A proposal submitted to the

Virginia Marine Resources Commission
Recreational Fishery Advisory Board

by

School of Marine Science
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The College of William and Mary
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TEMPERATURE SELECTIVITY AND MOVEMENT PATTERNS OF SPECKLED TROUT

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December 2014

VIRGINIA SALTWATER RECREATIONAL FISHING DEVELOPMENT FUND
SUMMARY PROJECT APPLICATION

Please complete all fields. This page should be used as a coversheet for a detailed application.

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DESCRIPTIVE TITLE OF EVENT:
Temperature selectivity and movement patterns of speckled trout

PROJECT LOCATION:
Corrotoman and Elizabeth Rivers

BRIEF PROJECT SUMMARY: (include a detailed description of activity as an attachment)

Speckled trout is an important species targeted by recreational fishing in the southeastern United States and has recently grown in popularity among recreation anglers in Virginia. Virginia is the northern extent of the population range of speckled trout and the cold winter temperatures sometimes have adverse (and possibly lethal) effects on speckled trout compared to populations further south. It is unknown how the large temperature swings of Chesapeake Bay (0-32 °C) affect the movements of speckled trout. This project aims to acoustically tag speckled trout to evaluate temperature selectivity, movement patterns, and site fidelity. The acoustic tags have an additional sensor to record the water temperature at the location of the fish. We will combine these data with regional water temperature data to understand if speckled trout select for certain temperatures or locations regardless of temperature. This will provide information about how winter weather patterns cause cold stun events in speckled trout. This project will also provide data on seasonal movements of speckled trout, as there is debate on the degree of connectivity of populations within and between Chesapeake Bay and North Carolina. The movement data will provide insight into how often speckled trout move between different estuaries. The data collected on temperature selectivity and movements will be novel for this population of speckled trout and will provide both managers and recreational fishermen with valuable information to both better manage the stock and locate the fish.

***This form alone does not constitute a complete application, see application instructions or contact Alicia Nelson at 757-247-8155 or alicia.nelson@mrc.virginia.gov**

EXPECTED BENEFITS: (Describe how your project directly benefits the average Virginia recreational angler)

Tracking the movements and temperature selectivity of speckled trout benefits the average Virginia recreational angler in many ways. Acoustic tags, unlike conventional tags, provide thousands of location points for a single fish. Couple the location data with the data from the temperature sensors and a picture develops about where and when speckled trout move and the preferred temperature regimes during each season. This will aid recreational anglers in finding speckled trout throughout the year. This project will also benefit recreational anglers by providing managers with information to better oversee the status of the stock. Temperature selectivity during cold stun events and connectivity of populations are two important pieces of data missing from the fishery manager's toolbox. This project has positive implications for recreational fishermen both directly in terms of catching fish and indirectly in terms of providing for better management practices.

SUMMARY COSTS: (Please attach a detailed budget including all sources of recipient funding)

SUMMARY COSTS

Requested VMRC Funding:	**$55,708**
Recipient Funding:	**$17,397**
Total Costs:	**$73,105**

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Temperature selectivity and movement patterns of speckled trout

I.) Need

The speckled trout (*Cynoscion nebulosus*) is an important recreational species in the southeastern United States. Recreational harvest nationally and within Virginia far exceeds commercial harvest (Jensen 2009). Recreational landings in Virginia were estimated to be 226,556 lbs in 2012 (NOAA MRIP data). This generates over $6 million in income and $10 million in sales (Duberg et al. 2006). The Atlantic States Marine Fisheries Commission (ASMFC) imposes a 12-inch minimum size length to protect the spawning stock abundance and limit the harvest of immature fish (ASFMC Ominbus Amendment 2011). A coast-wide stock assessment of speckled trout has not been conducted because speckled trout are recognized as a largely non-migratory species. **Speckled trout, however, do make some coastal movements, although there is a severe lack of information regarding the patterns and scale related to migration in this species.** Speckled trout in Virginia has been cited as both a transitional population and as a mostly non-migratory population. Historical studies have shown an average of 15% of the population may migrate to North Carolina (Jensen 2009). Even the most recent North Carolina speckled trout Fisheries Management Plan included speckled trout landings from Virginia. More recent data indicates that only approximately 4% population moves between Virginia and North Carolina (S. Musick, pers. comm.). Genetic work is currently being performed to determine if two (or more) stocks exist within these states. There is some indication that several rivers in Virginia are genetically unique (J. McDowell pers. comm.). Tagging studies outside of Virginia and North Carolina have also indicated that speckled trout are largely resident to their natal estuaries and often do not make coastal migrations (Iverson and Tabb 1962; Music 1981; Bryant et al. 1989). **The sparse data on speckled trout movements within Virginia hinders management practices for both Virginia and North Carolina fishery managers.**

