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ABSTRACT

A comparison was made of student understandings of marine science and marine resource concepts in two geographically distant but similar sociocultural regions of the United States. The study is based on the nature of ecological events, students' understanding in the context of meaningful learning, and the cultural context in which learning takes place. One hundred and fifty-nine Oregon students and 157 Maine students in 4th, 8th, and 11th grades were interviewed using modified clinical interview techniques. Results indicate great similarity in a number of conceptual areas and misconceptions. However, there was a distinct difference in some geological and natural resource areas. These differences may be attributable to regional, geo-cultural differences between the samples. One table and one figure present study findings. (Author/SLD)

A Comparison of Maine and Oregon Students' Science Knowledge Related to Marine Science and Natural Resources

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A Comparison of Maine and Oregon Students' Science Knowledge Related to Marine Science and Natural Resources

Abstract

This study reports on a comparison of student understanding of marine science and marine resource concepts in two geographically distant but similar socio-cultural regions of the USA. The study is based on the nature of ecological events, student understanding in the context of meaningful learning and the cultural context in which learning takes place. One hundred and fifty nine Oregon students and one hundred and fifty seven Maine students in fourth, eighth and eleventh grades were interviewed using modified clinical interview techniques. Results indicate great similarity in a number of conceptual areas and misconceptions. However there was a distinct difference in some geological and natural resource areas. This differences may be attributable to regional geo-cultural differences between the samples.

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Introduction

The interaction of basic sciences and natural resources can be an important part of the school curriculum and should be considered by teachers as an integral part of their teaching practices. In order for this to happen it is imperative that we consider relevant ecological topics and the scientific concepts which can help us better understand them. In particular, water related natural resources are critical for people to understand since we all share the need for these precious resources. Given the prevalence in mass media of scientific concepts related to everyday events, it is imperative to have societies which understand the role of science in the real world (Hively 1988, Gore 1992).

Among the modern science curriculum models which have emphasized the interrelatedness of science concepts and real world applications have been Human Ecology and Science Technology and Society (STS). The National Science Teachers' Association (NSTA 1982) recognized the need for interaction of the various disciplines and the interrelatedness of subjects in their position statement which acknowledged a commitment to useful science education for all students. The National Association of Biology Teachers (NABT) published *Human Ecology: A Perspective for Biology Education, Monograph Series II* (Bybee 1984) which focused on a framework for reconceptualizing the biology curriculum based on human interactions with the environment.

Among some of the most recent curriculum reform efforts in the USA are the National Science Teachers Association (NSTA), *Scope, Sequence and Coordination of Secondary School Science (SS&C)*, the American Association for the Advancement of Science (AAAS), *Project 2061*, and the National Research Council's (NRC), *Science Standards and Assessment*. Each of these reform efforts includes suggestions about how science should be taught in US schools in order to improve science education nation-wide. According to NSTA's SS&C (1992), there are basically three areas which curriculum reformists need to address: sequencing, coordination and assessment. If NSTA's suggestions that subjects should link together and that "less is more" are to be taken seriously, curricula examples based on these principles need to be implemented in real classrooms. A focus on the environment and marine resources as a curricula theme is appropriate.

The American Association for the Advancement of Science's (AAAS) Project 2061 is based on several principles of learning and teaching (Rutherford & Ahlgren 1990). Implications for teachers and curriculum developers are that values are critical in teaching and learning and that both extend beyond the schools. A focus on marine science and marine resources can help lead to the inclusion of values related to the environment and the application of school learning outside the classroom.

The science standards as proposed by the National Research Council (Coordinating Council, NRC 1992) focus on the content of school science. Among the most significant of the NRC's recommendations are that science is essential for all Americans, regardless of background, aspiration, or interest, and an understanding of the modes of science based on inquiry are essential. The integration of topics related to water (a concern of all people) and inquiry related to marine resource management into the school curriculum is congruent with these curriculum reform suggestions.

Decreasing marine resources such as depleted fish stocks coupled with increased coastal utilization, estuarine pollution and advanced technologies to harvest marine resources demand a society that is knowledgeable about basic science concepts related to marine science and resource management. Both Oregon's and Maine's marine environments are uniquely productive and valuable resources for the entire country and both have significant impact on the social, political and economic fabric of the regions. Both the Pacific Northwest and the Northeast Gulf of Maine have uniquely productive marine environments and a rich tradition of marine resource utilization. Although geographically distant, both ME and OR, are similar, in that they have an agriculture, forestry, marine fisheries and recreation as the basis of their economies. They are also similar in population size.

