PRE-SERVICE TEACHER LEARNING FROM MARINE RESEARCHERS:

SPECIFIC EXPERIENCES AT SEA

by

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(Under the Direction of Norman F. Thomson)

ABSTRACT

This study describes how ocean science concepts can be adapted for use in the secondary science classroom. The research questions for this study are (1) What are some examples of marine science topics currently being investigated on marine research vessels?
(2) What is it like to conduct an investigation on a marine research vessel? and (3) How can teacher research on a marine vessel be utilized by science teachers to (a) create authentic learning experiences and (b) promote ocean literacy? Using the framework of autoethnography, a personal account of scientific discovery was developed. Data collection included participatory research, direct observation, and informal interviews. The results of this study detail the nature of science at sea and offer recommendations for teachers wishing to apply ocean science concepts in their classrooms. This study also has implications for alternative approaches to implementing the National Science Education Standards.

INDEX WORDS: ocean literacy, science education, alternative teacher education programs, ethnography, inquiry, research vessel, science at sea, teacher research

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DEDICATION

For Dave, Sheila, Kaylen, Tanner and Erin

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CHAPTER 1

INTRODUCTION

Homo sapiens have been living by the sea for perhaps the past 160,000 years (Winchester, 2010, p. 29). Since that time we have made many discoveries about the ocean and the life in it. Our ancestors knew what species were of value as food or commodity and they built vessels that could survive in the ocean, and taught themselves to navigate and reach locations remote from their own (Pringle, 2010). These early relationships reflected our ancestors' knowledge of how to use the ocean and its resources as well as an appreciation for the ocean's influence on daily life. However, until our contemporaries began to study the ocean scientifically we lacked the knowledge necessary to make informed and responsible decisions regarding the ocean and its resources.

In the mid-nineteenth century scientists began to take an interest in the ocean; inquiry inspired investigation, and research became a focus. From trawls and observations in bathyspheres, we acquired information about the ocean at depth and found life in unexpected places. As an example, in the 1960s work in the ocean sciences yielded that the seafloor is cleaned by hydrothermal vents, recycled at subduction zones and elsewhere forced upward to form underwater mountain ranges. Currently, many scientists are studying the ways in which humans and the ocean impact one another. Their findings will likely help us to better understand the ocean's complex nature, and are essential because all life is dependent upon the ocean.

For all the mapping, modeling, tracking and trawling that has occurred to date; even those most invested in studies in the ocean have a relatively limited knowledge about the ocean and its systems. Adding to this problem—which has been acknowledged at national and local level by scientists and educators alike—oceanographic knowledge appreciated by the scientific community is typically not well understood by the general public (Schoedinger, Cava, & Jewell, 2006). Because we often overlook the importance of the ocean to our daily lives we are a largely ocean illiterate society (Steel, Smith, Opsommer, Curiel, & Warner-Steel, 2005). As a result we may be scientifically illiterate, as well (Strang, deCharon, & Schoedinger, 2007).

The current state of unfamiliarity about the ocean among the general population, despite the significance of the topic, highlights the importance of ocean science education. Fortunately, there are now resources educators can use to build ocean science content knowledge in their classrooms. One group spearheading this effort is the National Marine Educator's Association (NMEA) through their Ocean Literacy Campaign. Together with the work of other organizations including The National Geographic Society, Centers for Ocean Sciences Education Excellence (COSEE) and The National Oceanographic and Atmospheric Association (NOAA) they have produced a guide called *Ocean Literacy: The Essential Principles of Ocean Sciences K-12*—a collaborative and decentralized effort by scientists and educators to develop an understanding of both our influence on the ocean and its influence on us (Schoedinger, Uyen Tran, & Whitley, 2010). This document includes seven essential principles needed to promote both ocean literacy and increased scientific knowledge, and is aligned with the most current National Science Education Standards (NSES) (Schoedinger et al., 2006).

Educators may also prepare themselves to teach about the ocean through hands-on science experiences. In fact, teacher participation in research programs has been reported to improve their students' achievement in science (Silverstein, Dubner, Miller, Glied, & Loike, 2009). Authentic experiences, in which teachers work directly with scientists, are offered on land and at sea by a number of groups including NOAA, whose Teacher at Sea Program (TAS) provides K-12 educators an opportunity to sail aboard a research vessel.

As with any important environmental topic, the ability to accurately perceive the ocean and its resources is dependent on knowledge (Steel et al., 2005). This knowledge may be acquired through many routes. Teachers can improve student learning in their classrooms through the incorporation of real world data; for example, they could do this by using the information under continuous development by the ocean science community, or by participating in a research program.

Regardless of the means, achieving an ocean literate society will help us better understand the world in which we live by producing individuals who are able to communicate about the ocean in a meaningful way and make informed and responsible decisions regarding the ocean and its resources (National Geographic Society, 2005; Strang et al., 2007).

Purpose of the Study

Across academic fields there are programs that afford teachers access to meaningful learning experiences that can be brought back to the classroom for students. The same year that NOAA's K-12 principles were published, "The Need for Ocean Literacy in the Classroom" highlighted resources that encouraged further learning about the ocean and identified the need to make it easier for teachers to incorporate them into their classrooms. Many teacher opportunities now include studies of the ocean aboard marine research vessels, but prior to this study the benefits of these programs have mainly been described by the programs themselves (M. Timmons, personal communication, March 31, 2011).

The purpose of this study is to discover the nature of science as practiced by oceanographers at sea and to describe how ocean science concepts learned during an ocean going research journey can be adapted for a secondary science classroom. It is believed that these will help to address the “mystery box” problem that currently surrounds many ocean science topics, thereby making them easier to examine, to assess and to predict. What is presented in this study can be used to enhance current teaching practices by providing an alternate means for teachers to meet the current NSES standards using ocean science concepts. It is the hope of this researcher that the findings reported herein, and the advancement of ocean literacy more generally, will be considered and implemented in the secondary education setting.

The research questions for this study are:

(1) What are some examples of marine science topics currently being investigated on marine research vessels?

(2) What is it like to conduct an investigation aboard a marine research vessel?

(3) How can teacher research on a marine vessel be utilized by science teachers to (a) create authentic learning experiences and (b) promote ocean literacy?

The following chapters include a review of the history of ocean exploration that serves as the framework for a discussion of modern research efforts. Research methodology follows with a description of the methodological perspectives of participant observation and action research used in the execution of this study. The results section focuses on recommendations for authentic ocean literacy activities and is based on the researcher's work while at sea with prominent research scientists. Finally, an analysis of learning is included that offers personal insights and information about teacher-at-sea programs.

CHAPTER 2

EXPLORATION OF THE OCEAN

The open ocean used to be a place of terror (Winchester, 2010, p. 63). It was known to be so ferocious that innumerable stories and legends came to exist which kept even the bravest humans from letting the safety of the sight of land pass over the horizon. But, over time individuals grew venturesome. Emboldened by improvements in craft materials, craft construction and sailing aptitude honed during inshore ventures, the lure of the sea had reached a critical point by the seventh century B.C., and humans would wait no longer to set out upon the sea (Winchester, 2010, p. 64). In only a few hundred years' time since our ancestors set out from the West coast of Africa and locations throughout the Middle East, a nautical tipping point was reached; man had reached locations as far north as Scandinavia and as far east as China—thousands of miles from where any human had ever before set foot.

Our earliest motivations for ocean travel likely grew from a desire to explore, and soon trade and commerce grew to be additional motivating factors, but it was not until the Victorian age that scientists began to take an interest in the sea. Notably, Robert Boyle was interested in salinity, and Sir Isaac Newton was interested in the causation of the tides; others were engaged as well, although their methods were crude. Even into the early 19th Century, almost everything we knew about the oceans was based upon what washed ashore or came up in fishing nets (Bryson, 2004, p. 273). Still, some of these early observations did produce meaningful findings and, importantly, these reports were not based on anecdote and superstition, which previously dominated most explanations of the sea, its creatures and phenomena (Bryson, 2004, p. 273).

Soon scientists realized that more information could be obtained by leaving the shore and they sought passage aboard ships employed for other purposes to collect their data. These first scientists were similar to stowaways, and in many cases their interests had to be fit in or sneaked in wherever possible. Such secrecy and discretion was not the case for all, however. Charles Darwin, for example, began preparing for his first journey under slightly better circumstances.

By mid-September 1861, he could be found in the Devonport dockyard preparing for the second voyage of the HMS Beagle (his first). He would be one of the first scientists with the freedom to carry out investigations as he pleased. However, he would still be required to work as a crew member. Although there was a growing appreciation for research at sea it was not yet well established. Darwin was held in high regard with the ship's crew because upon finishing his own work he often would set about lending a helping hand to others—performing chores, hunting and setting out in search of water "when others lay crippled by thirst" (Darwin, 1962, p. xiii). Perhaps to the credit of individual pioneers such as Darwin, whose behavior and discoveries were outstanding, a tradition of scientists working at sea was established.

Not long after Darwin sailed on the Beagle research became a central focus on many ships. Arguably the first true research vessel was the HMS Challenger. Originally a corvette-style warship, it was reconfigured in 1872 for ocean exploration. One Challenger cruise lasted over three years and permitted as many diversions as science would allow (Winchester, 2010, p. 137). During that cruise, hundreds of water samples were taken and fish were caught hand over fist. A dredge was pulled almost continuously and so many specimens were collected that it took the better part of fifteen years to assemble a final report. The final documentation of the voyage was so immense it spanned 80 volumes. It has been said that at the time the report represented the entirety of human kinds' knowledge of the ocean (Winchester, 2010, p. 139). The work accomplished on this cruise even inspired the name of a NASA space shuttle—the other shuttles were named for famous exploration sailing ships, as well—a tribute to pioneering research of the past and an acknowledgment of the challenges associated with working in extreme environments.

Today, research vessels, also called marine research vessels, provide critical access to remote environments that cannot easily be sampled from land. As dedicated scientific ships they serve as floating, mobile platforms that allow researchers to carry out projects relevant to society. They are also used in times of emergency. For example, research vessels were essential to the initial assessment of the Deepwater Horizon oil spill in 2010, and many remain deployed in the gulf as part of ongoing survey efforts (see Figure 1). In the future research vessels will continue to serve these roles and with the incorporation of new technologies will expand sampling capabilities and enable the gathering of increasingly reliable data (National Research Council, 2009).

Figure 1: A mixture of seawater and oil collected near the Deepwater Horizon wellhead for chemical analysis May 31, 2010 (photo credit: David Nadeau)

Typically, research typically falls into one of the following three categories: Oceanographic (focused on physical, biological and chemical water tests), Fisheries (focused on sampling fish stocks using conventional means such as nets and traps and increasingly by employing remote operated vehicles and camera arrays), and Hydrographic (focused on seismology and geography) (46 U.S.C.S. § 2101). To meet these diverse needs, the United States maintains both Federal and Academic research fleets. The Federal fleet is comprised of vessels operated by the United States Navy (USN) and the National Oceanographic and Atmospheric

Association (NOAA). The academic fleet includes vessels operated by American research institutions managed by the University-National Oceanographic Laboratory System (UNOLS), a consortium responsible for bringing together schools, the education community, public and private need. Ship time on UNOLS vessels is also supported by at least nine federal agencies, including the Environmental Protection Agency (EPA) and NASA (National Research Council, 2009).

All vessel designs face pressure to interface with a growing number of investigation technologies, and their design is often dictated by a need to balance the costs associated with construction and operation, scientific capabilities and overall seaworthiness. Many ships have been purposefully built for oceangoing research and others, like the HMS, Challenger, have been retrofitted for scientific tasks at sea. A 2001 study by the National Science Foundation (NSF) found a modern and well-equipped research fleet to be essential for continued ocean science research, and that in the future, the need for flexible ocean going research platforms is likely to grow.

CHAPTER 3

RESEARCH METHODOLOGY AND METHODS

This chapter includes a description of the methodological perspective as well as a rationale for using action research. Finally, data collection and analysis are discussed.

Methodological Perspective

Knowledge can be constructed and shared in many ways (Monahan & Fisher, 2010). Participant observation is a research strategy in which a researcher attempts to gain knowledge about a group and their practices over the course of their normal, daily activities. An ethnographer may use this approach—which includes multiple methods and techniques including structured observation, interviewing and participation—to collect descriptive data via fieldwork, and render that data intelligible and significant to fellow academics and other readers in a work called an ethnography (Walford, 2009, p. 272).

Autoethnography allows for the production of new knowledge and is well suited to the tasks of understanding, explaining, and applying—actions central to the nature of science and which require mastery by new teachers in order to make accurate interpretations and coherent presentations (Chiappetta & Koballa, 2009, pp. 101-102, (Wall, 2006). Though it was once held as a research style reserved for the field of anthropology, ethnography is now used by researchers from many other disciplines, including education. Monahan and Fisher (2010) argue that its methods have the power to yield data which are equal in value to those obtained and expressed through other means while Doty (2010) praises its ability to make information accessible to a broader group of intelligent readers who may not otherwise want to read about a particular topic.

Methods

Connecting With the Ocean Science Community:

Outreach to facilitate joining scientists aboard research vessels was conducted in July, 2010 using two separate means: (1) a marine education email discussion list (Scuttlebutt) and (2) networking with a crew member who works aboard the University of Miami's ship, the R/V F.G. Walton Smith. Scheduling efforts continued through October, 2010.

