

Annual report to Ørsted Wind US

April 16, 2024

2023 field activities and data summation pertaining to acoustic telemetry monitoring of highly migratory pelagic fishes (HMS) in Revolution Wind (OCS-A 0486), South Fork Wind (OCS-A 0517), Sunrise Wind (OCS-A 0487), and Bay State Wind (OCS-A 0500)

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Abbreviations:

BOEM: Bureau of Ocean Energy Management

HMS: highly migratory species

MACEC: Massachusetts Clean Energy Center

OCS: outer continental shelf

SMAST: University of Massachusetts Dartmouth School for Marine Science & Technology

SNE: southern New England

WEA: Wind Energy Area

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Objectives

The objective of this project is to use passive acoustic telemetry to monitor the presence and persistence of highly migratory species (HMS) in Ørsted Wind lease areas in relation to offshore wind activities. Passive acoustic telemetry is a popular and powerful tool for studying the movement patterns and habitat use of marine fish over fine- and broad-scale spatial extents (e.g., Heupel et al., 2006; Kneebone et al., 2014abc; Bruce et al., 2019) and has been used previously to document baseline animal presence in wind energy areas (WEA) along the U.S. East Coast (e.g., Frisk et al., 2019; Haulsee et al., 2020; Secor et al., 2020; Gervelis and Kneebone, 2022). In 2023, our specific objectives were to:

- (1) Work cooperatively with commercial fishermen to maintain an array of 32 acoustic receivers to monitor the presence and persistence of tagged HMS within Ørsted lease areas,
- (2) Deploy 50 acoustic transmitters on HMS,
- (3) Use receiver ‘detection’ data to establish pre-turbine construction information on the presence, persistence, and habitat use of key HMS in Ørsted lease areas, and
- (4) Opportunistically monitor the presence and persistence of other acoustically-tagged marine species within the acoustic receiver array through cooperation with other project Principal Investigators (PIs) and regional acoustic telemetry data sharing programs.

Methods

Acoustic monitoring

To achieve our main objective of documenting HMS presence, persistence, and movements within the Ørsted Wind lease areas, VEMCO acoustic receivers (n = 32, INNOVASEA Systems Inc., Halifax, Nova Scotia, Canada) were deployed to continuously monitor for the presence of tagged HMS at specific locations during 2023 (Figure 1). VR2AR receivers were rigged in a custom-designed pop-up mooring system (Mooring Systems, Inc., Bourne, MA) that could be reassembled and redeployed after being summoned to the surface (Figure 2). Individual VR2AR receiver locations were selected based on the desire to minimize potential interaction with commercial fishing gear, particularly mobile fishing gear, and maximize the coverage of the popular recreational fishing area. Acoustic receiver deployment and maintenance occurred in cooperation with the F/V Cailyn & Maren. Details on the deployment location and duration of each receiver can be found in Table 1.

Thirty of the 32 VR2AR acoustic receivers were present on station during the November 14 – 15, 2022 trip and were recovered, downloaded, and redeployed until May 3 – 4, 2023. Two missing

receivers at stations SRW 10 and 13 were not deployed during the period of November 2022 to May 2023. On May 3 – 4, the 30 deployed receivers were recovered, downloaded, and brought to shore to upgrade the mooring hardware.

Prior to redeployment, multiple changes in station locations were made to account for holes in the receiver array resulting from the removal of Atlantic cod receivers in March 2023 by the University of Massachusetts-Dartmouth School for Marine Science & Technology (SMAST). Within South Fork, SF1 was moved to the west side of the lease area. Stations SRW 10 and SRW 13, both of which were lost in 2022, were moved to new locations: SRW 10 moved to the west side of Sunrise while SRW 13 was moved into Revolution Wind (REV 18) to reestablish receiver coverage near ‘The Mountain’, an important area for Atlantic cod.

All 32 VR2AR acoustic receivers were redeployed on May 31, 2023 and left in place until they were recovered and downloaded on November 20 – 21, 2023. The receiver at SF1 was caught by the ventless trap survey on September 5, recovered from the vessel, and redeployed on September 21. In November, all 32 receivers were present, 29 of which were redeployed and 3 of which (SRW 4, 7, and 9) were removed from the array due to unexpectedly low battery power in the release mechanism (Table 1). As requested, station locations for REV 2, 3, 4, 6, 7, 8, 9, 13, 16, and 17 as well as SF 1 were moved slightly to nearby locations during the November 2023 download trip to adjust for turbine construction in the area.

Acoustic tagging

Acoustic tagging efforts were conducted from June – September 2023 over 10 trips between F/V *Toro* (8 trips) and F/V *ArchAngel* (2 trips). A total of 49 transmitters were deployed within or near the Ørsted Wind lease areas, comprising 25 bluefin tuna (*Thunnus thynnus*), 19 shortfin mako (*Isurus oxyrinchus*), 2 blue sharks (*Prionace glauca*), 2 common thresher sharks (*Alopias vulpinus*), and 1 yellowfin tuna (*Thunnus albacares*) (Figure 3). All animals were observed to be in good health upon release after tagging. A single transmitter was not deployed due to low shark catch rates on the last trip of 2023 and will be deployed in 2024.

