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**Vessel Surveys for Protected
Marine Species in Navy
OPAREAs off the
U.S. Atlantic Coast:
2021 Annual Progress Report**



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Cover Photo Credit:

Rough-toothed dolphin (*Steno bredanensis*). Photographed by Greg Merrill (Duke University), taken under General Authorization Letter of Confirmation 19903 held by Andrew Read (Duke University).

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Acronyms and Abbreviations

AFTT	Atlantic Fleet Training and Testing
JSWTR	Jacksonville Shallow Water Training Range
km	kilometer(s)
M3R	Marine Mammal Monitoring on Navy Ranges
OPAREA	Operating Area
Photo-ID	photo-identification
R/V	research vessel
U.S.	United States

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1. Introduction

This report describes results of vessel surveys from a multi-institutional monitoring project 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 a passive acoustic monitoring component, in Onslow Bay, North Carolina, and has since expanded to include study areas off the coast of Jacksonville, Florida, and Cape Hatteras, North Carolina. In Onslow Bay, six 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 in this region ([Read et al. 2014](#)). Dedicated survey effort in the Onslow Bay site concluded in 2013. More than nine years of monitoring in the Jacksonville Operating Area (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, more than eight years of surveys have also provided information on the complex patterns of distribution and diversity of the marine mammals and sea turtles in this highly productive area and serve as a robust baseline for ongoing tagging and behavioral response projects.

This report describes vessel monitoring activities, including photo-identification (photo-ID), satellite tagging, and biopsy sampling, at the Jacksonville study area in 2021. Fieldwork at Cape Hatteras in 2021 was dedicated to the Satellite-Tagging and Behavioral Response Study Projects. Photographic identification work for multiple tagging projects and Atlantic Fleet Training and Testing (AFTT) protected species monitoring for Cape Hatteras and Jacksonville is reported separately ([Waples and Read 2022](#)).

2. Methods

2.1 Study Area

The study area within the Jacksonville OPAREA is 5,786 square kilometers (km), surrounding the Jacksonville Shallow Water Training Range (JSWTR), which is approximately 1,700 square km 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**).

2.2 Data Collection

In April, May, and December 2021, we employed visual survey methods to support species verification trials in conjunction with the Marine Mammal Monitoring on Navy Ranges (M3R) system in coordination with the Naval Undersea Warfare Center, Division Newport (NUWC Newport). We conducted surveys from the research vessels (R/V) *Richard T. Barber* (April) (**Figure 2**) and R/V *Shearwater* (May and December) (**Figure 3**). When we were informed of a possible cetacean location by the M3R team (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 and 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 as well as whenever survey conditions changed. Sighting and environmental data was 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 SLR 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 employed 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 biopsy tip attached to a modified bolt, typically fired from the bow of the survey vessel.

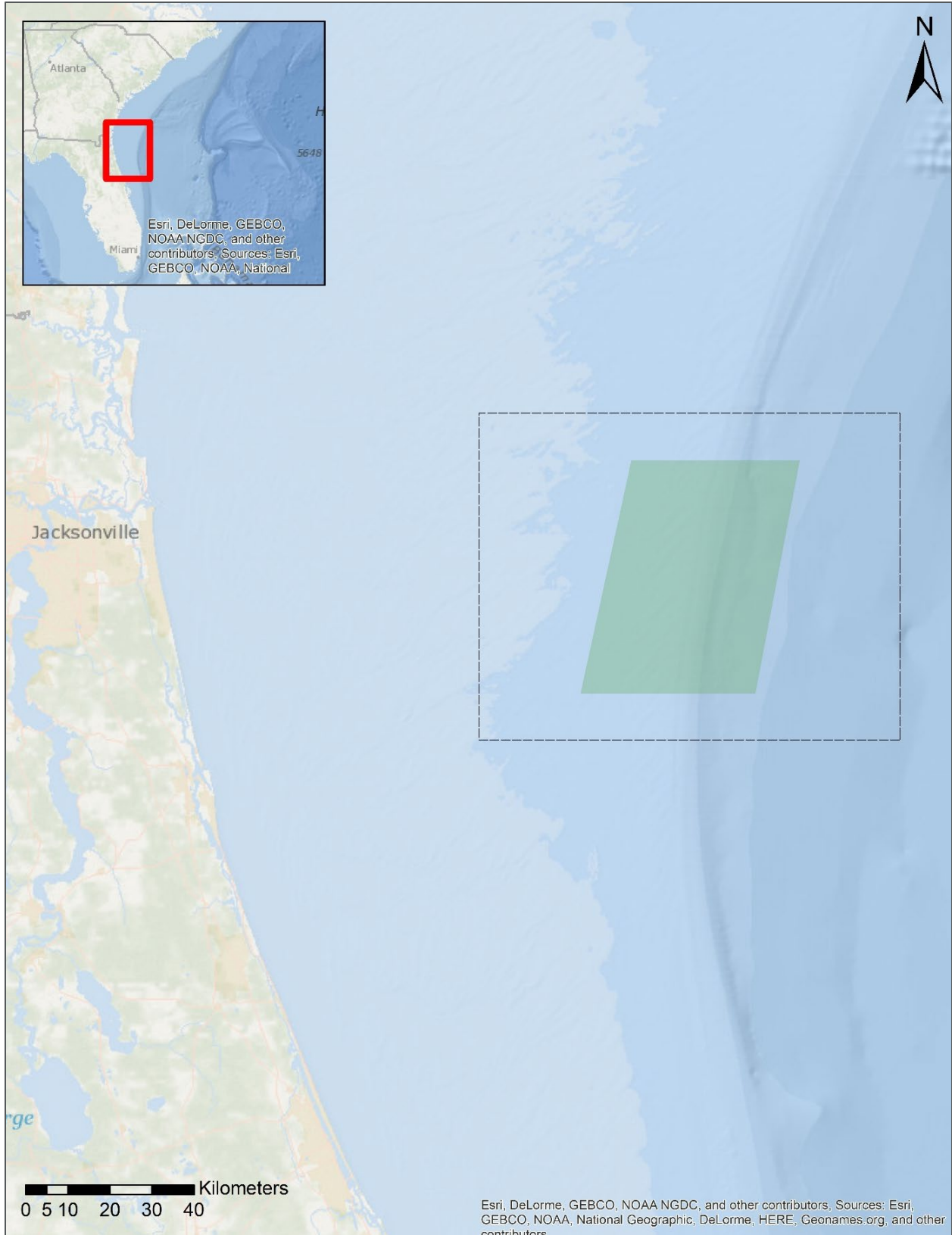


Figure 1. Map of the Jacksonville study area (dashed outline) and the JSWTR site (shaded box).



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 2.9 (Esri, Redlands, California). All sighting data collected will be posted on the data archive OBIS-SEAMAP (<http://seamap.env.duke.edu/>). Satellite-tagging data were processed as described by [Baird et al. 2019](#).

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 seven days of vessel surveys in the Jacksonville study area and 8 days of surveys during transits from and to Beaufort, NC in 2021, totaling 3,771.9 km, or 123.6 hours, of survey effort (Table 1). These surveys were conducted in Beaufort sea state 0 to 6 and covered the JSWTR site (**Figure 4**, **Figure 6**, and **Figure 8**), including shelf and pelagic waters between Florida and North Carolina (**Figure 5** and **Figure 7**).

Table 1. Dates, distances, and durations surveyed during vessel surveys in the Jacksonville survey area in 2021.

Date	Beaufort Sea State	Distance Surveyed (kilometers)	Survey Time (hours:minutes)	At-Sea Time (hours:minutes)	Platform
09-Apr-21	2-5	85.1	6:38	11:37	R/V <i>R.T. Barber</i>
12-Apr-21	4-6	67.3	5:10	10:25	R/V <i>R.T. Barber</i>
14-Apr-21	2-4	52.5	3:54	8:58	R/V <i>R.T. Barber</i>
16-Apr-21	2-3	94.9	6:50	11:55	R/V <i>R.T. Barber</i>
17-Apr-21	1-4	141.0	7:32	12:03	R/V <i>R.T. Barber</i>
20-May-21	2	486.1	10:25	11:59	R/V <i>Shearwater</i>
21-May-21	2-5	137.5	11:04	24:00	R/V <i>Shearwater</i>
22-May-21	2-4	126.9	9:52	24:00	R/V <i>Shearwater</i>
23-May-21	2-3	225.9	10:54	24:00	R/V <i>Shearwater</i>
24-May-21	2-4	513.2	10:40	24:00	R/V <i>Shearwater</i>
25-May-21	2	643.1	4:11	14:50	R/V <i>Shearwater</i>
06-Dec-21	1-3	114.7	6:14	14:20	R/V <i>Shearwater</i>
07-Dec-21	2-4	407.9	9:42	24:00	R/V <i>Shearwater</i>
08-Dec-21	2-4	268.0	10:42	24:00	R/V <i>Shearwater</i>
09-Dec-21	3-4	407.8	9:48	24:00	R/V <i>Shearwater</i>
10-Dec-21	3-4	-	-	8:00	R/V <i>Shearwater</i>

3.2 Marine Mammal and Sea Turtle Sightings

We recorded 85 cetacean sightings during these vessel surveys. Atlantic spotted dolphins (*Stenella frontalis*) ($n=41$) and bottlenose dolphins (*Tursiops truncatus*) ($n=38$) dominated the fauna. We also observed two groups of rough-toothed dolphins (*Steno bredanensis*), three groups of Risso's dolphins (*Grampus griseus*), and one unidentified dolphin (**Table 2 and Table 3**). We recorded eight sea turtles in the survey area during 2021, mostly loggerhead sea turtles (*Carreta caretta*) ($n=7$) (**Table 4**).

3.3 Distributions and Habitat Associations of Cetaceans

The distribution of marine mammal sightings from North Carolina to Florida and in the Jacksonville survey area are presented in Figure 10 and Figure 11, respectively. Similar to our observations in previous years, Atlantic spotted dolphins were restricted to shallow shelf waters, but bottlenose and rough-toothed dolphins were found both in shelf waters and offshore of the continental shelf break. Risso's dolphins were only sighted offshore of the continental shelf break.

3.4 Biopsy Sampling

We collected 13 biopsy samples in the Jacksonville survey area during 2021. Twelve samples were obtained from bottlenose dolphins and one sample came from an Atlantic spotted dolphin (**Table 5 and Figure 11**). Voucher specimens of these samples are archived at the Duke University Marine Laboratory in Beaufort, North Carolina.

Some of the samples we obtained were analyzed as part of a collaboration with Duke University's Bass Connections course, Learning from Whales, and resulted in a masters thesis project. Specifically, we investigated genetic variation between the coastal and pelagic ecotypes of bottlenose dolphins that occupy distinct habitats and engage in different patterns of diving behavior ([Shintaku 2021](#)).

To improve understanding of population structures in and between these groups, we investigated genome-wide genetic variation using restriction site associated DNA sequencing. A total of 96 samples was available from bottlenose dolphins in coastal and pelagic waters of the northwest Atlantic from North Carolina to Florida. Analysis of 14,783 single-nucleotide polymorphisms revealed at least three genetically differentiated populations through both Bayesian clustering analysis and Discriminate Analysis of Principal Components. These results suggest the existence of a coastal population along North Carolina's Outer Banks ($n=32$), a pelagic population off the continental shelf break from North Carolina to Jacksonville, Florida ($n=38$), and a shelf population off Jacksonville, Florida ($n=26$) (**Figure 12**).

Bayesian clustering showed significant admixture between the North Carolina and Jacksonville populations, providing potential evidence of historical or current gene flow (**Figure 13**). Thirty of the 32 coastal dolphins in the North Carolina population are confirmed to belong in the Western North Atlantic Southern Migratory Coastal Stock, which is thought to make seasonal migrations as far south as northern Florida. The spatial overlap of the Southern Migratory Stock with various other coastal stocks along the Atlantic coast may explain the mechanism of this

admixture. Most of the offshore samples were collected off Cape Hatteras, but this population also includes four individuals sampled beyond the continental shelf break off Jacksonville, Florida, in close spatial proximity to shelf animals (**Figure 14**). This suggests a sharp distinction between shelf and offshore individuals structured by the shelf break itself. The existence of this fine-scale population structure was unknown prior to the present analysis, as bottlenose dolphins are found on both sides of the shelf break. Such habitat heterogeneity is likely a driver in diversifying populations through influences on social behavior and foraging strategies ([Shintaku 2021](#)).

3.5 Satellite Tagging

Two satellite tags were deployed on rough-toothed dolphins in Jacksonville on 16 and 17 April, 2021 (**Table 6** and **Figure 15**). Tag Sbr001 transmitted for 6 days, showing the individual traveling out of the Jacksonville survey area and continuing north along the shelf break (**Figure 16**). Tag Sbr002 transmitted for less than 5 hours (**Figure 16**).