Obtaining Data:

Research for this project was conducted aboard three ships between September 27, 2010 and October 30, 2010 (IRB PROJECT NUMBER: 2011-10084-0). The information reported within this text was acquired through a combination of methods including *in situ* participation, direct observation and questioning, as well as semi-structured, in person interviews. Consistent with the larger scientific goal of sharing information, this approach was selected because it provided a way to give a true to life account of personal scientific discovery while making information accessible to a larger audience.

The reason for my presence was known to the members of the scientific parties with whom I worked from the outset of each cruise. For the sake of accuracy I observed the same work and sleep schedule as the scientific crew. Meals were eaten together, as well. During these times, background information was gleaned by listening and by asking clarifying questions when necessary. Informal, on-the-job conversation also produced additional knowledge. The data below about shipboard activities, research topics, scientific pursuits—including personal reflections and suggestions from scientists about marine education—were recorded a minimum of once per day in a journal or online blog and were supplemented with drawings, digital photographs and high definition (HD) video (see Table 1).

Table 1: Data Collection Tools and Their Respective Uses

Method	Use
Interviews	Question scientists about their research questions
Journal	Recount each day's events, reflection
Online Blog	Share events and learning with professors, family and friends
Drawings	Document specimens
Photographs	Capture examples of daily operations
HD Video	Record examples of shipboard activities

Reporting Data:

The media used for information capture in this study served the role of a modern field journal and enabled the researcher to report about place, daily occurrences and methods. Capturing important descriptions such as these is a tradition several hundreds of years in the making, and one which remains a part of modern inquiry. Today, we find value in the information contained within personal journals that recount history's expeditions, voyages and discoveries—texts which were not kept for the purposes of informing society, but which nevertheless fulfill that role. For example, Lewis and Clark were charged to take careful observations, and to become informed by inquiry during their survey of the American West

(Fritz, 2004, p. 59). Their accounts allowed for advancements in natural history and ethnology. Similarly, Darwin's account of his five-year cruise around the world aboard the HMS Beagle in 1826 provides many reflections and personal details regarding personal experiences and learning.

Procedural information (methods, conversations, reflections) presented in this report appears in unaltered form, but the names of all NOAA personnel with whom I worked have been changed to pseudonyms to protect their privacy.

CHAPTER 4

NATURE OF SCIENCE AT SEA

A typical image of science in practice might show a man wearing a lab coat conducting an experiment according to the scientific method (Chiappetta & Koballa, 2009, p. 103). Yet this picture does not reflect the complexity of the topic. Science is conducted by individuals from diverse backgrounds and in many different locations, including traditional laboratories and field sites ranging from mountaintop observatories to the seafloor. Also, scientific inquiry has no clear pattern of steps that will lead to new scientific understanding (Rutherford & Ahlgren, 1990, p. 3). Despite, being carefully planned to reduce error and maintain validity scientific investigations are subject to a number a variables and, as a result they often proceed in an idiosyncratic fashion (Chiappetta & Koballa, 2009, p. 110). This is especially true for scientific work conducted in the field.

Scientific fieldwork is an approach used by researchers to collect data in the natural environment and is of value because it allows scientists access to information that is difficult—and sometime impossible—to obtain remotely. Importantly, scientists conducting field studies must gather and prepare the equipment they will use ahead of their study, taking into consideration variables such as weather, safety and the environment in which the investigation is to take place (Inomata, 2011). Sometimes an entire study will be carried out *in situ*, requiring an even greater level of preparation. In other cases, data collected on location will be analyzed under controlled conditions at a later time (Marlow, 2011).

Acquiring data of interest from aboard a research vessel shares many attributes with other types of fieldwork. However, because of the dynamic environment in which these ships operate, science conducted at sea is unique. To begin, the ship itself is not the location of interest for researchers but rather a mode of transport to, and between, different ocean sites. While some scrutinizing of data may occur while at sea, doing so often presents a distinct set of challenges. For example, the movement of the boat on top of the water can make microscope work—especially when counting—difficult as items move under the lens. This motion can also cause seasickness which, by one estimate, may drop productivity by up to 90 percent (Kinder, 2009, p. 252). Additionally, these vessels routinely and repeatedly spend days to months at sea, during which they must meet the needs of the individuals on board. Because research vessels spend long intervals at sea with minimal distance between the individuals on board, conflict can also develop quickly and for atypical reasons (Bernard & Killworth, 1973; Kinder, 2009, p. 253). In general, the men and women who elect to conduct scientific research at sea do so motivated by curiosity and a need to collect data. Other observations include the following:

An organization or institution wishing to conduct research at sea must first secure funding for ship time. Next, scientists need to assemble the scientific party and then coordinate any necessary resources. This can be a challenging process. Planning begins several months in advance and as a result, ship time, personnel schedules, and gear logistics are typically planned and re-planned several times before the vessel will sail.

Life aboard a research vessel is a unique experience. Once the ship has left port it becomes a moving home that must provide personnel on board with everything they require each day while at sea—fuel, food and supplies. The scientific agenda largely dictates vessel operations and work schedules often modify one's daily routine. Every day rituals such as eating, sleeping and hygiene practices are modified, as are many scientific activities. Much of this has to do with the nature of working on a floating, mobile platform of a fixed size that can also be affected by the prevailing weather conditions.

Because a research vessel is employed for scientific research, its layout is different than other ships. There are dedicated spaces for the scientific party to work, which include wet labs, dry laboratories, and berths for them to sleep. Also, these ships carry specialized gear including cranes, winches and other machinery in addition to specific tools brought onto the ship by the scientific party. Often times a research vessel will also have a number of common-use items such as sonar or computers that can be used to further research efforts; since the vessel is always in motion these items must always be secured. Rope, latches, and cable ties are common for this.

The person in command of the vessel is the ship's captain. He or she is responsible for safety, navigation, crew management and all vessel operations. Members of the ship's crew are charged with assisting the captain in these capacities. On a research vessel some members of crew liaise with the scientific party to carry out scientific operations such as launching and recovering equipment, while other members of the ship's crew such as the first and second mates primarily assist the captain and share duties in command of the vessel. Specialty positions also commonly exist for cooks, mechanics, engineers and technicians—all of whom are also under that captain's authority. Everyone must work together if a cruise is to go smoothly. It is important to note that the maximum distance possible between two individuals on a ship is equal to the length of that ship. Because everyone operates in close contact, consideration and courtesy are of heightened importance.

Work aboard a research vessel is done in continuous shifts for the entire time the ship is at sea, and it is not uncommon for members of the scientific party to alternate their watches on a twenty-four h. cycle in an effort to maximize ship time, which can cost upwards of twenty thousand dollars per day. At the end of a shift, there is freedom to occupy the time as one sees fit, and it is common to relax during these periods—sometimes watching a movie, reading a book, playing cards, or retiring to one's bunk to sleep.

Sleeping quarters aboard a research vessel are compact, and rooms are likely to sleep multiple individuals. Bunk beds are common, and there are places in which to secure personal items, such as drawers or a locker. In general, however, personal space is extremely limited. Because there are multiple work and sleep schedules, care should be taken to prevent making excess noise. Also, unnecessary trips in and out of sleeping quarters should be avoided.

Food on a research cruise is typically abundant. The steward or cook will usually serve three meals each day and additional snacks can be had at any time of the day or night. Sometimes it is not possible to attend a meal due to ongoing scientific operations, but this should not be cause for concern. These instances are generally known in advance and in most cases a plate can be set aside to be eaten later.

Finally, hygiene experiences on a ship are generally the same as on land save for a few key differences. There are bathrooms and there are hot showers, but in general they are unisex; also, they may be communal. Other differences center on whether the ship has the ability to desalinate seawater, or “make water”. On a ship that lacks this ability, all water must be pumped onboard before the leaving the dock. The only way to obtain more is by returning to port. As a result, conservation practices may be in place. The captain will make an announcement about any special requirements, but showers need to be short in duration, and water should never be left running. To this end there may also be special toilets, called “heads”, equipped with water-saving motors.

CHAPTER 5

SUMMARY OF SCIENTIFIC RESEARCH AREAS

This chapter includes a description and brief history of the research topics under investigation by the respective scientific parties on three cruises research vessels. The first two cruises focused on sampling reef habitats along the southeastern continental shelf of the United States as part of an ongoing effort to determine the health of red snapper (*Lutjanus Camperchanus)* populations. The third cruise focused on collecting water and sediment samples in an effort to determine the regional and seasonal abundance of human-caused harmful algal blooms (HABs).

Fisheries Independent Sampling of *L. camperchanus*

L. camperchanus was first declared overfished in the United States in 1983 and has been regulated since that time. Strategies to reverse the overfishing trend are ongoing and include limitations on the type of gear that can be used to catch them, length and size requirements for commercial fisherman, and a total bag limit for recreational fisherman. Other updates to what is known as the "snapper grouper fisheries management plan" provided for the creation of deep water marine protected areas (MPAs) that provide havens for the fish (U.S. Department of Commerce, NOAA, and the U.S. Department of the Interior, 2010). However, as recently as summer, 2010 *L. camperchanus* were still being harvested at an unsustainable rate despite more than two decades of regulation. In response, the South Atlantic Fisheries Management Council

(SAFMC), a group responsible for the conservation and management of fish stocks within the United States' coastal waters, proposed that fishing for *L. camperchanus* be suspended. This action has now closed the fishery to recreational and commercial fisherman while an amendment to the current FMP (Fisheries Management Plan) is developed (National Marine Fisheries Service, 2010; The National Oceanographic and Atmospheric Administration, 2010)

Fisheries management is a complicated task made more difficult by its objective to safeguard species as a future resource while making them available to be caught today. Early management strategies tended to focus on a single species at a time and failed to recognize the importance of ecological communities (Ecosystem Principles Advisory Panel, 1998). Today, efforts are dominated by a combination of real world sampling aboard research vessels and modeling. As computing power has increased, such fisheries models have grown in complexity in an attempt to replicate full ecosystems. Whether they have been successful in this regard is a topic of debate. In many cases predictions made by the models are hindered by information that is unknown. The SAFMC (2011) has stated that because many data sets are incomplete, the condition of many of the species within the snapper grouper complex is unknown". Callum Roberts describes this modeling problem, generally, in his book *The Unnatural History of the Sea*:

> Even the most complex models...are cartoons of reality...Many of their assumptions are just as flawed as the simple models of the past...Furthermore, the more complex of today's models suffer from a crisis of complexity where more is really less...the model becomes erratic, and the conclusions drawn from the results can be downright misleading

Others agree with this analysis of current fisheries models, stating that the current ban on fishing for *L. camperchanus* is "unwarranted" (Waldner & Chesnes, 2009). They explain that they feel the data around which the ruling has been based are unreliable. Though the closure occurred in response to numbers reported by recreational anglers, commercial fisherman, and scientists, many fishermen still question the sufficiency of the collection methods and feel that the data necessary to make a closure ruling do not exist (Allen, 2010).

The most recent stock assessment, SEDAR 24 (2010), seems to lend support to the fishermen's claims that there was a spike in the number of red snapper between 2007 and 2009. In response, three important things have now happened: (1) the SAFMC has said that if the results of a new assessment suggest that a different course of action is needed they are "committed to making those adjustments" (2) fishery-independent sampling (data not from fisherman) has been prioritized in the past year because of the dire need for red snapper samples--even taking away scheduled boat time from other projects, and (3) a new research group called the Southeast Fishery-Independent Survey (SEFIS) has been formed under the NOAA architecture and tasked with the assessment of reef fish found in locations along the southeastern continental shelf of the Unites States (NOAA Gulf Marine Support, 2011). SEFIS (2011) states that their approach will, "lead to consistent improvements...for stock assessment and ecosystem-based management of southeast U.S. marine fisheries." Such efforts are needed as elements of new, smarter management strategies that focus on limiting fishing effort while protecting whole ecosystems so that fisheries may remain open and sustainable.

Harmful Algal Blooms and the Neurotoxin BMAA

Another area of research that underscores the relationship between humans and the ocean is the distribution of HABs and the neurotoxin β-Methylamino-L-alanine (BMAA). Cyanobacteria are understood to be relatives of the bacteria—not eukaryotes, though the literature often speaks of 'blue-green algae' and 'algal blooms' when referring to them. The reason is because they are both photosynthetic and aquatic. They are not a true alga, however. They occur naturally and colonies are found in great number across the ocean surface. Usually their growth is limited based on the availability of chemical nutrients such as nitrogen and phosphorus. Because many anthropogenic activities produce these nutrients, cyanobacteria blooms are also linked to human activities. Partially this is because the human population is growing, and as a result there is more human-caused pollution.

Nutrient runoff from fertilizer, animal waste, sewage and eroded soil are all currently entering natural systems at a faster rate and in greater quantities than would be expected to occur naturally. This change has caused the number of blooms occurring worldwide to increase, which is detrimental in that an overabundance of cyanobacteria can quickly deplete the oxygen in a given ecosystem. When this happens, eutrophication occurs. The process may first occur in smaller bodies of water such as ponds, but soon rivers and estuaries can also be affected as runoff travels towards, and then reaches, its eventual destination: the ocean. This process has been observed in many locations such as the Chesapeake Bay and Mississippi Delta in the United States and the Black Sea and the Baltic Sea in Europe. But the collapse of estuaries may well be a world phenomenon (Brand, Pablo, Compton, Hammerschlag, & Mash, 2010; Roberts, 2007).

Some species of cyanobacteria produce toxins harmful to humans, animals and other marine life. Contact may occur while swimming in water containing cyanobacterial toxins, as a result of ingestion or inhalation of the toxins. These exposures can produce a range of related symptoms including skin irritation, stomach cramps, vomiting, nausea, diarrhea, fever, sore throat, headache, muscle and joint pain, blisters of the mouth and liver damage. (World Health Organization, 2001). While many of these toxins are known, new species are frequently discovered and new information is learned about documented species. For example, scientists have recently discovered that more than 90% of cyanobacteria also produce the nuerotoxic amino acid BMAA (Jonasson et al., 2010).

