Topic/Lesson:	**Data Analysis of Atlantic Sturgeon**
Subject:	Summarizing numerical data sets and describing patterns in data
Author:	Kate Sundquist
Time Duration:	Five Days
Overview:	Students will use scientific data from sturgeon tagging databases to accurately read data tables and summarize numerical data sets in relation to their context. Students will first read a data table from the Atlantic Coast Sturgeon Tagging Database (US Fish and Wildlife 2009). Students will analyze "Table 3. Number of wild caught Atlantic sturgeon tagged and recaptured by region." They will use the data from this table to determine where tagged sturgeon are most likely to be recaptured. Students will answer questions to describe other patterns in the data. They will then use data from "Table 5. Gear types reported by fishermen who captured a tagged Atlantic and shortnose sturgeon" to create their own graphs indicating the type of gear most likely to catch sturgeon. Students will be guided in their discussions about the implications of this data on sturgeon bycatch in other fishing industries. Then, students will use data from the study, "Distribution, Habitat Use, and Size of Atlantic Sturgeon Captured during Cooperative Winter Tagging Cruises, 1988–2006" (Laney et al, 2007) to create their own "test" questions which they must write and provide an answer key. Finally, students will answer a writing prompt asking them to summarize a data set.
Objectives:	Students will be able to: • Recognize patterns in the data by reading numerical data sets presented in formal data tables. • Create their own graph to clearly illustrate the data presented in a formal data table. • Calculate measures of spread (range) and center (mean, median, and mode) of a given numerical data set.
Background Knowledge:	• Students should recognize a statistical question as one that anticipates variability in the data related to the question and accounts for it in the answers. • Students should already understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape. Students should recognize these measures, combined with description of data

	patterns, as summary of a data set.
Materials:	• Poster board for displaying anchor charts and student work • Magazines with data tables, graphs, and maps (e.g. National Geographic) for data scavenger hunt • Data Representation Homework Assignment • Copies of "Table 3. Number of wild caught Atlantic sturgeon tagged and recaptured by region" from the Atlantic Coast Sturgeon Tagging Database (US Fish and Wildlife 2009) and "Reading 'Table 3' Worksheet" • Copies of "Table 4. Number of hatchery reared Atlantic sturgeon tagged and recaptured by region" from Atlantic Coast Sturgeon Tagging Database (US Fish and Wildlife 2009) and "Reading 'Table 4' Worksheet" • Copies of "Table 5. Gear types reported by fishermen who captured a tagged Atlantic and shortnose sturgeon" from the Atlantic Coast Sturgeon Tagging Database (US Fish and Wildlife 2009), the "Redisplaying Data from 'Table 5' Worksheet," and the "Table 5 Writing Prompt Worksheet" • "Mean, Median, Mode, and Range Practice #1" and "Mean, Median, Mode, and Range Practice #2" Worksheets • Data from Winter Tagging Data report, "Create Your Own Test" worksheet, and Winter Sturgeon Tagging Data Writing Prompt with rubric
Vocabulary:	**Data Set:** A set of related numbers gathered through observation and treated as a unit, often displayed in table form. **Range:** A measurement of the spread, or dispersion, of a data set. The difference between the highest and lowest values in the set, calculated by subtracting the lowest data value in the data set from the highest data value in the set. **Mean:** A measurement of the center of a data set. Sometimes also referred to as the average of a data set, the mean is the sum of all of the data values divided by the number of data values. **Median:** A measurement of the center of a data set. The median is the middle value of a data set when it has been arranged in ascending order, from lowest value to highest value. **Mode:** A measurement of the center of a data set. The value that occurs most often in a set of data values.

Procedures:

Day One

The teacher begins by asking students what data is and what a data set is. The class develops a working definition of a “data set” that is displayed on an anchor chart in the classroom for student reference.

Next, students are put into small groups and are asked to brainstorm different ways that data can be represented. Students are given 5 minutes to brainstorm how data can be represented. Groups share their brainstorming with the class. Different ways to represent data are also displayed on the anchor chart. These should include at a minimum: Tables, pictographs, graphs (bar, line, circle), maps, and diagrams.

Once the students have shared their brainstorming, they will return to their groups to participate in a data scavenger hunt. Given a stack of magazines, students are asked to find and cut out as many representations of data as they can. Groups display their data representations by cutting them out and pasting them onto a poster board under the correct headings as brainstormed earlier.

Day One Homework

For homework, the students are to take home one example of data that they found during the scavenger hunt and convert it into another representation. For example, a student who brings home a data table showing money spent on video games might use the data table to create a bar graph showing the same thing. A student who brings home a temperature map might use the map to create a data table showing cities and temperatures. Students will complete the “Data Representation Homework Assignment” at home.

Day Two

Students share their homework assignments.

Next, students receive copies of "Table 3. Number of wild caught Atlantic sturgeon tagged and recaptured by region” from the Atlantic Coast Sturgeon Tagging Database (US Fish and Wildlife 2009). If students have not learned about sturgeon before, the teacher should briefly introduce the species and the importance of tagging efforts of sturgeon to students. If students have previously learned about sturgeon, they should be reminded of what they already know about them and why they are targeted for tagging.

Students are walked through the “Reading ‘Table 3’ Worksheet” that draws their attention to the title and variables represented in the data table. Once students understand how the data is represented, they work in partners to complete the remainder of the worksheet asking them to identify patterns in the data.

<table>
<tr>
<td></td>
<td>Day Two Homework

Students use “Table 4. Number of hatchery reared Atlantic sturgeon tagged and recaptured by region” to complete “Reading ‘Table 4’ Worksheet.”

Day Three

Students review homework from the night before.

They are then assigned partners and given a copy of “Table 5. Gear types reported by fishermen who captured a tagged Atlantic and shortnose sturgeon” from the Atlantic Coast Sturgeon Tagging Database (US Fish and Wildlife 2009). They are told that they should use the data represented in the table to create an appropriate graph. They are then handed the “Redisplaying Data from ‘Table 5’ Worksheet.” Students are reminded of the different graphs that they found during the data scavenger hunt.

Day Three Homework

Students are asked to use the data from Table 5 and their graphs to answer the prompt “What does this data tell us and what might it be used for? Why is it important?” in a short paragraph on the “Table 5 Writing Prompt Worksheet.”

Day Four

The teacher introduces range, mean, median, and mode vocabulary and asks students to work in groups to come up with an example of when each measure of a data set might be appropriate. Groups share their examples.

Next, students are given “Mean, Median, Mode, and Range Practice #1” worksheets to complete. When students are finished, they correct their work with a partner.

Day Four Homework

Students complete “Mean, Median, Mode, and Range Practice #2” worksheet.

Day Five

Students receive copies of the data gathered in “Distribution, Habitat Use, and Size of Atlantic Sturgeon Captured during Cooperative Winter Tagging Cruises, 1988–2006,” (Laney et al 2007). Working alone or with a partner, students are challenged to write their own math questions focusing on interpreting data and using measures of center and spread. Students complete the “Create Your Own Test” worksheets and then trade with another student or group.</td>
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<tr>
<td>Conclusions:</td>
<td>Students correct their “Create Your Own Test” packets and choose one data table or graph to describe in a short paragraph using the “Winter Sturgeon</td>
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	Tagging Data Writing Prompt.” Their paragraph should answer the questions “What does this data represent? How is it represented? What does this data tell us and why is it important?” The paragraphs are presented with the data tables or graphs and can be displayed in the classroom or hallway.
National Education Standards:	**6. SP Statistics and Probability** <u>Develop understanding of statistical variability.</u> 1. Recognize a statistical question as one that anticipates variability in the data related to the question and accounts for it in the answers. For example, “How old am I?” is not a statistical question, but “How old are the students in my school?” is a statistical question because one anticipates variability in students’ ages. 2. Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape. 3. Recognize that a measure of center for a numerical data set summarizes all of its values with a single number, while a measure of variation describes how its values vary with a single number. <u>Summarize and describe distributions.</u> 4. Display numerical data in plots on a number line, including dot plots, histograms, and box plots. 5. Summarize numerical data sets in relation to their context, such as by: a. Reporting the number of observations. b. Describing the nature of the attribute under investigation, including how it was measured and its units of measurement. c. Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered. Relating the choice of measures of center and variability to the shape of the data distribution and the context in which the data were gathered.
Resources:	http://www.fws.gov/northeast/marylandfisheries/reports/2009%20STG%20Coastal%20Report.pdf http://repository.lib.ncsu.edu/publications/bitstream/1840.2/1959/1/Laney...

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Data Representation Homework Assignment

Directions: In class today, you participated in a data representation scavenger hunt. You found many different ways that data can be displayed. Your task for homework tonight is to change the way that one of these data sets is displayed. You will bring home the original data representation that you cut out from your magazine, and you will use it to present the data in a new, appropriate way. For example, if you brought home a temperature map showing the temperature in different cities, you might take the same data and put it into a data table showing city name and temperature. Don't forget to add a title and labels to your new data representation!

Paste the original data representation that you cut out below. Then create your own data representation on a new piece of paper.

