Activity Title: Crunching the Numbers: How do scientists use data gathered at sea?

Subject (Focus/Topic): Scientific Process: Organizing and evaluating data to make logical inferences

Grade Level: 5-6 grades

Average Learning Time: 2-3 one hour sessions, plus an optional one-two hour extension

Lesson Summary (Overview/Purpose):
Students examine actual data from a NOAA sea scallop survey in 2012, organize it, and make inferences about what type of story the data might tell.

Overall Concept (Big Idea/Essential Question):
How do scientists use data?

Specific Concepts (Key Concepts):

- Scientists gather, organize, and analyze data to make logical inferences and develop hypotheses about the area/species/concept they are studying.
- Math and science are closely related disciplines.
- Scientists use data and evidence to support their hypotheses and inferences.

Focus Questions (Specific Questions):
What types of data do scientists gather?
Why might it be important for scientists to be skilled mathematicians?
How do scientists use data to tell a story?
What types of information can scientists infer from data?
How can scientists organize data in ways that help them see patterns/trends?
Do different scientists always come to the same conclusion when analyzing data? Why or why not?
How can scientists use data to develop logical hypotheses that they share with others?

Objectives/Learning Goals:

- Given a sample of scientific data from four stations, students will be able to identify the most relevant information and disregard extraneous information and give at least one valid reason for each decision.
- When asked to write down ways that scientists use data, students will identify at least one specific way scientists use data.
- Students will develop a written logical inference/hypothesis based on a given set of data that includes at least one verifiable piece of evidence.
- Given a sample of data from four stations, students will organize data in a logical manner (chart, table, graph, etc.) with 90% accuracy.

Background Information:
This lesson uses a small subset of actual data from the third leg of the 2012 NOAA Sea Scallop Survey. The survey gathered data about sea scallop populations using an underwater camera system called HabCam and by dredging. For additional information about the survey, see the video and additional resources noted in this lesson plan.

Before using this lesson, students should be familiar with basic landmarks of data, like mean, median, and mode and have experience viewing and analyzing data in numerous formats (variety of charts, graphs, tables, etc.)

Students should be comfortable working in groups, jotting their thoughts, and turning and talking with each other.

This lesson requires the teacher to actively circulate and confer with groups to help direct their thinking, but the teacher should be careful let students problem solve to the best of their ability.

Common Misconceptions/Preconceptions:
Students may assume that there is just one correct answer that they are trying to find, rather than allowing themselves to think creatively and analytically.

Materials: Chart paper, markers, white board, science notebook and pencil for each student, copies of NOAA data and animal identification chart for each group, supplies for group presentations (graph paper, chart paper, colored pencils, etc.), Google Earth research station tour (.kmz file), SMARTBoard file, index cards or post-it notes, Atlantic sea scallop shells (if available)

Technical Requirements:
Access to YouTube, SMARTboard and SMART Notebook software*, GoogleEarth installed on computer

*The SMART Notebook file is used throughout the lesson. Free "SMART Notebook Interactive Viewer" software can be downloaded to use the file, even if a teacher does not have a SMARTboard.

Teacher Preparation:
- Determine how to best place students into groups of three to five students.
- Copy NOAA data and animal identification sheet for each group.
- Identify how to best provide groups access to materials for their presentations

Keywords:
Scallop
Dredge
Data
Infer
Hypothesis

Pre-assessment Strategy/Anticipatory Set:
Post the guiding question, "How do scientists use data?" on SMARTboard. Ask students to turn and talk about what they think they know about the topic for about one minute. Invite a few students to share with the whole class.

Lesson Procedure:
Day 1

- Tell class, "Today you will have the opportunity to experience how scientists from a group called NOAA (National Oceanic and Atmospheric Administration) use data gathered from a six week study at sea to help protect sea scallops. Your job today is to analyze real data gathered by scientists in the Atlantic Ocean this summer to see what conclusions you can draw about sea scallops. But first, let's find out a little bit more about sea scallops and the research done at sea by watching this short video. As you watch, try to find out:
    1.) Why are sea scallops important?
    2.) What was the main purpose of the sea scallop survey?
    3.) What types of data did the scientists gather?

