SHARK SANCTUARIES: HABITAT & CLIMATE CHANGE

Kaitlyn O'Brien
Virginia Institute of Marine Science

Grade Level
High School

Subject area
Biology

The 2020-21 VA SEA project was made possible through funding from the National Estuarine Research Reserve System Margaret Davidson Fellowship Program which supports graduate students in partnership with research reserves where fieldwork, research, and community engagement come together. VA SEA is currently supported by the Chesapeake Bay National Estuarine Research Reserve, Virginia Sea Grant, and the Virginia Institute of Marine Science Marine Advisory Program.

Title: Shark Sanctuaries: Habitat and Climate Change

Focus: Utilize data collected from scientific surveys to explore the abiotic niche of multiple coastal shark species, and evaluate suitable habitats under differing climate change conditions

Grade Level: High School Biology

VA Science Standards

BIO.1) The student will demonstrate an understanding of scientific practices by
- 1a) Asking questions that arise from careful observation of organisms, from examining models, and seek additional information
- 1b) Generate hypotheses based on research and scientific principles
- 1c) Planning and carrying out investigations that select an appropriate tools and technology to collect, record, analyze, and evaluate data
- 1d) Interpret, analyze, and evaluate data through constructing graphical displays of data
- 1e) Make quantitative claims regarding the relationship between depending and independent variables
- 1f) Compare and evaluate competing arguments in light of new scientific evidence
- 1g) Obtain, evaluated, and communicate information

BIO.6) The students will investigate and understand the modern classification systems can be used as organizational tools for scientists in the study of organisms
- 6a) Organisms have structural similarities and differences
- 6b) The functions and processes of animals allow for comparisons and differentiations within the Eukarya kingdoms

BIO.7) The students will investigate and understand that populations change through time
- 7a) Environmental pressures affect the survival of populations

BIO.8) The student will investigate and understand that there are dynamic equilibria within populations, communities, and ecosystems.
- 8a) Natural events and human activities influence local and global ecosystems and may affect the fauna of Virginia

Learning Objectives

- ✓ Students will identify a selection of large coastal and small coastal sharks found along the US Atlantic coastline
- ✓ Students will generate hypotheses concerning which sharks they would expect to find under different abiotic conditions based on the animal's life history and ecology
- ✓ Students will count and sample sharks collected in a research survey and graph their data
- ✓ Students will compare and contrast their results to those from other groups in the class
- ✓ Students will assess both how scientific data can be used to draw conclusions and the limitations of sampling methods
- ✓ Students will utilize scientific data to make inferences on how fishing populations are expected to change under different climate change scenarios

Total Length of Lesson

Total time: 1 hour for prep (max), up to 120 minutes for the lesson. Total time will depend on the time allotted for discussion before and after the activity.

Advance preparation of materials: Approximately 1 hour to set up 'longlines' for the first time; set-up for subsequent lessons should be the time required to print handouts.

Key Words, vocabulary:

- Niche: The role an organism plays in a community
- Abiotic: non-living factors in the environment (water temperature, salinity, etc.)
- Distribution: the spatial area in which a species resides
- Fishery-independent survey: A standardized method of collecting data in the absence of any fishing activity
- Longline: A type of fishery-independent survey that is used for sampling sharks
- Life-history: The pattern of survival and reproduction for an organism
- Uncertainty: The amount of error in an estimated value
- Ecological niche: The role an organism plays in a community
- Chondrichthyes: The class of animals in which sharks belong, along with skates, rays, and chimeras
- Osteichthyes: The class of bony fishes, including salmon and tuna

Background Information

Most commonly known fishes such as tuna, salmon, and trout are part of the class Osteichthyes and have bony skeletons like humans. On the other hand, Sharks are members of the class Chondrichthyes or fish with skeletons made out of cartilage. Modern sharks arose 250 million years ago, with nearly 500 different species in the world's oceans. These species can differ in body shape, size, diet, and reproductive methods. Still, all sharks share common traits like a tooth replacement mechanism, cartilaginous skeletons, and an underbody mouth.

Sharks are a critical species in the world's oceans as many are apex predators in their ecosystems with few (if any) natural predators. Due to their high trophic level and lack of predators, sharks have evolved a slow metabolism compared to bony fishes. This slower metabolism supports a set of life-history characteristics known as a K-selected life history strategy. Some common features of a K-selected life-history strategy are a long lifespan, a low fecundity (few pups per year), a late age of maturity, and a slow growth rate. For example, many shark species cannot reproduce until 15-20 years old and live as long (if not longer) than the average human! This differs from an r-selected life history strategy exhibited by most bony fishes. The r-selected life history strategy generally includes a short lifespan, a high fecundity (lots of eggs per spawning event), a quick age of maturity, and a fast growth rate. While the K-selected life-history strategy has supported sharks for millions of years, it makes them more vulnerable to fishing pressures than most bony fishes. This is due to the relatively few sharks born per year, and the long time it takes a shark to reach sexual maturity. With this in mind, it is vital to carefully monitor shark populations.

To collect data for monitoring coastal Atlantic sharks, scientists use fishery-independent surveys. Fishery-independent surveys are long-term monitoring projects that collect data outside of the commercial fishing industry. These surveys are designed to follow consistent collection methods to limit

the amount of uncertainty, or the amount of error, in the results. For sharks, scientists use a longline to sample the shark populations at various locations along the Atlantic coast. At each sampling location, scientists identify the different shark species, measure each animal, count the number of animals caught, and record environmental conditions like water temperature and salinity. While scientists often use this information to examine how populations change from year to year, it can also be used to study suitable habitats for different species and age groups.

Species distributions are based on three specific factors; the accessibility of the habitat, the abiotic factors, and the biotic factors. Since most shark species are highly mobile, the accessibility of the habitat is not extremely important for consideration. Abiotic factors are the nonliving parts of the ecosystem, and examples include the water temperature, dissolved oxygen, salinity, and depth. Biotic factors are other living organisms within the ecosystem, such as prey and competitors. Sharks are considered habitat generalists. This means they can exploit a wide range of resources (e.g., water temperature, salinity) and habitat types (e.g., sandy bottoms, rocky bottoms) compared to habitat specialists. How shark species respond to long-term changes in their environment like climate change is currently unknown.

Scientists are trying to better understand how the changing environment will impact sharks. To accomplish this, scientists use fishery-independent surveys to assess the animal's ecological niche or the range of environmental factors that an animal occupies and lives in. This is done by examining the relationship between catch rates and the environmental factors and assuming that areas with a higher occurrence are areas with better conditions for the animal. Scientists can then use this information to predict how the highly suitable habitat will change over time and how the distribution of a species will change.

There are five species of shark highlighted in this study. Below and in the Atlantic Shark Field Guide are brief descriptions of these species.

Sandbar shark (*Carcharhinus plumbeus*): Sandbar sharks are a large coastal shark that inhabits tropical and warm temperate coastal waters from Florida to New York, in the Gulf of Mexico, and the Caribbean Sea. They undertake long seasonal migrations, heading south in the winter and north for the summer. Estuaries and Bays, such as the Chesapeake Bay, are essential nurseries for sandbar juveniles. This species can grow about 8 feet (2.5 meters) in total length for females and 7.7 feet (2.3 meters) in total length for males. To reach that maximum size takes a long time as they grow very slowly, not reaching maturity until 14-20 years old. Once mature, females only give birth to around 8 pups every 2 to 3 years. The maximum age of the animal is currently unknown but may exceed 50 years.

Tiger shark (*Galeocerdo cuvier*): Tiger sharks are another large coastal shark that inhabits warm temperature and tropical waters along the US East Coast, in the Gulf of Mexico, and the Caribbean Sea. Like Sandbar sharks, they take seasonal migrations heading northing in the summer. Pups and young juveniles remain in the southern part of their range during their first few years of life, while sub-adults and adults are found offshore in northern waters during the summer months. Most adults are less than 13 feet (4 meters) in length, but females can reach a maximum length of 18 feet (5.5 meters) and males a maximum length of 12.1 ft (3.7 meters). Tiger sharks mature quickly compared to other shark species, mature in 8-9 years, and live about 29 years. Tiger sharks are also very productive for sharks, averaging litter sizes of 41 pups every 2 years.

Blacktip shark (*Carcharhinus limbatus*): Blacktip sharks are another large coastal shark inhabiting the coastal areas from New England to Florida, the Gulf of Mexico, and the Caribbean Sea. During the summer months, adults migrate north as far as Cape Cod but are commonly found around the Southeast US year-round. These animals are primarily found in coastal areas but are sometimes located farther offshore. Females can grow up to 6.3 feet (1.93 meters) in length, while males grow up to 5.7 feet (1.75 meters) in length. Like tiger sharks, this animal reaches maturity faster than other shark species reaching maturity between 5 to 7 years old, depending on sex. They have a shorter life expectancy of 22 years old. Litters range from 4-11 pups every 2 years.

Blacknose shark (*Carcharhinus acronotus*): Blacknose sharks are a small coastal sharks species that inhabit warm inshore coastal waters from North Carolina to southern Brazil, the Gulf of Mexico, and the Caribbean Sea. They are found in coastal tropical and warm temperate waters. These animals mature around 4.5 years old in the Atlantic, with a maximum age of 19 and 11.5 years for females and males, respectively. Like large coastal sharks, Blacknose sharks migrate north in the summer and south in the winter. As a small coastal shark, animals reach a smaller maximum size of 6.5 feet (2 meters) but are more commonly seen at around 4 feet (1.25 meters). On average, the litter size for Blacknose sharks is between 3 to 6 pups every 2 years.

Bonnethead shark (*Sphyrna tiburo*): Another small coastal shark, bonnethead sharks are commonly found in inshore waters off the Carolinas and Georgia during the spring and summer. Bonnethead sharks are part of the hammerhead shark family. They are characterized by the rounded cephalofoil or the hammer shape of the hammerhead. In autumn, they are found off Florida and in the Gulf of Mexico. Bonnethead sharks make large daily and seasonal migrations following changes in water temperature. During the winter months, they are found closer to the equator while at higher latitudes during the summer months. Bonnethead sharks mature at around 7 years old and live between 16 to 18 years. Their maximum size is around 3.5 ft (1 meter) in total length.

Student Handouts and Worksheets

- ☐ Handout 1: Map of US Atlantic Coast, with site labels (one per group, also included in PowerPoint; can be laminated for reuse)
- ☐ Handout 2: Atlantic Shark Field Guide (one per group, 1 page – front and back; can be laminated for reuse)
- ☐ Handout 3: Ecological niche models – species-specific (one per group, 1 page; can be laminated for reuse)
- ☐ Handout 4: Climate Conditions (one per group, 1 page -front and back; can be laminated for reuse)
- ☐ Worksheet 1: Shark Sanctuaries – Sampling Data Sheet (one per student, 5 pages; key provided for the instructor)
- ☐ Worksheet 2: Shark Sanctuaries - Habitat Suitability Worksheet (one per species group – they are species specific, 1 page; key provided for the instructor)

Materials and Supplies

- ☐ Computer and projector for PowerPoint (introduction)
- ☐ Five (5) 'Longlines' samples with fish, one for each site. Each longline will need
    - A fabric pouch or other non-transparent container can easily be 'sampled' (e.g., large manilla folder, folded and taped paper).

- A string or zip tie to close the opening
- Site labels (#1-#5) with the associated environmental conditions
- Fish in the sampled location – this can be done by either using beads, beans, or any other object that is of similar shape and size that comes in 6 different colors
    - 6 bead colors, one for each species of shark (Sandbar, Blacktip, Tiger, Blacknose, Bonnethead) and one for 'No Shark'
    - Teachers will need to supply a key for what color corresponds with each shark. This is left to the discretion of the teacher for supply purposes, but an example would be: Sandbar → red beads, Tiger → orange beads, Blacktip → green beads, Blacknose → yellow beads, Bonnethead → blue beads, No Shark → black beads

☐ Colored pencils/ markers/ etc. for graphing
☐ Calculator
☐ Dry erase board/ chalkboard/ easel for sharking group data

Teacher Preparation

Students should be divided into 5 groups; set up the classroom accordingly.

Each group coincides with a different sampling location and should be labeled #1-#5 with the respective environmental conditions (Table 1). Instructors should print enough copies of the map, the Shark field guide, and habitat maps for each group. Ideally, these should be printed in color, and if possible, they can be laminated for repeat use.

	VASMAP	SEFSC (North)	SCDNR	GADNR	SEFSC (South)
Water Temperature (WT)	24	29	32	34	30
Dissolved Oxygen (DO)	7	6.5	6	5.5	7.5
Salinity (SA)	32	30	28	24	34
Depth (meters)	25	60	15	10	50
Distance from Shore (kilometers)	10	25	1.5	2	15

For Part 1, <u>each student</u> should receive (1) Shark Sanctuaries – Sampling Data Sheet and <u>each group</u> should receive: (1) Map of the US Atlantic Coast and (1) Atlantic Shark Field Guide.
For Part 2, <u>each group</u> will receive (1) Species-Specific Ecological Niche Model and (1) Climate Conditions Handout. Groups will also want to reference back to the Atlantic Shark Field Guide from Part 1.

Each 'Longline' sample should be filled with beads corresponding to the following chart. It is important to note that other species of shark, and fish, are often caught on the longline, but we are just focusing on these 5. This sampling will also stress the number of times a longline catches zero sharks – one of the difficulties when studying sharks! The total number of beads can also be scaled down as long as the proportions are maintained.

Site	Location/Survey	Sandbar	Tiger	Blacktip	Blacknose	Bonnethead	No Shark	Total
1	Virginia	28	14	16	2	0	40	100
2	North Carolina	18	18	10	2	0	52	100

3	South Carolina	4	2	4	24	12	54	100
4	Georgia	2	2	4	14	22	56	100
5	Florida	10	10	8	20	2	50	100
		88	60	40	58	40	260	500

Procedure

During this activity, students will conduct a mock fishery-independent survey to try and determine the realized niche of five species of shark. Students will then determine how each shark species distribution is expected to change over time. Finally, students will consider how scientists account for uncertainty within their findings and present that information to others.