Initially BMAA was linked only to the island of Guam where the Chamorro people have experienced disproportionately high rates of neurodegenerative diseases resembling Amyotrophic Lateral Sclerosis (ALS) and Parkinson's disease. Brain tissue analysis conducted on patients who died from these illnesses revealed high concentrations of BMAA. Initial hypotheses, occurring as early as 1865, linked the diseases to the Chamorro diet which is rich in cycad seeds; modern science seemed to confirm this hypothesis, except that no one could explain the observed levels of toxicity, as Chamorro people simply did not eat cycad seeds in sufficient quantity. Cox & Sacks (2002) offered that BMAA may be bioaccumulating within the local ecosystem. They reasoned that exposure to the amino acid occurred not only when Chamorros ate cycad seeds, but also when they consumed animals, such as flying foxes, that ate the seeds. Their hypothesis provided an important link to the cause.

Banack et al. (2007) demonstrated that BMAAs are produced by endosymbiotic cyanobacteria of the genus Nostec, which also inhabits cycad roots and explains the early connections between cycads and the observed symptoms. This means that the neurodegenerative diseases due to BMAA exposure in Guam amongst the Chamorro might not be unique. Indeed, Jonasson et al. (2010) report that BMAAs are spread through aquatic ecosystems globally and that BMAA production seems to be a "constitutive feature" of some species. These findings suggest that other humans, animals and marine organisms are likely to encounter them.

Because BMAA is a water-soluble amino acid is would not be expected to bioaccumulate, nonetheless, high concentrations of BMAA can accumulate in some aquatic animals near areas of cyanobacteria blooms. BMAA also bioaccumulates within animals eaten by humans such as the flying foxes in Guam. There is not a clear pattern of bioaccumulation; that animals occupy slightly different microhabitats may explain concentration differences amongst members of the same species, as may genetic differences and/or the age of animals. However, magnification of BMAA within a food system appears to concentrate in benthic species eaten by humans such as pink shrimp, crabs and mollusks (Brand et al., 2010). Accordingly, BMAA may enter our food chain and lead to impaired neurological functioning among humans as evidenced by high BMAA levels within the central nervous systems of American and Canadian Alzheimer's and ALS patients (Jonasson et al., 2010).

Toxic cyanobacteria blooms are increasing worldwide. It is unknown why cyanobacteria produce the BMAA; however, production appears to be widespread (Brand et al., 2010). This increase poses a potential threat to near-shore marine ecosystems and water supplies and highlights a pressing need to understand more about BMAAs and their role in the environment, especially as they relate to human health. In particular it will be important to discover to what extent bioaccumulation is possible and the means of BMAA transfer. It has been predicted that our growing population will cause cyanobacterial blooms to become more numerous in the future. As a result BMAA exposure will become more likely and probably at increasing concentrations; this has the potential to lead to a greater possibly for disease, and makes the answers to these questions even more valuable (Brand et al., 2010; Jonasson et al., 2010)

CHAPTER 6

SHIP ACTIVITY JOURNAL

Cruise One: R/V Savannah

This trip occurred between September, 27 and September 29, 2010 (3 days) departing from and returning to Skidaway Island, GA. The scientific crew consisted of eight personnel from NOAA Fisheries (Beaufort, NC laboratory) and the South Carolina Department of Natural Resources Marine Resources Monitoring, Assessment, and Prediction Program (MARMAP). The objectives for this cruise, focused on the offshore waters of northern Florida, included fishery-independent sampling of live bottom habitat using chevron trap and video camera methods, refining procedures for sampling off the R/V Savannah, further training of personnel in all aspects of sampling and work-up and training of personnel in the use of newly acquired Canon video cameras. Although the cruise was originally scheduled for seven sea days bad weather forced us back to port on the third.

The R/V Savannah is a 97-foot long ship owned by the University System of Georgia and operated by the Skidaway Institute of Oceanography (SkIO). It is a large, blue vessel that appears to bob high atop the water despite drawing 8 feet of water and displacing over 200 tons (see Figure 2). As a member of the University National Oceanographic Laboratory System (UNOLS) fleet, the Savannah carries the Local Class designation that specifies the ship will typically work in the near-shore environment (National Research Council, 2009).

Figure 2: The R/V Savannah Docked at the Skidaway Institute of Oceanography in Savannah, GA

The ship has three decks: one partially below the water line, and two above. The ship also has a 150 sq. ft. wet laboratory located on the starboard side main deck and a 300 sq. ft. dry laboratory located adjacently to the wet lab on the port side of the ship. These spaces are configurable to the needs of the scientific party. They can be set up to house computers or other monitoring equipment, as a place to conduct scientific experiments, or for storage, among other purposes. The aft working at the back of the ship, also known as the “fantail” and often called simply “the back deck”, provides another 600 sq. ft. of configurable space, and is where most of the ships operations take place. SkIO states that their ship represents a state-of-the-art improvement in seagoing opportunities for Skidaway and for the southeastern United States and is ideal for biological, chemical, physical, and geological oceanographic studies in estuarine and continental shelf waters throughout the southeastern US Atlantic and Gulf Coasts.

My first experience aboard a research vessel, was defined by seasickness—the chop of the Savannah River, the slosh of Wassaw Sound. As we entered open ocean a light rain grew heavier and the sloshing continued. Within the first two hours I knew something inside my head was wrong, and by that time it was too late for an antiemetic. The slow, insidious creep of nausea caused by the sea had begun. Within a matter of hours I began to appreciate one of the basic challenges of working aboard a floating science platform: seasickness affecting productivity. Given the right conditions anyone, even the most experienced sailor, can succumb to sickness as the balance organs in his or her inner ear struggles to make sense of motion stimuli that are incongruous with those perceived by the visual system (Benson, 2002; Kinder, 2009). Indeed, motion sickness has affected sea travelers and scientists for hundreds of years. Darwin, for example, was sick constantly on his trips, “unable to do anything but lie in his hammock or on the captain's sofa”. He expressed his misery in several letters from the ship. 'I hate every wave of the ocean...' he wrote to his family in 1833. In another letter to his wife Susan he wrote “I loathe, I abhor the sea and all the ships which sail upon it” (Browne & Neve, 1989, p. 17). Fortunately, I was only affected for 24 h.

Despite the poor weather, scientists and crew worked together using information from the ship's weather radio, and NOAA's offshore marine forecasts to devise a course of action that would maximize the likelihood of a successful cruise. We were primarily at the mercy of the prevailing weather conditions as to whether we could carry out work as intended, but moved between inshore and offshore locations (imprecise terms used to describe distance from a shoreline) to avoid the storms and building seas with some success. On the second day there was a window of improved weather and I watched as scientists and crew again synchronized their efforts in order to deploy and recover fish traps. The scientific party, working on the back deck and in the dry lab, communicated with the crew, who acted as spotters, to relay information about the ship's position, relative to each fish trap to the captain.

The weather that finally forced us to stop setting new traps coincided with a shift change, and at that time I moved into the wet lab to begin my duties working up, or dissecting, the fish caught that morning with two young NOAA scientists, both of whom were in their mid-twenties. We measured the length of each individual fish three different ways, according to total length (TL), from the tip of the snout to the end of the tail, with mouth closed and tail lobes pressed together; fork length (FL), from the tip of the snout to the fork of the tail; and standard length (SL), from the snout the end of the fleshy part of the body (see Figure 3). We also preformed a very specific dissection—removal of the otoliths and reproductive organs—that would help scientists in a lab back on shore to determine the age and growth of each individual in an assembly line fashion that made quick work of the task. In this case, the primary catch had been of vermillion snapper (*Rhomboplites aurorubens)*, and the preferred way to perform the dissection to remove the otoliths was to use a serrated knife to cut downward from the top of the head, above the operculum. Sex organs, removed to determine sex and reproductive status, were removed by cutting into the body cavity through the anus. Data for each fish was logged and a number generated that linked together information about the trap, location, day, and species from which tissue samples were taken.

Figure 3: Using a Fish Measuring Board to Determine the Length of vermillion snapper (R. aurorubens)

Cruise Two: NOAA Ship Nancy Foster

This trip occurred between October 13 and October 22, 2010 (9 days) departing from and returning to Charleston, SC. The scientific crew consisted of seven fish biologists from the National Marine Fisheries Service and the South Carolina Department of Natural Resources Marine Resources Monitoring, Assessment and Prediction Program (MARMAP). The objectives for this trip were: fishery-independent sampling of reef fishes on live bottom habitat using chevron traps and video camera methods; refining procedures for trapping off the *R/V Nancy Foster;* and training of personnel in the use of new Canon video cameras. All sampling was conducted within a 100 mi range off the coast of Cape Canaveral, FL.

NOAA Ship Nancy Foster is a large research vessel, named for pioneering marine biologist Dr. Nancy Foster who passed away in 2000. The ship is 187 feet from bow to stern and displaces nearly 2,000 tons, originally built for the United States Navy as a torpedo tester (see Figure 4). In its current configuration, it works in support of diverse research efforts ranging from water quality studies to seafloor mapping along the Atlantic and Gulf coasts, and south to the Caribbean.

Figure 4: NOAA Ship Nancy Foster Docked in Charleston, SC

To facilitate this wide range of scientific activities the ship is outfitted with specialized mechanical equipment and electronics. The large, aft working area supports five different types of machinery used for heavy lifting: On the main deck there is a knuckle-boom crane capable of lifting 10,000 lbs, a twelve foot tall moveable A-frame capable of supporting 25,000 lbs, an electrohydraulic J-frame capable of supporting 5,000 lbs, and two winches. Elsewhere on the ship there are more of these cranes and winches. The weight ratings for each have been painted conspicuously onto the machines following the letters SWL, or “Safe Working Load”, that remind the crew how much weight can be safely suspended or lowered by each piece of equipment. Inside, there is space for scientific operations including a 416 sq. ft. wet laboratory, and a 272 sq. ft. dry laboratory that houses a suite of electronics equipment used for navigation, seafloor profiling, and sampling of oceanic and atmospheric conditions. To manage a successful cruise, the ship employs six commissioned officers, three licensed engineers, two survey technicians, an electronics technician and ten additional crew members.

The short duration of the first cruise aboard the R/V Savannah limited accessibility to scientific personnel and to learning opportunities. As a result I was not able to grain much information in terms of the larger fisheries sampling efforts taking place within the South-East Atlantic Ocean off the coast of the United States. On the second cruise aboard the NOAA *Nancy Foster* a range of experiences helped to develop specific skills and a richer understanding of the science behind the topic under investigation.

On the *Nancy Foster* cruise the complexities of setting fish traps emerged. Although the scientists' efforts were highly planned before the cruise began, site selection occurred in real time. Even after this task was completed there were factors such as wave action, the speed of the Gulf Stream, the speed and direction of currents within the water column, and others that required consideration. The traps and the camera arrays mounted on them were the subject of discussion and consideration. These challenges are perhaps unique to setting fish traps, but remain indicative of the nature of conducting science in an environment that is in a perpetual state of flux. By planning, testing solutions, and monitoring variables of interest it is possible to produce reliable data.

To maximize the amount of high-quality data collected during the cruise, a scientific meeting that took place shortly after the ship left Charleston harbor. In it we discussed the techniques and technologies that would assist us in our sampling efforts and discussed way to maximize the statistical significance of the data we collected. Over the next nine days a host of additional situations were experienced and/or discussed that, taken together, developed an understanding among us of the unified efforts made in support of a successful fisheries cruise.

Each day, our goal was to sample snapper—specifically *L. campechanus*—and grouper species as successfully as possible, though before a single trap could be baited or deployed it was necessary to find habitat on the sea floor likely to provide a haven to these species, such as reefs, rocks and ledges. To make this task easier, the ship has four types of echo sounders that operate at different frequencies to produce charts of the seafloor at various depths. Generally, high frequencies offer the advantage of high-resolution imaging and are most useful for surveying small swaths of the seafloor which lie at shallow depths; low frequencies offer better penetration and are capable of scanning wider areas of the seafloor at deeper depths. The charts are created by software that aggregates sonic information into plots that represent the contours of the sea floor in a “best fit” output. Overseen by a geologist from the scientific party and a technician from the ship's crew, the acoustics equipment produces data in real time throughout the night and points of interest can be logged for later review. This information is then used by the chief scientist to select specific locations for trap deployment.

