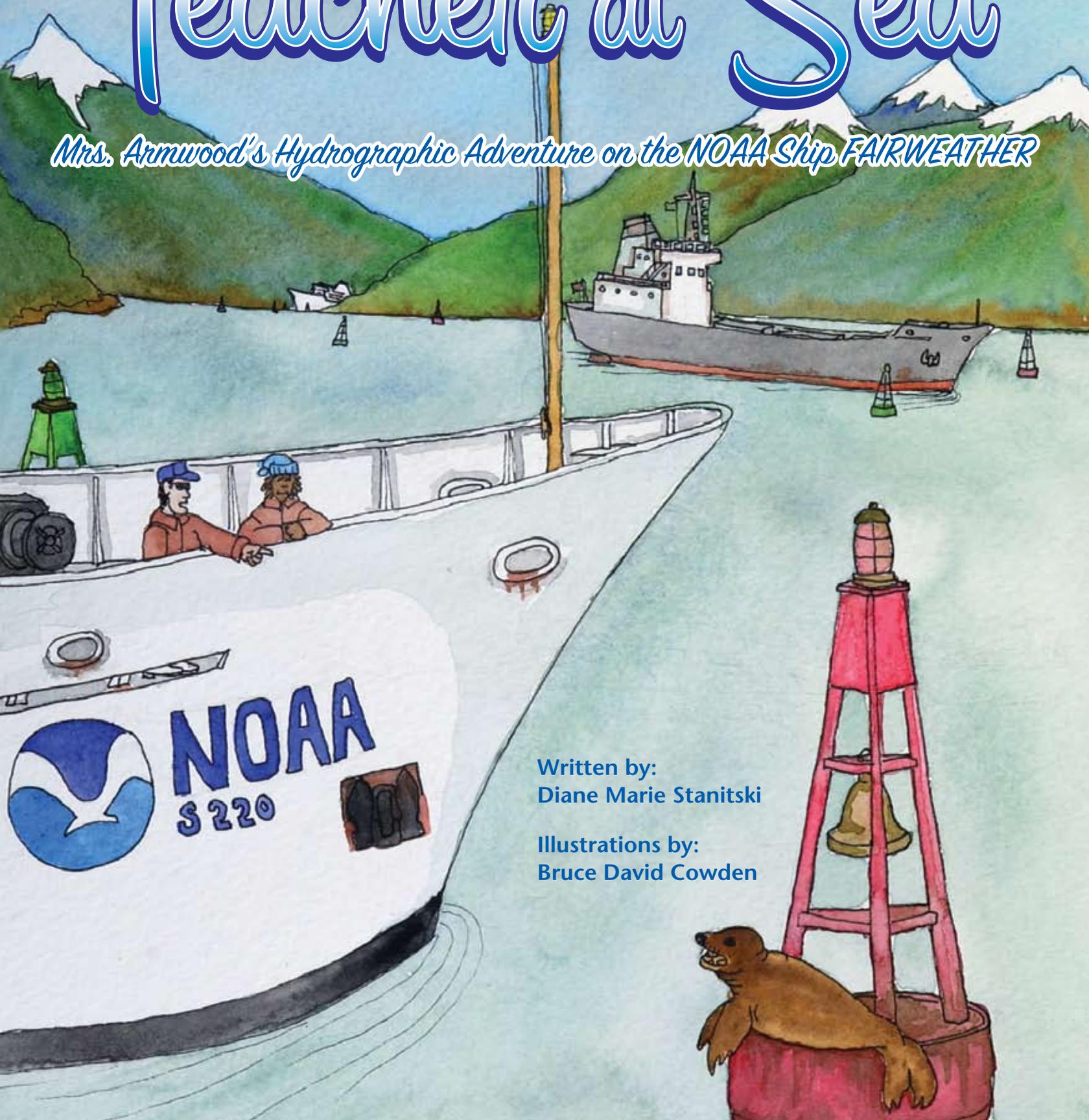


Teacher at Sea

Mrs. Armwood's Hydrographic Adventure on the NOAA Ship FAIRWEATHER



Written by:
Diane Marie Stanitski

Illustrations by:
Bruce David Cowden



Teacher at Sea

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A special note of appreciation goes to Rear Admiral Samuel P. De Bow, Jr., for his vision and support of each edition in the NOAA Teacher at Sea/Teacher in the Air children's science book series.

This children's science book is the third in a series of NOAA publications. As with the first two books, all items in **bold** are defined in the glossary starting on page 32. Words in **blue** are described at the bottom of the page where they appear.

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This book is dedicated to the crewmembers, NOAA Corps officers, and scientists who conduct hydrographic work on board NOAA survey vessels, for their tireless efforts to keep our waterways safe.



Teacher at Sea

Mrs. Armwood's Hydrographic Adventure on the NOAA Ship FAIRWEATHER

Mrs. Linda Armwood and her students at George Wythe High School in Richmond, Virginia, were working on ocean mapping projects in their classroom. They planned to present these projects to their peers to commemorate World **Hydrography** Day, June 21st. The students knew little about hydrography at the beginning of the school year, so Mrs. Armwood first explained that “hydro” means water and “graphy” means to write or describe. A scientist who measures, charts, and describes features of the sea and coastal areas is called a hydrographer. The surveys created by hydrographers are used by **cartographers** to make **nautical charts** for the safe movement of ships, cargo, and people on the water.

Mrs. Armwood worked closely with the History Department Chairperson to describe how the economy of the United States 200 years ago was largely dependent on **maritime** trade with Europe. During this time little was known about what lay beneath the water's surface, so shipwrecks often occurred due to hazards such as rocks and sandbars in the water. President Thomas Jefferson recognized that the success of the country depended upon maritime commerce. As a result, he established the Survey of the Coast in 1807 to map and produce nautical charts showing the safest way to travel through our waters. Today, nautical charts are made in the Office of Coast Survey, which is part of the **NOAA National Ocean Service**.

As soon as the students heard the word *shipwreck*, they became eager to learn more. During their **oceanography** unit they learned that there are approximately 10,000 submerged wrecks and obstructions in the coastal waters of the United States! These obstructions sometimes shift or break up into smaller pieces. Hurricane Katrina is an excellent example of this kind of event. The storm's extreme fury caused flooding and high waves to shift the sand and wrecks all along the Gulf of Mexico. Some areas deepened, while others became more shallow. This created dangerous conditions for the ships attempting to reach port, because objects on the nautical charts had moved to different locations. Hydrographers had to quickly survey the altered waterways and coastline to avoid problems with ships running aground or into hazards.

As the students worked on their projects, Mrs. Armwood shared the exciting news that she had been selected to sail aboard the **NOAA Ship FAIRWEATHER** along the Alaskan coast from Ketchikan to Sitka. She would soon be a NOAA Teacher at Sea! This also meant that she would learn more about coastal **bathymetric surveying**, or mapping of the sea floor, that she could share with her classes upon her return. Her students were proud that she was chosen to help conduct these important surveys.

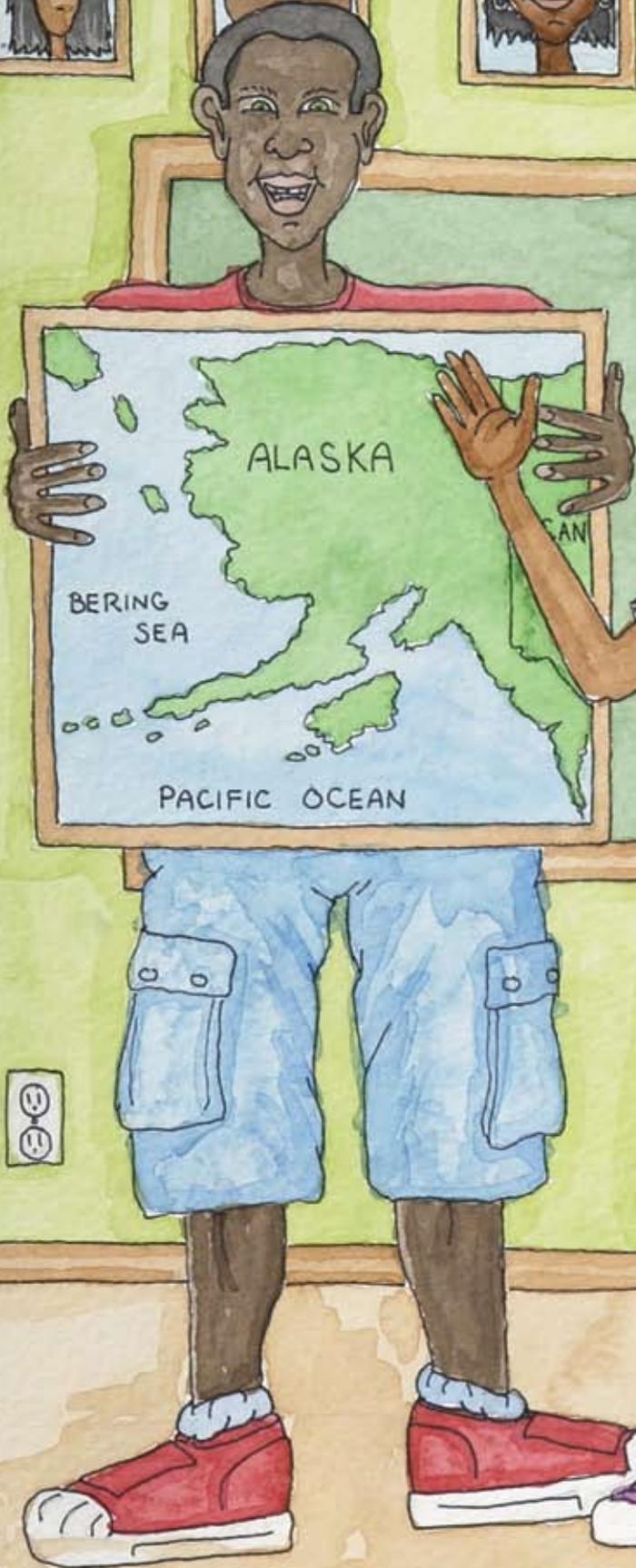


How did the National Oceanic and Atmospheric Administration (NOAA) Ship FAIRWEATHER receive its name?



What is the height of Mt. Fairweather in Alaska?

Answers on p. 36



TODAY'S SUBJECT
MAPPING
THE OCEAN
FLOOR



Before leaving on her exciting trip, Mrs. Armwood described the history of the NOAA Ship FAIRWEATHER to her students based on her research on the NOAA web site (www.noaa.gov). The home port for the FAIRWEATHER is Ketchikan, Alaska. The ship was **commissioned** in 1968 and designed specifically to conduct hydrographic surveys to make nautical charts. Mrs. Armwood explained that the ship is equipped with scientific instruments such as **multibeam echosounders** and **side-scan sonar**. Although these sounded very technical, she knew she would learn enough about these tools to explain to her students how they work and what purpose they serve. She would write daily journal entries while on board and NOAA would make them available to her students on the Teacher at Sea web site (www.teacheratsea.noaa.gov). What an opportunity this would be for everyone!

Four weeks later, Mrs. Armwood flew west from Virginia...over the Great Plains and Rocky Mountains to Seattle, and then along the coast to Alaska. What amazing scenery she saw out her window! She always chose a window seat whenever she flew so that she could study the changing landscape and learn more about the **physical geography** of the country.

Soon after Mrs. Armwood arrived in Ketchikan, a FAIRWEATHER **Survey Technician**, a crewmember responsible for the ship's **hydrographic** work on board, picked her up at the airport. After meeting the ship's **Executive Officer** and crewmembers who were on duty when Mrs. Armwood toured the ship, she caught her first glimpse of the instruments used to survey water depths. She stepped into a **launch**, the 29-foot boat that would be lowered from the ship into the water to conduct the actual hydrographic work. The tour ended with a quick view of her **stateroom** where she was assigned the top bunk. From her bed she could easily peer out the **porthole** to watch for seabirds and marine mammals.

She unpacked quickly since two of the crewmembers said that they would take her on a tour of Ketchikan to learn about its history. They showed her the beautiful totem poles designed and carved by the native Alaskans. These early inhabitants gave Ketchikan its name, meaning "spread wings of a thundering eagle." Originally, most of the people in the town made their living by fishing or lumbering. Ketchikan was once known as the salmon capital of the world. Today, tourism is the leading industry.

What an exhilarating day! Mrs. Armwood went to bed with dreams of tomorrow's surveying adventures.





After a peaceful night's rest and a delicious breakfast in the ship's **mess**, Mrs. Armwood traveled in the launch with crewmembers and scientists to a remote site along the shore. The team was called a *tide party*, led by a **Tides Officer** and three onshore groups: the exploration and planning team, the benchmark recovery and installation team, and the dive and install team. They first hiked to a spot on the beach in order to install a **tide gauge station** in preparation for the ship surveys. Tide gauges serve a very important purpose. The depth of objects underwater--like large rocks or shipwrecks surveyed by the ship--is recorded at all stages of the **tide**. Then, during data processing, the depths of these hazards must be corrected based on changing water levels due to the tide and weather. In order to determine these changes, temporary tide gauge stations are installed near survey areas to measure the water level every six minutes. Using special calculations, hydrographers can figure out the true depth of the water above the rock or hazard.