Data analysis

Raw acoustic detections downloaded from acoustic receivers were compiled into a database for analysis and filtered for Ørsted transmitters. Due to high mobility of HMS and the relatively large distance between individual acoustic receivers, single detection events were considered valid and retained for analysis. Tagging locations, detection histories, and residence maps were created to visually demonstrate the presence of each individual and species over time and in relation to acoustic receiver stations. A residency event was defined as any time an individual was detected at least once at a receiver station. Residences ended when individuals were not detected (i.e.,

absent) for at least 24 hours or if that individual was detected on another receiver, whichever occurred first. Monthly residency indices (RI) were calculated by dividing the cumulative number of residences by the cumulative amount of time (days) all receivers were deployed when each individual of a species was available for detection in each month. All analyses and map generations were performed in R (version 4.3.1; R Core Team, 2024), primarily with the *tidyverse* (Wickham et al., 2019) and *VTrack* (Campbell et al., 2012) packages.

Results

Presence of tagged HMS

Thirty-five of 49 Ørsted transmitters were detected by the Ørsted Wind receiver array, comprised of blue sharks ($n = 2$), shortfin mako ($n = 14$), bluefin tuna ($n = 16$), common thresher sharks ($n = 2$), and yellowfin tuna ($n = 1$) (Table 2). A total of 4,298 detections were recorded for these individuals. Bluefin tuna were detected between June 23 and November 5, blue sharks between June 23 and October 27, shortfin mako between July 7 and October 19, common thresher sharks between August 29 and November 5, and the single yellowfin tuna on August 11 (Figure 4). Tagged HMS were detected by all 32 recovered receivers (Table 3; Figures 5 and 6). Over the course of the study, REV 16 logged the most detections ($n = 338$), while SRW 5 detected the greatest number of individual fish ($n = 17$) (see Figure 1 for station locations). Overall, HMS presence at each station varied by species (Table 3, Figures 5 and 6).

A combined 502 residences were recorded in 2023 for all species from the 35 detected transmitters (Tables 3 and 5, Figure 6). Residences lasted from 1 to 1,487 minutes (24.8 hours), with shortfin mako having the longest average recorded residence time (119 ± 277 minutes), followed by common thresher sharks (50 ± 133 minutes), bluefin tuna (43 ± 171 minutes), and blue sharks (34 ± 54 minutes); only one residence was recorded for a residence time of one minute for the single yellowfin tuna (Tables 4 and 5). Residence counts varied by species and station, with bluefin tuna recording the most residences across all stations followed by shortfin mako, common thresher sharks, blue sharks, and yellowfin tuna (Tables 3 and 4). Monthly RI varied for each species, and aggregate non-zero values of all species ranged from 0.415 in September to 1.722 in August (Table 5). Values of RI peaked for blue shark in June (0.781), bluefin tuna in August (2.610), common thresher sharks in November (1.067), shortfin mako in July (0.901), and yellowfin tuna in August (0.101) from the single recorded residence (Table 5). Detections (and by extension any potential residences and indices) for December will be assessed following the next Ørsted receiver download in April 2024.

Other transmitter data collected

From November 14, 2022 to November 21, 2023, Ørsted Wind receivers recorded a total of 2,567 detections from 35 unique transmitters deployed on HMS by other wind companies. These detections ranged from June to November 2023. An additional 460 detections from 7 unique transmitters deployed under a project funded by the Massachusetts Clean Energy Center (MACEC; Gervelis and Kneebone, 2022) were recorded as well, with detections ranging from December 2022 to November 2023. Of the 7 MACEC transmitters recorded, 6 were deployed in 2021 and 1 was deployed in 2020. Finally, 595,230 detections were recorded from 510 transmitters that were deployed by groups other than wind companies or MACEC.

Discussion

Data from the 35 detected individuals revealed habitation of the Ørsted Wind lease areas by the five tagged species during warmer months (June to November). While transmitters were only deployed beginning in June 2023, the scarcity of detected individuals in November 2023 signify greatly reduced occupancy leading to emigration during cooler months. There is also evidence of some degree of fidelity to southern New England (SNE), as all (7) detected MACEC fish and a subset (19) of detected non-Ørsted wind company fish were tagged in previous years and therefore migrated back to the area in 2023. Residency patterns varied by month and by species, possibly indicating differences in space use due to environmental preferences, prey availability, or migration patterns, but variance in sample sizes among species and in timing of tag deployments may also account for any heterogeneity seen. Overall, these data preliminarily suggest that a range of HMS utilize this area of SNE seasonally and potentially on an interannual basis. Given that 2023 composed the first year of tagging, the scope of our observations is limited, prohibiting the formation of any detailed conclusions regarding spatiotemporal patterns until more data are collected. An additional 50 acoustic transmitters are planned for deployment in 2024 and will contribute to the existing dataset alongside any detections from returning fish. A regional report on HMS presence throughout all lease areas of the SNE WEA is currently underway and will provide additional insights into HMS presence, persistence, and movements in Ørsted leases.