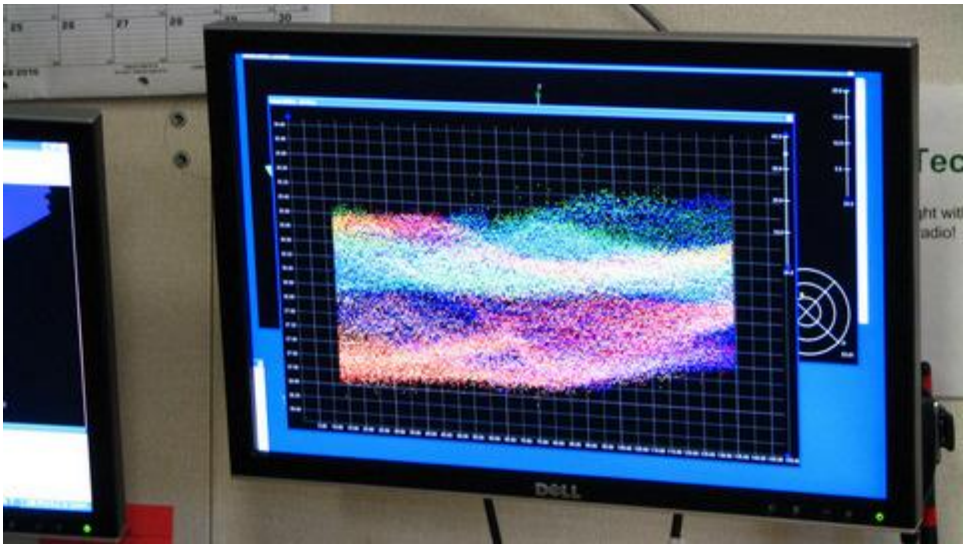

Figure 5: An Echogram Depicting Contours of the Seafloor

On the NOAA *Nancy Foster* we carried out the same age and growth dissections as we had done on the R/V Savannah, but there was a greater variety of fish caught and so the dissection techniques varied slightly. *L. campechanus* has fairly large otoliths. The tools used to remove them are crude, but they work very well (fish actually have three sets of otoliths, but only the largest set, the sagittae, were used in this study.) We used a serrated knife to cut the top of the opercula, a chisel to shave away bone mass from skull, and forceps to remove the otoliths from hollows in the base of the skull. For other species, such as scamp (*Mycteroperca phenax*), the technique was similar but the otoliths were smaller relative to the size of the fish and were a challenging to find and remove.

Figure 6: Using Basic Tools to remove Otoliths from a red snapper (L. campechanus)

Otoliths are of interest because they can revel powerful information about the age, growth and life history for a species of interest—essential information for scientists seeking to design appropriate fisheries management policies—though they must first be removed from the fish. Sometimes called ear stones, the otoliths are a bony matrix of protein and calcium. Age and growth are determined using a formula (which vary by species) to interpret rings in the matrix laid down much like the rings on a tree, although the rings are not as easy to count. In juvenile fish, the otolith can even be seen daily as a result of the rapid rate of growth during that period of development. The chief scientist added that reading of otoliths is important and necessary because fish of the same age may be different lengths, and likewise fish of equal lengths may be different ages. Dissection and measurement alone cannot give all the needed information to tell an accurate story; other factors including birth rate, age to maturity, mortality rate, and recruitment (the number of fish growing to the smallest harvestable size each year) are also important.

Video cameras are a relatively new addition to the sampling efforts; their use was brought about by a need sample fish that do not actually swim into a trap. Through the creative use of comparatively inexpensive HD video cameras normally used for action sports like surfing, it was possible to conduct minimum fish counts by mounting cameras to chevron traps and switching them on just before the traps were deployed (see Figure 7). On this cruise, a single person was responsible for video data analysis after the traps were recovered. To conduct a minimum count he would examine each frame of video to establish the number of fish in each. There may be more fish present, he said, but using this method one could always know that there were no fewer fish in the area than the maximum number counted by the end of the video.

Figure 7: Preparing Video Cameras atop a Chevron Trap Prior to Deployment

When preparing to deploy the traps we monitored sea conditions carefully using shipboard sensors and buoy data aggregated by NOAA on the website http://www.ndbc.noaa.gov, among others (see Figure 8). If the current was ever greater than approximately two knots we would move onto a new site without dropping a trap because at water moving at those speeds was likely to move the traps off site. Moving traps yield unusable data since it is difficult to say where the fish were actually caught. Also, if the waves were too large, we did not set traps for a similar reason: traps tethered to a floating buoy on the surface would bounce up and down off the seafloor under these conditions.

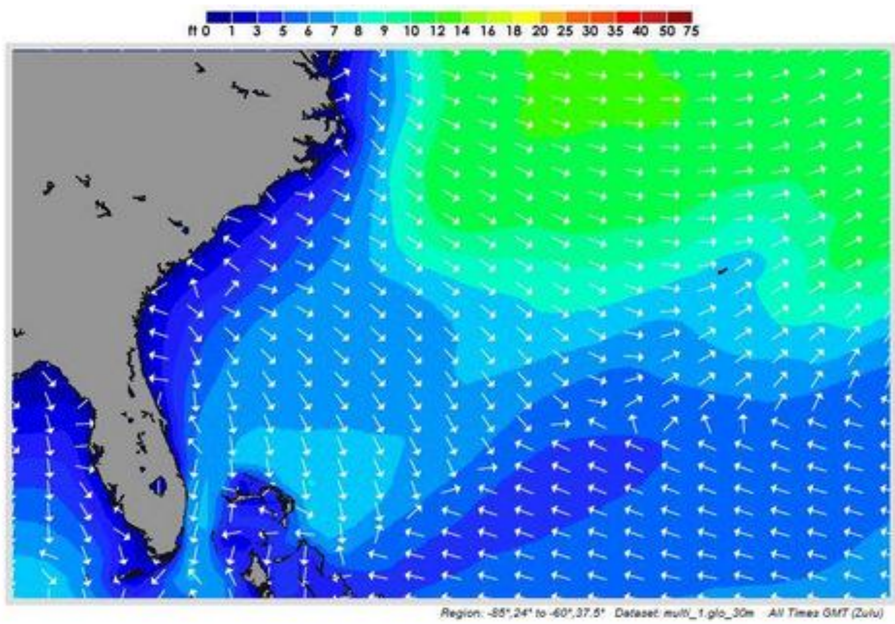

Figure 8: Swell Chart: Southeastern Seaboard of the United States

The traps themselves were of the chevron type, so called because of their shape. They feature a funneled opening on the concave side of the trap where fish can enter and a door on the convex side that can be opened by the researcher in order to remove the catch. These traps were well suited to the conditions in which we were using them: they are made of plastic coated metal so as not to be damaged by the rocky seafloor, and they have been found over the past thirty years not to exclude larger individuals from entering (which would reduce the reliability and validity of the trap data by misrepresenting the sample populations). Though the chevron design has been used successfully in the field for over thirty years, the NOAA scientists frequently discussed ways to improve their methods for more accurate data.

Because different traps catch different species, discussions frequently arose regarding the successes and shortcomings of various trap designs. While working each of the two shifts—06:00 to 18:00 and 09:00 to 21:00—over the course of the cruise, much was revealed about the methods used to establish the efficacy of any one fish trap design. For example, if evidence were to arise that suggested the use of a new style trap, it would first have to be used in tandem with the old style for a number of years to establish a conversion factor (e.g. X number of fish caught in "trap A" ≈ Y number of fish caught in "trap B")

The NOAA fish scientists on this cruise were a close group who took pride in their work (see Figure 9). Though close living conditions have been noted as problematic, there were no incidents on this cruise and spirits remained high throughout (Bernard & Killworth, 1973; Kinder, 2009). Equally willing to teach, consider and discuss, it was clear that they sought to conduct high-quality science using the best methods available. The chief scientist explained to me that the data from this and other SEFIS cruises in the 2010 season and beyond will influence management policies, but his hope was that the information they find will allow them to implement the best possible management strategies so that the fishery is healthy and can remain open.


Figure 9: NOAA Fish Biologists Working Together to Sort Fish Species of Interest

Cruise Three: R/V F.G. Walton Smith

Cruise three occurred between October, 25 and October 30, 2010 departing from Fort Myers, FL and returning to Key Biscayne, FL. The scientific crew consisted of two faculty and two graduate students from The University of Miami. The goals for this trip were to: collect water samples from predetermined locations using GPS waypoints; collect sediment samples from offshore locations identified using satellite data; and process both water and sediment samples aboard the ship for later laboratory analysis and incorporation into a predictive longitudinal data set.

The R/V F.G. Walton Smith is a 96 ft. long ship owned and operated by the University of Miami (see Figure 10). It is a catamaran-style research vessel designed for tropical oceanography. This means that the ship has a very shallow draft (the depth of water needed to float a ship) and is capable of accessing locations that would cause other ships of its size to run aground. As a member of the University National Oceanographic Laboratory System (UNOLS) fleet the Walton Smith carries a Regional Class designation that specifies that the ship will typically operate in shallow coastal bays and estuaries out to deep water beyond the shelf to carry out interdisciplinary oceanographic research (University-National Oceanographic Laboratory System, 2003)

Figure 10: The R/V F.G. Walton Smith at Sea as Seen From a Work Boat

The ship has three decks: the lower deck (actually a composite of the spaces inside of the two hulls) that houses the engines in the aft section, sleeping quarters, and bathrooms in the fore section. Upstairs on the main deck there is an working area with a large hydraulically operated a-frame, and a 200 sq. ft wet lab with adjacent access to a 480 sq. ft. dry lab; moving towards the bow of the ship there is a mess area, stairwell access to the bridge, and the kitchen. The rear section of the upper deck houses dual cranes mounted on the starboard and port sides. The

University of Miami states that it is the sole purpose of the vessel and the support personnel to provide researchers with the very best platform and equipment to accomplish the scientific goals of the project (The University of Miami, 2009)

This final cruise was a collaborative effort among two scientists focused on determining the regional and seasonal abundance of harmful cyanobacterial blooms so that the distribution of the neurotoxin BMAA may be better understood. In a departure from past cruises, we spent most of our time focused on a particular marine dinoflagellate, *Karenia brevis.* In support of these goals we sampled point source inputs from locations along ten rivers, collected offshore sediment samples in search of a bottom-resting dinoflagellate cells, and spent free time catching fish for toxin analysis. Two NOAA scientists were also aboard conducting research for a separate project.

One of the key procedural distinctions on this cruise that made it unique from the previous two was that the scientific crew did not have standardized shift schedules. Work was simply done until it was completed. Another unique feature was that the needs of four scientists, who were working on related but discrete projects, were coordinated to meet all goals during a single trip. Finally, students were responsible for carrying out a large portion of the necessary.

For inshore site sampling conducted during the day, the *Walton Smith* had work boats that we used each day to access canals, rivers, bays and estuaries. Before setting out from the ship, however, it was necessary to enter all of the locations of interest into a GPS device. We also consulted a very detailed tide chart that told us the maximum water depth in various locations—useful information that helped us from running aground. Upon arrival to a GPS waypoint everyone began to work as a team to record information about that site, including: a site number, a collection number, the date, the time, and latitude and longitude for every water sample taken. These numbers were referenced on log sheets and collection materials, which were later transferred onto bottles, test tubes, and other containers back aboard the *Walton Smith* (see Figure 13). The division of work during these work boat trips made the collection process very efficient.

Figure 11: Plastic Test Tubes Containing Cyanobacterial Samples Marked with Information Linking them to Field Sites

Offshore sediment sampling was conducted using a claw like device called a Van Veen Grab that was lowered to the seafloor to capture material. This was done in search of a hypothesized dinoflagellate cyst stage. Professor Larry Brand from the University of Miami described this to me as "high risk, high reward"; if found a resting state location of *K. brevis* would change the way the dinoflagellate is viewed, and would likely allow for better predictions concerning occurrences of blooms that are harmful to humans and marine organisms alike. Concurrent to sediment collection using the Van Veen Grab, a conductivity, temperature and density (CTD) tool was lowered into the water to log information about the physical properties of the sea water. These measurements informed data analysis; for instance, it was useful to correlate information about the temperature and salinity of sea water with the geographic location of blooms in order to better understand the environments in which cyanobacterial organisms can be found. These tasks were sometimes carried out by as few as two individuals late in the evening or as many as six individuals when many people were awake.

Inshore and offshore samples were both processed in the ship's dry lab following collection using equipment brought on board by the scientists. Again as a team we worked to complete the necessary tasks. For sediment, this process was simple and required only that ~100g be placed in a plastic container, covered with aluminum foil to block out light, and then frozen. Water samples were processed in three different ways: one filtering of 200-500 ml. (depending on the distance of the sample site to shore) was conducted to obtain water which could be analyzed for nutrient content; another filtering occurred in which filter media was saved to complete genetic assays, including species typing; finally, to a third subsample Lugol's solution was added to "fix" bacteria so their abundance could be determined at a later time.

One of the other projects serviced on this cruise was to collect fish for neural analysis (see Figure 12). Professor Brand speculates that BMAA produced by cyanobacteria may be bioaccumulating in ocean waters, meaning that anything that feeds on them, or on organisms that do, could be subject to the chemical's effects. This task was not an official part of this particular cruise, but during free time several members of the scientific party and one scientifically-minded member of the ship's crew volunteered to assist Professor Brand with this related topic of research.

Figure 12: Atlantic Sharpnose Shark (Rhizoprionodon terraenovae) Caught for Brain Tissue Analysis

CHAPTER 7

RREFLECTION AND RECOMMENDATIONS

This study provides an account of inquiry-driven scientific action and the resulting discoveries that took place aboard three research vessels in the fall of 2010. Aboard the *R/V Savannah* I first became acquainted with living and working aboard a research vessel, and through an experience with seasickness I came to appreciate the influence that weather has over operations at sea. However, because the first cruise ended early due to weather, it was difficult to understand the scientific actions taking place. This was remedied on the *Nancy Foster* cruise which provided necessary insight into the methods used to sample reef fish, including seafloor mapping and the use of chevron traps. As a result, I understood the closure of the *L. campechanus* fishery in more concrete terms, taking into consideration the roles of fisherman and regulatory agencies. The final cruise aboard the *R/V F.G. Walton Smith* was an introduction to topics with which I had little prior experience: human-caused harmful algal blooms and the occurrence of the neurotoxin BMAA. Working together with members of the scientific party and the ship's crew, I became educated about these topics and quickly developed an appreciation for the work being done.

