

**Promoting Sense of Place and Culture in Science:  
A Study of the Effectiveness of a Cross-Cultural, Marine Science  
Curriculum Through Experiential Exploration**

**By**

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**B.Sc., University of Victoria, 1999**

**B.Ed., University of Victoria, 2001**

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Requirements for the Degree of**

**MASTER OF ARTS**

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**University of Victoria**

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(Department of Curriculum and Instruction, University of Victoria)

Dr. Rick Kool, Co-Supervisor  
(School of Environment and Sustainability, Royal Roads University)

Dr. Lorna Williams, Departmental Member  
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## **Abstract**

This thesis presents the development, implementation and evaluation of a cross-cultural, experiential marine program that occurred in 2007 at a Senior High School in Sooke, British Columbia. The program consisted of a field-intensive, marine curriculum that acknowledged the contributions of Aboriginal science (Traditional Ecological Knowledge and Wisdom) as complementary to Western science, when understanding and monitoring the coastal environment. Students of both Aboriginal (N= 8) and non-Aboriginal (N= 11) heritage were surveyed before and after instruction of their knowledge and beliefs about marine science and Aboriginal culture. Prior to instruction, students tended to have positive opinions about Aboriginal culture and marine science, although their knowledge in marine ecology and oceanography was not strong. However, students showed a good understanding of human impacts on the environment. An important finding was that after instruction all students, regardless of cultural heritage, gender or previous coursework, gained positively in all measures from the experience.

## Table of Contents

<b>Supervisory Committee.....</b>	<b>ii</b>
<b>Abstract .....</b>	<b>iii</b>
<b>Table of Contents.....</b>	<b>iv</b>
<b>Acknowledgements .....</b>	<b>viii</b>
<b>Chapter 1: An Overview of the Study .....</b>	<b>1</b>
<i>Culture, Science and the Sea .....</i>	<i>1</i>
<i>Rationale .....</i>	<i>4</i>
<i>Purpose .....</i>	<i>12</i>
<i>Research Questions .....</i>	<i>14</i>
<i>Study Site &amp; Participants .....</i>	<i>16</i>
<i>Limitations .....</i>	<i>18</i>
<i>Significance of Study .....</i>	<i>20</i>
<b>Chapter 2: Review of Related Literature.....</b>	<b>23</b>
<i>Place-Based Education: An Umbrella Concept.....</i>	<i>23</i>
<i>Sense of place education.....</i>	<i>26</i>
<i>Environmental Education .....</i>	<i>31</i>
<i>Experiential Education .....</i>	<i>34</i>
<i>The Cross-Cultural Science Classroom .....</i>	<i>40</i>
<i>Constructivism in Curriculum Development.....</i>	<i>50</i>
<i>Summary.....</i>	<i>53</i>
<b>Chapter 3: Methodology .....</b>	<b>55</b>
<i>Purpose of the Study .....</i>	<i>56</i>
<i>Design of the Study .....</i>	<i>56</i>
<i>Phase 1: Pre- instructional survey- Establishing existing beliefs &amp; conceptions.....</i>	<i>57</i>
<i>The Case Study and Survey Method.....</i>	<i>60</i>
<i>Location and Setting of the Study Site .....</i>	<i>62</i>
<i>Data Sources- The Research Surveys .....</i>	<i>66</i>
<i>Procedures for Data Collection .....</i>	<i>76</i>
<i>Procedures for Data Analysis .....</i>	<i>78</i>
<i>Ensuring Validity and Reliability of the Survey Instruments .....</i>	<i>81</i>
<i>Time Line.....</i>	<i>83</i>
<i>Limitations of the Methodology .....</i>	<i>84</i>
<b>Chapter 4: Pre-Instructional Findings .....</b>	<b>87</b>
<i>Student Background .....</i>	<i>88</i>
<i>Survey Trends.....</i>	<i>88</i>
<i>The Students' Interests and Experience in Science and Environmental Education .....</i>	<i>96</i>
<i>Coastal Resources .....</i>	<i>98</i>
<i>Human Impacts .....</i>	<i>100</i>
<i>Oceanography.....</i>	<i>102</i>
<i>Marine Ecology.....</i>	<i>104</i>
<i>Sub-Culture of Science, Modern and Traditional .....</i>	<i>106</i>
<i>Locus of Control and the Environment .....</i>	<i>108</i>
<i>Relational Comparisons .....</i>	<i>110</i>
<i>Pre-Instructional Summary .....</i>	<i>111</i>
<b>Chapter 5: Applying a Cross-Cultural, Experiential Marine Science Curriculum .....</b>	<b>114</b>
<i>Introduction .....</i>	<i>114</i>
<i>Incorporating Pre-Instructional Knowledge and Opinions into Program Design .....</i>	<i>114</i>
<i>Classroom Learning Strategies .....</i>	<i>116</i>
<i>Field Explorations.....</i>	<i>124</i>
<i>Student Learning Assessment within the Curriculum .....</i>	<i>128</i>
<i>Summary.....</i>	<i>130</i>
<b>Chapter 6: Post-Instructional Findings.....</b>	<b>131</b>
<i>Student Background .....</i>	<i>132</i>
<i>Survey Trends.....</i>	<i>133</i>

<i>Student Interests and Experience in the Program</i> .....	149
<i>Coastal Resources</i> .....	151
<i>Human Impacts</i> .....	153
<i>Oceanography</i> .....	155
<i>Marine Ecology</i> .....	156
<i>Culture of Science, Modern and Traditional</i> .....	161
<i>Locus of Control and the Environment</i> .....	166
<i>Relational Differences</i> .....	168
<i>Post-Instructional Summary</i> .....	169
<b>Chapter 7: Implications &amp; Recommendations for Further Research</b> .....	<b>173</b>
<i>Summary of the Study</i> .....	173
<i>Implications for Program Development</i> .....	179
<i>Implications for Environmental Education</i> .....	181
<i>Implications for Cross-Cultural Science Education</i> .....	184
<i>Implications for Aboriginal Communities</i> .....	186
<i>Limitations of the Study</i> .....	187
<i>Recommendations for Future Research</i> .....	188
<b>References</b> .....	<b>192</b>
<b>Appendix A- Student Background Information</b> .....	<b>202</b>
<b>Appendix B- Pre-Instructional “Coastal Opinions Survey”</b> .....	<b>203</b>
<b>Appendix C- Post-Instructional “Coastal Opinions Survey”</b> .....	<b>206</b>
<b>Appendix D- “Coastal Knowledge Survey A”</b> .....	<b>209</b>
<b>Appendix E- “Coastal Knowledge Survey B”</b> .....	<b>215</b>
<b>Appendix F- “Coastal Open-Ended Questions”</b> .....	<b>221</b>
<b>Appendix G- Sample Lesson Plan: What is Traditional Science?</b> .....	<b>226</b>
<b>Appendix H- Sample Lesson Plan: Traditional Stories</b> .....	<b>236</b>
<b>Appendix I- Sample Lesson Plan: Rhythm of the Tides</b> .....	<b>242</b>
<b>Appendix J- Food Web Activity</b> .....	<b>248</b>
<b>Appendix K- Water Sampling Data Sheets</b> .....	<b>249</b>
<b>Appendix L- Whiffin Spit Ecology Project</b> .....	<b>255</b>

## List of Tables

Table 1. Internal consistency of applied surveys in this study .....	82
Table 2. Statistical analysis using one-tailed paired t-tests of average opinion scores of students between the pre- and post-instructional “Coastal Opinion” surveys (N= 14). Included is the mean difference in scores .....	136
Table 3. Statistical comparison through one-tailed paired t-tests of percentage mean student scores between the pre- instructional “Coastal Knowledge Survey ‘A’” and post- instructional knowledge survey ‘B’ (N= 12) and both pre & post instructional knowledge survey ‘A’ (N= 14) .....	140
Table 4. Statistical comparison of percentage student scores of the “Seashore Sketch” question item through one-tailed paired t-tests (N=10) .....	144
Table 5. Paired one-tailed t-test comparison of percentage mean for pre- and post- instructional students in scored categories for the open-ended “Applied Knowledge” question (N= 7) .....	145
Table 6. Independent one-tailed t-test of mean percentages for pre- (N=8) and post- instructional (N=13) scores in categories for the open-ended “Applied Knowledge” question .....	146

## List of Figures

Figure 1. Location of study site and important locations around Sooke used in the curriculum for field explorations. ....	62
Figure 2. Average opinion scores of students found from the pre-instructional “Coastal Opinions Survey”. ....	89
Figure 3. Student scores for the pre-instructional “Coastal Knowledge Survey A” .....	91
Figure 4. Summary of student scores in the pre-instructional “Seashore Sketch” .....	92
Figure 5. An example of a basic seashore sketch, where the student (Moss) does not include species specific names, detail of habitat, or large diversity of organisms .....	93
Figure 6. An example of a more skilled sketch (Oak).....	93
Figure 7. Summary of student scores in the pre-instructional “Applied Knowledge” question .....	94
Figure 8. An example of the seashore sketch, where organisms are labeled by general group names, instead of specific species .....	105
Figure 9. Example of Gloria Snively’s “Pacific Coast Information Cards” (1999). ....	120
Figure 10. Food webs built by students using Gloria Snively’s “Pacific Coast Information Cards”.....	121
Figure 11. A “traditional” halibut fishing line and bentwood hook made from bull kelp (line), cedar bark (twine) and Douglas fir (hook) made by D. Ashurst. ....	123
Figure 12. Petroglyph of seal or sea lion at East Sook park.....	125
Figure 13. A home-made Secchi disk used to visually record water turbidity in the water column.....	127
Figure 14. Two home made quadrats- 1 x 1 m, and 0.5 x 0.5m (left). Students using a 1x1m quadrat to explore intertidal life on Wiffin Spit near Sooke (right). ....	128
Figure 15. Students enjoying field explorations. A student enjoying kelp identification in East Sooke Park (Laminaria sp.) (left). Students exploring intertidal life from zodiac (right). ....	130
Figure 16. Average scores from students who completed both the pre-instructional and post-instructional “Coastal Opinion” surveys .....	135
Figure 17. Average topic scores and variances of responses on the pre- (N=17) and post-instructional “Coastal Opinions” surveys.....	136
Figure 18. Individual scores of students who took the “Coastal Knowledge Survey” prior to and after instruction.....	138
Figure 19. Student scores for the “Coastal Knowledge Survey”.....	139
Figure 20. An example of a pre-instructional seashore sketch (Salal), showing some diversity, using general group names, such as crabs, and lacking in habitat recognition, such as tidal zones .....	142
Figure 21. An example of a post-instructional seashore sketch (Salal) showing diversity of species, zonation, habitat recognition, and species specific naming .....	142
Figure 22. Mean student scores of the “Seashore Sketch” open- ended question item.....	143
Figure 23. Student scores of the open-ended “Applied Knowledge” question item. ....	145
Figure 24. Post-instructional seashore sketch showing improved naming, diversity, and habitat recognition (Dogwood) .....	158
Figure 25. Post-instructional seashore sketch showing improved recognition of seaweeds in naming and diversity .....	159

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## Chapter 1: An Overview of the Study

### *Culture, Science and the Sea*

Looking upon Earth from space, it quickly becomes apparent that a better name for this planet would be “Water.” Our “Blue Planet” travels a unique path in the solar system where the temperature gradient of Earth allows water to occur in all three states: solid, liquid and vapour. This combination of states of water is key to produce life as we know it. However, with over 90% of the world’s freshwater locked up in the poles, as ice, and as much as 85% in Antarctica alone (Shirihai, 2002), it is the blue oceans that are most noticeable from space. These oceans and seas cover over 70% of the planet, and it is from this saline solution that life evolved. To this day, the oceans contain the majority of the species that are found on the planet.

Throughout history, humans have had a close connection with the oceans. Food, transportation and the mediated effects of weather are all important aspects of living near the ocean. As a result, the majority of human civilizations have evolved along the coastlines, which are still the most populated part of the planet. British Columbia is no exception, with over 27,000 km of convoluted coastlines that have nurtured Aboriginal communities and cultures for the past 10,000- 14,000 years (Pojar & MacKinnon, 1994). Along the Northwest coast of North America, these multiple Aboriginal groups flourished, managing and harvesting nature’s resources for food, medicine and tools.

The coast of British Columbia is a vast and biologically diverse area. The cold waters off of the BC coast are rich in oxygen and nutrients to provide highly productive environments for the growth of phytoplankton, which is the hub of the oceanic food web. This highly productive marine environment has not gone unnoticed. “The intertidal zone

of the Pacific coast of North America supports an extraordinarily rich assortment of plants and animals...Probably in no other natural setting can so many different kinds of organisms be observed so readily” (Ricketts, Calvin, Hedgpeth, & Phillips, 1985, p. 1). Even Jacques Cousteau has been impressed with the BC marine environment and described the SCUBA diving along the coast as second only to the Red Sea, in terms of beauty and species diversity (Scuba Diving- Vancouver Island & the Gulf Islands, BC, 2009).

The rich and diverse coastal environment around Vancouver Island has provided prosperous resource extraction opportunities, such as intertidal harvesting, agriculture, timber and fishing. These resources have been widely studied, utilized and managed successfully throughout the past.

Although early European explorers described the northwest coast as untouched wilderness, in fact, the aboriginal peoples did have an impact on the landscape through selective harvesting of trees and controlled burning. Coastal people burned selected woods and meadowlands to maintain open conditions and promote the growth of desired plants including berries, nuts, root vegetables and forage plants for deer and other game. (Pojar & MacKinnon, 1994, p. 21)

This resource management extended to the sea and included harvesting within the intertidal zones and managing and maintaining rivers for salmon and eulachon runs. This successful management had continued until, in my opinion, Western exploitative civilization populated the coast.

I have been an educator on Vancouver Island for many years. Over the years, I have practiced as a public educator in marine, aquatic and terrestrial life for various local groups, including Sierra Club, Swan Lake Nature Sanctuary, BC Marine Awareness Society and Seachange. I have guided SCUBA diving charters on southern Vancouver Island, fishing charters along the coast from Victoria to Haida Gwaii, and whale watching

tours from Victoria. Furthermore, I have been fortunate enough to guide in Antarctica as a marine mammal and bird specialist for multiple years. My degree in Biology and Environmental Studies was achieved through the University of Victoria, after which I earned my teaching degree through the same university. Since 2001, I have been employed as a professional science and math teacher in central and southern Vancouver Island.

Throughout my post secondary education and in my professional career, I have been exposed to the Aboriginal cultures along the coast in a way to which I had never been exposed in high school. My keen interest in, and respect for, Aboriginal culture stems from their inherent ecological understandings and teachings woven into the culture. I am fascinated with the wealth of ethnobotanical knowledge and historical technological skills of the culture. I enjoy promoting this knowledge to encourage respect for Aboriginal culture and to exemplify how humans can survive without modern luxuries, such as grocery, hardware and drug stores.

I have felt that there is a need in schools for a curriculum that can bring students closer to their immediate environment. This need includes connecting students to their communities and the cultures found within those communities. I believe that the development of a cross-cultural science curriculum for both Aboriginal and non-Aboriginal students wherein they could learn about, and work together in, local ecosystems, has the potential to avert racism and encourage mutual respect between cultures. In addition, through acknowledging science as a cultural concept, where the contributions of Aboriginal traditional knowledge in the field of science are

acknowledged, could encourage participation of Aboriginal students in the academic field of science, where they are traditionally under-represented.

### ***Rationale***

As a public school senior science teacher, I have found that the curriculum in many schools has not encouraged the students to understand and appreciate the unique environment in which they live. Standardized high school science curriculum has not specifically engaged the students within their own environment and community. The use of generalized curricula has removed the incentive for educators to teach material that incorporates knowledge of one's particular locality and indigenous cultures. The previous concepts were important for why I chose to develop and examine the effectiveness of a program which engaged students in the marine environment within their community, and incorporated local Aboriginal culture in the context of cross-cultural, field-based scientific experiential education.

***Connecting education to home.*** In my experience, the high school curriculum has tended to present standardized science material taught using similar teaching methodologies regardless of the school's location in the province. The use of this standardized material has been further exacerbated by the Ministry of Education's implementation of Provincial exams in many high school courses. In order to meet the expectations of the Ministry's Prescribed Learning Outcomes, most educators have relied heavily upon provincially standardized textbooks. This prevalent use of textbooks has the potential to separate students from their immediate environment as "textbooks place

value on general, national, abstract examples and facts, through content and the nature of the printed medium” (Sanger, 1997, p. 4).

Although standardized curricula may help students gain the basic theories of the sciences from a western science viewpoint, they often have not encouraged building relationships between students and their immediate environment. Whether a class is located in a large, metropolitan area such as urban Toronto, or any of the small sized, coastal, rural towns of British Columbia, the teaching content and methodologies in high school science have tended to be incredibly similar. The environment of Toronto, with its large city center, expansive urban and sub-urban population, and large industrial/commercial areas is a very different cultural and ecological environment from that of coastal towns like Sooke, Duncan, Campbell River, Bella Bella and Port Simpson. Such towns have a close proximity to wilderness, such as the seashore or riparian forests, in addition to a tangible Aboriginal culture. Because of these differences, I felt that in teaching standardized education curriculum, students have failed to connect closely to their own unique environment, community and local Aboriginal culture.

***The cross-cultural classroom.*** In our increasingly multicultural communities I have felt that it is important to reflect this cultural diversity in the classroom. The British Columbia Ministry of Education has recognized the need for multicultural education in all areas, including science, as noted in the Integrated Resource Packages (IRP), such as Science K-7, and Science 8-10 (Ministry of Education, Province of British Columbia, 1995b; Ministry of Education, Province of British Columbia, 1996).

Unfortunately, in my experience, most science classrooms and curricula have lacked perceptions and contributions from any culture besides the dominant Western culture. Aikenhead (1997) recognized “science” as a subculture of Western culture and that teaching is a form of cultural transmission. Therefore, in educating students in Western Modern Science (WMS), teachers have been indoctrinating all students into Western culture, regardless of their cultural backgrounds. In teaching WMS, educators have been consciously or unconsciously marginalizing the validity of other cultures’ contributions to the field of science. Regardless of individual students’ cultural backgrounds, Snively and Corsiglia (1997) have noted “Acknowledging the contributions of multicultural science ... is a necessary step in enabling students to recognize and learn from groups outside the dominant culture” (p. 743). Thus, teaching science from a cross-cultural perspective can be more inclusive to students from various cultures and helps to promote intercultural understanding.

As part of the program I intended to focus on cross-cultural education, as opposed to multicultural education. Multicultural education, as described by the Ministry of Education (IRP’s) incorporates Aboriginal education as an addition to, or grouped with, multicultural education (Ministry of Education, Province of British Columbia, 1995b; Ministry of Education, Province of British Columbia, 1996; Ministry of Education, Province of British Columbia, 2006b). However, as Aikenhead and Jegede (1999) noted, school science is its own culture and may not be the home culture of many students; therefore, cross-cultural education encourages students to acknowledge this difference and make the appropriate personal cultural crossings as they are comfortable. This approach encourages students to not be assimilated, but to maintain their own culture and

extract what they feel is relevant to their lives. It is part of the educator's focus to facilitate these "border-crossings" in an appropriate manner. However, due to the nature of upper level science courses, it is important that students are able to understand western science concepts for exam purposes, as part of their school culture, though they may not necessarily accept it comfortably in their own personal worldview.

In addition to the Western Modern Science perspective, I included a significant part of the program curriculum to the concept of Traditional Ecological Knowledge and Wisdom (TEKW). TEKW of various coastal Aboriginal groups was utilized in the program to present local and alternative cultural view of science. TEKW promotes a worldview that includes long-term resource management, ecological connections, survival skills, culture and respect that has been recognized more as an important source of verifiable scientific and ecological knowledge by the Government of Canada and around the world (Johnson, 1992). The idea of introducing students to the concept of traditional knowledge of the Aboriginal people of British Columbia complemented many cross-curricular aspects encouraged by the Ministry of Education, in addition to supporting Aboriginal students. First Nations studies, multiculturalism, anti-racism and environmental education are all areas of cross-curricular education in the sciences as recommended by the Ministry of Education IRP's (Ministry of Education, Province of British Columbia, 1995b; Ministry of Education, Province of British Columbia, 1996).

Including TEKW in a traditionally Western modern science dominated classroom has cross-cultural learning benefits for both Aboriginal and non-Aboriginal students. TEKW has the benefits of presenting all students with hands-on, tangible views of science that are applicable without the strict analytical and scientific methodology driven

aspects WMS (Johnson, 1992). Applying this aspect of science can help students whose prior conceptions do not fall into the realm of the sub-culture of Western science. These students need not only be Aboriginal students, whose cultural and community views of science may differ from WMS, but may help students of any culture whose perspective may vary from a male, Western science dominated background, and whose prior conceptions may be at conflict with traditional classroom WMS (Snively & Corsiglia, 2001). Therefore, this cross-cultural science education could access alternative cognitive routes for student acceptance of the scientific concepts into their personal beliefs. In this context, both bodies of knowledge and science could be presented in terms for not only comparison and contrast, but for co-existence, reinforcement and inclusion into students' overall worldviews, without forcing students to either build a separate Western scientific worldview, or replace existing aspects of their worldview (Aikenhead, 2001).

Additionally, through this two-way sharing and application of Aboriginal and WMS scientific views, Aboriginal and non-Aboriginal students could experience and validate other cultural perspectives of scientific understanding. The cross-cultural approach is important in recognizing that Western science is just one form of the many sciences in our world and that "every culture has its own science" (Elkana, 1981, as cited in Snively & Corsiglia, 2001, p. 10).

***Marine and riparian education.*** A program of applied science in the local marine and riparian environment can encourage environmental literacy and connect students' education to their immediate environment, thereby establishing a stronger sense of place. In the sense of exploring the ecology and resources of the coast of BC, the

classroom science becomes immediately tangible and connects to the students' real world. The incredible marine and coastal diversity of British Columbia's flora, fauna and ecosystems presents a treasure trove for students to explore.

Encouraging students to explore the marine environment does not pose a problem, as Snively and Sheppy (1991) found that students across Canada are eager to learn about the oceans and marine environments, even if access to this environment is restricted. Unfortunately, Snively and Sheppy (1991) also found that students have limited knowledge of science as it is applied to the ocean. This lack of understanding how science can be used in the real world may impede students' abilities to continue learning in the field of science, or discourage them from pursuing science in later grades. These aspects alone should make studying the marine and coastal ecosystems a priority in schools that have access to these environments. However, when examining the Ministry of Education K-7 (1995) and 8-10 (1996) science curriculum, local marine science resources were rare, which is surprising, considering how important the ocean and coast is to the culture and economy of British Columbia.

***Encouraging Aboriginal student participation.*** Disregarding the local Aboriginal cultures has the potential to alienate Aboriginal students from the educational institution; however, the incorporation of Aboriginal culture into a locally based science curriculum has the ability to draw in students conventionally lost to the standard curriculum. Statistics show that the numbers of Aboriginal students, as with many minority groups, who continue with math or science through secondary education has traditionally been very low (Snively, 1995). In British Columbia, the completion rates of

Aboriginal students who earn a Dogwood certificate within 6 years of entering the eighth grade increased by 9% between 1999-2003, to a total of 46%, whereas the non-Aboriginal completion rate increased by 5% to 82% in the same time span (Ministry of Education, Province of British Columbia, 2004a; Ministry of Education, Province of British Columbia, 2004b). Although there was a large discrepancy between these total values, the completion rate of Aboriginal students had increased almost twice that of non-Aboriginal students in the last 5 years which reflected the increased effort by school districts to improve Aboriginal graduation.

Further examination of the data collected by the BC Ministry of Education revealed some interesting trends. Among student cohorts who began the eighth grade and completed their Dogwood certificate, the most significant years of student drop out were grades 11 and 12. This suggested that efforts need to be put into encouraging both Aboriginal and non-Aboriginal success in grades 8-10, before students become disenfranchised or distracted enough to drop out. Although Aboriginal drop out from eighth grade was improving, down to 13% in 2002 from 18.7 % in 1997, it was still unacceptable, at three times the drop out rate of non-Aboriginal students. The largest discrepancy of student drop out was between Aboriginal males (63%) and non-Aboriginal females (16%). From this data, it was obvious that more effort and attention needs to be paid to Aboriginal males to encourage high school completion.

One method to increase the overall Aboriginal completion rate in high school is to encourage Aboriginal participation in upper level science courses. Participation of Aboriginal students in upper level science and math classes has been traditionally low, especially in classes that are required for acceptance in post-secondary college or

university academic areas (Snively & Williams, 2006). However, when Aboriginal students do participate in these upper level math and science courses, they tend to not only pass, but achieve high test results (Ministry of Education, Province of British Columbia, 2006a; Snively & Williams, 2006). Therefore, it is important to encourage Aboriginal student participation, which tends to lead to success in upper level sciences and math.

Increasing Aboriginal participation and success in senior high school level sciences is important to communities and the individual students. As mentioned, at least one upper level science course of grade 11 or equivalent is required for minimal graduation with a Dogwood Certificate. Through encouraging Aboriginal students to continue in science, these students can earn the credits and skills to gain entry into the post-secondary field of science. If science educators can nurture Aboriginal students to pursue science as a career, the coastal communities from where these students come may be able to support their own scientists to manage territorial resources. Currently, the majority of professional scientists, such as geologists and biologists, used by coastal Aboriginal communities are non-Aboriginal, and thus has limited understanding as to the communities' beliefs and requirements. Professional, local Aboriginal scientists would be a huge asset to these communities in establishing long-term, sustainable resource goals.

Incorporating Aboriginal culture and environmental knowledge into the curriculum as a complementing science may encourage Aboriginal student participation rates. A method in which educators can increase Aboriginal participation may be through the exploration of Traditional Ecological Knowledge and Wisdom (TEKW). Kawagley

and Barnhardt (1999) note that promoting a sense of place is of key importance to successful Aboriginal education. Therefore, fostering this sense of place may also encourage Aboriginal students to pursue science as a field of study. In addition, students actively working outdoors, within the natural environment, may interest and engage Aboriginal students through hands-on, practical skills not experienced in typical classroom work.

The 2003 Annual Report on Aboriginal success rates in BC (Ministry of Education, Province of British Columbia, 2003) recommended that schools need to ensure that Aboriginal students feel supported by their peers, teachers, the school, family and community, in addition to ensuring culture, history and language are part of the educational experience for *all* students. Therefore, the cultural aspects of working in the field and incorporating TEKW have the ability to aid both Aboriginal and non-Aboriginal students through cultural exposure and understanding to create a stronger community.

### ***Purpose***

The main purpose of this project was to develop and evaluate an effective, senior level, locally based, cross-cultural marine science program. In this project, local marine science was explored through two cultural perspectives: Aboriginal and Western Modern Science (WMS). The Aboriginal perspective involved an introduction to concepts and examples of Traditional Ecological Knowledge and Wisdom of the Aboriginal people of the coast of BC, which was paired with senior high school level Western scientific knowledge and modern scientific field techniques. Utilizing both of these perspectives, it was intended that students would recognize Western Modern Science and Traditional

Ecological Knowledge and Wisdom together as complementary and effective ways of understanding and studying our local marine environment.

In achieving the purpose of developing a successful cross-cultural, marine science program, it was considered necessary to be able to analyze the effectiveness of the program. Therefore, an additional purpose of this program was to develop assessment surveys and questionnaires. These instruments were used to establish the knowledge and opinions of students about their local marine environment and Aboriginal culture prior to and after instruction. The knowledge and opinions of students prior to instruction were taken into account during the curriculum development phase, and compared to the post-instructional response in order to determine the effectiveness of instruction. The effectiveness of the program was measured through comparison of student knowledge and opinions in marine ecology and traditional knowledge and culture prior to and after implementation of the program. In addition, the effectiveness of the program was examined through changes in student opinions in selected topics, including comparing this program to their previous experiences in school science.

The analysis of the effectiveness of the program was an important aspect to making successful upper level science curriculum materials. These materials were designed to provide students with an adequate level of knowledge and experience that would be acceptable for senior science credit toward graduation and their Dogwood Diploma.