Deployment and/or retrieval of receivers in both trips in May 2023 as well as in November 2023 were largely successful, indicating the overall efficacy of the current placement of stations throughout the Ørsted Wind lease areas. A subset of receivers were moved at various times either to adjust for holes in the array left by now-vacated SMAST receivers or to adjust for upcoming turbine construction; any potential interactions with mobile fishing gear in these new locations will be monitored and stations relocated accordingly. The only noted difficulties occurred with receivers at SRW 11 and 12, which failed to connect and were manually recovered. Further inspection after shipment back to INNOVASEA Systems Inc. revealed a circuit board failure in the receiver at SRW 11 but no apparent defect in the receiver at SRW 12, which may otherwise have had low remaining life on the device battery that could have interfered with connection. Subsequent connection failures on any receivers cannot be anticipated and will be addressed on a case-by-case basis. Unexpectedly low charge in the acoustic release motor batteries has also been

a recent issue that may make future recoveries difficult and will be circumvented by checking remaining capacities and exchanging with new batteries as needed during at-sea maintenance. Lastly, bronze hardware that was implemented in the float plate component of the pop-up mooring system during on-shore maintenance proved to be effective against crevice corrosion that was present on the previous stainless steel hardware. Full conversion to bronze hardware in the canister component of the pop-up mooring system as well as any acoustic release motor battery replacements will be implemented in an upcoming maintenance and download trip in April 2024.

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Table 1 – Metadata for the 32 acoustic receivers that were deployed in the Ørsted Wind lease areas in 2023. Receivers were removed for maintenance on May 3 – 4, 2023 and redeployed on May 31, 2023. SF 1* was caught on September 5, 2023 and redeployed at a new location on September 21, 2023. SRW 11 and 12 were unable to be recovered in early May but were retrieved and replaced on May 31, 2023. SRW 4, 7, and 9 were removed on November 20 – 21, 2023 due to low release motor batteries. All other receivers were downloaded and redeployed on November 20 – 21, 2023. REV = Revolution Wind, SF = South Fork Wind, SRW = Sunrise Wind

Station	Latitude	Longitude	Depth (m)	Deployment 1	Deployment 2	Total Days Deployed
REV 01	41.28	-71.13	38	11/14/22 – 5/3/23	5/31/23 – 11/20/23	345
REV 02	41.22	-71.15	36	11/14/22 – 5/3/23	5/31/23 – 11/20/23	345
REV 03	41.21	-71.12	36	11/14/22 – 5/3/23	5/31/23 – 11/20/23	345
REV 04	41.21	-71.07	34	11/14/22 – 5/3/23	5/31/23 – 11/20/23	345
REV 05	41.20	-71.20	39	11/14/22 – 5/3/23	5/31/23 – 11/21/23	346
REV 06	41.19	-71.15	37	11/14/22 – 5/3/23	5/31/23 – 11/20/23	345
REV 07	41.16	-71.24	40	11/15/22 – 5/4/23	5/31/23 – 11/21/23	346
REV 08	41.16	-71.17	38	11/15/22 – 5/4/23	5/31/23 – 11/21/23	346
REV 09	41.16	-71.12	35	11/15/22 – 5/4/23	5/31/23 – 11/21/23	345
REV 10	41.11	-71.25	34	11/15/22 – 5/4/23	5/31/23 – 11/21/23	346
REV 11	41.10	-71.20	34	11/15/22 – 5/4/23	5/31/23 – 11/21/23	346
REV 12	41.16	-71.00	33	11/14/22 – 5/3/23	5/31/23 – 11/20/23	345
REV 13	41.12	-71.04	34	11/14/22 – 5/3/23	5/31/23 – 11/20/23	345
REV 14	41.13	-70.97	30	11/14/22 – 5/3/23	5/31/23 – 11/20/23	345
REV 15	41.12	-70.89	36	11/14/22 – 5/3/23	5/31/23 – 11/20/23	345
REV 16	41.08	-71.02	35	11/14/22 – 5/3/23	5/31/23 – 11/20/23	345
REV 17	41.09	-70.96	37	11/14/22 – 5/3/23	5/31/23 – 11/20/23	345
REV 18	41.13	-71.11	30	5/31/23 – 11/20/23	NA	174
SF 01*	41.07; 41.09	-71.11; -71.18	34; 33	11/14/22 – 5/3/23	5/31/23 – 9/5/23; 9/21/23 – 11/20/23	330
SF 02	41.09	-71.09	33	11/14/22 – 5/4/23	5/31/23 – 11/20/23	346
SRW 01	40.96	-71.26	52	11/14/22 – 5/4/23	5/31/23 – 11/21/23	347
SRW 02	40.98	-71.18	52	11/14/22 – 5/4/23	5/31/23 – 11/21/23	347
SRW 03	40.97	-71.13	48; 50	11/14/22 – 5/4/23	5/31/23 – 11/21/23	347
SRW 04	41.00	-71.00	46	11/15/22 – 5/3/23	5/31/23 – 11/20/23	344
SRW 05	41.01	-70.94	45	11/15/22 – 5/3/23	5/31/23 – 11/20/23	344
SRW 06	40.99	-70.91	49	11/15/22 – 5/3/23	5/31/23 – 11/21/23	345
SRW 07	41.00	-70.87	48	11/15/22 – 5/3/23	5/31/23 – 11/21/23	345
SRW 08	41.00	-70.82	47	11/15/22 – 5/3/23	5/31/23 – 11/21/23	345
SRW 09	40.94	-70.96	50	11/15/22 – 5/3/23	5/31/23 – 11/21/23	345
SRW 10	41.03	-71.22	47	5/31/23 – 11/21/23	NA	175
SRW 11	40.89	-71.01	58; 57	6/1/22 – 5/31/23	5/31/23 – 11/21/23	512
SRW 12	40.91	-70.91	51; 52	11/15/22; 5/31/23	5/31/23 – 11/21/23	366