In these studies, basic scientific research related to the marine environment was conceptually analyzed and used as a framework for modified clinical interviews with 4th, 8th and 11th grade students in order to establish the extent of students' knowledge about the nature and utilization of marine systems. This research addressed basic issues in science education by asking the following questions: (1) What science and natural resource concepts do 4th, 8th and 11th grade students in Maine and Oregon possess concerning the marine environment? (2) What misconceptions do students possess concerning marine environment and (3) What are the similarities and differences in student understanding between two geographically distant yet similar regions of the US?

Understanding of Ecological Events

There is a great deal of variety in the way people describe ecological events. For some, they may be a change in the environment such as a blowdown of spruce trees during a storm or a mud slide following heavy rains. Other people include negative impacts to the environment, but only in the context of the effect on human beings. In the case of this study, ecological events are related to the marine environments of both Oregon and Maine.

Some of the most recent issues which the citizens of these states have been exposed to are: oil spills, coastal pollution, closing of fishing grounds and depleted fish stocks. As they read about these in the newspaper or see reports on television people are being exposed to number of social and natural science concepts and issues related to specific problems.

A certain degree of cultural bias exists in defining these ecological events involving natural resources and not only are there differences in understanding among cultures but within cultures as well (Fritchen 1987). Regional differences exist in the nature of the resource, the issues surrounding resource utilization and problems associated with their management. A study comparing children's understanding of marine resources in two geographically proximate but culturally different regions pointed out significant differences between children's knowledge related to marine resources (Stilwell & Brody 1987). Students living in Newfoundland, Canada and in the state of Maine, USA provide a clear example of how different people perceive their marine resources in different ways. Based on the result of modified clinical interviews, it was determined that students in Maine, USA considered the Gulf of Maine (one of the most important resources in their state) rather intellectually and removed from their experience, something they would learn about in school but would not have direct experience with. On the other hand, students interviewed in Newfoundland, Canada commented on the availability and importance of marine resources found in their offshore waters and the need to utilize them.

Environmental degradation, resource depletion and related problems are not simply the result of science, technology and society. The underlying causes of pollution and thus our understanding appears to be the collective behavior and belief systems of individuals within society. Wether it's clear cutting in the national forests of the Pacific Northwest, USA or the contamination of groundwater in the Great Lakes Region, USA, people's interactions with and beliefs about natural resources are driven by cultural relationships with nature. These factors suggest the need to better understand student knowledge of the environment as a multidimensional and multidisciplinary understanding of natural and social phenomena.

Meaningful Learning Theory

This analysis is based on the premise that teaching, learning, and curriculum development are based on the comprehension and acceptance of concepts which are intelligible and rational and lead to a change in the meaning of experience for the learner (Novak, 1977). Based on a human constructivist paradigm (Novak, 1987b) this study assumes that children have existing conceptions which influence their understanding of the world and their acquisition of new knowledge and that knowledge is in part a result of children's direct experience with the environment within particular cultural contexts. Learning can not be considered as simply the acquisition of a set of correct responses. Therefore, a critical condition for meaningful learning is for the teacher to determine what the learner already knows. Of the many variables that influence learning in science, the learner's relevant background knowledge and his or her existing internal conceptual framework are two of the most important (Carey, 1986; Novak & Gowin, 1984; West & Fensham, 1976).

Consideration is given to what a student knows as an integrated set, conceptual framework or cluster of concepts related to marine science and marine resources rather than student understanding of a single concept and thus reflects a complex, integrated and multidisciplinary conception of a natural phenomena by the learner. In the process of completing several studies concerning children's conceptions of the world we have found that seldom do students see the multiple connections that science concepts have to the real world. Students are unable to explain higher order concepts such as food webs, nutrient cycling or productivity in terms other than those provided in their text (Brody, 1987). They are unable to apply the knowledge to every day occurrences in their lives. Yet, when probed in interviews concerning the nature of local environmental issues, children have rich understandings of a number of concepts from a variety of disciplines (Brody, Chipman, & Marion, 1988-89). Similar studies related to comprehensive, interdisciplinary assessment of children's conceptions have been conducted in the Learning in Science Project (Osborne & Freyberg, 1985). If we tie together several typical misconception studies, for example, we find that students have limited conceptions of the nature of light (Stead & Osborne, 1980) and plants (Bell, 1981). This can lead to further misconceptions about the distribution of plants as a function of light penetration at various depths of the ocean (Brody & Stilwell, 1987). Studies of children's conceptions recently reported in many popular journals have given a better understanding of what we can expect children to understand concerning specific science concepts (Helm & Novak, 1983; Novak, 1987a; West & Pines 1985).