Table 3. Number of wild caught Atlantic sturgeon tagged and recaptured by region. (See regional descriptions in Table 2.)

Release Region	Total Number Marked	Recapture Region								
		Northeast	LIS	Hudson	Coast NJ-NY	Delaware Bay	Coast NC-DE	Chesapeake	Inland NC	Southeast
Northeast	117	1	-	-	-	-	-	-	-	-
LIS	884	2	25	1	2	1	2	2	-	-
Hudson	1,887	1	13	70	23	2	5	6	-	-
Coast NJ-NY	926	3	8	1	25	4	9	2	-	-
Delaware Bay	2,024	1	10	1	16	179	18	2	-	-
Coast NC-DE	455	-	1	1	2	3	10	5	-	2
Chesapeake	2,426	-	2	-	9	7	20	217	4	-
Inland NC	613	-	-	-	-	-	1	3	75	-
Southeast	364	-	1	-	1	1	3	-	1	53

Table 4. Number of hatchery reared Atlantic sturgeon tagged and recaptured by region. (See regional descriptions in Table 2.)

Region	Number Marked	Northeast	LIS	Hudson	Coast NJ-NY	Delaware Bay	Coast NC-DE	Chesapeake	Inland NC	Southeast
Hudson	5,210	-	12	208	2	10	2	17	1	-
Chesapeake	3,200	-	1	-	4	1	12	558	1	-

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Reading "Table 3. Number of wild caught Atlantic sturgeon tagged and recaptured by region"

1. In which region were the most sturgeon tagged and released, and how many were tagged and released there?

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2. In which region were the fewest sturgeon recaptured and how many were recaptured there?

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3. How many sturgeon were recaptured in the Chesapeake?

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4. How many sturgeon that were tagged and released in the Chesapeake were also recaptured in the Chesapeake?

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5. Sturgeon that were released in Inland North Carolina were recaptured in which regions? Why do you think there were none from Inland North Carolina recaptured in the Northeast?

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6. Overall, do you think that tagged sturgeon are more likely to be recaptured in the same region that they were released in, or do you think they are more likely to be recaptured in a different region than the one in which they were released? Why do you think this?

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Name: ____________________________

Date: _____________________________

Reading "Table 3. Number of wild caught Atlantic sturgeon tagged and recaptured by region" Answer Key

1. In which region were the most sturgeon tagged and released and how many were tagged and released there?

The most sturgeon were tagged and released in the Chesapeake and 2,426 sturgeon were released there.

2. In which region were the fewest sturgeon recaptured and how many were recaptured there?

The fewest sturgeon were recaptured in the Northeast. Eight sturgeon were recaptured there.

3. How many sturgeon were recaptured in the Chesapeake?

237 sturgeon were recaptured in the Chesapeake.

4. How many sturgeon that were tagged and released in the Chesapeake were also recaptured in the Chesapeake?

217 sturgeon that were tagged and released in the Chesapeake were also recaptured there.

5. Sturgeon that were released in Inland North Carolina were recaptured in which regions? Why do you think there were none from Inland North Carolina recaptured in the Northeast?

Sturgeon released in Inland North Carolina were recaptured in Inland North Carolina, the Chesapeake, and Coast NC-DE. None were recaptured in the Northeast, probably because it is so far from North Carolina.

6. Overall, do you think that tagged sturgeon are more likely to be recaptured in the same region that they were released in, or do you think they are more likely to be recaptured in a different region than the one in which they were released? Why do you think this?

Overall, sturgeon were more likely to be recaptured in the same region as the one in which they were released. For every release region, the majority of recaptured sturgeons were found in their original release regions.

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Reading "Table 4. Number of hatchery reared Atlantic sturgeon tagged and recaptured by region."

1. Were more sturgeon reared and tagged in the Hudson or in the Chesapeake?

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2. How many sturgeon reared and tagged in the Chesapeake were recaptured in Delaware Bay?

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3. How many sturgeon reared and tagged in the Hudson were recaptured in the Chesapeake?

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4. Of all of the sturgeon reared and tagged in the Hudson, how many were recaptured?

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5. Of all of the sturgeon reared and tagged in the Hudson, how many were not recaptured?

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6. Why do you think that sturgeon reared and tagged in the Hudson and the Chesapeake were not found in the Northeast or the Southeast?

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7. If you were asked to generalize overall where hatchery reared sturgeon are most likely to be found, what would you say?

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Date: _______________________________

Reading "Table 4. Number of hatchery reared Atlantic sturgeon tagged and recaptured by region." Answer Key

1. Were more sturgeon reared and tagged in the Hudson or in the Chesapeake?

More sturgeon were reared and tagged in the Hudson.

2. How many sturgeon reared and tagged in the Chesapeake were recaptured in Delaware Bay?

One sturgeon reared and tagged in the Chesapeake was recaptured in Delaware Bay.

3. How many sturgeon reared and tagged in the Hudson were recaptured in the Chesapeake?

17 sturgeon reared and tagged in the Hudson were recaptured in the Chesapeake.

4. Of all of the sturgeon reared and tagged in the Hudson, how many were recaptured?

Of all of the sturgeon reared and tagged in the Hudson, 252 were recaptured.

5. Of all of the sturgeon reared and tagged in the Hudson, how many were not recaptured?

Of all of the sturgeon reared and tagged in the Hudson, 4,958 were not recaptured.

6. Why do you think that sturgeon reared and tagged in the Hudson and the Chesapeake were not found in the Northeast or the Southeast?

Sturgeon reared and tagged in the Hudson and Chesapeake were probably not found in the Northeast or Southeast because those regions are furthest away, and sturgeon usually return to spawn in the same rivers in which they hatched.

7. If you were asked to generalize overall where hatchery reared sturgeon are most likely to be found, what would you say?

Hatchery reared sturgeon are most likely to be found in the same regions in which they were released, but overall they are not likely to be recaptured at all.

Table 5. Gear types reported by fishermen who captured a tagged Atlantic and shortnose sturgeon.

Gear	Number of Reports	Percent of Reports
Anchored Gillnet	183	52%
Drift Gillnet	54	15%
Gillnet	38	11%
Fyke Net	2	<1%
Haul Seine	2	<1%
Hook & Line	16	5%
Pound Net	23	7%
Trawl	30	9%

Table 6. Target species reported by fishermen who captured a tagged Atlantic and shortnose sturgeon.

Target Species	Number of Reports	Percent of Reports
Baitfish	4	2%
Bluefish	6	2%
Catfish	2	1%
Croaker	4	2%
Dogfish	15	6%
Flounder	40	16%
Horseshoe Crab	3	1%
Menhaden	5	2%
Monkfish	7	3%
Mullett	5	2%
Sand Shark	1	<1%
Seabass	1	<1%
Seatrout	4	2%
Shad	22	9%
Shad and Trout	1	<1%
Skate	2	1%
Spot	2	1%
Squid	2	1%
Striped Bass	95	38%
Sturgeon	13	5%
Various	4	2%
Weakfish	6	2%
White Perch	7	3%

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Redisplaying Data from:
"Table 5. Gear types reported by fishermen who captured a tagged Atlantic and shortnose sturgeon."

Directions: Attached you will find a copy of Table 5, which shows the gear types in which Atlantic and shortnose sturgeon are often caught. Recall the homework assignment from earlier in this unit, during which you took one form of data representation found during your data scavenger hunt, and redisplayed it in another way. We discussed as a class how some ways of displaying data were more appropriate than others. Using what you learned from this discussion, find a way to appropriately redisplay the data presented in Table 5. For a list of forms of data representation, refer to the chart that we made together in class.

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Table 5 Writing Prompt

Directions: Review the data displayed in "Table 5. Gear types reported by fishermen who captured a tagged Atlantic and shortnose sturgeon." Using what you learn from reviewing this data, please write a well-developed paragraph to address this writing prompt:

What does this data tell us and what might it be used for? Why is it important?

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Name: ______________________________

Date: _______________________________

Scoring Guide for Math “Table 5” Writing Prompt

SCORE	DESCRIPTION
4	The response demonstrates a thorough understanding of the data set through describing overall data patterns in context, and through summarizing relevant uses for this data.
3	The response demonstrates a general understanding of the data set through describing overall data patterns in context, and through summarizing relevant uses for this data.
2	The response demonstrates a limited understanding of the data set through describing overall data patterns in context, and through summarizing relevant uses for this data.
1	The response demonstrates a minimal understanding of the data set through describing overall data patterns in context, and through summarizing relevant uses for this data.
0	The response is incorrect or contains some work that is irrelevant to the skills or concept being measured.

Name: ______________________________

Date: _______________________________

Mean, Median, Mode, and Range Practice #1

Directions: Below are several fictional data sets showing lengths of sturgeon caught in a fictional study. Please refer to the data sets below to solve the following problems:

Sturgeon Length in Feet - Data Set A

5, 9, 10, 6, 1, 7, 1, 8, 9, 14, 12, 11, 1, 11, 10

Sturgeon Length in Feet - Data Set B

1, 2, 1, 7, 7, 1, 9, 10, 7, 12, 9, 11, 8, 8, 7

Sturgeon Length in Feet - Data Set C

10, 10, 10, 9, 11, 10, 8, 8, 7, 12, 13, 9, 9, 10, 8

1. For each data set above, rewrite each in numerical order starting with the smallest number and going from there. Once they are rewritten, record the range of each data set below.