When I began this study I reasoned that an ethnographic approach would yield high quality data and the benefit of firsthand learning experiences and real-time access to researchers in the field could be easily translated to readers interested in learning more about ocean science education (Wall, 2006). I expected that being on deck and working alongside scientists would help to produce an account more reflective of the nature of science at sea than a study conducted on land. Additionally, I anticipated that such experiences might boost my comprehension and enthusiasm for teaching. For these reasons I needed to be present for the salt spray, the eighteen h. days and irregular sleep schedules, the sea sickness, the planning, the discovery, and the excitement of overcoming daily challenges. I now recognize that learning about ocean science topics in this first hand way has made them more memorable. I believe that this has occurred because the learning was neither rote nor abstract. Instead, I frequently needed the information I learned to properly complete a specific task—such as removing an otolith or fixing bacteria using Lugol's solution. Also, because these tasks were completed many times they became well rehearsed and more difficult to forget. In other words, because my learning was authentic, I have been able to better understand and better remember the new information that I learned. Now, as a result of my time living and working with scientists conducting research at sea, I am able to effectively communicate about the topics under investigation, a skill that is central to ocean literacy.

During each cruise I witnessed that science at sea has a different look and feel than one might otherwise imagine. For example, many of the scientists were very young, and no one wore a lab coat. In fact, most of the work was carried out in shorts and t-shirts. More substantively, I was never made to feel like an outsider despite the fact that I was not a scientist. There were even instances when the chief scientists asked how I would proceed in a given situation. These events, and others like them, made me feel a part of the group.

On the *Nancy Foster* cruise, the researchers were very willing to answer my curious questions. In addition to providing direct answers, the researchers also focused my understanding of new material by asking me follow up questions. For example, during a fish dissection I asked: "at what age reef fish change sex from male to female, or vice versa?" They followed up the immediate answer--that it varies depending on both internal cues and signals in the environment--with a secondary question: “why would that matter for the research we are doing?" Without exception the scientific party on that cruise was positive and the mood remained upbeat. We were at sea to conduct important research, and although there was never any relaxation in the level of diligence with which we completed each required task, most of the work we did was carried out with a smile on our faces. I believe that this approach has applicability in the classroom. I have experienced that many classrooms suffer from one of two problems: they are either too strict, or they are too relaxed. On the *Nancy Foster* I was also expected to do many types of work—even difficult tasks with which I had little prior knowledge. Nevertheless, we made jokes and relaxed when appropriate. That science is often fun is an important lesson. And although such a balance between the hard work and enjoyment may prove elusive in a school classroom I believe it is worth striving for as an educator.

Professor Brand, on the *R/V Walton Smith*, was very willing to explain his research questions and methods; in particular, I appreciated that he presented his scientific interests humbly even though they represent an important area of research. The day to day outcomes of Professor Brand's research may have little day-to-day impact upon the human society, however his longitudinal data certainly do. I believe there is applicability for science education in his approach. For instance, studies like those conducted aboard the R/V Walton Smith should remind teachers to guide learning so that students are able to understand how discrete tasks may contribute to a larger body of scientific work. Teachers who anticipate the “why are we doing this?” question common from students may ultimately provide more meaningful learning experiences.

Though an independent approach to nontraditional learning at sea is not common there are formal programs that offer teachers the opportunity to conduct research at sea (see Appendix A). Participation in research programs such as these may promote ocean literacy and improve student's learning (NOAA Teacher at Sea, 2010; Silverstein et al., 2009). I believe that teachers who elect to work with researchers at sea might also realize other benefits in their classrooms such as increased credibility and perhaps an increased level of respect from students.

For educators who cannot (or wish not to) go to sea I still recommend using the Ocean Literacy Principles when teaching science concepts. Although the ocean literacy document is relatively new, there are already a numerous resources that help make the process easy (see Appendix B). Also, because the Ocean Literacy Principles have been aligned with the NSES, ocean science topics can be addressed in most any existing science class. This means they can be taught in the K-12 classroom without altering the current curriculum or creating a dedicated class. Furthermore, the NSES alignment makes it easy to adapt the activities you create to meet state standards and informal science settings (Schoedinger et al., 2006). Developing a learning experience based on ocean literacy principles proceeds just as it would for any other topic.

This study is limited by the length of my time at sea, and the narrow range of issues I encountered during only three cruises. For these reasons I would not assume universality of my experiences; I experienced a positive environment with support from the scientists aboard each ship and was engaged in interesting studies. In reality, the opposite may be a more common experience. Future studies that are longer in duration and wider in scope may help to normalize my account of what it was like to learn from marine researchers.

During my time, at sea I was able to capture examples of creativity, open-mindedness, teamwork, a demand for data-driven evidence, and *ad hoc* problem solving—for example, when changing sea conditions caused our work schedules and planned operations to change unexpectedly. The sum of my experiences confirm that scientific work aboard research vessels is consistent with the nature of science generally—a team effort that requires cooperation between scientists, technicians and assistants that is expensive, tedious constantly in flux and sometimes dangerous (Chiappetta & Koballa, 2009, p. 103).

As a pre-service teacher I have made conjectures and suggestions for classroom activities that as of yet remain untested and which may require modification before they can be incorporated into science classrooms—especially with respect to grade level. However, I anticipate that many of the lessons I have learned about science content and the nature of science presented in this study will resonate with practicing educators and promote ocean literacy, and therefore science literacy.

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APPENDICIES

APPENDIX A

Opportunities For Teachers To Conduct Research At Sea

Opportunity Through: American Sail Training Association
Description: The mission of the American Sail Training Association is to encourage character building through sail training, promote sail training to the North American public, and support education under sail.
Website: http://www.sailtraining.org/membervessels/database.php (sort by sea education type)

Opportunity Through: California Current Ecosystem LTER
Description: Offered for the past three years, this long term ecological research experience affords teacher s the opportunity to is for individuals interested in broadening their scientific knowledge, participating in state-of-the-art, hands-on, oceanic research, and communicating interdisciplinary educational experiences in the classroom and beyond. May - July
Website: http://cce.lternet.edu/outreach/teachers/teachersatsea/

Opportunity Through: COSEE Great Lakes
Description: Science workshop that is aboard the EPA's R/V Lake Guardian, the largest US research vessel on the Great Lakes. Work side by side with scientists on limnological inquiry, and stop in ports for additional science learning.
Website: http://coseegreatlakes.net/events/shipboard11

Opportunity Through: Deep Earth Academy
Description: Educators are selected through a competitive application and interview process. If selected, educators have the opportunity to learn shipboard science aboard the JOIDES Resolution alongside the expedition's science party and translate their learning experiences for students, families and the general public through creation of blogs, videos, social networking sites, live video conferencing from the ship and classroom activities.
Website: http://joidesresolution.org/node/453

Opportunity Through: Down Under, Out Yonder
Description: This program focuses on scuba field experience and is an introduction to coral reefs and the National Marine Sanctuary System. It also includes training in conducting Reef Environmental Education Foundation fish counts in the sanctuary.
Website: http://www.gulfmex.org/teachers.htm

Opportunity Through: Marine Science and Nautical Training Academy (MANTA)
Description: Invites one high school science teacher to accompany the regular MANTA staff to explore coral reefs aboard a **catamaran sailboat in the British Virgin Islands.**
Website: www.manta-online.org

Opportunity Through: NOAA Teacher at Sea Program
Description: provides teachers opportunities to participate in real- world scientific research and maritime activities through teacher research experiences aboard one of NOAA's 18 ships. Participants can expect to be at sea anywhere from one week to one month where they will conduct Research related to biology, physical science, or sea floor scanning.
Website: http://teacheratsea.noaa.gov/

Opportunity Through: Rhode Island Teacher at Sea (RITAS)
Description: A partnerships between ocean scientists, researchers and teachers who live and teach in Rhode Island. Cruises for educators last for three days to three weeks at a time.
Website: http://www.gso.uri.edu/rv-endeavor/endeavor-expeditions

Opportunity Through: Science Teachers Aboard Research Ships (STARS)
Description: Approximately once a month the University of Hawaii, Manoa operates a four-day research cruise that offers teachers a chance to participate in research related to the field of microbial oceanography.
Website: http://cmore.soest.hawaii.edu/education/teachers/stars.ht

Opportunity Through: Salish Sea Expeditions
Description: Teachers can participate in sea expeditions with their students. Also offers courses for teachers focused on inquiry based learning in a field research setting.
Website: http://salish.org/Educators/

Opportunity Through: Whale Camp (paid)
Description: The Whale Camp, on Grand Manan Island off the coast of Northern Maine, offers summer programs for students and teachers to observe and study whales, dolphins, porpoises, seals, and puffins in their natural habitats through direct observation, data collection, and hands-on experience with marine science equipment. The programs focus on the ecology of the Bay of Fundy and how the highest tides in the world produce huge quantities of plankton to establish a diverse food web.
Website: http://www.whalecamp.com/

APPENDIX B

Selected Activities

Tricky Traps

Grade Level: 9-12
Lesson Time: 45 min.-1.25 hr

Summary

Investigate sampling methods, formulate and test solutions to real world scientific problems. In this hands-on activity students explore the challenges that fisheries biologists face when conducting reef-fish surveys at sea.
Students use online resources to examine the types of data that scientists use to increase the validity of their research and apply that knowledge to a classroom inquiry activity.

Objectives

- Identify what it means to sample a population
- Describe why and how fish populations are sampled
- Predict how abiotic variables affect trap deployment
- Synthesize data and formulate solutions to overcome challenges (ship maneuvers, trap design, information)
- Identify the most affective outcomes

Vocabulary

Bathymetry, Sounding, Hydrographic

Standards

Science as Inquiry (12ASI)
Abilities necessary to do scientific inquiry [5-8, 9-12]
Understandings about scientific inquiry [5-8, 9-12]
Physical Science (12BPS)
Interactions of energy and matter [9-12]
Transfer of energy [5-8]
Life Science (12CLS)
The interdependence of organisms [9-12]
Matter, energy, and organization in living systems [9-12]
Populations and ecosystems [5-8]
Earth and Space Science (12DESS)
The origin and evolution of the earth system [9-12]
Structure of the earth system [5-8]

Science and Technology (12EST)
Abilities of technological design [5-8, 9-12]
Understandings about science and technology [5-8, 9-12]
Science in Personal and Social Perspectives (12FSPSP)
Natural resources [9-12]
Environmental quality [9-12]
Science and technology in local, national, and global challenges [9-12]
Populations, resources, and environments [5-8]
Science and technology in society [5-8]
History and Nature of Science (12GHNS)
Science as a human endeavor [5-8, 9-12]
Nature of scientific knowledge [5-8, 9-12]
Historical perspectives [5-8, 9-12]

Background

Scientists use a variety of sampling gear, including traps, to catch and quantify the overall health of fish populations. Specialized trap designs help researchers catch fish that live in different areas in the ocean. Setting traps effectively can be a challenge, especially in deep water where wave action, currents and the contour of the seafloor affect trap placement on the bottom.

Research vessels are specially outfitted, mobile platforms that afford scientists access to marine environments where they can carry-out studies not possible from land. Nevertheless, there are many challenges associated working in (and on) the ocean. Ships and their operations are often influenced by wind, waves and currents. These variables must be taken into consideration when conducting activities at sea. Using instruments aboard the ship—sensors, gauges, probes, etc—the scientific party and vessel crew (who assist scientists in their activities) are better able to understand the conditions in which they are working and modify their efforts accordingly.

The synthesis of many types of data is often necessary to achieve the best possible outcomes. In the case of snapper and grouper fisheries sampling, traps need to be set on “hard bottom” sites that that have moderate to high relief. In order to identify these areas additional technologies, such as multibeam sonar (echosounders), are used to produce maps which reveal the contour of the ocean floor. Information about wind, waves and current information is used to increase the likelihood that that fish traps, tethered to a ball floating on the surface, land in the desired location and do not bounce along the bottom.

Materials

- ~10 gallon fish tank (or a large Rubbermaid-type container)
- Materials suitable for building a sinking trap (such as paperclips, wire, etc)
- Rocks to place in the tank
- String (slightly longer than the height of the tank)
- Balloons
- Split shot sinkers (or equivalent) to weight the trap
- Hose (to create current)

Teacher Preparation

- Using tape make a coordinate grid on the bottom of the tank
- Arrange tank with rocks in the tank to simulate areas of habitat. (make sure to leave some areas bare.)
- Fill the tank approximately ¾ full with water

Procedure

- As a class, take a depth soundings (in cm) in each quadrant
- In pairs, transform this hydrographic data to make a topographic map of your “seafloor”
- In pairs, determine an appropriate sampling site based on the map
    - construct a trap that is likely to orient itself properly on the seafloor, bottom down.
    - carefully measure string to the correct length
- Test the design (mind the current!)

Closure

On scratch paper students should write down the information that was most helpful in their planning.

Independent Practice or Extension for Diverse Learners
At home, create an advertisement for you trap. Be sure to highlight the new design features you have incorporated and explain what problem(s) they address.

Online Resources
Investigate types of sonar: http://oceanexplorer.noaa.gov/technology/tools/sonar/sonar.html
Learn about hydrographic surveying: http://oceanservice.noaa.gov/navigation/hydro/#6
Determine sea state: http://www.ndbc.noaa.gov/
Visualize wind and wave action: http://magicseaweed.com/msw-surf-charts2.php?chart=64&res=750&type=swell&starttime=

Can I Keep It?
Grade Level: K-4, 5-8, 9-12
Lesson Time: 45 min

Summary
Knowing how to properly measuring fish is an important skill for scientists and fisherman alike. In this activity students will examine three ways that fish length is determined and evaluate the appropriateness of each in different situations.

