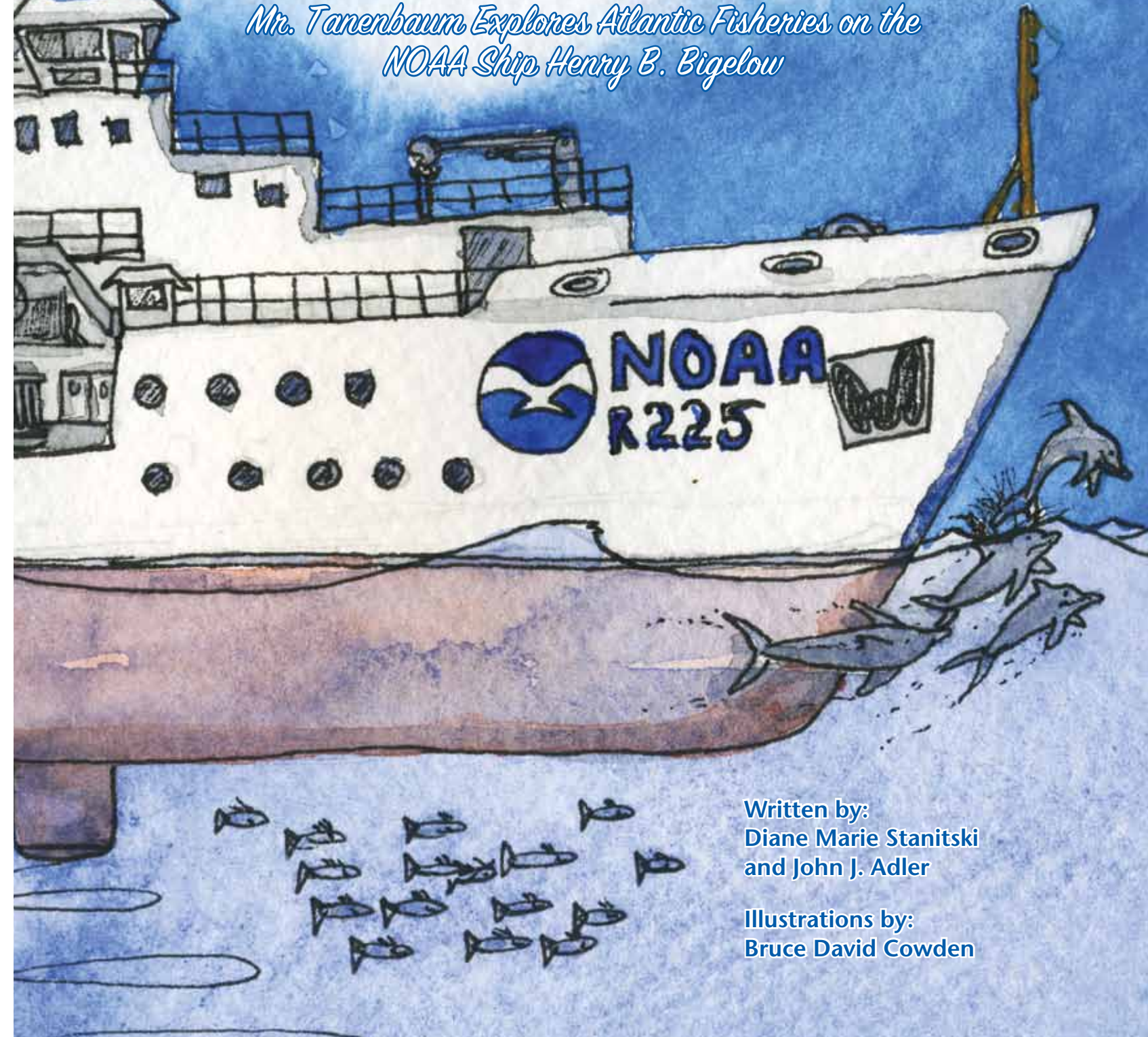


TEACHER at SEA, Teacher at Sea: Mr. Tanenbaum Explores Atlantic Fisheries on the NOAA Ship HENRY B. BIGELOW Diane Marie Stanitski and John J. Adler

Teacher at Sea

*Mr. Tanenbaum Explores Atlantic Fisheries on the
NOAA Ship Henry B. Bigelow*



Written by:
Diane Marie Stanitski
and John J. Adler

Illustrations by:
Bruce David Cowden

Biographies



Diane Stanitski is a climatologist and adjunct professor in the Department of Geography at the University of Colorado at Boulder. Diane was a NOAA Teacher in the Air in 2005 and a NOAA Teacher at Sea in 2002. She serves as a consultant to NOAA to help expand the global ocean observing system and recently started her own science education consulting business, Geocation. Diane is co-author of the books, *Teacher in the Air: Dr. Diane's Flight with the NOAA Hurricane Hunters* and *Teacher at Sea: Miss Cook's Voyage on the RONALD H. BROWN*, and author of *Teacher at Sea: Mrs. Armwood's Adventure on the NOAA Ship FAIRWEATHER*. She loves life in the mountains of Colorado and enjoys traveling and exploring with her husband by plane, bike, and boat.



John Adler is a Commander in the NOAA Corps, and a Navigator on the NOAA Hurricane Hunter aircraft. Currently he is studying for his Ph.D. in Geography at the Cooperative Institute for Research in Environmental Sciences (CIRES) at the University of Colorado at Boulder. His research takes place in Greenland using unmanned aerial systems to monitor changes in glacial lakes. John co-authored the book, *Teacher in the Air: Dr. Diane's Flight with the NOAA Hurricane Hunters*. His wife and three sons, Austen, Ian, and Collin, share his love of scientific inquiry.



Jacob Tanenbaum teaches computer technology in the South Orangetown schools located in Rockland County, just north of New York City. In addition to schools in the New York area, Mr. Tanenbaum has taught in Tucson, Arizona; Buffalo, New York; Alabama, Georgia; Guatemala City, Guatemala; Guayaquil, Ecuador; and Bogotá, Colombia. He was a NOAA Teacher At Sea in 2006 and 2007.



Bruce Cowden is Chief Boatswain on the *Ronald H. Brown* (RHB) and was illustrator for the books, *Teacher at Sea: Mrs. Armwood's Adventure on the NOAA Ship FAIRWEATHER*, *Teacher in the Air: Dr. Diane's Adventure with the NOAA Hurricane Hunters* and *Teacher at Sea: Miss Cook's Voyage on the RONALD H. BROWN*. He lives in Charleston, SC, the homeport of the RHB. He started going to sea at the age of eighteen where he cruised around the Caribbean on sailing vessels. He then joined the US Navy and sailed with them for six years. In 1988, he began his career with NOAA on the research vessel *Malcolm Baldrige*. He worked his way up to Boatswain group leader and then took the Chief Boatswain position on the NOAA Ship *Ferrel*. After a few years on the *Ferrel*, he started working in Gray's Reef National Marine Sanctuary in Savannah, GA, where he served as Captain of the Sanctuary's support vessel and was a diver, ROV operator, and submersible pilot for sustainable seas operations. He then started working on the RHB where he currently serves as Chief Boatswain. He worked on the NOAA Ship *Nancy Foster* assisting in the aftermath of the 2005 hurricane season. His hobbies include cartooning and watercolor painting, and carving jewelry and figurines.



Teacher at Sea

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This children's science book is the fourth in a series of NOAA publications. As with the first three books, all items in **bold** are defined in the glossary starting on page 28. Words in **blue** are described at the bottom of the page where they first appear.

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Flip the pages and watch Conrad Crab dance!

This book is dedicated to the scientists, crewmembers, and NOAA Corps officers, who conduct research on board NOAA fisheries vessels, for their commitment to making fisheries healthy and sustainable for the people of the United States



Teacher at Sea:

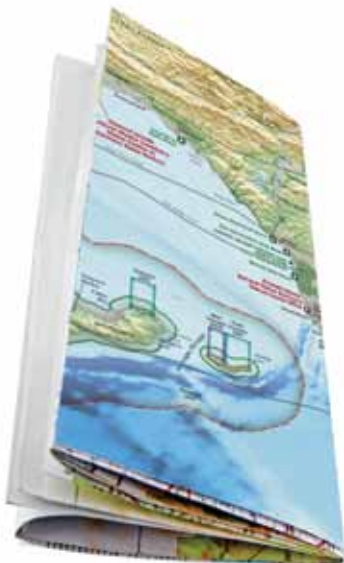
Mr. Tanenbaum Explores Atlantic Fisheries on the NOAA Ship *Henry B. Bigelow*

Mr. Tanenbaum, a fifth grade science and technology teacher from the South Orangetown school district near New York City, loved the outdoors! Every summer, he traveled with his sons to explore a new area of the country. This year they decided to venture westward to the Pacific Ocean. His children had heard of the big surf and rocky cliffs there. It sounded much different than the gently sloping eastern seaboard they explored on past family trips.

While in California, they visited the Channel Islands, a series of islands off the coast of Santa Barbara that are rich in living marine resources. Their first stop was at the **NOAA National Marine Sanctuaries (NMS)** office near the wharf, to learn about the fascinating marine environment surrounding the islands. There they discovered that they would need a fishing license and a permit to fish and hike in the Sanctuaries. This would enable them to explore both the ocean and the land.

As they spoke with a **fisheries enforcement officer**, they learned how important it is to have **fishing regulations** in place so that not too many fish are removed from the ocean. This could put them on the **endangered** species list. The officer provided a map of the Channel Islands Sanctuary, which they studied to learn exactly where they were allowed to fish. They also were thrilled to discover that they could dive or snorkel to observe marine life.

The Tanenbaums learned more about the wide variety of ocean life and **diversity** of the Channel Islands by attending a presentation on the marine sanctuaries. When the fisheries officer discovered that Mr. Tanenbaum was a teacher, she said, "Why not become a **NOAA Teacher at Sea** and travel on board a NOAA ship to learn more about our marine resources? Since our country has one of the longest coastlines in the world, we all need to be more aware of our marine environment, especially fisheries."