Management of speckled trout has also been marred by cold stun events which can kill a significant portion of the stock and have detrimental localized effects. Unfortunately, it has not been possible to quantify the increased mortality due to cold stuns. Cold stuns have been linked to an increase in fishing mortality rate in North Carolina (Jensen 2009). Virginia is the northern extent of speckled trout populations and this region is the most likely portion of its range to experience cold stun events. Virginia water temperatures can reach 0°C during some winters. Although no formal study has been conducted at looking at the lethal temperatures for adult speckled trout, dead or moribund fish have been found in water temperatures from 0 - 7 °C (Storey and Gudger 1936; Tabb 1958; Moore 1976; Ellis 2014). The thermal tolerance for juvenile speckled trout was tested in the laboratory and significant mortality occurred between 3 and 4 °C (Anweiler et al. 2014). The latest cold stun event in Virginia occurred in 2014 and caused a closure to the speckled trout fishery. Although cold stun events are not under the control of fishery managers it might be possible to include them into fishery management plans if managers had more knowledge of speckled trout behavior during the colder months. This would require information on how speckled trout react during the winter months to dramatic decreases in water temperature and long stretches of extremely cold conditions. **This study will employ acoustic tagging and telemetry methods to fill in these data gaps so that habitat use, movement patterns, and environmental responses of speckled trout can be better understood and the species better managed.**

Acoustic tagging has many benefits beyond those of conventional tagging methods. Conventional tagging data typically includes two points: release and recapture locations. Acoustic tags constantly emit signals that, when picked up by receivers, give a more detailed picture of a fishes movement patterns. The downside of acoustic tagging is the expense of receivers and therefore the density of locations where individuals can be detected. However, there are currently several multi-year acoustic tagging studies ongoing in the Chesapeake Bay. Combining the resources of all acoustic tagging studies allows for an increased number of receivers at a minimal cost per study. Currently, acoustic receivers are deployed within the James, Elizabeth, York, Pamunkey, Mattaponi, Rappahannock, Patuxent, and Potomac Rivers. There are also receiver arrays extending off Virginia Beach and stretching across the mouth and northern portion of Chesapeake Bay (Figure 1). Additionally, an acoustic receiver array can be found in most major river systems from Canada to southern Florida. Receiver data are shared between researchers via the Atlantic Coastal Telemetry Network (ACT). In other words, if one of the tagged speckled trout from this proposed study should leave Virginia and enter another estuary, there will be a good chance another research or monitoring project will record its detection and send us the data. Based on acoustic receiver data, it is known that speckled trout do move between adjacent regions. For example, in the fall of 2013 a speckled trout that was tagged in North Carolina was detected off the Virginia Institute of Marine Science (VIMS) pier; these occurrence data was relayed back to Dr. Tim Ellis within a month of the detection.

The proposed acoustic study seeks to better understand how speckled trout react to declining water temperatures as well as to describe the general movements of this species in Chesapeake Bay (and possibly beyond) over the course of a year. Few studies have conducted acoustic telemetry on speckled trout (Callihan et al. 2013; Lowerre-Barbieri et al. 2013; Callihan et al. 2014; Ellis 2014) and none have included tags that are equipped with a temperature sensor. Speckled trout have been reported to mostly stay within the location of tagging and directed movements up and down the estuary depending upon the season. The apparent residency of speckled trout benefits acoustic tagging and increases our likelihood of detecting tagged fish. The densities of the current and proposed acoustic arrays are sufficient to ensure a high degree of probability that a tagged fish will be detected numerous times during the lifespan of the tag. This will provide managers and recreational fishermen with important location and temperature preference data for this species over the course of a year.