Data Set A: **Data Set B:** **Data Set C:**

2. Find the median of each data set.

Data Set A: **Data Set B:** **Data Set C:**

3. Find the mode of each data set.

Data Set A: **Data Set B:** **Data Set C:**

4. Find the mean of each data set.

Data Set A: **Data Set B:** **Data Set C:**

5. A scientist is designing a sampling device that would be limited by a sturgeon's size. If she designs it too small or too large, it will be ineffective. If she were working with Data Set B, which measure of center would be most useful to her and why?

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6. Another scientist is designing a sampling device that will be effective regardless of a sturgeon's size, but needs to be able to hold the sturgeons on a tray during sampling. If she wants to be sure to design the tray to accommodate all sizes, which measure of center or spread would be most useful to her and why?

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7. Create your own scenario in which the mean would be the most useful measure of data to know.

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Name: ______________________________

Date: _______________________________

Mean, Median, Mode, and Range Practice #1 Answer Key

Directions: Below are several fictional data sets showing lengths of sturgeon caught in a fictional study. Please refer to the data sets below to solve the following problems:

Sturgeon Length in Feet - Data Set A

5, 9, 10, 6, 1, 7, 1, 8, 9, 14, 12, 11, 1, 11, 10 *1, 1, 1, 5, 6, 7, 8, 9, 9, 10, 10, 11, 11, 12, 14*

Sturgeon Length in Feet - Data Set B

1, 2, 1, 7, 7, 1, 9, 10, 7, 12, 9, 11, 8, 8, 7 *1, 1, 1, 2, 7, 7, 7, 7, 8, 8, 9, 9, 10, 11, 12*

Sturgeon Length in Feet - Data Set C

10, 10, 10, 9, 11, 10, 8, 8, 7, 12, 13, 9, 9, 10, 8 *7, 8, 8, 8, 9, 9, 9, 10, 10, 10, 10, 10, 11, 12, 13*

1. For each data set above, rewrite each in numerical order starting with the smallest number and going from there. Once they are rewritten, record the range of each data set below.

Data Set A: *14-1=**13*** **Data Set B:** *12-1=**11*** **Data Set C:** *13-7=**6***

2. Find the median of each data set.

Data Set A: ***9*** **Data Set B:** ***7*** **Data Set C:** ***10***

3. Find the mode of each data set.

Data Set A: ***1*** **Data Set B:** ***7*** **Data Set C:** ***10***

4. Find the mean of each data set.

Data Set A: ***7.67*** **Data Set B:** ***6.67*** **Data Set C:** ***9.6***

5. A scientist is designing a sampling device that would be limited by a sturgeon's size. If she designs it too small or too large, it will be ineffective. If she were working with Data Set A, which measure of center would be most useful to her and why?

For Data Set A, the median would be most useful to this scientist. The mode of this data set is very low (1) and the mean (7.53) is affected by the cluster of sturgeons measuring only one foot. The median, though, is a good measure of center for this data set because it is not affected by the number of extreme outliers measuring only one foot.

6. Another scientist is designing a sampling device that will be effective regardless of a sturgeon's size, but needs to be able to hold the sturgeons on a tray during sampling. If she wants to be sure to design the tray to accommodate all sizes, which measure of center or spread would be most useful to her and why?

This scientist will need to use the range of the data. Knowing the mean or median might be helpful, but if the goal is to accommodate all sturgeons in the data set, the scientist will need to know a measure of spread, not center. Therefore the range is most important to her.

7. Create your own scenario in which the mean would be the most useful measure of data to know.

Answers will vary.

Name: ____________________________

Date: _____________________________

Mean, Median, Mode, and Range Practice #2

Directions: Below are several fictional data sets showing weights of sturgeon caught in a fictional study. Please refer to the data sets below to solve the following problems:

Data Set A: Sturgeon Weight in Pounds

58, 72, 49, 106, 109, 73, 109, 116, 207, 47, 263, 41, 159, 133, 168

Data Set B: Sturgeon Weight in Pounds

247, 19, 59, 134, 89, 83, 236, 31, 34, 57, 124, 235, 42, 238, 124

Data Set C: Sturgeon Weight in Pounds

92, 238, 109, 29, 47, 80, 179, 186, 278, 238, 82, 68, 65, 98, 56

1. For each data set above, rewrite each in numerical order starting with the smallest number and going from there. Once they are rewritten, record the range of each data set below.

Data Set A: **Data Set B:** **Data Set C:**

2. Find the median of each data set.

Data Set A: **Data Set B:** **Data Set C:**

3. Find the mode of each data set.

Data Set A: **Data Set B:** **Data Set C:**

4. Find the mean of each data set.

Data Set A: **Data Set B:** **Data Set C:**

5. Describe a scenario in which the mode of one of these data sets would be the most useful measure of data to know.

6. Describe a scenario in which the range of one of these data sets would be the most useful measure of data to know.

7. Describe a scenario in which the mean of one of these data sets would be the most useful measure of data to know.

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Mean, Median, Mode, and Range Practice #2 Answer Key

Directions: Below are several fictional data sets showing weights of sturgeons caught in a fictional study. Please refer to the data sets below to solve the following problems:

Sturgeon Weight in Pounds - Data Set A

58, 72, 49, 106, 109, 73, 109, 116, 207, 47, 263, 41, 159, 133, 168
41, 47, 49, 58, 72, 73, 106, 109, 109, 116, 133, 159, 168, 207, 263

Sturgeon Weight in Pounds - Data Set B

247, 19, 59, 134, 89, 83, 236, 31, 34, 57, 124, 235, 42, 238, 124
19, 31, 34, 42, 57, 59, 83, 89, 124, 124, 134, 235, 236, 238, 247

Sturgeon Weight in Pounds - Data Set C

92, 238, 109, 29, 47, 80, 179, 186, 278, 238, 82, 68, 65, 98, 56
29, 47, 56, 65, 68, 80, 82, 92, 98, 109, 179, 186, 238, 238, 278

1. For each data set above, rewrite each in numerical order starting with the smallest number and going from there. Once they are rewritten, record the range of each data set below.

Data Set A: ***263-41 = 222*** **Data Set B:** ***247-19 = 228*** **Data Set C:** ***278-29 = 249***

2. Find the median of each data set.

Data Set A: ***109*** **Data Set B:** ***89*** **Data Set C:** ***92***

3. Find the mode of each data set.

Data Set A: ***109*** **Data Set B:** ***124*** **Data Set C:** ***238***

4. Find the mean of each data set.

Data Set A: ***114*** **Data Set B:** ***116.8*** **Data Set C:** ***123***

5. Describe a scenario in which the mode of one of these data sets would be the most useful measure of data to know.

Answers will vary.

6. Describe a scenario in which the range of one of these data sets would be the most useful measure of data to know.

Answers will vary.

7. Describe a scenario in which the mean of one of these data sets would be the most useful measure of data to know.

Answers will vary.

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Distribution, Habitat Use, and Size of Atlantic Sturgeon Captured during Cooperative Winter Tagging Cruises, 1988–2006

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Abstract.—Declines in Atlantic sturgeon *Acipenser oxyrinchus* abundance in the early 1990s led the Atlantic States Marine Fisheries Commission (ASMFC) to prepare a mandatory fishery management plan. The principal management measures are fishery closure, bycatch assessment, and bycatch reduction in other ASMFC-managed fisheries (i.e., American shad *Alosa sapidissima*). To better understand Atlantic sturgeon geographic distribution and habitat use, as well as risk of bycatch, we examined offshore distribution of Atlantic sturgeon based on incidental captures in winter tagging cruises conducted off the coasts of Virginia and North Carolina, including in and near extensive sand shoals adjacent to Oregon Inlet and Cape Hatteras. From 1988 to 2006, 146 juvenile Atlantic sturgeon were captured by bottom trawling in depths from 9.1 to 21.3 m. Numbers of Atlantic sturgeon captured and tagged in a given year ranged from 0 (1993, 1995) to 29 (2006). Atlantic sturgeon were encountered in 4.2% of tows, with

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the percentage varying from 0 in 1993 and 1995 to 12.6% in 1988. Capture patterns suggested that Atlantic sturgeon were likely aggregating to some degree. Total lengths of captured Atlantic sturgeon ranged from 577 to 1,517 mm (mean of 967 mm), suggesting that most fish were juveniles. Limited tag returns and genetic data suggest that fish wintering off North Carolina constitute a mixed stock. Information about their distribution and habitat utilization should benefit fishery managers seeking to reduce bycatch and protect key habitats.