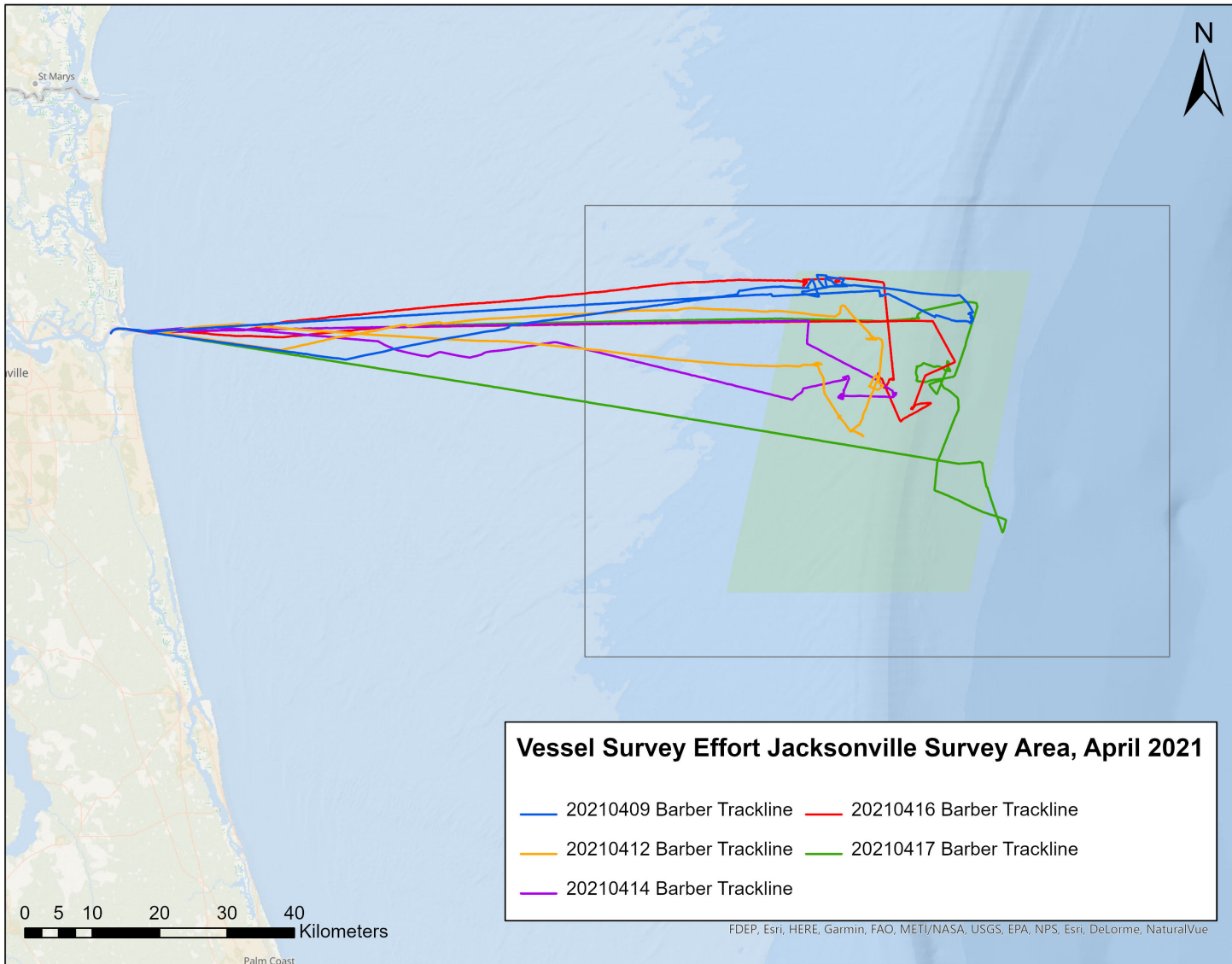


Figure 4. Effort during vessel surveys in the Jacksonville survey area in April 2021.

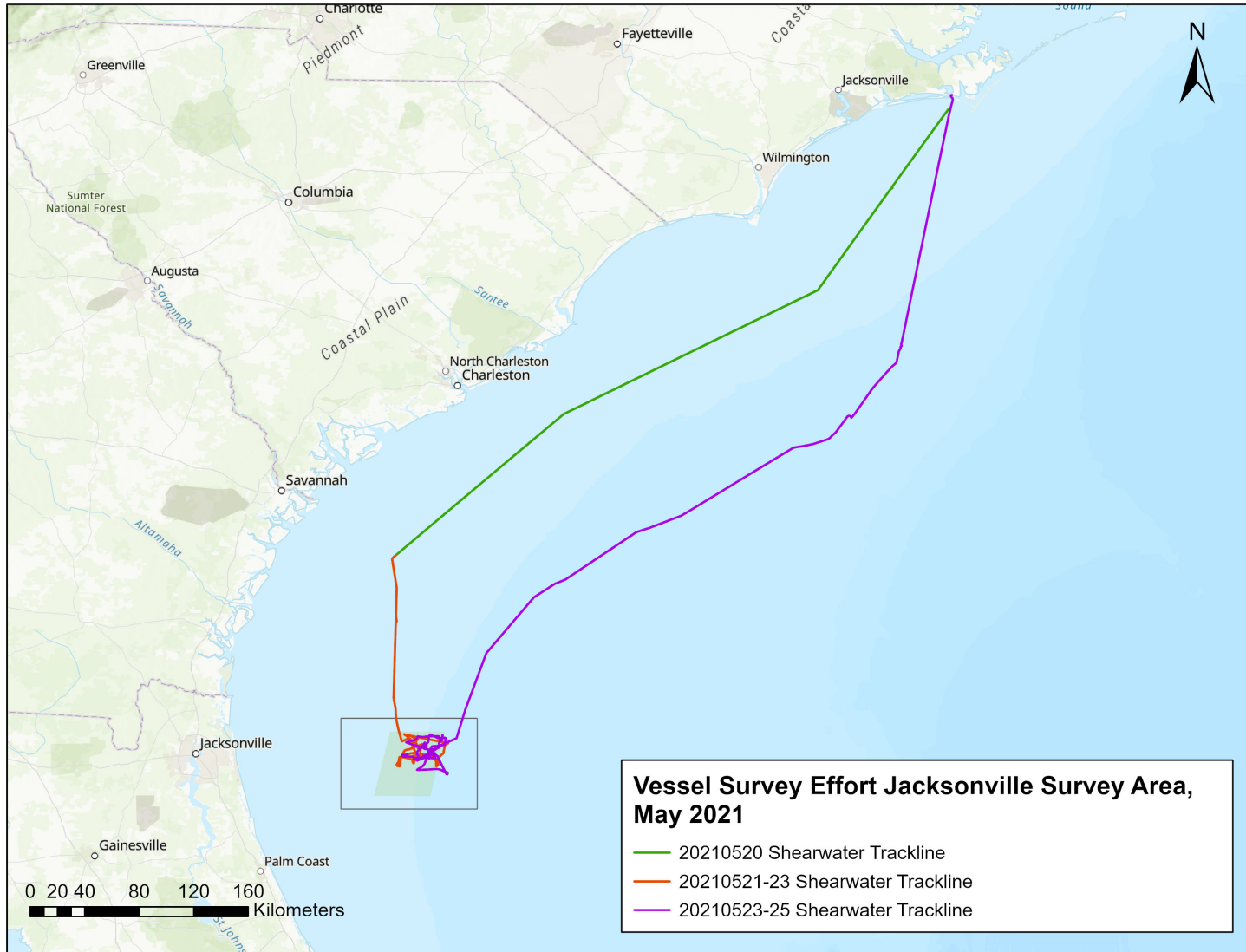


Figure 5. Survey effort during vessel transits and surveys in the Jacksonville survey area in May 2021.

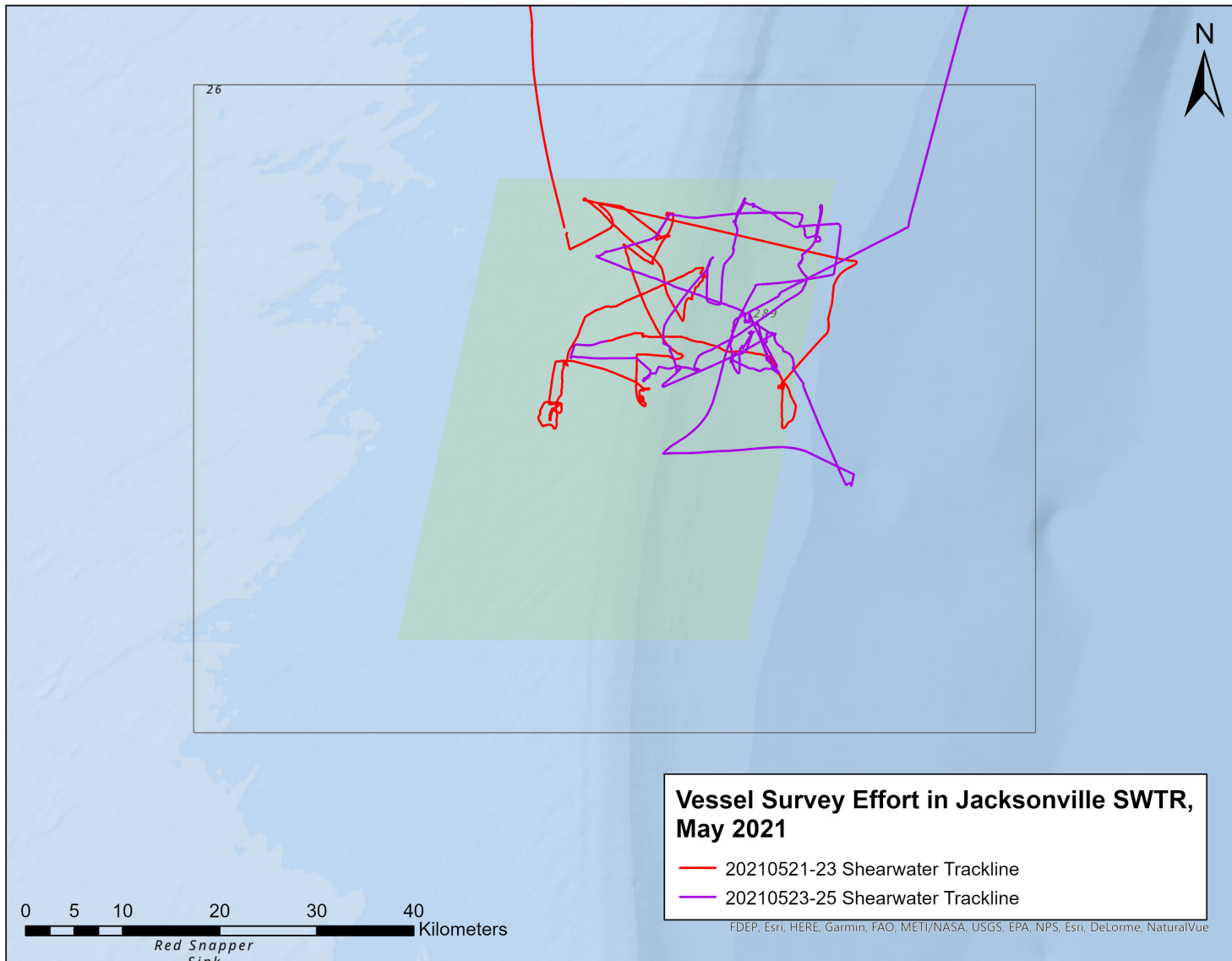


Figure 6. Effort during vessel surveys within the Jacksonville SWTR in May 2021.

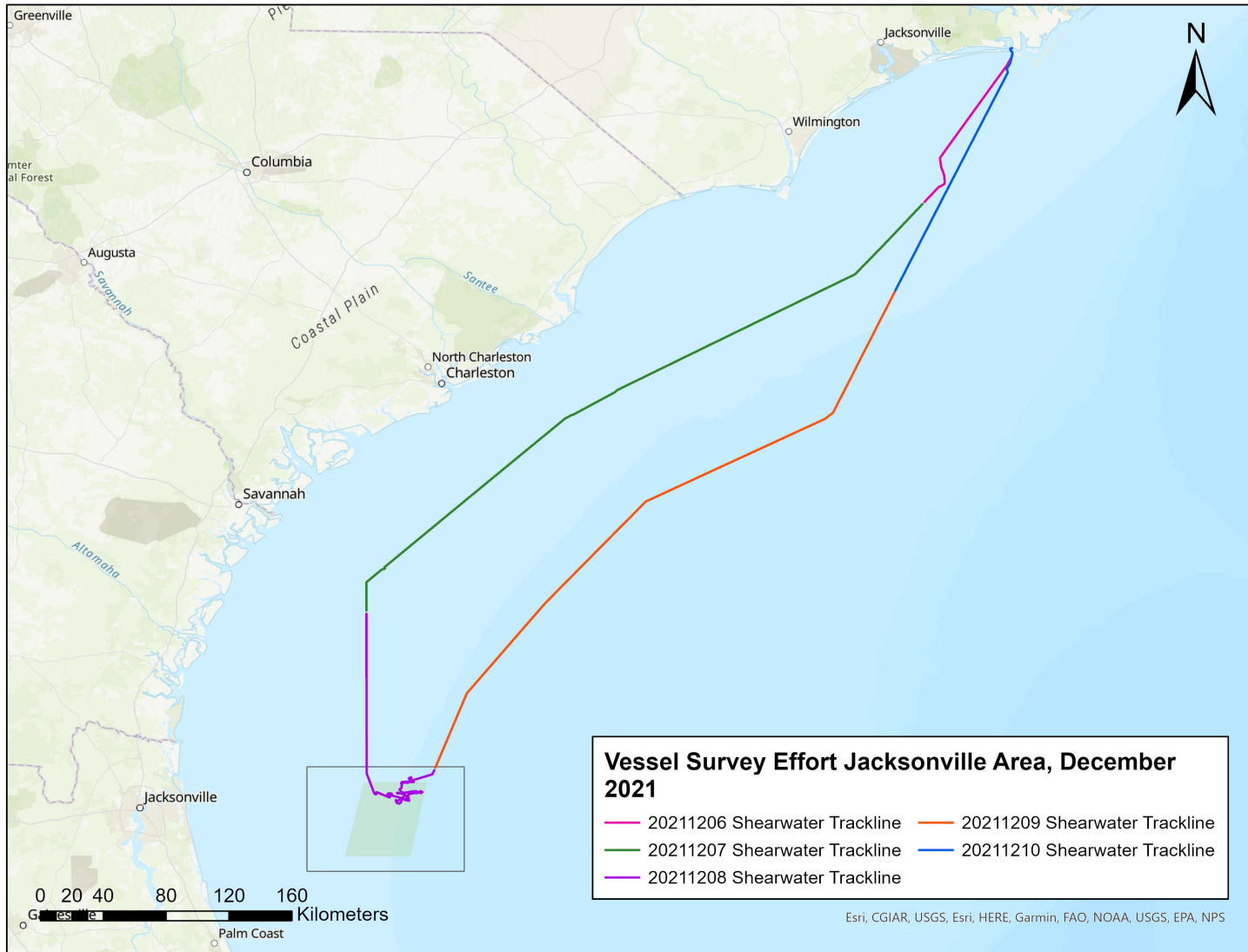


Figure 7. Survey effort during vessel transits surveys in the Jacksonville survey area in December 2021.

