Tagging and Tracking of Endangered North Atlantic Right Whales in Florida Waters: 2017-2018 Progress report

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Tag attachment to North Atlantic right whale (*Eubalaena glacialis*) in southeastern U.S. waters during 2014. Photo collected under National Marine Fisheries Service Permit #14791 to Douglas P. Nowacek.

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Acronyms and Abbreviations

DTAG	digital acoustic tag
EGNO	identification number assigned to each identified individual in the North Atlantic Right Whale Catalog (i.e. *Eubalaena glacialis* number)
EWS	Early Warning System
GPS	Global Positioning System
hr	hour(s)
R/V	research vessel
USWTR	undersea warfare training range

1. Background and Objectives

North Atlantic right whales (*Eubalaena glacialis*) migrate to coastal waters off Florida and Georgia during the winter months. The planned construction and use of an undersea warfare training range (USWTR) off the Atlantic coast of Florida may result in interactions with right whales on their winter calving ground. Aerial- and vessel-based visual surveys and passive acoustic monitoring are currently being used to detect right whales in the coastal waters of Florida and Georgia, as well as in offshore areas in and near the planned USWTR. Aerial surveys give the positions of individual whales, but only provide information about right whale locations at single points in time. Passive acoustic monitoring establishes presence and provides a general location of at least one whale; multiple acoustic sensors can provide more accurate locations, as well as estimates of numbers of whales (Zimmer 2011). Currently, limited data exist on the movement patterns of individuals, including movement rates in both north-south and east-west directions, durations and depths of dives, and rates of sound production by individuals on the calving grounds. These data are important to assess the effectiveness of current monitoring techniques and the potential for disturbance to right whales as the construction and operation of the USWTR commence.

The primary objective of this targeted tagging program is to fill these knowledge gaps by collecting data on horizontal movements, dive profiles, and vocal behavior from individual right whales using non-invasive, suction-cup-attached, digital acoustic tags (DTAGs). In 2017, our expanded objectives included: (1) continuing to increase the sample size of extended-duration tag attachments, along with Fastloc® Global Positioning System (GPS) technology.

Surveys and tagging field work began in 2014. In February 2014, weather conditions were suitable for tagging operations on 11 days, right whales were encountered on 9 days, and 7 DTAGs were successfully deployed (Nowacek et al. 2015). In February–March 2015, 8 days of field effort were conducted, but few right whales were present and only one whale was tagged successfully (Nowacek et al. 2016). In 2016, 11 days of field effort were conducted, right whales were encountered on 10 days, and 7 DTAGs were deployed (Nowacek et al. 2017). This report covers the fourth field season in 2017, with a brief synopsis of the most recent 2018 field work.

2. Methods

The fourth field season for this project was conducted in February 2017. The field team consisted of members from Duke University and Syracuse University, and operated out of Fernandina Beach, Florida, in the Jacksonville study area. The Research Vessel (R/V) *Richard T. Barber*, Duke Marine Lab's 9.1-meter aluminum rigid-hull inflatable boat (Safe Boats International, Bremerton, WA), powered by twin 300-horsepower outboard engines, was used for tag deployment and daytime follows. Tagging was accomplished using non-invasive suction-cup DTAGs (anticipated tag duration from 1 to 36 hours [hr]) that included Fastloc® GPS receivers, time-depth recorders, three-dimensional movement measurements, and acoustic recording capability. DTAGs were deployed from the bow pulpit of R/V *Barber* using a fiberglass pole (**Figure 1**), and retrieved either after the tags were dislodged by another whale or when the automatic release mechanism engaged. Tags were located and retrieved via the radio beacon incorporated into the tag, and then data were downloaded via PC. Researchers browsed audio recordings visually and aurally in RavenPro 1.5 (Cornell Bioacoustics Research Program) for

evidence of right whale vocalizations, positions were logged from the GPS tag, and behavior of the whales analyzed from the sensor suite (e.g., accelerometers, depth sensor). National Marine Fisheries Service permits to conduct this research this year were held by the Northeast Fisheries Science Center with Drs. Nowacek and Parks as named co-investigators. Institutional Animal Care and Use Committee approvals were obtained from Duke University and Syracuse University prior to data collection.

Figure 1. Image of DTAG deployment to a right whale in the southeastern United States in February 2016. Photo credit Florida Fish and Wildlife Conservation Commission, collected under National Marine Fisheries Service Permit #17355.

