

Spatiotemporal Distributions of Species Detected within Virginia's Offshore Lease Areas

Volume 2: Virginia Wind Energy Lease Area OCS A-0483



Spatiotemporal Distributions of Species Detected within Virginia's Offshore Lease Areas

Volume 2: The Virginia Wind Energy Lease Area OCS A-0483

April 2025

Authors:
Christian Hager, PhD.
Kyle Breault

Prepared under contract No.:140M0122P0023
By
Chesapeake Scientific LLC
100 Six Pence Court
Williamsburg, Virginia 23185

**U.S. Department of the Interior
Bureau of Ocean Energy Management
BOEM Office of Renewable Energy Programs**



DISCLAIMER

Study concept, oversight, and funding were provided by the U.S. Department of the Interior, Bureau of Ocean Energy Management (BOEM), Environmental Studies Program, Washington, DC, under Contract Number 140M0122P0023, with Chesapeake Scientific, LLC. This report has been technically reviewed by BOEM, and it has been approved for publication. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of BOEM, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

REPORT AVAILABILITY

Download a PDF file of this report at https://epis.boem.gov/Final%20Reports/BOEM_2024-072.pdf. Visit BOEM's website to search other studies funded by BOEM's Environmental Studies Program.

CITATION

Hager CH, Breault DK (Chesapeake Scientific LLC, Williamsburg, Va.). 2025. Spatiotemporal distributions of species detected within the Virginia's offshore lease areas. Volume 2: the Virginia wind energy lease area OCS A-0483. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 140 p. Contract No.:140M0122P0023. Report No.: BOEM 2024-072.

ABOUT THE COVER

Offshore wind farm northern Scotland, Christian Hager, Chesapeake Scientific LLC

ACKNOWLEDGMENTS

We would first like to thank BOEM and the U.S. Navy (USN) for funding for equipment and monitoring costs. This project built upon USN research that established the groundwork and suitable methodologies without which this work would not have been possible. To that point we would like to acknowledge all the crew members at Chesapeake Scientific LLC. These brave souls ventured into Atlantic Ocean often working under dangerous conditions every month of the year for six years in order to collect data and maintain a working array. They are Christian Hager, Craig Marcuson, Jay Russo, Tracy Massey, and Noel Mathies. We also gratefully acknowledge all of the researchers who tagged the animals. They are listed in order to acknowledge them independently: Debra Abercrombie, Mike Arendt, Matt Balazik, Charles Bangley, Barbara Block, Beth Bowers, Hal Brundage, Jeff Buckel, Caroline Collatos, Tobey Curtis, Andy Danylchuck, Keith Dunton, Kristine Edwards, Dewayne Fox, Bryan Franks, Bryan Frazier, Mike Frisk, Ben Gahagen, Riley Gallagher, Christian Hager, Neil Hammerschlag, Danielle Haulsee, Eric Hilton, Bill Hoffman, Evan Ingram, Jason Kahn, Stephen Kajiura, Matt Kenworthy, Jeff Kneebone, Jake LaBelle, Mike Loeffler, Madeline Marens, Anne Markwith, Pat McGrath, Bill Murphy, Matt Ogburn, Samir Patel, Matt Perkinson, Steve Poland, Bill Post, Ian Park, Doug Peterson, Eric Reyier, Roger Rulifson, Tom Savoy, Dave Secor, Greg Skomal, Matt Skumkall, Chuck Stence, Bradley Stevens, James Sulikowski, Steve Szedlmayer, Carter Watterson, Kevin Weng, Holly White, Jessica Wingar, Gail Wippelhauser, Anne Wright, and Jennifer Wyffels. The sources of funding for tagging are too numerous and diverse to acknowledge all of them but the majority of funding for tagging, to our knowledge, came from NMFS and the USN. There were also some private funds provided through Friends of Sturgeon and Chesapeake Scientific LLC that were crucial.

Contents

List of Figures	iv
List of Tables	iv
List of Abbreviations and Acronyms	vi
Summary	7
1 Introduction	8
2 Methods	12
2.1 Study Site.....	12
2.2 Data Collection Methods.....	13
2.3 Data Analysis Methods	15
3 Results	16
3.1 Deployment Results.....	16
3.2 Detection Data by Species	19
3.2.1 Atlantic sturgeon (<i>Acipenser oxyrinchus oxyrinchus</i>)	21
3.2.2 Striped Bass (<i>Morone saxatilis</i>).....	32
3.2.3 White shark (<i>Carcharodon carcharias</i>)	34
3.2.4 Cobia (<i>Rachycentron canadum</i>)	36
3.2.5 Sand tiger shark (<i>Odontaspis taurus</i>)	37
4 Discussion	38
4.1 Atlantic sturgeon (<i>Acipenser oxyrinchus oxyrinchus</i>).....	39
4.2 Striped Bass (<i>Morone saxatilis</i>)	45
4.3 White shark (<i>Carcharodon carcharias</i>).....	46
4.4 Cobia (<i>Rachycentron canadum</i>).....	48
4.5 Sand tiger shark (<i>Odontaspis taurus</i>).....	49
4.6 Concluding Remarks	50
5 References.....	52
Appendix A: SIRI Manuscript.....	65
Appendix B: Minor Species Detection Data.	78
Appendix C: Taggers by Species	85
Appendix D: Major Species Detection Data.	89
Appendix E: Water temperatures from CTD casts between 2003 and 2016 in the NY WEA, DE WEA (surrogate for MD), VA WEA, and NC-KH WEA copied from Guida et al. 2017.	135

List of Figures

Figure 1. The locations of the 20 receivers deployed in the CRA and WFA are illustrated with depths. All the inshore receivers out to the BOEM 1 site were placed on buoys.	14
Figure 2. Regional CRA detection data is graphed above to illustrate fluctuations in detection statistics with bottom temperature.	24
Figure 3. Regional WFA detection data is graphed above to illustrate fluctuations in detection statistics with bottom temperature.	27
Figure 4. Map from Guida et al. 2017 showing site locations on detailed benthic map.	41

List of Tables

Table 1. Sampling days per month within the two regions was not equal across months because the study started on 12/20/15 and ended on 8/18/21.	17
Table 2. CRA receiver sites are in the columns with months of maintenance in the rows.	18
Table 3. WFA receiver sites are in the columns with months of maintenance in the rows.	19
Table 4. A summation of CRA detection data is presented with species that had 100 or more individuals detected in bold.	20
Table 5. A summation of WFA detection data is presented with species that had 100 or more individuals detected in bold.	21
Table 6. The total number of individual Atlantic sturgeon, detections, and the number of days with detections in the CRA are listed by year.	22
Table 7. The total number of individual Atlantic sturgeon, detections, and the number of days with detections for the CRA region are listed by month.	23
Table 9. The annual number of individual Atlantic sturgeon, detections, and the number of days with detections in the WFA are listed.	26
Table 10. The number of individual Atlantic sturgeon, detections, and the number of days with detections within the WFA are listed by month.	27
Table 11. The WFA's SIRI identifies the most important periods of regional occupation and important differences in the relative importance of sites over time.	28
Table 12. The number of active tags per year is given as are the number detected in the CRA and WFA.	29
Table 13. The total number of individual York River adults, detections, and the number of days with detections for the CRA are listed by year.	29
Table 14. The CRA %SIRI for York River adults identifies the late fall and spring as migration periods with some winter preference for specific sites like 4 BOEM and 13 BOEM.	30
Table 15. The total number of individual Atlantic sturgeon, detections, and the number of days with detections for the WFA region are listed by year.	31
Table 16. The WFA % SIRI identifies the winter and early spring periods as the only periods with York River sturgeon present.	31
Table 17. The site-specific depth data from depth tagged York River adults in the WFA.	32
Table 19. The total number of individual striped bass, total detections, and the number of days with detections within the CRA from 2016 -2020 are listed by month.	33

Table 20. The total number of individual striped bass, total detections, and the number of days with detections within the WFA are listed by year.	33
Table 21. The total number of individual striped bass, total detections, and the number of days with detections within the WFA are listed by month.	34
Table 22. The total number of White shark, total detections, and the number of days with detections within the CRA are listed by year.	34
Table 23. The total number of White shark, detections, and the number of days with detections within the CRA are listed by month.	35
Table 24. The total number of White sharks, total detections, and the number of days with detections within the WFA are listed by year.....	35
Table 25. The total number of White sharks, detections, and the number of days with detections within the WFA are listed by month.....	36
Table 26. The total number of individual cobia, total detections, and the number of days with detections within the CRA are listed by year.	36
Table 27. The total number of individual Cobia, total detections, and the number of days with detections within the CRA are listed by month.	37
Table 28. The total number of individual sand tigers, total detections, and the number of days within the CRA are listed by year.	37
Table 29. The total number of individual sand tigers, total detections, and the number of days with detections within the CRA for the sampling period are listed by month.....	38

List of Abbreviations and Acronyms

AR	VR2WAR receiver
BOEM	Bureau of Ocean Energy Management
CS	Chesapeake Scientific LLC
CRA	Cable Route Array
EMF	Electromagnetic field
kg	Kilogram
km	Kilometers
Lb	pound
MAB	Mid-Atlantic Bight
NMFS	National Marine Fisheries Service
SBA	Sandbridge Shoal Borrow Area
SIRI	Site Specific Index of Relative Importance
US	United States
USN	United States Navy
USCG	United States Coast Guard
VLA	Virginia Wind Energy Lease Area
WEA	Wind Energy Area
WFA	Wind Farm Array

Summary

Favorable domestic policies are currently a major impetus to the leasing and development of offshore wind energy sites by the Bureau of Ocean Energy Management along the United States' continental shelf; however, the impacts of such farms on shelf ecosystems are poorly understood. One aspect that complicates our ability to address impacts in specific regions of the shelf is the vast area and different ecosystems that are found along the shelf's habitats that stretch from Cape Hatteras, North Carolina to George's Bank off of Massachusetts. This vast area contains many ecosystems that are primarily influenced by latitude and resulting thermal dynamics. Seasonally, animals migrate along the shelf motivated and restricted by temperature alterations in order to take advantage of the high level of productivity it contains which is largely due to the primary production of numerous estuaries along its western border. These estuaries and the seasonal dynamics which make their productivity available to the shelf's benthic systems (Guida et al. 2017) are why the shelf is one of the most productive coastal systems on the planet (O'Reilly et al. 1984), providing our country with food and financial stability (Guida et al. 2017, Hogan et al. 2023).

The Virginia Wind Energy Lease Area A-0483 (VLA) is located on the shelf's Mid-Atlantic Bight (MAB) just southeast of the Chesapeake Bay. In order to better understand fish occupation within this Wind Energy Area (WEA), Chesapeake Scientific LLC, in collaboration with the United States Navy and HDR Inc., conducted an extensive marine acoustic monitoring project from December of 2015 until August of 2021. This array collected detection data on any and all species carrying Vemco® (69 Khz) transmitters using a passive array of Vemco® receivers. We divided our study site into two sections, the Cable Route Array and Wind Farm Array, in order to improve our ability to understand detection data and apply it to minimize impacts specific to each section. Though geographically close, each section contains unique ecological attributes due to the varied physical dynamics that shape each seasonally.

The Cable Route Array was a line of receivers located slightly south of the Chesapeake Bay's mouth and extended from shore in about 6 m of depth out 44.4 km to about 24 m of depth. The inshore portion of this array's benthos consists of mostly sand with little topographic variation, and its environmental attributes are strongly influenced by the tidal flow from the Chesapeake Bay (Guida et al. 2017). Its offshore sites resemble those found in the Wind Farm Array in that they are more benthically diverse and dominated by ocean driven forces (Guida et al. 2017). The Wind Farm Array was located within the Wind Energy Area's 457.3 km² area. This region is a much deeper region (25-36 m), and it owes many of its physical characteristics to ocean conditions. Physical attributes that persist here are not influenced by bay waters that flow south and are typical of the dynamics found across the continental shelf zones in the MAB. Stratification develops in early April and persists until September or October when ocean winds fully mix the water column (Guida et al. 2017). During the winter months until April, the Wind Farm Array region is essentially isothermal. The seasonal fluctuation in temperature pattern is likely the major driver for migrations, re-distribution of highly mobile demersal nekton and mobile epibenthos, and perhaps the settlement of new demersal and benthic organisms of all types from the plankton (Guida et al. 2017). Therefore, if wind farm construction were to change any part of this seasonal stratification pattern, especially across large areas, that change could have effects.

The two arrays consisted of 20 receivers in total (**Figure 1**), 14 in the Cable Route Array and 6 in the Wind Farm Array. Assuming a .5 km range on each side of the two planned cable lines, the routes would contain ~ 89 km² of impacted area. Therefore, the receivers are assumed to have monitored 11 km² of 89 km² or 12% of the area. This is likely an overestimation of the area monitored because it assumes the cables will be in straight lines to the Wind Energy Area, which is inaccurate. The Wind Energy Area contains 457.3 km² (113,000 acres, Guida et al. 2017). Following the same assumptions as above, each covered .785 km, so in total 4.71 km² or approximately 1% (4.71/457.3) of the region was monitored.

Twenty-eight species occurred within the entire VAWEA. Twenty-six of these were detected in the Cable Route Array in the 2066 days it was monitored. Five species occurred at numbers of 100 or more individuals: Atlantic sturgeon (n=974), striped bass (n=243), white shark (158), cobia (n=115), and sand tiger shark (n=112). Twenty-one species were detected in the Wind Farm Area region and only three contained data on 100 or more individuals: Atlantic sturgeon (n=555), striped bass (n=368), and white shark (n=126). The spatiotemporal distributions of these species were extremely different in the two array and varied considerably by species. Seasonal migrations were recorded in all species. However, seasons of greatest availability varied between species. While the endangered Atlantic sturgeon and commercially important striped bass were most abundant in both arrays fall through early spring, both demonstrated a preference for the offshore waters within the Wind Farm Array during the coldest months. White sharks migrate through the arrays in both spring and fall but were available in small numbers throughout the year. Sand tiger shark and cobia were summer residents, and both showed preference for inshore waters. Atlantic sturgeon detections indicate that the species overwinters within the Virginia Wind Farm Area. In fact, the region appears extremely important to the York River stock as 88% of the active transmitters of this population were detected overwintering there. Cable route array detections indicate that it is an important migration route for sturgeon, but only the sites farthest offshore appear to be occupied over winter. Detection statistics also suggest that sturgeon habitat preference is not independent of benthic composition, topography, prey availability, or water temperature.

Despite the recognized importance of shelf habitats to our ecosystems and society, there is a noticeable scarcity of empirical data regarding the spatiotemporal distributions, behavior of, and designation of Essential Fish Habitats of commercially important and protected fishes while in shelf habitats (Wahlberg and Westberg 2005, Kikuchi 2010, Bergstrom et al. 2013, Reubens et al. 2013, Ingram et al. 2019, Rothermel et al. 2020, Hogan et al. 2023). This lack of data underscores the need for targeted research to better quantify the spatiotemporal distributions and preferred habitats especially of commercially important and protected species that are likely to be affected by WEA development and operation (Furness et al. 2013, Bailey et al. 2014, Vellejo et al. 2017, Hogan et al. 2023). The need to quickly identify essential and critical habitats on the continental shelf has been elevated recently due to the extremely rapid expansion of wind energy leases within the Mid-Atlantic Bight, leases that directly overlap with known migration corridors (Rothermel et al. 2020) and extend into recognized overwintering habitats (Overton et al. 2008, Waldman et al. 2012, Rulifson et al. 2020). This research strongly suggests that we have a great deal to learn about our shelf's ecosystems and the role they play, before we alter them, as these roles are crucial to the life such ecosystems support including ours.

1 Introduction

Favorable domestic policies are currently a major impetus to the leasing and development of numerous offshore wind energy sites by the Bureau of Ocean Energy Management (BOEM) along the United States' continental shelf. The majority of proposed Wind Energy Areas (WEA) will be placed within the shelf's Mid-Atlantic Bight (MAB) near the mouths of estuaries (Guida et al. 2017). Development of offshore wind farms has resulted in significant concerns as to their impacts on marine life world-wide (Wahlberg and Westberg 2005, Gill 2005, Drewitt and Langston 2006, Gilles et al. 2009, Inger et al. 2009, Boehlert and Gill 2010, Verfuss et al. 2016, Ingram et al. 2019, Rothermel et al. 2020, Raghukumar et al. 2023).

Naturally, concerns have been expressed in reference to the development of such farms along our continental shelf (Ingram et al. 2019, Rothermel et al. 2020, Hogan et al. 2023). These concerns are well founded as our continental shelf is one of the most productive coastal systems on the planet (O'Reilly et al. 1984), providing our country with food and financial stability (Guida et al. 2017, Hogan et al. 2023). Although a plethora of ecosystem level effects associated with wind farm construction, operation, and

deconstruction are recognized, there is a great need for more data to help us assess these ecosystem level alterations as they pertain to our shelf ecosystems (Hogan et al. 2023). As the shelf's ecosystems' abilities to provide future fisheries resources are already threatened, as are global fisheries, by overharvest and climate change which alter the distribution and vitality of fish populations (Crear et al. 2020a), it is imperative that we understand and assess the impacts of further system alterations resulting from offshore wind farms prior to their construction.

The Virginia Wind Energy Lease Area A-0483 (VAWEA) is located on the shelf's MAB just southeast of the Chesapeake Bay. The Chesapeake Bay is the largest of 850 estuaries that border the United States (US), and it is fed by 20 major tributaries (Murdy et al. 1997). It borders two states (Virginia and Maryland), and its watersheds extends across Maryland, Virginia, Delaware, Pennsylvania, and New York. The Chesapeake Bay is over 6500 sq km (2,500 square miles) and 314 km long (195 miles) (White 1989). Due to the Chesapeake Bay's, size, location, productivity, and extreme temperature range, it contains a vast diversity of fishes seasonally (Hildebrand and Schroeder 1928, Murdy et al. 1997). These belong to five major categories: freshwater, estuarine, marine, anadromous, and catadromous species. While the bay provides spawning grounds, nurseries, and a plethora of prey items to commercially important and protected anadromous species like striped bass and Atlantic sturgeon, numerous marine species also depend upon it for nurseries and trophic resources seasonally.

Estuarine habitats are highly productive. Many species have evolved to be critically dependent upon them for reproduction and growth. Primary production within estuaries is so large that a significant portion of its production is exported into shelf waters where it remains suspended in surface water until it is mixed throughout the water column in the fall. This mixing not only supplies the shelf's ecosystem with valuable nutrients, but it re-distributes highly mobile demersal nekton and mobile epibenthic species and promotes the settlement of new demersal and benthic organisms of all types from the plankton (O'Reilly et al. 1984, Valiera 1995, Guida et al. 2017). Thus, shelf production and biodiversity are fundamentally linked through this seasonal turnover. However, for some species, this turnover is critical for other reasons. For many species, seasonal migrations between estuarine and coastal waters are not only cued by predictable alterations in photoperiod and river temperature (Ingram et al. 2019, Hager et al. 2020) but also by these seasonal shifts in shelf water stratification (Guida et al. 2017). Thus, alterations in this stratification and the natural circulation of energy it provides may not only have significantly negative impacts on the shelf's ecosystem productivity and biodiversity and may also effect the natural cues that motivate seasonal fish migrations.

The continental shelf is very large extending from Cape Hatteras, North Carolina to George's Bank off of Massachusetts. Across this vast area, the shelf contains many ecosystems that are primarily influenced by latitude and resulting thermal dynamics. The Chesapeake region is relatively moderate in its thermal minimum (Guida et al. 2017), and many species that must head south in the winter in more northern latitudes like clearnose skates, black sea bass, scup, butterfish, northern sea robins, and summer flounder instead undertake an east west migration to overwinter in nearshore shelf habitats (Nesbit and Neville 1935, Colvocoresses and Musick 1984, Murdy et al. 1997). Here, due to the region's latitude, they can find moderate bottom temperatures (Guida et al. 2017) that are suited for warm-temperate as well as boreal species (Murdy et al. 1997).

In order to access these overwintering habitats and critical estuarine habitats, species must migrate across the shelf each spring and fall using migration corridors that are not well understood currently. Anything that disturbs these migrations could have unintended and detrimental effects on numerous stocks (Rothermel et al. 2020). These effects would vary according to the location where these disturbances occur since species are not evenly distributed across shelf habitats (Guida et al. 2019). However, because life stages of various species require different shelf habitats (Diaz et al. 2013), and intra-population differentiation in life histories, migration patterns, and stock mixing in offshore waters occur; the

potential for localized threats to congruently affect numerous species and/or distinct populations of a given species in very different ways is augmented (Dunton et al. 2012, O’Leary et al. 2014).

Research regarding the potential impacts of offshore wind development have largely focused on marine mammals and seabirds (Drewitt and Langston 2006, Gilles et al. 2009, Thompson et al. 2013, Russel et al. 2016). They have not focused on the ecological or commercial value of the fishes that seasonally depend upon both estuarine and shelf habitats (Hogan et al. 2023). In fact, there is a noticeable scarcity of empirical data regarding the spatiotemporal distributions, behavior of, and designation of Essential Fish Habitats (EFH) of commercially important and protected fishes while in shelf habitats (Wahlberg and Westberg 2005, Kikuchi 2010, Bergstrom et al. 2013, Reubens et al. 2013, Ingram et al. 2019, Rothermel et al. 2020, Hogan et al. 2023). This lack of data underscores the need for targeted research to better quantify the spatiotemporal distributions and preferred habitats especially of commercially important and protected species that are likely to be affected by WEA development and operation (Furness et al. 2013, Bailey et al. 2014, Vellejo et al. 2017, Hogan et al. 2023).

In order to better understand fish occupation within this WEA, Chesapeake Scientific LLC (CS), in collaboration with the United States Navy (USN) and HDR Inc., conducted an extensive marine acoustic monitoring project from December of 2015 until August of 2021. This array collected detection data on all species carrying Vemco® (69 Khz) transmitters using a passive array of Vemco® receivers. Previously, shelf research was heavily reliant on fisheries dependent data (Vladykov and Greeley 1963, Musick et al. 1993, Stein et al. 2004) and surveys using commercial gear with the same inherent sampling biases (Laney et al. 2007). Acoustic monitoring provides a means of collecting spatiotemporal data that is not dependent on recaptures or biased by collection methodology. It can monitor across large areas for long periods of time without influencing natural behavior. Because animals exercise free will and choose to occupy habitats based on preference due to some benefit (Niklitschek 2001, Stein et al. 2004, Niklitschek and Secor 2005, Breece et al. 2016), sites that are more often occupied are preferred and in most cases are thus more important to the species. As more individuals are telemetered, the inferences a researcher can make become more powerful and far-reaching. Given large enough sample sizes from across the significant populations of a species, acoustic telemetry is capable of not only identifying the incidence of critical species (Lowerre-Barbieri et al. 2019) but also describing migration corridors (Ingram et al. 2019, Rothermel et al. 2020), habitat preferences (Kieffer and Kynard 1993, Ingram and Peterson 2016, Melnychuk et al. 2017), and even identifying previously unrecognized Essential or Critical Fish Habitats. Acoustic telemetry has recently gained wide acceptance as a valuable tool to understand survival, movement, migrations, and habitat occupation patterns in aquatic systems (Cooke et al. 2013, Hussey et al. 2015), and with the provision of such valuable data, occupancy modeling has also greatly expanded (MacKenzie et al. 2017) in the 21st century.

While a gridded array design would have provided an improved ability to assess the behavior and habitat preferences of species as they relate to environmental conditions over time (Rothermel et al. 2020), we chose a linear array design to monitor the VAWEA despite its inherent limitations (Kraus et al. 2018, Hutchison et al. 2021) for various reasons. The placement of the VAWEA and its cable route had already been decided when we initiated monitoring. Therefore, we were not designing an array to determine where the best location for a VAWEA would be; we were monitoring to determine the spatiotemporal distributions of tagged species to determine their exposure to potential local impacts. In recognition of the fact that the disturbances related to windfarms are not isolated to the wind farm itself but extend back to the shore along the cable route (Hutchison et al. 2021), our linear design extended from the shore along the cable route through the WEA to its outer eastern edge. In order to try to monitor different benthic habitats within the WEA, we placed receivers in sites that contained diverse topography and were also previously sampled by Guida et al. (2017) for various abiotic and biotic factors.

Though our linear array design limited its ability to compare environmental variability between sites related to species distribution (Breece et al. 2016, Melnychuk et al. 2017, Rothermel et al. 2020), there were numerous arrays that were congruently being maintained by CS and others to the north (Ingram et al. 2019, Hutchison et al. 2021) and south (Hager and Breault 2023) along the shelf as well as at the mouth of the Chesapeake Bay (Hager 2019) that could provide such data in the future if appropriate. The linear approach was also preferred because it was less expensive which ultimately meant that we could collect more years of data due to a reduced cost per year. This was paramount because the timing and spatial distributions of species are dynamic between years and linked to abiotic/climate variables as well as biotic environmental properties (Kieffer and Kynard 1993, Ingram and Peterson 2016, Melnychuk et al. 2017, Guida et al. 2017, Rothermel et al. 2020, Hager et al. 2020). Thus, more time is necessary to characterize what can be considered typical occupation patterns. The linear design also built upon an existing USN array, successfully run by CS since 2012, that refined a method attaching receivers to United States Coast Guard (USCG) aids to navigations at the surface, a technique that virtually eliminated receiver loss. Thus, assuming aids remained in place, this approach was also considered more reliable. Costs were further reduced through this surface attachment approach because VR2Ws that do not have automated release mechanisms are much less expensive to purchase and maintain and can be checked more quickly than VR2WAR (AR) receiver units placed on the ocean floor and released remotely via a surface-based computer. AR units also require a new anchor and release lug be used ever time data is downloaded. These not only increase costs, but they are also permanently left on site. This remote deployment technique and its reliance on computer technology also resulted in many unexplained losses of expensive equipment and irreplaceable data. Use of a private contractor rather than a state affiliated entity further reduced cost and provided for elongated data acquisition.

New remote tracking technologically is now enabling us to monitor and compare the value of coastal environments, and this valuable tool has emerged at a time when most needed. Shelf habitats are essential to the production and sustainability of numerous important fishes; however, the role such zones provide as seasonal migration corridors, overwintering habitats, and trophic resource reservoirs remains poorly described (Ingram et al. 2019, Rothermel et al. 2020, Rulifson et al. 2020, Hogan et al. 2023). Regardless, shelf habitats are no less critical to species than the well-studied spawning, nursery, and feeding grounds that are currently considered destinations of migrations. Though migrations often occur over vast distances, as man expands his impact on the planet, animals are left with fewer and fewer suitable habitats (Robinson et al. 2009). The need to quickly identify essential and critical habitats on the continental shelf has been elevated recently due to the extremely rapid expansion of wind energy leases within the MAB, leases that directly overlap known migration corridors (Rothermel et al. 2020) and extend into recognized overwintering habitats (Overton et al. 2008, Waldman et al. 2012, Rulifson et al. 2020). The fact that only one species detected in our arrays was sampled in the BOEM trawl surveys within the VAWEA region (Guida et al. 2017) highlights the value of acoustic monitoring and illustrates how it can describe the spatiotemporal distributions of species that completely escape detection by other traditional sampling methods. Such methods are especially useful for larger oceanic residents like the protected Atlantic sturgeon that spend the majority of their lives on and depend heavily upon the prey resources found in shelf habitats (Johnson et al. 1997).

In order to maximize the usefulness of the detection data with regard to the Atlantic sturgeon, which is listed under the Endangered Species Act (ESA) and thus impacts on it must be understood, considered, and mitigated, a Site Specific Index of Relative Importance (SIRI) model was applied to all sturgeon detections. This simple technique combines the three types of detections statistics we acquired into one value that can be used to compare the relative importance of the region and individual receiver sites within it over time. The advantage of the SIRI approach is that it does not rely on the type of information that is unavailable for this study, such as number of transmitters in the environment or the size of populations. Because we have metadata that provided life stage, sex, depth, genetic identification, an

accurate population estimate, and data on tagging location, time, and tag type and life; sturgeon belonging to the York River's adult population were examined separately.

Raw detection data is presented in the appendices to improve our conservation capacity through disseminating as much information as possible without revealing the data of individual researchers. Taggers are identified by species to facilitate future collaborations. Future investigations will require not only the data we have provided but the metadata related to tagged fish and, when applicable, data related to congruent anthropogenic alterations. We are providing all of this data in hopes that it will enable future research and help fill the numerous data gaps related to WEAs identified by Hogan et al. (2023).

2 Methods

2.1 Study Site

We divided our study site into two sections, the Cable Route Array (CRA) and Wind Farm Array (WFA) in order to improve our ability to understand detection data and apply it to minimize impacts specific to each section. Though geographically close, each region contains unique ecological attributes due to the varied physical dynamics that shape each seasonally. The CRA is slightly south of the Chesapeake Bay, and thus, like the Delaware Wind Energy Area (DWEA) its topography and habitats are strongly influenced by the tidal flow from their respective bays (Guida et al. 2017). While the inshore CRA area is mostly sand with little topographic variation, the offshore CRA sites resemble those found in the WFA in that they are more benthically diverse and dominated by ocean driven forces (Guida et al. 2017). In addition, the anthropogenic alterations planned within each region are dissimilar. The CRA is to contain the large cable that carries electricity back to shore, and its area will, presumably, be disturbed less often. The WFA will contain a vast array of hundreds of windmills and cables and significant environmental disturbance will be associated with the construction of, operation of, and maintenance of the WFA throughout the project's duration.

The CRA line of receivers was located slightly south of the Chesapeake Bay's mouth and extended from shore in about 6 m of depth out 44.4 km to about 24 m of depth. While the inshore CRA area is mostly sand with little topographic variation, the offshore CRA sites resemble those found in the WFA in that they are more benthically diverse and dominated by ocean driven forces (Guida et al. 2017). Due to its location, the topography, habitats, and abiotic characteristics of the inshore region are strongly influenced by the bay's seasonal dynamics (Guida et al. 2017). The CRAs linear design was intended to mimic the cable line's route and thus provide a representative sample of species migrating along the inner shelf within 44.4 km of shore. Species would presumably in the future have to cross the two transmission lines that will extend out to the WFA (Guida et al. 2017).

The WFA was located within the WEA's 457.3 km² area. This region is a much deeper region (25-36 m), and it owes many of its physical characteristics to ocean conditions. Physical attributes that persist here are not influenced by bay waters that flow south and are typical of the dynamics found across the continental shelf zones in the MAB. Stratification develops in early April and persists until September or October when ocean winds fully mix the water column (Guida et al. 2017). During the winter months until April, the WFA region is essentially isothermal. The seasonal fluctuation in temperature pattern is likely the major driver for migrations, re-distribution of highly mobile demersal nekton and mobile epibenthos, and perhaps the settlement of new demersal and benthic organisms of all types from the plankton (Guida et al. 2017). Therefore, if wind farm construction were to change any part of this seasonal stratification pattern, especially across large areas, that change could have impacts to fish movements.

2.2 Data Collection Methods

The two arrays consisted of 20 receivers in total (**Figure 1**), 14 in the CRA and 6 in the WFA. The first six within the CRA were VR2W receivers suspended from floating aids to navigation with USCG permission. Each was tethered to the aid by two independent stainless-steel cables with stainless steel Flemish crimps at each end that resulted in greater than 3175 kg (7000 lbs.) of holding strength. Cables were attached to a turn buckle on the top of the buoy and to the receiver at the other end by custom U-bolts made from stainless steel flat bar (3/16 by 1 inch) and a 3/8-inch stainless bolt and nut. This allowed USCG to remove and redeploy units if buoys were changed out during their maintenance. Each receiver was cushioned by wrapping it in neoprene and placing it within a conduit pipe held in place with the U-bolt. The remaining 8 units that made up the CRA were AR units, referred to as such because they automatically release from a lug that keeps them on the bottom when directed to do so via a computer operated hydrophone at the surface.

WFA receivers were placed in variable habitats with different depths, sediment types, and surrounding topography/slope in order to examine if occupation patterns might be influenced by these various factors (**Figure 1**). In several cases receiver location was selected to align with sites sampled by Guida et al. (2017) to provide more accurate and diverse data. Each AR unit was anchored by a 36.3 kg (80 lbs.) concrete block approximately 76.2 cm (2.5 ft) square and 10.2 cm (4 in) high. A piece of stainless-steel cable was molded into each anchor and a rope woven in a circle connected the anchor to the AR's release lug and the AR to a buoy. This buoy kept the unit vertical in the water column approximately 1 m from the bottom. The anchor and remote release mechanism (lug) were left on site when the AR was released and after downloading each AR was re-rigged with a new lug and anchor and redeployed. The flat anchor design was developed to allow trawls to skip over the anchor and receiver. A glass buoy was also used because it could not be punctured by trawl gear once it was recognized that trawl chains could puncture the original rubber buoys deployed.

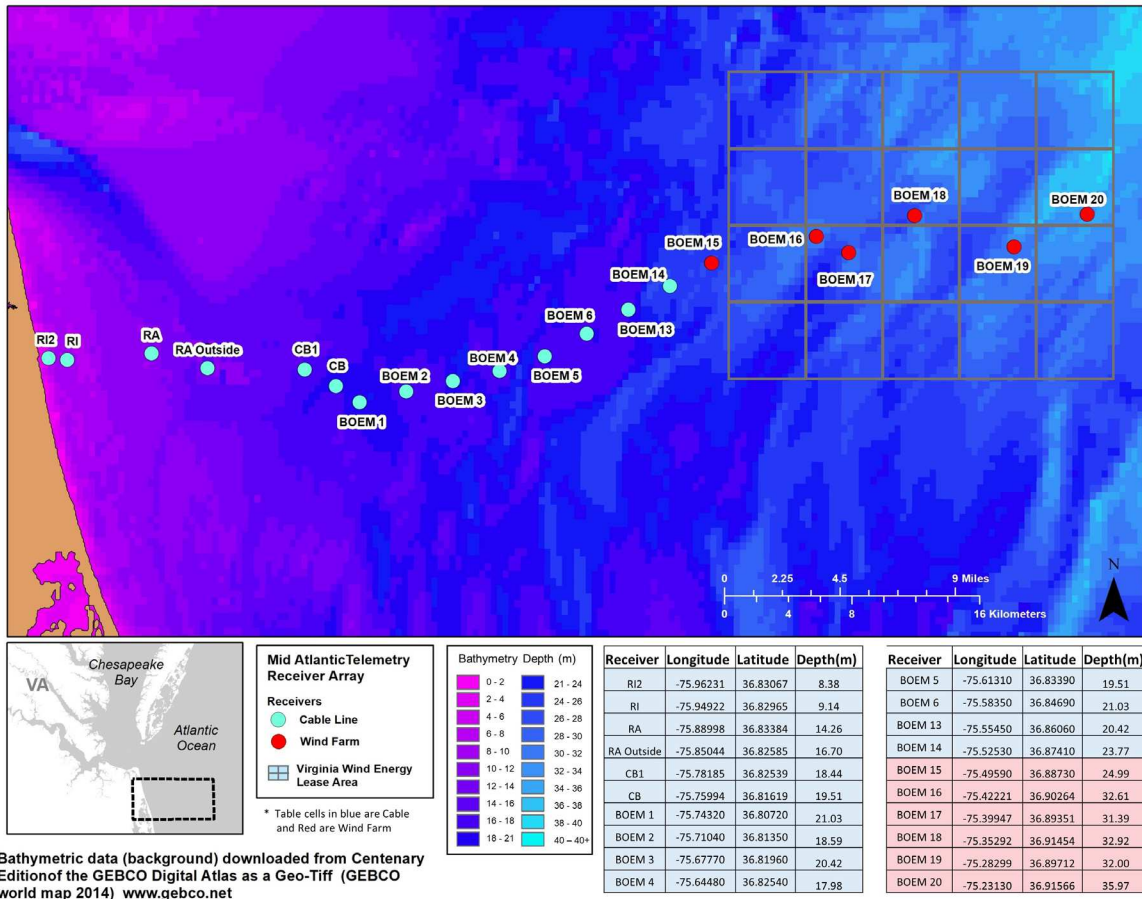


Figure 1. The locations of the 20 receivers deployed in the CRA and WFA are illustrated with depths. All the inshore receivers out to the BOEM 1 site were placed on buoys.

Though some have detected Vemco 69 kHz tags at distances up to 1400 m during detection distance tests (Wingate and Secor 2007, Kilfoil et al. 2017), others have settled on 600 m based on short term test using surface based VR100 computers and VR2AR transceivers (Ingram et al. 2019). Using Vemco® V16 transmitters, like those in most fish we detected, Simpfendorfer et al. (2002) determined this 600 m to be a maximum range not an average. Several researchers using different methods (Egli and Babcock 2004, Humston et al. 2005, Brooking et al. 2006) have agreed that the distance is around 500 m and since this distance is continually changing due to abiotic (Heapel et al. 2006, Simpfendorfer et al. 2008, Singh et al. 2009, Mathies et al. 2014) and biotic conditions like fouling (Heapel et al. 2008, Mathies et al. 2014) we felt 500 m is a more conservative estimate. Based on the 500 m assumption, the 14 receivers in the CRA monitored 0.785 km² each or 11 km² total. The VAWEA is approximately 44.5 km from shore (Guida et al. 2017). There are two cables planned that must be at least this long to reach the wind farm, thus there will very conservatively be at least 89 km of cable. Assuming a 0.5 km range on each side of the two planned AWC cable lines, the planned cable routes would contained ~ 89 km² of impacted area. Therefore, the receivers are assumed to have monitored 11 km² of 89 km² or 12% of the CWA area. This is likely an overestimation of the area monitored because it assumes the cables will be in straight lines to the WEA which is not accurate. The WEA contains 457.3 km² (113,000 acres) of area (Guida et al. 2017) and it was monitored by 6 receivers. Following the same assumptions as above, each covered 0.785 km, so in total 4.71 km² or approximately 1% (4.71/457.3) of the region was monitored.

2.3 Data Analysis Methods

Telemetry produces three principle statistics over time: a count of tags detected, a count of the number of detections, and a count of how frequently each tag was detected. These counts reflect the number of subjects present at a station during a given time. The numbers of detections at a station reflect how long individuals used a particular location and percent occurrence shows population-level occupation by monitoring the proportion of days any individual is detected at that station. Traditionally, diet content studies contain strikingly similar counts: a numeric count, mass or volume count, and a count that reflects frequency of occurrence (Hyslop 1980). Pinkus et al. (1971) derived a way to combine these three variables through an indices of relative importance (IRI) that canceled out some of the inherent biases of each individual component and provided a standardized means of comparison. A single index also allows for development of advanced models that can produce correlations between patterns and physical and environmental variables over time and space.

The diet IRI (Pinkus et al. 1971) is expressed as:

$$IRI = (\%N + \%M) * \%O$$

where, % N is the summed count of a particular prey item out of the total number of prey items counted in all stomachs, % M is the percent of the summed mass of a particular prey item out of the mass of all prey items observed in all stomachs, and % O is the percent of stomachs containing a prey item.

The model we applied to our detection data is a similar analytical tool to the IRI (Pinkus et al. 1971, Cortes 1997) that establishes a site-specific index of relative importance (SIRI) based on the varied statistics detection data produces. Unlike, the dietary approach that looks at numerous stomachs until a cumulative prey curve indicates that a sufficient number of stomachs have been examined to describe dietary variability (Ferry and Cailliet 1996, Cortes 1997), the SIRI divides detection data spatiotemporally. By examining detection statistics over different periods of time and space it is possible, given enough data, to determine spatial and temporal distributions. Identifying spatiotemporal patterns of distribution and the migration pathways that enable such alterations in distribution over time is a necessary component for protecting natural resources (Ingram et al. 2019, Rothermel et al. 2020, Hogan et al. 2023). Like the dietary IRI, the SIRI incorporates all the statistics derived from detection data into a single standard value for each passive receiver site that reduces the inherent bias of each detection-based component alone and provides a means of site comparisons within or between studies over time. Unlike stomach content where different types of prey items congruently occur in a single stomach and are often grouped based on taxonomic, detection data is discrete. Though different fish may be detected at the same time, all detections are of equal value. There is no potential for varied nesting approaches or unintentional overweighting of one type of detection verse another Thus, the weaknesses in the Pinkus et al. (1971) IRI formula do not occur, and there is no need to address them through modifications proposed by Brown et al. (2012a).

Therefore, the SIRI approach is very similar to the simple original diet IRI proposed by Pinkus et al. (1971):

$$SIRI = (\%N + \%D) * \%O$$

where, % N is the number of fish detected during a given time at each site over the total detected over the entire period at all sites, % D is the percent of detections during that time over the entire period, and % O

is the percent of sub-periods containing detections over the entire period. For our purposes, %N is the number of unique transmitters detected at a site in a month divided by the total number of transmitters detected during a given year, % D is the number of detections at a given site during a given month divided by the sum of all detections at all stations annually, and % O is the number of days that contained detections in a given month divided by the number of days in a year. Because the final product of a SIRI or diet IRI can be numbers ranging from quite large to relatively small, Cortes (1997) recommends using the percent diet IRI as a more robust analysis. To attain % SIRIs, monthly SIRI values were determined for each in each year for all years containing complete monitoring (2016-2020). SIRI values per site month were summed across years then divided by the sum of these averages to attain the average % SIRI. When these % SIRIs are summed across a given month, the relative importance of the region can be determined by month. If summed across a given site one can compare the relative importance of each site during the study. Individually, each value in the site month matrix compares the average relative importance of each site across time and space.

We applied the % SIRI method because we wanted to compare the average relative importance of sites within each array over time and space. This averaging approach best suited our long-term data set's ability to identify short term alterations in spatiotemporal distributions due to abiotic factors as well as our lack of metadata related tagged individuals that could alter detections statistics temporally, such as the number of tags available for detection. This approach also best suited the ability to identify potential effects and mitigation measures within each array.

3 Results

3.1 Deployment Results

The BOEM array consisted of 20 receiver sites. Six (RI1-CB) were already being monitored as part of a USN array when BOEM began its study on 12/20/15. Under the USN contract, each receiver was checked once a month, and this continued through 2019. When BOEM began to pay for this portion of the array in 2020, the maintenance period became once every other month. The assumption of the contract also resulted in a data gap at RA offshore as the buoy on this site had been removed in June of 2017 (**Table 1**). When Chesapeake Scientific LLC was informed in late 2019 of the continuation of the BOEM project into 2020, a new VR2AR owned by BOEM was deployed at the RA offshore in advance of the contract. This was not done under the USN contract because they had no VR2ARs to deploy. The USN agreed to allow the data from 2015-2018 to be used by Chesapeake Scientific which provided the historic data necessary to complete the BOEM data set for all 14 stations in the CRA. The deployment record in the WFA was much simpler. The array was fully deployed on 12/20/15 and it was picked up the same day as the CRA array.

Though the project was not originally planned to extent through 2020 or into 2021, it did so because the array was to be checked every other month and weather often delayed the actual checking date due to safety concerns. Over the years, the time between proposed checks and actual checks accumulated and thus monitoring occurred across a longer total time period though the total number of trips to sites was not increased.

Because maintenance checks were postponed due to unsafe condition and associated safety concerns, the array was in the water from 12/20/15 until 8/18/21 for a total of 2066 days. Since the array was deployed in mid-December of 2015 and removed in mid-August of 2021, every season was not monitored for the same amount of time. If all the array's data is used without consideration to the deployment period, raw detection data is skewed against animals detected in fall (**Table 1**).

Table 1. Sampling days per month within the two regions was not equal across months because the study started on 12/20/15 and ended on 8/18/21.

Month	Sampling Days	Percent of Total
Jan	186	0.09
Feb	168	0.08
Mar	186	0.09
Apr	180	0.09
May	186	0.09
Jun	180	0.09
Jul	186	0.09
Aug	173	0.08
Sep	150	0.07
Oct	155	0.08
Nov	150	0.07
Dec	166	0.08
SUM	2066	1.00

Though receivers at individual sites were deployed for the same amount of time at every site, holes in the data occurred due to receiver loss and failure. Receivers were also removed by ill-informed USCG buoy crews, and in some cases the buoys themselves were lost and never replaced. The every-other-month checking schedule chosen by BOEM also resulted in larger data gaps when failures occurred than the once-a-month schedule required under USN contract. The planned longer periods between monitoring also introduced more postponements due to weather, as many good weather periods were passed up because two months had not past since the last trip. **Table 2** contains the receiver sites from the CRA and **Table 3** contains the WFA sites.

Table 2. CRA receiver sites are in the columns with months of maintenance in the rows.

	RI2	RI	RA	RA out	CB1	CB	1	2	3	4	5	6	13	14
Dec-15														
Mar-16														
May-16														
Jul-16														
Sep-16														
Nov-16														
Jan-17														
Apr-17														
Jun-17														
Aug-17				3						3				
Oct-17										18				
Dec-17														
Feb-18														
Apr-18														
Jul-18														
Oct-18														
Jan-19														
Mar-19														
May-19						20								
Jun-19						27							27	
Aug-19														
Nov-19												5		5
Feb-20												9	9	
Mar-20	30		30	30										
May-20														13
Aug-20														
Sep-20	4	4	4											
Nov-20														
Jan-21							14							
Apr-21							18		18		18			
Aug-21									18		18			
	1908	1723	1908	1077	2066	2081	1971	2066	1944	1990	1944	2001	1839	1871

Months with no data interruption are green and months missing data are red. If a number appears, it's the day of the month the event occurred. If no number is given, then the entire month was missed. The total number of days of data at each site are at the bottom. Site names were intentionally shortened to make the table fit the page.

Table 3. WFA receiver sites are in the columns with months of maintenance in the rows.

	15	16	17	18	19	20
Dec-15						
Mar-16						
May-16						
Jul-16				8		
Aug-16					11	
Sep-16				9		
Jan-17					17	
Mar-17						
May-17						
Aug-17						
Oct-17						
Dec-17						
Mar-18						
May-18						
Jul-18						
Aug-18						
Nov-18						
Dec-18						
Apr-19						
Jun-19						
Aug-19						
Nov-19						5
Feb-20						9
May-20						
Jul-20						
Aug-20						
Dec-20						
Feb-21						
May-21			28			
Aug-21			18			
Sum	2066	2066	1984	2003	1907	1970

Months with no data interruption are green and months missing data are red. If a number appears, it's the day of the month the event occurred and the total number of days at each site are at the bottom.

3.2 Detection Data by Species

Twenty-eight species occurred within the entire VAWEA. 26 of these were detected in the CRA array in the 2066 days it was monitored. Five species occurred at numbers of 100 or more individuals: Atlantic sturgeon, striped bass, white shark, cobia, and sand tiger shark (**Table 4**). Twenty-one species were detected in the WFA region, and only three contained data on 100 or more individuals: Atlantic sturgeon,

striped bass, and white shark (**Table 5**). Summary tables of detection data for the CRA (**Table 4**) and the WFA are presented below (**Table 3, Table 4**) and data by species, month, and year for all species that did not occur in significant numbers (100 <) are presented in **Appendix B (B.1, B.2)**.

Table 4. A summation of CRA detection data is presented with species that had 100 or more individuals detected in bold.

Species	Individuals	Detections	Days
Atlantic sturgeon	974	112832	1172
Unknown	289	22540	649
Striped bass	243	19108	265
White shark	158	4969	335
Cobia	115	10327	359
Sand tiger shark	112	1433	184
Blacktip shark	46	2105	144
Sandbar shark	43	1062	59
Dusky shark	36	811	51
Cownose ray	33	389	52
Smooth dogfish	8	261	16
Spiny dogfish	6	44	7
Common thresher shark	5	127	18
Loggerhead sea turtle	3	9	2
Tiger shark	3	27	4
Spotted trout	3	10	4
American shad	3	29	3
Black sea bass	2	729	7
Bull shark	2	24	15
Winter skate	2	74	2
Roughtail skate	2	34	4
Tarpon	2	17	3
Black drum	1	1	1
Atlantic sting ray	1	3	1
Atlantic bluefin tuna	1	1	1
Atlantic angel shark	1	9	2
Little skate	1	22	2

Table 5. A summation of WFA detection data is presented with species that had 100 or more individuals detected in bold.

