2010

Identifying Obstacles to Incorporating Ocean Content into California Secondary Classrooms

https://doi.org/10.33015/dominican.edu/2010.edu.01

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Submitted in Partial Fulfillment of the Requirements for the Degree

Master of Science in Education

School of Education and Counseling Psychology
Dominican University of California

San Rafael, CA

May 2010

Acknowledgements

Thank you to Dr. Madalienne Peters, Dr. Linda Sartor, Sarah Zykanov, and Suzanne Roybal at Dominican University; Colleagues: Dr. Meghan Marrero-U.S. Satellite Laboratory; Sarah Schoedinger-National Oceanic and Atmospheric Administration; Dan Basta-Director of the National Marine Sanctuary Program; the National Marine Sanctuary Program education team; staff at Cordell Bank National Marine Sanctuary; my parents for instilling an "ocean ethic" in me at a young age; my sister Julie Stock; and my husband Joseph Kinyon.

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Abstract

The ocean is the dominant feature on this planet that makes all life on Earth possible. Marine educators and scientists across the country have identified essential principles and concepts that define what an "ocean literate" person should know, but there is a lack of comprehensive ocean content coverage in secondary classrooms across the United States. In California, limited ocean content standards exist in the primary grades, and diminish in the secondary grades. The main purpose of this study was to examine obstacles for secondary (grades 6-12) teachers to teach about the ocean in California public schools. Interviews were conducted with five teachers with professional development in ocean related curricula, to identify their personal obstacles to including ocean content in their classrooms. Obstacles identified ranged from high stakes testing to lack of time, but not a perceived lack of importance.

Chapter 1 Introduction

California coastal waters contain one of the most productive and diverse marine ecosystems in the world. Just outside the Golden Gate of San Francisco, the waters are so rich with marine life that three contiguous federally protected national marine sanctuaries are designated there. In my role as the education coordinator with the Cordell Bank National Marine Sanctuary, one of the three sanctuaries, I create and distribute educational materials that help to increase awareness and knowledge about our local national marine sanctuaries and ocean ecosystems to multiple types of audiences.

Over the years, I have hosted and taught professional development workshops for teachers, and consistently I hear how much they personally love the ocean. They want their students to build their own personal connections to the ocean and learn how important it is to the natural Earth system. Yet, the study of the ocean is not well covered in the mandated state-content science standards, and so for the most part, teachers have expressed that they can only minimally use the materials they have received from my programs due to various constraints, many of which I explored in this study.

I have come to a point where I wonder how it can be that teachers in schools located in a significantly important watershed that feeds into one of the most important marine ecosystems in the world (Pacific Ocean) are unable to teach about the ocean to the students that live in these watersheds. Students I have met are curious about the ocean and intrigued by its mysteries, yet it is barely covered as content in the classroom. This study intends to uncover some of the educational hurdles that need to be addressed in order for secondary (grades 6-12) teachers in California to be able to teach about the ocean in their classrooms.

Statement of Problem

The ocean covers 71% of our planet, yet only one in ten of Americans can answer four of five questions correctly about the ocean and its functions (Ocean Project, 1999). Our country is surrounded by water. Knowingly or not, we are all affected by it and have an ecological impact on it. Physical benefits provided by the ocean are not always easy to recognize on a daily basis. A few of these fundamental benefits that are taken for granted include: that the ocean provides us with oxygen to breathe, absorbs carbon dioxide from the atmosphere, makes life on Earth habitable with its thermal absorption, and impacts the weather which controls Earth's climate (National Geographic Society, 2007). In order for citizens to be literate about ocean issues, they need to know and understand what the role of the ocean is in their lives.

Purpose

The purpose of this study is to investigate obstacles to ocean science instruction in formal secondary classrooms while fulfilling state standards in schools in California. As a result of the study, further insight will be gained into how organizations that specialize in marine science education can help support secondary teachers and tailor programming efforts to the needs of those teachers.

Research Question

What obstacles limit teachers from including ocean content in the secondary grades (6-12) in California public schools?

Theoretical Rationale

Ocean education is not a new topic. Along with the environmental education movement that started in the 1970s, the ocean as a habitat fit into the greater need for overall environmental awareness and informed decision making. However, the lack of ocean education in K-12

education now stands in stark contrast to the fact that the declining health of the ocean is an urgent issue. This deficiency may be partially responsible for the destructive environmental consequences that have resulted from a lack of an "ocean ethic." The term "ocean literacy" came about in 2004, when a group of marine education leaders, institutions, and scientists started working on a consensus-based process to define what an ocean literate person should know (Ocean Literacy Network, 2009). As of 2004, ocean literacy is defined as "*an understanding of the ocean's influence on you and your influence on the ocean,"* and is further defined by seven essential principles and concepts (see appendix) (National Geographic Society, 2007).

Ocean literacy, like other environmental-related concepts, may best be achieved through a constructivist approach in which students continually construct new information based on existing pieces of information and knowledge gained independently. In order for the new information to be assimilated, however, it needs to fit or relate to an existing scheme of knowledge (Piaget, 1951). Similarly, as the reconstruction of knowledge occurs as new facts and experiences are gained, they form a basis for experiential learning that John Dewey felt made learning "transformative" and meaningful, shifting away from memorization to inquiry (Dewey, 1960). Ocean literacy can be accomplished through situational experiences or hands-on learning opportunities (Steel et al., 2005), allowing an emotional connection with the marine environment to develop along with the learning of facts (Ocean Project, 1999). In Steele's study of the public, there was a greater awareness of ocean-related issues among those that visit and/or use the coastal environment than among those that do not have those experiences (Steel et al., 2005).