3. Results

3.1 Field Effort

Field effort in 2017 took place in February. Weather conditions were suitable for tagging operations (i.e., sea state forecast of Beaufort 3 or less) on six days during this time. The team surveyed approximately 594 kilometers during 30.4 hr of effort on the R/V *Richard T. Barber* over these six days (**Table 1, Figure 2**).

In addition to the six days focused solely on inshore North Atlantic right whale tagging, we also surveyed farther offshore on 14 and 17 February in an attempt to locate right whales that may be utilizing offshore habitats, as well as conducting broader surveys supporting Atlantic Fleet Testing and Training monitoring (**Figure 2**). We were prepared to deploy tags if we or the Early Warning System aerial survey team was to spot a right whale; however, no right whales were sighted on these offshore survey days.

Table 1. Summary of 2017 surveys conducted on the R/V *R.T. Barber*

Date	BSS	Survey Time (hh:mm)	At-Sea Time (hh:mm)	Distance Surveyed (km)
2-Feb-17	0–2	5:52	6:22	160.9
3-Feb-17	1–4	5:11	6:05	107.34
6-Feb-17	2	6:17	6:58	124.9
7-Feb-17*	3–4	3:12	4:00	22.1
8-Feb-17	2–3	3:10	6:00	68.5
12-Feb-17	2–4	6:39	7:30	110.0
14-Feb-17	2–4	4:00	10:18	81.6
17-Feb-17	2–4	4:51	9:34	126.1

* cruise with successful tag deployment and/or tracking. Key: BSS = Beaufort sea state