I. Background and Introduction to Activity

- Instructors should divide the classroom into 5 different groups, correlating to five locations. Once the students sit down, assign each student within each group one of the five shark species. If there are more than 25 students, students can be paired up for either sandbar or blacknose sharks. If there are less than 20 students, remove the bonnethead shark.
- Instructors should load the accompanying PowerPoint presentation and walk through slides #1-#23 (some slides are very quick). Suggested talking points and discussion questions are included in the comments section of each slide. Key ideas to highlight include:
    - Sharks are key species within their environment and are more susceptible to overfishing than other species of fish
    - A shark's distribution (the habitat it occupies) depends on its ecology, especially related to its physical environment (e.g., warm vs. cool water). The distribution of a species can vary over time in response to environmental shifts.
    - Scientists monitor sharks using fishery-independent surveys, specifically a longline. But longlines are not 100% effective and often catch no sharks, which scientists need to deal with regularly.
    - Spend time on the question slide (#16).
    - Also possible to skip the species slides and instead have students read through the Atlantic Shark Guide
- Instructors should introduce the activity and the scientist's main objectives on slide #24
    - We are only focusing on five species here, but there are many more
        - These focal species are examples of large coastal and small coastal shark species. It is crucial to study how they may respond to changing climate.

II. Activity

Part I: Sample the stations

- Each group is assigned one of the five sites along the US Atlantic coast. Working together, students should use the map of the longline sites to identify where they are sampling and answer questions #1-#3 on the Sampling datasheet
    - Slide #25 on the PowerPoint also has the questions. If desired and if time permits, instructors could ask groups to share their predictions and hypotheses

- Each group will receive a bag representing the diversity at their sample location. **DO NOT LOOK IN OR DUMP OUT THE BAG**.
    - Students will work together to conduct 3-5 separate sampling events for their location. To sample the site, have the students take ten different beads from the bag without looking. Sort the beads out into the different shark species and record the observations from the sample (ex: 3 sandbar sharks, 1 tiger sharks, 6 no sharks).
    - Students can record just their own species or have one student work as a recorder. Make sure everyone gets their species information! Science is a collaborative, team effort!
- When the sampling is complete for all groups, have the students regroup by species instead of by location. Now, students will work with their species group to graph the ecological niche for their species and answer questions #4 - #7 on the worksheet

When all groups are finished, ask students to share their data with their classmates. If the instructors choose, fill in the provided excel sheet with the samples from all groups. Then have the students discuss the trends they see in certain species and how that relates to their ecology described in the Shark Guide. Slide #26 also has these questions. The general conclusions should be that:

- Shark sampling is filled with zero catches! Why do you think this is? Does this mean that sharks aren't actually there? Or does this mean that sharks are there and we just didn't catch them? How do we take this into consideration? These are all important questions to consider when evaluating sharks, so thinking about the sampling method and the uncertainty of any study is very important to science!
- While this is a good baseline and gives valuable information, more samples would be needed to make any management or assessment decisions. The sample size is vital! As scientists, we can't make inferences on things we haven't sampled.
- The small coastal sharks tend to be in shallower waters that are closer to shore when compared to large coastal sharks.

Part II: Predict future distributions

- Instructors should review slides #27-28 in PowerPoint to introduce how the information gathered from the previous activity is used to predict changes in the suitable habitat for different species.
- Each shark group will be provided an ecological niche model for their species, a set of environmental maps of the sampled area, and the habitat suitability worksheet.
    - Working as a group, students will identify areas on each map that are highly suitable for their species by circling the area on each map. Once all the highly suitable areas are identified, the maps can be combined to identify areas where all abiotic needs are met.
    - Laminating and then using dry erase markers on the maps is an option to reuse maps in the following years.
    - Once the graphing is done, have the group answer the questions on the worksheet.
- Once all groups are fished, have each group present to the class how they hypothesize their species distribution may change.

Assessment

Instructors should assess students based on worksheets and graphing exercises, group participation, and contributions to the class discussions.

References

For more information on sharks and shark surveying, visit:

VIMS Shark Longline

https://www.vims.edu/research/departments/fisheries/programs/multispecies_fisheries_research/sharks/index.php

For more information on shark biology:

Abel, D. C. author, & Grubbs, R. D. (2020). *Shark Biology and Conservation: Essentials for Educators, Students, and Enthusiasts*. Johns Hopkins University Press.

Castro, J. I. (2010). *The Sharks of North America*. Oxford University Press.

Dulvy, N., & Forrest, R. (2010). Life Histories, Population Dynamics, and Extinction Risks in Chondrichthyans. In *Sharks and their Relatives II: Biodiversity, Adaptive Physiology, and Conservation* (pp. 639–679). Taylor and Francis Group.

Musick, J. A., Burgess, G., Cailliet, G., Camhi, M., & Fordham, S. (2000). Management of Sharks and Their Relatives (Elasmobranchii). *Fisheries*, *25*(3), 9–13.

For more information on climate change:

Alexander, M. A., Shin, S., Scott, J. D., Curchitser, E., & Stock, C. (2020). The Response of the Northwest Atlantic Ocean to Climate Change. *Journal of Climate*, *33*(2), 405–428. https://doi.org/10.1175/JCLI-D-19-0117.1

Perry, A. L., Low, P. J., Ellis, J. R., & Reynolds, J. D. (2005). Climate Change and Distribution Shifts in Marine Fishes. *Science*, *308*(5730), 1912–1915. https://doi.org/10.1126/science.1111322

For more information on sharks and climate change:

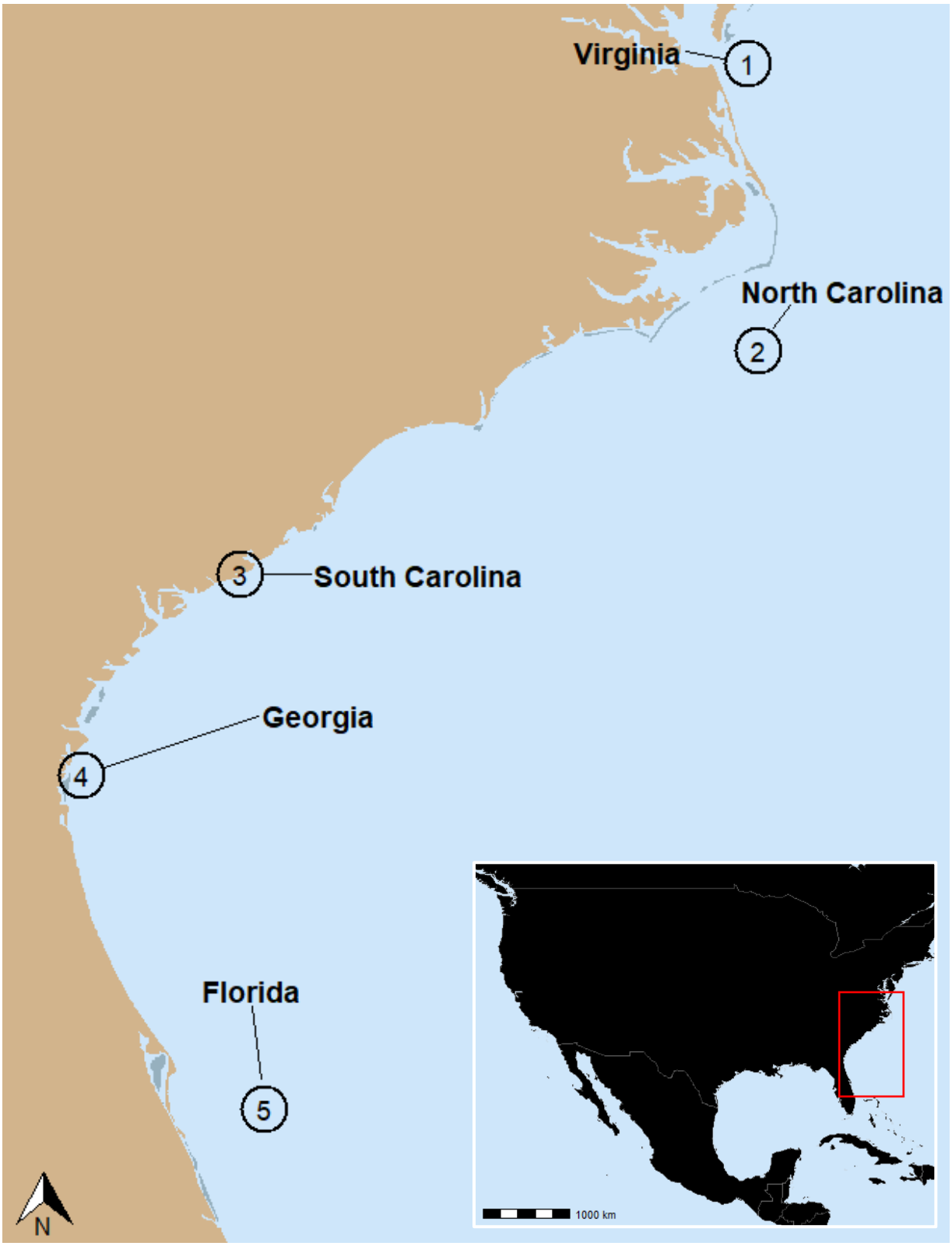
Birkmanis, C. A., Freer, J. J., Simmons, L. W., Partridge, J. C., & Sequeira, A. M. M. (2020). Future Distribution of Suitable Habitat for Pelagic Sharks in Australia Under Climate Change Models. *Frontiers in Marine Science*, *7*, 570. https://doi.org/10.3389/fmars.2020.00570

Birkmanis, C. A., Partridge, J. C., Simmons, L. W., Heupel, M. R., & Sequeira, A. M. M. (2020). Shark conservation hindered by lack of habitat protection. *Global Ecology and Conservation*, *21*, e00862. https://doi.org/10.1016/j.gecco.2019.e00862

Chin, A., Kyne, P. M., Walker, T. I., & McAULEY, R. B. (2010). An integrated risk assessment for climate change: Analysing the vulnerability of sharks and rays on Australia's Great Barrier Reef. *Global Change Biology*, *16*(7), 1936–1953. https://doi.org/10.1111/j.1365-2486.2009.02128.x

Hare, J. A., Morrison, W. E., Nelson, M. W., Stachura, M. M., Teeters, E. J., Griffis, R. B., Alexander, M. A., Scott, J. D., Alade, L., Bell, R. J., Chute, A. S., Curti, K. L., Curtis, T. H., Kircheis, D., Kocik, J. F., Lucey, S. M., McCandless, C. T., Milke, L. M., Richardson, D. E., … Griswold, C. A. (2016). A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast US Continental Shelf. *PLOS ONE*, *11*(2), e0146756. https://doi.org/10.1371/journal.pone.0146756

Map of the US Atlantic Coast



Map Photo Credit: Kaitlyn O'Brien

Atlantic Shark Field Guide


Photo Credit: NOAA Flickr

Sandbar shark (*Carcharhinus plumbeus*)
Description: A large coastal shark with a brownish or dark grey body, whitish belly, and rounded snout.
Habitat: A temperate and sub-temperate demersal (bottom-dwelling) shark often found over muddy or sandy bottoms from intertidal to deeper waters. They are often found at the mouths of estuaries and rivers.


Photo Credit: Florida Fish and Wildlife

Tiger shark (*Galeocerdo cuvier*)
Description: A large coastal shark with defined stripes along the body.
Habitat: An extreme habitat generalist with a notable tolerance for many different marine environments. Found in nearly all warm temperate and tropical waters. Usually found farther offshore, at least 10 to 20 miles, but also common in shallow waters.


Photo Credit: Florida Fish and Wildlife

Blacktip shark (*Carcharhinus limbatus*)
Description: A large coastal shark with distinct black tips on both dorsal fins, pectoral fins, pelvic fins, and caudal fin.
Habitat: A tropical to temperate species. Blacktip sharks are often found in inshore coastal areas. They are often seen at the mouths of rivers and estuaries.


Photo Credit: Wikipedia Commons

Blacknose shark (*Carcharhinus acronotus*)
Description: A small coastal shark with a yellow to brownish coloring. Distinct black to brown “smudge” on the tip of the nose.
Habitat: Found in coastal tropical and warm temperate waters. Generally, a coastal species that resides over sandy and coral bottoms. They are commonly seen schooling by size and sex.


Photo Credit: Florida Fish and Wildlife

Bonnethead shark (*Sphyrna tiburo*)
Description: A small hammerhead species. It can easily be identified by a shovel-shaped head.
Habitat: A small coastal shark. They are often found in warm-water coastal areas over reefs, around estuaries, and shallow water outlets. Can be found schooling at a smaller size.

Sandbar shark (*Carcharhinus plumbeus*): Sandbar sharks are a large coastal shark that inhabits tropical and warm temperate coastal waters from Florida to New York, in the Gulf of Mexico, and the Caribbean Sea. They undertake long seasonal migrations, heading south in the winter and north for the summer. Estuaries and Bays, such as the Chesapeake Bay, are essential nurseries for sandbar juveniles. This species can grow about 8 feet (2.5 meters) in total length for females and 7.7 feet (2.3 meters) in total length for males. To reach that maximum size takes a long time as they grow very slowly, not reaching maturity until 14-20 years old. Once mature, females only give birth to around 8 pups every 2 to 3 years. The maximum age of the animal is currently unknown but may exceed 50 years.