The research was guided by the following principles: (a) before attempting to assess student knowledge in any domain, the major concepts and organizing principles of the knowledge domain should be identified (Champagne & Klopfer, 1984); these principles should be broad and inclusive, stressing conceptual relationships and meaning rather than isolated facts, (b) the assessment of student knowledge through interviews provides a more comprehensive picture of student understanding of concepts and conceptual relationships than other, more frequently used assessment techniques, such as multiple choice tests (Novak & Gowin, 1984), and (c) the assessment of student knowledge in a given domain can provide information useful in the design of curricula and educative materials that address students' conceptual problems and misconceptions directly, and that introduce new and difficult concepts in ways that facilitate non-arbitrary (meaningful) linkage of those concepts to existing relevant knowledge in students' cognitive structures (Ausubel, et al, 1978).

Social Context and Student Understanding

Student understanding of science concepts has been an interest of science educators for a number of years, yet little research has been conducted on the social context which influences children's existing conceptions. The educational research related to social contexts comprises a limited number of empirical studies that have measured student achievement and compared it to what are referred to as macro and micro cultural factors . Lockheed and Gorman (1987) identified less than seventy of these types of studies, most of which focused on broad socio-demographic factors, such as race, ethnicity, region, and gender. Of those identified, the concept of regional differences is of particular concern in regards to this study. In many of the macrocultural studies, region has been documented as related to science achievement. For example, results of the National Assessment of Educational Progress (NAEP) indicate that students from the northeast region of the USA as well as those from advantaged urban and suburban communities perform above the national average (NCES 1978). Of the studies reported, the author's noted the predominant use of pencil and paper/questionnaires to gather data on both contextual variables and science achievement. There were no reported cases of qualitative or emergent data collected. Although research on cultural factors has been done in science education there are few studies and they are not comprehensive in nature.

Charron (1991) argues that there is a need for contextual frame of reference for science education research and that it is a small step to include the society-science education link. A contextual orientation would take into consideration that social beings and events are inextricably tied to their surroundings. This belief is congruent with science educators' interests in existing children's conceptions including misconceptions. In terms of meaningful learning theory, context is critical to understanding what children know and how we can be help them learn science.

There appears to be a great need for matching teaching, learning and curriculum with cultural context. Lerner (1984) suggests that student learning could be enhanced if more attention were given to adjusting teaching strategies, classroom activities, and curriculum and cultural milieu of the students within the classroom. Lockheed and Gorman (1987) assume that effecting a match between culture and science instruction is best accomplished through modification of the curriculum. This should be a concern of educators from single classrooms to national curriculum developers.

Methodology

The research topic analyzed in this paper was selected following several news media surveys of current ecological issues in the states of Maine and Oregon in the USA. The key ecological issue selected for study was the marine environment.

Primary research and secondary sources related to marine resources were identified. A total of 21 graduate students in science education analyzed related scientific reports. These papers were discussed by each research group. Through this discussion and the sharing of different perspectives, the groups constructed concept maps (Novak & Gowin, 1984) and negotiated meaning from the reports. The construction of the concept maps was a collaborative process in which all members of the research team participated. The process of negotiating meaning over the material and the concept mapping activities subsequently yielded several concept maps representing a variety of major content principles which the research group considered to be essential for an understanding of the environmental issues identified. The research teams constructed content principles from the concept maps. Since the concept maps included the essential concepts related in propositional and hierarchical form, it was an easy task to combine associated concepts into content principles. The concept maps were broken up into relevant semantic chunks and listed as complete sentences within the content principles. The content principles served as the basis for the design of our interviews and the analysis of student responses. The content principles represent clusters of concepts related to a particular content area.

