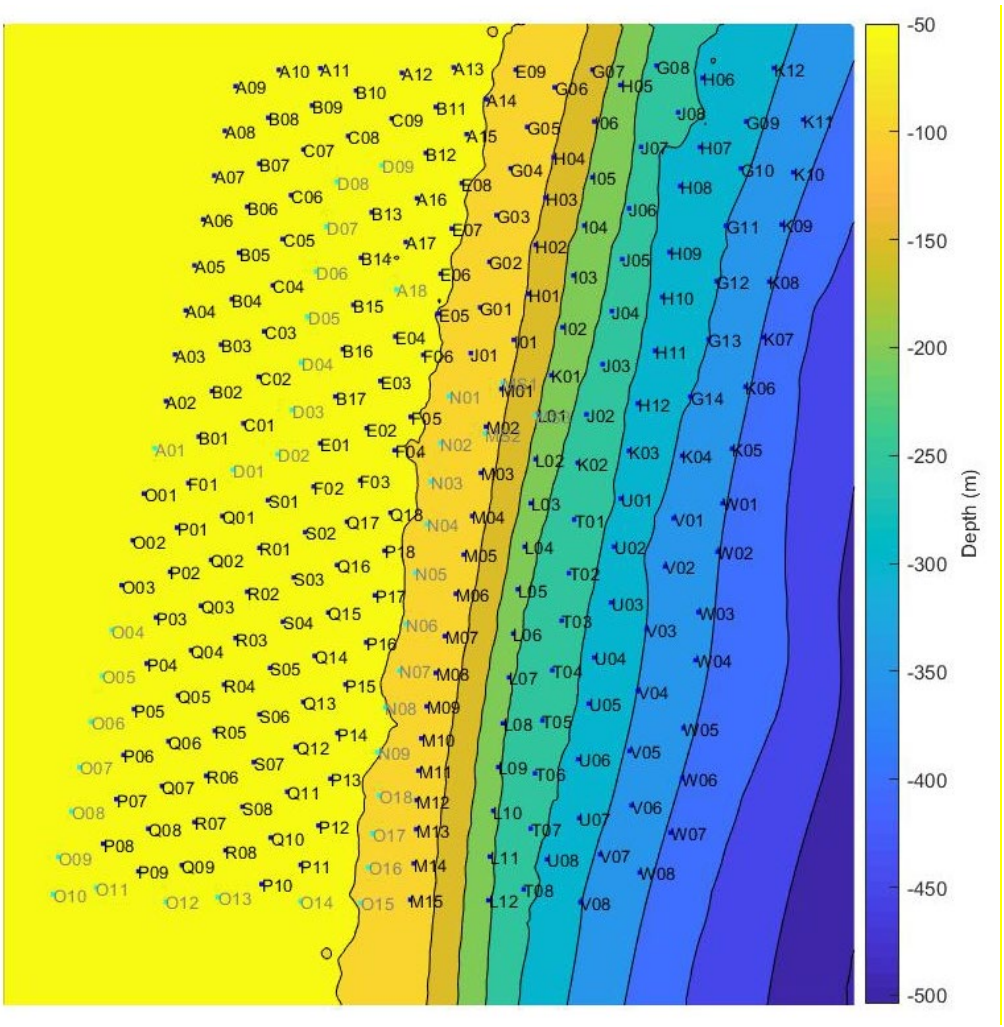

Figure 13. Hydrophone range at JSWTR with bathymetry.

During the two field sessions conducted in 2022, two of the five focal species were acoustically identified by M3R and visually verified by the on-water team: 11 groups of bottlenose dolphins and 2 groups of Atlantic spotted dolphins. **Table 13** and **Table 14** as well as **Figure 14** and **Figure 15** summarize the acoustic detections and visual verifications from these field trials.

Table 13. M3R acoustic detections and visual verifications at JSWTR in May 2022.