Looking at a more psychological aspect of learning, Howard Gardner's concept of multiple intelligences includes a recent addition of the *naturalist intelligence.* This *naturalist intelligence* describes a learner who may naturally identify with, recognize, and/or categorize

their world in terms of the natural world, much like Gardner describes other students who may learn better through the use of the arts, movement, language, etc. (Gardner, 1999).

Furthermore, many students as well as adults may have a natural interest in the ocean. Dangerous and mysterious animals, as well as unknown depths and exploration, are topics about which students are naturally inquisitive. Ocean content highlighted in media, books, movies, and magazines may help inspire students with this ocean interest. Constructivism may provide a sound pedagogical foundation for inquiry-based learning that utilizes the student's natural interest the ocean and further develops a solid understanding of the essential ocean literacy principles and concepts.

As already stated, in California's science content standards, the ocean is minimally included in the K-5 standards and nearly disappears in grades 6-12. Many of the elementary standards could be taught in the context of the ocean. In second grade, standards cover adaptations of animals, providing an opportunity to include the many adaptations of ocean animals throughout different ocean habitats, e.g. deep sea, nearshore, coral reef etc. In fourth grade, students learn about primary producers and plants, providing another opportunity to introduce plankton and its role in the ocean and contribution to oxygen in the atmosphere. In fifth grade, students learn that the ocean covers ¾ of the earth's surface and influences weather and climate, which should be a concept nurtured further in secondary grades with higher cognitive concepts and ecological links. Even though the potential exists to teach about the ocean in these grades, many elementary teachers have less time to teach science, let alone ocean sciences, due to an increased focus on testing of English language arts, and math. Teachers also lack the skills/knowledge/resources to teach it (Marx & Harris, 2006; Gruenewald & Manteaw, 2007). This leaves secondary classes even further behind in science. After grade 5, the word

ocean only appears once in the content standards, therefore minimizing the opportunity to directly teach about it, unless the teacher has the knowledge and experience to teach other standards in the context of the ocean (California Department of Education, 1998).

Leading marine education organizations, such as the National Geographic Society, Centers for Ocean Science Education Excellence, National Marine Educators Association and the National Oceanic and Atmospheric Administration encourage ocean literacy concepts and principles to be adopted by each state as states revise and update their content standards (Schoedinger, Cava, Strang & Tuddenham, 2005). Even in the current culture of standards-aligned curriculum and assessment, ocean education professionals are encouraging teachers to consider teaching some of their current science standards in the context of the ocean and offering curriculum resources to do so. To help teachers with this, the ocean literacy effort has highlighted national science standards that align with ocean literacy concepts to show them how they can teach about the ocean using the current national standards (Schoedinger, Cava, & Jewell, 2006).

Assumptions

In order for our country to embrace an environmentally sustainable way of living, I believe both ocean and ecological concepts need to be identified and brought into our K-12 education system. I believe that ocean content, in addition to more rigorous ecological principles, should be covered in K-12 classrooms and required for all students in the standards, especially in the secondary grades in this coastal state of California. I also believe that teachers who have a personal interest in the ocean can easily incorporate ocean content into their classrooms to match their standards, if they believe they can do so. Education's purpose is to equip students with lifelong skills and knowledge to be able to make informed decisions in the world. In my opinion,

education that lacks ecological concepts, such as the ocean and its role on this planet, is not complete and leaves a great void with regard to making environmentally responsible decisions throughout one's life.

Background and Need

Two critical national commissions, one private and one public, charged with creating recommendations to protect the future of the health of the ocean, recommend strengthening ocean education, and call for a "*new era of ocean literacy*" (Pew Oceans Commission, 2003, p.91). In order for students to become knowledgeable voting citizens that can exhibit responsible behavior in regards to the ocean, students need to learn to make informed and conscientious decisions about the ocean and to communicate about it in a meaningful way. In the privately funded Pew Oceans Commission's (2003) recommendations for a new ocean policy, the commission reports:

> To create a new national ocean policy that restores and maintains ocean ecosystems, we will need more than new laws and institutions. We must also build a national constituency for the oceans that includes all Americans, whether we live along the coast or in the Rocky Mountains. We must prepare today's children to be tomorrow's ocean stewards. (p. 91)

In addition to these reports, marine educators around the country recognize this deficiency in the education system and have been working to promote inclusion of marine topics in formal and informal learning opportunities. These national reports help illustrate the recognized link between education and environmental protection.

Chapter 2 Review of the Literature

Introduction

The historical context of the creation of the national content standards provides background that sheds light on where ocean content was left behind. The purpose of this review is to provide background information and research results that highlight the urgent need for ocean literacy. The review also provides a look at how the ocean has declined and how we as humans are tied to its health. It also examines how ocean content can fit in with the existing earth science standards and gives a "report card" on how these earth science standards are being implemented nationally.

Historical Context

Following a report in 1983 titled *A Nation at Risk*, the U.S. education system called for system reform and created standards that would be adopted nationally by content areas. Several scientific societies and organizations were already creating innovative science curricula in the 1980s (The National Academies Press, 1996). The American Association for the Advancement of Science (AAAS) published *Science for All Americans (Project 2061)*, defining scientific literacy for all high school graduates. In 1991, the National Science Teachers Association (NSTA) pushed the National Research Council to coordinate development of science content standards. An advisory committee was formed consisting of several science organizations, but none representing environmental, earth-based, or ocean-related sciences. Several committees formed, and drafts were created, reviewed, and allowed public comment. In 1998, California adopted science content standards. The AAAS defines a scientifically literate person as one who is, "familiar with the natural world and recognizes both its diversity and unity" ("AAAS", 2004). This statement mentions the potential for inclusion of ecology or ocean content in any of the

standards. There was no consensus on what to include in the classroom related to marine topics (Ocean Literacy Network, 2009).