The analysis includes interviews with 159 students from 9 schools in Oregon; 45 fourth graders, 53 eighth graders and 61 eleventh graders and 187 students in 12 schools in Maine; 64 fourth, 60 eighth graders and 63 eleventh graders, . Although schools were selected primarily on the basis of proximity and the convenience of interviewers, both urban and rural schools were represented, as well as schools in communities representing a range of socio-economic levels. There were approximately even numbers of students from cities below and above 40,000 people. These towns and cities were in counties which represent a variety of economic bases. All students were selected from single classrooms in each school system based on the cooperating teachers' willingness to have their students participate in the study. Students volunteered to be interviewed with permission of their guardian(s). Interviewees were selected based on convenience and the use of volunteers have the potential of introducing sampling biases, but we believe the heterogeneous nature of the entire group of student interviewees kept sampling biases to a minimum. This is supported, in part, by general agreement of previous similar results with those of the state-wide Maine Assessment of Education Progress in Science (1984), which involved a random sample of 4,000 Maine students from the same grade levels we investigated (Brody & Koch, 1989-90).

Interviewers were the same graduate students who previously analyzed the primary research documents and secondary sources. Each member of the research team was assigned to one grade level in one school system. Interviewers were selected for each grade level based on their interest, experience and familiarity with pupils at that grade level. It was our intent that the interviewers' understanding of the students at a given grade level would help ensure appropriate probing of responses given to interview questions. Interview techniques were standardized and refined during practice sessions using audio and video tapes. The modified clinical interviews were guided by general lead-in focus questions developed from the previously constructed concept maps (see Novak & Gowin, 1984, Ch. 7). Lead-in questions were followed by more specific probing questions based on the concept maps. Interview props were used to sustain student interest and to focus their attention.

Student response to the lead-in questions guided the interviewer to more specific probing questions to determine the presence or absence of concepts and misconceptions as well as the students' overall level of understanding of the major content principles. The specific probing questions were based on the idiosyncratic responses of the children and asked students to explain their responses, give examples or make connections of individual concepts to a specific situation. Following the interview, each interviewer completed a two page evaluation sheet for the student's responses. As the interviewer reviewed the audio-tape of each interview session the evaluation sheet was filled out. The evaluation sheet was divided into sections corresponding to the major content principles. Within each principle the pertinent concepts were identified. Each concept was then ranked for basic understanding, that is, it was awarded a complete, incomplete or missing rank. The ranking of student understanding was then supported by evidence recorded on the evaluation sheet as a child's direct response, statement or assertion. Following the concept rank and supporting evidence, space was provided for the interviewer to include notes on specific misconceptions or other noteworthy aspects of the interview.

The analysis of interviews extended over several weeks and each week interviewers worked in groups based on the particular grade level that they were interviewing. During this time the interviewers identified concepts which were noticeably absent or lacking in student understanding. Our intention was to analyze and resolve any procedural discrepancies. One such interviewer inconsistency which we addressed was the probing of marine plant life. Several interviewers had consistently probed student understanding of the distribution of plants and found a clear misconception. When this was brought to the attention of the group it was apparent that other interviewers had overlooked this area and agreed to pursue it in future interviews. It subsequently was found to be a pervasive misconception and important research finding. The importance of this procedure in studies involving teams of researchers is that it provides for consistency and the corroboration of independent findings. This protects any of the individual researchers from imposing their personal biases on the analysis while providing for the input of various perspectives and expertise that are brought to the investigation by the different members of the research team. This results in a richer description of student knowledge and provides a qualitative version of interrater agreement.

Results

The Nature of Marine Science and Natural Resource Knowledge

The results of this study has led to a greater realization that there are a number of critical concepts for understanding marine science and natural resources. The creation of concept maps to identify key science and natural resource concepts was a complex and arduous activity. It was also tremendously enlightening as researchers shared meaning over scientific research articles and negotiated new meanings which helped focus the studies.

Restructuring of concept maps led to a single summary concept map related to the marine environment (see Figure 1.). Concepts and relationships from individual maps (most were constructed in hierarchical relationships from most inclusive at the top to more specific at the bottom) were combined, reduced and restructured in a radially symmetrical format. Hierarchy of concepts was transformed with the most inclusive concepts centrally located and more specific concepts radiating out from the center. This transformation is necessary because the top down hierarchy of concept maps as described by Novak & Gowin (1984) typically does not give evidence of the centrality of the concept which is the basis of the map. This centrality is better communicated when the most inclusive concept is located in the middle of the map. This also provides a better opportunity for the concept mapper to balance different areas of the map in relation to each other. Since there were multiple concept maps this transformation allows the combination of concept maps to focus on the higher order concepts which then become the concept links for individual maps.