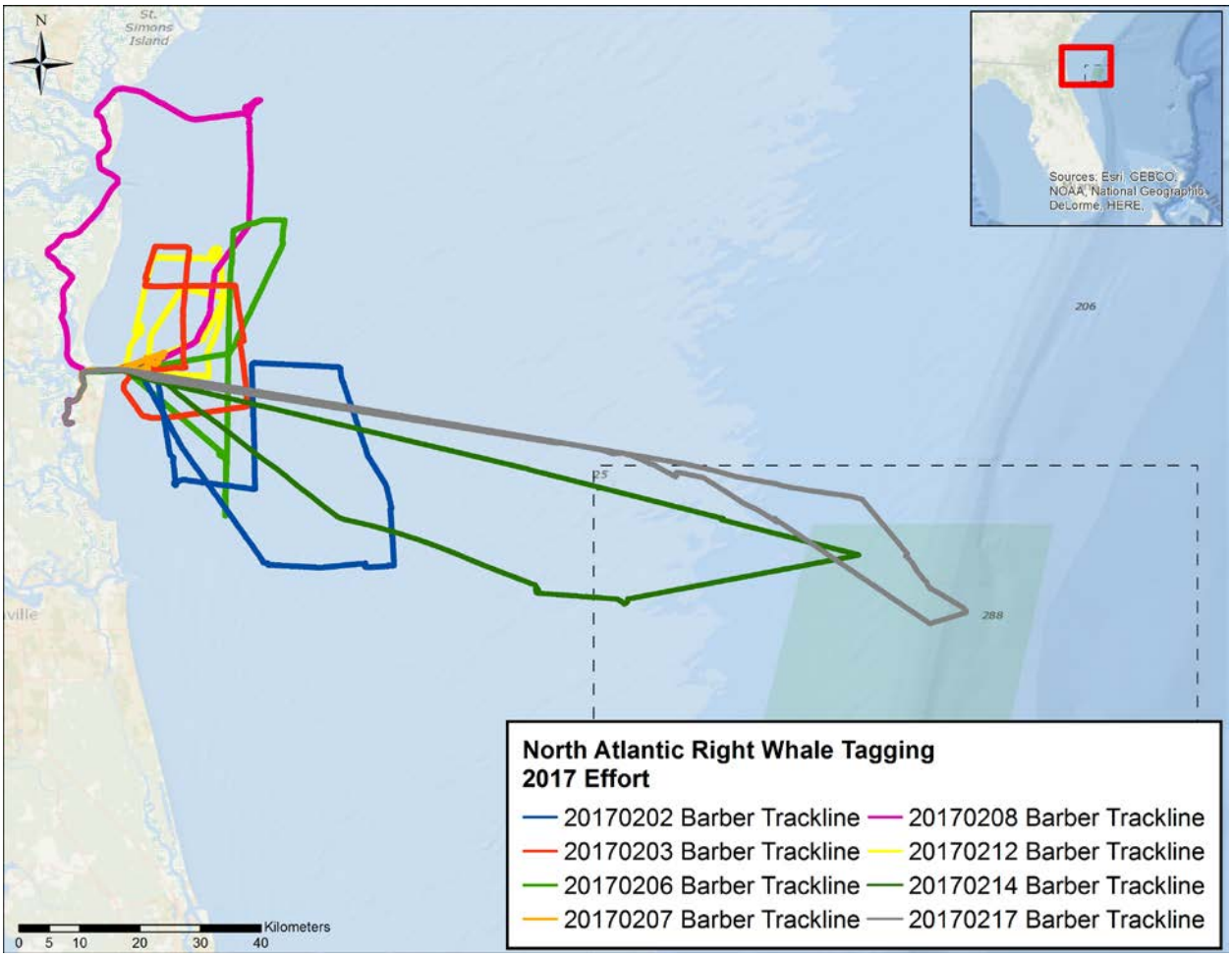

Figure 2. Map of search effort by the tagging vessel (colored lines) for each survey day in February 2017.

3.2 Right Whale Sightings and Tagging

We recorded two separate sightings of a single right whale mother-calf pair (North Atlantic Right Whale Catalog identification number [EGNO] 2614, a 21-year-old female and calf) (NEAQ 2017) in February 2017 **(Table 2**). This female and her calf were the only right whale mother-calf pair sighted on the calving grounds in the month of February (three sightings reported over 2 days 07 and 08 February), with a total of only five calves born in the season (Pettis et al. 2017). Right whale sightings on their wintering grounds were significantly lower in 2017 than historic levels (S. Kraus, New England Aquarium, pers. comm.). Overall, only seven whales, including three mother-calf pairs, were observed in the southeastern United States from 01 December 2016 to 01 March 2017.

We deployed a Version 2 DTAG on #2614 on 07 February 2018 **(Table 2, Figure 3)**. The tag was programmed for a 24-hr attachment, but was shed from the animal early, and recovered at 12:02 local time on 08 February. The tag is currently at the Woods Hole Oceanographic Institute in an attempt to retrieve data (previous attempts have not been successful). A Fastloc® GPS was mounted to the DTAG housing and tracked the whale's location through the first hours of the deployment **(Figure 4).** However, as GPS receptions ceased approximately 2.5 hr after deployment, we assume the tag slid on the animal to a position below the water line, and as such, additional positions were not successfully recorded.

Table 2. Summary of right whale sightings from February 2017.

Date	Latitude (°N)	Longitude (°W)	Group Size	Whale ID	Tag ID
7-Feb-17	30.70589	81.36832	2	2614+calf	Eg17_038a (deployment)
8-Feb-17	31.10973	81.20559	2	2614+calf	Eg17_038a (recovery)