Due to the rapid decline in ocean health in the last 30 years, two important national commissions set out to investigate what needs to happen to conserve what we have left of coastal and ocean resources, and who needs to be involved. The privately funded Pew Oceans Commission published a final report in 2003, making recommendations for a new ocean policy. In its recommendations, the commission calls for "*a new era of ocean literacy*" to generate broad public support for ocean conservation (Pew Oceans Commission, 2003, p. 91). The Commission points out that scientific understanding in traditional science content areas such as biology, chemistry, physics, geology, mathematics, and engineering could be advanced with the use of the ocean in context. This idea is supported by studies that integrate science content in marine science-oriented courses, resulting in greater understanding of science in general and marine science related content (Lambert, 2005; Walker, Coble, & Larkin, 2000).

In addition to the privately funded Pew Oceans Commission, the president's appointed U.S. Commission on Ocean Policy generated another report. This report dedicates an entire chapter to promoting "*lifelong ocean education"* (U.S. Commission on Ocean Policy, 2004, p. 122). *An Ocean Blueprint for the 21st Century* encourages collaborations and new networks of educators working with the U.S. Department of Education to achieve meaningful, lifelong learning on ocean issues, which includes putting more ocean content into K-12 curriculum. These nationally and internationally recognized reports that detail the need for ocean literacy are telling, in that many ocean policy leaders believe the health of the ocean and environment is directly related to education.

Review of the Previous Research

Human Impact on the Ocean

Sea creatures provide food for humans, and the seafood industry contributes greatly to the economy. Fifty percent of the U.S. population inhabits coastal states (Steel, Smith, Opsommer, Curiel, & Warner-Steel, 2005) and the state of California generates substantial dollars to the U.S. economy via coastal tourism. One of every six jobs in the United States is related to the ocean and over one-third of the U.S. Gross National Product is generated in coastal areas (NOAA, 2009).

With this close link to the sea, Americans have had a substantial impact on the ocean to date. Since the 1700s there has been an estimated 50% loss of wetlands in the United States (Dahl, 1997). As of 2001, 23% of United States estuarine areas were considered impaired for wildlife survival and human recreation (U.S. Commission on Ocean Policy, 2004). Harmful algal blooms are on the rise in coastal waters, impacting fisheries and local marine wildlife (U.S. Commission on Ocean Policy, 2004). Twenty-five to 30% of the United States' economically important fish stocks are considered overfished (U.S. Commission on Ocean Policy, 2004; Pew Oceans Commission, 2003). The ocean is a complex system, and the perturbations that humans have imposed on this system for decades have had dramatic short-term impacts. In order to help stem the tide on destructive behavior, a policy shift needs to occur, which includes informed decision making not just by policymakers, but by all citizens. As a basis for this research, it is assumed that formal education of the ocean ecosystem, and human interaction with the ocean, is critical for informed decision making to protect the health of the ocean and its benefits to humankind.

Level of Ocean Awareness Nationally

In 1999, the Ocean Project, a collaborative of zoos, museums, and aquaria, sought to better understand how the American public viewed its values, attitudes, knowledge and connection to the ocean. A national study was conducted to understand what steps needed to be taken to raise awareness, sense of urgency, and will, to protect the ocean's health. A survey was utilized and its results revealed that the citizens in the United States are fairly illiterate when it comes to the ocean. A series of recommendations were created to plan for better results in education programs based on the study's results. This study reveals how little the American citizenry is aware of the condition of the oceans and how the majority of citizens do not perceive ocean health to be an urgent issue (Ocean Project, 1999). A follow up survey was conducted nine years later, and unfortunately yielded similar results with no change in the American public's ocean awareness. An alarming 35% of the sample for this survey could not identify a single ocean-related issue affecting the country, and were more familiar with pop stars and sporting events than ocean topics (Ocean Project, 2009). Surely, although not solely, this lack of familiarity can be attributed to the K-12 education system, in which critical thinking skills are typically developed.

In 2003, researchers at Oregon State University conducted a study to better understand ocean literacy trends. They found similar results and further correlate what people know about the ocean, how ocean knowledge relates to socioeconomic status, and how personal experiences with the ocean may help to increase ocean knowledge (Steel et al., 2005). Their findings suggest that hands-on learning or field-based ocean education programs may enhance public support for ocean protection. Many educators would agree, including David Orr, who describes the importance of the concept of place in education and that observing nature firsthand leads to a

deeper comprehension and construction of the interconnectedness of the environment (Orr, 2005).

Science Standards and the Ocean

Leading marine educators have long argued that fundamental science concepts can be taught in the context of the ocean (Strang, DeCharon, & Schoedinger, 2007). In addition, they also point out that the ocean offers its own built-in value in the context of the bigger "*scientific literacy*" picture, pointing out *"the science-literate person is familiar with the natural world and recognizes both its diversity and unity"* (Strang, et al., 2007). The call to recognize the diversity and unity of the natural world highlights the need to increase ocean content in classrooms across the United States in order to contribute not only to an ocean literate populace, but a scientifically literate one. In a study conducted in Florida, high school students who took an integrated marine science course showed an overall increase in their knowledge of integrated science topics typically taken as individual courses, illustrating the potential for integration of marine science with other science concepts (Lambert, 2005).