Introduction

The Atlantic sturgeon *Acipenser oxyrinchus* is a large, imperiled, anadromous species that spends a portion of its juvenile and adult life in marine waters off the East Coast of North America. Adults range from Hamilton Inlet, Labrador (Scott and Scott 1988) south to the St. Johns River in Florida (Vladykov and Greeley 1963; Van Den Avyle 1984; Gilbert 1989). After spawning, spent adults return gradually to the ocean (Bigelow and Schroeder 1953; Vladykov and Greeley 1963; Scott and Crossman 1973; Smith 1985a). Juveniles (441–1,429 mm fork length [FL]) are reported to spend from 2 to 6 years in freshwater or the tidal portions of rivers (Smith 1985b), particularly in the transition zone between fresh and saline waters, prior to migrating to the sea (Bigelow and Schroeder 1953; Vladykov and Greeley 1963; Van Den Avyle 1984; Gilbert 1989). Once in the ocean, juveniles undertake extensive excursions and may enter sounds and inlets other than those in which they were originally encountered (Holland and Yelverton 1973; Van Den Avyle 1984; Gilbert 1989).

Atlantic sturgeon are imperiled for multiple reasons and fisheries in the United States are currently closed (Atlantic Sturgeon Plan Development Team 1998; Atlantic Sturgeon Status Review Team 1998; Collins et al. 2000). Depletion of Colonial era stocks was initially due to intensive commercial fisheries that targeted mature females for caviar (Hildebrand and Schroeder 1928). Further declines were likely due to dam construction reducing access to historic spawning habitats and to water quality degradation. Currently, bycatch in commercial fisheries and degraded water quality in estuarine nursery areas constitute major factors inhibiting restoration (Collins et al. 1996; Secor and Gunderson 1998; Secor and Niklitschek 2001; Stein et al. 2004b; Oakley and Hightower 2007, this volume).

Past reviews of Atlantic sturgeon literature have concluded that little was known regarding distribution of Atlantic sturgeon offshore along the East Coast (Rulifson et al. 1982; Van Den Avyle 1984; Gilbert 1989). However, several recent reports address the marine distribution of Atlantic sturgeon in this region and are beginning to portray the habitats they frequent while at sea (Collins and Smith 1997; Moser et al. 1998; Stein et al. 2004b). Collins and Smith (1997) reported Atlantic sturgeon from the Atlantic Ocean off South Carolina in months of low water temperatures (November–April) from nearshore to well offshore in depths up to 40 m. Moser et al. (1998) obtained sturgeon records from federal, private, and state surveys and documented use of nearshore Atlantic Ocean habitats from the North/South Carolina state line to off the mouth of Chesapeake Bay. Stein et al. (2004b) found peak Atlantic sturgeon captures along the coast in 10–50 m depths.

Incidental capture of Atlantic sturgeon during the course of fishery-independent sampling programs can yield important information about Atlantic sturgeon distribution, movements, and habitat use. Annual Cooperative Winter Tagging Cruises (hereafter Cruises) were initiated by the Atlantic States Marine Fisheries Commission in 1988 to capture and tag migratory striped bass *Morone saxatilis* off the coasts of Virginia and North Carolina. The annual Cruise was designed to capture, tag, and release fish and was not conducted in a systematic manner that surveyed the same habitats each year. Atlantic sturgeon were captured, documented, tagged, and released opportunistically when initially encountered on these Cruises, and subsequently (beginning 1992) were incorporated as part of a coastwide Atlantic sturgeon tagging effort (Eyler et al. 2004). The objective of this paper is to summarize the distribution and habitat characteristics of capture locations, sizes of fish encountered, and locations of fish recaptured.

Study Site

Cruises were generally conducted in the nearshore Atlantic Ocean from just north of Cape Lookout, North Carolina, to as far north as Cape Charles, Virginia, during mid-January to early February. Most of the habitat covered during sampling is within state waters, inside 5.6 km offshore. In some years, habitat outside 5.6 km, within the territorial sea boundary (located at 22.2 km, see Figure 1) or in the federal exclusive economic zone (EEZ; i.e., from 22.2 to 370.4 km offshore) was sampled. Some areas with known obstructions or hard bottom were not sampled in order to avoid gear damage or loss. Therefore, all habitat types within the study area were not sampled equally. Since striped bass is the primary species targeted by the Cruise, sampling effort targeted that species, and in some years, Virginia waters were not sampled because striped bass were abundant in North Carolina waters. In other years, limited ship time necessitated bypassing the southern portion of the study area, between Cape Lookout and Cape Hatteras, and proceeding di-

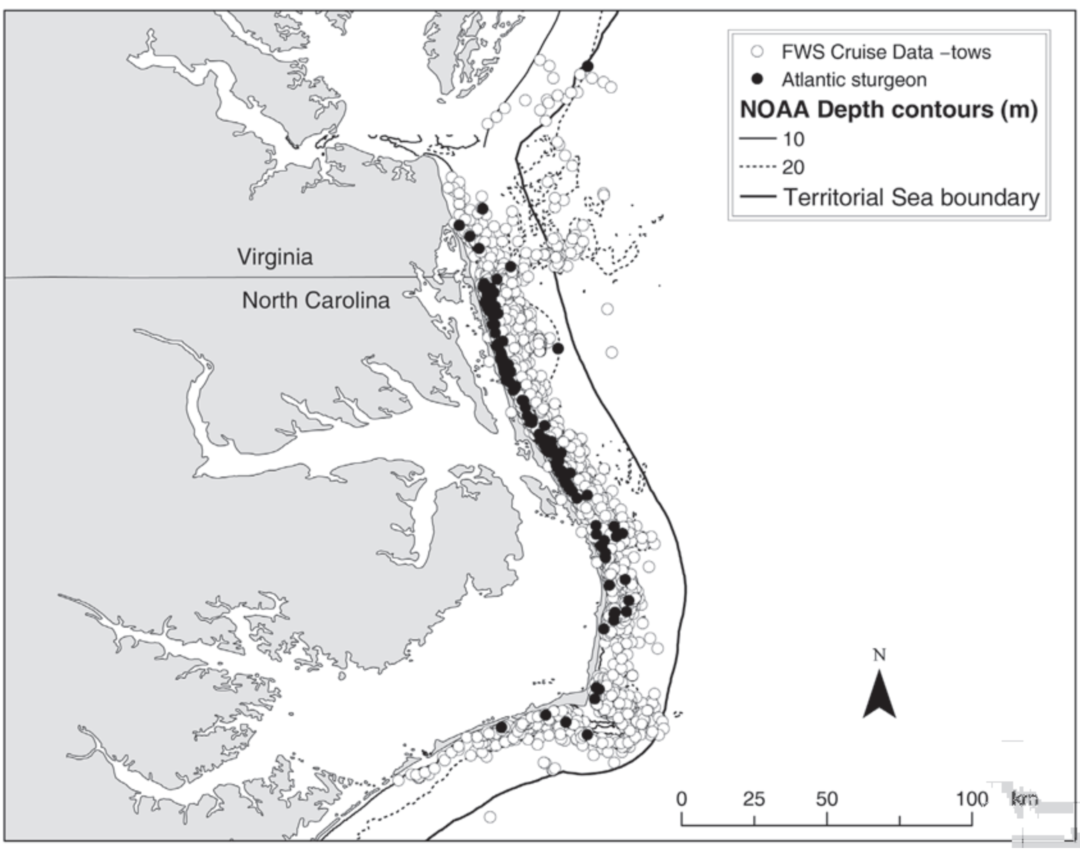

FIGURE 1. Distribution of all Cruise tows and Atlantic sturgeon captures relative to 10- and 20-m depth contours and territorial sea (22.2 km) boundary (Atlantic sturgeon captures solid circles; negative tows open circles).

rectly to the vicinity of Wimble Shoals. In such years, only the northern portion of the study site was sampled.

Methods

One National Science Foundation (NSF) and three National Oceanic and Atmospheric Administration (NOAA) research vessels were used for the Cruises. The *Albatross IV* (NOAA, 57 m), *Cape Hatteras* (NSF, 41.1 m), and *Chapman* (NOAA, 38.7 m) are stern trawlers that tow single nets. The *Oregon II* (NOAA, 51.8 m) is a side trawler towing paired nets. Bottom-tending otter trawls of several sizes and configurations were deployed from these vessels. In most years, National Marine Fisheries Service standard Gulf of Mexico 19.8-m headrope bottom survey trawls were employed, but in 2 years (1990, 1992) a 35.4-m headrope trawl was used on the stern trawlers. In 1993, a 27.4-m trawl was employed on the Chapman. Trawling operations on the *Albatross IV*, *Cape Hatteras*, and *Oregon II* were conducted continuously during each 24-h interval unless gear problems, weather conditions, or logistic necessity (changing general area of trawling, bringing aboard additional personnel, or picking up extra supplies) dictated a temporary cessation. Operations on the *Chapman* were confined to 16-h periods (0600–2200 hours daily). Maximum tow duration was 30 min, in order to reduce bycatch and maximize survival of target species. The majority of tows were of shorter duration, ranging from 5 to 20 min. Trawls generally were towed oblique or parallel to the shoreline within the depth range. Beginning and ending tow times and positions, and the ship's speed, were recorded for each tow.