Mrs. Armwood then helped set tidal **benchmarks**, marks placed on permanent objects on the ground where an accurate **latitude**, **longitude**, and **elevation** can be established. She worked with the benchmark recovery and installation team to place a benchmark on a flat surface on the beach. As she drilled into the bedrock with a small jackhammer, she noticed how rapidly the water levels changed due to the tide's **ebb** and **flow**.

The tide party leader told her to be alert and watch for bears as she walked along the water's edge. In order to scare them off, each member of the party was issued an air horn and told to use it immediately if a bear appeared. Mrs. Armwood was ready!

Tides are the alternating rise and fall in sea level with respect to the land, produced by the gravitational attraction of the moon and the sun. The recurrence of high and low water usually occurs twice daily.

Did you know that to a much smaller extent, tides also occur in large lakes, the atmosphere, and within the solid crust of the earth, acted upon by the same gravitational forces of the moon and sun?

? What are the names given to the tides during the full moon, new moon, and quarter moons? ?

Where is the highest tidal fluctuation experienced in the world?



After working most of the day at the tide gauge station, Mrs. Armwood and the Tides Officer stood on shore waiting for the launch to pick them up. The Officer explained the history of surveying, including how early **mariners** collected and mapped data about the surface and shallow water features of the earth and ocean. One tool that was used for surveying is the **lead line** (which rhymes with deadline). This is one of the oldest tools used to navigate – even ancient Egyptian tomb paintings show sailors using it!

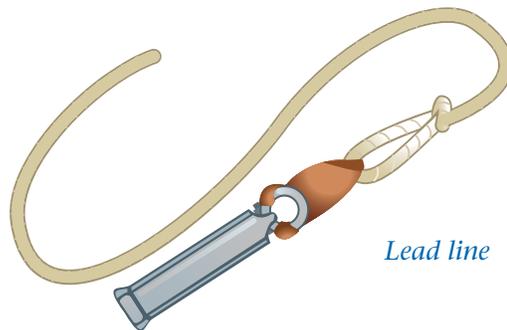
The lead line consists of a lead weight on the end of a long rope. The rope is marked at different points with strips of cloth or leather to indicate the depth. Sailors would toss out the line, read the mark where it touched bottom, and haul it back in. Often, the end of the lead weight was shaped like an upside down bowl and filled with tallow, a type of animal fat. When the weight hit the sea floor, the sediment would stick to the tallow. Sailors would then know whether the bottom was good for holding anchors, and they could add this information to their charts.

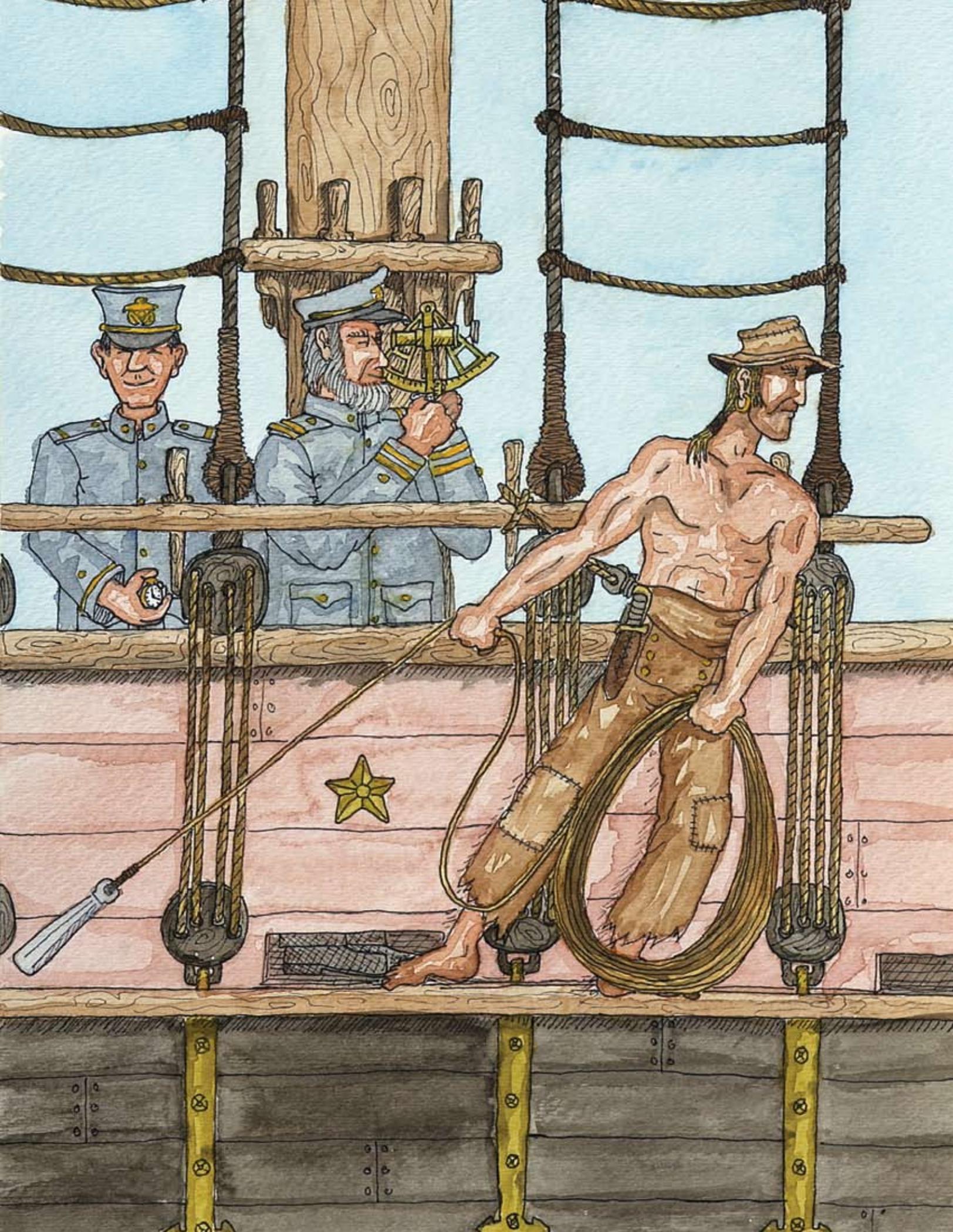
After Mrs. Armwood and the Tides Officer boarded the launch, they discussed the technique known as triangulation that surveyors once used to precisely determine an accurate position on a point of land and then on the water. **Triangulation** is based on the laws of **trigonometry** stating that, if one side and two angles of a triangle are known, the other two sides and angle can be easily calculated. Mrs. Armwood also learned that surveyors used to measure the angles using a **theodolite** before a more modern way was developed.

At 1900 **military time** (7:00 PM) in Alaska, Mrs. Armwood emailed her students in Virginia to share what she had learned so far and to ask them to complete a **time zone** exercise. She knew that they would read this exercise aloud during first period the following day while she was still sleeping, due to the four hour time difference between Alaska and Virginia.

? How many degrees make up the circumference of the Earth? If the Earth rotates once on its axis in 24 hours, how many degrees does the Earth rotate in one hour? This is equivalent to one time zone. ?

With a four hour time difference, approximately how many degrees are there between the students and Mrs. Armwood?



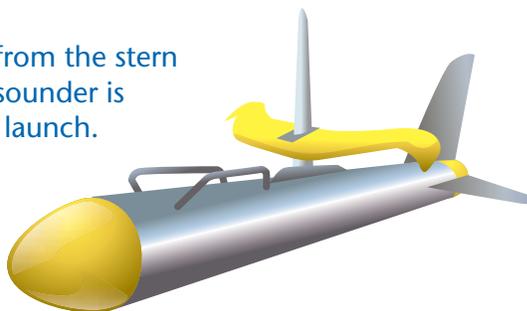


The next morning was full of activity. The hydrographers and scientists buzzed around the ship preparing for their projects at sea. One surveyor explained to Mrs. Armwood the newest technologies used to conduct hydrographic work on board the FAIRWEATHER. These included the **Global Positioning System (GPS)** satellites to navigate, similar to the system now found in many cars to assist with driving directions, yet capable of much more precise measurement. The unit was known as a GPS Navigator, and it showed the latitude and longitude of the ship for accurate placement of water depth on NOAA nautical charts. Other instruments were the **echosounder** (a device that shows the water's depth by sending a sound wave from the bottom of the ship to the sea floor), and **radar** used to spot nearby vessels and prominent points of land.

NOAA Corps officers, crewmembers, and scientists on board answered Mrs. Armwood's questions and those of her students that arrived via email each morning. One student asked about sonar, so the **Chief Survey Technician** described this technology. A large **multibeam echosounder** that uses sonar is attached to the **hull**, or bottom, of the ship. It is useful in both deep and shallow ocean water. In shallow water the seafloor is much closer so smaller objects can be discovered. Depth measurements are generated by measuring the time it takes for each of hundreds of sound pulses, sent out in a fan-like shape, to travel from the echosounder through the water to the seafloor and back again. The distance from the instrument to the ocean floor is calculated by multiplying the travel time by the speed of sound through the seawater (roughly 1500 meters/second or 4921 feet/second). Since the bottom of the ocean in any area can change due to strong storms, water currents, earthquakes or the buildup of sand and sediment, it is critical to take new measurements to make the most accurate charts of water depth and hazards to navigation. With the newest technologies, hydrographers can find interesting features that lie below the water, such as rocks, **seamounts**, or shipwrecks.

In shallow water, a **side-scan sonar "fish"** (which looks like a torpedo) is towed behind the ship or fixed to the hull of a small survey launch. Surveyors on the launch control where the boat scans the water to locate underwater objects like rocks or shipwrecks. Side-scan sonar sends out a horizontal fan-shaped series of sound waves, wider than those from the multibeam echosounder. It shows the outline and shadow of objects like wrecks, rocks, or debris that its sound wave encounters. The approximate height of a submerged shipwreck, for example, can be determined by measuring the length of the shadow that forms. Then the multibeam echosounder is used to verify the actual shape and precise depth of the object. The Chief Survey Technician told Mrs. Armwood that she would be able to gather sonar data the next day. Excited, she snapped digital photos of the instruments and sent them to her students along with an explanation of how to run the equipment.