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Ecological Niche Model – Sandbar shark

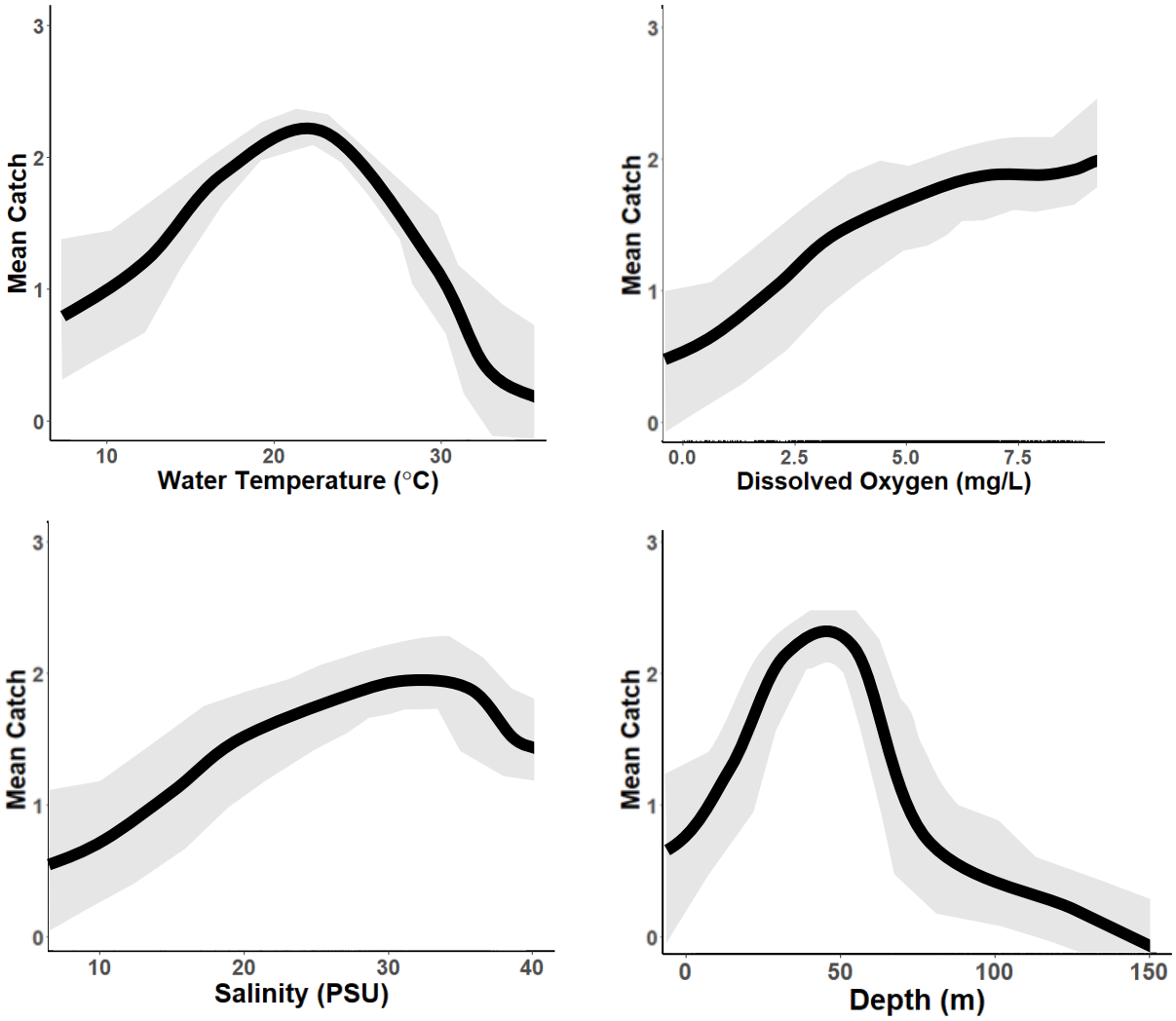


Photo Credit: Kaitlyn O'Brien

Ecological Niche Model – Tiger shark

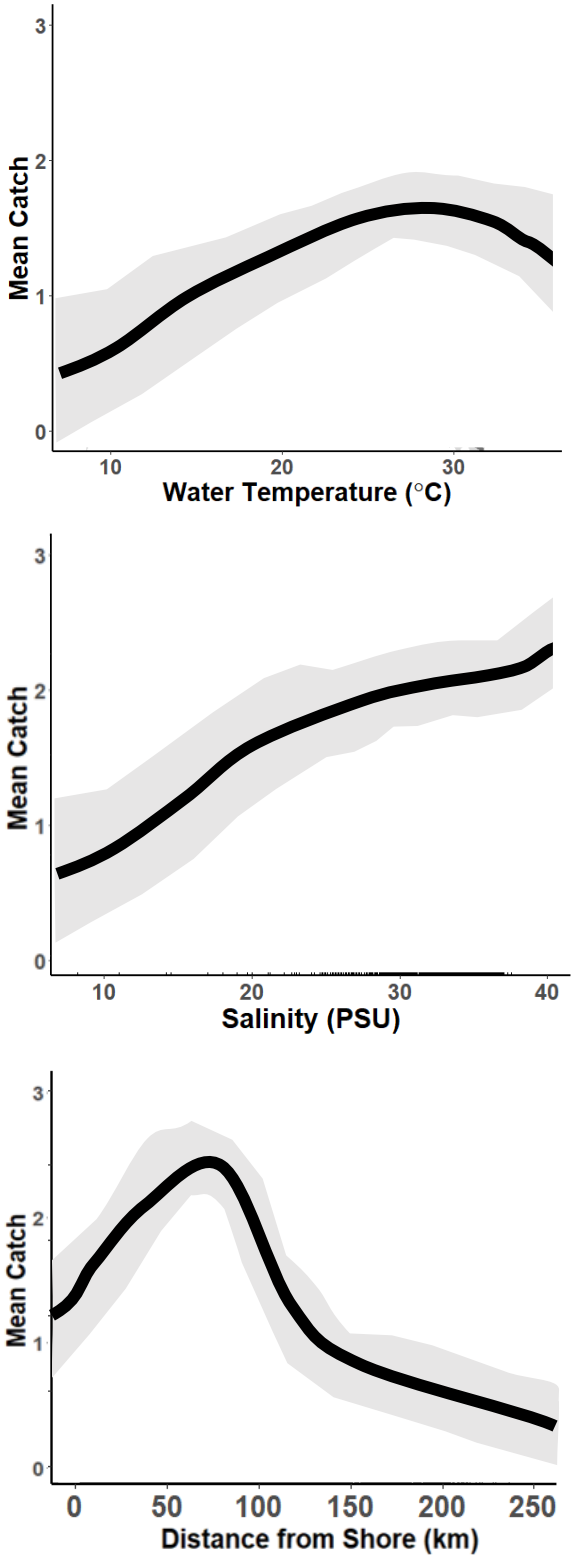


Photo Credit: Kaitlyn O'Brien

Ecological Niche Model – Blacktip shark

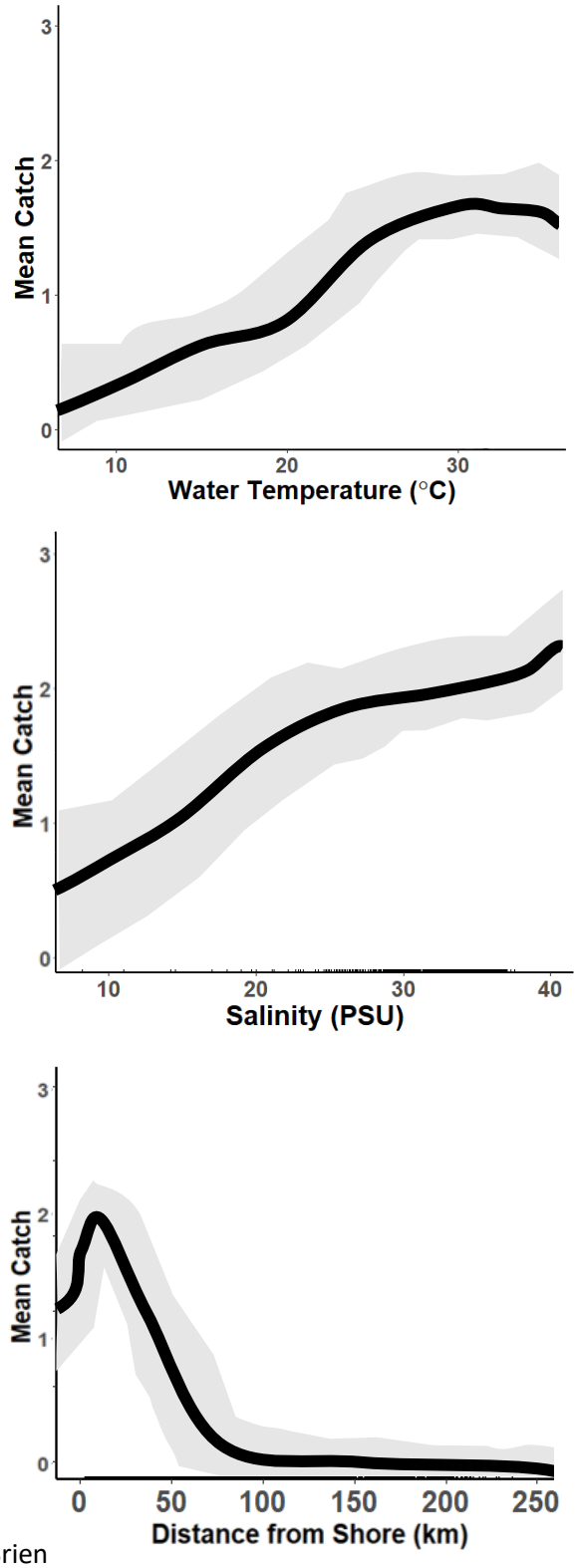


Photo Credit: Kaitlyn O'Brien

Ecological Niche Model – Blacknose shark

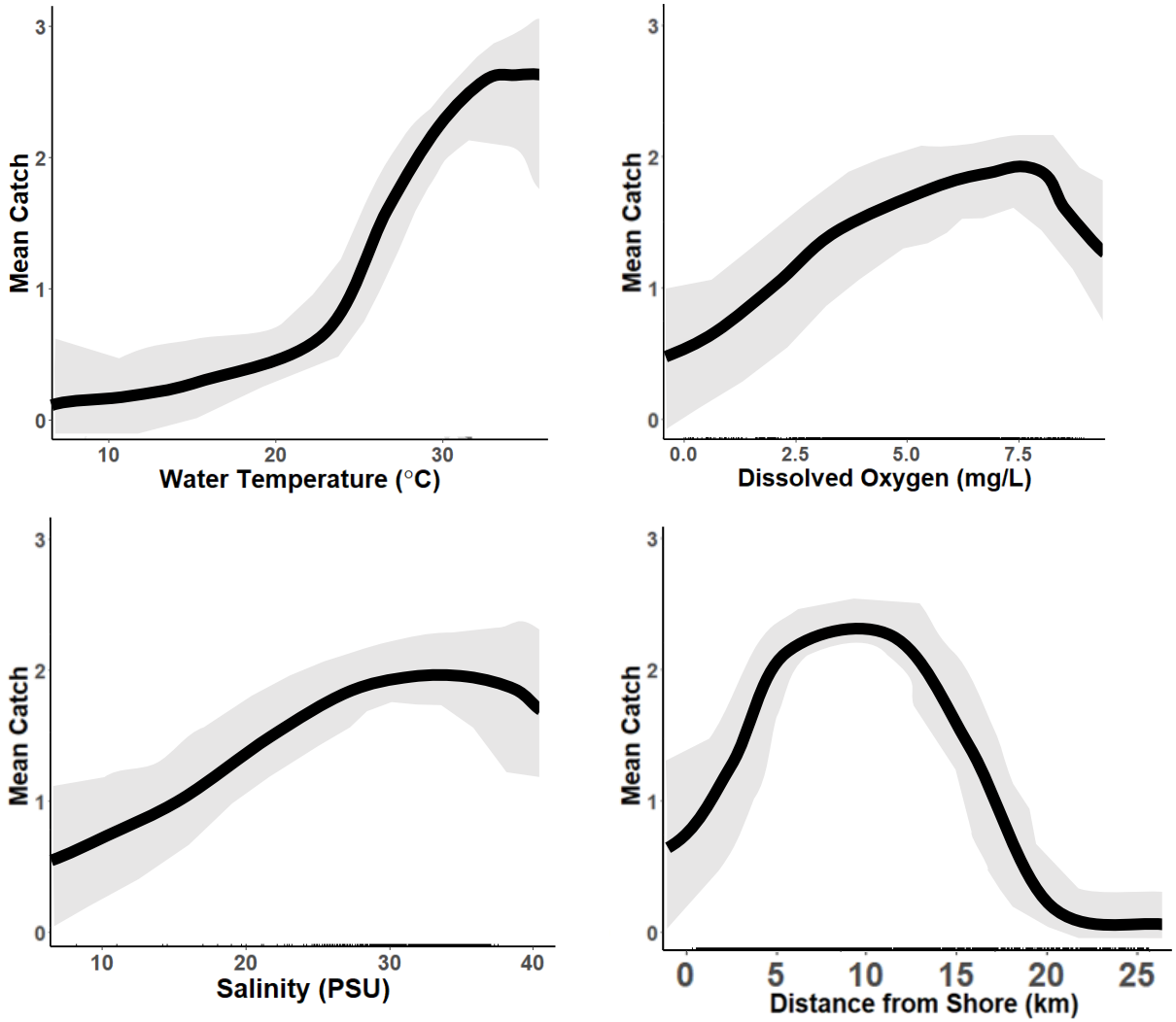


Photo Credit: Kaitlyn O'Brien

Ecological Niche Model – Bonnethead shark

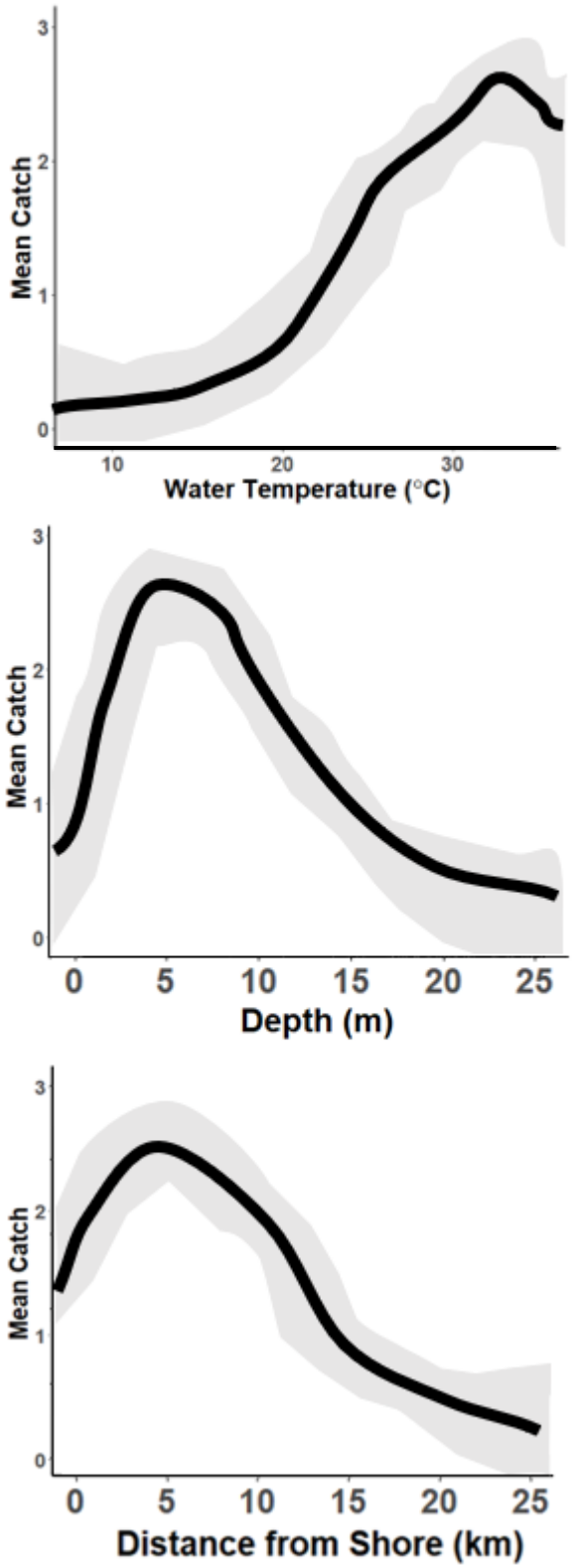
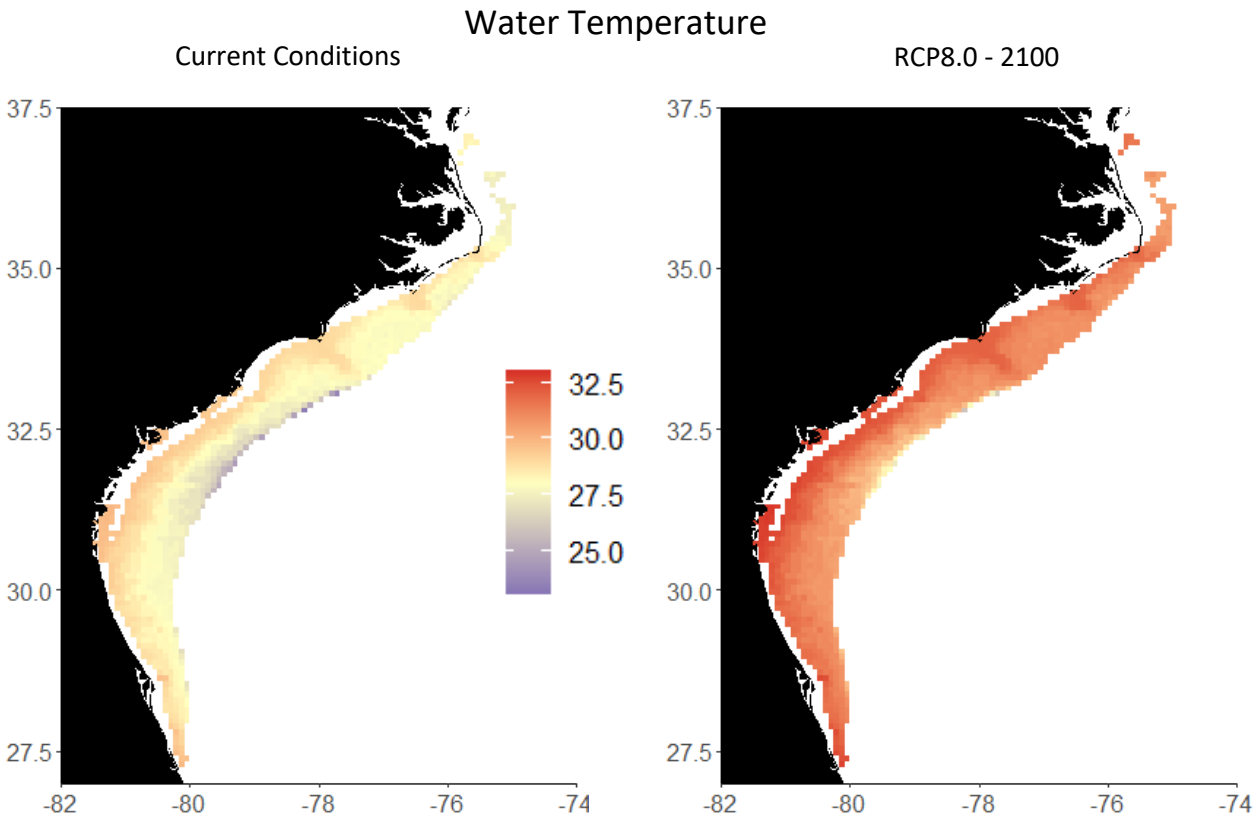


Photo Credit: Kaitlyn O'Brien

Climate Conditions – Handout



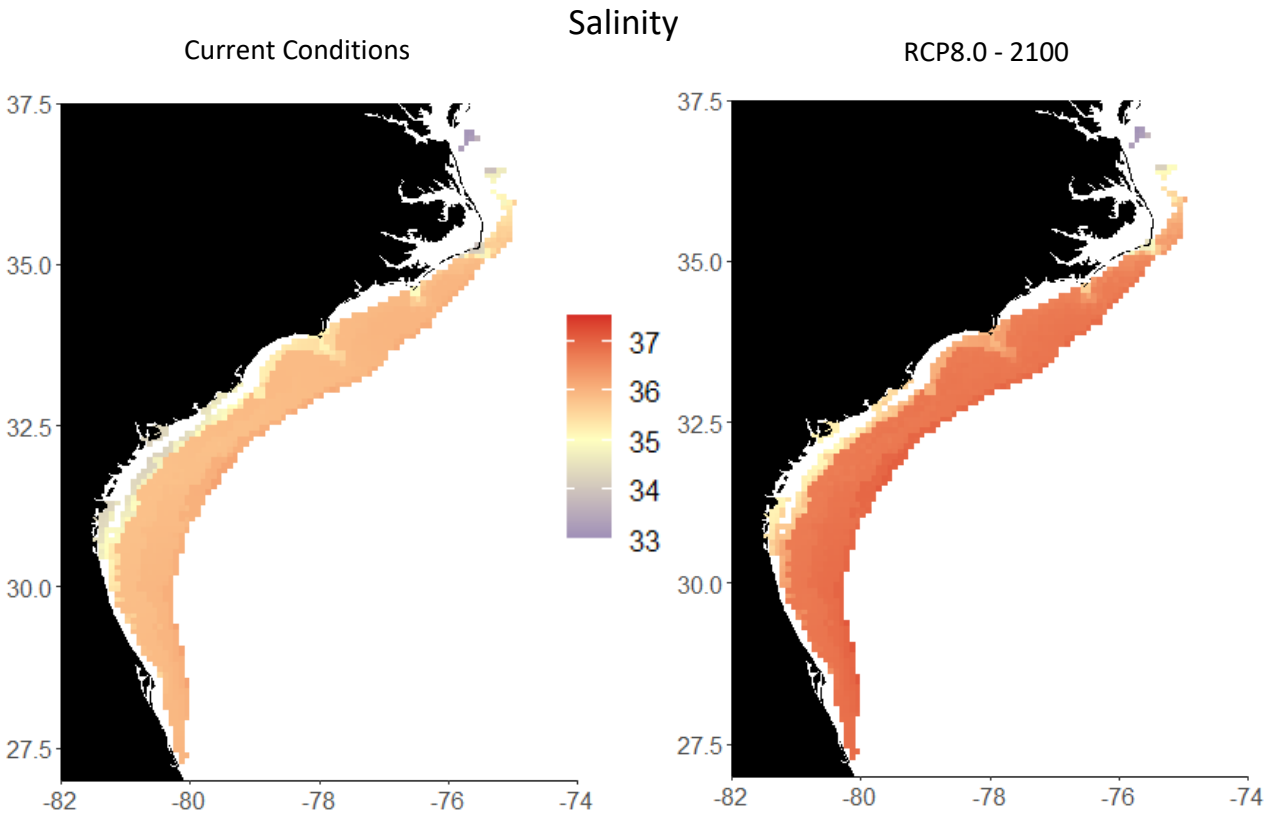
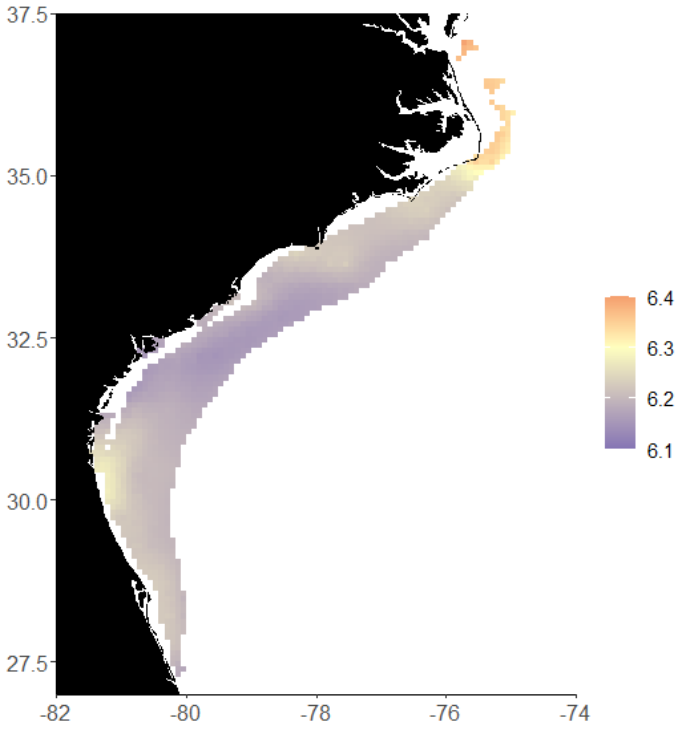
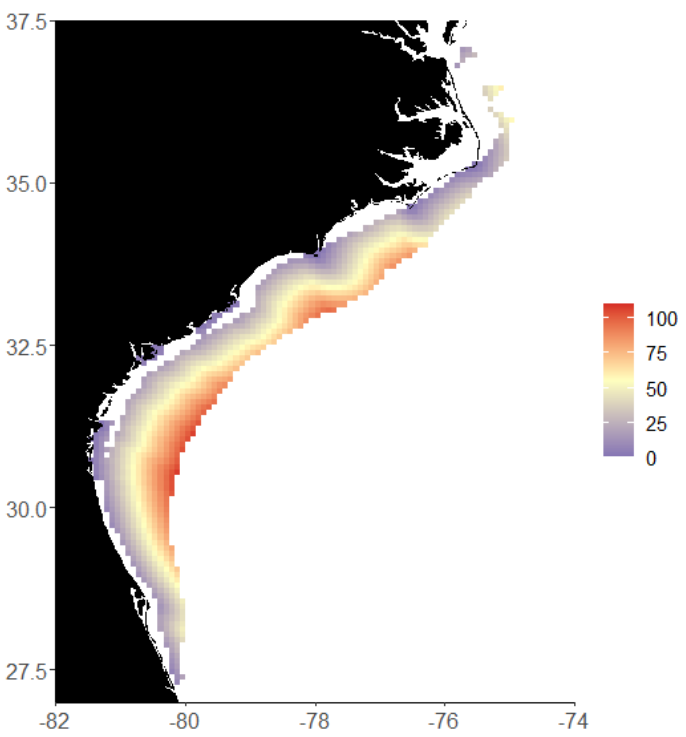


Photo Credits: Kaitlyn O'Brien

Dissolved Oxygen



Distance from Shore



Depth

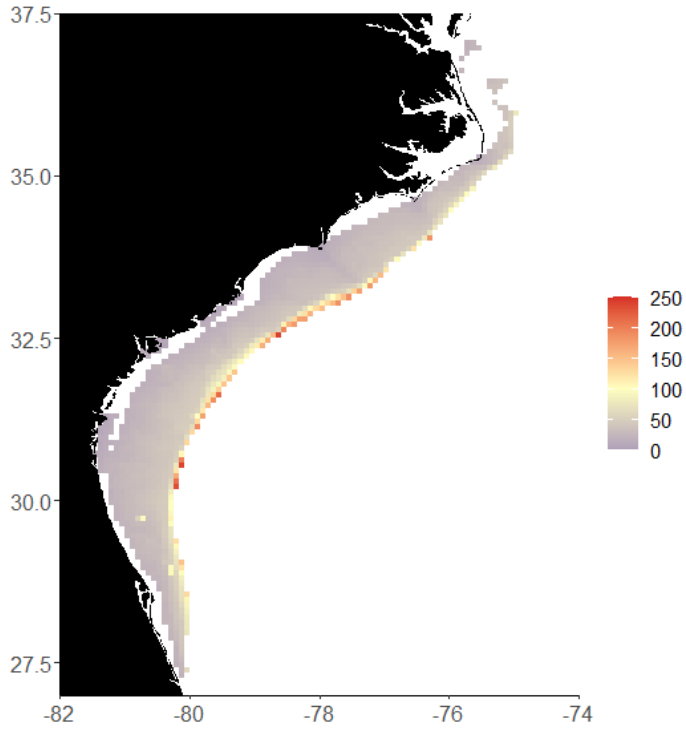


Photo Credits: Kaitlyn O'Brien

Shark Sanctuaries – Sampling Data Sheet

Name: _____

Date: _____

Station No: #1 - #5 based on their Sample label

Using fishery-independent surveys, scientists monitor how shark populations change over time and environmental changes. The most common form of fishery-independent survey for sharks is a longline. Your class will mimic a longline survey today by 'sampling' at multiple locations. In groups, you will work as a crew of scientists to identify, sort, and sample five different shark species found along the US Atlantic Coast. The five species of sharks that will be observed today are:

- Sandbar shark
- Tiger shark
- Blacktip shark
- Blacknose shark
- Bonnethead shark

Your class will also experience one of the most significant challenges in shark science – NO CATCH!

Pre-sampling question:

Q1: Is your sample station farther north or south along the Atlantic coast? Is your station closer to or farther from shore? How do you think the placement of your station affects the environmental conditions?

Q2: Develop a hypothesis for which shark species you think you will most likely sample at this station? What is your evidence for this?