Species			# Acoustic Detections Logged	# Acoustic Detections Directed	# Acoustic Detections Visually Verified
ID	Common Name	Scientific Name			
Tt	Bottlenose dolphin	*Tursiops truncatus*	8	4	3
Sf	Atlantic spotted dolphin	*Stenella frontalis*	5	5	5
UD	Unidentified dolphin	Delphinidae sp.	31	8	1

Table 14. M3R acoustic detections and visual verifications at JSWTR in December 2022.

Species			# Acoustic Detections Logged	# Acoustic Detections Directed	# Acoustic Detections Visually Verified
ID	Common Name	Scientific Name			
Tt	Bottlenose dolphin	*Tursiops truncatus*	8	8	8
Sf	Atlantic spotted dolphin	*Stenella frontalis*	8	8	8
UD	Unidentified dolphin	Delphinidae sp.	52	8	1

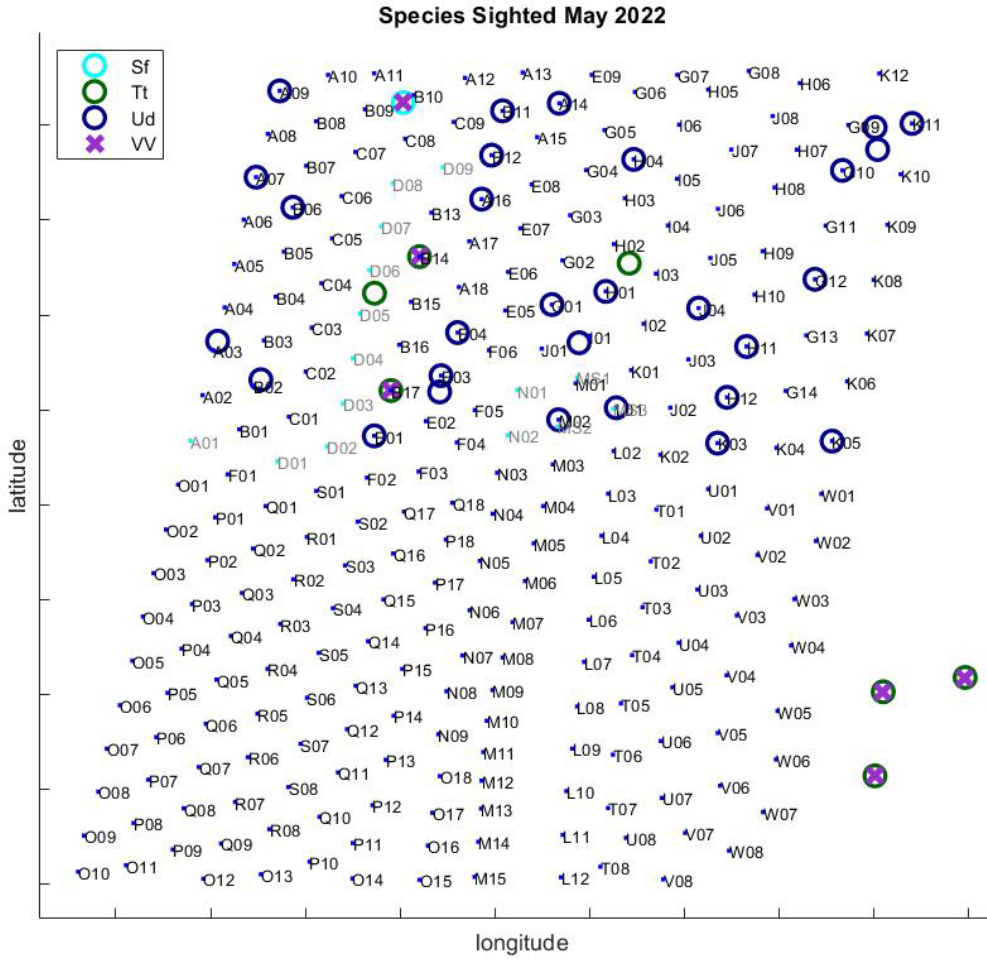

Figure 14. Acoustic detections and visual verifications of marine mammal species during May 2022 species verification trials. Note only northern phones were active at the time of this trial.