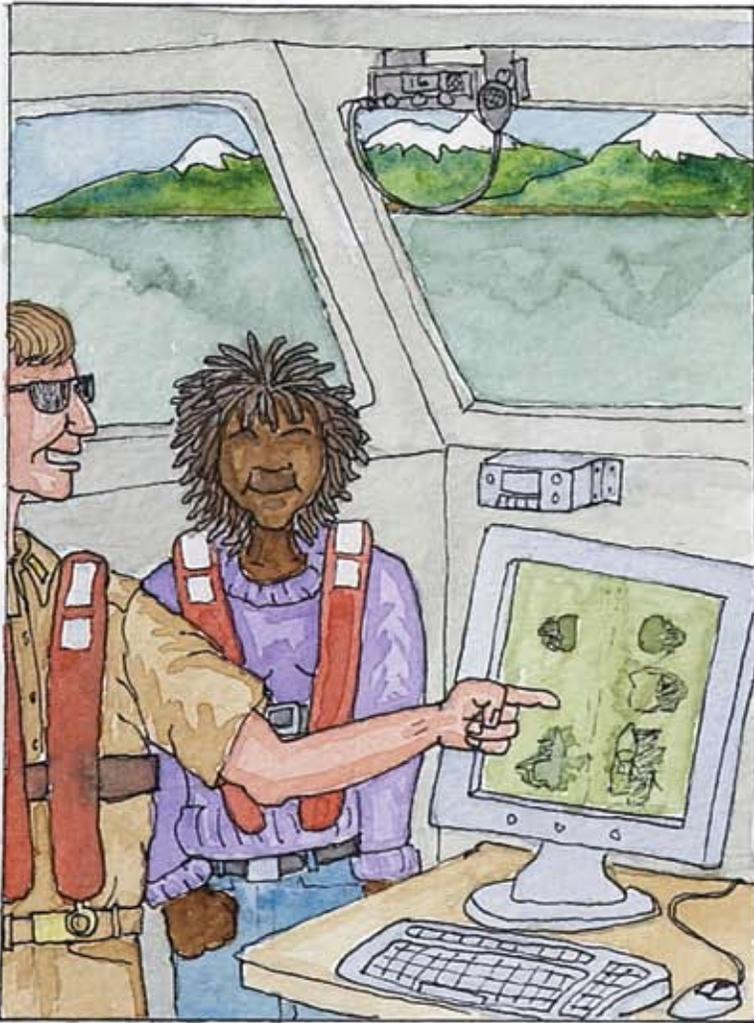
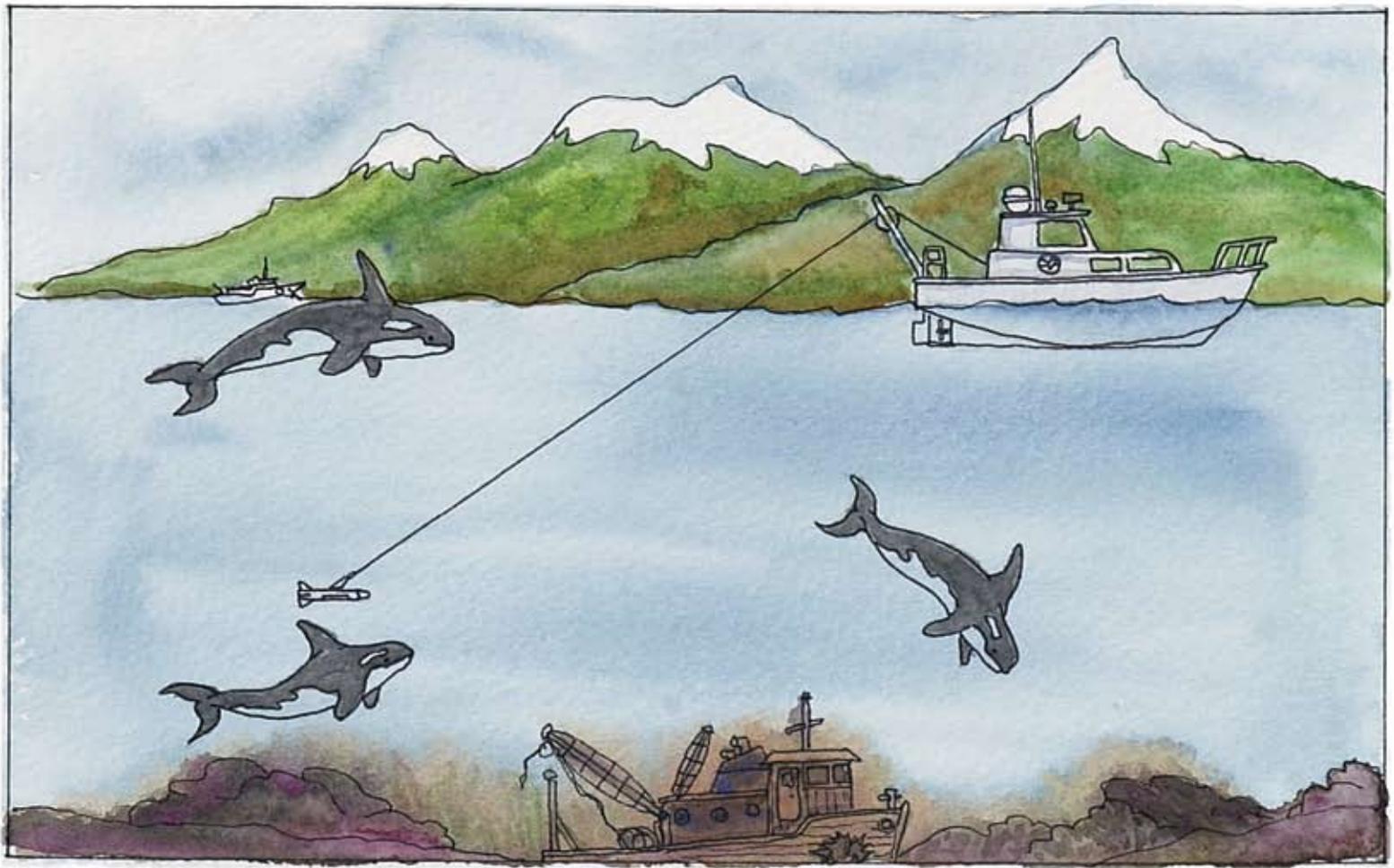
A side-scan sonar fish is towed from the stern of the ship. A multibeam echosounder is attached to the hull of a survey launch.



Side-scan Sonar



Multibeam Echosounder



The **Chief Boatswain** (pronounced boh-sun), a **plank owner** of the FAIRWEATHER, showed Mrs. Armwood how to use a bottom sampler. The sampler is a metal claw-like scoop that is lowered through the water to collect a bottom sample and identify the contents and makeup of the ocean floor. When she raised the bottom sampler she found lots of mud, shell pieces, and a beautiful wiggling starfish in the scoop!

The Chief Boatswain and Chief Survey Technician then emailed Mrs. Armwood's entire class and suggested that the students look at the tags on their shirts to discover where they were made. Many shirts read "Made in Guatemala" or "Made in China." Since they were made overseas, it is likely that a huge container ship carrying cargo transported the shirts across the ocean. This is one of many reasons why hydrographic work is so important...because there are so many ships sailing to and from our ports. They might be carrying clothes, fruit, grain, oil, cars – the list of goods carried on ships is endless! Every ship needs to navigate safely in the more shallow waters near shore. The surveying work done on the FAIRWEATHER locates features that a ship must avoid, like rocks and shoals -- shallow areas where a ship could run aground. The survey work helps to prevent accidents at sea.

Another fact shared with the students via email was that seawater is used to flush the toilets in each bathroom, or **head**, aboard the ship. If you turn out the lights in the bathroom at night you can often see **bioluminescent** phytoplankton, which are a type of free-floating aquatic plant, in the water. Flushing the toilet energizes the plankton, making them a bright green color. The same can be seen as the **bow** of the ship cuts through the water at night. Flashes of bright green are often seen in the water as the plankton are stimulated.

The Chief Boatswain always enjoyed talking with the NOAA Teachers at Sea and their students. He loved to describe the hydrographic work done on the FAIRWEATHER and general life as a sailor. He promised that he would visit Mrs. Armwood's class once the ship's crew completed its current mission.

A plank owner is a member of the original commissioning crew of a ship. In the old days, a plank owner on a wooden ship was awarded a piece of wood from the ship when he or she retired or was transferred. On metal ships a plank owner receives a plaque or certificate.



The next morning, Mrs. Armwood and two fellow crewmembers were lowered down the side of the ship in a launch to begin scanning, or surveying water depths. The scan path is typically referred to as “mowing the lawn” and requires that the launch travel back and forth in a series of closely spaced lines to determine the bathymetry (seafloor topography) along the bottom of the ocean.

A CTD probe is **deployed** in the same location where the sonar data are collected to determine the **conductivity**, temperature, and depth of the water, which helps correct the data due to the **refraction**, or bending, of sound through water. Sound waves travel quickly through water at a speed of 1500 m/s (4921 ft/s), faster than they move through the air (350 m/s or 1148 ft/s), but the interesting thing is that water temperature, pressure, and **salinity** also affect the speed of sound through water.

Back on board the FAIRWEATHER, a **Junior Officer** gave Mrs. Armwood instructions for driving the launch during the survey. As she “mowed the lawn,” Mrs. Armwood noticed that several whales were detected by the sound waves and displayed on the monitor. Porpoise appeared in front of the ship to ride the **bow wave**. Mrs. Armwood also spotted **icebergs** dotting the surface of the water like ice cubes in a punch bowl. The **Captain** told her that seemingly small icebergs reveal only 1/8th of their mass above the water. The rest of each iceberg is submerged, making it easy to miscalculate its size. Icebergs can be real hazards to mariners, although they cannot be charted since they constantly move.

After lunch, Mrs. Armwood arrived in the main science lab just in time to see how depth **soundings** (with numbers stated in **fathoms**, feet, or meters) are displayed on the computer’s monitor. She also saw the multibeam echosounder in action that she had learned about the day before. It was neat to watch a picture of an underwater rock that the boat was passing over at that moment, appear before her very eyes on the screen. Digital technology is truly amazing! If a side-scan image shown on the computer monitor cannot be identified, a NOAA diver often goes down to the object to locate, identify, measure and investigate it to determine the least depth over the object. This provides enough information to accurately produce a chart for navigation purposes.

The Chief Survey Technician told Mrs. Armwood that “chart” is the correct term to use instead of “map” for any ocean document used for navigation. Based on the survey data collected, cartographers produce an easy-to-read nautical chart of the ocean bottom so that mariners can identify the “best water,” or safest path, that ships and boats should take through the water.

A fathom is a unit of measurement used on the seas to measure depth and is equal to 6 feet or 1.8 meters. Originally, it was the distance between a sailor’s outstretched arms.



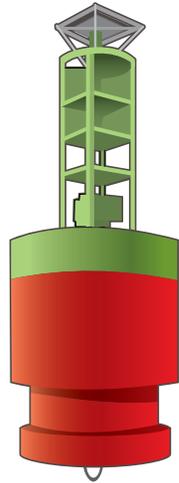
After one week and many discussions with the hydrographers on board, Mrs. Armwood was prepared to talk about the significance of coastal surveying with her students. Safe navigation is incredibly important for many reasons, especially for the movement of commercial vessels and cruise ships, protection of the environment, commercial fishing, and **ecotourism**. Mrs. Armwood remembered when one of her friends returned from a cruise with her family and mentioned that the cruise ship had nearly run aground due to a sandbar that had shifted. All vessels rely on accurate **nautical charts** to reveal features like rocks and wrecks that must be avoided. The job of the coastal surveyor is extremely important for the safety of many people!

This was Mrs. Armwood's last morning on board and, as a dense fog set in, she was especially appreciative that there were many **aids to navigation** available. She appreciated the buoys and lights that helped the ship navigate at night and in low visibility conditions to travel safely into port. The fog reminded Mrs. Armwood of the importance of documenting changing weather patterns along the way. Fortunately, NOAA delivers the marine weather information needed by ships at sea and communities along the coast. Ships depend on the forecasts from the NOAA **National Weather Service** Ocean Prediction Center and coastal Forecast Offices to alert them to dangerous conditions. The NOAA **National Environmental Satellite, Data, and Information Service (NESDIS)** reports real-time sea level data. The NESDIS **Geostationary Operational Environmental Satellites (GOES)** provide weather data that are updated every six minutes, which is useful for weather forecasting for a ship's safe travel.

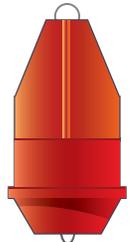
Aids to navigation



Nautical Chart



Lighted
Navigation
Buoy



Nun Buoy



Can Buoy

The U.S. Aids to Navigation System is intended for use with Nautical Charts, which are one of the most important tools used by boaters to safely navigate waterways. Charts show the coastline, presence of buoys and beacons, water depth, features on the land, and marine hazards. Buoys are floating aids that come in an array of shapes and sizes and are intended to convey information to the boater by their shape or color, by a visible or audible signal, or a combination of the two. For example, red buoys mark the right side of a channel when a vessel is returning from sea while the green buoys mark the left side of the channel.



NOAA
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Upon arrival back on shore in Sitka, Alaska, Mrs. Armwood was delighted to hear that she and her students had been invited by an Admiral in the NOAA Corps to visit the NOAA Ship THOMAS JEFFERSON in Norfolk, Virginia, in just a few weeks. There would be a change of command ceremony, at which Mrs. Armwood would represent all NOAA Teacher at Sea alumni who had contributed to ocean science research in the past. The ceremony would also serve as an opportunity to highlight NOAA's many years of science and service, and its early history surveying the nation's coastal waters.

Mrs. Armwood said her goodbyes to all of the scientists, officers, and crew on board the FAIRWEATHER. They gave her gifts of charts and sample benchmarks to share with her students. She expressed her sincere gratitude to everyone for their help in making her experience educational and so much fun! She would encourage all of her teacher friends to apply for the NOAA Teacher at Sea Program so that they too could have this opportunity. Before flying home later that day, she took pictures of the beautiful scenery in Sitka to show her students.

...two weeks later...

Mrs. Armwood and her students arrived at the dock in Norfolk in time to take a launch to the NOAA Ship THOMAS JEFFERSON. After hearing her stories and seeing her photographs taken during the past two weeks, Mrs. Armwood's students were beyond excited! They brought their cameras and notebooks and wore NOAA pins that she had given them. As they approached the ship, the students realized they would get to be part of a very significant event.

During the change of command ceremony, many speakers described the significance of the name, THOMAS JEFFERSON. One woman spoke about Thomas Jefferson's interest in science--that he was one of the first weather observers and a visionary who tirelessly promoted science. Mrs. Armwood's students watched the Captain beam with pride as she handed off the ship to the incoming **Commanding Officer**. Both officers spoke about the exciting and very important coastal surveying work conducted on board the ship.