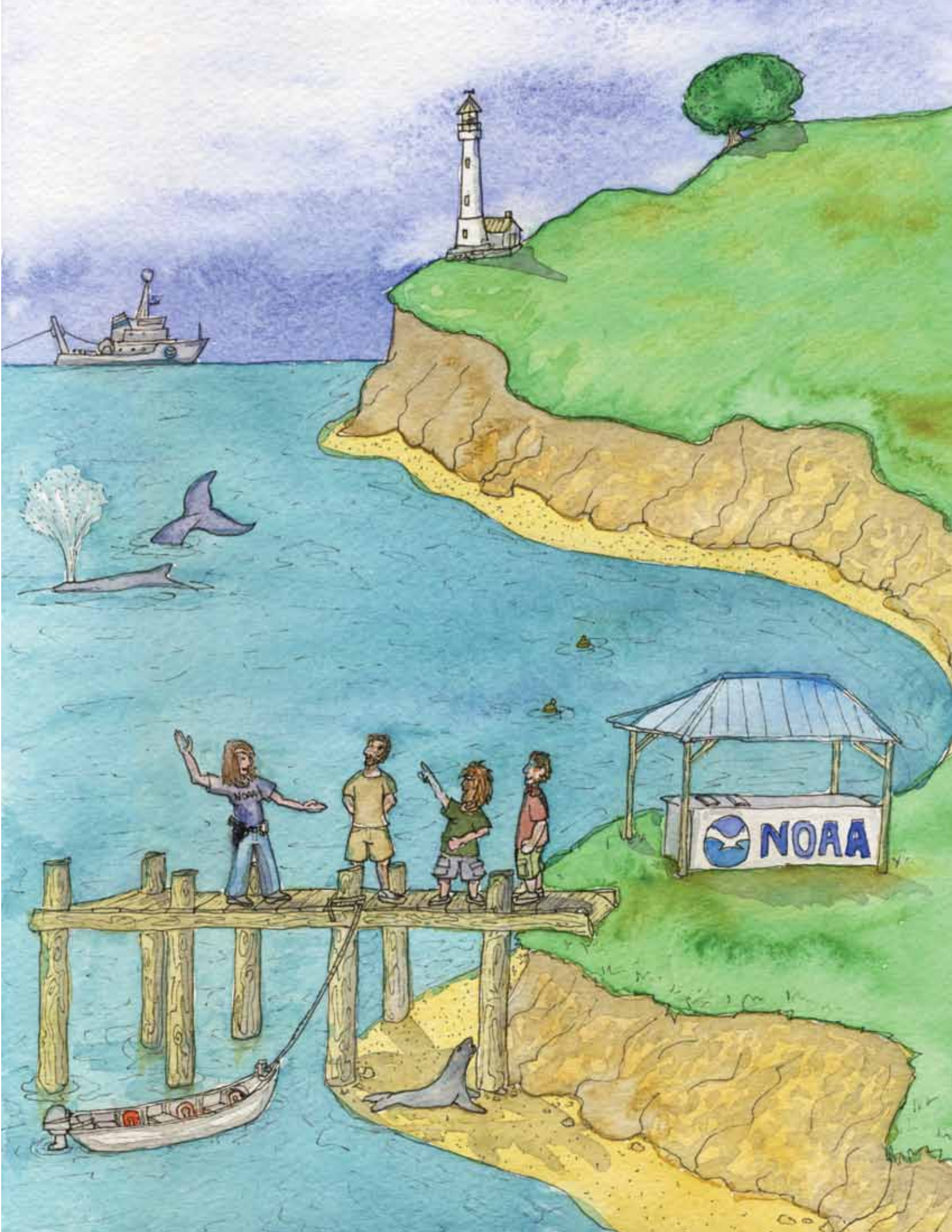


NOAA is the National Oceanic and Atmospheric Administration (www.noaa.gov)

Fishing regulations are in place to protect, maintain, and restore marine **ecosystems** for their ecological value and their use and enjoyment by the public. They also ensure that the number of fish remains sustainable, or stable through time.

Channel Islands National Marine Sanctuary map





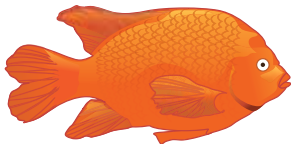
The next day, the family sailed to Santa Cruz Island to snorkel, explore the marine environment, and take underwater photographs. The older son, Simon, noticed the sleek and playful dolphins jumping in the **bow wake** of the sailboat while traveling to the island. The younger son, Nicky, yelled in delight when a flying fish was discovered on the **foredeck** of the vessel. "I thought they were only imaginary creatures!" he exclaimed.

Arriving at the island, they saw abalone, starfish, barracuda, and the mysterious looking **kelp forests**. As they swam, they heard California sea lions barking in the distance looking for mackerel and other fish to eat. Around the tide pools they saw sea cucumbers, small fish, and colorful coral.

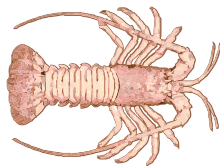
The many **species** found in this area also include bony fish, sharks, **skates**, and **rays** that live within a variety of habitats including kelp forests, flat sandy bottoms, open water, and rocky reefs. It is possible for scuba divers to see more than 40 types of fish in a single dive in the Channel Islands, including the bright orange garibaldi, California's state fish, that can live up to 17 years!

While snorkeling, Mr. Tanenbaum pointed out a lobster walking along the sandy bottom. He shouted to his family over the surf, "Did you know that west coast lobsters don't have claws like their east coast cousins?" Later, when everyone was drying off on the boat, he talked about a unique fish, the California Sheephead, that is always born as a female. "Most of them become males part way through their lives, for reasons scientists don't fully understand," he said. Cool concepts like these are what marine biologists love to investigate.

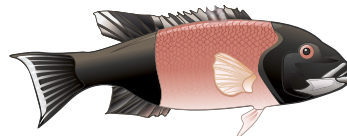
Mr. Tanenbaum noticed the excitement in his children when they explored the ocean and its life. He imagined the impact he could make with the students in his school if he *did* become a NOAA Teacher at Sea.



Garibaldi



West Coast Lobster



Sheephead

Kelp forests provide a unique habitat for many different animal species, including the west coast sea nettle jellyfish that lacks a brain, eyes, ears, gills, and a heart. The kelp forest provides protection from predators like killer whales, and is also a food source for the invertebrates that live there. Gray whales also stop in the kelp forest during their 12,000 mile (~20,000 km) migration between the Arctic Ocean and the Gulf of California.



Question: The long **fronds** in a kelp forest can grow to 330 feet in height, making it one of the tallest plants, nearly the length of the Giant Sequoia tree! If an average person is 66" tall, how many people would have to stand on top of each other to reach the height of a giant kelp frond?



Answer on p. 35





Upon returning home to New York, Mr. Tanenbaum applied to the NOAA Teacher at Sea Program. Three months later, he was selected to travel on board the NOAA Ship *Henry B. Bigelow*, one of the newest of NOAA's 19 research vessels! He told his class, "This 209-foot ship was designed to study and **survey** fish, and is one of the most technologically advanced fisheries survey vessels in the world." The *Bigelow* would soon replace the aging NOAA Ship *Albatross IV*. The *Bigelow* was being **calibrated** to ensure that it would collect measurements and data consistent with that of the *Albatross*. The ship's primary survey area is the coastal water of the northern Atlantic Ocean. Mr. Tanenbaum was to report in October for a two-week survey of **fish and marine mammal** populations near the **continental shelf** off the New England states. Needless to say, he and his students were excited!

Mr. Tanenbaum's students had been working on a project to build a **drifting buoy**, an instrument that moves with the ocean currents and measures sea surface temperature. They would be able to collect data from their buoy after he **deployed** it from the ship at sea. They tested it in the Hudson River to ensure that it would work. Voila! It did! As they collected the water temperature data from their buoy and graphed it in their classroom they realized they were real scientists! The class then joined the **NOAA Adopt a Drifter Program**, and linked with a partnering school in South Korea. Together they would collect and share data results with students in the Eastern Hemisphere through email and **blogs**.

As part of their preparation to follow Mr. Tanenbaum on his journey, the students were asked, "Who can explain the marine **food web**?" One of them said, "A food web is the interaction of all organisms from **phytoplankton** to the killer whale." Mr. Tanenbaum smiled and illustrated on the board exactly what the student said. He showed photos of several different types of **zooplankton** gathering around some phytoplankton. "This is the beginning of the food web," he said. The phytoplankton **algae** serve as food for many little creatures in the sea. Then the zooplankton, **copepods** (small **crustacean** animals that provide the biggest source of protein in the ocean), small fish and krill eat the tiny phytoplankton. The krill and small fish are then prey for even larger fish and other predators.



An example of the interactions of a marine food web

? **Question:** What is the difference between a fish and a marine mammal? ?





When Mr. Tanenbaum arrived at the harbor in Newport, Rhode Island, he met the ship's crew, officers, and scientists. These 30 people would be working with him in close quarters for the next two weeks. He was given a tour of the ship by the **Junior Officer** and shown to his **stateroom** where he met his roommate. The stateroom was small, yet comfortable, and equipped with a **head**. His roommate was a marine biologist who described the types of fish and marine life that would be counted during each survey, including the beautiful sea scallop. Mr. Tanenbaum found it fascinating and expressed interest in learning more about these tasty and interesting sea **mollusks**.

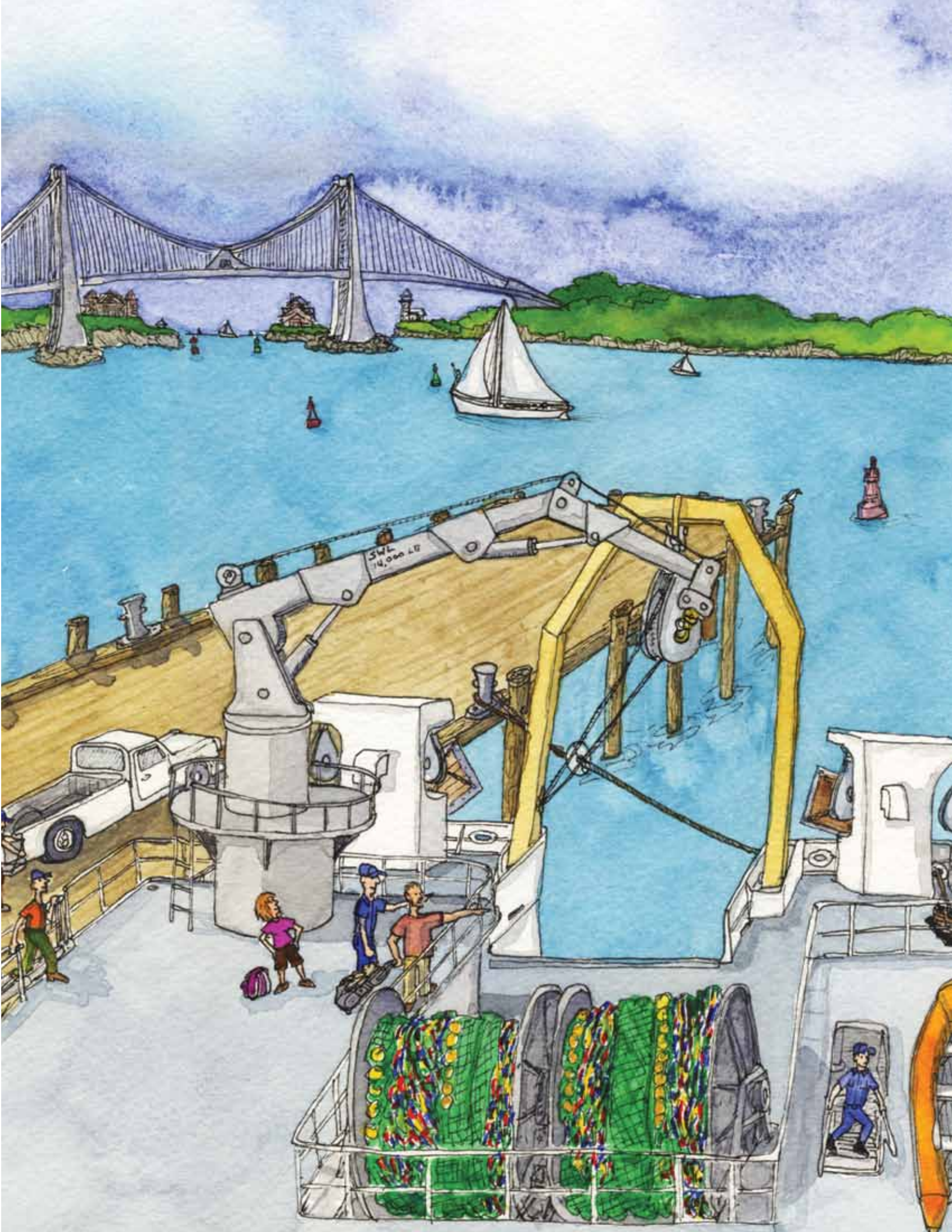
That afternoon, the **Executive Officer**, known as the XO, informed the group of their schedule for the entire cruise. He showed everyone a **chart** of the North Atlantic where the cruise would inventory the fish that live at the bottom of the ocean by conducting **bottom trawl surveys**, or **survey tows**. Fish inventories, called stock assessments, have been completed for many years, allowing scientists to see how fish populations have increased or decreased over time. The **NOAA National Marine Fisheries Service** collects data and information about marine fish and other sea creatures that are used by managers to make regulations like setting the length of fishing seasons for the **total allowable catch**. This catch limit is set specifically for each different fish species. These limits will ensure the fish do not become endangered!