### ***Research Questions***

The big question that was the focus of this study was: “Can Western Science and Aboriginal Science (Traditional Ecological Knowledge and Wisdom) be taught together in an effective cross-cultural program in which students learn, enjoy and understand alternative views of science?” In order to answer this large question, I examined the knowledge and opinions of students through breaking the big question down into discreet questions that could be comparatively analysed between pre- and post-instructional treatment of the program. Therefore, the specific, comparative research questions examined in this study were:

1. What are students’ knowledge and beliefs about local marine ecology and oceanography concepts, such as habitat, the tidal cycle, food energy flow, human impacts, environmental monitoring and resource management?
2. To what extent are students familiar with local Aboriginal culture and the concept of Traditional Ecological Knowledge and Wisdom?
3. What are students’ opinions about their experience and recognition of the applicability of science, both traditional and Western, as part of their daily life?
4. How do students’ opinions and knowledge change after implementation of the program?

Addressing the first question aided my research in two ways. In addition to gathering baseline comparative data, I felt that an acknowledgement of the level of knowledge and prior beliefs of the students was important to identify and adjust the program to address any weaknesses in understandings about local marine environment. This approach helped me ensure students gain an understanding of scientific concepts at a

level that would be acceptable as senior science credit and understanding the strengths and weaknesses of their knowledge helped focus the instructional material during the limited duration of the program. Furthermore, as marine science is not a required area of study in the science curriculum from K-12, I could not assume that students had any standardized level of marine science concepts.

Unlike marine science, most students should have had some basic understanding of Aboriginal culture through previous courses in Social Studies 8-10 (Ministry of Education, Province of British Columbia, 2006e). However, these courses would have only presented students with very broad and superficial exploration into Aboriginal culture. Therefore, the second research question focused on describing student conceptions and understanding of local and coastal Aboriginal culture and this culture's use and management of marine resources.

Students' experiences in science and how they feel about science's applicability to their own life was important in developing this program and was addressed as the third research question. The local focus differed from "textbook science" in that students could have hands-on experience with these concepts outside of instruction, in the local environment and community. I was interested in finding out if students had found past science experiences enjoyable or relevant, both within and outside their schooling experience.

Finally, the analysis of the effectiveness of the program was based on comparing students' responses before and after the treatment of the program. It was only through answering this final question that I was able to assess whether the program resulted in favorable changes in students' knowledge and opinions of science and local culture.

### ***Study Site & Participants***

The study occurred at Edward Milne Community School (EMCS), which is located in the municipality of Sooke, in Southern Vancouver Island. The school is located in close proximity with the outdoors, being only a few hundred meters from Sooke River, which empties into the Sooke Basin. In addition, behind the school are extensive trails through the nearby coastal temperate rainforest. The school has a very open design and includes a full size grey whale skeleton in the common area, as well as incorporating many carvings and art into the design to reflect the local T'Sou-ke, Scianew and Pacheedaht First Nations influence. This local Aboriginal culture is also reflected in the student population of EMCS, where Aboriginal students may come from any of the three different Aboriginal bands within the catchment area. The resultant Aboriginal and non-Aboriginal school population consisted of approximately 700 students from grade 9-12, who come from the local community of Sooke, as well as from as far away as Port Renfrew, which is 80 km west of Sooke.

The participants of the program consisted of students of both Aboriginal and non-Aboriginal heritage at Edward Milne Community School in Sooke. These students were in either grade 11 or 12, enrolled in the fall 2007 Environmental Education 11/12 program taught by Mike Bobbitt and Megan Bondurant, ranging from 16- 19 years of age. There was a total of 19 students enrolled in the course, with eight of these students registered as Aboriginal students. In the class, ten of the students were male and nine were female, with four of the males and four of the females registered as Aboriginal.

The students and this class were selected as the focus of my case study for a number of reasons. The Sooke district appears to have a need for development of school programs that keep students in school and interested in completing their high school degree. In Sooke, the number of students achieving their Dogwood Certificate within six years of entering Grade 8 are lower than average for both Aboriginal and non-Aboriginal students. The 65% completion rate of students during 2004/05 was 14% lower than the provincial average of 79%. Vancouver Island has the largest number of Aboriginal students enrolled in high school (Ministry of Education, Province of British Columbia, 2003) and the Aboriginal student completion rate during 2004/05 year in SD #62 (Sooke) was 36%, compared to a provincial Aboriginal average of 48% (Ministry of Education, Province of British Columbia, 2005; Ministry of Education, Province of British Columbia, 2006c).

In addition, the Environmental Studies 11/12 program was already focused at having the students experience hands-on science and outdoor education. The class enjoyed regular outdoor walks and field trips, often utilized school buses that were relatively easy to access and Edward Milne is in close proximity to the seashore. These aspects ensured that this school program would be able to get into the field with minimal difficulty, and that the students were familiar with expectations of field explorations. Pikal and Lindquist (1999) describe important facets of developing a successful, multidisciplinary, experiential program as having a strong administration, non-traditional, flexible educators, not bound by textbooks, with flexible scheduling to permit time for field outings. With support from both school and district administration, in addition to Mike Bobbitt and Megan Bondurant, this class exceeded in all of these criteria.

Exploration into attempting the same program within the Victoria School District was not met with similar support and flexibility, and would have involved significantly more preparation and expenditures.

### ***Limitations***

As a science oriented, city based, non-Aboriginal educator, there were certain biases that may have affected the program design and research. However, acknowledging these biases allowed me, the teacher/researcher, to take certain proactive actions to control any negative effects these biases may have had on the implementation and analysis on the of the program.

Having spent much of my life working in, or enjoying the outdoors, I have a natural predisposition to believe that this is an ideal place for students to learn. In the research of students' stances and prior beliefs about the outdoors, I had to consider what experiences the students have had in the out-of-doors and adjust the program to accommodate students who may not be as outdoor oriented as other students. Furthermore, I acknowledged differing types of learning, where some students may be action/ kinesthetically oriented, while others may enjoy being outdoors, but prescribe to a more visual and reflective type of learning.

A bias from my personal stances in environmental education was that I would be classified a conservationist/ preservationist according to Snively and Sheppy (1991). I have gleaned this attitude from my own personal experiences at home and in my education. This stance may not be that held by many families in Sooke, where hunting, commercial fishing and timber extraction play important economical and recreational

roles. Any contradictions in personal beliefs were tempered in the fact that the focus of the school program was to understand the local marine environment, the impacts of humans on the environment, and how various sciences could be used to explore the coastal waters.

I am not Aboriginal, nor have I lived in a Aboriginal community for extended periods of time, which may have lead to biases about what I feel was beneficial for students to learn about Aboriginal culture and knowledge. In addition, much of my education in Aboriginal culture was through post-secondary institutions and based in academic generalities. However, I have lived and studied in an intensive, total immersion Environmental and First Nations graduate program in Alert Bay for six weeks and worked with the community elders, and so had a limited experience with a sample of the Aboriginal community.

An additional issue was the program's aim to expose students to the concept of TEKW in the umbrella of science. Because of my Western scientific training, my perspective for curriculum development and teaching likely reflected a bias from a Western scientific position, and not from a truly Aboriginal standpoint. The fact that part of the program involved classroom teaching, and the data collection for analysis of the program involved testing-style surveys, further removed this research and program from the essence of the traditional transmission of TEKW. However, I felt that these were necessary constructs for assessment in educating students in the current schooling system while achieving Ministry acceptable results for both Aboriginal and non- Aboriginal students in the senior sciences.

### ***Significance of Study***

The significance of this study and program was fourfold. First, recognition of students' existing worldviews about science, culture and the environment was important for developing curricula to encourage successful teaching. Second, providing students with hands-on, experiential learning presented them with real world applications of science and helped develop a bridge between school education and their immediate environment and community. Third, cross-cultural science education introduced students to a broader view of science, and encouraged recognition and appreciation for multiple cultural perspectives beyond the traditional Western dominated views prevalent in school. Finally, rigorous analysis of students' perceptions prior to, and after instruction was used to demonstrate the effectiveness of this education and validate its inclusion as part of a senior level science equivalent.

Understanding students' previous conceptions and opinions toward science is an important aspect of students' worldviews to acknowledge prior to instruction. Understanding existing alternate conceptions of the proposed curriculum helps to focus the educational aspects of the program where students' conceptions were weak or incorrect, as opposed to re-instructing previously acquired knowledge and beliefs. Additionally, as Snively has noted, instruction tends to be more effective when taught parallel to current student beliefs (Snively, 1990; Snively & Corsiglia, 2001). This is an aspect that is significant to recognize, so that the presentation of the program can effectively educate students, while working within their worldviews, without confrontationally challenging personal beliefs.

The application of science concepts in exploring the students' own natural environment can be used to increase the learning and retention of environmental and ecological concepts. This experiential education helps students transform scientific theory and research methods into applied knowledge. Through connecting learning to the immediate environment and community, students are able to experience how scientific knowledge and research are directly applicable to their lives outside of school. Furthermore, engaging students in natural environments, through utilizing science outside the classroom can, hopefully, interest and encourage these students to further their education in this field.

The culturally inclusive aspects of this science program encourages mutual respect and co-operation between Aboriginal and non-Aboriginal students. Introducing Aboriginal concepts, such as Traditional Ecological Knowledge, resource management and cultural heritage can support Aboriginal students through validating their culture in the scientific field, where it has traditionally been dismissed, in addition to exposing non-Aboriginal students to an alternative scientific worldview. This emphasizes the benefits of cross-cultural learning where students of different cultures retain their own culture, but can recognize and incorporate important aspects from other cultures without losing connection to their own heritage.

Finally, it was important that this study and program be testable to prove its effectiveness. If this program is to be used as part of a senior high school science course, which provides credit toward graduation, establishing the effectiveness and the level of scientific learning accomplished through this unit is important to defend the program as part of an effective senior science. This program contains a level of skills and

information as to be comparable to other senior science courses, such as Earth Science 11 and Biology 11. Without verification of the effectiveness of upper level science knowledge, this course would not adequately meet the Ministry of Education grade 11 science learning objectives.

## Chapter 2: Review of Related Literature

This chapter addresses the overriding concepts behind the curriculum and intended goals of the project. Firstly, I explore the importance, implications and applications of “place-based education” and the research and theoretical underpinnings that this large topic includes. Next, the theory and importance of both environmental and experiential education are examined, with a focus on implementing this education outdoors. The “cross-cultural science classroom” examines the importance of recognizing the many differing perspectives between cultures in the science classroom, noting the importance of acknowledging and utilizing Aboriginal culture and science. The final section recognizes the theory of constructivism and how acknowledging students’ prior conceptions and beliefs is critical in developing an effective cross-cultural marine science program.

### *Place-Based Education: An Umbrella Concept*

The plain fact is that the planet does not need more successful people. But it does desperately need more peacemakers, healers, restorers, storytellers, and lovers of every kind. It needs people who live well in their places. It needs people of moral courage willing to join the fight to make the world habitable and humane. And these qualities have little to do with success as our culture has defined it. (David W. Orr, 1993, p. 9)

When creating curriculum, one needs to consider the learning goals and applicability of the subject matter. There are a number of important goals in designing a locally specific curriculum. One goal is to educate students toward understanding and respecting their immediate environment, and in doing so, develop a sense of empathy for this environment. Another goal is to encourage students to become socially and environmentally conscientious members of the community, where these students will be

able to participate in the decision making processes that affect the future of their community. Students should learn skills that can be transferred into everyday life while possessing the necessary knowledge base to enable students to pursue a higher education, should they choose. In addition, students should respect and protect not only the biological diversity of their locality, but also the cultural diversity of their communities.

*On defining place-based education.* Place-based education, outdoor education, environmental education and ecological education have similar connotations; however, the definitions and applications of these terms do differ. Woodhouse and Knapp (2000) describe “outdoor education” as a broader concept than “environmental education.” Outdoor education can be used to provide meaningful experiences in the outdoor context to complement classroom learning activities, such as textbooks and electronic media. Outdoor education includes group building activities, such as camping experiences, community projects and ecological explorations. Environmental education is, as David Orr would describe, “developing citizenry prepared to live in a place without destroying it” (Woodhouse & Knapp, 2000, p. 2) and can occur in and outside of the classroom. Thus, environmental education is about learning how humans impact the environment and recognizing that we function as a part of the environment and not independent from it.

Smith and Williams (1999) promote the concept of “ecological education.” Ecological education presents the concept that humans are intrinsically entwined with natural systems and processes. This standpoint encourages people to treat the environment not as separate phenomena for humans to observe and manipulate, but

acknowledges that it is part of our everyday existence and our immersion in our ecological environment demands that we are directly connected to our environment and its health. Unlike environmental education and outdoor education, ecological education includes a cultural perspective, where culture is part of human existence and therefore part of our ecological surroundings. “The practice of ecological education requires viewing human beings as one part of the natural world and human cultures as an outgrowth of interactions between our species and particular places” (Smith & Williams, 1999, p. 3). Smith and Williams (1999) outline seven tenets of ecological education that make it a broad concept with many implications. In addition to incorporating the concept of environmental education, ecological education includes promoting outdoor experience, and, thus, includes outdoor education as previously defined. Ecological education promotes developing people’s “sense of place” through understanding local culture and human and natural communities. In addition, ecological education counters the trend toward social and economic individualism. It is this individualism, encouraged in school through over-emphasis on individual competition in sports, academic studies and the goal of personal income, that students have become distanced from social co-operation and community perspectives. Widely encompassing, ecological education is an important part of a larger, locally specific concept– “place-based education” (Woodhouse & Knapp, 2000, p. 2)

Place-based education is an educational concept that includes outdoor, environmental, and ecological education as part of a larger educational umbrella. Although the concept is relatively new, Woodhouse and Knapp (2000) note that educators have promoted the idea for over a century. In 1915, John Dewey espoused the

importance of the experiential approach to learning in the local environment in his book “The School and Society” (Dewey, 1915, as cited in Woodhouse & Knapp, 2000, p. 2). Dewey recognized that students learn best about nature, when they are immersed in the natural environment, as opposed to learning nature through textbooks in the traditional classroom environment. Woodhouse and Knapp (2000) describe place-based education as an understanding of both ecology, and community, to achieve ecological and cultural sustainability (p. 2). In order to prepare a sustainable culture and ecology of an area, Knapp (2003) defends the beliefs of David Orr in that people need to understand ecological patterns and how human activity can affect the environment over the long-term. The importance of educating students in this understanding of ecology and promoting lifestyles sensitive to human impacts is key to successful, sustainable, place-based education. Through this strategy, educators can produce what Capra (1999) terms as “ecoliterate” citizens (p. 2).

### *Sense of place education.*

Without a sense of place, students cannot fully know who they are and where they fit into the community. Many youth are growing up with little firsthand knowledge of where they live and therefore, don’t know their ecological addresses or understand how their ecological footprints relate to their consumptive lifestyles. (Knapp, 2003, p. 23)

“Sense of place” as a definition varies somewhat in literature, but can be described from as a feeling of connection with oneself and the environment, through knowledge, experience and empathy. Sanger (1997) refers to sense of place as “experientially based intimacy with the natural processes, community, and history of one’s place” (p. 4). Butz and Eyles (1997) suggest that sense of place includes “cultural

attitudes toward place or cultural representations of place” (p. 7). Therefore, sense of place consists of more than one’s feelings or connections with their environment, but includes a community’s historical and present cultural perspective of the world around them. For the Haida Nation of the Queen Charlotte Islands of British Columbia, part of their environment includes the large evergreen, Western red-cedar (*Thuja plicata*). Part of the sense of place for this nation may include more than understanding the unique role that the cedar plays in their environment, or its importance in providing jobs as commercial timber. Cedar is one of the most important trees to the Haida people and its many cultural aspects include extensive uses for traditional tools and weaving material, to help produce a wide variety of objects such as baskets, mats, clothing, fishing gear and the community bighouses. This importance is reflected in many references to red-cedar in the stories and narratives that persist in the Haida culture (Turner, 2004).

Sense of place education recognizes that, although landscape and space exist objectively, *places* and *sense of place* are subjective mental constructs involving memories through encounters, associations and mental feelings toward a spatial area, which further involve ecological understanding, and are filtered through culture and community (Butz & Eyles, 1997). Sense of place is acquired through direct contact with the elements of one’s place, sharing stories and observations about a place with fellow inhabitants and through education, “...but not the education that predominates in today’s education system” (Sanger, 1997, p. 4).

Sanger (1997) describes how the current education system tends to detach student education from environment and community through various methods. These methods include focusing students on accomplishments and autonomy as an individual where

students are encouraged to learn as a detached observer without tangible connections to environment or community. Furthermore, using texts “as an impersonal authority” (Sanger, 1997, p. 4) undermines local forms of knowledge and community connections, such as intergenerational oral traditions with elders. Gandhi describes how “text-books ... never [teach the student] any pride in his surroundings” (Prakash & Esteva, 1998, p. 7). Currently our institutional schools tend to reflect no part of the living world in a sense of biology or its ecological place and, thus, educate little about our immediate environment. Orr (1999) recognizes how institutional buildings, such as schools, fail to encourage connections between people and their environment as these buildings, are built to be “convenient, efficient, or aesthetically pleasing, but not instructional” (p. 229).

Through disregarding the importance of sense of place, the education system is not serving the needs of their students or communities. E.O. Wilson describes “biophilia” as our natural affinity for nature (Knapp, 2003, p. 24), and if we ignore this natural affinity we are passively assisting in the dissociation between students and their natural community and environment. Developing a healthy sense of place develops a strong sense of being that underpins a sense of well-being (Butz & Eyles, 1997). This is important for developing confident, concerned citizenry of a sustainable community.

Sense of place education attempts to develop within students a strong sense of both ecological belonging and community belonging. As society becomes more urbanized and further removed from the land, sense of place and sense of place education are increasing in popularity (Sanger, 1997). There is more recognition that as students are becoming enveloped in technology and urban landscapes, their connection

to the natural cycles and local ecology is being lost where, tragically, these students are growing up with little first hand knowledge about their immediate natural environment (Knapp, 2003; Sobel, 1995). The mall and our living rooms have begun to replace our natural world as the environment with which we connect and understand. Although technology and media allow us to connect more closely with the planet on a global scale, we are becoming increasingly alienated from our immediate natural environment. These associations with the urbanized environment, technology and human artifacts have led to what Cajete (1999) refers to as “biophobia”- an “urbanity of the mind” that disconnects nature from mankind and is propagated by the growth of cities (p. 190).

In order to counter this loss of connection with one’s immediate environment, it is recognized that we need to educate students about the natural cycles and ecology of their unique place. This develops what Butz and Eyles (1997) describe as “ecological sense of place” (p. 10). “Ecological senses of place are the knowledge of a places’ ecological characteristics that yield meanings which make persons identify with the place” (Butz & Eyles, 1997, p. 10). David Sobel (1995) supports this concept and suggests that if we are going to ask the future generations to save the planet, we first need them to love it, and this can be achieved by engaging them more deeply with the flora and fauna of their immediate environments, such as local woods and neighborhoods.

Creating a personal relationship with our immediate surroundings can occur during interactions with organisms and other experiences within one’s environment. These interactions and experiences help students develop what Lutts (1985) refers to as a “particularized experience” (p. 38). It is from this particularized experience that students can build empathy for nature. It may be empathy from these particularized experiences in

the local environment that can be used to encourage students to continue studying science and nature. This empathy may lead students to learn to respect and protect their unique environment. It is the promotion of this “sense of place” which would benefit countries as vast as Canada, where the subject material needs to vary with the multitudes of local, unique environments across the nation.

However, as noted, sense of place is made up of more than solely an ecological understanding of an area, but a sense of community and culture. Butz and Eyles (1997) suggest that the need for place and sense of place has increased as industrial society has drawn people into urbanized environments. Within these urban environments, we have become individualized, with selfish concerns and, thus, experienced a loss of community and place. Place-based education has an important community component and this is incorporated in fostering a sense of community within peoples’ places. It is recognized that developing a relationship between places, and therefore a sense of place, requires a strong social element wherein students can share and compare experiences to guide and confirm their own feelings of place. It is in this necessary communicative action that relates mental construct of place to social construct and community (Butz & Eyles, 1997; Sanger, 1997). Through shared experiences, student discussion within the class or the community has the ability to strengthen students’ sense of place in the community, because people who have common history and experiences in place tend to share similar orientations (Butz & Eyles, 1997). Rydeen (2003) found that altering school environment to reflect culture and heritage, can encourage a sense of community and place. Furthermore, Brown and Perkins (1992, as cited in Butz & Eyles, 1997, p. 2) note that the development of a strong sense of place and attachments to place are key in

developing self-definitions as students find that “place” provides an anchor for stability in their world.

Developing shared experiences in the outdoor environment to encourage students’ ecological understanding of place has the equal ability to encourage students’ sense of community. Encouraging this aspect of place-based education strengthens students’ internal sense of place and further strengthens community and ecological connections as a whole.

### ***Environmental Education***

Instead of teaching our children to consume, it’s time we taught them to conserve. Not just for the earth’s sake, but for themselves.  
(Suzuki, 2004, p. 3)

Environmental education is much more than education about the world around us, but an education in the interdependence of humankind and the natural environment. As previously noted, increasingly urban centres are segregating people from their ecological sense of place. Part of environmental education is to re-engage people with their environment. McClaren (1989) emphasizes our need to realize that mankind is not outside of nature, but an intrinsic part of it. Priest states that “Environmental education is concerned with two relationships: ecosystemic and ekistic. Ecosystemic relationships refer to the interdependence of living organisms in an ecological microclimate... Ekistic relationships refer to the key interactions between human society and natural resources of an environment” (as cited in Bisson, 1996, p. 44). A more human oriented and student motivated definition of the purpose of environmental education can be found in the Belgrade Charter where “The goal of environmental education is to develop a world population that is aware of, and concerned about, the environment and its associated

problems, and which has the knowledge, skills, attitudes, motivations, and commitment to work individually and collectively toward solutions of current problems and the prevention of new ones” (Adkins & Simmons, 2002, p. 4). Regardless of the exact definition, a general goal of environmental education is to produce environmentally aware and responsible citizens.

The importance of including environmental education in the educational system has been widely recognized. Weilbacher (1995) expounds on environmental education in that “classroom teachings must possess a relevance to the larger world, while the larger world must be invited into the classroom with greater frequency” (p. 11). Because environmental education is inherently a multidisciplinary field (Weilbacher, 1995), its goals can be integrated across all or many subject areas of the curricula at all levels in the education system. “The central message of modern ecology is that everything is connected ultimately to everything else” (McClaren, 1989, p. 84). Furthermore, Jaus (1982) found that by encouraging the promotion of environmental education in the school curricula, students could retain even small amounts of environmental education over time.

There is much support behind implementing environmental education. The National Environmental Education and Training Federation found that 95% of the parents it questioned, support environmental education in schools (The North American Association for Environmental Education, 2001). The British Columbia Ministry of Education (Ministry of Education, 1995a, 1995b, 2001) acknowledged that environmental concepts need to be included in all subjects, including math and science, so that children learn how the environment is linked to their everyday life (Ministry of

Education, Province of British Columbia, 1995a; Ministry of Education, Province of British Columbia, 1995b; Ministry of Education, Province of British Columbia, 1996; Ministry of Education, Province of British Columbia, 2001; Ministry of Education, Province of British Columbia, 2006b). From this acknowledgement, most BC Ministry of Education integrated resource packages (IRP) after 1995 include a section referring to the incorporation of environmental education as cross-curricular goals.

It is important for educators and students to recognize the values presented in environmental education as a cross-curricular, ongoing topic in the class (Smith, 1993). The students and the schooling system must recognize environmental education as part of everyday life, and not a separate study to be taught and then forgotten, or acknowledge on special occasions, such as Earth Day, Ocean Day, Bike to Work Week- “It must become a way of life” (Wilson, 1995, p. 107).

Unfortunately, despite the increasing amount of relevant literature, and the recognition for its need in education, environmental education appears to be falling short of the mark. Weilbacher (1995) noted that although more students than ever before were receiving environmental education, environmental literacy was at an “all time low” (p. 8). Even though environmental education is included in the BC Ministry of Education IRP’s, it entails as a small, standardized section, which appears optional, at best, and leaves interpretations up to the individual teachers. A more detailed publication, *Environmental Concepts in the Classroom* (Ministry of Education, Province of British Columbia, 2000), provides further readings, background information, ideas and a basic understanding of environmental education; however, this publication is an optional resource, is not included as a prescribed curriculum, and has not been updated in 10 years. Furthermore,

only a few grades of science and social science formally acknowledge environmental education concepts as mandatory instruction. This concurs with a study by Wilson and Smith (1996), who note that environmental education is still relegated almost exclusively to sciences and social sciences. In addition, schools and the educational constructs of the system still keep students alienated from their immediate surroundings, where the learning inside of the class often has little to do with, or in the actual local environment (Orr, 1999). Wilson and Smith (1996) propose one possible explanation for the poor inclusion of environmental education into the schooling system is that few teachers are trained in, or committed to environmental education, and few, if any pre-service teacher education programs contain an environmental education component.

### ***Experiential Education***

Tell me, I will forget. Show me... I may remember.

Involve me and I take the experience as my own.

-Ancient Chinese proverb (as cited in Ostrishko, 1997, p. 227)

I feel science educators and the school curricula need to encourage interactions with students and our local outdoor environment, and thus, move away from the purely theoretical and decontextualized environment of the classroom. Boyle notes “making students think beyond the four walls of a classroom is one of an instructor’s most important responsibilities” (as cited in Scarce, 1997, p. 220). Interactions between students and the environment allow students to learn through direct experience. Outside the institutional walls of the school, nature provides students with a living laboratory, where textbook theory becomes reality. When educators encourage students to actively

participate in the outdoor, real-world environment, these students' learning becomes *experiential learning*.

William Glasser popularized the statement that:

“We learn...

10% of what we read

20% of what we hear

30% of what we see

50% of what we see and hear

70% of what we discuss with others

80% of what we experience personally

95% of what we teach someone else”

It is from comments like Glasser's and ideas proposed by Dewey that, the BC Ministry of Education (1996) suggests that students have direct experiences in the environment to engage students and encourage learning. However, Prochazka (1995) found that in education, 80% or more of the time spent by learners is in listening. It is this imbalance that needs correcting. One method to correct the imbalance is to remove the walls of the classroom, wherein most learning is theoretical, and move the classroom into the realm of hands-on, practical involvement with our environment- both man-made and natural. This idea is supported by Roth (1987), who found that students who received traditional textbook science instruction tended to lose interest in science, possibly from viewing it as a foreign world found only within the science classroom and outside the world of experience. Glasser (1969) stated that what students learn should have relevant connections to their lives. If students see the world of science outside their realm of experience and unconnected to their “real life,” it is only natural to lose interest. However, experiential education is one method to connect education to students' lives and encourage personal success (Crosby, 1995).

The Association for Experiential Education (AEE) states “experiential Education is the process through which a learner constructs knowledge, skill, and value from direct experiences” (as cited in Bisson, 1996, p. 45). It can be argued that “all learning is experiential” (Joplin, 1995, p. 22); however, if educators keep in mind the theories of learning, such as that developed by John Dewey (1859-1952), they can focus the effectiveness of education through acknowledging the importance of experience.

In Dewey’s theory, people tend to accept the world as they experience it, and not through some *theoretical* reality (Crosby, 1995). Dewey’s theoretical foundation, now considered *experiential learning*, is a holistic style of learning. Dewey’s theory of education works with students’ unique learning cycles, where personal experience is followed by observation/ reflection and then further application of these skills and knowledge in new situations. This is what Dennison and Kirk (1990) simplify as “do, review, learn, apply” (as cited in Coll, Lay, & Zegwaard, 2002, p. 198). When students are exposed to, and interact with, their environment, they learn during the process. However, it is through examination and reflection of what they experienced, that deeper learning is obtained. Furthermore, their knowledge is strengthened when these students take reflected experiences and apply it to different situations, through hypothesis or action. For example, if students had explored the forest ecosystem with various research tools, having them develop and hypothesize on how to conduct a seashore exploration would help develop the skills and knowledge learned from their forest experiences.

The education system, as a whole, agrees with the fathers of pedagogy, such as John Dewey, William Glasser and Jean Piaget, in that the best way for students to learn is through first hand experience, or “learning by doing.” This act of “doing” is what makes

an experience our own, and it is from this personalized experience that we learn most effectively (Ostrishko, 1997). However, Proudman suggests that the idea of experiential education as “learning by doing” is oversimplifying the concept, which should be recognized more as a “process” that emotionally engages students in the learning experience, rather than the singular act of “doing” (Chapman, McPhee, & Proudman, 1995, p. 240). This emotional engagement arises when the student is so involved in the experience and environment that they become uninterested in disengaging themselves from the experience. Proudman further suggests that the process of effective experiential education requires developing proper relationships between the learner and themselves (through journaling and self-reflection), the teacher (where the teacher provides support and developing parameters to focus the student), and the learning environment (content material, personal relationships and the physical environment) (Chapman et al., 1995).