NOAA Ship FAIRWEATHER



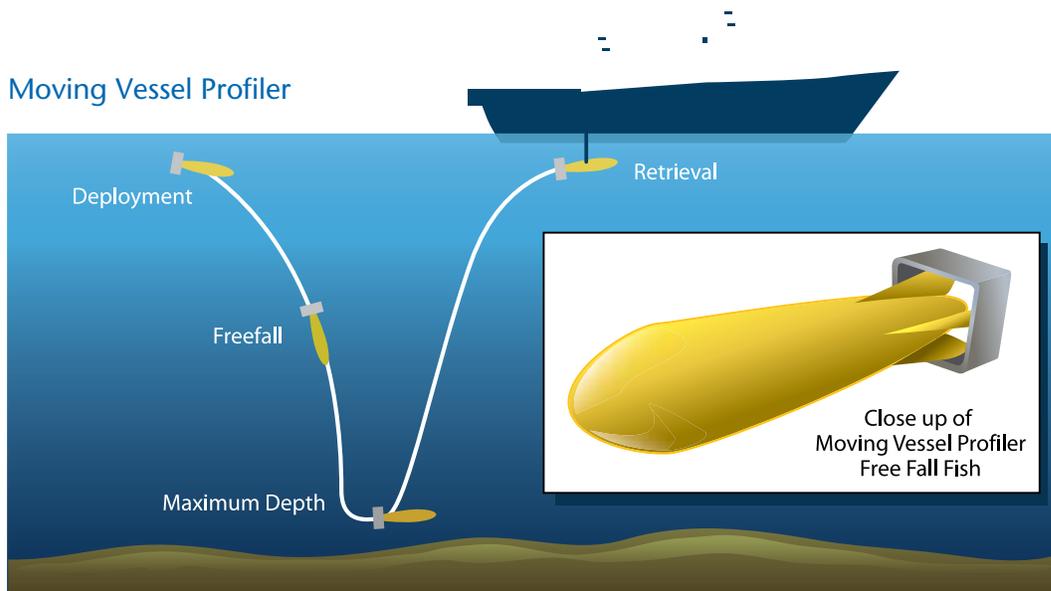
NOAA Ship THOMAS JEFFERSON

It wasn't until hearing the outgoing Captain describe what had been accomplished under her command that Mrs. Armwood realized just how much work is done on board the NOAA ships. All the science would not be possible without the dedication of the **NOAA Corps** officers who typically spend two to three years on a ship for their tour of duty, and the wage mariners (crew) who serve under their command. As part of the **NOAA Office of Marine and Aviation Operations (OMAO)**, hydrographic officers and survey technicians take charge of every facet of survey operations. All NOAA Corps officers have a background in science, engineering, or mathematics so they can participate in oceanic and atmospheric research.

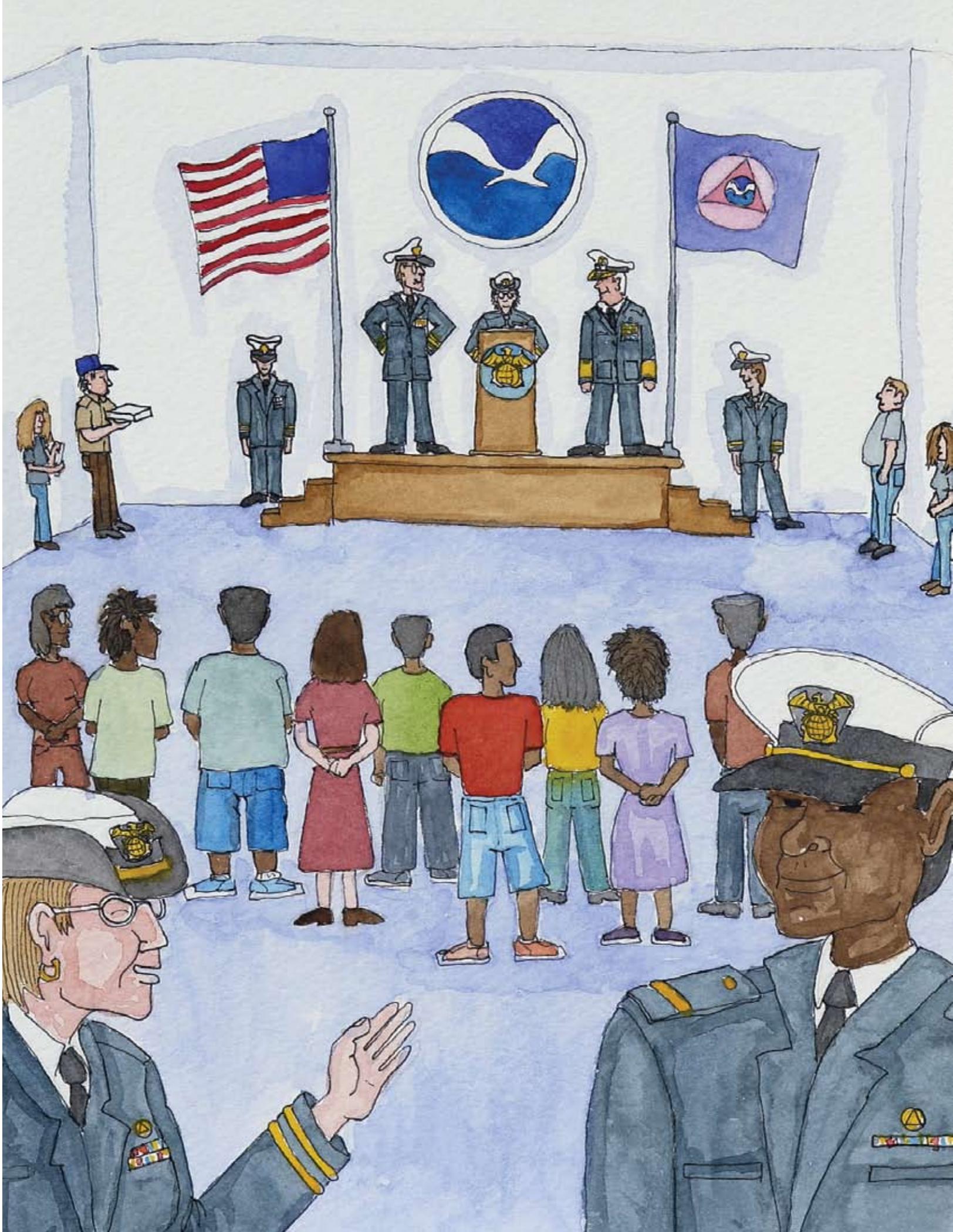
The Corps officers and an array of crewmembers introduced themselves and welcomed Mrs. Armwood and her students. They said that there would be many instruments to see and field activities in which to participate while visiting the THOMAS JEFFERSON.

One of the newest instruments that the crew and officers were very proud of is the **Moving Vessel Profiler**. This is a CTD probe (similar to the one on the FAIRWEATHER) programmed to stop at three meters above the bottom of the ocean. Then, it continuously moves up and down collecting important temperature and salinity data to help correct data due to bending of the sound waves. The instrument deploys a shiny brass "fish" that measures sound velocity from the bottom to the top of the water. With these new data, critical corrections to the water depth measurements by the multibeam echosounders are made.

As Mrs. Armwood and her students began a tour of the ship, they spoke with a member



Men and women of the NOAA Commissioned Officer Corps are an integral part of the National Oceanic and Atmospheric Administration. Officers can be found operating NOAA ships and aircraft to provide support to meet NOAA's missions. Duties and areas of operations can range from launching a weather balloon at the South Pole, conducting hydrographic or fishery surveys in Alaska, maintaining buoys in the tropical Pacific, or flying snow surveys or into hurricanes. To find out how to become a NOAA Corps officer, go to www.noaacorps.noaa.gov.

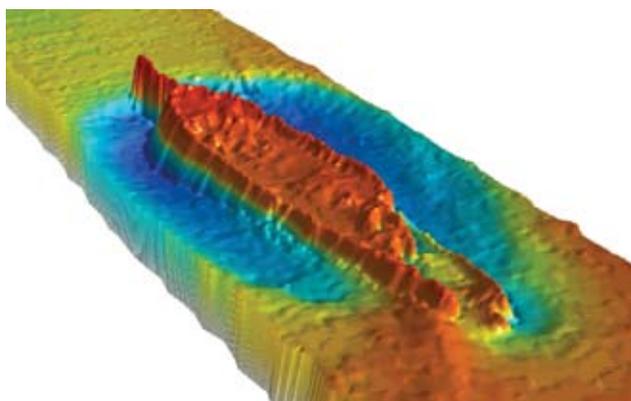


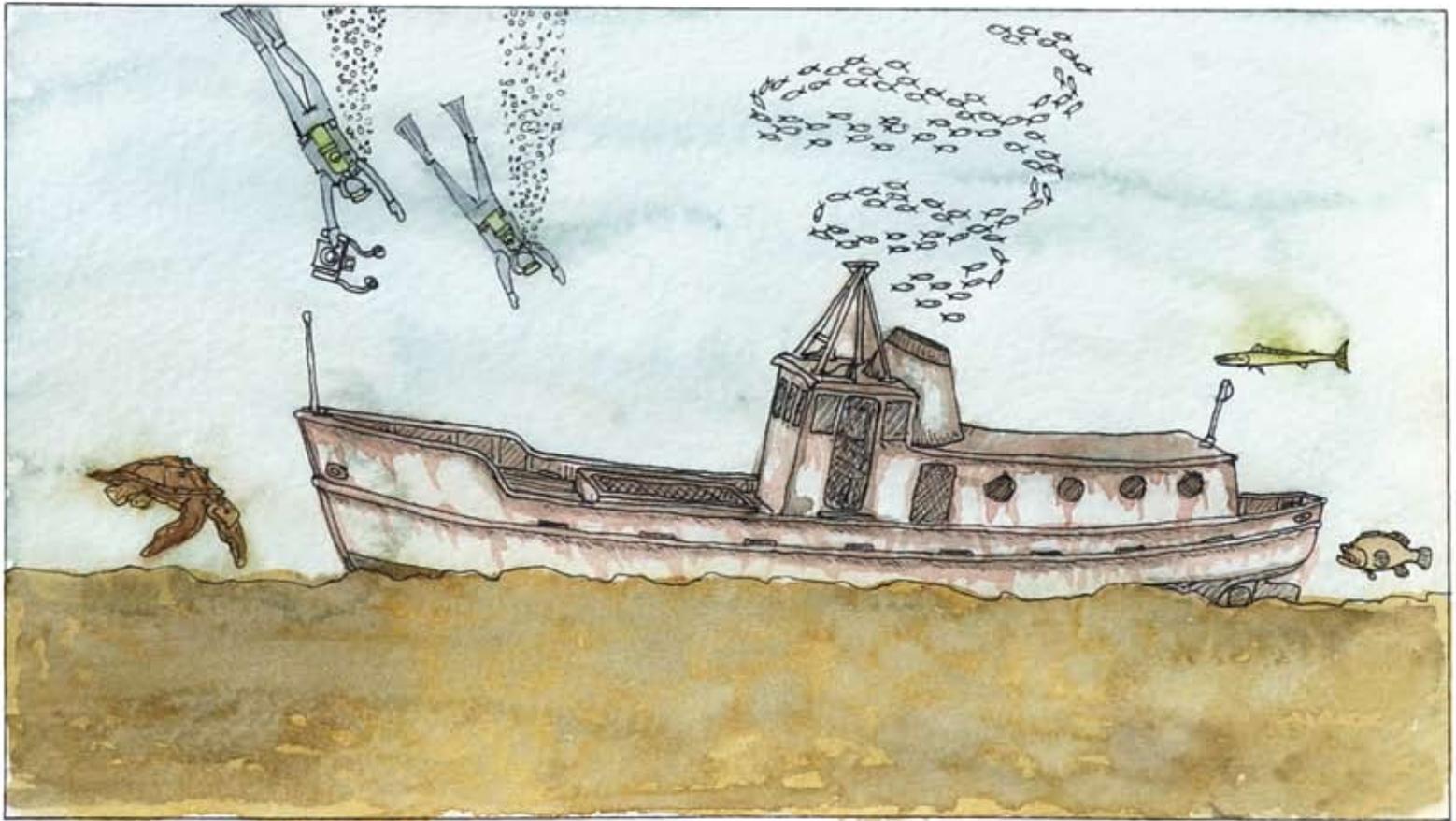
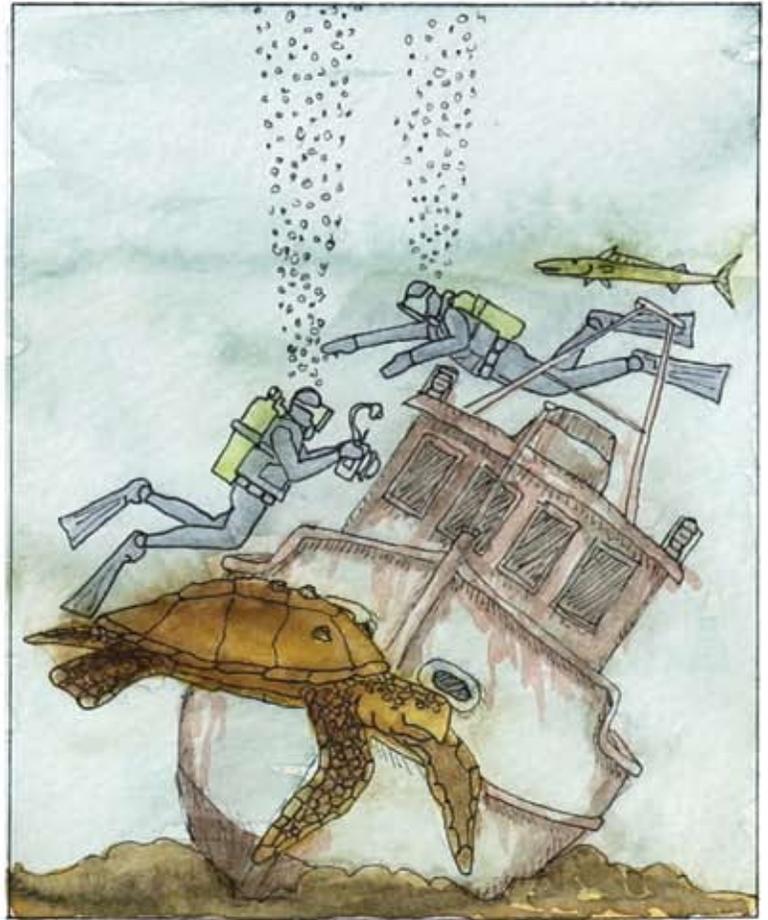
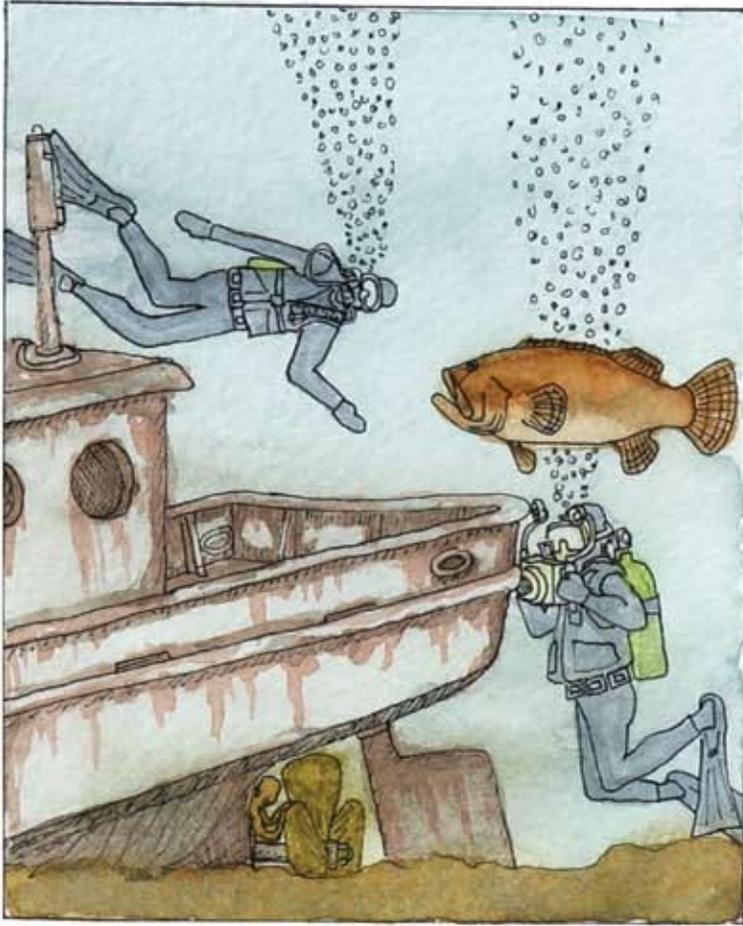
of the NOAA Office of Ocean Exploration. As a diver, he focuses on deep ocean water and the new resources that can be detected, including minerals, sea worms, and **hydrothermal vents**. He shared a story about the ship's hydrographic work involving the discovery of an uncharted obstruction during a routine hydrographic survey far off the coast of Cape Hatteras, North Carolina. Side-scan sonar detected an object approximately 60 feet (18.3 meters) in length. Multibeam echosounders accurately imaged it, revealing a large sunken ship that could be a potential hazard to navigation.