Statistical Information: National Review of Earth Science Standards

To advance NOAA's educational mission of increasing environmental literacy, the agency funded a study to better understand how earth science standards are being incorporated into classrooms across the United States. Earth science standards fit closely with environmental literacy topics NOAA has most interest in, such as ocean and atmosphere. Through a state-by-state analysis of the earth science standards and how well they address a "21st century view of earth science", a baseline was established for where our country currently is in educating about earth science topics. The results revealed much room for improvement with regard to Earth system education. When looking directly at how earth science standards covered ocean literacy

concepts and principles, the reviewers assigned a national grade of "D" with no state addressing more than 20 of the 35 potential earth science standard-related concepts. Only 35 were examined of the potential 45 ocean literacy concepts, as 10 of these concepts directly relate to biology content standards. California includes only 11-15 ocean literacy concepts, out of the potential 35 for this study, in its earth science standards. The overall report detailed recommendations for improving this dire situation for earth system related education, including a differentiated and interdisciplinary approach to teaching earth system concepts. Specific recommendations for improving adoption of ocean literacy principles included taking a systems perspective, and highlighting interactions between the ocean and other systems, rather than as a stand-alone theme in the standards (Hoffman & Barstow, 2007). This recommendation supports the idea of integrating ocean content into existing content standards and multiple subject areas as well.

Building Ocean Literacy into Content Standards

States like California and Michigan are poised to become leaders in the United States in educating students in ocean literacy principles and concepts, because each of these states has dedicated funds to create a standards-based curriculum that includes ocean and environmental literacy principles (Schoedinger, Cava, & Jewell, 2006). Ocean education leaders are working with states like these to seek inclusion of the ocean literacy principles and concepts in new materials meant for widespread adoption. This effort is just one of several ways in which educators are working to get ocean and environmental literacy content included in classrooms across the state.

While California does not currently (as of 2009) have an active timeline to consider revision or adoption of new content standards, one way the state may be able to incorporate some of these ocean literacy principles and concepts is through the creation and adoption of a state

approved K-12 environmental education curriculum that was initiated by law in 2003. As of October 2009, the California Environmental Education Initiative draft curriculum has finished its public comment period, and the curriculum commission has accepted the majority of new curriculum units as acceptable to teaching the current education standards in an environmentally focused context. This curriculum should be available in 2010 sometime (State of California & Environmental Protection Agency, 2006). Ocean literacy leaders are encouraging adoption of ocean literacy principles and concepts into this curriculum that will be available to all districts as a state approved curriculum.

Interview with an Expert

According to Mike Roa, a science curriculum specialist with the Sonoma County Office of Education, it is most likely that the approved California Environmental Education Initiative modules will be supplementary and may help replace some existing lessons in classrooms, but in the context of an environmental concept. There will need to be a large training effort to put these materials into the hands of teachers to try them out before it can be expected that they will be implemented. It is too early to tell what type of training effort will take place in California after the curriculum is approved by the Board of Education, but without this effort, it will likely be less than effective.

Special Collections

In addition to the soon-to-be released California Environmental Education Initiative curriculum, there are other sources of state approved curriculum resources that are ocean-related. The Foss Teacher Guide and Kit, put out through the Lawrence Hall of Science, University of California, Berkeley, has *Water Planet.* This state standard aligned curriculum resource is an approved curriculum by the state, but is for K-5. The California Coastal Commission Agency has

a Marine, Coastal and Watershed Resource Directory for K-12, that is online and highlights several cheap, if not free, marine education activity guides and resources available to all educators. There are links to grant opportunities, a lending library of marine education resources, information about art and photography contests for youth and the public, and a resource directory that lists organizations in California that provide professional development, curriculum, teaching aids, speakers and the like, for marine education. It is a clearinghouse of resources for teachers. California's national marine sanctuaries from Santa Barbara to Marin County have a diversity of locally-focused marine education programs, curriculum, and resources and offer professional development opportunities for educators. There are literally hundreds of organizations in California offering free marine education materials and opportunities, and nationally, there is the National Marine Educators Association which puts on an annual conference for educators and a quarterly journal offering national and international marine education resources and pedagogical research findings.

Educational Mandates

The United States educational content standards vary from state to state and across the country, the ocean is minimally covered in content standards (Schoedinger, Cava, Strang, & Tuddenham, 2005). Ocean sciences are not completely absent from schools, but are typically only included as an optional elective, if at all (Walker, Coble, & Larkin, 2000). From this, I infer that ocean content is seen as inconsequential for lifelong knowledge and may be perceived as "extra knowledge of interest" for secondary grades. Personally, I don't think it needs to be a separate course, as many of the essential principles and concepts can be taught within the existing framework of the standards in interdisciplinary classrooms now.

Since No Child Left Behind was implemented, teaching of science has come second, if not further, behind required subjects for testing; namely, language arts and mathematics (Marx & Harris, 2006). Teachers in public schools often are focused on content that is necessary for high-stakes tests and are limited in the extra things they can teach.

Summary

Research indicates that ocean literacy in classrooms is needed to help build a national constituency of informed citizens. Marine education leaders are examining ways to build ocean content into existing educational practices. Research shows that it may be integrated with existing standards, but it also offers its own subject value. Nationwide, the country is not performing well on implementing Earth science-related content standards, which are the standards that ocean content would tie closest with. Due to the increased focus on mathematics and language arts, science is diminishing in content on campuses across the United States.

Chapter 3 Method

Sample and Site

I focused my research on teachers throughout California that participated in a three-day workshop which focused on training of the NOAA-sponsored curriculum Animals in Curriculum Based Ecosystem Studies (referred to as ACES hereafter). This curriculum utilizes ocean concepts in teaching content standards. By working with a population of teachers that have a known level of training with ocean-related curricula, I was able to target obstacles they experience in using the ocean related materials, eliminating access to ocean-related curriculum materials as a possible cause. These workshops were conducted in 2007 and 2008 respectively, so a full two years have passed since the time the study began. This time lapse allowed time for teachers to consider how they would include/adapt their teaching practice to utilize these materials. The teachers I targeted for interviews in 2010 were located in Sonoma, Marin, San Francisco, Los Angeles, and Santa Barbara Counties. The potential for the sample of teachers to choose from was 50, but I targeted a total of 5 individuals as a sample size throughout these geographic areas.

