Modelling Surf Clam Growth with Latitude

Materials

For the leader:

Projector

Whiteboard to project data graph onto

For the activity:

Copy of data tables

Computer program to graph in or graphing paper

Copy of surf clam maps

Copy of data tables

Overview

Atlantic surf clams (*Spisula solidissima*) can live up to about 35 years and are found in the western North Atlantic from the southern Gulf of St. Lawrence to Cape Hatteras, North Carolina. They're most abundant on Georges Bank, the south shore of Long Island, New Jersey, and the Delmarva Peninsula. The surf clam fishery is one of New Jersey's most valuable fisheries. More than 80% of the total Mid-Atlantic and New England area catch of surf clams are landed in New Jersey. However, over the last decade, the stocks of New Jersey surf clams, along with those of within the mid-Atlantic region, including in southern Virginia and the Delmarva Peninsula have dramatically declined.

One theory for the decline of the surf clam population is that the water is getting warmer in the mid-Atlantic. This increase in temperature may be causing mortality in larger surf clams and recruitment failure (a decrease in larval survival causing decreases in the population). In addition, growth rates depend on water temperature - southern surf clam populations in warmer water grow more slowly than the more northern populations. Another impact of the warmer waters is a gradual shift in the distribution of surf clams to the north. Recent federal surf clam stock assessments indicate that nearly 50% of the stock was located off Georges Bank in 2008 whereas only 5% of the stock was located there in 1986.

Scientists use data about the location, size, and condition of surf clams as well as bottom temperature and depth throughout the range of surf clams to study the health of the population and make predictions about the population in the future. In this activity students will investigate the differences in size of surf clams from two locations using model data from the NOAA Fisheries federal stock assessment surveys that Dr. Daphne Munroe uses in her research. The activity places a strong emphasis on teaching students how to look for patterns in data. The students will plot, fit, and compare data to draw conclusions about the influence of geography on biological patterns. Through gaining these data interpretations skills, students will also gain a better understanding of how scientists look at evidence when asking questions.

Students will first plot the age vs. length (mm) data for the surf clams from off of New Jersey and fit the data to a model. Students will then use these data to calculate a growth model for surf clams off of New Jersey. Finally, students will compare growth model outputs for surf clams from three locations along the mid-Atlantic to observe differences in growth with latitude.

Motivating Questions: **How do scientists observe changes in the population with respect to geography? How does latitude affect a how individuals grow?**

Take Home Message

Scientists collect data from a sample of surf clams from the wild population and then use that information to model the growth curves (changes in individual size over time) of the population. By collecting this information from multiple places, scientists can compare differences in populations based upon geography.

Engage: Lead the students in a discussion about what they know about surf	10 minutes

clams and how animals change with latitude.	
Explore: Students plot the growth data (age vs. length) and model the von Bertalanffy growth curves for the population.	50 minutes
Make Sense: Students use model outputs from different regions of the mid-Atlantic to observe differences in growth with respect to latitude.	20 minutes
Total:	**80 minutes**

Audience

High school students (9^{th}-12^{th} grade).

New Jersey Core Curriculum Content Standards - Science

Grade	Content Statement	CPI#
12	Logically designed investigations are needed in order to generate the evidence required to build and refine models and explanations.	5.1.12.B.1
12	Mathematical tools and technology are used to gather, analyze, and communicate results	5.1.12.B.2
12	Empirical evidence is used to construct and defend arguments.	5.1.12.B.3
12	Scientific reasoning is used to evaluate and interpret data patterns and scientific conclusions.	5.1.12.B.4
12	Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions, and small-group work.	5.3.12.D.1
12	Biological communities in ecosystems are based on stable interrelationships and interdependence of organisms.	5.3.12.C.1

Preparation (15 minutes)

1. Write the motivating questions on the board:

   How do scientists observe changes in the population with respect to geography? How does latitude affect a how individuals grow?