Objectives
- Classify fish based on size
- Practice taking appropriate fish measurements
- Distinguish different measurement types from one another
- Compare fish fins and propose a reason for their differences
- Evaluate the advantages and disadvantages of using multiple measurement types

Vocabulary
Fork Length (FL), Standard Length (SL), Total Length (TL), Ichthyologist

Standards
Science as Inquiry
Abilities necessary to do scientific inquiry [K-4, 5-8, K-12]
Understandings about scientific inquiry [K-4, 5-8, K-12]
Life Science
The characteristics of organisms [K-4]
Diversity and adaptations of organisms [5-8]
Biological evolution [9-12]
Science and Technology
Abilities of technological design [K-4]
History and Nature of Science
Science as a human endeavor [K-4, 5-8, 9-12]
Nature of science [5-8]

Background
When an Ichthyologist measures fish he/she may do so in one of three ways depending on the fish. Those measurements are as follows: fork length: (FL) from the tip of the snout to the fork of the tail, standard length: (SL) from the snout the end of the fleshy part of the body, and total length: (TL) from the tip of the snout to the end of the tail, with mouth closed and tail lobes pressed together.

But why have different measurements? Well, sometimes these measurements can be tricky. For example, it is difficult to determine maximum total length for a fish with a damaged caudal fin. Fork length can sometimes help in these situations, but not all fish species have forked tail. In such cases, standard length is also important.

This information is valuable for fisherman because local and national governments have established minimum size limitations to protect young fish from being removed from the population too quickly. Did you know it is illegal to keep a fish that is does not meet these requirements? The US Coast Guard and local law enforcement agencies take these minimums seriously and impose heavy fines for violations. It would be a shame to receive a ticket because you were unsure of how to properly measure the fish you catch!

Materials

- Non-living fish to be measured (these can be real, paper, Swedish Fish, etc.)
- Metric ruler or meter stick, as appropriate

Teacher Preparation

- Make paper fish cut outs if applicable
- Before class begins a fish (or equivalent, as noted above) should be placed out with the instruction, “please measure this fish”. It is anticipated that the fish will be measured several different ways

Procedure

- Short discussion (~15 min.)
    - Entry: students are asked to measure a fish before the start of class, but are given no other directions
    - Clarification: teacher directs student talk
    - Investigation: “what is the definition of length?” and “why are there multiple ways determine length, do you think?”
    - Closure: Evaluation of ideas
- Students receive 3-5 fish to measure (using each of the three ways)
- Guided practice: teacher walks around room, asks questions to check technique and for understanding
- Students evaluate the measurements of their peers

Closure:

Show examples of fish with different body types and injuries. Ask students to defend which measurement is most appropriate for each.

Independent Practice or Extension for Diverse Learners

Aboard a research vessel samples are often collected and processed quickly. Simulate this procedure by having students compete in groups to measure a basket full of paper fish. Points should be awarded for both speed and accuracy.

Online Resources:

Virginia Marine Resources Commission:
http://www.mrc.state.va.us/regulations/swrecfishingrules.shtm
How to Measure Your Sportfish:
http://crd.dnr.state.ga.us/content/displaycontent.asp?txtDocument=384
For Younger Students: http://www.pbs.org/parents/earlymath/grades_games_timetomove.html

(Most states produce their own versions of this information available for freshwater and saltwater fish. Make it local by checking with your local department of natural resources, or an analogous state agency!)

Educators who wish to have more information regarding these and other ocean science topics should visit The Bridge (http://web.vims.edu/bridge/), a website hosted by the Virginia Institute of Marine Science and sponsored by NOAA Sea Grant and the National Association of Marine Educators (NMEA), for "an ocean of teacher-approved marine education resources", including activities such as the following, which are based on topics encountered while on the R/V Savannah, NOAA Nancy Foster and the R/V F.G. Walton Smith cruises:

Satellites and Storms (http://www2.vims.edu/bridge/DATA.cfm?Bridge_Location=archive1007.html)
"Which does more damage to the coast, a fast moving, super-powerful hurricane, or a slow-moving, powerful northeaster (more commonly referred to as a nor'easter)? How does ocean temperature affect hurricane strength? Where does the name nor'easter come from? This activity serves as an introduction to these weather phenomena which critically impact our coasts each year. Students will use weather maps and ocean observing system data to explore hurricanes and nor'easters and their effects on vital habitats, our beaches, and our communities."

Sea State (http://www2.vims.edu/bridge/DATA.cfm?Bridge_Location=archive0906.html)
"Being able to accurately forecast the conditions at sea, or sea state, has been the goal of explorers, sailors, and fishermen for thousands of years. Now, through the use of ocean observing systems, we can not only predict, but pinpoint, exactly what the sea state will be like before leaving the dock."

Off the Hook (http://www2.vims.edu/bridge/DATA.cfm?Bridge_Location=archive0404.html)
"Bycatch is a global problem that is associated with almost every type of fishery, gear, and body of water. In this data tip we'll examine data that show how changes in fishing methods can help avoid the bycatch of sea turtles."

For the Love of Seafood (http://www2.vims.edu/bridge/DATA.cfm?Bridge_Location=archive1000.html)
"It was once believed that the oceans provided an endless bounty of seafood, but with an increasing world population and more efficient fishing gear it's become apparent that that is not the case. Take a look at the Monterey Bay Aquarium's Seafood Watch Chart and see which species are in danger of being overfished. Then examine the fisheries management issue from all sides—the fishery managers, the fishers, and the concerned activists."

In Full Bloom (http://www2.vims.edu/bridge/DATA.cfm?Bridge_Location=archive0402.html)
"Spring is upon us and flowers are beginning to bloom, but along with the warmer temperatures and April showers can come a bloom of a different color -- harmful algal blooms (HABs). Find out more about harmful algal blooms and their causes, then use graphs of recent Florida HABs to determine if they are increasing in number and/or intensity."

APPENDIX C

Cruise Journal

R/V Savannah
September, 27-September 29, 2010

27 September 2010

15:00 – When I pulled into the SkIO parking lot I was immediately greeted by one of the chief scientists, John. An outgoing guy in his 30s, he is genuinely nice and seemed to take an interest in what I was here to accomplish. After our introductions to one another he shared the news that we might not leave the dock due to weather! I had already been bumped from one cruise and had another canceled. This was awful. I shrugged and said that I hoped it worked out, but inside I was devastated.

While the crew worked to load ship with ice and bait fish John and I talked in that slightly awkward way two people do when they don't know each other that well. Right away he asked about my goals and started to give me a rundown of the program and what the cruise would be about. This was great because all I knew was that it was a fisheries independent survey. He explained that this cruise was being conducted by members of the newly assembled South Eastern Fisheries Independent Survey (SEFIS) group. The goal is to assess the health of the red snapper population in the South-Eastern Atlantic Ocean.

After we spoke I watched the crew prepare the boat: a trailer with food pulled up to the dock...good, normal looking food. Next a fuel truck arrived to pump several thousand gallons of marine diesel into the ship. All of this bought time while the trip was debated. It was reassuring to see the crew moving forward like we would be going to see even though it was really yet to be decided. First we delayed for a few hours, and then it started raining. I think everyone else must have been caught in weather trying to get to the dock because even though the boat was supposed to leave at 11:00, but at 12:00 John and I were still the only ones there from the scientific party at the boat. As folks arrived they weighed in on the merits of going out versus the risks (there are nine of us all together, counting me), the season was coming to an end one said. The conditions off shore were deteriorating, said another. Maybe we would just get out there and not be able to do any work. In my mind, however, we just had to go.

16:00 - I’m on the ship now so we know how things turned out. We just had a safety meeting to go over our muster stations (The place we are to report in case of emergency). We also reviewed the procedures that accompany a call to abandon ship (which can only be given by the captain), fire and a man over situations. As part of the meeting I tried on an immersion suit (it has built in boots and a tight hood and watertight wrist seals). Mostly everyone just calls it a Gumby suit since when you are wearing the thing you look like the 60s era cartoon character “Gumby”. It was somewhat of a funny moment for me. I ended up in the suit in front of the rest of the crew and scientific party, who were in their regular clothes watching, because I was the only one who had never had put one on. I wish that I had a picture. It was odd to talk about abandoning the ship in open water, but I appreciate that I know what to do should the situation ever arise. Apparently we will be doing more formal drills for each of these scenarios soon, but they are unannounced. Lastly we talked about seasickness. I hope that isn't an issue. I noticed during the meeting that the water was getting choppier as we left the Savannah River.

18:30 – Well, I made it about four hours. I didn't think that I got seasick, but I just did... The weather outside is pretty bad. I hope it gets better so this doesn't continue. I felt okay for a while. I was just talking to people about how not to get seasick and they said, —well when you are seasick you can't sleep very well. So, I came down to my berth to sleep, and that worked pretty well. When I woke up though, I knew it was coming…I didn't even try to get to the bathroom, I just made use of the trashcan that's here. I feel much better for right now but I can't imagine it will to last. I don't know. I guess I will just have to wait and see. I'm afraid that these few hours of rest won't be enough if we are out in this foul weather for very long.

September 28, 2010

10:50 – I'm out on deck watching the morning shift finish a trap set. The weather is better this morning. The seas are around 6 feet. I haven't been able to eat or drink anything, but I feel slightly better. A few minutes ago a member of crew explained to me how everyone on the boat works together to deploy and recover the fish traps. His job is as a spotter; he points out the floating orange buoys, and communicates between the back deck and whoever is driving the boat.

21:45 – Things have improved a lot since this time yesterday and a lot has happened today. We got a modest window of good weather that allowed us to drop some traps. The shift that worked from 06:00 to 12:00 dropped six traps and three of them were successful in terms of catching the types of fish that they wanted to. The shift that I'm on; from 12:00 to 18:00 ...we dropped some traps as well, but ran into bad weather around 13:30. There were squalls surrounding us and by the end a storm that was 12 mi. behind us was bearing down on top of us only minutes later. When we were forced to stop setting new traps, we came inside to work up the fish caught by the morning group.

At this time the weather has started to deteriorate further and for now we are headed inshore in hopes of additional sampling in improved sea conditions closer to shore. When we left savannah we had a storm chasing us out to sea, and now it seems we're sandwiched between that storm and a hurricane that is forming south of Cuba. The forecast is calling for eleven foot seas in the next few hours. It looks like we might be coming in early just because we're not able to do the work we're out here to do. It's not the case that the ship is in danger...the problem is that that the type of trap being used is tethered has a buoy-ball tethered to it at the surface and when the swells are really big it causes the traps to get rattled around and that's not conducive to having fish swim into them.

29 September 2010

09:30 – Last night saw periods of 40 kt. sustained winds and large thunderstorms. At 12:30 this morning a decision was made to steam back into the Savannah River and SKIO. I am strangely thankful that I was sick early, because I wasn't affected by the storm last night; I was able to watch a movie and to stay up and write whereas a few other people were very sick throughout the night. It was an experience unlike any other I've had. Throughout the night the boat was listing so hard that the refrigerator doors, which are latched shut, flew open several times. Inside the wet lab there is an analog display called a "roll angle indicator" that shows the relationship of the ship to the horizon and it was displaying seemingly fictional numbers. This has been a very long 72 hours.

NOAA Ship Nancy Foster
October, 13-October 22, 2010

October 12, 2010

22:30 – I am spending the night on the boat with other members of the scientific crew and we will get underway in the morning, after breakfast. Apparently, arriving early like this is common practice.

I was given a quick tour of the main deck which includes scientific bunks, a mess area, wet and dry labs. One of the first things they had me do after putting my stuff down was to pick out a mug and put my name on it. I thought that was funny but I guess they think I will be drinking a lot of coffee. We spent about an hour after that below deck where the ship's crew have set up a movie room and waited for others to arrive.

Tomorrow we have meetings for safety and to go over operations while we steam southward. I'm ready to get started. I think this will be an interesting trip.

October 13, 2010

21:00 – The first 24 hours have passed since I arrived to the ship last night. We had our ship safety briefing as planned. It was conducted by one of the ship's lieutenants.
After that John called a scientific meeting to discuss our schedules and to do some training. Among other things we talked about problems associated with having a small, overall sample size.

We are set to arrive near Cape Canaveral about 06:30 Friday morning, a little less than a day and a half from now. Until then we will observe our normal watches (mine is 9am-9pm) but otherwise we are free to occupy our time however we like, aside from necessary prep and organization.

I am really happy that without exception everyone here is very welcoming. It seems like this might be a fun group. Of course, we are here to do serious work but the people on this trip from SCDNR, SEFIS and MARMAP are very nice. That is good. I have heard things can become very tense in closed quarters above a ship when there are clashing personalities.

Very tired, but not seasick!

October 14, 2010

07:00 – At breakfast I had everyone sign consent forms. After, Chris went outside to thaw some menhaden for a trap set tomorrow morning. Today we will have a lot of down time, but there are going to be periodic meetings, I'm told, to discuss tomorrow's goings on (procedures, etc).

Earlier John was talking about currents affecting trap dropping. We will be just off the Atlantic shelf so the Gulf Stream might come into play as a factor, I guess. I will have to ask about this and the equipment used to measure the currents within the water column under the boat.

10:15 – There has been a lot of talk about cameras before lunch. GoPro Cameras (~$300) normally used for action sports are being used in an underwater housing with good results. In fact, the video from these devices has been more valuable in terms of clarity and depth of field than the images from the $1000.00 camcorders mounted in $1000.00 housings.