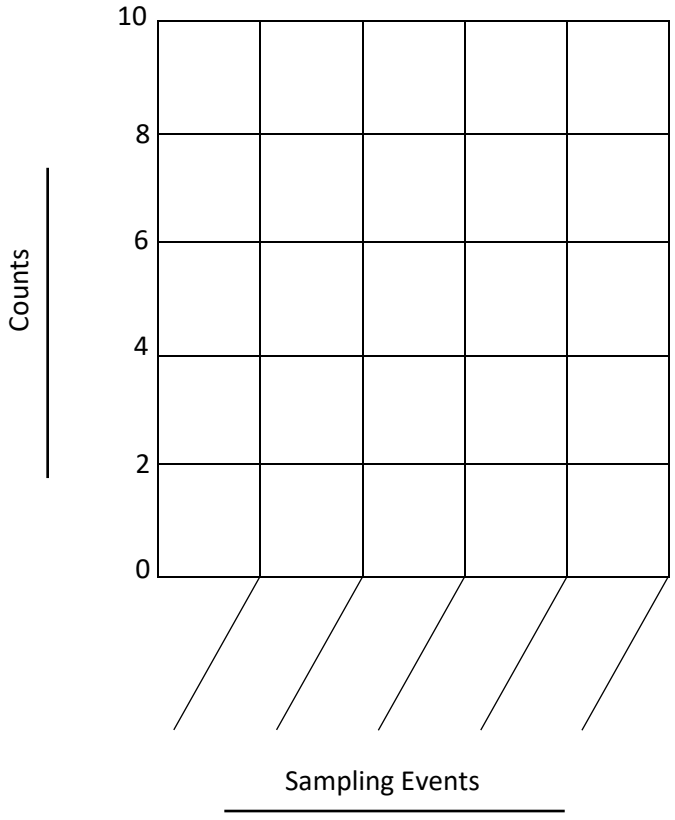
Q3: Are there any species you do not expect to find at this site? Why or why not?

Instructions

1) Start by preparing for the sampling. First, determine from your teacher what colored bead relates to which shark species. Then for each sampling event, one group member will blindly take out 10 beads from the bag.
2) Record the species and number of "sharks" sampled. The different bead colors correspond to different species. One bead color corresponds to "No Catch". These beads still count as part of the sampling. **DO NOT PUT THESE BEADS BACK IN THE BAG**. Put them off to the side.
3) Repeat steps 1 and 2 the number of times specified by your teacher.

Species	Sampling #1	Sampling #2	Sampling #3	Sampling #4	Sampling #5	Color
Sandbar						
Tiger						
Blacktip						
Blacknose						
Bonnethead						
No Shark						

Graphing: Each student will graph only their species – so everyone's graph should look different. Fill in the X-axis with the sampling events for your species. Create a bar graph to demonstrate the count at each sampling event. Label your axis



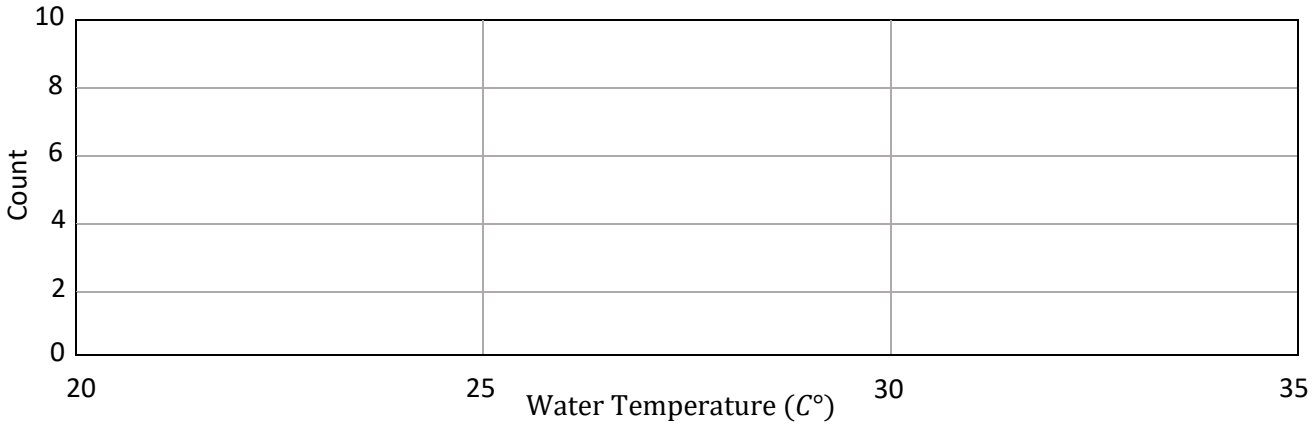
Rearrange! Now you will get together with people that focused on your species. Every sampling location should be represented in the new group.

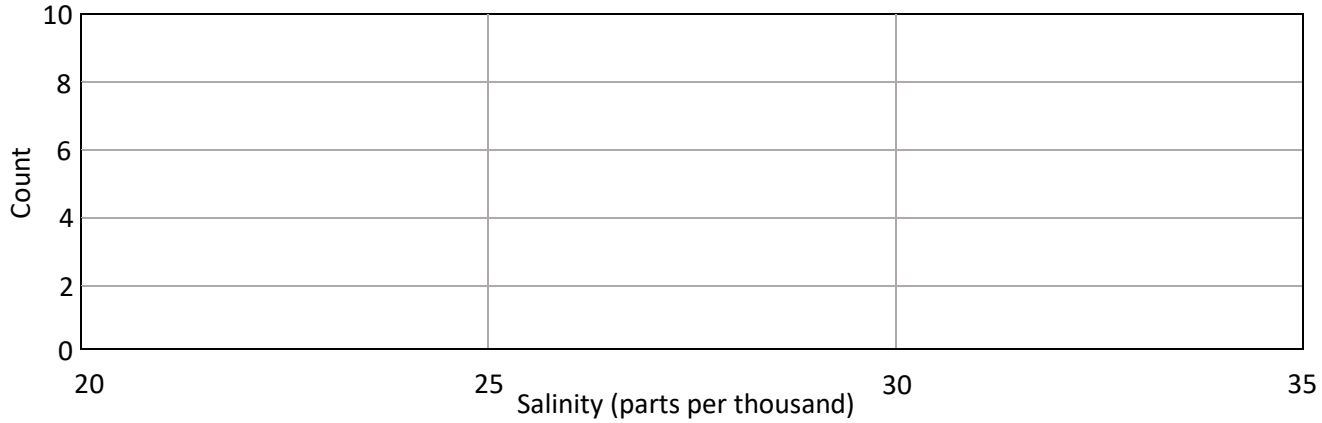
4) While out sampling, other scientists collected environmental information (table below). Using this environmental information and the longline results compare how the different stations caught your shark species by graphing and answering the post-sampling questions. Also, start preparing what you will say to the class about your species.

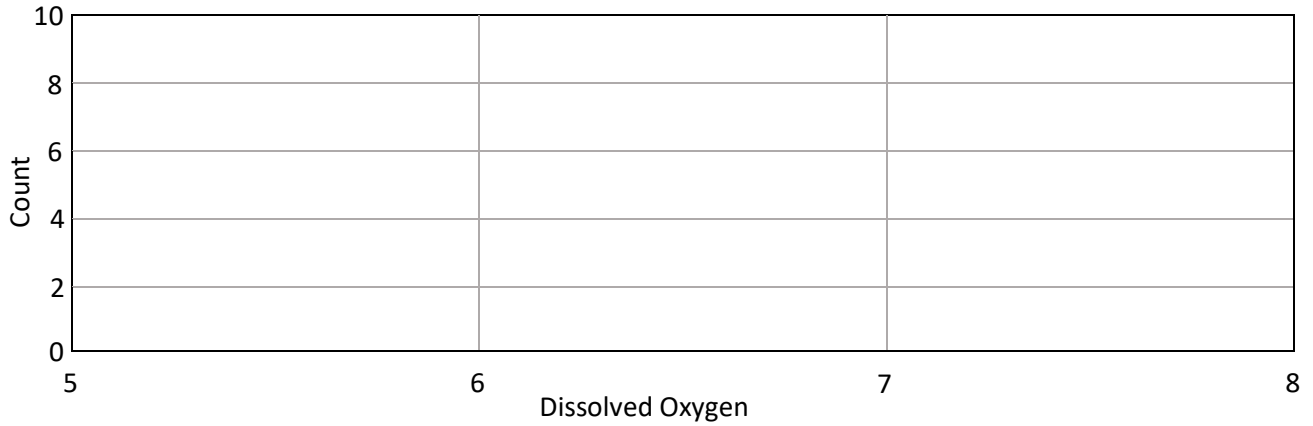
	Virginia	**North Carolina**	**South Carolina**	**Georgia**	**Florida**
Water Temperature (WT)	24	29	32	34	30
Dissolved Oxygen (DO)	7	6.5	6	5.5	7.5
Salinity (SA)	32	30	28	24	34
Depth (meters)	25	60	15	10	50
Distance from Shore (kilometers)	10	25	1.5	2	15

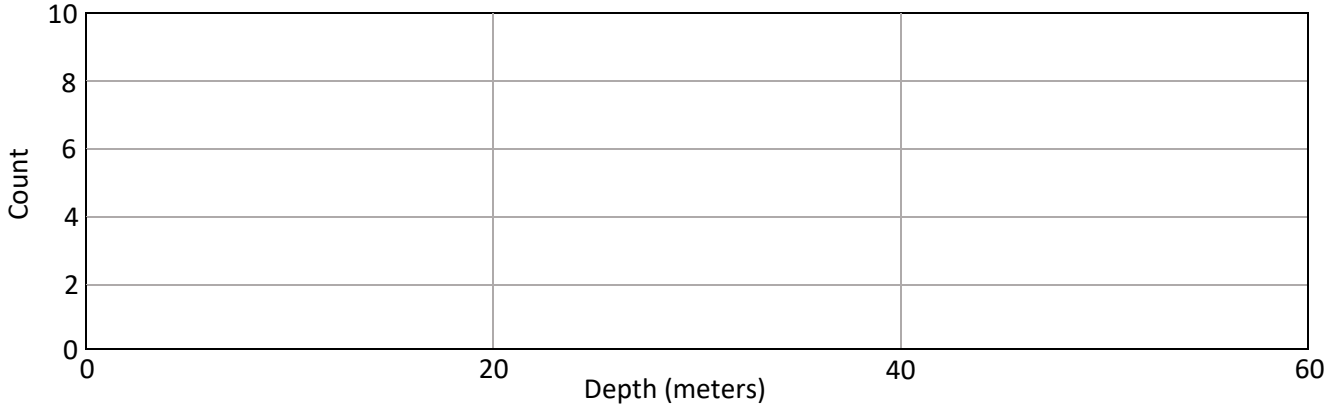
Graphing: As a group, come together and graph your sampled species different abiotic niche for each environmental variable. The X and Y axis have been supplied for you, but you need to plot each point.

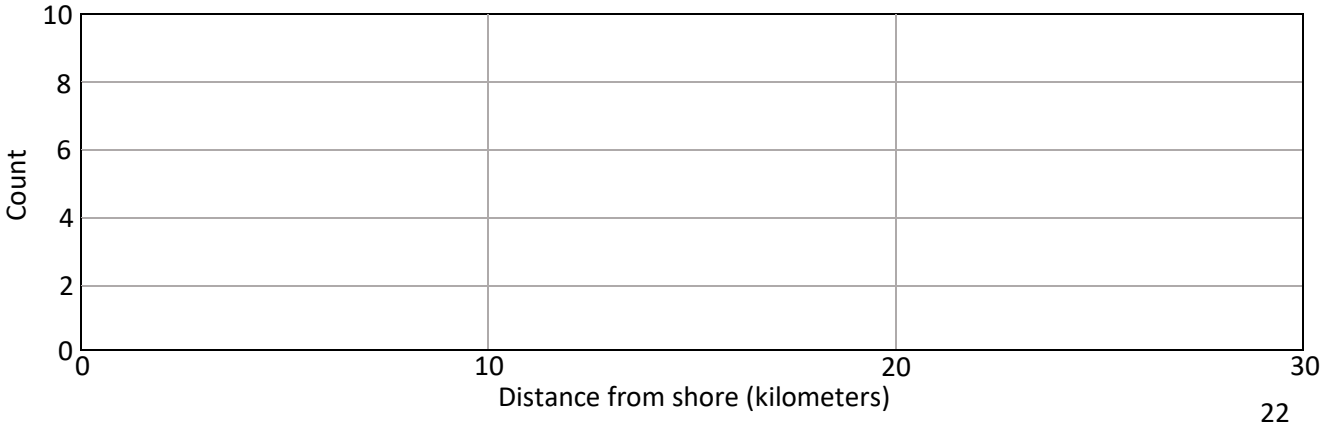
Sampling event	Virginia	North Carolina	South Carolina	Georgia	Florida
1					
2					
3					
4					
5					




10
8
6
4
2
0
Count
20
25
30
35
Salinity (parts per thousand)


10
8
6
4
2
0
Count
5
6
7
8
Dissolved Oxygen


10
8
6
4
2
0
Count
0
20
40
60
Depth (meters)


10
8
6
4
2
0
Count
0
10
20
30
Distance from shore (kilometers)

Post-Sampling Questions:

Q4: Was there any particular station where your species was never caught? Do you have any hypotheses as to why?

Q5: Looking at your graphs, describe your species' optimal environment is (ex: best water temperatures). Are there any abiotic factors that do not appear to be important for your species?

Q6: How often did you sample "No sharks"? Was this surprising? Do you think catching "No sharks" really means your species wasn't there or did you just not sample any? Do you think there was a purpose to sampling your station multiple times?

Q7: How would you improve on your shark's estimated ecological niche?

Shark Sanctuaries - Habitat Suitability Worksheet (Sandbar)

Species: ___Sandbar _____

We learned that while sharks are difficult to sample, the information gathered from fishery-independent surveys can be used for various reasons. Shark data is used to determine a sharks' ecological niche – which you did in Part 1 of this exercise. Your task now is to use an ecological niche model for sandbar sharks to predict how climate change will impact the distribution of sandbar sharks.

Scientists use different evidence-based scenarios to predict how the climate could change by 2100. For this exercise, we will be looking at Representative Concentration Pathway (RCP) 8.0 – the most extreme prediction. Scientists have continued your sampling at multiple stations and created ecological niche models based on more information. Your task is to estimate the changes in suitable habitat for your species using the Ecological Niche Model, Climate Conditions, and Atlantic Shark Field Guide handouts.