It has been generally accepted that fishes move towards deep holes in the winter because temperatures in these habitats are more constant. However, this theory is still untested for speckled trout and the use of acoustic tags with temperature sensors can analyze this paradigm in more detail. Acoustic telemetry, used in combination with temperature sensors, can give insight into the movement of speckled trout associated with declining temperatures. In other words, this project will allow insight into whether speckled trout continue to seek out a thermal refuge or if they find a deep hole and remain there regardless of how cold the temperature becomes. This will lead to a better understanding of how different weather patterns, such as a dramatic drop in temperature or a prolonged cold event, may lead to cold stuns. The lifespan of the tags being used in this study (405 days) is also long enough to determine if speckled trout display site fidelity to winter sites between years. If a fish returns to the same over-wintering location then it can be hypothesized that individuals in more northern rivers may be more adversely affected by

cold stuns occurring in concurrent years. This could lead to localized depletion and possibly could be detrimental to local river stocks.

The data gained from the proposed project will also provide information on movements of speckled trout throughout the year. Acoustic tagging can help answer questions about how often fish move between river systems. The connectivity between river systems is important to understand when describing and managing an important recreational stock of fish. It is also important to understand how often and when speckled trout leave the Bay and if/when they return. This acoustic study will also explore if water temperature has a role in the migration patterns throughout the year and is there a thermal zone in which the species tries to remain. Information regarding site fidelity to both Chesapeake Bay and a river system, along with temperature selectivity has great implications for the management of speckled trout within Virginia. Conventional tagging methods provide two points of reference for each fish tagged, and it always unknown where that fish swam during its time at liberty. The technology of acoustic tags and the current high density of acoustic receivers will allow for greater picture of speckled trout movements and temperature selectivity.

II.) Objectives

1) Describe winter movements of speckled trout to inform management and recreational fishing communities

The primary objective of this project is to provide managers and recreational fishermen with information regarding speckled trout movements during the winter months. Specifically, we aim to acoustically tag speckled trout during the winter within two river systems of Virginia and examine their movements related to declining water temperatures. Acoustic receivers will be placed throughout both rivers allowing the location of tagged fish to be monitored. By using temperature reporting tags and temperature loggers associated with the acoustic receivers, both the temperature of the water around the tagged fish and a temperature profile of the entire river will be recorded. This will enable us to determine if fish are selecting a certain temperature or a specific location. Based upon those results we will have a better understanding if fish are caught by a sudden onset of cold temperatures or if their preferred location became lethally cold. Fishery managers can use this information to model what weather patterns could result in cold stun events and give them the tools to be proactive instead of reactive. It will also enable recreational fishermen to better target speckled trout by utilizing not only certain locations but also environmental conditions (i.e., water temperature).

2) Describe seasonal movements of speckled trout

The second objective of this project is to track fish throughout the year and garner information on seasonal movements and locations. The populations of speckled trout south of Virginia typically remain in their natal estuaries year round. However, these estuaries do not have the temperature swings like that of Chesapeake Bay, which can see temperatures from 0 – 32 °C over the course of one year. The vast difference in temperature may influence speckled trout to seek both thermal refuges in the winter and summer months. The acoustic tags with temperature

sensors used in this study will provide seasonal movements and surrounding temperatures throughout each season.

3) Determine degree and scale of site fidelity of speckled trout

The third objective of this project is to examine if speckled trout display site fidelity and if so on what type of scale. Speckled trout that were conventionally tagged within Virginia (2005-2014) were recaptured in the same river system 85% of the time (S. Musick pers. comm). However, movements between those recapture dates are unknown and understanding how long fish remain within the river it was tagged in or elsewhere has clear management implications. Further, it is important to understand the connectivity between river systems. We will analyze the proportion of fish that switch river systems and the proportion of fish that leave Chesapeake Bay. This information can then be used to understand stock dynamics within Virginia and nearby regions, such as North Carolina. The implanted tags will also have a long enough life span to determine if fish return to the same wintering habitat each year. If site fidelity for wintering habitats does occur then cold stuns over multiple years might be more detrimental to some locations then others.