2. Make copies of the different surf clam sampling areas (strata) maps (at the end of this write-up).
3. Make copies of the data tables.
4. Write the von Bertalanffy growth equation: $l_t = L_\infty (1 - e^{-K(t-t_0)})$ [Length = MaxLength(1 – $e^{-\text{How fast it grows(Age)}}$)] and variables on the board.

   l_t = predicted length at time t

   L_∞ = maximum length predicted by the equation

   t = time

   t_0 = length of an individual theoretically at time 0

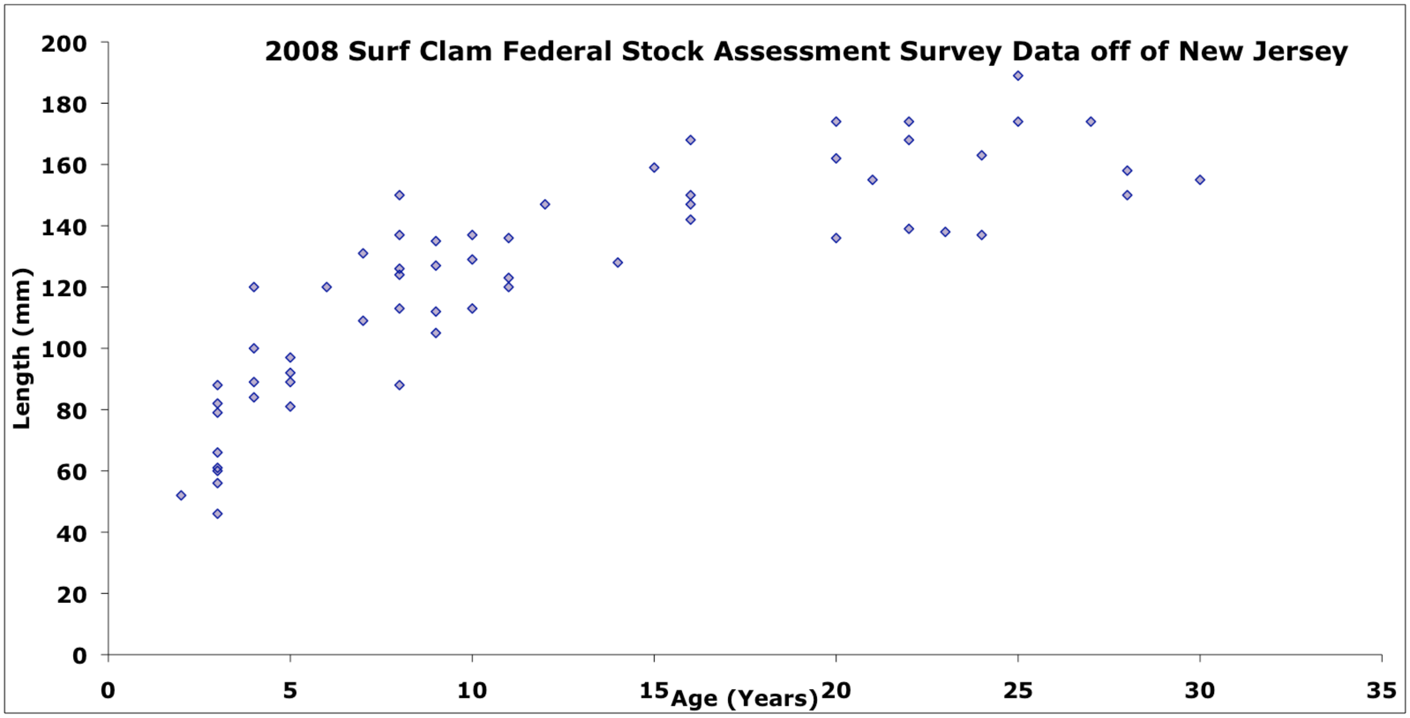
   K = growth coefficient (instantaneous rate)