Environmental variables associated with each tow were measured and recorded using various means through the years. Surface temperature (°C) was measured in all years using either mercury thermometers, shipboard conductivity, temperature and depth (CTD) recording equipment, or expendable bathythermographs. Ambient air temperature (°C) was recorded from each ship's bridge sensors. Depth at beginning and end of each haul was measured using each ship's echo-sounding gear. Surface salinity was measured to the nearest part per thousand (ppt) using either shipboard CTD gear (primary) or a refractometer (backup).

Nets were hauled back and catch emptied either on deck or directly into two 3,785.4-L holding tanks supplied with continuously running ambient seawater. Any Atlantic sturgeon captured was removed from the tank and measured (both FL and total length [TL]) to the nearest mm. Tissue (barbel or caudal fin clip) was removed and retained for genetic analysis. Pectoral fin spine sections were removed from some fish in some years for aging. Beginning in 1994, all fish encountered were scanned for the presence of coded wire tags and passive integrated transponder (PIT) tags, since Atlantic sturgeon juveniles implanted with these tag types had been released in the Hudson River (Peterson et al. 2000) and Chesapeake Bay (Welsh et al. 2002) in 1994 and 1996, respectively. All untagged Atlantic sturgeon were tagged prior to release with two T-bar tags (yellow Hallprint[2] TBA-2, T-bar, Holden Hill, Australia) implanted, one each at the base of the dorsal fin (left dorsolateral musculature) and base of the left pectoral fin. Larger individuals (greater than 700 mm) were also tagged anterodorsolaterally with a yellow double barb tag (FIM 96, Floy Tag & Mfg., Inc.[2]). An additional PIT tag (Biomark[2], 125 KHz; see Eyler et al. 2004) was implanted under the third dorsal scute in some years. Fish were released in the vicinity of the capture location. All external tags were imprinted with the toll-free telephone number and address of the U.S. Fish and Wildlife Service Maryland Fisheries Resources Office to encourage and facilitate reporting, with a reward provided for recapture information.

We used a variety of geographic information systems (GIS) data layers to examine the distribution of capture locations and the relationship of captured fish to depth and substrate. Layers denoting the territorial sea boundary

[2] Reference to trade names or manufacturers does not imply government endorsement of commercial products.

(22.2-km limit) for the southeastern United States and 10-m depth contours were obtained from the NOAA Coastal Services Center (http://www.csc.noaa.gov/opis/html/data.htm). The Continental Margin Mapping Project (CONMAP) layer provided a 1:1,000,000 scale overview of marine surficial sediments (Poppe and Polloni 2000). Finer-scale information was obtained by plotting individual points where sediment sampling was done off the North Carolina coast (Poppe and Polloni 2000).

Results

During the months of January and February from 1988 through 2006, 146 Atlantic sturgeon were captured in 2,819 tows (Table 1). Annual effort, as reflected by the number of completed tows and area swept, varied widely among years. The number of Atlantic sturgeon captured in an individual year varied from 0 to 29 (Table 1). Dates sampled varied among years, and Atlantic sturgeon were captured at low rates throughout the sampled periods (Table 2). Surface water temperature at Atlantic sturgeon capture locations averaged 6.7°C (SE = 0.21); surface salinity averaged 31.5 ppt (SE = 0.23).

The capture of Atlantic sturgeon during Cruises was a relatively uncommon event (Table 3). Atlantic sturgeon were encountered in 4.2% of all processed tows in the time series, with the annual percentage varying from 0 in 1993 and 1995 to 12.6% in 1988. When Atlantic sturgeon were captured during Cruises, they most often were present in tows as single individu-

TABLE 1. Year, sampling dates, research vessel, number of nets towed and headrope width, estimated area swept (km^2), completed tows, total Atlantic sturgeon captures, and catch per unit effort (CPUE; number/1,000 km^2) for Cooperative Winter Tagging Cruises, 1988–2006.

Year	Dates	Vessel	Net(s)	Area	Tows	Sturgeon	CPUE
1988	January 15–22	Oregon II	2 @ 19.9 m	17,168.4	167	21	1.3
1989	January 16–22	Oregon II	2 @ 19.9 m	15,380.2	175	2	0.1
1990	January 17–24	Chapman	1 @ 35.5 m	6,132.7	77	11	1.8
1991	January 24–31	Oregon II	2 @ 19.9 m	18,181.5	162	3	0.2
1992	January 18–19 February 3–5	Albatross IV	1 @ 35.5 m	6,138.3	53	6	1.0
1993	February 2–8	Chapman	1 @ 19.9 m	3,909.9	55	0	0.0
1994	January 22–25	Oregon II	2 @ 19.9 m	7,888.7	96	6	0.8
1995	January 24–28	Chapman	1 @ 19.9 m	2,692.9	57	0	0.0
1996	January 23–25 February 6–12	Oregon II	2 @ 19.9 m	15,024.7	204	15	1.0
1997	February 1–7	Oregon II	2 @ 19.9 m	13,267.2	131	5	0.4
1998	January 16–23	Chapman	1 @ 19.9 m	2,489.2	64	1	0.4
1999	January 31– February 9	Oregon II	2 @ 19.9 m	8,345.7	146	2	0.2
2000	January 28– February 4	Oregon II	2 @ 19.9 m	11,540.1	141	8	0.7
2001	January 14–19	Oregon II	2 @ 19.9 m	9,193.2	163	4	0.4
2002	January 14–21	Oregon II	2 @ 19.9 m	12,170.0	212	23	1.9
2003	January 14–22	Oregon II	2 @ 19.9 m	17,774.1	227	8	0.5
2004	January 16–24	Cape Hatteras	1 @ 19.9 m	12,307.2	250	1	0.1
2005	January 25– February 2	Oregon II	1 @ 19.9 m	8,119.9	146	1	0.1
2006	January 19–28	Oregon II	2 @ 19.9 m	19,831.5	293	29	1.7
Totals				273,271.0	2,819	146	

TABLE 2. Atlantic sturgeon captures by date (total in 24-h period) during Cooperative Winter Tagging Cruises, 1988–2006.

Date	January																		February											
Year	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12
1988		2	0	2	4	6	5	2	0																					
1989			0	0	0	1	1	0	0																					
1990				0	0	5	1	4	0	1	0																			
1991											1	0	0	0	1	0	0	1												
1992					0	0															0	4	2							
1993																				0	0	0	0	0	0	0				
1994									3	2	0	1																		
1995												0	0	0	0															
1996										0	5	6													0	0	3	1	0	0
1997																				0	1	1	0	3						
1998			0	0	0	1	0	0	0																					
1999																					0	1	0	0	1	0				
2000																1	0	0	2	5	0	0								
2001	0	1	1	2	0	0																								
2002	0	1	6	3	7	0	4	2																						
2003	0	1	2	2	1	1	1	0																						
2004			0	0	0	0	0	0	0	0	1																			
2005												0	0	0	0	0	0	0	0	0	1									
2006						0	5	0	16	7	1	0	0	0	0															

TABLE 3. Distribution of Atlantic sturgeon catches in individual tows and frequency (percent) with which sturgeon appeared in consecutive or trios of tows, by year, 1988–2006.

		Atlantic sturgeon catch in individual tows				
		0	1	2	3	
Year	Vessel	Tows (no. consecutive or trio tows with catch)-%				Total tows
1988	Oregon II	146–87.4	21(4)–12.6	0–0	0–0	167
1989	Oregon II	173–98.9	2(0)–1.1	0–0	0–0	175
1990	Chapman	68–88.3	7(4)–9.1	2(1)–2.6	0–0	77
1991	Oregon II	159–98.1	3(0)–1.9	0–0	0–0	162
1992	Albatross IV	50–94.3	1(0)–1.9	1(0)–1.9	1(0)–1.9	53
1993	Chapman	55–100	0–0	0–0	0–0	55
1994	Oregon II	90–93.8	6(2)–6.3	0–0	0–0	96
1995	Chapman	57–100	0–0	0–0	0–0	57
1996	Oregon II	191–93.6	11(6)–5.4	2(0)–1.0	0–0	204
1997	Oregon II	126–96.2	5(0)–3.8	0–0	0–0	131
1998	Chapman	63–98.4	1(0)–1.6	0–0	0–0	64
1999	Oregon II	144–98.6	2(0)–1.4	0–0	0–0	146
2000	Oregon II	135–95.7	4(1)–2.8	2(1)–1.4	0–0	141
2001	Oregon II	159–97.5	4(1)–2.5	0–0	0–0	163
2002	Oregon II	195–92.0	12(3)–5.7	4(0)–1.9	1(0)–0.5	212
2003	Oregon II	219–96.5	8(0)–3.5	0–0	0–0	227
2004	Cape Hatteras	249–99.6	1(0)–0.4	0–0	0–0	250
2005	Oregon II	145–99.3	1(0)–0.7	0–0	0–0	146
2006[a]	Oregon II	276–94.2	10(4)–3.4	5(1)–1.7	1(1)–0.3	293
	Totals	2,700–95.8	99(25)–3.5	16(3)–0.6	3(0)–0.1	2,819

[a] One tow in 2006, not shown in the table since it was a one-time event, had six sturgeon.

als (Table 3). However, on 16 occasions, pairs of Atlantic sturgeon were captured; on 3 occasions, 3 were captured; and on 1 occasion (2006), 6 were captured in the same tow. Two or more individuals were present in 16.8% of tows containing sturgeon. There were also multiple instances in some years where consecutive tows, or tows separated by an intervening tow with no sturgeon present, caught Atlantic sturgeon. In those years (1988, 1990, 1994, 1996, 2000, 2001, 2002 and 2006), consecutive captures (within pairs or trios of tows) occurred 31.2% of the time, and Atlantic sturgeon were clearly more geographically closely associated with each other (Table 3).