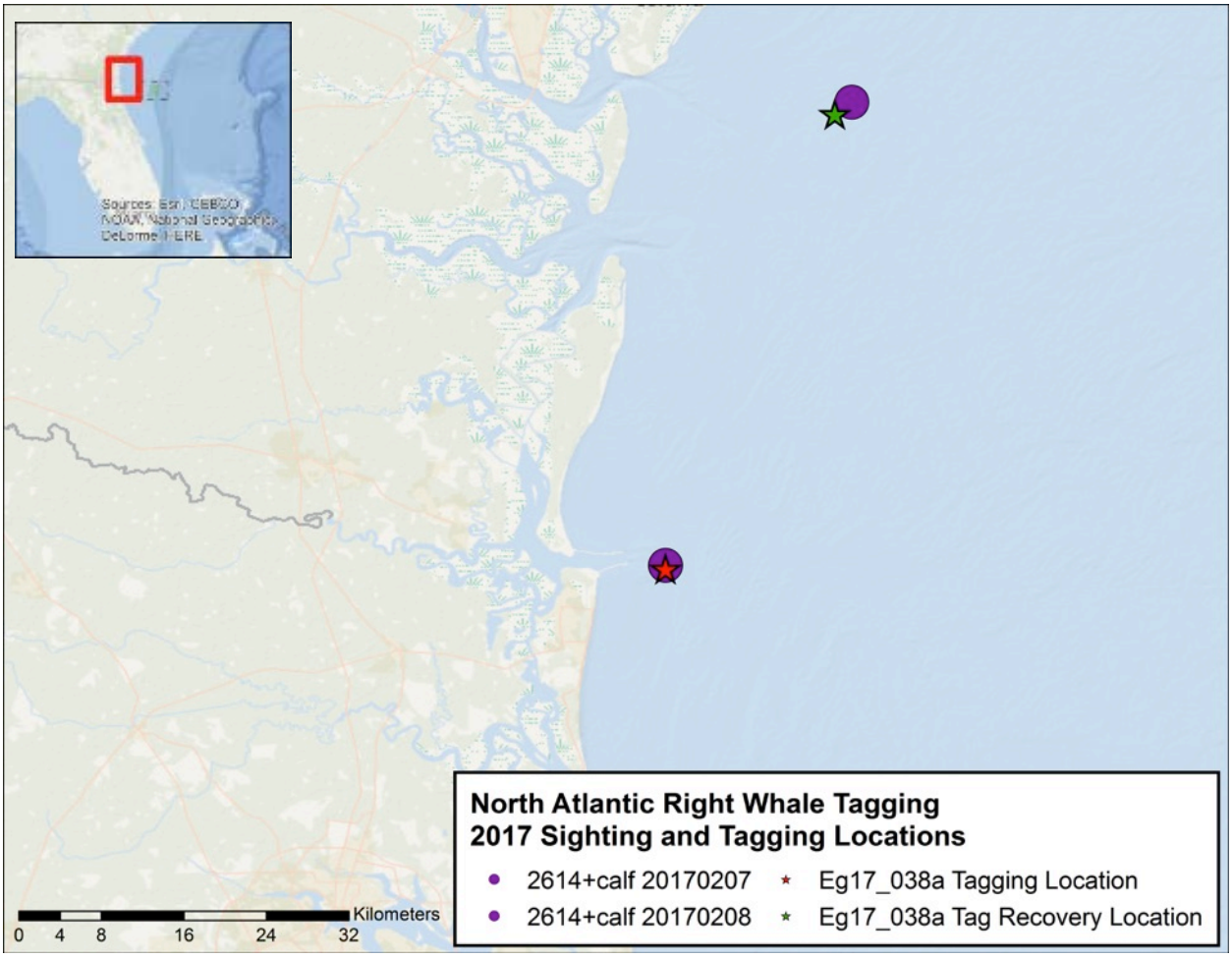

Figure 3. North Atlantic right whale sighting locations (circles), and DTAG deployment and recovery locations (red and green stars) during tagging operations in February 2017.