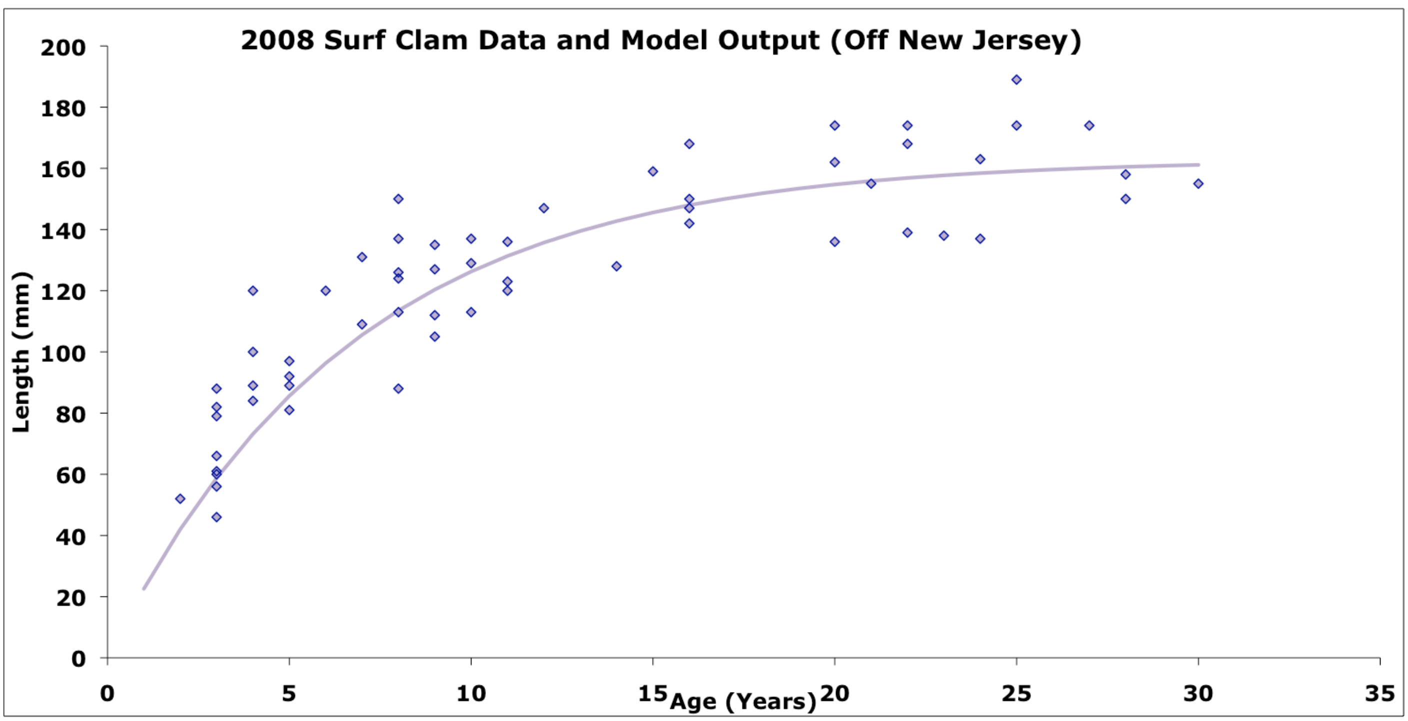
5. Make or project the Class Surf Clam Data Table on the board:

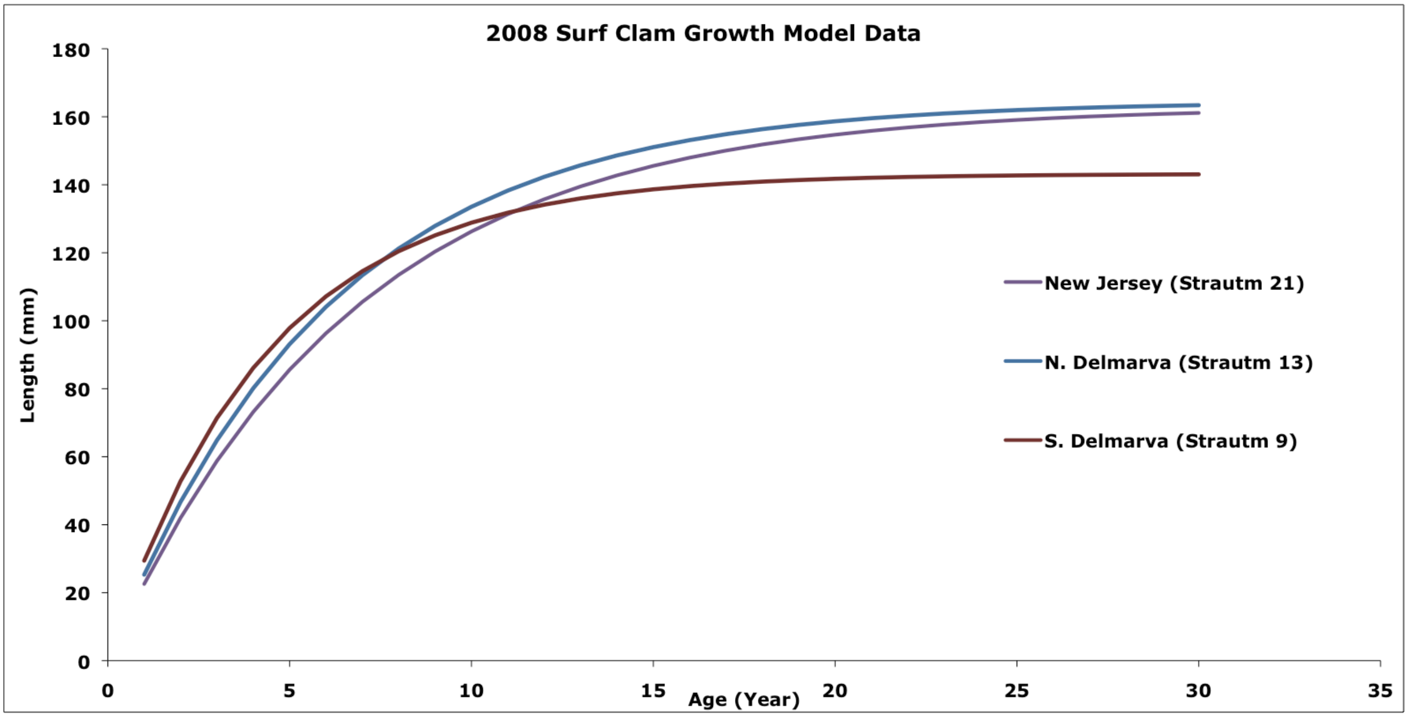
	Off the coast of New Jersey (stratum 21)	Off the coast of the Northern Delmarva Peninsula (stratum 13)	Off the coast of the Southern Delmarva Peninsula (stratum 9)
Maximum Length (how big)			
Maximum Age			

(how old)			

6. Make or project the graphs on the board, but make sure it is hidden from the students.







Engage (10 minutes)

1. Lead the students in a discussion about changes in animals with latitude.

Q. Do the same animals live at the equator as in the North Pole? What about in Florida and Maine? What about Virginia and New Jersey?

Q. What about marine animals that live from North Carolina to Nova Scotia, are they all the same?

2. Be accepting of all responses from the students.
3. Lead the students in a discussion about shellfish and surf clams.

Q. Do you know about shellfish? What do you know about surf clams? What do they need to survive? Where do they live?

4. After a minute or two, and depending on what the students already know, share some information with them that you feel they need to know to understand the activity of the day. (Note – it might be helpful to show the students images of Atlantic surf clams.)