  Jot down your answers in your science notebook so you won't forget." (Teacher should post questions on chart paper or white board so students can easily refer to them)
- Show video on SMARTboard: http://www.youtube.com/watch?v=PTXX_UWqsSY and briefly discuss answers to the posted questions.
- Pass around sample sea scallop shells, if available.
- Ask students what they wonder after watching the video and seeing the scallop shells. Encourage them to record their questions in their science notebooks. Teacher adds some of the students' questions to a class "Wonder" chart.
- Teacher says, "The scientists at NOAA shared some of the data with me for us to use. Today, you are scientists that works for NOAA. Your job is to look at the data from the sea scallop survey and see what kind of story it tells. What hypothesis can you develop about sea scallops, based on the data? With a group, you will write one hypothesis about sea scallops, supported by the data and share the evidence from the data in a logical way."
- "The six-week scallop survey gathered TONS of data from more than 400 different locations (show map of survey stations on SMARTboard), but for today we are only going to look at data for four stations. Even with just four stations, we have a lot of data to look at. Let's begin by looking at all the data provided for these four stations, then decide what data to focus on and what data to ignore for now. Let's divide into groups, then I'll give you a little more information."
- Divide students into groups of 3-5 and provide each group with the spreadsheet data and animal identification chart.
- Teacher days, "Let's look at a couple of column headings that might be a little confusing. Look at the column called "TRASH AMOUNT'. This refers to the

overall weight of the uncounted catch that was thrown back overboard. This includes rocks, mud, snails, clams, and other species that came up in the dredge, but were not counted individually. The 'Cable Out' column is talking about how much wire was let out into the water to allow the dredge to touch the bottom of the ocean and drag behind the boat. I think you can figure out what the other column headings mean, but let me know of you get stuck. With your group, I'd like you to consider, what data is most important for our purposes and what data is unnecessary at this point?"

- Allow time for group discussion, then lead a whole class discussion. Encourage groups to mark on their data sheets and /or make notes in their science notebooks in ways that help them keep track of their thinking. Students may need assistance determining the meaning of some of the headings.
- "So, your group has decided what data is most important to consider for our purposes. Before we move on, I wanted to give you a visual of the area of the ocean we are talking about." Show Google Earth tour (.kmz file linked to in SMART Notebook file) on SMARTboard. Lead class in a brief exploration of the map. Ask, "What do you notice?" "What do you wonder?" You may wish to add more to the class wondering chart/ question list in science notebooks. Point out each of the sample locations and lead a quick discussion about George's Bank if students don't bring it up on their own. (George's Bank is an underwater "shelf" that is shallower than the ocean floor nearby. The shallower waters are home to numerous species of animals.)
- When finished for the day, the teacher will collect data sheets and animal ID sheets from each group or a responsible student in each group will hold on to them until the next day.

<u>Day 2-3</u>

This could take one or two days. Let your students be the gauge of how much time you need to devote to this portion of the lesson. It took two days in my classroom.

- Briefly review work from yesterday.
    - Essential question, "How do scientists use data?"
    - Goal: "Today, you are scientists that work for NOAA. Your job is to look at the data from the sea scallop survey and see what kind of story it tells, what hypothesis you can make about sea scallops, and then find a logical way to share this information with a wider audience."
- Say, "You know your goal, you have already decided what data is most important, and you know the geographic area you are dealing with. As scientists, your group now has some organizing and analyzing work ahead of you. Here are some questions to consider as you work (show on SMARTboard or chart paper):

- How can you organize the data in a way that helps you see patterns/trends?
- In what other ways might you organize the data?
- How might data landmarks help you analyze the data?
- What relationships do you see when you study the data? What story is the data telling?
- How can you best share your findings and hypothesis with a wider audience?" Students should consider charts, graphs, tables, etc.