The timeline for our progress is as follows:

July - September 2015: Purchase materials and locate areas for receiver deployment

October 2015: Deploy receivers and temperature loggers. Speak to local fishing clubs and appear on Don Lancaster's Fishing Tidewater radio program to advertise the project.

November 2015: Tag fish in the Corrotoman and Elizabeth Rivers.

November 2015 – January 2016: Download receiver data and perform receiver maintenance once per month.

May 2016: Complete a preliminary analysis of winter and spring movement data.

January 2016: All acoustic tag batteries will have died.

February 2016: Complete analysis and report data.

III.) Expected Results and Benefits

We expect the information generated by this study will help both managers and recreational fishermen better understand the ecology and behavior of speckled trout. Managers will be able to use the temperature selectivity data to predict what type of scenarios could lead to a cold stun event. The movement data will also help managers determine the spatial resolution of a stock. The degree to which fish move between rivers and between systems (i.e., Virginia to North Carolina) will lead to better management efforts for each stock.

Recreational fishermen will benefit from the location and temperature preference data. Acoustic monitoring of speckled trout will give predictive insight into the daily, seasonal, and annual movements of this species. Coupling this information with the temperature data will allow the recreational fishermen an even greater chance of targeting speckled trout during each season.

IV.) Approach

In November 2015, a total of 50 speckled trout will be externally tagged with a t-bar tag and have acoustic transmitters with temperature sensors (VEMCO V9T tags) surgically implanted into the gut cavity. The temperature sensor has a range from -5 to 35 °C and a resolution of 0.15 °C. The ectothermic (cold-blooded) nature of speckled trout ensures the temperature readings within the body cavity will be approximately the same as the water where the tagged fish is swimming. The t-bar tag will be of a different color then those used in the Virginia Game Fish Tagging program. Local fishing clubs will be alerted to the color of tags and told to please release the fish if caught alive. If the fish is caught dead, local fishermen will be asked to save the tag and we will pick it up so it can be implanted in another fish. Tagged speckled trout will be greater than 17 inches to ensure the tag is less than 1% of the body weight and thus not adversely affect survival or behavior. Forty fish will be tagged in the Corrotoman River (Figure 2) and ten fish will be tagged in the Elizabeth River (Figure 3). The Corrotoman River was selected to be the primary site due to its more northern location and recent history of cold stun events. The tagged fish in the Elizabeth River will serve as a control group and allow for comparison of movements between the two tributaries. Due to the large number of fish needed in the Corrotoman River, we plan on haul seining from a VIMS vessel. All bycatch and speckled trout not used for tagging will be released alive. The use of this fishing gear will allow us to catch the required forty fish in one or two days of fishing. Speckled trout in the Elizabeth River will be caught via hook-n-line over the course of one or two days with the help of local recreational fishermen.

Each fish caught will be measured and if it measures 17 inches or greater it will be placed in a holding tank until tagging. The tagging procedures will consist of externally tagging each fish with a t-bar tag, removing a fin clip for on-going and future genetic analysis (J. McDowell et al., pers. comm.), and then placing the fish in a restraining device so that the ventral side is exposed. A small aquarium pump will move water over the gills ventilating the fish during surgery. Surgery will consist of making a 1-cm incision on the ventral side of the fish anterior to the anal fin. The tag will be placed inside the abdominal cavity and the wound will be closed via a series of sutures. The fish will then be allowed to recover in a tank for 30 minutes to ensure the procedure was successful. After 30 minutes each fish will be released and their movements and temperatures will be recorded when they swim within a ½ mile radius of an acoustic receiver.