Successful implementation of experiential education depends significantly on the teacher’s open-mindedness, commitment to the process and student interaction. The Association for Experiential Education stresses the teacher’s foresight in that “experiential learning occurs when carefully chosen experiences are supported by reflection, critical analysis and synthesis” (Bisson, 1996, p. 45). To strengthen experiential education, educators need to encourage students to question, develop anticipating hypotheses, design experiments to test their ideas, and time for both personal and group reflection.

***Outdoor experiential education.*** The outdoor environment is an ideal location for the application of experiential education. Butz and Eyeles (1997) note that the

environment is perceived in a cultural context, and what we experience and understand is converted through our cultural filters. Nature and ecology are similar to the rest of our environment in that they cannot wholly be observed from an objective and detached perspective and so students need to be directly engaged with their natural environment- “Life is lived in engagement, not disengagement, with the environment” (Butz & Eyles, 1997, p. 7). This engagement with the natural environment allows students to utilize the naturalistic intelligence. This is one of the eight human intelligences described by Howard Gardner, and it refers to “how people recognize patterns in nature and culture, classify objects, and understand relationships in their environment” (Knapp, 2003, p. 23).

One of the key components to experiential education is the internal motivation of students to question, learn and be emotionally involved with the experience. As Phipps (1988) notes, one of the strengths of experiential learning is that the lessons begin with already motivated students. Thus, they are more apt to get involved and participate in the learning process.

Outdoor experiential education takes advantage of this concept to promote long-term knowledge acquisition and retention. Although there are several different learning styles, and students excel in different styles, Caine and Caine (1994) found that students understand and remember facts and skills best when they occur outdoors (as cited in Knapp, 2003, p. 23). Even skills such as mathematics, which are often abstract and decontextualized within the classroom, have the ability to become relevant and contextualized when applied to tangible problems in fieldwork experiences. These findings are supported by Leiberman and Hoody (1998), who performed a study of forty schools who use natural and socio-cultural environments as integrating contexts (EIC)

and found that student performance increased in reading, writing, math, science and social studies (as cited in Knapp, 2003, p. 25). In addition, bringing community and experiential education together can be extremely beneficial when combined into environmental action.

Other programs successfully utilizing outdoor experiential education include the Expeditionary Learning Outward Bound program, the Foxfire program and the Community Environmental Involvement (CEI) program, in the United States. Success with these programs has resulted from transformation from outdoor experiential education to environmental action where, student participation provides community benefits, such as environmental monitoring and wilderness trail building (Knapp, 2003; Pikal & Lindquist, 1999). The importance of the success in these programs is that they produce both environmentally literate students, and active, positive members of the community, where students know that their learning and action, directly benefits the community (Weilbacher, 1995). Students are encouraged by the fact that they are gaining skills and actively involved in the outdoors, in addition to working toward improving their community. This outlook contrasts with mainstream schooling, where student goals tend to focus around competition, with other students and schools (Chapman et al., 1995). This community involvement of the programs is important for students to realize the classroom is not separate from the community and environment, but intrinsically connected.

### *The Cross-Cultural Science Classroom*

Using a multicultural framework in environmental education is a way of acknowledging that students have different learning styles; that all students do not have the same beliefs or experiences; and that to understand any environmental issue, whether local or global, we need to understand the cultural factors that have created it. (Peter, 1997, p. 14)

Educational institutions tend to promote a form of Western Modern Science that all too frequently separates students from their sense of place. WMS disseminates the world into compartmentalized, culturally neutral and value-free knowledge, without cultural or local context (Corsiglia & Snively, 1997; Kawagley & Barnhardt, 1999). This separation of the standard science classroom from real-world content and situations extends beyond ecological dissociation and has inherent social and cultural contradictions in our multicultural world.

Aikenhead describes the science class as “socially and culturally sterile” (Aikenhead, 1980, p. 19) that ill prepares students for their future in society. From textbooks to video, students are infused with knowledge acquired from anonymous authority figures that present science as a culturally neutral entity with few social applications. However, this view of the science classroom as culturally sterile is valid, but only from the dominant viewpoint of Western culture. Aikenhead (1997) notes that science is a subculture of Western culture and that the dominant science education is cultural transmission, and therefore, the expected learning includes cultural acquisition. Hodson (1993) argues that modern science texts are almost exclusively Western science, and thus, Western culture where some of the curriculum material is still inherently sexist and racist (as cited in Snively, 1995, p. 55). Aikenhead and Huntley (1999) suggest that the significant difference of classroom science from most students’ non-school world views requires “cultural border crossings” (p. 161), regardless of cultural backgrounds.

Furthermore, teaching and learning methods from a Western perspective, may clash with cultural traditions and beliefs of some students, especially where the scientist is seen as a controller and manipulator of nature (Snively, 1995).

It is important for educators to recognize the extent of multiculturalism within their classrooms despite that classroom diversity may not be obvious. Peter (1997) notes that skin colour and ethnicity are obvious indicators of different cultures; however, “culture is also a product of language, economic status, geography, religion and many other factors” (p. 14). Grass (1994) emphasizes the often-overlooked cultural differences in residences such as urban, suburban and rural communities, in addition to economic status that plays a role in these environments and their conditions.

Sonja Nieto (1996) describes many of the key characteristics of multicultural/ environmental education (as cited in Peter, 1997, p. 15). These characteristics include: *antiracism* through embracing diversity and acknowledging that all cultures are responsible for the environmental crisis; *importance for all students* through the need for students to understand the environmental biases and experiences that have resulted in environmental problems; *pervasive* as all teaching and knowledge acquisition is filtered through cultural experiences; and finally, *social justice* is an important aspect of multicultural environmental education as students become aware of the connections between environmental degradation and human oppression. Furthermore, Grass (1994) describes teachers as cultural workers through multicultural environmental education, as these educators promote the survival of the biodiversity of the natural world, upon which sustains the diversity of the world’s cultures.

Cross-cultural education has important attributes beyond reducing racism and providing students with broader, global perspectives- it can improve the success of marginalized or minority groups in an otherwise Western dominated education system. As noted by Snively and Williams (Snively & Williams, 2006) participation and success are closely related, where Aboriginal participation in science and math tends to result in success in these areas. The use of cross-cultural education to counter balance the non-success of minority groups, such as Aboriginal, Maori, Inuit and African, in mainstream public education and secondary science has been recognized by several authors as noted by Snively (1995) and Aikenhead & Jegede (1999). To encourage participation and success of these groups, the responsibility lies not with the students, but for the education system to design a learning setting in which students of all cultural backgrounds feel comfortable to participate (Snively, 1995). This encouragement includes recognition of, and addressing the various prior beliefs of traditional cultures, whose concepts of topics, such as time, life cycles, evolution, classification and death, may differ from mainstream Western science (Snively, 1990). Peter (1997) recognizes the need to include examples from as many cultures as possible as “it can risk alienation of students who see no depictions like themselves” (p. 15). If we are to focus on support of Aboriginal culture in BC, Peter (1997) further points out educators need to recognize that there is not one single Aboriginal culture on the coast, but diverse groups with unique dialects and their own cultural beliefs.

Through acknowledging several cultural perspectives in the science classroom, there is an increased chance that the science culture presented to minority students will work with their own culture and support their overall worldview. This integration of

science concepts into a student's accepted worldview is what MacIvor (1995) refers to as *enculturation*. However, if the science subculture of Western culture is at odds with students' cultural world beliefs, students may feel the need to marginalize or abandon their cultural beliefs through *assimilation* of Western culture (Aikenhead, 1996; MacIvor, 1995). MacIvor (1995) found that students tend to resist assimilation, which contributes to non-success in the science classroom. Further resistance to adopting Western science may be that Aboriginal cultures see Western science taught in the classroom "as an icon of cultural imperialism" (Aikenhead, 1997, p. 220) whose beliefs, such as man over nature, threaten aspects of the Aboriginal worldview.

In order to increase science participation of Aboriginal students, it is important to recognize science as a culture, and the goal of transmitting science is to support Aboriginal culture and community. "First Nations peoples are the most disadvantaged minority in North American education and are the least represented in science and technology careers" (Aikenhead, 1997, p. 218). Jerry Schwab (2001) observed how making science relevant is of enormous value in trying to engage, or re-engage young Aboriginal people (as cited in McLisky & Day, 2004, p. 27).

***The Science-Technology-Society classroom.*** Aikenhead (1997) espouses the concept of the Science-Technology-Society (STS) classroom. This concept involves connecting Western science concepts with Aboriginal beliefs through recognizing community needs and social goals that can be achieved from the application of scientific principles. This concept allows science to work within students' beliefs through enculturation, where students selectively adopt the relevant aspects of Western science

that support their cultural worldview (Aikenhead, 1997). Cajete (1999) recognizes the benefits of STS for Aboriginal students who are familiar with the already contextualized information of Aboriginal science, compared to the decontextualized Western science. STS removes Western science from the decontextualized classroom and places it within a framework of applicability within the community. Furthermore, Cajete (1999) notes that Aboriginal students would be more apt to knowingly adopt certain aspects of Western science, than feel as though they are being indoctrinated into Western culture. MacIvor (1995) recognizes adopting Western science for individual needs in the Aboriginal community include working at a job, establishing a career in science and technology, and aiding the community. Among the larger goals of STS in Aboriginal communities include economic development, environmental survival and cultural survival (Aikenhead, 1997).

***Traditional Ecological Knowledge as classroom science.*** Aboriginal science and the related body of knowledge have been termed Traditional Ecological Knowledge (TEK). There is no standardized definition of TEK, where both “traditional” and “ecological” are both ambiguous (Snively & Corsiglia, 2001), however, a common aspect of all definitions of TEK include its long-term and cultural aspects with a close connection to the environment. This knowledge “represents experience acquired over thousands of years of direct human contact with the environment” (Snively & Corsiglia, 2001, p. 11). Berkes (1993) states that TEK refers “to the knowledge, practice and belief concerning the relationship of living things to one another and to the physical environment which is held in non-technological societies with direct dependence upon

local resources” (as cited in Kimmerer, 2002, p. 432-433). Although the term “traditional” in TEK may appear to refer to an old-fashioned and immutable body of knowledge, Berkes and Folke (2002) note that traditional refers to historical and cultural continuity of knowledge; therefore it is dynamic and changes over time. Johnson (1992) suggests that TEK may be better labeled as Indigenous ecological knowledge, in order to eliminate the perceptions inherent with “traditional.” Finally, Ogawa (1995) defines the cultural science aspect of Aboriginal knowledge as “indigenous science” (as cited in Snively & Corsiglia, 2001, p.10) which reflects the local aspect of one culture’s understanding of its own world.

Similar to TEK, another often used description of Aboriginal knowledge is Traditional Ecological Knowledge and Wisdom (TEKW). Although the *wisdom* element is often implied in definition of TEK and these terms are often used interchangeably, the recognition of traditional wisdom is an important aspect of Aboriginal knowledge. Snively and Corsiglia (2001) recognize that wisdom is a guiding component of TEK, through its guiding values and ethics. Among the important aspects of this wisdom, TEKW includes an inherent respect for nature and the universal spirituality of all living and non-living components of the world. Within this view, humans and nature all have spiritual entities and are acknowledged as equals. Unlike the traditional Western hierarchical chain of being, Aboriginal worldviews tend not to place human needs above those of the natural world (Snively & Corsiglia, 2001). This worldview promotes “an ethic of reciprocal respect and obligations between the humans and the nonhuman world” (Kimmerer, 2002, p. 434). Through the aspect of this connected worldview, Aboriginal wisdom encourages a holistic view of nature and community, as any one aspect is

interdependent upon the whole and important for sustaining both community and environment (Snively & Williams, 2006). It is through Aboriginal oral stories and narratives which preserve these views that are passed on from generation to generation, instilling the ecological and moral lessons of traditional knowledge and wisdom in future generations. “The Great Flood,” “Creation” and “Raven” stories are just a few examples of general Aboriginal narratives used to encourage a perception of the world where “humans, nature and the supernatural are inextricably linked” (Nelson, 1993, as cited in Snively & Corsiglia, 2001, p. 14).

Traditional science and wisdom have had, and continue to have a number of important implications which benefit modern society. Snively and Corsiglia (2001) present a number of modern scientific fields which are reflected in TEKW, including ecology, biology medicine, agriculture, astronomy, navigation and mathematics, to name a few (p. 12). Additionally, many other governments, associations and scholars, including the United Nations Environmental Program (UNEP), recognize how TEKW complements Western Modern Science (WMS) in numerous fields, including pharmaceuticals, geology, agriculture and wildlife and resource management (Christie, 1991; Johnson, 1992; Kimmerer, 2002; Snively & Corsiglia, 1996; Turner, Ignace, & Ignace, 2000). The complementary aspect of TEKW is due, in part to the many biological concepts which overlap with mainstream Western ecological knowledge, including population biology, resource management, climatic trends and ethnotaxonomy (Kimmerer, 2002). Turner, Ignace and Ignace (2000) further contend that use of TEKW can enhance resource management practices, including forestry, fisheries and ecological restoration.

A number of research projects, practices and important “discoveries” in modern science reflect the application of TEKW. Important pharmaceuticals derived from the Rosy Periwinkle (*Catharanthus roseus*), Western Yew (*Taxus brevifolia*), and the Neem (*Azadirachta indica*) tree exemplify key uses and abuses of modern acquisition of TEKW, where companies utilized the knowledge for solely corporate gain (Garrick, 2004; Kimbrell, 2002). However, as TEKW becomes increasingly recognized and appreciated, numerous projects around the world work co-operatively with Indigenous peoples, utilizing and incorporating TEKW into modern science. In Northern Canada the Dene Project reflects a huge effort in acquiring and incorporating vast amounts of traditional knowledge into modern wildlife and resource management projects, through working with the Aboriginal people (Johnson, 1992). TEK is further being utilized in Arctic Canada for numerous resource management and ecological work which focuses on co-management of the tundra and Arctic Ocean with Aboriginal peoples (Berkes, Mathias, Kislalioglu, & Fast, 2001).

One direct example of how TEKW has been used in modern ecological monitoring occurred along the BC coast. A NisGa’a fisher, in the Naas River Valley of BC, observed abnormal migration of crabs in the coastal area. With this observation, further analysis of the water quality resulted in identification of heavy metal pollution upriver caused by a nearby molybdenum mine (Corsiglia & Snively, 1997). This observation exemplifies the importance of long term application ecological knowledge of a local area, which is often lacking in modern scientific methods.

*The “new” science classroom- modern and traditional science.* In addressing the cross-cultural science classroom and Aboriginal participation, the BC Ministry of Education has encouraged the incorporation of Aboriginal culture in all classrooms. The science IRP’s (Ministry of Education, Province of British Columbia, 1995a; Ministry of Education, Province of British Columbia, 1996) include a small standardized section of the value of Aboriginal studies in the multicultural classroom. This section notes that Aboriginal values are relevant and there is a need to validate Aboriginal culture, especially among Aboriginal children, and to recognize the similarities and differences between cultures in order to raise awareness and tolerance of other cultures. However, the most recent K-7 IRP (Ministry of Education, 2005) emphasizes the inclusion of Aboriginal science in a large, in-depth chapter. The focus of this topic is upon Traditional Ecological Knowledge and Wisdom (TEKW). In addition, the new IRP’s in senior sciences also incorporate Aboriginal ways of learning, TEKW, and inclusion in the classroom (Ministry of Education, Province of British Columbia, 2006b; Ministry of Education, Province of British Columbia, 2006d). These additions to the IRP’s are necessary in that they recognize the BC Aboriginal population and their contributions to society to encourage Aboriginal success. However, in order for educators to utilize these concepts successfully, they need more than just quick reading about TEKW and Aboriginal ways of learning. These educators should have sufficient understanding of the cultural, traditional and moral implications found within Aboriginal science.

There are many ways in which TEK can be incorporated into the science classroom and curriculum. With government level recognition of the importance of traditional knowledge, TEK has a definite place in modern science education at the

school level. Students with difficulty grasping WMS, because of cultural conflict, or disinterest, may find TEK a more tangible form of science. Traditional science works with students' sense of place and natural curiosity, as TEK is dependent on direct experience in the natural environment. Among these tangible aspects of TEK include identifying the Aboriginal food plants in our environment, how to make natural resources into useful tools, how to predict weather, and harvesting practices that sustain habitat and wildlife resources over long periods of time. Even students who excel at WMS can benefit from the cultural education and environmental respect inherent in TEK.

A number of aspects of TEK are relevant in the discussion of the multicultural classroom, STS and Aboriginal participation. It is recognized that when Aboriginal students are introduced to concepts that run parallel their cultural worldview and do not drastically contradict their prior beliefs they are more likely to understand that concept (Aikenhead, 1997; MacIvor, 1995; Snively, 1990). The validity of TEK as complementary to Western science (Kimmerer, 2002) permits the combination of these knowledge bases together in the multicultural classroom. With Aboriginal students, the use of TEK can be used to put Western scientific concepts in context with the learner's cultural and social influences (Snively, 1990), such as fishing and resource management within the Aboriginal community. Corsiglia and Snively (1997) note how the NisGa'a, of BC, prefer to examine environmental issues and ecology in local terms that are relevant to their spatial context. In the STS view, students can place Western science back into a social and environmental context by using knowledge about stream and estuary ecology, to aid in the management of traditionally important plant and fish habitat. Working with students in their local environment, or community, incorporating

both TEK and Western science, allows for the recognition in the benefits and limitations of both forms of knowledge, without removing students from cultural connections. Because students' own culture is validated and incorporated into the science curriculum, students may be more willing to adopt appropriate Western science concepts, while learning new, or reinforcing established traditional knowledge ideas.

### ***Constructivism in Curriculum Development***

From a constructivist perspective, it is important for educators to acknowledge students' prior beliefs and knowledge and address these when presenting new material. The constructivist approach originates from the belief that learning is internal, where information is processed, clarified and categorized within the learner (DeLay, 1996). Recognizing that students aren't "empty vessels" in which to pour knowledge, educators must acknowledge that information presented will be filtered through previously established world constructs and beliefs (Colburn, 2000). Pajares (1992) "found that beliefs are formed early, are acquired through cultural transmission, and are self-perpetuated" and "strongly influence perception...of phenomena" (as cited in Haney, Lumpe, & Czerniak, 2003, p. 367). Therefore, information is not internalized directly, but is processed and modified by the learner to fit within their worldview. These prior conceptions, beliefs and ideas, can impede a student's ability to learn, especially if these beliefs contradict accepted science concepts. In addition, students of different cultural backgrounds may interpret the concept of science differently, as in comparing holistic traditional knowledge to compartmentalized Western science, which could impede their ability to learn new concepts (Snively, 1995). As a result, science educators need to

address the complex problem of not only addressing beliefs that are different from standard science concepts, but competing with the influences of community and culture that is beyond the control of the classroom.

*Addressing prior beliefs and alternate conceptions.* Addressing and working with students' prior conceptions in developing a curriculum is important. Research has shown that the prior knowledge and beliefs of students has a strong impact upon these students' abilities to learn new concepts and can interfere with an educator's best intentions, as students tend to base acquired knowledge upon pre-existing constructs, even more so than presented material (Roschelle, 1995).

When students' prior conceptions conflict with reality, Colburn (2000) believes that a goal of science educators is to help students change their beliefs, to those more inline with what is accepted by the scientific community. There are various constructivist techniques to assess and address prior beliefs and alternate conceptions, such as the assimilation stand, where educators recognize potential problems in understanding and by working through the constructivist process, these educators can encourage students to accommodate new concepts and assimilate new experiences into these and pre-developed concepts, allowing for correction of incorrect alternate conceptions (Coll et al., 2002). Student alternate conceptions may be dealt with by exposing them to a situation which challenges their prior notions, and if the new information is more plausible, they may completely delete the old knowledge (Sewell, 2002).

By contrast, Snively (1995) suggests that it is far easier to teach students science concepts by working along with their current beliefs and values than teaching those

concepts that conflict with students' prior beliefs. This idea suggests instruction presented parallel to student beliefs and orientations provides more effective learning retention without students losing their own cultural connection (Snively, 1990; Snively & Corsiglia, 2001). If students feel that their personal worldview and culture are being contested by this new information, they may resist accepting the learning outcomes. However, if science curriculum is developed for Aboriginal students that acknowledge prior student orientations, including the validity of traditional knowledge, the educator may present material in a fashion that coaxes students toward the desired goals, instead of forcing them to accept the expected outcomes. The importance of constructivism as a guiding pedagogy in the reform of science has been recognized by major American science organizations including the National Research Council, through projects such as Project 2061 and the Biological Science Curriculum Study and by many science educators (Colburn, 2000; Haney et al., 2003; Kinchin, 2003).

Preconceptions may clash with the presented material when comparing various western cultural concepts to Aboriginal students. When teaching western science concepts, students from a western cultural background may find the concepts of interest easier to accept, as it is part of their culture, and thus, tends to be parallel with their overall worldview. Aboriginal American, Inuit, Maori and other Aboriginal cultures have different interpretations of such concepts as time, evolution, weather and resource management (Snively, 1995), which may inhibit their understanding and acceptance of the Western Modern Scientific perspectives.

One such clash of cultures arises when discussing the habitation of North America. The teacher is likely to tell the students that humans arrived to the continent

approximately 11,000- 40,000 years ago, whereas the Aboriginal community often defines their occupation of the land as “since time immemorial” (Indian and Northern Affairs Canada, 1996). The conflict within the student may arise as the Aboriginal student’s perception of having roots in the land throughout time collide with the scientific view that Aboriginal peoples’ occupation on the continent has a relatively recent, concrete, archeologically-defined beginning. As western science explanations often conflict with these cultural perceptions, Aboriginal students may have a more difficult time modifying their understandings and reject the new view. Thus, it is important for educators to acknowledge where students’ prior conceptions are grounded, and take appropriate steps to either cause students to question that prior conception, or to introduce concepts harmoniously with that conception by retaining the student’s cultural worldview. In a cultural context, this may require the student to understand the concept in a dual fashion, where there is a Western Modern Scientific explanation and traditional, culturally applicable explanation, both of which are valid.

### ***Summary***

The literature is rich in supporting the importance of students developing a strong sense of place, to develop sense of community and ecological belonging. As pressures increase upon the natural environment and resources become more threatened, we need community members that understand their place in and impacts upon the environment. Environmental science is one gateway through which students are able to gain a sense of place and the scientific literacy required to make informed decisions as a positive

member of the community. These decisions of the future are critical in producing and maintaining a sustainable community and environment.

Furthermore, it is critical that curriculum acknowledges the cross-cultural nature of science and the multicultural nature of our communities, to ensure that no students are alienated from our educational system and to provide students with a broad cultural understanding of our world. The nature of Traditional Ecological Knowledge imparts on both Aboriginal and non-Aboriginal students a knowledge and respect for the environment. Utilizing the cross-curricular aspect of learning with other cultures empowers all groups in recognizing their own cultural contributions and those of different cultures. In addition, students are presented with knowledge and beliefs of other cultures that they may take with them outside of the science classroom and incorporate into their own lives.

### **Chapter 3: Methodology**

This chapter describes and defends the various steps taken in developing and implementing the project and cross-cultural, experiential marine program. The chapter initially describes “Purpose of the Study” and the reasoning behind approaching this project at Edward Milne Community School (EMCS). The “Design of the Study” describes in detail the three main phases in the design of this project, and provides supporting research for the selection of the research style used. The “Location and Setting of the Study Site” describe important aspects in the selection of EMCS and the Sooke community, noting the influences of the environment, local industries and both the Aboriginal and non-Aboriginal communities. The “Data Sources” describe the development of the surveys used in the collection of quantitative and qualitative data for analysis in the project. “Procedures for Data Collection” describe how the survey data was ethically collected from the voluntary, anonymous participants throughout the project. “Procedures for Data Analysis” describes the how the data was compiled and analysed for the discussion. In addition, this section provides the methods and results used in ensuring the validity and reliability of the survey instruments. The “Time Line” provides information about the order and progress in which this project was developed, implemented, analysed and presented. Finally, the “Limitations of the Study” presents the influences and personal biases that may have affected the overall success and applicability of the project.

### ***Purpose of the Study***

In the fall of 2007, I had the opportunity to work with two peer teachers at Edward Milne Community School (EMCS) in Sooke, British Columbia. Megan Bondurant and Mike Bobbitt had spent the last number of years at EMCS developing and teaching a grade 11/12 Environmental Studies class that was unique to the school and the district. Within this program, they introduced students to various concepts about environmental ethics, ethnobotany, marine studies and coastal resource and management issues. A central aspect of this program was the regular field excursions and hikes in which students were expected to participate. As my experiences as teacher still involved regularly moving between schools on various temporary contracts, I found that the groundwork that these instructors had developed in the Sooke district (SD #62) would provide a perfect opportunity to develop and implement a locally based science unit that took into account the unique coastal environment and Aboriginal culture. Thus, I undertook a study to develop and analyse the effectiveness of a senior level, cross-cultural, experiential marine science program, utilizing the local environment.

### ***Design of the Study***

This study consisted of two main design components and three main phases in the implementation. The first design component was the *development and application of survey instruments* that sought to assess the knowledge and opinions of students, both before and after instruction of the locally developed, marine focused, cross cultural program. These surveys collected both quantitative and qualitative data that could be

used as baseline and comparative data. The use of the surveys was an essential aspect of the study, as this data would be essential to analyse the effectiveness of the program.

The *development of the program* was the second main design component of this study. An initial marine science program of approximately 3 weeks was developed, in which both Western Modern Science (WMS) techniques and Traditional Ecological Knowledge and Wisdom (TEKW) were used in a program that utilized outdoor experiences and cross cultural learning about various perspectives of science.

The three phases in which this program was implemented were as follows:

***Phase 1: Pre- instructional survey- Establishing existing beliefs & conceptions.***

Although this study was not a constructivist-based project, some of the theoretical concepts of constructivism were recognized and incorporated into the study's design and analysis. Students enrolled in the Environmental Studies 11 course for the Fall 2007 semester completed a pre-instructional survey early in the course, shortly before the beginning the marine program. The purpose of the pre-instructional survey was to provide a baseline quantitative and qualitative assessment of the students' existing conceptions, beliefs and opinions about a number of topics to be addressed in this program. These topics included their prior science experiences and understandings of this field with regards to humans and the environment. Concepts about the local marine environment, such as marine ecology, oceanography and resource uses were examined, in addition to students' understandings and beliefs of local Aboriginal culture and Traditional Ecological Knowledge and Wisdom (TEKW).

This pre-instructional survey was comprised of 3 separate sections which included an opinion survey, a knowledge survey and an open-ended, written section which involved a seashore sketch and an application of science problem. The opinion section of the survey utilized statements which sought to explore students' personal feelings about their science and environmental educational experiences, personal interests, and understandings of coastal resource use and human impacts upon the coastal environment. This survey also examined students' feelings about Aboriginal culture and traditional science. The knowledge section established students' understandings of various aspects of marine science, including marine ecology, oceanography and coastal resources, and Aboriginal Traditional Ecological Knowledge. The open-ended questions sought to examine students' understandings of these concepts in less constraining, holistic format. In addition to establishing baseline data, this information was also used to further develop and alter the program of instruction.

***Phase 2: The marine program.*** Implementation of the marine program was aimed to coincide with tides and weather conditions more amenable toward an outdoor program. In order to take most advantage of weather and tides found around the latitudes of Southern Vancouver Island, coastal intertidal excursions need to be around the summer months, from May to September. In addition to amenable weather, this timing was important because low tides falling to close to the zero mark tend to occur during school hours for these summer months. Attempting this program in winter would likely be a dark and cold experience for students. As a result, I timed my fall marine program to start in September.

The program was taught both in the classroom and on several field excursions. Classroom material included presentations by the teacher/researcher, discussions and group activities exploring various aspects of marine science. These aspects of marine science included a cultural exploration of science, learning about various methods and techniques used to study the coastal environment, understanding the role and importance of TEKW and various ecological and cultural concepts. In addition, the classroom was used to present background knowledge and fieldtrip logistics prior to field excursions. A detailed description of the instructional component of this research is described in Chapter 5: Applying a cross-cultural, experiential marine science curriculum (p. 114).