Access and Permissions

Access to the evaluation data from the workshops was granted by U.S. Satellite Inc., the authors of the ACES curriculum (Marrero & Stock, 2009). I e-mailed the 50 teachers who participated in the workshops, and selected five teachers based on availability and response. A formal Institutional Review Board proposal from Dominican University was approved, and a 'consent to participate letter' for the teacher was sent out prior to each interview, read and signed, and returned to me prior to the interview.

Data Gathering Strategies

To investigate what obstacles exist for teaching about the ocean in secondary teachers in California, I studied archived pre/post-workshop evaluation data to help determine the set of questions to ask and conducted a case study utilizing semi-structured interviews. I pre-determined a set of open-ended questions, and a set of prompts to further develop responses if needed. I asked permission to re-contact each teacher if necessary for clarification and fact checking if needed. I recorded all the interviews by a phone conferencing service to return to the data for coding and IRB requirements. The interview questions were formulated to identify challenges and or obstacles teachers faced when attempting to include ocean-related content in their classroom.

Data Analysis Approach

I reviewed evaluation data collected pre/post-workshop from the teachers that participated in the workshop, which allowed me to identify how teachers did or did not include ocean content in their classroom prior to the workshop, and to identify their attitudes about including ocean topics in the curriculum. This also allowed me to see how this impression changed immediately after the workshop, with the new curriculum materials that they were trained on in-depth. I identified themes in the responses of the pre/post surveys, which helped formulate a series of questions for the interview. I interviewed teachers from four different school districts and counties in California that had all participated in the three-day ocean literacy based curriculum training. I asked the teachers questions that identified the challenges they experienced in using these resources and obstacles they encountered in implementing them.

Ethical Standards

Due to the nature of the study and its methods, there was no identified potential harm to research subjects (teachers). Teachers voluntarily participated with the knowledge that their participation would take some of their personal time. To ensure that ethical standards were met, Dominican University IRB procedures were followed. IRB approval number is 8053.

Chapter 4 Analysis

Description of Site, Individuals, Data

I interviewed five secondary teachers via conference call. Teachers were asked to volunteer to participate via a broadcast e-mail that went out to the entire group of teachers that were trained on the ACES curriculum. Five participants were selected based on availability and geographic distribution. Two of the teachers teach at the high school level (9^{th} and 10^{th}) and the remaining three teach at the middle school level (7^{th} and 8^{th} grades). Each call averaged 45 minutes. The calls were recorded for transcription and fact checking. After each interview, I summarized the themes from the questions and e-mailed my summary to the participant to verify that I captured the ideas they intended to communicate.

Analysis of Themes

This analysis covers components from the pre/post-workshop data from the evaluation conducted at the ACES workshop that relate to the research question, and also the results of the interviews conducted for this study.

The pre/post-workshop data is a summary of 50 teachers in California, and not solely representative of the five interviewed individuals, but the trends and themes were consistent. Teachers participated in the ACES workshops because they wanted to learn more about marine biology and how to apply it in their classrooms. Many sought to attend this workshop because it provided instruction on how to utilize real data, and they wanted their students to have access to real world examples about the ocean. Prior to the workshop, most teachers said they taught about the ocean already, but mostly abiotic factors such as physical properties of water, geology, and currents. After the workshop, there was a clear increase in the desire to teach more about

ecosystem properties of the ocean, and the interconnections between land, sea, animals, and how humans play a role. The majority of participants stated that they thought the ocean should be part of the school curriculum, but had a difficult time doing so, due to a lack of time and resources, and also mentioned the fact that the ocean was not part of the scope and sequence. One teacher stated:

"They should understand its importance and interconnectedness of it to us for one, but to the atmosphere and land as well. They need to know our effects on the ocean and how we can reduce them."

Evaluation results indicated that teachers had an increase in their own personal ocean literacy and gained a genuine comfort with the ocean-related materials they received and had practice using at the workshop. Two to three years after these workshops, I interviewed five of the workshop participants for this study. I revisited what they thought was most important for students to learn about the ocean and examined obstacles they faced to including these in their curriculum. The idea about interconnectedness between the ocean and our lives was a consistent theme expressed. One teacher stated:

"Students have a hard time realizing how the ocean affects us globally in terms of weather patterns, food webs, climate and the influence it has on us. You don't just go to the ocean, it is affecting you."

Other ideas expressed as being important for students to know consisted of ocean facts such as the food webs and the importance of phytoplankton, the seafloor bathymetry, and different ocean biomes. One teacher found the importance of clearing up misconceptions as "a-ha" moments for students. Also, the idea that there is real scientific research going on and there are careers associated with the ocean that could be interesting to them. Each of these concepts goes beyond

the abiotic factors that are somewhat covered in the secondary content standards into more complex Earth system understanding.

When asked about the obstacles and challenges the teachers encountered in regards to including more ocean content in the curriculum, the role of the content standards and the accountability to teaching about the content that will be on the statewide STAR tests rose to the top as a big issue. Equally problematic was the lack of instructional time. Each teacher expressed a different scenario in regards to how the standards were a challenge. For the 7th grade teachers, where science isn't tested, there was the sense of a bit more leniency, and the feeling that they could bring in a bit more ocean content, because they weren't prepping their students for the STAR test. In the high school, the focus on prepping students to perform on the test in the classroom was the primary goal. One teacher I interviewed is now in an administrative role, and now has a different perspective about the importance of showing achievement through these statewide exams in order to get funding for the school. She expressed how it is difficult, but necessary, to set the priority on achievement on these exams.