Some groups of students may need to see the teacher briefly model how she thinks through the task at hand with an unrelated set of data. *"Let me show you how I might think through a set of data. Let's say that I was researching sea scallop clappers (shells that are still connected, but have nothing inside). First, I think I will highlight any information on my data sheets that relate to sea scallop clappers (show example data chart with highlighted rows; linked to in SMART Notebook file). I want to organize the data in a way that helps me see relationships, so I think I will make a chart. I want to know the station number, the number of clappers found at that station, and the depth of the station. I've decided that I am only concerned about the average depth of the station and that I'm not concerned about the weight of the clappers at this time. I think I will also include the number of live sea scallops found at this station, so I can see if there is a relationship between the number of live sea scallops and clappers. I know that sea stars eat sea scallops, so I'm wondering if there were more sea scallop clappers in areas that had lots of sea stars. So, I think I will include sea stars in my chart, too. (Model creating chart; see example chart). Now, I will look at my chart and see what observations I might make. I notice that that at station 155, there were no clappers and only 43 sea scallops, but this was the area where we found the most sea scallops. (Share other observations) Next, I will think about the types of conclusions I might draw based on this data. I will look for patterns, consider what additional data I might need to consider, then write my hypothesis and support it with evidence. My hypothesis will sound like this, 'I infer_____, because___.' The data should support the hypothesis. The data is your evidence. I will think about the best way to share my conclusions: chart, graph, etc."*

Station number	**Depth (meters)**	**#of clappers**	**# of live sea scallops**	**# of sea stars**
142	98	2	161	0
155	72	0	43	1803
169	78	10	230	449
187	55	20	2068	1449

- Students work and teacher circulates to guide, assist, and push thinking. Groups decide on a logical way to share their conclusions (chart, graph, table, etc.) and write a logical hypothesis, based on the data.
    - If needed, provide students with the following frame for writing a hypothesis: We infer_____, because_____. *Example: We infer that sea scallops prefer shallow water because more sea scallops were found in areas with a depth of less than 50 meters than in areas with a depth greater than 50 meters.*
- Students share their conclusions and recommendations with the class.
- Teacher leads students in a debriefing discussion:
    - What did you notice about the hypotheses of the various groups of scientists in our class? *(Kids will likely notice that not every group developed the same hypothesis, even though they all looked at the same set of data)* Why might one group of scientists interpret data differently than another group of scientists and arrive at different conclusions?
    - What can you tell about the relationships between different species by looking at the data?
    - What additional data might be helpful for future scientists conducting this type of work?
    - Why might it be important for scientists to be skilled mathematicians?
    - How do scientists use data? (Have students record their thoughts on individual notecards and use an assessment, then lead a whole class discussion)
    - What lingering questions, related to your work the past two days, do you most want to find answers to? (Each student writes one or two on a notecard and returns to the teacher, who uses them to create interest-based groups for the inquiry experience the following day)

Day 3 or 4 (Optional extension):

Student groups (formed by the teacher, based on the questions recorded on notecards the previous day) seek answers to their lingering questions related to the work of the previous two days, using both print and non-print resources. Students informally share their learning with the class or another group. (This honors student questions that might not for neatly within the designed curriculum, sends the message that asking questions is valuable, and provides an opportunity for students to practice vital research skills in a nonthreatening manner.)

Assessment and Evaluation:

- At the conclusion of day two or three, students respond in writing to the question, "How do scientists use data?" on a notecard and turn it in as an assessment of

their understanding of the essential question of the lesson. Teacher looks for at least one valid description of how scientists use data.

- Teacher informally assesses students' ability to identify necessary and extraneous data thorough conversations with groups, whole class discussion, and by evaluating the notes/marks groups made on their data sheets and in science notebooks. Additionally, she will take note of the data cited in the written hypothesis and the final information presented by groups to gauge students' understanding of relevant and extraneous information.
- Each group will write an inference/hypothesis about sea scallops based on the shared data set that includes the inference and the evidence supporting the hypothesis. The teacher will assess the written work for both parts of the hypothesis, checking to ensure the inference is logical and that the cited evidence is valid and relevant.
- Teacher will assess student understanding of how to use data to organize information through conferences with individual groups and by examining the final product (chart, graph, table, etc.) created by each group. She will look for accuracy in presentation of the data and consider how suited the choice of data organization is for the group's purpose.