Later that day as the *Bigelow* slowly departed from the pier, Mr. Tanenbaum and other scientists stood on the **bow** of the ship and watched a harbor seal that came by to see them off. They also discovered a stowaway passenger on board: there on the bridge was Snuggly, a stuffed bear that Mr. Tanenbaum's students managed to smuggle into his suitcase. Mr. Tanenbaum would take photos of Snuggly on all decks of the ship and as an observer of all the fisheries science conducted on board.



Chart of North Atlantic showing initial cruise track of the Bigelow



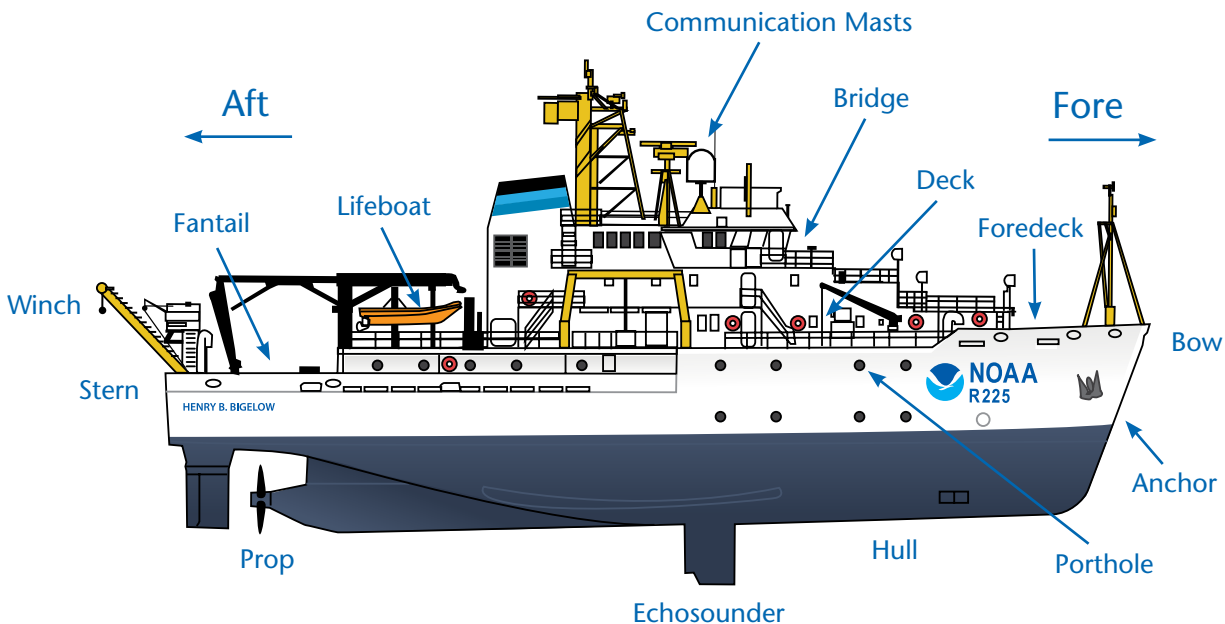


In the morning, the **Field Operations Officer (FOO)** assigned Mr. Tanenbaum to the noon to midnight watch. Mr. Tanenbaum discovered that each crewmember works in 12-hour increments, either the noon to midnight shift, or midnight to noon shift. The ship never sleeps; work continues around the clock!

To catch and count fish, the ship's **winch** operator deployed a **bottom trawl**, which was towed across the bottom of the ocean for 20 minutes to collect a sample of fish living in that specific area. From these samples, the overall number of fish species in the region could be estimated.

When the tow emerged from the water, it was filled with all kinds of sea creatures, along with bottom sediment like rocks and sand. Mr. Tanenbaum immediately recognized the lobsters (although these lobsters, called American lobsters, had claws!). He also noticed many fish he had never seen before! The net was emptied of its contents on the **fantail**, and then it was the scientists' turn to sift through its contents. All marine life was sorted into blue buckets according to their species. The **Watch Chief** taught everyone how to identify the different species when sorting through the massive pile of fish.

After counting, measuring, and weighing each species of marine life, they were returned to the sea, or as the **Chief Boatswain** said, "Back to Davy Jones's locker." The buckets and baskets were then washed and stored for the next tow, which occurred 45 minutes later.





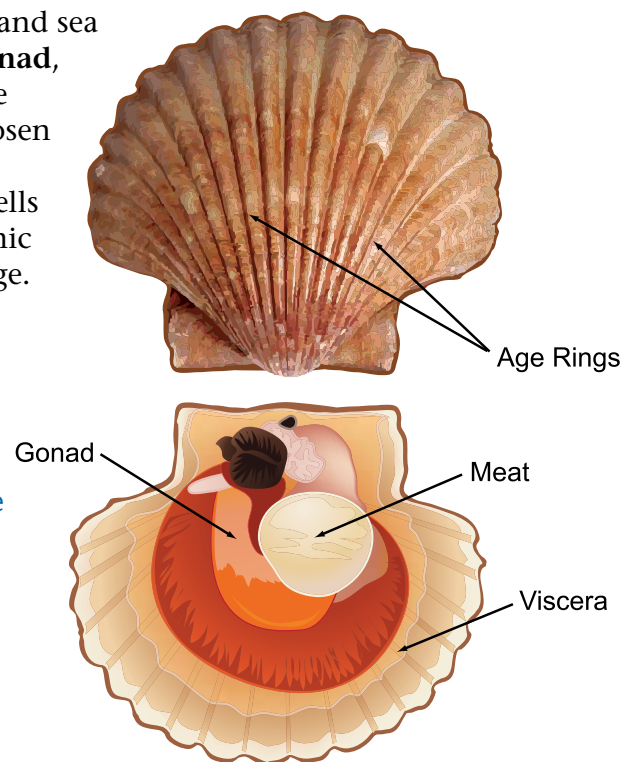
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The measuring and weighing procedures took place when work pairs (teams of two people) were assigned to a workstation. All of the biological data about the fish were recorded using a **Fisheries Scientific Computer System**, a waterproof computer that everyone referred to as the **FSCS** (pronounced “fiscus”, which rhymes with “discus”). At first, the job of measuring, weighing, and recording seemed complicated, but after doing this for a few days, Mr. Tanenbaum felt like a pro. He still had many questions, especially when he didn’t recognize a fish. The Watch Chief gladly answered them and even added interesting stories about each specimen. There was a real team spirit on board.

The FSCS had digital scales, electronic measuring boards, touch screen displays and barcode scanners to record and archive data on deck. Each fish was assigned an identification number, measured, and weighed. A few fish were sampled for age and growth patterns. Each species, such as bony fish, sharks, lobsters, rays, and crabs was measured using a different technique due to their unique shapes and sizes. Mr. Tanenbaum was fascinated with the measuring system. You lay the species on an electronic board, and the team marks each sample using a magnetic stick. Once marked, the measurement goes into the computer along with a species count. What really amazed Mr. Tanenbaum is that you hose down the computer after you are finished. As a technology teacher, he always emphasized that liquids should not be brought into the computer lab because of fear of damaging the computers. What a different world he was exploring!

At last, Mr. Tanenbaum could work with the fish and sea scallops that fascinated him. He measured the **gonad**, **meat**, and **viscera** (pretty much everything in the shell) along with the weight of five randomly chosen sea scallops. He heard that at one station, a work pair counted 788 scallops! He learned that the shells would be taken back to Woods Hole Oceanographic Institution in Massachusetts to determine their age.

Scientists can determine the age of marine life in different ways. For a scallop, they count the rings on the outer shell just like you would count tree rings to determine the age of a tree. Similarly, otoliths, or fish ear bones, are used to date fish since an annual pattern in growth rings can be seen. Slower otolith growth occurs in winter, leading to daily growth increments that are closer together. A seasonal pattern in growth results, which allows determination of the age of the fish in years.



? **Question:** Approximately how long do sea scallops live? ?

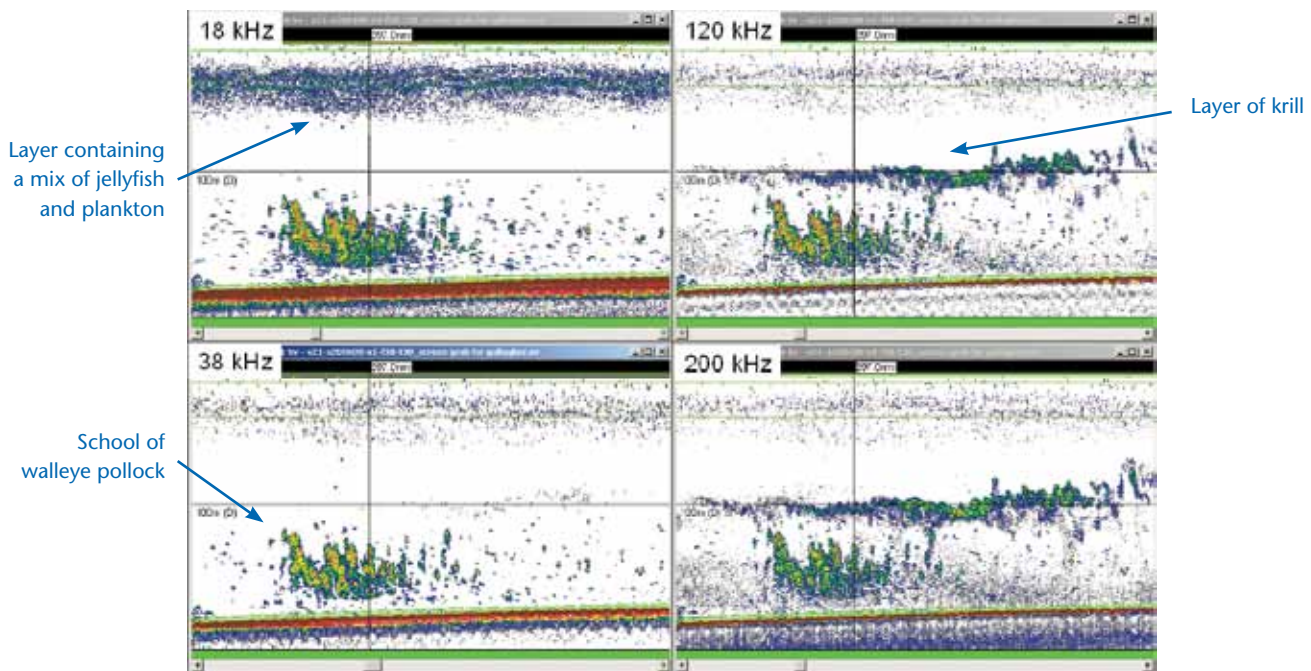




During the cruise, a **hydroacoustic** survey was conducted during the transit between bottom trawl stations. Using an **echosounder** attached to the bottom of the *Bigelow*, four different **transducers** emit different **sonar** signals. The sound signal, known as a ‘ping’, is sent from the ship to determine the number of fish swimming below the hull. Pings reflect off the bottom of the ocean or off anything else in between the ship and the bottom as the ship moves across the water. This helps determine the seasonal distribution (where they are) and abundance (how many) of fish and invertebrate species along the continental shelf. The four sensors send different frequencies of sound, allowing many different sized species to be identified, from **krill** and jellyfish to sharks and fish.