The diversity of challenges expressed in regards to the standards ranged from set department-wide curriculum that "can't be altered," to being on a certain page in the textbook at a point in the semester, to the content standards being so specific that there is no way to bring in certain ocean content as it doesn't relate (ex. human body systems). A few teachers felt that they could tie many content standards to ocean themes and felt that lessons could be replaced by these ACES (ocean focused) lessons. One teacher stated:

"You don't do it as well (meaning in addition to existing lesson), you do it instead of."

Four out of five of the teachers expressed their personal appreciation and understanding of the ocean. One has an educational background in oceanography and finds he can more easily

incorporate ocean examples into his curriculum than other teachers at his school. Some teachers have learned through the ACES professional development and other professional development courses the important role the ocean plays on Earth and have realized the importance of making the connection in the classroom. They expressed that they increased the amount of ocean content they had in their classroom after these workshops. Some expressed that they would like even more training, but recognize that other teachers without this training or personal affection for the ocean could be a limiting factor for these other teachers to include ocean content in their classrooms, because it is not prominently featured in the content standards. A few expressed a desire for stand-alone activities that don't require scaffolding concepts. If they have an opportunity to teach one different thing, something they can easily pull out and reference would be easier to implement than a curriculum that requires a building up of marine science concepts. While this option may require less time and may allow some teachers to teach an ocean concept or two, it may not achieve the level of ocean literacy that is necessary to understand the ocean's influence on us as humans, and our influence on the ocean.

One teacher expressed her interest in the content standards being revised and including some of the ocean literacy essential principles and concepts in the revisions. Two of these teachers have taken the time to correlate the ocean literacy principles and concepts and ACES ocean related lessons to their assigned textbook, to show their administration the linkages and prove that it can be done. The teachers that have an extreme passion and appreciation for the ocean seem to be taking the extra time and effort to bring the ocean into the classroom and working past these obstacles.

For teachers that had a difficult time correlating ocean content to their standards, they shared ways they bring in ocean content as "extras." Activities such as "bell ringers" a 10-minute

wake up type of activity to do when students first arrive to get their attention and ready for class focusing on the ocean are utilized. Extra credit assignments such as weekend lectures, walks, beach cleanups, or ocean related articles are other ways teachers described they could bring in ocean content, but they recognized these techniques as enhancement. Using ocean-related films, and planning substitute lessons based on the use of these ocean films, is also another tool that teachers used.

Chapter 5 Discussion

Summary of Major Findings

By contacting the teachers and initiating an interview that focused on ocean literacy and education standards in classrooms, the teachers I interviewed gained a greater perspective of the importance of this issue and expressed interest in continuing to work to conquer the obstacles. In summary, teachers recognize and are frustrated by the constraints of high stakes testing in determining the content they teach in their curriculum. Teachers that participated in the ACES workshops ended up with greater ocean literacy themselves. This greater knowledge may impact the content they are able to teach about in the classroom by enhancing their existing curriculum or in some cases replacing lessons with ocean examples. Teachers that participated in an ocean-related professional development course gained a greater ecological view of the ocean's impact on us, and our impact on the ocean, and wanted to see their students gain this point of view as well. Time restrictions, the constraints of high stakes testing, and ecologically limited content standards are major obstacles for increasing ocean content in schools. There is a great diversity of school situations that range from full support to be creative and teach a globally minded curriculum, to a very restricted, highly regulated curriculum content that teachers have to teach, with little room for additional content. Within this broad range, there are lots of different teaching situations in between. Students respond well to the "wild and weird," and connect to ocean content as it relates to animals, making a great launching off point for many content standards to revolve around.

The teachers commented on the value of professional development and how excited they are to interact with "experts in the field" such as scientists or management agency personnel, such as within national marine sanctuaries. They like having the opportunity to hear their real

stories from the field, and what research is taking place. One teacher commented how she would enjoy continued trainings after the initial ACES workshop to keep up on the skills, interact with other teachers doing the ACES curriculum, and share implementation practices, describing a *community of practice* type of opportunity. They also commented on the opportunity to learn curriculum activities that are based on real research and science where the student feels they are "making discoveries." In the ACES program, the students write observations and hypotheses in an online journal, and a scientist from the ACES program will respond. One teacher enthusiastically expressed how validating this was for the students and how seriously they took their comments due to the scientist looking at their work. The teacher remarked how this "outside expert" is extremely important in helping the students to learn, that it's not just a textbook, but they are interacting with someone besides their teacher. Teachers also commented that their personal experiences with the ocean fuels their interest in teaching about the ocean, emphasizing the value of *in the field* professional development opportunities.

Comparison of Findings with Existing Studies

The findings from this study were not a surprise. Teachers and administrators and marine educators continue to remark on the state of education since the No Child Left Behind Act was implemented. The challenge exists in how to overcome the realities of high stakes testing, limited instruction time, increasing class sizes, reduced funds for schools, and many other rising challenges faced by schools. Some educators are leading the way by providing ocean literacy related training and resources and making connections to the existing standards. Existing studies show that integration with multiple subjects and hands-on or place-based learning increases ocean literacy.

Limitations of the Study

This study is limited in its sample size. The workshop evaluation data analysis is reflective of the entire possible sample size, but due to realities of busy teaching schedules, change in career, and change of contact information, the sample size potential for the interviews of these same workshop participants was small. Some teachers may have participated in the workshop and may not be teaching science anymore, or were hesitant to participate due to lack of use of materials.