Species	Individuals	Detections	Days
Atlantic sturgeon	555	80690	697
Striped bass	368	77926	432
Unknown	172	13566	403
White shark	126	2331	245
Cobia	42	1592	98
Sandbar shark	30	595	40
Dusky shark	29	699	53
Blacktip shark	28	579	58
Sand tiger shark	9	62	10
Tiger shark	7	128	17
Smooth dogfish	5	138	5
Cownose ray	4	33	4
Spiny dogfish	3	15	4
Common thresher shark	3	35	5
American shad	2	49	2
Atlantic bluefin tuna	1	1	1
Black drum	1	5	2
Loggerhead sea turtle	1	50	1
Winter skate	1	262	4
Blueback herring	1	12	1
Little skate	1	1	1
Spinner shark	1	10	2

Two species listed on the ESA were detected in the CRA: the Atlantic sturgeon and the loggerhead turtle. Atlantic sturgeon were detected at a significant level in both arrays and thus warranted further investigation in both. It is suspected that many of the unknown tags detected in both arrays were indicative of turtles. However, since those tags were not in the Atlantic Coast Tagging (ACT) database. The majority of tag identification was not available for this report.

There are numerous biological factors that affect the behavior, movements, and spatiotemporal distribution of any individual/tag. Virtually none of this important metadata related to each tag was made available to us. Researchers' contacts are referenced by species in **Appendix C (C.1 and C.2)** so that they can be contacted in order to access this metadata in the future as it is essential to understanding the true implications of detection data in the VLA.

3.2.1 Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*)

The total number of individual sturgeon detected in the CRA region over all the time monitored was 974. Though tagging location implies very little since the species is highly migratory and Distinct Population Segments (DPS) intermix offshore, 53% (n=515) of the sturgeon detected were tagged in the New York Bight, 37% (n=357) were tagged in the Chesapeake Bay, 10% (n= 100) were tagged in the Carolinas, and

0.1% were tagged in the Gulf of Maine and the South Atlantic (**Appendix C.1**). Thus, all DPS were represented.

The total number of sturgeon detected in the CRA region in years with complete monitoring (2016-2020) varied from 308 (2017 and 2019, **Table 6**) to 435 (2016), and the total number of days varied from 186 (2017) to 238 (2016). The total number of detections varied from a high of 28,988 in 2016, which calculates to an average of 67 detections per fish or 122 detections per day, to a low of 9250 in 2017 and average of 30 detections per fish and 50 detections per day. The average number of fish across all years with complete seasonal monitoring was 345, the average number of detections was 16,989, and the average number of days was 204. Using these numbers, the average number of detections per fish is 49 and the average number of detections per day is 83. The CRA detection data by year and month (**Appendix D.1**) and all the CRA detection data by site, year, and month (**Appendix D.2**) are presented in **Appendix D**.

Table 6. The total number of individual Atlantic sturgeon, detections, and the number of days with detections in the CRA are listed by year.

Species	Year	Individuals	Detections	Days
Atlantic sturgeon	2015	96	9508	17
Atlantic sturgeon	2016	435	28988	238
Atlantic sturgeon	2017	308	9250	186
Atlantic sturgeon	2018	356	19504	204
Atlantic sturgeon	2019	308	10514	195
Atlantic sturgeon	2020	317	16690	199
Atlantic sturgeon	2021	235	18378	133

Regional detection data by month (**Table 7**) identifies apexes in occupation indicated by increases in all three detection statistics in March and April and December and January, corresponding to known ocean migration periods. A short period of reduced occupancy is evident in February. Severely reduced occupation in July and August corresponds to known estuarine and river residence periods in the bay (Hager 2019).

Table 7. The total number of individual Atlantic sturgeon, detections, and the number of days with detections for the CRA region are listed by month.

Species	Month	Individuals	Detections	Days
Atlantic sturgeon	Jan	388	20101	158
Atlantic sturgeon	Feb	202	14948	152
Atlantic sturgeon	Mar	415	22863	175
Atlantic sturgeon	Apr	726	22795	179
Atlantic sturgeon	May	177	2456	98
Atlantic sturgeon	Jun	44	190	45
Atlantic sturgeon	Jul	3	41	7
Atlantic sturgeon	Aug	13	94	12
Atlantic sturgeon	Sep	19	58	22
Atlantic sturgeon	Oct	46	409	47
Atlantic sturgeon	Nov	282	4399	115
Atlantic sturgeon	Dec	548	24478	162

Graphing the CRA region's detection statistics over time (**Figure 2**) illustrates how these statistics correlate with seasonal alterations in temperatures at the farthest sites out to sea only. This is the case because all temperature measurements were attained from AR receivers located only in offshore sites. Because the CRA extended from shallow water sites near shore that are predominantly influenced by bay waters to offshore sites where dynamics are more influenced by oceanic forces (Guida et al. 2017), it was not possible to adequately graph all the temperatures relevant. While the graph does not reflect the diversity of temperatures that occurred across CRA nor does it reflect the extreme temperature fluctuations that occurred, it does illustrate the correlation between seasonal bottom temperature fluctuations and increases in regional sturgeon abundance during spring and fall migrations. It also reflects the impoverished number of sturgeon in the CRA in February during the lowest water temperatures recorded but fails to capture the true declines in temperature that occur across most of the CRA sites. Again, the absence of detections in July and August and very low numbers in September corresponds to periods of high estuarine occupancy and spawning by adults in the Chesapeake Bay region (Balazik et al. 2012, Hager et al. 2014, Hager et al. 2020).

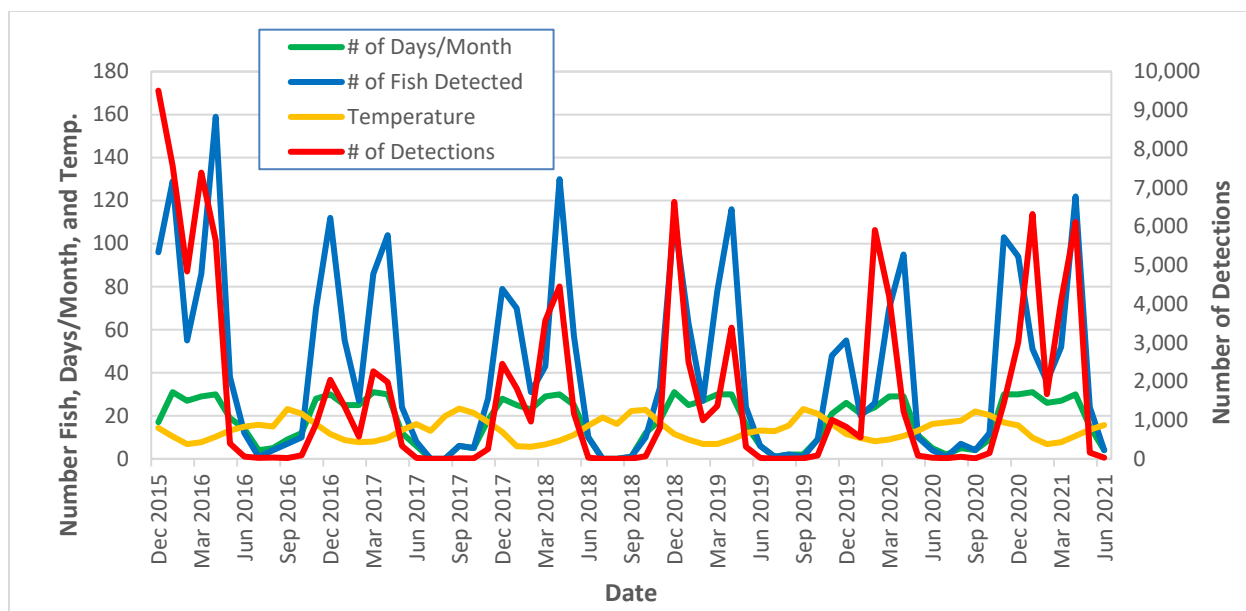


Figure 2. Regional CRA detection data is graphed above to illustrate fluctuations in detection statistics with bottom temperature.

The % SIRI results in **Table 8** provide a relative comparison between each receiver site over time (month) based on the average monthly SIRI for each site in the CRA and was calculated using completely monitored years. Summing across the monthly matrix horizontally provides a relative comparison between sites annually. Summing vertically provides a relative comparison between months. Based on an assumption that each site is equal in its relative importance across time and space, each cell within the matrix would have identical and equal % SIRI values. If there is no difference in site selection over time, each possible outcome or cell would have a % SIRI value equal to 100 divided by the number of cells ($n = 168$) or in this case 0.6. To help further illustrate differences between sites, those exceeding the assumption of no difference (0.6) are in bold.

Shifts in the relative importance from inshore sites in November to deeper sites located to the east in December are indicative of fish migrating to their over wintering sites in the WFA. Similar shifts from east to west in March and April illustrate sturgeon migrating towards the west and inshore during spring migrations. Larger values along the shore in shallow sites near the beach (RI and RI 2) that are warmed by bay waters in early spring indicate sturgeon moving northward towards the bay, fish that likely overwintered in more southern regions.

Table 8. The CRA's percent SIRIs identify the most important periods of regional occupation and important differences in the relative importance of sites over time.

Receiver Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Sum
RI 2	0.1	0.0	0.9	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.6
RI	0.2	0.2	3.5	3.0	0.2	0.1	0.0	0.0	0.0	0.0	0.2	0.0	7.7
RA	0.1	0.0	0.4	0.3	0.1	0.0	0.0	0.0	0.0	0.1	0.9	0.2	2.1
RA Out	0.0	0.0	0.0	0.3	0.1	0.1	0.0	0.0	0.0	0.1	1.9	0.3	2.9
CB 1	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2	1.1
CB	0.1	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.4	1.9
1 BOEM	0.2	0.1	0.5	1.5	0.1	0.0	0.0	0.0	0.0	0.1	0.9	1.5	4.8
2 BOEM	0.7	0.5	0.3	2.1	0.2	0.0	0.0	0.0	0.0	0.0	1.0	1.4	6.2
3 BOEM	0.2	0.0	0.3	2.1	0.1	0.0	0.0	0.0	0.0	0.0	0.2	1.8	4.6
4 BOEM	1.0	0.5	2.1	4.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	3.3	11.2
5 BOEM	3.4	0.4	1.7	3.1	0.1	0.0	0.0	0.0	0.0	0.0	0.2	2.3	11.2
6 BOEM	2.6	0.8	1.4	5.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	3.7	13.9
13 BOEM	5.6	5.4	6.2	3.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	4.7	25.6
14 BOEM	1.6	1.0	0.9	0.8	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.8	5.2
Regional sum/month	15.5	9.1	18.6	26.6	1.9	0.4	0.0	0.0	0.1	0.3	6.8	20.7	100.0

The total number of individual sturgeon detected in the WFA over all the total time monitored was 555. As in the CRA, fish tagged in the New York Bight were detected most often. In fact, 59% (n = 327) of the sturgeon detected were tagged in the New York Bight, 36% (n = 202) were tagged in the Chesapeake Bay, and 5% (n = 25) were tagged in the Carolinas. Only one fish was detected (5 %) that had been tagged in the Gulf of Maine, and none were detected that were tagged in the South Atlantic (**Appendix C.2**). Thus, all DPS were not represented, but New York Bight fish represented a larger percentage than in the CRA.

The total number of sturgeon detected in the WFA region in years with complete monitoring (2016-2020) was approximately half as many as in the nearshore CRA. While the CRA detected 308 in 2017 and 2019 only 130 and 129 were detected in the deeper WFA in the same years (**Table 9**). The number of individuals detected was greatest in 2016 in both arrays with again roughly half as many being detected in the WFA (194 vs 435). The total number of days with detections varied from 186 (2017) to 238 (2016) in the CRA and from 108 (2020) to 124 (2018) in the WFA.

Table 9. The annual number of individual Atlantic sturgeon, detections, and the number of days with detections in the WFA are listed.

Species	Year	Individuals	Detections	Days
Atlantic sturgeon	2015	12	539	10
Atlantic sturgeon	2016	194	16766	123
Atlantic sturgeon	2017	130	13496	120
Atlantic sturgeon	2018	142	8640	124
Atlantic sturgeon	2019	129	9155	112
Atlantic sturgeon	2020	122	21333	108
Atlantic sturgeon	2021	142	10761	100

In the WFA, the largest number of detections ($n = 21333$) occurred in 2020 with an average of 175 detections per fish and 198 per day. The lowest number of 8640 occurred in 2018. The average number of detection per fish was 61, and there was an average of 70 detections per day. Regardless of whether one compares the number of detections per fish between years with the largest number of detections ($n = 67$ vs 175), or the smallest ($n = 30$ vs 61), or the averages across years with complete data ($n = 49$ vs 97), the average number of detections per fish is always greatest in the WFA. The same trend is evident when comparing the number of detections per day within each array at the maximum number of detections in each ($n = 122$ vs 198), the minimum ($n = 49$ vs 70) and the average across years ($n = 83$ vs 118). Clearly, though there are not as many sturgeon detected within the WFA, and they are detected for a fewer number of days, while they are within the WFA, sturgeon spend more time within the detection distance of each receiver. The WFA detection data by year and month (**Appendix D.3**) and all the WFA detection data by site, year, and month (**Appendix D.4**) are presented in **Appendix D**.

CRA detection data by month (**Table 7**) identified apexes in occupation due to migration periods in March and April and December and January. WFA detection data by month (**Table 10**) clearly identifies the late winter period from January through March when the region is isothermal as the period with greatest occupancy and slowest movement around receivers. While CRA data was reduced in February, February boasts the second largest number of fish and by far the greatest number of detections in the WFA. The high average number of detections per fish per day at this time signifies that they are illustrating sedentary behavior. Though CRA detection data suggests that sturgeon are greatly reduced in number and moving more quickly during the warmer months of July and August, the species was not detected at all within the WFA from June through October.

Table 10. The number of individual Atlantic sturgeon, detections, and the number of days with detections within the WFA are listed by month.

Species	Month	Individuals	Detections	Days
Atlantic sturgeon	Jan	306	20600	174
Atlantic sturgeon	Feb	298	37998	159
Atlantic sturgeon	Mar	238	13921	160
Atlantic sturgeon	Apr	150	4834	103
Atlantic sturgeon	May	14	109	13
Atlantic sturgeon	Jun	0	0	0
Atlantic sturgeon	Jul	0	0	0
Atlantic sturgeon	Aug	0	0	0
Atlantic sturgeon	Sep	0	0	0
Atlantic sturgeon	Oct	0	0	0
Atlantic sturgeon	Nov	6	138	7
Atlantic sturgeon	Dec	121	3090	81

Graphing WFA detection data by month and year clearly illustrates periods of absence in warmer months and increased abundance during the colder isothermal periods (**Figure 2**). Direct comparisons between the CRA (**Figure 1**) and the WFA (**Figure 2**) graphs clearly illustrate sturgeon moving through the CRA to overwinter in the WFA during the isothermal winter and early spring periods. When the thermocline starts to be reestablished in late March and early April (Guida et al. 2017), sturgeon move west out of the WFA and back through the CRA towards shore.

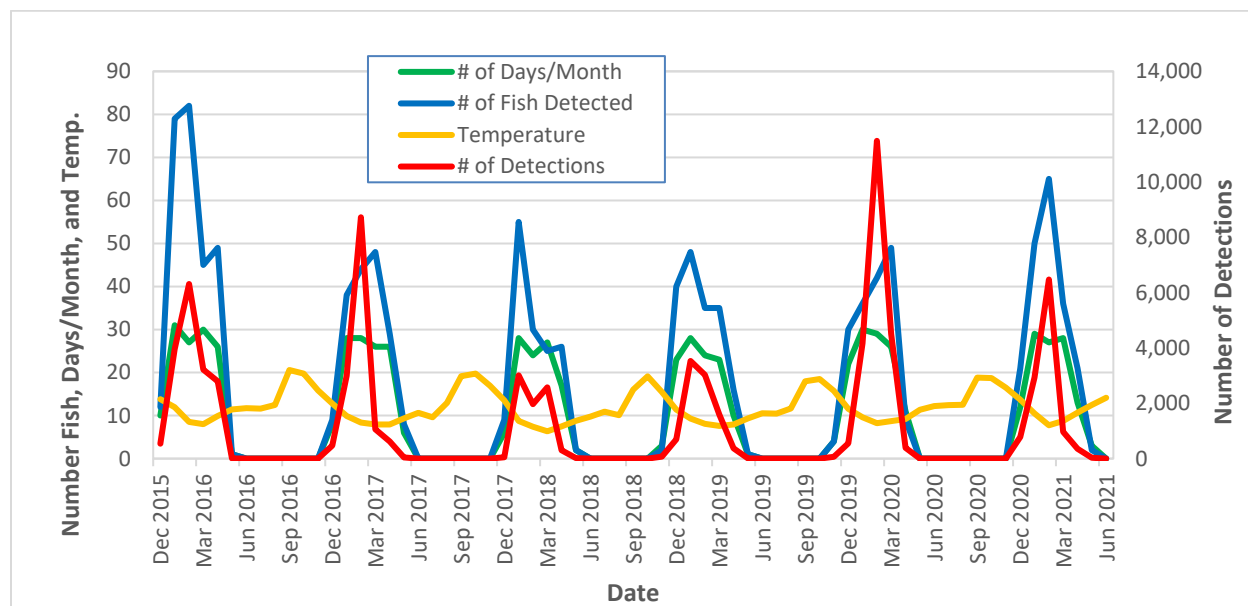


Figure 3. Regional WFA detection data is graphed above to illustrate fluctuations in detection statistics with bottom temperature.

The % SIRI applied to the WFA data was identical to that applied to the CRA data. The % SIRI results in **Table 11** examine each receiver site's relative importance over time (month) and space (receiver site) based on the average SIRI across years with complete seasonal (12 month) monitoring. Summing across the matrix of average monthly site-specific SIRI values horizontally provides relative comparisons between sites, while summing vertically provides a relative comparison between months as an indicator of the region's temporal importance. Based on an assumption that each site is equal in its relative importance across time and space, each cell within the matrix would have identical and equal SIRI value. If there is no difference in site selection over time, each possible outcome or cell would have an equal SIRI value equal 100 divided by the number of cells ($n = 72$) or in this case 1.39. To help further illustrate comparisons between % SIRI values, higher than the expected average SIRI values are in bold.

Table 11. The WFA's SIRI identifies the most important periods of regional occupation and important differences in the relative importance of sites over time.

Receiver Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Sum
BOEM 15	6.3	4.9	5.5	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	23.9
BOEM 16	4.5	3.0	1.4	0.7	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3	12.2
BOEM 17	12.2	16.1	7.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	36.8
BOEM 18	6.2	12.5	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	24.8
BOEM 19	0.3	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.0
BOEM 20	0.2	0.7	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.2
Monthly Sum	29.7	37.4	19.7	6.9	2.4	0.0	0.0	0.0	0.0	0.0	0.0	3.8	100.0

The CRA % SIRI identified that November and December are months of increased relative importance as sturgeon migrated east. The WFA % SIRI identifies February, a month of impoverished importance in the CRA, as being by far the most important time in the WFA. This finding illustrates that sturgeon belonging to various DPS are overwintering in the WFA. In March, as preferred overwintering sites (BOEM 17 and 18) decrease in relative importance congruent with the reestablishment of thermocline in the WFA (Guida et al. 2017), sturgeon shift to the west into sites closer to shore such as BOEM 15 and numerous offshore CRA sites (**Table 8**).

CS, the USN, and NMFS have been cooperatively tagging and tracking the York River, Virginia population of sturgeon since 2012. During this BOEM project, sturgeon were being tagged every year through this project and others. However, since we were tagging the York River sub-set of sturgeon, we have much more valuable data on these fish, metadata that includes life stage, sex, depth, genetic identification, an accurate population estimate, and data on tagging location, time, tag type, and tag battery life. We are examining this population separately because all this metadata provides for a much more thorough understanding. All York River tags were V 16 tags, and all were placed in native adult fish while on the spawning grounds. Sex was identified for the vast majority of fish, and all belonged to this genetically distinct stock (White et al. 2021). Numerous population models have been run on the annual tag return and mark recapture data that has been collected since 2013, and our current adult population estimate is 450 individuals. Table 12 describes the number of tags available for detection per year and the number detected in each array.

Table 12. The number of active tags per year is given as are the number detected in the CRA and WFA.

Year	Active tags	Detected in CRA	Detected in WFA
2013	12	NA	NA
2014	40	NA	NA
2015	43	5	1
2016	50	24	12
2017	63	31	9
2018	66	32	15
2019	79	36	11
2020	73	12	8
Total	92	71	38

The annual percentage of the total adult York River population that was tagged in years with complete seasonal coverage varied from 9-18%. The annual percentage of tagged fish detected varied from 12-50% in the CRA and from 2-23% in the WFA. These numbers represent 3-8% of the total population in the CRA and 2-3% in the WFA. By the end of 2020, the last year with complete monitoring, 81 tags out of the 92 implanted or 88% of the tags were detected in the arrays, a number that represents 18% of the total population. The CRA recorded 77% of the tagged individuals. 41% were detected in the WFA even though its array only covered 1% of its area.

The total number of York River tags detected in the CRA region in years with complete monitoring (2016-2020) varied from 24 (2016, **Table 13**) to 36 (2019), and the total number of days varied from 65 (2018) to 42 (2020). Detection number varied from 4197 (2018) to 542 (2020). Regionally 71 individuals, 37 female, 33 male, and one unknown were detected 887 times for 275 days out of the 1836 days monitored.

Table 13. The total number of individual York River adults, detections, and the number of days with detections for the CRA are listed by year.

Species	Year	Individuals	Detections	Days
Atlantic sturgeon	2015	5	220	6
Atlantic sturgeon	2016	24	2189	46
Atlantic sturgeon	2017	31	710	43
Atlantic sturgeon	2018	32	4197	65
Atlantic sturgeon	2019	36	884	54
Atlantic sturgeon	2020	29	542	42
Atlantic sturgeon	2021	12	135	19

The % SIRI applied to the York River adult data was identical across data sets. Values above those attained based on an assumption of equal relative importance of all sites across time and space are again highlighted. In this case, that value is 0.6 (100/168), and again this value mathematically equates to an assumed equal distribution of detection statistics across all months and sites (**Table 14**).

Table 14. The CRA %SIRI for York River adults identifies the late fall and spring as migration periods with some winter preference for specific sites like 4 BOEM and 13 BOEM.

Receiver Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Sum
RI 2	0.0	0.0	0.2	0.2	0.0	0.1	0.0	0.0	0.0	0.2	0.0	0.1	0.8
RI	0.0	0.0	1.5	2.1	0.0	0.0	0.0	0.0	0.1	0.0	0.9	0.1	4.8
RA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	2.4	1.6	4.8
RA Out	0.0	0.0	0.1	0.2	0.0	0.1	0.0	0.5	0.1	0.1	1.3	0.8	3.1
CB 1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.5	1.4
CB	0.0	0.0	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.7	3.3
1 BOEM	0.0	0.3	0.1	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.5	2.7	4.3
2 BOEM	0.9	0.1	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.2	4.0
3 BOEM	0.3	0.0	0.2	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.4	4.2
4 BOEM	5.8	0.1	0.1	2.5	0.2	0.0	0.0	0.0	0.0	0.0	0.1	16.7	25.5
5 BOEM	1.3	0.0	2.3	0.6	0.2	0.0	0.0	0.0	0.0	0.0	0.3	1.2	5.9
6 BOEM	3.9	0.4	1.7	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	11.3
13 BOEM	11.3	0.3	3.3	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9	20.9
14 BOEM	0.4	1.2	4.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	5.9
Monthly Sum	23.9	2.3	13.8	15.1	0.4	0.2	0.0	0.5	0.2	1.0	7.5	35.0	100.0

The tight correlation between the CRA % SIRI (**Table 8**) that includes all sturgeon detected and the one in the CRA that only includes York River adults (**Table 14**) is almost hard to believe because York River tags were never more than 12% of those detected and on average were only 8%. Shifts in the relative importance of inshore sites to offshore sites from November through January are evidenced as are the inshore movements to shallower eastern sites in March and April. Clearly, York River adults are simply part of an aggregation consisting of members belonging to numerous DPS. Adult York River fish are even recorded contributing to the larger values recorded at the RI in close proximity to the beach in March and April, a clear indication that some York River adults migrate south in the fall.

The total number of York River tags detected in the WFA (2016-2020) varied from 8 (2020, **Table 15**) to 15 (2018), and the total number of days varied from 11 (2019) to 30 (2018). Detection numbers varied from 1885 (2018) to a low of 70 (2019). Regionally, 38 individuals, 14 female, 23 male, and one unknown, were detected 3848 times for 113 days out of the 1836 monitored. In comparison, the 71 individuals detected in the CRA were only detected 887 times during their 275 days of detection. Approximately 38% of the females detected in the CRA were subsequently detected in the WFA while 70% of the males were.

Table 15. The total number of individual Atlantic sturgeon, detections, and the number of days with detections for the WFA region are listed by year.

Species	Year	Individuals	Detections	Days
Atlantic sturgeon	2015	1	29	3
Atlantic sturgeon	2016	12	379	19
Atlantic sturgeon	2017	9	326	14
Atlantic sturgeon	2018	15	1885	30
Atlantic sturgeon	2019	11	70	11
Atlantic sturgeon	2020	8	726	14
Atlantic sturgeon	2021	14	433	22

The % SIRI conducted on York River adults (**Table 16**) in the WFA also closely correlates with the one run on all sturgeon (**Table 11**). York River tags were never more than 11% of the sturgeon tags detected and on average were only 8%. As in all previous % SIRI tables, all values above 1.39 (100/72), which represent an equal distribution across all possible months and sites, are highlighted.

Table 16. The WFA % SIRI identifies the winter and early spring periods as the only periods with York River sturgeon present.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Sum
BOEM 15	1.0	8.1	8.0	6.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	6.0	30.0
BOEM 16	6.6	6.4	1.2	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	16.6
BOEM 17	12.5	11.9	9.7	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	35.2
BOEM 18	9.6	1.6	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0
BOEM 19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	1.4
BOEM 20	0.0	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	1.8
Monthly Sum	29.7	28.3	23.1	9.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	9.2	100.0

The WFA % SIRI for York River fish is only slightly different than the one that includes all sturgeon detected in the WFA. Though these differences may be due to the reduced number of individuals in the analysis, they may also indicate that York River adults have slightly different preferences for some site/habitats. While the seasonal trends correspond with the previous inclusive WFA % SIRI (**Table 11**), the BOEM 17 site again appears to be preferred throughout the overwintering period, and the WFA inshore sites are preferred over deeper offshore ones, York River fish appear to be dispersed slightly more evenly across the WFA's inshore sites. Again, these differences may be entirely due to the reduced sample size.

In order to better understand where in the water column sturgeon were when detected and potentially gain a better understanding of how they were behaving while within the WFA, we examined the depth tag data on the 12 sturgeon with tags detected. The results (**Table 17**) suggest that sturgeon are not migrating through the water column but are in very close proximity to the benthos which suggests they are holding

and likely feeding during overwintering. The average depth determined at BOEM 17 is below that detected at the receiver drop site. Of the 506 detections this was based on, 480 were attained from the same fish over a 6-day period. This tag consistently indicated a depth that was between 40-43 meters, and this may have biased the average depth. Though much less likely, there could also be a depression that was not detected by Guida et al (2017) within the BOEM 17's detection distance.

Table 17. The site-specific depth data from depth tagged York River adults in the WFA.

Receiver site	Measure depth (m)	Average Tag Depth	Months Present	Number of Tags	Depth Samples
BOEM 15	25.99	25.78	12,1,2,3,4,5	9	267
BOEM 16	32.61	33.5	1,2,3,4	5	58
BOEM 17	31.39	42	12,1,2,3	5	506
BOEM 18	32.92	30	3	2	5
BOEM 19	32	32.62	12	1	5
BOEM 20	35.98	34	12,1	2	5

3.2.2 Striped Bass (*Morone saxatilis*)

The total number of striped bass detected in the CRA region in years with complete monitoring (2016-2020) varied from 12 (2020, **Table 18**) to 111 (2018), and the total number of days varied from 14 (2020) to 69 (2017). Examining regional detection data across the entire sample period by month (**Table 19**) clearly identifies apexes in all three detection statistics from January through March during the coldest water temperatures when the region is isothermal. Detection data by year and month (**Appendix D.5**) and complete detection data by site, year, and month (**Appendix D.6**) can be found in **Appendix D**.

Table 18. The total number of individual striped bass, total detections, and the number of days with detections within the CRA are listed by year.

Species	Year	Individuals	Detections	Days
Striped bass	2016	73	7451	64
Striped bass	2017	107	4925	69
Striped bass	2018	111	3127	50
Striped bass	2019	58	2395	47
Striped bass	2020	12	139	14
Striped bass	2021	48	1071	21

Table 19. The total number of individual striped bass, total detections, and the number of days with detections within the CRA from 2016 -2020 are listed by month.

Species	Month	Individuals	Detections	Days
Striped bass	Jan	202	6572	74
Striped bass	Feb	221	4651	57
Striped bass	Mar	145	4832	67
Striped bass	Apr	17	230	20
Striped bass	May	0	0	0
Striped bass	Jun	1	15	3
Striped bass	Jul	0	0	0
Striped bass	Aug	0	0	0
Striped bass	Sep	0	0	0
Striped bass	Oct	0	0	0
Striped bass	Nov	0	0	0
Striped bass	Dec	64	2808	44

The number of striped bass detected in the WFA region annually in years with complete monitoring (2016-2020) was consistently larger than that recorded in the CRA as was the number of detections. The correlation between years with minimums (2020) and maximums (2018) in fish number (**Table 18 and 20**) as well as the number of days with detections (2020 and 2017) in both arrays evidences bass moving from one array to the other sequentially. Differences in annual behavior are suggested by the lack of correlation between the number of detections and the number of fish detected or the number of days with detections (**Table 20**). In December, when fish are entering the WFA, and in April, when they are departing it, (**Table 21**) the CRA experiences increased levels of occupation (**Table 19**) suggesting that bass are migrating east and west. During the isothermal cold-water period from January to March, many more striped bass were detected within the WFA for a greater number of days than in the CRA. Annual detection statistics are highly variable in both the CRA the WFA (**Table 18 and 20**), variability that could be due to any number of abiotic or biotic factors but, given the metadata we have, are beyond our ability to consider. Detection data by year and month (**Appendix D.7**) and complete detection data by site, year, and month (**Appendix D.8**) can be found in **Appendix D**.

Table 20. The total number of individual striped bass, total detections, and the number of days with detections within the WFA are listed by year.

Species	Year	Individuals	Detections	Days
Striped bass	2016	111	14479	90
Striped bass	2017	167	27412	92
Striped bass	2018	200	10755	88
Striped bass	2019	127	12701	71
Striped bass	2020	55	8201	43
Striped bass	2021	75	4378	48

Table 21. The total number of individual striped bass, total detections, and the number of days with detections within the WFA are listed by month.

Species	Month	Individuals	Detections	Days/Month
Striped bass	Jan	468	23567	131
Striped bass	Feb	591	37443	151
Striped bass	Mar	334	15706	115
Striped bass	Apr	7	521	14
Striped bass	May	0	0	0
Striped bass	Jun	0	0	0
Striped bass	Jul	0	0	0
Striped bass	Aug	0	0	0
Striped bass	Sep	0	0	0
Striped bass	Oct	0	0	0
Striped bass	Nov	0	0	0
Striped bass	Dec	40	689	21

3.2.3 White shark (*Carcharodon carcharias*)

The total number of white sharks detected in the CRA region over the entire study was 158, but over years with complete monitoring (2016-2020) it varied from only 18 (2016, **Table 22**) to 78 (2020) with the number detected increasing annually. As the number of individual sharks detected increased, the annual number of days with detections and detection number also increased (24 days and 168 detections in 2016 to 111 days and 2311 detections in 2020). While monthly data across years with complete data (**Table 23**) indicates that white sharks are within the CRA year-round, the three detection statistics that describe their patterns of occupation vary considerably seasonally. While peak tag abundance occurred in June (n=52) and November (n=84), the number of detections was greater in June than November (1039 vs 891), but the large number of detections recorded in June occurred on a fewer number of days (48 vs 67). A similar disconnection between the three statistics occurs during the two months with very small numbers of sharks detected. In both February and September seven fish were detected. In the cold February ocean conditions, white sharks were detected for 8 days and resulted in 66 detections. In the very warm waters of September, white sharks were detected for fewer days (n=6) but resulted many more detections (110 vs 66). Data by year and month for the CRA (**Appendix D.9**) and by site, year, and month (**Appendix D.10**) appears in **Appendix D**.

Table 22. The total number of White shark, total detections, and the number of days with detections within the CRA are listed by year.

Species	Year	Individuals	Detections	Days
White shark	2016	18	168	24
White shark	2017	29	321	37
White shark	2018	37	620	47
White shark	2019	44	819	64
White shark	2020	78	2311	111
White shark	2021	43	730	52

Table 23. The total number of White shark, detections, and the number of days with detections within the CRA are listed by month.

Species	Month	Individuals	Detections	Days
White shark	Jan	6	31	7
White shark	Feb	7	66	8
White shark	Mar	15	90	17
White shark	Apr	29	334	42
White shark	May	45	371	38
White shark	Jun	52	1039	48
White shark	Jul	14	552	27
White shark	Aug	12	771	16
White shark	Sep	7	110	6
White shark	Oct	40	586	43
White shark	Nov	84	891	67
White shark	Dec	16	128	16

The total number of white sharks detected in the WFA over the entire study was slightly less than that detected in the CRA further inshore (126 vs 158). Over years with complete monitoring (2016-2020), it steadily increased over time varying from 11 in 2016 to 56 in 2020 (**Table 24**). As the number of animals detected increased, the annual number of days with detections and number of detections also increased (18 and 118 in 2016 to 71 and 655 in 2020), but the values again lacked precision in their correlation. While monthly data across years with complete data (**Table 25**) in the WFA also indicates that white sharks are within the WFA year-round, there are fewer in the WFA than the CRA. Again, a lack of correlation between the three detections statistics that describe patterns of occupation make it difficult to interpret occupation patterns or behavior. Peak tag abundance occurred in May ($n = 52$) and November ($n = 34$). Detection number was greater in May ($n = 539$) and October ($n = 436$). However, the larger number of detections in May occurred over 46 days while the slightly smaller number that occurred in October occurred over much less time ($n = 29$). The three statistics recorded during the two months with the fewest numbers of sharks detected also lack consistency over time. In January, only two sharks were detected for 1 day, and they resulted in 13 detections. In the warm waters of August, four sharks were detected for four days, and they resulted in 47 detections. These relationships between the three statistics are not consistent between arrays and appear disconnected from water temperature fluctuations. Data by year and month (**Appendix D.11**) and by site, year, and month (**Appendix D.12**) are presented in **Appendix D**.

Table 24. The total number of White sharks, total detections, and the number of days with detections within the WFA are listed by year.

Species	Year	Individuals	Detections	Days
White shark	2016	11	118	18
White shark	2017	14	353	20
White shark	2018	27	245	32
White shark	2019	43	615	61
White shark	2020	56	655	71
White shark	2021	44	345	43

Table 25. The total number of White sharks, detections, and the number of days with detections within the WFA are listed by month.

Species	Month	Individuals	Detections	Days
White shark	Jan	2	13	1
White shark	Feb	6	26	7
White shark	Mar	14	113	15
White shark	Apr	33	250	37
White shark	May	52	539	46
White shark	Jun	32	207	34
White shark	Jul	19	135	14
White shark	Aug	4	47	4
White shark	Sep	10	82	12
White shark	Oct	30	436	29
White shark	Nov	34	356	32
White shark	Dec	11	127	14

3.2.4 Cobia (*Rachycentron canadum*)

Many more cobia were detected in the CRA (n = 115) than in the WFA (n = 42). Despite the fact that no cobia were tagged until 2017 (ACT data base), they were detected after that in the CRA in high enough numbers to warrant further investigation. Annually, the three detection statistics within the CRA varied in non-correlated ways. For example, roughly half as many individual fish were detected in 2020 verses 2019 for essentially the same number of days, yet the year with fewer fish resulted in more detections (**Table 26**). Detection data by month is straight forward in comparison (**Table 27**), illustrating the species' well documented seasonal availability (Murdy et al. 1997) due to its dependence on warm water (Jensen and Graves 2020). Detection data by month and year (**Appendix D.13**) and by site, month, and year (**Appendix D.14**) are presented in **Appendix D**.

Table 26. The total number of individual cobia, total detections, and the number of days with detections within the CRA are listed by year.

Species	Year	Individuals	Detections	Days
Cobia	2017	7	89	10
Cobia	2018	50	2029	73
Cobia	2019	85	3408	117
Cobia	2020	44	3894	103
Cobia	2021	23	907	56

Table 27. The total number of individual Cobia, total detections, and the number of days with detections within the CRA are listed by month.

Species	Month	Individuals	Detections	Days
Cobia	Jan	0	0	0
Cobia	Feb	0	0	0
Cobia	Mar	0	0	0
Cobia	Apr	0	0	0
Cobia	May	38	356	31
Cobia	Jun	65	1751	79
Cobia	Jul	52	1920	69
Cobia	Aug	42	1308	62
Cobia	Sep	86	2694	65
Cobia	Oct	65	2298	53
Cobia	Nov	0	0	0
Cobia	Dec	0	0	0

3.2.5 Sand tiger shark (*Odontaspis taurus*)

The sand tiger occurred almost exclusively in the CRA ($n = 112$ vs 9) indicating its well documented preference for nearshore coastal waters. The largest number of sharks, detections, and days occurred in 2018 (**Table 28**). The three detection statistics for sand tiger shark, like cobia, do not always correlate well. For example, essentially the same number of sharks were present for the same amount of time in 2017 and 2019, but they resulted in almost twice as many detections in 2019 as in 2017. This may suggest that the way the species uses the region or sites within the region varies considerably on an annual basis. Detection data by month (**Table 29**) identifies peaks in May and October, with May having 63 total detections and October 67. In April, detections rise until May, then bottom out towards July, to rise again in September and fall in November. When broken up by month and year, the two highest peaks for individuals detected fall in or around May and October for every year in the sample period (**Table 29**). No individuals were present from December to March in any year. Detection data by month and year (**Appendix D.15**) and by site, month, and year (**Appendix D.16**) are presented in **Appendix D**.

Table 28. The total number of individual sand tigers, total detections, and the number of days within the CRA are listed by year.

Species	Year	Individuals	Detections	Days/Year
Sand tiger shark	2016	14	359	13
Sand tiger shark	2017	28	519	28
Sand tiger shark	2018	38	2258	36
Sand tiger shark	2019	27	917	27
Sand tiger shark	2020	15	408	14

Table 29. The total number of individual sand tigers, total detections, and the number of days with detections within the CRA for the sampling period are listed by month.

Species	Month	Individuals	Detections	Days
Sand tiger shark	Jan	0	0	0
Sand tiger shark	Feb	0	0	0
Sand tiger shark	Mar	0	0	0
Sand tiger shark	Apr	3	34	3
Sand tiger shark	May	63	391	54
Sand tiger shark	Jun	44	199	42
Sand tiger shark	Jul	5	40	6
Sand tiger shark	Aug	3	133	8
Sand tiger shark	Sep	6	30	6
Sand tiger shark	Oct	67	413	43
Sand tiger shark	Nov	26	193	22
Sand tiger shark	Dec	0	0	0

4 Discussion

The VAWEA array was divided into two regional arrays: the CRA which consisted of 14 receivers that monitored approximately 12% of the area and the WFA which consisted of 6 receiver sites that monitored approximately 1% of it (**Figure 1**). While receivers were placed in locations of convenience along the CRA line, the six in the WFA were located in various habitats at roughly equal distances from one another extending to the western edge of the lease. WFA sites were selected in order to monitor locations containing unique topography. The sites also varied in substrate and benthic fauna (Guida et al. 2017). Twenty-eight different acoustically telemetered species were detected in the entire VAWEA, 26 in the CRA and 21 in the WFA. The inshore CRA line detected more individuals ($n = 2095$ vs 1390) for more days ($n = 3362$ vs 2085 days) than the WFA. This is partially because many of the species detected are estuarine-dependent and thus are more likely to be detected in the inshore CRA array that is closer to the mouth of the Chesapeake Bay. However, there was also more area monitored in the CRA (11km^2) than in the WFA (4.7km^2) which equates to 12% coverage of the CRA versus 1% in the WFA, and this difference may have also influenced results. Despite there being more species, individuals, and days with data in the CRA, more detections were recorded in the WFA during a much shorter period than in the CRA ($178,779$ vs $176,997$). This disproportionate number of detections was due to occupation of the region by two species, the ESA-listed Atlantic sturgeon and the striped bass. Both overwintered in the region when isothermal conditions were present (Guida et al. 2017).

Striped bass and white sharks followed sturgeon in abundance in both the CRA (**Table 4**) and WFA (**Table 5**). In the WFA, these were the only two other species with more than 100 individuals detected. In the CRA, which contained more species at greater numbers, more than 100 individuals belonging to five species were detected. The remaining two species are cobia and sand tiger shark. While over 100 cobia and sand tiger shark were detected in the CRA, the two species did not occur in the WFA in sufficient numbers to warrant further analysis.

4.1 Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*)

When the Atlantic sturgeon was listed under the ESA on 12 February 2012 (NMFS 2012a, 2012b) by the National Marine Fisheries Service (NMFS), its populations were divided into Distinct Population Segments (DPS) based upon genetic similarities within geographically relevant areas. The DPSs were the Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic. All DPSs were listed as endangered except the Gulf of Maine, which was listed as threatened (NMFS 2012a, 2012b). While the DPSs are discrete entities, individuals belonging to each may range widely, migrating long distances across the shelf to find optimal temperatures and forage resources (Gross et al. 1988, Dingle and Drake 2007), which results in significant overlap with individuals from other DPSs in preferred locations. The areas of greatest overlap will be the areas of greatest non-reproductive importance such as migration corridors and foraging and overwintering habitats. Atlantic sturgeon are at risk from a variety of anthropogenic threats (NMFS 2007). Many researchers have concluded that due to slow growth and late maturity (sometimes over 25 years), relatively low rates of mortality can cause a decline in the abundance of each population and DPS (Boreman 1997, Secor and Waldman 1999, Gross et al. 2002). Therefore, it is imperative that we identify preferred migration routes and aggregation areas in order to enable their recovery.

When listed, very little was known about the specific variables necessary for conservation of Atlantic sturgeon. In fact, there were, and likely still are, reproducing populations of sturgeon that had and have not yet been identified (Hager et al. 2014, Balazik et al. 2017, Farrae et al. 2017, Savoy et al. 2017). Since listing, two genetically unique reproducing populations have been discovered in the Chesapeake Bay: one in the York River, Virginia (Hager et al. 2014) and one in the James River, Virginia (White et al. 2021).

The adult population in the York River has been intensively studied for 11 years (Hager 2019). During this time, important and valuable metadata has been obtained on its small adult population (Kahn et al. 2014) of what is now estimated at approximately 600 individuals (Kahn and Hager, unpublished data). No population assessments have been done on either of the James River's distinct genetic populations, one reproducing in the spring and one in the fall (White et al. 2021), and it took over 12 years to identify that there was a spring population. Thus, research catch records support the theory that it is also small (Balazik, ERDC, personal communication). Since smaller populations are at greater risk of extinction (Lande 1988, Mace and Lande 1991, Frankam 1995), it is necessary to identify these populations, clarify their spatiotemporal distributions and their critical habitats, and minimize impacts on them. Because we have good metadata on the York River population, we examined its spatiotemporal distribution separately in order to expand our understanding as to how this small population occupies the VAWEA and further our ability to conserve it through this understanding.

The Atlantic sturgeon dominated the statistics in both VAWEA arrays. There were 974 individual sturgeon detected in the CRA, and sturgeon were detected in every month. Sturgeon accounted for 46% of the tags detected and 64% of the detections. Sturgeon from every DPS were detected; however, the vast majority were tagged in the New York Bight (53%), the Chesapeake Bay (37%), and the Carolina's (10%). Though only within the WFA for approximately three months, 555 individual sturgeon were detected, and the species contributed to 40% of the tags detected and 45% of the detections. Similarly, the vast majority of fish were tagged in the New York Bight (59%), the Chesapeake Bay (36%), and the Carolinas (4.5%).

While information on the natal origin of most tagged sturgeon is lacking because most fish tagged in the New York Bight are tagged in the ocean where stocks mix, we know the age, natal origin, sex, and return rate to spawn for fish tagged in the York River system, and we have detection data from between spawning events. The CRA recorded 77% of the tagged individuals, and 41% of the tags were detected in the WFA (**Table 12**) even though its array only covered 1% of its area. While approximately 7% of the total sturgeon detected in both the CRA and WFA were York River adults, by the end of the last year with

complete monitoring (2020), 81 tags out of the 92 implanted were detected. Therefore, 88% of the tags implanted were detected, and, assuming tagged fish are an approximation of how untagged fish also behave, 88% of the population was present in the WEA.

Detection results vary significantly between the CRA and WFA, indicating that sturgeon are not distributed across the two regions in similar spatiotemporal manners. Given the receiver deployment pattern within the entire WEA, greater coverage was achieved within the cable region (12% coverage) than within the WFA (1% coverage); thus, a larger near shore area was monitored than was monitored in offshore habitats. This disparity in area coverage was one of the main reasons the WEA was divided into the CRA and WFA so that the much greater coverage in the CRA would not bias the importance of the less frequently occupied WFA sites. Despite the limited coverage within the WFA area, comparisons between the two arrays' detection results point out stark differences in the seasonal behavior of sturgeon while inhabiting the two areas.

From 2016 through 2020 (1,825 days), there were 1,724 sturgeon detected 84,946 times over 1,022 days on the 14 CRA receivers and 717 detected 69,390 times over only 587 days on the WFA's 6 receivers. Though the average number of sturgeon detected per receiver in the CRA (1,724/14) and the WFA (717/6) were roughly equal (123 vs 120 individuals), each WFA receiver detected the species for more days on average (98 vs 73 days) and for a greater number of detections, which is indicative a greater period of time with each receiver's detection distance (11,565 vs 6,068 detections). If we consider that sturgeon were absent from June to October (total days = 765) in every year (n=5) in the WFA (**Table 16**), then all 69,390 detections occurred over only 1,060 days not 1,825. Thus, there were roughly 65 detections per day (69,390/1,060) or 11 detections per receiver per day (65/6) in the WFA on days when sturgeon were detected while only 3.3 detections per receiver per day (84,946/1,825/14) in the CRA.

The 38 York River adults recorded in the WFA were detected 3,848 times during the 113 days they were present, while 71 York River individuals were detected 887 times during the 275 days with detections in the CRA. The higher number of detections per York River fish and per day observed in the WFA verses the CRA mimic the ratios for all sturgeon detected in the two arrays. The greater frequency of sturgeon detections over a shorter period of time and the larger average number of detections per site is indicative of more sedentary behavior within the WFA, while the reduced frequency and number of detections per receiver is more indicative of migration behavior in the CRA (**Figure 2**).

January, February, and March were the months with the largest relative indices of importance to sturgeon in the WFA with February consistently being of most importance. During these months, sturgeon detections also suggest a preference for specific receiver sites. The BOEM 15, 16, 17, and 18 sites account for 85% of the total annual WFA SIRI (**Table 11**) during winter. Higher SIRI values at site 13 (**Table 8**) in the CRA and at 15 in the WFA, which remain relatively high from January through April, may suggest that some sturgeon also overwinter in these sites. When the lowest bottom temperatures occur, most often in February, the 17 and 18 sites are by far the most frequently occupied. The lack of detections at the deeper 19 and 20 sites appears at first to potentially suggest that sturgeon show a preference for overwintering in depths between 30 and 34 m (98-112 ft). However, a significant number of sturgeon were detected at a BOEM receiver located much further to the east in much deeper water (55 m (180 ft) during the winter of 2016-2017, and St. John River sturgeon were found to occupy depths between 76-81.6 m (249-268 ft) over the winter (Taylor et al. 2016). Therefore, depth alone is not the determining factor for Atlantic sturgeon site selection off Virginia.

Though little is known about the BOEM 13 or 15 sites except that the benthos at the 15 site appears to be composed of a more complex benthic topography than usual, Guida et al. (2017) provided valuable data on numerous parameters that likely influenced sturgeon selecting the BOEM 17 and 18 sites for overwintering. Two of the abiotic factors that the BOEM 17 and 18 sites had in common were finer sediments (Guida et al. 2017) and locations in deeper depressions surrounded by shallower regions

(**Figure 4**). In addition, both sites contained infaunal and epifaunal samples with rich seasonal abundances of sand shrimp (68% by number in all catch), polychaetes, and oligochaetes which are preferred sturgeon prey items (Scott and Crossman 1973, Johnson et al. 1997) as well as increased shellfish diversity specifically during the isothermal period (Guida et al. 2017). The less occupied BOEM 19 site was located on a plain containing deeper waters than BOEM 17 or 18, and it is not surrounded by complex benthic topography with increased slope. BOEM 20, though in a depression, is in much deeper water than BOEM 17 or 18, but since sturgeon have been detected in much deeper waters (Taylor et al. 2016) than those found at the BOEM 20 site, likely of more importance is that less occupied sites contained much coarser sediments (gravel) and less shellfish diversity (Guida et al. 2017).