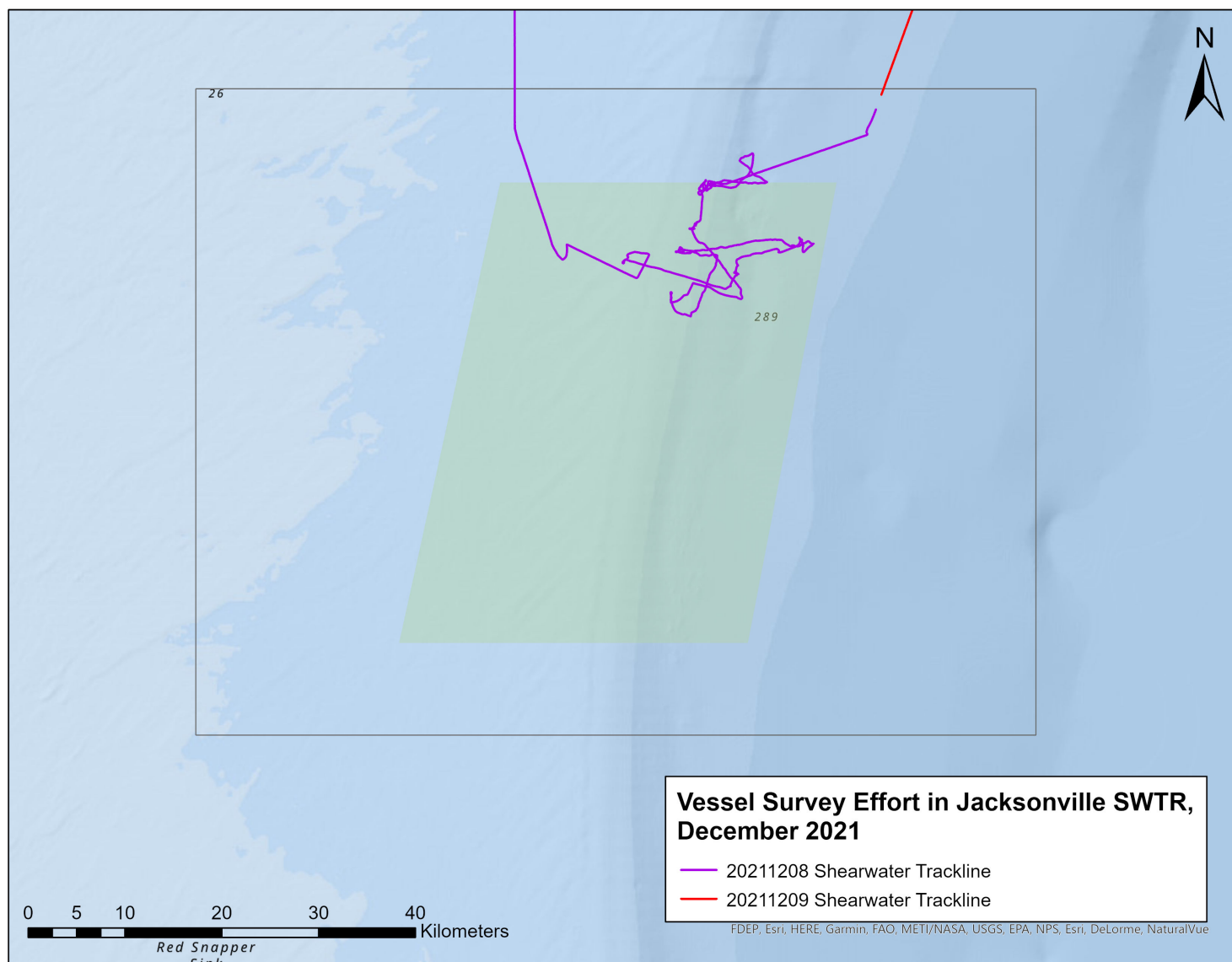


Figure 8. Survey effort during vessel surveys within the Jacksonville SWTR in December 2021.

Table 2. Cetacean sightings from vessel surveys in 2021.

Date	Time (local)	Latitude (°N)	Longitude (°W)	Species	Common Name	Group Size	Biopsy Samples	Photo-ID images
9-Apr-21	9:46:12	30.45165	80.46483	<i>Stenella frontalis</i>	Atlantic spotted dolphin	15		131
9-Apr-21	10:17:05	30.45730	80.35855	<i>Tursiops truncatus</i>	Bottlenose dolphin	3		33
9-Apr-21	14:37:45	30.42376	80.10945	<i>Tursiops truncatus</i>	Bottlenose dolphin	25	HJF-21-01	338
9-Apr-21	16:21:58	30.44713	80.24683	<i>Stenella frontalis</i>	Atlantic spotted dolphin	35		342
9-Apr-21	16:50:21	30.44637	80.41027	<i>Tursiops truncatus</i>	Bottlenose dolphin	4	ZTS-21-01	33
12-Apr-21	9:52:05	30.42730	80.56069	<i>Tursiops truncatus</i>	Bottlenose dolphin	1		0
12-Apr-21	10:48:31	30.41914	80.31971	<i>Tursiops truncatus</i>	Bottlenose dolphin	1		0
12-Apr-21	11:41:23	30.38948	80.26789	<i>Tursiops truncatus</i>	Bottlenose dolphin	4	ZTS-21-02	125
12-Apr-21	13:41:22	30.26599	80.28833	<i>Tursiops truncatus</i>	Bottlenose dolphin	1		15
12-Apr-21	14:17:20	30.28558	80.31025	<i>Tursiops truncatus</i>	Bottlenose dolphin	4		164
12-Apr-21	15:07:18	30.35629	80.34663	<i>Stenella frontalis</i>	Atlantic spotted dolphin	18		163
12-Apr-21	16:43:18	30.38547	80.81593	<i>Stenella frontalis</i>	Atlantic spotted dolphin	6		110
14-Apr-21	10:23:00	30.31591	80.37023	<i>Stenella frontalis</i>	Atlantic spotted dolphin	12		175
14-Apr-21	11:28:52	30.31541	80.30616	<i>Tursiops truncatus</i>	Bottlenose dolphin	3	ZTS-21-03	174
14-Apr-21	12:25:53	30.31698	80.22693	<i>Tursiops truncatus</i>	Bottlenose dolphin	3		29
14-Apr-21	13:37:41	30.40292	80.35776	<i>Stenella frontalis</i>	Atlantic spotted dolphin	3		46
16-Apr-21	12:00:00	30.32451	80.24159	<i>Steno bredanensis</i>	Rough-toothed dolphin	12		928
16-Apr-21	12:25:00	30.33027	80.23447	<i>Tursiops truncatus</i>	Bottlenose dolphin	1		15
16-Apr-21	14:49:00	30.29996	80.19500	<i>Tursiops truncatus</i>	Bottlenose dolphin	6	ZTS-21-04	110
17-Apr-21	15:03:20	30.35232	80.15765	<i>Steno bredanensis</i>	Rough-toothed dolphin	30		472
17-Apr-21	16:54:46	30.42206	80.18862	<i>Tursiops truncatus</i>	Bottlenose dolphin	2		26
17-Apr-21	17:14:42	30.41268	80.24513	<i>Stenella frontalis</i>	Atlantic spotted dolphin	5		32
20-May-21	16:14:16	33.91728	77.20019	<i>Stenella frontalis</i>	Atlantic spotted dolphin	3		0
20-May-21	19:09:46	33.56770	77.44893	<i>Stenella frontalis</i>	Atlantic spotted dolphin	4		0
20-May-21	20:12:47	33.44551	77.53568	<i>Tursiops truncatus</i>	Bottlenose dolphin	4		0
21-May-21	7:36:08	32.65604	79.10170	<i>Stenella frontalis</i>	Atlantic spotted dolphin	2		11

Date	Time (local)	Latitude (°N)	Longitude (°W)	Species	Common Name	Group Size	Biopsy Samples	Photo-ID images
21-May-21	10:05:57	32.42694	79.42692	<i>Stenella frontalis</i>	Atlantic spotted dolphin	2		0
21-May-21	10:38:13	32.37592	79.48722	<i>Stenella frontalis</i>	Atlantic spotted dolphin	2		0
21-May-21	11:13:53	32.31587	79.55818	<i>Stenella frontalis</i>	Atlantic spotted dolphin	2		0
21-May-21	12:40:08	32.17099	79.72911	<i>Stenella frontalis</i>	Atlantic spotted dolphin	2		0
21-May-21	13:01:31	32.13513	79.77143	<i>Stenella frontalis</i>	Atlantic spotted dolphin	6		129
21-May-21	14:00:22	32.04000	79.88349	<i>Stenella frontalis</i>	Atlantic spotted dolphin	2		31
21-May-21	15:07:22	31.93671	80.00510	<i>Stenella frontalis</i>	Atlantic spotted dolphin	5		57
21-May-21	15:39:38	31.88699	80.06348	<i>Stenella frontalis</i>	Atlantic spotted dolphin	3		18
21-May-21	18:11:44	31.65458	80.33627	<i>Stenella frontalis</i>	Atlantic spotted dolphin	2		14
21-May-21	18:34:41	31.61638	80.36129	<i>Stenella frontalis</i>	Atlantic spotted dolphin	2		0
22-May-21	8:17:18	30.43780	80.25340	<i>Stenella frontalis</i>	Atlantic spotted dolphin	7		107
22-May-21	9:59:04	30.44830	80.19408	<i>Tursiops truncatus</i>	Bottlenose dolphin	2		8
22-May-21	11:35:21	30.31672	80.18143	<i>Stenella frontalis</i>	Atlantic spotted dolphin	12		91
22-May-21	17:22:10	30.39391	80.15792	<i>Grampus griseus</i>	Risso's dolphin	9		159
23-May-21	10:02:33	30.33297	80.21997	<i>Tursiops truncatus</i>	Bottlenose dolphin	10	ZTS_21_05	148
23-May-21	10:13:12	30.33529	80.22045	<i>Stenella frontalis</i>	Atlantic spotted dolphin	11		89
23-May-21	10:52:00	30.32294	80.29529	<i>Stenella frontalis</i>	Atlantic spotted dolphin	20	ZTS_21_06	268
23-May-21	12:23:46	30.30114	80.16115	<i>Stenella frontalis</i>	Atlantic spotted dolphin	2		69
23-May-21	13:07:09	30.39017	80.04813	<i>Grampus griseus</i>	Risso's dolphin	26		138
23-May-21	14:35:15	30.43988	80.05248	<i>Grampus griseus</i>	Risso's dolphin	25		104
23-May-21	15:11:36	30.44657	80.18839	<i>Tursiops truncatus</i>	Bottlenose dolphin	1		7
23-May-21	15:49:47	30.40845	80.26700	<i>Tursiops truncatus</i>	Bottlenose dolphin	1		0
23-May-21	16:34:12	30.35265	80.11187	<i>Tursiops truncatus</i>	Bottlenose dolphin	15	ZTS_21_07	210
23-May-21	18:08:19	30.32720	80.09019	<i>Tursiops truncatus</i>	Bottlenose dolphin	15		21
23-May-21	19:55:23	30.19455	80.00379	<i>Tursiops truncatus</i>	Bottlenose dolphin	5		35
24-May-21	9:12:46	30.44229	80.12168	<i>Stenella frontalis</i>	Atlantic spotted dolphin	3		46
24-May-21	10:52:28	30.39582	80.15194	<i>Stenella frontalis</i>	Atlantic spotted dolphin	9		64