The areas of geology, physical and chemical, ecological and natural resources are the major organizing superordinate concepts found in Figure 1. Each of these areas has a number of subordinate related concepts. Overall the concept map in Figure 1. gives a two dimensional representation of a number of critical concepts related to the marine environment. There are unlimited number of smaller related concepts that could be included. Due to the constraints imposed by the two dimensional nature of concept maps and the size limitations of these pages there are a number of subconcepts and relationships between different areas of the map that can simply not be expressed. The purpose of this map was to organize the major concepts that were considered essential to understanding ecological crises.

-insert Figure 1 Concept Map-

The research teams then constructed content principles from the concept maps. The maps were broken up into relevant knowledge chunks and listed as complete sentences within content principles. The principles served as the basis for the design of the interviews and the analysis of student responses. The content principles represent clusters of concepts related to a particular content area.

-insert Table 1 Content Principles-

Student Knowledge Related to Geography and Geology

In comparing the Maine and Oregon students we found, in both cases, students throughout the samples understood where their state was located in relation to the ocean, neighboring states and Canada. For example a student in Maine would typically respond to the interviewer, "Maine is located on the Atlantic Ocean, New Hampshire is on the south and Canada on the north". Oregon students responded similarly. Missing from Maine student understanding was specific knowledge about the Gulf of Maine. In both samples, students had no knowledge of political boundaries in the ocean.

There was a significant difference between Oregon and Maine students understanding of geological structures and processes. Maine students had no understanding of submerged ocean floor structures off their coast. In particular they were missing concepts related to offshore banks, shoals and canyons that were created by glacial activity, erosion and the fluctuating level of both ocean and continents. Oregon students on the other hand had very good knowledge related to geologic activity and land and ocean formations. Eleventh graders had the most complete understanding,

> "Geological formations on the Oregon coast such as slope, mountains, bottom sediments, bays, beaches and rocky shores are the result of geologic processes such as subduction, erosion and vulcanism".

Student Knowledge Related to Physical and Chemical Characteristics of Water

In both samples students throughout the grades understood that ocean water is salty, has a low temperature and moves by wind and waves. This indicates rather limited understanding in both samples. They were missing knowledge of how salinity and temperature may differ in seasonally and in different parts of the marine environment. The concept of nutrients was missing in both samples. Nutrients and mixing of nutrients in the ocean are the basis for understanding resources associated with the marine environment.

Student Knowledge Related to Marine Ecology

All children in both samples understood that plants are eaten small animals and these are in turn eaten by larger animals. This represents basic understanding of the food chain that we would expect fourth graders to understand. There was little differentiation of these ideas throughout the grades.

Although the majority of the 11th graders knew or recalled that green plants make their own food in the presence of light, only about one third could identify the nature of this food. There was considerable confusion over the role of oxygen and carbon dioxide; many students were confusing photosynthesis with respiration. In addition, less than 10% of the 11th graders recognized the functional role of water in photosynthesis. When asked why plants need water, the typical response was "to prevent them from drying out (wilting)". Some suggested that water, or the "stuff" in the water, was a plant's primary source of food. Additional probing revealed that the vast majority of the 11th graders had no conception of how water and carbon dioxide would be combined to form a simple sugar. Finally, many students were perplexed when asked to explain the function of plant fertilizers. The majority of students who knew that plants produce their own food believe fertilizers to be an additional source of food for plants. Others, when reminded of plant fertilizers, concluded they were a plants sole food source. More than 90% of the students in our study were incapable of properly differentiating between nutrient and food.

In terms of ecological relationships few students had an understanding of food webs and the interdependent nature of marine life. Aside from one type of animal eating another, students could not explain that organisms have a number of multiple relationships. For example, a typical student response to the question, "What happens if we take all these animals out of the ocean?" would be, "All the animal above it in the food chain would die". This indicates little or no understanding that when organisms are absent for whatever reason other animals can and will take their place. Although students understand that animals and plants occur in specific places they do not seem to realize the "big picture".

Student Knowledge of Natural Resources

Student understanding of marine natural resources was similar in that it included some knowledge of basic types of resources and the fact that they could be managed in some way. A typical eleventh grade response to "What are Oregon's ocean resources" would include:

> "Oregon's ocean resources are mostly living, like fish. They are utilized for economic gain. Commercial interests include fishing for a variety of fish like salmon and shellfish, like crab, using a variety of methods, like nets and poles. There are lots of recreational opportunities, too. Oregon's ocean resources can be preserved and protected. They are controlled by government management."