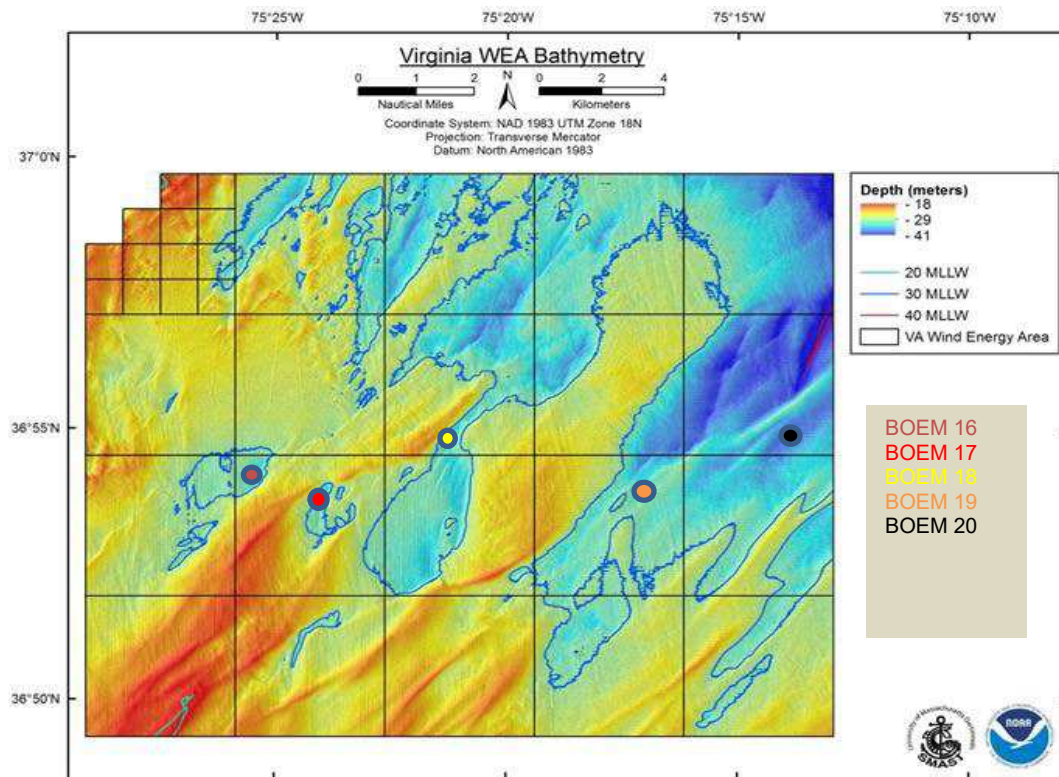


Figure 4. Map from Guida et al. 2017 showing site locations on detailed benthic map.

Atlantic sturgeon are opportunistic feeders (Scott and Crossman 1973, Johnson et al. 1997) most often found over soft sediments (Bain et al. 2000, Savoy and Pacileo 2003, Taylor et al. 2016) where presumably they can feed more efficiently on the prolific infaunal prey items like the worms found in abundance in the VA WFA during isothermal conditions (Guida et al. 2017). The fact that all sturgeon tagged with depth sensitive tags were found to be in close proximity to the bottom while in the WFA (**Table 17**) suggests that they aggregated in sites that were not only temperately beneficial but that also contained prolific trophic resources in sediments that increased foraging efficiency. While it is unclear how dormant sturgeon become while overwintering or at what temperature this may occur, this site selection implies that when appropriate feeding temperatures occur prior to and post dormancy, the fish are already aggregated in beneficial habitats. Sturgeon distributions in two other proposed WEAs along the continental shelf have been published: one in New York Wind Energy Areas (NY WEA) southeast of the Hudson River estuary (Ingram et al. 2019) and one in the Maryland Wind Energy Areas (MD WEA) located southeast of the Delaware Bay (Rothermel et al. 2020). Interestingly, though winter sturgeon occurrence was severely diminished in the MD WEA, the few locations with sturgeon detected

(Rothermel et al. 2020) were also correlated with softer sediments and increased topographic diversity (Guida et al. 2017). The same correlation in the NY WEA (Ingram et al. 2019) was not obvious because variations in topography were widespread and fewer sturgeon detections were reported.

The NY WEA (Ingram et al. 2019) and MD WEA (Rothermel et al. 2020) studies used a gridded array design and focused on spatial environmental gradients to provide a better context for evaluating some of the abiotic conditions selected for or avoided during residency. These studies did not evaluate the importance of the transmission line component of the wind development projects. In contrast, our CRA inclusive approach was able to identify how important this region is especially as a migration corridor in a spatiotemporal fashion and thus provide guidance as to how impacts can be avoided or minimized. While approaches and goals varied between the three studies, our complimentary monitoring methods and the latitudinal variation in our study site locations along the continental shelf near the mouths of estuaries containing spawning populations of sturgeon provide valuable comparisons and help address data gaps between the studies caused by coverage limitations. These comparisons help to elicit important commonalities as well as differences in sturgeon distributions over time and space within each study area.

Many studies have found that sturgeon prefer the deepest environments like channels and holes while within shallow water habitats (Moser and Ross 1995, Bain et al. 2000, Savoy and Pacileo 2003, Musick and Hager 2007, Hager 2022) in estuaries and inshore regions. While Ingram et al. (2019), Rothermel et al. (2020), and this study found sturgeon occupying the deepest sites monitored, these sites were not preferred in any of the three studies. In fact, marine sites differed significantly in their individual relative importance across seasons. None of the WEA studies found sturgeon remaining predominantly close to shore in the winter, so though most sturgeon taken by trawls in Virginia were captured in depths of less than 20 m (66 ft; Musick et al. 1993) and most captures in other regions occurred close to shore (Vladykov and Greeley 1963, Stein et al. 2004, Laney et al. 2007), it appears that these data are biased by sampling effort which was not equally distributed across time or space. Our acoustic data and that of others clearly indicates that sturgeon venture into deeper shelf waters (> 90 m [295 ft]) in offshore regions during the winter (Stein et al. 2004, Erickson et al. 2011, Dunton et al. 2015, Taylor et al. 2016).

The use of specific regions as thermal refuges by sturgeon during extreme cold and warm periods has been documented by numerous researchers in various coastal systems (Brundage and Meadows 1982, Dovel and Berggren 1983, Wooley and Crateau 1985, Moser and Ross 1995, Secor et al. 2000, Musick and Hager 2007, Hager 2011). Clearly, young of the year and pre-migratory fish that remain in natal systems, which exist in cold northern climates, cannot migrate to avoid extreme winter conditions. While sub-adults and adults can and do migrate to maximize their bioenergetics, it remains unclear if temperature alterations influence the migrations and overwintering shelf habitat site selection equally across the species or if populations vary in their physiological tolerances and thresholds. The varied latitudes of each WEA lead to significantly different thermal minimums as well as the temporal extent of isothermal conditions in each (**Appendix E**), with the duration of the isothermal period and average minimum temperature increasing inversely with latitude. Guida et al.'s (2017) thermal dynamics model (2003-2016) calculated an average low temperature of ~ 3.5°C (38.3°F) and isothermal conditions from early November until March in the NY WEA, while the VAWEA only reaches an average low of 6°C (43°F) and its isothermal condition persists from mid-October through early April. Cumulative data (Taylor et al. 2016, Ingram et al. 2019, Rothermel et al. 2020) suggests that migrating sturgeon avoid water temperatures of less than 4.9° C (41°F; Taylor et al. 2016) regardless of natal origin; therefore, it appears the VAWEA provides a thermal winter sanctuary that is not available in the two more northern WEAs studied.

Interestingly and in partial contrast to these findings, based on a one-year study with an extremely small sample size, some smaller adult sturgeon from the Gulf of Maine DPS appear to have overwintered in much shallower water (< 20 m) at the mouth of the Saco River (Hylton et al. 2018). Though only 6 fish

were tagged using automatic release satellite tags and three released before temperatures decreased below 4.5 °C, two fish appear to have remained in Saco Bay when temperatures dropped to 2 °C, at which time their tags released. Of even more interest, however, is that the only fish recorded making spawning runs the next spring chose a completely different overwintering strategy. It did not remain in these frigid shallows but overwintered in deeper warmer waters containing mud sediments which mimics what Taylor et al. (2016) and we found. Based on this data, Hylton et al. (2018) suggest that individuals preparing to spawn have different overwintering requirements than those that are not and this motivates them to select overwintering habitats with more beneficial environmental characteristics linked to fitness and thus successful spawning.

The migrations recorded in all three WEAs were strikingly similar due to their similar locations near the mouths of estuaries containing spawning populations and preferable foraging habitats. Our findings concur with other researchers that the timing and spatial distributions of species across the shelf are dynamic between years and linked to climate variables (Murdy et al. 1997, Guida et al. 2017, Rothermel et al. 2020). The NY and the MD WEAs experienced very low numbers of fish during the coldest water periods in February and March. While this is consistent with our findings in the CRA, especially in its shallower inshore sites, it starkly contrasts with WFA detections that peaked during this isothermal period suggesting that sturgeon were aggregating and overwintering there. In fact, it appears that as Rothermel et al. (2020) proposed, many sturgeon are leaving northern waters in the fall and passing through the MD WEA on their way to known aggregation areas further south (Holland and Yelverton 1973, Moser et al. 1998, Dunton et al. 2010) to overwinter in more temperate waters off of Virginia and North Carolina. Interestingly, in the North Carolina-Kitty Hawk WEA (NC-KH WEA), the bottom water temperature ranges from 6-23° C (43-73°F; Guida et al. 2017), which likely makes this region even more important as an overwintering destination than the VAWEA. Perhaps when studied, the NC-KH WEA will contain similar aggregations throughout the winter relying on similar soft-bottom foraging habitats.

All WEA studies recorded coincidental fall (November-January) and spring (late March-May) migration periods and summer (July –September) depletions (Ingram et al. 2019, Rothermel et al. 2020). The preference for warmer shallow water sites in the spring following deep water overwintering that was recorded in the NY WEA, MD WEA, (Ingram et al. 2019, Rothermel et al. 2020) and the VA WEA has been observed in other studies as well (Taylor et al. 2016, Erickson et al. 2011). While all studies recorded emigrations out of the regional estuaries followed by offshore movement in the fall, due to the shape of the gridded array deployed in MD, they were able to detect southern movements (Rothermel et al. 2020) as well. Though our VA WEA array was linear, several factors augmented receiver coverage over time and space as a larger gridded array would and thus it provided for a greater understanding of coastal migration patterns.

The first significant difference was that the CRA extended to the beach in Virginia while monitoring stopped many miles from shore in the northern studies. In addition, another gridded array was also being congruently monitored miles south of the CRA beach sites by CS for BOEM off of Sandbridge, Virginia. By combining data, direction of travel for some fish was determined seasonally. While the number of sturgeon detected at shallow beach (8 m [26 ft]) receivers (RI and RI 2, **Figure 1**) in the spring was not as large as that recorded moving west towards the bay along the deeper CRA sites; detections were unique in ways that convey important aspects of migration off the coast. Almost none of the sturgeon detected at beach sites in the spring were detected in the WEA the previous winter and when direction could be determined all were moving south in the fall and north in the spring. SIRIs (**Table 8 and 14**) note the much greater seasonal importance of these shallow beach sites in the spring whether you examine all sturgeon detected or just York River fish. Therefore, sturgeon of various DPSs are overwintering to the south of the VA WEA and the Sandbridge area and moving along shore close to the beach in the spring more so than in the fall. Interestingly, although the two beach sites (RI and RI2) are spatially very close together and contain the same abiotic conditions, the slightly deeper (RI) site was much more important

than shallower (RI 2) one (**Table 10**). This suggests that migration corridors can be very specific over time and space, perhaps driven by minor variations in longshore currents. This migration pattern could also have important ramifications with regard to bycatch as numerous fisheries operate in the nearshore coastal region in the spring and fall.

The vast majority of sturgeon leaving the bay moved east and then some moved south as waters cooled. This pattern was reversed in the spring when fish first moved west and then north. The vast majority of fish that pass by the bay and go further north in the spring are males. Interestingly, a few females have been detected moving north after spawning in early October. It is presumed they do this in order to take advantage of the prolific seasonal resources known to occur across the northern shelf. Because our York River sturgeon were sexed we could reexamine data to determine if migration corridors or habitat selection varied by sex. While we did not find any significant differences in the migration patterns of males and females, detection differences in the WFA in the winter suggest that more males overwinter there than females. Of the 71 York River adults detected in the CRA, 37 were female, 33 were male, and one was unknown. Of the 38 York River individuals detected in the WFA, 14 were female, 23 were male, and one was unknown. This implies that approximately 38% of the females detected in the CRA were subsequently detected in the WFA while 70% of the males were detected in both the CRA and WFA. Because a much higher percentage of the males were subsequently detected in the WFA than females, it is likely that fewer females overwintered there. Combine this with data from others' arrays that indicate that more females are detected in southern arrays than males (Bill Post, South Carolina, personal communication) and the fact that females do not return to spawn as frequently (Hager et al. 2020), and it suggests that females can and do travel to more distant destinations between spawning events. From a bioenergetic perspective, this differentiated approach is logical. While males save precious energy by shortening their seasonal migrations by overwintering in the closest suitable shelf habitats, females can migrate greater distances to warmer southern clines where faster growth rates can be achieved given sufficient resources (Niklistchek and Secor 2005).

Critical habitat for spawning areas and juvenile rearing were designated in 2017 (82 FR 39160), but NMFS was unable to identify critical habitat for Atlantic sturgeon in offshore areas because data on offshore migration "flyways" (Rothermel et al. 2020), feeding grounds, and overwintering sites remains too limited to identify the physical and biological features of these habitats that are essential for the conservation of the species (Erickson et al. 2011, 82 FR 39160). This is a significant oversight for all anadromous fishes which migrate long distances across the shelf in order to optimize temperature and temporal availability of predictable foraging and spawning conditions (Gross et al. 1998, Dingle and Drake 2007). However, this oversight may be especially damaging to sturgeon because it spends the majority of its life feeding in and/or migrating across the continental shelf (Smith 1985). Because each population has evolved to be uniquely suited to best utilize the benefits of the shelf habitats available within its geographic range, understanding the factors that motivate occupancy within shelf habitats is vital. Because numerous populations form mixed aggregations in offshore waters, there is the potential for threats within these aggregation areas to impact numerous DPSs and/or populations (Dunton et al. 2012, O'Leary et al. 2014, Rulifson et al. 2020). While some of these aggregation areas have been identified (Laney et al. 2007, Erikson et al. 2011, Rulifson et al. 2020), commercial bycatch data indicates other potential sites (Stein et al. 2004, Dunton et al. 2015) that have not been recognized. Improving our knowledge on the spatiotemporal distributions across and behavior within offshore habitats is also important because recent survival rate estimates are already below the suggested threshold to allow for increasing abundance (Boreman 1997, Melnychuk et al. 2017, ASMFC 2007b, Hightower et al. 2015), and a reduction in the mortality during the marine residence period is necessary to restore populations (ASMFC 2007a, ASMFC 2009, Boreman 1997). If, as our data suggests, females are traveling greater distances to aggregate in preferred habitats, this not only highlights the importance of identifying and preserving these habitats, but it also implies that females are at greater risk to shelf habitat alterations because they have a larger geographic range to cross and thus spend more time in shelf habitats.

4.2 Striped Bass (*Morone saxatilis*)

The striped bass was once overfished and suffered from severe degradation of its freshwater riverine spawning habitats (Richards and Rago 1999). Today, it has recovered due to long-term fishing closures and restocking and is once again a very commercially and recreationally important species (Fabrizio et al. 2017). Like Atlantic sturgeon, it is native primarily to northern temperate regions, highly migratory, and anadromous. Along the east coast, its range extends from the St. Lawrence River in Canada to the St. Johns in Florida (Murdy et al. 1997).

The Chesapeake Bay contains the largest and most important spawning and nursery regions (Speir et al. 1999). Unlike sturgeon that spawn in the spring and/or fall, the anadromous striped bass only spawns in the spring with its spawning success is positively linked to freshwater flow (Martino and Houde 2010). Juvenile striped bass exhibit contingent or flexible behavior when it comes to migration (Secor 2007) which is thought to promote colonization of new environments (Morissette et al. 2016). In some cases, juveniles may even inhabit non-natal estuaries where spawning does not occur (Able et al. 2012) before joining coastal migrants. As bass age, they transition to become coastal migrants, and by age 13, 75% of females and 50% of males leave the Chesapeake Bay and make their way north to New England (Hollema et al. 2017). Some even go as far north as southern Canada (Murdy et al. 1997). Though it is true that as bass age they are more likely to exhibit coastal migrations, some reside in estuarine environments far longer than others (Secor and Piccoli 2007). From 2008 through 2010, bass of Chesapeake Bay origin were the largest contributor to the population residing off of Massachusetts, returning to the same feeding grounds and migrating close to shore while in these northern waters (Kneebone et al. 2014).

In some years, fish congregate near the mouths of bays like the Delaware and Chesapeake with aggregations that consist of many different coastal populations (Waldman et al. 2012). One tracking study conducted at the mouth of the Chesapeake Bay found that fish spent 90% of their time in the upper 10 m (33 ft) of the water column (Graves et al. 2009), which implies pelagic feeding in this area. Acknowledged weaknesses of this study included a very small sample size and tagging of the fish on location. Large aggregations of striped bass are also known to occur in ocean waters from Cape Hatteras, N.C. to as far north as Sandy Hook, N.J. with peak locations varying annually (Waldman et al. 2012).

Our findings in the CRA and WFA provide much needed information because little is known about habitat use by striped bass in the winter (Fabrizio et al. 2017), and this is when the species was at its most abundant in both the CRA and WFA (**Table 19 and 21**). Striped bass was the only species detected in greater numbers ($n = 368$ vs 243), for more days ($n = 432$ vs 265), and more times ($n = 77,926$ vs $19,108$) in the deeper WFA than in the CRA across every year. And, though the total number of bass varied considerably between years (**Table 18 and 20**), the number detected annually in both, across years with complete monitoring (2016-2020), was correlated. Minimums in both occurred in 2020 when 12 were detected in the CRA and 55 were detected in the WFA, and maximums occurred in both in 2018 with 111 in the CRA and 200 in the WFA (**Table 18 and 20**). The number of days with detections was also correlated with the fewest occurring in 2020 ($n = 14$ vs 43) and the most in 2017 ($n = 69$ vs 92). Detection number was not directly correlated which suggests that behavior varies on an annual basis within the two regions.

Bass are recruiting into both regions in December and exiting in April. During December while fish are arriving, all three detections statistics and the average number of detections per fish are greatest in the CRA. The average number of individuals in the WFA in January through March is more than twice that detected in the CRA, and on average each fish is detected 3 times more often in the WFA. This much stronger site fidelity within the WFA implies that once a fish enters, they are less mobile/active in the WFA or that they are remaining within a more confined area due to schooling associated with prey availability and/or predator avoidance. Because large numbers of tagged bass were detected every winter

in both the CRA and the WFA over all 5 years, data shows that winter residence is normal. Striped bass appear to be less site selective than the benthically oriented sturgeon because many striped bass were also detected at BOEM stations in much deeper water to the east in close proximity to the slope in the winter of 2017-2018, illustrating that bass can be very widespread across outer shelf habitats. In April, though fish remaining in the WFA continue to be detected more often on average, the number of fish detected and the number of days with detections in the CRA exceeds that recorded in the WFA (**Table 16 and 19**). These regional shifts in detection statistics that occur annually during rapid transitions of water temperature suggests that a significant number of the tagged bass are migrating through the CRA to overwinter in the WFA.

Because we lack the metadata on bass tagged, our ability to interpret what detections imply is limited. Study specifics suggests that an equal percentage of fish were tagged in Delaware, Maryland, and Massachusetts (**Appendix C**); therefore, one may assume this data best reflects behavior patterns of fish natal to the Chesapeake and Delaware Bays. The fact that roughly a third were tagged in Massachusetts actually implies the majority of these fish were older adults from the Chesapeake Bay (Kneebone et al. 2014). Each fall, bass are migrating south in order to overwinter in milder conditions (Rothermel 2020), and for the majority of tagged bass that originated in the Chesapeake Bay, an overwintering location close to the bay's mouth places them in suitable water temperatures (Murdy et al. 1997, Rothermel et al. 2020) in close proximity to their natal Chesapeake Bay estuaries for spring spawning.

It is still unclear exactly why striped bass occupy these offshore marine habitats and therefore not possible to predict how important these offshore grounds are to the species or how anthropogenic alterations within these overwintering grounds may impact the species. These regions provide striped bass, as they do Atlantic sturgeon, with temporally beneficial abiotic and biotic characteristics because they are preferred (Breece et al. 2016, Melnychuk et al. 2017, Rothermel et al. 2020). However, the striped bass is a critically important species to many coastal economies, and its dependence on these regions and how our alterations to them may impact the species is very important to understand. More ocean-derived data is necessary to expand our understanding and reduce impacts on this commercially and recreationally important species that has already suffered one stock collapse due to mismanagement (Murdy et al. 1997, Richards and Rago 1999).

4.3 White shark (*Carcharodon carcharias*)

The white shark, *Carcharodon carcharias*, is a migratory apex predator found globally in temperate to sub-tropical waters (Compagno 1984, Franks et al. 2021). It has been reported from Newfoundland to Argentina along the western shore of the Atlantic, but it is rare in equatorial waters. It is one of the largest sharks, and it has reached iconic stature through media productions. White sharks are lamniformes and members of the Lamnidae family (Compagno 1984). Seven regions have white sharks: Southern Africa, Australia and New Zealand, the Northwest Pacific, Northeast Pacific, Mediterranean, Southwest Atlantic, and the Western North Atlantic. While there is some genetic mixing, sharks in these regions form distinct groups possessing different movement and behavioral patterns, and these groups may consist of genetically distinct populations (Franks et al. 2021). Sharks of different populations may have varied life histories, reproductive cycles, and maximum sizes (Franks et al. 2021); it is therefore more appropriate to assess them on a regional level.

The mating behavior of the white sharks in the Western North Atlantic region still lacks research (Skomal et al. 2017, Verkamp et al. 2021); however, we know that white sharks grow slowly (Natanson and Skomal 2014) and mature at advanced ages, but this varies regionally and by sex (Skomal et al. 2017). For example, in the Western North Atlantic region the species does not reach maturity as a female until 26 years and males until 34 years (Skomal et al. 2017). Though little is known about preferred temperature range of the white shark or the prey species consumed within nursery areas (Curtis et al.

2018), an important summer nursery has recently been identified in the New York Bight (Franks et al. 2021, Skomal et al. 2017), and another important juvenile white shark overwintering site spans from northern North Carolina to South Carolina along the shelf (Curtis et al. 2018, Franks et al. 2021, James et al. 2021). After overwintering, the juveniles migrate north in late spring and early summer (Franks et al. 2021). Though our research on juvenile white shark distributions in the Western North Atlantic region remains impoverished, what has been done suggests they spend most of their time along the continental shelf (Curtis et al. 2018) as do the adults (Skomal et al. 2017). Thus, they are also heavily dependent upon continental shelf habitats for foraging and migration corridors (Curtis et al. 2018).

While on the shelf, smaller individuals feed on demersal fish and invertebrates while larger ones prefer marine mammals (Casey and Pratt 1985). Most evidence still supports a generalist diet of fish and cetaceans, but in the Western North Atlantic adult white sharks have begun to consume more pinnipeds, and as seal populations have rebounded, so too have the shark populations (Curtis et al. 2018, Skomal et al. 2017). When feeding on pinnipeds along the New England coasts in the summer, large white sharks are in close proximity to humans participating in recreational and commercial activities (Natanson and Skomal 2014). Large gaps in data and our fascination with the fish's ominous reputation have made it an easily marketable species for public outreach and financial participation in research efforts. This coupled with its population expansion and now common sightings along the New England coast in the summer have resulted in a massive increase in its public awareness and increased funding for acoustic research. In fact, there are townships in New England that now sponsor tagging and tracking efforts to learn about white sharks in their local waters in an effort to minimize risks to bathers (Kneebone, personal communication). This has significantly increased the number of tagged white sharks and what we know about them.

White sharks in the Western North Atlantic region were not as well studied as in other regions which was in large part due to their reduced populations (Curtis et al. 2018, Franks et al. 2021), but with the population rebounding and increased public concern, more sharks are being tagged and tracked. Historically, as was the case with Atlantic sturgeon, most of what we knew about white sharks was based on fishing records (Skomal et al. 2017), accidental captures, and rare sampling opportunities (Verkamp et al. 2021). Prior to the development of sonic tracking, the semi-solitary existence of the species made it difficult to study and define its life history. In fact, we still know very little about the species' reproduction and early life history. Occupation patterns of the species across their ontogeny are largely unknown (Curtis et al. 2018, Franks et al. 2021, James et al. 2021, Skomal et al. 2017), but understanding the movement patterns of white sharks across all age classes is vital for its conservation (Skomal et al. 2017). Our acoustic array data provides some of the first purely observation-based data on the species in shelf waters off of Virginia.

As was the case with all of the other species most commonly detected in the VAWEA arrays, except for striped bass, more white sharks were detected in the shallower CRA ($n = 158$ vs 126) than in the WFA (**Table 4 and 5**). However, it is very hard to determine if such small differences in shark numbers imply any habitat preference by life stage or any other biologically significant attribute because we lack all metadata on the tagged individuals. The number of white sharks steadily increased over time in both arrays based on years with complete annual monitoring (**Table 22 and 24**) which is a reflection of the steadily increasing numbers reported tagged over the same time period (ACT data). Based on averages across years, the species was most abundant in the CRA in June and November and in the WFA in May and November. It was least abundant in January and September in the CRA and in January and August in the WFA (**Table 23 and 25**).

White sharks spend a large amount of time along the continental shelf where it exhibits a consistent presence which is reflected though our detections which occurred during every month of the year (Franks et al. 2021). Our detections also demonstrate that the Western North Atlantic population spends time between Cape Hatteras, North Carolina, and the Gulf of Maine (Skomal et al. 2017); however, we do not

know how movement or distribution patterns are related to life stage due to a lack of data access. Therefore, though our detections illustrate that white sharks migrate through Virginia coastal waters in November, we do not know if these are juvenile white sharks on their way to overwintering sites along the Carolina shelf (Curtis et al. 2018, Franks et al. 2021, James et al. 2021) or adults on their way to the Gulf of Mexico for the winter (Skomal et al. 2017, Franks et al. 2021). A lack of data also affects our ability to interpret the spring through early summer migrations north that were documented in both of our arrays; thus, we do not know if these are juveniles on their way to nursery grounds in the New York Bight (Skomal et al. 2017, Franks et al. 2021) or adults bound for the New England coast. And though we have many years of data, without access to life stage and depth tag information, we are unable to examine our data to determine if white sharks become progressively more pelagic with age (Skomal et al. 2017, Franks et al. 2021). Of interest, though of unknown importance, while white sharks were more evenly distributed across the WFA over time and space (**Appendix D.10**), a few individuals showed regional site fidelity in 2020 from June to August between the CB and BOEM 5 sites (**Appendix D.12**).

Though we lack the metadata on all three species, it is safe to assume based on the literature that only adults of the anadromous sturgeon and striped bass were present in offshore habitats. Conversely, white sharks are present in these ocean habitats during every life phase. Since different white shark life stages have unique characteristics with regard to habitat occupancy and movement, white shark detections are more likely to consist of individuals with vastly different behaviors and patterns of movement. Larger fish like white shark also swim at much greater speeds than small ones. Therefore, adult white sharks that are at least twice the size of an adult sturgeon and likely five times the size of a large striped bass would not remain within the detection distance of a receiver for long in comparison. Our linear array design was in no way designed to track such large, fast-moving fish. Since we do not have essential data related to specimens tagged and our array was poorly designed for this large a fish, the resulting data is not adequate to describe white shark presence or occupancy patterns. Therefore, we must rely on existing research by white shark experts. Current literature suggests that the shelf, upon which wind farms are to be constructed, contain essential nursery habitats and sub-adult, and adult feeding grounds. Because the species also demonstrates high seasonal site fidelity, in combination, these attributes imply the species is at high risk from anthropogenic factors related to the development of windfarms (Franks et al. 2021).

4.4 Cobia (*Rachycentron canadum*)

Cobia is of recreational importance in Virginia because in the past few years its popularity as a sports fish and its subsequent landings have expanded considerably (Jensen and Graves 2020). Congruently, this has resulted in increased concerns regarding potential overharvest predicated primarily on a lack of movement and habitat utilization data necessary for sufficient management. There is also genetic evidence for distinct subpopulations and spawning site fidelity within stock management units (Darden et al. 2014, Perkinson et al. 2019) which augments concerns that increased harvest pressures and habitat alterations in one location will have disproportionate consequences for certain subpopulations.

The cobia is the only member of the family Rachycentridae, and it is distributed worldwide in warm tropical and temperate coastal waters (Shaffer and Nakamura 1989). Along the east coast of North America, its range extends from Massachusetts to Argentina with residents occurring in the Gulf of Mexico and the Caribbean. Cobia supports a major recreational fishery throughout its U.S. Atlantic and Gulf of Mexico range (SEDAR 2013). It is attractive to anglers in that it is larger than most inshore fish, is aggressive, and is often found in the surface eddies created by anthropogenic structures. Thus, it offers a unique visual fishing experience to mid-Atlantic anglers.

The temporal nature of our detections confirms (**Table 27**) that cobia are seasonal visitors to Virginia, arriving in the Chesapeake Bay in May and staying into October (Murdy et al. 1997). Though often found solitary in the mid-summer during pre and post migration periods, it can sometimes be found in

aggregation. Aggregations of cobia, indicated by more than ten individuals detected more than 100 times for more than 10 days in a month, occurred at RA and CB in September of 2019 and at BOEM 1 in September and October. In 2020, cobia aggregated further inshore at RA outside July through September. These aggregations may indicate spawning since it occurs during spring and summer (Lefebvre and Denson 2012) along the continental shelf (Hassler and Rainville 1975). Late summer aggregations may also demonstrate fish staging to depart to overwinter in the offshore waters of North Carolina near the continental shelf break (Perkinson et al. 2019, Jensen and Graves 2020).

Three times as many Cobia were detected within the CRA as compared to the WFA (**Table 4 and 5**). The species demonstrates a strong affinity for waters $\geq 20^{\circ}\text{C}$ ($\geq 68^{\circ}\text{F}$; Jensen and Graves 2020), and warm estuarine waters ($> 20^{\circ}\text{C}$ [$> 68^{\circ}\text{F}$]) extend across the surface of the shelf, especially those located near the bay's entrance from May to October (**Appendix E**, Guida et al. 2017), the exact same period that cobia inhabit the region. However, the fish's preference for waters $\geq 20^{\circ}\text{C}$ ($\geq 68^{\circ}\text{F}$) restricts the species to surface waters while inhabiting the shelf. This isolates and increases concerns for this species that global temperature changes due to climate change or more direct anthropogenic increase in water temperatures along the shelf will shift suitable habitats northward and lead to degradation of currently suitable shelf habitats (Crear et al. 2020b).

Cobia were the fourth most commonly detected species in the VAWEA (**Table 4**) despite the fact none were tagged until 2017 and that they were not tagged in significant numbers until 2018 (ACT data base). There are numerous reasons why cobia were detected so often during their short residence from May through October. As previously mentioned, spawning occurs during spring and summer in inshore and potentially shelf waters (Lefebvre and Denson 2012), and due to the thermocline during this period, cobia must spend a significant amount of time near the surface (Jensen and Graves 2020). However, as fishermen know, the species is attracted to eddies and prey found around anthropogenic structures in nearshore waters, especially those that intersect the surface. The most common structures that occur at the surface in the CRA are the buoys upon which we placed most of our inshore receivers (**Figure 1**). As was the case with white shark, our array design drastically affected results in a species-specific manner. There is at least one paper being written (Riley et al.) by the researchers who tagged the cobia we detected in the BOEM offshore arrays, and it should be consulted when published for more detailed information.

4.5 Sand tiger shark (*Odontaspis taurus*)

The sand tiger shark (*Carcharias taurus*) was the fifth most commonly detected species in the CRA. It is a lamniform or mackerel shark in the family of Odontaspidae like the white shark. Also, in accordance with the white shark, sand tigers range broadly in the Western North Atlantic Ocean from Maine to the Gulf of Mexico (Kneebone et al. 2012). Unlike the white shark, as the lack of detection data in the WFA suggests, the sand tiger primarily inhabits coastal waters (Compagno 1984). Sand tigers primarily eat a variety of bony fishes, small elasmobranchs, and crustaceans, implying at least adults are more benthically dependent than white shark.

Like other literature has suggested, our detection data illustrates that the sand tiger is in residence regionally from May to November. Like all the other species we examined in more detail, the sand tiger is a temporal resident exhibiting highly migratory behavior moving north in the spring and south in the late fall (Haulsee et al. 2018). However, though the species migrates through the CRA array in May and November, it is of notable lower abundance from July and August (**Table 29**). Literature suggests that during this period the species often aggregates around nearshore wrecks (Paxton et al. 2019) and at the mouths of bays where it preys primarily on sandbar sharks (Compagno 1984, Haulsee et al. 2018) that use the bay as pupping grounds and are abundant at this time (Murdy et al. 1997). The species is also known to pup around the barrier islands of Virginia's Eastern shore (Murdy et al. 1997), and many sand tigers migrate further north. Regardless of where the species is located, for our purposes it is sufficient to

document that they are not within the CRA except during migration periods and they are much rarer in the WFA.

There are several species-specific factors that increase the vulnerability of the sand tiger to anthropogenic impacts that deserve discussion. Similar to other lamniform sharks, in utero, the largest pups will eat the other smaller pups and/or eggs. Female sand tiger sharks have two uteri, resulting in two pups being born, one from each uterus (Compagno 1984). Sand tiger sharks have a gestation period of an estimated 8 to 9 months (Compagno 1984). Pups are born every two years and have a late reproductive age, resulting in a low fecundity, putting sand tiger sharks at a high risk of overexploitation (Teter et al. 2015). The sand tiger shark is also recorded in fisheries data as bycatch and commercial harvest. Since the mid-1970s, population declines for the sand tiger shark have been estimated to reach 80 to 90% (Kneebone et al. 2012). In 1997, the NMFS made harvesting sand tiger sharks illegal (Kneebone et al. 2012, Teter et al. 2015); however, because a good population assessment does not exist for this species, quantifying if the shark's population has recovered at all is difficult. Sand tiger sharks are currently listed as vulnerable in federal waters (Haulsee et al. 2018, Teter et al. 2015).

4.6 Concluding Remarks

Very little is known about most species movements and distributions while on the continental shelf. Our acoustic detection results are the first and only attempt to determine regional movements and spatiotemporal patterns of habitat occupation along Virginia's coast. Movement, regardless of its temporal scale, is a fundamental biological process that affects a population's spatial, demographic, and genetic structure (Hays et al. 2016, Wittemyer et al. 2019); therefore, understanding the spatiotemporal responses of species to system alterations is critical for assessment, management, and conservation (Pittman and McAlpine 2001, Lennox et al. 2019). Current data, however, is so lacking that we are only barely beginning to understand species-specific life histories enough to interpret what normal behavior and distributions are. As we learn more about each species' life history, we find more links between behavior and the genetic population segment to which each individual belongs. In fact, behaviors, occupation patterns, and even migration corridors are often more influenced by natal origin than by species alone. Thus, our current ability to understand and discuss results is limited because we know so little about each species' sub-populations, spatiotemporal distributions, and movements.

There are also evolutionary characteristics that make some fishes more likely to be impacted by wind farms than others. Some marine organisms are equipped with different sensory organs that are far more sensitive to environmental alterations than are terrestrial animals (Kajiura and Holland 2002, Ernst and Lohmann 2018). In fact, all chondrichthyan fishes, as well as Atlantic sturgeon, possess numerous receptors called Ampullae of Lorenzini located ventrally in their heads (Kajiura and Holland 2002). If we consider the 28 species detected in the VLA, 18 of these are known to possess and actively use such receptors and unique capabilities to detect thermal, mechanical, and salinity changes. Behavior experiments have made it clear that these ampullae are extremely sensitive electroreceptors capable of detecting minute electric currents generated by prey down to a few microvolts in amplitude (Murray 1974, Kalmijn 1978). However, other marine animals are also capable of detecting electromagnetic fields (Ernst and Lohmann 2018).

Understanding the spatiotemporal responses of species to system alterations is critical for assessment, management, and conservation (Pittman and McAlpine 2001, Lennox et al. 2019). In most cases, however, we are only barely beginning to understand species specific life histories enough to interpret what normal behavior and distributions are in the mid-Atlantic. Based on intrapopulation variability between contingents, sturgeon (ASMFC 1998), striped bass (Clark 1968), cobia (Darden et al. 2014, Perkinson et al. 2019), and potentially white shark (Franks et al. 2021) all occupy non-natal habitats differently. Differences in the spatiotemporal distributions between contingents require them to seek out

geographically different beneficial habitats which requires them to move along varied migration corridors. Habitats differ in their value based not only on the species considered but the intrapopulation contingent to which an individual belongs. Alterations within a given habitat or migration corridor could have undesirable contingent specific consequences (Rothermel et al. 2020). If this subpopulation is small, as the York River sturgeon population is, mis-management could drive a population segment to extinction, thus placing the entire species at greater risk. Therefore, we must better understand not only how each species relies on shelf habitats but also how each population of a given species relies upon specific shelf habitats in order to mitigate the risks associated with wind farm development.

Our research and that of others suggests that certain shelf habitats provide more benefit to sturgeon due to their temperate suitability, benthic composition, and increased prey availability. While sand habitats have been proposed to be protected from tower placement due to their habitat provision for other species (Guida et al. 2017), our data suggests that mud bottoms are more preferred by the endangered sturgeon. Therefore, hardening the benthos and reducing mud bottom habitat may have greater impact to species, such as the sturgeon, that prefer mud bottom habitat. More research on habitat preference and usage is necessary to determine the least destructive siting of WEA and the structures within them with regard to numerous species including the protected Atlantic sturgeon. Other indirect effects due to wind farms such as possible migration corridor disruption, possible displacement, EMF disturbances, and possible area avoidance due to the combination of construction, maintenance, and EMF from operating cables (Rothermel et al. 2020, Hutchison et al. 2021) could cause physiological stress and thus cause harm. These potential long term impacts due to windfarms are recognized and deserve more attention with regard to not just sturgeon but also to other shelf dependent species. Estuarine dependent species that migrate east rather than south in the fall deserve priority attention as the majority of WEA are located to the east of important estuarine systems.

The VA WEA is likely of increased importance for sturgeon in comparison to other WEA due to its latitude which appears to offer the furthest north overwintering temperatures that consistently stay above temperatures that are actively avoided ($> 4.9^{\circ}\text{C}$). Similar thermal refuges can be found closer to spawning rivers off of Canada due to topography and currents (Taylor et al. 2016), and the expansive shelf along the MAB encourages southerly migrations in the fall to attain suitable winter temperatures. Historically, temperature has likely been the most influential abiotic habitat structuring force (Coutant 1987) because large changes in temperature have important physiological and behavioral consequences (Guida et al. 2017, Niklitschek and Secor 2005). When temperature shifts are large enough and/or species-specific thresholds are reached, fish will relocate to more advantageous conditions (Niklitschek and Secor 2005). If temperature alterations persist over time, fish will alter their movements and distributions to relocate to habitats that contain environmental properties that benefit them (Breece et al. 2016, Melnychuk et al. 2017). The same seasonal temperature dynamics that moderate bottom temperatures (Murdy et al. 1997) and drive seasonal migrations are also responsible for the shelf's increased productivity through the re-distribution of species and settlement of new benthic organisms from the plankton to the benthic habitats (Guida et al. 2017). However, entire benthic communities cannot relocate. If the seasonal pattern of enrichment that leads to shelf production is significantly altered due to physical obstruction and/or thermal inputs below the thermocline and this upsets seasonal mixing, the entire system's current biological function and trophic connectivity could be changed.

Acoustic telemetry provides insights into previously undiscovered aspects of movement and habitat occupation over varied time scales (Hussey et al. 2015, Lowerre-Barbieri et al. 2021) through the provision of large volumes of presence/absence data over extended periods (Donaldson et al. 2014, Hidalgo et al. 2016). However, even with our monitoring data, the life histories, movements, migrations, and habitat occupation patterns of the species we detected are poorly understood at present. This lack of available relevant biological data combined with the fact that we have no tracking data on the majority of species inhabiting the shelf or how these species respond to anthropogenic activities limits our ability to

comprehend the results or to predict how these species will be affected by human activities and habitat alterations and/or degradation. Therefore, while the results from this study help us understand the spatiotemporal distribution of acoustically tagged species in the VA WEA, they also illustrate the large data gaps about the species we detected and how they use shelf habitats.

5 References

- Able KW, Grothues TM, Turnure DM, Byrne DM, Clerkin P. 2012. Distribution, movements, and habitat use of small striped bass (*Morone saxatilis*) across multiple spatial scales. *Fish Bull.* 110(2):176-192.
- ASMFC and Atlantic Sturgeon Plan Development Team. 1998. Amendment 1 to the interstate fishery management plan for Atlantic sturgeon. Washington, D.C. Fishery Management Report No.: 31. <http://www.asmfc.org/uploads/file/sturgeonAmendment1.pdf>.
- ASMFC Status Review Team. 2007a. Status review of Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*). Washington D.C. Report to National Marine Fisheries Service, Northeast Regional Office. <https://repository.library.noaa.gov/view/noaa/16197>.
- ASMFC. 2007b. Estimation of Atlantic Sturgeon Bycatch in Coastal Atlantic Commercial Fisheries of New England and the Mid-Atlantic. Washington, D.C. Special Report to the ASMFC Atlantic Sturgeon Management Board. <https://repository.library.noaa.gov/view/noaa/42436>.
- ASMFC. 2009. Atlantic coast diadromous fish habitat; a review of utilization, threats, recommendations for conservation and research needs. Washington D.C. Atlantic States Marine Fisheries Commission Habitat Management Series No.: 9. <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.734.2517&rep=rep1&type=pdf>.
- Bailey H, Brookes KL, Thompson PM. 2014. Assessing environmental impacts of offshore wind farms: lessons learned and recommendations for the future. *Aquat Biosyst.* 10(1). <https://doi.org/10.1186/2046-9063-10-8>.
- Bain MB, Haley N, Peterson D, Waldman JR, Arend K. 2000. Harvest and habitats of Atlantic sturgeon *Acipenser oxyrinchus* Mitchel, 1815, in the Hudson River estuary: Lessons from sturgeon conservation. Instituto Espanol de Oceanografia. Boletin 16(1-4):43-53.
- Balazik MT, Garman GC, Van Eenennaam JP, Mohler J, Woods LC. 2012. Empirical evidence of fall spawning by Atlantic sturgeon in the James River, Virginia. *Trans Am Fish Soc.* 141(6):1465-1471. <https://doi.org/10.1080/00028487.2012.703157>.
- Balazik MT, Farrae DJ, Darden TL, Garman GC. 2017. Genetic differentiation of spring-spawning and fall-spawning male Atlantic sturgeon in the James River, Virginia. *PLoS ONE* 12(7):e0179661. <https://doi.org/10.1371/journal.pone.0179661>.
- Ball RE, Oliver MK, Gill AB. 2016. Early life sensory ability-ventilatory responses of thornback ray embryos (*Raja clavata*) to predator-type electric fields. *Dev Neuobiol.* 76(7):721-729. <https://doi.org/10.1002/dneu.22355>.

- Bennet MVL, Clusin WT. 1978. Electrical Senses. In: Technical Information Divison, Naval Research Laboratory, editors. *Sensory Biology of Sharks, Skates, and Rays*. Arlington (VA): Office of Naval Research Department of the Navy. p. 483-506.
- Bergström L, Sundqvist F, Bergström U. 2013. Effects of an offshore wind farm on temporal and spatial patterns in the demersal fish community. *Mar Ecol Prog Ser*. 485:199-210. <https://doi.org/10.3354/meps10344>.
- Boehlert GW, Gill AB. 2010. Environmental and ecological effects of ocean renewable energy development. *Oceanography*. 23(2):68-81. <https://doi.org/10.5670/oceanog.2010.46>.
- Boreman J. 1997. Sensitivity of North American sturgeons and paddlefish to fishing mortality. *Environ Biol Fishes*. 48(1):399-405. https://doi.org/10.1007/0-306-46854-9_28.
- Breece WM, Fox DA, Dunton KJ, Frisk MG, Jordaan A, Oliver MJ. 2016 Dynamic seascapes predict the marine occurrence of an endangered species: Atlantic Sturgeon *Acipenser oxyrinchus oxyrinchus*. *Methods Ecol Evol*. 7(6). <https://doi.org/10.1111/2041-210X.12532>.
- Brooking P, Doucette G, Tinker S, Whoriskey FG. 2006. Sonic tracking of wild cod, *Gadus morhua*, in an inshore region of the Bay of Fundy: a contribution to understanding the impact of cod farming for wild cod and endangered salmon populations. *ICES Jour. Mar. Sci.* 63: 1364–1371.
- Brown, SC, Bizzarro, JJ, Cailliet GM, Ebert DA. 2012a. Breaking with tradition: redefining measures for diet description with a case study of the Aleutian skate *Bathyraja aleutica* (Gilbert 1896). *Env. Bio. Fish.* 95:3-20.
- Brown JJ, Murphy GW. 2012. Atlantic sturgeon vessel-strike mortalities in the Delaware estuary. *Fisheries*. 35(2):72-83. <https://doi.org/10.1577/1548-8446-35.2.72>.
- Brundage HM III, Meadows RE. 1982. The Atlantic sturgeon, *Acipenser oxyrinchus* in the Delaware River and Bay. U.S. Fish and Wildlife Service. *Fish Bull.* 80:337-343.
- Casey JG, Pratt HL. 1985. Distributions of white shark, *carcharodon carcharinus*, in the western north Atlantic. Southern California Academic Scientific Memorandum No.:9. p. 2-14.
- Chapman BB, Bronmark C, Nilsson J, Hansson L. 2011. The ecology and evolution of partial migration. *Oikos*. 120(12):1764–1775.
- Clark J. 1968. Seasonal movements of striped bass contingents of Long Island Sound and the New York Bight. *Trans Am Fish Soc.* 97(4):320–343.
- Colvocoresses JA, Musick J. 1984. Species associations and community composition of Middle Atlantic Bight continental shelf demersal fishes. *Fish Bull US.* 82:295–313.
- Compagno LJ. 1984. Vol.4 *Sharks of the World: An annotated and illustrated catalogue of shark species known to date; Part 1- Hexanchiformes to Lamniformes*. 125(4/1):1-655.
- Compagno LJ. 1999. Systematics and body form. In *Sharks, Skates, and Rays: Biology of Elasmobranch Fishes* (ed. WC Hamlett) p. 1-42. Baltimore, MD, USA: Johns Hopkins University Press.