*Phase 3: Post-instructional questionnaire.* Success of the program was examined through the post-instructional survey completed by the students. This survey was similar to the pre-instructional survey. The first section of the survey again examined students' opinions, but included specific statements describing their feelings toward the program, and re-examined their opinions on specific topics. The knowledge survey included two components- the original survey and an alternate survey that covered questions on the same concepts, but were not identical. In addition, the original open-ended questions were re-administered to examine differences in how students applied their knowledge acquired during the program. These results were assessed and compared statistically to the pre-test results to determine the effectiveness of the program.

The questionnaires utilized in this study are described in further detail in the "Data sources- The research surveys" section of this chapter (p. 66).

### *The Case Study and Survey Method*

This project was approached in the form of a case study. The case study method seemed most applicable in the collection of qualitative and quantitative data in the design and analysis of the program of instruction and to determine its effectiveness. Creswell (1998) describes the methodology of the case study as “an exploration of a ‘bounded system,’ or a case... over time” (p. 61), where this “bounded system” is bounded by “place and time” (Creswell, 1998, p.61). In this case, the bounds of the case study group were the Environmental Studies 11/12 fall class, where the “context of the case,” (Creswell, 1998, p.61) or place, was the marine program applied at the school for the time period of three weeks. Furthermore, Creswell (1998) recommends that in the successful utilization of the case study method, multiple sources of data should be used. This view is corroborated by Sudman and Bradburn (1982), who note the importance of the use of multiple research strategies and careful survey and questionnaire design in order to successfully address case studies of this kind. In recognition of the need for multiple sources of data, the survey instruments applied in this research included both quantitative data collected from multiple choice knowledge surveys, and qualitative data from opinion surveys, written comments from students and open-ended question responses.

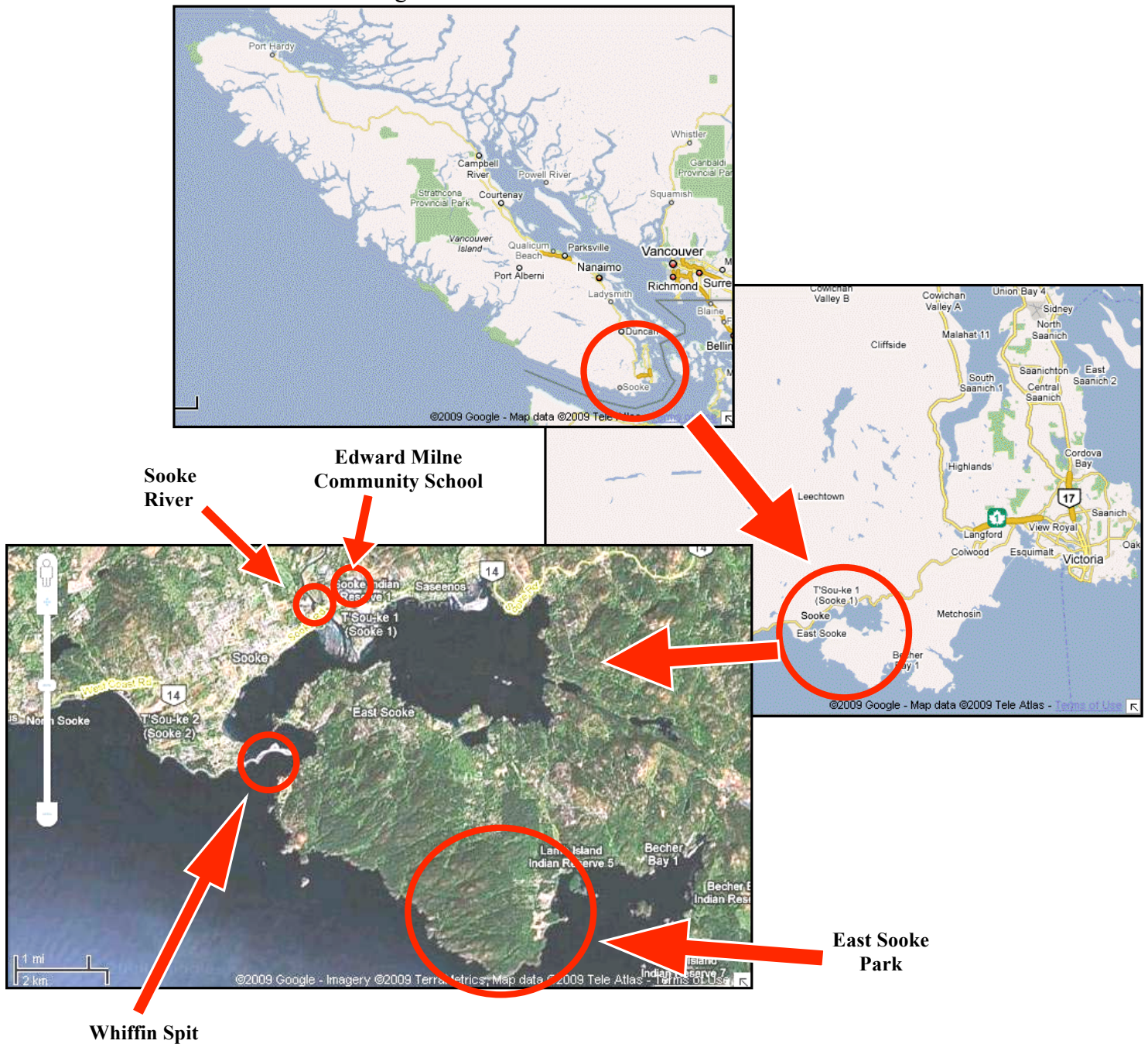
The aspect of the study that examined the effectiveness of the program should be described as a quasi-experimental, longitudinal case study. Within this framework, the students’ knowledge and opinions were described at two temporally separated stages, before and after, the intended cause of change, which was the program (Creswell, 1998; Trochim, 2006). Additionally, the quasi-experimental aspect of this study reflects that the control data was considered to be the results from the pre-instructional surveys.

Answering the questions about how the program affected students' opinions and the exploration of the effectiveness of an educational program lead toward the use of a case study utilizing surveys. Yin (2003) notes that utilizing a survey within a case study is useful where the program and class are the "case" and a survey is able to be used in determining the "change," which in this situation was the knowledge and opinions of students.

Examining the effectiveness of programs through a survey driven case study has been successfully utilized before. Within these studies, the instrument of change was the instructional treatment of a program or course. McMillan, Wright, and Beazley (2005) used a survey driven case study to examine the effectiveness of upper level environmental studies courses on students' values. The effectiveness of government programs as successful educational initiatives have also utilized the case study method (Tellis, 1997). Of particular interest was Cummins (1997), who utilized similar surveys and questionnaires developed by Snively and Sheppy (1991) to assess students' knowledge and stances about the marine environment. Like my study, Cummins (1997) used these instruments to compare changes in students' stances and opinions prior to and post instruction, whereas the original study by Snively and Sheppy (1991) utilized a single application of the surveys in various regions in a descriptive case study, without an instructional treatment.

### *Location and Setting of the Study Site*

The study site of the program involved Edward Milne Community School (EMCS), in the municipality of Sooke, in Southern Vancouver Island. A map of this location can be found in Figure 1.



*Figure 1.* Location of study site and important locations around Sooke used in the curriculum for field explorations.

EMCS is a relatively new community building, being almost 15 years old. The school consists of approximately 700 students, and is located near the Sooke River, which empties into the Sooke Basin. The school's design is fairly open and incorporates much art and design reflecting the local T'Sou-ke and Pacheedaht First Nations influence. The school offers several specialty programs such as Culinary Arts, a theater program, and the Environmental Education program. Additionally, as a community school, the school is also used by the community for the theatre and various other community programs.

***Community profile.*** Edward Milne Community School incorporates three different communities, which are part of the Capital Regional District (Victoria, BC). These three different regions include Sooke Municipality, Capital H- Part 1 (Otter Point, Shirley, Jordan River & East Sooke) and Capital H- Part 2 (Port Renfrew).

The central and largest of the communities is the city of Sooke. Sooke is located 35 km west of Victoria, British Columbia. The total Aboriginal and non-Aboriginal community population of Sooke was 9,704 as of the 2006 census, an 11.1% increase since the 2001 census (Statistics Canada, 2007c).

The communities of Jordan River, Otter Point, Shirley and East Sooke are located on either sides of the city of Sooke. Jordan River is the furthest west of the local communities and is located 25 km west of Sooke, whereas East Sooke is located east of Sooke, closer to Victoria. Together the Aboriginal and non-Aboriginal population totaled around 4250. This total population increased by 11.8% between 2001 and 2006 (Statistics Canada, 2007a).

Port Renfrew is a small community 107 km northwest of Victoria (80 km west of Sooke). In contrast to the other districts, Port Renfrew has had a declining population up to 2001. However, this decline has significantly reversed, and the population has increased 45.3% between 2001 and 2006(Statistics Canada, 2007b). The nearby Pacheedaht First Nation community had approximately 100 registered members living within the reserve (Department of Indian Affairs and Northern Development, 2008).

***Aboriginal community.*** The Edward Milne Community School encatchment includes students from 4 different First Nation reserves, from three different Aboriginal communities of the Coast Salish linguistic group. The T'Sou-ke Nation has 2 reserves within the city limits of Sooke and is the namesake for the city of Sooke. Of the 203 members of the T'Sou-ke Nation, 130 lived within the reserves. Scianew First Nation is located at Beecher Bay, as part of East Sooke, with 200 members. The Pacheed-aht First Nation reserve is located at Port Renfrew, with 100 members living on the reserve and approximately 150 members living elsewhere (Department of Indian Affairs and Northern Development, 2008; Royal Canadian Mounted Police, 2005; Statistics Canada, 2007b; Statistics Canada, 2007c).

***Industry and employment.*** Traditionally the main industries of the study site have been in the fishing and timber industry. Both of these industries have shrunk significantly in the area, thus leading to the small population of Port Renfrew. The growing size of Sooke and it's proximity to Victoria has resulted in more employment in the service and social industries of the city, and movement away from a resource-based

economy. In addition, the communities of East Sooke, Sooke and Jordan River are growing as sub-urban areas to Victoria and the city of Sooke.

***Geography and resources.*** The Sooke area is diverse, both geographically and biologically. This area straddles the boundary between the Coastal Temperate Rainforest and the dry rocky habitat of the Greater Victoria area. These areas are defined as the Montane Very Wet Maritime (Coastal Western Hemlock) and Eastern Very Dry Maritime (CWH) biogeoclimatic zones, respectively (Ministry of Sustainable Resource Management, 2000). The communities are all coastal, near the rocky southwest coast of Vancouver Island. East Sooke Park is a protected area east of the city of Sooke containing an excellent example of coastal forest, with a popular five hour long hiking trail following the convoluted rocky shoreline. The Sooke Basin is an expansive bay that dominates the shoreline of the city of Sooke, with the inner waters of the basin protected by Whiffin Spit. This basin consists of rocky, cobblestone, and sandy shorelines. Off the shore, shallow kelp beds (*Nereocystis leutkeana*) and eelgrass (*Zostera* spp.) beds can be found. The old growth forests of the area have long since been cut down; however, dense second growth forests including red-cedar (*Thuja plicata*), western hemlock (*Tsuga heterophylla*), and Sitka spruce (*Picea sitchensis*) surround the area.

Traditionally timber and fishing were very important industries in the area. Commercial vessels still moor in Sooke Basin; however, the importance of the commercial fishing industry, like many parts of BC, has been drastically reduced. In the basin, two salmon aquaculture farms had operated, but were closed within the past few years (Ministry of Agriculture and Lands, British Columbia, 2006). Timber resources are

still important in the area and logging occurs through both Crown and private lands. The British Columbia Commission on Resources and Environment (CORE) reported past, existing and potential resource and cultural uses of the Vancouver Island and summarized them in the Vancouver Island Summary Land Use Plan (VILUP) (Ministry of Sustainable Resource Management, 2000). The VILUP, identified the area west of Sooke as enhanced forestry management zone, which describes areas of intensive silviculture and logging (Ministry of Sustainable Resource Management, 2000). In addition, this report identified potential mining deposits and aquaculture areas for future development. In addition, both Sooke and Port Renfrew have the potential for increased tourism and recreational growth in sport fishing and marine wildlife tours.

### ***Data Sources- The Research Surveys***

For the case study nature of this project, it was important that multiple sources of data were collected, as noted by Creswell (1998) and Sudman & Bradburn (2004). The multiple sources of data used in this project was collected through a set of surveys that were administered prior to and after the instructional treatment of the program. Data collection in the form of surveys has been utilized many times in both environmental and educational areas of research (e.g. Cummins, 1997; Halls, 2002; Kempton, Boster, & Hartley, 1999; McMillan et al., 2005; Snively & Sheppy, 1991).

Reflecting the need for multiple sources of data, the research surveys were designed to collect information about students' opinions and knowledge through multiple choice and Likert-style questions, in addition to an open-ended question and student

drawing. This broad base of information permitted the collection of both qualitative and quantitative data for analysis.

The research questionnaire was delivered in three different parts to analyse students' backgrounds, knowledge and opinions about the coastal environment, science and culture. Part 1, "Coastal Opinions Survey," explored students' backgrounds, experiences and beliefs about the coastal environment through their own opinions. Part 2, "Coastal Knowledge Survey," examined students' knowledge of various coastal concepts through a multiple choice questionnaire. Part 3, "Coastal Open-Ended Questions," presented students with two extensive open-ended questions, one of which was a sketch that would reflect their perceptions of the seashore, while the other utilized applied knowledge asking how students would approach a study of the coastal environment. The "Coastal Opinions Survey" and "Coastal Knowledge Survey" were administered online utilizing SurveyMethods.com, while the open-ended questions were completed by hand during class time.

The design of the Knowledge and Opinion surveys were based on a standardized questionnaire developed and utilized by Snively and Sheppy (Snively & Sheppy, 1991), titled "Students and the Ocean" in examining opinions and knowledge of grade 5 and grade 9 students from various locations in BC. This questionnaire was chosen as a framework for my own questionnaire as it had been proven an effective model in adapted versions for other research projects (Cummins, 1997; Halls, 2002). These instruments were adjusted to be compatible online and to reflect target students' knowledge level, background, local geography, resource, and history aspects relevant to the Sooke district. Question design, and formatting were completed in accordance with appropriate

recognized survey design techniques (Belson, 1981; Gray & Guppy, 1994; Trochim, 2006).

A trial survey was implemented in January 2007 upon a previous Environmental 11/12 class, which included a comments section for student input. This on-line trial survey utilized the website TigerSurvey.com. The completed survey instruments were peer reviewed by one public educator, three high school educators, and three university professors, which resulted in several adjustments prior to implementation.

***Assessing students' personal background.*** In order to establish student background and track student responses through the surveys, the first five questions of the pre- and post-instructional versions of the “Coastal Opinions” and “Coastal Knowledge” surveys involved the same structure. The first question asked for the students' code names, which was a type of local flora or fauna, which the students would use instead of their name on every survey. The reason for this code name was so that I could track the individual student responses for statistical and analytical comparison, while protecting anonymity. The following questions asked students about their gender, cultural status, and whether they had taken First Nations studies and/or a senior science course. These questions were asked each time so that data could be sorted according to several different relational groups. The student background questions used in the pre- and post-instructional surveys can be found in Appendix A (p. 202).

***The “Coastal Opinions” survey.*** The Coastal Opinions Survey was designed to assess students' overall feelings toward, and understanding of, science in their local environment. This survey sought to analyse what students' feelings were about their

science experience regarding their perceptions of the coastal environment and Aboriginal cultures. In assessing this, the survey was broken down into several related topics that addressed one aspect of the overall question. Students were presented with a number of statements, wherein each question focused on a specific theme.

Students responded to these statements by selecting one of four opinions; “Strongly Disagree,” “Disagree,” “Agree,” or “Strongly Agree.” Student responses were scored on a Likert-style scale from 1-4, in accordance to what was considered positive opinions that would be desirable outcomes of the program instruction (Gray & Guppy, 1994). These desirable outcomes would be, for example, an understanding and respect for multiple cultural perspectives of science, a sense of environmental awareness, and interest in learning about the local environment.

Some statements were reverse coded so that the selected student opinions were scored accordingly. This ensured that students read and understood the statements without assuming that a desired response would always be “Strongly Agree,” for example. Additionally, the survey utilized an even numbered Likert-style scale, with no “neutral” or “no opinion” choice, which forced students to make a decision and in order to more effectively discriminate opinions (Bradburn et al., 2004; Gray & Guppy, 1994).

As noted, the students completed an opinion survey prior to, and after the marine program. The first survey, “Coastal Opinions Survey A,” consisted of 29 items. After instruction, the students were administered “Coastal Opinions Survey B,” which consisted of 25 items and was similar to the initial opinion survey. The post-instructional survey contained small changes as some statements were reworded to reflect opinions either about the marine program, or with recognition that the statement referred to student

opinion after the program. Additionally, at the end of this post-instructional opinion survey, students had the opportunity to add additional comments regarding the program and their own thoughts.

The following examples show the student opinion concepts explored and some questions used in the pre and post- instructional “Coastal Opinion” surveys:

### **Student prior science experiences**

- I have enjoyed the science classes I have taken in the past. (pre)
- I **do not** feel that what I learned in this science class in the last month will be useful outside of school. (post)

### **Student ecological interests**

- I am interested in learning various ways to study the coastal marine environment. (pre)
- I would have preferred to learn about life in a different environment than the marine environment. (post)

### **Student experiences about learning about the environment at school**

- I often learn about the local plants and animals in school. (pre)
- I found learning the various ways to study the coastal marine environment interesting. (post)

### **Student beliefs about coastal resources**

- I feel that I know of a number of edible seashore plants and animals. (pre)
- I don't feel that seaweed is a food resource in BC. (post)

### **Student beliefs about human impacts on the coastal environment**

- I do not feel that my everyday life impacts the ocean. (pre)
- I feel that farmed salmon has negative impacts on the coast. (post)

### **Student beliefs about traditional knowledge and science culture**

- I do not feel that Aboriginal knowledge has contributed much to modern science. (pre)
- I feel that science should always involve the Scientific Method: observation, question, hypothesis and experimentation to draw accurate conclusions. (post)

The complete pre- and post-instructional “Coastal Opinions” surveys can be found in Appendix B (p. 203) and Appendix C (p. 206), respectively.

*The “Coastal Knowledge” survey.* The Coastal Knowledge Survey was a questionnaire designed as a typical, standardized multiple choice test with which students would be familiar. The questions focused on different aspects of marine and coastal studies such as oceanography, marine ecology, ocean resources and human impacts upon the coastal environment. Additionally, students’ familiarity with Aboriginal culture was explored through questions about TEKW, local Aboriginal groups, stories and traditional beliefs.

The questions in both the pre- and post-instructional knowledge surveys were adapted from Snively and Sheppy’s original survey entitled “Students and the Ocean” (1991), as previously noted. The adaptations included adjusting questions to a grade 11 level, adding local references and adding questions that would be addressed in the marine program, such as cross-cultural Aboriginal aspects involving TEKW and traditional stories.

One of the adjustments for the multiple choice questions was offering the occasional response of “I don’t know” in the pre-instructional knowledge survey. Rea and Parker (1992) suggest that there is a possibility of student guesses if they feel that they do not know the most correct answer, therefore, the possibility of including an “I don’t know” response may alleviate feelings of anxiety or random guesses (Sudman & Bradburn, 1982). A response of “I don’t know” can be interpreted as an incorrect response in the fact that students do not know enough to comfortably give another response. However, the option of this response was limited as this response may be overused by students not fully engaged in the questionnaire.

An initial multiple choice question set was established with 58 items, and grouped into related concepts. From this grouped item set, I ensured that all concept items were paired. The odd numbered questions were assigned to the pre-instructional knowledge test (Coastal Knowledge Survey A), and the even numbered questions were assigned to the post-instructional test (Coastal Knowledge Survey B).

Examples of the concepts and questions used in the “Coastal Knowledge” surveys were as follows (note that the online survey did not include concept headings, such as oceanography, traditional knowledge, *etc.*):

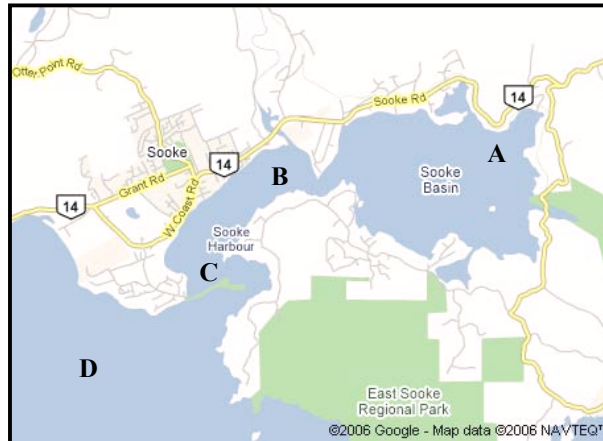
### **Oceanography**

Which statement is true about the sea water around Southern Vancouver Island?

- a) The sea water is cold and high in nutrients, but low in oxygen
- b) The sea water is relatively warm and low in nutrients
- c) The sea water is cold, high in oxygen and nutrients
- d) The sea water is cold and low in nutrients, but high in oxygen

In the map of Sooke, which area has the least movement of water?

- a) A
- b) B
- c) C
- d) D



## Marine Ecology

The main groups of seaweeds can be differentiated by...

- a) Their different types of photosynthetic pigments shown by their colour
- b) Their by-product of photosynthesis
- c) The part of the intertidal zone where they are found
- d) The habitat they provide for other organisms

What is plankton?

- a) Tiny single and multicellular **plants** floating in the ocean
- b) Tiny single and multicellular **animals** floating in the ocean
- c) Tiny single and multicellular **plants and animals** floating in the ocean
- d) All living things in the ocean that move with the current

## Coastal Resources

Which one of the following would not be found in B.C.?

- a) A seaweed farm
- b) A lobster farm
- c) An oyster farm
- d) A salmon farm

Which statement is true about seaweeds?

- a) Seaweeds are popular dried and eaten
- b) Seaweeds taste bad and are tough, so they are rarely eaten by humans
- c) Seaweeds are used to produce a thickener for puddings and ice cream
- d) None of these are true
- e) A and C are true

## Human Impacts

Household wastes and sewage...

- a) Do not contain chemicals like wastes from commercial industry
- b) Usually contain harmful chemicals from cleaning products
- c) Are always treated, so they are not harmful to sea creatures
- d) Do not damage the marine environment because of the dilution effects of the ocean

Which of the following environments will be most easily damaged by nearby human activities?

- a) A sandy beach on a surf swept outer coastline
- b) Rocky shores on a surf swept outer coastline
- c) In protected bays and estuaries
- d) The deep sea

## Traditional Knowledge

Many Aboriginal stories...

- a) Have little value other than entertainment and have no scientific merit
- b) Contain ecological and moral lessons
- c) Often change from generation to generation
- d) Both a & c
- e) I don't know

Many modern medicines have been derived from natural plants that were used medically by Aboriginal peoples for hundreds of years or more. This is an example of...

- a) The success of Modern Western Science
- b) Utilizing Traditional Knowledge
- c) A coincidence
- d) An important area in which to invest money

The complete “Coastal Knowledge” surveys “A” and “B” can be found in Appendix D (p. 209) and Appendix E (p. 215), respectively.

***Open-ended questions.*** The final part of the questionnaire involved two open-ended questions, titled “Coastal Open-Ended Questions.” This part of the survey included a student sketch of the local seashore and an “Applied Knowledge” question about studying potential human impacts upon the local marine environment. This open-ended section was used to expand upon the quantitative information gathered by the standardized knowledge survey, through the inclusion of more qualitative data. The benefit of these qualitative questions was that it allowed me to examine student beliefs

and knowledge, in a format that was “longer, more detailed and variable in content...” without “predetermining their perspective through prior selection of questionnaire categories...” (Patton, 1987, p. 11).

The following two questions were presented to the students for this open-ended section:

**1) Seashore Drawing and Identification of Seashore Creatures**

- a) Make a **sketch** of the *local (Sooke) seashore* and include as many organisms that you can think of in the sketch.
- b) Neatly **label** these animals in your sketch.
- c) Beneath the picture, include a **list of other marine organisms** found around Sooke that you were unable to include in the diagram

**2) Applied Knowledge**

The local Aboriginal Elders believe that the waters in and around the Sooke Basin have been affected since the introduction of salmon farms.

You are in charge of studying the possible effects of these farms. How would you approach the problem and what methods would you use to determine the possible impacts of the farms (use extra paper if you need)?

The student version of the “Open-ended Questions” section of the survey can be found in Appendix F (p. 221), along with the rubrics used to score these questions. More detail about the scoring of the open-ended questions can be found in “Procedures for Analysis” section of this chapter (p. 78).

The purpose of the seashore sketch was to examine the students’ conceptions and knowledge of the local marine environment, and to provide an alternative to the written response used for the second question. In addition to exploring students’ conceptions of life on the seashore, a sketch would allow an examination of students’ spatial perceptions of where on the shore these organisms live relative to the water. Students may know multiple seashore creatures, but may not be aware of the organisms’ habitat on the seashore (on rocks, in tidal pools, in sand, in mud, *etc.*), or may perceive that animals have an even distribution throughout this environment. Additionally, what kinds of

organisms were identified and what names the students used for specific organisms could be examined.

The applied knowledge question was a more challenging question. Of concern was seeing how students approached the problem of comparative marine study which sought to assess the potential environmental impact of a salmon farm. When required to utilize science in a practical sense outside of the classroom, it was examined if students were aware of any science related techniques in studying the marine environment and whether they saw traditional knowledge input as a potential source of information. In this sense, students' ideas in the practical use of water and population sampling for determination of ecological health were explored. Additionally, exploring what students viewed as valid scientific approaches could be noted. In this sense, it was examined if students recognized that scientific explorations of the environment incorporated more than just quantitative tests, but could involve qualitative information gathered through oral historical data from long term residents, such as the local Aboriginal people.

These same two questions were given in the same format to the students both before and after instruction.

### ***Procedures for Data Collection***

My integration into the EMCS Environmental Studies program for the purposes of this study, as well as the recruitment of the students involved many steps, but did not pose any great problems. I have had experience in the past working at Edward Milne in the past as a regular teacher-on-call for the science department, in addition to developing a First Nations self-paced classroom for students. As a result, I was well known to school

administration and students. I had mentioned to the administration, Mike Bobbitt and Megan Bondurant about utilizing the Environmental Studies program as a focus form my study. Formal letters and outlines of my intentions were sent to the Sooke school board district office as well as the principle of Edward Milne Community School.

Furthermore, information letters were sent to the three local Aboriginal band offices: T'Sou-ke, Pacheed-aht and Scianew. These letters were sent as there may have been students in the program from any one of these bands. Because I was introducing students to Aboriginal stories and the concept TEKW, and I felt that the bands should know that input, help or criticisms in the design and implementation of this program would be welcome. Repeated attempts to contact the band offices resulted with no responses, which meant that, unfortunately, there was no feedback from the local Aboriginal community for the program.

Prior to my first experience with the study group, Bobbitt and Bondurant had prepared the class for the expectations of the next few weeks and administered the pre-instructional surveys. Prior to the surveys, students had selected their code name, which was used to track their progress anonymously. The online surveys were completed during class hours in one of the school's computer labs, while the open-ended questions were completed in the classroom.

After the program, students again completed the surveys, as administered by Bobbitt and Bondurant. The surveys completed online were scored and stored securely online. In order to access the survey data, SurveyMethods.com required a secure login. Additionally, because of the use of codenames with the survey data, this information ensured student privacy. The scoring and recording of the data was completed

automatically online with a predetermined code developed when the surveys were designed. This eliminated human error in data marking and recording. This data was downloaded in Microsoft Excel format to my computer for analysis.

The open-ended questions were analysed by hand after the completion of the program. These questions were marked with rubrics and the scores were entered into Excel according to student codenames, awaiting analysis. Because of the use of codenames, student results from these questions could be matched with the online surveys and correlated with other personal information, while still maintaining anonymity of the students.

### ***Procedures for Data Analysis***

Both quantitative and qualitative data were included in the data collection as each presented their own strengths and weaknesses. Patton (1987) notes that the strength of quantitative data gathered from standardized questionnaire items is “succinct, parsimonious, and easily aggregated for analysis” (p. 11), which is important in simplifying the comparative nature of the data in this project. The multiple choice knowledge survey was already quantified as student responses were recorded as correct or incorrect. From this score, test means could be statistically compared. Furthermore, a closer look at what concepts received high and low results could be compared and examined for trends.