Two NOAA Corps officers, members of a two-person dive team, were sent down to accurately measure and identify the ship. They described the object as completely covered with algae, kelp, and growth with a fish population living around the wreck. It sat in fine white sand and served as an artificial reef for a thriving underwater ecosystem. The divers determined that the ship's mast was just 9 feet (2.7 meters) below the ocean surface at low tide. A Cape Hatteras resident who had been around for many years said that the Outer Banks of North Carolina were famous for shipwrecks due to shifting sandbars and storms. He said that his grandfather often spoke of the nor'easters, or powerful storms forming in the Atlantic, that caused many ships to go down around Cape Hatteras. Perhaps the ship that the NOAA survey team discovered years later ran aground in such a storm. The ship's location was noted, and a danger to navigation was posted in the U.S. Coast Guard "**Local Notice to Mariners.**" This publication alerts mariners to changes in aids to navigation, and other updates they need to know about on the nautical charts.

At the end of the tour, Mrs. Armwood and her students had an opportunity to speak

Shipwreck shown with side-scan sonar (top) and multibeam sonar (bottom)





with an expert from the NOAA **National Marine Fisheries Service (NMFS)**. He described the technology used to determine the health of habitats for sea creatures, both plants and animals. This technology includes the use of side-scan and multibeam sonars, which Mrs. Armwood had observed on the FAIRWEATHER. A **Sea Grant** student explained the importance of using environmentally friendly practices when in port. This means that a researcher must always consider the animals and plants that are affected by the research. The Sea Grant student wanted to introduce Mrs. Armwood's students to the engineer who could tell them more about these concerns, so she took them to the engine room in the hull of the ship.

The engineer explained that many invasive species, or creatures that are not native to U.S. waters, arrive here as stowaways in ship **ballast** water. Ballast water is water that is pumped into the bottom of a ship in one port to help stabilize it as it uses fuel in transit to another port. Then, when it reaches its destination, sometimes thousands of miles away, it discharges the ballast water into the sea. It is hard to believe, but every hour about two million gallons of foreign ship ballast waters are discharged somewhere in U.S. waters. This can release many foreign organisms into the new habitat. Many of the alien species compete with native North American species for food, space to live, and spawning ground. The invaders can also bring diseases that can threaten our natural environment.

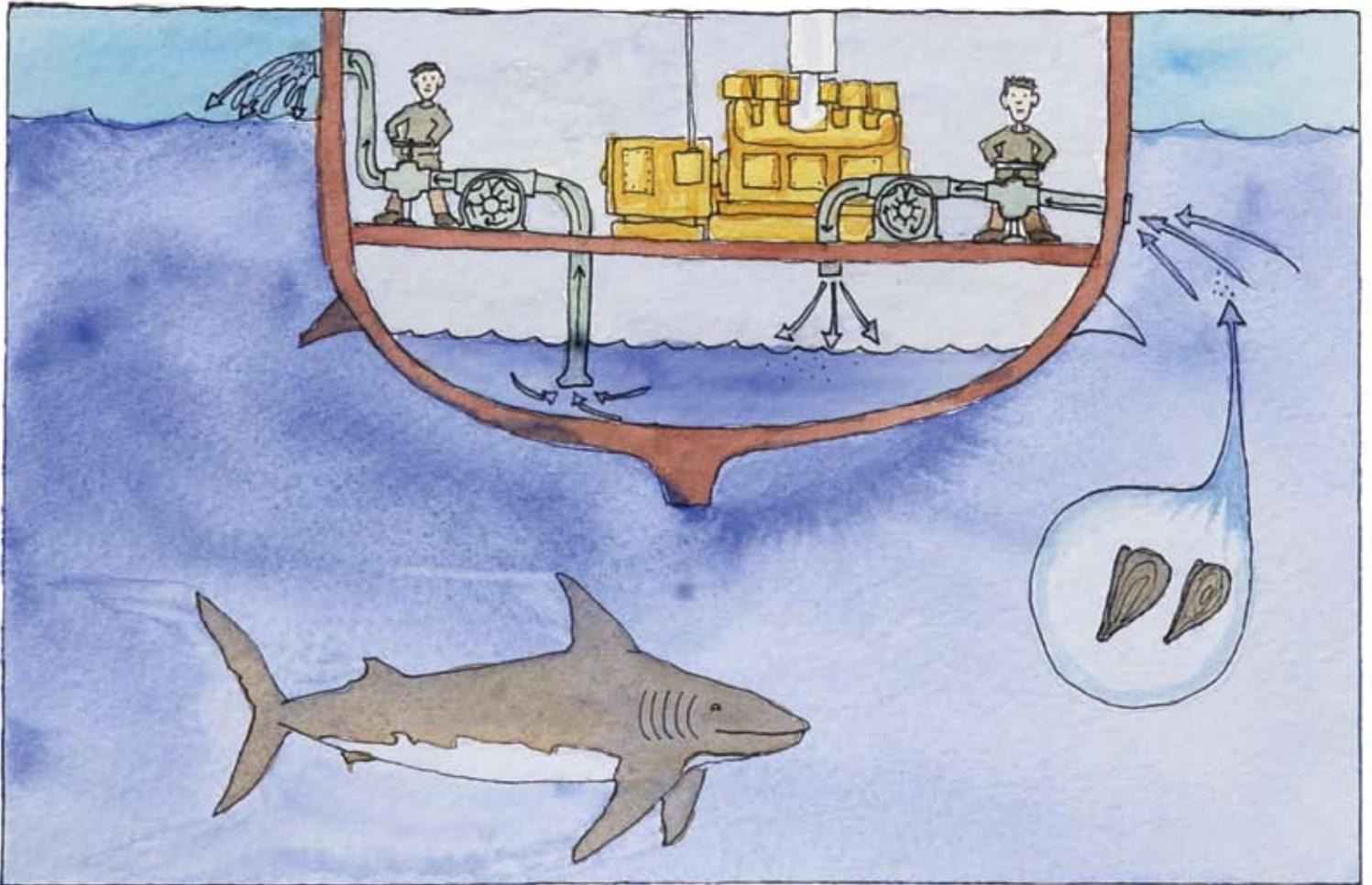
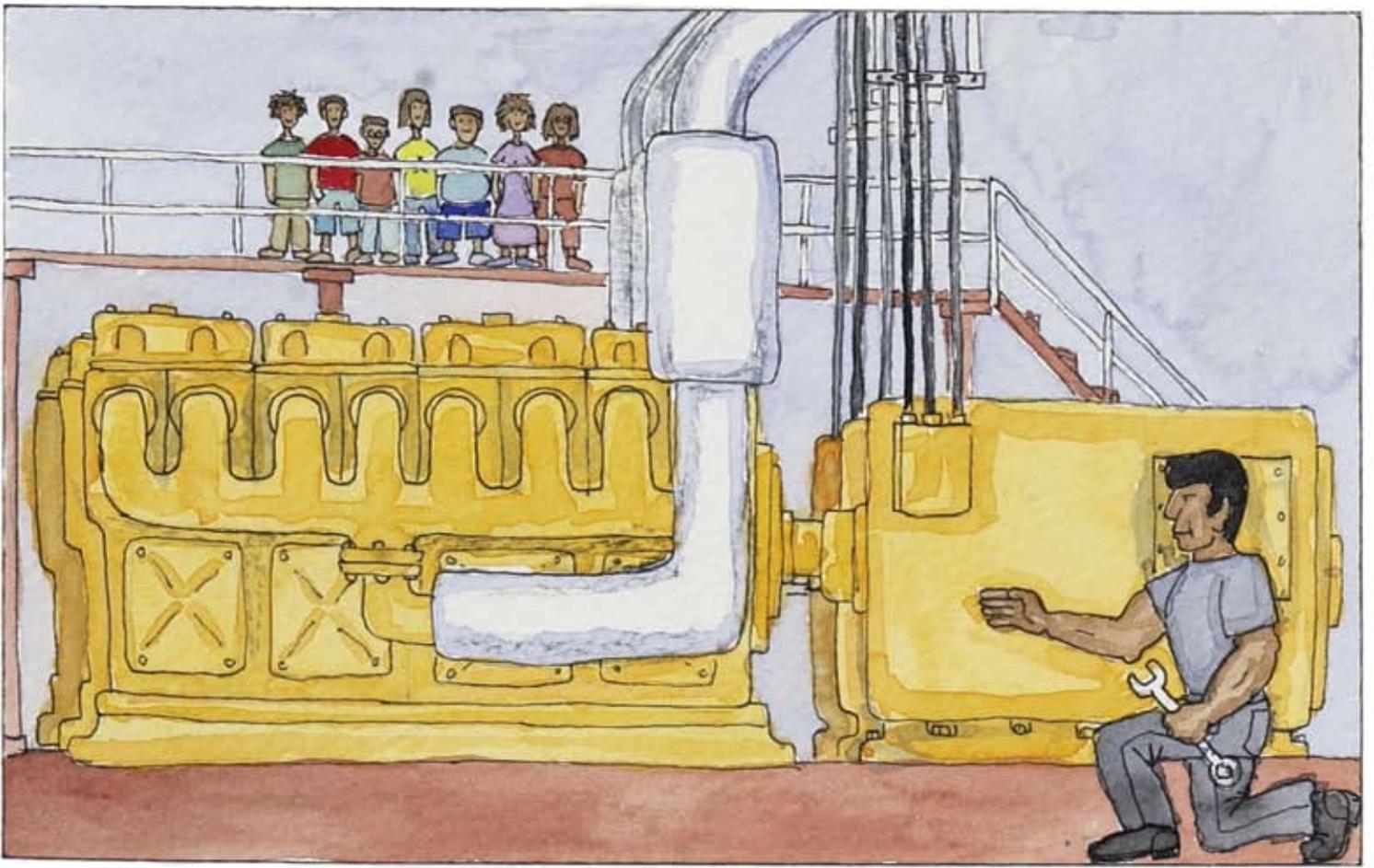
The students had heard of the major problems caused by the zebra mussel in the Great Lakes. Zebra mussels originated in the North Sea, but were carried by ballast waters to North America. Although no bigger than your thumbnail, one female zebra mussel can produce between 30 thousand and 1 million eggs per year, threatening native wildlife and damaging structures. These and other invasive species cost the United States over \$120 billion annually. They also cost utilities and industrial users hundreds of millions of dollars by clogging pipes and affecting drinking water. Eliminating an invasive marine species is very difficult and rarely happens, but it is possible. NOAA is very busy working on these problems.