Implications for Future Research

Some areas to focus on for future research include professional development and educational background, including teacher training, about ocean related content. It seems that teachers who have a personal love and affinity for the ocean are more likely to teach about it and seek out professional development opportunities to better their abilities to bring in ocean content into their classrooms. A study that examines methods for bringing meaningful ocean content to the population of teachers that may not live near the ocean, or that do not have a personal connection to it would be valuable. Teachers that have taken steps to relate their content standards to ocean literacy principles and concepts may be an asset to other teachers, showing them how they developed their instructional practices. This peer mentoring of teachers who are practicing ocean literacy aligned with their state standards could provide a useful professional development opportunity to bring in more teachers into the ocean literacy aware population with the current constraints of the content standards. Further research should go into the content standards themselves and how they are determined and how ocean literacy concepts and principles may be able to be included in future updates. Are the standards reflective of the types

of information that young adults need as they move forward in life after graduation, and will students have the background knowledge and skills to understand ecological principles as we approach a different climate on our planet? Efforts to revise content standards should consider topics of ecology in serious consideration with the ocean's role being a significant part of it.

Overall Significance of the Study

While the content standards were developed and adopted with the good intention of standardizing the types of things students should know, they should be looked at with a 21st century point of view with the health of the planet in mind, and be revised periodically. In the meantime, education communities should consider how to apply these necessary principles to the current standards wherever possible and marine education organizations should continue to seek out new audiences of teachers that may not have personal experiences with the ocean.

In 2010, ocean sciences are becoming more recognized both in the scientific world and public eye, and the health of the oceans is an issue that is hard to ignore anymore. With globally significant events such as the Indian Ocean Tsunami and Hurricane Katrina, the ocean has been in the forefront of news and environmental issues of concern. For educators, there is a plethora of ocean science resources and programs geared towards teachers in the United States, especially in California, yet many teachers may not know they are available and/or know how to use them with the constraints they face daily. In order to get these high quality ocean related materials into teachers' practices, obstacles need to be addressed to best assess limitations and challenges, so an appropriate strategy can be implemented to increase the use of ocean-related curricula by teachers.

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Appendix A

Ocean Literacy Essential Principles and Concepts

Definition of Ocean Literacy

Ocean literacy is an understanding of the ocean's influence on you and your influence on the ocean. An ocean-literate person understands the fundamental concepts about the functioning of the ocean, can communicate about the ocean in a meaningful way, and is able to make informed and responsible decisions regarding the ocean and its resources.

1. The Earth has one big ocean with many features.
a. The ocean is the dominant physical feature on our planet Earth—covering approximately 70% of the planet's surface. There is one ocean with many ocean basins, such as the North Pacific, South Pacific, North Atlantic, South Atlantic, Indian and Arctic.
b. An ocean basin's size, shape and features (such as islands, trenches, mid-ocean ridges, rift valleys) vary due to the movement of Earth's lithospheric plates. Earth's highest peaks, deepest valleys and flattest vast plains are all in the ocean.
c. Throughout the ocean there is one interconnected circulation system powered by wind, tides, the force of the Earth's rotation (Coriolis effect), and water density differences. The shape of ocean basins and adjacent land masses influence the path of circulation.
d. Sea level is the average height of the ocean relative to the land, taking into account the differences caused by tides. Sea level changes as plate tectonics cause the volume of ocean basins and the height of the land to change. It changes as ice caps on land melt or grow. It also changes as sea water expands and contracts when ocean water warms and cools.
e. Most of Earth's water (97%) is in the ocean and contains a constant proportion of dissolved salts (i.e. average salinity of 35). Seawater has unique properties: its freezing point is slightly lower than fresh water, its density is slightly higher, its electrical conductivity is much higher, and it is slightly basic. The salt in the water comes from eroding land, volcanic emissions, reactions at the seafloor, and atmospheric deposition.
f. The ocean is an integral part of the water cycle and is connected to all of the earth's water reservoirs via evaporation and precipitation processes.
g. The ocean is connected to major lakes, watersheds and waterways because all major watersheds on Earth drain to the ocean. Rivers and streams transport nutrients, salts, sediments and pollutants from watersheds to coastal estuaries (where rivers meet the sea) and to the ocean.
h. Although the ocean is large, it is finite and resources are limited.

2. The ocean and life in the ocean shape the features of the Earth.
a. Many of the sedimentary rocks now exposed on land were formed in the ocean. Ocean life laid down the vast volume of siliceous and carbonate rocks.
b. Sea level changes over time have expanded and contracted continental shelves, created and destroyed inland seas, and shaped the surface of land.
c. Erosion—the wearing away of rock and soil—occurs in coastal areas as wind, waves, and currents in rivers and the ocean move sediments.
d. Most beach sand is carried to the coast by rivers and redistributed by waves and coastal currents. Erosion builds and destroys beaches. Winter storm waves carry sediments away from

the beach and small summer waves carry sediments back onto the beaches.
e. Tectonic activity, sea level changes, and waves influence the physical structure and landforms of the coast.

3. The ocean is a major influence on weather and climate.
a. The ocean controls weather and climate by dominating the Earth's energy, water and carbon systems.
b. The ocean absorbs much of the solar radiation reaching Earth. The ocean releases heat by evaporation and this heat loss drives atmospheric circulation when heat released as water vapor condenses as rain. Condensation of water evaporated from warm seas provides the energy for hurricanes, cyclones and typhoons.
c. The El Niño Southern Oscillation causes the most important changes in global weather patterns because it changes the way heat is released to the atmosphere in the Pacific.
d. Most rain that falls on land originally evaporated from the tropical ocean.
e. The ocean dominates the Earth's carbon cycle. Half the primary productivity on Earth takes place in the sunlit layers of the ocean and the ocean absorbs roughly half of all carbon dioxide added to the atmosphere.
f. The ocean has had, and will continue to have, a significant influence on climate change by absorbing, storing, and moving heat, carbon and water.
g. Changes in the ocean's circulation have produced large, abrupt changes in climate during the last 50,000 years.