Table 2 – Metadata from 49 highly migratory species (HMS) tagged for Ørsted Wind in 2023. In the “# Detected” column, numbers outside parentheses represent the total number of the deployed tags that were detected, and numbers in parentheses represent the number of detected MACEC individuals that were tagged in previous years. FL = fork length

Species	# Tagged	# Detected	Sex			Size	Tag Placement	
			Male	Female	Unknown	FL (cm)	External	Internal
Blue shark	2	2 (1)	1	1	0	137 - 259	2	0
Bluefin tuna	25	16 (5)	-	-	25	83 - 259	1	24
Common thresher	2	2	0	2	0	152 - 183	2	0
Shortfin mako	19	14 (1)	-	8	11	121 - 259	19	0
Yellowfin tuna	1	1	-	-	1	102	0	1

Table 3 – Summary of the number of detections (Dtx), residences (Res), and unique transmitters (Tx) observed at each receiver station by species from June – November 2023. Refer to Figure 1 for the location of each station. REV = Revolution Wind, SF = South Fork Wind, SRW = Sunrise Wind

Station	Blue shark			Bluefin tuna			Common thresher shark			Shortfin mako			Yellowfin tuna		
	Dtx	Res	Tx	Dtx	Res	Tx	Dtx	Res	Tx	Dtx	Res	Tx	Dtx	Res	Tx
REV 01	0	0	0	12	3	3	0	0	0	49	2	1	0	0	0
REV 02	0	0	0	70	11	8	11	1	1	19	1	1	0	0	0
REV 03	0	0	0	127	14	7	14	1	1	0	0	0	0	0	0
REV 04	0	0	0	202	17	6	14	1	1	31	2	2	0	0	0
REV 05	0	0	0	35	5	4	0	0	0	10	1	1	0	0	0
REV 06	0	0	0	48	7	7	0	0	0	1	1	1	0	0	0
REV 07	4	1	1	20	5	5	0	0	0	11	1	1	0	0	0
REV 08	3	1	1	21	5	4	9	1	1	0	0	0	0	0	0
REV 09	0	0	0	79	9	8	0	0	0	35	3	3	0	0	0
REV 10	0	0	0	36	7	6	0	0	0	27	3	2	0	0	0
REV 11	0	0	0	13	4	3	0	0	0	0	0	0	0	0	0
REV 12	0	0	0	85	17	7	0	0	0	18	3	3	0	0	0
REV 13	0	0	0	89	15	7	7	1	1	175	5	2	0	0	0
REV 14	0	0	0	42	7	5	0	0	0	37	4	2	0	0	0
REV 15	0	0	0	34	5	3	33	2	2	39	3	2	0	0	0
REV 16	0	0	0	178	31	10	10	1	1	150	7	4	0	0	0
REV 17	0	0	0	149	15	9	16	1	1	61	5	4	0	0	0
REV 18	0	0	0	54	9	7	0	0	0	250	5	3	0	0	0
SF 01	0	0	0	63	8	5	0	0	0	46	3	1	0	0	0
SF 02	18	1	1	114	18	10	0	0	0	29	6	4	0	0	0
SRW 01	0	0	0	62	10	8	0	0	0	44	5	5	0	0	0
SRW 02	0	0	0	47	12	8	0	0	0	11	3	2	0	0	0
SRW 03	0	0	0	34	9	5	0	0	0	37	3	3	0	0	0
SRW 04	0	0	0	72	19	9	0	0	0	47	4	4	0	0	0
SRW 05	76	1	1	71	18	11	3	2	2	100	4	3	0	0	0
SRW 06	0	0	0	55	10	7	78	4	2	91	3	3	0	0	0
SRW 07	23	1	1	126	16	11	10	1	1	63	4	3	0	0	0
SRW 08	1	1	1	12	6	5	131	1	1	22	2	2	0	0	0
SRW 09	11	1	1	114	21	10	11	2	1	26	3	3	0	0	0
SRW 10	0	0	0	21	8	5	4	1	1	32	3	1	0	0	0
SRW 11	0	0	0	170	27	9	26	2	2	0	0	0	2	1	1
SRW 12	15	1	1	36	13	7	0	0	0	16	1	1	0	0	0
<i>Total</i>	151	8	2	2291	381	16	377	22	2	1477	90	14	2	1	1

Table 4 – Summary of the number and duration of residences documented for each species from June – November 2023. Tx = unique transmitters

Species	Tx	Residences	Duration (minutes)			
			Minimum	Maximum	Mean	Standard deviation
Blue shark	2	8	2	162	34	54
Bluefin tuna	16	381	1	1436	43	171
Common thresher shark	2	22	2	630	50	133
Shortfin mako	14	90	1	1487	119	277
Yellowfin tuna	1	1	1	1	1	-

Table 5 – Summary of the residency index (RI), residences (Res), and unique transmitters (Tx) by month for all species from June – November 2023. *NA* entries denote that receivers were present but no tags were deployed/available for detection at that time. Dashes indicate no data availability at this time for December 2023.