Sea Grant is a nationwide network, administered through the National Oceanic and



Atmospheric Administration, of 30 university-based programs that work with coastal communities to conduct scientific research, education, training, and projects about the use and conservation of our aquatic resources.

The **Field Operations Officer** (otherwise known



as the FOO) stated that one of the most important aspects of daily life aboard the ship is **safety**. There are many details to think about while conducting scientific research on the launches, working on the decks, and even while moving from your stateroom to the mess. Some of the safety policies include:

- wearing a hard hat when a crane is lifting things overhead
- wearing a life vest when working near the side of the ship or on the launch
- wearing long sleeves, pants, and a hat during an emergency
- wearing closed toe shoes when walking or working on deck

During hydrographic operations, safety is of the greatest importance. The most challenging operation is deploying and recovering the launches from the side of the ship. Workers must use all of the necessary safety precautions, otherwise someone could get seriously injured. Launches are raised and lowered from the ship using a pair of **davits**, which are crane-like devices that project over the side of the ship. A davit is used to raise and lower the small boat. A davit operator lowers the launch to a lower deck. Two lines are secured (**fore** and **aft**) to the rail and two additional lines are held by deckhands to maintain control of the launch.

Hydrographers board the launch and transport their science gear while wearing a life jacket and hardhat at all times. One person gets on the bow and another on the stern and they untie a line from the hooks.

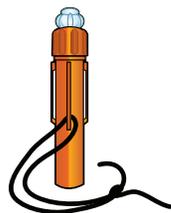
The launch is then lowered into the water. The crewmembers release the hooks from the bow and the stern and the davit operator lifts the hook out of harm's way. The deckhands then throw off the lines and the launch is ready to survey.

What is another name for a life jacket?

? ?
Scientists and crewmembers wear and use the following safety equipment while conducting hydrographic work on a ship.



Whistle



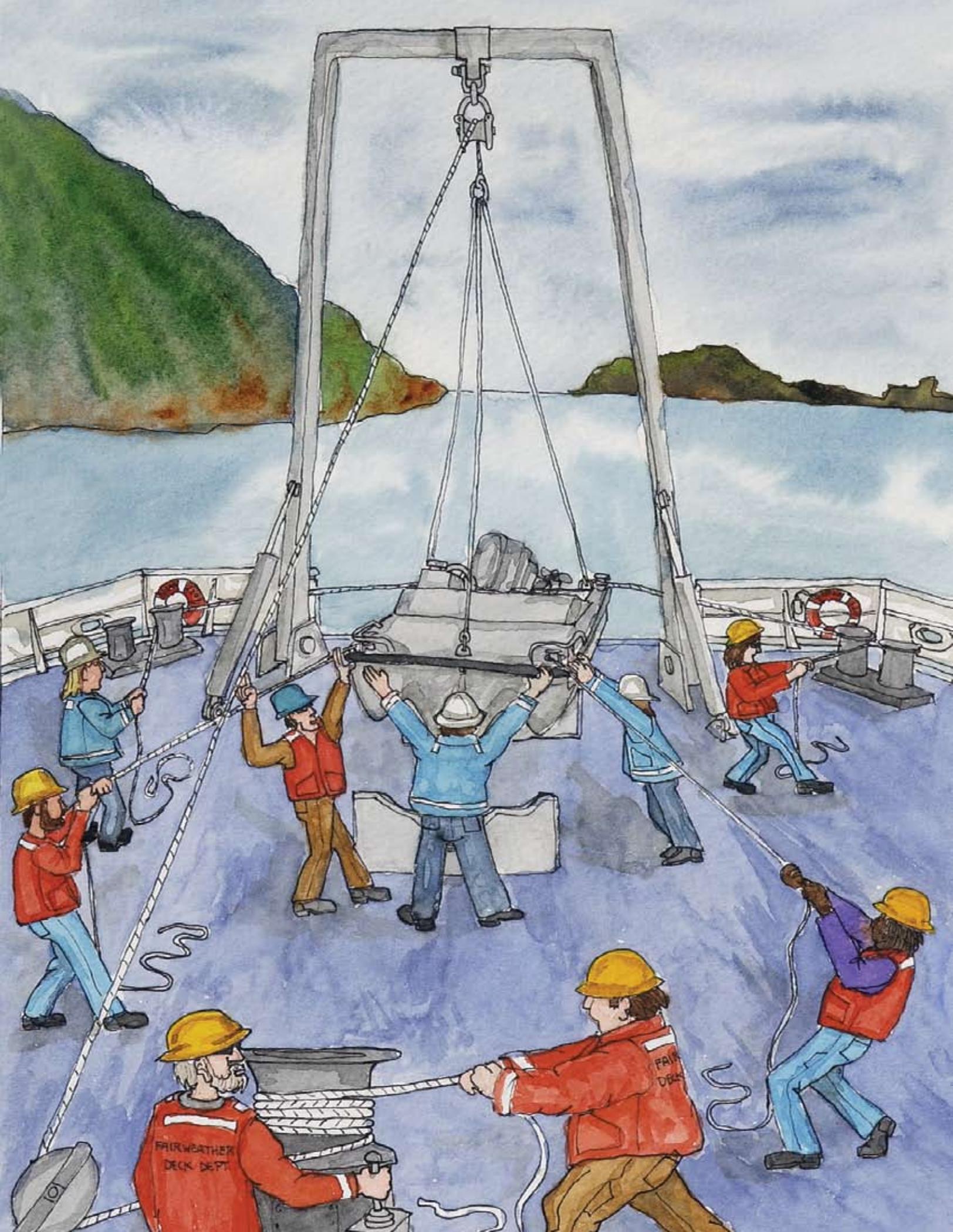
Water Light



Life Jacket



Hard Hat



and her students boarded their bus to return to Richmond. One thing Mrs. Armwood had noticed about the NOAA people she spoke with that day was their incredibly diverse science backgrounds. Many were trained in geography, biology, engineering, geology, or chemistry, as well as other scientific and mathematical fields. She reminded her students of the opportunities and excitement involved in work on board a ship. They might even discover their own shipwreck someday!

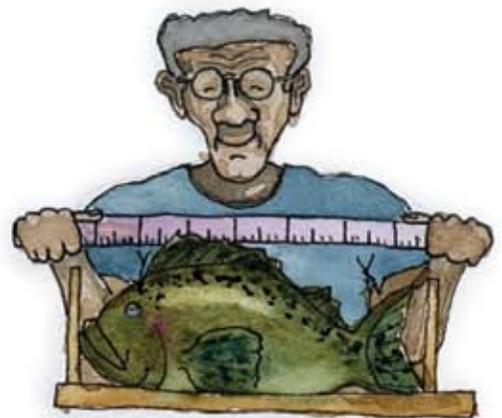
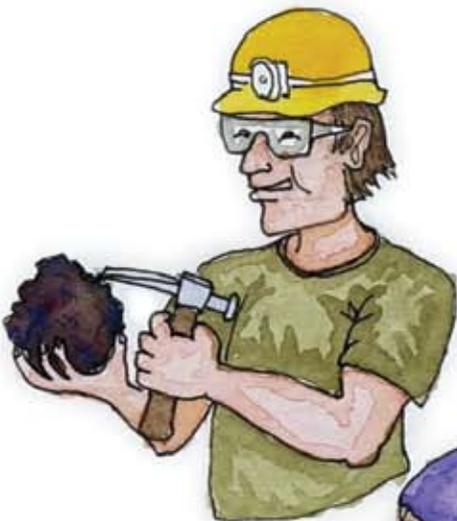
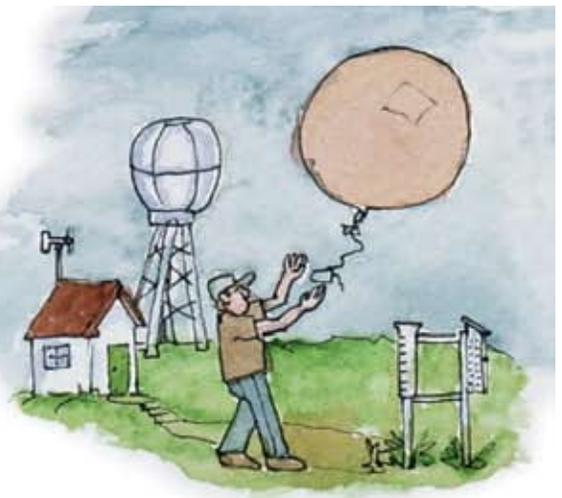
As they rode home, Mrs. Armwood explained that people know very little about their country's **Exclusive Economic Zone (EEZ)**. An EEZ is an area extending from shoreline out to 200 nautical miles that every coastal country has the right to manage. She stated that hydrographic surveys are necessary within each country's EEZ to determine boundaries for safety and navigation, especially as offshore industry becomes common and **globalization** increases demand for ships that can carry more cargo. More and bigger ships push the need for deeper channels and harbors.



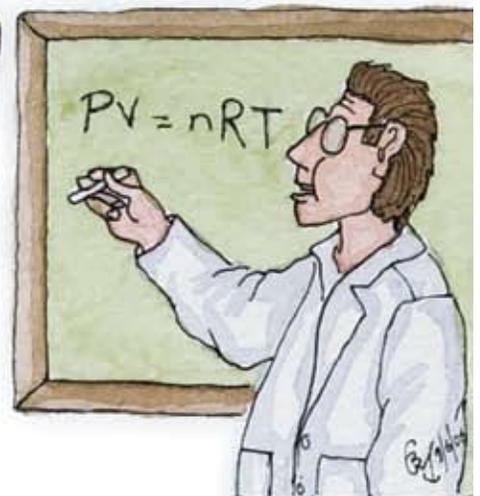
The public also knows little about our protected National Marine **Sanctuaries**. These areas vary in size from less than one square mile to nearly 138,000 square miles, each with unique characteristics that require special protection. Sanctuaries can range from areas where giant humpback whales breed...to places where special reefs are found... to regions where there are large shipwrecks that tell us about our maritime history.

Hydrographers have the chance to survey in many beautiful parts of the world. They also help their country by providing important data about hazards during navigation. The students were excited to discuss these topics again when visitors from the ship came to their classroom.

Two months later, a NOAA Corps officer who was a member of the dive team



? Name each scientist represented on this page. ?

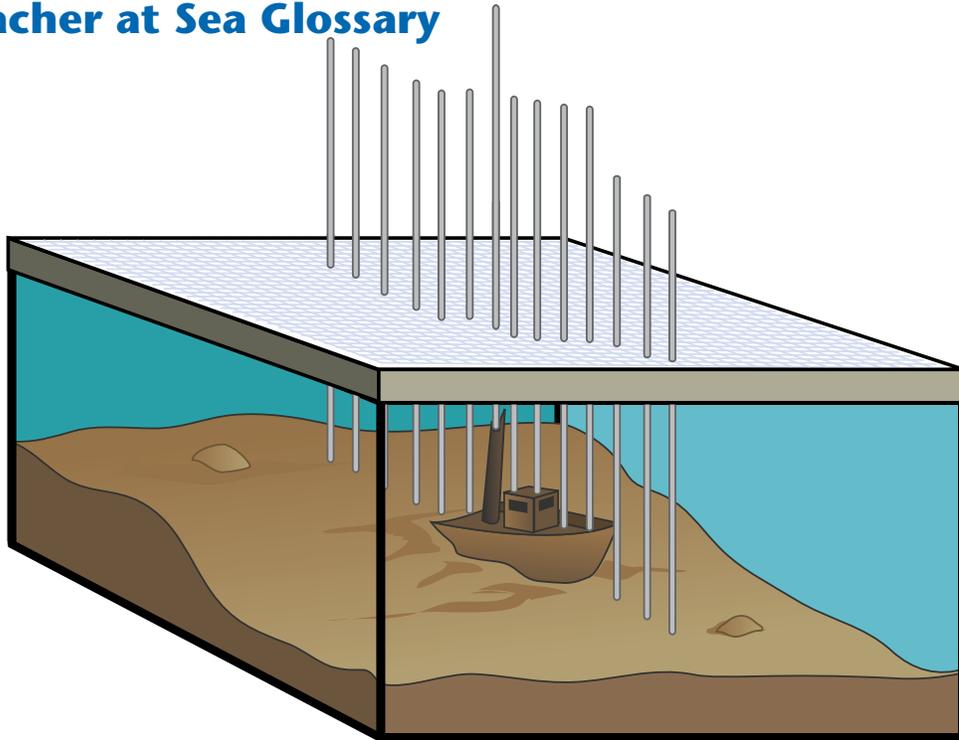


visited Mrs. Armwood and her students. Mrs. Armwood had also contacted the FAIRWEATHER Chief Boatswain to remind him of his promise to visit. Since the students had been on board the THOMAS JEFFERSON earlier that school year, they were familiar with the terms and instruments described by both visitors. The NOAA Corps officer gave an update on recently discovered shipwrecks, and the Chief Boatswain told stories of other exciting discoveries made in the past both on and off the ship. They answered questions and assisted as the students created their own **hydrography boxes** to learn how to collect soundings.