Instructions:

1) As a group, examine the maps provided of outputs from current conditions and RCP8.0 for water temperature and salinity. Depth and distance from shore are also provided but are not expected to change over time.
2) Identify areas on each map that you would expect (species) to be found based on the ecological niche models provided. This can be done by circling areas you expect to be highly suitable.
3) Once you have identified areas on each map that you would expect (species), look for any overlapping areas between the different maps.
4) Repeat this process for both current conditions and RCP8.0, then compare how the suitable habitat is expected to change.

Post-Exercise questions

Q1) Were there any abiotic factors that do not appear to be significant to your species? Does this surprise you? What reasons do you think this factor is not significant?

Q2) According to climate change predictions, does the suitable habitat for your species appear to be increasing, decreasing, or staying the same in the future?

Q3) Do you think these habitat predictions are entirely accurate? What are some other factors that should be considered?

Shark Sanctuaries - Habitat Suitability Worksheet - Tiger

Species: ___Tiger _____

We learned that while sharks are difficult to sample, the information gathered from fishery-independent surveys can be used for various reasons. Shark data is used to determine a sharks' ecological niche – which you did in Part 1 of this exercise. Your task now is to use an ecological niche model for Tiger sharks to predict how climate change will impact the distribution of Tiger sharks.

Scientists use different evidence-based scenarios to predict how the climate could change by 2100. For this exercise, we will be looking at Representative Concentration Pathway (RCP) 8.0 – the most extreme prediction. Scientists have continued your sampling at multiple stations and created ecological niche models based on more information. Your task is to estimate the changes in suitable habitat for your species using the Ecological Niche Model, Climate Conditions, and Atlantic Shark Field Guide handouts.

Instructions:

1) As a group, examine the maps provided of outputs from current conditions and RCP8.0 for water temperature and salinity. Depth and distance from shore are also provided but are not expected to change over time.
2) Identify areas on each map that you would expect (species) to be found based on the ecological niche models provided. This can be done by circling areas you expect to be highly suitable.
3) Once you have identified areas on each map that you would expect (species), look for any overlapping areas between the different maps.
4) Repeat this process for both current conditions and RCP8.0, then compare how the suitable habitat is expected to change.

Post-Exercise questions

Q1) Were there any abiotic factors that do not appear to be significant to your species? Does this surprise you? What reasons do you think this factor is not significant?

Q2) According to climate change predictions, does the suitable habitat for your species appear to be increasing, decreasing, or staying the same in the future?

Q3) Do you think these habitat predictions are entirely accurate? What are some other factors that should be considered?

Shark Sanctuaries - Habitat Suitability Worksheet -Blacktip

Species: ___Blacktip _____

We learned that while sharks are difficult to sample, the information gathered from fishery-independent surveys can be used for various reasons. Shark data is used to determine a sharks' ecological niche – which you did in Part 1 of this exercise. Your task now is to use an ecological niche model for Blacktip sharks to predict how climate change will impact the distribution of Blacktip sharks.

Scientists use different evidence-based scenarios to predict how the climate could change by 2100. For this exercise, we will be looking at Representative Concentration Pathway (RCP) 8.0 – the most extreme prediction. Scientists have continued your sampling at multiple stations and created ecological niche models based on more information. Your task is to estimate the changes in suitable habitat for your species using the Ecological Niche Model, Climate Conditions, and Atlantic Shark Field Guide handouts.

Instructions:

1) As a group, examine the maps provided of outputs from current conditions and RCP8.0 for water temperature and salinity. Depth and distance from shore are also provided but are not expected to change over time.
2) Identify areas on each map that you would expect (species) to be found based on the ecological niche models provided. This can be done by circling areas you expect to be highly suitable.
3) Once you have identified areas on each map that you would expect (species), look for any overlapping areas between the different maps.
4) Repeat this process for both current conditions and RCP8.0, then compare how the suitable habitat is expected to change.

Post-Exercise questions

Q1) Were there any abiotic factors that do not appear to be significant to your species? Does this surprise you? What reasons do you think this factor is not significant?

Q2) According to climate change predictions, does the suitable habitat for your species appear to be increasing, decreasing, or staying the same in the future?

Q3) Do you think these habitat predictions are entirely accurate? What are some other factors that should be considered?

Shark Sanctuaries - Habitat Suitability Worksheet -Blacknose

Species: ___Blacknose _____

We learned that while sharks are difficult to sample, the information gathered from fishery-independent surveys can be used for various reasons. Shark data is used to determine a sharks' ecological niche – which you did in Part 1 of this exercise. Your task now is to use an ecological niche model for Blacknose sharks to predict how climate change will impact the distribution of Blacknose sharks.

Scientists use different evidence-based scenarios to predict how the climate could change by 2100. For this exercise, we will be looking at Representative Concentration Pathway (RCP) 8.0 – the most extreme prediction. Scientists have continued your sampling at multiple stations and created ecological niche models based on more information. Your task is to estimate the changes in suitable habitat for your species using the Ecological Niche Model, Climate Conditions, and Atlantic Shark Field Guide handouts.

Instructions:

1) As a group, examine the maps provided of outputs from current conditions and RCP8.0 for water temperature and salinity. Depth and distance from shore are also provided but are not expected to change over time.
2) Identify areas on each map that you would expect (species) to be found based on the ecological niche models provided. This can be done by circling areas you expect to be highly suitable.
3) Once you have identified areas on each map that you would expect (species), look for any overlapping areas between the different maps.
4) Repeat this process for both current conditions and RCP8.0, then compare how the suitable habitat is expected to change.

Post-Exercise questions

Q1) Were there any abiotic factors that do not appear to be significant to your species? Does this surprise you? What reasons do you think this factor is not significant?

Q2) According to climate change predictions, does the suitable habitat for your species appear to be increasing, decreasing, or staying the same in the future?

Q3) Do you think these habitat predictions are entirely accurate? What are some other factors that should be considered?

Shark Sanctuaries - Habitat Suitability Worksheet - Bonnethead

Species: ___Bonnethead _____

We learned that while sharks are difficult to sample, the information gathered from fishery-independent surveys can be used for various reasons. Shark data is used to determine a sharks' ecological niche – which you did in Part 1 of this exercise. Your task now is to use an ecological niche model for Bonnethead sharks to predict how climate change will impact the distribution of Bonnethead sharks.

Scientists use different evidence-based scenarios to predict how the climate could change by 2100. For this exercise, we will be looking at Representative Concentration Pathway (RCP) 8.0 – the most extreme prediction. Scientists have continued your sampling at multiple stations and created ecological niche models based on more information. Your task is to estimate the changes in suitable habitat for your species using the Ecological Niche Model, Climate Conditions, and Atlantic Shark Field Guide handouts.

Instructions:

1) As a group, examine the maps provided of outputs from current conditions and RCP8.0 for water temperature and salinity. Depth and distance from shore are also provided but are not expected to change over time.
2) Identify areas on each map that you would expect (species) to be found based on the ecological niche models provided. This can be done by circling areas you expect to be highly suitable.
3) Once you have identified areas on each map that you would expect (species), look for any overlapping areas between the different maps.
4) Repeat this process for both current conditions and RCP8.0, then compare how the suitable habitat is expected to change.

Post-Exercise questions

Q1) Were there any abiotic factors that do not appear to be significant to your species? Does this surprise you? What reasons do you think this factor is not significant?

Q2) According to climate change predictions, does the suitable habitat for your species appear to be increasing, decreasing, or staying the same in the future?

Q3) Do you think these habitat predictions are entirely accurate? What are some other factors that should be considered?

Worksheet Keys

Shark Sanctuaries – Sampling Data Sheet (KEY)

Name: _____

Date: _____

Station No: #1 - #5 based on their Sample label

Using fishery-independent surveys, scientists monitor how shark populations change over time and environmental changes. The most common form of fishery-independent survey for sharks is a longline. Your class will mimic a longline survey today by 'sampling' at multiple locations. In groups, you will work as a crew of scientists to identify, sort, and sample five different shark species found along the US Atlantic Coast. The five species of sharks that will be observed today are:

- Sandbar shark
- Tiger shark
- Blacktip shark
- Blacknose shark
- Bonnethead shark

Your class will also experience one of the most significant challenges in shark science – NO CATCH!

Pre-sampling question:

Q1: Is your sample station farther north or south along the Atlantic coast? Is your station closer to or farther from shore? How do you think the placement of your station affects the environmental conditions?

Sites #1 and #2 are the farthest north, whereas sites #4 and #5 are farther south. Site #3 is in the middle. Sites #2 and #5 are offshore sites, while sites #3 and #4 are inshore, with site #1 in the middle.

The position of the stations is expected to impact the environmental conditions. As the distance from shore increases, there are a few general trends of note; depth, dissolved oxygen, and salinity increase while water temperature decreases. Depth at offshore stations increases due to the structure of the ocean bottom. Offshore stations are expected to have higher salinity than inshore stations due to limited freshwater input. Increased temperature is also likely coastal compared to offshore. Still, southern stations are also expected to be warmer than northern stations. Finally, the dissolved oxygen is generally lower close to shore due to the high productivity in coastal waters but is also inverse of water temperature.

Q2: Develop a hypothesis for which shark species you think you will most likely sample at this station? What is your evidence for this?

Each student should develop their own hypothesis, but students should hopefully connect the sharks' ecology and the station's environment. In general, large coastal sharks are farther offshore than small coastal sharks. Small coastal sharks tend to be in warmer waters than large coastal sharks.

Q3: Are there any species you do not expect to find at this site? Why or why not?

Again, answers will vary for the same reasons as above (ecology and life history of different species).

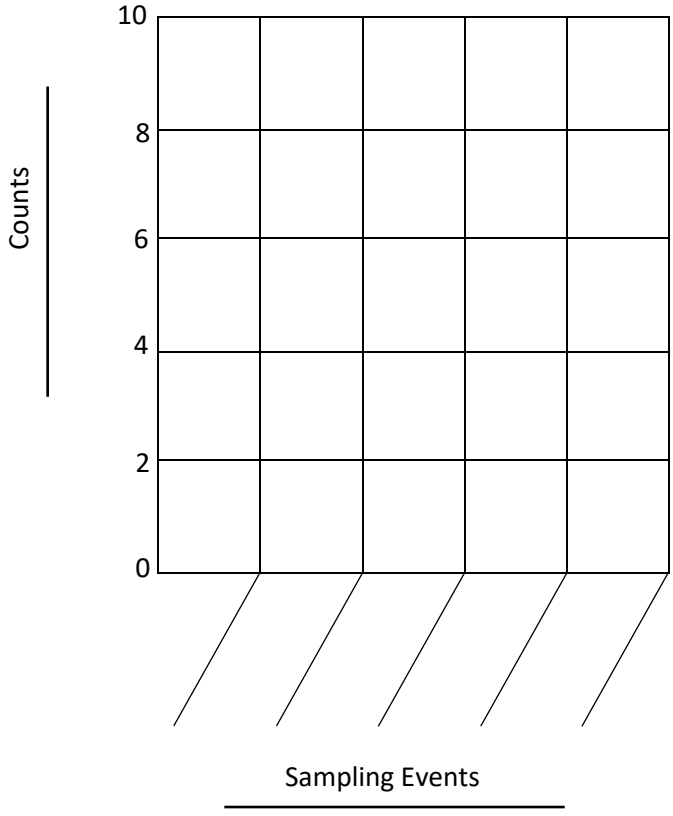
Instructions

1) Start by preparing for the sampling. First, determine from your teacher what colored bead relates to which shark species. Then for each sampling event, one group member will blindly take out 10 beads from the bag.
2) Record the species and number of "sharks" sampled. The different bead colors correspond to different species. One bead color corresponds to "No Catch". These beads still count as part of the sampling. **DO NOT PUT THESE BEADS BACK IN THE BAG**. Put them off to the side.
3) Repeat steps 1 and 2 the number of times specified by your teacher.

Species	Sampling #1	Sampling #2	Sampling #3	Sampling #4	Sampling #5	Color
Sandbar						
Tiger						
Blacktip						
Blacknose						
Bonnethead						
No Shark						

These counts will vary every time due to the randomness of the sampling.

Graphing: Each student will graph only their species – so everyone's graph should look different. Fill in the X-axis with the sampling events for your species. Create a bar graph to demonstrate the count at each sampling event. Label your axis



This graph should look different every time and for every species, but there will be times where a species is never caught at a specific station (eg. Bonnethead for Virginia and North Carolina). In this case just mark that there were zero sharks caught at all sampling events. This will still be important information to take back to the species group later.

Rearrange! Now you will get together with people that focused on your species. Every sampling location should be represented in the new group.

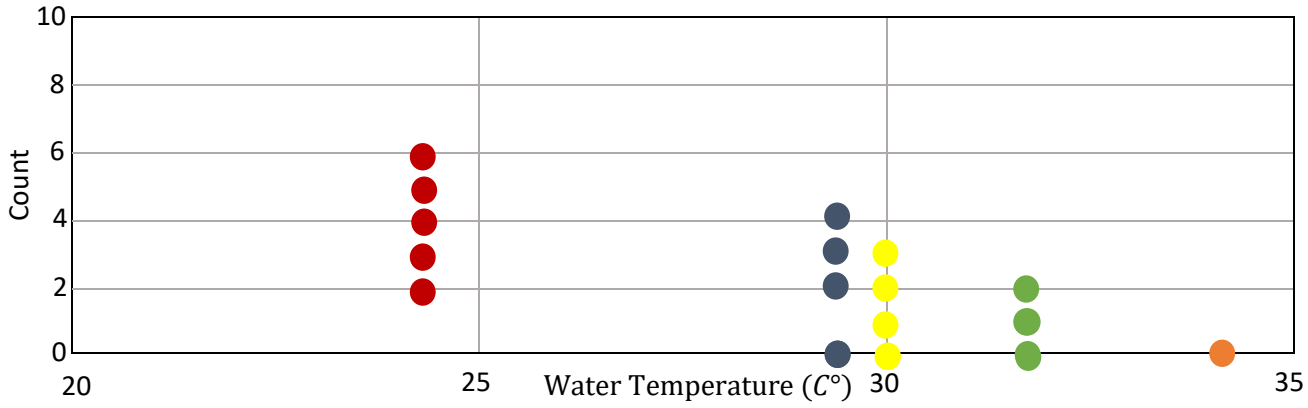
4) While out sampling, other scientists collected environmental information (table below). Using this environmental information and the longline results compare how the different stations caught your shark species by graphing and answering the post-sampling questions. Also, start preparing what you will say to the class about your species.