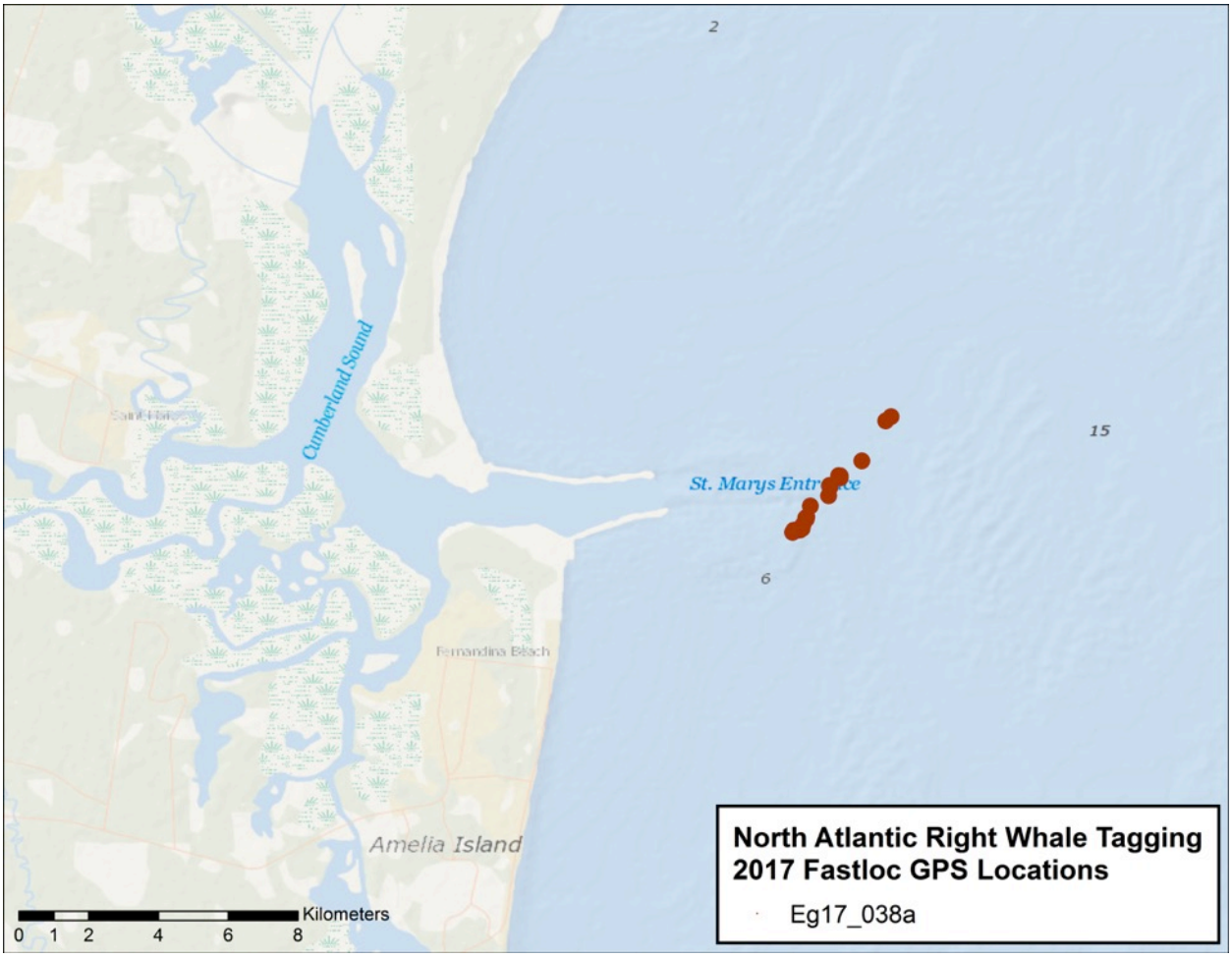

Figure 4. Fastloc® GPS positions for tagged North Atlantic right whale Eg17_038a, 07 February 2017.

3.3 DTAG Data Analyses

Analyses of the GPS, acoustic, and dive data from the DTAGs were completed for the 2016 data, and further analyses of these data are being conducted under the supervision of Drs. Nowacek and Parks with students and technicians in their laboratories. Preliminary results from these analyses were presented at the 173rd Meeting of the Acoustical Society of America and 3rd Joint Meeting of the Acoustical Society of America and the European Acoustics Association on 25–29 June 2017 in Boston, Massachusetts (Parks et al. 2017a), and at the 22nd Biennial Conference on the Biology of Marine Mammals on 22–27 October 2017 in Halifax, Nova Scotia, Canada (Dombroski et al. 2017, Parks et al. 2017b).

3.3.1 Acoustic Analyses

In 2017, analyses focused on synthesis of acoustic data from all DTAG deployments from 2014 to 2016 (**Table 3**). Overall approximately 85 hr of acoustic data have been recorded from right whales on the calving grounds. The upcall is the primary call used for right whale passive acoustic monitoring (Van Parijs et al. 2009). The upcall production rate for lactating females was extremely low, with only 0.7 upcalls/hr recorded on the tags (range 0–-4.5/hr). The call rate for the pregnant female (EGNO 3101 in 2016) was much higher. This same whale was tagged while lactating, for a comparable tagging duration, where the upcall production rate dropped to 0. These detailed analyses have identified novel, previously undescribed call types produced by right whale mother-calf pairs on the calving grounds. All of these newly identified call types are low amplitude and are not detectable except in close proximity to the whales. These calls have not been detected from vessel-based towed-array surveys from a previous study. These new calls will not be useful for passive acoustic monitoring, but do identify a mode of communication between mothers and their calves that may be impacted by noise in the environment and warrants further exploration of their function. A manuscript is planned for submission to a peer-reviewed journal in 2018 to publish these findings.