The geographic distribution of Atlantic sturgeon captured was nearly continuous from Cape Henry, Virginia, on the southern side of the Chesapeake Bay entrance, to Hatteras Inlet, North Carolina (Figure 1). Relatively few tows were made on the north side of the Chesapeake Bay entrance off Cape Charles, but one Atlantic sturgeon was captured. That individual was also the only one not captured in state or territorial waters, although relatively few tows (56) were made in the EEZ (Figure 1).

Atlantic sturgeon captures typically occurred near shore at depths less than 18 m (Figures 1–2). Analysis of the depth of tows in which Atlantic sturgeon were captured, versus tows in which they were absent, indicated that the depth distributions were significantly different (Chi-square test, $P < 0.001$). Atlantic sturgeon were encountered more frequently than expected (based on the distribution of trawling effort) at depths up through 14 m (Figure 2).

Based on a GIS data layer produced for the Continental Margin Mapping Project, cap-

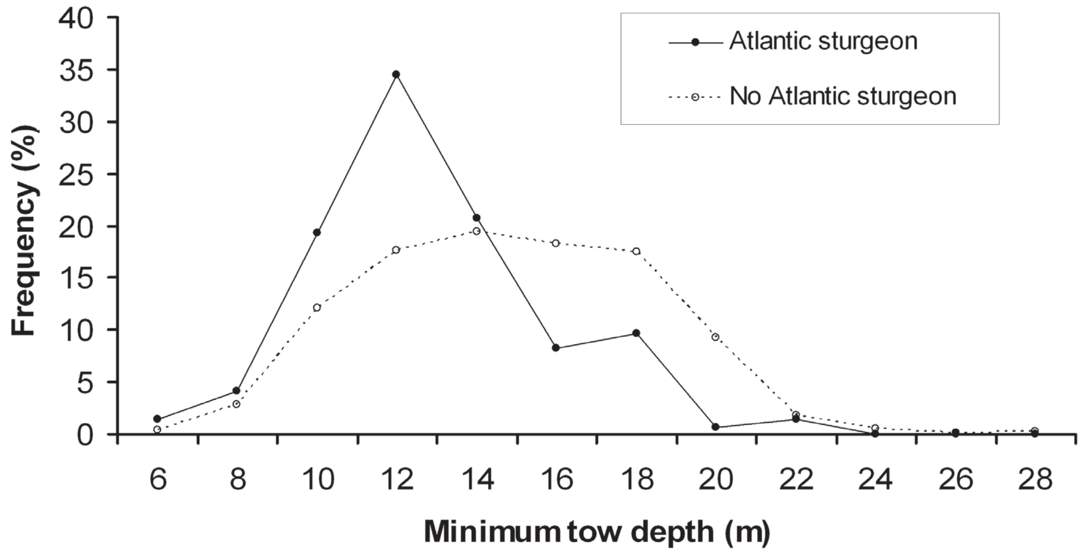

FIGURE 2. Depth distribution for tows with and without Atlantic sturgeon.

tures of Atlantic sturgeon occurred consistently over sand substrates (Figure 3). However, that GIS layer provides only a broad overview of sediment patterns and is not intended to depict small-scale sediment distribution (Poppe and Polloni 2000). Very little substrate sampling has been done in the nearshore region where Atlantic sturgeon tended to occur. Sediment sampling done at specific locations along the North Carolina coast indicates that gravel substrates (particles with nominal diameters greater than 2 mm) consistently occur near (but further offshore) the area where Atlantic sturgeon were typically encountered (Figure 3, inset).

Total length of captured Atlantic sturgeon (Table 4; Figure 4) averaged 967 mm and ranged from 577 to 1,517 mm (FL average 830 mm, range 492–1,350 mm). There was a significant linear trend ($P < 0.0001$) of increasing size of Atlantic sturgeon encountered through the years (Figure 5). There was also a significant trend of decreasing size with increasing latitude ($P = 0.002$; Figure 6), although the relationship is confounded by the year-to-year differences in the range of latitudes sampled.

During the course of the 19 years, one previously tagged Atlantic sturgeon was captured. The fish was tagged by the Delaware Division of Marine Fisheries in July 1993 at km 81 in the lower Delaware River and recaptured off North Carolina in January 1994. Three Atlantic sturgeon tagged during the Cruises were recaptured in other sampling. One was tagged off North Carolina in January 1996 and recaptured in November 1996 off New York; encountered in the Atlantic Ocean at Fire Island Inlet, New York in June 1997; and encountered a third time in the Hudson River at km 78.7 in July 1998. The second fish was tagged off the North Carolina coast in February 2000 and recaptured in February 2000 off Coles Point in the Potomac River, Virginia, 26 d later. The final fish was tagged in January 2003, off North Carolina, and recaptured in March 2004, in the Atlantic Ocean near Hatteras Village.

Discussion

The Cooperative Winter Tagging Cruises provide useful information about Atlantic sturgeon status and distribution, even though the Cruises were intended to tag target numbers of fish rather than to conduct a systematic survey of the study area. Sampling periods were constrained by the schedules of research vessels

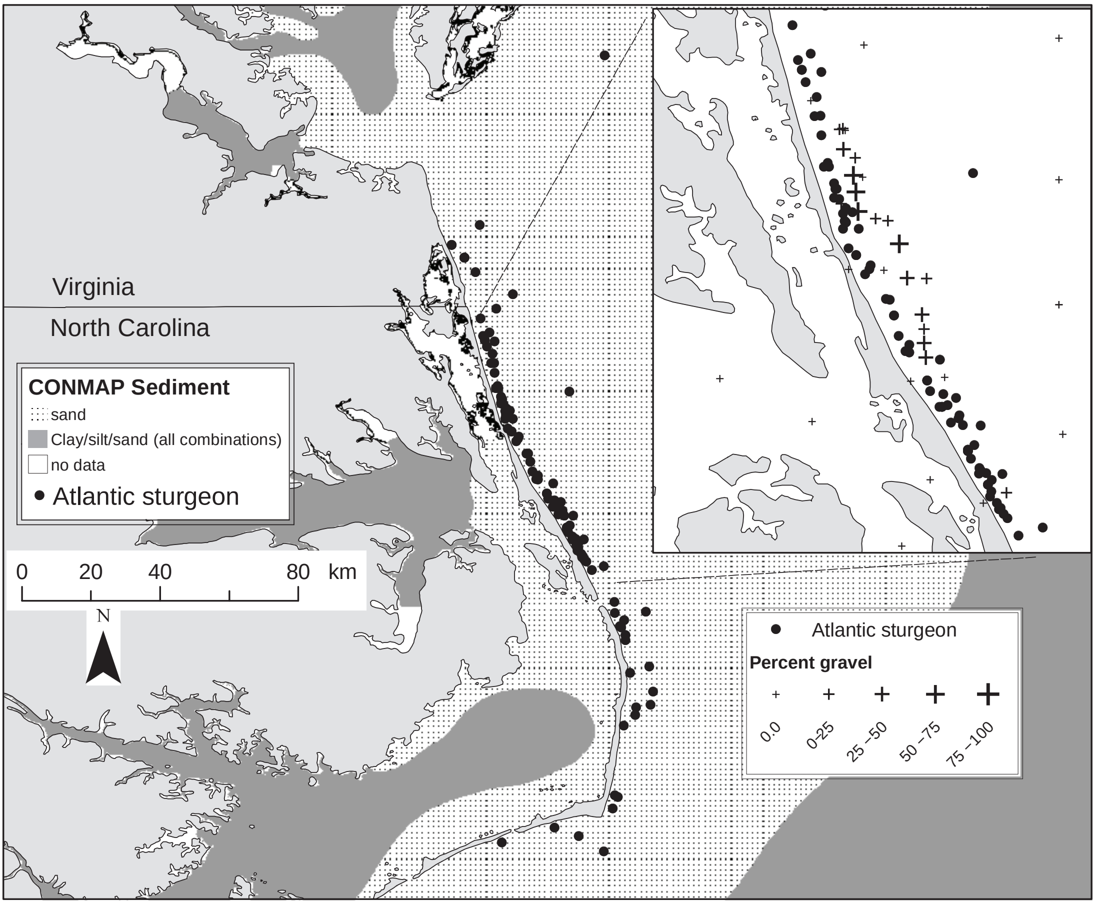

FIGURE 3. Distribution of all Atlantic sturgeon captures plotted over substrate type based on the Continental Margin Mapping Project. Inset illustrates the primary area of Atlantic sturgeon capture locations (north of Oregon Inlet) and percent gravel at sediment sampling sites (Poppe and Polloni 2000).

being used for other sampling programs. Sampling effort also was adversely affected by the occasional need to cease operations for ship repairs and adverse weather conditions.