Month	Blue Shark (n = 2)			Bluefin Tuna (n = 16)			Common Thresher (n = 2)			Shortfin Mako (n = 14)			Yellowfin Tuna (n = 1)			All (n = 35)		
	RI	Res	Tx	RI	Res	Tx	RI	Res	Tx	RI	Res	Tx	RI	Res	Tx	RI	Res	Tx
January	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
February	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
March	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
April	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
May	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
June	0.781	2	1	0.391	1	1	NA	NA	NA	0	0	0	NA	NA	NA	0.586	3	2
July	0.101	1	1	0.453	38	9	NA	NA	NA	0.901	47	9	0	0	0	0.589	86	19
August	0	0	0	2.610	233	9	0.893	2	2	0.470	23	5	0.101	1	1	1.722	259	17
September	0	0	0	0.444	42	10	0.265	5	2	0.423	4	1	0	0	0	0.415	51	13
October	0.504	5	1	0.512	61	12	0.101	1	1	0.538	16	3	0	0	0	0.492	83	17
November	0	0	0	0.457	6	2	1.067	14	2	0	0	0	0	0	0	0.762	20	4
December	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

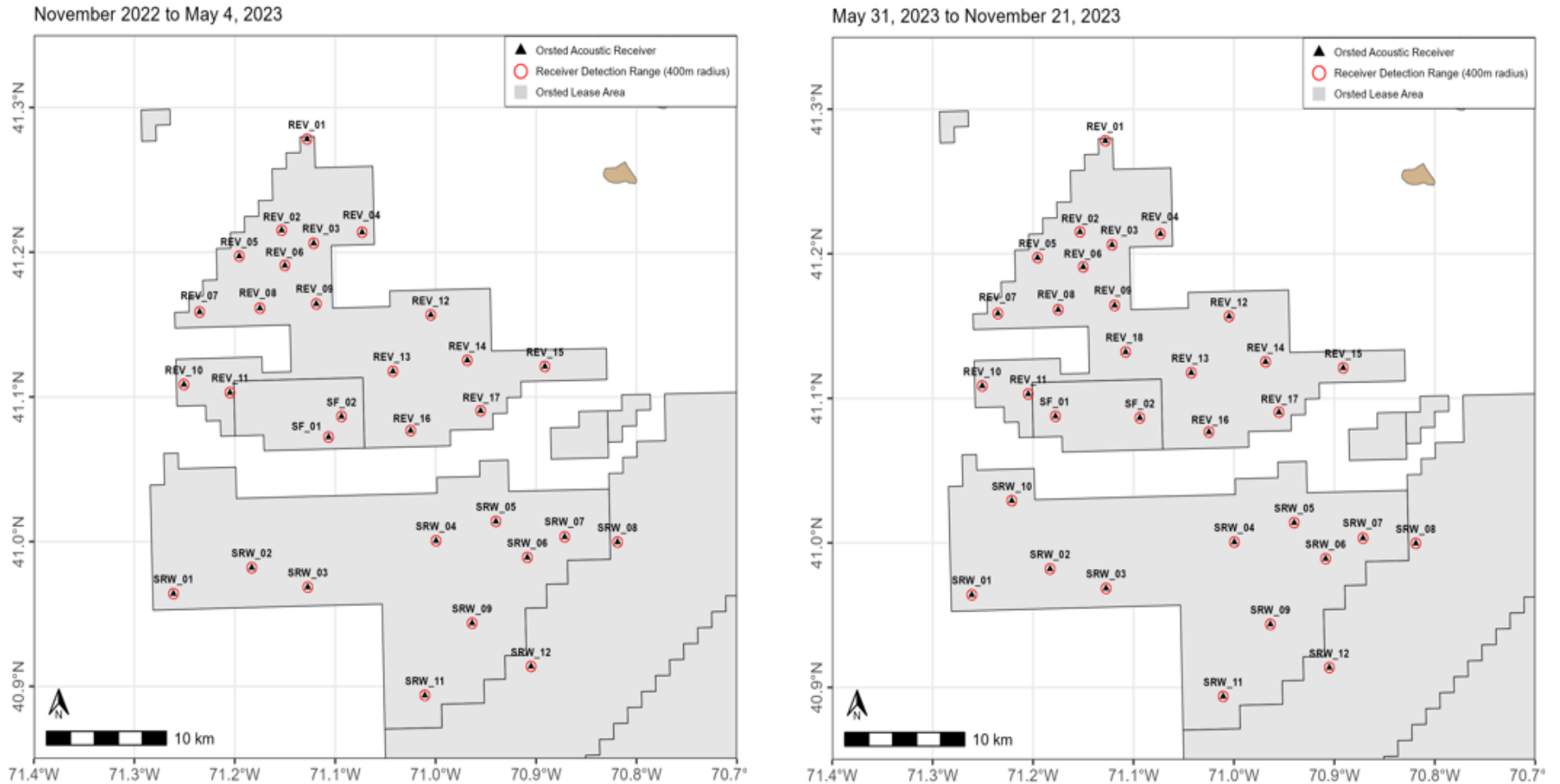


Figure 1 – Map showing the locations of acoustic receiver stations in the Ørsted Wind lease areas from November 2022 to May 4, 2023 and May 31, 2023 to November 21, 2023. Note that SRW 10 and 13 were missing in November 2022 and not replaced. On May 31, SF1 was moved to the west side of South Fork, SRW 10 was moved to the northwest portion of Sunrise, and SRW 13 was moved to a new station (REV 18). REV = Revolution Wind, SF = South Fork Wind, SRW = Sunrise Wind



Figure 2 – Mooring configuration used to deploy VEMCO VR2AR acoustic receivers.

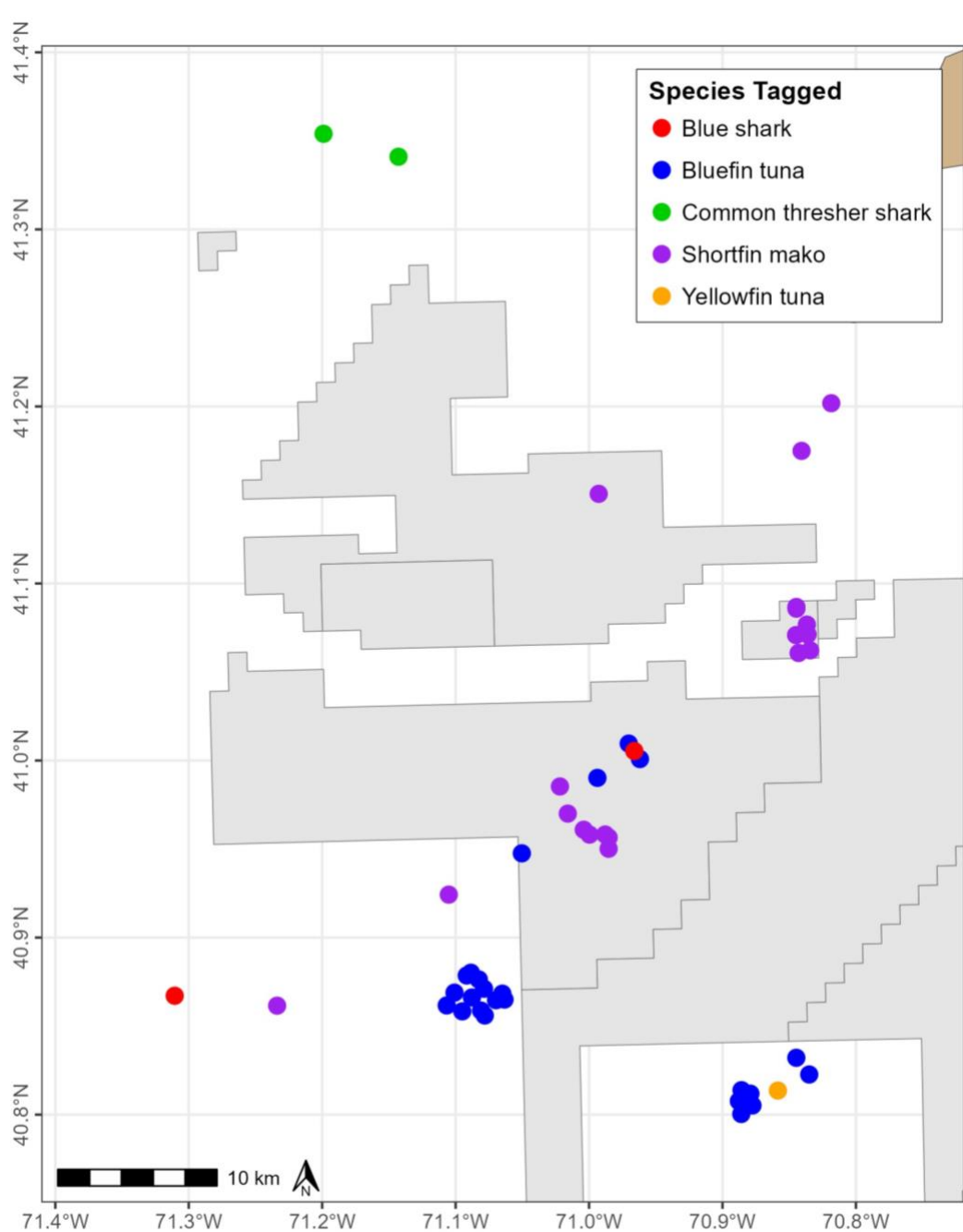


Figure 3 – Locations of tagging relative to the Ørsted Wind lease areas for the 49 individuals tagged in 2023.