3.3.2 Dive Analyses

In 2017, dive analyses of the existing DTAG data focused on summarizing the depth distribution (**Figure 5**) to quantify the percentage of time in which whales are detectable for visual boat-based and aerial surveys in their calving habitat in the southeastern United States. Tagging operations conducted during January–March of 2006 and 2014–2016 contributed to these analyses, and 15 tag deployments have been included (**Table 4**). Thresholds for availability for visual surveys were determined based on water transparency estimated from remotely sensed surface chlorophyll data from the Moderate-resolution Imaging Spectroradiometer obtained from the NASA Goddard Space Flight Center, Ocean Ecology Laboratory, Ocean Biology Processing Group (Greenbelt, Maryland: https://oceancolor.gsfc.nasa.gov/). At the surface (depth ≤ 0.5 m) whales would be available to be detected by boat and aerial surveys; between 0.6 and 2.5 m whales would be available only for aerial surveys, whereas at depths deeper than 2.5 m whales would be unavailable to be detected by visual surveys. To account for possible differences in diving behavior, time spent at each depth bin was compared among 3 categories: juvenile - whales ≥ 1 and <9 years old; pregnant - adults previously unaccompanied that were subsequently sighted accompanied by a young calf <1 year old; nursing - adults accompanied by a calf <1 year old.

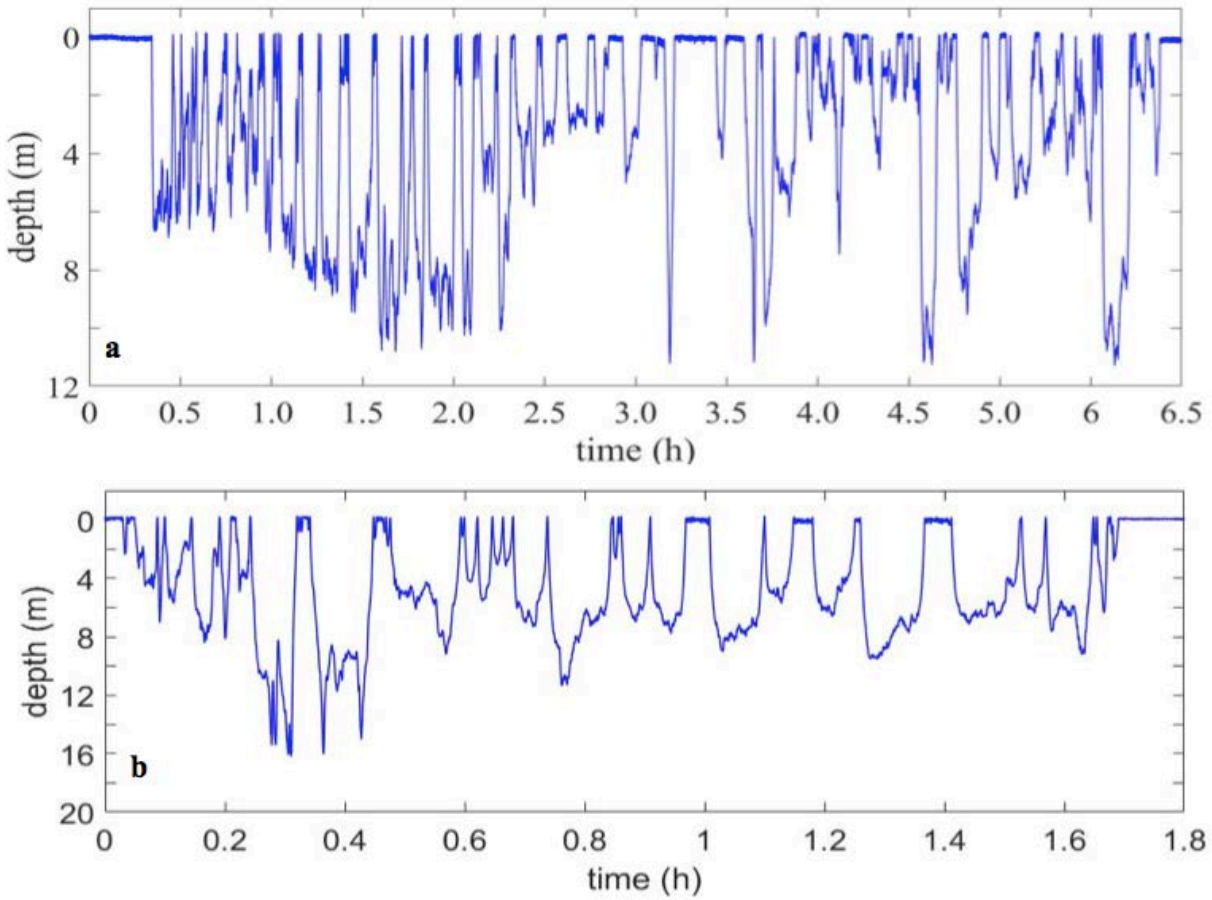

Figure 5. Dive profile of (a) a nursing female, Eg14_056a; (b) a juvenile, Eg06_024a.