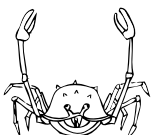
At dinner each night, Mr. Tanenbaum met different scientists, each studying a specific scientific field. He made a note to himself to tell his students about the universities and institutions with **oceanography** and marine studies programs. He knew that many of them were interested in these fields as a possible career.

Image of undersea life taken by an echosounder



During fisheries surveys, NOAA ships record ‘echograms’ at four different frequencies. In each panel, the sea floor can be seen at the bottom and the marine life is shown as the colored dots. Large groupings of dots can indicate schools of fish or a clustering of krill. By comparing the image at each frequency, scientists can then further identify what type of organism is below, such as jellyfish, krill or plankton. Scientists on board the ship examine displays like this during a survey.

Source: Midwater Assessment and Conservation Engineering (MACE) Program, Alaska Fisheries Science Center

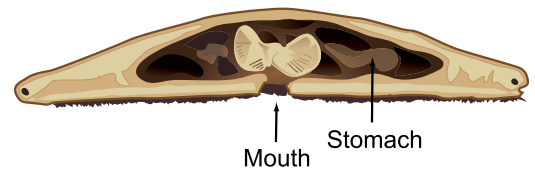




On the fifth night, Mr. Tanenbaum tried to sleep as the ship tossed in wild seas. His laboratory notebook fell from the shelf above his bunk and woke him when he heard the “clunk.” According to the NOAA National Weather Service, there had been a storm brewing the night before which made for a rolling sea with a series of ups and downs and sideways rocking movements, known as the **roll**, **pitch**, and **yaw** of the ship. Fortunately, by the time he had finished eating a hearty breakfast in the **mess**, the seas had calmed down.

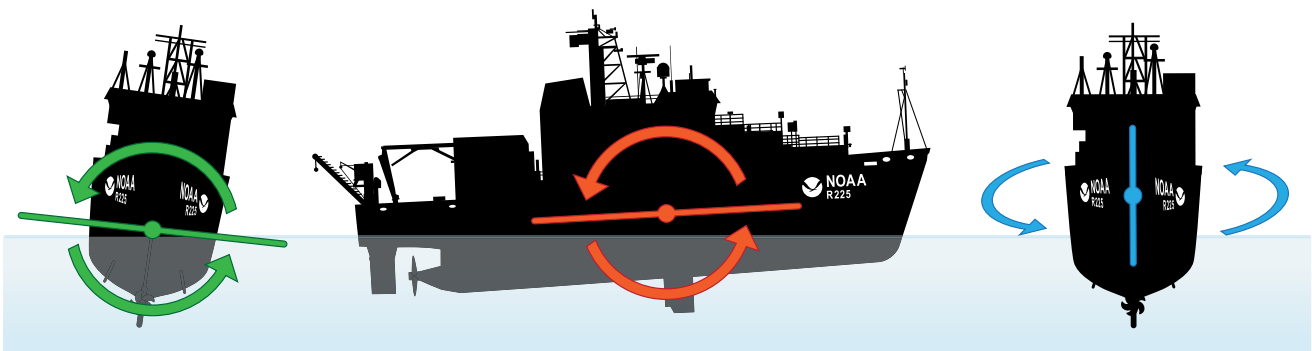
Today, Mr. Tanenbaum was assigned to the starfish study. He learned that these star-shaped creatures are also referred to as sea stars. It was amazing to see their diversity in size and shape. At his work station there were loads of starfish. Out of 4.5 liters of marine life that were collected (about 5 large handfuls), he counted dozens of small starfish. It’s hard to imagine how many there actually were at the bottom of the ocean!

Mr. Tanenbaum thought about the first few days of the trip. He remembered that on the first night, they collected mostly starfish, while on the third night there were more sand dollars. Now he knew why it was important to do surveys of the ocean so we know what species live in each area. Sand dollars are a type of **echinoderm**, along with the sea stars. Sand dollars appear white when you see them in the souvenir shops, but are actually a dark purple color when they are alive.



Cross section of Sand Dollar

Over time, the scientists collected sand dollars, cod, haddock, herring, quahogs (clams), flounders, huge sea stars, and wonderfully slimy skates. Mr. Tanenbaum filmed each day’s procedures and placed the videos and his interviews with the scientists online for his class to see. He also exchanged daily blogs with his students so that they felt as if they knew about every aspect of life and science on board the ship.



Can you identify a ship’s pitch, roll, and yaw?





One scientist on board was studying North Atlantic **right whales**, which are massive **cetaceans** that eat thousands of krill and zooplankton each day. He told Mr. Tanenbaum that there are only about 350 remaining in the ocean, compared with more than 50,000 killer whales. Luckily, there are many groups of people that keep track of the location of whales, so they can warn ships to stay away from whale **Pods**, as they travel up and down the Eastern Seaboard. A NOAA plane called a Twin Otter often flies over coastal waters to help with this process. While touring the bridge as the ship departed from Newport, Mr. Tanenbaum heard a Coast Guard report broadcasting “Securite! All mariners are urgently warned to avoid right whales in the vicinity of ...” and they named a few locations. Once ship captains hear these reports, they can adjust the ship’s course and speed so they will not accidentally impact the whales. Protecting these endangered species will keep them from becoming **extinct**.

Securite! Pan-Pan!!

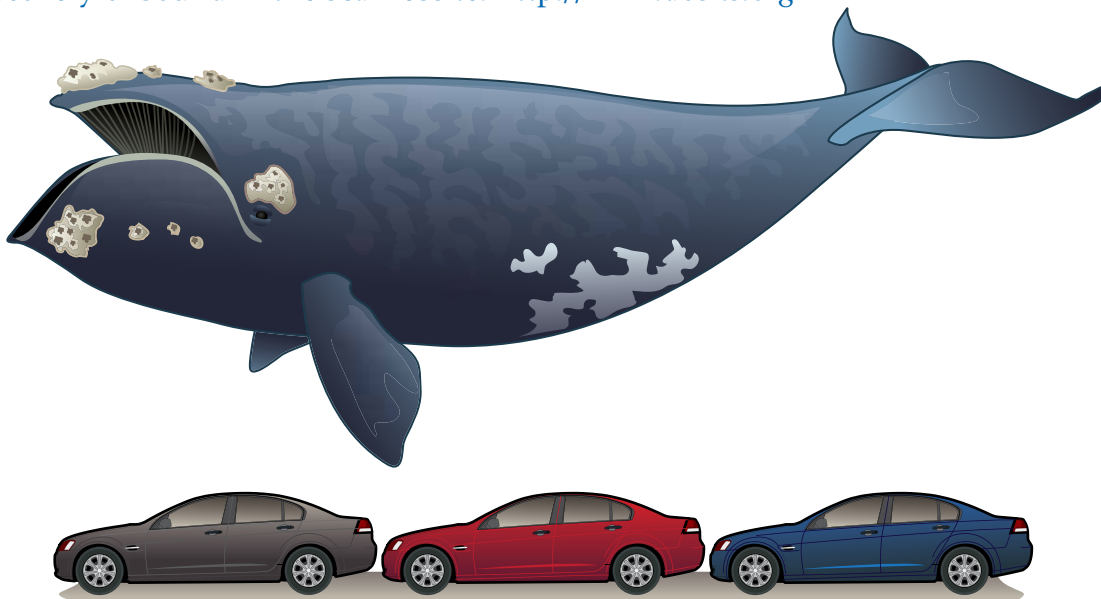


These are distress and urgency calls. Securite is for general safety information, while pan-pan means there is an emergency without immediate danger to anyone's life.

In one of his blogs, Mr. Tanenbaum asked his students to check out the **Discovery of Sound in the Sea website** where they could listen to the sound of fish and marine mammals in the sea. When they viewed the website, the students couldn't believe the sounds made by the Atlantic croaker and manatees. Jason said, “The snapping shrimp remind me of popcorn crackling.” Sarah wrote, “The **baleen** whale sounds are eerie like an underwater siren.”