The exclusive use of quantitative data, as through only a multiple choice survey would present some problems. Overemphasis on quantitative data has been criticized by some authors as linked with positivism (Miles & Huberman, 1994). My personal

preference to avoid this association with positivism is due to both the “case study” requirement for multiple sources of data, and my program’s goal of teaching students that not all science needs to be in the form of Modern Western Science’s “Scientific Method” mode of thought. However, in order to increase the analytical strength of examining my program for its effectiveness, I needed to quantify much of my data for statistical analysis.

Qualitative data were collected from the opinions survey and the open-ended questions and for analytical purposes these data were quantified. Miles and Huberman (1994) notes that despite the benefits that qualitative data captures more essence, without restricting the scope of data collection, quantifying the data is often needed for analytical purposes. Furthermore, Weinstein and Tamur (1978) see quantification as a step which adds power and sensitivity to the overall ends of identifying patterns (as cited in Miles & Huberman, 1994).

The opinion surveys converted qualitative student opinions and feelings into quantifiable and comparable data. Kaplan (1964) recognizes that magnitudes of measured qualities can be seen as quantities (as cited in Miles & Huberman, 1994). In this sense, utilizing the scored Likert-style scale for student responses to how they felt about particular statements was an example of this quantifying of qualitative data.

Student responses to the open-ended questions were quantified using a marking rubric for each question. After the post-instructional surveys, all of the responses to the drawing and problem solving questions from both pre- and post-instruction were read. From examining the varied responses, themes and trends were coded to build a rubric for scoring each question. These rubrics broke each question down to three potential aspects

of students responses and these were scored from 1-4 in their level of detail. The “Seashore Sketch” was scored by the number and appropriateness of species shown, students’ ability to name locally and specifically, and evidence of ecological understandings, such as zonation and habitat. The “Applied Knowledge” question was scored by the thoroughness and detail of students’ responses, and the recognition and application of both traditional knowledge and Western modern science concepts. Of interest was noting how students would approach this problem, what they would identify were key components to examine and how they felt they could attempt to answer their questions. The thoroughness in addressing the problems that students identified, I looked to see how they understood how Western modern science could be applied. Additionally, I was interested in how students felt they could collect and apply traditional knowledge in a research setting. The marking rubrics for both open-ended questions are included with the “Coastal Open-ended Questions” in Appendix F (p. 221).

Multiple programs were utilized in the analysis of the quantified data collected in the pre and post surveys. As mentioned, the opinion and knowledge surveys were completed online with SurveyMethods.com, where the raw data was stored, and basic descriptive statistics were recorded. This data was downloaded and further organized in Microsoft Excel, with the quantified open-ended question data. Both SurveyMethods.com and Excel could be used to correlate data with individual participants for use in longitudinal analysis. Additionally, the data could be organized for relational analysis with participant data grouped according to their responses to the various background questions asked at the beginning of the surveys. Excel spreadsheets were used to find means, and to create comparative graphs.

Statistical analysis of data was completed using the Statistical Program for Social Sciences 14.0 (SPSS 14.0). This program was used to compare mean scores from the surveys utilizing one-tailed paired *t*-tests for equal variance ( $\alpha = .05$ ). In these *t*-tests the null hypothesis was that the marine program made no difference in student survey scores. One-tailed *t*-tests were used as it was assumed that student scores were unlikely to drop after instruction. Further use of SPSS 14.0 was for testing the internal reliability of the survey instruments with Cronbach's  $\alpha$  (alpha) and Guttman split-half as described in the next section: "Ensuring Validity and Reliability of the Survey Instruments."

### ***Ensuring Validity and Reliability of the Survey Instruments***

The validity and reliability of all three survey instruments were increased by various means. The basic validity and reliability of the survey instruments should have been reasonable as they were based on previously administered successful surveys (Cummins, 1997; Snively & Sheppy, 1991) that in themselves have been recognized. Furthermore, any alterations were tested with a trial group and peer reviewed.

The final "Coastal Opinions Survey" was analyzed for reliability through statistical tests for internal consistency with both Cronbach's  $\alpha$  (alpha) and Guttman split-half reliability tests. These tests for internal reliability are standard for a wide variety of survey instruments (Garson, 2008; Trochim, 2006). When the surveys were applied, questions exploring related constructs, or themes, were divided into two separate groups, which were administered in the same test. Essentially, the second half of the test utilized different items to examine similar themes. When using these tests, it was recognized that Cronbach's alpha should be at least 0.6 for exploratory research, but ideally higher than

0.7 to be considered a good instrument, whereas Guttman split-half should be closer to 0.8 or higher (Garson, 2008). Both tests for reliability were within acceptable, to good results. However, some questions did have slightly negative correlations with other questions. Although these questions were still valid questions in themselves in an exploratory sense, removing these questions increased the reliability of the test, as seen in Table 1.

Table 1

*Internal consistency of applied surveys in this study.*

<b>Survey</b>	<b>Cronbach's alpha</b>	<b>Guttman split-half</b>
Coastal opinion survey A (N=17, 29 items)	<b>0.831</b> (0.799) <sup>a</sup>	<b>0.859</b> (0.807) <sup>a</sup>
Coastal opinion survey B (N=16, 25 items)	<b>0.848</b>	<b>0.787</b>
Coastal knowledge survey A + B (N=14, 58 items)	<b>N/A</b>	<b>0.872</b>

*Note.* The score in brackets reflects correlation prior to removal of largest negatively correlated item.

<sup>a</sup> Prior to removal of question #22 due to poor correlation. This question was not used in statistical analysis.

The “Coastal Knowledge Surveys” were tested for internal reliability slightly differently than the opinion surveys. The knowledge survey was designed as one large, 58 item questionnaire that looked into several different aspects of the marine environment, including ecology, oceanography and others as described earlier. When this test was divided into two different, but matched surveys, it was assumed that the skill and knowledge level of each half would be equivalent. Because student knowledge levels were different during the pre and post surveys, the students also re-wrote the pre-instructional knowledge survey. Therefore both tests were written with the same level of knowledge. It was this result that was statistically analysed with Guttman split-half, to ensure both tests were equal in skill and knowledge level. The split-half was very high at

0.872, and no questions were removed (Table 1) Only the split-half method was used as Cronbach's alpha looks at inter-item correlation, which was not pertinent here, because only the paired items were of concern.

### ***Time Line***

Providing students with an effective outdoor marine program which incorporates an intertidal exploration requires convenient and sufficiently low tides during school hours. The best weather and time of low tides occur during May/ June and September/ October. Because of this limiting time factor, I needed to have the program prepared to run as soon as possible during the fall 2007 school year.

The peer review and administration of the trial survey instruments occurred during Semester 2 (Spring) 2007 Edward Milne Environmental Studies cohort. From feedback and analysis of the trial surveys, both survey questions and the curriculum were modified over the summer of 2007. Additionally, this group was used for several trial lessons and field excursions when tides were amenable for intertidal explorations.

I was introduced to the Environmental Studies Fall 2007 cohort in early September. The regular classroom teachers, Mike Bobbitt and Megan Bondurant introduced students to the program and handed out information and recruitment forms during the second week of the Fall program. I was made more acquainted with the students over a 4 day camping trip to Gabriola Island, which was not part of my marine program. The initial survey instruments were administered early during the third week of school. These surveys were examined for themes and preconceptions, so that any program adjustments could be made as soon as possible. I began the marine program by

the end of the third week of school. The initial field excursion and beach transect were organized to be completed before the end of September, in order to work with convenient time and tide. The marine program continued over three weeks, and the post instructional surveys were completed by mid October.

### ***Limitations of the Methodology***

The use of case studies has been criticized by some experts; however, it is the expectations and goals of the study that determine the research procedures. Tellis (1997) notes that case study methods, such as those used in this study are limited in providing generalizing conclusions. This lack in generalizability comes from the tendency of case studies to utilize small numbers. However, Tellis (1997) notes that even one case is sufficient, providing that it meets the stated goals of the program, and do not attempt to apply these findings to a greater population without further research. Therefore it was important that I applied my research findings to my specific research questions, within the bounds of my case.

Further limiting the generalizations of my particular case study was that this research violates some statistical and scientific underpinnings. The students in the program consisted of a non-random sample, as the whole Fall 2007 cohort was selected to participate in the study because they were enrolled in the Environmental Studies class. However, with the small samples that are often used in case studies, this case study utilized purposive sampling, in that I was specifically targeting the students taking the Environmental Studies course, and that I was able to obtain data from nearly the whole

cohort (Trochim, 2006). In this sense, the strength of my study increased with regards to this particular case, as data was collected and analysed from almost the whole cohort.

Improved testing of the survey instruments could have been used. The statistical analysis for reliability was limited to few tests of only a two groups, the trial group and the case cohort. Testing multiple groups, with the chance to alter and examine the effects of changes in retests would have increased the validity of the statistical calculations by reducing the chance of a type II error (rejecting the null hypothesis when there were differences). Other potential problems with the testing could have arisen from students' cognitive and reading abilities, as the surveys were very biased toward the assumption that reading would not pose a threat. Additionally, the test- retest instrument may have been biased toward improved scores in the post tests as students would have been familiar with the format and question style involved.

The timing of the program and testing was a further limitation. Because the class was not my own, and took place in another district, I could not apply the pre-instructional surveys immediately. The class experienced a multi-day camping trip to Gabriola Island prior to the program. On this field trip, many environmental aspects of forestry, invasive species and fish-farming were some of the topics addressed. The result is that the group was exposed to some of the concepts and ideas prior to instruction.

Furthermore, the assumption that my program was the sole causal factor of change may be incorrect. I was unable to follow what outside influences the students were exposed to during the program. These influences include media information from television, internet and books, what students were covering in other courses, or what

social interactions, or local environmental issues, may have altered students' knowledge and perceptions.

## Chapter 4: Pre-Instructional Findings

The following chapter examines the results and describes trends that emerged from the analysis of the pre-instructional “Coastal Opinions” and “Coastal Knowledge” surveys, in addition to the open-ended “Seashore Sketch” and “Applied Knowledge” questions. “Student Background” presents the diversity of backgrounds that students had in the study group through identifying gender, senior science experience, cultural heritage and previous experience with of Aboriginal culture. “Survey Trends” presents overall student opinions and understandings found in each of the pre-instructional surveys, independent of the other surveys.

Due the large amount of data collected, important findings were organised in topical and conceptual groupings. The trends presented in these sections were compiled from examining multiple surveys. “Student Interests and Experience in Science and Environmental Education” explored how students perceived prior science classes, experiences, and application to everyday life. Other topics included students’ knowledge and perceptions of the human use and management of “Coastal Resources,” and “Human Impacts” on the environment were examined from a community and ecological perspective. Student knowledge in modern marine science topics of “Oceanography,” and “Marine Ecology” were examined. Students’ perceptions and understandings of the “sub-culture” of science were examined, focusing on both WMS and TEKW. Students’ understandings, opinions and confidence in these topics were found to impact how students felt that they could monitor and help protect their environment, through their

feelings of “Locus of Control and the Environment.” Finally, “Relational Comparisons” explored how student backgrounds could affect any of the previously mentioned topics.

A detailed statistical analysis of the pre- and post-instructional surveys was completed. This examination of this data focused on results within each survey and topic, and directly compared the results of student scores prior to and after instruction, through a survey-to-survey and topic-to-topic analysis. The results from this examination were used in establishing the trends described in the pre- and post-instructional findings described in this chapter and Chapter 6: Post-Instructional Findings (p. 131).

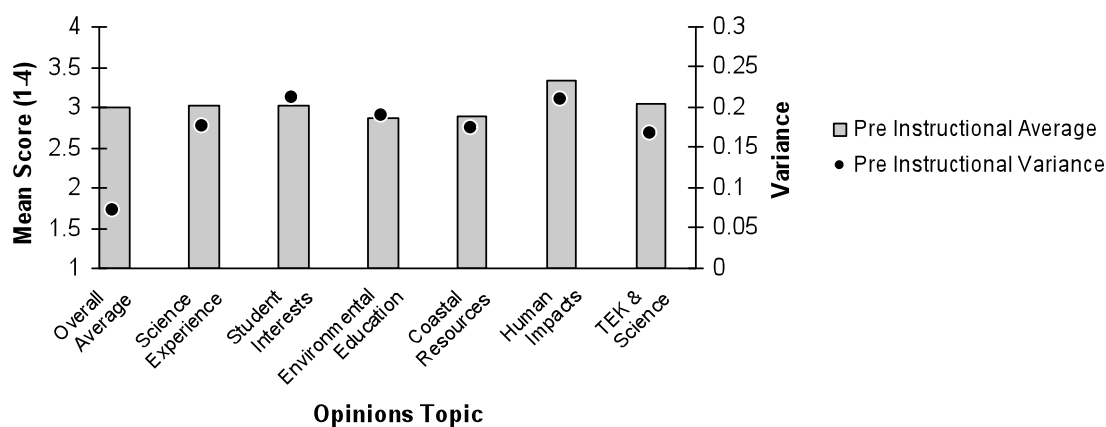
### ***Student Background***

The students participating in the program came from a variety of backgrounds and for aid in identifying any group trends in the data, these students described their personal background at the beginning of the Coastal Opinions and Coastal Knowledge surveys. From the total class size of 19 students (N=19) who were enrolled in the Fall 2007 Environmental Studies program, 10 (52.6 %) were male, 11 (57.9%) had previously taken a senior level science, such as biology, chemistry, or physics, and 5 students (26.3%) had taken First Nations 12. From this class, 8 (42.1%) students identified themselves at one point as either agreeing or strongly agreeing with considering themselves of Aboriginal heritage.

### ***Survey Trends***

***Coastal opinions survey.*** The “Coastal Opinions Survey” found that, overall, students’ opinions about the coastal environment and cultural science were in line with

the goals of the program (Figure 2). The mean score of 3.01 (out of a possible 4) showed that, on average, students “agreed” with the various statements presented in the survey. Although some students had opinions which averaged closer to a neutral overall opinion (2.5), other students held opinions that were already closely in line with the goals of the program (3.5).



*Figure 2.* Average opinion scores of students found from the pre-instructional “Coastal Opinions Survey” ( $M= 3.01$ ,  $SD= 0.265$ ,  $N=17$ ). Scores were recorded as an overall class average, and within the various topic areas explored in this survey. Also recorded was variation in student responses. From this data, the most positive opinion in line with the goals of the program scored 4, a neutral opinion scored 2.5 and the most negative opinion scored a 1.

These positive opinions were held, on average, across the topics explored in the opinion survey. These results suggested that students had positive opinions about their past science experience, such as enjoying previous science classes, and feeling that science is pertinent outside of school in understanding current events and possible future careers. Students showed an interest in learning about their local natural environment, feeling that understanding this environment should not be left only to “scientists.” Students also had positive opinions about their past environmental education at school, such as learning about the local forest and seashore environment. Students also felt that

they had a good understanding of coastal resources, such what resources may be found and how humans utilize these. Student opinions on human impacts suggested that they were often aware of how humans affect the coastal environment. Finally, overall, students had positive opinions about traditional knowledge, showing an understanding and respect for the culture and importance of Aboriginal stories.

The positive students' opinions towards the goals of the program were important findings. Ensuring that the students' opinions tended to be in line with the goals of the program was a key aspect to the implementation and success of the program. Snively and Corisglia (Snively, 1990; Snively & Corsiglia, 2001) already established the importance of teaching students parallel with their preconceived beliefs. Teaching parallel to students' beliefs can increase ease of learning and retention as students do not feel pressured to directly challenge aspects of their worldview where they may struggle against extensive assimilation of the new knowledge, instead of modifying current beliefs. As no students held opinions that were consistently opposed to the program's goals, it was expected that achieving the learning outcomes of the marine program would be successful and effective. However, areas of lower average opinion and high variance, such as "Coastal Resources" were recognized to require emphasis in instruction to guide all students' opinions toward the desired outcomes as supported by the community.

*Coastal knowledge survey.* The pre- instructional "Coastal Knowledge Survey" was used to examine students' current level of knowledge and preconceptions about various aspects of marine science, coastal resources and Aboriginal knowledge. The overall average in the pre-instructional knowledge survey showed that students had a

poor understanding of many of these concepts, with the class average of less than 48% (Figure 3). Analysis of the questions by concept topic showed the lowest understandings in the areas of ecology and coastal resources. However, like the student opinions survey, which showed strong positive opinions in understanding causes and effects of human impacts on the environment, students also scored high in the human impacts section of the knowledge survey; with a mean of over 70% correct.

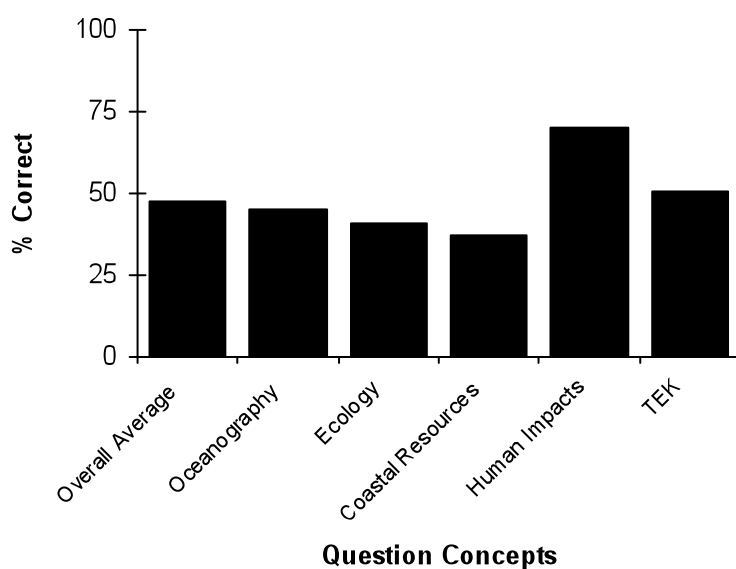
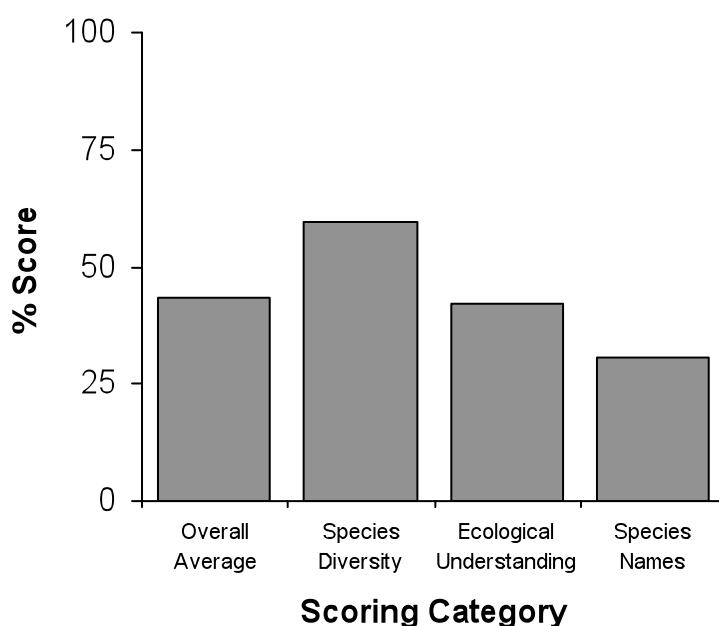


Figure 3. Student scores for the pre-instructional “Coastal Knowledge Survey A” ( $M= 47.4$ ,  $SD= 12.9$ ,  $N= 16$ ). Shown is the overall average of student scores, in addition to the average scores of specific topics examined in the survey.

***Seashore sketch.*** Prior to instruction, 13 students attempted the open-ended “Seashore Sketch.” This represented all of the students who successfully attempted at least one of the two parts of the open-ended section of the surveys, where the other part was the “Applied Knowledge” question. Overall, the students who attempted the seashore sketch had fairly low results, scoring an average of 43.6% (Figure 4), as scored with the marking rubric (Appendix F, p. 221). Examining the average student scores in

the three rubric marking categories found that the highest mean score was for “Species Diversity” at 59.6%, which focused upon only the number of different species included in the drawing. “Ecological Understanding” scored a lower mean, at 42.3%, where students were scored by their representation of organisms in correct habitats, such as tidal pools, under rocks, in the sand or in the correct tide zone. The lowest mean was 30.8% for naming specific species, which showed students tended to use general groupings for organisms, without specifying specific species.



*Figure 4.* Summary of student scores in the pre-instructional “Seashore Sketch” (N=13). Shown is the overall average, found through the scoring topics of “Species Diversity,” shown through numbers of different species, “Ecological Understanding,” shown by presenting organisms in proper habitats, such as tidal pools and intertidal zone, and use of specific “Species Names.”

Recognizing the range in skill levels of students in diagramming how they perceive their local sea shore, the specifics of the drawings ranged from a rudimentary understanding to detailed, but general impressions. Two examples of this range, with respective student scores are shown in Figure 5 and Figure 6.

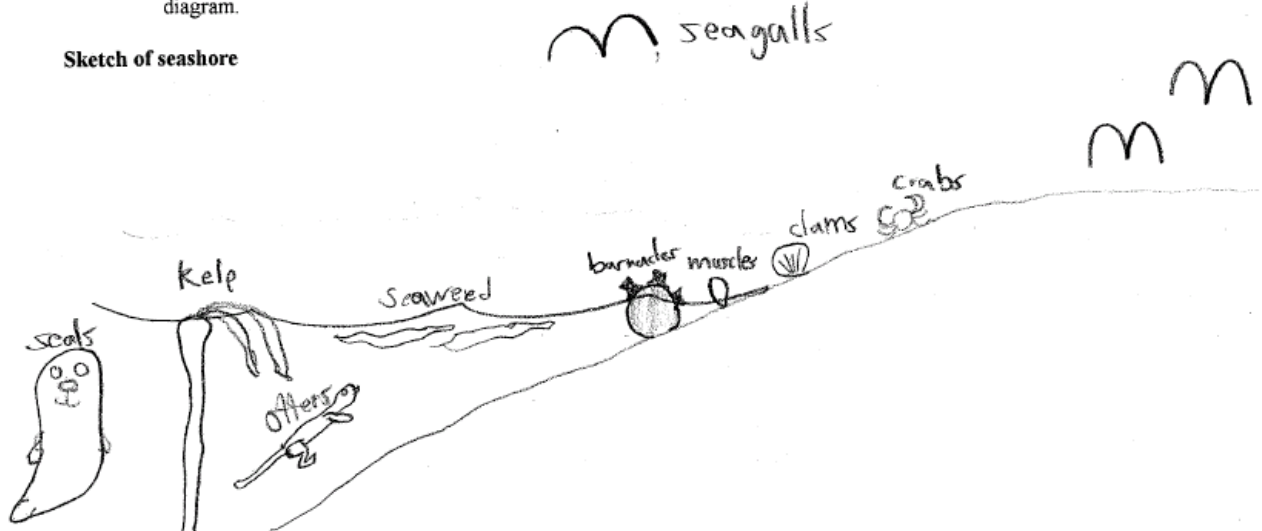
**Part 3: Open-Ended Questions**

Personal BC animal or plant code: Moss

**1) Seashore Drawing and Identification of Seashore Creatures**

- i. Make a sketch of the local (Sooke) seashore and include as many organisms that you can think of in the sketch.
- ii. Neatly label these animals in your sketch.
- iii. Beneath the picture, include a list of other marine organisms found around Sooke that you were unable to include in the diagram.

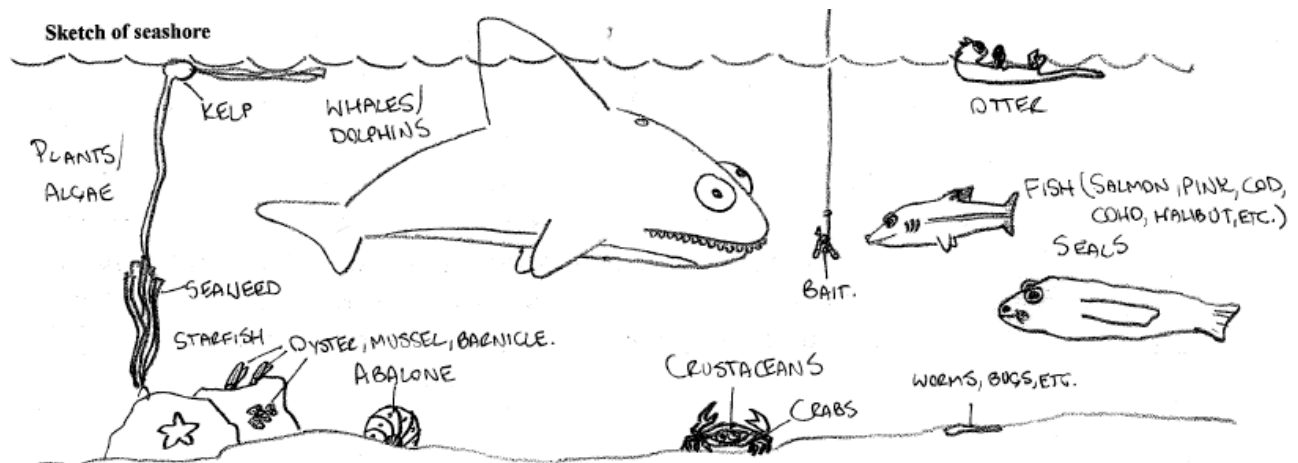
Sketch of seashore



Other marine organisms along the coast of BC

Figure 5. An example of a basic seashore sketch, where the student (*Moss*) does not include species specific names, detail of habitat, or large diversity of organisms. This diagram scored 5 of 12, showing low species diversity (2/4), minimal species specific naming (1/4), and a low recognition of habitat or ecological understanding (2/4).

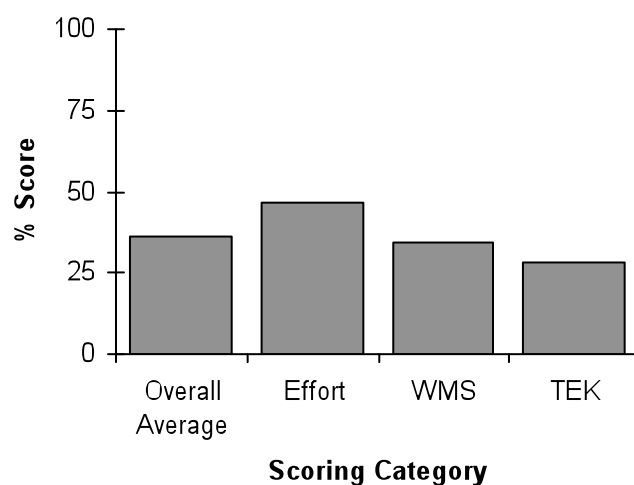
Sketch of seashore



Other marine organisms along the coast of BC

Figure 6. An example of a more skilled sketch, which scored 6/12. The student (*Oak*) included some species specific names (2/4), and a number of different species (3/4), but a minimal recognition of various specific seashore habitats (1/4) (drawn by *Oak*). This sketch scored 6/12.

**Applied knowledge.** The “Applied Knowledge” open- ended question was attempted by few students, and resulted in low scores. This question asked the students how they would approach a study to determine if the introduction of salmon farms in Sooke Basin may be affecting the water quality. Only 8 of the 13 students who attempted the open-ended part of the pre-instructional surveys attempted this question. Of the students who did attempt this question, the average score was very low, at only 36.5%, as scored with the rubric (Figure 7). Within the aspects of the question that were scored using the marking rubric which included overall effort and use of modern science equipment and techniques, students’ use of Traditional Ecological Knowledge appeared to be the most unfamiliar, with only two students directly addressing opinions or knowledge held by Aboriginal peoples. It was only these two students who scored above the minimum 1 out of 4 (25%) in this area.



*Figure 7.* Summary of student scores in the pre-instructional “Applied Knowledge” question (N=8). Shown is the overall average, found through the scoring topics “Effort,” use of “Western Modern Science (MWS),” and use of “Traditional Ecological Knowledge (TEK).”

The low number of students attempting this question, and the corresponding low scores, may have been because the students were able to visualize the concept of a seashore sketch over the open-ended written response. This question also posited an unfamiliar situation for students, such as being asked to design a study. A good response would have included examining water quality and marine life in the Sooke basin, while comparing this information to a site away from the affected area. In addition, a good approach to this research problem would have been to interview the Aboriginal elders who first noticed the theoretical problem, in order to establish some contextual and historical ecological information.