Table 3. Summary of acoustic data from 12 DTAGs deployed on 11 lactating and one pregnant female right whales as part of this study from 2014 to 2016, with detected upcalls from each tag and a calculated call rate per hour.

Date	Whale ID (EGNO)	Acoustic record duration (hh:mm)	Status	Upcalls produced by the tagged whale	Upcalls per hour of tag recording
9-Feb-14	2123	1:33	Nursing	7	4.5
10-Feb-14	2040	5:49	Nursing	3	0.5
18-Feb-14	3157	11:36	Nursing	0	0
25-Feb-14	2645	5:34	Nursing	0	0
21-Feb-15	3292	23:05	Nursing	0	0
25-Jan-16	3101	5:00	Pregnant	45	9.0
30-Jan-16	3405	4:45	Nursing	0	0
31-Jan-16	1281	6:44	Nursing	0	0
1-Feb-16	1810	1:45	Nursing	0	0
17-Feb-16	3101	4:56	Nursing	0	0
17-Feb-16	1281	2:50	Nursing	3	1.06
22-Feb-16	3317	11:48	Nursing	0	0

Table 4. Summary of percentages of tagged time each whale was available for detection by vessel and/or aerial surveys based on tag depth data.

Deployment id[1]	Class	Available for boat and aerial surveys (%time)	**Available for only aerial surveys (%time)**	**Unavailable (%time)**
Eg06_021a	**Juvenile**	**12.7**	**14.8**	**72.5**
Eg06_024a	**Juvenile**	**25.8**	**9**	**65.2**
Eg06_025e	**Juvenile**	**15.5**	**5.6**	**78.9**
Eg06_028a	**Pregnant**	**28**	**9.7**	**62.3**
Eg14_040a	**Nursing**	**13.9**	**25**	**61.1**
Eg14_041a	**Nursing**	**20.6**	**37.6**	**41.8**
Eg14_049a	**Nursing**	**38.5**	**10.1**	51.4
Eg14_056a	**Nursing**	**36.5**	**17.7**	**45.8**
Eg15_052a	**Nursing**	**11.7**	**21.6**	**66.7**
Eg16_025a	**Pregnant**	**13**	**6.6**	**80.4**
Eg16_030a	**Nursing**	**47.6**	**16.6**	**35.8**
Eg16_031a	**Nursing**	**9.5**	**12.4**	**78.1**
Eg16_032a	**Nursing**	**26.1**	**21.4**	**52.5**
Eg16_048a	**Nursing**	**19.6**	**52.2**	**28.2**

Overall, whales spent an average of 59.1 percent (+/-16) of the time at depths deeper than 2.5 m where they cannot be detected by either visual survey method. Juveniles spent more time unavailable for visual surveys than other age classes. Spending more time at depths deeper than 2.5 m would benefit travelling animals because of reduced drag. Pregnant females spent less time available for only aerial surveys than other age/sex classes. Variable buoyancy may affect how much time whales spend at different depth ranges. Nursing females spent more time available for only aerial surveys than other age classes, suggesting that the calf's presence limits their time in depths deeper than 2.5 m. These results indicate that whales of all age and sex classes spend most of their time out of visual detection range of either vessel or aerial surveys, which impacts detectability on the calving grounds. Additional analyses exploring swimming activities sub-surface (i.e., stationary versus active directional swimming) are being completed before submission of a manuscript to a peer-reviewed journal planned for 2018.

[1] Data from tag deployments in 2006 and 2014-2016.

3.4 Future Directions

A fifth year of fieldwork is currently underway in February 2018. The focus of the additional research will be to increase the sample size of tagged individuals, with an emphasis on single animals (not mother-calf pairs) when feasible. Additional years of data collection may be proposed to further assess movement and dive patterns, as well as acoustic behavior.