Eight acoustic receivers (VEMCO VR2W) and temperature loggers (HOBO Water Temperature Pro v2 Data Logger) will be placed strategically throughout the Corrotoman River. The receivers will be placed so that they form an acoustic barrier across the river approximately every 2 miles along the main stem of the river and its east and west branches. Five acoustic receivers maintained by the United Sates Navy are already in place in the Elizabeth River (Figure 1). These receivers will remain in place for the duration of the proposed study (C. Waterson, pers. comm.). A temperature logger will also be deployed at the location of each receiver. Acoustic

receivers are either present or will be deployed in the Atlantic Ocean off Virginia Beach, at the mouth of Chesapeake Bay, from the mouth of the James River to Richmond, in Chesapeake Bay near York spit, from the mouth of the York River to West Point, at the mouth of Mobjack Bay, in the Rappahannock River just upstream of the Corrotoman River, in the Potomac River, in the Patuxent River, and across the northern portion of Chesapeake Bay in Maryland waters. Most of these receivers are deployed for a 10-year study involving the movements of Atlantic sturgeon and all will be in place during the time frame of the proposed study on speckled trout.

Data from the proposed study will be mapped with ArcGIS and analyzed for trends in movement patterns. Movement patterns will be examined with regards to time of year and water temperature. The temperature data from tagged fish, temperature loggers, and other devices measuring water temperature (i.e., monitoring buoys, trawl surveys, etc.) will also be analyzed with a selectivity model. This will give insight into whether the fish are attempting to remain within a specific thermal zone or if their movements are the result of other biotic or abiotic factors. Findings from the study will be verbally shared to the public via presentations at local fishing clubs and scientific meetings. The results will also be summarized and presented in the form of reports and peer-reviewed journal articles.

V.) Location

The Corrotoman River is a tidal estuarine tributary of the Rappahannock River (Figure 1). It is found on the northern bank approximately 8 miles upstream from the mouth of the Rappahannock River. This river consists of a main stem that splits into two branches (eastern and western branch). The Corrotoman River is bordered primarily by residential houses and farm land. The Elizabeth River is a tidal estuarine tributary of Hampton Roads harbor (Figure 3). It is located on the southern side of the mouth of the James River. The Elizabeth River is highly industrialized and contains both military and commercial ports.

VI.) Estimated cost

See attached budget spreadsheet for details of costs associated with this project. The total request to RFAB is $55,708.

Personnel ($4,760). We request 1.0 month for co-PI McGrath ($3,400) to complete this study. McGrath will be the primary team member responsible for project design, conducting the field work, data analysis, dissemination, and publication. Fringe is calculated as 40% of total salary ($1,360).

Supplies ($37,677). For this project we request funds to purchase eight VEMCO VR2W Receivers ($1,500 each; $12,000 total), 50 VEMCO V9T acoustic tags ($440 each; $22,000 total), and 13 temperature loggers ($129 each; $1,677 total). In addition, we request $2,000 for miscellaneous equipment (sutures, anchors, buoys, stainless steel lines and attachments, etc.) used in this project.

Travel ($785). We request funds for travel to and from the boat launch, estimated at 66 miles, for 14 trips (at $0.85/mile; $785 total).

Vessels ($1,680). We request funds to cover 14 days of boat time (estimated at $120/day; total $1,680).

Indirect Costs ($10,806). Indirect costs are charged as 25% modified total direct costs (total minus vessels; = $43,222).

Matching funds ($17,397). We use 0.5 months of salary and fringe for PI Hilton ($4,143 + $1,657 fringe; $5,800 total) as matching funds. Hilton will be responsible for assisting with project design, field work, data analysis, dissemination and publication. The federally negotiated indirect rate at VIMS is 45.7% and the difference between it and the 25% rate cap is used as matching funds ($11,597). The total matching funds for this project are 31% of the requested funds.

VII. References

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Storey M, Gudger EW (1936) Mortality of fishes due to cold at Sanibel Island, Florida, 1886–1936. Ecology 17: 640–648.

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Personnel	**Time**	**Monthly**	**Agency**	**VIMS**	**Total**
Hilton	0.50	$8,286	$0	$4,143	$4,143
McGrath	1.00	$3,400	$3,400	$0	$3,400
Personnel, salaried			$3,400	$4,143	$7,543
Fringe, 40% salaries			$1,360	$1,657	$3,017
Total Personnel			$4,760	$5,800	$10,560
Supplies			$37,677	$0	$37,548
Travel			$785	$0	$785
Vessels			$1,680	$0	$1,680
SUBTOTAL: Direct Costs			$44,902	$5,800	$50,702
Facilities & Administrative Costs		**25.0%**	$10,806	$11,597	$22,403
TOTAL			**$55,708**	**$17,397**	**$73,105**

Figure 1. Current and proposed buoy locations for the Chesapeake Bay watershed.