Standards:

National Science Education Standards Addressed:

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry:
    - Identify questions that can be answered through scientific investigations.
    - Think critically and logically to make the relationships between evidence and explanations.
    - Use mathematics in all aspects of scientific inquiry.

Content Standard C: Life Science

- Populations and ecosystems
    - The number of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition. Given adequate biotic and abiotic resources and no disease or predators, populations (including humans) increase at rapid rates. Lack of resources and other factors, such as predation and climate, limit the growth of populations in specific niches in the ecosystem.

Content Standard F: Science in Personal and Social Perspectives

- Science and technology in society
    - Science influences society through its knowledge and world view. Scientific knowledge and the procedures used by scientists influence the way many individuals in society think about themselves, others, and the environment. The effect of science on society is neither entirely beneficial nor entirely detrimental.

Content Standard G: History and Nature of Science

- Science as a human endeavor
    - Women and men of various social and ethnic backgrounds—and with diverse interests, talents, qualities, and motivations—engage in the activities of science, engineering, and related fields such as the health professions. Some scientists work in teams, and some work alone, but all communicate extensively with others.
    - Science requires different abilities, depending on such factors as the field of study and type of inquiry. Science is very much a human endeavor, and the work of science relies on basic human qualities, such as reasoning, insight, energy, skill, and creativity—as well as on scientific habits of mind, such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas
- Nature of science
    - Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models…

Ocean Literacy Principles Addressed:

- Principle 1: The earth has one big ocean with many features.
    - 1h: Although the ocean is large, it is finite and resources are limited.
    - Linked to grade 5-8 National Science Standards:
        - C:4 Populations and Ecosystems
        - D:1 Structure of the Earth System
        - F:1 Populations, resources, and ecosystems

- Principle 5: The ocean supports a great diversity of life and ecosystems.
    - 5f: Ocean habitats are defined by environmental factors. Due to interactions of abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate, and circulation, ocean life is not evenly distributed temporally or spatially, i.e., it is "patchy". Some regions of the ocean support more diverse and abundant life than anywhere on earth, while much of the ocean is considered desert.
    - Linked to grade 5-8 National Science Standards:
        - C:4 Populations and Ecosystems
        - C:5 Diversity and adaptations of organisms

- Principle 6: The ocean and humans are inextricably interconnected
    - 6b: From the ocean we get foods, medicines, and mineral and energy resources. In addition, it provides jobs, supports our nation's economy, serves as a highway for transportation of goods and people, and plays a role in national security.
    - 6e: Humans affect the ocean in a variety of ways. Laws, regulations, and resource management affect what is taken out of and out into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes to

beaches, shores, and rivers). In addition, humans have removed most of the large vertebrates from the ocean.
    - Linked to grade 5-8 National Science Standards:
        - C:4 Populations and Ecosystems
        - F:1 Populations, resources, and ecosystems
        - F:4 Science and Technology in Society

Oklahoma State 5th and 6th Grade Science Standard(s) Addressed

- 5th Grade Process Standard 4: Interpret and Communicate
    - 1. Report data using tables, line, bar, trend, and/or simple circle graphs.
    - 3. Make predictions based on patterns in experimental data.
    - 4. Communicate the results of investigations and/or give explanations based on data.
- 5th Grade Process Standard 5: Inquiry
    - Formulate a general statement to represent the data.
- 5th Grade Life Science Standard 2: Organisms and Environments
    - 2. Changes in environmental conditions due to human interactions or natural phenomena can affect the survival of individual organisms and/or entire species.
- 6th Grade Process Standard 2: Classify – Classifying establishes order
    - 2. Identify properties by which a set of objects, organisms, or events could be ordered
- 6th Grade Process Standard 4: Interpret and Communicate
    - 1. Report and record both quantitative/qualitative data in an appropriate method when given an experimental procedure or data.
    - 3. Evaluate data to develop reasonable explanations and/or predictions.
    - 5. Communicate scientific processes, procedures, and conclusions (e.g., model, poster, diagram, journal entry, lab report, scientific paper, oral presentation, and digital presentation).
- 6th Grade Process Standard 5: Inquiry
    - Develop a logical relationship between evidence and explanation to form and communicate a valid conclusion, and suggest alternative explanations.