This lack of familiarity in study design was not unexpected. Often school-based scientific studies follow pre-designed methodology, to achieve pre-determined goals. Although such studies are used to educate students in methodology and theory, open thinking may often be discouraged for procedural and safety considerations in standard classroom laboratory explorations. However, aside from the low student attempts in the “Applied Knowledge” question, students also had very low scores, often resulting from students not knowing where to start. Some students admitted “I don’t know!” (*Lichen*), or “...before [I can help], I need to know what I’m doing,” (*Pine*). Many students responded to this question by describing the problems of fish farming, without addressing how to examine this as a method. All but one of the students (*Oak*) did not appear to recognize that interviews with long term residents, such as Aboriginal elders, could be used as a valid source of data, in addition to the more obvious modern western science techniques of water, sediment and population sampling. Additionally, some students might have felt that interviewing an elder for knowledge would not be an acceptable

response in the “science” classroom. Overall, it appeared that this question was outside of their realm of experience and beyond their pre-instructional skill level to answer.

### ***The Students’ Interests and Experience in Science and Environmental Education***

Prior to instruction, students already held generally positive opinions towards previous science instruction. Most students had found that past science classes were enjoyable, but found to lesser extents that science was useful outside of school, or applicable in finding a job. These are important aspects to acknowledge when designing science curriculum. Although making science interesting and enjoyable may be important in maintaining students’ attention, our goals as educators should be in connecting our subject areas to students and their environments outside the confines of the classroom. I feel that we need to reconsider the goals of science education to extend beyond a primarily academic scientific literacy in science and encourage students to believe in the applicability of science outside of the science classroom. Encouraging students to apply their knowledge in their community and environment reinforces learned concepts and promotes students’ understanding as to why they are learning specific science concepts.

When trying to engage students in learning science concepts, it was important to try to encourage interest in the subject and the local environment in which we would be studying. It was encouraging to find that students felt that studying the environment should not be left solely to trained scientists, and that students showed a strong interest in wanting to learn how to study the coastal environment. This aspect was important to

recognize and promote when trying to engage the students in the local environmental program.

There were a number of students who were more interested in studying tropical ecosystems, such as coral reefs, over the local environment. This interest in the tropical environment was expected, and one of the goals of the program was to establish a similar sense of wonder in the local environment. Tropical ecosystems hold a high percentage of popular media attention, to which students are inundated. Representing exotic travel destinations, the concentrations of life and colours in tropical hot spots, such as coral reefs, give these environments a “Hollywood sexy” for filmmakers and photographers. Unfortunately, many of our own BC students simply are not aware of the great diversity of intriguing and colourful organisms that occur in our own coastline, which may account for the high interest in coral reefs. Although this interest in the tropical environment should not be discouraged, it was important to encourage a sense of wonder and respect for the local, temperate environment, to successfully engage all of the students.

Although students felt that they had previously had positive learning experiences in environmental education and the coastal environment, opinions were split as to the frequency with which they were taught about the local environment. It was found that, overall, students did not feel strongly that education about the local environment was emphasized in school. However, a number of students felt that they were not taught about their local environment with any frequency. It is an unfortunate finding that students do not feel that they learn about their local environment with consistency, as making the connection between students and their community and environment should be an important aspect to any school education. This lack of emphasis on students’ local

environment may be part of the reason why many students did not feel that their science education was applicable outside of class, or in finding a coastal science related career.

### ***Coastal Resources***

Students' opinions and knowledge about coastal resources suggested a large discrepancy between what students believed they understood, and what knowledge they actually knew. Additionally, there was a wide variation of responses about coastal resources between students. While some students felt that they had a good understanding about coastal resources, such as fishing and from where their seafood comes, others admitted that they had no idea.

Students tended to recognize the diversity and importance of coastal food resources, however, when examining their knowledge of these topics, students scored less than 50% on the "Coastal Knowledge Survey" in this area. Only one student recognized that the total weight of fish being caught worldwide was still increasing, while the size of individual fish was decreasing. The majority of students thought the total weight of fish being caught worldwide was decreasing. Surprisingly, only four students recognized fishing as a shrinking economy in British Columbia, while most students believed that fishing was still a major resource. Less than half of the students recognized that most of the fish processing in BC is focused in Vancouver and the most common incorrect assumption being that fish were processed in towns near where they were caught.

This discrepancy between what students thought they knew about coastal resources and the actual findings, revealed some dangerous prior conceptions of students. If students weren't presented with contradicting evidence to challenge their previous

understandings in this area, they may carry these incorrect ideas into their adulthood. With incorrect understandings about resources, as decision making individuals, these students may unknowingly be making poor environmental choices, such as purchasing non-sustainable fish products at the local grocery store.

Part of the design of the marine program was to correct misled prior conceptions, and these surveys showed that it was definitely important to address these issues, in order to help form ecoliterate, decision- making adults. Nonetheless, it was still interesting to note that some of these conceptions about commercial fishing were still present in Sooke, which has seen a substantial decrease in commercial fishing over the past two decades. Unfortunately, students' experiences in gathering food from the grocery store, instead of the natural environment, and that the students are not old enough to remember expanded fishing fleets may contribute to their weak understandings of the coastal resources. The short term memories of part of the greater Sooke community may be a contributing factor for some residents who don't particularly believe in fishery and forestry conservationist strategies, while encouraging large-scale development.

Finally, students had a poor understanding of the term "conservation," which is an important aspect in understanding ecology and resource topics. In the knowledge survey, about two-thirds of the students did not recognize that "conservation" meant "using natural resources carefully, so that they are used slowly or replaced." Most of the incorrect responses chose "the total protection of all living plants and animals," which was a definition for "preservation." Differentiating the difference between these two terms is critical in environmental education, as these terms are common in all media when dealing with ecology and resource use. Students need to understand that

conservation officers and conservationists still recognize the need to use resources, while protecting the long term viability of these resources. If students assumed that any terms involving “conservation” were incompatible with human use may affect students’ beliefs and make acceptance of the program’s learning objectives difficult in communities such as Sooke, which have traditionally focused on resource extraction-based economies. Furthermore, it is important to have students recognize that there is a spectrum of levels in protecting and utilizing the environment and that many issues cannot be perceived in “black and white,” such as the stereotypical “logger” versus “tree- hugger.” Recognizing these ranges in conservation values may allow students to understand more perspectives in environmental issues.

### ***Human Impacts***

The pre-instructional surveys found that students already had very positive opinions, and knowledge of human impacts upon the coastal environment. These results showed that students were previously aware of many issues, such as the effects of salmon farms, logging and human development upon the coastal environment. The variations in student responses were mostly reflected in only the degree to which students’ opinions were parallel to the goals of the program. Additionally, the human impact section of the knowledge survey had the highest average score, which reinforced the extent to which students were familiar with this topic.

One of the contradicting results for human impacts in the pre-instructional surveys was the impacts of the timber industry upon the coast. There was a range of opinions on this aspect, and many students either felt that the timber industry did not impact the coast,

or were unsure as to these impacts. However, in the knowledge survey, most students recognized that the timber industry impacts the coast. Although students had little difficulty recognizing that salmon farming directly affects the water in its immediate environment, these students seemed to have less success in recognizing the connection between different industries and different ecosystems. In a resource-based community such as Sooke, it is an important understanding that irresponsible timber practices can increase run-off and siltation of salmon rivers, increase the deposition in bays, and decrease the diversity and productivity of the coastal environment. This is where studying the marine environment could make huge connections for students in understanding how human impacts can have effects all along coastal BC, as no ecosystem is truly independent from the others.

The level of knowledge and opinions in aspects of human impacts on the coast was important to identify. It was not clear whether these students gained their knowledge and perspectives from programs prior to the Environmental Studies program at Edward Milne, or whether this type of program would naturally attract students who were aware of these perspectives. Regardless of where students had previously gained their knowledge and opinions, understanding that students had a sufficient background in these areas helped expedite some of the goals of the program. The strict time limit on this program made teaching students all aspects of environmental impacts not practical, however, knowing that the students had some previous experience permitted the lessons to focus on reduced class time and more time for fieldtrips and environmental methodology. This jumpstart in environmental impacts also allowed the program more

time and effort in exploring other topic goals of the program, such as gaining skills in critical thinking for addressing environmental issues.

### ***Oceanography***

Prior to instruction, overall student averages suggested that they did not have a strong understanding of the oceanographic concepts examined. The class average for oceanographic concepts scored under 50% on the knowledge survey. A strong majority (81%) of students understood how much of the earth was covered by water, while most students (69%) recognized that the inshore waters in the Sooke Basin were most likely to see the warmest summer temperatures. Neither of these results came as a surprise, as many students are exposed to the statistics about our “Blue Planet” through educational films and many school programs which focus on water ecology. Additionally, students in Sooke have a good chance at experiencing the warmer waters of the Sooke Basin first hand, as it lies near to where many students live.

The more abstract questions scored predictably lower averages. About half of the students were not aware that corals occurred in both cold and warm waters, with 5 students assuming that corals lived exclusively in warm waters, and 3 responding “I don’t know.” I was surprised that half of the students did recognize that corals occurred in our coastal waters as well as warm waters, as cold water corals are not a commonly presented in media, when compared to the extensively filmed and photographed tropical reefs.

Another question with poor results involved understanding hydrodynamics about the mixing of waters when large rivers flowed into the ocean. Six students did recognize that the freshwater would remain on the surface and mix slowly, however, the majority of

students answered either “very quick mixing,” “fresh water sinks to the bottom” or that “the water would be evenly mixed when it reaches the ocean.” The latter response was understandable if a slow moving river traveled across an extensive delta or bay; however, the other responses suggested a poor understanding in hydrodynamics that affect many coastal areas. It is ecologically important to recognize that, under normal conditions, the less dense freshwater tends to flow above the denser salt water, which slowly mixes further down in the water column, until dispersion through distance or currents mix the water.

Finally, a surprising result was the extremely poor conception of the physical geography of British Columbia’s shoreline. The majority of students (81%) described the BC coast as mostly rocky and surf swept, while only 2 students recognized that it was mostly protected shoreline. This coastline is protected by a multitude of islands including Vancouver Island and the Gulf Islands, in addition to the coastal mountains protecting the numerous inland reaching fjords along the coast. This incorrect perception of a dominant rocky, surf swept coast may be due to the fact that the most dramatic and popularized representations of the BC coast focus on the extreme weather and rugged shore, as found in areas such as the Pacific Rim National Park. Additionally, Sooke is located on the southern end of Vancouver Island, where the Strait of Juan de Fuca opens to the Pacific Ocean, and is surrounded by many rocky beaches. For many of these students, their experiences with the BC coast confirmed the belief that it was rocky and surf swept. For students to understand the ecology and diversity of the BC coastal environment, it is important for students to recognize the variety of shorelines, from rocky, surf swept shores, to muddy tidal estuaries.

### ***Marine Ecology***

Pre- instructional conceptions regarding marine ecology came from the “Knowledge Survey” and the seashore sketch. These showed that students had a good understanding of sunlight as a primary source of energy, and that this same sunlight quickly disappeared with depth. Additionally, the importance of kelp forests in the coastal marine ecosystem was recognized, although most students thought that kelps and seaweeds were types of vascular plants. Notable weaknesses in student knowledge were found in recognition of species diversity and importance of habitat and zonation, in the intertidal environment. Reflecting these weaknesses were the mean knowledge survey score of only 41% for ecology questions and a mean seashore sketch score of 44%.

The effect of habitat on species diversity was found to be poorly understood through various examples. Only about one third of the students recognized that different species of clams would be found in different habitats, such as high surf conditions compared to calm waters conditions. One of the lowest scoring questions in the knowledge survey addressed recognizing that different sizes of barnacles in different tidal zones was due to different species. Many students assumed that the larger size of barnacles was due to increased food access. Some students may have assumed, through their own observations of the seashore, that the smaller barnacles founding the higher tide zones were immature or young barnacles of those larger ones found lower in the intertidal zone. In addition, students showed a poor understanding of the biotic and abiotic factors that affect intertidal organisms, such as predation and competition.

These prior conceptions which represented a lack in understanding of how habitat directly affects species composition and diversity were also reflected in the seashore sketches. Within these sketches, students rarely presented organisms within a specific tidal zone, or habitat, such as under rocks, or in the high tide zone. Organisms tended to be grouped as either below the sea level or in the intertidal. Most students were unable to identify more than ten different types of organisms in their drawings and in naming these organisms students tended to use general groups, such as “seaweeds,” or “barnacles,” without recognizing more specific species, such as “bull kelp,” or “acorn barnacles” (Figure 8).

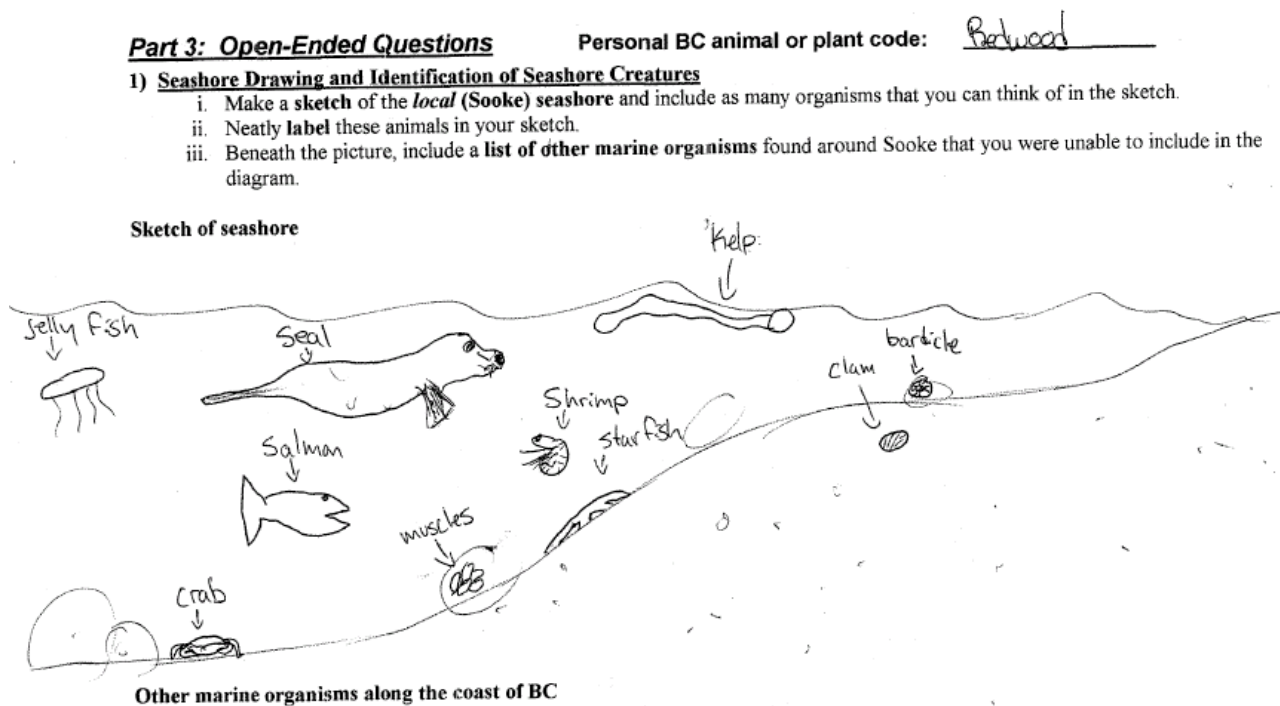


Figure 8. An example of the seashore sketch, where organisms are labeled by general group names, instead of specific species. This drawing scored 5 of 12 (42%).

This poor understanding of the specifics of seashore habitat and intertidal life may reflect students’ prior experiences in this environment. Many students were familiar with many beaches and the coastline in their local environment, but when asked for specifics,

these students showed a lack of an intimate understanding of their own local environment. This poor detailed understanding may be due to students' recreational experiences, and cursory explorations of these environments. The level of knowledge suggests a lack of guided, close examination of their environment, which would challenge students' previous conceptions of uniform habitats and lack of species diversity. When students are not subjected to these experiences in their personal life, it is very important for educators to take the responsibility in encouraging students to explore and question their environment with more rigor, and try to instill the sense of wonder and interest.

### ***Sub-Culture of Science, Modern and Traditional***

The students' conceptions and opinions about the culture of science was found through their understanding of how science is used now and its traditional uses by Aboriginal cultures. Students tended to have slightly favourable overall opinions about traditional knowledge and Aboriginal culture that were in line with the goals of the program. These favourable opinions were similar when exploring modern science concepts. However, the only slightly overall positive opinions and the approximately 51% score on the knowledge survey reflected that there were a number of students whose opinions were not already in line with the goals of the program and a number of incorrect perceptions were held by the students.

Students' opinions and knowledge of Aboriginal culture and traditional science were varied. When asked which band was not a local First Nations band, only one student did not incorrectly select the name of a local band that was in the Edward Milne

catchment area. Fortunately, no students selected the T'Sou-ke, after which the town of Sooke derives its name, and a number of students recognized that they simply did not know. Even the Aboriginal students and those that had taken First Nations 12 were unaware of the names of all three local bands. Other examples of poor understandings of Aboriginal culture was that students tended to not recognize that Aboriginal culture often considers its history with the local environment as "since time immemorial," one third of the students did not recognize the ability of Aboriginal groups to travel long distances along the coast, and two-thirds of the students did not recognize that the culturally universal stories of the "Great Flood" were scientifically valid. This validity has been recognized by numerous anthropologists who agree that flood stories passed down over generations may not represent any single, global flood event, but numerous different climatic events over the past, depending on geographic location of the culture (Wright et al., 1976).

The low score in the traditional ecological and Aboriginal knowledge section of the "Knowledge Survey" suggested that there were mixed opinions and experience in this concept. Although students tended to recognize the importance of moral and environmental lessons contained in Aboriginal stories for modern scientists on the knowledge survey, they held less positive opinions about the contributions of Aboriginal knowledge to modern science in the "Opinion Survey." Furthermore, students had very little idea of how to incorporate traditional knowledge into an actual ecological study, as presented in the "Applied Knowledge" question. In this written question, only one response suggested to "consult Aboriginal people" for traditional knowledge (*Oak*), but the response lacked any specific information or use of this knowledge.

Examining student knowledge and opinions in modern science uncovered a number of important trends. Students felt very strongly that science should not be left solely to professional scientists. Students were often able to recite scientific rhetoric presented to them about salmon farming, such as that it is bad for wild salmon because of sea lice contamination and that salmon farming introduces drugs into the environment; however, they seemed to lack the understanding about how this information could be collected. Additionally, a number of students responded simply with “I don’t know,” when asked to present some techniques in scientific ecological studying.

Recognizing Western Modern Science as a sub-culture also had mixed responses. It is important to recognize Modern Western Science as culturally based and biased, in order for students to recognize the importance of other cultural forms of science, or ways of knowing, and the possible associated biases. However, students had a varied response to recognizing the connection between culture and science, averaging a neutral class position. Reflecting students’ indoctrination to MWS concepts, about half of the class thought that science should only be done utilizing the Scientific Method. Although students may be recognizing the validity of the Scientific Method, students should realize that there are alternative methods in establishing valid knowledge, and as Elkana (1981) notes, all cultures have their own science (as cited in Snively & Corsiglia, 2001).

### ***Locus of Control and the Environment***

One of the major impressions about science that students held was that they felt they had little control in effective contributions to science, through such aspects as surveying, monitoring, protecting or even expressing their opinions regarding

environmental issues. Although students felt that science should not be left solely to scientists, that they wanted to learn how to study the local environment, students did not feel that they could do much to help. This lack in locus of control of the students was reflected in many of their responses in the surveys. In the written “Applied Knowledge” question, students felt unable to participate in this aspect of science through responses such as “Nobody listens to kids. I don’t know” (*Lichen*), “Before [I can help] I need to know what I am doing” (*Pine*), and “Someone just needs to smack somebody higher in government...and do something before [it’s] too late...” (*Dogwood*). The students’ perceptions were that either science was too difficult for them, or that their participation would not be acceptable. Additionally, several students were not comfortable with their knowledge in certain questions in the “Knowledge Survey” and in the 4 questions where the response of “I don’t know” was an option, students chose this option a total of 12 times.

Acknowledging that many students may not be comfortable with their ability in effectively participating in science is important. As educators, it is important to teach students more than just acknowledging the impacts of humans upon the environment, but to nurture a feeling of personal empowerment to address these issues. With this empowerment, teachers could not only encourage and ecoliterate community, but an eco-active community, that is willing to take an active role in ensuring the ecological integrity of their environment.

### ***Relational Comparisons***

Analysis of relational comparisons in the pre-instructional surveys found no obvious trends between gender, senior science or First Nations 12 experience. Through 2-tailed  $t$ -tests ( $\alpha = .05$ ) small relational differences in various aspects of the surveys were found, but none of these differences were common enough to be assessed as an overall trend. One significant difference was that students who had taken senior science showed an almost 24% higher in score for “Species Diversity” in the seashore sketch ( $M = 68.9$ ,  $SD = 17.7$ ,  $N = 8$ ) than students who had not taken a senior science ( $M = 45.0$ ,  $SD = 20.9$ ,  $N = 5$ ),  $t(11) = 2.20$ ,  $p = 0.050$ ). This increase may be due to students who had taken Biology 11, which focuses on examining and identifying species diversity of organisms, or experience in a more analytical view of the environment. Other considerations may be due to experiences and influences outside of the school; however determination of these influences was not an aspect of the study. Other differences found in this study sample was that students of Aboriginal heritage scored about 22% lower than average in opinions of human impacts on the coast ( $M = 2.97$ ,  $SD = 0.311$ ,  $N = 8$ ) than students who did not consider themselves of Aboriginal heritage ( $M = 3.64$ ,  $SD = 0.309$ ,  $N = 9$ ),  $t(15) = 4.45$ ,  $p < .001$ ). Additionally, students of Aboriginal heritage also had a 13% overall lower average in the knowledge survey ( $M = 40.9$ ,  $SD = 12.3$ ,  $N = 8$ ) than students considering themselves of non-Aboriginal heritage ( $M = 53.9$ ,  $SD = 10.4$ ,  $N = 8$ ),  $t(13.6) = 2.27$ ,  $p = .040$ ). The lower score in the knowledge survey was mostly due to low scores in the “Ecology” and “TEK” sections. This lower scoring in the “Coastal Knowledge Survey” may be seen as reflecting the traditionally lower provincial academic scores which Aboriginal students have been found to have in school sciences (Ministry of Education,

Province of British Columbia, 2006a). This lower scoring may be due, in part, to the teaching and testing strategies utilized in most schools, which is different from the traditional oral and experiential traditions of Aboriginal groups. It is not clear as to why Aboriginal students would have a lower scoring opinion of “Human Impacts,” however, like the “Senior Science” relational differences, there may be a number of influences which were not explored in this study.

### ***Pre-Instructional Summary***

The pre-instructional surveys uncovered a number of important findings in assessing students’ opinions and knowledge prior to the implementation of the cross-cultural marine program. Overall, students’ opinions were in line with the goals of the program, in regards to prior experience in science and environmental education, in addition to the opinions about Aboriginal culture and traditional knowledge.

Trends uncovered in this analysis are summarized in accordance to topic covered by this chapter:

- ***Student Interest & Experiences in Science and Environmental Education***
  - Students had positive opinions and experiences with previous science classes, scoring 3.0 out of a possible 4 points.
  - Students were interested in learning about and how to study the environment and using scientific equipment, scoring 3.1 out of a possible 4 points.
  - 24% of responses felt that the local environment was not emphasized in school and local ecology appears to have been taught inconsistently.

- ***Coastal Resources***
  - Students' opinions suggested that many felt they knew the issues surrounding various coastal resources (3.9/ 4), however, their actual knowledge of these industries and resources were shown to be weak, with only 37.5% correct responses in this area.
  - 63% (10 of 16) students were unaware of the differences between conservation and preservation, in resource management.
  
- ***Human Impacts***
  - Students had strong opinions (3.3/4) recognizing how humans impact the environment.
  - Students had a high level of knowledge about various human impacts upon the environment with a class mean of 70.3% in this topic.
  - It was apparent that students had previously been exposed to environmental issues through school or community.
  
- ***Oceanography***
  - Students did not have strong understandings of various concepts of oceanography, such as hydrodynamics and diversity of coastal shorelines, where the class mean was 50% for this concept.
  
- ***Marine Ecology***
  - Students tended to score low in ecological concepts with a class mean of 40.6% in the knowledge survey for this topic.
  - Seashore sketches showed a low understanding of species diversity, with 7 of 13 students unable to name more than 10 types of seashore organisms.
  - Only 3 of 13 students used any species specific names, such as "purple shore crab" instead of "crab."
  - Most students did not show an understanding of the importance of abiotic and biotic factors affecting organism habitat and biological zonation in the intertidal environment.

- ***Sub-culture of Science, Modern and Traditional***
  - Many students viewed science as enjoyable, but not applicable to everyday life.
  - Only 3 of 13 students were able to show some understanding of scientific methodology and techniques in developing and approach to study the environment.
  - Students had positive opinions respecting Aboriginal culture, with an average opinion score of 3.3/4.
  - Although general TEKW principals were acknowledged by most students, only one student was able to apply TEKW in an environmental monitoring situation.
  - 53% of the students (9 of 17) did not recognize the association between science and culture which suggests that most students were unaware of the cultural biases behind WMS and how it affects typical school science education.
  
- ***Locus of Control and the Environment***
  - All students' opinions expressed that scientists should not be the only ones to know how to research and monitor the environment; however 30% of written student responses suggested students believed that their opinions were not valid, and felt an inability to effectively participate in monitoring and protecting the environment.
  
- ***Relational Comparisons***
  - Gender and First Nations 12 experience had no significant impact on student knowledge or opinions in any category.
  - Students who had taken senior science (N=11) tended to have a 24% higher recognition of species diversity in the intertidal zone.
  - Students with Aboriginal heritage (N=8) scored 22% lower in opinions of human impacts on the coast and scored 13% lower than average on the knowledge survey. Both of these differences were significant.

## **Chapter 5: Applying a Cross-Cultural, Experiential Marine Science Curriculum**

### ***Introduction***

This chapter describes in some detail how the cross-cultural marine program was implemented after the pre-instructional surveys. This program was implemented over three intensive weeks, where classes were 2-3 hours per day. Fortunately, these long classes enabled many concepts to be covered as well as numerous field excursions.

This chapter covers three main components of the program: incorporating pre-instructional knowledge and opinions into the program design, classroom learning strategies, field explorations, and student learning assessment within the curriculum. “Incorporating pre-instructional knowledge and opinions into the program design” describes how the program was altered to reflect student responses in the trial group and the pre-instructional surveys. The “classroom learning strategies” is a large section which describes the methods utilized in establishing the theoretical background for the program, as well as a number of group activities to reinforce these concepts. These strategies include how Aboriginal science and TEKW was addressed and incorporated throughout the curriculum. This section also includes the methods in teaching coastal marine topics on ecology, resources and methods to monitor the coastal environment. The final section of the chapter addresses how students were evaluated in the program for school marks.

### ***Incorporating Pre-Instructional Knowledge and Opinions into Program Design***

Prior to instruction, the trial group, the pre-instructional questionnaire and my personal experience with EMCS students was used to recognize trends in the students’

prior conceptions and identify areas of interest to focus the program development and implementation of the curriculum. It was important to identify these prior conceptions before instruction as I previously had little experience with the Fall 2007 students, in terms of understanding their personal background, beliefs and level of knowledge in the program's material.

Working with the student trial and study groups allowed me to adjust some of the curriculum to address various aspects of these students' preconceptions. The experiences with the trial group were especially important as I did not have much time for alterations to the curriculum between the pre-instructional surveys and the instruction of the study group. The pre-instructional questionnaires and information observed and collected from the students suggested that most students enrolled in this program tended to not be academically strong, especially in the maths and sciences. However, the students did show an aptitude for the outdoors and had environmentally oriented opinions when it came to human impacts and environmental disturbances. Among the aspects of the curriculum I adjusted was salmon farming, which was removed from the program as students had previous knowledge of many of the negative impacts of this industry, and they tended to have opinions in this area already in line with the goals of the program. Omitting this section helped provide time for other concepts to which the students were less familiar, such as exploring various aspects of zonation of organisms in the intertidal environment. Many students were familiar with the diverse nature of seashore organisms, but emphasizing the contributing factors and patterns of zonation while in the field was required to effectively embed this concept. Many students had not had hands-on experience with scientific instruments outside of the class so utilizing class time prior

to field excursions to explain and practice with scientific instruments helped focus field experiences toward desired objectives, and maximized the use of outdoor time.