- Cooke SJ, Midwood J, Thiem J, Klimley AP, Lucas MC, Thorstad EB, Eiler J, Holbrook CM, Ebner BC. 2013. Tracking animals in freshwater with electronic tags: Past, present and future. *Anim Biotelemetry*. 1(5). <https://doi.org/1186/2050-3385-1-5>.
- Cortes, E. 1997. A critical review of methods of studying fish feeding habitats based on analysis of stomach contents: application to elasmobranch fishes. *Can J Fish Sci*. 54(3):726-738. <https://doi.org/10.1139/cjfas-54-3-726>.
- Coutant CG. 1987. Thermal preference: when does an asset become liability? *Env Biol Fishes*. 18(3): 161-172. <https://doi.org/10.1007/BF00000356>.
- Crear DP, Watkins BE, Saba VS, Graves JE, Jensen DR, Hobday AJ, Weng KC. 2020a. Contemporary and future distributions of cobia, *Rachycentron canadum*. *Divers Distrib*. 26(4):1002-1015. <https://doi.org/10.1111/ddi.13079>.
- Crear DP, Brill RW, Averilla LM, Meakem SC, Weng KC. 2020b. In the face of climate change and exhaustive exercise: the physiological response of an important recreational fish species. *R Soc Open Iso*. 7(3):200049. <https://doi.org/10.1098/rsos.200049>.
- Cresci A, Durif C, Paris CB, Shema SD. 2019. Glass eels (*Anguilla anguilla*) imprint the magnetic direction of tidal currents from their juvenile estuaries. *Commun Biol*. 2(1). <https://doi.org/10.1038/s42003-019-0619-8>.
- Curtis TH, Metzger G, Fischer C, McBride B, McCallister M, Winn LJ, Quinlan J, Ajemian MJ. 2018. First insights into the movements of young-of-the-year white sharks (*Carcharodon carcharias*) in the western North Atlantic Ocean. *Sci Rep*. 8(1):1-8. <https://doi.org/10.1038/s41598-018-29180-5>.
- Darden TL, Walker MJ, Brenkert K, Yost JR, Denson MR. 2014. Population genetics of cobia (*Rachycentron canadum*): implications for fishery management along the coast of the southeastern United States. *Fish Bull*. 112(1):24-35. <https://doi.org/10.7755/FB.112.1.2>.
- Department for Energy and Climate Change (DECC). 2012. <https://www.sciencedirect.com/science/article/abs/pii/S0308597X18309345>.
- Diaz R, Cutter G., Able K. 2013. The importance of physical and biogenic structure to juvenile fishes on the shallow inner continental shelf. *Estuaries* 26(1):12-20.
- Dingle H, Drake VA. 2007. What is migration? *BioScience*. 57(2):113-121.
- Donaldson MR, Hinch SG, Suski CD, Fisk AT, Heupel MR, Cooke SJ. 2014. Making connections in aquatic ecosystems with acoustic telemetry monitoring. *Front Ecol Environ*. 12(10):565-573. <https://doi.org/10.1890/130283>.
- Dovel WL, Berggren TJ. 1983. Atlantic sturgeon of the Hudson estuary, New York. N.Y. *Fish Game J*. 30:140-172.
- Drewitt AL, Langston RHW. 2006. Assessing the impacts of wind farms on birds. *Ibis*. 148:29-42. <https://doi.org/10.1111/j.1474-919X.2006.00516.x>.
- Dunton KJ, Chapman D, Jordaan A, Felheim K, O'Leary S, Mckown K, Frisk M. 2012. Genetic mixed-stock analysis of Atlantic sturgeon *Acipenser oxyrinchus oxyrinchus* in a heavily exploited marine

- habitat indicates the need for routine genetic monitoring. *J Fish Biol* 80(1):207-217.
<https://doi.org/10.1111/j.1095-8649.2011.03151.x>
- Dunton KJ, ordain A, Conover DO, Mckown K, Bonacci LA, Frisk M. 2015. Marine distribution and habitat use of Atlantic sturgeon in New York lead to fisheries interactions and bycatch. *Mar Coast Fish*. 7(1):18-32. <https://doi.org/10.1080/19425120.2014.986348>.
- Egli DP, Babcock RC. 2004. Ultrasonic tracking reveals multiple behavioural modes of snapper (*Pagrus auratus*) in a temperate no-take marine reserve. *ICES J Mar Sci*. 61:1137–1143.
<https://doi.org/10.1016/j.icesjms.2004.07.004>.
- Erickson DL, Kahnle A, Millard MJ, Mora EA, Bryja M, Higgs A, Mohler J, DuFour MR, Kenney G, Sweka JA, et al. 2011. Use of pop-up satellite tags to identify oceanic-migratory patterns for adult Atlantic Sturgeon, *Acipenser oxyrinchus oxyrinchus* Mitchell, 1815. *J Appl Ichthyol*. 27(2):356-365.
<https://doi.org/10.1111/j.1439-0426.2011.01690.x>.
- Ernst DA, Lohmann KJ. 2018. Size-dependent avoidance of a strong magnetic anomaly in Caribbean spiny lobsters. *J Exp Biol*. 221(5). <https://doi.org/10.1242/jeb.172205>.
- Fabrizio MC, Tuckey TD, Musick S. 2017. A Brief Guide to Striped Bass Ecology & Management in Chesapeake Bay. Virginia Institute of Marine Science, College of William and Mary.
<https://doi.org/10.21220/V5NQ9X>.
- Farrae DJ, Post WC, Darden TL. 2017. Genetic characterization of Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus*, in Edisto River, South Carolina and identification of genetically discrete fall and spring spawning. *Conserve Genet* 18(4):813-823. <https://doi.org/10.1007/s10592-017-0929-7>.
- Ferry LA, Cailett GM. 1996. Sample size and data analysis: are we characterizing and comparing diet properly? In: Mackinlay D, Shearer K, editors. Feeding ecology and nutrition in fish symposium proceedings. San Francisco (CA): Am Fish Soc. 71-80.
- Formicki K, Korzelecka-Orkisz A, Tański. 2019. Magnetoreception in fish. *J Fish Biol*. 95:73-91.
<https://doi.org/10.1111/jfp.13998>.
- Franks BR, Tyminski JP, Hussey NE, Braun CD, Newton AL, Thorrold SR, Fischer GC, McBride B, Hueter RE. 2021. Spatio-Temporal Variability in White Shark (*Carcharodon carcharias*) Movement Ecology During Residency and Migration Phases in the Western North Atlantic. *Front Mar Sci*. 8:774202. <https://doi.org/10.3389/fmars.2021.744202>.
- Frankham R. 1995. Effective population size/adult population size ratios in wildlife: a review. *Genet Res*. 66(2):95-107. <https://doi.org/10.1017/S0016672308009695>.
- Furness RW, Wade HM, Masden EA. 2013. Assessing vulnerability of marine bird populations to offshore wind farms. *J Environ Manag*. 119: 56-66. <https://doi.org/10.1016/j.jenvman.2013.01.025>.
- Gill AB. 2005. Offshore renewable energy: ecological implications of generating electricity in the coastal zone. *J Appl Ecol*. 42(4):605-615. <https://doi.org/10.1111/j.1365-2664.2005.01060.x>.
- Gill AB, Gloyne-Phillips I, Kimber JA, Sigray P. 2014. Marine Renewable Energy Technology and Environmental Interactions. Dordrecht (Netherlands): Springer Dordrecht. Chapter 6, Marine Renewable Energy, Electromagnetic (EM) Fields and EM-Sensitive Animals. p. 61-79.

- Gilles A, Scheidat M, Siebert U. 2009. Seasonal distribution of harbor porpoises and possible interference of offshore wind farms in the German North Sea. *Mar Ecol Prog Ser.* 383:295-307. <https://doi.org/10.3354/meps08020>.
- Graves JE, Horodysky AZ, Latour RJ. 2009. Use of pop-up satellite archival tag technology to study postrelease survival of and habitat use by estuarine and coastal fishes: an application to striped bass (*Morone saxatilis*). *Fish Bull.* 107:373–383.
- Gross MR, Coleman RM, McDowall RM. 1998. Aquatic productivity and the evolution of diadromous fish migration. *Science.* 239(4845):1291-1293. <https://doi.org/10.1126/science.239.4845.1291>.
- Gross MR, Repka RJ, Robertson CT, Secor DH, and Van Winkle W. 2002. Sturgeon Conservation: Insights from elasticity analysis. Pages 13-30 in W. Van Winkle, PJ Anders, DH Secor, and DA Dixon, editors. *Biology, management, and protection of North American sturgeon*. American Fisheries Society Symposium 28, Bethesda, Maryland.
- Guida V., Drohan A., Welch H., McHenry J., Johnson D., Kentner V., Brink J., Timmons D., Estela-Gomez E. 2017. Habitat Mapping and Assessment of Northeast Wind Energy Areas. Sterling, VA: US Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2017-088.
- Hager CH. 2011. Atlantic sturgeon habitat occupation and migration patterns in the James River. Silver Spring (MD): NOAA/NMFS Office of Protected Resources. Contract No.: EA13310CN0317.
- Hager C. 2019. Operation of the Navy's Telemetry Array in the Lower Chesapeake Bay: Final Report or 2013-2018. Cumulative Report. Norfolk (VA): Naval Facilities Engineering Command Atlantic. Contract No.: N62470-10-3011, Task Order 53, issued to HDR Inc., Virginia Beach, Virginia.
- Hager C. 2022. Acoustic Telemetry Array Installation and Maintenance, Naval Station Norfolk and Craney Island, Norfolk/Portsmouth Virginia: 2022 Final Report. Norfolk (VA): Naval Facilities Engineering Command Atlantic. Contract No.: N62470-15-D-8006, Task Order 53, issued to HDR Inc., Virginia Beach, Virginia.
- Hager C, Kahn J, Watterson C, Russo J, Hartman K. 2014. Evidence of Atlantic sturgeon spawning in the York River system. *Trans Am Fish Soc.* 143(5): 1217-1219. <https://doi.org/10.1080/00028487>.
- Hager CH, Watterson JC, Kahn JE. 2020. Spawning drivers and frequency of Atlantic sturgeon in the York River system. *Trans Am Fish Soc.* 149(4). <https://doi.org/10.1002/tafs.10241>
- Hager CH, Breault DK. 2023. Spatiotemporal Distributions of Species Detected within the Virginia's Offshore Lease Areas, Volume 1: Sandbridge Shoal Borrow Area. Sterling VA: U.S. Department of the Interior, Bureau of Ocean Energy Management. xx p. Report No.: OCS Study BOEM 20xx-xxx. Contract No.:140M0122P0023.
- Hassler WW, Rainville RP. 1975. Techniques for hatching and rearing cobia, *Rachycentron canadum*, through larval and juvenile stages. Raleigh (NC): University of North Carolina Sea Grant College. Report No.: UNC-SG-75-30.
- Haulsee DE, Breece MW, Brown LM, Wetherbee BM, Fox DA, Oliver MJ. 2018. Spatial ecology of *Carcharias taurus* in the northwestern Mid-Atlantic coastal ocean. *Mar Ecol Prog Ser.* 597:191-206. <https://doi.org/10.3354/meps12592>.

- Hays GC, Ferreira LC, Sequeira AM, Meekan MG, Duarte CM, Bailey H, Bailleul F, Bowen WD, Caley MJ, Costa DP, et al. 2016. Key questions in marine megafauna movement ecology. *Trends in ecology & evolution*. 31(6): 463-475. <https://doi.org/10.1016/j.tree.2016.02.015>.
- Heupel MR, Reiss KL, Yeiser BG, Simpfendorfer CA. 2008. Effects of biofouling on performance of moored data logging acoustic receivers. *Limnol Oceanogr: Methods*. 6(7):327-335. <https://doi.org/10.4319/lom.2008.6.327>.
- Hightower JE, Loefer M, Post WC, Peterson DL. 2015. Estimated survival of subadult and adult Atlantic Sturgeon in four river basins in the southeastern United States. *Mar Coast Fish*. 7(1): 514-522. <https://doi.org/10.1080/19425120.2015.1088491>.
- Hidalgo M, Secor DH, Browman HI. 2016. Observing and managing seascapes: linking synoptic oceanography, ecological processes, and geospatial modelling. *ICES J Mar Sci*. 73(7):1825-1830. <https://doi.org/10.1093/icesjms/fsw079>.
- Hildebrand SF, Schroeder WC. 1928. *Fishes of the Chesapeake Bay*. Washington D.C.: Smithsonian Institution Press.
- Hogan F, Hooker B, Jensen Brandon, Johnston L, Lipsky A, Methratta E, Silva A, Hawkins A. 2023. *Fisheries and Offshore Wind Interactions: Synthesis of Science*. Wood Hole (MA): National Oceanic and Atmospheric Administration. NOAA Technical Memorandum NMFS-NE-291. <https://doi.org/10.25923/tcjt-3a69>.
- Høines ÅS, Bergstad OA, Albert OT. 1998. The structure and temporal stability of the fish community on a coastal bank utilized as a spawning ground by herring. *ICES J Mar Sci*. 55(2): 271-288. <https://doi.org/10.1006/jmsc.1997.0268>.
- Holland BF, and GF Yelverton. 1973. *Distributions and biological studies of anadromous fishes off of North Carolina*. Department of Natural Resources Special Science. Report No.: 24.
- Hollema HM, Kneebone J, McCormick SD, Skomal GB, Danylchuk AJ. 2017. Movement patterns of striped bass (*Morone saxatilis*) in a tidal coastal embayment in New England. *Fish Res*. 187:168-177. <https://doi.org/10.1016/j.fishres.2016.11.006>.
- Humston RJ, Ault JS, Larkin MF, Luo J. 2005. Movements and site fidelity of the bonefish *Albula vulpes* in the northern Florida Keys determined by acoustic telemetry. *Mar Ecol Prog Ser*. 291:237-248. <https://doi.org/10.3354/meps291237>.
- Hussey NE, Kessel ST, Aarestrup K, Cooke SJ, Cowley PD, Fisk AT, Harcourt RG, Holland KN, Iverson SJ, Kockik JF, et al. 2015. Aquatic animal telemetry: a panoramic window into the underwater world. *Science*. 348(6240): 1255642. <https://doi.org/10.1126/science.1255642>.
- Hutchison ZL, Secor DH, Gill AB. 2020. The interaction between resource species and electromagnetic fields associated with electricity production by offshore wind farms. *Oceanography*. 33(4): 96-107. <https://doi.org/10.5670/oceanog.2020.409>.
- Hutchison ZL, Gill AB, Sigra P. 2021. A modelling evaluation of electromagnetic fields emitted by buried subsea power cables and encountered by marine animals: Considerations for marine renewable energy development. *Renew Energy*. 177: 72-81. <https://doi.org/10.1016/j.renene.2021.05.041>.

- Hyslop E. 1980. Stomach content analysis: a review of methods and their application. *J Fish Biol.* 17(4): 411-429. <https://doi.org/10.1111/j.1095-8649.1980.tb02775.x>.
- Hylton SN, Weisman AM, Wippelhauser GS, Sulikowski, JA. 2018. Identification of potential wintering habitat for threatened Atlantic sturgeon *Acipenser oxyrinchus oxyrinchus* in Saco Bay, Maine USA. *Endang Species Res.* 37:249-254. <https://doi.org/10.3354/esr00929>.
- Inger RM, Attrill MJ, Bearhop S, Broderick AC, Grecian WJ, Hodgson DJ, Mills C, Sheehan E, Votier SC, Witt MJ, et al. 2009. Marine renewable energy: potential benefits to biodiversity? An urgent call for research. *J Appl Ecol.* 46(6):1145-1153. <https://doi.org/10.1111/j.1365-2664.2009.01697.x>.
- Ingram EC, Peterson DL. 2016. Annual spawning migrations of adult Atlantic sturgeon in the Altamaha River, Georgia. *Mar Coast Fish.* 8(1): 595-606. <https://doi.org/10.1080/19425120.2016.1243599>.
- Ingram E., Cerrato R., Dunton K., Frisk M. 2019. Endangered Atlantic Sturgeon in the New York Wind Energy Area; implications of future development in an offshore wind energy site. *Sci. Rep.* 9:12432. <https://doi.org/10.1038/s41598-019-48818-6>.
- James RC, Curtis TH, Galuradi B, Metzger G, Newston A. McCallister MP, Fischer GC, Ajemian MJ. 2021. Overwinter habitat use of young-of-the-year white sharks (*Carcharodon carcharias*) off the eastern United States. *Fish Bull.* 120:68-73. <https://doi.org/10.7755/FB.120.1.6>.
- Jensen DR, Graves J. 2020. Movements, habitat utilization, and post-release survival of cobia (*Rachycentron canadum*) that summer in Virginia waters assessed using pop-up satellite archival tags. *Anim Biotelemetry.* 8(24). <https://doi.org/10.1186/s40317-020-00212-0>.
- Johnson JH, Dropkin DS, Warkentine BE, Rachlin JW, Andrews WD. 1997. Food habits of Atlantic sturgeon of the central New Jersey coast. *Trans Am Fish Soc.* 126(1): 166-170. [https://doi.org/10.1577/1548-8659\(1997\)126<0166:FHOASO>2.3.CO;2](https://doi.org/10.1577/1548-8659(1997)126<0166:FHOASO>2.3.CO;2).
- Kalmijn AJ. 1978. Sensory Biology of Sharks, Skates, and Rays. Arlington (VA): Office of Naval Research Department of the Navy. Chapter 5, Electrical Senses; p. 507-528.
- Kajiura, SM, Holland KN. 2002. Electoreception in juvenile hammerhead and sandbar sharks. *Exp Bio.* 205:3609-3621.
- Kahn JE, Hager CH, Watterson JC, Russo J, Moore K, Hartman K. 2014. Atlantic sturgeon annual spawning run estimate in the Pamunkey River, Virginia. *Trans Am Fish Soc.* 143:1598-1514. <https://doi.org/10.1080/00028487.2014.945661>.
- Kieffer MC, Kynard B. 1993. Annual movements of shortnose and Atlantic sturgeon in the Merrimack River, Massachusetts. *Trans Am Fish Soc.* 122(6):1088-1103. [https://doi.org/10.1577/1548-8659\(1993\)122%3c1088:AMOSAA%3e2.3.CO;2](https://doi.org/10.1577/1548-8659(1993)122%3c1088:AMOSAA%3e2.3.CO;2).
- Kikuchi R. 2010. Risk formulation for the sonic effects of offshore wind farms on fish in the EU region. *Mar Pollut Bull.* 60(2):172-177. <https://doi.org/10.1016/j.marpolbul.2009.09.023>.
- Kilfoil J, Wetherbee BM, Carlson JK, Fox DA. 2017. Targeted catch-and-release of prohibited sharks: sand tigers in coastal Delaware waters. *Fisheries.* 42(5):281-287. <https://doi.org/10.1080/03632415.2017.1306974>.

- Kneebone J, Chisholm J, Skomal GB. 2012. Seasonal residency, habitat use, and site fidelity of juvenile sand tiger sharks *Carcharias taurus* in a Massachusetts estuary. *Mar Ecol Prog Ser.* 471:165-181. <https://doi.org/10.3354/meps09989>.
- Kneebone J, Hoffman WS, Dean MJ, Fox DA, Armstrong MP. 2014. Movement patterns and stock composition of adult striped bass tagged in Massachusetts coastal waters. *Trans Am Fish Soc.* 143: 1115-1129. <https://doi.org/10.1080/00028487.2014.889752>.
- Kraus RT, Holbrook CM, Vandergoot CS, Stewart TR, Faust MD, Watkinson DA, Charles C, Pegg M, Ender EC, Krueger CC. 2018. Evaluation of acoustic telemetry grids for determining aquatic animal movement and survival. *Methods Ecol Evol.* 9(6):1489–1502. <https://doi.org/10.1111/2041-210X.12996>.
- Lande R. 1988. Genetics and demography in biological conservation. *Science* 241(4872):1455-1460. <https://doi.org/10.1126/science.3420403>.
- Laney RW, Hightower JE, Versak BR, Mangold MF, Cole Jr. WW, Winslow SE. 2007. Distribution, habitat use and size of Atlantic sturgeon captured during cooperative winter tagging cruises 1988-2006. In: Munro J, Hatin D, Hightower JE, McKown K, Sulak KJ, Kahnle AW, Caron F, editors. *Anadromous sturgeons: Habitats, threats, and management*. Bethesda (MD): American Fisheries Society Symposium 56.
- Lefebvre LS, Denson MR. 2012. Inshore spawning of cobia (*Rachycentron canadum*) in South Carolina. *Fish Bull.* 110:397–412.
- Lennox RJ, Paukert CP, Aarestrup K, Auger-Méthé M, Baumgartner L, Birnie-Gauvin K, Bøe K, Brink K, Brownscombe JW, Chen Y, et al. 2019. One hundred pressing questions on the future of global fish migration science, conservation, and policy. *Front Ecol Evol.* 7:286. <https://doi.org/10.3389/fevo.2019.00286>.
- Lowerre-Barbieri SK, Catalán IA, Frugård Opdal A, Jørgensen C. 2019. Preparing for the future: integrating spatial ecology into ecosystem-based management. *ICES J Mar Sci.* 76(2):467-476. <https://doi.org/10.1093/icesjms/fsy209>.
- Lowerre-Barbieri SK, Kays R, Thorson JT, Wikelski M. 2019. The ocean's movescape: fisheries management in the bio-logging decade (2018–2028). *ICES J Mar Sci.* 76(2):477–488. <https://doi.org/10.1093/icesjms/fsy211>.
- Lowerre-Barbieri SK, Friess C, Griffin LP, Morley D, Skomal GB, Bickford JW, Brownscombe JW. 2021. Movescapes and eco-evolutionary movement strategies in marine fish: Assessing a connectivity hotspot. *Fish and Fisheries.* 22(6):1321-1344. <https://doi.org/10.1111/faf.12589>.
- Mace GM and Lande R. 1991. Assessing extinction threats: towards a reevaluation of IUCN threatened species categories. *Conserv Bio* 5:148-157. <https://doi.org/10.1111/j.1523-1739.1991.tb00119.x>.
- MacKenzie DI, Nichols JD, Royle JA, Pollock KH, Bailey LL and Hines JE. 2017. *Occupancy Estimation and Modeling: Inferring Patterns and Dynamics of Species Occurrence*. Cambridge (MA): Academic Press.

- Martino EM, Houde ED. 2010. Recruitment of striped bass in Chesapeake Bay: spatial and temporal environmental variability and availability of zooplankton prey. *Mar Ecol Prog Ser.* 409:213-228. <https://doi.org/10.3354/meps08586>.
- Mathies NH, Ogburn MB, McFall G, Fangman S. 2014. Environmental interference factors affecting detection range in acoustic telemetry studies using fixed receiver arrays. *Mar Ecol Prog Ser.* 495: 27-38. <https://doi.org/10.3354/meps10582>.
- Melnychuk MC, Dunton KJ, Jordaan A, McKown KA, Frisk MG. 2017. Informing conservation strategies for the endangered Atlantic sturgeon using acoustic telemetry and multi-state mark-recapture models. *J Appl Ecol.* 54(3):914-925. <https://doi.org/10.1111/1365-2664.12799>.
- Morissette O, Lecomte F, Verreault G, Legault M, Sirois P. 2016. Fully equipped to succeed: migratory contingents seen as an intrinsic potential for striped bass to exploit a heterogeneous environment early in life. *Estuaries Coasts.* 39:571-582. <https://doi.org/10.1007/s12237-015-0015-7>.
- Moser ML, Ross SW. 1995. Habitat use and movements of short nosed and Atlantic sturgeon in the lower Cape Fear, North Carolina. *Trans Am Fish Soc.* 124:225-234. [https://doi.org/10.1577/1548-8659\(1995\)124<0255:HUAMOS>2.3.CO;2](https://doi.org/10.1577/1548-8659(1995)124<0255:HUAMOS>2.3.CO;2).
- Murdy EO, Birdsong RS, Musick JA. 1997. *Fishes of the Chesapeake Bay*. Washington D.C.: Smithsonian Institution Press.
- Murray RW. 1974: The ampullae of Lorenzini. In: Fessard A, editor. *Handbook of Sensory Physiology*, Vol. 3: Electoreceptors and Other Specialized Receptors in Lower Vertebrates. Berlin (Germany): Springer-Verlag. p. 125-145.
- Musick JA, Jenkins RE, Burkhead NM. 1993. Sturgeons, Family Acipenseridae. In: Jenkins RE, Burkhead NM, editors. *Freshwater Fishes of Virginia*. Bethesda (MD): American Fisheries Society.
- Musick JA, Hager CH. 2007. Atlantic sturgeon, *Acipenser oxyrinchus* restoration in the Chesapeake Bay. Silver Spring (MD): Submitted to National Marine Fisheries Service. Annual Report, contract A06NMF4050068.
- Naisbett-Jones L, Putman N, Stephenson JF, Ladak S. 2017. A magnetic map leads juvenile European eels to the Gulf Stream. *Curr Biol.* 27(8):1236-1240. <https://doi.org/10.1016/j.cub.2017.03.015>.
- Natanson LJ, Skomal GB. 2014. Age and growth of the white shark, *Carcharodon carcharias*, in the western North Atlantic Ocean. *Mar Freshw Res.* 66(5). <https://doi.org/10.1071/MF14127>.
- Nesbit RA, Neville WC. 1935. Conditions affecting the southern winter trawl fishery. US Government Printing Office.
- Newton KC, Gill AB, Kajiura SM. 2019. Electoreception in marine fishes: chondrichthyans. *J Fish Biol.* 95(1):135-154. <https://doi.org/10.1111/jfb.14068>.
- Niklitschek EJ. 2001. Bioenergetics modeling and assessment of suitable habitat for juvenile Atlantic and shortnose sturgeons (*Acipenser oxyrinchus* and *A. brevirostrum*) in the Chesapeake Bay [doctoral dissertation]. Solomons (MD): University of Maryland at College Park.

- Niklitschek EJ, Secor DH. 2005. Modeling spatial and temporal variation of suitable nursery habitats for Atlantic sturgeon in the Chesapeake Bay. *Estuar Coast Shelf Sci.* 64:135-148.
<https://doi.org/10.1016/j.ecss.2005.02.012>.
- NMFS (National Marine Fisheries Service). 2012a. Endangered and threatened wildlife and plants; threatened and endangered status for distinct population segments of Atlantic sturgeon in the northeast region. *Federal Register* 77:5880–5912.
- NMFS (National Marine Fisheries Service). 2012b. Endangered and threatened wildlife and plants; final listing determinations for two distinct population segments of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*). *Federal Register* 77:5913–5982.
- O’Leary SJ, Dunton KJ, King TL, Frisk MG, Chapman DD. 2014. Genetic diversity and effective number of breeders of Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus*. *Conserv Genet.* 15(5):1173-1181. <https://doi.org/10.1007/s10592-014-0609-9>.
- O’Reilly J, Busch D. 1984. Phytoplankton primary production on the northwestern Atlantic shelf. *Rapp PVReun Cons Int Explor Mer.* 183:255–68.
- Overton AS, Manooch CS III, Smith JW, Brennan K. 2008. Interactions between adult migratory striped bass (*Morone saxatilis*) and their prey during winter off the Virginia and North Carolina Atlantic coast from 1994 through 2007. *Fish Bull.* 106(2):174–182.
- Paxton AB, Blair E, Blawas C, Fatzinger MH, Marens M, Holmberg J, Kingen C, Houppermans T, Keusenkothen M, McCord J, Silliman BR, Penfold LM. 2019. Citizen science reveals female sand tiger sharks (*Carcharias taurus*) exhibit signs of site fidelity on shipwrecks. *Ecology.* 100(8).
<https://doi.org/10.1002/ecy.2687>.
- Perkinson M, Darden T, Jamison M, Walker MJ, Denson MR, Franks J, Hendon R, Musick S, Orbesen ES. 2019. Evaluation of the stock structure of cobia (*Rachycentron canadum*) in the southeastern United States by using dart-tag and genetics data. *Fish Bull.* 117(3):220–233.
<https://doi.org/10.7755/FB.117.3.9>.
- Pinkus L, Oliphant MS, Iverson ILK. 1971. Food habits of albacore, bluefin, and bonita in California waters. *Cal Dep Fish Game Bull.* 152:1-105.
- Pittman SJ, McAlpine CA. 2001. Movements of marine fish and decapod crustaceans: process, theory and application. *Adv Mar Biol.* 44(1):205-294. [https://doi.org/10.1016/S0065-2881\(03\)44004-2](https://doi.org/10.1016/S0065-2881(03)44004-2).
- Putman NF, Lohmann KJ, Putman EM, Quinn TP, Klimley AP, Noakes DLG. 2013. Evidence for geomagnetic imprinting as a homing mechanism in Pacific salmon, *Curr Biol.* 23(4):312e316.
<https://doi.org/10.1016/j.cub.2012.12.041>.
- Raghukumar K, Nelson T, Jacox M, Chartrand C, Fiechter J, Chang G, Cheung L, Roberts J. 2023. Projected cross-shore changes in upwelling induced by offshore wind farm development along the California coast. *Commun Earth Environ.* 4(1). <https://doi.org/10.1038/s43247-023-00780-y>.
- Reubens JT, Pasotti F, Degraer S, Vincx M. 2013. Residency, site fidelity and habitat use of Atlantic cod (*Gadus morhua*) at an offshore wind farm using acoustic telemetry. *Mar Environ Res.* 90:128-135.
<https://doi.org/10.1016/j.marenvres.2013.07.001>.

- Richards RA, Rago PJ. 1999. A case history of effective fishery management. Chesapeake Bay striped bass. *N Am J Fish Manag.* 19:356-375. [https://doi.org/10.1577/1548-8675\(1999\)019<0356:ACHOEF>2.0.CO;2](https://doi.org/10.1577/1548-8675(1999)019<0356:ACHOEF>2.0.CO;2).
- Robinson RA, Crick HQ, Learmouth JA, Maclean IM, Thomas CD, Bairlein F, Forchhammer MC, Francis CM, Gill JA, Godley BJ, et al. 2009. Travelling through a warming world: climate change and migratory species. *Endanger Species Res.* 7(2):87-99. <https://doi.org/10.3354/esr00095>.
- Rothermel ER, Balazik MT, Best JE, Breece MW, Fox DA, Gahagan BI, Haulsee DE, Higgs AL, O'Brian MH, Oliver MJ, et al. 2020. Comparative migration ecology of striped bass and Atlantic sturgeon in the US Southern mid-Atlantic bight flyway. *PLoS ONE* 15(6): e0234442. <https://doi.org/10.1371/journal.pone.0234442>.
- Rulifson RA, Bangle CW, Cudney JL, Dell'Apa A, Dunton KJ, Frisk MG, Loeffler MS, Balazik MT, Hager C, Savoy T, et al. 2020. Seasonal presence of Atlantic Sturgeon and sharks at Cape Hatteras, a large continental shelf constriction to coastal migration. *Mar Coast Fish.* 12(5):308-321. <https://doi.org/10.1002/mcf2.10111>.
- Russel DJF, Hastie GD, Thompson D, Janik VM, Hammond PS, Scott-Hayward LAS, Matthiopoulos J, Jones EL, McConnell BJ. 2016. Avoidance of wind farms by harbor seals is limited to pile driving activities. *J Appl Ecol.* 53(6):1642-1652. <https://doi.org/10.1111/1365-2664.12678>.
- Savoy T, Pacileo D. 2003. Movements and important habitats of subadult Atlantic sturgeon in Connecticut waters. *Trans Am Fish.* 132:1-8.
- Savoy T, Maceda L, Roy NK, Peterson D, Wirgin I. 2017. Evidence of natural reproduction of Atlantic sturgeon in the Connecticut River from unlikely sources. *PLoS ONE* 12(4): e0175085. <https://doi.org/10.1371/journal.pone.0175085>.
- Scott WB, Crossman EJ. 1973. *Freshwater Fishes of Canada.* Fish Res Boar Can Bul. 184, Ottawa, Canada.
- Secor DH, Niklitschek EJ, Stevenson JT, Gunderson TE, Minkinen SP, Richardson B, Mangold FM, Skjeveland J, Henderson-Arzapalo A. 2000. Dispersal and growth of yearling Atlantic sturgeon, *Acipenser oxyrinchus*, released into Chesapeake Bay. *Fish Bull.* 98:800-810.
- Secor DH. 2007. The year-class phenomenon and the storage effect in marine fishes. *J Sea Res.* 57(2-3):91-103. <https://doi.org/10.1016/j.seares.2006.09.004>.
- Secor DH, Piccoli PM. 2007. Oceanic migration rates of upper Chesapeake Bay striped bass *Morone saxatilis*, determined by otolith microchemical analysis. *Fish Bull.* 105(1):62-73.
- Secor DH, and Waldman JR. 1999. Historical abundance of Delaware Bay sturgeon and potential rate of recovery. *American Fisheries Society Symposium* 23, 203-216.
- SEDAR. 2013. SEDAR 28 – South Atlantic Cobia Stock Assessment Report. North Charleston (SC): SEDAR. Report No.: 28. http://www.sesc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshotNum=28.
- Shaffer RV, Nakamura EL. 1989. Synopsis of biological data on the cobia *Rachycentron canadum* (Pisces: Rachycentridae). *FAO Fisheries Synopsis* 153. NOAA Technical Report No.: NMFS 82.

- Simpfendorfer CA, Heupel MR, Hueter RE. 2002. Estimation of short-term centers of activity from an array of omnidirectional hydrophones and its use in studying animal movements. *Can J Fish Aquat Sci.* 59(1):23–32. <https://doi.org/10.1139/f01-191>.
- Simpfendorfer CA, Heupel MR, Collins AB. 2008. Variation in the performance of acoustic receivers and its implication for positioning algorithms in a riverine setting. *Can J Fish Aquat Sci* 65(3):482–492. <https://doi.org/10.1139/F07-180>.
- Singh L, Downey NJ, Roberts MJ, Webber DM, Smale MJ, van den Berg MA, Harding RT, Engelbrecht DC, Blows BM. 2009. Design and calibration of an acoustic telemetry system subject to upwelling events. *Afr J Mar Sci* 31(3):355–364. <https://doi.org/10.2989/AJMS.2009.31.3.8.996>.
- Sisneros JA, Tricas TC, Luer CA. 1998. Response properties and biological function of the skate electrosensory system during ontogeny. *J Comp Physiol A.* 183(1): 87-99. <https://doi.org/10.1007/s003590050237>.
- Skomal GB, Braun CD, Chisholm JH, Thorrold SR. 2017. Movements of the white shark *Carcharodon carcharias* in the North Atlantic Ocean. *Mar Ecol Process Ser.* 580:1–16. <https://doi.org/10.3354/meps12306>.
- Smith P. 2014. London Array phase 2 extension scrapped. United Kingdom: Windpower Monthly; [accessed 2023 Jan 21]. <http://www.windpoweroffshore.com/article/1281530/london-array-phase-2-extension-scrapped>
- Smith, TIJ. 1985. The fishery, biology, and management of Atlantic Sturgeon, *Acipenser oxyrinchus*, in North America. *Environ. Biol. Fishes* 4:61–72.
- Speir H, Uphoff Jr JH, Durell E. 1999. A review of management of large striped bass and striped bass spawning grounds in Maryland. Annapolis (MD): Maryland Department of Natural Resources/ Fisheries Technical Memo No.: 15.
- Stein AB, Friedland KD, Sutherland M. 2004. Atlantic sturgeon marine distribution and habitat use along the northeastern coast of the United States. *Trans Am Fish Soc.* 133:527–537. <https://doi.org/10.1577/T02-151.1>.
- Taylor AD, Ohashi K, Sheng J, Litvak MK. 2016. Oceanic Distribution, behaviour, and a winter aggregation area of adult Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus*, in the bay of Fundy, Canada. *PLoS ONE* 11(4):e0152470. <https://doi.org/10.1371/journal.pone.0152470>.
- Tesch FW. 1974. Influence of geomagnetism and salinity on the directional choice of eels. *Helgoländer Meeresuntersuchungen.* 26(3):382-395. <https://doi.org/10.1007/BF01627623>.
- Teter SM, Wetherbee BM, Fox DA, Lam CH, Kiefer DA, Shivji M. 2015. Migratory patterns and habitat use of the sand tiger (*Carcharias taurus*) in the western North Atlantic. *Mar Freshw Res.* 66:158-169. <https://doi.org/10.1071/MF14129>.
- Thompson PM, Hastie GD, Nedwell J, Barham R, Brookes KL, Cordes LS, Bailey H, McLean N. 2013. Framework for assessing impacts of pile-driving noise from offshore wind farm construction on a harbour seal population. *Environ Impact Asses Rev.* 43:73-85. <https://doi.org/10.1016/j.eiar.2013.06.005>.
- Valiela I. 1995. *Marine Ecological Processes*. Second Edition. New York (NY): Springer-Verlag.

- Vallejo GC, Grellier K, Nelson EJ, McGregor RM, Canning SJ, Caryl FM, McLean N. 2017. Responses of two marine top predators to an offshore wind farm. *Ecol Evo.* 7(21). <https://doi.org/10.1002/ece3.3389>.
- Verfuss UK, Sparling CE, Arnot C, Judd A, Coyle M. 2016. Review of offshore wind farm impact monitoring and mitigation with regard to marine mammals. *Adv Exp Med Biol.* 875:1172-1182. https://doi.org/10.1007/978-1-4939-2981-1_147.
- Verkamp HJ, Skomal G, Winton M, Sulikowski JA. 2021. Using reproductive hormone concentrations from the muscle of white sharks *Carcharodon carcharias* to evaluate reproductive status in the Northwest Atlantic Ocean. *Endanger Species Res.* 44: 231-236. <https://doi.org/10.3354/esr01109>.
- Vladykov VD, Greenly JR. 1963. Order Acipenseroidae. In: Bigelow HB, editor. *Fishes of the Western North Atlantic. Memoir I, Part 3: Sturgeons, Gars, Tarpon, Ladyfish, Bonefish, Salmon, Chars, Anchovies, Herrin, Shads, Smelt, Capelin et al.* New Haven (CT): Sears Foundation for Marine Research, Yale University.
- Wahlberg M, Westerberg H. 2005. Hearing in fish and their reactions to sounds from offshore wind farms. *Mar Ecol Prog Ser.* 288:295-309. <https://doi.org/10.3354/meps288295>.
- Waldman J, Maceda L, Wirgin I. 2012. Mixed-stock analysis of wintertime aggregations of striped bass along the mid-Atlantic coast. *J Appl Ichthyol.* 28:1-6.
- White CP. 1989. *Chesapeake Bay*. Centerville (MD): Tidewater Publishers.
- White SL, Kazyak DC, Darden TL, Farrae DJ, Lubinski BA, Johnson RL, Eakles MS, Balazik MT, Brundage III HM, Fox AG, et al. 2021. Establishment of a microsatellite genetic baseline for North American Atlantic sturgeon (*Acipenser o. oxyrinchus*) and range-wide analysis of population genetics. *Conserv Genet.* 22:977–992. <https://doi.org/10.1007/s10592-021-01390-x>.
- Wingate RL, Secor DH. 2007. Intercept telemetry of the Hudson River striped bass resident contingent: migration and homing patterns. *Trans Am Fish Soc.* 136(1):95–104. <https://doi.org/10.1577/T06-056.1>.
- Wittemyer G, Northrup JM, Bastille-Rousseau G. 2019. Behavioral valuation of landscapes using movement data. *Philos Trans R Soc B.* 374(1781):20180046. <https://doi.org/10.1098/rstb.2018.0046>.
- Wooley CM, Crateau EJ. 1985. Movement, microhabitat, exploitation, and management of Gulf of Mexico sturgeon, Apalachicola River, Florida. *N Am J Fish Manag.* 5:590-605. [https://doi.org/10.1577/1548-8659\(1985\)5<590:MMEAMO>2.0.CO;2](https://doi.org/10.1577/1548-8659(1985)5<590:MMEAMO>2.0.CO;2).

Appendix A: SIRI Manuscript

A Site-Specific Detection Based Index of Relative Importance for Tracking Data

Hager, C. H.¹ and J.E. Kahn²

¹ Chesapeake Scientific

100 Sixpence Court

Williamsburg, Virginia 23185

² National Marine Fisheries Service

1315 East West Highway

Silver Spring, Maryland 20910

Corresponding author and address:

Christian Hager

Tel: (804) 824-4530

christian.hager@chesapeakescientific.org

Impact Statement

The site-specific index of relative importance (SIRI) provides a means of combining different detection-based data into a single, standardized value. This provides a means of comparing sites within and between studies based on habitat preference and expands the utility of telemetry data in more advanced models.

Abstract

A passive telemetry array records the temporal and spatial distribution of telemetered individuals in terms of presence and absence but there is no generally agreed upon method of analyzing those detections to objectively identify habitat preference. However, a statistical approach that derives an index of relative importance (IRI) has long been accepted in the trophic literature. Here, we propose and validate a similar analytical tool that establishes a site-specific index of relative importance (SIRI) based on detection data. It incorporates the number of subjects detected, how many detections occurred, and the frequency of site occupation into a single index. This produces a standard value for each passive receiver site that reduces the inherent bias of each detection-based component alone and provides a means of site comparisons within or between studies over time. A single index per site also allows for development of advanced models that can produce correlations between occupancy patterns and physical and environmental variables over time and space.

Introduction

The use of remote passive telemetry monitoring has become standard practice in examination of animal movement and habitat selection in recent years. This method relies on an array of passive/fixed receivers that detect the presence of acoustically telemetered individuals passing

within a detectable distance. Over time the array records the temporal and spatial distribution of telemetered individuals. Telemetry has greatly expanded what we know about species distributions, both supporting and refuting our initial understanding of species' ecology based on limited mark recapture and/or harvest data (Stein et al. 2005, Thorstad et al. 2013, Cramer 2015, Ingram and Peterson 2016). While detection data have increased our understanding of habitat occupation and preference (Hatin et al. 2007, Aarts et al. 2008), there is not a simple metric for combining the different types of information collected by passive receiver arrays.

Many telemetry analyses rely on total detections per location (Hatin et al. 2007, Hale et al. 2016, Hollensead et al. 2018, Ingram et al. 2019, Secor et al. 2021), describe movement in terms of detections on a receiver on a particular day (Hatin et al. 2002, Koster et al. 2014, Hollensead et al. 2018, Ingram et al. 2019, Brownscombe et al. 2022), or frequency of detections/non-detections of individuals in a given location (Hatin et al. 2002, Reyier et al. 2014, Ingram and Peterson 2016, Ingram et al. 2019, Secor et al. 2021). Each of these metrics and others are useful for identifying habitat selection, habitat function, habitat connectivity, spatio-temporal habitat use or occupation, or multi-species habitat use (Brownscombe et al. 2022). As beneficial as those individual assessments can be, there is no means of standardizing the data in telemetry analyses, and therefore assessments in other times and places are generally not comparable to one another. Modeling techniques such as a habitat suitability index are quite useful and can effectively predict habitat usage (Verner et al. 1986, Morrison et al. 1992, Roloff and Kernohan 1999) but require considerable knowledge of fine-scale habitat composition, which can be challenging for aquatic species and even more so for wide-ranging aquatic species. Habitat suitability indices for aquatic species in passive arrays are also complicated by the presence of a variety of potentially preferential habitats within the detection radius around a receiver, often requiring analysis of spatially constant habitat variables such as flow, depth, temperature, or salinity (Wang et al. 2013, Yu et al. 2018, Rudolfson et al. 2021). Likewise, kernel density estimates from passive arrays in open water (large estuaries and ocean) may be misleading (Reyier et al. 2014).

An emerging problem is standardizing telemetry detections across broad geographic regions to allow for broad-scale comparison (Udyawer et al. 2018). An index of relative importance (IRI) was developed and improved to promote consistency, reduce bias, and standardize statistical methodology of diet studies (Pinkas 1971, Bigg and Perez 1985, Brown et al. 2012) by producing a single value to describe the importance of each prey item. These prey items could then be compared easily, within a species, across species, and through time (Manooch and Mason 1983). There are important and useful parallels between diet preference studies and habitat preference studies.

Prior to the IRI, assessments of gut contents focused on qualitative descriptions of prey (Hartley 1948) or quantitative measures of prey counts, weight of prey, or frequency of occurrence, but not in a standardized way (Hynes 1950, Medin 1970). In diet analyses, each measure provides a different insight into the feeding dynamics and trophic dependencies of the predator and provides independent value. Counts or numeric abundance provide insight into feeding behavior (MacDonald and Green 1983) and/or prey abundance/availability (Paltridge 2002). Mass or weight provides a means of measuring nutritional or bioenergetic value (MacDonald and Green 1983), and occurrence represents the relative importance of a prey item at the population level (Cailliet 1977).

The diet IRI (Pinkas 1971) is expressed as:

$$IRI = (\%N + \%M) * \%O$$

where, % N is the percent of the summed counts of a particular prey item out of the total number of prey items counted, % M is the percent of the summed mass of a particular prey item out of the mass of all prey items observed, and % O is the percent of stomachs containing a prey item. Telemetry, like gut content analyses, produces measures of counts that measure the number of subjects present at a station during a given time, the numbers of detections at a station reflect how long individuals used a particular location, and percent occurrence shows population-level occupation by monitoring the proportion of days any individual is detected at that station, which can be used to produce indices of relative importance, providing a standardized means of comparison.

The purpose of our study was to establish an index of relative importance for site specific telemetry data that can be used to compare spatiotemporal occupation patterns between receiver sites and the habitats they monitor. Based on the assumption that animals preferentially occupy habitats that increase their species' odds of survival, occupation patterns over time can be used as a surrogate for habitat preference. We compared our model with an accepted model for identifying habitat utilization to evaluate its product. Once measured in a standardized way, comparisons of preferences at regional and global scales can be made.

Methods

Model development. – A single passive receiver provides insight into species presence or absence, while an array provides insight into habitat occupation, movement, and site preference through time within a geographic area. Given a large enough receiver array in a geographic area over time, we are able to make inferences about habitat preferences by assessing each receiver site for the number of individuals detected, the number of detections, and the frequency at which individuals were detected. All three of these variables are valuable in describing a given location's occupation by telemetered individuals but in different ways. The first reflects how many transmitters were detected at a particular site in a given time period. The second records how long these subjects remained within detection distance, and the third the proportion of time periods a location was visited. Because a fish stomach is a finite unit and time is not, time must be standardized for this analysis. We used a one-day period. However, as long as the time period across which variables are considered is consistent, any time period can be used. In doing so, we create two matrices just as we do with gut contents, where one allows the summation of individuals per time period at each station and one allows the summation of detections per time period at each station, with percent occupation being calculable for each station using either matrix:

$$\begin{array}{c} \text{Passive receiver stations (i)} \\ \text{Individuals detected in a day (j)} \end{array} \begin{bmatrix} x & x & x \\ x & x & x \\ x & x & x \end{bmatrix}$$

and

$$\begin{matrix} & \text{Passive receiver stations (i)} \\ \text{Total detections in a day (j)} & \begin{bmatrix} x & x & x \\ x & x & x \\ x & x & x \end{bmatrix} \end{matrix}$$

Brown et al. (2012), proposed a modification to the diet IRI to account for prey-specific weights (%PSW) and counts (%PSN) being related to observed frequency (%O), leading to an over-emphasis of frequently occurring prey and an under-emphasis of the importance of rare prey (Brown et al. 2012). This approach helped address differences in the taxonomic levels of prey and/or different nesting of prey items by categories applied by various researchers that inhibited comparisons between diet content studies. This approach, however, is not necessary or appropriate for detection data. Detection data is discrete, thus there is no potential for varied nesting approaches or unintentional overweighting of one taxonomic level verse another. Our original SIRI approach thus remained simple like the diet IRI proposed by Pinkas (1971):

$$\text{SIRI} = (\%N + \%D) * \%O$$

where, % N is the percent of the number of fish detected during a given sub-period over the summed total detected over the entire period, % D is the percent of detections during the same sub-period over the sum across the entire period, and % O is the percent of sub-periods containing detections. For our purposes, N is the number of unique transmitters detected at a site each day divided by the total number of detections that occurred during the entire study period being considered, % D is the number of detections at each station each day divided by all detections at all stations, and % O is the percent of days containing detections.

Because receivers can be lost or fail during a study, we are still able to use the partial data collected during a study by modifying % O to represent the percent of time a transmitter is detected over the number of days that particular receiver was functional. Because the final product of a SIRI or diet IRI can be numbers ranging from quite large to relatively small, Cortes (1997) recommends using the percent diet IRI as a more robust analysis and we applied this approach as well.

Validation location and telemetry. – The York River, Virginia, located along the western edge of the Chesapeake Bay is known to contain a spawning population of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) that return each fall (Hager et al. 2014). The receiver array examined in this study consisted of nine Vemco VR2W-69 kHz receivers in the York River and one in the Pamunkey River. This stretch of water transitions from polyhaline at the lowest York River station to oligohaline, which is known to be important to pre- and post-spawn Atlantic sturgeon (Hatin et al. 2002, Ingram and Peterson 2016). Salinities are monitored within the river as part of the National Estuarine Research Reserve System (NERRS) at rkms 11, 27, 39, and 74 (Table 1). The changes between monitoring stations was interpolated and presented as a range of salinities, caused by changing tides and flows, in the river throughout the study periods. Stations were

established at rkms 11.3, 14, 20.3, 26.8, 36.8, 39, 46.3, 49.4, 51.5, and 64.5 with detection ranges of approximately 700 m (Hager 2016).

Ten adult Atlantic sturgeon (FL > 1550 mm) were implanted with 10-year transmitters (Vemco V16) and two others with 18-month (Vemco V13) transmitters at rkm 129.5 between 19 August and 25 September, 2013. To ensure there were no behavioral effects from surgical transmitter implantation, we use the following year's spawning behavior to demonstrate the SIRI model. In the fall of 2014, nine of these individuals returned to spawn, but one of the 18-month transmitters failed after 15 months, so only eight transmitters were used for this SIRI demonstration. The removed transmitter was last detected at rkm 14 on 21 October 2014 but because the transmitter's battery was failing, the individual was only detected 8 times at 3 stations during outmigration and only 10 times the entire month of October. Atlantic sturgeon migrate from ocean water to fresh water to spawn so movements were monitored during the immigration and emigration periods from the first arrival on May 31, 2014 through the last departure on November 3, 2014. Immigration was complete on August 14, 2014 and at no time did any of the sturgeon return to the oligohaline station until emigrating. Emigration commenced September 29, 2014. Therefore, the immigration period lasted for 76 days and the emigration period lasted for 36 days.