Additional Resources:

Alicia Gillean's blog entries about her experiences aboard the R/V Hugh R. Sharp on the Sea Scallop Survey can be accessed here:
http://teacheratsea.wordpress.com/category/alicia-gillean/

NOAA's FishWatch website has excellent information about the Atlantic Sea Scallop.
http://www.fishwatch.gov/seafood_profiles/species/scallop/species_pages/atlantic_sea_scallop.htm

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Animals listed on data sheet

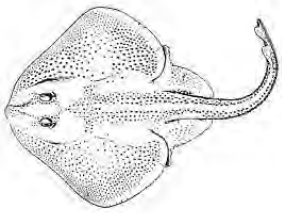
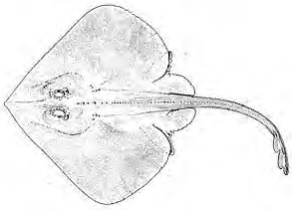
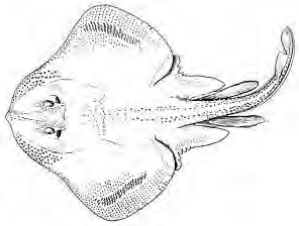
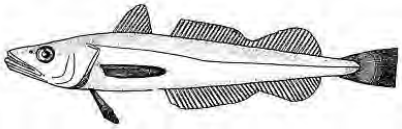
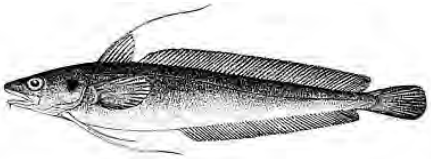
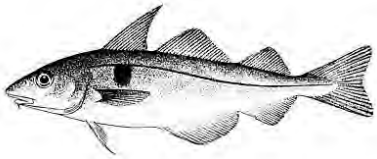
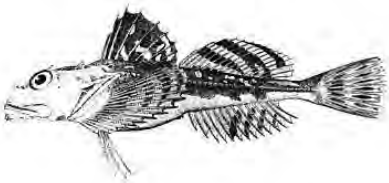
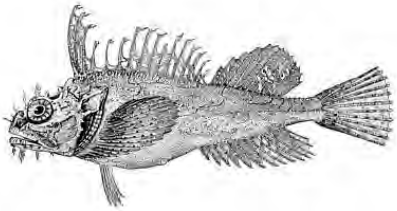
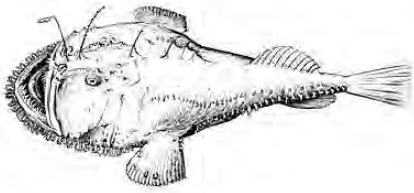
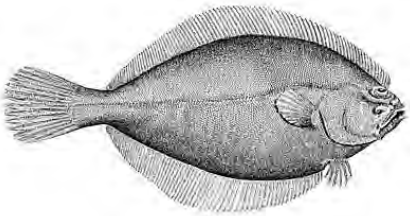
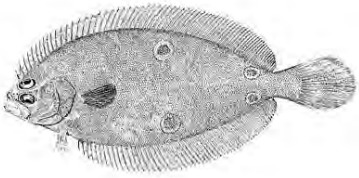
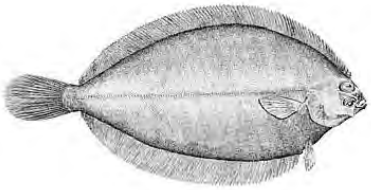
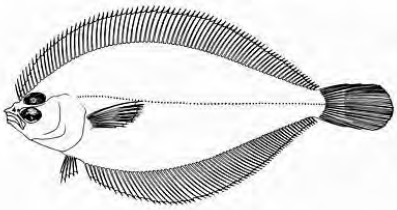
Little Skate 	Smooth Skate 	Winter Skate 
Silver Hake 	Red Hake 	Haddock 
Longhorn Sculpin 	Sea Raven 	Goosefish 
Ocean Pout 	American Plaice 	Fourspot Flounder 
Witch Flounder 	Gulf Stream Flounder 	Cancer Crab 
Sea Stars (Variety) 	Sea Scallop Live 	Sea Scallop Clapper 