In addition, a Slocum glider with passive acoustic monitoring capabilities will be deployed during the winter of 2018 to assess the distribution of right whales offshore of the Virginia/North Carolina border during the migration period.

4. Publications and Presentations

The following list contains the publications and presentations (either made/published or currently in progress) associated with this project:

Dombroski, J., S.E. Parks, and D.P Nowacek. 2017. Out of sight: How much time do North Atlantic right whales spend within the detection range of visual surveys? 22nd Biennial Conference on the Biology of Marine Mammals. October 22-27, 2017, Halifax, Nova Scotia, Canada.

Parks, S.E., A.J. Read, and D.P. Nowacek. 2017a. Acoustic environment of North Atlantic right whales in the southeastern United States. 173rd Meeting of the Acoustical Society of America and 3rd Joint Meeting of the Acoustical Society of America and the European Acoustics Association, 25-29 June, 2017, Boston, Massachusetts. Abstract in: *Journal of the Acoustical Society of America* 141(5):3942.

Parks, S.E., D. Cusano, S. Van Parijs, and D. Nowacek. 2017b. Acoustic communication of North Atlantic right whale (*Eubalaena glacialis*) mother-calf pairs on the calving grounds. 22nd Biennial Conference on the Biology of Marine Mammals. October 22-27, 2017, Halifax, Nova Scotia, Canada.

Root-Gutteridge , H., D.A. Cusano, Y. Shiu, D.P. Nowacek, S.M. Van Parijs, and S.E. Parks 2018, in press. A lifetime of changing calls: North Atlantic right whales, *Eubalaena glacialis*, refine call production as they age. Animal Behaviour 137.

The following are in progress for final peer-reviewed manuscript submission:

- Acoustic analyses of DTAGs
- Dive behavior analyses of DTAGs.

5. Literature Cited

Dombroski, J., S.E. Parks, and D.P Nowacek. 2017. Out of sight: How much time do North Atlantic right whales spend within the detection range of visual surveys? 22nd Biennial Conference on the Biology of Marine Mammals. October 22-27, 2017, Halifax, Nova Scotia, Canada.

NEAQ (New England Aquarium). 2017. The North Atlantic Right Whale Catalog. New England Aquarium, Boston, Massachusetts. http://rwcatalog.neaq.org/Default.aspx (accessed 02/22/2017)

Nowacek, D.P., S.E. Parks, and A.J. Read. 2015. *Year 1 Report: Tagging and Tracking of Endangered Right Whales in Florida Waters. Final Report.* Prepared for U.S. Fleet Forces Command. Submitted to Naval Facilities Engineering Command Atlantic, Norfolk, Virginia, under Contract No. N62470-10-3011, Task Orders 44 and 52, issued to HDR, Inc., Virginia Beach, Virginia. 27 February 2015.

Nowacek, D.P., S.E. Parks, and A.J. Read. 2016. *Year 2 Report: Tagging and Tracking of Endangered North Atlantic Right Whales in Florida Waters. Final Report*. Prepared for U.S. Fleet Forces Command. Submitted to Naval Facilities Engineering Command Atlantic, Norfolk, Virginia, under Contract Nos. N62470-10-3011, Task Orders 44 and 52 and N62470-15-8006, Task Order 14, issued to HDR, Inc., Virginia Beach, Virginia. 02 August 2016.

Parks, S.E., Read, A. J., & Nowacek, D. P. 2017a. Acoustic environment of North Atlantic right whales in the Southeastern United States. *The Journal of the Acoustical Society of America*, *141*(5), 3942. 173rd Meeting of the Acoustical Society of America and 3rd Joint Meeting of the Acoustical Society of America and the European Acoustics Association, 25-29 June, 2017, Boston, MA.

Parks, S.E., D. Cusano, S. Van Parijs, and D. Nowacek. 2017b. Acoustic communication of North Atlantic right whale (*Eubalaena glacialis*) mother-calf pairs on the calving grounds. 22nd Biennial Conference on the Biology of Marine Mammals. October 22-27, 2017, Halifax, Nova Scotia, Canada.

Pettis, H.M., R.M. Pace III, R.S. Schick, and P.K. Hamilton. 2017. North Atlantic Right Whale Consortium 2017 Annual Report Card. North Atlantic Right Whale Consortium, Boston, Massachusetts. October 2017.

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