As validation of the percent SIRI estimates for each station, we present a kernel density estimate analysis (Rosenblatt 1956, Whittle 1958) of the same dataset, estimating the habitat use during immigration and emigration. Kernel density estimates were calculated within ArcGIS pro 2.9.3 (Esri Inc.). Kernel density probabilities calculated the diminished density radii around the passive receivers (Silverman 1986), effectively revealing the areas of the York River most heavily used during immigration and emigration. We report the results of percent SIRI and kernel density estimates during the immigration and emigration periods for comparative purposes.

Results

The SIRI effectively combines count data, total detections, and days present during a migratory period into one index that provides a standard value for each passive telemetry station (Table 2). During immigration, half of the fish avoided detection at rkm 14 and 26.8, while all fish were detected at all other stations. Nearly twice as many detections occurred at the station with highest salinity located at rkm 11.3 than any other station (Table 2). However, numbers of detections and frequency of occurrence were slightly higher at rkm 64.5, the station with lowest salinity and last location before entering freshwater. During emigration, all fish were detected at all stations with the exception of one fish at rkm 14. The highest counts, detections, and percent occupancy occurred at rkm 26.8. The SIRI objectively ranks the relative importance of all 10 stations, with stations at rkm 11.3 and 64.5 indicated as being most important during immigration and rkm 26.8 as being of primary importance during emigration. Kernel density estimations conducted using the same data used for the SIRI reveal similarly modeled habitat utilization (Figure 1).

Temporal elasticity in the SIRI equation also allowed for weekly analyses of habitat utilization during immigration and emigration (Table 3). Because immigration occurs over broader time frames, many weeks are observations of individual fish. Each week, the most frequently used

immigration stations were near the mouth of the York River or near the saltwater interface. Emigration time frames were more focused and therefore in the first week, most fish were near the saltwater interface but in all subsequent weeks, all fish spent most of their time at rkm 26.8. In all cases, individual stations in different weeks showed variability, but the overall trends observed in Table 2 are still apparent.

Discussion

The percent diet IRI is based on a long-accepted approach of deriving a single index from stomach content analyses that can be used to compare the relative importance of each prey item. The SIRI provides a single index to compare the varied types of data inherent to tracking studies to identify the relative importance of receiver sites based on detections. The major shortcomings of diet studies are a difference in digestion rate for some foods and a difference in ease of identification between food resources (Buckland et al. 2017). Further, because of the challenges with identification, food items are not always identified to the same taxonomic level (Brown et al. 2012). Similarly, the SIRI or any other passive telemetry study could be criticized for variability in transmitter detection range due to tag transmission power and/or environmental conditions affecting receiver receptive distances. While there is no overlap in receiver coverage in this study, each station is evaluated independently, so if signals from an individual fish were recorded on multiple receivers, the final product would reveal the importance of that general area. Depending on the area covered by the passive telemetry array, conditions affecting detection distance may act uniformly on all receivers in the study (Mathies et al. 2014). The SIRI relies on the assumption that habitat is selected based on its benefit to species' survival and while an animal may have to move through less optimal physiological conditions to reach preferred habitats, over sufficient time the SIRI will indicate sites of preferred occupancy. Another important assumption to the application of the SIRI is that the sample size and its biological characteristics adequately represent a non-biased subset of the population being examined. At low sample sizes, of receiver coverage or tracked individuals, one runs the risk of telemetered individuals inadequately reflecting the true habitat occupation of the species or population. Researchers have a responsibility to ensure that the overall composition of telemetered individuals is representative of the population being described. We recommend considering life stage, sex, behavior or habitat use, abiotic conditions, and whether the analysis is considering one population or several, at a minimum, to address this issue. In our SIRI all sturgeon were adult males that exhibit similar behavior during the spawning season (Hager et al. 2020) which were all genetically assigned to the York River population (Kazyak et al. 2021).

The kernel density estimation model and SIRI both show that different York River system receiver sites were preferentially occupied by adult sturgeon during immigration versus emigration in 2014. Further, the two models show strong correlation in their outputs. During immigration, adults spent the majority of their time at a deep constriction point in the river at rkm 11.3, with additional habitat selection closer to the freshwater-saltwater interface. While fish were detected at all stations to some extent during immigration, the mainstem York River channel was used more for relatively rapid upstream passage. On emigration, there was a primary preference for rkm 26.8 in the mesohaline region and a secondary preference for habitats around rkm 11.3 near the confluence with the bay. Though these locations differ in their salinity the preference exhibited for these locations in 2014 may be linked to the fact that both were

located in zones of gradual transition between salinities. Because the SIRI model relies on temporal detection information and not just raw detection data it can be easily manipulated to examine the effects of temporal alterations in attributes like salinity, temperature, or dissolved oxygen on habitat selection. Therefore, SIRI is not only able to identify and rank the relative importance of habitats but it can be more easily manipulated to examine preference for these locations under varied physical conditions. Because the kernel analysis' relies on raw data alone it is not as well suited for such temporal analytical manipulation. Further, the SIRI model can account for periods of missing receiver days if a station were lost or the battery failed during the study and account for shorter sampling time at one station relative to other stations during the study, which the kernel model does not.

Another significant advantage to application of the SIRI is that it allows for the development of models that can incorporate a single standardized value, rank, or score per monitored site. This index value is calculated by real-time occupation data along with real time abiotic data. Thus, this relatively simple index provides a means of advancing array-based analysis. Acquiring a single representative value per site, at specific times when we know individuals to be present, allows spatial and temporal comparisons within and between studies. Models that build upon the SIRI and incorporate abiotic variables provide a means of assigning habitat value based on environmental attributes, similar to habitat suitability index models, but more simply incorporate telemetry detection data (Roloff and Kernohan 1999, Mitchell et al. 2002, Yu et al. 2018). Such models can guide management to avoid sites or regions with elevated potential interaction rates between human-caused stressors and species of interest and thus minimize harm, or be used to ensure desired attributes are incorporated into habitat improvement or recovery projects. Another added advantage of the SIRI is its flexibility, in which the analysis considerations can be modified to suit the investigator's hypothesis. In this case, we used a day as our set temporal component but studies on differences in habitat use between day and night, weeks, seasons, years, or any other appropriate segmentation (e.g. temperature ranges) could be applied. Developing an index of relative importance, which we have demonstrated here, will standardize habitat occupancy studies, increasing site specific telemetry utility across geographic scales.

Acknowledgments

This research was aided by the support and assistance of the following contributors. Ramsey Noble, Gabriel Irigaray, Jay Russo, Tracy Massey, Craig Marcusson, Kirk Moore, and Carter Griggs were senior technicians. We are also grateful to April Deacy, Desiree Nuckols, Kirk Moore, and Kevin Brown from the Pamunkey Tribe and to William Tyler for river access. We thank Albert Spells of the U.S. Fish and Wildlife Service and Dave MacDuffee, Dave Noble, Brittany Bartlett, and Jessica Bassi and Laura Busch of the U.S. Department of the Navy. Additionally, we thank the U.S. Department of the Navy for providing personnel and funding through Contract N62470-09-D-2003 for the telemetry tags and receivers; the National Marine Fisheries Service for providing personnel and issuing the Endangered Species Act sampling permits, and the Virginia Department of Game and Inland Fisheries and the Virginia Marine Resources Commission for issuing the state sampling permits. Sampling was conducted under Virginia Marine Resources Commission Permits 13-059, 14-016, 15-023, and 16-036 for 2013, 2014, 2015, and 2016, respectively; Virginia Department of Game and Inland Fisheries Permits 047061, 051600, 053337,

055949, 060198, 061577, and 065154 for 2013, 2014, 2015, 2016, 2017, 2018, and 2019, respectively; and National Marine Fisheries Service Permits 16547 and 19642.

Citations

- Aarts, G., M. MacKenzie, B. McConnell, M. Fedak, and J. Matthiopoulos. 2008. Estimating space-use and habitat preference from wildlife telemetry data. *Ecography* 31:140-160.
- Bigg, M.A., and M.A. Perez 1985. Modified volume: a frequency-volume method to assess marine mammal food habits. Pages 277-283 in J.R. Beddington, R.J.H., Beverton, and D.M. Lavigne editors. *Marine mammals and fisheries*. George Allen and Unwin, London, U.K.
- Brown, S.C., J.J. Bizzarro, G.M. Cailliet, and D.A. Ebert. 2012. Breaking with tradition: redefining measures for diet description with a case study of the Aleutian skate *Bathyraja aleutica* (Gilbert 1896). *Environmental Biology of Fishes* 95:3-20.
- Brownscombe, J.W., L.P. Griffin, J.L. Brooks, A.J. Danylchuk, S.J. Cooke, and J.D. Midwood. 2022. Applications of telemetry to fish habitat science and management. *Canadian Journal of Fisheries and Aquatic Sciences* 99:1-13; <https://cdnsiencepub.com/doi/10.1139/cjfas-2021-0101>.
- Buckland, A., R. Baker, N. Loneragan, and M. Sheaves. 2017. Standardizing fish stomach content analysis: the importance of prey condition. *Fisheries Research* 196:126-140.
- Cailliet, G.M., 1977. Several approaches to feeding ecology of fishes. Pages 1-13 in C.A. Simenstad and S.J. Lipovsky editors. *Fish food habit studies: Proceedings of the 1st Pacific Northwest Technical Workshop*. Edited by Washington Sea Grant Publication. Washington Sea Grant Program, University of Washington, Seattle Washington.
- Cortes, E. 1997. A critical review of methods of studying fish feeding based analysis of stomach contents: application to elasmobranch fishes. *Canadian Journal of Fisheries Science* 54:726-738.
- Cramer, A. 2015. Large-scale patterns in marine fish habitat use as determined from a meta-analysis of acoustic telemetry studies. Master's Thesis, California State University Monterey Bay. 52p.
- Hager, C. 2016. Operation of the Navy's telemetry array in the lower Chesapeake Bay. Contract # N62470-10-D-3011, Task Order CTO 53. 2015 Annual Report to US Navy, Norfolk, Virginia, USA.
- Hager, C., J. Kahn, C. Watterson, J. Russo, and K. Hartman. 2014. Evidence of Atlantic sturgeon (*Acipenser oxyrinchus*) spawning in the York River system. *Transactions of the American Fisheries Society* 143(5):1217-1219.
- Hager C. H., Watterson J.C., Kahn J.E. 2020. Spawning frequency and drivers of endangered Atlantic sturgeon in the York River system. *Transactions American Fisheries Society* 149: 474-485.
- Hartley, P.H.T. 1948. The assessment of the food of birds. *Ibis* 90:361-381.
- Hatin, D., R. Fortin, and F. Caron. 2002. Movements and aggregation areas of adult Atlantic sturgeon (*Acipenser oxyrinchus*) in the St Lawrence River Estuary, Québec, Canada. *Journal of Applied Ichthyology* 18:586-594.
- Hatin, D., J. Munro, F. Caron, and R.D. Simons. 2007. Movements, home range size, and habitat use and selection of early juvenile Atlantic sturgeon in the St. Lawrence estuarine transition zone. *American Fisheries Society Symposium* 56:129-155.

- Hollensead, L.D., R.D. Grubbs, J.K. Carlson, and D.M. Bethea. 2018. Assessing residency time and habitat use of juvenile smalltooth sawfish using acoustic monitoring in a nursery habitat. *Endangered Species Research* 37:119-131.
- Hynes, H.B.N., 1950. The food of freshwater sticklebacks (*Gasterosteus aculeatus* and *Pygosteus pungitius*) with a review of methods used in study of food of fishes. *Journal of Animal Ecology* 19:36-58.
- Hylop, E.J., 1980. Stomach content analysis: a review of methods and their application. *Journal of Fish Biology* 17:411-429.
- Ingram E.C. and D.L. Peterson. 2016. Annual spawning migration of adult Atlantic sturgeon in the Altamaha River, Georgia. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science* 8:595-606.
- Ingram, E.C., R.M. Cerrato, K.J. Dunton, and M.G. Frisk. 2019. Endangered Atlantic sturgeon in the New York wind energy area: implications for future development in an offshore wind energy site. *Scientific Reports* 9:12432.
- Johnson, J.W. and J.M. LeBreton. 2004. History and use of relative importance indices in organizational research. *Organizational Research Methods* 7:238-257.
- Kahn, J.E., C. Hager, J.C. Watterson, J. Russo, K. Moore, and K. Hartman. 2014. Atlantic sturgeon (*Acipenser oxyrinchus*) annual spawning run estimate in the Pamunkey River, Virginia. *Transactions of the American Fisheries Society* 143(6):1508-1514.
- Kazyak, D.C., S.L. White, B.A. Lubinski, R. Johnson, M. Eackles. 2021. Stock composition of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) encountered in marine and estuarine environments along the US Atlantic Coast. *Conservation Genetics* 22:767-781.
<https://doi.org/10.1007/s10592-021-01361-2>
- Koster, W.M., D.R. Dawson, D.J. O'Mahony, P.D. Moloney, and D.A. Crook. (2014). Timing, frequency and environmental conditions associated with mainstem-tributary movement by a lowland river fish, golden perch (*Macquaria ambigua*). *PloS one* 9(5):e96044.
- LeBreton, J.M. and S. Tonidandel. 2008. Multivariate relative importance: Extending relative weight analysis to multivariate criterion spaces. *Journal of Applied Psychology* 93:329-345.
- MacDonald, J.S., and R.H. Green, 1983. Redundancy of variables used to describe importance of prey species in fish diets. *Canadian Journal of Fisheries and Aquatic Sciences* 40:635-637.
- Manooch, C.S. and D.L. Mason. 1983. Comparative food studies of yellowfin tuna, *Thunus albacres*, and blackfin tuna, *Thunus atlanticus*, from the southeastern and gulf coast of the United States. *Brimleyana* 9:33-52.
- Mathies, N.H., M.B. Ogburn, G. McFall, and S. Fangman. 2014. Environmental interference factors affecting detection range in acoustic telemetry studies using fixed receiver arrays. *Marine Ecology Progress Series* 495:27-38.
- Medin, D.E. 1970. Stomach content analyses: collections from wild herbivores and birds. Pages 133-143 in *Range and Wildland Habitat Evaluation – A Research Symposium*. US Department of Agriculture, Forest Service Miscellaneous Publication 1147.
- Mitchell, M.S., J.W. Zimmerman, and R.A. Powell. 2002. Test of a habitat suitability index for black bears in the southern Appalachians. *Wildlife Society Bulletin* 30(3):794-808.
- Morrison, M.L., B.G. Marcot, and R.W. Mannan. 1992. *Wildlife-habitat relationships: concepts and applications*. University of Wisconsin, Madison.
- NMFS. 2012. Endangered and threatened wildlife and plants; threatened and endangered status for distinct population segments of Atlantic sturgeon in the northeast region. *Federal Register* 77:24 (2 February 2012):5880.

- Paltridge, R. 2002. The diets of cats, foxes, and dingoes in relation to prey availability in the Tanami Desert, Northern Territory. *Wildlife Research* 29:389-403.
- Pinkas, L. 1971. Food habits of albacore, bluefin tuna, and bonito in California waters. California Department of Fish and Game Fish Bulletin 152:1-105.
- Reyier, E.A., B.R. Franks, D.D. Chapman, D.M. Scheidt, E.D. Stolen, and S.H. Gruber. 2014. Regional-scale migrations and habitat use of juvenile lemon sharks (*Negaprion brevirostris*) in the US South Atlantic. *PLoS ONE* 9(2): e88470.
- Roloff, G.J. and B.J. Kernohan. 1999. Evaluating reliability of habitat suitability index models. *Wildlife Society Bulletin* 27:973-985.
- Rosenblatt, M. 1956. Remarks on some nonparametric estimates of a density function. *The Annals of Mathematical Statistics* 27:832-837.
- Rudolfson, T.A., D.A. Watkinson, C. Charles, C. Kovachik, and E.C. Enders. 2021. Developing habitat associations for fishes in Lake Winnipeg by linking large scale bathymetric and substrate data with fish telemetry detections. *Journal of Great Lakes Research* 47:635-647.
- Silverman, B.W. 1986. Chapter 6: Density estimation in action. *Density estimation for statistics and data analysis*. Chapman and Hall/CRC, New York, New York. ISBN 0-412-24620-1.
- Stein, A.B., K.D. Friedland, and M. Sutherland. 2004. Atlantic sturgeon marine distribution and habitat use along the northeastern coast of the United States. *Transactions of the American Fisheries Society* 133:527-537.
- Thorstad, E.B., A.H. Rikardsen, A. Alp, F. Økland. 2013. The use of electronic tags in fish research – an overview of fish telemetry methods. *Turkish Journal of Fisheries and Aquatic Sciences* 13:881-896.
- Verner, J., M. Morrison, and C.J. Ralph. 1986. *Wildlife 2000: modeling habitat relationships of terrestrial vertebrates*. University of Wisconsin, Madison.
- Wang, C., B. Kynard, W. Wei, H. Du, and H. Zhang. 2013. Spatial distribution and habitat suitability indices for non-spawning and spawning adult Chinese sturgeons below Gezhouba Dam, Yangtze River: effect of river alterations. *Journal of Applied Ichthyology* 29:31-40.
- Whittle, P. 1958. On the smoothing of probability density functions. *Journal of the Royal Statistical Society Series B*. 20:334-343.
- Yu, L., J. Lin, D. Chen, X. Duan, Q. Peng, and S. Liu. 2018. Ecological flow assessment to improve the spawning habitat for the four major species of carp in the Yangtze River: a study on habitat suitability based on ultrasonic telemetry. *Water* 10(5):600
<https://doi.org/10.3390/w10050600>.

Figure 1. Depiction of relative habitat selection during a) immigration and b) emigration during the 2014 Atlantic sturgeon spawning run using the kernel density estimator (left) and site-specific index of relative importance (right).

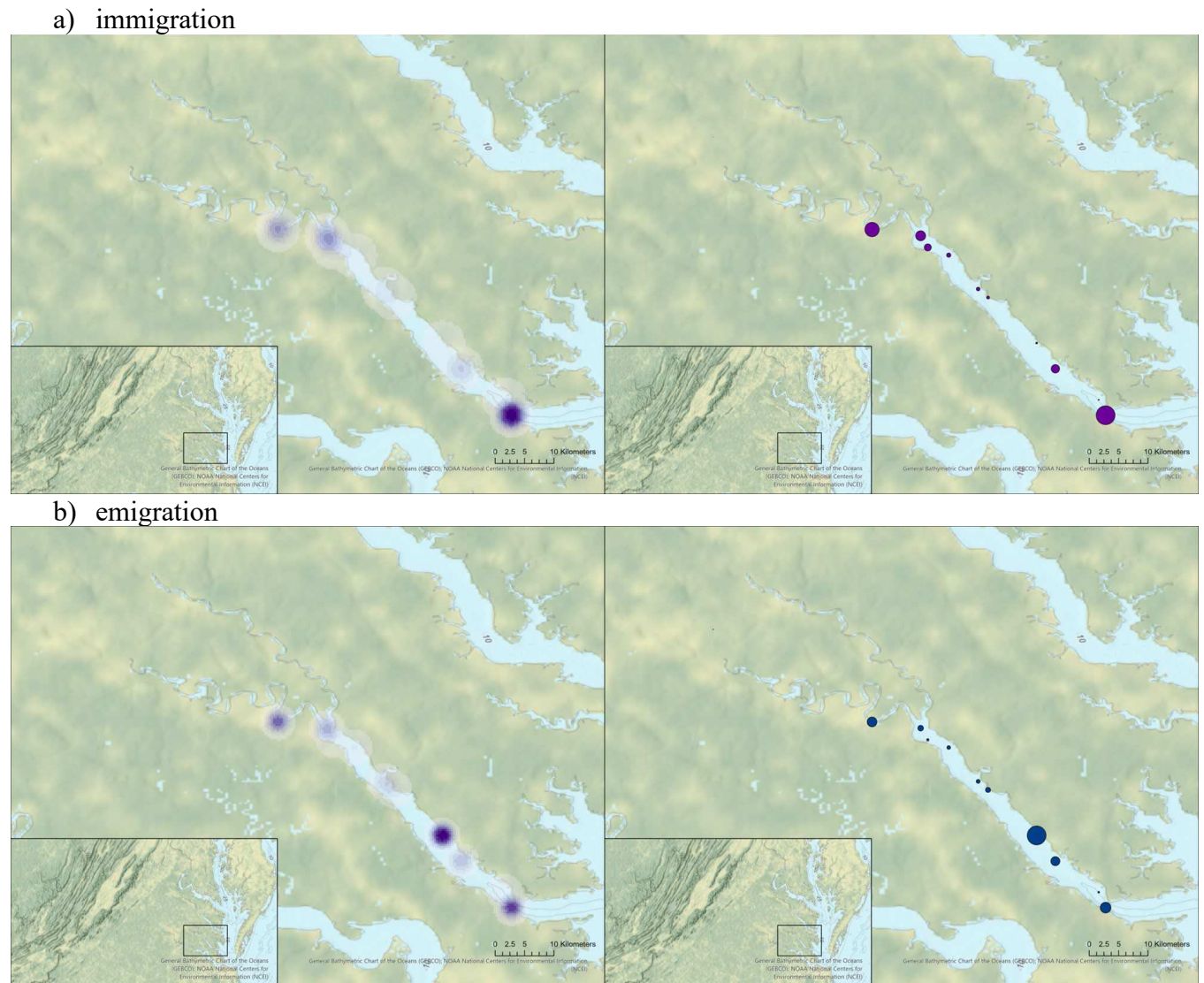


Table 1. Salinity variation within the York River and lower Pamunkey River during immigration and emigration periods in 2014, where rkm is river kilometer and salinity is expressed in units of parts per thousand.

Rkm	10	15	20	25	30	35	40	45	50	55	60	65	70
Salinity	18-20	16-18	14-16	12-14	9-12	7-11	3-10	2-9	2-7	1-6	1-4	1-2	0-1

Table 2. Site specific data during a) immigration and b) emigration are organized by river kilometer, count data (SN), detection data (SD), percent site-specific numbers (%SN), percent site-specific detections (%SD), frequency of occupation (%T), calculated SIRI, and % SIRI. Values for each category were rounded to the nearest hundredth except for the SIRI calculation to prevent one value from being rounded to 0.

a)

Site km	SN	Detection	%SN	%SD	%T	SIRI	%SIRI
11.3	16	1014	0.12	0.35	0.21	0.049	0.26
14	7	22	0.05	0.01	0.09	0.003	0.01
20.3	15	318	0.12	0.11	0.20	0.022	0.12
26.8	8	77	0.06	0.03	0.11	0.005	0.02
36.8	11	75	0.09	0.03	0.14	0.008	0.04
39	11	142	0.09	0.05	0.14	0.010	0.05
46.3	13	90	0.10	0.03	0.17	0.011	0.06
49.4	15	216	0.12	0.07	0.20	0.019	0.10
51.5	15	448	0.12	0.15	0.20	0.027	0.14
64.5	18	530	0.14	0.18	0.24	0.038	0.20

b)

Site km	SN	Detection	%SN	%SD	%T	SIRI	%SIRI
11.3	17	844	0.12	0.20	0.36	0.057	0.15
14	9	30	0.06	0.01	0.22	0.008	0.02
20.3	19	420	0.13	0.10	0.42	0.048	0.13
26.8	25	1094	0.17	0.26	0.47	0.101	0.27
36.8	15	169	0.10	0.04	0.36	0.026	0.07
39	12	264	0.08	0.06	0.28	0.020	0.06
46.3	12	115	0.08	0.03	0.33	0.018	0.05
49.4	9	98	0.06	0.02	0.25	0.011	0.03
51.5	12	475	0.08	0.11	0.31	0.03	0.08
64.5	16	750	0.11	0.18	0.36	0.052	0.14

Table 3. Weekly habitat use at each river kilometer (rkm), shown as % SIRI, for a) immigration and b) emigration through the saline portions of the lower Pamunkey and mainstem York rivers. Stations with no detections in a week were left blank. The last week of the immigration period was six days and emigration was eight days, all other weeks were seven days.

a)

Dates	rkm 11.3	rkm 14	rkm 20.3	rkm 26.8	rkm 36.8	rkm 39	rkm 46.3	rkm 49.4	rkm 51.5	rkm 64.5
5/31-6/6	0.29	0.08	0.29	0.13	0.03	0.03	0.02	0.04	0.05	0.04
6/7-13									0.05	0.95
6/14-20	0.52	0.48								
6/21-27	0.02	0.01	0.22	0.08	0.06	0.07	0.05	0.16	0.18	0.15
6/28-7/4	0.02		0.10	0.05	0.08	0.12	0.07	0.10	0.16	0.30
7/5-11					0.11	0.30	0.12	0.19	0.15	0.13
7/12-18	0.95	0.02	0.03							
7/19-25	0.17		0.50		0.06	0.05	0.05	0.05	0.07	0.05
7/26-8/1	0.05		0.03	0.01	0.02	0.03	0.14	0.18	0.27	0.27
8/2-8/8										
8/9-8/14	0.17		0.04	0.03	0.05	0.03	0.04	0.19	0.34	0.11

b)

Dates	rkm 11.3	rkm 14	rkm 20.3	rkm 26.8	rkm 36.8	rkm 39	rkm 46.3	rkm 49.4	rkm 51.5	rkm 64.5
9/29-10/5	0.18	0.01	0.03	0.01	0.01	0.01	0.04	0.05	0.13	0.53
10/6-10/12	0.02		0.12	0.47	0.08	0.11	0.08	0.03	0.05	0.04
10/13-10/19	0.34	0.02	0.10	0.41	0.06	0.03	0.02		0.01	0.01
10/20-10/26	0.22	0.14	0.18	0.32	0.01	0.01	0.01	0.01	0.05	0.05
10/27-11/3		0.05	0.26		0.35	0.04	0.04	0.04	0.17	0.05

Appendix B: Minor Species Detection Data.

B.1 CRA detections of minor species by month and year

Species	Year	Month	Individuals	Detections	Days
American shad	2017	Apr	1	9	1
American shad	2020	May	1	11	1
American shad	2020	Jun	1	9	1
Atlantic angel shark	2018	Nov	1	2	1
Atlantic angel shark	2021	Jun	1	7	1
Atlantic bluefin tuna	2017	Mar	1	1	1
Atlantic sting ray	2016	Nov	1	3	1
Black drum	2016	Sep	1	1	1
Black sea bass	2016	Jan	1	3	1
Black sea bass	2021	Aug	1	726	6
Blacktip shark	2016	Jun	5	53	4
Blacktip shark	2016	Jul	2	28	5
Blacktip shark	2016	Oct	5	72	8
Blacktip shark	2017	Jun	5	59	4
Blacktip shark	2017	Aug	1	4	1
Blacktip shark	2017	Sep	3	10	2
Blacktip shark	2017	Oct	5	24	5
Blacktip shark	2018	Jun	9	145	11
Blacktip shark	2018	Jul	4	71	9
Blacktip shark	2018	Aug	2	30	3
Blacktip shark	2018	Sep	6	72	10
Blacktip shark	2018	Oct	11	135	8
Blacktip shark	2019	May	1	8	1
Blacktip shark	2019	Jun	7	190	13
Blacktip shark	2019	Jul	2	106	7
Blacktip shark	2019	Aug	2	69	2
Blacktip shark	2019	Sep	3	23	4
Blacktip shark	2019	Oct	9	210	14
Blacktip shark	2020	May	1	8	1
Blacktip shark	2020	Jun	4	517	10
Blacktip shark	2020	Jul	3	131	6
Blacktip shark	2020	Sep	1	19	3
Blacktip shark	2020	Oct	2	9	2
Blacktip shark	2020	Nov	1	10	1

Species	Year	Month	Individuals	Detections	Days
Blacktip shark	2021	Jun	4	81	5
Blacktip shark	2021	Jul	1	10	3
Blacktip shark	2021	Aug	1	11	2
Bull shark	2016	Jul	1	4	1
Bull shark	2017	Aug	1	1	1
Bull shark	2018	Jul	1	1	1
Bull shark	2018	Aug	1	1	1
Bull shark	2018	Oct	1	2	2
Bull shark	2020	Jul	1	1	1
Bull shark	2020	Aug	1	2	2
Bull shark	2020	Sep	1	1	1
Bull shark	2020	Oct	1	1	1
Bull shark	2021	Jun	1	1	1
Bull shark	2021	Aug	1	9	3
Common thresher shark	2018	Oct	1	1	1
Common thresher shark	2018	Nov	1	23	1
Common thresher shark	2019	May	1	1	1
Common thresher shark	2019	Oct	2	22	4
Common thresher shark	2019	Dec	1	15	2
Common thresher shark	2020	Jan	1	10	1
Common thresher shark	2020	May	1	3	1
Common thresher shark	2020	Oct	1	3	1
Common thresher shark	2020	Nov	2	23	4
Common thresher shark	2021	May	2	26	2
Cownose ray	2016	May	8	25	6
Cownose ray	2016	Sep	1	7	2
Cownose ray	2016	Oct	1	3	1
Cownose ray	2017	May	2	3	2
Cownose ray	2017	Sep	1	8	3
Cownose ray	2017	Oct	2	15	2
Cownose ray	2017	Nov	6	22	4
Cownose ray	2018	May	5	20	5
Cownose ray	2018	Jun	1	5	1
Cownose ray	2018	Oct	2	3	2
Cownose ray	2019	May	11	16	7
Cownose ray	2019	Jun	2	7	2
Cownose ray	2019	Jul	1	11	1

Species	Year	Month	Individuals	Detections	Days
Cownose ray	2019	Sep	2	24	2
Cownose ray	2019	Oct	1	4	1
Cownose ray	2020	Sep	1	135	4
Cownose ray	2020	Oct	3	71	4
Cownose ray	2021	May	5	10	3
Dusky shark	2016	Nov	1	37	2
Dusky shark	2017	May	2	13	1
Dusky shark	2017	Nov	8	114	5
Dusky shark	2018	Jun	2	5	2
Dusky shark	2018	Oct	3	70	3
Dusky shark	2018	Nov	4	38	4
Dusky shark	2019	May	1	5	1
Dusky shark	2019	Sep	1	14	1
Dusky shark	2019	Oct	13	304	13
Dusky shark	2019	Nov	5	85	4
Dusky shark	2020	May	2	5	2
Dusky shark	2020	Sep	1	16	2
Dusky shark	2020	Oct	6	67	7
Dusky shark	2020	Nov	3	25	3
Dusky shark	2021	May	1	13	1
Little skate	2019	Dec	1	19	1
Little skate	2020	Jan	1	3	1
Loggerhead sea turtle	2016	May	1	1	1
Loggerhead sea turtle	2017	Aug	2	8	1
Roughtail skate	2020	Jun	1	12	1
Roughtail skate	2020	Aug	1	6	1
Roughtail skate	2021	Jun	1	16	2
Sandbar shark	2017	Jun	1	1	1
Sandbar shark	2017	Oct	1	11	1
Sandbar shark	2018	May	1	9	1
Sandbar shark	2018	Aug	1	11	1
Sandbar shark	2018	Sep	1	2	1
Sandbar shark	2018	Oct	3	29	2
Sandbar shark	2018	Nov	2	64	4
Sandbar shark	2019	May	2	2	2
Sandbar shark	2019	Jun	1	24	2
Sandbar shark	2019	Sep	2	25	2
Sandbar shark	2019	Oct	9	253	8
Sandbar shark	2019	Nov	2	14	2
Sandbar shark	2020	May	6	66	4

Species	Year	Month	Individuals	Detections	Days
Sandbar shark	2020	Jun	8	115	4
Sandbar shark	2020	Sep	2	63	3
Sandbar shark	2020	Oct	7	122	7
Sandbar shark	2020	Nov	3	24	3
Sandbar shark	2021	May	8	130	6
Sandbar shark	2021	Jun	5	97	5
Smooth dogfish	2016	Nov	1	15	2
Smooth dogfish	2017	Nov	1	12	1
Smooth dogfish	2017	Dec	1	16	1
Smooth dogfish	2018	Nov	2	64	2
Smooth dogfish	2019	Apr	3	76	4
Smooth dogfish	2019	May	2	4	2
Smooth dogfish	2019	Nov	1	44	2
Smooth dogfish	2020	Apr	1	30	2
Spiny dogfish	2016	Feb	1	1	1
Spiny dogfish	2017	Dec	1	13	1
Spiny dogfish	2018	May	1	1	1
Spiny dogfish	2018	Nov	1	3	1
Spiny dogfish	2018	Dec	1	1	1
Spiny dogfish	2019	Feb	1	21	1
Spiny dogfish	2019	Apr	1	4	1
Spotted trout	2016	Dec	2	9	3
Spotted trout	2017	Apr	1	1	1
Striped bass	2016	Jan	49	2622	16
Striped bass	2016	Feb	44	1508	16
Striped bass	2016	Mar	52	2727	18
Striped bass	2016	Apr	1	1	1
Striped bass	2016	Jun	1	15	3
Striped bass	2016	Dec	7	578	10
Striped bass	2017	Jan	56	1905	22
Striped bass	2017	Feb	72	1556	15
Striped bass	2017	Mar	21	760	16
Striped bass	2017	Apr	6	115	7
Striped bass	2017	Dec	16	589	9
Striped bass	2018	Jan	54	990	13
Striped bass	2018	Feb	52	713	9
Striped bass	2018	Mar	12	67	6
Striped bass	2018	Apr	6	70	6
Striped bass	2018	Dec	37	1287	16
Striped bass	2019	Jan	26	724	15

Species	Year	Month	Individuals	Detections	Days
Striped bass	2019	Feb	12	203	7
Striped bass	2019	Mar	42	1074	14
Striped bass	2019	Apr	3	42	4
Striped bass	2019	Dec	3	352	7
Striped bass	2020	Jan	1	18	1
Striped bass	2020	Feb	7	63	4
Striped bass	2020	Mar	5	56	7
Striped bass	2020	Dec	1	2	2
Striped bass	2021	Jan	16	313	7
Striped bass	2021	Feb	34	608	6
Striped bass	2021	Mar	13	148	6
Striped bass	2021	Apr	1	2	2
Tarpon	2020	Oct	1	16	2
Tarpon	2021	Jun	1	1	1
Tiger shark	2016	Oct	1	4	1
Tiger shark	2018	Jul	1	22	2
Tiger shark	2019	Aug	1	1	1
Winter skate	2018	Jan	1	71	1
Winter skate	2021	Feb	1	3	1

B.2 WFA detections of minor species by month and year.

Species	Year	Month	Individuals	Detections	Days
American shad	2016	May	1	21	1
American shad	2018	May	1	28	1
Atlantic bluefin tuna	2016	Mar	1	1	1
Black drum	2016	Oct	1	5	2
Blacktip shark	2016	Sep	1	1	1
Blacktip shark	2016	Oct	4	20	4
Blacktip shark	2017	Jun	5	60	9
Blacktip shark	2017	Sep	1	9	1
Blacktip shark	2017	Oct	5	50	6
Blacktip shark	2018	Jun	6	100	8
Blacktip shark	2018	Jul	1	20	2
Blacktip shark	2018	Sep	1	6	1
Blacktip shark	2018	Oct	1	9	1
Blacktip shark	2019	May	2	11	2
Blacktip shark	2019	Jun	2	24	4
Blacktip shark	2019	Sep	1	83	3
Blacktip shark	2019	Oct	2	74	4

Species	Year	Month	Individuals	Detections	Days
Blacktip shark	2019	Nov	2	52	2
Blacktip shark	2019	Dec	1	2	1
Blacktip shark	2020	Jul	2	10	2
Blacktip shark	2020	Oct	2	20	2
Blacktip shark	2020	Nov	1	11	2
Blacktip shark	2021	May	1	7	1
Blacktip shark	2021	Jun	2	10	2
Blueback herring	2018	Dec	1	12	1
Cobia	2017	Sep	2	10	2
Cobia	2017	Oct	1	4	1
Cobia	2018	May	1	12	1
Cobia	2018	Jun	4	91	5
Cobia	2018	Jul	6	63	7
Cobia	2018	Oct	2	56	3
Cobia	2019	May	2	36	2
Cobia	2019	Jun	5	140	8
Cobia	2019	Jul	7	85	8
Cobia	2019	Aug	2	96	2
Cobia	2019	Sep	5	258	9
Cobia	2019	Oct	5	51	5
Cobia	2020	Jun	6	291	11
Cobia	2020	Jul	6	138	10
Cobia	2020	Aug	6	88	6
Cobia	2020	Sep	3	25	4
Cobia	2020	Oct	4	76	5
Cobia	2021	Jun	2	36	2
Cobia	2021	Jul	6	36	7
Common thresher shark	2019	May	1	7	1
Common thresher shark	2019	Nov	1	10	1
Common thresher shark	2019	Dec	1	7	1
Common thresher shark	2020	May	1	9	1
Common thresher shark	2020	Nov	1	2	1
Cownose ray	2016	Oct	1	8	1
Cownose ray	2018	Oct	1	10	1
Cownose ray	2019	Jul	1	10	1
Cownose ray	2020	Sep	1	5	1
Dusky shark	2016	Nov	1	1	1
Dusky shark	2017	May	1	18	1

Species	Year	Month	Individuals	Detections	Days
Dusky shark	2017	Oct	1	4	1
Dusky shark	2017	Nov	2	12	2
Dusky shark	2018	May	2	17	2
Dusky shark	2018	Jun	7	94	9
Dusky shark	2018	Oct	1	5	1
Dusky shark	2018	Nov	1	11	1
Dusky shark	2019	May	1	9	1
Dusky shark	2019	Sep	1	12	1
Dusky shark	2019	Oct	7	155	10
Dusky shark	2019	Nov	10	161	6
Dusky shark	2020	Jun	1	8	1
Dusky shark	2020	Sep	1	5	1
Dusky shark	2020	Oct	5	32	4
Dusky shark	2020	Nov	7	96	7
Dusky shark	2021	May	1	12	1
Dusky shark	2021	Jun	2	47	3
Little skate	2020	Apr	1	1	1
Loggerhead sea turtle	2017	May	1	50	1
Sand tiger shark	2017	Oct	2	5	2
Sand tiger shark	2018	Jun	1	13	1
Sand tiger shark	2018	Jul	1	6	1
Sand tiger shark	2018	Oct	1	4	1
Sand tiger shark	2019	Oct	1	5	1
Sand tiger shark	2019	Nov	1	19	1
Sand tiger shark	2020	Oct	2	8	2
Sand tiger shark	2020	Nov	1	2	1
Sandbar shark	2017	Jun	2	6	1
Sandbar shark	2018	May	3	38	2
Sandbar shark	2018	Aug	1	11	1
Sandbar shark	2018	Sep	1	1	1
Sandbar shark	2018	Oct	1	10	1
Sandbar shark	2018	Nov	2	32	2
Sandbar shark	2019	May	2	23	2
Sandbar shark	2019	Sep	1	29	1
Sandbar shark	2019	Oct	3	79	5
Sandbar shark	2019	Nov	3	80	5
Sandbar shark	2020	Jun	2	12	2
Sandbar shark	2020	Oct	1	85	1
Sandbar shark	2020	Nov	3	17	3
Sandbar shark	2020	Dec	2	13	2

Species	Year	Month	Individuals	Detections	Days
Sandbar shark	2021	May	7	98	7
Sandbar shark	2021	Jun	6	58	3
Sandbar shark	2021	Aug	1	3	1
Smooth dogfish	2017	Nov	2	65	2
Smooth dogfish	2017	Dec	1	18	1
Smooth dogfish	2019	May	1	30	1
Smooth dogfish	2019	Nov	1	25	1
Spinner shark	2020	Jun	1	4	1
Spinner shark	2021	Jun	1	6	1
Spiny dogfish	2017	Mar	1	6	2
Spiny dogfish	2018	May	1	6	1
Spiny dogfish	2019	Jan	1	3	1
Tiger shark	2016	Jan	1	1	1
Tiger shark	2016	Jul	1	24	2
Tiger shark	2016	Aug	1	17	2
Tiger shark	2017	May	1	1	1
Tiger shark	2017	Aug	1	1	1
Tiger shark	2017	Oct	1	16	1
Tiger shark	2018	Jul	1	45	3
Tiger shark	2018	Aug	1	3	1
Tiger shark	2019	Jun	1	5	1
Tiger shark	2019	Aug	2	5	2
Tiger shark	2019	Sep	1	6	1
Tiger shark	2020	Jul	1	4	1
Winter skate	2018	Jan	1	72	2
Winter skate	2018	Feb	1	190	2

Appendix C: Taggers by Species

C.1 CRA Tagger data.

Species	Tagger	Tags Detected	Institute
American shad	Holly White	3	North Carolina Division of Marine Fisheries
Atlantic angel shark	Keith Dunton	1	Monmouth University
Atlantic bluefin tuna	Barbara Block	1	Stanford University
Atlantic sting ray	Matt Ogburn	1	Smithsonian Institute
Atlantic sturgeon	Keith Dunton	191	Monmouth University
Atlantic sturgeon	Matt Balazik	165	US Army Corps of Engineers
Atlantic sturgeon	Dewayne Fox	163	Delaware State University
Atlantic sturgeon	Eric Hilton	111	Virginia Institute of Marine Science

Species	Tagger	Tags Detected	Institute
Atlantic sturgeon	Evan Ingram	109	Stony Brook University
Atlantic sturgeon	Bill Post	94	South Carolina Division Natural Resources
Atlantic sturgeon	Christian Hager	71	Chesapeake Scientific LLC
Atlantic sturgeon	Tom Savoy	33	Connecticut Department of Energy and Environmental Protection
Atlantic sturgeon	Ian Park	7	Delaware Division of Fish and Wildlife
Atlantic sturgeon	Mike Loeffler	6	North Carolina Division of Marine Fisheries
Atlantic sturgeon	Anne Wright	6	Virginia Commonwealth University
Atlantic sturgeon	Kristine Edwards	5	New York State Thruway Authority
Atlantic sturgeon	Charles Stence	4	Maryland Division of Natural Resources
Atlantic sturgeon	Hal Brundage	4	Environmental Research and Consulting Inc.
Atlantic sturgeon	James Sulikowski	2	University of New England
Atlantic sturgeon	Gayle Zydlewski	1	University of Maine
Atlantic sturgeon	Doug Peterson	1	University of Georgia
Atlantic sturgeon	Bill Hoffman	1	Massachusetts Division of Marine Fisheries
Black drum	Eric Reyier	1	Kennedy Space Center
Black sea bass	Bradley Stevens	1	University of Maryland Eastern Shore
Black sea bass	Samir Patel	1	Cohasset Farm
Blacktip shark	Stephen Kajiura	18	Florida Atlantic University
Blacktip shark	Beth Bowers	13	Florida Atlantic University
Blacktip shark	Bryan Frazier	9	South Carolina Department of Natural Resources
Blacktip shark	Mike Frisk	3	Stony Brook University
Blacktip shark	Keith Dunton	2	Monmouth University
Blacktip shark	Matt Ogburn	1	Smithsonian Institute
Bull shark	Debra Abercrombie	2	Stony Brook University
Cobia	Jeff Buckel	52	North Carolina State University
Cobia	Kevin Weng	50	Virginia Institute of Marine Science
Cobia	Unknown	6	Florida Fish and Wildlife Research Institute
Cobia	Steve Poland	3	North Carolina Division of Marine Fisheries
Cobia	Joy Young	2	Florida Fish and Wildlife Research Institute
Cobia	Anne Markwith	2	North Carolina Division of Marine Fisheries
Common thresher shark	Mike Frisk	5	Stony Brook University
Cownose ray	Matt Ogburn	30	Smithsonian Institute
Cownose ray	Charles Bangley	3	Smithsonian Institute
Dusky shark	Matt Ogburn	13	Smithsonian Institute
Dusky shark	Charles Bangley	10	Smithsonian Institute
Dusky shark	Keith Dunton	8	Monmouth University
Dusky shark	Tobey Curtis	3	National Oceanic Atmospheric Administration
Dusky shark	Mike Frisk	2	Stony Brook University
Little skate	Mike Frisk	1	Stony Brook University
Loggerhead sea turtle	Mike Arendt	2	South Carolina Department of Natural Resources
Loggerhead sea turtle	Carter Watterson	1	United States Navy

Species	Tagger	Tags Detected	Institute
Roughtail skate	Keith Dunton	2	Monmouth University
Sand tiger shark	Danielle Haulsee	27	University of Delaware
Sand tiger shark	Madeline Marens	18	University of North Carolina Wilmington
Sand tiger shark	Keith Dunton	15	Monmouth University
Sand tiger shark	Jeff Kneebone	14	New England Aquarium
Sand tiger shark	Dewayne Fox	12	Delaware State University
Sand tiger shark	Jake Labelle	11	Wildlife Conservation Society
Sand tiger shark	Greg Skomal	11	Massachusetts Division of Marine Fisheries
Sand tiger shark	Jennifer Wyffels	2	South-East Zoo Alliance for Reproduction and Conservation
Sand tiger shark	Bryan Franks	1	OCEARCH
Sand tiger shark	Mike Frisk	1	Stony Brook University
Sandbar shark	Keith Dunton	30	Monmouth University
Sandbar shark	Caroline Collatos	4	New England Aquarium
Sandbar shark	Mike Frisk	4	Stony Brook University
Sandbar shark	Jessica Wingar	4	Coastal Carolina University
Sandbar shark	Steve Szedlmayer	1	Auburn University
Smooth dogfish	Matt Ogburn	7	Smithsonian Institute
Smooth dogfish	Tobey Curtis	1	National Oceanic Atmospheric Administration
Spiny dogfish	Keith Dunton	5	Monmouth University
Spiny dogfish	Roger Rulifson	1	East Carolina University
Spotted trout	Pat Mcgrath	3	Virginia Institute of Marine Science
Striped bass	Bill Hoffman	93	Massachusetts Division of Marine Fisheries
Striped bass	Ian Park	85	Delaware Division of Fish and Wildlife
Striped bass	Dave Secor	55	University of Maryland Eastern Shore
Striped bass	Gail Wippelhauser	5	Maine Division of Marine Resources
Striped bass	Bill Murphy	3	Massachusetts Division of Marine Fisheries
Striped bass	Steven Zottoli	1	Marine Biological Laboratory
Striped bass	Jason Bartlett	1	Maryland Division of Natural Resources
Tarpon	Andy Danylchuk	2	Bonefish and Tarpon Trust
Tiger shark	Bryan Frazier	2	South Carolina Department of Natural Resources
Tiger shark	Neil Hammerschlag	1	Rosenstiel School of Marine and Atmospheric Science
Unknown		289	
White shark	Greg Skomal	120	Massachusetts Division of Marine Fisheries
White shark	Bryan Franks	25	OCEARCH
White shark	Tobey Curtis	13	National Oceanic Atmospheric Administration
Winter skate	Dewayne Fox	1	Delaware State University
Winter skate	Mike Frisk	1	Stony Brook University

C.2 WFA Tagger Data.