Image Sources: http://www.nefsc.noaa.gov/lineart/ and Alicia Gillean's personal photographs

NOAA SEA SCALLOP SURV

STATION	TOW DATE	YEAR	TIME	TOW DURATION	SET DEPTH	END DEPTH	MINIMUM DEPTH
142	30-Jun-12	2012	21:03:06	15.12	98	100	92
155	1-Jul-12	2012	21:11:58	15.12	72	72	72
169	3-Jul-12	2012	2:19:22	15.15	78	78	78
187	5-Jul-12	2012	12:40:14	15.07	54	54	54

VEY 2012 SAMPLE DATA

MAXIMUM DEPTH	AVERAGE DEPTH	CABLE OUT	AIR TEMPERATURE	WIND DIRECTION	WIND SPEED	TRASH AMOUNT	DREDGE SPEED
102	98	354	16.55	236	13.9	1288	4
75	72	266	17.83	218	12.9	184	3.8
81	78	284	15.3	207	6.8	92	3.9
58	55	196	16.44	323	14.1	690	3.8

NOAA SEA SCALLOP SURVEY 2012 SAMPLE DATA

STATION	CatchNumber	CatchWeight	Species Name
142	3	1.34	LITTLE SKATE
142	2	0.58	SMOOTH SKATE
142	1	0.12	SILVER HAKE
142	3	0.42	HADDOCK
142	7	1.56	RED HAKE
142	2	0.24	LONGHORN SCULPIN
142	3	0.46	OCEAN POUT
142	2	3.26	GOOSEFISH
142	11	0.02	CANCER CRAB UNCL
142	2	0.374	SEA SCALLOP CLAPPER
142	161	38.12	SEA SCALLOP LIVE
155	6	1	LITTLE SKATE
155	3	0.26	SILVER HAKE
155	65	9.58	RED HAKE
155	1	0.52	AMERICAN PLAICE
155	5	1.02	FOURSPOT FLOUNDER
155	3	1.14	WITCH FLOUNDER
155	5	0.006	GULF STREAM FLOUNDER
155	5	8.86	GOOSEFISH
155	28	3.1	CANCER CRAB UNCL
155	1803	0.184	SEA STAR UNCL
155	43	9.46	SEA SCALLOP LIVE
169	1	0.3	LITTLE SKATE
169	23	2.727	SILVER HAKE
169	2	0.007	HADDOCK
169	26	4.547	RED HAKE
169	1	0.62	PLAICE AMERICAN
169	20	2.386	FOURSPOT FLOUNDER
169	2	0.008	GULF STREAM FLOUNDER
169	1	0.064	SEA RAVEN
169	42	7.34	CANCER CRAB UNCL
169	449	0.041	SEA STAR UNCL
169	10	0.922	SEA SCALLOP CLAPPER
169	230	43.682	SEA SCALLOP LIVE
187	3	1.4	WINTER SKATE
187	15	4.96	LITTLE SKATE
187	1	0.14	SILVER HAKE
187	1	0.52	HADDOCK
187	17	3.44	RED HAKE
187	1	0.14	FOURSPOT FLOUNDER
187	4	2.14	WINTER FLOUNDER
187	8	0.84	LONGHORN SCULPIN
187	6	1.14	OCEAN POUT
187	7	14.7	GOOSEFISH
187	47	0.6	CANCER CRAB UNCL