I asked about minimum ("min") fish counts since I have been hearing that term a lot and I was soon shown how to do one. It's time consuming, but not difficult. Someone very young could do it. In fact, it might be a neat way to do math for younger kids, to count fish and then perform different mathematical operations (add, subtract, multiplication, division) between the number in one frame versus another.

12:20 – I sat up on the top deck for lunch today. There was blue water as far as you could see in every direction. It feels good to "stretch out" your eyes, and it's easy to do because you have nothing blocking your vision. The expansiveness of the view makes me appreciate how large the ocean is and what a job it is to get anywhere traveling by sea. (I mean, we've been steaming for 22 hours and we're only about 150 mi. from Charleston. I think the top speed for this ship is 12 kt., ~14 mph.) Anyhow, while I was up there taking in the view I began thinking about school labs that could be created based around the fisheries research being done here.
(It seems to me that pulling otoliths and reproductive tissues could make a good one.) For example, we aren't interested in the whole animal on this trip so a very specific type of dissection occurs. It is purposeful, and that could be brought into the classroom. For one, it would reflect

science in the field. Second, it would be easy to assess based on performance (did you cut the right thing?, how well did you do it, etc.) That is more true to life.

Misc: The food has been really good. We even get a choice for most meals. I had planned to be hungry and brought many snacks (really a lot), but I think I'll be gaining weight instead of going hungry. There is lamb tonight for dinner! I suppose good food must help to keep morale up.

13:20 – Woke up from a 15 minute power nap to alarm bells: 7 short blasts on the ship's whistle and the general alarm bell, followed by one prolonged blast. Abandon Ship! It was a drill... I got to put on another Gumby suit. Unfortunately, I didn't get to jump in to try it out.

16:50 – Here are some words I keep hearing:

> **Isobath** – a contour line on a chart connecting points of equal depth in a body of water or below the earth's surface. Akin to an underwater contour line. (I was incorrectly calling them isobars, which denote differences in atmospheric pressure. oops.)
> **Otolith** – Hard, calcium carbonate structures located directly behind the brain of bony fishes and useful for determining the age of fishes. Age and growth studies of fish are important for understanding such things as timing and magnitude of spawning, recruitment and habitat use, larval and juvenile duration, and population age structure.
> **NAVTEQ** – creates the digital maps and chart content that run navigation and location-based services
> **HYPACK** – hydrographic and navigation software
> **Nobeltec** – PC-based marine navigation software program
> **Fathom** – Knew this was depth, but learned the conversion, 1 fathom = 6 feet. It's how all the charts I've seen on the ship are labeled.

I spent the past hour talking with crew, and I learned how to tie several knots from Steve and Chris. While we were tying Steve explained that his lab uses four cameras mounted at ninety degree angles on top of a heavy metal disk to look at fish in the Gulf of Mexico. They don't even always use traps there, but they can only do it because the water is clearer and there is much greater visibility.

I also learned from the group that MPA stands for marine protected area. No fishing is allowed there, but sampling can be done with a permit. We will be near the Oculina Bank MPA soon. We also talked about mapping software briefly. This ship is running four different programs and each does something slightly different. Nobeltec and HYPACK are for navigation purposes. Other systems running produce GIS information and additional information output in chart layers.

<u>Classroom activity ideas</u>: 1. Students select a trap type for prevailing conditions (current affects door type, placement and number I found out) then suggest improvements or design and defend a new trap design. 2. Have a debate about sampling in a MPA. 3. Learn to read navigational charts.

October 15, 2010:

We left Charleston Harbor at 14:00 yesterday, but this morning we were still about 80nm from our start point just north of satellite 2 of the Oculina Bank [28 17.044 N, 80 01.167W]. At 18:45 we reached that point. A CTD was then dropped to collect hydrographic data mapping began in search of "live-bottom" fish habitats. We are currently making wide 5 mi. transects east and west and narrower 0.2 mi. passes north.

Today's events also included general prep for Friday morning trap sets; additional safety drills; discussion of otolith data, GIS and other mapping software, fish trap design, and learning how to tie several new knots (they all have specific applications around the ship).

October 16, 2010: Site Surveys

08:48 – This morning's report is that overnight mapping was productive. Steven from our group, along with the ship's hydrographic survey technicians, located a ledge on which AM traps will be set. It is near [28 43.810N, 80 08.514W]. These folks all have degrees in geology and none are older than 30.

The echograms produced by the mapping software represent the contours of the sea floor in sort of a "best fit" output. The use of top and side scanning radar produce gigabytes of sonic information that is aggregated to produce plots that can be understood visually.

The fish we are interested in typically live near hard bottom (this is what we are looking for with the side scan and multi-beam sonar) This means they are commonly found around oil rigs, reefs, rocks and ledges. This is why we have come out to the continental shelf to drop traps.

22:54 – Current Location: [28 42.293 N, 80 07.500 W]

We dropped 13 traps today. The return was mixed.

Several traps contained bycatch and some traps caught no fish. Still, we did see red snapper and a large scamp in others. Also, from the trap-mounted cameras we were able to see that there was a combination of fast moving current and wave action that probably discouraged fish from entering. In any case, the day was largely a success. Snapper and scamp were "worked up". Age and growth measurements were taken.

As I worked up fish I asked for feedback frequently. My "science" teachers were great. They explained about the history of what we were doing, offered advice and showed me how to improve my technique (which varies fish to fish due to the size and location of the otolith relative to the fish). I'm getting faster and faster at it. The things they have done to support my learning are things I will want to do also in the classroom.

Potential classroom discussion: Some of the fish that we put on ice are still alive when it is time for dissection. To me it seems inhumane to starting cutting on a living thing so I have decided to kill such fish before I start. I am never excited to do it, but it makes me feel better about going ahead with the workup. In the classroom we could debate the value of information gained from the workup, the morality of killing them first.

October 17, 2010

08:51 – I just learned about S*argassum spp.* and the many organisms that live under these small floating patches of vegetation. It is unclear why organisms take shelter under them since there are too small to provide any type of protection (camouflage). Maybe they serve as a reference point for some species that swimming around in an ocean that's surface is basically featureless.

17:35 – Fish we will work up are tagged with a number that links them to the trap and then put on ice. Other fish are tossed back overboard . Unfortunately, many of these fish will not survive. This process is done quickly because we have to get ready to pick up the next trap.

October 18, 2010

08:58 – I got up at 5:30 and dressed in a hurry so I could run up to the bridge before my shift at 06:00 (I switched today to 06:00-18:00). I wanted a picture from the bridge. It was still dark when I went up there. The night shift must be a challenge for the officers driving the boat. Especially when we were doing transects, or "mowing the lawn" as I've heard it called referring to the back and forth patterns traced in the open ocean. There are no seats up there and, I believe, that except for executing the turns at the ends of each track they have little to do because there is an autopilot feature that completes the longer passes. It must be hard to stay awake. I guess there is a lot to watch out for.

Fun Fact: I learned at breakfast that The Nancy Foster was built in 1988, but was never used for its intended purpose as a torpedo tester. Instead, it sat in dry storage for 10 years before being commissioned by NOAA.

Need to hurry, one minute until I am supposed to be on station...

After breakfast I went exploring through an escape hatch (maybe they shouldn't have told me about the ship's history) and I ended up in a room with the bow thrusters where I found the torpedo tubes! Had the thrusters turned on for any reason I would have surely gone deaf. They are freakishly loud and they make everything shudder even on the back deck.

20:30 – I think the blog I started, "A Very Salty Month", has helped me to keep track of each day's major events quite well. At first I was so pleased with how well it was going that I figured it could suffice as a store of information. Now though, I am realizing that there is just too much happening each day (and too little bandwidth on the ship) to rely on it.

John just came to join me in the galley. I'm going to take some notes...

- Science is:
  - an approach to answering questions you have
  - question driven
- He became a scientist because he was "around the right people at the right time"
  - they helped him take his interests and make them into a career.
  - He was interested in a lot of different topics and this is part of why he likes science so much. It's a way of answering questions that helps him to make sense of the world around him.
  - He is driven to get to the point "where you can ask your own questions about a topic."
  - Science can let people guide their own curiosity.
- He presented some related examples of wildlife management: for example, duck hunters pay for a stamp that goes towards wetland conservation (didn't know that). Also, there is a tax on hunting and fishing gear. In this model the hunters are also the stewards of their own domain. (I think this is a cool idea, and one that has an economic facet)

Now we are talking about trap design and modeling:
Specific Things:

- Trap design
  - Certain fish go into certain traps.
  - Cameras helps to determine if the traps are working
  - Trap data are used to make models and predictions, but there is error.
- Problems:
  - Bait lures in some species, and these species may lure in others not necessarily attracted to the bait. This can lead to a feeding frenzy and that affects normal fish behavior.
  - Using complex models that many, including scientists, cannot fully understand can cause problems.
    - How do you make people understand and trust your outputs
    - leads to a need to make statistical choices.

John has now left

Today everyone worked very hard, but we didn't catch any fish of interest. I have been thinking about this and here are some possible causes I have come up with:

1. Old Bait, which really could be a whole experiment on its own (e.g. "H0=fish species X do not prefer bait type Y more than Z hours old")

2. Traps not set properly due to the boats lack of maneuverability. (e.g. set on the wrong side of the shelf break)
3. Poor locations chosen
    i. current
    ii. geography
4. Inaccurate data analysis (misinterpretation of sonar data)

October 19, 2010

06:50 – One interesting thing that I have noticed looking at the ship navigation software is that the chart legend also contains cautionary information. On today's chart there are several areas denoting undetonated munitions! I don't believe we will be operating in their vicinity, and anyhow the boat would be in no risk simply floating about them, but for anyone towing something along the bottom or setting traps that is very important information! I really didn't know that stuff was out here. I remember reading that as late as the 1950's ammunition and nuclear waste was being sunk off our coasts, but I didn't think it would be so close to us.

19:13 – Tonight I wanted share a picture of what it is like to sleep on board a ship at sea. In general they are single bed bunks. On this ship there is the added bonus, and I am not being facetious, of a curtain. Since people are coming and going on different watch schedules it is wonderful to have a closed in space that is dark. This time around only one of is working this night shift, but for him the curtain fills a whole other role in making it seem like night time when it is really the middle of the day. I have seen that in some cabins the bunks run from bow to stern—as mine does—but for others they are oriented so that your head is against the hull. My preference is to ride out the waves as the ship does, from my head to my feet. I seem not to get sick that way. On nights when the seas have become rough and the ship lists from port to starboard, I wedge myself between the mattress and the wall which keeps me from rolling out of the bed. In my bunk there are vent hoses, water pipes, some electrical wires and miscellaneous other ducting running above my head. I climb into the bed from the foot of it and shimmy towards the pillow. They are tight quarters, but I find my bunk to be cozy and comforting...it's my space in a ship full of communal areas.

October 20, 2010

"Red Snapper Bonanza"

21:43 – There are 2.5 days left. I'm not dissecting the fish anymore since changing shifts, and though didn't mind doing it, it's just as well because I was seeing fish guts when I closed my eyes. One scientist here said he has done the particular dissection we are doing over 50,000 times on one species alone!
On my new shift we get up and string menhaden throughout the traps, we eat breakfast and then we get to work setting and recovering by 8am. The process is repeated at least once, sometimes twice with each cycle taking about 3-4 hours. We usually finish by 7pm and I pass out by 9:30.

Overall the trip has gone quickly. I can see how being at sea could become monotonous over time, but really I have enjoyed it so far. Working shifts gives me a sense of purpose, and everyone in the science party does works for the same purpose which makes us feel like a team.

About the title of today's entry: In an effort to confirm reports that many large red snapper can be found in the South-Eastern fishery NOAA has asked fishermen to supply them with sites where such fish can be found. As a result, some of the sites we have been sampling are fisherman-sourced. (One fisherman called his site “The Party Grounds”. Everyone thought this was funny and so in recent days we have been giving our non-fisherman sourced sites fun names as well like the one today, Red Snapper Bonanza.)

October 21, 2010

“The Little Ledge That Could”

06:58 – I regret that I don't have our location for yesterday's sampling. We have been catching some unexpected things here in the traps too...things like eels, jackknife fish, a cobia, and an octopus.

We have been working hard to get out an extra set each day for the last two days. It could be stressful because of the hours, but the whole scientific party is on board with it. There is no complaining that I have heard, and the positive attitudes are infectious. With everyone pulling their weight no one wants to be the one to let anyone else down.

12:15: – Since we are close to the end I thought I should take a few minutes to describe what it's like on deck during operations:

On a 187-foot craft like the Nancy Foster every task requires a lot of cooperation. No task, however, asks more of the ship's crew and the scientific party than recovering the chevron traps set over the stern. To pick up the trap sets with any efficiency eleven people must work closely together for 90 to 120 minutes at a stretch. Every 20 minutes or so the intensity spikes as nearly a dozen of us work to recover a new trap. As we come on site we try to have the buoys pass along the port side of the boat for recovery. At this point the back deck gets ready for action!

Two people are in charge of hooking the polyball with a grappling hook from up to 20 feet away. The people doing this job wear heavy woven belts that are hooked to the deck, a hard hat and a self-inflating life jacket. On a successful try, the line is hooked and both people heave to. I like doing this job.

At this point things start to happen quickly. The poly balls are unhooked and carried away, while the line is hooked to another line with a carabiner. The line is then wound in, passing through a pulley-block suspended from the J frame above, by a winch that has been given the name “Tugga”. The controls for this winch have been wired (or rewired) in a way that requires you to hold the button down to use it.