### ***Classroom Learning Strategies***

The classroom was used to introduce and develop students' understandings for theoretical concepts, such as TEKW, marine ecology, and marine survey equipment. These concepts were reinforced with group activities and discussions. Through teacher-guided PowerPoints, discussions and guided worksheets, students gained a background of information to further explore through the activities. Formal note taking was not emphasized as the program was focusing on experiential learning through activity and discussion. In addition, class time was used to prepare students for field excursions, such as purpose, logistics and equipment practice.

***Promoting Aboriginal science.*** Introducing students to the concept of Aboriginal Traditional Ecological Knowledge and Wisdom (TEKW) was an important aspect of my program. TEKW is being increasingly validated and utilized in modern research, and the Ministry of Education is encouraging more inclusion of TEKW into the study of the science. The most recent description of TEKW by the ministry in the Science 10 Integrated Research Package is:

Traditional Ecological Knowledge and Wisdom (TEKW) is defined as the study of systems of knowledge developed by a given culture. It brings the concept of wisdom to our discussion of science and technology. TEKW tends to be holistic, viewing the world as an interconnected whole where humans are not regarded as more important than nature. It is a subset of traditional science, and is considered a branch of biological and ecological science (Ministry of Education, Province of British Columbia, 2006d, p. 14)

Incorporating TEKW into the curriculum was carefully approached as I was aware that I had a Western scientific bias in my experience and culture. It was hoped that on at least two of the explorations I would have an elder accompany the class to share knowledge and stories, unfortunately both attempts did not materialize.

Introducing students to the concept of TEKW in the classroom involved encouraging the students to recognize that “Western Modern Science” was a view from one cultural perspective. In recognizing how science varied depending on cultural background, students were encouraged to think about the purpose of “science” and how it is affected by culture and spatial connections. In exploring the sub-culture of science, I felt that it was important to recognize how WMS and TEKW varied, and how they were similar, as one goal of this program was for students to acknowledge how different cultural views of science differ, yet can be complementary to each other. These lessons also explored the important concept of Intellectual Property Rights, and how, when working with TEKW, it is important to remember whose knowledge is being used, and respect its cultural sources. This introductory lesson in TEKW and the accompanying worksheets can be found in Appendix G (p. 226).

In exploring TEKW and the sub-culture of science, one of the instructional strategies I utilized was the use of stories, which is an integral form of cultural transmission of traditional knowledge with coastal Aboriginal cultures. Coastal Aboriginal stories were read to the class and examined for ecological and ethical validity, through guided group discussions. One such story read to the class was “Salmon Boy” (Caduto & Bruchac, 1991, p. 95). Through discussion, this story was found to have moral implications of respect for the environment and the organisms with which we share

our environment, as well as implicit ecological lessons about ecology and the recycling of nutrients. “Octopus and Raven” (Caduto & Bruchac, 1991, p. 73) taught young people to respect their elders, learn through observation, be aware of one’s surroundings on the seashore, and information on traditional tools and harvesting methods. In examining traditional orations, such as these stories, we explored how traditional cultures maintained ethics, environmental knowledge, and sustainable communities and environments.

Students also explored various “creation” and “flood” stories from several cultures around the world, and compared these with each other, as well as Western Modern Scientific beliefs. An interesting compilation of these stories was found online at “Morgana’s Observatory” (Morgana's Observatory, 2006), which included stories from various cultures including Greco-Roman, Salish, Sumerian, Judeo-Christian, Mayan, Japanese and many others. Creation stories were examined for relationships and differences, and how these stories may reflect these cultures’ beliefs. The common story of the flood was represented by many cultures including Western (Noah’s Ark), and numerous traditional cultures. Students were encouraged to recognize that some of these “stories” can be seen as a source of information to complement modern science in corroboration of a true historical rise in sea levels after the last ice age, or for other localized environmental anomalies. Additionally, other stories may represent metaphorical literature to impart important morals and lessons to children. The lesson on traditional stories and TEKW can be found in Appendix H (p. 236).

It was an important part of the program to show how traditional science, including traditional resource use and management could be used on its own, or complementary to WMS. Because of this, TEKW was a theme that was integrated with many of the lessons

and, whenever possible, students were presented with different cultural perspectives about similar topics. The cause, importance and effects of the rhythm of the tides were explored in both WMS and through coastal Aboriginal culture (Appendix I, p. 242). This concept was introduced through the Aboriginal story of “Raven and the Man who Sat on the Tides” as compiled by Barry McWilliams (1996), where the story was discussed for its importance and relevance. The information from the story were compared to and reinforced by guided notes on how the moon and sun affect the tidal cycles of the sea and how we can predict tides. These led to addressing how humans have traditionally, and continue to take advantage of these cycles in harvesting various resources from the coast, including fishing weirs and shellfish and seaweed harvesting.

Other forms of TEKW were examined when we explored coastal marine ecology, methods of monitoring the coastal environment and examples coastal resources. Within these aspects of the cross cultural marine program, the use and description of TEKW was incorporated into these topics, along with WMS. The purpose of this blending of perspectives was to encourage mutual respect for the application and viability of both cultural and scientific worldviews. It was felt that if both views were taught independently, students may perceive these perspectives as contrasting, instead of appreciating the cross-cultural views as complementary. Through this dual representation of science, it was hoped that student would feel comfortable to internalize each to the extent to which they felt comfortable.

***Marine ecology and resources.*** The concept of marine ecology was explored in the classroom utilizing PowerPoints and activities which focused on local coastal life and

resources. One of the first aspects addressed in ecology was to understand and brainstorm the various biotic (living) and abiotic (non-living) factors that influence the lives of marine organisms. These influences were examined with reference to impact on organisms that live in different intertidal zones, and how many of these organisms are adapted to these factors. This built upon an understanding of the tides, established by the cross-cultural tidal lesson.

Two important activities utilized Gloria Snively's "Pacific Coast Information Cards" (1999). These cards include a wide assortment of coastal marine organisms from various trophic levels, from primary producers to top predators (consumers), and decomposers. Each card has a drawing of the organism, or group of organisms in the case of microscopic organisms, on one side, and a description of these organisms on the back sides (Figure 9). These descriptions include formal naming, ecological information and human use and impacts.

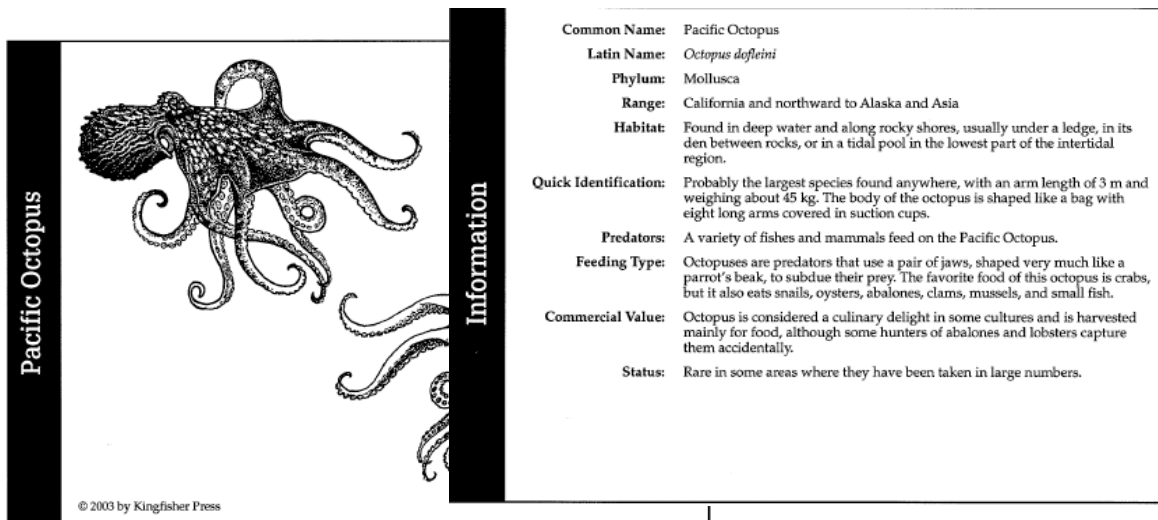
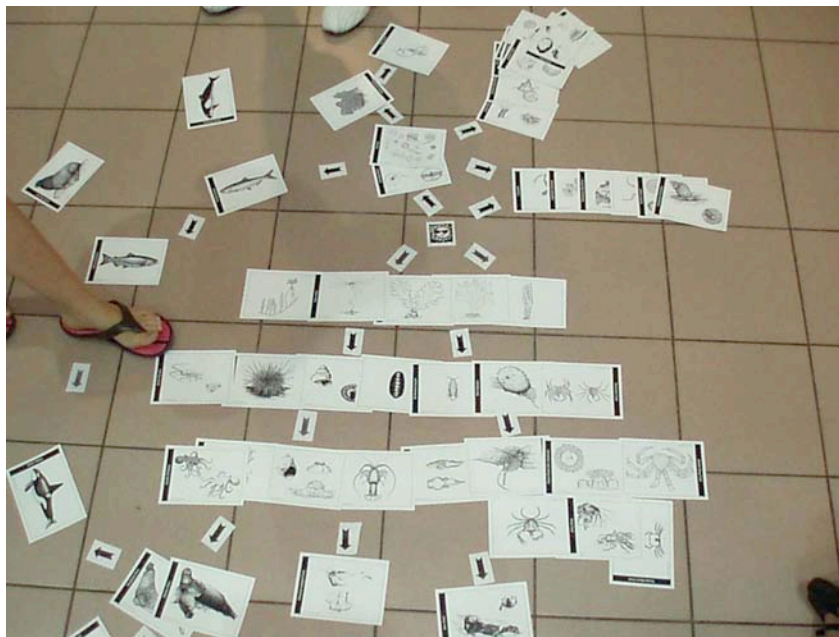


Figure 9. Example of Gloria Snively's "Pacific Coast Information Cards" (1999).

The first activity utilizing these cards involved students gathering an assortment of organisms across trophic levels and write a detailed description and sketch of each in their journal. It was important for students to note what biotic and abiotic factors may affect these animals, and their adaptations for survival. Once students had an understanding of the biology of a number of coastal organisms, they worked in groups to develop intricate marine food webs (Figure 10). While working on these food webs, groups were asked key questions, such as what organisms were important, what would happen an organism was removed and what impacts do humans have on this food web. This activity can be found in Appendix J (p. 248).



*Figure 10.* Food webs built by students using Gloria Snively's "Pacific Coast Information Cards." Arrows show the energy flow in these food webs.

After students were comfortable with some organisms, energy flow and tidal cycles in the marine environment, we explored the intertidal environment in more detail. Students were introduced to a survey of intertidal marine organisms including plankton, various kelps, cnidarians (sea anemones, jellies), echinoderms (sea stars, urchins),

crustaceans (crabs, shrimp), sponges, mollusks (clams, chitons, limpets, octopus) and to the higher consumers and predators. These organisms were presented within proper biological classifications, as utilized in Biology 11, so that students would develop a comparable knowledge for identifying and classifying organisms. Additionally, students worked with identification guides so that they would be able to utilize these effectively during field excursions.

With students' understandings of the organisms found along the coast, students were introduced to coastal resource management and issues. Modern views of resource management were examined, including addressing the potentially misunderstood preservationism (Muir) compared to conservationism (Pinchot) aspect, found in the pre-instructional surveys. Western/ European exploitationist and expansionist historical resource use was compared to and traditional Aboriginal resource views of long-term subsistence resource management. Effects from the modern fisheries and timber industry were discussed; in terms of over harvesting and water quality degradation. Traditional intertidal resource harvesting was presented, in addition to the traditional technology involved this harvesting, such as weirs, bentwood hooks and bull kelp fishing line (Figure 11). Modern smaller scale traditional resource use was introduced, such as seaweed farming and herring roe-on-kelp, showing how traditional science is still applicable to modern resource management.



*Figure 11.* A “traditional” halibut fishing line and bentwood hook made from bull kelp (line), cedar bark (twine) and Douglas fir (hook) made by D. Ashurst.

***Monitoring the coastal environment.*** Introducing students to methods and techniques of monitoring the coastal environment was an important part of the marine program. This concept intended to engage students in the field with modern scientific equipment in analyzing and exploring their own coastal environment. From this exploration, it was hoped that students would gain a deeper understanding about the factors that affect their community and ecosystems, develop a more intimate knowledge and association with the organisms on the coast and feel that they have a better understanding how science is accomplished in the environment. A PowerPoint introduced the purpose and various techniques in assessing coastal environmental health. This presentation included water quality testing for pH, temperature, dissolved oxygen and turbidity while assessing biotic conditions included the use of quadrats and plankton tows. The class brain stormed why these factors were important and how they could be utilized by not only scientists, but many other community members. Additionally, the

importance of traditional knowledge, observed by the long-term Aboriginal community, was discussed as important in understanding ecological trends in an area.

When specialized survey equipment was going to be used during an excursion, students were introduced to the equipment, its care and proper use, prior to the field experience. Some of this equipment was personally built at minimal costs and left with EMCS, including Secchi disks, and quadrat grids. Other equipment was borrowed from various local non-profit groups, such as The Marine Ecological Station, located in Sidney, BC ([www.mareco.org](http://www.mareco.org)) and West Wind Sea Lab, located in Victoria, BC (250-386-8036). Preparations and planning for field trips followed personal experience and suggestions presented by Gloria Snively in “Beach Explorations” (2003).

### ***Field Explorations***

An important aspect in developing the program was the focus on outdoor and experiential learning with the students. During the program, I was fortunate enough to have the opportunity to take the class on several excursions, with each excursion lasting between 2- 4 hours. These excursions resulted in approximately half of the instructional time with the student out of the classroom. This significant amount of time outside engaged students with hands-on, real life interactions with the environment, utilizing tools and enjoying social interactions that was critical in integrating this direct experience of the science lessons into students’ personal constructs. Locations of these field explorations and study sites can be found in Figure 1 (p. 62).

The field trips focused on exploration and experience in the coastal and marine environment to create a sense of wonder and appreciation for where the students lived

and to encourage closer analysis and questioning of their surroundings. For example, one field trip involved a hike through East Sooke Park. The goal of this trip was to informally explore the coastal environment in the region and examine a petroglyph (Figure 12) that was etched into the granitic rock near the shore. The walk along the shoreline and amongst the coastal forest had many informal teaching moments for the students as they examined and questioned various aspects of the environment.



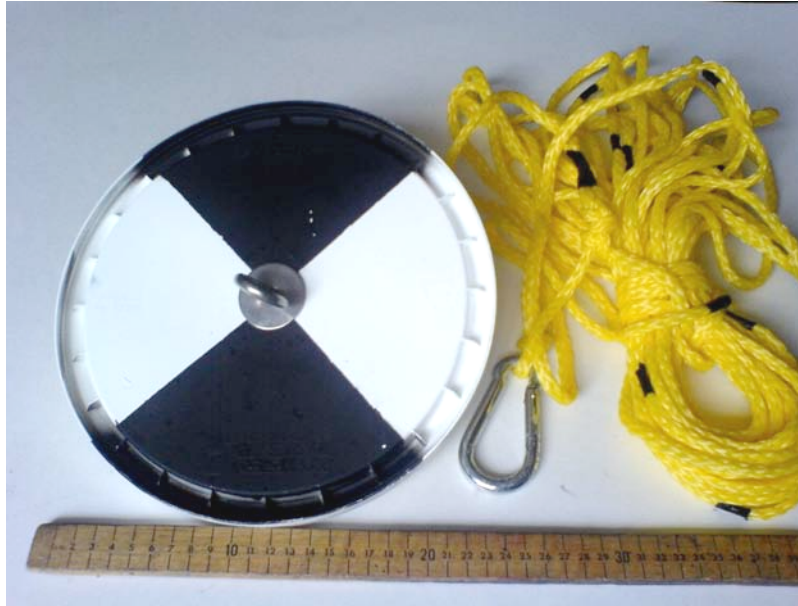
*Figure 12.* Petroglyph of seal or sea lion at East Sook park.

When we reached the petroglyph, many students were familiar with its existence but did not know much about its significance. It was during this time that we discussed aspects of Coast Salish people who lived along this part of the coast. This discussion included what the students thought about possible meanings of the petroglyph, how it was created and how Aboriginal people along the coast utilized resources. Theories regarding coastal petroglyphs included recognizing their importance as markers for hunting grounds, for a fresh water sources, and identifying territorial boundaries.

Other field trips had more specific purposes, including the use of various methods in studying the coastal environment. An exploration of the nearby Sooke River involved a class project of analyzing and recording water temperature and salinity at several

different locations from upstream to the Sooke Basin. The water was also visually analysed for turbidity, which is, essentially, the clarity of the water. The turbidity of the water could be affected by number of factors, such as sediment run-off and algal growth, which add particulate material to the water. Sample locations were recorded by the student groups on a map, and by GPS location, temperature was recorded using a thermometer, while salinity was recorded utilizing both a refractometer and a hydrometer. From the data collected, students were able to graph the increasing salinity and decreasing temperature of the water as we approached Sooke Basin. From this information students assessed different factors that would affect temperature, salinity and turbidity, and how these factors could affect organisms. Student individual and group data sheets for this project can be found in Appendix K (p. 249).

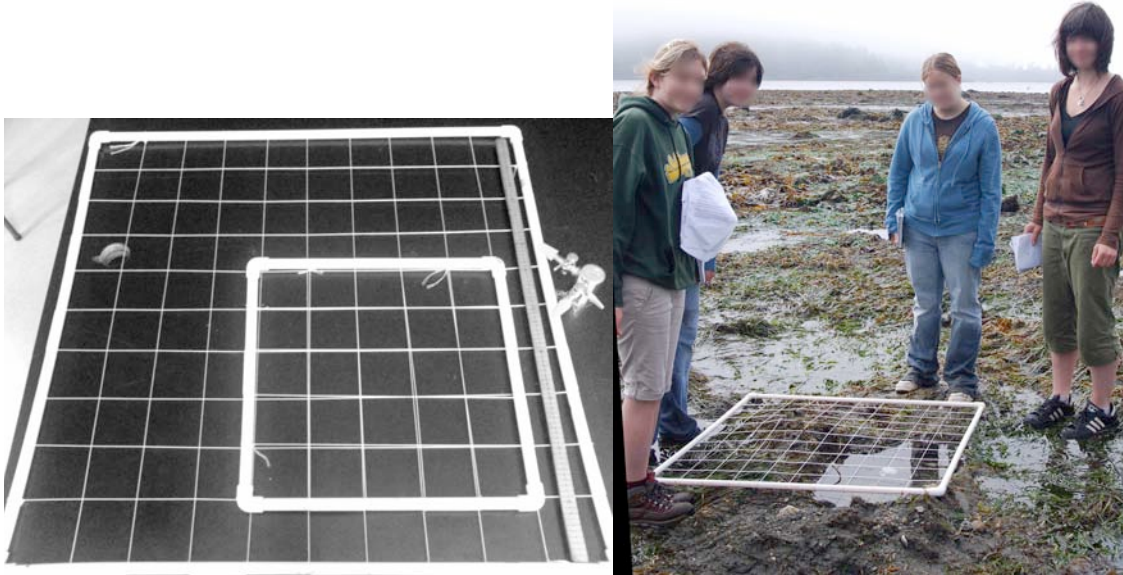
Students experienced a wildlife excursion by boat to look at various aspects of coastal wildlife and utilize different research instruments. While at sea the students were able to use a plankton net for a plankton tow from the vessel, in addition to successfully using the Secchi disks as instruments of marine science. The plankton tow uses a fine mesh dragged through the water column to concentrate small organisms, such as algae and animal larvae, for analysis. The Secchi disks are used to visually record water clarity, or turbidity, in the vertical water column (Figure 13) by recording the average depth between which the disc is no longer visible while being lowered, and the depth at which it is again visible while drawing it to the surface.



*Figure 13.* A home-made Secchi disk used to visually record water turbidity in the water column.

During this expedition the students visited Race Rocks Ecological Reserve/ Marine Protected Area ([www.racerocks.com](http://www.racerocks.com)), located off the southern tip of Vancouver Island, which is home to various species of seals, sea lions, bald eagles and other seabirds. In addition, the students visited Pearson International Collage of the Pacific, where they examined a grey whale skeleton near the docks.

The main project in the program involved an in-depth survey of the intertidal zone at nearby Whiffin Spit. This project incorporated students' understandings of the organisms and factors affecting these organisms in the intertidal zone. In preparation for this project, students practiced with identification cards and ID books of seaweeds and intertidal life. In class we had discussed how quadrats (Figure 14) and transect lines were to be used, and the importance of randomization in surveys which covered a large area. At the seahore, students were tasked specific jobs within their groups, including a recorder, an organism identifier, a quadrat setup and sampler and a habitat restorer (Figure 14).



*Figure 14.* Two home made quadrats- 1 x 1 m, and 0.5 x 0.5m (left). Students using a 1x1m quadrat to explore intertidal life on Wiffin Spit near Sooke (right).

Students surveyed one quadrat in each tidal zone, along one of three transects on the beach. Within each quadrat students photographed the sample area, identified and counted the organisms within the quadrat and detailed the factors affecting these organisms. Students were to theorize the impacts on their transect due to the effects of a salmon farm and global warming on this area. Additionally, students were to sketch one quadrat in detail, as well as a cross section of their entire transect. This project can be found in Appendix L (p. 255).

### ***Student Learning Assessment within the Curriculum***

The students were not subjected to formal testing during this program. They were expected to complete group projects, individual worksheets, and participate in class outings and discussions. Learning outcomes were reinforced through a weekly reflective journal entry in which they expressed their learnings and personal opinions. This

approach was used to maintain consistency with the student evaluations used the regular Environmental Studies instructors, Mike Bobbitt and Megan Bondurant. Through this evaluative method, students were graded holistically on participation, effort and class work. Formal testing was removed and appeared to work effectively to reduce the negative experiences associated with forced learning and formal assessments.

Additionally, the process of writing the reflective journals aided the students in summarizing their experiences, while providing me insight into what the students found interesting and important to their personal lives. This use of journals by students, through drawings, recording personal thoughts and summaries, has been shown to take experiential activities and “fixes that experience in long-term memory and stimulates relational thought” (Hammond, 2003, p. 34).

Although the formal assessment instruments of the success of the cross-cultural marine program reflected traditional testing methodology, the negative aspects that the students may have felt from this were mediated. As noted in the “Methodology” chapter, the students were aware that these surveys were voluntary and anonymous, and most students were willing to participate in every survey. Additionally, students were not expected to study for these assessments, as I was interested in what students were able to retain through the experiential nature of the program. Finally, I did not want the assessment of my program to negatively impact students’ experiences in the Environmental Studies program.

### *Summary*

The implementation of the cross-cultural marine science program was able to cover numerous topics in a very short timeframe. Adjusting the program to reflect trial and pre-instructional student responses was challenging in the short time frame, however, removing a some topics proved beneficial for making the most of the time allotted for the program. Introduction to Traditional science and TEKW was enjoyed by the students, as many of the activities were oral, reflecting the oral traditions of traditional cultures. Students also enjoyed an alternative approach to science that did not appear as strict as WMS. Encouraging students to learn about their local coastal environment seemed to be successful and most of the projects worked out as planned. The field excursions tended to have spare time for students to enjoy being outdoors and exploring and interacting outside of the school environment (Figure 15). Overall, students appeared to be eager and able to learn much of this material through practice and discussion. Additionally, students consistently showed respect for Aboriginal culture in class projects and discussions.



*Figure 15.* Students enjoying field explorations. A student enjoying kelp identification in East Sooke Park (*Laminaria sp.*) (left). Students exploring intertidal life from zodiac (right).

## Chapter 6: Post-Instructional Findings

This chapter examines the overall trends in student opinions and knowledge after the implementation of the cross-cultural experiential marine program. These opinions and knowledge were found through the post-instructional versions of the “Coastal Opinion Survey,” “Coastal Knowledge Survey,” and the open-ended “Seashore Sketch” and “Applied Knowledge” questions. Although this chapter does look at findings of the post-instructional surveys, there is a focus upon the effects of the program, through comparison between the surveys prior to and after instruction.

The topics for analysis and the order in which they are presented in this chapter are similar to Chapter 4: Pre-Instructional Findings (p. 87). “Student Backgrounds” examines how some students’ opinions about their cultural heritage were inconsistent. “Survey Trends” examines the general trends and scoring in the four post-instructional surveys, and their comparisons to the pre-instructional surveys. “Student interests and experience in the Program” examines how students enjoyed participation in the program and how it had changed their opinions regarding various aspects of environmental education and science. “Coastal Resources” explores changes in students’ opinions and knowledge about resource use, management and impacts upon the coast. “Human Impacts” explores how students perceived the effects of humans on the environment and their local ecology after instruction. “Oceanography” and “Marine Ecology” examines what level of knowledge students were able to demonstrate about some general marine science concepts regarding the abiotic and biotic coastal systems. “Culture of Science” explores how students’ perceptions of TEKW and WMS had changed and their recognition of science as sub-cultures. Changes in how students felt they could effect

change and sustainability in their local community and environment are explored in “Locus of Control and the Environment.” Finally, in “Relational Differences,” the students’ survey results were examined to identify if gender, education or cultural background affected the success of the program.

### ***Student Background***

All student background information remained the same between the beginning and end of the program, except for students who considered themselves Aboriginal heritage. Throughout the program, 8 students had considered themselves of Aboriginal heritage at some point, however, only 5 students maintained consistency in all responses (4 strongly agree, 1 agree). Two students changed their opinion from strongly disagreeing in the pre-instructional surveys, to strongly agreeing in the post-instructional, while one student had the opposite response.

In my experience, I have known a number of students who were of Aboriginal heritage, yet did not openly present themselves as Aboriginal. These students may have felt trepidation about presenting themselves as Aboriginal because of possible concerns over racial stereotyping, or they may have only wanted to their cultural differences recognized from the majority of non-Aboriginal students. One of the goals of the program was to encourage respect and understanding between Aboriginal and non-Aboriginal culture. With this mutual respect, all students were encouraged to recognize the contributions and perspectives of different cultures in the field of science. Additionally, this recognition of the important contributions of Aboriginal science would hopefully encourage pride and empowerment in Aboriginal students. It was possible that

the two students, whose responses changed toward strongly acknowledging their Aboriginal heritage, may have felt more pride or confidence in their heritage after recognizing the positive opinions presented toward TEKW in the program.

One student's opinion moved from strongly recognizing his Aboriginal heritage, to strongly denying this heritage. It is unclear as to why this student felt this way about acknowledging his heritage, and how the program may have moved his feelings in this direction. Unfortunately, due to the anonymous nature of the program, I can not identify any situations that may have affected a student negatively in this fashion. It is also possible that this student may have made a comprehension error in answering the question. Because of the small sample size of Aboriginal students, any differences in personal opinions were notable, and may be over examined.

### ***Survey Trends***

When the post-instructional findings were examined and compared to the pre-instructional, it was important to recognize that questions from the pre- and post-instructional surveys were not directly addressed during the program. Information related to the learning outcomes was presented in context, as part of activities or presentations. Many senior science classes that utilize practice tests and exemplar questions to teach toward the final provincial tests; however, this program did not concern students about the post- instructional knowledge surveys. Therefore, student knowledge in these questions was assessed by their impressions and recollection of the activities and not through focused study. I felt that this was important in assessing how and which parts of the program were incorporated into the students' schemas conceptual frameworks.

After instruction, the students were administered surveys to determine the changes in their knowledge and opinions. The “Coastal Opinions Survey” was similar to the pre-instructional survey, although some statements were adjusted to reflect the completed state of the program. The post-instructional “Coastal Knowledge Survey” was of a similar format and knowledge level as the pre-instructional knowledge survey, but consisted of different questions. The “Seashore Sketch” and the “Applied Knowledge” open-ended questions were identical to the pre-instructional questions. The students were also administered the exact same pre-instructional “Coastal Knowledge Survey” for direct comparison between pre- and post-instructional knowledge.

*Coastal opinions survey.* The post-instructional “Coastal Opinions Survey” found that after the program, students’ opinions towards the program’s goals were very positive. Although students’ opinions were generally favourable before the instruction, after instruction, these opinions tended overall to be even more positive (Figure 16). One student was noted whose opinions score decreased (*Pine*), however, the lower score was small and the student still had very positive overall opinions.