Aside from this basic understanding students did not know how decisions concerning natural resources might be made and how they could be implemented.

There was a significant difference between Maine and Oregon students' conceptions of threats to marine resources. Students in Oregon were keenly aware that oil transportation by ocean tankers is a significant threat to their coastal environment, whereas students in Maine were basically unconcerned by oil tanker traffic offshore.

Student Misconceptions

Common misconceptions held by both groups of students were:

-No one owns the ocean and there are no political boundaries. The oceans are a limitless resource. Anyone can go anywhere and do anything.
-The ocean is shaped like a bowl and the bottom is sandy rock.
-Some plants like seaweeds at the bottom of the ocean do not need sunlight to live. They must grow in soil to get nutrients.
-Coral reefs exist throughout the oceans.

Discussion

Students in the states of Maine and Oregon share similar understandings of their respective marine environments. Their understanding tends to be superficial as evidenced by most students' inability to explain interrelationships between concepts or reason concerning possible changes in marine ecology.

Several general conclusions concerning student knowledge of marine science and natural resources emerged from the comparison of these two studies: (1) students learned a few basic marine science and resource concepts in the elementary grades, relevant to current marine natural resource issues, (2) there was relatively little further assimilation of new concepts or differentiation of existing concepts as students progressed through the grades and (3) overall, the level of understanding of basic concepts and principles related to marine ecosystem dynamics, resource utilization, management and decision-making processes was low. It seems that students in both Maine and Oregon may not understand or appreciate the significant role of the marine environment in their state's socio-economic past, present and future.

Differences in student understanding between Maine and Oregon can be classified as geo-cultural. This refers to the fact that Oregon students have much richer understanding of geological concepts related to the marine environment. Concepts related to subduction, volcanoes and the formation of various landforms are well developed in their understanding. This reflects student awareness based on recent events such as the eruption of Mount Saint Helens. The inclusion of these concepts in school science curriculum is also a possibility based on teachers' appreciation of these concepts. Maine students on the other hand had little knowledge of geologic events which formed the northeastern portion of the US. Of course most of the events occurred ten thousand years ago and are thus less evident than more recent geologic history.

Culturally students in Oregon have been exposed to oil spills in nearby regions of the world. Oil Exploration and transportation is an everyday part of their culture and thus they are more aware of the ecological consequences of related disasters.

The concept of geo-cultural differences is one that should be considered by science educators and curriculum developers. Even within similar cultural settings like those in Maine and Oregon, slight differences should have an effect on what and how we teach students.

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Table 1.
Major Content Principles Related to the Marine Environment

Geological
1. Oregon and Maine are located in specific geographic locations in relation to the world's oceans. Oregon and Maine share national and state maritime boundaries with their neighbors. Within their coastal waters regional and local authority exists.
2. Geological formations on the coast such as ocean continental slope & shelf, bottom sediments, coastal bays & estuaries, beaches and rocky shores are the result of geologic processes such as subduction, erosion,vulcanism and glaciation.

Physical & Chemical
3. The waters off the coast are characterized by salinity, temperatures and available nutrients. These may change due to atmospheric and seasonal variations.
4. The movement of water off the coast is critical to marine produc ivity. Water movement is primarily due to wind, tides and currents. These often result in upwelling and abundant available nutrients. However variations in climate and weather can affect these characteristics.

Ecology
5. Marine ecology is characterized by physical parameters which influence biological characteristics. Energy supplied by the sun is utilized by plants, such as microscopic plankton and macroscopic algae, together with water and nutrients to provide food for animals. Together plants and animals contribute to diversity and complex food webs and chains.
6. Particular plants and animals are found in specific habitats. These habitats support communities of living organisms. These may include, sandy and rocky intertidal areas, estuaries, bays and open ocean.

Natural Resources.
7. Marine resources are both living and non-living as well as renewable and non-renewable. Non-living resources include oil, gas and minerals. Living resources include birds, mammals and fish.
8. Marine resources are utilized by private.enterprises for economic gain. Commercial interests include fishing for a variety of marine fish and shellfish using a variety of methods. Recreational interests includes fishing, surfing, SCUBA, boating, sailing and aesthetics.
9. Marine resources can be conserved through preservation of natural areas and designated protected habitats.
10. Marine resources are controlled through resource management based on public decision making and legal processes.

Figure 1. Marine Science and Natural Resource Concept Map