187	276	0.345	HENRICIA
187	1449	3.105	SEA STAR UNCL
187	20	1.7	SEA SCALLOP CLAPPER
187	2068	252.32	SEA SCALLOP LIVE

Scallop shell heights in mm

Station	2.5	7.5	13	18	23	28	33	38	43	47.5	52.5	57.5
142	0	0	0	0	0	2	3	2	3	1	0	3
155	0	0	0	0	0	0	0	0	0	2	2	1
169	0	0	0	0	0	0	1	0	7	16	5	0
187	0	0	0	0	0	4	4	4	0	64	292	232

62.5	67.5	72.5	77.5	82.5	87.5	92.5	97.5	102.5	107.5	112.5	117.5	122.5	127.5
3	7	3	1	0	3	3	10	5	11	23	15	12	6
3	0	0	1	1	2	0	1	1	0	0	1	1	6
2	0	3	1	1	1	4	5	12	36	37	37	21	21
84	32	76	108	144	160	220	128	88	116	68	60	48	64

132.5	137.5	142.5	147.5	152.5	157.5	162.5	167.5	172.5	182.5	Total
4	3	14	15	6	2	1	0	0	0	161
5	8	3	2	0	0	0	0	0	0	43
13	4	2	1	0	0	0	0	0	0	230
56	12	4	0	0	0	0	0	0	0	2068

EXAMPLE Data

STATION	CatchNumber	CatchWeight	Species Name
142	3	1.34	LITTLE SKATE
142	2	0.58	SMOOTH SKATE
142	1	0.12	SILVER HAKE
142	3	0.42	HADDOCK
142	7	1.56	RED HAKE
142	2	0.24	LONGHORN SCULPIN
142	3	0.46	OCEAN POUT
142	2	3.26	GOOSEFISH
142	11	0.02	CANCER CRAB UNCL
142	2	0.374	SEA SCALLOP CLAPPER
142	161	38.12	SEA SCALLOP LIVE
155	6	1	LITTLE SKATE
155	3	0.26	SILVER HAKE
155	65	9.58	RED HAKE
155	1	0.52	AMERICAN PLAICE
155	5	1.02	FOURSPOT FLOUNDER
155	3	1.14	WITCH FLOUNDER
155	5	0.006	GULF STREAM FLOUNDER
155	5	8.86	GOOSEFISH
155	28	3.1	CANCER CRAB UNCL
155	1803	0.184	SEA STAR UNCL
155	43	9.46	SEA SCALLOP LIVE
169	1	0.3	LITTLE SKATE
169	23	2.727	SILVER HAKE
169	2	0.007	HADDOCK
169	26	4.547	RED HAKE
169	1	0.62	PLAICE AMERICAN
169	20	2.386	FOURSPOT FLOUNDER
169	2	0.008	GULF STREAM FLOUNDER
169	1	0.064	SEA RAVEN
169	42	7.34	CANCER CRAB UNCL
169	449	0.041	SEA STAR UNCL
169	10	0.922	SEA SCALLOP CLAPPER
169	230	43.682	SEA SCALLOP LIVE
187	3	1.4	WINTER SKATE
187	15	4.96	LITTLE SKATE
187	1	0.14	SILVER HAKE
187	1	0.52	HADDOCK
187	17	3.44	RED HAKE
187	1	0.14	FOURSPOT FLOUNDER
187	4	2.14	WINTER FLOUNDER
187	8	0.84	LONGHORN SCULPIN
187	6	1.14	OCEAN POUT
187	7	14.7	GOOSEFISH
187	47	0.6	CANCER CRAB UNCL

187	276	0.345	HENRICIA
187	1449	3.105	SEA STAR UNCL
187	20	1.7	SEA SCALLOP CLAPPER
187	2068	252.32	SEA SCALLOP LIVE