Date	Time (local)	Latitude (°N)	Longitude (°W)	Species	Common Name	Group Size	Biopsy Samples	Photo-ID images
24-May-21	12:03:59	30.32709	80.19933	<i>Stenella frontalis</i>	Atlantic spotted dolphin	54		395
24-May-21	12:45:54	30.32356	80.19232	<i>Tursiops truncatus</i>	Bottlenose dolphin	14		142
24-May-21	14:29:59	30.35188	80.10640	<i>Tursiops truncatus</i>	Bottlenose dolphin	6	ZTS_21_08	60
24-May-21	15:38:49	30.31236	80.12513	<i>Tursiops truncatus</i>	Bottlenose dolphin	14	ZTS_21_09	87
24-May-21	16:23:55	30.33706	80.10532	<i>Tursiops truncatus</i>	Bottlenose dolphin	6		30
24-May-21	17:09:33	30.31152	80.12657	<i>Tursiops truncatus</i>	Bottlenose dolphin	21	ZTS_21_10	130
25-May-21	6:00:00	32.07510	78.19562	<i>Tursiops truncatus</i>	Bottlenose dolphin	2		0
6-Dec-21	10:40:50	34.66287	76.67404	<i>Tursiops truncatus</i>	Bottlenose dolphin	6		0
6-Dec-21	10:43:09	34.66287	76.67404	<i>Tursiops truncatus</i>	Bottlenose dolphin	3		0
6-Dec-21	11:11:42	34.58900	76.71936	<i>Tursiops truncatus</i>	Bottlenose dolphin	3		0
6-Dec-21	12:51:44	34.38663	76.86468	<i>Stenella frontalis</i>	Atlantic spotted dolphin	6		0
6-Dec-21	13:37:59	34.27987	76.94115	<i>Stenella frontalis</i>	Atlantic spotted dolphin	7		0
7-Dec-21	7:15:04	32.64939	79.08874	<i>Stenella frontalis</i>	Atlantic spotted dolphin	1		0
7-Dec-21	7:28:12	32.63175	79.12101	<i>Stenella frontalis</i>	Atlantic spotted dolphin	4		0
7-Dec-21	8:58:40	32.49246	79.32862	<i>Stenella frontalis</i>	Atlantic spotted dolphin	2		0
7-Dec-21	10:47:57	32.30916	79.54979	<i>Stenella frontalis</i>	Atlantic spotted dolphin	2		0
7-Dec-21	10:54:15	32.29917	79.56188	<i>Stenella frontalis</i>	Atlantic spotted dolphin	10		106
7-Dec-21	11:33:22	32.23471	79.63950	<i>Stenella frontalis</i>	Atlantic spotted dolphin	10		118
7-Dec-21	13:22:39	32.06448	79.84433	unidentified dolphin	unidentified dolphin	2		0
7-Dec-21	14:56:59	31.91571	80.02300	<i>Stenella frontalis</i>	Atlantic spotted dolphin	7		199
7-Dec-21	16:33:23	31.76121	80.20820	<i>Stenella frontalis</i>	Atlantic spotted dolphin	8		96
7-Dec-21	16:55:10	31.72508	80.25130	<i>Tursiops truncatus</i>	Bottlenose dolphin	7		28
7-Dec-21	17:15:24	31.70748	80.27034	<i>Stenella frontalis</i>	Atlantic spotted dolphin	9		41
8-Dec-21	7:06:38	30.41079	80.23846	<i>Stenella frontalis</i>	Atlantic spotted dolphin	2		0
8-Dec-21	8:04:00	30.38160	80.13208	<i>Tursiops truncatus</i>	Bottlenose dolphin	30	ZTS-21-024	249
8-Dec-21	9:12:27	30.42452	80.05411	<i>Tursiops truncatus</i>	Bottlenose dolphin	4		33
8-Dec-21	9:34:30	30.42093	80.05074	<i>Tursiops truncatus</i>	Bottlenose dolphin	3		63

Date	Time (local)	Latitude (°N)	Longitude (°W)	Species	Common Name	Group Size	Biopsy Samples	Photo-ID images
8-Dec-21	12:35:34	30.35755	80.18223	<i>Stenella frontalis</i>	Atlantic spotted dolphin	13		216
8-Dec-21	14:05:34	30.43406	80.16898	<i>Tursiops truncatus</i>	Bottlenose dolphin	1	ZTS-21-025	41
9-Dec-21	10:28:27	32.62054	77.68846	<i>Tursiops truncatus</i>	Bottlenose dolphin	1		0
9-Dec-21	10:43:21	32.65049	77.67346	<i>Tursiops truncatus</i>	Bottlenose dolphin	1		0
9-Dec-21	12:54:34	32.89683	77.54934	<i>Tursiops truncatus</i>	Bottlenose dolphin	4		5

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

Table 3. Numbers of cetacean sightings for each species observed during vessel surveys in 2021.

Species	Sightings 2021
<i>Grampus griseus</i>	3
<i>Stenella frontalis</i>	41
<i>Steno bredanensis</i>	2
<i>Tursiops truncatus</i>	38
Unidentified	1
Total	85

Table 4. Sea turtle sightings from vessel surveys in 2021.

Date	Time (local)	Latitude (°N)	Longitude (°W)	Species	Common Name	Group Size
14-Apr-21	11:13:23	30.32064	80.30308	<i>Caretta caretta</i>	Loggerhead sea turtle	1
16-Apr-21	13:59:20	30.29780	80.22534	<i>Caretta caretta</i>	Loggerhead sea turtle	1
20-May-21	14:48:35	34.06626	77.09399	<i>Caretta caretta</i>	Loggerhead sea turtle	1
21-May-21	11:36:49	32.27731	79.60365	<i>Caretta caretta</i>	Loggerhead sea turtle	1
25-May-21	10:11:00	32.44129	77.46845	<i>Caretta caretta</i>	Loggerhead sea turtle	1
7-Dec-21	8:56:03	32.49246	79.32862	<i>Caretta caretta</i>	Loggerhead sea turtle	1
7-Dec-21	11:04:41	32.28201	79.58249	unidentified turtle	unidentified turtle	1
8-Dec-21	11:15:14	30.41531	80.17906	<i>Caretta caretta</i>	Loggerhead sea turtle	1

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

Table 5. Biopsy samples collected in the Jacksonville survey area in 2021.

Date	Time (local)	Latitude (°N)	Longitude (°W)	Species	Sample #
9-Apr-21	14:37:45	30.42376	80.10945	<i>Tursiops truncatus</i>	HJF-21-01
9-Apr-21	16:50:21	30.44637	80.41027	<i>Tursiops truncatus</i>	ZTS-21-01
12-Apr-21	11:41:23	30.38948	80.26789	<i>Tursiops truncatus</i>	ZTS-21-02
14-Apr-21	11:28:52	30.31541	80.30616	<i>Tursiops truncatus</i>	ZTS-21-03
16-Apr-21	14:49:00	30.29996	80.19500	<i>Tursiops truncatus</i>	ZTS-21-04
23-May-21	10:02:33	30.33297	80.21997	<i>Tursiops truncatus</i>	ZTS-21-05
23-May-21	10:52:00	30.32294	80.29529	<i>Stenella frontalis</i>	ZTS-21-06
23-May-21	16:34:12	30.35265	80.11187	<i>Tursiops truncatus</i>	ZTS-21-07
24-May-21	14:29:59	30.35188	80.10640	<i>Tursiops truncatus</i>	ZTS-21-08
24-May-21	15:38:49	30.31236	80.12513	<i>Tursiops truncatus</i>	ZTS-21-09
24-May-21	17:09:33	30.31152	80.12657	<i>Tursiops truncatus</i>	ZTS-21-10
8-Dec-21	8:04:00	30.38160	80.13208	<i>Tursiops truncatus</i>	ZTS-21-024
8-Dec-21	14:05:34	30.43406	80.16898	<i>Tursiops truncatus</i>	ZTS-21-025

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

Table 6. Satellite tags deployed in the Jacksonville survey area in 2021.

Date	Time (local)	Latitude (°N)	Longitude (°W)	Species	Tag #
16-Apr-21	12:00:00	30.32451	80.24159	<i>Steno bredanensis</i>	SbrTag001
17-Apr-21	15:03:20	30.35232	80.15765	<i>Steno bredanensis</i>	SbrTag002

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

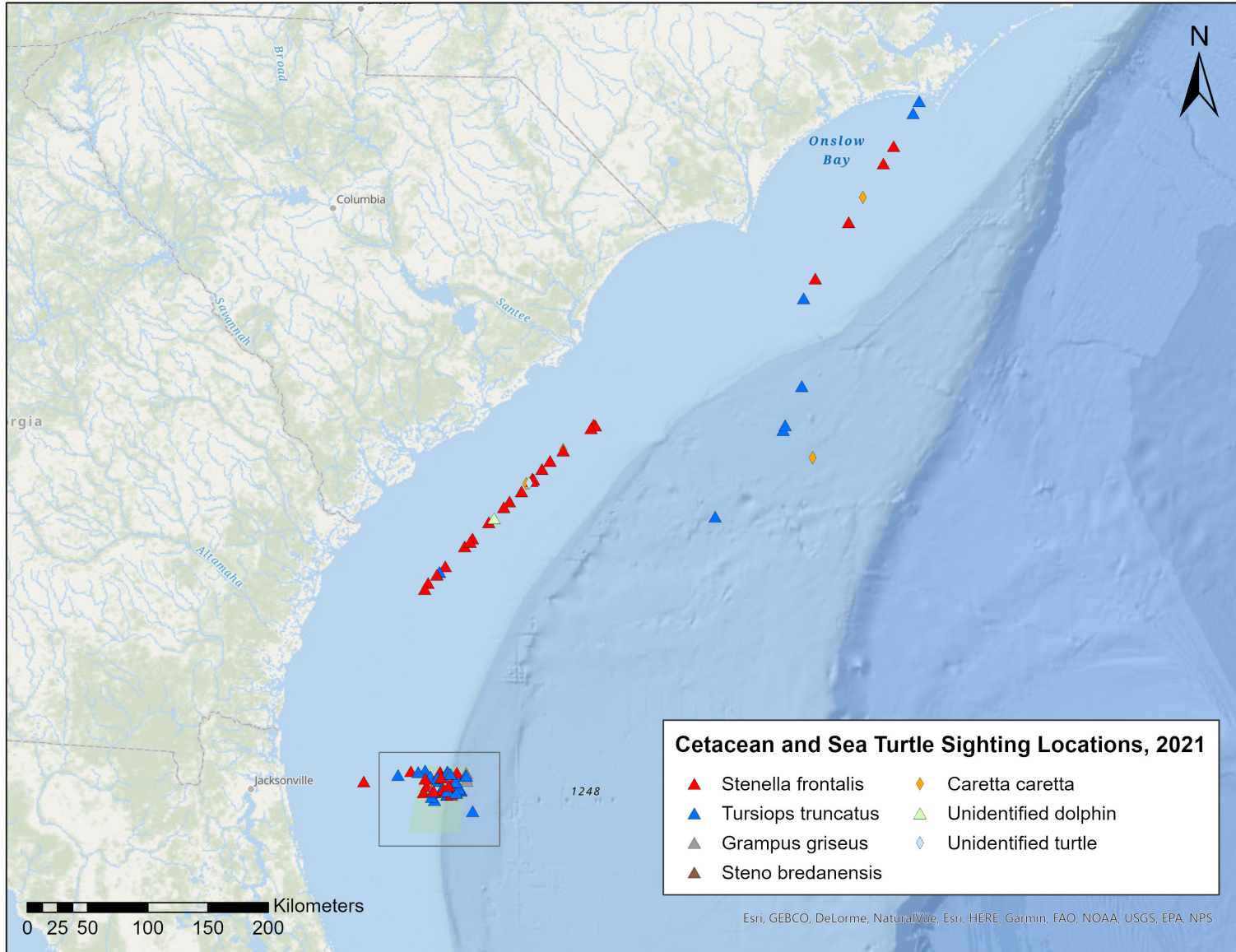


Figure 9. Distribution of all cetacean and sea turtle sightings made during vessel surveys in 2021.