Explore (50 minutes)

1. Explain to the students that scientists use age and size information to learn about how an animal grows over time. Ask them about why scientists are interested in understanding the relationship between the age and size of an animal? Be accepting of all answers, as this is a brainstorming session.
2. Explain to the students that they are going to be shellfish scientists and will get to see how scientists use age and size information of surf clams to learn about their population. First, we will all look at data of the age and size of surf clams off the coast of New Jersey.
3. Have the students make a graph of the age and size data for the surf clams off the coast of New Jersey. Have them plot the length vs. age for each surf clam on their graphs with Age (Years) as the x-axis and Length (mm) as the y-axis. They should be making a X-Y Scatterplot (i.e., do not average the values by age, but rather plot all of the data).

4. Once the students have completed their graphs, have them talk with a partner to answer:

Q. What patterns do you observe in the data?

Q. Is there a relationship between age and size of Atlantic surf clams off the coast of New Jersey? How old do they get? How big do they get?

5. After a few minutes, have the students come back together and share their observations as a class. Make sure to have the students support their statements of the patterns and trends by stating what evidence they are using. (Note – It might be helpful to project the New Jersey data from Table 1on the board so everyone can be looking at the graph when discussing it.)

6. Make sure to talk about the variability within the data. Have the students discuss why there is variability (not all individuals, even those of the same age, are the same size). Stress that even though there is variability the students were able to see patterns in the data.

7. Discuss with the students why scientists would use models to look for patterns in the data: impossible to sample every individual in a population, time/resource constraints to collecting data, voluminous amounts of data to process, incomplete data, etc. Therefore, scientists develop models, grounded in the data, to summarize patterns in the data. They can then use these models to predict, on average, the size of an individual at a given age (or vice versa).

8. Many factors influence the growth of an individual. Have the students brainstorm with one another what factors/concepts would need to be included in a model to predict the average growth rate of a surf clam over time.

9. After a few minutes, bring the students back together to discuss their ideas. Be accepting of all answers as this is a brainstorming activity and they are not expected to know the answer or all agree. (Note – some topics to hit on would be that they should include information about how large an individual is at different ages, the minimum and maximum size that an individual can reach, and time. The important thing is to help students think about what concepts would need to be included in the model of growth rates of individuals over time.)

10. Explain to the students that scientists use field data to determine the mean lengths of an organism at various ages. These averaged data can then be used to create theoretical growth models, which help them make predictive estimates about the average growth rates of an individual over time. The most popular growth rate model in fisheries science is the von Bertalanffy growth equation:

$$l_t = L_\infty (1 - e^{-K(t-t_0)}) \quad \text{OR} \quad \text{Length} = \text{MaxLength}(1 - e^{-\text{How fast it grows(Age)}})$$

l_t = predicted length at time t (the length at each age)

L_∞ = maximum length predicted by the equation

t = time

t_0 = length of an individual theoretically at time 0

K = growth coefficient (derived constant that describes the instantaneous rate at which growth slows through the lifespan of the individual)

Today, scientists use computer programs to calculate these parameters; however, they also can be calculated graphically by hand.

11. Instead of calculating the values, the students will investigate a range of parameters to see how it alters of the shape of the growth curve to determine which values fit the data the best. Project the SurfClam_VBGF_Calculator.xlsx file onto the screen. Have the students select different values for the K and L_∞ parameters to observer how the model fit line (red) varies. Use the suggested parameter values listed in the spreadsheet or others that the students recommend.

12. Allow the students to play with the model for a few minutes before pulling them back together to decide as a class what the best parameter values are (K = 0.149 and L_∞ = 163). Explain to the students that the activity that they just completed, varying the parameter values to determine which values resulted in the best fit of the line to the data, is what the computer model calculates when it returns values for each of the parameters.