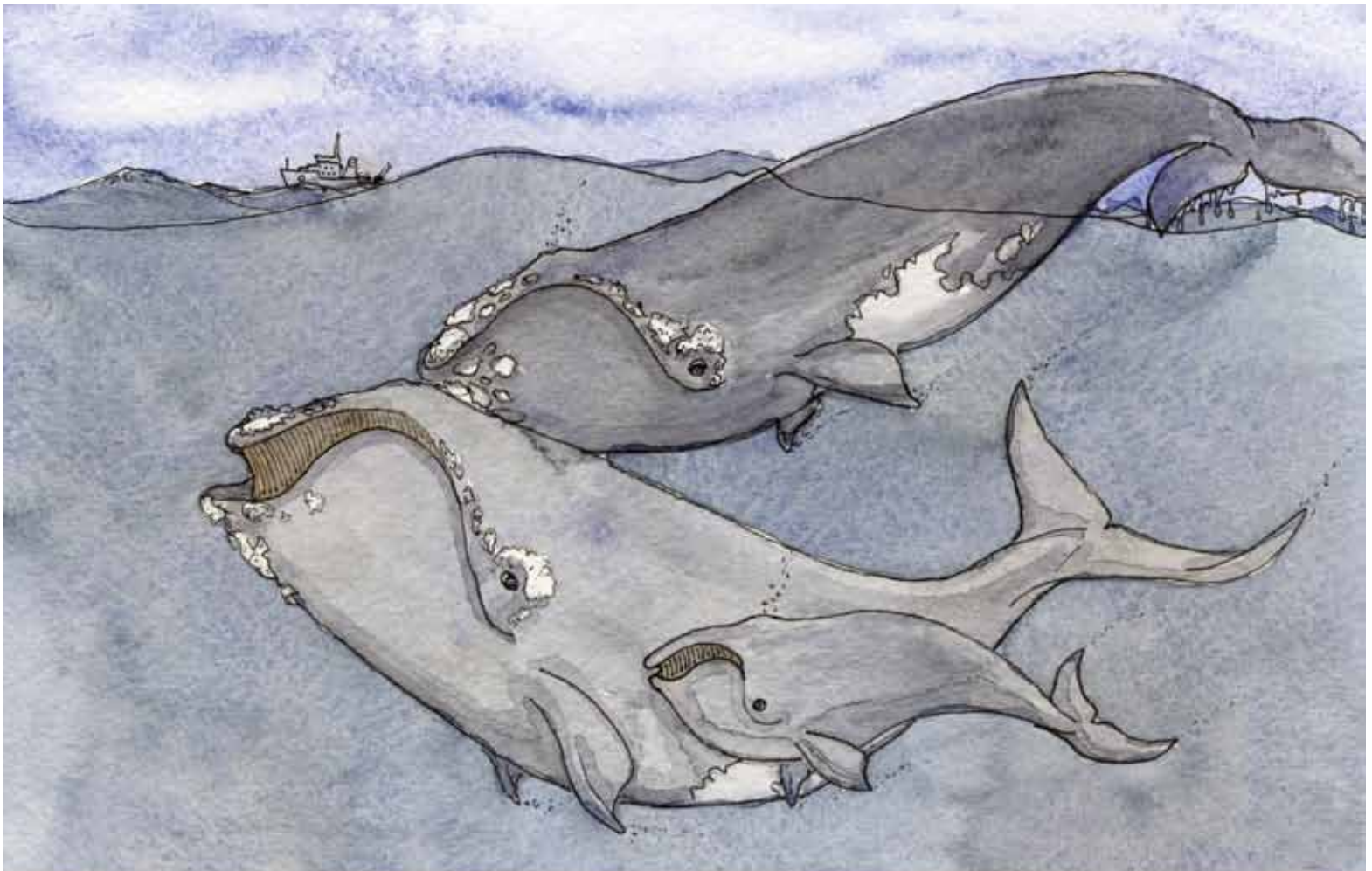
Another student, Chantal, emailed Mr. Tanenbaum asking if he had encountered any sharks during the cruise. “As a matter of fact, as we headed south to Charleston, South Carolina, we identified great white, tiger, and mako sharks, but did not spot the biggest shark that lives in these waters...the massive whale shark,” wrote Mr. Tanenbaum. These sharks can grow to 40 feet long and have 3,000 tiny teeth. They feed on plankton, krill, and small fish that they filter through their gills.

Discovery of Sound in the Sea website: <http://www.dosits.org>



North Atlantic Right Whale relative to a standard sized automobile



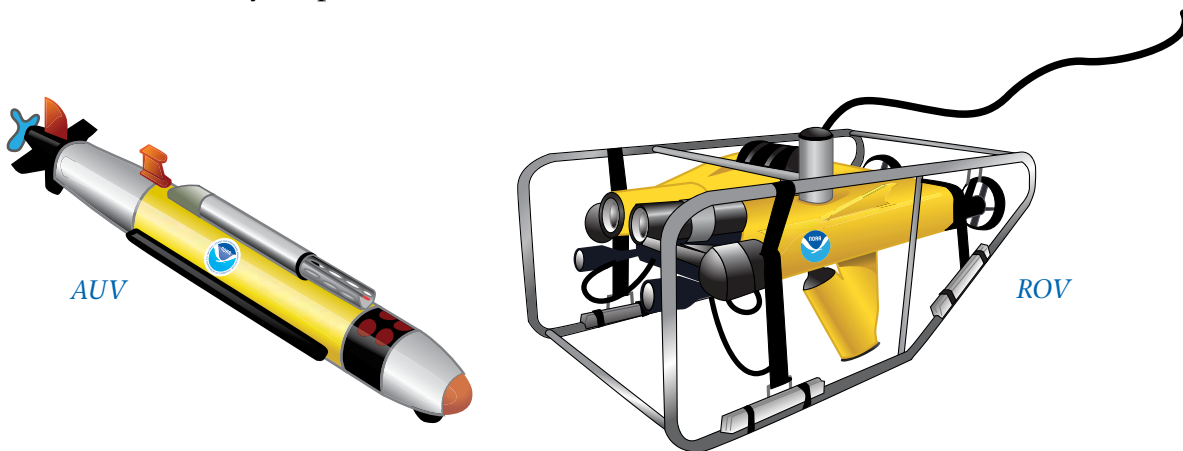


After seven days conducting the bottom trawl survey, another project planned for the NOAA Ship *Bigelow* involved **remotely operated vehicles**, or **ROV's**. They are small unmanned rovers that operate underwater. ROV's are deployed from a ship and controlled by a long cable. Another underwater vehicle used on the *Bigelow* is an **AUV**, or **autonomous underwater vehicle**, which is programmed to move underwater by someone aboard the surface ship, instead of using a cable. Mr. Tanenbaum learned that, with the use of ROV's and AUV's, NOAA is involved in deep ocean exploration in the United States and around the world.

One ROV on board the *Bigelow* was able to descend to more than 2,400 feet (~730 meters). The ROV took pictures of the deep Atlantic to document its unique life. This included fascinating **bioluminescent** creatures and undersea volcanic vents of the mid-Atlantic ridge. Laser beams emitted from the ROV were used to determine species size, so biological surveys can be conducted in hard to reach places. Robotic arms allowed the scientists to collect water and marine life samples that previously were very difficult to obtain.

Through videos, Mr. Tanenbaum's students could witness the ROV in action below the ship. This excited his students because earlier in the school year they built their own robots. Next, as a team they would join a competition to design an ROV.

The marine scientist on board told the students how AUV's are used. "AUV's have sonar and internal computers that enable the vessel to map the seabed while it moves around near the ocean bottom. The sonar sensor works similarly to the echosounder that is attached to the bottom of the *Bigelow*. As the AUV moves along its pre-programmed track it can see the fish's underwater habitats, shipwrecks, and other features on the bottom of the ocean. These vessels help researchers visualize and more accurately map the underwater environment."



Do you want to design and build your own working ROV? The Marine Advanced Technology Education (MATE) ROV Competition encourages students to create teams to do just that. Each year the competition focuses on a new theme in order to expose students and educators to the many different aspects of the ocean workplace and the scientific and technological advancements that are taking place. Find out more at http://www.marinetech.org/rov_competition.



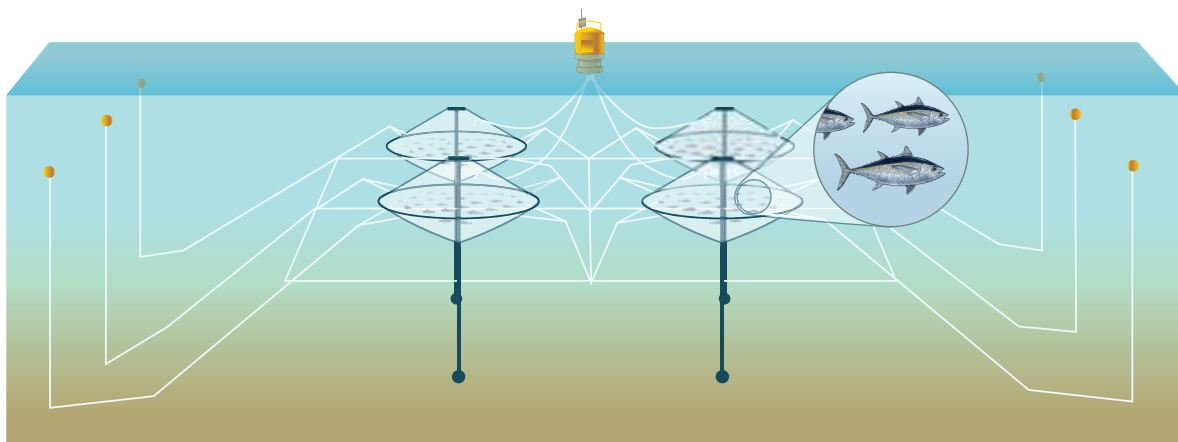
The *Bigelow* made its way south and stopped at the Hollings Marine Laboratory in Charleston, South Carolina. Mr. Tanenbaum helped the scientists from the ship deliver the samples that they had collected for analysis, and then toured the NOAA fisheries research lab. Mr. Tanenbaum learned that the Hollings Laboratory helps protect and restore coastal ecosystems.

Nearby there was a NOAA **aquaculture** test facility where different marine species are grown. Aquaculture can be thought of as a farm where marine animals are raised in an aquatic environment, such as ponds, tanks, or coastal waters. Aquaculture is used to support commercial and recreational fisheries as well as to build and maintain fish populations in the ocean. In the U.S., aquaculture facilities raise mostly oysters, clams, and mussels, followed by salmon and shrimp.

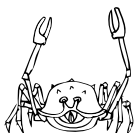
The scientists spent the afternoon on a tour of the facility and learned a great deal about the U.S. reliance on fish and the importance of aquaculture. Mr. Tanenbaum discovered that this facility is part of the **NOAA Aquaculture Program**. Here, tests are conducted to determine the best way to manage marine resources, so we will always have plenty of fish to eat. A program called **NOAA FishWatch** has an informative Internet site to educate the public about safe ways to prepare and eat seafood, and its healthy benefits.