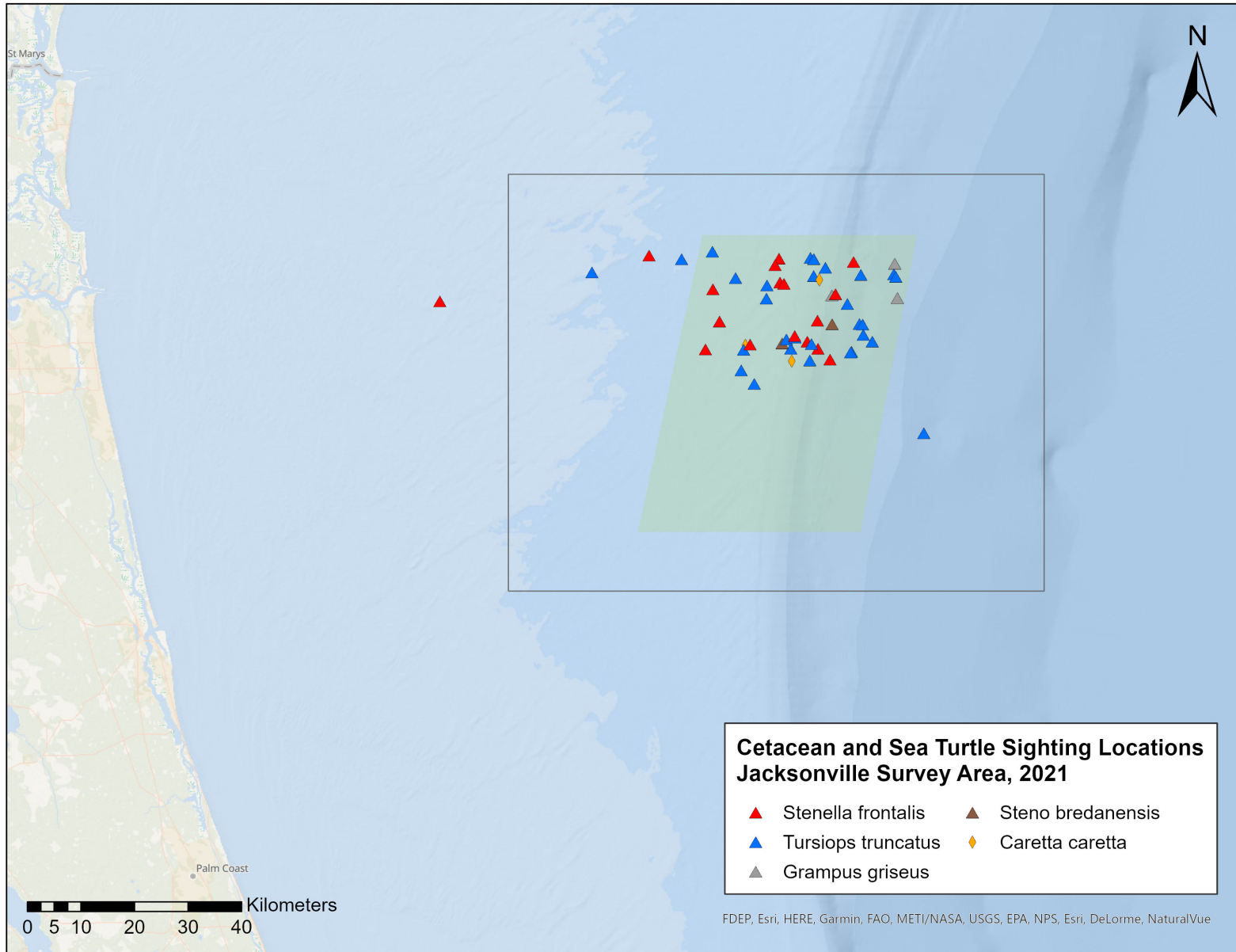


Figure 5. Distribution of all cetacean and sea turtle sightings made during vessel surveys in the Jacksonville survey area in 2021.

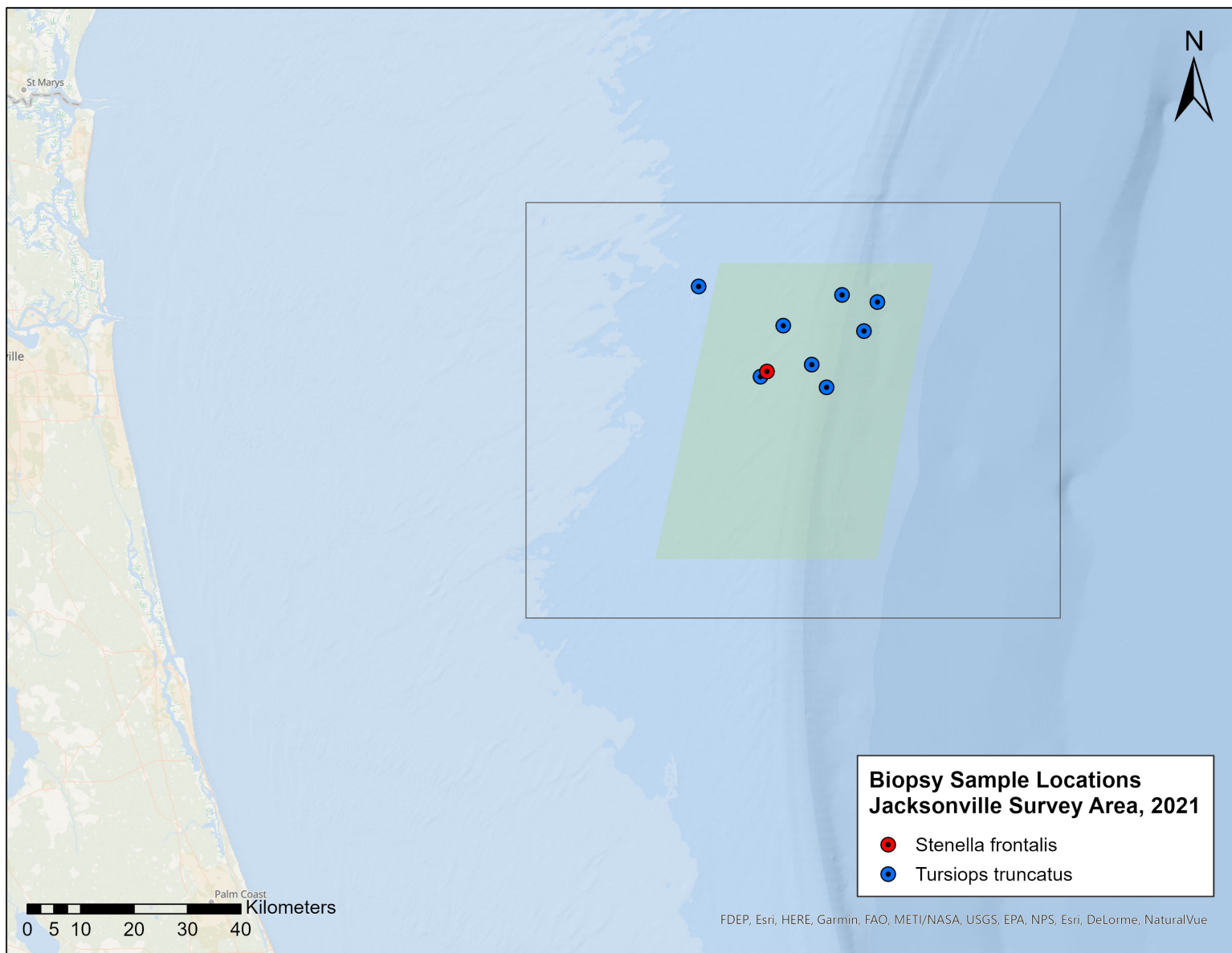


Figure 6. Locations of biopsy samples collected in the Jacksonville study area in 2021.

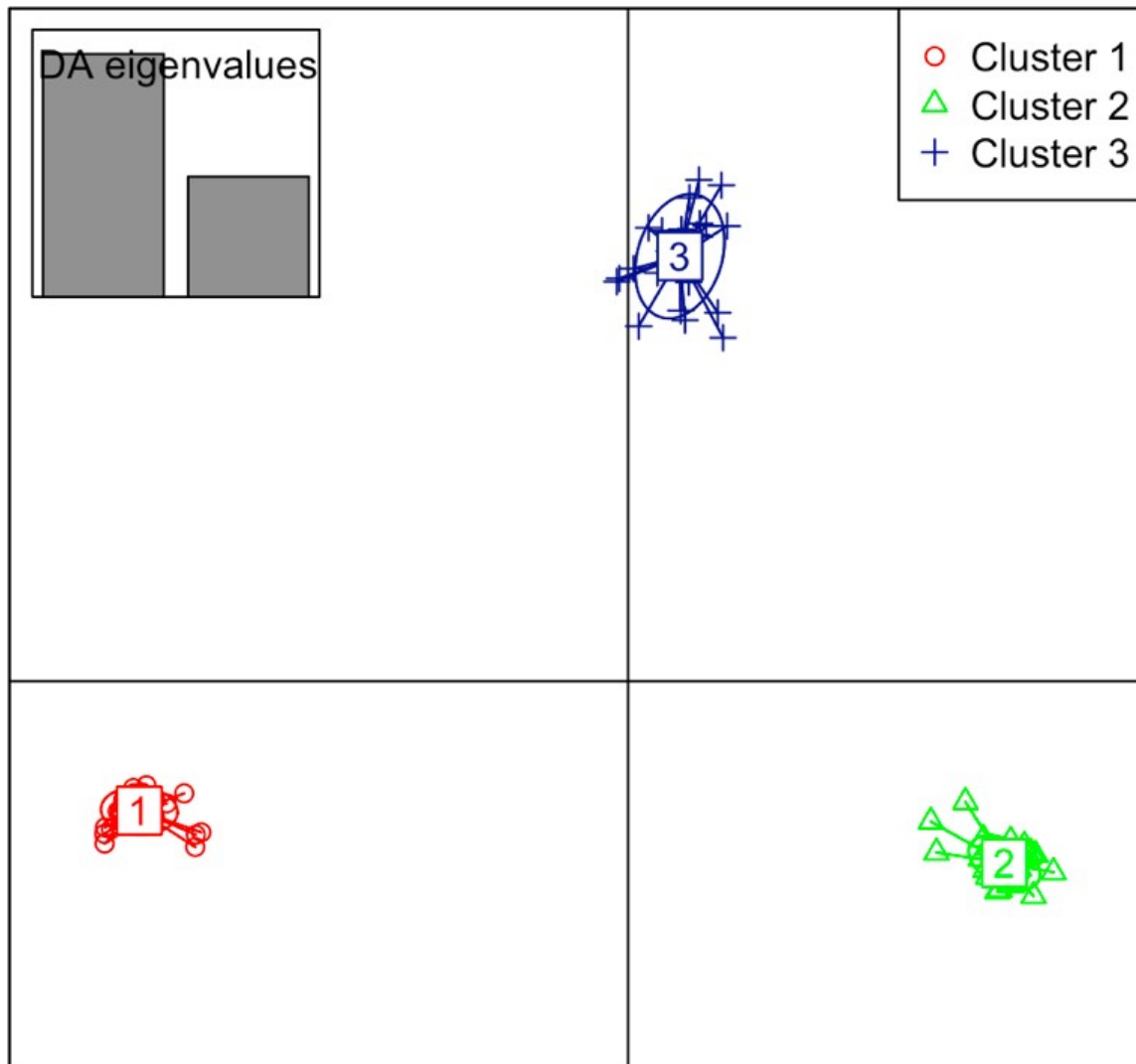


Figure 7. Discriminate Analysis of Principal Components results color coded by cluster. Eigenvalues correspond to the ratio of the variance between groups over the variance within groups for each discriminant function. 1 (red): Inshore cluster, 2 (green): Offshore cluster, and 3 (blue): Jacksonville, Florida cluster.

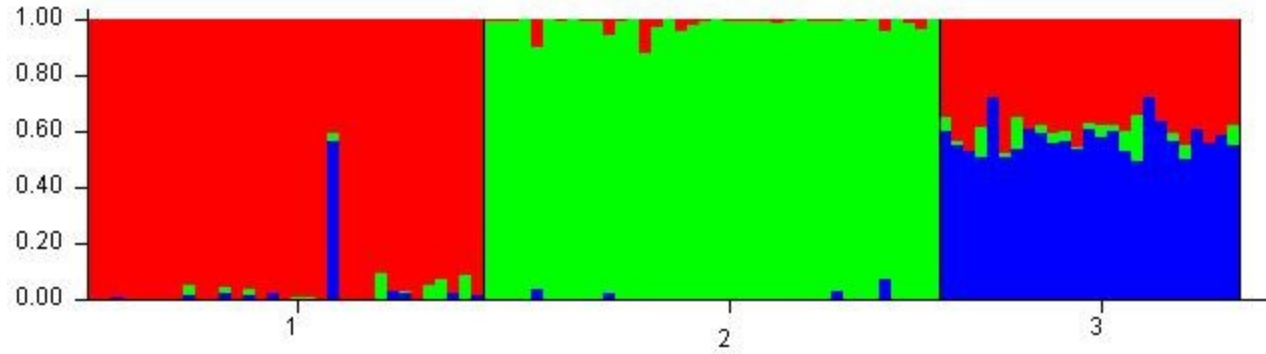


Figure 8. Structure results ordered by geographic sampling location. 1 (red): Inshore cluster, 2 (green): Offshore cluster, and 3 (blue): Jacksonville, Florida cluster.