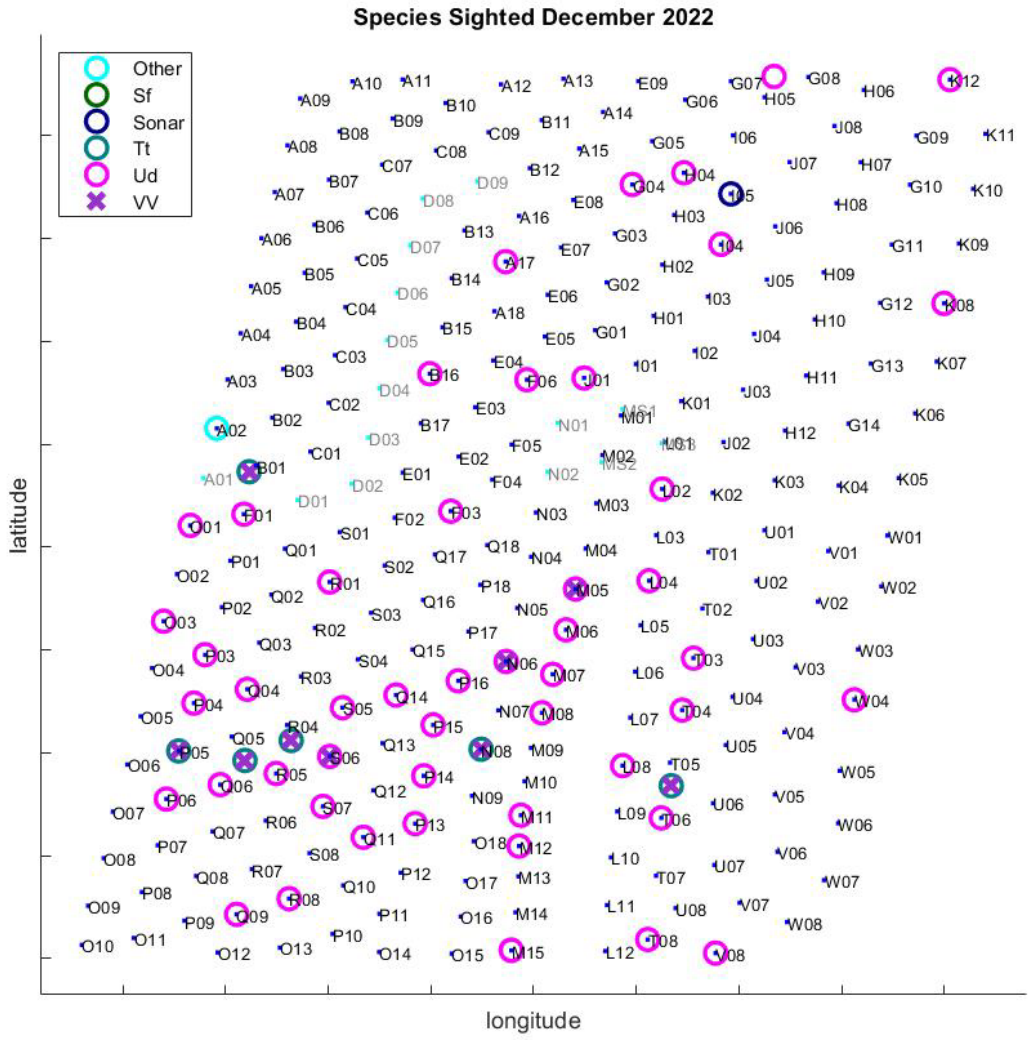

Figure 15. Acoustic detections and visual verifications of marine mammal species during December 2022 species verification trials.

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