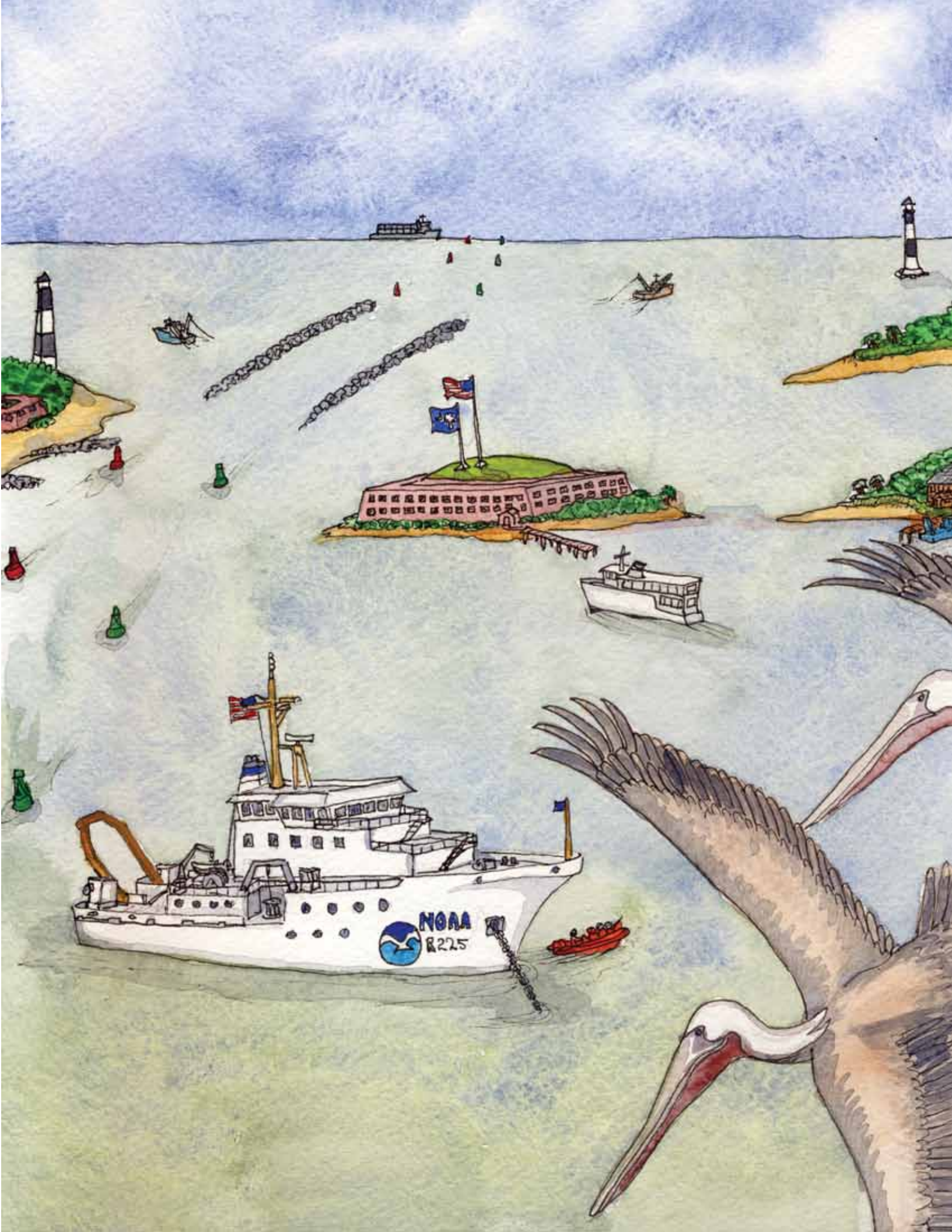
Towards the end of the day, everyone rode the **dinghy** back to the ship. They would continue the cruise southward to the coral reefs in the Florida Keys. A new team of scientists joined them on board to investigate corals.

Learn more about NOAA FishWatch at <http://www.nmfs.noaa.gov/fishwatch>



An example of an offshore aquaculture facility





The **Commanding Officer**, or captain, of the *Bigelow* was a NOAA Corps officer with 20 years of experience. He announced that they would head south to investigate the impact of a recent **coral bleaching** event in the Florida Keys. Coral bleaching harms the fish and other species of the reef, creating what some people call an “underwater desert.”

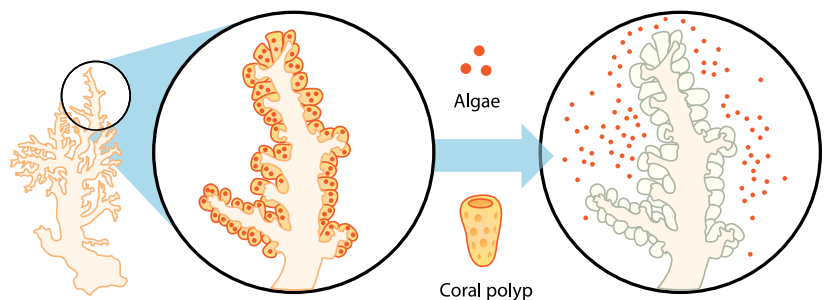
Mr. Tanenbaum had arranged to hold a videoconference with his students during this leg of the cruise. He and the coral experts on board would discuss coral reefs and the different ways that reefs support fish and other marine species. Mr. Tanenbaum reminded his students that coral are actually animals, even though they look like plants. They have mouths and tentacles that feed their stomach with plankton and other prey.

Algae, which live within the coral, are plants that rely on **photosynthesis** to produce their food. Corals and algae have a **symbiotic** relationship. **Coral polyps** provide a home for the algae, while the algae provide nutrients for the coral. Corals are typically brightly colored due to the algae that live within their tissues.

As soon as they arrived at the Keys, Mr. Tanenbaum and the other scientists spotted the bleached coral reef. This coral bleaching had most likely been caused by unusually warm seawater, but could also have been triggered by pollution or increased sediment in the water. These conditions prevent algae from photosynthesizing, so they become stressed and decline in number. With the vivid colors of the algae gone, all that remains of the coral is their white skeleton.

The scientists informed Mr. Tanenbaum’s students that NOAA’s **Coral Reef Conservation Program** helps to manage and conduct science related to coral reef ecosystems. They said, “Many species rely on the presence of the coral reef, which provides a habitat for fish, lobsters, turtles, and other marine life. The fish communities in the coral reefs are extremely diverse because corals provide many unique locations for fish to live, feed, and reproduce.” Up to 200 different fish species can live within a small coral reef. U.S. coral reefs cover 6500 square miles (16,835 km²), almost the size of Connecticut and Rhode Island combined.

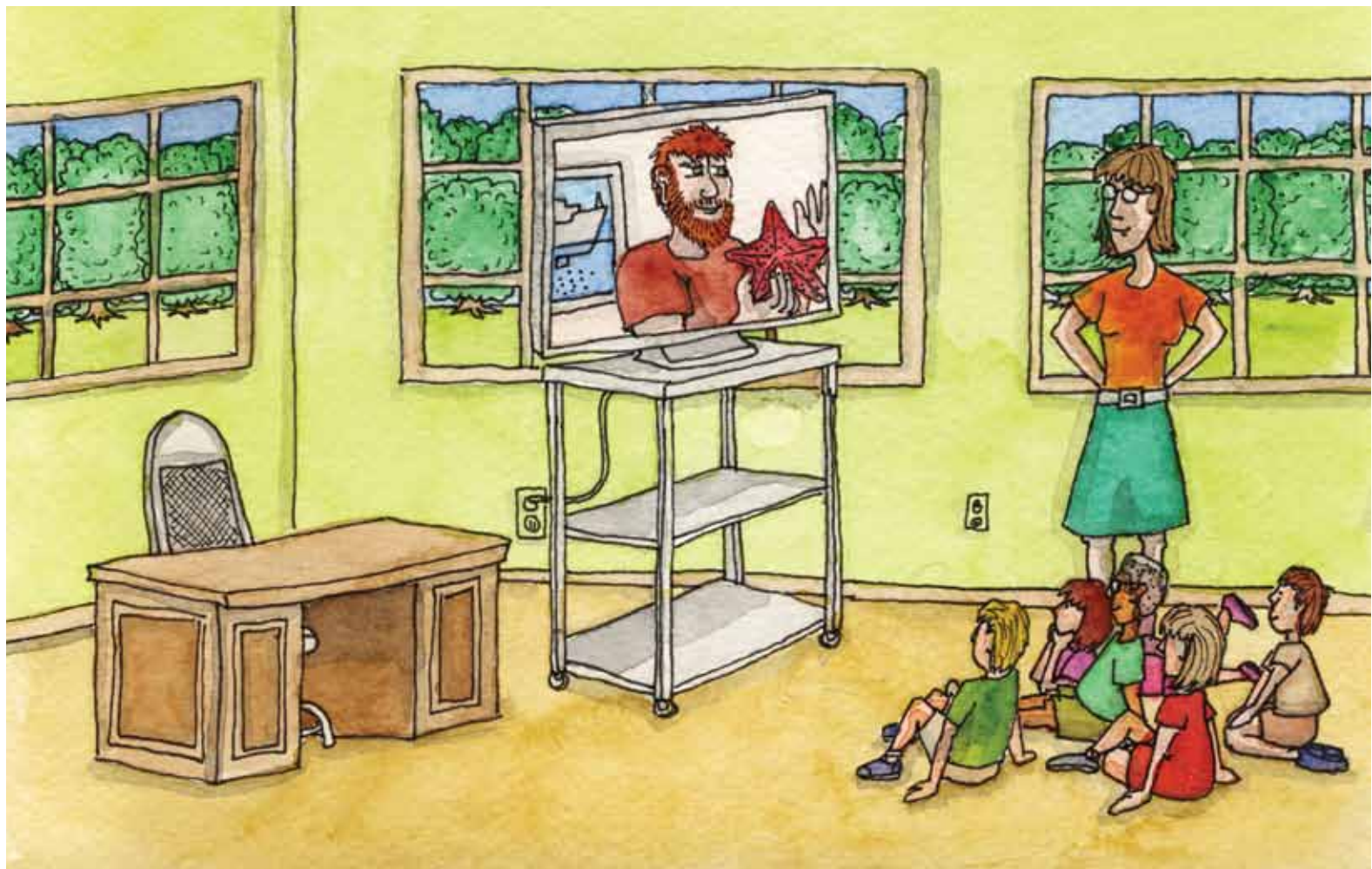
To end the videoconference with his students, Mr. Tanenbaum thanked the NOAA officers, scientists, and crew for their support of him and his students, and for the opportunity to help conduct the fish surveys on board. The students applauded loudly and asked if they could email any questions as they worked on their marine projects during the school year. The scientists said that they would be glad to help out. Mr. Tanenbaum closed with, “I can’t wait to show you my sea specimens and photos in the classroom next week! See you soon!” He smiled at the thought of sharing all of his recent experiences.



Healthy Coral: algae living in coral tissue

Bleached coral: algae expelled from coral tissue





Upon return to his classroom, Mr. Tanenbaum was surprised that his class had updated the bulletin boards with elaborate diagrams and pictures of everything he had discussed during his trip. He was impressed with their detail and their genuine enthusiasm for the projects. He noticed that the students created drawings of the food web, sonar beams from the bottom of the *Bigelow*, the FSCS to weigh and measure fish, and a deep water AUV. Others sketched coral reefs, sea stars, and one student even illustrated the thousands of small teeth found in the mouth of the whale shark. His students must have done a huge amount of research on their own. He knew that this trip had a large impact on them and he was happy to answer their questions, this time in person.