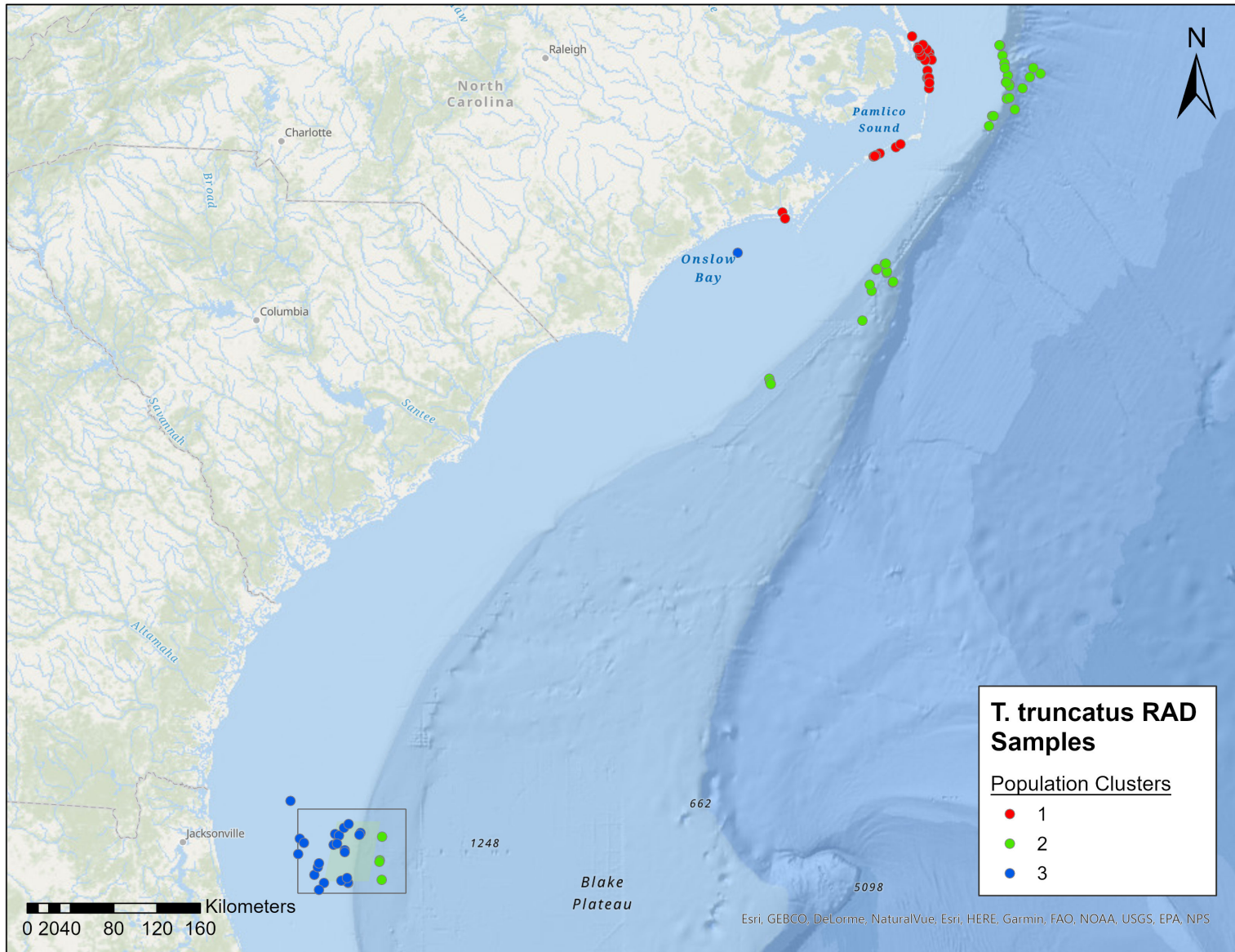


Figure 9. Locations of bottlenose dolphin samples displaying population cluster assignments designated from Discriminate Analysis of Principal Components and Structure results.

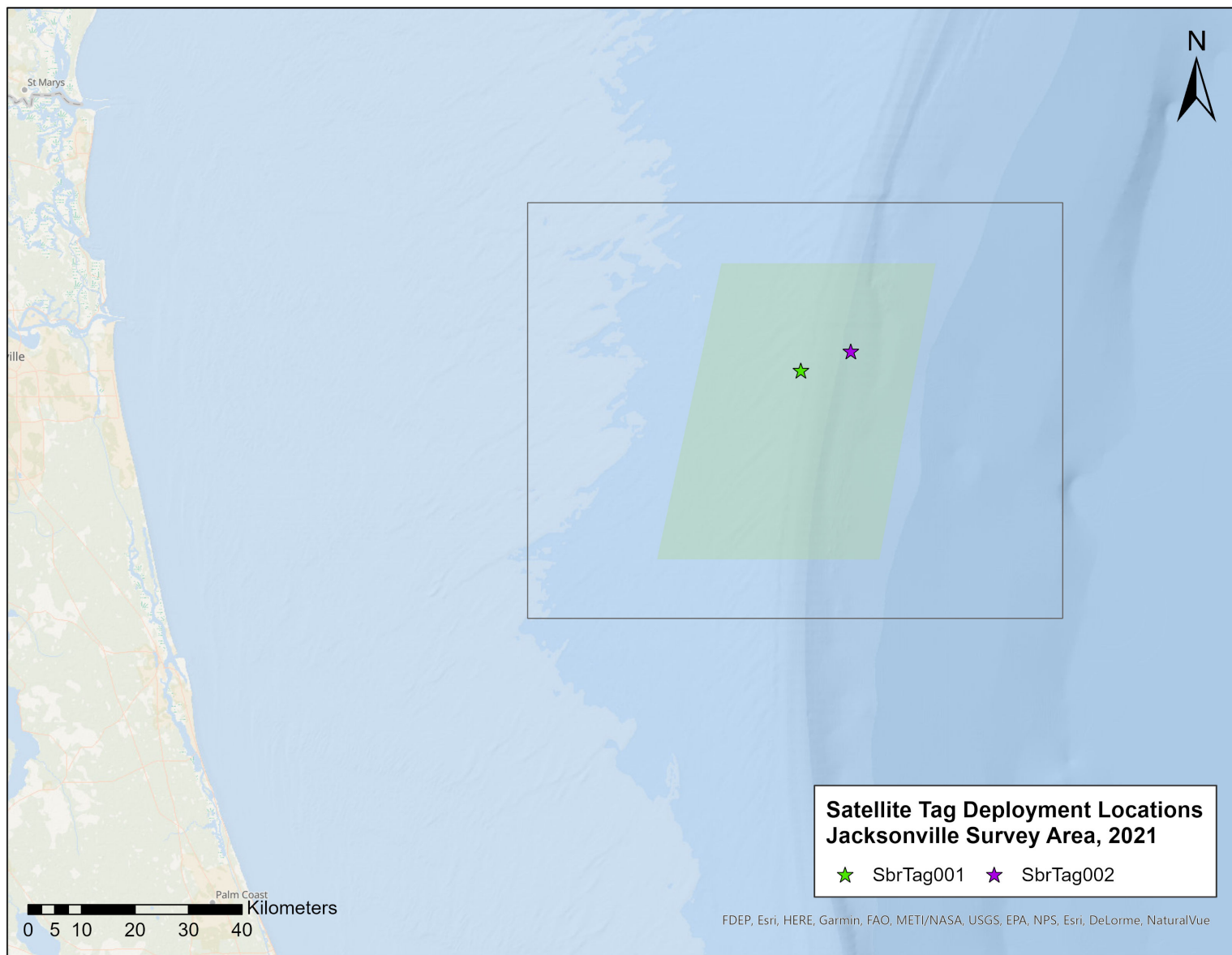


Figure 10. Locations of rough-toothed dolphin satellite-tag deployments in the Jacksonville survey area in 2021.

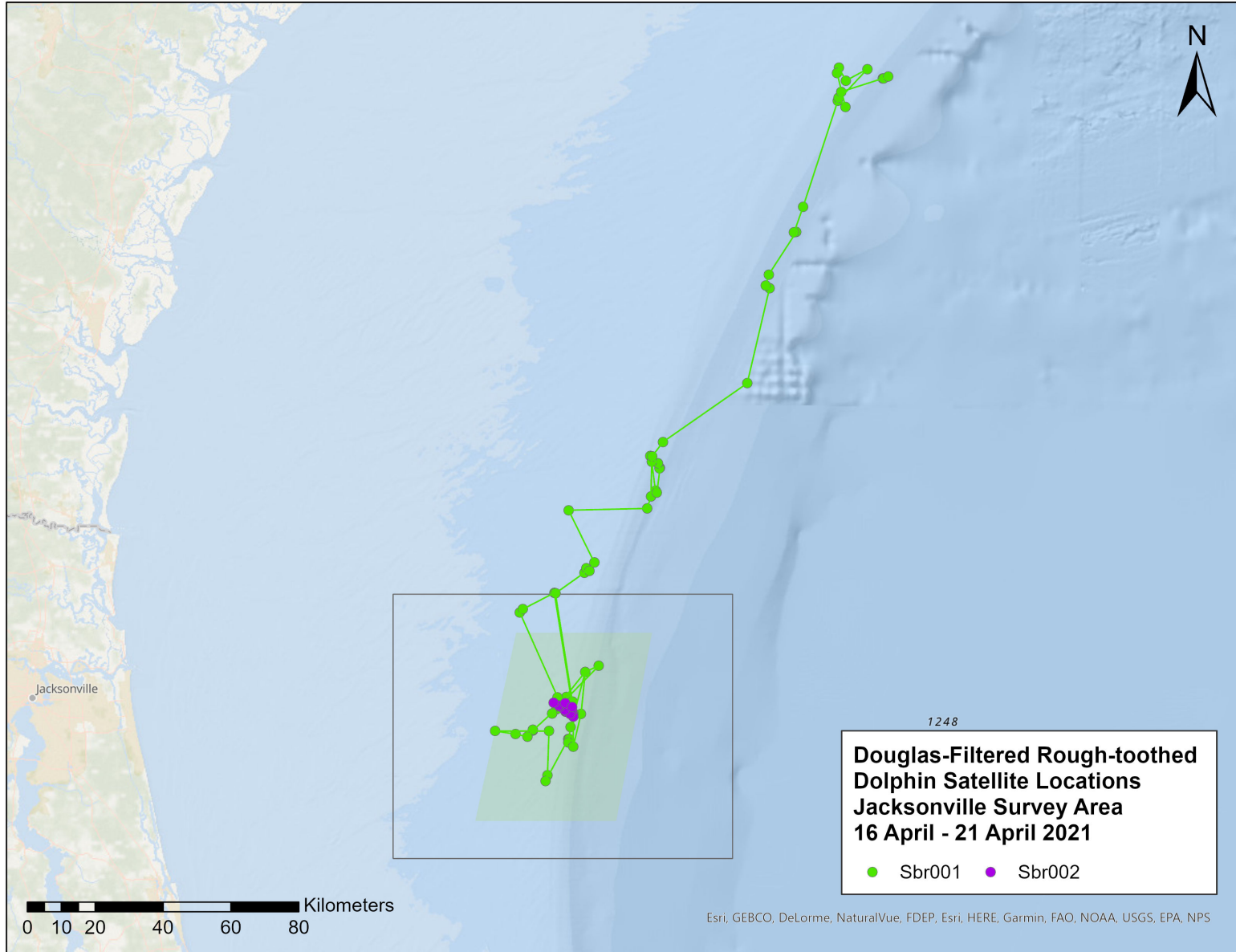


Figure 11. Locations of satellite-tagged rough-toothed dolphins tagged in the Jacksonville survey area in 2021.

3.6 Photographic Effort

Over 7,350 digital images were collected for species confirmation and individual identification during 2021. All images have been coded and graded for distinctiveness and photographic quality. Photo-ID analysis has identified 17 new Risso’s dolphins, 52 new Atlantic spotted dolphins, 55 new bottlenose dolphins, and 24 new rough-toothed dolphins (**Table 7**).

Table 7. Summary of photographs taken of animals in the Jacksonville survey area in 2021, with photo-ID catalog sizes and total number of matches within the catalog to date.

Species	Common Name	Images 2021	Catalog Size	Matches To Date
<i>G. macrorhynchus</i>	Short-finned pilot whale	0	52	0
<i>G. griseus</i>	Risso's dolphin	400	73	1
<i>S. frontalis</i>	Atlantic spotted dolphin	3151	256	25
<i>T. truncatus</i>	Bottlenose dolphin	2345	186	23
<i>S. bredanensis</i>	Rough-toothed dolphin	1400	78	10

To date, 25 individual Atlantic spotted dolphins, or 9.7 percent of the catalogued individuals, have been re-sighted within the Jacksonville survey area (Figure 18). Our longest match of a pair of Atlantic spotted dolphins was made this year. First observed together in October 2014, Sfr 8-027 and Sfr 1-008 were seen together again in 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 8**). Three of these eight individuals were observed together in July of 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 in each sighting (Table 8).

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-sights in Jacksonville across two 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, then again in July 2013. Ttr 6-037 and Ttr 6-038 were first observed together in September 2013 and seen again in February 2017. Ttr 6-007, first catalogued 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 in the Jacksonville survey area, first seen together in 2015 and then again in 2017 (**Table 8** and **Figure 17**). One individual from this trio (Ttr 7-030) was also observed in April 2015, before the trio was first documented, but photo 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 first for this catalog. Ggr 1-013 was first observed in June 2017 and seen 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 originally observed in September 2016, then seen again in April 2021. Sbr 7-019 was originally observed in July 2017 and re-sighted in April 2021 (**Table 8**). 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 in the following paragraphs.

Table 8. Photo-ID matches of delphinids observed in the Jacksonville survey area.