Species	Tagger	Tags Detected	Institute
American shad	Holly White	2	North Carolina Division of Marine Fisheries

Species	Tagger	Tags Detected	Institute
Atlantic bluefin tuna	Barbara Block	1	Stanford University
Atlantic sturgeon	Keith Dunton	124	Monmouth University
Atlantic sturgeon	Matt Balazik	121	US Army Corps of Engineers
Atlantic sturgeon	Dewayne Fox	99	Delaware State University
Atlantic sturgeon	Evan Ingram	83	Stony Brook University
Atlantic sturgeon	Christian Hager	38	Chesapeake Scientific LLC
Atlantic sturgeon	Eric Hilton	34	Virginia Institute of Marine Science
Atlantic sturgeon	Bill Post	21	South Carolina Division Natural Resources
Atlantic sturgeon	Tom Savoy	12	Connecticut Department of Energy and Environmental Protection
Atlantic sturgeon	Anne Wright	5	Virginia Commonwealth University
Atlantic sturgeon	Ian Park	5	Delaware Division of Fish and Wildlife
Atlantic sturgeon	Charles Stence	4	Maryland Division of Natural Resources
Atlantic sturgeon	Mike Loeffler	4	North Carolina Division of Marine Fisheries
Atlantic sturgeon	Kristine Edwards	2	New York State Thruway Authority
Atlantic sturgeon	Hal Brundage	2	Environmental Research and Consulting Inc.
Atlantic sturgeon	James Sulikowski	1	University of New England
Black drum	Matt Kenworthy	1	University of North Carolina Chapel Hill
Blacktip shark	Stephen Kajiura	13	Florida Atlantic University
Blacktip shark	Beth Bowers	6	Florida Atlantic University
Blacktip shark	Mike Frisk	5	Stony Brook University
Blacktip shark	Keith Dunton	2	Monmouth University
Blacktip shark	Bryan Frazier	1	South Carolina Department of Natural Resources
Blacktip shark	Matt Ogburn	1	Smithsonian Institute
Blueback herring	Bill Post	1	South Carolina Division Natural Resources
Cobia	Jeff Buckel	22	North Carolina State University
Cobia	Kevin Weng	15	Virginia Institute of Marine Science
Cobia	Unknown	3	Florida Fish and Wildlife Research Institute
Cobia	Steve Poland	1	North Carolina Division of Marine Fisheries
Cobia	Anne Markwith	1	North Carolina Division of Marine Fisheries
Common thresher shark	Mike Frisk	3	Stony Brook University
Cownose ray	Matt Ogburn	3	Smithsonian Institute
Cownose ray	Charles Bangley	1	Smithsonian Institute
Dusky shark	Matt Ogburn	14	Smithsonian Institute
Dusky shark	Charles Bangley	7	Smithsonian Institute
Dusky shark	Keith Dunton	4	Monmouth University
Dusky shark	Tobey Curtis	3	National Oceanic Atmospheric Administration
Dusky shark	Mike Frisk	1	Stony Brook University
Little skate	Mike Frisk	1	Stony Brook University

Species	Tagger	Tags Detected	Institute
Loggerhead sea turtle	Mike Arendt	1	South Carolina Division Natural Resources
Sand tiger shark	Madeline Marens	4	University of North Carolina Wilmington
Sand tiger shark	Danielle Haulsee	2	University of Delaware
Sand tiger shark	Jeff Kneebone	2	New England Aquarium
Sand tiger shark	Keith Dunton	1	Monmouth University
Sandbar shark	Keith Dunton	21	Monmouth University
Sandbar shark	Mike Frisk	4	Stony Brook University
Sandbar shark	Caroline Collatos	3	New England Aquarium
Sandbar shark	Tobey Curtis	1	National Oceanic Atmospheric Administration
Sandbar shark	Jessica Wingar	1	Coastal Carolina University
Smooth dogfish	Matt Ogburn	4	Smithsonian Institute
Smooth dogfish	Keith Dunton	1	Monmouth University
Spinner shark	Matt Ogburn	1	Smithsonian Institute
Spiny dogfish	Keith Dunton	2	Monmouth University
Spiny dogfish	Roger Rulifson	1	East Carolina University
Striped bass	Bill Hoffman	155	Massachusetts Division of Marine Fisheries
Striped bass	Ian Park	104	Delaware Division of Fish and Wildlife
Striped bass	Dave Secor	88	University of Maryland Eastern Shore
Striped bass	Gail Wippelhauser	9	Maine Division of Marine Resources
Striped bass	Bill Murphy	5	Massachusetts Division of Marine Fisheries
Striped bass	Steven Zottoli	4	Marine Biological Laboratory
Striped bass	Jason Bartlett	2	Maryland Division of Natural Resources
Striped bass	Keith Dunton	1	Monmouth University
Tiger shark	Bryan Frazier	3	South Carolina Department of Natural Resources
Tiger shark	Matt Smukall	2	Bimini Shark Lab
Tiger shark	Neil Hammerschlag	1	Rosenstiel School of Marine and Atmospheric Science
Unknown		172	
White shark	Greg Skomal	98	Massachusetts Division of Marine Fisheries
White shark	Bryan Franks	19	OCEARCH
White shark	Tobey Curtis	9	National Oceanic Atmospheric Administration
Winter skate	Dewayne Fox	1	Delaware State University

Appendix D: Major Species Detection Data.

D.1 CRA Atlantic sturgeon detections by year and month.

Species	Year	Month	Individuals	Detections	Days	Temperature
Atlantic sturgeon	2015	Dec	96	9508	17	14.32
Atlantic sturgeon	2016	Jan	129	7560	31	10.39
Atlantic sturgeon	2016	Feb	55	4838	27	6.88
Atlantic sturgeon	2016	Mar	86	7390	29	7.72
Atlantic sturgeon	2016	Apr	159	5639	30	10.25
Atlantic sturgeon	2016	May	38	395	19	13.15
Atlantic sturgeon	2016	Jun	12	58	14	14.95
Atlantic sturgeon	2016	Jul	1	25	4	15.84
Atlantic sturgeon	2016	Aug	4	34	5	15.03
Atlantic sturgeon	2016	Sep	7	19	9	23.15
Atlantic sturgeon	2016	Oct	10	93	12	21
Atlantic sturgeon	2016	Nov	70	896	28	16.12
Atlantic sturgeon	2016	Dec	112	2041	30	11.53
Atlantic sturgeon	2017	Jan	55	1346	25	8.73
Atlantic sturgeon	2017	Feb	27	576	25	7.7
Atlantic sturgeon	2017	Mar	86	2260	31	8.02
Atlantic sturgeon	2017	Apr	104	1980	30	9.67
Atlantic sturgeon	2017	May	24	335	12	13.41
Atlantic sturgeon	2017	Jun	8	24	6	16.13
Atlantic sturgeon	2017	Jul	0	0	0	13.02
Atlantic sturgeon	2017	Aug	0	0	0	19.89
Atlantic sturgeon	2017	Sep	6	13	6	23.34
Atlantic sturgeon	2017	Oct	5	11	5	21.35
Atlantic sturgeon	2017	Nov	28	252	18	17.09
Atlantic sturgeon	2017	Dec	79	2453	28	12.47
Atlantic sturgeon	2018	Jan	70	1822	25	5.9
Atlantic sturgeon	2018	Feb	31	962	23	5.6
Atlantic sturgeon	2018	Mar	43	3568	29	6.69
Atlantic sturgeon	2018	Apr	130	4448	30	8.49
Atlantic sturgeon	2018	May	57	1173	25	11.12
Atlantic sturgeon	2018	Jun	10	28	10	15.48
Atlantic sturgeon	2018	Jul	0	0	0	19.16
Atlantic sturgeon	2018	Aug	0	0	0	16.2
Atlantic sturgeon	2018	Sep	1	3	1	22.26
Atlantic sturgeon	2018	Oct	10	68	12	22.79
Atlantic sturgeon	2018	Nov	33	798	18	16.83
Atlantic sturgeon	2018	Dec	112	6634	31	11.56
Atlantic sturgeon	2019	Jan	63	2500	25	8.91
Atlantic sturgeon	2019	Feb	27	994	27	6.92
Atlantic sturgeon	2019	Mar	78	1364	30	6.95

Species	Year	Month	Individuals	Detections	Days	Temperature
Atlantic sturgeon	2019	Apr	116	3386	30	9.02
Atlantic sturgeon	2019	May	24	308	16	11.91
Atlantic sturgeon	2019	Jun	6	23	6	13.14
Atlantic sturgeon	2019	Jul	1	1	1	12.83
Atlantic sturgeon	2019	Aug	2	6	2	15.49
Atlantic sturgeon	2019	Sep	1	11	2	23.13
Atlantic sturgeon	2019	Oct	9	87	9	20.96
Atlantic sturgeon	2019	Nov	48	1009	21	16.21
Atlantic sturgeon	2019	Dec	55	825	26	11.52
Atlantic sturgeon	2020	Jan	20	552	21	9.67
Atlantic sturgeon	2020	Feb	26	5908	24	8.15
Atlantic sturgeon	2020	Mar	70	4197	29	9.01
Atlantic sturgeon	2020	Apr	95	1228	29	10.66
Atlantic sturgeon	2020	May	10	83	11	13.09
Atlantic sturgeon	2020	Jun	4	30	5	16.19
Atlantic sturgeon	2020	Jul	1	15	2	16.93
Atlantic sturgeon	2020	Aug	7	54	5	17.67
Atlantic sturgeon	2020	Sep	4	12	4	22.05
Atlantic sturgeon	2020	Oct	12	150	9	20.27
Atlantic sturgeon	2020	Nov	103	1444	30	16.92
Atlantic sturgeon	2020	Dec	94	3017	30	15.57
Atlantic sturgeon	2021	Jan	51	6321	31	9.82
Atlantic sturgeon	2021	Feb	36	1670	26	6.86
Atlantic sturgeon	2021	Mar	52	4084	27	7.73
Atlantic sturgeon	2021	Apr	122	6114	30	10.64
Atlantic sturgeon	2021	May	24	162	15	13.57
Atlantic sturgeon	2021	Jun	4	27	4	15.66

D.2 CRA Atlantic sturgeon detections by receiver site, month, and year.

Species	Site	Month	Year	Individuals	Detections	Days
Atlantic sturgeon	1 BOEM	Jan	2016	3	11	3
Atlantic sturgeon	1 BOEM	Jan	2017	6	54	6
Atlantic sturgeon	1 BOEM	Jan	2018	4	53	4
Atlantic sturgeon	1 BOEM	Jan	2019	4	27	4
Atlantic sturgeon	1 BOEM	Jan	2020	2	24	2
Atlantic sturgeon	1 BOEM	Jan	2021	1	1	1
Atlantic sturgeon	1 BOEM	Feb	2016	2	17	2
Atlantic sturgeon	1 BOEM	Feb	2017	1	3	1
Atlantic sturgeon	1 BOEM	Feb	2018	1	24	2
Atlantic sturgeon	1 BOEM	Feb	2019	1	22	1

Species	Site	Month	Year	Individuals	Detections	Days
Atlantic sturgeon	1 BOEM	Feb	2020	4	49	5
Atlantic sturgeon	1 BOEM	Mar	2016	2	20	2
Atlantic sturgeon	1 BOEM	Mar	2017	4	22	4
Atlantic sturgeon	1 BOEM	Mar	2018	5	38	5
Atlantic sturgeon	1 BOEM	Mar	2019	11	76	11
Atlantic sturgeon	1 BOEM	Mar	2020	13	112	10
Atlantic sturgeon	1 BOEM	Apr	2016	11	51	10
Atlantic sturgeon	1 BOEM	Apr	2017	9	63	7
Atlantic sturgeon	1 BOEM	Apr	2018	12	77	10
Atlantic sturgeon	1 BOEM	Apr	2019	18	278	15
Atlantic sturgeon	1 BOEM	Apr	2020	20	165	11
Atlantic sturgeon	1 BOEM	Apr	2021	3	9	2
Atlantic sturgeon	1 BOEM	May	2016	3	32	4
Atlantic sturgeon	1 BOEM	May	2017	5	18	4
Atlantic sturgeon	1 BOEM	May	2018	7	27	5
Atlantic sturgeon	1 BOEM	May	2020	1	13	2
Atlantic sturgeon	1 BOEM	May	2021	1	8	1
Atlantic sturgeon	1 BOEM	Jun	2016	1	7	1
Atlantic sturgeon	1 BOEM	Jun	2018	1	1	1
Atlantic sturgeon	1 BOEM	Jul	2016	1	4	1
Atlantic sturgeon	1 BOEM	Sep	2019	1	1	1
Atlantic sturgeon	1 BOEM	Sep	2020	1	2	1
Atlantic sturgeon	1 BOEM	Oct	2016	1	8	1
Atlantic sturgeon	1 BOEM	Oct	2017	1	4	1
Atlantic sturgeon	1 BOEM	Oct	2018	3	10	4
Atlantic sturgeon	1 BOEM	Oct	2019	4	61	5
Atlantic sturgeon	1 BOEM	Oct	2020	1	1	1
Atlantic sturgeon	1 BOEM	Nov	2016	12	215	11
Atlantic sturgeon	1 BOEM	Nov	2017	8	67	6
Atlantic sturgeon	1 BOEM	Nov	2018	12	205	11
Atlantic sturgeon	1 BOEM	Nov	2019	9	96	6
Atlantic sturgeon	1 BOEM	Nov	2020	16	161	10
Atlantic sturgeon	1 BOEM	Dec	2015	10	131	7
Atlantic sturgeon	1 BOEM	Dec	2016	19	252	15
Atlantic sturgeon	1 BOEM	Dec	2017	12	92	11
Atlantic sturgeon	1 BOEM	Dec	2018	17	162	11
Atlantic sturgeon	1 BOEM	Dec	2019	13	249	9
Atlantic sturgeon	1 BOEM	Dec	2020	14	89	10
Atlantic sturgeon	2 BOEM	Jan	2016	6	132	6
Atlantic sturgeon	2 BOEM	Jan	2017	8	104	8
Atlantic sturgeon	2 BOEM	Jan	2019	7	343	10
Atlantic sturgeon	2 BOEM	Jan	2020	4	201	7
Atlantic sturgeon	2 BOEM	Jan	2021	6	66	6
Atlantic sturgeon	2 BOEM	Feb	2016	2	275	4
Atlantic sturgeon	2 BOEM	Feb	2017	3	22	3
Atlantic sturgeon	2 BOEM	Feb	2019	4	265	15
Atlantic sturgeon	2 BOEM	Feb	2020	4	147	4
Atlantic sturgeon	2 BOEM	Feb	2021	1	7	1
Atlantic sturgeon	2 BOEM	Mar	2016	2	19	2
Atlantic sturgeon	2 BOEM	Mar	2017	4	25	3

Species	Site	Month	Year	Individuals	Detections	Days
Atlantic sturgeon	2 BOEM	Mar	2019	7	59	7
Atlantic sturgeon	2 BOEM	Mar	2020	9	145	11
Atlantic sturgeon	2 BOEM	Mar	2021	5	80	5
Atlantic sturgeon	2 BOEM	Apr	2016	13	98	10
Atlantic sturgeon	2 BOEM	Apr	2017	16	345	14
Atlantic sturgeon	2 BOEM	Apr	2019	18	286	14
Atlantic sturgeon	2 BOEM	Apr	2020	16	207	19
Atlantic sturgeon	2 BOEM	Apr	2021	15	160	11
Atlantic sturgeon	2 BOEM	May	2016	6	153	8
Atlantic sturgeon	2 BOEM	May	2017	1	30	1
Atlantic sturgeon	2 BOEM	May	2018	9	137	8
Atlantic sturgeon	2 BOEM	May	2019	2	20	1
Atlantic sturgeon	2 BOEM	May	2020	1	11	1
Atlantic sturgeon	2 BOEM	Jun	2016	1	2	1
Atlantic sturgeon	2 BOEM	Oct	2016	2	21	2
Atlantic sturgeon	2 BOEM	Nov	2016	4	176	4
Atlantic sturgeon	2 BOEM	Nov	2018	7	147	6
Atlantic sturgeon	2 BOEM	Nov	2019	9	674	12
Atlantic sturgeon	2 BOEM	Nov	2020	7	53	8
Atlantic sturgeon	2 BOEM	Dec	2015	5	109	4
Atlantic sturgeon	2 BOEM	Dec	2016	21	468	18
Atlantic sturgeon	2 BOEM	Dec	2018	18	315	15
Atlantic sturgeon	2 BOEM	Dec	2019	6	20	7
Atlantic sturgeon	2 BOEM	Dec	2020	13	125	12
Atlantic sturgeon	3 BOEM	Jan	2016	9	91	6
Atlantic sturgeon	3 BOEM	Jan	2017	2	28	2
Atlantic sturgeon	3 BOEM	Jan	2018	4	25	4
Atlantic sturgeon	3 BOEM	Jan	2019	5	62	5
Atlantic sturgeon	3 BOEM	Jan	2021	5	76	5
Atlantic sturgeon	3 BOEM	Feb	2016	1	15	1
Atlantic sturgeon	3 BOEM	Feb	2017	2	8	2
Atlantic sturgeon	3 BOEM	Feb	2018	1	41	1
Atlantic sturgeon	3 BOEM	Feb	2019	1	16	1
Atlantic sturgeon	3 BOEM	Feb	2020	3	64	3
Atlantic sturgeon	3 BOEM	Feb	2021	7	82	7
Atlantic sturgeon	3 BOEM	Mar	2016	3	21	3
Atlantic sturgeon	3 BOEM	Mar	2017	6	20	5
Atlantic sturgeon	3 BOEM	Mar	2018	4	17	3
Atlantic sturgeon	3 BOEM	Mar	2019	12	138	9
Atlantic sturgeon	3 BOEM	Mar	2020	10	133	11
Atlantic sturgeon	3 BOEM	Mar	2021	3	31	3
Atlantic sturgeon	3 BOEM	Apr	2016	12	84	10
Atlantic sturgeon	3 BOEM	Apr	2017	14	160	12
Atlantic sturgeon	3 BOEM	Apr	2018	15	566	12
Atlantic sturgeon	3 BOEM	Apr	2019	23	200	18
Atlantic sturgeon	3 BOEM	Apr	2020	13	122	11
Atlantic sturgeon	3 BOEM	Apr	2021	15	1806	13
Atlantic sturgeon	3 BOEM	May	2016	1	14	1
Atlantic sturgeon	3 BOEM	May	2017	2	14	1
Atlantic sturgeon	3 BOEM	May	2018	8	79	5

Species	Site	Month	Year	Individuals	Detections	Days
Atlantic sturgeon	3 BOEM	May	2019	1	4	1
Atlantic sturgeon	3 BOEM	May	2020	2	9	2
Atlantic sturgeon	3 BOEM	Oct	2016	2	20	2
Atlantic sturgeon	3 BOEM	Nov	2016	7	62	8
Atlantic sturgeon	3 BOEM	Nov	2017	1	5	1
Atlantic sturgeon	3 BOEM	Nov	2018	5	222	4
Atlantic sturgeon	3 BOEM	Nov	2020	4	153	4
Atlantic sturgeon	3 BOEM	Dec	2015	10	170	7
Atlantic sturgeon	3 BOEM	Dec	2016	17	278	17
Atlantic sturgeon	3 BOEM	Dec	2017	4	104	4
Atlantic sturgeon	3 BOEM	Dec	2018	16	361	13
Atlantic sturgeon	3 BOEM	Dec	2020	15	724	16
Atlantic sturgeon	4 BOEM	Jan	2016	13	178	8
Atlantic sturgeon	4 BOEM	Jan	2017	9	603	11
Atlantic sturgeon	4 BOEM	Jan	2018	7	19	6
Atlantic sturgeon	4 BOEM	Jan	2019	4	67	5
Atlantic sturgeon	4 BOEM	Jan	2020	5	45	4
Atlantic sturgeon	4 BOEM	Jan	2021	7	945	10
Atlantic sturgeon	4 BOEM	Feb	2016	2	20	2
Atlantic sturgeon	4 BOEM	Feb	2018	14	454	13
Atlantic sturgeon	4 BOEM	Feb	2019	3	23	3
Atlantic sturgeon	4 BOEM	Feb	2020	5	97	6
Atlantic sturgeon	4 BOEM	Feb	2021	4	56	4
Atlantic sturgeon	4 BOEM	Mar	2016	3	17	5
Atlantic sturgeon	4 BOEM	Mar	2017	7	1490	11
Atlantic sturgeon	4 BOEM	Mar	2018	5	958	6
Atlantic sturgeon	4 BOEM	Mar	2019	9	125	10
Atlantic sturgeon	4 BOEM	Mar	2020	7	209	5
Atlantic sturgeon	4 BOEM	Mar	2021	11	336	11
Atlantic sturgeon	4 BOEM	Apr	2016	19	242	18
Atlantic sturgeon	4 BOEM	Apr	2017	12	154	13
Atlantic sturgeon	4 BOEM	Apr	2018	22	748	16
Atlantic sturgeon	4 BOEM	Apr	2019	18	1090	20
Atlantic sturgeon	4 BOEM	Apr	2020	10	238	8
Atlantic sturgeon	4 BOEM	Apr	2021	21	220	16
Atlantic sturgeon	4 BOEM	May	2016	2	12	2
Atlantic sturgeon	4 BOEM	May	2018	8	179	9
Atlantic sturgeon	4 BOEM	May	2019	6	42	6
Atlantic sturgeon	4 BOEM	Aug	2019	1	5	1
Atlantic sturgeon	4 BOEM	Oct	2016	3	18	3
Atlantic sturgeon	4 BOEM	Nov	2016	3	10	3
Atlantic sturgeon	4 BOEM	Nov	2018	2	6	2
Atlantic sturgeon	4 BOEM	Nov	2019	4	13	5
Atlantic sturgeon	4 BOEM	Dec	2015	10	101	7
Atlantic sturgeon	4 BOEM	Dec	2016	16	576	15
Atlantic sturgeon	4 BOEM	Dec	2017	7	82	7
Atlantic sturgeon	4 BOEM	Dec	2018	14	1857	22
Atlantic sturgeon	4 BOEM	Dec	2019	15	127	12
Atlantic sturgeon	4 BOEM	Dec	2020	15	227	12
Atlantic sturgeon	5 BOEM	Jan	2016	36	2855	23

Species	Site	Month	Year	Individuals	Detections	Days
Atlantic sturgeon	5 BOEM	Jan	2017	4	60	3
Atlantic sturgeon	5 BOEM	Jan	2019	16	194	12
Atlantic sturgeon	5 BOEM	Jan	2020	10	265	15
Atlantic sturgeon	5 BOEM	Jan	2021	5	547	10
Atlantic sturgeon	5 BOEM	Feb	2016	9	407	10
Atlantic sturgeon	5 BOEM	Feb	2017	5	148	5
Atlantic sturgeon	5 BOEM	Feb	2019	6	55	6
Atlantic sturgeon	5 BOEM	Feb	2020	1	1	1
Atlantic sturgeon	5 BOEM	Mar	2016	5	3769	11
Atlantic sturgeon	5 BOEM	Mar	2017	14	119	15
Atlantic sturgeon	5 BOEM	Mar	2019	7	53	7
Atlantic sturgeon	5 BOEM	Apr	2016	20	2493	21
Atlantic sturgeon	5 BOEM	Apr	2017	9	373	12
Atlantic sturgeon	5 BOEM	Apr	2019	15	245	21
Atlantic sturgeon	5 BOEM	May	2016	1	7	1
Atlantic sturgeon	5 BOEM	May	2017	3	38	2
Atlantic sturgeon	5 BOEM	May	2019	4	110	5
Atlantic sturgeon	5 BOEM	Nov	2016	3	47	3
Atlantic sturgeon	5 BOEM	Nov	2018	4	53	4
Atlantic sturgeon	5 BOEM	Nov	2019	8	104	6
Atlantic sturgeon	5 BOEM	Nov	2020	3	98	7
Atlantic sturgeon	5 BOEM	Dec	2015	28	5346	16
Atlantic sturgeon	5 BOEM	Dec	2016	11	122	11
Atlantic sturgeon	5 BOEM	Dec	2018	16	285	15
Atlantic sturgeon	5 BOEM	Dec	2019	21	280	18
Atlantic sturgeon	5 BOEM	Dec	2020	13	988	13
Atlantic sturgeon	6 BOEM	Jan	2016	41	995	20
Atlantic sturgeon	6 BOEM	Jan	2017	4	59	5
Atlantic sturgeon	6 BOEM	Jan	2018	15	449	7
Atlantic sturgeon	6 BOEM	Jan	2019	28	775	11
Atlantic sturgeon	6 BOEM	Feb	2016	8	250	7
Atlantic sturgeon	6 BOEM	Feb	2017	5	102	5
Atlantic sturgeon	6 BOEM	Feb	2018	5	47	5
Atlantic sturgeon	6 BOEM	Feb	2019	5	153	8
Atlantic sturgeon	6 BOEM	Feb	2020	5	659	11
Atlantic sturgeon	6 BOEM	Mar	2016	5	55	5
Atlantic sturgeon	6 BOEM	Mar	2017	8	143	6
Atlantic sturgeon	6 BOEM	Mar	2018	7	959	14
Atlantic sturgeon	6 BOEM	Mar	2019	9	361	11
Atlantic sturgeon	6 BOEM	Mar	2020	8	91	10
Atlantic sturgeon	6 BOEM	Apr	2016	17	334	14
Atlantic sturgeon	6 BOEM	Apr	2017	22	585	18
Atlantic sturgeon	6 BOEM	Apr	2018	31	1005	24
Atlantic sturgeon	6 BOEM	Apr	2019	15	937	15
Atlantic sturgeon	6 BOEM	Apr	2020	7	88	8
Atlantic sturgeon	6 BOEM	Apr	2021	8	195	7
Atlantic sturgeon	6 BOEM	May	2016	3	12	3
Atlantic sturgeon	6 BOEM	May	2017	6	45	4
Atlantic sturgeon	6 BOEM	May	2018	8	248	6
Atlantic sturgeon	6 BOEM	May	2019	4	75	5

Species	Site	Month	Year	Individuals	Detections	Days
Atlantic sturgeon	6 BOEM	Jun	2018	1	1	1
Atlantic sturgeon	6 BOEM	Nov	2016	1	11	1
Atlantic sturgeon	6 BOEM	Nov	2020	1	9	1
Atlantic sturgeon	6 BOEM	Dec	2015	19	392	9
Atlantic sturgeon	6 BOEM	Dec	2016	9	66	8
Atlantic sturgeon	6 BOEM	Dec	2017	24	958	15
Atlantic sturgeon	6 BOEM	Dec	2018	31	1070	23
Atlantic sturgeon	6 BOEM	Dec	2020	4	73	4
Atlantic sturgeon	BOEM 13	Jan	2016	33	2892	25
Atlantic sturgeon	BOEM 13	Jan	2018	27	1061	19
Atlantic sturgeon	BOEM 13	Jan	2019	23	901	15
Atlantic sturgeon	BOEM 13	Jan	2021	27	3882	30
Atlantic sturgeon	BOEM 13	Feb	2016	15	3536	19
Atlantic sturgeon	BOEM 13	Feb	2018	10	265	12
Atlantic sturgeon	BOEM 13	Feb	2019	3	372	8
Atlantic sturgeon	BOEM 13	Feb	2020	5	4868	12
Atlantic sturgeon	BOEM 13	Feb	2021	9	547	9
Atlantic sturgeon	BOEM 13	Mar	2016	14	840	17
Atlantic sturgeon	BOEM 13	Mar	2018	14	1154	17
Atlantic sturgeon	BOEM 13	Mar	2019	15	237	13
Atlantic sturgeon	BOEM 13	Mar	2020	17	3393	22
Atlantic sturgeon	BOEM 13	Mar	2021	11	2846	14
Atlantic sturgeon	BOEM 13	Apr	2016	16	1063	18
Atlantic sturgeon	BOEM 13	Apr	2018	33	1347	21
Atlantic sturgeon	BOEM 13	Apr	2019	15	173	12
Atlantic sturgeon	BOEM 13	Apr	2020	13	159	12
Atlantic sturgeon	BOEM 13	Apr	2021	18	2275	17
Atlantic sturgeon	BOEM 13	May	2016	3	40	3
Atlantic sturgeon	BOEM 13	May	2018	14	338	10
Atlantic sturgeon	BOEM 13	May	2019	1	2	1
Atlantic sturgeon	BOEM 13	Nov	2018	2	10	2
Atlantic sturgeon	BOEM 13	Dec	2015	23	2850	12
Atlantic sturgeon	BOEM 13	Dec	2017	18	1027	15
Atlantic sturgeon	BOEM 13	Dec	2018	30	2385	21
Atlantic sturgeon	BOEM 13	Dec	2020	8	290	8
Atlantic sturgeon	BOEM 14	Jan	2016	31	321	20
Atlantic sturgeon	BOEM 14	Jan	2017	8	186	8
Atlantic sturgeon	BOEM 14	Jan	2018	20	175	14
Atlantic sturgeon	BOEM 14	Jan	2019	11	101	9
Atlantic sturgeon	BOEM 14	Jan	2021	22	756	24
Atlantic sturgeon	BOEM 14	Feb	2016	19	231	18
Atlantic sturgeon	BOEM 14	Feb	2017	12	178	14
Atlantic sturgeon	BOEM 14	Feb	2018	8	96	9
Atlantic sturgeon	BOEM 14	Feb	2019	3	25	3
Atlantic sturgeon	BOEM 14	Feb	2021	10	914	17
Atlantic sturgeon	BOEM 14	Mar	2016	16	588	13
Atlantic sturgeon	BOEM 14	Mar	2017	13	141	12
Atlantic sturgeon	BOEM 14	Mar	2018	3	27	3
Atlantic sturgeon	BOEM 14	Mar	2019	11	86	7
Atlantic sturgeon	BOEM 14	Mar	2021	11	600	19

Species	Site	Month	Year	Individuals	Detections	Days
Atlantic sturgeon	BOEM 14	Apr	2016	21	142	15
Atlantic sturgeon	BOEM 14	Apr	2017	13	90	10
Atlantic sturgeon	BOEM 14	Apr	2018	12	73	10
Atlantic sturgeon	BOEM 14	Apr	2019	4	34	4
Atlantic sturgeon	BOEM 14	Apr	2021	16	1175	15
Atlantic sturgeon	BOEM 14	May	2016	2	6	2
Atlantic sturgeon	BOEM 14	May	2017	4	159	3
Atlantic sturgeon	BOEM 14	May	2018	3	57	3
Atlantic sturgeon	BOEM 14	Oct	2016	1	1	1
Atlantic sturgeon	BOEM 14	Nov	2016	1	2	1
Atlantic sturgeon	BOEM 14	Nov	2018	2	7	2
Atlantic sturgeon	BOEM 14	Dec	2015	15	305	12
Atlantic sturgeon	BOEM 14	Dec	2016	6	23	4
Atlantic sturgeon	BOEM 14	Dec	2017	12	99	10
Atlantic sturgeon	BOEM 14	Dec	2018	10	78	10
Atlantic sturgeon	BOEM 14	Dec	2020	10	292	12
Atlantic sturgeon	CB	Jan	2017	4	25	4
Atlantic sturgeon	CB	Jan	2019	4	12	4
Atlantic sturgeon	CB	Jan	2020	2	9	2
Atlantic sturgeon	CB	Jan	2021	3	18	3
Atlantic sturgeon	CB	Feb	2016	2	4	2
Atlantic sturgeon	CB	Feb	2017	1	4	1
Atlantic sturgeon	CB	Feb	2021	3	23	3
Atlantic sturgeon	CB	Mar	2016	3	6	3
Atlantic sturgeon	CB	Mar	2017	3	12	3
Atlantic sturgeon	CB	Mar	2018	6	7	5
Atlantic sturgeon	CB	Mar	2019	8	47	7
Atlantic sturgeon	CB	Mar	2020	6	26	5
Atlantic sturgeon	CB	Mar	2021	6	35	6
Atlantic sturgeon	CB	Apr	2016	2	4	1
Atlantic sturgeon	CB	Apr	2017	1	9	1
Atlantic sturgeon	CB	Apr	2018	4	13	4
Atlantic sturgeon	CB	Apr	2019	5	16	4
Atlantic sturgeon	CB	Apr	2020	13	33	9
Atlantic sturgeon	CB	Apr	2021	6	33	6
Atlantic sturgeon	CB	May	2016	1	3	1
Atlantic sturgeon	CB	May	2017	1	2	1
Atlantic sturgeon	CB	May	2018	1	10	1
Atlantic sturgeon	CB	Sep	2020	1	3	1
Atlantic sturgeon	CB	Oct	2018	2	7	2
Atlantic sturgeon	CB	Oct	2019	1	4	1
Atlantic sturgeon	CB	Nov	2016	9	86	8
Atlantic sturgeon	CB	Nov	2017	1	8	1
Atlantic sturgeon	CB	Nov	2018	2	12	1
Atlantic sturgeon	CB	Nov	2019	13	56	13
Atlantic sturgeon	CB	Nov	2020	20	312	14
Atlantic sturgeon	CB	Dec	2015	3	8	3
Atlantic sturgeon	CB	Dec	2016	12	50	10
Atlantic sturgeon	CB	Dec	2018	12	52	9
Atlantic sturgeon	CB	Dec	2019	9	84	7

Species	Site	Month	Year	Individuals	Detections	Days
Atlantic sturgeon	CB	Dec	2020	6	60	5
Atlantic sturgeon	CB1	Jan	2016	4	7	4
Atlantic sturgeon	CB1	Jan	2017	1	30	1
Atlantic sturgeon	CB1	Jan	2018	1	6	1
Atlantic sturgeon	CB1	Jan	2019	1	7	1
Atlantic sturgeon	CB1	Jan	2020	1	8	2
Atlantic sturgeon	CB1	Feb	2016	1	8	1
Atlantic sturgeon	CB1	Feb	2017	1	5	1
Atlantic sturgeon	CB1	Feb	2019	4	19	3
Atlantic sturgeon	CB1	Feb	2020	2	4	2
Atlantic sturgeon	CB1	Mar	2016	4	10	3
Atlantic sturgeon	CB1	Mar	2017	5	22	5
Atlantic sturgeon	CB1	Mar	2019	3	11	3
Atlantic sturgeon	CB1	Mar	2020	1	3	1
Atlantic sturgeon	CB1	Mar	2021	1	6	1
Atlantic sturgeon	CB1	Apr	2016	10	30	10
Atlantic sturgeon	CB1	Apr	2017	2	23	2
Atlantic sturgeon	CB1	Apr	2019	3	9	3
Atlantic sturgeon	CB1	Apr	2020	10	35	10
Atlantic sturgeon	CB1	Apr	2021	8	36	8
Atlantic sturgeon	CB1	May	2016	2	9	2
Atlantic sturgeon	CB1	May	2018	4	26	4
Atlantic sturgeon	CB1	May	2019	1	7	1
Atlantic sturgeon	CB1	May	2021	1	2	1
Atlantic sturgeon	CB1	Sep	2018	1	3	1
Atlantic sturgeon	CB1	Oct	2018	2	2	2
Atlantic sturgeon	CB1	Oct	2020	1	6	1
Atlantic sturgeon	CB1	Nov	2016	9	106	7
Atlantic sturgeon	CB1	Nov	2017	2	9	2
Atlantic sturgeon	CB1	Nov	2018	4	134	5
Atlantic sturgeon	CB1	Nov	2019	6	55	4
Atlantic sturgeon	CB1	Nov	2020	15	96	9
Atlantic sturgeon	CB1	Dec	2015	1	1	1
Atlantic sturgeon	CB1	Dec	2016	11	78	8
Atlantic sturgeon	CB1	Dec	2017	7	30	5
Atlantic sturgeon	CB1	Dec	2018	3	22	3
Atlantic sturgeon	CB1	Dec	2019	5	50	3
Atlantic sturgeon	RA	Jan	2016	3	8	2
Atlantic sturgeon	RA	Jan	2017	5	30	5
Atlantic sturgeon	RA	Jan	2018	3	26	3
Atlantic sturgeon	RA	Jan	2019	1	9	1
Atlantic sturgeon	RA	Feb	2016	1	3	1
Atlantic sturgeon	RA	Feb	2018	1	4	1
Atlantic sturgeon	RA	Feb	2019	2	7	3
Atlantic sturgeon	RA	Feb	2020	3	17	4
Atlantic sturgeon	RA	Feb	2021	1	4	1
Atlantic sturgeon	RA	Mar	2016	5	18	5
Atlantic sturgeon	RA	Mar	2017	3	4	3
Atlantic sturgeon	RA	Mar	2018	3	15	3
Atlantic sturgeon	RA	Mar	2019	11	95	14

Species	Site	Month	Year	Individuals	Detections	Days
Atlantic sturgeon	RA	Mar	2020	4	37	4
Atlantic sturgeon	RA	Mar	2021	6	11	6
Atlantic sturgeon	RA	Apr	2016	2	21	2
Atlantic sturgeon	RA	Apr	2018	7	32	7
Atlantic sturgeon	RA	Apr	2019	8	50	8
Atlantic sturgeon	RA	Apr	2020	8	39	7
Atlantic sturgeon	RA	Apr	2021	11	48	9
Atlantic sturgeon	RA	May	2016	1	2	1
Atlantic sturgeon	RA	May	2018	4	15	5
Atlantic sturgeon	RA	May	2019	5	24	4
Atlantic sturgeon	RA	May	2020	1	1	1
Atlantic sturgeon	RA	May	2021	6	46	7
Atlantic sturgeon	RA	Jun	2016	1	4	1
Atlantic sturgeon	RA	Jun	2018	2	11	2
Atlantic sturgeon	RA	Jun	2019	3	8	3
Atlantic sturgeon	RA	Jun	2020	1	3	1
Atlantic sturgeon	RA	Jun	2021	2	4	2
Atlantic sturgeon	RA	Jul	2016	1	5	2
Atlantic sturgeon	RA	Jul	2020	1	15	2
Atlantic sturgeon	RA	Aug	2016	1	2	1
Atlantic sturgeon	RA	Aug	2020	4	9	3
Atlantic sturgeon	RA	Sep	2016	1	5	1
Atlantic sturgeon	RA	Sep	2017	2	4	3
Atlantic sturgeon	RA	Sep	2019	1	4	1
Atlantic sturgeon	RA	Sep	2020	1	5	1
Atlantic sturgeon	RA	Oct	2016	1	1	1
Atlantic sturgeon	RA	Oct	2017	2	3	2
Atlantic sturgeon	RA	Oct	2018	5	36	5
Atlantic sturgeon	RA	Oct	2019	3	19	3
Atlantic sturgeon	RA	Oct	2020	7	47	6
Atlantic sturgeon	RA	Nov	2016	10	26	8
Atlantic sturgeon	RA	Nov	2017	11	114	9
Atlantic sturgeon	RA	Nov	2019	3	8	3
Atlantic sturgeon	RA	Nov	2020	24	117	16
Atlantic sturgeon	RA	Dec	2015	2	7	2
Atlantic sturgeon	RA	Dec	2016	5	6	5
Atlantic sturgeon	RA	Dec	2017	6	59	4
Atlantic sturgeon	RA	Dec	2018	1	1	1
Atlantic sturgeon	RA	Dec	2019	1	4	1
Atlantic sturgeon	RA	Dec	2020	7	24	7
Atlantic sturgeon	RA Outside	Jan	2016	1	7	1
Atlantic sturgeon	RA Outside	Jan	2017	3	13	2
Atlantic sturgeon	RA Outside	Jan	2021	2	18	2
Atlantic sturgeon	RA Outside	Feb	2016	2	18	2
Atlantic sturgeon	RA Outside	Feb	2021	3	36	3
Atlantic sturgeon	RA Outside	Mar	2017	4	26	4
Atlantic sturgeon	RA Outside	Mar	2021	8	121	8
Atlantic sturgeon	RA Outside	Apr	2016	6	19	6
Atlantic sturgeon	RA Outside	Apr	2017	2	11	2
Atlantic sturgeon	RA Outside	Apr	2020	16	142	10

Species	Site	Month	Year	Individuals	Detections	Days
Atlantic sturgeon	RA Outside	Apr	2021	16	132	15
Atlantic sturgeon	RA Outside	May	2016	7	37	7
Atlantic sturgeon	RA Outside	May	2017	2	14	2
Atlantic sturgeon	RA Outside	May	2020	7	49	7
Atlantic sturgeon	RA Outside	May	2021	14	94	11
Atlantic sturgeon	RA Outside	Jun	2016	3	13	3
Atlantic sturgeon	RA Outside	Jun	2017	2	5	2
Atlantic sturgeon	RA Outside	Jun	2020	3	27	4
Atlantic sturgeon	RA Outside	Jun	2021	2	23	2
Atlantic sturgeon	RA Outside	Jul	2016	1	16	2
Atlantic sturgeon	RA Outside	Aug	2020	5	45	4
Atlantic sturgeon	RA Outside	Sep	2016	1	1	1
Atlantic sturgeon	RA Outside	Sep	2020	1	1	1
Atlantic sturgeon	RA Outside	Oct	2020	6	96	5
Atlantic sturgeon	RA Outside	Nov	2016	11	57	11
Atlantic sturgeon	RA Outside	Nov	2020	37	443	24
Atlantic sturgeon	RA Outside	Dec	2015	5	51	5
Atlantic sturgeon	RA Outside	Dec	2016	5	47	5
Atlantic sturgeon	RA Outside	Dec	2020	14	111	13
Atlantic sturgeon	RI	Jan	2016	4	58	3
Atlantic sturgeon	RI	Jan	2017	8	110	10
Atlantic sturgeon	RI	Jan	2018	2	8	2
Atlantic sturgeon	RI	Jan	2019	1	2	1
Atlantic sturgeon	RI	Feb	2016	6	30	4
Atlantic sturgeon	RI	Feb	2017	3	99	12
Atlantic sturgeon	RI	Feb	2018	5	22	5
Atlantic sturgeon	RI	Feb	2019	4	20	4
Atlantic sturgeon	RI	Feb	2020	1	2	1
Atlantic sturgeon	RI	Mar	2016	22	1923	24
Atlantic sturgeon	RI	Mar	2017	22	185	20
Atlantic sturgeon	RI	Mar	2018	14	389	21
Atlantic sturgeon	RI	Mar	2019	9	47	7
Atlantic sturgeon	RI	Mar	2020	5	9	4
Atlantic sturgeon	RI	Apr	2016	32	996	20
Atlantic sturgeon	RI	Apr	2017	19	137	13
Atlantic sturgeon	RI	Apr	2018	25	562	23
Atlantic sturgeon	RI	Apr	2019	12	52	9
Atlantic sturgeon	RI	May	2016	8	39	6
Atlantic sturgeon	RI	May	2017	4	12	3
Atlantic sturgeon	RI	May	2018	6	49	11
Atlantic sturgeon	RI	May	2019	6	22	6
Atlantic sturgeon	RI	Jun	2016	7	16	9
Atlantic sturgeon	RI	Jun	2017	5	13	4
Atlantic sturgeon	RI	Jun	2018	5	13	5
Atlantic sturgeon	RI	Jun	2019	3	15	4
Atlantic sturgeon	RI	Jul	2019	1	1	1
Atlantic sturgeon	RI	Aug	2016	4	25	4
Atlantic sturgeon	RI	Sep	2016	3	8	4
Atlantic sturgeon	RI	Sep	2017	1	5	1
Atlantic sturgeon	RI	Oct	2016	3	21	4

Species	Site	Month	Year	Individuals	Detections	Days
Atlantic sturgeon	RI	Oct	2017	1	1	1
Atlantic sturgeon	RI	Oct	2018	2	13	3
Atlantic sturgeon	RI	Nov	2016	12	83	9
Atlantic sturgeon	RI	Nov	2017	8	45	7
Atlantic sturgeon	RI	Dec	2015	4	18	5
Atlantic sturgeon	RI	Dec	2016	5	38	6
Atlantic sturgeon	RI	Dec	2017	1	1	1
Atlantic sturgeon	RI	Dec	2018	3	5	4
Atlantic sturgeon	RI2	Jan	2016	3	5	3
Atlantic sturgeon	RI2	Jan	2017	5	44	4
Atlantic sturgeon	RI2	Jan	2021	3	12	3
Atlantic sturgeon	RI2	Feb	2016	3	24	2
Atlantic sturgeon	RI2	Feb	2017	3	7	3
Atlantic sturgeon	RI2	Feb	2018	3	9	4
Atlantic sturgeon	RI2	Feb	2019	3	17	2
Atlantic sturgeon	RI2	Feb	2021	1	1	1
Atlantic sturgeon	RI2	Mar	2016	26	104	17
Atlantic sturgeon	RI2	Mar	2017	14	51	11
Atlantic sturgeon	RI2	Mar	2018	2	4	2
Atlantic sturgeon	RI2	Mar	2019	7	29	5
Atlantic sturgeon	RI2	Mar	2020	9	39	5
Atlantic sturgeon	RI2	Mar	2021	5	18	5
Atlantic sturgeon	RI2	Apr	2016	13	62	11
Atlantic sturgeon	RI2	Apr	2017	14	30	10
Atlantic sturgeon	RI2	Apr	2018	8	25	6
Atlantic sturgeon	RI2	Apr	2019	6	16	5
Atlantic sturgeon	RI2	Apr	2021	8	25	8
Atlantic sturgeon	RI2	May	2016	9	29	9
Atlantic sturgeon	RI2	May	2017	2	3	2
Atlantic sturgeon	RI2	May	2018	3	8	3
Atlantic sturgeon	RI2	May	2019	2	2	2
Atlantic sturgeon	RI2	May	2021	2	12	2
Atlantic sturgeon	RI2	Jun	2016	6	16	6
Atlantic sturgeon	RI2	Jun	2017	2	6	2
Atlantic sturgeon	RI2	Jun	2018	2	2	2
Atlantic sturgeon	RI2	Aug	2016	2	7	2
Atlantic sturgeon	RI2	Aug	2019	1	1	1
Atlantic sturgeon	RI2	Sep	2016	4	5	3
Atlantic sturgeon	RI2	Sep	2017	3	4	3
Atlantic sturgeon	RI2	Sep	2019	1	6	1
Atlantic sturgeon	RI2	Sep	2020	1	1	1
Atlantic sturgeon	RI2	Oct	2016	1	3	1
Atlantic sturgeon	RI2	Oct	2017	1	3	1
Atlantic sturgeon	RI2	Oct	2019	1	3	1
Atlantic sturgeon	RI2	Nov	2016	6	15	6
Atlantic sturgeon	RI2	Nov	2017	1	4	1
Atlantic sturgeon	RI2	Nov	2018	1	2	1
Atlantic sturgeon	RI2	Nov	2019	2	3	2
Atlantic sturgeon	RI2	Nov	2020	1	2	1
Atlantic sturgeon	RI2	Dec	2015	4	19	5

Species	Site	Month	Year	Individuals	Detections	Days
Atlantic sturgeon	RI2	Dec	2016	8	37	7
Atlantic sturgeon	RI2	Dec	2017	1	1	1
Atlantic sturgeon	RI2	Dec	2018	4	41	5
Atlantic sturgeon	RI2	Dec	2019	1	11	1
Atlantic sturgeon	RI2	Dec	2020	5	14	4

D.3 WFA Atlantic sturgeon detections by year and month.

Species	Year	Month	Individuals	Detections	Days	Temperature
Atlantic sturgeon	2015	Dec	12	539	10	13.82
Atlantic sturgeon	2016	Jan	79	3956	31	11.94
Atlantic sturgeon	2016	Feb	82	6312	27	8.52
Atlantic sturgeon	2016	Mar	45	3220	30	7.99
Atlantic sturgeon	2016	Apr	49	2797	26	9.9
Atlantic sturgeon	2016	May	1	8	1	11.43
Atlantic sturgeon	2017	Jun	0	0	0	11.71
Atlantic sturgeon	2018	Jul	0	0	0	11.61
Atlantic sturgeon	2019	Aug	0	0	0	12.46
Atlantic sturgeon	2020	Sep	0	0	0	20.59
Atlantic sturgeon	2021	Oct	0	0	0	19.77
Atlantic sturgeon	2022	Nov	0	0	0	15.86
Atlantic sturgeon	2016	Dec	9	473	8	12.79
Atlantic sturgeon	2017	Jan	38	3001	28	9.9
Atlantic sturgeon	2017	Feb	44	8726	28	8.37
Atlantic sturgeon	2017	Mar	48	1058	26	7.93
Atlantic sturgeon	2017	Apr	29	622	26	7.94
Atlantic sturgeon	2017	May	8	40	6	9.36
Atlantic sturgeon	2017	Jun	0	0	0	10.63
Atlantic sturgeon	2017	Jul	0	0	0	9.62
Atlantic sturgeon	2017	Aug	0	0	0	12.97
Atlantic sturgeon	2017	Sep	0	0	0	19.18
Atlantic sturgeon	2017	Oct	0	0	0	19.75
Atlantic sturgeon	2017	Nov	0	0	0	16.93
Atlantic sturgeon	2017	Dec	9	49	6	13.56
Atlantic sturgeon	2018	Jan	55	3010	28	8.75
Atlantic sturgeon	2018	Feb	30	1969	24	7.4
Atlantic sturgeon	2018	Mar	25	2576	27	6.35
Atlantic sturgeon	2018	Apr	26	302	17	7.5
Atlantic sturgeon	2018	May	2	18	2	8.8
Atlantic sturgeon	2018	Jun	0	0	0	9.75
Atlantic sturgeon	2018	Jul	0	0	0	10.91

Species	Year	Month	Individuals	Detections	Days	Temperature
Atlantic sturgeon	2018	Aug	0	0	0	10.09
Atlantic sturgeon	2018	Sep	0	0	0	16.04
Atlantic sturgeon	2018	Oct	0	0	0	19.12
Atlantic sturgeon	2018	Nov	2	70	3	15.47
Atlantic sturgeon	2018	Dec	40	695	23	11.39
Atlantic sturgeon	2019	Jan	48	3532	28	9.31
Atlantic sturgeon	2019	Feb	35	3030	24	8.09
Atlantic sturgeon	2019	Mar	35	1592	23	7.58
Atlantic sturgeon	2019	Apr	16	370	10	7.92
Atlantic sturgeon	2019	May	1	10	1	9.33
Atlantic sturgeon	2019	Jun	0	0	0	10.52
Atlantic sturgeon	2019	Jul	0	0	0	10.45
Atlantic sturgeon	2019	Aug	0	0	0	11.66
Atlantic sturgeon	2019	Sep	0	0	0	17.99
Atlantic sturgeon	2019	Oct	0	0	0	18.48
Atlantic sturgeon	2019	Nov	4	68	4	15.76
Atlantic sturgeon	2019	Dec	30	553	22	11.59
Atlantic sturgeon	2020	Jan	36	4167	30	9.61
Atlantic sturgeon	2020	Feb	42	11488	29	8.23
Atlantic sturgeon	2020	Mar	49	4506	26	8.7
Atlantic sturgeon	2020	Apr	9	391	11	9.21
Atlantic sturgeon	2020	May	0	0	0	11.37
Atlantic sturgeon	2020	Jun	0	0	0	12.2
Atlantic sturgeon	2020	Jul	0	0	0	12.42
Atlantic sturgeon	2020	Aug	0	0	0	12.49
Atlantic sturgeon	2020	Sep	0	0	0	18.84
Atlantic sturgeon	2020	Oct	0	0	0	18.73
Atlantic sturgeon	2020	Nov	0	0	0	16.48
Atlantic sturgeon	2020	Dec	21	781	12	13.7
Atlantic sturgeon	2021	Jan	50	2934	29	10.49
Atlantic sturgeon	2021	Feb	65	6473	27	7.73
Atlantic sturgeon	2021	Mar	36	969	28	8.76
Atlantic sturgeon	2021	Apr	21	352	13	10.67
Atlantic sturgeon	2021	May	2	33	3	12.47
Atlantic sturgeon	2021	Jun	0	0	0	14.16
Atlantic sturgeon	2021	Jul	0	0	0	12.42
Atlantic sturgeon	2021	Aug	0	0	0	13.23

D.4 WFA Atlantic sturgeon detections by receiver site, month, and year.