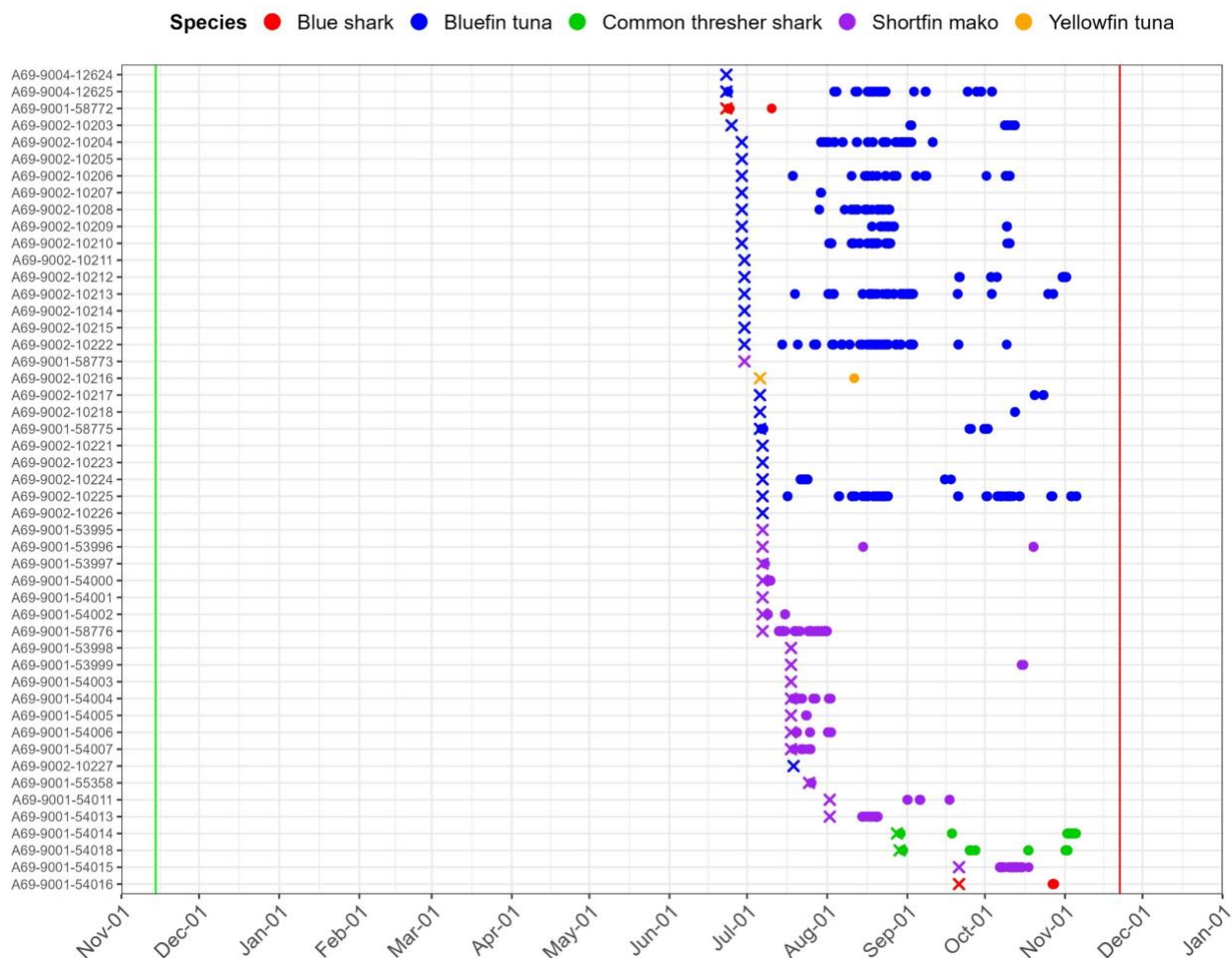


Figure 4 – Detection histories for 49 individuals that were tagged in 2023. Each dot represents one detection on one of the acoustic receivers, and X’s represent transmitter deployment dates. The green vertical line represents the earliest time any receivers were deployed (November 14, 2022), and the red vertical line represents the latest time all receivers were downloaded (November 21, 2023).