Make Sense (20 minutes)

1. After a few minutes of discussion about the von Bertalanffy growth curve model, explain to the students that in order for scientists to understand differences within a species across an area they must take samples of the animals in different locations. The fisheries scientists who collected these data off of New Jersey also collected samples off of the Delmarva Peninsula (north and south). Tell the students that we are going to interpret and analyze the data from multiple locations together as a class.
2. Project the "2008 Surf Clam Growth Model Data" graph on the board. Explain which lines are from which locations. (Note – It might also help to show the students the map of the study locations as well.)
3. Have the students discuss with a partner what patterns they observe in the data using the following discussion prompts:

Q. Compare the growth curves from the three sampling areas (stata 9, 13, and 21), what patterns a can you observe in the data? Are they similar? Are they different?

Q. Is there a relationship between age and size of Atlantic surf clams throughout the mid-Atlantic? Is it the exact same relationship at different locations or are there differences?

4. After a few minutes, bring everyone back together as a class to discuss that patterns they observed. Make sure to have the students support their statements of the patterns and trends by stating what evidence they are using.
5. As the conversation slows, ask the students to determine the maximum age (how old) and maximum size (how big) the surf clams get to be for each location. As the students are talking, record their answers to how big and how old the surf clams got on the Class Surf Clam Data Table.
6. Have the students answer the following writing prompt:

Q. Is there a difference in maximum age and/or size of surf clams between the locations? If so, in which area do surf clams grow bigger?

7. After a few minutes, have the students report out what patterns they observed to the class. Make sure to have the students support their statements of the patterns and trends by stating what evidence they are using. Help the students see that surf clams in the south are smaller than in the north of the mid-Atlantic.
8. As the conversation slows, ask the students to form a hypothesis on why there is a difference in size of the surf clams between the north and south. Be accepting of all responses. Then, ask them how they could test this hypothesis. (Note – The idea is to have the students understand that in science answering one question can often lead to more questions.)
9. Once the discussion slows down, point to the motivating questions and ask:

Q. How do scientists observe changes in the population with respect to geography? How does latitude affect a how individuals grow?

10. Ask students to share their ideas about the questions with a partner. After a minute, ask volunteers to share the ideas they discussed with the entire class. Be accepting of all responses from the students. This is your opportunity to make sure the students understand the "take home message".

11. Ask if the students have any final questions about the activity, graphing, or relationship between surf clam growth and geography.