Species	Site	Month	Year	Individuals	Detections	Days
Atlantic sturgeon	BOEM 15	Jan	2016	43	893	26
Atlantic sturgeon	BOEM 15	Jan	2017	18	330	22
Atlantic sturgeon	BOEM 15	Jan	2018	21	358	15
Atlantic sturgeon	BOEM 15	Jan	2019	11	123	7
Atlantic sturgeon	BOEM 15	Jan	2020	14	153	17
Atlantic sturgeon	BOEM 15	Jan	2021	21	624	18
Atlantic sturgeon	BOEM 15	Feb	2016	30	567	20
Atlantic sturgeon	BOEM 15	Feb	2017	21	1138	23
Atlantic sturgeon	BOEM 15	Feb	2018	12	86	11
Atlantic sturgeon	BOEM 15	Feb	2019	10	93	9
Atlantic sturgeon	BOEM 15	Feb	2020	10	245	12
Atlantic sturgeon	BOEM 15	Feb	2021	18	385	16
Atlantic sturgeon	BOEM 15	Mar	2016	28	1858	27
Atlantic sturgeon	BOEM 15	Mar	2017	20	299	22
Atlantic sturgeon	BOEM 15	Mar	2018	7	65	7
Atlantic sturgeon	BOEM 15	Mar	2019	12	81	8
Atlantic sturgeon	BOEM 15	Mar	2020	14	166	14
Atlantic sturgeon	BOEM 15	Mar	2021	16	270	12
Atlantic sturgeon	BOEM 15	Apr	2016	35	2403	26
Atlantic sturgeon	BOEM 15	Apr	2017	18	499	21
Atlantic sturgeon	BOEM 15	Apr	2018	9	68	8
Atlantic sturgeon	BOEM 15	Apr	2019	6	92	5
Atlantic sturgeon	BOEM 15	Apr	2020	5	24	5
Atlantic sturgeon	BOEM 15	Apr	2021	12	201	12
Atlantic sturgeon	BOEM 15	May	2017	3	25	3
Atlantic sturgeon	BOEM 15	May	2018	1	9	1
Atlantic sturgeon	BOEM 15	May	2021	1	1	1
Atlantic sturgeon	BOEM 15	Nov	2019	3	13	3
Atlantic sturgeon	BOEM 15	Dec	2015	12	534	10
Atlantic sturgeon	BOEM 15	Dec	2016	7	201	6
Atlantic sturgeon	BOEM 15	Dec	2017	7	33	5
Atlantic sturgeon	BOEM 15	Dec	2018	16	110	11
Atlantic sturgeon	BOEM 15	Dec	2019	15	149	13
Atlantic sturgeon	BOEM 15	Dec	2020	6	46	5
Atlantic sturgeon	BOEM 16	Jan	2016	31	577	20
Atlantic sturgeon	BOEM 16	Jan	2017	11	102	8
Atlantic sturgeon	BOEM 16	Jan	2018	21	192	16
Atlantic sturgeon	BOEM 16	Jan	2019	18	956	15
Atlantic sturgeon	BOEM 16	Jan	2020	3	12	3
Atlantic sturgeon	BOEM 16	Jan	2021	16	217	12
Atlantic sturgeon	BOEM 16	Feb	2016	29	389	20
Atlantic sturgeon	BOEM 16	Feb	2017	9	76	10
Atlantic sturgeon	BOEM 16	Feb	2018	10	122	12
Atlantic sturgeon	BOEM 16	Feb	2019	8	689	13
Atlantic sturgeon	BOEM 16	Feb	2020	8	43	8
Atlantic sturgeon	BOEM 16	Feb	2021	11	165	9
Atlantic sturgeon	BOEM 16	Mar	2016	11	184	11
Atlantic sturgeon	BOEM 16	Mar	2017	13	76	12
Atlantic sturgeon	BOEM 16	Mar	2018	6	27	5
Atlantic sturgeon	BOEM 16	Mar	2019	13	113	9

Species	Site	Month	Year	Individuals	Detections	Days
Atlantic sturgeon	BOEM 16	Mar	2020	9	42	9
Atlantic sturgeon	BOEM 16	Mar	2021	6	65	9
Atlantic sturgeon	BOEM 16	Apr	2016	7	28	6
Atlantic sturgeon	BOEM 16	Apr	2017	6	55	6
Atlantic sturgeon	BOEM 16	Apr	2018	11	82	10
Atlantic sturgeon	BOEM 16	Apr	2019	5	208	5
Atlantic sturgeon	BOEM 16	Apr	2020	1	13	1
Atlantic sturgeon	BOEM 16	Apr	2021	4	122	5
Atlantic sturgeon	BOEM 16	May	2017	4	9	3
Atlantic sturgeon	BOEM 16	May	2018	1	9	1
Atlantic sturgeon	BOEM 16	Nov	2018	1	56	1
Atlantic sturgeon	BOEM 16	Dec	2015	1	5	1
Atlantic sturgeon	BOEM 16	Dec	2016	1	5	1
Atlantic sturgeon	BOEM 16	Dec	2017	2	16	2
Atlantic sturgeon	BOEM 16	Dec	2018	6	37	6
Atlantic sturgeon	BOEM 16	Dec	2019	1	12	1
Atlantic sturgeon	BOEM 16	Dec	2020	5	255	6
Atlantic sturgeon	BOEM 17	Jan	2016	17	2233	23
Atlantic sturgeon	BOEM 17	Jan	2017	18	2304	24
Atlantic sturgeon	BOEM 17	Jan	2018	21	2384	23
Atlantic sturgeon	BOEM 17	Jan	2019	18	718	12
Atlantic sturgeon	BOEM 17	Jan	2020	6	111	8
Atlantic sturgeon	BOEM 17	Feb	2016	25	4814	21
Atlantic sturgeon	BOEM 17	Feb	2017	19	6385	25
Atlantic sturgeon	BOEM 17	Feb	2018	7	1262	13
Atlantic sturgeon	BOEM 17	Feb	2019	14	698	16
Atlantic sturgeon	BOEM 17	Feb	2020	12	1173	14
Atlantic sturgeon	BOEM 17	Mar	2016	7	659	16
Atlantic sturgeon	BOEM 17	Mar	2017	15	597	19
Atlantic sturgeon	BOEM 17	Mar	2018	13	2478	23
Atlantic sturgeon	BOEM 17	Mar	2019	11	186	12
Atlantic sturgeon	BOEM 17	Mar	2020	8	107	8
Atlantic sturgeon	BOEM 17	Apr	2016	8	106	9
Atlantic sturgeon	BOEM 17	Apr	2017	7	41	9
Atlantic sturgeon	BOEM 17	Apr	2018	6	138	5
Atlantic sturgeon	BOEM 17	Apr	2019	5	69	5
Atlantic sturgeon	BOEM 17	Apr	2020	1	26	2
Atlantic sturgeon	BOEM 17	May	2017	1	6	1
Atlantic sturgeon	BOEM 17	May	2019	1	10	1
Atlantic sturgeon	BOEM 17	Nov	2018	1	1	1
Atlantic sturgeon	BOEM 17	Nov	2019	1	2	1
Atlantic sturgeon	BOEM 17	Dec	2016	1	262	2
Atlantic sturgeon	BOEM 17	Dec	2018	12	152	14
Atlantic sturgeon	BOEM 17	Dec	2019	7	32	6
Atlantic sturgeon	BOEM 17	Dec	2020	3	77	3
Atlantic sturgeon	BOEM 18	Jan	2016	13	184	11
Atlantic sturgeon	BOEM 18	Jan	2017	5	84	6
Atlantic sturgeon	BOEM 18	Jan	2019	14	1671	19
Atlantic sturgeon	BOEM 18	Jan	2020	15	3776	21
Atlantic sturgeon	BOEM 18	Jan	2021	16	1980	18

Species	Site	Month	Year	Individuals	Detections	Days
Atlantic sturgeon	BOEM 18	Feb	2016	17	247	12
Atlantic sturgeon	BOEM 18	Feb	2017	6	1116	11
Atlantic sturgeon	BOEM 18	Feb	2019	13	1471	13
Atlantic sturgeon	BOEM 18	Feb	2020	21	9940	29
Atlantic sturgeon	BOEM 18	Feb	2021	16	5601	25
Atlantic sturgeon	BOEM 18	Mar	2016	2	12	2
Atlantic sturgeon	BOEM 18	Mar	2017	8	61	6
Atlantic sturgeon	BOEM 18	Mar	2019	8	1190	12
Atlantic sturgeon	BOEM 18	Mar	2020	23	4145	21
Atlantic sturgeon	BOEM 18	Mar	2021	14	571	14
Atlantic sturgeon	BOEM 18	Apr	2016	3	13	3
Atlantic sturgeon	BOEM 18	Apr	2017	1	7	1
Atlantic sturgeon	BOEM 18	Apr	2020	1	11	1
Atlantic sturgeon	BOEM 18	Apr	2021	4	19	3
Atlantic sturgeon	BOEM 18	May	2016	1	8	1
Atlantic sturgeon	BOEM 18	May	2021	1	32	2
Atlantic sturgeon	BOEM 18	Nov	2018	2	13	2
Atlantic sturgeon	BOEM 18	Nov	2019	1	53	1
Atlantic sturgeon	BOEM 18	Dec	2018	9	324	12
Atlantic sturgeon	BOEM 18	Dec	2019	6	307	7
Atlantic sturgeon	BOEM 18	Dec	2020	5	380	6
Atlantic sturgeon	BOEM 19	Jan	2016	1	12	1
Atlantic sturgeon	BOEM 19	Jan	2017	4	179	3
Atlantic sturgeon	BOEM 19	Jan	2019	4	20	5
Atlantic sturgeon	BOEM 19	Jan	2020	8	115	7
Atlantic sturgeon	BOEM 19	Jan	2021	9	72	11
Atlantic sturgeon	BOEM 19	Feb	2016	7	193	7
Atlantic sturgeon	BOEM 19	Feb	2019	4	27	4
Atlantic sturgeon	BOEM 19	Feb	2020	5	44	6
Atlantic sturgeon	BOEM 19	Feb	2021	21	208	18
Atlantic sturgeon	BOEM 19	Mar	2016	4	29	5
Atlantic sturgeon	BOEM 19	Mar	2017	2	10	2
Atlantic sturgeon	BOEM 19	Mar	2019	1	9	1
Atlantic sturgeon	BOEM 19	Mar	2020	1	20	2
Atlantic sturgeon	BOEM 19	Mar	2021	4	24	4
Atlantic sturgeon	BOEM 19	Apr	2016	2	138	4
Atlantic sturgeon	BOEM 19	Apr	2017	1	16	2
Atlantic sturgeon	BOEM 19	Apr	2020	1	312	3
Atlantic sturgeon	BOEM 19	Apr	2021	1	10	1
Atlantic sturgeon	BOEM 19	Dec	2018	3	19	4
Atlantic sturgeon	BOEM 19	Dec	2019	4	53	5
Atlantic sturgeon	BOEM 19	Dec	2020	3	20	4
Atlantic sturgeon	BOEM 20	Jan	2016	1	57	2
Atlantic sturgeon	BOEM 20	Jan	2017	2	2	2
Atlantic sturgeon	BOEM 20	Jan	2018	3	76	6
Atlantic sturgeon	BOEM 20	Jan	2019	2	44	7
Atlantic sturgeon	BOEM 20	Jan	2021	6	41	6
Atlantic sturgeon	BOEM 20	Feb	2016	5	102	8
Atlantic sturgeon	BOEM 20	Feb	2017	1	11	1
Atlantic sturgeon	BOEM 20	Feb	2018	4	499	10

Species	Site	Month	Year	Individuals	Detections	Days
Atlantic sturgeon	BOEM 20	Feb	2019	4	52	7
Atlantic sturgeon	BOEM 20	Feb	2020	2	43	4
Atlantic sturgeon	BOEM 20	Feb	2021	11	114	10
Atlantic sturgeon	BOEM 20	Mar	2016	3	478	9
Atlantic sturgeon	BOEM 20	Mar	2017	3	15	3
Atlantic sturgeon	BOEM 20	Mar	2018	2	6	2
Atlantic sturgeon	BOEM 20	Mar	2019	1	13	1
Atlantic sturgeon	BOEM 20	Mar	2020	2	26	2
Atlantic sturgeon	BOEM 20	Mar	2021	4	39	3
Atlantic sturgeon	BOEM 20	Apr	2016	2	109	4
Atlantic sturgeon	BOEM 20	Apr	2017	1	4	1
Atlantic sturgeon	BOEM 20	Apr	2018	2	14	2
Atlantic sturgeon	BOEM 20	Apr	2019	1	1	1
Atlantic sturgeon	BOEM 20	Apr	2020	1	5	1
Atlantic sturgeon	BOEM 20	Dec	2016	1	5	1
Atlantic sturgeon	BOEM 20	Dec	2018	3	53	7
Atlantic sturgeon	BOEM 20	Dec	2020	1	3	2

D.5 CRA striped bass detections by year and month

Species	Year	Month	Individuals	Detections	Days
Striped bass	2016	Jan	49	2622	16
Striped bass	2016	Feb	44	1508	16
Striped bass	2016	Mar	52	2727	18
Striped bass	2016	Apr	1	1	1
Striped bass	2016	Jun	1	15	3
Striped bass	2016	Dec	7	578	10
Striped bass	2017	Jan	56	1905	22
Striped bass	2017	Feb	72	1556	15
Striped bass	2017	Mar	21	760	16
Striped bass	2017	Apr	6	115	7
Striped bass	2017	Dec	16	589	9
Striped bass	2018	Jan	54	990	13
Striped bass	2018	Feb	52	713	9
Striped bass	2018	Mar	12	67	6
Striped bass	2018	Apr	6	70	6
Striped bass	2018	Dec	37	1287	16
Striped bass	2019	Jan	26	724	15
Striped bass	2019	Feb	12	203	7
Striped bass	2019	Mar	42	1074	14
Striped bass	2019	Apr	3	42	4
Striped bass	2019	Dec	3	352	7
Striped bass	2020	Jan	1	18	1
Striped bass	2020	Feb	7	63	4

Species	Year	Month	Individuals	Detections	Days
Striped bass	2020	Mar	5	56	7
Striped bass	2020	Dec	1	2	2
Striped bass	2021	Jan	16	313	7
Striped bass	2021	Feb	34	608	6
Striped bass	2021	Mar	13	148	6
Striped bass	2021	Apr	1	2	2

D.6 CRA striped bass detections by receiver site, month, and year

Species	Site	Month	Year	Individuals	Detections	Days
Striped bass	1 BOEM	Jan	2016	1	7	1
Striped bass	1 BOEM	Jan	2017	1	52	1
Striped bass	1 BOEM	Feb	2016	6	93	4
Striped bass	1 BOEM	Feb	2017	2	23	2
Striped bass	1 BOEM	Feb	2018	12	90	5
Striped bass	1 BOEM	Feb	2019	1	5	1
Striped bass	1 BOEM	Mar	2016	14	117	8
Striped bass	1 BOEM	Mar	2019	10	112	4
Striped bass	1 BOEM	Mar	2020	1	2	1
Striped bass	1 BOEM	Apr	2017	1	4	1
Striped bass	1 BOEM	Apr	2018	1	3	1
Striped bass	1 BOEM	Apr	2019	1	2	1
Striped bass	1 BOEM	Dec	2018	8	61	4
Striped bass	1 BOEM	Dec	2019	2	45	2
Striped bass	2 BOEM	Jan	2016	3	22	2
Striped bass	2 BOEM	Jan	2017	2	50	2
Striped bass	2 BOEM	Feb	2016	3	41	3
Striped bass	2 BOEM	Feb	2017	5	38	4
Striped bass	2 BOEM	Feb	2020	1	3	1
Striped bass	2 BOEM	Feb	2021	1	10	1
Striped bass	2 BOEM	Mar	2016	20	238	12
Striped bass	2 BOEM	Mar	2017	2	19	2
Striped bass	2 BOEM	Mar	2019	8	90	3
Striped bass	2 BOEM	Mar	2020	1	1	1
Striped bass	2 BOEM	Mar	2021	3	24	1
Striped bass	2 BOEM	Apr	2017	1	4	1
Striped bass	2 BOEM	Dec	2016	2	120	2
Striped bass	2 BOEM	Dec	2018	9	195	4
Striped bass	2 BOEM	Dec	2019	2	105	2
Striped bass	3 BOEM	Jan	2016	7	50	3
Striped bass	3 BOEM	Jan	2017	1	17	1
Striped bass	3 BOEM	Jan	2018	2	29	2
Striped bass	3 BOEM	Jan	2019	1	2	1
Striped bass	3 BOEM	Feb	2016	4	43	3
Striped bass	3 BOEM	Feb	2017	5	23	4
Striped bass	3 BOEM	Feb	2018	11	62	4
Striped bass	3 BOEM	Feb	2019	1	5	1
Striped bass	3 BOEM	Feb	2021	1	13	1

Species	Site	Month	Year	Individuals	Detections	Days
Striped bass	3 BOEM	Mar	2016	20	280	12
Striped bass	3 BOEM	Mar	2017	5	40	5
Striped bass	3 BOEM	Mar	2019	14	124	6
Striped bass	3 BOEM	Mar	2021	2	7	2
Striped bass	3 BOEM	Apr	2017	2	28	3
Striped bass	3 BOEM	Dec	2016	2	168	3
Striped bass	3 BOEM	Dec	2017	6	101	4
Striped bass	3 BOEM	Dec	2018	9	106	5
Striped bass	4 BOEM	Jan	2016	11	173	4
Striped bass	4 BOEM	Jan	2017	2	52	2
Striped bass	4 BOEM	Jan	2018	6	37	2
Striped bass	4 BOEM	Jan	2019	2	7	2
Striped bass	4 BOEM	Jan	2020	1	18	1
Striped bass	4 BOEM	Feb	2016	6	139	6
Striped bass	4 BOEM	Feb	2017	3	28	2
Striped bass	4 BOEM	Feb	2018	9	77	5
Striped bass	4 BOEM	Feb	2019	4	31	4
Striped bass	4 BOEM	Feb	2021	4	8	2
Striped bass	4 BOEM	Mar	2016	10	139	8
Striped bass	4 BOEM	Mar	2017	7	162	7
Striped bass	4 BOEM	Mar	2019	15	142	6
Striped bass	4 BOEM	Mar	2021	3	14	3
Striped bass	4 BOEM	Apr	2017	2	13	3
Striped bass	4 BOEM	Apr	2018	1	14	1
Striped bass	4 BOEM	Dec	2016	1	25	1
Striped bass	4 BOEM	Dec	2017	5	76	3
Striped bass	4 BOEM	Dec	2018	5	91	4
Striped bass	4 BOEM	Dec	2019	2	177	5
Striped bass	4 BOEM	Dec	2020	1	1	1
Striped bass	5 BOEM	Jan	2016	15	394	8
Striped bass	5 BOEM	Jan	2017	6	303	5
Striped bass	5 BOEM	Jan	2019	1	36	1
Striped bass	5 BOEM	Feb	2016	7	273	6
Striped bass	5 BOEM	Feb	2017	7	83	5
Striped bass	5 BOEM	Feb	2019	5	38	4
Striped bass	5 BOEM	Mar	2016	19	342	11
Striped bass	5 BOEM	Mar	2017	11	237	4
Striped bass	5 BOEM	Mar	2019	17	226	6
Striped bass	5 BOEM	Apr	2017	2	12	3
Striped bass	5 BOEM	Dec	2016	3	36	3
Striped bass	5 BOEM	Dec	2018	2	6	2
Striped bass	5 BOEM	Dec	2019	1	25	1
Striped bass	5 BOEM	Dec	2020	1	1	1
Striped bass	6 BOEM	Jan	2016	14	354	7
Striped bass	6 BOEM	Jan	2017	7	183	7
Striped bass	6 BOEM	Jan	2018	7	82	4
Striped bass	6 BOEM	Jan	2019	1	3	1
Striped bass	6 BOEM	Feb	2016	9	93	5
Striped bass	6 BOEM	Feb	2017	27	238	6
Striped bass	6 BOEM	Feb	2018	10	105	4

Species	Site	Month	Year	Individuals	Detections	Days
Striped bass	6 BOEM	Feb	2019	6	28	3
Striped bass	6 BOEM	Feb	2020	1	4	1
Striped bass	6 BOEM	Mar	2016	22	593	13
Striped bass	6 BOEM	Mar	2017	6	99	3
Striped bass	6 BOEM	Mar	2018	2	2	1
Striped bass	6 BOEM	Mar	2019	11	112	4
Striped bass	6 BOEM	Mar	2020	1	12	1
Striped bass	6 BOEM	Apr	2017	3	28	3
Striped bass	6 BOEM	Apr	2019	1	12	1
Striped bass	6 BOEM	Dec	2016	2	49	2
Striped bass	6 BOEM	Dec	2017	6	155	5
Striped bass	6 BOEM	Dec	2018	7	74	3
Striped bass	BOEM 13	Jan	2016	29	773	12
Striped bass	BOEM 13	Jan	2018	21	336	8
Striped bass	BOEM 13	Jan	2019	5	238	6
Striped bass	BOEM 13	Jan	2021	7	192	5
Striped bass	BOEM 13	Feb	2016	27	466	8
Striped bass	BOEM 13	Feb	2018	10	166	5
Striped bass	BOEM 13	Feb	2019	6	71	3
Striped bass	BOEM 13	Feb	2020	6	56	3
Striped bass	BOEM 13	Feb	2021	21	331	6
Striped bass	BOEM 13	Mar	2016	27	510	9
Striped bass	BOEM 13	Mar	2018	5	11	4
Striped bass	BOEM 13	Mar	2019	8	73	4
Striped bass	BOEM 13	Mar	2020	2	28	3
Striped bass	BOEM 13	Mar	2021	8	65	5
Striped bass	BOEM 13	Apr	2016	1	1	1
Striped bass	BOEM 13	Apr	2018	4	41	4
Striped bass	BOEM 13	Apr	2019	1	16	1
Striped bass	BOEM 13	Apr	2021	1	2	2
Striped bass	BOEM 13	Dec	2017	8	183	5
Striped bass	BOEM 13	Dec	2018	20	350	12
Striped bass	BOEM 14	Jan	2016	32	837	15
Striped bass	BOEM 14	Jan	2017	51	1248	20
Striped bass	BOEM 14	Jan	2018	42	506	13
Striped bass	BOEM 14	Jan	2019	25	438	12
Striped bass	BOEM 14	Jan	2021	13	121	5
Striped bass	BOEM 14	Feb	2016	26	348	12
Striped bass	BOEM 14	Feb	2017	48	1102	10
Striped bass	BOEM 14	Feb	2018	23	206	8
Striped bass	BOEM 14	Feb	2019	4	23	3
Striped bass	BOEM 14	Feb	2021	26	240	6
Striped bass	BOEM 14	Mar	2016	19	375	8
Striped bass	BOEM 14	Mar	2017	12	201	11
Striped bass	BOEM 14	Mar	2018	5	51	4
Striped bass	BOEM 14	Mar	2019	9	100	5
Striped bass	BOEM 14	Mar	2021	4	27	3
Striped bass	BOEM 14	Apr	2017	2	25	2
Striped bass	BOEM 14	Apr	2018	1	7	1
Striped bass	BOEM 14	Apr	2019	1	2	1

Species	Site	Month	Year	Individuals	Detections	Days
Striped bass	BOEM 14	Dec	2016	4	178	5
Striped bass	BOEM 14	Dec	2017	7	74	4
Striped bass	BOEM 14	Dec	2018	17	326	9
Striped bass	CB	Jan	2016	1	5	1
Striped bass	CB	Feb	2017	2	11	1
Striped bass	CB	Feb	2019	1	2	1
Striped bass	CB	Mar	2016	9	61	8
Striped bass	CB	Mar	2019	8	68	4
Striped bass	CB	Mar	2020	1	3	1
Striped bass	CB	Mar	2021	4	11	2
Striped bass	CB	Apr	2018	1	3	1
Striped bass	CB	Apr	2019	1	1	1
Striped bass	CB	Dec	2016	1	2	1
Striped bass	CB	Dec	2018	4	45	2
Striped bass	CB 1	Jan	2016	1	7	1
Striped bass	CB 1	Feb	2017	2	10	2
Striped bass	CB 1	Feb	2018	4	7	3
Striped bass	CB 1	Feb	2021	1	4	1
Striped bass	CB 1	Mar	2016	13	39	9
Striped bass	CB 1	Mar	2019	5	27	2
Striped bass	CB 1	Mar	2020	1	9	1
Striped bass	CB 1	Apr	2019	1	2	1
Striped bass	CB 1	Dec	2018	6	33	3
Striped bass	RA	Feb	2016	1	11	1
Striped bass	RA	Mar	2016	5	24	2
Striped bass	RA	Apr	2019	1	7	1
Striped bass	RA outside	Feb	2016	1	1	1
Striped bass	RA outside	Mar	2016	3	6	2
Striped bass	RI 2	Feb	2021	1	2	1
Striped bass	RI 2	Mar	2016	1	3	1
Striped bass	RI 2	Mar	2017	1	2	1
Striped bass	RI 2	Mar	2018	1	3	1
Striped bass	RI 2	Mar	2020	1	1	1
Striped bass	RI 2	Apr	2017	1	1	1
Striped bass	RI 2	Apr	2018	1	2	1
Striped bass	RI 2	Jun	2016	1	15	3

D.7 WFA striped bass detections by year and month

Species	Year	Month	Individuals	Detections	Days
Striped bass	2016	Jan	57	4072	27
Striped bass	2016	Feb	84	6247	29
Striped bass	2016	Mar	76	3924	26
Striped bass	2016	Dec	7	236	8
Striped bass	2017	Jan	122	6968	27
Striped bass	2017	Feb	155	12699	27
Striped bass	2017	Mar	94	7625	30

Species	Year	Month	Individuals	Detections	Days
Striped bass	2017	Apr	2	51	3
Striped bass	2017	Dec	8	69	5
Striped bass	2018	Jan	140	4732	29
Striped bass	2018	Feb	134	3791	21
Striped bass	2018	Mar	67	1402	23
Striped bass	2018	Apr	3	448	8
Striped bass	2018	Dec	24	382	7
Striped bass	2019	Jan	101	6187	29
Striped bass	2019	Feb	103	4127	18
Striped bass	2019	Mar	58	2364	21
Striped bass	2019	Apr	1	21	2
Striped bass	2019	Dec	1	2	1
Striped bass	2020	Jan	26	1324	12
Striped bass	2020	Feb	55	6857	28
Striped bass	2020	Mar	5	20	3
Striped bass	2021	Jan	22	284	7
Striped bass	2021	Feb	60	3722	28
Striped bass	2021	Mar	34	371	12
Striped bass	2021	Apr	1	1	1

D.8 WFA striped bass detections by receiver site, month, and year

Species	Site	Month	Year	Individuals	Detections	Days
Striped bass	BOEM 15	Jan	2016	26	792	15
Striped bass	BOEM 15	Jan	2017	58	1688	20
Striped bass	BOEM 15	Jan	2018	53	795	14
Striped bass	BOEM 15	Jan	2019	42	840	15
Striped bass	BOEM 15	Jan	2020	4	274	6
Striped bass	BOEM 15	Jan	2021	15	193	6
Striped bass	BOEM 15	Feb	2016	19	368	11
Striped bass	BOEM 15	Feb	2017	55	995	12
Striped bass	BOEM 15	Feb	2018	27	298	9
Striped bass	BOEM 15	Feb	2019	1	5	1
Striped bass	BOEM 15	Feb	2020	22	487	11
Striped bass	BOEM 15	Feb	2021	29	229	8
Striped bass	BOEM 15	Mar	2016	17	216	7
Striped bass	BOEM 15	Mar	2017	32	533	14
Striped bass	BOEM 15	Mar	2018	6	54	6
Striped bass	BOEM 15	Mar	2019	20	229	8
Striped bass	BOEM 15	Mar	2020	1	2	1
Striped bass	BOEM 15	Mar	2021	5	42	5
Striped bass	BOEM 15	Apr	2018	1	428	4
Striped bass	BOEM 15	Apr	2019	1	2	1
Striped bass	BOEM 15	Dec	2016	6	101	7
Striped bass	BOEM 15	Dec	2017	7	68	5

Species	Site	Month	Year	Individuals	Detections	Days
Striped bass	BOEM 15	Dec	2018	17	190	7
Striped bass	BOEM 16	Jan	2016	37	1401	18
Striped bass	BOEM 16	Jan	2017	54	1420	18
Striped bass	BOEM 16	Jan	2018	74	1169	21
Striped bass	BOEM 16	Jan	2019	44	1375	13
Striped bass	BOEM 16	Jan	2020	12	167	9
Striped bass	BOEM 16	Jan	2021	6	39	2
Striped bass	BOEM 16	Feb	2016	37	1113	20
Striped bass	BOEM 16	Feb	2017	69	1772	15
Striped bass	BOEM 16	Feb	2018	37	423	7
Striped bass	BOEM 16	Feb	2019	26	369	6
Striped bass	BOEM 16	Feb	2020	47	1604	20
Striped bass	BOEM 16	Feb	2021	37	509	15
Striped bass	BOEM 16	Mar	2016	23	415	11
Striped bass	BOEM 16	Mar	2017	83	2169	19
Striped bass	BOEM 16	Mar	2018	4	29	4
Striped bass	BOEM 16	Mar	2019	27	319	13
Striped bass	BOEM 16	Mar	2020	4	18	3
Striped bass	BOEM 16	Mar	2021	9	76	5
Striped bass	BOEM 16	Apr	2017	2	3	2
Striped bass	BOEM 16	Apr	2018	1	7	1
Striped bass	BOEM 16	Apr	2021	1	1	1
Striped bass	BOEM 16	Dec	2016	2	78	2
Striped bass	BOEM 16	Dec	2017	1	1	1
Striped bass	BOEM 16	Dec	2018	6	118	3
Striped bass	BOEM 17	Jan	2016	32	579	18
Striped bass	BOEM 17	Jan	2017	55	1860	20
Striped bass	BOEM 17	Jan	2018	91	1375	24
Striped bass	BOEM 17	Jan	2019	50	922	14
Striped bass	BOEM 17	Jan	2020	15	299	6
Striped bass	BOEM 17	Feb	2016	44	1200	20
Striped bass	BOEM 17	Feb	2017	83	2326	20
Striped bass	BOEM 17	Feb	2018	59	774	8
Striped bass	BOEM 17	Feb	2019	38	529	7
Striped bass	BOEM 17	Feb	2020	48	2298	20
Striped bass	BOEM 17	Mar	2016	30	1128	10
Striped bass	BOEM 17	Mar	2017	81	2286	24
Striped bass	BOEM 17	Mar	2018	7	113	7
Striped bass	BOEM 17	Mar	2019	35	607	17
Striped bass	BOEM 17	Apr	2018	1	4	1
Striped bass	BOEM 17	Apr	2019	1	19	2
Striped bass	BOEM 17	Dec	2016	1	57	1
Striped bass	BOEM 17	Dec	2018	6	55	1
Striped bass	BOEM 18	Jan	2016	30	974	17
Striped bass	BOEM 18	Jan	2017	72	1273	18
Striped bass	BOEM 18	Jan	2019	60	1677	19
Striped bass	BOEM 18	Jan	2020	13	283	8
Striped bass	BOEM 18	Jan	2021	7	52	4
Striped bass	BOEM 18	Feb	2016	37	1203	20
Striped bass	BOEM 18	Feb	2017	117	4034	21

Species	Site	Month	Year	Individuals	Detections	Days
Striped bass	BOEM 18	Feb	2019	45	713	9
Striped bass	BOEM 18	Feb	2020	51	1681	23
Striped bass	BOEM 18	Feb	2021	40	933	19
Striped bass	BOEM 18	Mar	2016	31	627	13
Striped bass	BOEM 18	Mar	2017	68	2271	22
Striped bass	BOEM 18	Mar	2019	37	648	15
Striped bass	BOEM 18	Mar	2021	15	158	8
Striped bass	BOEM 18	Dec	2018	1	19	1
Striped bass	BOEM 18	Dec	2019	1	2	1
Striped bass	BOEM 19	Jan	2016	9	266	4
Striped bass	BOEM 19	Jan	2017	28	393	9
Striped bass	BOEM 19	Jan	2019	57	814	12
Striped bass	BOEM 19	Jan	2020	13	301	8
Striped bass	BOEM 19	Feb	2016	31	1317	17
Striped bass	BOEM 19	Feb	2017	100	2385	24
Striped bass	BOEM 19	Feb	2019	82	1716	12
Striped bass	BOEM 19	Feb	2020	26	787	9
Striped bass	BOEM 19	Feb	2021	41	1230	20
Striped bass	BOEM 19	Mar	2016	30	995	16
Striped bass	BOEM 19	Mar	2017	29	273	12
Striped bass	BOEM 19	Mar	2019	23	409	5
Striped bass	BOEM 19	Mar	2021	2	10	2
Striped bass	BOEM 19	Apr	2017	2	48	2
Striped bass	BOEM 20	Jan	2016	2	60	1
Striped bass	BOEM 20	Jan	2017	16	334	7
Striped bass	BOEM 20	Jan	2018	65	1393	18
Striped bass	BOEM 20	Jan	2019	48	559	13
Striped bass	BOEM 20	Feb	2016	32	1046	17
Striped bass	BOEM 20	Feb	2017	74	1187	14
Striped bass	BOEM 20	Feb	2018	99	2296	21
Striped bass	BOEM 20	Feb	2019	34	795	11
Striped bass	BOEM 20	Feb	2021	41	821	20
Striped bass	BOEM 20	Mar	2016	31	543	11
Striped bass	BOEM 20	Mar	2017	8	93	3
Striped bass	BOEM 20	Mar	2018	61	1206	21
Striped bass	BOEM 20	Mar	2019	6	152	2
Striped bass	BOEM 20	Mar	2021	13	85	3
Striped bass	BOEM 20	Apr	2018	2	9	2

D.9 CRA White shark detections by year and month

Species	Year	Month	Individuals	Detections	Days
White shark	2016	Feb	3	11	3
White shark	2016	Mar	1	1	1
White shark	2016	Apr	1	40	2
White shark	2016	May	2	10	2
White shark	2016	Jun	5	42	5
White shark	2016	Aug	1	6	1

Species	Year	Month	Individuals	Detections	Days
White shark	2016	Oct	3	29	4
White shark	2016	Nov	4	20	4
White shark	2016	Dec	2	9	2
White shark	2017	Jan	2	7	2
White shark	2017	Feb	2	46	3
White shark	2017	Mar	1	8	2
White shark	2017	May	4	14	4
White shark	2017	Jun	3	35	3
White shark	2017	Jul	2	18	2
White shark	2017	Oct	3	19	3
White shark	2017	Nov	17	134	14
White shark	2017	Dec	3	40	4
White shark	2018	Mar	1	1	1
White shark	2018	Apr	4	54	9
White shark	2018	May	5	80	4
White shark	2018	Jun	4	63	4
White shark	2018	Jul	1	10	1
White shark	2018	Aug	1	18	1
White shark	2018	Sep	1	2	1
White shark	2018	Oct	6	42	5
White shark	2018	Nov	21	329	17
White shark	2018	Dec	5	21	4
White shark	2019	Jan	1	8	1
White shark	2019	Mar	1	12	2
White shark	2019	Apr	5	63	5
White shark	2019	May	10	45	8
White shark	2019	Jun	11	169	11
White shark	2019	Jul	1	16	1
White shark	2019	Sep	2	21	2
White shark	2019	Oct	15	372	21
White shark	2019	Nov	15	112	12
White shark	2019	Dec	1	1	1
White shark	2020	Jan	1	9	2
White shark	2020	Feb	2	9	2
White shark	2020	Mar	5	30	6
White shark	2020	Apr	10	124	15
White shark	2020	May	10	85	7
White shark	2020	Jun	16	454	13
White shark	2020	Jul	8	317	16
White shark	2020	Aug	6	719	12

Species	Year	Month	Individuals	Detections	Days
White shark	2020	Sep	4	87	3
White shark	2020	Oct	13	124	10
White shark	2020	Nov	27	296	20
White shark	2020	Dec	5	57	5
White shark	2021	Jan	2	7	2
White shark	2021	Mar	6	38	5
White shark	2021	Apr	9	53	11
White shark	2021	May	14	137	13
White shark	2021	Jun	13	276	12
White shark	2021	Jul	2	191	7
White shark	2021	Aug	4	28	2

D.10 CRA white shark detections by receiver site, month, and year.

Species	Site	Month	Year	Individuals	Detections	Days
White shark	1 BOEM	Jan	2019	1	8	1
White shark	1 BOEM	Jan	2020	1	5	1
White shark	1 BOEM	Feb	2016	1	1	1
White shark	1 BOEM	Apr	2019	3	6	2
White shark	1 BOEM	Apr	2020	3	9	2
White shark	1 BOEM	May	2017	1	1	1
White shark	1 BOEM	May	2018	1	23	1
White shark	1 BOEM	May	2019	1	2	1
White shark	1 BOEM	May	2020	4	28	4
White shark	1 BOEM	May	2021	3	30	2
White shark	1 BOEM	Jun	2016	2	23	2
White shark	1 BOEM	Jun	2017	1	21	1
White shark	1 BOEM	Jun	2019	1	4	1
White shark	1 BOEM	Jun	2020	1	8	1
White shark	1 BOEM	Jun	2021	4	20	5
White shark	1 BOEM	Jul	2020	2	12	2
White shark	1 BOEM	Jul	2021	1	147	4
White shark	1 BOEM	Aug	2018	1	18	1
White shark	1 BOEM	Aug	2020	3	23	2
White shark	1 BOEM	Aug	2021	2	3	1
White shark	1 BOEM	Sep	2019	1	4	1
White shark	1 BOEM	Oct	2018	1	1	1
White shark	1 BOEM	Oct	2019	3	34	4
White shark	1 BOEM	Nov	2016	1	9	1
White shark	1 BOEM	Nov	2017	3	10	3
White shark	1 BOEM	Nov	2018	2	19	2
White shark	1 BOEM	Nov	2019	3	13	2
White shark	1 BOEM	Nov	2020	3	18	3
White shark	1 BOEM	Dec	2017	1	6	1
White shark	1 BOEM	Dec	2018	2	4	2
White shark	1 BOEM	Dec	2020	2	5	1
White shark	2 BOEM	Jan	2020	1	4	1

Species	Site	Month	Year	Individuals	Detections	Days
White shark	2 BOEM	Mar	2020	1	1	1
White shark	2 BOEM	Apr	2019	3	28	3
White shark	2 BOEM	Apr	2020	2	24	4
White shark	2 BOEM	May	2018	2	13	1
White shark	2 BOEM	May	2020	2	18	2
White shark	2 BOEM	May	2021	2	11	1
White shark	2 BOEM	Jun	2016	3	15	2
White shark	2 BOEM	Jun	2018	1	11	1
White shark	2 BOEM	Jun	2019	2	15	2
White shark	2 BOEM	Jun	2020	4	70	4
White shark	2 BOEM	Jun	2021	3	33	3
White shark	2 BOEM	Jul	2020	1	17	1
White shark	2 BOEM	Jul	2021	1	6	2
White shark	2 BOEM	Aug	2020	3	516	3
White shark	2 BOEM	Oct	2016	1	1	1
White shark	2 BOEM	Oct	2019	6	73	7
White shark	2 BOEM	Oct	2020	2	17	2
White shark	2 BOEM	Nov	2016	1	1	1
White shark	2 BOEM	Nov	2018	6	68	6
White shark	2 BOEM	Nov	2019	3	28	3
White shark	2 BOEM	Nov	2020	4	17	4
White shark	2 BOEM	Dec	2016	1	3	1
White shark	2 BOEM	Dec	2018	1	8	1
White shark	2 BOEM	Dec	2019	1	1	1
White shark	2 BOEM	Dec	2020	1	7	1
White shark	3 BOEM	Jan	2017	1	4	1
White shark	3 BOEM	Feb	2017	1	7	1
White shark	3 BOEM	Mar	2021	2	14	2
White shark	3 BOEM	Apr	2018	1	1	1
White shark	3 BOEM	Apr	2019	2	3	2
White shark	3 BOEM	Apr	2021	2	9	2
White shark	3 BOEM	May	2018	2	17	2
White shark	3 BOEM	May	2019	4	15	3
White shark	3 BOEM	May	2020	1	1	1
White shark	3 BOEM	Jun	2018	1	7	1
White shark	3 BOEM	Jun	2019	2	12	2
White shark	3 BOEM	Jun	2020	3	52	3
White shark	3 BOEM	Jul	2020	3	24	3
White shark	3 BOEM	Aug	2020	2	35	3
White shark	3 BOEM	Oct	2017	1	2	1
White shark	3 BOEM	Oct	2019	2	14	2
White shark	3 BOEM	Oct	2020	3	25	3
White shark	3 BOEM	Nov	2017	4	12	4
White shark	3 BOEM	Nov	2018	5	74	5
White shark	3 BOEM	Nov	2020	7	62	4
White shark	3 BOEM	Dec	2020	1	6	1
White shark	4 BOEM	Feb	2017	1	14	1
White shark	4 BOEM	Mar	2019	1	6	2
White shark	4 BOEM	Apr	2016	1	16	2
White shark	4 BOEM	Apr	2018	3	8	3

Species	Site	Month	Year	Individuals	Detections	Days
White shark	4 BOEM	Apr	2019	2	23	1
White shark	4 BOEM	Apr	2020	2	7	2
White shark	4 BOEM	Apr	2021	3	9	2
White shark	4 BOEM	May	2018	1	13	1
White shark	4 BOEM	May	2020	1	5	1
White shark	4 BOEM	May	2021	3	38	4
White shark	4 BOEM	Jun	2016	1	4	1
White shark	4 BOEM	Jun	2017	1	1	1
White shark	4 BOEM	Jun	2018	2	13	2
White shark	4 BOEM	Jun	2019	5	40	4
White shark	4 BOEM	Jun	2020	4	28	4
White shark	4 BOEM	Jun	2021	3	12	3
White shark	4 BOEM	Jul	2020	2	23	2
White shark	4 BOEM	Aug	2020	3	9	2
White shark	4 BOEM	Sep	2020	2	46	1
White shark	4 BOEM	Oct	2016	1	11	1
White shark	4 BOEM	Oct	2018	1	8	1
White shark	4 BOEM	Oct	2019	2	10	2
White shark	4 BOEM	Nov	2016	1	8	1
White shark	4 BOEM	Nov	2017	3	29	2
White shark	4 BOEM	Nov	2018	4	27	4
White shark	4 BOEM	Nov	2019	7	47	6
White shark	4 BOEM	Nov	2020	8	36	6
White shark	4 BOEM	Dec	2018	1	3	1
White shark	4 BOEM	Dec	2020	1	3	1
White shark	5 BOEM	Feb	2017	1	13	1
White shark	5 BOEM	Feb	2020	1	1	1
White shark	5 BOEM	Mar	2017	1	6	1
White shark	5 BOEM	Mar	2019	1	6	1
White shark	5 BOEM	Apr	2016	1	5	1
White shark	5 BOEM	May	2016	1	8	1
White shark	5 BOEM	May	2019	1	1	1
White shark	5 BOEM	May	2020	1	5	1
White shark	5 BOEM	Jun	2019	2	20	3
White shark	5 BOEM	Jun	2020	6	146	5
White shark	5 BOEM	Jul	2018	1	10	1
White shark	5 BOEM	Jul	2020	1	7	1
White shark	5 BOEM	Aug	2020	2	9	2
White shark	5 BOEM	Sep	2019	1	10	1
White shark	5 BOEM	Oct	2018	1	4	1
White shark	5 BOEM	Oct	2019	1	13	1
White shark	5 BOEM	Oct	2020	1	5	1
White shark	5 BOEM	Nov	2018	6	48	6
White shark	5 BOEM	Nov	2019	1	2	1
White shark	5 BOEM	Nov	2020	2	22	3
White shark	5 BOEM	Dec	2018	1	3	1
White shark	5 BOEM	Dec	2020	1	9	1
White shark	6 BOEM	Feb	2016	1	4	1
White shark	6 BOEM	Feb	2017	1	2	1
White shark	6 BOEM	Feb	2020	1	8	1

Species	Site	Month	Year	Individuals	Detections	Days
White shark	6 BOEM	Mar	2020	3	19	3
White shark	6 BOEM	Apr	2016	1	11	1
White shark	6 BOEM	Apr	2018	1	6	1
White shark	6 BOEM	Apr	2019	1	3	1
White shark	6 BOEM	Apr	2020	2	14	2
White shark	6 BOEM	May	2017	1	5	1
White shark	6 BOEM	May	2019	1	10	1
White shark	6 BOEM	May	2020	3	27	3
White shark	6 BOEM	May	2021	3	10	3
White shark	6 BOEM	Jun	2017	1	7	1
White shark	6 BOEM	Jun	2018	2	11	2
White shark	6 BOEM	Jun	2019	5	47	6
White shark	6 BOEM	Jun	2020	5	63	5
White shark	6 BOEM	Jun	2021	5	33	4
White shark	6 BOEM	Jul	2019	1	16	1
White shark	6 BOEM	Jul	2021	2	5	2
White shark	6 BOEM	Aug	2020	1	3	1
White shark	6 BOEM	Sep	2020	3	36	2
White shark	6 BOEM	Oct	2019	3	155	3
White shark	6 BOEM	Oct	2020	1	21	1
White shark	6 BOEM	Nov	2017	2	3	1
White shark	6 BOEM	Nov	2018	1	15	1
White shark	6 BOEM	Nov	2020	3	41	4
White shark	6 BOEM	Dec	2017	1	25	1
White shark	BOEM 13	Feb	2016	1	6	1
White shark	BOEM 13	Mar	2016	1	1	1
White shark	BOEM 13	Mar	2020	2	5	2
White shark	BOEM 13	Mar	2021	1	7	1
White shark	BOEM 13	Apr	2016	1	8	1
White shark	BOEM 13	Apr	2018	1	20	2
White shark	BOEM 13	Apr	2020	4	43	6
White shark	BOEM 13	Apr	2021	1	7	1
White shark	BOEM 13	May	2020	1	1	1
White shark	BOEM 13	May	2021	5	19	3
White shark	BOEM 13	Jun	2018	1	8	1
White shark	BOEM 13	Jun	2019	2	8	2
White shark	BOEM 13	Jun	2020	2	28	2
White shark	BOEM 13	Jun	2021	4	75	5
White shark	BOEM 13	Aug	2020	1	1	1
White shark	BOEM 13	Oct	2017	1	14	1
White shark	BOEM 13	Oct	2019	3	13	3
White shark	BOEM 13	Oct	2020	3	22	2
White shark	BOEM 13	Nov	2018	2	11	2
White shark	BOEM 13	Nov	2019	1	10	1
White shark	BOEM 13	Nov	2020	3	25	2
White shark	BOEM 13	Dec	2020	1	20	1
White shark	BOEM 14	Jan	2017	1	3	1
White shark	BOEM 14	Jan	2021	2	7	2
White shark	BOEM 14	Mar	2018	1	1	1
White shark	BOEM 14	Mar	2021	1	7	1

Species	Site	Month	Year	Individuals	Detections	Days
White shark	BOEM 14	Apr	2018	2	12	2
White shark	BOEM 14	Apr	2021	3	12	3
White shark	BOEM 14	May	2019	2	9	2
White shark	BOEM 14	May	2021	3	11	2
White shark	BOEM 14	Jun	2018	1	13	1
White shark	BOEM 14	Jun	2019	3	23	4
White shark	BOEM 14	Jun	2020	3	14	2
White shark	BOEM 14	Jun	2021	1	4	1
White shark	BOEM 14	Jul	2017	1	7	1
White shark	BOEM 14	Jul	2020	3	25	3
White shark	BOEM 14	Sep	2018	1	2	1
White shark	BOEM 14	Oct	2016	1	17	2
White shark	BOEM 14	Oct	2018	3	29	3
White shark	BOEM 14	Oct	2019	3	23	4
White shark	BOEM 14	Oct	2020	3	34	2
White shark	BOEM 14	Nov	2017	7	65	5
White shark	BOEM 14	Nov	2018	7	61	5
White shark	BOEM 14	Nov	2020	2	34	3
White shark	BOEM 14	Dec	2016	1	6	1
White shark	BOEM 14	Dec	2017	1	8	1
White shark	BOEM 14	Dec	2020	2	7	2
White shark	CB	Feb	2017	1	3	1
White shark	CB	Mar	2020	1	5	1
White shark	CB	Apr	2018	2	7	2
White shark	CB	Apr	2020	2	5	2
White shark	CB	May	2018	1	14	1
White shark	CB	May	2019	1	8	1
White shark	CB	May	2021	3	13	2
White shark	CB	Jun	2017	1	6	1
White shark	CB	Jun	2020	3	45	4
White shark	CB	Jun	2021	1	97	3
White shark	CB	Jul	2017	1	11	1
White shark	CB	Jul	2020	2	169	3
White shark	CB	Jul	2021	1	21	2
White shark	CB	Aug	2020	3	74	4
White shark	CB	Aug	2021	2	22	1
White shark	CB	Sep	2019	1	7	1
White shark	CB	Sep	2020	1	5	1
White shark	CB	Oct	2017	1	3	1
White shark	CB	Oct	2019	6	24	5
White shark	CB	Nov	2017	2	6	1
White shark	CB	Nov	2019	4	12	3
White shark	CB	Nov	2020	1	3	1
White shark	CB	Dec	2017	1	1	1
White shark	CB	Dec	2018	1	3	1
White shark	CB 1	Feb	2017	2	7	1
White shark	CB 1	Mar	2017	1	2	1
White shark	CB 1	Mar	2021	2	10	1
White shark	CB 1	Apr	2021	2	5	1
White shark	CB 1	May	2016	1	2	1

Species	Site	Month	Year	Individuals	Detections	Days
White shark	CB 1	May	2017	2	8	2
White shark	CB 1	Jun	2021	1	2	1
White shark	CB 1	Jul	2020	2	4	1
White shark	CB 1	Jul	2021	1	4	1
White shark	CB 1	Nov	2016	1	2	1
White shark	CB 1	Nov	2017	1	2	1
White shark	CB 1	Nov	2018	1	6	1
White shark	CB 1	Nov	2020	2	9	2
White shark	RA	Apr	2021	1	2	2
White shark	RA	Oct	2019	1	13	1
White shark	RA	Nov	2017	1	7	1
White shark	RA	Nov	2020	1	10	1
White shark	RA outside	Apr	2020	1	22	3
White shark	RA outside	Apr	2021	1	9	2
White shark	RA outside	May	2021	1	5	1
White shark	RA outside	Jul	2020	3	36	4
White shark	RA outside	Jul	2021	1	8	1
White shark	RA outside	Aug	2016	1	6	1
White shark	RA outside	Aug	2020	2	49	3
White shark	RA outside	Aug	2021	2	3	1
White shark	RA outside	Nov	2020	2	19	2

D.11 WFA white shark detections by year and month

Species	Year	Month	Individuals	Detections	Days
White shark	2016	Feb	2	6	2
White shark	2016	Apr	2	38	5
White shark	2016	May	1	6	1
White shark	2016	Oct	3	33	3
White shark	2016	Nov	4	25	4
White shark	2016	Dec	1	10	3
White shark	2017	Feb	1	1	1
White shark	2017	Mar	1	37	2
White shark	2017	Apr	2	24	2
White shark	2017	May	2	166	2
White shark	2017	Jul	1	4	1
White shark	2017	Aug	1	19	1
White shark	2017	Sep	1	8	1
White shark	2017	Oct	4	28	3
White shark	2017	Nov	3	25	4
White shark	2017	Dec	3	41	3
White shark	2018	Apr	5	35	7
White shark	2018	May	6	38	4
White shark	2018	Jun	5	16	5
White shark	2018	Jul	1	2	1

Species	Year	Month	Individuals	Detections	Days
White shark	2018	Sep	2	8	2
White shark	2018	Oct	5	60	4
White shark	2018	Nov	8	53	6
White shark	2018	Dec	1	33	3
White shark	2019	Apr	8	52	9
White shark	2019	May	16	171	16
White shark	2019	Jun	10	90	11
White shark	2019	Sep	3	61	6
White shark	2019	Oct	11	136	11
White shark	2019	Nov	7	101	7
White shark	2019	Dec	1	4	1
White shark	2020	Feb	1	12	2
White shark	2020	Mar	6	27	6
White shark	2020	Apr	6	31	6
White shark	2020	May	11	67	10
White shark	2020	Jun	11	58	12
White shark	2020	Jul	7	57	6
White shark	2020	Aug	3	28	3
White shark	2020	Sep	4	5	3
White shark	2020	Oct	7	179	8
White shark	2020	Nov	12	152	11
White shark	2020	Dec	5	39	4
White shark	2021	Jan	2	13	1
White shark	2021	Feb	2	7	2
White shark	2021	Mar	7	49	7
White shark	2021	Apr	10	70	8
White shark	2021	May	16	91	13
White shark	2021	Jun	6	43	6
White shark	2021	Jul	10	72	6

D.12 WFA white shark detections by receiver site, month, and year.