4. The ocean makes Earth habitable.
a. Most of the oxygen in the atmosphere originally came from the activities of photosynthetic organisms in the ocean.
b. The ocean is the cradle of life—the first life is thought to have started in the ocean. The earliest evidence of life is found in the ocean.

5. The ocean supports a great diversity of life and ecosystems.
a. Most life in the ocean exists as microbes, although ocean life ranges in size from the smallest virus to the largest animal that has lived on Earth, the blue whale.
b. Microbial organisms are the most important primary producers in the ocean. They not only are the most abundant life form in the ocean but also have growth rates that range from hours to days.
c. Most major groups of organisms (phyla) have many representatives living in the ocean.
d. Ocean biology provides many unique examples of important relationships among organisms (such as symbiosis, predator-prey dynamics and energy transfer).
e. There are examples of life cycles in the ocean that are not often seen on land.
f. The ocean is three-dimensional, offering a lot of living space from the surface through the water column to the seafloor. As a result, most of the living space on Earth is in the ocean.
g. Ocean habitats are defined by environmental factors. Due to interactions of abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substratum and circulation, ocean life is not evenly distributed temporally or spatially, i.e., it is "patchy".
h. There are deep ocean ecosystems that rely only on chemical energy to support life (such as hydrothermal vents, methane cold seeps and whale falls).

i. Zonation patterns of organisms along the shore are influenced by tidal ranges and waves.
j. Coastal estuaries (where rivers meet the ocean) provide important and productive nursery areas for many marine species.

6. The ocean and humans are inextricably interconnected.
a. The ocean affects every human life. It supplies freshwater (most rain comes from the ocean) and almost all Earth's oxygen. It moderates the climate and influences our weather.
b. From the ocean we get foods, medicines, and mineral and energy resources. In addition, it provides jobs, supports our nation's economy, serves as a highway for transportation of goods and people, and plays a role in national security.
c. The ocean is a source of inspiration, recreation, rejuvenation and discovery. It is an important element of our cultural heritage.
d. Most of the world's population lives in coastal areas.
e. Humans affect the ocean in a variety of ways. Wastes (such as trash, sediments and sewage) enter the ocean from run off (non-point source pollution) and dumping (point source pollution). The pollution leads to habitat degradation, development of harmful algal blooms, and depletion of oxygen, as well as the endangerment, depletion, and extinction of ocean species. Coastal development, such as building structures along
coasts and damming rivers leads to loss of beaches and increased coastal erosion. Through fishing, humans have removed most of the large vertebrates from the ocean, either directly or by harvesting their prey.
f. Coastal regions (where most people live) are susceptible to natural hazards (such as tsunamis, hurricanes, cyclones, typhoons, and storm surges).
g. Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.

7. The ocean is largely unexplored.
a. The ocean is the last and largest unexplored place on Earth—less than 5% of it has been explored. This is the great frontier for the next generation's explorers and researchers, where they will find great opportunities for inquiry and investigation.
b. Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes. Our very survival may hinge upon it.
c. Over the last 40 years, use of ocean resources has increased significantly, therefore the future sustainability of ocean resources depends on our understanding of those resources and their potential.
d. New technologies, sensors and tools are expanding our ability to explore the ocean. Oceanographers are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.
e. Use of computer models is now an essential part of oceanography. They help us understand the complexity of the ocean and its interaction with Earth's climate. These models process observations and help describe the interactions among systems.
f. Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, and physicists, and new ways of thinking.

Appendix B

Sample of ocean knowledge questions asked in public opinion survey by the Ocean Project in 1999

Q1. As far as you know, is the climate and the amount of rainfall on earth regulated more by the rotation of the earth or by the oceans?
A= oceans

Q2. As far as you know, is more plant and animal life found on land, more in the ocean, or is it about equally divided?
A=more in the ocean

Q3. As far as you know, is more of the earth's oxygen produced by the forests or the oceans?
A=oceans

Q4. As far as you know, is extinction of plant and animal life in the oceans being caused mainly by humans, mainly by natural causes, or both about equally?
A=humans

Q5. As far as you know, is most ocean pollution being caused by: runoff from yards, pavements and farms, trash and litter washed into the oceans from beaches or waste dumped by industry?
A=runoff from yards, pavements, and farms

Appendix C

Interview Questions

Name
Type of School you teach in
Grade Level you teach?
Subjects you teach?
Number of years teaching?

In what ways do you currently teach about the ocean in your classes?

In terms of ocean concepts, what do you think students most need to know about the ocean?

Describe the challenges and obstacles you see to including the amount of ocean literacy related curriculum you feel students need?

Reworded: what are barriers to teaching more ocean sciences:

- standards;
- tests and accountability;
- lack of materials;
- lack of content knowledge;
- lack of instructional time;
- lack of support from principals/parents;
- lack of relevance (my school isn't on the beach);
- perception that it's not important enough...?

You participated in an ACES workshop in 2007 or 2008. How have the training and curriculum materials you received in that training helped you to teach about the ocean in your class?

Since part of the curriculum required use of computers, in what ways was that a challenge?

PROMPT Did it limit your ability to implement aspects of the program/curriculum?
If there were challenges
PROMPT
Describe ways you were able to overcome these challenges?

How have you been able to find ways to incorporate ocean content into your local school standards?

What type of materials/ training/ workshops would you recommend to help other teachers gain access to ocean related curricula and gain a better understanding of the ocean themselves?
What type of professional development opportunities do you prefer?

What additional information would you like to share related to this topic?