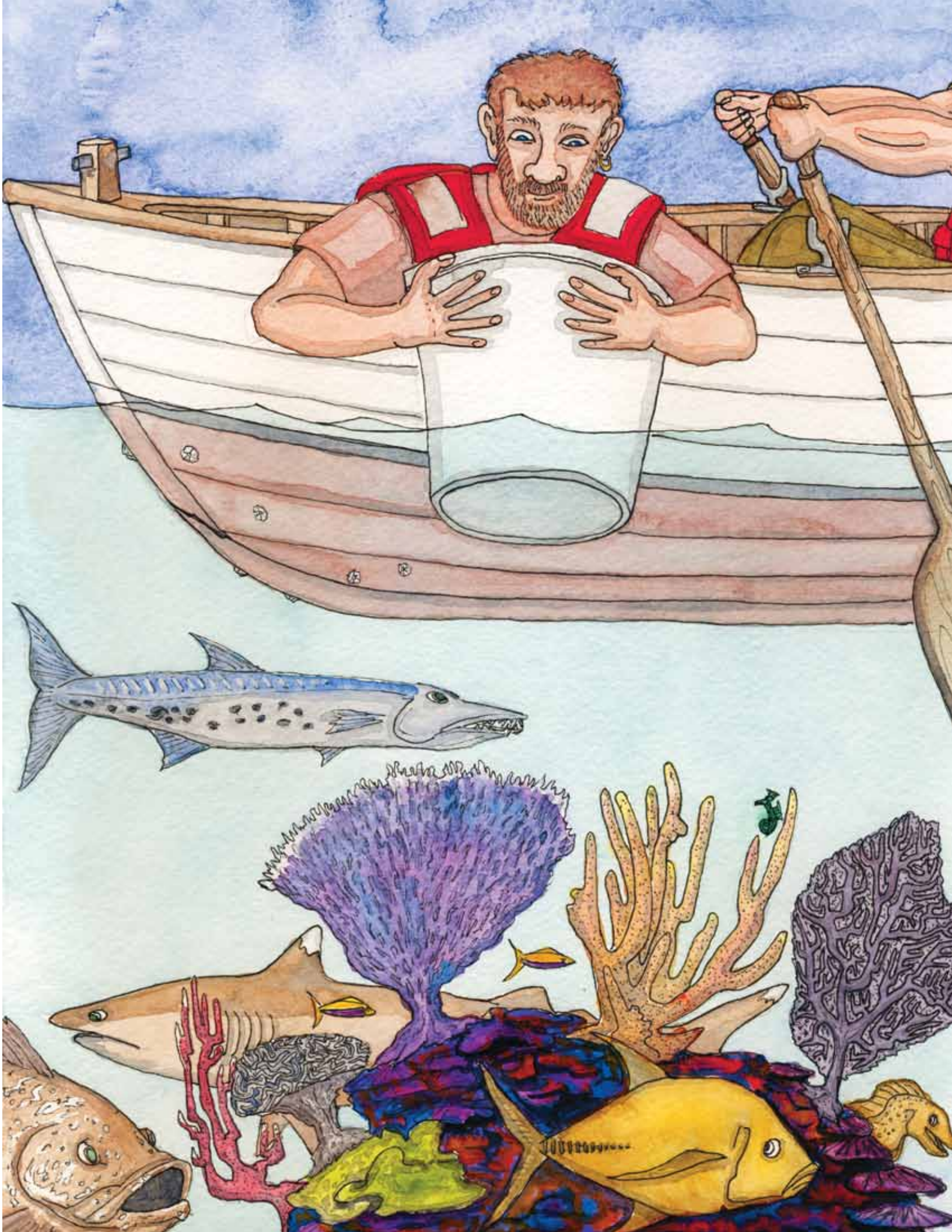
Later that week, Mr. Tanenbaum surprised the students with a field trip to the local aquarium. A scientist from the nearby NOAA Fisheries laboratory joined them to give them a tour. The scientist showed the students samples of the sand dollars and sea stars that Mr. Tanenbaum had surveyed just two weeks before. He also explained that we each have a responsibility to keep our oceans clean which, in turn, will keep our fish populations healthy.

As a result of Mr. Tanenbaum's NOAA Teacher at Sea experience, he and his students learned some astounding facts about fish in addition to the way that fish are surveyed and the significance of fish to our lives. They realized that all Americans are affected by the health of our fisheries, and that it is important that we have proper management of our marine environment for future generations to enjoy.



Shark Jaw





Glossary

Scientific words in bold print in the text are defined below.

Algae - a simple plant that lacks true stems, roots, leaves, and vascular tissue; the first level in the aquatic food chain

Aquaculture - the cultivation of aquatic organisms in controlled or selected aquatic environments for any commercial, recreational, or public purpose

Autonomous Underwater Vehicle (AUV) - crewless submersible vehicle that is not tethered to a vessel on the surface; its path is programmed prior to deployment

AUV - Autonomous Underwater Vehicle

Baleen - fringed filter in the mouth of some whales that is used to strain food from seawater

Bioluminescent - light produced by organisms from the conversion of chemicals to radiant energy

Blog - short for web-log; ongoing update of experiences on a website; an online journal

Bottom trawl - a large net or similar device, which is towed across the seabed

Bottom trawl survey - a count of marine species by collecting a sample of those species at the bottom of the ocean

Bow - the foremost point of the hull of a ship or boat; the point that is ahead when the vessel is underway

Bow wake - the wave that forms at the bow of a boat when it moves through the water

Calibrate - to check a piece of measuring equipment against equipment that is known to be accurate to ensure that the correct measurements are being made

Cetaceans - the large group of marine mammals that includes whales, dolphins, and porpoises

Chart - a map designed to assist navigation by air or sea

Chief Boatswain (pronounced boh-sun) - the primary person who is responsible for the boats, sails, rigging, anchors, and cables on a ship

Commanding Officer - the captain of a ship

Continental shelf - the relatively shallow seabed surrounding a continent

Copepods - any of numerous minute marine and freshwater crustaceans of the subclass Copepoda, having an elongated body and a forked tail and usually about 0.02 – 0.08 in. (0.5 – 2 mm) long

Coral bleaching - the loss of color of corals, due to expulsion of symbiotic algae normally living within coral animals, which occurs when coral animals are stressed

Coral Polyps: cylindrical shaped aquatic animals that have a mouth at the end of the tube which is surrounded by small tentacles.

Crustacean - a group of marine animals with a hard outer shell

Deploy - to place an object into a new position for use

Dinghy - a small boat used to transport people and supplies between a ship and shore

Diversity - the number and distribution of different plant and animal communities within a given area

Drifting buoy - an ocean instrument that drifts in the currents and measures sea surface temperature

Echinoderm - any of numerous marine invertebrates, which includes the starfishes, sea urchins, and sea cucumbers, having an internal skeleton and five-part radial symmetry

Echosounder - a device to transmit and receive underwater sound signals to determine the distance to an object

Ecosystem - a community of organisms and the non-living environment in which they interact

Endangered - a species that has so few members left that it is in danger of becoming extinct

Executive Officer (XO) - the officer second in command on a ship



Extinct - a species that no longer exists

Fantail - the rear of a ship

Field Operations Officer (FOO) - an officer responsible for all field operations on board; the link between the ship's officers and the scientific party

Fisheries Enforcement Officer - a person who enforces fishing laws and regulations and provides coastal management permits

Fisheries Scientific Computer System (FSCS) - a computer that provides a "digital" method of recording catch, or species, information

Food web - the interconnected feeding relationships in an ecosystem that usually begins with photosynthesis

Foredeck - the forward part of a ship's main deck

Fron - the leaf and limb structure of a plant such as a fern or kelp

Gonad - a reproductive gland

Head - bathroom on ship

Hydroacoustic - the study and application of sound in water used most commonly for detection, assessment, and monitoring of underwater physical and biological objects

Junior Officer - a commissioned officer holding rank equivalent to a naval Lieutenant Commander, or lower

Kelp forest - very large brown algae or seaweed, often growing in oceanic "forests"

Krill - small, shrimp-like crustaceans that feed on plankton

Mean - the average value of a series of numbers

Meat - the bulk of the scallop except for its reproductive organs and intestines

Median - the number found by arranging the values in order and then selecting the one in the middle

Mess - a military dining room where people eat and relax

Mode - the most frequently occurring number in a sequence of numbers

Mollusks - any of a broad range of animals with a soft body that is protected by a hard calcareous shell such as clams

NOAA - the National Oceanic and Atmospheric Administration, under the U.S. Department of Commerce, is responsible for prediction and research of weather and climate-related events, charting the sea and skies, and providing environmental stewardship of the nation's coast and marine resources

NOAA Adopt a Drifter Program - a program designed to enable U.S. schools to adopt a drifting buoy along with a school abroad and track their buoy as it moves in the ocean currents

NOAA Aquaculture Program - a program designed to foster additional domestic marine aquaculture production to meet the growing demand for safe, healthy seafood, create jobs for U.S. coastal communities, increase regional food supply and security, and help restore depleted commercial and recreational marine species

NOAA Coral Reef Conservation Program - a partnership program to preserve, sustain and restore coral reef ecosystems using mapping, monitoring and other techniques

NOAA Corps - the smallest of the seven Uniformed Services of the United States, with approximately 321 commissioned officers

NOAA FishWatch - an authority on marine fisheries science, conservation, and management that provides consumers with relevant, factual data to assist in decisions about sustainable seafood

NOAA National Marine Fisheries Service (NMFS) - an office of NOAA dedicated to the stewardship of living marine resources through science-based conservation and management, and the promotion of healthy ecosystems

NOAA National Marine Sanctuaries - unique natural water-related habitats that are under special protection and management of their conservation, recreational, ecological, and historical resources

NOAA National Weather Service (NWS) - an office of NOAA that provides weather, hydrologic, and climate forecasts and warnings for the United States, for the protection of life and property

NOAA Teacher at Sea Program - a program that enables teachers to experience life and science on board a research vessel

Oceanography - the branch of science dealing with physical and biological aspects of the oceans

Photosynthesis - process of using energy in sunlight to convert water and carbon dioxide into carbohydrates and oxygen

Phytoplankton - tiny floating aquatic plants that use photosynthesis

Pitch - abrupt up-and-down motion; the fore and aft rocking motion of a boat

Pod - a small herd or school of marine animals, especially whales

Rays - fish having horizontally flattened bodies and enlarged wing-like pectoral fins with gills on the underside; most swim by moving the pectoral fins

Remotely Operated Vehicle (ROV) - crewless submersible vehicle that is manually controlled from a surface vessel and tethered by a cable

Right whale - a large baleen whale that can grow up to 60 feet (18 meters) in length

Roll - the side-to-side motion of a boat

ROV - Remotely Operated Vehicle

Skates - part of the shark family with a flattened body and a thin, fleshy tail

Sonar - the use of transmitted and reflected sound waves to detect underwater objects

Species - a group of plants or animals having similar appearance

Stateroom - a room or accommodation on board a ship, also called a cabin

Survey - to examine and record the features, species, or habitat of an area

Survey tow - the dragging of a net through the water to catch a sample of organisms

Symbiotic - an ecological relationship between two organisms that may be beneficial to one or both organisms

Total allowable catch - the total amount of fish allowed to be caught from a particular region by all resource users over a particular period of time

Transducer - an underwater transmitter of sound waves

Viscera - the intestines

Watch Chief - the person on board a fisheries vessel who coordinates all planning and scheduling of surveys on deck

Winch - a machine for lifting and lowering heavy items on a ship

Yaw - the rotation of a ship about its vertical axis to cause it to create a fish-tail like motion

Zooplankton - small aquatic animals that are suspended or swimming in water



Teacher at Sea Program / Teacher in the Air Program

Since its inception in 1990, the NOAA Teacher at Sea (TAS) program has offered educators around the country the opportunity to see NOAA's exciting scientific research first hand. As of 2008, over 500 teachers have participated in the program, representing 48 states, American Samoa, Chile, Argentina, and Puerto Rico. The program provides kindergarten through college-level teachers the chance to live and work side-by-side, day and night, with those who contribute to the world's body of scientific knowledge, and then take that experience back to the classroom.