Any loss of pressure, even a hair's width on the button, seems to make the winch's spinning cease, at which point everyone looks at you (and it's easy to have happen when you're reeling in two-to-three hundred feet of line at a paltry 1.5 feet per second).

While the trap is being hoisted to the surface the bridge works to hold the ship on position, which can be especially challenging when there is a surface current.

15:31 – We have just finished scientific operations for the cruise. Three NOAA divers just went under the boat to remove sonar equipment before we return to Charleston harbor. The safety boat was lowered into the water by crane to be a spotter and to discourage sharks from coming around. Pretty cool.

October 22, 2010

08:00 – Everyone took the liberty of sleeping in until breakfast at 07:00, save for two who skipped breakfast altogether in favor of some extra shuteye. After eating I headed up to the bow of the ship to watch the sun come up and have some mental health time. It was really cold inshore compared to the weather we had on the shelf break. As we approached Charleston Harbor I could see that the ship was lined up to pass the red channel marker on the starboard side: "red, right return" as the saying goes. We passed battleship row and eased back to the Navy pier where we were met by the crew of the USCGC Gallatin who helped us tie on.

12:00 – We have spent the last few hours offloading the scientific supplies onto various vehicles that will carry them to storage until next years' season. Since we did almost all of the cleaning and preparations for this last night it wasn't too strenuous. I am now waiting for a ride to the airport. Three of us will be going as soon as one of the vehicles returns from donating the fillets of red snapper and grouper to a local food bank.

Nearly everyone else has left at this point...the ship's crew were especially quick to leave. They have been doing this since March and this was their final cruise of the season.

R/V F. G. Walton Smith
October, 25-October 30, 2010

October 25, 2010

09:25 – The Nancy Foster cruise ended on the 22nd. Late that afternoon I flew from Charleston to Atlanta; I would be home for 48 hours. That was enough time to wash my clothes, send some emails, empty my digital drives, buy new batteries and head back to the airport for my next adventure.

I know from the University of Miami's Rosenstiel School of Marine and Atmospheric Science (RAMAS) website that professor Brand is interested in all things marine phytoplankton. But I don't know what to expect for the cruise. I asked around on the Nancy Foster for an idea of what it might be like and the response was unpromising. “Oh, a plankton cruise”, they said, “you'll probably stand in one place and count things under a microscope for four hours at a stretch”. We'll see.

I'm on the plane in Ft. Myers, Florida. I left from Atlanta's Hartsfield-Jackson airport on a 7am flight this morning. I am to meet the R/V Walton Smith at Moss Marine in Fort Myers Beach, about 20 mi. away, by 13:00.

15:25 – I am on the ship now. I discovered there was an afternoon bus route that could get me from the airport part of the way to where I needed to go for just $1.25.

So, using a combination of public transport, walking and hitchhiking I made it to Moss Marine around 12:30 where I met the other people who would be boarding the ship with me; four people were getting off the boat here and five are getting on.

It turned out that the Walton Smith was anchored up offshore because the tide is going out. We were picked up by her two work boats and they shuttled us back to the ships. Actually, the two boats had a race back to the ship. It was pretty fun.

I need to get clarity about each of the scientists on board and their projects, but here is what I have put together so far: There are four scientists on board who are each focused, in one way or another, on pathogens. One scientist is interested in red tides, and so we will be tracking them in real-time using satellite imagery. When a bloom occurs we will travel to the location to collect and filter water samples. NASA satellites take these images and they are aggregated for marine applications by the University of South Florida (http://modis.marine.usf.edu/weekly/).

I got a tour of the ship and saw that in the wet lab everything is tied down or secured with cord. The equipment I noticed so far includes: microscopes, suction pumps, a homemade vacuum filtering system of sorts, graduated cylinders, petri dishes, several different reagents, incubators, fixing solution, and many different storage containers.

18:32 – I am slightly embarrassed to admit that I was falling asleep at dinner; especially because there was so much talk about the various projects going on aboard the ship.

Cruise Objectives Update:
Larry works with plankton and on this cruise is tracking *Karenia brevis*—he is interested in this species linked to an idea he has about nutrient flow.

Elaine is a physical geographer and on this cruise is searching for a never before seen cyst stage. Larry says this is “high risk, high reward”, and that finding such a stage would change how red tides are viewed altogether. In short, her hypothesis is that a cyst stage exists. We will be using a scooping apparatus suspended from a winch to do this.

Glen and Vicki are husband and wife. They work as "civilian feds" for NOAA through the University of Miami. Together they are looking for marine pathogens, like MRSA, and verifying their presence using multiple media and culture types. Of special interest to them is identifying host species and correlating that information with a geoposition. (e.g. if they see livestock pathogens it they would expect to find that the runoff is from a farm.)

19:15 – I will be staying up to take water and sediment samples as we move between sites tonight. I think we are scheduled to reach the first site around 22:00.

October 26, 2010

02:50 – I just finished up grabbing sediment from the sea floor with an apparatus that looks like a grabber from an arcade game except bigger and controlled by a winch.
I looked this up on my phone (we are close enough to shore that I have a signal) and it appears to be called a "Van Veen Grab" – I also took conductivity, temperature and density using the smaller of two onboard CTDs. I think we did six sites tonight.

08:25 – Only a few quick seconds to write. We're going out for water samples at 8:45. Now I need to eat something...

17:30 – We went out in small boats (aluminum hull rescue boats) this morning and collected water samples from multiple locations in Estero bay. We stored the samples for professor brand in bottles that I think hold 1000 ml. At each place we logged our coordinates and sample time then were on our way. For this cruise record keeping and the ability to link data has been very important.

The first mate on this ship and has been providing me with loads of useful and interesting facts, as always. Today my education was about mangroves. I learned specific mangrove species occupy the coastline in an organized way.

- Generally, red mangroves live on the banks very close to the water because they have a particularly high salt tolerance. The saline environment stunts their growth but since it is an exclusionary habitat for which they have very little competition they thrive there. Interestingly, in fresh water the mangroves cease to be shrub-like and instead grow to be as large as trees.
- Black mangroves are found next closest in from the shore. Their salt tolerance is much lower, but they possess the ability to excrete it out through their leaves.
- Furthest from the water, white mangroves are found.

Some of the other University of Miami graduate students on the trip have been helping me to understand how these facts tie into coastal ecology issues. For example, the mangroves provide important protective habitat for other species such as fish and blue crabs, which rely upon mangroves for part of their diet. By taking the mangrove leaves into the water first to release harmful tannins blue crabs are able to eat the otherwise toxic plant.

Before dinner I talked to Glen at length about genetics assays. Mostly we talked about qPCR, or quantitative polymerase chain reaction which, as the name suggests, allows both detection and quantification of genetic material in real time. This type of assay can be carried out using specific or non-specific dyes as needed and both offer results as the test is run—a big advantage over traditional PCR. Any assay we discussed uses a pigment called "cyber green" that causes complementary strands to glow green after binding to a probe. Dyes like cyber green are said to be non-specific; they reveal the total amount of genetic information present in a sample, but they cannot distinguish living cells from dead ones. Other, specific tests are selectively phosphorescent and only glow under when certain parameters are met (techniques such as the use of quenchers will suppress glowing under certain conditions and may help to produce more valuable output.) In the end, each type of assay faces trade-offs. The best results can be achieved by choosing the most appropriate test or tests for the question you want to answer.

I closed our conversation by asking him if he though science was inherently good given the pace of scientific advancements like those realized in genetic sequencing. His answer is one of the best I've heard. He explained his point of view like this:

> "Science is neither good nor ill, it's a tool. It provides information. It's a guess, a best effort. For example, consider a hurricane: We can know all kinds of things about it—where it is, wind speed, the barometric pressure, and we can plug these things into a model to make predictions—these things are done using science. What we can't do with science is tell you what to do with the information we get; like, say, for example, if you should run away or board up your windows or do nothing. Science can't do any of those thing and it's not its job [to do so], that is not its domain."

October 27, 2010

09:00 – Lake Okeechobee in southeastern Florida is filled mainly via the Kissimmee River and is drained by the Caloosahatchee River. This system is a major input of freshwater including waste and agricultural runoff into the marine system in the harbor and bay. Sampling in the bay today will tell us more about these inputs. We also plan to sample the Peace River, Hendry Creek area and associated canals where there is a lot of potential septic discharge and "urban terrestrial runoff" (new construction leads to more impervious ground and increases runoff). This anthropogenic runoff often leads to an increase in the number of human pathogens in the water, and that's what we are going to investigate. I was told that in puddles bacteria are often super-concentrated to near sewage levels. Another small boat with head Northwest up the Myakka river to do similar work.

An identified problem: Free bacteria remain viable for long periods of time in materials like sand. When bacterial indicators are used the result is just an association (especially for non point sources) because it is not known where the bacteria came from or if they are living or dead.

I also had this thought: prokaryotes can be killed without hurting our own cells so they are probably easier to deal with. Eukaryotes and protozoan parasites probably produce nastier infections because what would interfere with their cells is likely to interfere with our cells too.

13:32 – We have moved offshore and are continuing to do transects. We have been doing transects for several hours in the afternoon and again after dinner for several hours. The operations vary only slightly during each time: In the afternoon we used the large, multi-well CTD, which also collects water samples at various depths, to obtain hydrographic data. At night the process is similar, but we use a smaller CTD that can be lowered by hand into the water and water samples are only taken at the surface. That process takes about 20 minutes, which leaves us with 40-75 minutes until we reach the next station. Lately, at night when we are between stations the whole scientific group has taken to playing dominoes. It's been a great way to break up the long transect lines.

This afternoon there was a brown booby (*Sula leucogaster*) that joined us for several hours. I learned from the Captain that many birds use boats to help them fish in this way. That is exactly what this particular bird was up to. When the ship is at speed flying fish scatter from under the bow as we approach them and the bird would cruise from side to side above the ship and then, all at once, bring its wings backwards at slightly different angles, which sent it into a high-speed dive towards the water and the fish. When the boat was stopped it would sit on the A-frame. It was fun to watch.

October 28, 2010

02:49 – I got to steer the ship for a few mi. tonight. It’s a fly-by-wire system and so it feels like a really sophisticated video game, but there was so much to pay attention to—heading, course made true, rudder angle, swing—that suddenly a big ship felt even bigger. On the bridge of the ship a faint red glow provides just enough light to see what is going on without bleaching out the rods in your eyes. Every hour the ship's coordinates and operations are noted including any incidents.

Tonight on the bridge I was asking as many questions as I could think of. I talked with Alan for awhile about the effective range of radar. In simplified terms the radar range can be limited by a number of factors, including weather and equipment type, which means you can only see so far. One of the biggest influences on a ship's radar range is its line of sight which related to the height of the antenna above the ground (basically the higher up the antenna is the further the radio waves can travel). This explains why communications equipment is found on the very top of a ship. Though it is obvious, I had not considered that at some point however, “visibility” breaks down due to the curvature of the earth. What a fun, but challenging job. It is very difficult trying to keep these hours, but since my time here is so short I am really trying to get in all that I can.

08:10 – This morning after breakfast I noticed Marco coming and going from the engine room more often than usual. While he took a smoke break I asked what was up. It turns out that one of the ships two generators went out over night and he had been up all night figuring out just what exactly had gone wrong. “The stator broke”, he said. As he described his night I realized that his troubleshooting mirrored problem solving in science. “I knew the generator was out, but I didn't know what was up. I had to go through the electronics to pinpoint the problem. Can I do this? No. Okay, what about this? Yes, etc.” Eventually this flowchart approach led him to the culprit, a faulty stator; the stationary part of the generator.

October 29, 2010

Yesterday on one of the small boat trips we went up the Shark River into the Everglades. The Walton Smith anchored in the shallows off shore and we entered the river through Ponce de Leon Bay. It was one of the most peaceful places I have ever been—silent, except for the wildlife which included many birds (wood storks, egrets, and roseate spoonbills), turtles, dolphins, and a manatee. The river is at sea level and is very shallow. Many of the maps we used date to a century or more ago, and were the work of early explorers in these areas. The further we pressed upstream more narrow the river became until, in an area near Cane Patch, we could go no further.

22:10 – Even offshore, the water around south Florida has had a green tint different than the deep blue color in the Atlantic. Right now we have moved inshore and are headed back to Biscayne Bay. About an hour ago we were cruising through the Florida Keys and under the seven mi. bridge in only a meter and a half of water.—the catamaran design of this boat gives it a very shallow draft and that means it can go places that other ships of its size cannot.

Not including offshore sites, so far we have sampled the following places:

- Myakka River
- Peace River
- Charlotte Harbor
- Matlacha Pass
- North Estero Bay
- South Estero Bay
- Rodgers River
- Lost Man's River
- Shark River
- Caloosahatchee River

October 30, 2010

12:00 – Essentially I did not sleep last night and now I'm paying for it. Instead of resting I stayed up to ask questions and to watch our return from the bridge. While on a break Alan explained about the ships plumbing and I learned the term “black water” which refers to the waste water from all the ships drains (e.g. sinks, showers and heads). When I did try to get some sleep around 04:30 it was stormy and the seas were becoming rough. I took a Bonine (meclizine) pill just to be sure.

We docked starboard side to around 09:00. I helped to offload supplies and samples into a truck and used a dolly to take other items back to a UM lab just a few hundred yards away where the samples we collected will be analyzed further. After this I helped to clean the boat. With a freshwater hose I climbed up to reach the aloft systems (satellite, radar, GPS, and communications antennas) on top of the bridge—a place you can never go when they are on due to the extremely high amounts of radiation emitted—and started spraying. Along with help from two other crew members the boat was cleaned from the top down to the waterline.