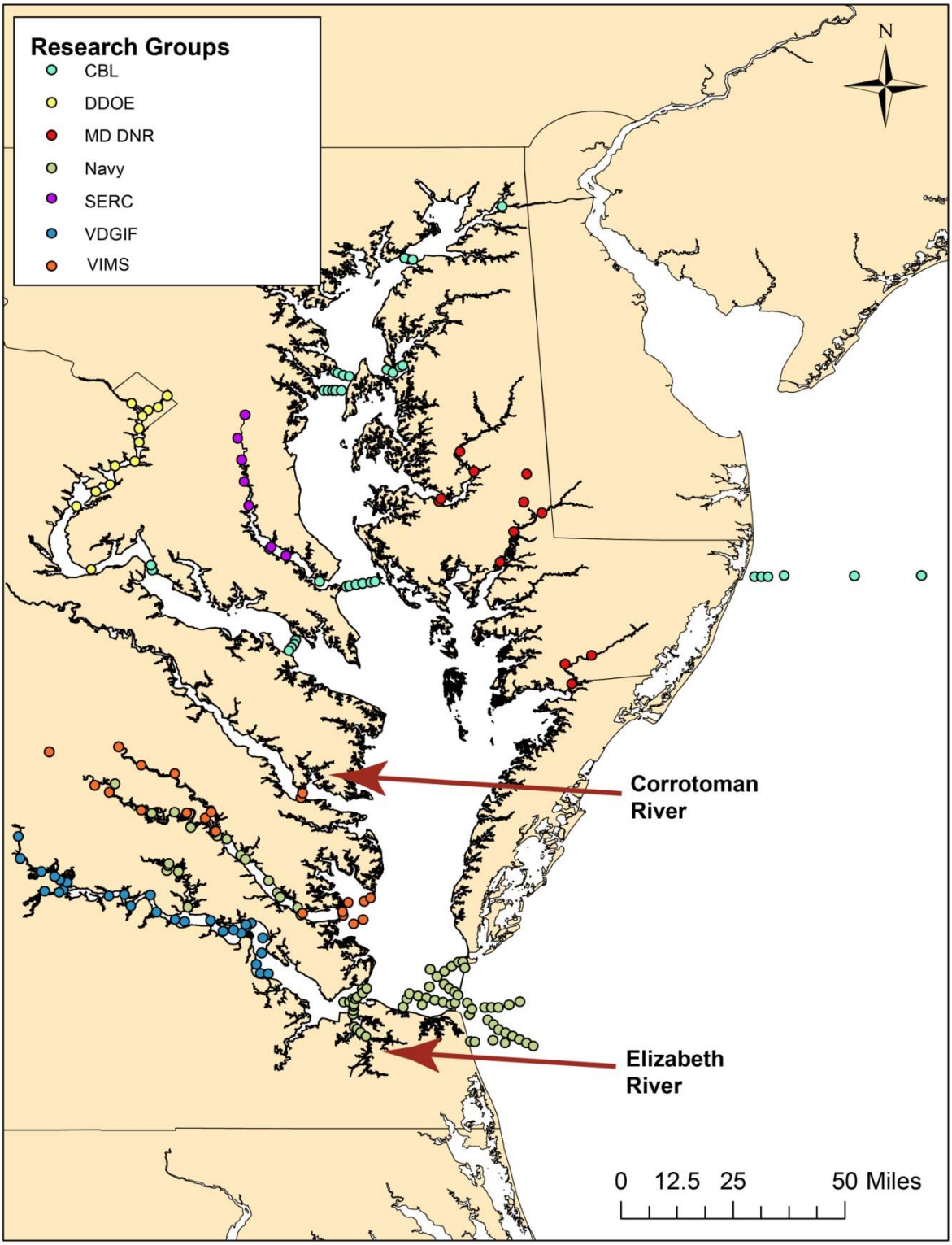

Figure 2. Corrotoman River (receiver and temperature logger locations denoted by red marks).