Mrs. Armwood was so pleased that her students had a much better understanding of the importance of hydrography and how it could be applied in practical situations. Throughout the school year, the students raised questions about scientific topics related to hydrography and found it to be a very enticing field. It gave Mrs. Armwood great satisfaction when several of her students expressed intentions of pursuing careers in marine research. Together, they researched various universities and institutions where hydrography programs are offered and organizations where coastal surveying expertise is needed.

What an enlightening and rewarding experience to be a NOAA Teacher at Sea!

Teacher at Sea Glossary



Hydrography Box

To learn how to create your own unique hydrography box,
see <http://oceanservice.noaa.gov/education>



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

Aft - toward the back or stern of the boat

Aids to Navigation - charted marks, such as buoys, beacons, or lights, used to assist navigators

Ballast - any heavy material used to stabilize a ship; usually water is carried as ballast in tanks that are specially designed for that purpose

Bathymetric Surveying - mapping of the bottom of the ocean to show depth contours of the soil, rock, and sand

Benchmark - a point of reference for a measurement. The term originates from the chiseled horizontal marks that surveyors made where an angle-iron could be placed to bracket a leveling rod to ensure that the leveling rod can be repositioned in the exact same place in the future.

Bioluminescent - producing light by organisms from conversion of chemical to radiant energy

Bow Wave - the wave that forms at the front of a boat when it moves through the water

Captain - an officer in command of a ship

Cartographer - one who makes maps

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

Chief Boatswain - the primary person who is responsible for the boats, sails, rigging, anchors, and cables

Chief Survey Technician - person in charge of the hydrographic work on board a ship

Commanding Officer - a captain of a ship

Commissioned - appointed to a certain task, mission, function or duty

Conductivity - the ability of a material to allow the flow of electrical current; the salinity of the ocean is derived from the conductivity

CTD - an instrument package that measures conductivity, temperature, and depth

Davit - a crane that projects over the side or stern of a ship and is used as a hoist; a pair of davits is used to carry and launch/recover small boats such as a survey launch

Deploy - to launch systematically or strategically

Ebb - the reflux or flowing back of the tide; the return of the tidal wave toward the sea -- opposed to flood; as, the boats will go out on the ebb

Echosounder - an instrument for determining the depth of water by measuring the time interval between the transmission of a sound signal and the return of its echo from the sea floor

Ecotourism - responsible travel to natural areas where the environment is conserved and the livelihood of local people is sustained

Elevation - the height above sea level

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

Exclusive Economic Zone (EEZ) - a zone under national jurisdiction (up to 200 nautical miles wide) declared in line with the provisions of the 1982 United Nations Convention of the Law of the Sea, within which the coastal State has the right to explore and exploit, and the responsibility to conserve and manage, all living and non-living resources therein

Fathom - means "outstretched arms" - estimated to average 6 feet from fingertip to fingertip. The fathom became the standard measure for gauging the depth of the ocean. 1 fathom = 6 feet = 1.83 meters

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

Flow - a flood tide; where water moves from the sea toward the land

Fore - toward the front or bow of a vessel or aircraft

Geostationary Operational Environmental Satellites (GOES) - a series of weather satellites, in geosynchronous orbit, launched by the U.S. and operated by NOAA/NESDIS

Globalization - the integration of economic, cultural, political, and social systems across geographical boundaries

Global Positioning System (GPS) - a satellite-

based navigation system that allows land, sea, and airborne users to determine their exact location and time in all weather conditions, anywhere in the world

Head - bathroom on ship

Hook - a device designed to catch a line when alongside a pier or mooring

Hull - the frame or body of a ship or buoy

Hydrographic - referring to the study of water features (oceans, lakes, rivers), including physical characteristics (oceanography) and elements affecting safe navigation

Hydrography - the science of the measurement, description, and mapping of the sea bottom and tidal mudflats, as well as the positions of stationary objects at sea (both below and above the water's surface), with special reference to navigation

Hydrothermal Vents - fissures in a planet's surface from which geothermally heated water issues; hydrothermal vents are commonly found in places that are also volcanically active

Iceberg - ice that calves, or breaks, off a glacier into a body of water

Junior Officer - an officer who reports to the Commanding Officer, typically a lieutenant or below in rank

Latitude - the distance north or south of the equator of a point on the Earth's surface; an imaginary line that runs east-west and ranges from 0-90°N and 0-90°S

Launch - a boat, typically less than 30 feet, used to conduct surveys

Lead Line - a line with a weight on the end used to measure depth in the water

Local Notice to Mariners - a United States Coast Guard publication listing changes in aids to navigation, chart changes, and other information of interest to mariners

Longitude - the distance east or west of the Prime Meridian of a point on the Earth's surface; an imaginary line that runs north-south and ranges from 0-180°E and 0-180°W

Mariner - a person who serves as a sailor and is employed on board a ship

Maritime - related to the sea

Mess - a military dining room where people eat

and relax

Military Time - the 24-hour clock in which the day runs from midnight to midnight and is divided into 24 hours, numbered from 0 to 23

Multibeam Echosounder - a high-resolution seabed mapping system that uses sonar to determine the depth to the seafloor

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

Nautical Chart - a graphic representation of a maritime area and adjacent coastal regions

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 Corps - the smallest of the seven Uniformed Services of the United States, with approximately 299 commissioned officers. It is the uniformed service of NOAA.

NOAA National Environmental Satellite, Data, and Information Service (NESDIS) - an office of NOAA that provides timely access to global environmental data from satellites and other sources to promote, protect, and enhance the Nation's security, environment, and quality of life

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 Ocean Service (NOS) - an office of NOAA that measures and predicts coastal and ocean phenomena, protects large areas of the oceans, and works to ensure safe maritime navigation

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

NOAA Office of Marine and Aviation

Operations (OMAO) - an office of NOAA that operates specialized aircraft and ships to complete NOAA's environmental and scientific missions; also responsible for the administration and implementation of the NOAA Diving Program

NOAA Office of Ocean Exploration - an office of NOAA that supports expeditions, exploration projects, and field campaigns for the purpose of discovery and documentation of our ocean

NOAA Office of Oceanic and Atmospheric Research (OAR) - an office of NOAA that is responsible for all of NOAA's research, the driving force behind NOAA environmental products and services that protect life and property

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

Physical Geography - the study of the physical elements and processes that make up Earth

Porthole - a window in the side of a boat

Radar - stands for "Radio Detection And Ranging" and returns echoes from transmitted pulses on any target it hits. In the atmosphere, raindrops reflect the energy, and therefore it is an excellent tool to visualize a storm's structure.

Refraction - the tendency of a wave to bend as the result of a change in density within the medium (such as water) through which it is passing

Salinity - the total amount of dissolved salts in a water sample

Sanctuaries - unique marine-protected areas

Seamount - an underwater mountain

Side-Scan Sonar - a towed instrument that sends out sound waves to create images of the ocean floor that are used to locate and map wrecks, rocks and other obstructions that may be hazardous to coastal navigation. Items are identified by the shadows they create on the image and general measurements of the size of the object can be scaled from the image to determine length, width and height off the bottom.

Sonar - the use of transmitted and reflected

sound waves to detect underwater objects

Soundings - a method to measure the depth of water beneath a ship

Stateroom - cabin accommodation on board a ship

Stern - the aftmost part or rear end of the hull of a ship or boat

Survey Technician - a worker aboard a ship who provides technical support to hydrographic survey operations; such support includes operating equipment and processing survey data

Surveying - method of making relatively large-scale, accurate measurements of the Earth's surfaces

Theodolite - basic surveying instrument going back to the 16th-century; it is used to measure horizontal and vertical angles. A telescope mounted to swivel both horizontally and vertically.

Tide Gauge Station - a group of instruments used to measure the change in surface water elevation, especially tides, through time

Tides Officer - person who is responsible for documenting tidal fluctuations on board a ship

Triangulation - a method for finding a position by means of bearings from two fixed points a known distance apart

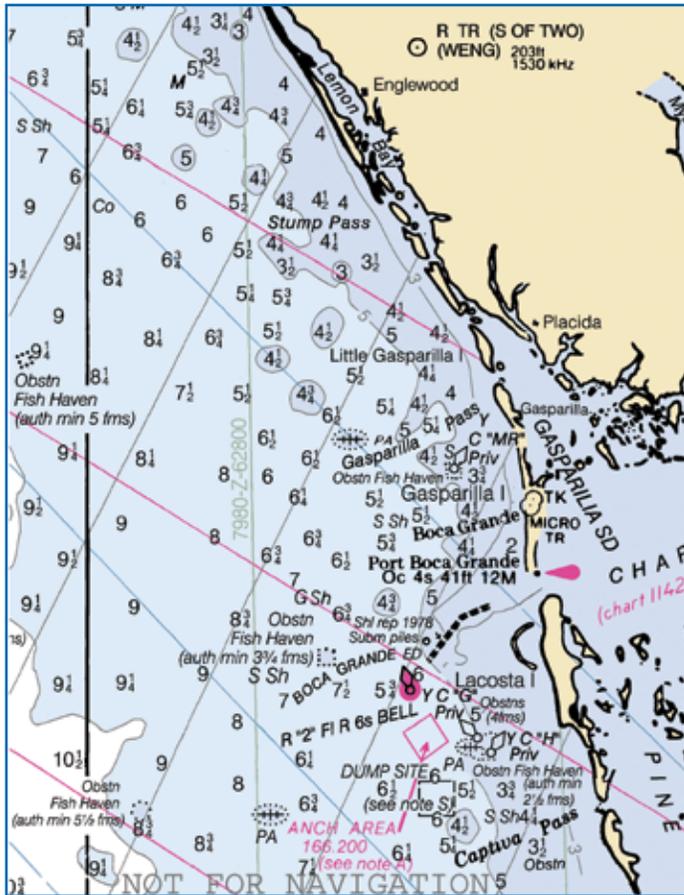
Trigonometry - a branch of mathematics that combines arithmetic, algebra, and geometry; used in surveying, navigation, and various sciences such as physics

Learn How to Analyze a

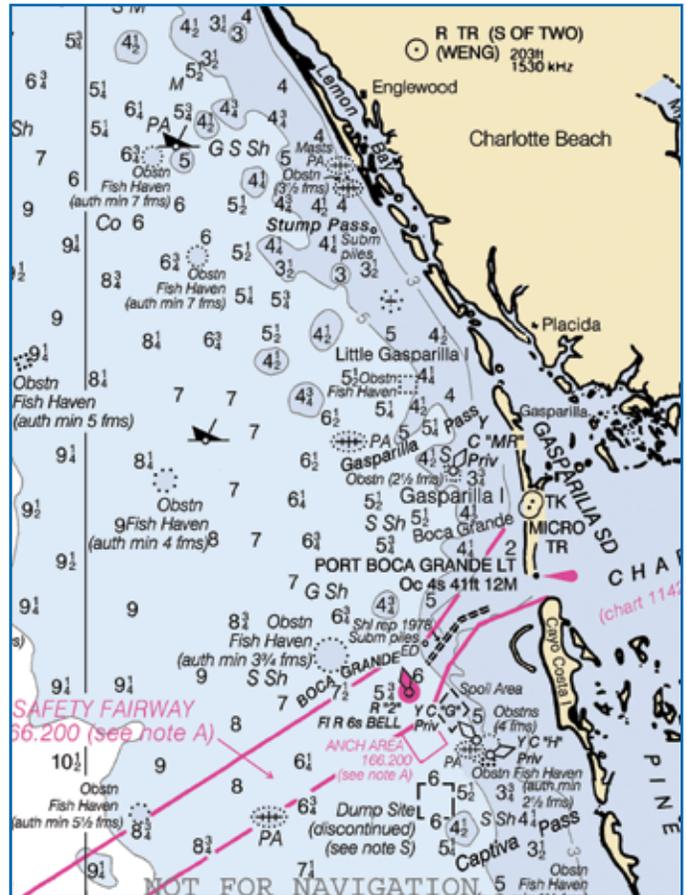
Chart, Just Like a Coastal Surveyor!