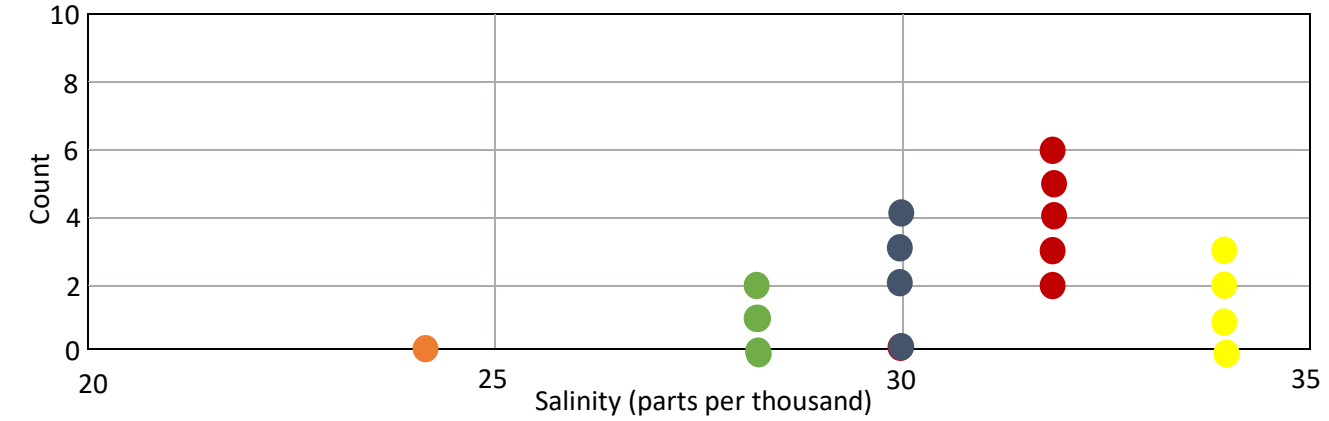
	Virginia	**North Carolina**	**South Carolina**	**Georgia**	**Florida**
Water Temperature (WT)	24	29	32	34	30
Dissolved Oxygen (DO)	7	6.5	6	5.5	7.5
Salinity (SA)	32	30	28	24	34
Depth (meters)	25	60	15	10	50
Distance from Shore (kilometers)	10	25	1.5	2	15

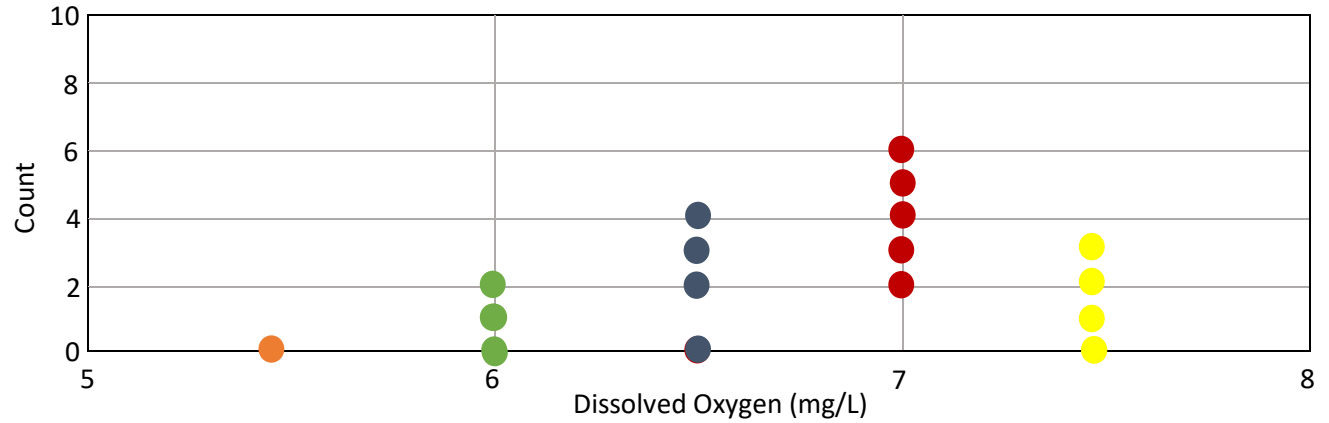
Graphing: As a group, come together and graph your sampled species different abiotic niches for each environmental variable. The X and Y axis have been supplied for you, but you need to plot each point.

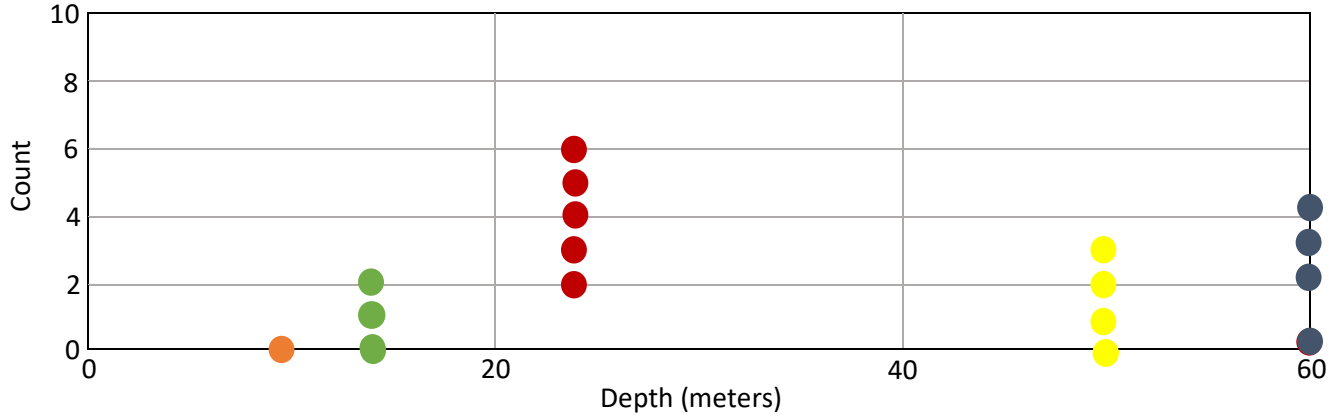
This is an example output for sandbar sharks. Below is an example sampling scenario followed by the respective graphs. Colored dots are not necessary, but may be useful.

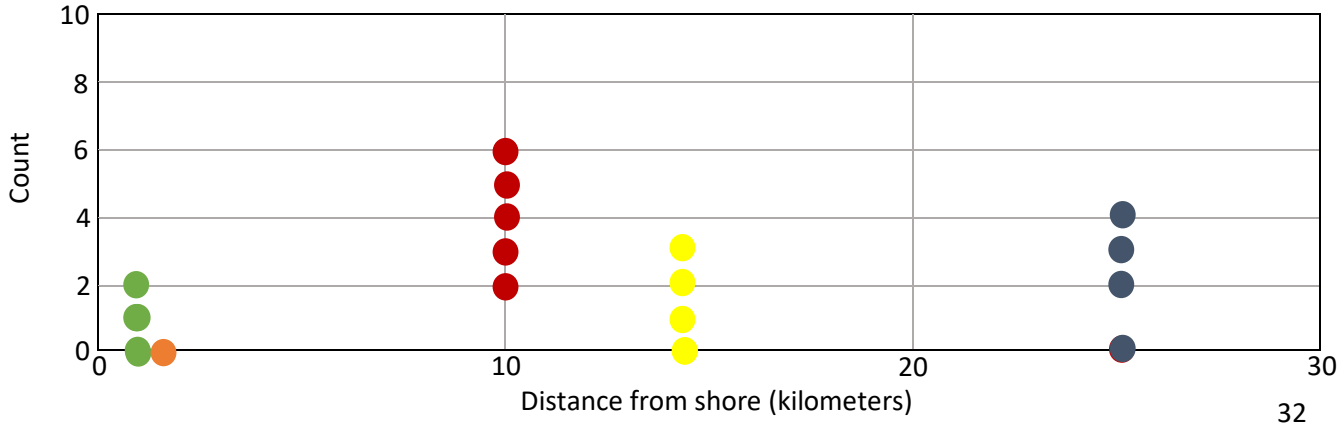
Sampling event	Virginia (red)	North Carolina (blue)	South Carolina (green)	Georgia (orange)	Florida (yellow)
1	6	2	0	0	0
2	2	3	0	0	3
3	4	0	2	0	1
4	3	4	0	0	0
5	5	0	1	0	2




Count
10
8
6
4
2
0
20
25
30
35
Salinity (parts per thousand)


Count
10
8
6
4
2
0
5
6
7
8
Dissolved Oxygen (mg/L)


Count
10
8
6
4
2
0
0
20
40
60
Depth (meters)


Count
10
8
6
4
2
0
0
10
20
30
Distance from shore (kilometers)

Post-Sampling Questions:

Q4: Was there any particular station where your species was never caught? Do you have any hypotheses as to why?

Sandbar: Sandbar sharks can be caught at every station, but it is doubtful to find them at the Georgia station. This could be because this station has the highest temperature and the lowest salinity. Also, it is unlikely to catch them in the SC survey, possibly for the same reasons.

Tiger shark: Tiger sharks are also rarely caught at the South Carolina and Georgia stations – this could be due to the temperature, salinity, and the distance from shore. Tiger sharks are known to be an offshore species.

Blacktip shark: Very similar to sandbar sharks.

Blacknose sharks: Blacknose sharks are scarce in the northern stations – most likely due to the decreased water temperature. As a Small coastal species, they are very water temperature-dependent.

Bonnethead sharks: Bonnethead sharks are an inshore species and are rarely caught offshore. This means that the chance of seeing one at the SEFSC southern survey is rare, and impossible to see any at the two northern stations.

Overall, these trends should follow the difference between large coastal and small coastal species.

Q5: Looking at your graphs, describe your species' optimal environment is (ex: best water temperatures). Are there any abiotic factors that do not appear to be essential for your species?

Sandbar: Prefers colder, high saline, oxygen-rich waters.

Tiger: Tiger sharks are more dependent on depth and offshore saline waters. They may not depend on temperature as much as other species

Blacktip: Very similar to sandbar.

Blacknose: Highly dependent on warmer waters.

Bonnethead: Inshore species! Warm waters, lower salinity, close to shore.

Q6: How often did you sample "No sharks"? Was this surprising? Do you think catching "No sharks" really means your species wasn't there or did you just not sample any? Do you think there was a purpose to sampling your station multiple times?

Students should sample "No sharks" approximately 50% of the time, but this is definitely dependent upon the station. This is a question that scientists struggle with constantly when it comes to sampling. Students should note that the repeated samples help determine what stations species are actually at vs. which ones they are not.

Q7: How would you improve on your shark's estimated ecological niche?

More samples! Sampling more frequently and at more stations with different environmental values will help refine this ecological niche.

Habitat Suitability Worksheet (KEY)

Species: ___Species name will be pre-filled here_____

We learned that while sharks are difficult to sample, the information gathered from fishery-independent surveys can be used for various reasons. Shark data is used to determine a sharks' ecological niche – which you did in Part 1 of this exercise. Your task now is to use an ecological niche model for (species) to predict how climate change will impact the distribution of (species).

Scientists use different evidence-based scenarios to predict how the climate could change by 2100. For this exercise, we will be looking at Representative Concentration Pathway (RCP) 8.0 – the most extreme prediction. Scientists have continued your sampling at multiple stations and created ecological niche models based on more information. Your task is to estimate the changes in suitable habitat for your species using the Ecological Niche Model, Climate Conditions, and Atlantic Shark Field Guide handouts.

Instructions:

1) As a group, examine the maps provided of outputs from current conditions and RCP8.0 for water temperature and salinity. Depth and distance from shore are also provided but are not expected to change over time.
2) Identify areas on each map that you would expect (species) to be found based on the ecological niche models provided. This can be done by circling areas you think are highly suitable.
3) Once you have identified areas on each map that you would expect (species), look for any overlapping areas between the different maps.
4) Repeat this process for both current conditions and RCP8.0, then compare how the suitable habitat is expected to change.

Post-Exercise questions

1) Were there any abiotic factors that do not appear to be significant to your species? Does this surprise you? What reasons do you think this factor is not significant?

Overall: It should always be in the back of your mind that something might not be significant due to the sample size! Remember how often we have zero catches? This can make determining what variables are essential complicated! An abiotic factor may ACTUALLY be significant, but we haven't sampled the animal enough or at a wide enough range of environmental variables to understand its importance.

Sandbar: Distance from shore. This is not surprising because depth and distance to shore are similar metrics. The similarity between depth and distance to shore may be why this factor is not important.

Tiger: Dissolved oxygen and depth. Again, this is not too surprising. Think of the ecology of the animal! Tiger sharks are extreme habitat generalists. The fact that dissolved oxygen does not appear to be important isn't concerning.

Blacktip: Dissolved oxygen and depth. Dissolved oxygen is a little surprising. Blacktip sharks are more coastal than tiger sharks, meaning they encounter a wider range of dissolved oxygen concentrations.

It is interesting that dissolved oxygen is not part of their ecological niche. Remember that this might be due to the sample size as well.

Blacknose: Depth – similar reasons to sandbar shark.

Bonnethead: Salinity and dissolved oxygen. Very similar to the blacktip shark. This is surprising given how coastal of an animal they are.

2) According to climate change predictions, does the suitable habitat for your species appear to be increasing, decreasing, or staying the same in the future?

Sandbar: Decreasing! This is a more temperate species, so there is a significant decrease in available habitat.

Tiger: Staying about the same/slightly increasing. Water temperatures may be starting to get warmer than tiger sharks prefer, but not extremely. The main positive point is the increase in salinity, which is good for tiger sharks.

Blacktip, Blacknose, and Bonnethead: Increasing! These are more tropical species, so the warming waters are excellent for these species!

3) Do you think these habitat predictions are entirely accurate? What are some other factors that should be considered?