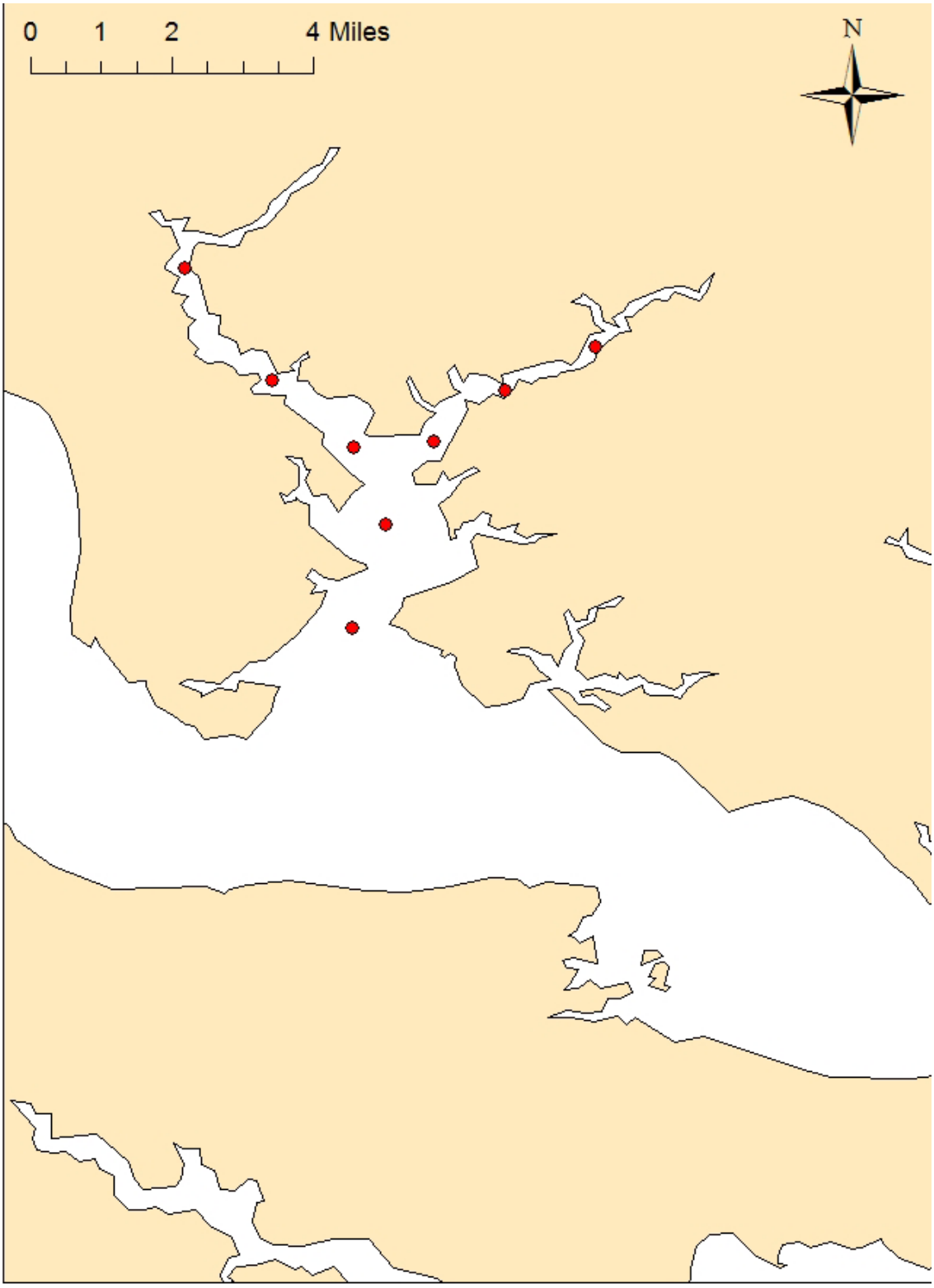

Figure 3. Elizabeth River (receiver and temperature logger locations denoted by red marks).