Results from the Cooperative Winter Tagging Cruises indicate that shallow nearshore waters off North Carolina are an important winter habitat for Atlantic sturgeon, reinforcing prior studies. Holland and Yelverton (1973) were the first investigators to capture, tag, and release Atlantic sturgeon in this area. During November 1968 to February 1969, they reported capturing Atlantic sturgeon north of Cape Hatteras, fairly evenly distributed along the beach at depths ranging from 0 to 18.3 m. From 1969 to 1971, most Atlantic sturgeon were caught between Cape Lookout and the North Carolina/Virginia border (Holland and Yelverton 1973). In 1978, five Atlantic sturgeon were captured during February, all within 1.6 km of the beach in depths of 7.2–12.6 m (Johnson et al. 1978). Stein et al. (2004b) found that Atlantic sturgeon from New England through Cape Hatteras occurred in shallow inshore areas of the continental shelf, mainly in depths less than 60 m. Captures off North Carolina occurred primarily inside the 25 m isobath and were associated with inlets. Off New York,

TABLE 4. Number of sturgeon, range and mean of total length by year for Cooperative Winter Tagging Cruises, 1988–2006.

Year	*N*	Range (mm TL)	Mean (mm TL)
1988	21	577–1,068	794
1989	2	1,086–1,118	1,102
1990	11	675–1,046	881
1991	3	721–990	887
1992	6	782–1,120	909
1993	0		
1994	6	695–1,142	945
1995	0		
1996	15[a]	752–1,200	884
1997	5	1,073–1,502	1,300
1998	1	1,062	1,062
1999	2	895–968	932
2000	8	862–1,028	943
2001	4	910–1,115	1,007
2002	23[b]	802–1,517	1,159
2003	8	932–1,474	1,096
2004	1	1,191	1,191
2005	1	950	950
2006	29	684–1,451	940
All years	146	577–1,517	967

[a] One individual's caudal fin was injured; therefore range and mean are based on only 14 measurements.
[b] One individual was seen caught in the net, but was never retrieved and measured, due to circumstances beyond control of the Scientific Party; therefore mean and range are based on 22 measurements.

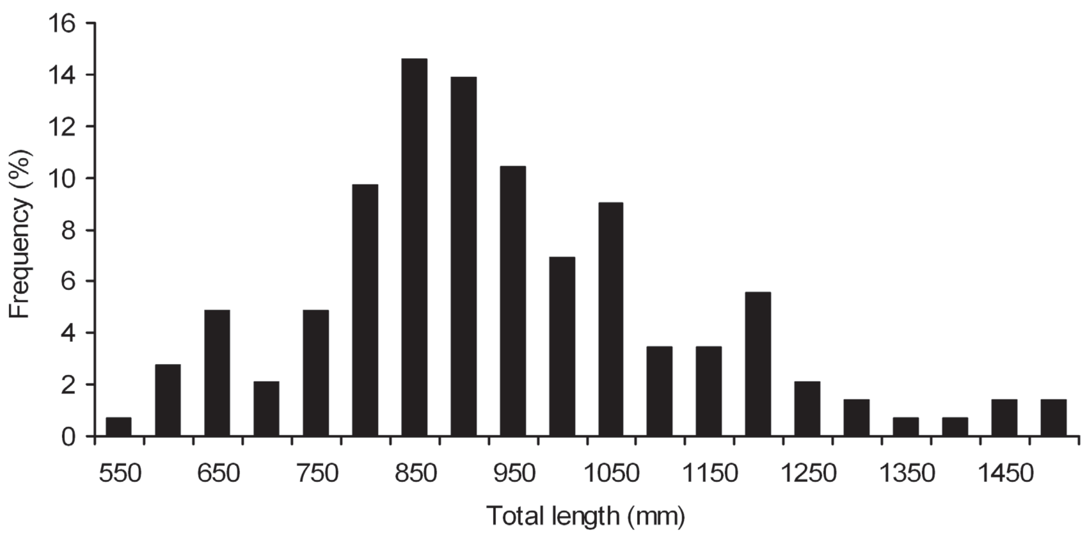

FIGURE 4. Frequency distribution for total length (mm) of Atlantic sturgeon captured during Cruises, 1988–2006.

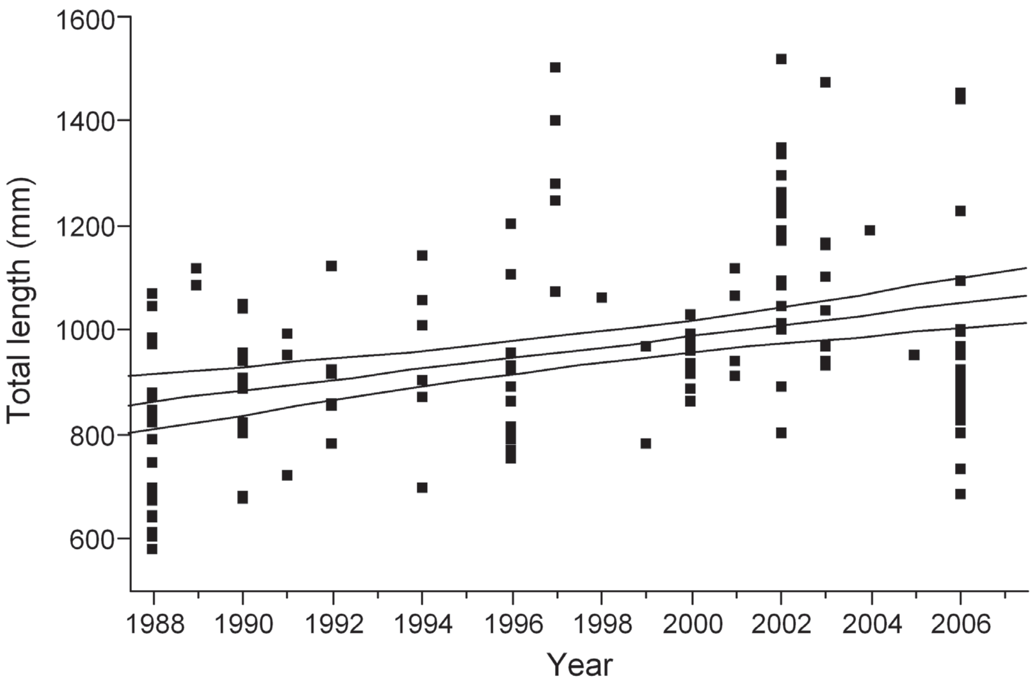

FIGURE 5. Total length (mm) of Atlantic sturgeon versus capture year (outer lines are 95% confidence intervals).

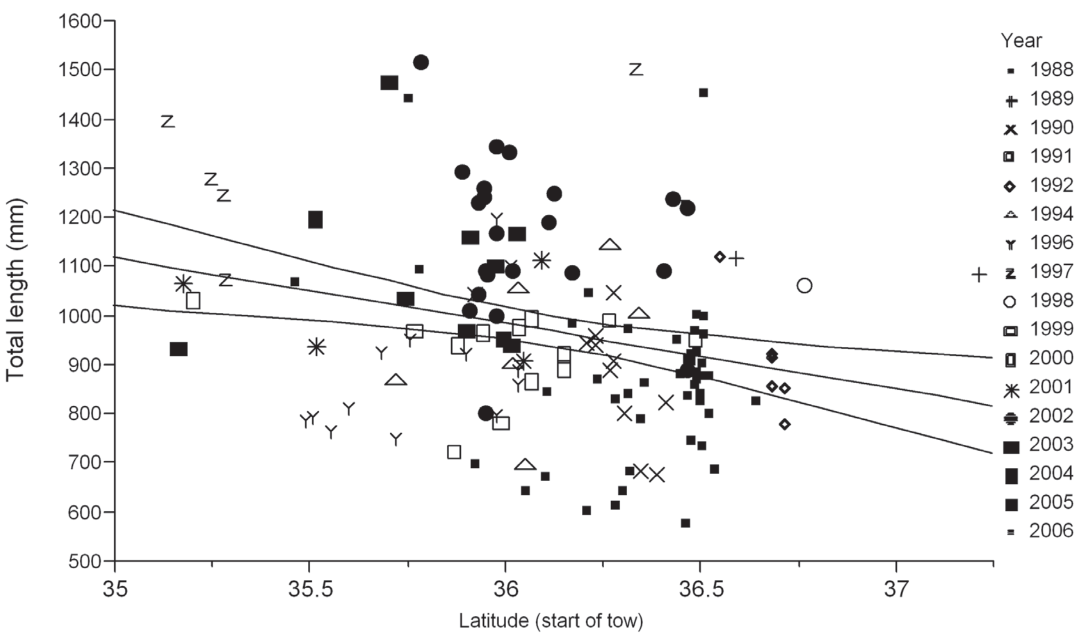

FIGURE 6. Total length (mm) of Atlantic sturgeon versus capture latitude (outer lines are 95% confidence intervals).

Timoshkin (1968) reported the capture of a single specimen in 110 m.