No, this is just one part of understanding an animal's habitat! This study is only looking into the abiotic factors! Remember that we also need to consider biotic factors (prey species, competition). Suppose the prey species are more affected by the changing climate than the predator species. In that case, the suitable habitat will be further constricted for the predator. Also, species expanding their range may encounter new competition from other shark species. For example, Atlantic blacknose's suitable habitat appears to be expanding north. Still, they may not survive in those waters due to increased competition for prey.

Rearrange! Now you will get together with people that focused on your species. Every sampling location should be represented in the new group.

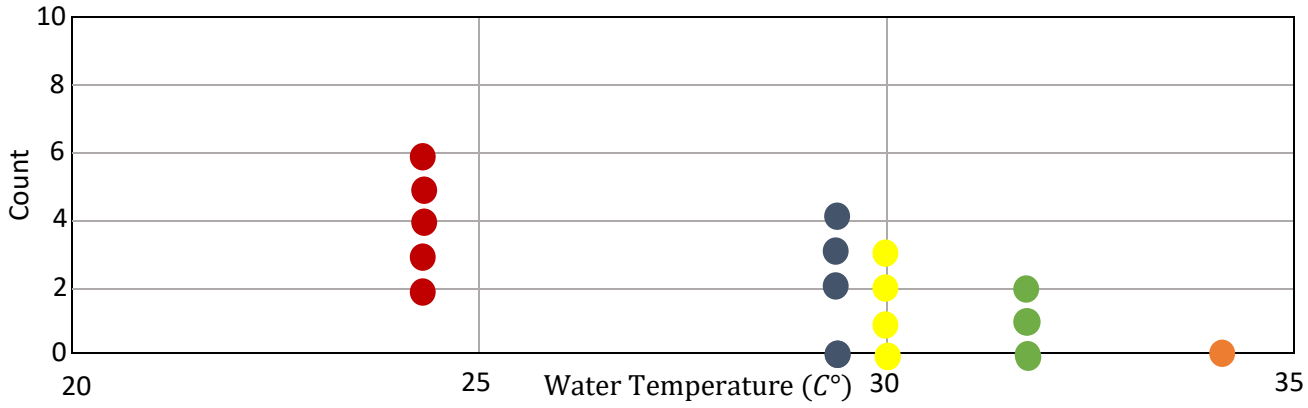
4) While out sampling, other scientists collected environmental information (table below). Using this environmental information and the longline results compare how the different stations caught your shark species by graphing and answering the post-sampling questions. Also, start preparing what you will say to the class about your species.

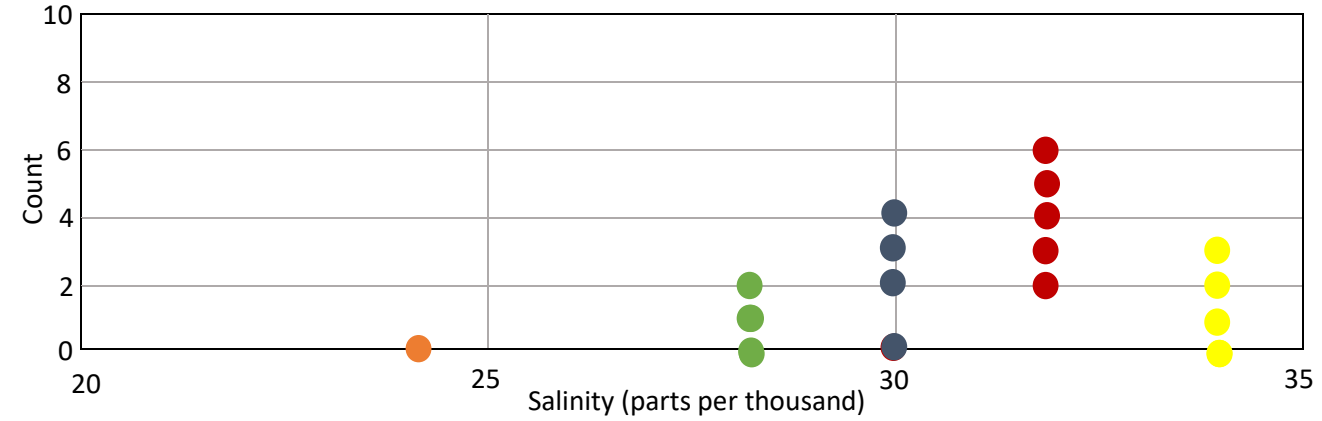
	Virginia	**North Carolina**	**South Carolina**	**Georgia**	**Florida**
Water Temperature (WT)	24	29	32	34	30
Dissolved Oxygen (DO)	7	6.5	6	5.5	7.5
Salinity (SA)	32	30	28	24	34
Depth (meters)	25	60	15	10	50
Distance from Shore (kilometers)	10	25	1.5	2	15

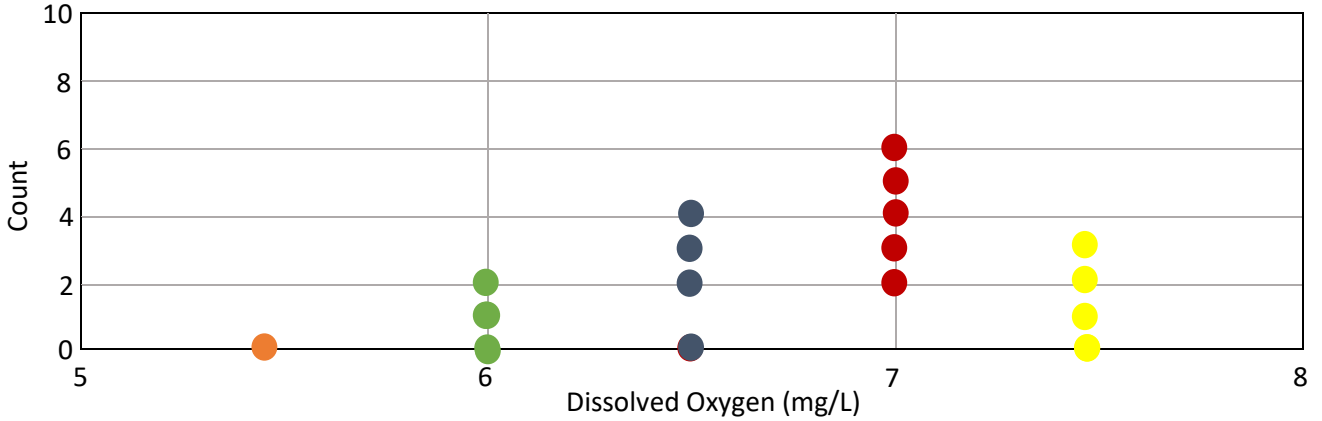
Graphing: As a group, come together and graph your sampled species different abiotic niches for each environmental variable. The X and Y axis have been supplied for you, but you need to plot each point.

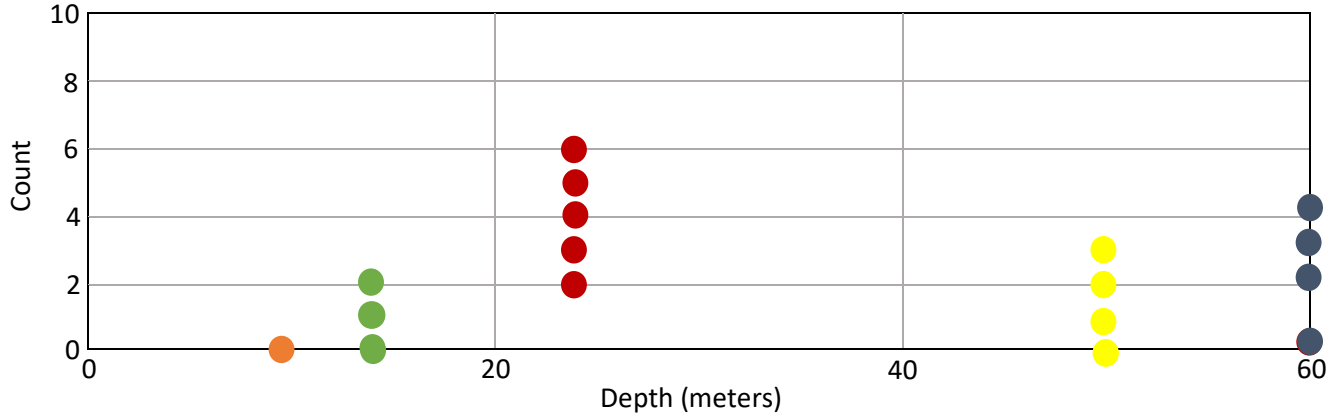
This is an example output for sandbar sharks. Below is an example sampling scenario followed by the respective graphs. Colored dots are not necessary, but may be useful.

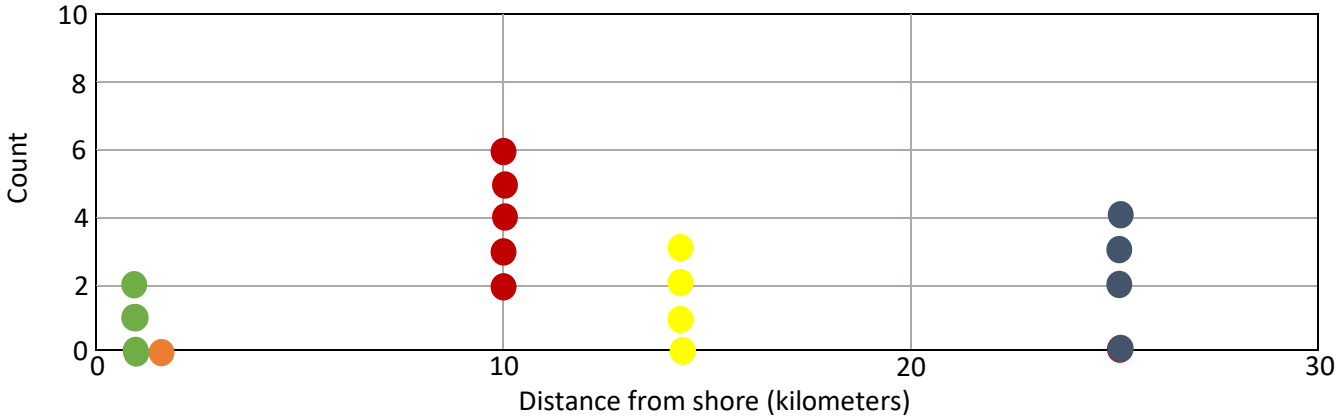
Sampling event	Virginia (red)	North Carolina (blue)	South Carolina (green)	Georgia (orange)	Florida (yellow)
1	6	2	0	0	0
2	2	3	0	0	3
3	4	0	2	0	1
4	3	4	0	0	0
5	5	0	1	0	2




10
8
6
4
2
0
Count
20
25
30
35
Salinity (parts per thousand)


10
8
6
4
2
0
Count
5
6
7
8
Dissolved Oxygen (mg/L)


10
8
6
4
2
0
Count
0
20
40
60
Depth (meters)


10
8
6
4
2
0
Count
0
10
20
30
Distance from shore (kilometers)

Post-Sampling Questions:

Q4: Was there any particular station where your species was never caught? Do you have any hypotheses as to why?

Sandbar: Sandbar sharks can be caught at every station, but it is doubtful to find them at the Georgia station. This could be because this station has the highest temperature and the lowest salinity. Also, it is unlikely to catch them in the SC survey, possibly for the same reasons.

Tiger shark: Tiger sharks are also rarely caught at the South Carolina and Georgia stations – this could be due to the temperature, salinity, and the distance from shore. Tiger sharks are known to be an offshore species.

Blacktip shark: Very similar to sandbar sharks.

Blacknose sharks: Blacknose sharks are scarce in the northern stations – most likely due to the decreased water temperature. As a Small coastal species, they are very water temperature-dependent.

Bonnethead sharks: Bonnethead sharks are an inshore species and are rarely caught offshore. This means that the chance of seeing one at the SEFSC southern survey is rare, and impossible to see any at the two northern stations.

Overall, these trends should follow the difference between large coastal and small coastal species.

Q5: Looking at your graphs, describe your species' optimal environment is (ex: best water temperatures). Are there any abiotic factors that do not appear to be essential for your species?

Sandbar: Prefers colder, high saline, oxygen-rich waters.

Tiger: Tiger sharks are more dependent on depth and offshore saline waters. They may not depend on temperature as much as other species

Blacktip: Very similar to sandbar.

Blacknose: Highly dependent on warmer waters.

Bonnethead: Inshore species! Warm waters, lower salinity, close to shore.

Q6: How often did you sample "No sharks"? Was this surprising? Do you think catching "No sharks" really means your species wasn't there or did you just not sample any? Do you think there was a purpose to sampling your station multiple times?

Students should sample "No sharks" approximately 50% of the time, but this is definitely dependent upon the station. This is a question that scientists struggle with constantly when it comes to sampling. Students should note that the repeated samples help determine what stations species are actually at vs. which ones they are not.

Q7: How would you improve on your shark's estimated ecological niche?

More samples! Sampling more frequently and at more stations with different environmental values will help refine this ecological niche.

Habitat Suitability Worksheet (KEY)

Species: ___Species name will be pre-filled here_____

We learned that while sharks are difficult to sample, the information gathered from fishery-independent surveys can be used for various reasons. Shark data is used to determine a sharks' ecological niche – which you did in Part 1 of this exercise. Your task now is to use an ecological niche model for (species) to predict how climate change will impact the distribution of (species).

Scientists use different evidence-based scenarios to predict how the climate could change by 2100. For this exercise, we will be looking at Representative Concentration Pathway (RCP) 8.0 – the most extreme prediction. Scientists have continued your sampling at multiple stations and created ecological niche models based on more information. Your task is to estimate the changes in suitable habitat for your species using the Ecological Niche Model, Climate Conditions, and Atlantic Shark Field Guide handouts.

Instructions:

1) As a group, examine the maps provided of outputs from current conditions and RCP8.0 for water temperature and salinity. Depth and distance from shore are also provided but are not expected to change over time.
2) Identify areas on each map that you would expect (species) to be found based on the ecological niche models provided. This can be done by circling areas you think are highly suitable.
3) Once you have identified areas on each map that you would expect (species), look for any overlapping areas between the different maps.
4) Repeat this process for both current conditions and RCP8.0, then compare how the suitable habitat is expected to change.

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