Recently, you were promoted to Captain of a NOAA ship - congratulations!! You now need to navigate safely to shore along the west coast of Florida. Based on NOAA's most recent hydrographic surveys, you have in your possession an updated chart showing the current coastal survey. Your curiosity gets the best of you and you begin to compare the old chart (on left below) with the new chart (on right below) to see how many changes to the channel have occurred since the old chart was produced. After reviewing the old chart and the new chart find five of the twelve significant changes on the updated chart!!

Coastal Survey Before



Coastal Survey After



- | | |
|-----------|---|
| G S Sh | ISTICS (Gravel, Sand, Shells) |
| | BUOYS (for navigation) |
| | HAZARDS (for chemical waste) |
| 5 1/2 fms | FATHOMS (units) |
| | LIGHT (for navigation) |
| | LINE (red diagonal, green vertical) |
| | OBSTRUCTIONS (fisheries, piles, unknown) |
| PA | POSITION APPROXIMATE |
| | WRECK (shown in red, at level of chart datum) |
| | WRECK (dangerous wreck, depth unknown) |
| | WRECK (shown in red) |

Conversions

1 fathom = 1.83 meters = 6 feet

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)

1 knot (kt) = 1.7 feet per second (ft/s) = .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)

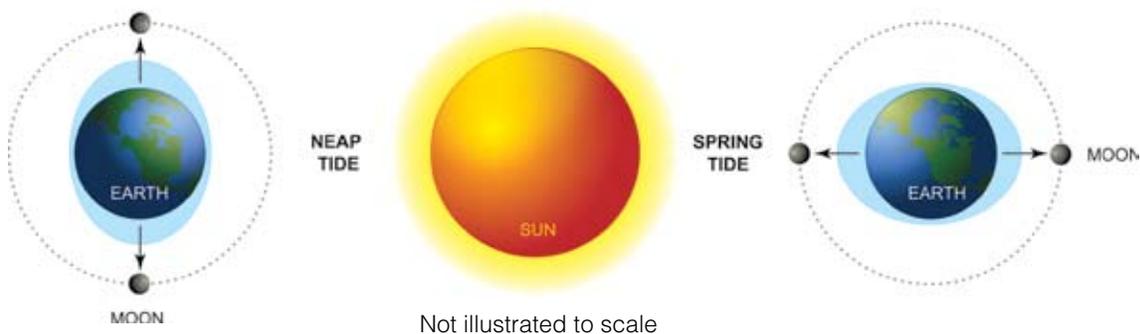
1 atmosphere (atm) = 14.7 pounds per square inch (psi)

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

Answers to sidebar questions:

Page 2: Named for Mt. Fairweather in southeast Alaska, the highest peak in the Fairweather Range

Elevation of Mt. Fairweather: 15,300 feet (4663 meters)



Page 6: When the Sun, Moon and Earth are aligned, we have a spring tide. Spring tides occur during the full moon and the new moon. When the Sun, Moon, and Earth are at right angles the forces are not aligned, producing a weaker neap tide. These occur during quarter moons.

Highest Tidal Fluctuation: Bay of Fundy, between Nova Scotia and New Brunswick, Canada

Page 8: Circumference of the Earth = 360°; Earth rotates 15° in one hour; Four hour time difference = approximately 60° longitude

Page 26: A life jacket is also known as a Personal Flotation Device (PFD)

Page 29: (Clockwise from upper left) Geographer, Meteorologist, Biologist, Physicist, Chemist, Geologist

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 2007, over 460 teachers have participated in the program, representing 47 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 in the Air Program is an offshoot of NOAA's Teacher at Sea Program and was first piloted in 2004. It has enabled teacher participants to observe research activities and interact with scientists while on board NOAA aircraft. Science projects have focused on wind flow patterns, hurricane awareness, and monsoons. Future TIA opportunities may be available for K-12 and university teachers; they will be posted at www.teacheratsea.noaa.gov.

Internet Resources for Teachers, Parents, and Students

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

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

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

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

NOAA's Educational Partnership Program: <http://epp.noaa.gov>

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 (NMS): <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/index.shtml>

NOAA Office of Coast Survey (OCS): <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 FAIRWEATHER: <http://www.moc.noaa.gov/fa>

NOAA Ship THOMAS JEFFERSON: <http://www.moc.noaa.gov/tj>

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

Sounding Box Activity: http://ta.nos.noaa.gov/education/seafloor-mapping/sounding_box_make1.html

Tides Online: <http://tidesonline.nos.noaa.gov>

NOAA currently has a fleet of 20 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. Following are descriptions of NOAA's four hydrographic survey vessels that acquire the data NOAA uses to make its nautical charts, and a NOAA coastal research and survey vessel.

The NOAA Ship **FAIRWEATHER** is a hydrographic survey ship that was originally commissioned with NOAA in 1968. The ship was deactivated in 1989 but a critical backlog of surveys for nautical charts in Alaska was a motivating factor to reactivate the ship in 2004.



The FAIRWEATHER is designed and outfitted primarily for conducting hydrographic surveys in support of nautical charting, but is capable of many other missions in support of NOAA programs. The ship is equipped with the latest in hydrographic survey technology – multibeam survey systems; high-speed, high-resolution side-scan sonar; position and orientation systems; hydrographic survey launches; and an on-board data-processing server. Increased mission space and deck machinery enable FAIRWEATHER to be tasked with anything from buoy operations to fisheries research cruises.

The FAIRWEATHER operates in Alaskan coastal waters. The FAIRWEATHER is named for Mt. Fairweather in southeast Alaska, which is the highest peak in the Fairweather Range—the tallest coastal range on earth. The vessel is operated by NOAA's Office of Marine and Aviation Operations, and home ported in Ketchikan, Alaska.

The **THOMAS JEFFERSON** is one of a fleet of research and survey vessels used by NOAA to improve our understanding of the marine environment. The ship is home ported in Norfolk, Virginia, and primarily operates along the Atlantic and Gulf coasts, including Puerto Rico and the U.S. Virgin Islands. The primary mission of the THOMAS JEFFERSON is to conduct hydrographic surveys for updating NOAA's nautical charts.



Hydrographic surveys used for nautical charting include thousands of systematic depth measurements, as well as positions of wrecks or obstructions in navigable waters. These data are acquired by THOMAS JEFFERSON and its two survey launches equipped with specialized echo sounders, multibeam sonars, and side-scan sonars. Data acquisition and processing relies heavily on state-of-the-art computers, specialized software, and highly skilled ship personnel. Commercial shipping relies on accurate nautical charts for the safe transportation of goods such as petroleum, coal, steel, automobiles, grain, and containerized cargo.

The NOAA Ship **RAINIER** is designed and outfitted primarily for conducting hydrographic surveys in support of nautical charting. Scientific equipment normally aboard is limited to equipment that supports these survey operations. The ship operates off the U.S. Pacific coast, and in Alaskan coastal waters. The RAINIER is named for Mount Rainier. The vessel is operated by NOAA's Office of Marine and Aviation Operations.



The RAINIER is a highly capable platform for conducting coastal hydrographic survey operations. It has a crew of 55, including ten commissioned officers. The ship is equipped with an intermediate depth multibeam sonar system.

It carries six aluminum survey launches equipped with multibeam, side-scan sonar, and single beam echo sounders. The vessel also has two small boats providing support to shore stations and dive operations. Seven crewmembers are trained as certified NOAA divers.

The RAINIER carries other equipment to support hydrographic survey operations. This includes five CTDs used for sound velocity profiles and various sediment sampling equipment.

The NOAA Ship **RUDE** (pronounced "Rudy") performs inshore hydrographic surveys along the east coast in support of NOAA's nautical charting mission, specializing in the location and accurate positioning of submerged hazards to navigation. The RUDE is named for Captain Gilbert T. Rude.



RUDE is equipped with some of the most technically advanced hydrographic and navigation equipment available, including Differential Global Positioning Systems DGPS, a multibeam bathymetric sonar system, and side-scan sonar. The RUDE is equipped with several hydrographic data acquisition and data processing systems. The ship is also fully prepared for diving operations to allow determination of the precise nature of submerged obstructions.

When conducting a search for an underwater obstruction, RUDE deploys a side-scan sonar and multibeam bathymetric sonar system. Housed in a small torpedo-shaped shell called a "fish," the side-scan sonar provides an accurate acoustical image (sonogram) of the bottom extending up to 150 meters on each side of the ship. The actual amount of bottom coverage acquired is dependent upon the depth of water, the towfish height and specific water characteristics. During typical survey operations in depths between 10 and 60 meters, a 200-meter wide bottom swath can be examined as the "fish" is towed slowly astern. All potential hazards to navigation identified using side-scan sonar are further investigated using the multibeam bathymetric sonar system and ship's divers to determine a precise description of the hazard and the minimum depth of clearance.

At 90 feet and 220 tons displacement, RUDE is the smallest ship in the NOAA fleet. RUDE carries a 19-foot Boston Whaler used as a diving platform and personnel transport. A 26' Monark, transported by trailer, assists RUDE with inshore surveying.

Because of its hydrographic surveying capabilities, RUDE has been called upon to assist the U.S. Coast Guard and Navy in search, rescue, and recovery operations. The RUDE located the TWA Flight 800 wreckage off of Moriches, New York in 1996; located John F. Kennedy Jr.'s plane off Martha's Vineyard, Massachusetts; found the BOW-MARINER wreckage off the coast of Chincoteague, Virginia; and discovered an uncharted wreck--the IONNIS P. GOULANDRIS--on the edge of a major ship traffic lane approaching New York.

The NOAA Ship **NANCY FOSTER** was originally built as a Navy yard torpedo test (YTT) craft. In 2001, the Navy transferred the vessel to NOAA, which outfitted the ship to conduct coastal research along the U.S. Atlantic/Gulf coasts, and the Caribbean. NANCY FOSTER is named for Dr. Nancy Foster in tribute to her outstanding contributions in advancing NOAA's mission through her leadership within the National Marine Fisheries Service and National Ocean Service from 1986 until 2000.



NANCY FOSTER supports applied research for the NOAA National Ocean Service's Office of Ocean and Coastal Resource Management, the NOAA Oceanic and Atmospheric Research's Office of Ocean Exploration, and the National Sea Grant College Program. Operations include the characterization of various habitats in NOAA's National Marine Sanctuaries, pollution assessments, and studies to improve understanding of the connection between marine habitats and estuaries. NANCY FOSTER's mission supports scientific data collection through bottom fish trawling, sediment sampling, side-scan sonar and multibeam surveying, sub-bottom profiling, core sampling, diving with air and NITROX, ROV operations, and servicing oceanographic/atmospheric surface and subsurface buoys. The vessel employs state-of-the-art navigation and propulsion systems resulting in high quality and efficient data collection.

Biographies



Diane Stanitski is a climatologist and associate professor at Shippensburg University in Pennsylvania where she teaches courses in meteorology, climatology, and geography. She enjoys taking students to remote and beautiful geographic regions of the globe, including Australia, Vietnam, and Grand Canyon National Park. Diane was a NOAA Teacher in the Air in 2005 and a NOAA Teacher at Sea in 2002. She worked in the NOAA Office of Climate Observation from 2003-2005 and currently serves as a consultant to NOAA to help expand the global ocean observing system for climate. 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*. She is passionate about science, and loves traveling and exploring with her husband and family, biking, playing soccer, and running.



Linda Ashford-Armwood is an Educational Consultant specializing in grant writing, program and curriculum design, and organization collaboration. As a Teacher at Sea, Mrs. Armwood fulfilled a teenage dream to sail and conduct research on a ship. At the time of her Alaska exploration as Teacher at Sea, she was the pioneer instructor for the Geospatial (GIS & GPS) and Environmental Science courses at George Wythe High School in Richmond, Virginia. Mrs. Armwood's 27-year teaching career has afforded her many opportunities to share her passion for learning and science with students in four school districts: her hometown of Washington, D.C.; Prince George's County, Maryland; Petersburg, Virginia and Richmond, Virginia. Mrs. Armwood has taught mathematics, science, and technology courses, served as the first IB-MYP science teacher for Richmond Public Schools, received educational grants to enhance classroom instruction, served on numerous curriculum design and state assessment teams, facilitated and presented at science and technology workshops, including the Virginia Association of Science Teachers and the National Science Teachers Association, and was a recipient of the Virginia regional R.E.B Award for Teaching Excellence. She is a talented multi-tasker who especially enjoys time with her husband and two young adult children while balancing her personal and public life through prayer, singing, reading, paper engineering, and flower gardening.



Bruce Cowden is Chief Boatswain on the RONALD H. BROWN (RHB) and was illustrator for the books, *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, South Carolina, the home port 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 U.S. 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, Georgia, 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 and Dive Master. 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.