Surf Clam Sampling Areas (Strata) Maps & Data Table

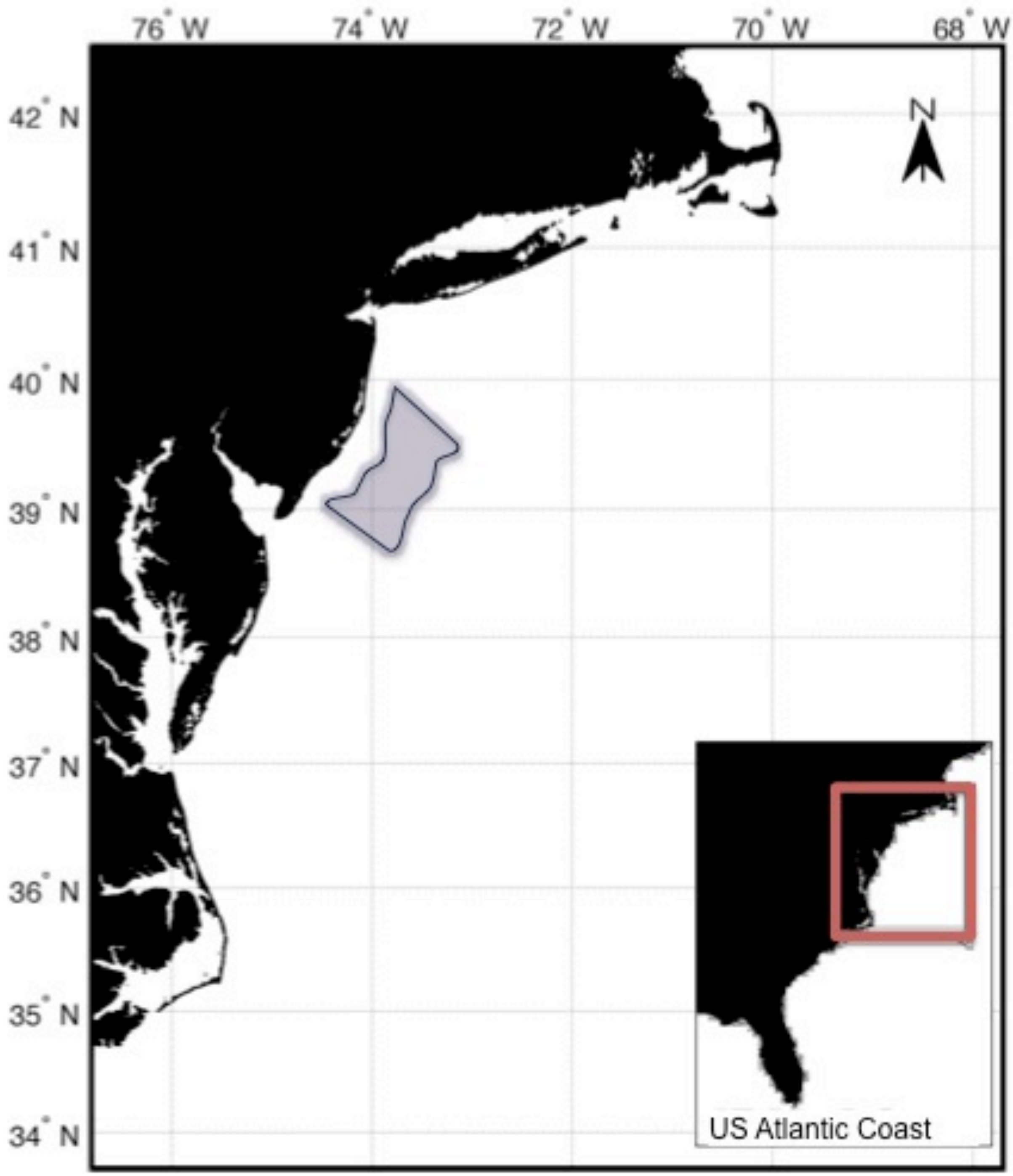


Figure 1. Sampling area (stratum) of surf clams off of New Jersey from NOAA Fisheries Federal Stock Assessment Surveys.