Species	Site	Month	Year	Individuals	Detections	Days
White shark	BOEM 15	Jan	2021	2	13	1
White shark	BOEM 15	Feb	2017	1	1	1
White shark	BOEM 15	Mar	2017	1	11	1
White shark	BOEM 15	Mar	2020	1	3	1
White shark	BOEM 15	Mar	2021	1	1	1
White shark	BOEM 15	Apr	2017	1	13	1
White shark	BOEM 15	Apr	2018	3	8	3
White shark	BOEM 15	Apr	2019	3	12	3

Species	Site	Month	Year	Individuals	Detections	Days
White shark	BOEM 15	Apr	2020	1	4	1
White shark	BOEM 15	May	2017	1	45	1
White shark	BOEM 15	May	2018	1	8	1
White shark	BOEM 15	May	2019	5	37	4
White shark	BOEM 15	May	2021	8	30	6
White shark	BOEM 15	Jun	2018	1	2	1
White shark	BOEM 15	Jun	2019	3	32	5
White shark	BOEM 15	Jun	2021	3	27	3
White shark	BOEM 15	Jul	2021	2	8	1
White shark	BOEM 15	Aug	2020	1	4	1
White shark	BOEM 15	Sep	2018	1	2	1
White shark	BOEM 15	Sep	2019	1	8	1
White shark	BOEM 15	Sep	2020	2	3	1
White shark	BOEM 15	Oct	2017	1	2	1
White shark	BOEM 15	Oct	2018	3	49	3
White shark	BOEM 15	Oct	2019	4	44	4
White shark	BOEM 15	Oct	2020	3	27	2
White shark	BOEM 15	Nov	2018	2	3	1
White shark	BOEM 15	Nov	2019	1	14	1
White shark	BOEM 15	Nov	2020	3	58	3
White shark	BOEM 15	Dec	2017	1	10	1
White shark	BOEM 15	Dec	2020	4	24	3
White shark	BOEM 16	Feb	2021	1	5	1
White shark	BOEM 16	Mar	2017	1	8	1
White shark	BOEM 16	Mar	2020	1	8	1
White shark	BOEM 16	Apr	2016	1	10	1
White shark	BOEM 16	Apr	2017	1	7	1
White shark	BOEM 16	Apr	2018	2	6	2
White shark	BOEM 16	Apr	2019	2	13	2
White shark	BOEM 16	Apr	2020	1	2	1
White shark	BOEM 16	Apr	2021	8	39	6
White shark	BOEM 16	May	2017	1	62	1
White shark	BOEM 16	May	2018	3	16	3
White shark	BOEM 16	May	2019	2	17	2
White shark	BOEM 16	May	2020	2	9	2
White shark	BOEM 16	May	2021	5	22	4
White shark	BOEM 16	Jun	2018	2	3	2
White shark	BOEM 16	Jun	2019	1	6	1
White shark	BOEM 16	Jun	2020	2	12	3
White shark	BOEM 16	Jun	2021	1	2	1
White shark	BOEM 16	Jul	2020	1	19	1
White shark	BOEM 16	Aug	2017	1	8	1
White shark	BOEM 16	Aug	2020	2	17	2
White shark	BOEM 16	Sep	2018	1	6	1
White shark	BOEM 16	Sep	2019	2	8	2
White shark	BOEM 16	Oct	2016	2	11	2
White shark	BOEM 16	Oct	2017	1	2	1
White shark	BOEM 16	Oct	2018	1	10	1
White shark	BOEM 16	Oct	2020	4	35	3
White shark	BOEM 16	Nov	2017	2	6	2

Species	Site	Month	Year	Individuals	Detections	Days
White shark	BOEM 16	Nov	2018	1	13	1
White shark	BOEM 16	Nov	2019	2	9	2
White shark	BOEM 16	Nov	2020	4	21	3
White shark	BOEM 16	Dec	2017	1	21	1
White shark	BOEM 16	Dec	2018	1	12	1
White shark	BOEM 17	Feb	2020	1	12	2
White shark	BOEM 17	Mar	2017	1	18	2
White shark	BOEM 17	Mar	2020	2	10	2
White shark	BOEM 17	Apr	2016	2	9	2
White shark	BOEM 17	Apr	2018	2	19	2
White shark	BOEM 17	Apr	2019	1	5	1
White shark	BOEM 17	Apr	2020	2	9	2
White shark	BOEM 17	May	2017	2	59	2
White shark	BOEM 17	May	2018	3	14	2
White shark	BOEM 17	May	2019	6	52	6
White shark	BOEM 17	May	2020	6	21	5
White shark	BOEM 17	Jun	2018	1	7	1
White shark	BOEM 17	Jun	2019	3	9	2
White shark	BOEM 17	Jun	2020	2	19	2
White shark	BOEM 17	Jul	2020	2	14	2
White shark	BOEM 17	Aug	2017	1	11	1
White shark	BOEM 17	Aug	2020	1	7	1
White shark	BOEM 17	Sep	2019	1	33	3
White shark	BOEM 17	Oct	2016	2	11	2
White shark	BOEM 17	Oct	2017	1	11	1
White shark	BOEM 17	Oct	2019	2	39	2
White shark	BOEM 17	Oct	2020	6	71	5
White shark	BOEM 17	Nov	2017	1	10	1
White shark	BOEM 17	Nov	2018	4	24	3
White shark	BOEM 17	Nov	2019	1	8	1
White shark	BOEM 17	Nov	2020	2	29	2
White shark	BOEM 17	Dec	2016	1	6	1
White shark	BOEM 17	Dec	2017	2	10	2
White shark	BOEM 17	Dec	2018	1	9	2
White shark	BOEM 18	Feb	2016	1	5	1
White shark	BOEM 18	Feb	2021	1	2	1
White shark	BOEM 18	Mar	2020	1	4	1
White shark	BOEM 18	Mar	2021	3	16	3
White shark	BOEM 18	Apr	2016	1	3	1
White shark	BOEM 18	Apr	2019	1	7	1
White shark	BOEM 18	Apr	2020	2	9	3
White shark	BOEM 18	Apr	2021	3	12	2
White shark	BOEM 18	May	2019	2	9	2
White shark	BOEM 18	May	2020	4	19	4
White shark	BOEM 18	May	2021	6	17	4
White shark	BOEM 18	Jun	2019	3	17	4
White shark	BOEM 18	Jun	2020	2	7	2
White shark	BOEM 18	Jun	2021	2	11	2
White shark	BOEM 18	Jul	2020	2	13	3
White shark	BOEM 18	Jul	2021	1	7	1

Species	Site	Month	Year	Individuals	Detections	Days
White shark	BOEM 18	Sep	2020	1	1	1
White shark	BOEM 18	Oct	2016	1	3	1
White shark	BOEM 18	Oct	2019	3	20	2
White shark	BOEM 18	Oct	2020	2	46	3
White shark	BOEM 18	Nov	2016	2	14	2
White shark	BOEM 18	Nov	2018	1	12	1
White shark	BOEM 18	Nov	2019	1	10	1
White shark	BOEM 18	Nov	2020	5	35	4
White shark	BOEM 18	Dec	2016	1	3	1
White shark	BOEM 18	Dec	2018	1	6	1
White shark	BOEM 19	Feb	2016	1	1	1
White shark	BOEM 19	Mar	2021	5	32	4
White shark	BOEM 19	Apr	2016	2	11	3
White shark	BOEM 19	Apr	2019	1	3	1
White shark	BOEM 19	Apr	2020	1	7	1
White shark	BOEM 19	Apr	2021	3	6	2
White shark	BOEM 19	May	2019	4	18	4
White shark	BOEM 19	May	2020	4	16	3
White shark	BOEM 19	May	2021	4	14	3
White shark	BOEM 19	Jun	2019	2	10	2
White shark	BOEM 19	Jun	2020	3	14	3
White shark	BOEM 19	Jul	2020	1	8	1
White shark	BOEM 19	Jul	2021	4	24	3
White shark	BOEM 19	Sep	2019	1	9	1
White shark	BOEM 19	Sep	2020	1	1	1
White shark	BOEM 19	Oct	2018	1	1	1
White shark	BOEM 19	Oct	2019	2	12	2
White shark	BOEM 19	Nov	2019	3	35	2
White shark	BOEM 19	Nov	2020	1	2	1
White shark	BOEM 19	Dec	2018	1	6	1
White shark	BOEM 19	Dec	2019	1	4	1
White shark	BOEM 20	Mar	2020	1	2	1
White shark	BOEM 20	Apr	2016	1	5	1
White shark	BOEM 20	Apr	2017	1	4	1
White shark	BOEM 20	Apr	2018	1	2	1
White shark	BOEM 20	Apr	2019	4	12	3
White shark	BOEM 20	Apr	2021	3	13	2
White shark	BOEM 20	May	2016	1	6	1
White shark	BOEM 20	May	2019	6	38	6
White shark	BOEM 20	May	2020	2	2	2
White shark	BOEM 20	May	2021	2	8	2
White shark	BOEM 20	Jun	2018	1	4	1
White shark	BOEM 20	Jun	2019	4	16	4
White shark	BOEM 20	Jun	2020	3	6	3
White shark	BOEM 20	Jun	2021	1	3	1
White shark	BOEM 20	Jul	2017	1	4	1
White shark	BOEM 20	Jul	2018	1	2	1
White shark	BOEM 20	Jul	2020	1	3	1
White shark	BOEM 20	Jul	2021	4	33	2
White shark	BOEM 20	Sep	2017	1	8	1

Species	Site	Month	Year	Individuals	Detections	Days
White shark	BOEM 20	Sep	2019	1	3	1
White shark	BOEM 20	Oct	2016	1	8	1
White shark	BOEM 20	Oct	2017	1	13	1
White shark	BOEM 20	Oct	2019	1	21	1
White shark	BOEM 20	Nov	2016	2	11	2
White shark	BOEM 20	Nov	2017	1	9	1
White shark	BOEM 20	Nov	2018	1	1	1
White shark	BOEM 20	Nov	2019	1	25	2
White shark	BOEM 20	Nov	2020	1	7	1
White shark	BOEM 20	Dec	2016	1	1	1
White shark	BOEM 20	Dec	2020	1	15	1

D.13 CRA cobia detections by year and month.

Species	Year	Month	Individuals	Detections	Days
Cobia	2017	Aug	1	8	1
Cobia	2017	Sep	4	16	4
Cobia	2017	Oct	3	65	5
Cobia	2018	May	4	87	4
Cobia	2018	Jun	17	172	16
Cobia	2018	Jul	8	54	10
Cobia	2018	Aug	8	164	14
Cobia	2018	Sep	17	539	12
Cobia	2018	Oct	23	1013	17
Cobia	2019	May	21	218	15
Cobia	2019	Jun	24	527	23
Cobia	2019	Jul	13	112	16
Cobia	2019	Aug	10	224	18
Cobia	2019	Sep	46	1567	28
Cobia	2019	Oct	29	760	17
Cobia	2020	May	1	2	1
Cobia	2020	Jun	13	571	17
Cobia	2020	Jul	20	1445	27
Cobia	2020	Aug	19	844	23
Cobia	2020	Sep	19	572	21
Cobia	2020	Oct	10	460	14
Cobia	2021	May	12	49	11
Cobia	2021	Jun	11	481	23
Cobia	2021	Jul	11	309	16
Cobia	2021	Aug	4	68	6

D.14 CRA cobia detections by receiver site, month, and year.

Species	Site	Month	Year	Individuals	Detections	Days
Cobia	1 BOEM	May	2021	1	11	1
Cobia	1 BOEM	Jun	2018	2	11	2
Cobia	1 BOEM	Jun	2019	4	36	4
Cobia	1 BOEM	Jun	2020	5	29	6
Cobia	1 BOEM	Jun	2021	6	70	7
Cobia	1 BOEM	Jul	2018	2	27	2
Cobia	1 BOEM	Jul	2020	2	34	4
Cobia	1 BOEM	Jul	2021	3	35	4
Cobia	1 BOEM	Aug	2018	2	28	3
Cobia	1 BOEM	Aug	2019	2	9	2
Cobia	1 BOEM	Aug	2020	7	53	6
Cobia	1 BOEM	Sep	2017	1	3	1
Cobia	1 BOEM	Sep	2018	5	124	4
Cobia	1 BOEM	Sep	2019	20	338	12
Cobia	1 BOEM	Sep	2020	4	44	5
Cobia	1 BOEM	Oct	2018	3	61	3
Cobia	1 BOEM	Oct	2019	13	349	11
Cobia	1 BOEM	Oct	2020	1	85	2
Cobia	2 BOEM	May	2018	1	28	2
Cobia	2 BOEM	Jun	2018	2	21	2
Cobia	2 BOEM	Jun	2019	4	98	6
Cobia	2 BOEM	Jun	2020	3	58	4
Cobia	2 BOEM	Jun	2021	4	32	6
Cobia	2 BOEM	Jul	2020	3	15	3
Cobia	2 BOEM	Jul	2021	1	2	2
Cobia	2 BOEM	Aug	2018	1	11	1
Cobia	2 BOEM	Aug	2020	7	217	6
Cobia	2 BOEM	Sep	2018	2	36	2
Cobia	2 BOEM	Sep	2019	8	65	7
Cobia	2 BOEM	Sep	2020	1	1	1
Cobia	2 BOEM	Oct	2018	3	241	3
Cobia	2 BOEM	Oct	2019	2	17	2
Cobia	3 BOEM	May	2018	1	10	1
Cobia	3 BOEM	Jun	2019	6	65	5
Cobia	3 BOEM	Jun	2020	4	67	3
Cobia	3 BOEM	Jul	2020	4	36	4
Cobia	3 BOEM	Aug	2018	1	5	1
Cobia	3 BOEM	Aug	2020	3	56	4
Cobia	3 BOEM	Sep	2017	1	1	1
Cobia	3 BOEM	Sep	2018	3	106	2
Cobia	3 BOEM	Sep	2019	5	41	5
Cobia	3 BOEM	Sep	2020	4	12	4
Cobia	3 BOEM	Oct	2017	1	13	1
Cobia	3 BOEM	Oct	2018	3	32	3
Cobia	3 BOEM	Oct	2019	1	1	1
Cobia	3 BOEM	Oct	2020	1	3	1
Cobia	4 BOEM	May	2018	1	19	1
Cobia	4 BOEM	May	2019	4	31	4

Species	Site	Month	Year	Individuals	Detections	Days
Cobia	4 BOEM	Jun	2019	3	39	3
Cobia	4 BOEM	Jun	2020	6	92	7
Cobia	4 BOEM	Jun	2021	3	36	4
Cobia	4 BOEM	Jul	2019	1	4	1
Cobia	4 BOEM	Jul	2020	7	56	6
Cobia	4 BOEM	Jul	2021	4	33	6
Cobia	4 BOEM	Aug	2020	2	18	2
Cobia	4 BOEM	Sep	2018	2	8	2
Cobia	4 BOEM	Sep	2019	2	3	2
Cobia	4 BOEM	Sep	2020	2	22	2
Cobia	4 BOEM	Oct	2018	2	167	4
Cobia	4 BOEM	Oct	2019	1	17	1
Cobia	5 BOEM	May	2019	2	48	3
Cobia	5 BOEM	May	2020	1	2	1
Cobia	5 BOEM	Jun	2018	1	31	1
Cobia	5 BOEM	Jun	2019	4	58	5
Cobia	5 BOEM	Jun	2020	4	56	4
Cobia	5 BOEM	Jul	2018	1	2	1
Cobia	5 BOEM	Jul	2019	1	7	1
Cobia	5 BOEM	Jul	2020	9	106	11
Cobia	5 BOEM	Aug	2018	1	46	3
Cobia	5 BOEM	Aug	2019	1	11	1
Cobia	5 BOEM	Aug	2020	6	92	6
Cobia	5 BOEM	Sep	2019	2	2	2
Cobia	5 BOEM	Sep	2020	3	50	3
Cobia	5 BOEM	Oct	2018	2	66	3
Cobia	5 BOEM	Oct	2019	4	36	3
Cobia	5 BOEM	Oct	2020	1	66	1
Cobia	6 BOEM	May	2019	2	33	2
Cobia	6 BOEM	Jun	2018	1	18	1
Cobia	6 BOEM	Jun	2019	4	22	4
Cobia	6 BOEM	Jun	2020	3	31	3
Cobia	6 BOEM	Jun	2021	3	86	3
Cobia	6 BOEM	Jul	2018	1	6	2
Cobia	6 BOEM	Jul	2019	2	8	2
Cobia	6 BOEM	Jul	2020	6	111	7
Cobia	6 BOEM	Jul	2021	3	16	3
Cobia	6 BOEM	Aug	2018	2	11	2
Cobia	6 BOEM	Aug	2020	3	66	3
Cobia	6 BOEM	Sep	2019	2	13	2
Cobia	6 BOEM	Oct	2017	1	17	1
Cobia	6 BOEM	Oct	2018	5	234	4
Cobia	6 BOEM	Oct	2019	2	32	2
Cobia	6 BOEM	Oct	2020	1	1	1
Cobia	BOEM 13	May	2019	3	45	4
Cobia	BOEM 13	Jun	2018	2	17	2
Cobia	BOEM 13	Jun	2019	3	50	4
Cobia	BOEM 13	Jun	2020	2	70	2
Cobia	BOEM 13	Jun	2021	2	56	2
Cobia	BOEM 13	Jul	2018	1	1	1

Species	Site	Month	Year	Individuals	Detections	Days
Cobia	BOEM 13	Jul	2020	5	111	5
Cobia	BOEM 13	Jul	2021	2	13	2
Cobia	BOEM 13	Aug	2018	1	3	1
Cobia	BOEM 13	Aug	2020	3	77	3
Cobia	BOEM 13	Sep	2019	3	117	4
Cobia	BOEM 13	Sep	2020	2	173	3
Cobia	BOEM 13	Oct	2018	2	23	2
Cobia	BOEM 13	Oct	2019	4	52	4
Cobia	BOEM 13	Oct	2020	1	6	1
Cobia	BOEM 14	May	2018	1	19	1
Cobia	BOEM 14	May	2019	1	10	1
Cobia	BOEM 14	May	2021	1	10	1
Cobia	BOEM 14	Jun	2018	3	29	3
Cobia	BOEM 14	Jun	2019	6	54	4
Cobia	BOEM 14	Jun	2021	4	66	4
Cobia	BOEM 14	Jul	2018	1	1	1
Cobia	BOEM 14	Jul	2019	1	3	1
Cobia	BOEM 14	Jul	2020	3	56	3
Cobia	BOEM 14	Jul	2021	2	4	2
Cobia	BOEM 14	Aug	2019	1	7	1
Cobia	BOEM 14	Aug	2020	3	32	4
Cobia	BOEM 14	Sep	2017	1	11	1
Cobia	BOEM 14	Sep	2019	2	23	2
Cobia	BOEM 14	Oct	2018	1	33	1
Cobia	BOEM 14	Oct	2019	3	10	3
Cobia	CB	May	2019	1	1	1
Cobia	CB	May	2021	1	3	1
Cobia	CB	Jun	2020	3	21	3
Cobia	CB	Jun	2021	4	21	5
Cobia	CB	Jul	2018	1	2	1
Cobia	CB	Jul	2019	4	14	4
Cobia	CB	Jul	2020	2	203	5
Cobia	CB	Jul	2021	3	22	5
Cobia	CB	Aug	2018	1	4	1
Cobia	CB	Aug	2019	1	2	1
Cobia	CB	Aug	2020	3	97	5
Cobia	CB	Sep	2018	4	29	3
Cobia	CB	Sep	2019	16	215	10
Cobia	CB	Sep	2020	2	46	2
Cobia	CB	Oct	2017	2	11	2
Cobia	CB	Oct	2018	3	20	4
Cobia	CB	Oct	2019	9	121	8
Cobia	CB	Oct	2020	2	28	2
Cobia	CB 1	May	2018	1	9	1
Cobia	CB 1	Jun	2018	1	3	1
Cobia	CB 1	Jun	2019	1	1	1
Cobia	CB 1	Jun	2020	2	17	2
Cobia	CB 1	Jun	2021	4	19	5
Cobia	CB 1	Jul	2018	1	6	1
Cobia	CB 1	Jul	2019	2	4	2

Species	Site	Month	Year	Individuals	Detections	Days
Cobia	CB 1	Jul	2020	5	139	6
Cobia	CB 1	Jul	2021	3	23	4
Cobia	CB 1	Aug	2018	1	2	1
Cobia	CB 1	Aug	2019	3	17	3
Cobia	CB 1	Aug	2020	2	7	2
Cobia	CB 1	Aug	2021	1	1	1
Cobia	CB 1	Sep	2018	3	21	3
Cobia	CB 1	Sep	2019	1	2	1
Cobia	CB 1	Oct	2017	1	1	1
Cobia	CB 1	Oct	2018	6	54	6
Cobia	CB 1	Oct	2020	2	16	2
Cobia	RA	May	2019	1	1	1
Cobia	RA	May	2021	3	7	3
Cobia	RA	Jun	2018	1	4	1
Cobia	RA	Jun	2019	4	17	3
Cobia	RA	Jun	2020	1	1	1
Cobia	RA	Jun	2021	4	16	4
Cobia	RA	Jul	2018	1	2	1
Cobia	RA	Jul	2019	3	26	4
Cobia	RA	Jul	2020	8	269	9
Cobia	RA	Jul	2021	5	34	4
Cobia	RA	Aug	2017	1	8	1
Cobia	RA	Aug	2018	2	13	3
Cobia	RA	Aug	2019	5	47	6
Cobia	RA	Aug	2020	6	23	7
Cobia	RA	Aug	2021	3	30	3
Cobia	RA	Sep	2017	1	1	1
Cobia	RA	Sep	2018	5	23	5
Cobia	RA	Sep	2019	25	465	23
Cobia	RA	Sep	2020	9	51	10
Cobia	RA	Oct	2017	2	23	2
Cobia	RA	Oct	2018	7	79	6
Cobia	RA	Oct	2019	11	111	8
Cobia	RA	Oct	2020	1	1	1
Cobia	RA outside	May	2021	1	4	1
Cobia	RA outside	Jun	2020	2	129	5
Cobia	RA outside	Jun	2021	4	79	5
Cobia	RA outside	Jul	2020	10	309	18
Cobia	RA outside	Jul	2021	6	122	9
Cobia	RA outside	Aug	2020	10	106	11
Cobia	RA outside	Aug	2021	2	37	4
Cobia	RA outside	Sep	2020	10	160	9
Cobia	RA outside	Oct	2020	5	254	6
Cobia	RI	May	2018	1	1	1
Cobia	RI	May	2019	7	30	4
Cobia	RI	Jun	2018	7	29	7
Cobia	RI	Jun	2019	8	64	7
Cobia	RI	Jul	2018	3	4	3
Cobia	RI	Jul	2019	3	46	5
Cobia	RI	Aug	2018	4	40	4

Species	Site	Month	Year	Individuals	Detections	Days
Cobia	RI	Aug	2019	7	115	12
Cobia	RI	Sep	2018	5	192	5
Cobia	RI	Sep	2019	12	232	9
Cobia	RI	Oct	2018	1	3	1
Cobia	RI	Oct	2019	1	7	1
Cobia	RI 2	May	2018	1	1	1
Cobia	RI 2	May	2019	11	19	7
Cobia	RI 2	May	2021	7	14	5
Cobia	RI 2	Jun	2018	3	9	2
Cobia	RI 2	Jun	2019	6	23	5
Cobia	RI 2	Jul	2018	1	3	1
Cobia	RI 2	Jul	2021	1	5	1
Cobia	RI 2	Aug	2018	1	1	1
Cobia	RI 2	Aug	2019	3	16	4
Cobia	RI 2	Sep	2019	8	51	7
Cobia	RI 2	Sep	2020	1	13	1
Cobia	RI 2	Oct	2019	1	7	1

D.15 CRA sand tiger shark detections by year and month.

Species	Year	Month	Individuals	Detections	Days
Sand tiger shark	2016	May	8	48	7
Sand tiger shark	2016	Jun	16	57	13
Sand tiger shark	2016	Jul	2	21	2
Sand tiger shark	2016	Aug	1	17	1
Sand tiger shark	2016	Sep	2	6	2
Sand tiger shark	2016	Oct	16	53	10
Sand tiger shark	2016	Nov	3	13	3
Sand tiger shark	2017	Apr	1	28	1
Sand tiger shark	2017	May	7	28	5
Sand tiger shark	2017	Jul	1	7	1
Sand tiger shark	2017	Sep	2	10	2
Sand tiger shark	2017	Oct	7	31	6
Sand tiger shark	2017	Nov	7	72	5
Sand tiger shark	2018	Apr	1	1	1
Sand tiger shark	2018	May	8	31	9
Sand tiger shark	2018	Jun	10	23	8
Sand tiger shark	2018	Jul	1	3	1
Sand tiger shark	2018	Oct	12	62	7
Sand tiger shark	2018	Nov	3	14	3
Sand tiger shark	2019	Apr	1	5	1
Sand tiger shark	2019	May	13	73	12
Sand tiger shark	2019	Jun	8	54	9
Sand tiger shark	2019	Jul	1	9	2

Species	Year	Month	Individuals	Detections	Days
Sand tiger shark	2019	Aug	2	116	7
Sand tiger shark	2019	Sep	1	12	1
Sand tiger shark	2019	Oct	16	192	9
Sand tiger shark	2019	Nov	6	24	5
Sand tiger shark	2020	May	8	47	7
Sand tiger shark	2020	Jun	5	41	5
Sand tiger shark	2020	Sep	1	2	1
Sand tiger shark	2020	Oct	16	75	11
Sand tiger shark	2020	Nov	7	70	6
Sand tiger shark	2021	May	19	164	14
Sand tiger shark	2021	Jun	5	24	7

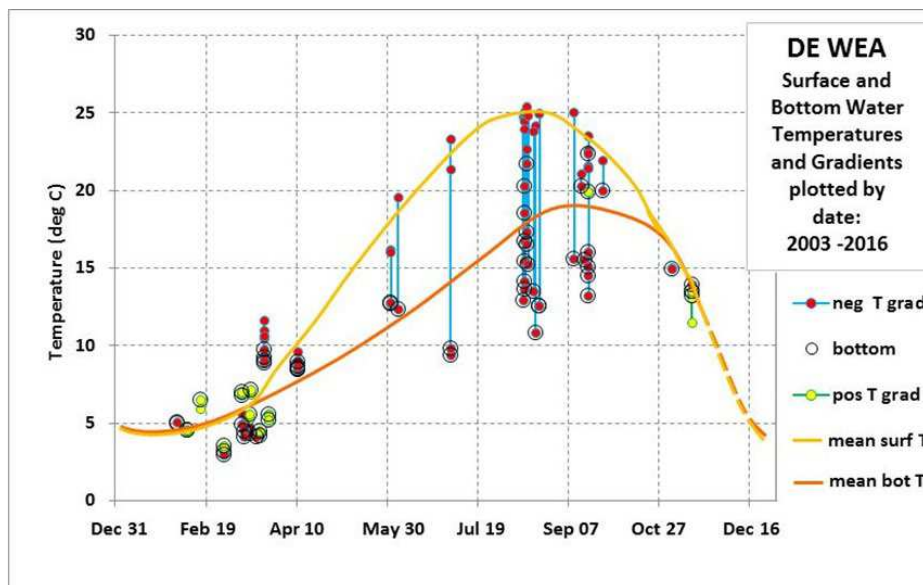
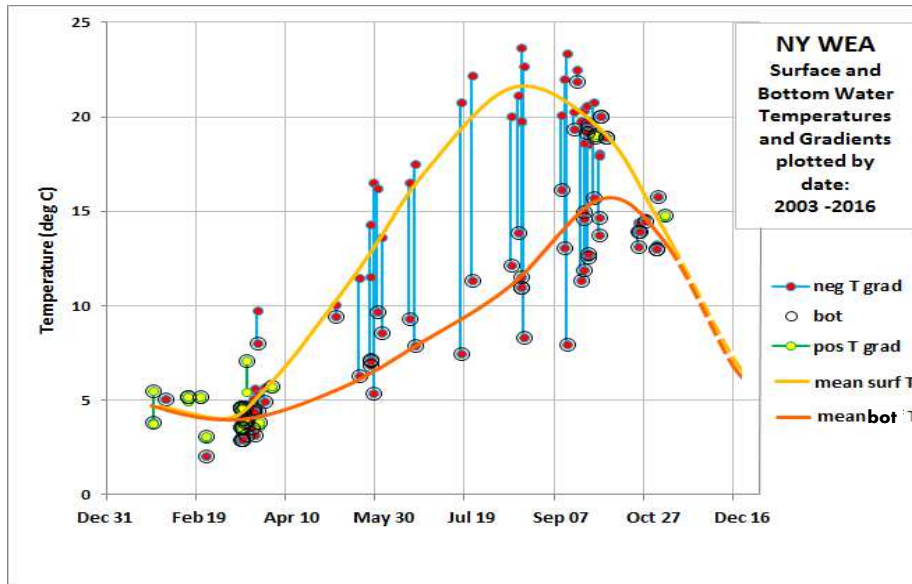
D.16 CRA sand tiger shark by receiver site, month, and year.

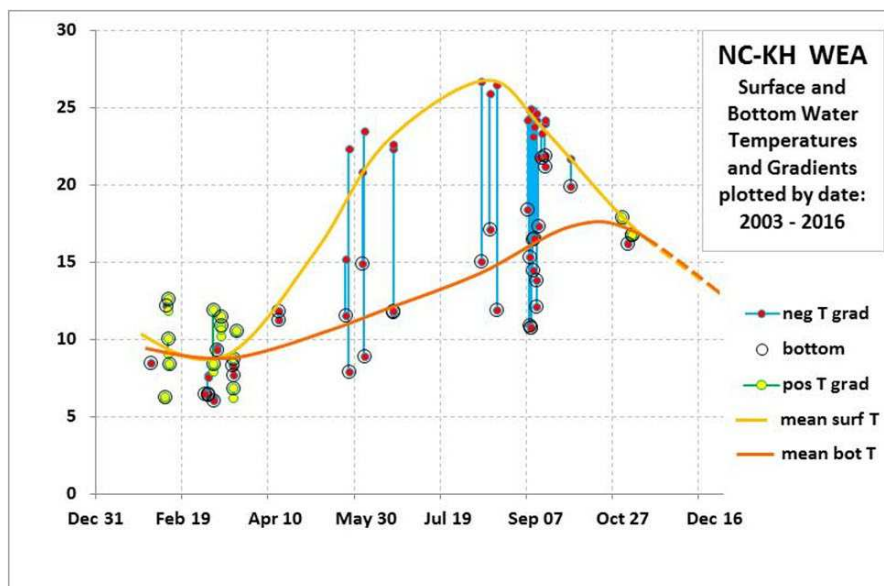
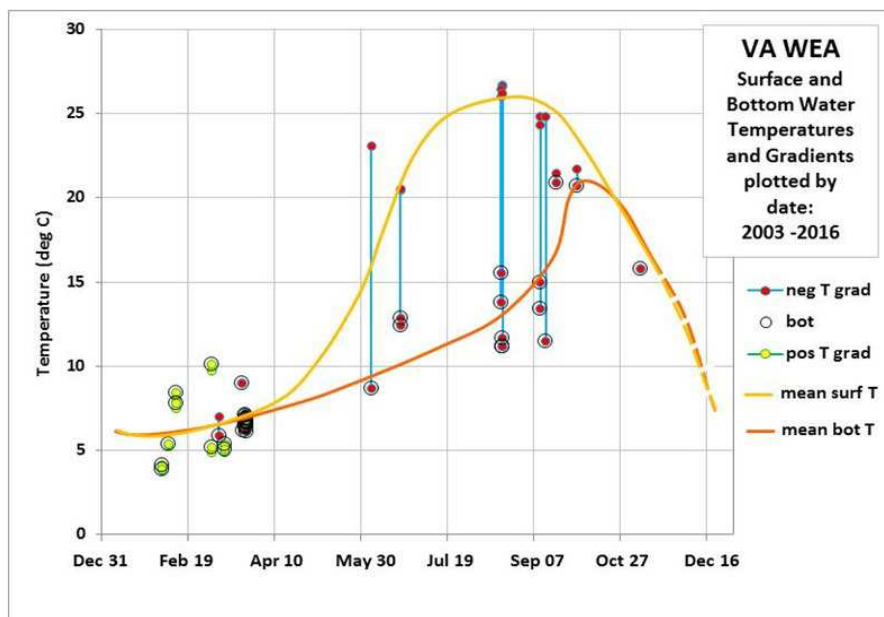
Species	Site	Month	Year	Individuals	Detections	Days
Sand tiger shark	1 BOEM	May	2018	1	5	1
Sand tiger shark	1 BOEM	May	2019	2	4	2
Sand tiger shark	1 BOEM	May	2021	1	9	1
Sand tiger shark	1 BOEM	Jun	2016	3	10	3
Sand tiger shark	1 BOEM	Jun	2018	1	1	1
Sand tiger shark	1 BOEM	Jun	2020	1	15	1
Sand tiger shark	1 BOEM	Jul	2016	1	8	1
Sand tiger shark	1 BOEM	Aug	2016	1	17	1
Sand tiger shark	1 BOEM	Oct	2016	1	10	1
Sand tiger shark	1 BOEM	Oct	2017	1	8	1
Sand tiger shark	1 BOEM	Oct	2018	4	24	3
Sand tiger shark	1 BOEM	Oct	2019	8	150	5
Sand tiger shark	1 BOEM	Oct	2020	2	2	2
Sand tiger shark	1 BOEM	Nov	2017	1	6	1
Sand tiger shark	1 BOEM	Nov	2019	2	6	2
Sand tiger shark	1 BOEM	Nov	2020	1	8	1
Sand tiger shark	2 BOEM	Jun	2016	1	1	1
Sand tiger shark	2 BOEM	Jun	2018	2	4	2
Sand tiger shark	2 BOEM	Sep	2019	1	12	1
Sand tiger shark	2 BOEM	Oct	2016	1	1	1
Sand tiger shark	2 BOEM	Oct	2018	1	4	1
Sand tiger shark	2 BOEM	Oct	2019	3	12	3
Sand tiger shark	2 BOEM	Oct	2020	1	3	1
Sand tiger shark	2 BOEM	Nov	2019	2	8	2
Sand tiger shark	3 BOEM	Jun	2018	1	1	1
Sand tiger shark	3 BOEM	Oct	2016	2	4	2
Sand tiger shark	3 BOEM	Oct	2017	1	1	1
Sand tiger shark	3 BOEM	Oct	2018	2	8	1
Sand tiger shark	3 BOEM	Oct	2019	1	5	1
Sand tiger shark	3 BOEM	Oct	2020	2	19	2
Sand tiger shark	3 BOEM	Nov	2018	1	5	1
Sand tiger shark	4 BOEM	Jun	2016	1	10	1

Species	Site	Month	Year	Individuals	Detections	Days
Sand tiger shark	4 BOEM	Oct	2016	1	3	1
Sand tiger shark	4 BOEM	Oct	2018	1	3	1
Sand tiger shark	4 BOEM	Oct	2019	2	16	2
Sand tiger shark	4 BOEM	Oct	2020	2	4	2
Sand tiger shark	4 BOEM	Nov	2017	1	3	1
Sand tiger shark	4 BOEM	Nov	2020	1	3	1
Sand tiger shark	5 BOEM	Jul	2016	1	13	1
Sand tiger shark	5 BOEM	Sep	2016	1	1	1
Sand tiger shark	5 BOEM	Oct	2016	3	16	3
Sand tiger shark	5 BOEM	Oct	2020	1	7	1
Sand tiger shark	5 BOEM	Nov	2019	1	6	1
Sand tiger shark	6 BOEM	May	2019	1	6	1
Sand tiger shark	6 BOEM	Jun	2019	1	2	1
Sand tiger shark	6 BOEM	Sep	2017	1	5	1
Sand tiger shark	6 BOEM	Oct	2017	1	2	1
Sand tiger shark	6 BOEM	Oct	2020	3	25	3
Sand tiger shark	6 BOEM	Nov	2020	1	11	1
Sand tiger shark	BOEM 13	Jun	2018	1	1	1
Sand tiger shark	BOEM 13	Jun	2021	1	9	1
Sand tiger shark	BOEM 13	Oct	2018	1	6	1
Sand tiger shark	BOEM 13	Nov	2017	1	14	1
Sand tiger shark	BOEM 13	Nov	2020	1	7	1
Sand tiger shark	BOEM 14	Jun	2018	1	4	1
Sand tiger shark	BOEM 14	Jun	2021	1	4	1
Sand tiger shark	BOEM 14	Nov	2020	2	13	2
Sand tiger shark	CB	May	2017	1	2	1
Sand tiger shark	CB	Oct	2016	2	6	1
Sand tiger shark	CB	Oct	2018	1	7	1
Sand tiger shark	CB	Oct	2019	3	7	3
Sand tiger shark	CB	Oct	2020	3	7	3
Sand tiger shark	CB	Nov	2019	2	4	2
Sand tiger shark	CB	Nov	2020	1	13	1
Sand tiger shark	CB 1	May	2018	1	6	1
Sand tiger shark	CB 1	May	2020	3	5	2
Sand tiger shark	CB 1	May	2021	2	8	2
Sand tiger shark	CB 1	Jun	2016	1	1	1
Sand tiger shark	CB 1	Jun	2018	1	4	1
Sand tiger shark	CB 1	Jun	2019	1	1	1
Sand tiger shark	CB 1	Jul	2018	1	3	1
Sand tiger shark	CB 1	Oct	2020	2	2	2
Sand tiger shark	CB 1	Nov	2017	1	3	1
Sand tiger shark	RA	Apr	2018	1	1	1
Sand tiger shark	RA	May	2016	3	5	3
Sand tiger shark	RA	May	2018	3	10	3
Sand tiger shark	RA	May	2019	6	22	6
Sand tiger shark	RA	May	2020	1	12	1
Sand tiger shark	RA	May	2021	5	36	6
Sand tiger shark	RA	Jun	2016	2	5	3
Sand tiger shark	RA	Jun	2018	4	8	3
Sand tiger shark	RA	Jun	2019	4	10	4

Species	Site	Month	Year	Individuals	Detections	Days
Sand tiger shark	RA	Jun	2021	1	4	2
Sand tiger shark	RA	Oct	2016	1	2	1
Sand tiger shark	RA	Oct	2017	1	10	1
Sand tiger shark	RA	Oct	2018	2	10	2
Sand tiger shark	RA	Oct	2019	1	2	1
Sand tiger shark	RA	Oct	2020	1	6	1
Sand tiger shark	RA	Nov	2017	2	16	2
Sand tiger shark	RA	Nov	2018	1	2	1
Sand tiger shark	RA	Nov	2020	1	15	1
Sand tiger shark	RA outside	May	2016	3	32	3
Sand tiger shark	RA outside	May	2017	3	13	2
Sand tiger shark	RA outside	May	2020	5	30	5
Sand tiger shark	RA outside	May	2021	7	70	6
Sand tiger shark	RA outside	Jun	2016	1	3	1
Sand tiger shark	RA outside	Jun	2020	4	26	4
Sand tiger shark	RA outside	Jun	2021	2	4	2
Sand tiger shark	RA outside	Sep	2020	1	2	1
Sand tiger shark	RA outside	Oct	2016	2	6	2
Sand tiger shark	RA outside	Nov	2016	1	2	1
Sand tiger shark	RI	Apr	2017	1	28	1
Sand tiger shark	RI	Apr	2019	1	2	1
Sand tiger shark	RI	May	2016	3	11	3
Sand tiger shark	RI	May	2017	2	10	2
Sand tiger shark	RI	May	2018	3	5	3
Sand tiger shark	RI	May	2019	4	33	4
Sand tiger shark	RI	Jun	2016	5	19	5
Sand tiger shark	RI	Jun	2019	2	17	3
Sand tiger shark	RI	Jul	2019	1	9	2
Sand tiger shark	RI	Aug	2019	2	102	6
Sand tiger shark	RI	Sep	2016	1	5	1
Sand tiger shark	RI	Sep	2017	1	5	1
Sand tiger shark	RI	Oct	2016	1	2	1
Sand tiger shark	RI	Oct	2017	2	7	2
Sand tiger shark	RI	Nov	2016	2	11	2
Sand tiger shark	RI	Nov	2018	1	7	1
Sand tiger shark	RI 2	Apr	2019	1	3	1
Sand tiger shark	RI 2	May	2017	2	3	2
Sand tiger shark	RI 2	May	2018	1	5	2
Sand tiger shark	RI 2	May	2019	2	8	2
Sand tiger shark	RI 2	May	2021	6	41	5
Sand tiger shark	RI 2	Jun	2016	2	8	2
Sand tiger shark	RI 2	Jun	2019	1	24	3
Sand tiger shark	RI 2	Jun	2021	1	3	1
Sand tiger shark	RI 2	Jul	2017	1	7	1
Sand tiger shark	RI 2	Aug	2019	2	14	3
Sand tiger shark	RI 2	Oct	2016	2	3	2
Sand tiger shark	RI 2	Oct	2017	1	3	1
Sand tiger shark	RI 2	Nov	2017	1	30	1

Appendix E: Water temperatures from CTD casts between 2003 and 2016 in the NY WEA, DE WEA (surrogate for MD), VA WEA, and NC-KH WEA copied from Guida et al. 2017.







U.S. Department of the Interior (DOI)

DOI protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.



Bureau of Ocean Energy Management (BOEM)

BOEM's mission is to manage development of U.S. Outer Continental Shelf energy and mineral resources in an environmentally and economically responsible way.

BOEM Environmental Studies Program

The mission of the Environmental Studies Program is to provide the information needed to predict, assess, and manage impacts from offshore energy and marine mineral exploration, development, and production activities on human, marine, and coastal environments. The proposal, selection, research, review, collaboration, production, and dissemination of each of BOEM's Environmental Studies follows the DOI Code of Scientific and Scholarly Conduct, in support of a culture of scientific and professional integrity, as set out in the DOI Departmental Manual (305 DM 3).