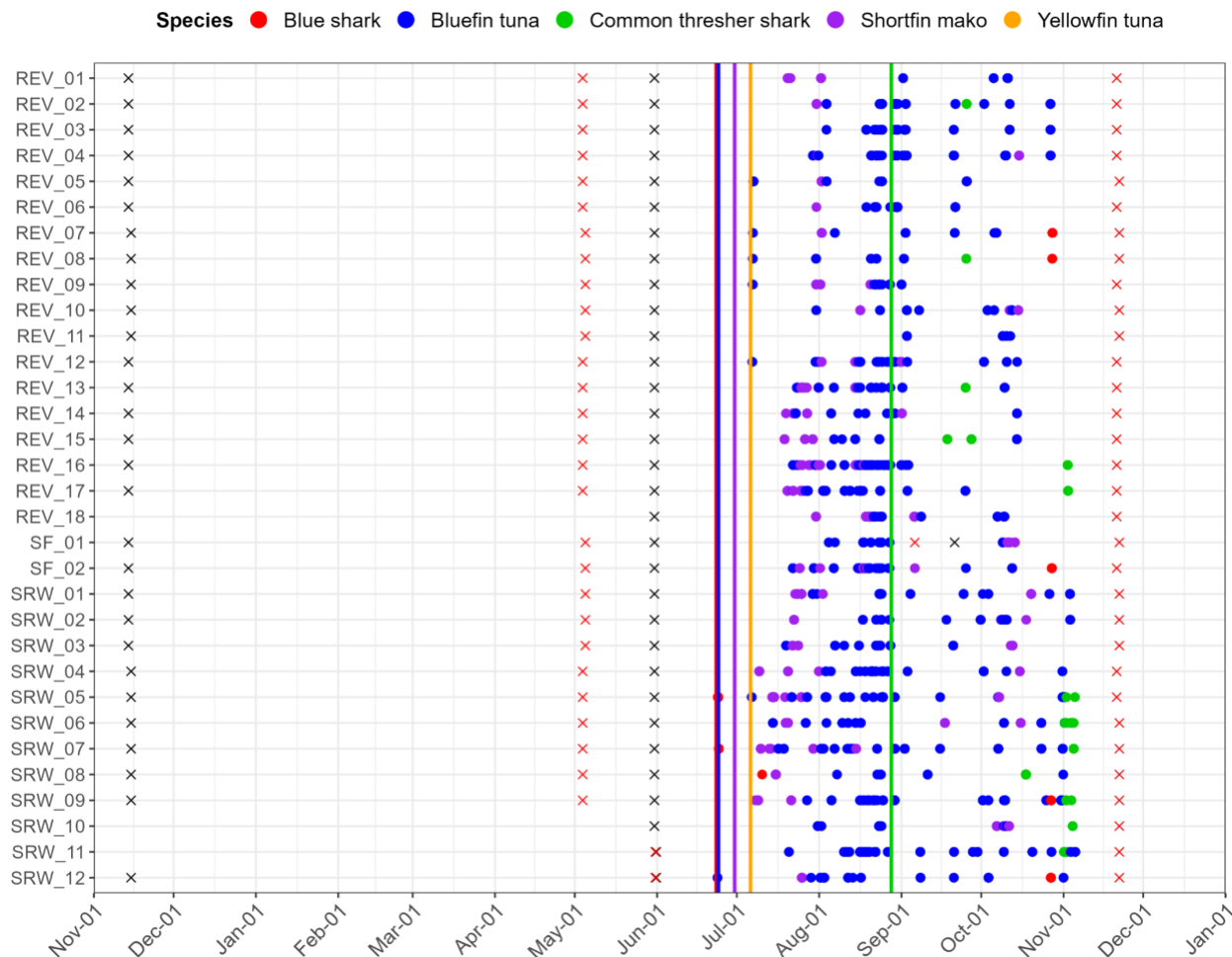


Figure 5 – Detection histories of each species on each receiver station deployed in the Ørsted Wind lease areas from November 14, 2022 to November 21, 2023. Colored circles indicate when that species was observed at a given station. Black ‘Xs’ represent the time when a receiver was deployed, and red ‘Xs’ represent the time it was last hauled and downloaded. Receivers were hauled on May 3 - 4, 2023, brought ashore for maintenance, and redeployed on May 31, 2023. Note that Sunrise 11 remained deployed since June 2022 due to connection difficulties that prevented acoustic release; both Sunrise 11 and 12 were hauled on May 31, 2023 for this reason. Sunrise 10 was moved to a new location on May 31, 2023 after being caught and not recovered in 2022, and Revolution 18 was a new addition in 2023. REV = Revolution Wind, SF = South Fork Wind, SRW = Sunrise Wind

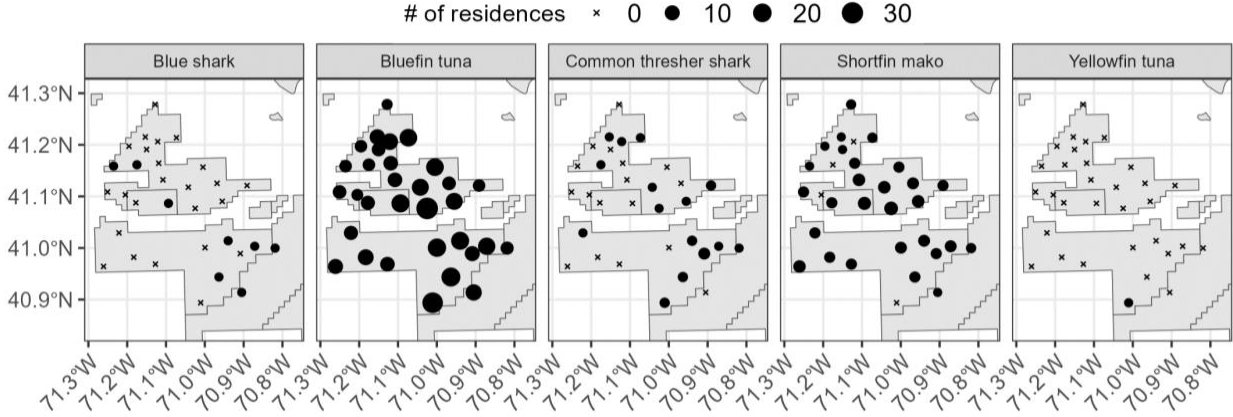


Figure 6 – Number of residences observed at each receiver station by species in 2023.