The NOAA Teacher at Sea Program plans to expand its current offerings by including Teacher in the Air, Teacher in the Lab and Teacher in the Field components. Visit <http://teacheratsea.noaa.gov> to learn more.

Activities:

1. Know Your Nautical Navigators

Research famous oceanographers! Using the Internet and other resources, learn more about these and other ocean explorers.

Robert Ballard

Henry B. Bigelow

Eugenie Clark

Jacques-Yves Cousteau

Sylvia Earle

William Ewing

Jacques Piccard

2. Haddock survey data exercise

Calculate the **mean**, **median**, and **mode** for the length and weight of haddock caught during a survey tow. While working on these tough math problems, don't get a haddock!

| Length (in cm) | Weight (in kg) |
|----------------|----------------|
| 34 | 0.42 |
| 41 | 1.08 |
| 36 | 0.52 |
| 37 | 0.93 |
| 38 | 0.56 |
| 39 | 0.72 |
| 40 | 0.66 |
| 41 | 0.93 |
| 36 | 0.84 |
| 43 | 0.92 |
| 36 | 1.08 |
| 45 | 0.93 |
| 46 | 1.16 |

3. Marine Matching

Directions: Identify the following marine species based on your own knowledge and the information provided in this book.

Skate

Mako shark

Whale shark

Scallop

East Coast (American) lobster

West Coast lobster

Sheephead

Garibaldi

Phytoplankton

Krill

Manta Ray

Salmon



4. Say it like a Scientist!

Use the Internet to improve your fisheries vocabulary!

Directions: Use your knowledge, the text in this book, and the Internet as resources to help you match the following technical terms with their definitions or examples.

Anadromous \ə-'na-drə-məs\ **fish**

Brachiopod \brā-kē-ə-pād\

Catadromous \kə-'ta-drə-məs\ **fish**

Cetacean \si-'tā-shən\

Coral \kór-əl\

Crustacean \krəs-'tā-shən\

Echinoderm \i-'kī-nə-dərm\

Marine fish

Marine plant

Mollusk \mā-ləsk\

Pinniped \pi-nə-ped\

fish that are born in the ocean, live in fresh water for a while, and return to the ocean to spawn

bottom-dwelling, filter-feeding invertebrates

seals, sea lions, walrus

any of a broad range of animals with a soft body that is protected by a hard calcareous shell such as clams

seagrasses, mangroves, algae

spend entire life in salt water

invertebrate animal with polyps

any of numerous radially symmetrical marine invertebrates having an internal calcareous skeleton

whales, dolphins, porpoises

fish that are born in fresh water, migrate to the ocean to grow into adults, and return to fresh water to spawn

crabs and lobsters



Conversions

1 kilometer (km) = 1,000 meters (m) = .6214 miles (mi)

1 foot (ft) = .3048 meters (m)

1 mile (mi) = 5,280 feet (ft) = .8690 nautical mile

1 knot (kt) = 1 nautical mile per hour = 1.15 miles per hour (mph)

1 knot (kt) = 1.85 kilometers per hour (kph) = .51 meters per second (m/s)

1 meter (m) = 39.37 inches (in)

1 centimeter (cm) = .3937 inches (in)

1 kilogram (kg) = 2.205 pounds (lb)

1 yard (yd) = .9144 meters (m)

Internet Resources for Teachers, Parents, and Students

Discovery of Sound in the Sea: <http://www.dosits.org>

Mr. Tanenbaum's website: <http://www.jacobtanenbaum.com/noaa08>

National Oceanic and Atmospheric Administration (NOAA): <http://www.noaa.gov>

NOAA Adopt a Drifter Program: <http://www.adoptadrifter.noaa.gov>

NOAA Aquaculture Program: <http://aquaculture.noaa.gov>

NOAA Coastal Services Center (NCSC): <http://www.csc.noaa.gov>

NOAA Commissioned Officer Corps: <http://www.noaacorps.noaa.gov>

NOAA Coral Reef Watch Program: <http://coralreefwatch.noaa.gov>

NOAA Diving Program: <http://www.ndc.noaa.gov>

NOAA FishWatch Program: <http://www.nmfs.noaa.gov/fishwatch>

NOAA National Environmental Satellite, Data, and Information Service (NESDIS): <http://www.nesdis.noaa.gov>

NOAA National Marine Fisheries Service (NMFS): <http://www.nmfs.noaa.gov>

NOAA National Marine Sanctuaries: <http://sanctuaries.noaa.gov>

NOAA National Ocean Service (NOS): <http://www.oceanservice.noaa.gov>

NOAA National Weather Service (NWS): <http://www.nws.noaa.gov>

NOAA NWS Ocean Prediction Center (OPC): <http://www.opc.ncep.noaa.gov>

NOAA Office of Coast Survey: <http://chartmaker.ncd.noaa.gov>

NOAA Office of Education (OESD): <http://www.oesd.noaa.gov>

NOAA Office of Marine and Aviation Operations (OMAO): <http://www.omaο.noaa.gov>

NOAA Office of Oceanic and Atmospheric Research (OAR): <http://www.research.noaa.gov>

NOAA Ship *Henry B. Bigelow*: <http://www.moc.noaa.gov/hb>

NOAA Ship *Albatross IV*: <http://www.moc.noaa.gov/al>

NOAA Teacher at Sea Program: <http://www.teacheratsea.noaa.gov>

NOAA Research Vessels

NOAA currently has a fleet of 19 active research and survey ships from which scientists can gather information at sea. These ships do oceanographic and atmospheric research, fisheries and coastal research, and hydrographic surveys. The following are descriptions of NOAA's fisheries vessels that acquire the data NOAA uses for marine habitat health.

The NOAA Ship *Henry B. Bigelow* is one of the most technologically advanced fisheries survey vessels in the world. It was launched at VT Halter Marine, in Pascagoula, Mississippi on July 8, 2005. *Henry B. Bigelow* is the second of four new fisheries survey ships to be built by NOAA. The ship was named by Catherine Silver of Winnacunnet High School in Hampton, N.H., who won the NOAA ship-naming contest in 2004.

Henry B. Bigelow supports NOAA's mission to protect, restore and manage the use of living marine, coastal, and ocean resources through ecosystem-based management. Its primary objective is to study and monitor Northeast Marine Fisheries throughout New England. The ship also observes weather, sea state, and other environmental conditions, conducts habitat assessments, and surveys marine mammal and marine bird populations.

Henry B. Bigelow (1879–1967) was an oceanographer and marine biologist who worked at Harvard University for 62 years and was the first director of the Woods Hole Oceanographic Institution.



Henry B. Bigelow

The NOAA Ship *Albatross IV* (recently decommissioned) conducted fishery and living marine resource research in support of NOAA's National Marine Fisheries Service, Northeast Fisheries Science Centers, and Woods Hole Laboratory in Woods Hole, Massachusetts. The ship's normal operating area was the Gulf of Maine, Georges Bank, and the continental shelf and slope from Southern New England to Cape Hatteras, North Carolina. Typical assessment work included fish and ecosystem monitoring surveys.



Albatross IV

Other vessels that support the NOAA Fisheries Service and the management of marine ecosystems (home port shown in parentheses) include the:

Delaware II (Woods Hole, Massachusetts)

Oscar Dyson (Kodiak, Alaska)

Miller Freeman (Seattle, Washington)

Gordon Gunter (Pascagoula, Mississippi)

Hi'ialakai (Honolulu, Hawaii)

David Starr Jordan (San Diego, California)

McArthur II (Seattle, Washington)

Oregon II (Pascagoula, Mississippi)

Oscar Elton Sette (Honolulu, Hawaii)



Answers to sidebar and activity questions:

Page 4: 60 people

Page 6: Marine mammals have hair, warm blood, lungs, mammary glands, and a hinged jaw. They are able to keep themselves warm, breathe air, give live birth and are highly adapted to swimming.

Fish are highly adapted for ocean life with gills where they take in water and extract air. They have a swim bladder and scales. Fish are cold blooded and are the most diverse group of vertebrates.

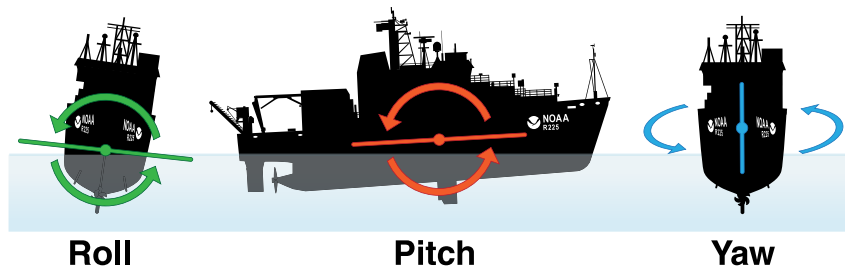
Here is a table showing the differences and similarities between marine mammals and fish.

| Characteristic | Mammals | Fish | Both |
|----------------------------|---------|------|------|
| Hatch from eggs | | X | |
| Have a backbone | | | X |
| Have brains | | | X |
| Have fins | | | X |
| Have gills | | X | |
| Have hair | X | | |
| Have a heart | | | X |
| Have live birth | X | | |
| Have lungs | X | | |
| Have scales | | X | |
| Have swim bladder | | X | |
| Live in water | | | X |
| Most do not care for young | | X | |
| Move tail side to side | | X | |
| Move tail up and down | X | | |
| Nurse babies | X | | |
| Swim | | | X |

Based on a lesson at <http://marinediscovery.arizona.edu/lessonsS01/gobies/2.html>

Page 12: Sea scallops live up to 20 years, with adult scallops typically found in dense groups called “beds” on the ocean floor.

Page 16: Drawing of roll, pitch, and yaw:



Page 31: Activity 2 Answer Key

| | Length | Weight |
|--------|--------|--------|
| mean | 39.4 | 0.83 |
| median | 39 | 0.92 |
| mode | 36 | 0.93 |

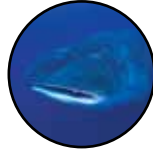
Page 32: Activity 3 Answer Key



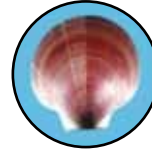
Skate



Mako shark



Whale shark



Scallop



East Coast
(American) lobster



West Coast
lobster



Sheephead



Garibaldi



Phytoplankton



Krill



Manta Ray



Salmon

Page 32: Activity 4 Answer Key

Anadromous fish: fish that are born in fresh water, migrate to the ocean to grow into adults, and return to fresh water to spawn

Brachiopod: bottom-dwelling, filter-feeding invertebrates

Catadromous fish: fish that are born in the ocean, live in fresh water for a while, and return to the ocean to spawn

Cetacean: whales, dolphins, porpoises

Coral: invertebrate animal with polyps

Crustacean: crabs and lobsters

Echinoderm: any of numerous radially symmetrical marine invertebrates having an internal calcareous skeleton

Marine fish: spend entire life in salt water

Marine plant: seagrasses, mangroves, algae

Mollusk: any of a broad range of animals with a soft body that is protected by a hard calcareous shell such as clams

Pinniped: seals, sea lions, walrus