Use of relatively shallow, nearshore marine habitat appears to be a consistent feature of North American anadromous sturgeon life history. Other investigators working with Gulf sturgeon *Acipenser oxyrinchus desotoi* in the Gulf of Mexico and green sturgeon *Acipenser medirostris* on the Pacific coast have observed similar patterns of winter residence in nearshore marine habitats. Fox et al. (2002) found that some Gulf sturgeon moved from the Choctawhatchee River system into the Gulf of Mexico during winter. Telemetered fish were relocated close to shore (0.8–2.0 km) in shallow water (mean = 8.0 m). Edwards et al. (2007, this volume) confirmed that adult Gulf sturgeon emigrate from coastal river systems to shallow, nearshore marine environments during October–November and return to natal rivers in March–April. All movements and habitats documented were coastal, nearshore, and shallow, with postulated movements to deeper offshore habitats documented to date by a single capture (Timoshkin 1968). Erickson and Hightower (2007, this volume) used pop-off archival tags and commercial trawl logbook data to establish that green sturgeon typically winter in nearshore marine habitats in the northeast Pacific Ocean at depths less than 100 m.

Based on the pattern of encounters with Atlantic sturgeon during these tagging Cruises, there is some indication that these fish select habitats in the same general vicinity or may even school to some extent. Stein et al. (2004b) observed similar concentrations of Atlantic sturgeon captures off North Carolina and near Cape Hatteras. Captures in the tagging Cruises occurred over substrates similar to those reported by other investigators. Stein et al. (2004b) found Atlantic sturgeon occurring predominantly over sand substrates, as did Fox et al. (2002) for Gulf sturgeon. Another possible indication of Atlantic sturgeon association with sand substrates is that the stomachs of Atlantic sturgeon captured off New Jersey contained a high percentage (26.3–75.4% by weight) of sand and organic debris (Johnson et al. 1997). The authors noted such occurrence has been observed previously by others (Vladykov 1948; Smith 1985b) for Atlantic sturgeon and, while it may be incidental, may also be associated with some nutritional value (from detritus and associated microbes; Mason and Clugston 1993). More refined information about substrate distribution is needed, however, because point samples of sediments (Poppe and Polloni 2000) indicate that gravel is a substantial fraction of the sediments in areas near where a majority of Atlantic sturgeon were captured.

Based on the length-frequency of Atlantic sturgeon captured, a majority of individuals encountered in the tagging Cruises were juveniles. Smith (1985b) designated all Atlantic sturgeon between 441 and 1,429 mm FL as juveniles, and all but five (1,451, 1,474, 1,502, and two at 1,517 mm) Atlantic sturgeon captured on the Cruises lie within these limits. This could be a reflection of the age distribution of the population, in that the low abundance of adult Atlantic sturgeon prompted the coastwide fishery closure. Ocean-caught Atlantic sturgeon reported in Collins and Smith (1997) ranged from 640 to 1,510 mm TL, and possibly included some adult fish. Atlantic sturgeon captured in the NOAA-Fisheries Northeast Fisheries Science Center (NEFSC) bottom trawl survey from 1972 to 1996 in waters from Canada to South Carolina ranged in size from 510 to 2,260 mm TL (Savoy and Pacileo 2003; NEFSC, unpublished data). The mean depth of capture for those fish was 17.3 m, with 40% of the fish being collected at 15 m and 13% at 13 m. Other authors reporting the capture of Atlantic sturgeon in the ocean did not include length information (Moser et al. 1998; Stein et al. 2004a, 2004b). The failure of the Cruises to encounter adult Atlantic sturgeon might also be a function of gear selectivity, with adults better able to avoid trawls. Subadult Atlantic sturgeon captured in the Connecticut River and Long Island Sound exhibited size ranges somewhat smaller (Connecticut River, FL range 508–1,070 mm; mean 774) and larger (Long Island Sound, FL range 625–1,910 mm; mean 1,049) than fish captured during the Cruises

(Savoy and Pacileo 2003). Juvenile sturgeon captured by gill netting in more inland waters of Albemarle Sound in North Carolina were smaller, ranging from 400 to 500 mm FL (Armstrong and Hightower 2002), typical of age 1 fish. Atlantic sturgeon captured in the Cape Fear River estuary by Moser and Ross (1995) ranged in size from 340 to 1,240 mm TL, but most were 600–800 mm TL (overall mean, 708 mm TL). Gear selectivity may be a factor in their observed capture range.

Information from tagging and genetic studies document that the study area is used in winter by Atlantic sturgeon stocks originating from nearly throughout the species' range. Genetic analysis conducted on Cruise-captured fish indicated that fish encountered off North Carolina and Virginia (N = 43) originated from the St. Lawrence (2.3%), St. John (2.3%), Hudson River (41.9%), Delaware River (23.2%), Albemarle Sound (14.0%) and Altamaha River (16.3%) stocks (T. King, U.S. Geological Survey, Leetown Science Center, personal communication). Genetic studies conducted in other areas also documented use by mixed stocks. Composition of sturgeon in the New York Bight Atlantic sturgeon fishery was determined to consist of an estimated 2.8% of fish from southeastern populations (Waldman et al. 1996). Despite the prohibition on commercial fishing and possession of sturgeon, some movement information has been obtained from tagging. Of 5,500 Atlantic sturgeon tagged, nearly 800 have been captured one or more times (Eyler et al. 2004). The few Cruise-tagged recaptures obtained thus far, coupled with the genetic analysis of tissue from Cruise-captured fish, confirm that juvenile Atlantic sturgeon wintering off North Carolina travel widely and represent several stocks. Previous authors have observed the same behavior (see review in Gilbert 1989:15).

Data collected and analyzed through the Cruises and other investigations have documented the presence of at least two wintering aggregations of Atlantic sturgeon, one off the coasts of North Carolina and Virginia (present study) during January–February and the second off the mouth of the Hudson River (NEFSC, unpublished data, as reported in Savoy and Pacileo 2003), during January, February, and March. Both aggregations are located in relatively shallow coastal waters less than 18 m in depth, and are composed of Atlantic sturgeon from mixed stocks. These stocks are clearly susceptible to bycatch in ongoing commercial fisheries for other species (Stein et al. 2004a, 2004b). Additional offshore studies should be conducted to further refine Atlantic sturgeon habitat preferences, document dietary content and preferences, and document seasonal and long-term movements, migrations, and stock composition. Such information is essential to future management of these stocks, which once constituted a significant ecological component of both oceanic and riverine ecosystems, as well as the basis for a highly significant commercial fishery.

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SCUTES

Students Collaborating to Undertake Tracking Efforts for Sturgeon

Name: ______________________________

Date: _______________________________

Create Your Own Test

Directions: You have just received a number of data tables, graphs, and maps showing data gathered in a study entitled “Distribution, Habitat Use, and Size of Atlantic Sturgeon Captured during Cooperative Winter Tagging Cruises, 1988–2006,” (Laney et al 2007). Using this data, your task is to come up with five questions that test the knowledge of interpreting the data and using measures of center and spread. Once you have developed your five test questions, you will write them below. On the next page, please create an answer key that clearly shows how to find the solution for each problem.

1.

2.

3.

4.

5.

SCUTES

Students Collaborating to Undertake Tracking Efforts for Sturgeon

Name: ______________________________

Date: _______________________________

Create Your Own Test ANSWER KEY

1.

2.

3.

4.

5.

Name: ______________________________

Date: _______________________________

Winter Sturgeon Tagging Data Writing Prompt

Directions: Please choose one data set from the study "Distribution, Habitat Use, and Size of Atlantic Sturgeon Captured during Cooperative Winter Tagging Cruises, 1988–2006," (Laney et al 2007). For this data set, please carefully consider and answer the following writing prompt below. When you are finished, please cut out the data set and mount it on a piece of construction paper to display with your explanation of it.

What does this data represent? How is it represented? What does this data tell us and why is it important? Who might use this data?

____

____

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____

____

____

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____

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____

____

SCUTES

Students Collaborating to Undertake Tracking Efforts for Sturgeon

Name: ______________________________

Date: ________________________________

Scoring Guide for Winter Tagging Writing Prompt

SCORE	DESCRIPTION
4	The response demonstrates a thorough understanding of the data set through summaries of numerical data in context by identifying the statistical question, describing the nature of its attributes such as how it was measured and its units of measurement, gives quantitative measures of center and spread where applicable, and describes overall data patterns.
3	The response demonstrates a general understanding of the data set through summaries of numerical data in context by identifying the statistical question, describing the nature of its attributes such as how it was measured and its units of measurement, gives quantitative measures of center and spread where applicable, and describes overall data patterns.
2	The response demonstrates a limited understanding of the data set through summaries of numerical data in context by identifying the statistical question, describing the nature of its attributes such as how it was measured and its units of measurement, gives quantitative measures of center and spread where applicable, and describes overall data patterns.
1	The response demonstrates a minimal understanding of the data set through summaries of numerical data in context by identifying the statistical question, describing the nature of its attributes such as how it was measured and its units of measurement, gives quantitative measures of center and spread where applicable, and describes overall data patterns.
0	The response is incorrect or contains some work that is irrelevant to the skills or concept being measured.