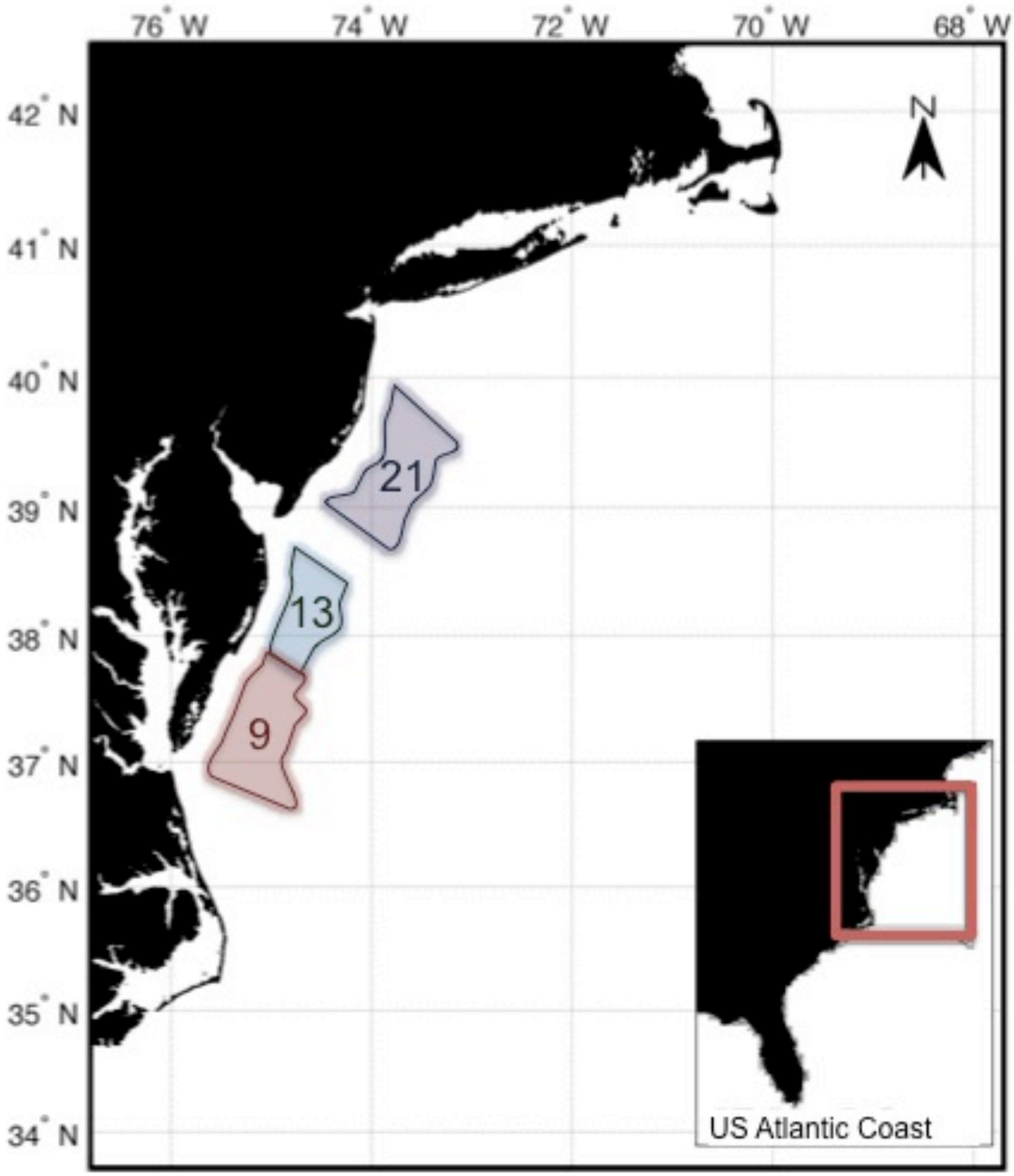


Figure 2. Sampling areas (strata) 9, 13, and 21 of surf clams in the mid-Atlantic from NOAA Fisheries Federal Stock Assessment Surveys.

Table 1. Data of surf clams age and size from samples collected off of New Jersey (stratum 21) from NOAA Fisheries Federal Stock Assessment Surveys.

Age (Year)	Length (mm)
2	52
2	52
3	88
3	88
3	56
3	56
3	79
3	66
3	79
3	66
3	82
3	82
3	61
3	61
3	60
3	60
3	46
3	46
4	120
4	120

4	84
4	84
4	100
4	89
4	100
4	89
5	97
5	97
5	89
5	89
5	81
5	92
5	81
5	92
6	120
6	120
7	131
7	131
7	109
7	109
8	150
8	150
8	124
8	137
8	126
8	124
8	137
8	126
8	88
8	88
8	113
8	113
9	112
9	112

9	135
9	135
9	105
9	105
9	127
9	127
10	129
10	129
10	113
10	113
10	129
10	137
10	129
10	137
11	136
11	136
11	120
11	120
11	123
11	123
12	147
12	147
14	128
14	128
15	159
15	159
16	168
16	168
16	147
16	147
16	142
16	142
16	150
16	150

20	174
20	174
20	162
20	162
20	136
20	136
21	155
21	155
22	174
22	174
22	168
22	168
22	139
22	139
23	138
23	138
24	163
24	163
24	137
24	137
25	189
25	189
25	174
25	174
27	174
27	174
28	150
28	150
28	158
28	158
30	155
30	155