ID ¹	Year										
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2021
Ttr 1-017											X ^m
Ttr 1-018											X ^m
Ttr 1-023											X ^m
Ttr 6-007					X				X		
Ttr 6-010 [^]				X	X						
Ttr 6-036 [^]				X	X						
Ttr 6-037 [^]					X				X		
Ttr 6-038 [^]					X				X		
Ttr 6-047											X ^m
Ttr 6-048											X ^m
Ttr 6-050											X ^m
Ttr 6-051											X ^m
Ttr 7-022 [^]							X		X		
Ttr 7-030 [^]							X ^y		X		
Ttr 7-031 [^]							X		X		
Ttr 7-042											X ^m
Ttr 7-043											X ^m
Ttr 7-047											X ^m
Ttr 8-018											X ^m
Ttr 9-025											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 2-002		X							X		
Sfr 2-006				X				X			
Sfr 3-001		X	X								
Sfr 7-008 [^]					X			X	X		
Sfr 9-011 [^]					X				X		
Sfr 7-010					X				X		
Sfr 7-015						X			X		
Sfr 8-005			X ^m								
Sfr 8-037 [^]									X ^y		
Sfr DU 8-014 [^]									X ^y		
Sfr 6-006 [^]						X			X ^m		
Sfr 7-013 [^]						X			X ^m		
Sfr 7-014 [^]						X			X ^m		
Sfr 8-027						X					X
Sfr 8-038 [^]									X ^m		
Sfr 9-037 [^]									X ^m		
Sfr DU 1-003 [^]									X ^m		
Sfr DU 6-010 [^]									X ^m		
Sfr DU 7-008 [^]									X ^m		

Sfr 6-024^								X	X		
Sfr 7-035^								X	X		
Sfr 9-040^								X	X		
Sfr 6-010		X							X		
Sfr 8-052											X ^m
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

¹ Sfr=*Stenella frontalis* (Atlantic spotted dolphin); Ttr=*Tursiops truncatus* (bottlenose dolphin); Sbr = *Steno bredanensis* (rough-toothed dolphin); Ggr= *Grampus griseus* (Risso's dolphin)

^ – Observed together in multiple sightings

^m – re-sighted within same month

y – re-sighted within same year

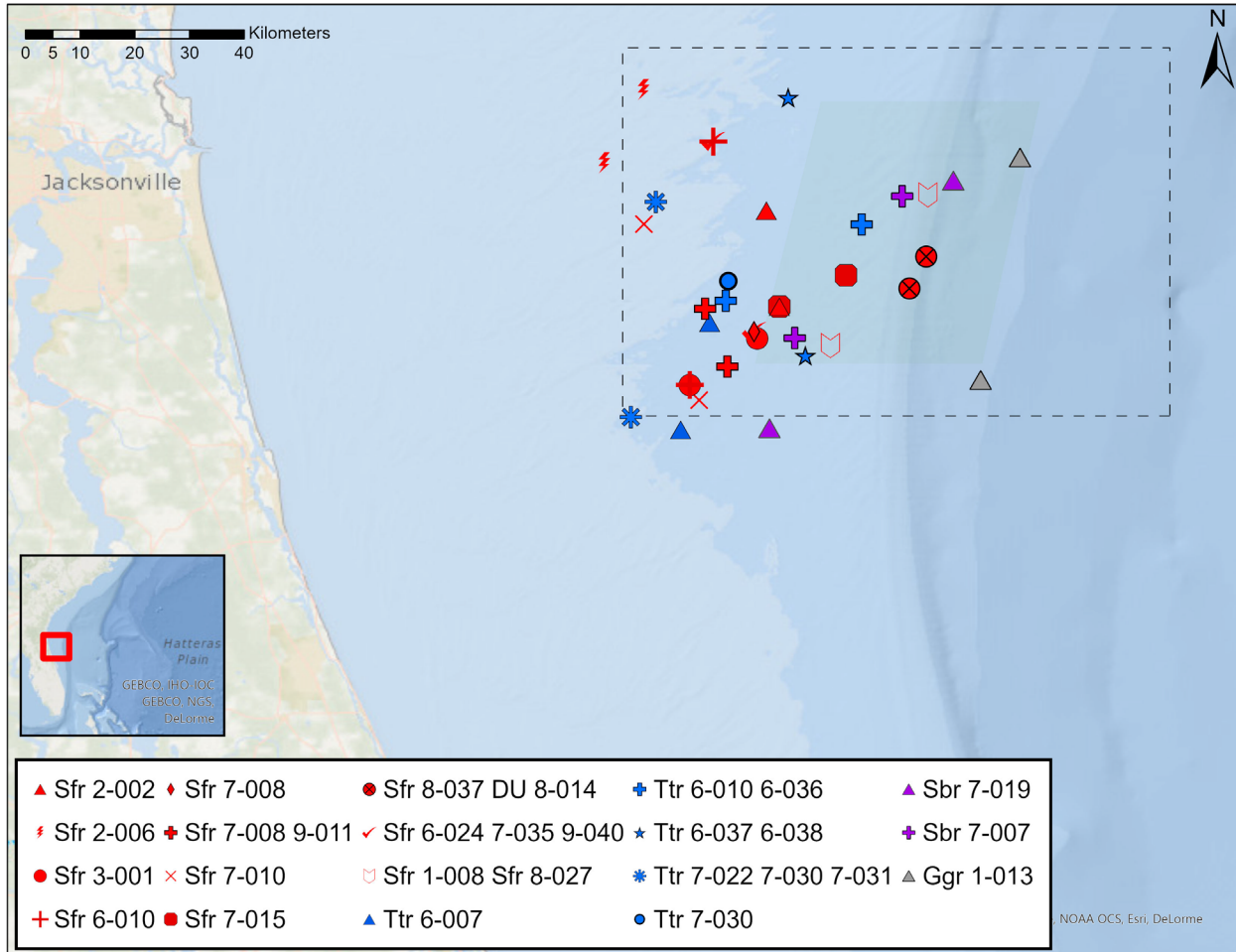


Figure 12. Locations of photo-matched dolphins within the Jacksonville survey area, excluding same-day or next-day re-sightings.

The Jacksonville short-finned pilot whale photo-identification catalog had been compared previously to both the Onslow Bay and Cape Hatteras short-finned pilot whale photo-ID catalogs, and no matches had been identified.

However, as reported in [Foley et al. \(2017\)](#), seven short-finned pilot whales were observed in the Bahamas in 2007 and then in 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 in Onslow Bay two months later.

4. Summary Tables

Total survey effort conducted since the beginning of the monitoring program in the Jacksonville study area, including all AFTT protected species monitoring and tagging effort, is reported in **Table 9**. The annual numbers of sightings by species for both cetaceans and sea turtles in Jacksonville are presented in **Table 10** and **Table 11**. The number of biopsy samples collected to date is reported in **Table 12**. **Table 13** summarizes the photo-ID catalog sizes and matches by species to date and images taken during the reporting period in the Jacksonville survey area. For information on Cape Hatteras survey effort and sighting information, please refer to [Southall et al. 2022](#).

Table 9. Vessel survey effort from July 2009 through December 2021.

	2009–10	2011	2012	2013	2014	2015	2016	2017	2018	2021	Total
Survey Hours	127.1	20.9	58.6	58.7	66.8	44.2	130.7	66.1	15.3	123.6	712
km Surveyed	2,073.5	345.7	937.4	1,021.7	1,227.4	858.2	2,135.5	1424.2	315.0	3,941.6	14,280.2

Table 10. Cetacean sightings by species from July 2009 through December 2021 during vessel surveys in the Jacksonville survey area.

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

Table 11. Sea turtle sightings by species from July 2009 through December 2021 during surveys in the Jacksonville survey area.

Species	Sightings									
	2009–10	2011	2012	2013	2014	2015	2016	2017	2018	2021
<i>Caretta caretta</i>	52	20	41	33	31	22	22	24	0	7
<i>Dermochelys coriacea</i>	8	3	4	1	3	2	4	2	0	0
<i>Lepidochelys kempii</i>	1	0	1	0	0	0	0	0	0	0
Unidentified sea turtle	8	3	3	1	0	0	0	3	0	1
Total	69	26	49	35	34	24	26	29	0	8

Table 12. Biopsy samples collected from July 2009 through December 2021 during vessel surveys in the Jacksonville survey area.

Species	2009-10	2011	2012	2013	2014	2015	2016	2017	2018	2021	Total
<i>Globicephala macrorhynchus</i>	0	0	0	0	0	0	5	0	1	0	6
<i>Grampus griseus</i>	0	0	0	1	2	0	0	0	0	0	3
<i>Stenella attenuata</i>	0	0	0	0	0	0	1	0	0	0	1
<i>Stenella frontalis</i>	0	0	19	6	19	3	7	8	0	1	63
<i>Steno bredanensis</i>	0	0	0	0	0	0	4	2	0	0	6
<i>Tursiops truncatus</i>	0	0	12	5	10	5	5	2	0	12	51
Total	0	0	31	12	31	8	22	12	1	13	130

Table 13. Summary of images collected during all vessel surveys in the Jacksonville survey area from 2009 through 2021, with photo-identification catalog sizes and matches to date.

Species	2009-10		2011		2012		2013		2014		2015		2016		2017		2018		2021	
	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
<i>G. macrorhynchus</i>	0	0	0	0	0	0	12	0	12	0	12	0	29	0	29	0	52	0	52	0
<i>G. griseus</i>	1	0	1	0	1	0	7	0	22	0	36	0	36	0	56	0	56	0	73	1
<i>S. frontalis</i>	0	0	41	0	60	2	77	2	111	2	118	2	154	3	199	20	204	22	256	25
<i>T. truncatus</i>	0	0	21	0	41	0	52	2	80	2	100	2	114	2	132	8	132	8	186	23
<i>S. bredanensis</i>	0	0	0	0	0	0	0	0	0	0	0	0	43	8	54	8	54	8	78	10

5. Marine Mammal Monitoring on Navy Ranges (M3R) Species Verification Trials

The Marine Mammal Monitoring on Navy Ranges (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 100-200+ 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), the Southern California Tactical Training Range (SCTTR), the Pacific Missile Range Facility (PMRF), the Jacksonville Shallow Water Training Range (JSWTR), and the Canadian Forces Maritime Experimental and Test Ranges (CFMETR) 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, habitat use; for understanding the effects of Navy activities and the long-term health of the populations; and for the development of detection, classification, localization, and density estimation algorithms.

The M3R system was installed at the JSWTR in December 2019 and initially connected to 126 hydrophones installed on the northern half of the range at the time (**Figure 18**). The M3R team conducted three species verification trials in 2021 in collaboration with Duke University and HDR, Inc.: April 9-17, May 20-24, and December 7-11 (see section 2.1.1.2). During these trials M3R personnel used the system passive acoustic monitoring displays to look for species of interest, and vector the on-water team to the locations of the animals via satellite phone text messages. Upon finding the animals, the vessel survey crew verified the species, collected behavioral and environmental data, photos for photo-ID catalogs, biopsy samples, and potentially also deploy satellite telemetry tags on individuals. The focal species for these efforts are:

1. Short-finned pilot whales (*Globicephala macrorhynchus*)
2. Bottlenose dolphins (*Tursiops truncatus*)
3. Atlantic spotted dolphins (*Stenella frontalis*)
4. Risso's dolphin (*Grampus griseus*)
5. Rough-toothed dolphins (*Steno bredanensis*)

During the three field sessions conducted in 2021, four of the five focal species were acoustically identified by M3R and visually verified by the on-water team (all but pilot whales). Satellite telemetry tags were deployed on two rough-toothed dolphins, and numerous biopsy samples were collected. Tables 14 to 16 and Figures 19 to 21 summarize the M3R findings from these three field trials.

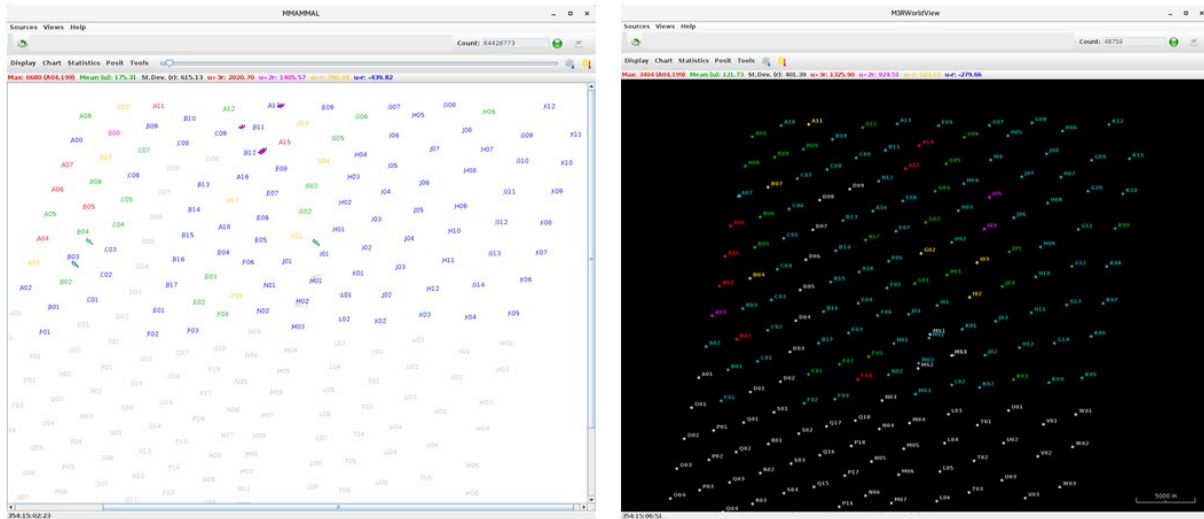


Figure 18. M3R monitoring displays at JSWTR. *Left: MMAMMAL; Right: Worldwind*

Table 14. April 2021 Field Effort: Species acoustically identified with the M3R system at JSWTR. Data are extracted from the logs of the field test completed in April 2021. Visual sightings logged in the M3R notes without a corresponding acoustic detection are noted below the table.

Species			# Acoustic Detections Logged	# Acoustic Detections Directed	# Acoustic Detections Visually Verified	# Biopsies	# of Tags
ID	Common Name	Scientific Name					
Tt	Bottlenose dolphin	<i>Tursiops truncatus</i>	4	4	4	4	0
Sf	Atlantic spotted dolphin	<i>Stenella frontalis</i>	5	5	5	1	0
Sb	Rough-toothed dolphin	<i>Steno bredanensis</i>	1	1	1	0	1
Uz	Unidentified beaked whale	Ziphiidae sp.	1	0	0	0	0
UD	Unidentified dolphin	Delphinidae sp.	43	3	1	0	0
LF	Unknown low frequency	NA	2	2	0	0	0

Notes: A cow-calf pair of bottlenose dolphins (*Tursiops truncatus*) was seen by the visual at 21:04 UTC on 04/16/2021.

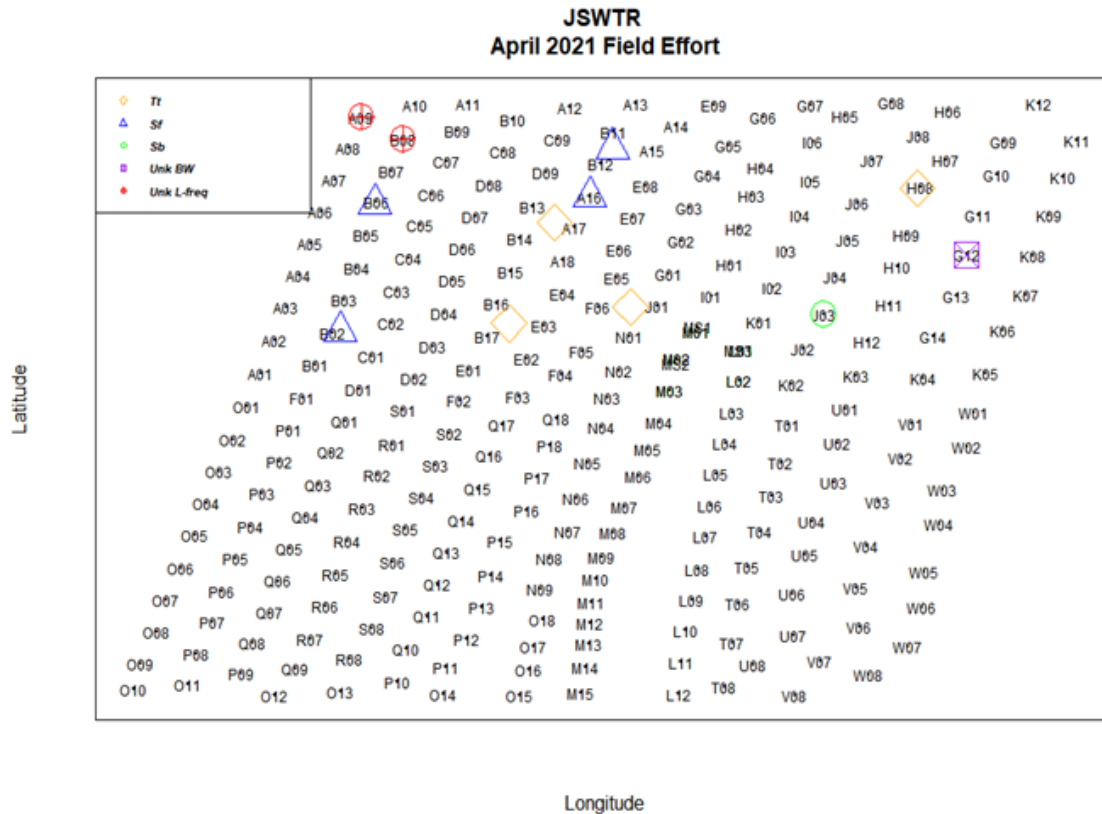


Figure 19. Acoustic detections made during the April 2021 field effort at JSWTR. Visually verified species included bottlenose dolphins (*Tursiops truncatus*), Atlantic spotted dolphins (*Stenella frontalis*), and rough-toothed dolphins (*Steno bredanensis*). Non-visually verified acoustic detections included an unknown beaked whale species (*Ziphius*), and an unknown low-frequency source. Unknown dolphin species that were acoustically detected during this effort are not depicted.

Table 15. May 2021 Field Effort: Species acoustically identified with the M3R system at JSWTR. Data are extracted from the logs of the field test completed in May 2021. Visual sightings logged in the M3R notes without a corresponding acoustic detection are noted below the table.

Species			# Acoustic Detections Logged	# Acoustic Detections Directed	# Acoustic Detections Visually Verified	# Biopsies	# of Tags
ID	Common Name	Scientific Name					
Tt	Bottlenose dolphin	<i>Tursiops truncatus</i>	10	10	10	5	0
Sf	Atlantic spotted dolphin	<i>Stenella frontalis</i>	7	7	7	1	0
Gg	Risso's dolphin	<i>Grampus griseus</i>	2	2	2	0	0
UD	Unidentified dolphin	Delphinidae sp.	64	8	0	0	0

Notes: Duke sighted an additional group of bottlenose dolphins (*Tursiops truncatus*) and spotted dolphins (*Stenella frontalis*) visually, bringing the total group numbers to 11 and 8 respectively.

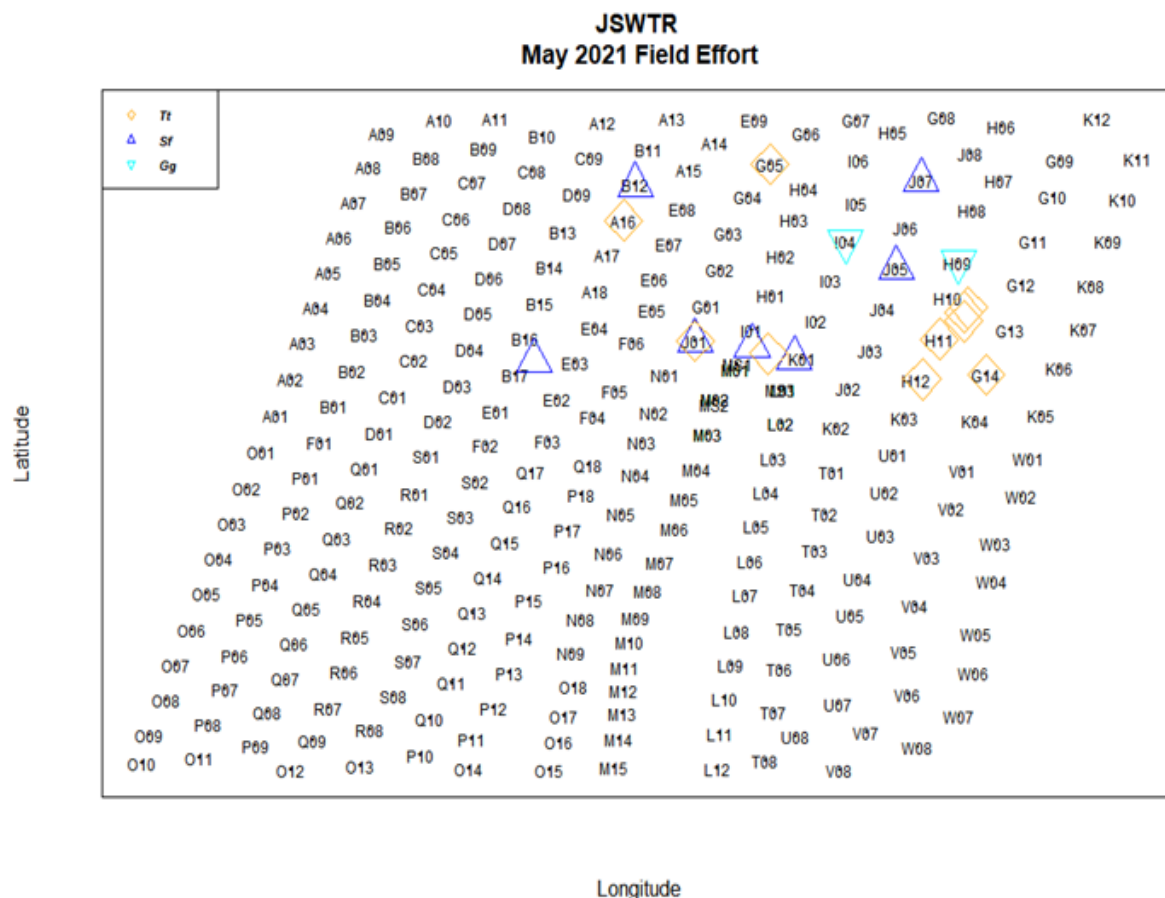


Figure 20. Acoustic detections made during the May 2021 field effort at JSWTR. Visually verified species included bottlenose dolphins (*Tursiops truncatus*), Atlantic spotted dolphins (*Stenella frontalis*), and Risso’s dolphins (*Grampus griseus*). Unknown dolphin species that were acoustically detected during this effort are not depicted.

Table 16. Species acoustically identified with the M3R system at JSWTR. Data are extracted from the logs of the field test completed in December 2021. Visual sightings logged in the M3R notes without a corresponding acoustic detection are noted below the table.

Species			# Acoustic Detections Logged	# Acoustic Detections Directed	# Acoustic Detections Visually Verified	# Biopsies	# of Tags
ID	Common Name	Scientific Name					
Sb	Rough-toothed dolphin	<i>Steno bredanensis</i>	3	0	0	0	0
Tt	Bottlenose dolphin	<i>Tursiops truncatus</i>	3	3	3 (4)	2	0
Sf	Atlantic spotted dolphin	<i>Stenella frontalis</i>	2	2	2	0	0
UD	Unidentified dolphin	Delphinidae sp.	22	2	0	0	0

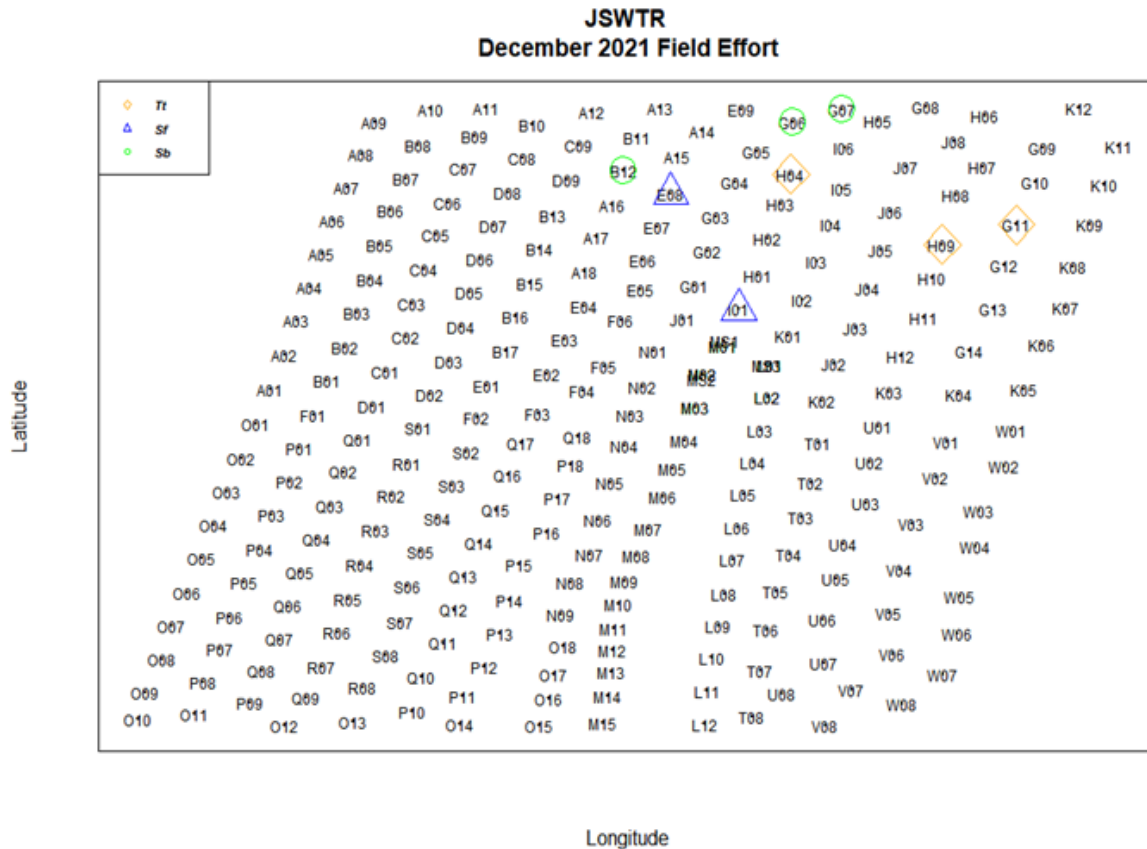


Figure 21. Acoustic detections made during the December 2021 field effort at JSWTR. Visually verified species included bottlenose dolphins (*Tursiops truncatus*), Atlantic spotted dolphins (*Stenella frontalis*). Non-visually verified acoustic detections included rough-toothed dolphins (*Steno berdanensis*). Unknown dolphin species that were acoustically detected during this effort are not depicted. Note that visual effort was limited to one day due to impending tropical storm.

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