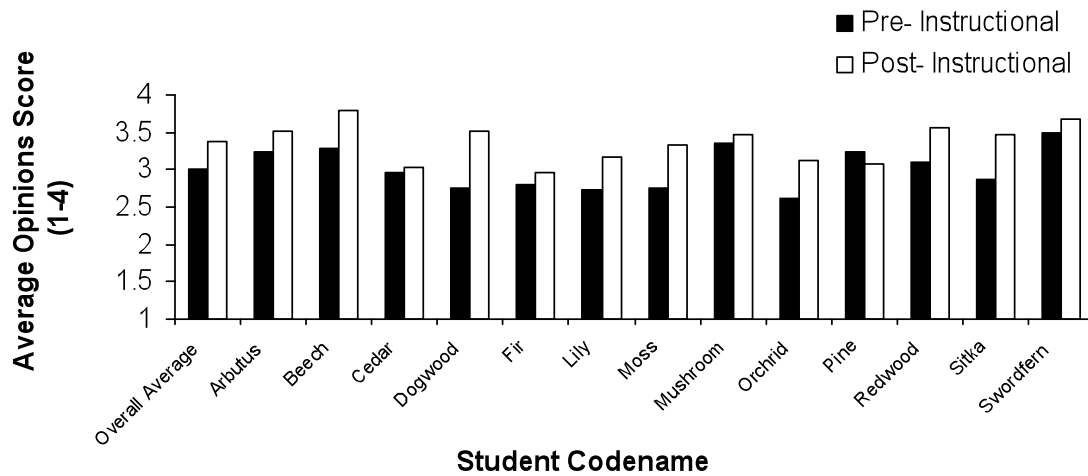


Figure 16. Average scores from students who completed both the pre-instructional and post-instructional “Coastal Opinion” surveys (N= 14). Student opinions were scored on a Likert-style scale representing student opinions toward the goals of the program.

The improvement in student opinions was reflected in most aspects of the survey examined (Figure 17), in both mean score and a decrease in response variance. Paired *t*-tests of these 14 students found that average pre- instructional opinion score ( $M= 3.01$ ,  $SD= 0.271$ ) significantly increased by 0.368 (12.3%) after instruction ( $M= 3.38$ ,  $SD= 0.264$ ),  $t(13)= 5.35$ ,  $p< .001$  (Table 2). These figures correspond similarly with a *t*-test of means between the pre- instructional ( $M= 3.01$ ,  $SD= 0.265$ ,  $N= 17$ ) and the post- instructional scores ( $M= 3.39$ ,  $SD= 0.247$ ,  $N= 16$ ) which showed a significant increase in opinion score by 12.7% (0.381),  $t(15)= 6.17$ ,  $p< .001$ ). This improved score was important to find as it showed that the program’s education goals had not exhausted the students, who enjoyed the program, despite the short time line, and encouraged their interest in many of the areas covered in the program, such as Traditional Ecological Knowledge and marine ecology.

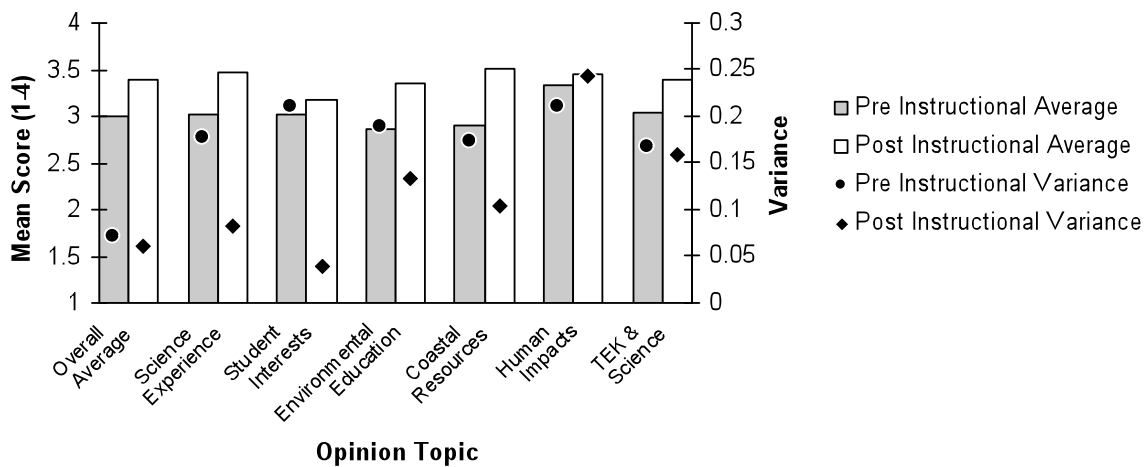


Figure 17. Average topic scores and variances of responses on the pre- (N=17) and post-instructional (N=16) “Coastal Opinions” surveys. In this scale, 1 represented a negative opinion and a 4 represented the most favorable opinion.

Table 2

Statistical analysis using one-tailed paired *t*-tests of average opinion scores of students between the pre- and post-instructional “Coastal Opinion” surveys (N= 14). Included is the mean difference in scores.

Topic Section	Survey: Pre/Post	M	SD	Mean Difference	df	<i>t</i> -value	<i>p</i> -value ( $\alpha = .05$ )																																																													
Overall Average	Pre	3.01	.271	+0.368	13	5.35	<.001																																																													
	Post	3.38	.264					Science Experience	Pre	2.98	.433	+0.482	13	4.28	<.001	Post	3.46	.308	Student Interests	Pre	3.05	.482	+0.125	13	1.02	.163 <sup>a</sup>	Post	3.18	.206	Environmental Education	Pre	2.87	.477	+0.524	13	3.56	.002	Post	3.39	.376	Coastal Resources	Pre	2.89	.435	+0.607	13	4.40	<.001	Post	3.50	.340	Human Impacts	Pre	3.36	.401	+0.0893	13	0.637	.268 <sup>a</sup>	Post	3.45	.521	TEK & Science	Pre	3.05	.431	+0.298	13
Science Experience	Pre	2.98	.433	+0.482	13	4.28	<.001																																																													
	Post	3.46	.308					Student Interests	Pre	3.05	.482	+0.125	13	1.02	.163 <sup>a</sup>	Post	3.18	.206	Environmental Education	Pre	2.87	.477	+0.524	13	3.56	.002	Post	3.39	.376	Coastal Resources	Pre	2.89	.435	+0.607	13	4.40	<.001	Post	3.50	.340	Human Impacts	Pre	3.36	.401	+0.0893	13	0.637	.268 <sup>a</sup>	Post	3.45	.521	TEK & Science	Pre	3.05	.431	+0.298	13	2.76	.008	Post	3.35	.400						
Student Interests	Pre	3.05	.482	+0.125	13	1.02	.163 <sup>a</sup>																																																													
	Post	3.18	.206					Environmental Education	Pre	2.87	.477	+0.524	13	3.56	.002	Post	3.39	.376	Coastal Resources	Pre	2.89	.435	+0.607	13	4.40	<.001	Post	3.50	.340	Human Impacts	Pre	3.36	.401	+0.0893	13	0.637	.268 <sup>a</sup>	Post	3.45	.521	TEK & Science	Pre	3.05	.431	+0.298	13	2.76	.008	Post	3.35	.400																	
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	Post	3.35	.400																																																																	

<sup>a</sup> Not statistically significant

Although the average opinion score for each topic increased after instruction, paired *t*-tests (N=14) showed that not all were significant, as seen in Table 2. Significant

increases in opinions included 16.1% in science experience, 17.5% in environmental education, 20.2% in coastal resources and a 9.93% in Traditional Ecological Knowledge and science. The exception to this trend was “Human Impacts,” where the overall opinion score increased, however, the variance also increased, suggesting minimal effect from instruction.

The decrease in student opinion variance in most aspects of the survey was a strong indicator of the overall student opinions matching the goals of the program. The increase in opinion scores suggested that more students felt that they “Agreed” or “Strongly Agreed” with many of the survey statements, however, the decrease in variance of student responses in most of the topics indicated that despite a diversity of responses, students were much more likely to select similar positive responses. This showed that the overall student trend resulted in very few negative responses, and that most of the variance was between whether students agreed or strongly agreed with the survey statements.

***Coastal knowledge surveys.*** Both versions of the “Coastal Knowledge” surveys had similar results in verifying that overall student knowledge was significantly improved by program participation (Figure 18). The post- instructional re-test of the “Coastal Knowledge Survey-A” was completed by 15 students with a mean score of 18.6 of 29, or 64.1% (SD= 4.36). A paired *t*-test found a significant increase in student mean score by 15.8% between the pre-instructional survey (M= 50.0, SD= 8.38, N= 12) and the same survey administered after instruction (M= 65.8, SD= 16.1, N= 12),  $t(11)= 4.75$ ,  $p= <.001$ . A comparison of means showed similar results (N=15).

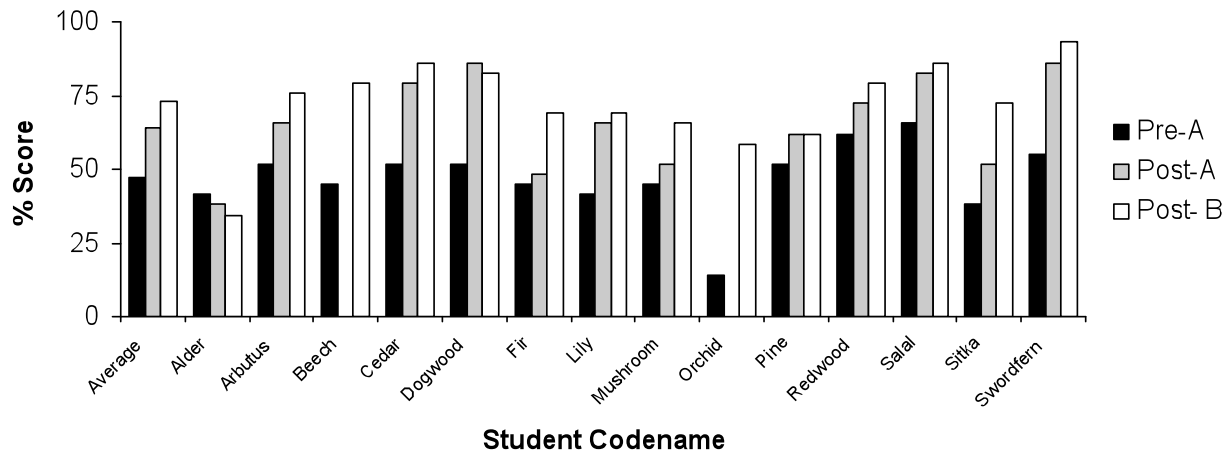


Figure 18. Individual scores of students who took the “Coastal Knowledge Survey” prior to and after instruction (N=14). Version A was administered prior to and after instruction while version B was only administered after instruction.

The post- instructional “Coastal Knowledge Survey- B” was completed by 17 students of 19 students in the program, whose mean score was 21.1 of 29, or 72.8% (SD= 4.18). A paired *t*-test showed that the mean student score of 47.0 % in the pre-instructional survey (SD=12.4, N= 14) increased 25.4% to 72.4% for the post-instructional knowledge survey “B” (SD= 14.8, N= 14),  $t(13)= 7.29, p < .001$ . This result was similar when comparing *t*-test of means (N=17). Comparison by topic of the pre- and post- instructional knowledge surveys A & B are summarized in (Figure 19).

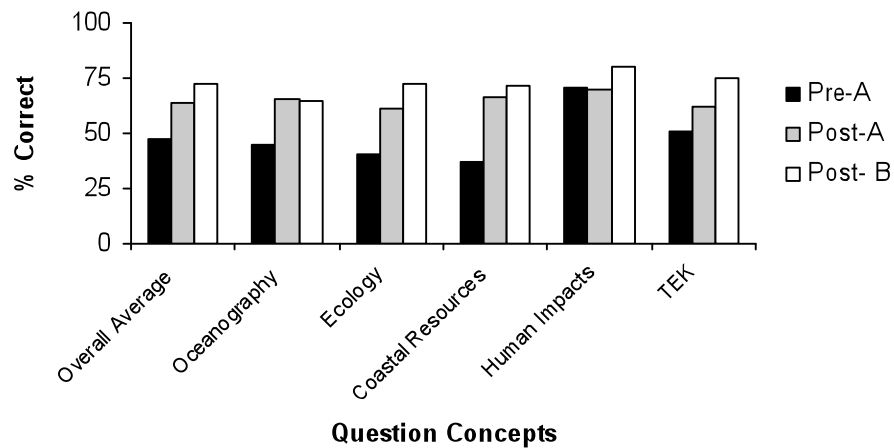


Figure 19. Student scores for the “Coastal Knowledge Survey.” Compared is the total score and combined scores for questions focusing on similar concepts. Three tests were compared, pre-instructional, version A (pre-A, N=16), post-instructional version A (post-A, N= 15) and the post-instructional version B (post- B, N= 17).

These results are statistically compared in paired *t*-tests in Table 3. Comparison of student performance in pre- instructional knowledge test ‘A’ and post- instructional knowledge test ‘B’ showed significant improvement in all concept areas except for “Human Impacts” (N=12). The re-test of knowledge survey ‘A’ after instruction showed significant improvements ( $p < .05$ ) in “Oceanography,” “Ecology,” and “Coastal Resources” (N= 14). The mean score for questions on “Human Impacts” on this re-test of version ‘A’ actually dropped slightly (2.08%), although insignificantly ( $p > .1$ ).

Table 3

Statistical comparison through one-tailed paired *t*-tests of percentage mean student scores between the pre-instructional “Coastal Knowledge Survey ‘A’” and post- instructional knowledge survey ‘B’ (*N*= 12) and both pre & post instructional knowledge survey ‘A’ (*N*= 14)

Topic Section	Survey:		M	SD	Mean Difference	df	<i>t</i> -value	<i>p</i> - value ( $\alpha = .05$ )
	Pre/Post (Version)							
Overall Average	Pre (A)		47.0	12.4	25.4	13	4.75	<.001
	Post (B)		72.4	14.8				
	Pre (A)		50.0	8.38	15.8	11	7.29	<.001
	Post (A)		65.8	16.1				
Oceanography	Pre (A)		45.7	19.9	20.0	13	2.19	.024
	Post (B)		65.7	27.7				
	Pre (A)		50.0	18.1	16.7	11	1.97	.038
	Post (A)		66.7	17.8				
Ecology	Pre (A)		40.2	17.8	28.2	13	4.85	<.001
	Post (B)		68.4	16.0				
	Pre (A)		41.7	18.7	19.8	11	3.98	.001
	Post (A)		61.5	20.3				
Coastal Resources	Pre (A)		35.7	22.4	35.7	13	4.23	<.001
	Post (B)		71.4	28.0				
	Pre (A)		36.7	20.6	33.3	11	4.24	<.001
	Post (A)		70.0	27.6				
Human Impacts	Pre (A)		69.6	22.3	11.8	13	1.54	.074 <sup>a</sup>
	Post (B)		81.4	18.3				
	Pre (A)		75.0	18.5	-2.08	11	-.266	.398 <sup>a</sup>
	Post (A)		72.9	27.1				
TEK	Pre (A)		51.0	20.8	24.5	13	4.04	<.001
	Post (B)		75.5	16.3				
	Pre (A)		54.8	15.9	8.33	11	1.21	.127 <sup>a</sup>
	Post (A)		63.1	16.6				

Note: <sup>a</sup> not significant results ( $p > .05$ )

These results suggest that the program increased students’ knowledge effectively in most of the aspects of the program that were the educational goals. Some increases in average student scores could be seen around 25%, such as in “Coastal Resources” and “Ecology” topics. Although questions about “Human Impacts” showed that instruction did not effect the same amount of improvement as other topic areas, the pre- and post-instructional scores were already very high in this area for both versions of the survey.

Notably, after instruction, no concept areas had a mean class score lower than 64%, which was higher than the pre-instructional scores in all areas, except “Human Impacts.” Additionally, although 17 questions scored below 50% on the pre-instructional “A” survey, only 5 questions scored below 50% on each of the post-instructional knowledge surveys.

The improvement in student scores for both versions of the survey was important for different reasons. The improvement in the post-instructional survey “B” was of particular importance as this was the formal comparative survey. This survey had not previously been attempted by students, yet had the most significant increase. This result showed that students increased their knowledge through the instruction and not due to student discussion about the questions or test-retest improvement. The re-application of the knowledge survey “A” showed the expected improved results. However, the post-instructional knowledge survey “A” could be used, along with the survey “B” to indicate areas of instruction that were not adequately addressed. These areas are discussed within the appropriate topic sections later in this chapter.



Of the students who attempted the open-ended questions, 16 of 17 students completed the seashore sketch. Through the scoring rubric, the total mean score increased by about 30% to 72.4% (SD= 20.1, N=16), with similar strong effect sizes in all the scoring categories (Figure 22). “Species Diversity” had the smallest increase as a total mean (12%), but showed a 25% increase when comparing students who completed both the pre- and post-instructional drawings. Paired t-tests between the 10 students who completed both pre- and post- instructional drawings showed statistically significant improvements of at least 25% in the mean scores in all categories ( $p < .05$ ), as shown in Table 4.

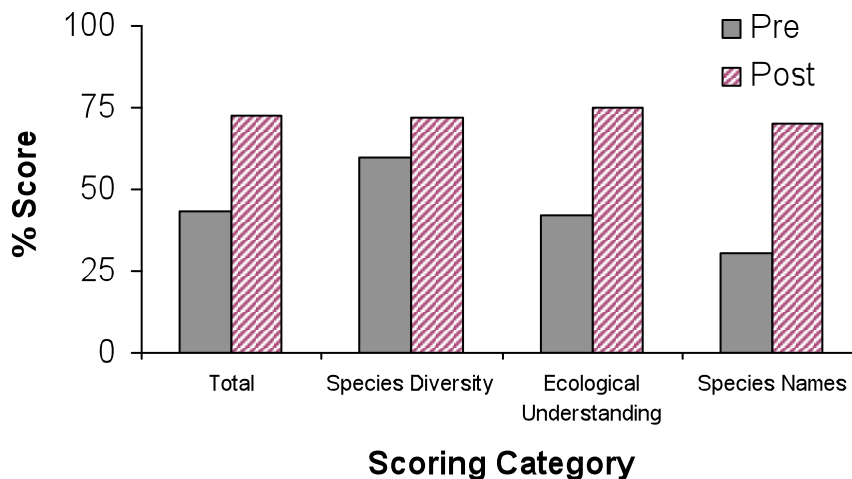


Figure 22. Mean student scores of the “Seashore Sketch” open-ended question item. Compared is the total score and individually scored categories between the pre (N= 13) and post- instructional (N= 17) surveys.

Table 4

Statistical comparison of percentage student scores of the “Seashore Sketch” question item through one-tailed paired *t*-tests ( $N=10$ ).

Topic Section	Pre/Post	M	SD	Mean Difference	df	<i>t</i> -value	<i>p</i> - value ( $\alpha=.05$ )
Total	Pre	41.7	8.78	31.7	9	5.12	<.001
	Post	73.3	23.5				
Species Diversity	Pre	52.5	18.4	25.0	9	4.74	<.001
	Post	77.5	24.9				
Ecological Understanding	Pre	45.0	10.5	30.0	9	4.81	<.001
	Post	75.0	23.6				
Species Naming	Pre	30.0	10.5	37.5	9	4.03	.002
	Post	67.5	29.0				

These improvements in the seashore sketch were important and expected. One of the focal instructional aspects of the program was a seashore field study, wherein students explored and surveyed the various intertidal zones utilizing the quadrats. A goal of this field trip was to better understand the diversity of seashore organisms, as well as how species distribution reflects the biotic and abiotic factors found in the high, mid and low intertidal zones, also known as zonation. Student experience in this field trip appeared to directly influence their improved representation and understanding of the seashore, as represented through this sketch. Notable improvements are found in showing zonation and habitat, and identifying a diverse number of species with species specific names.

**Applied knowledge.** The post- instructional “Applied Knowledge” question showed strong positive effect from instruction, considering the open nature of the question (Figure 23). The overall mean after instruction increased from 36.5% (SD= 11.7, N=8) to 53.9% (SD= 17.6, N= 13).

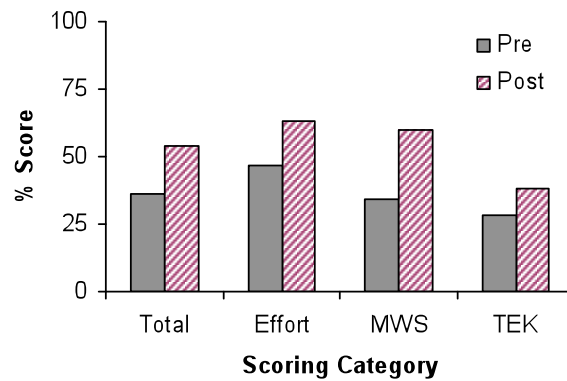


Figure 23. Student scores of the open-ended “Applied Knowledge” question item. Compared is the total score and individually scored categories between the pre (N= 8) and post- instructional (N= 13) surveys.

Paired *t*-tests of the 7 students who completed both the pre- and post- instructional “Applied Knowledge” question showed that there was only a strong effect from instruction found in the total mean score and the category of “Modern Western Science” as seen in Table 5. The “Effort” category did find a moderate effect from instruction.

Table 5

Paired one-tailed *t*-test comparison of percentage mean for pre- and post- instructional students in scored categories for the open-ended “Applied Knowledge” question (N= 7). Categories include student effort in attempting to answer question (Effort), use of Western Modern Science concepts (WMS) and use of Traditional Ecological Knowledge ideas (TEK).

Category	Pre/Post	M	SD	Mean Difference	df	<i>t</i> -value	<i>p</i> - value ( $\alpha = .05$ )
Total	Pre	33.3	25.0	15.5	6	2.17	.037
	Post	48.8	18.3				
Effort	Pre	52.5	18.4	17.9	6	1.70	.070 <sup>a</sup>
	Post	77.5	24.9				
MWS	Pre	45.0	10.5	21.4	6	3.29	.009
	Post	75.0	23.6				
TEK	Pre	30.0	10.5	7.1	6	1.00	.178 <sup>a</sup>
	Post	67.5	29.0				

Note: <sup>a</sup> not a statistically significant result ( $p > .05$ )

Analysis of the “Applied Knowledge” question, found that this question was the only aspect of all the student surveys where paired *t*-tests (N=7) showed a significant difference when compared to a *t*-test of means. This difference is likely due to the small sample size (N=7) of the paired *t*-tests, comparing students who responded to this question in both pre and post tests. The differences found using the *t*-test of means, which included all responses prior to (N=8), and after instruction (N=13), found statistically significant improvement in student scores in all categories; except for use of “Traditional Ecological Knowledge” (Table 6).

**Table 6**

*Independent one-tailed t-test of mean percentages for pre- (N=8) and post- instructional (N=13) scores in categories for the open-ended “Applied Knowledge” question.*

Category	Pre/Post	M	SD	Mean Difference	df	t-value	p- value (α= .05)
Total	Pre	36.5	11.7	17.4	12	3.57	.002
	Post	53.8	17.6				
Effort	Pre	46.9	20.9	16.6	12	3.08	.005
	Post	63.5	19.4				
MWS	Pre	34.4	12.9	25.3	12	3.79	.002
	Post	63.5	24.0				
TEK	Pre	28.1	8.84	10.3	12	1.42	.091 <sup>a</sup>
	Post	38.5	26.3				

Note: <sup>a</sup> not a statistically significant result ( $p > .05$ )

This question showed that many of the students were able to improve on synthesizing their prior and learned knowledge into study. An important aspect of the program’s success was that a higher proportion of students felt able, or willing to approach this problem. Although there were only 8 of 13 students who attempted the open-ended questions in the pre-instructional survey, 13 of 17 students attempted this question after instruction, including 7 of the students who had previously attempted this

question. This result, in itself, showed that students who may have been intimidated by the question previously, had developed enough confidence in their learning to address this same question after instruction.

Although student scores increased in all aspects examined for the question, not all categories increased significantly. The category with the largest increase was in students' use of "Modern Western Science." The improvement in use of MWS was both encouraging and an expected result. Learning field techniques with hands-on experience with scientific equipment was an important focus of the experiential explorations. In these explorations, students practiced using scientific instruments such as using Secchi disks, quadrats, GPS and salinity meters. During these explorations we would follow scientific procedures, including data collection, using controls and identifying variables in the environment. Many of these techniques discussed and utilized in the field were reflected in their responses for this question.

One of the weaknesses in the pre-instructional responses was that 5 of the 8 students attempting this question focused their responses on the impacts of salmon farming on the environment, or their own opinions, while the object was to develop a methodology for a study. However, after instruction, only 3 of the 13 attempts approached the question similarly, with 2 of these students belonging to the initial group that answered by focusing on effects of salmon farms. In this respect, fewer students addressed the question by repeating environmental concerns presented to them previously, through prior media and educators. Most students were able to develop their own procedure about assessing the impacts of salmon farms on the environment. This synthesis represented a deeper cognitive and applied understanding of the process of

environmental assessment, as opposed to the more superficial repetition of facts or opinions.

Examples of responses that show some understanding of methodology ranged from recognition of need for control sites (*Lily*) to additionally including TEKW to establish baseline data for comparison (*Dogwood*), as seen in the following:

*...sample the water from near a salmon farm and sample the water from an area of the ocean where there is no salmon farms. This will tell you the pollution created from them. (Lily)*

*I would gather traditional knowledge from elders and base some observations from that point. Do some sort of experiments and monitor the health of the seashore animals... Take samples from areas further and closer to the salmon farm and compare the data and make some conclusions from that data and compare it to older data already collected. (Swordfern)*

Unfortunately, there was minimal increase in the use of Traditional Ecological Knowledge in the post instructional “Applied Knowledge” question. There were a number of possible reasons for this poor measure of improvement. Many of the students had previously heard of TEK, and understood some of the aspects to which it applied, such as plants for medicines, or tool making. However, it was unlikely that any students’ had practical experience in its application for approaching a scientific study. The students had discussed TEK and engaged in practical activities in the classroom and in the field; however, the program was unsuccessful in its attempt to engage Aboriginal guests for class presentations or field excursions. Regrettably, both chances for Aboriginal guests had fallen through, and the short time span of the program prohibited rescheduling these activities. As a result, these students likely only developed an understanding of TEK in an academic sense, without being able to actively apply it to real world situations.

### ***Student Interests and Experience in the Program***

As previously noted, students had positive opinions about their science experience and interests before instruction and these feelings were further encouraged through the program. The students held very favourable positive opinions about their experiences in the program, especially enjoying their experiential, hands-on explorations. Using various instruments for studying the environment interested the students in utilizing new techniques and learning about their environment in greater detail. Additionally, as expected, the students were very positive about their experiences on the field trips. This enjoyment of the program was reflected in both the opinion survey and in written comments of the students, as follows:

*I liked playing with some of the nifty instruments (like the salinity tester thingy) because not only are they useful but they are really interesting how they work. (Sealion)*

*I enjoyed it and learned a lot about the environment and how to use the equipment to gain more information and to help study. (Dogwood)*

*I enjoyed learning what tools are used for the study of the environment, and how to use them. I can not think of a situation where I might use them, but I believe in expanding one's knowledge in any way. (Swordfern)*

*I liked it a lot better then if we were to learn about it in the class room. Doing our projects in [their] natural habitat is a better [way] to learn about it. (Pine)*

Removing the students from the classroom environment and into their community and natural environment encouraged the students to see what they were learning as part of their real life. The experiential aspects of the program helped students understand how this science was applicable outside of the classroom, aiding their understanding of current events and the applicability of this knowledge to their own life and career opportunities.

This showed how important the strategy of instruction was to encouraging students to form a bridge between their education and personal lives. Although the classroom environment may allow for a greater amount of knowledge to be presented to students in a short amount of time, these students may have more difficulty to incorporate this learning into their conceptions, without experiencing and applying their knowledge first hand. This experience was especially important when attempting to remove faulty prior conceptions as students who have not successfully incorporated the new ideas into their conceptual reality may internalize the new information separate from the old, without synthesizing it into their new understanding (Coll et al., 2002; Sewell, 2002). Without experience to adopt the new information, students' cognitive separation of information reflects the sense of the separation between their education and personal lives.

The connection between academic learning and experience was reflected in students' comments about the field trips:

*I loved our field trips. You got to see first hand how some organisms lived in their natural environment and how they act naturally. It's different seeing things from slides in real life. It was awesome to flip over a rock and see your entire marine handbook alive and crawling around underneath it. And there were even some things that weren't in the handbook. And aside from that, the trips were FUN! (Sealion)*

*I feel that our field trips were really good and that we benefited a lot from them and that it makes a class more fun instead of just doing paperwork and tests. (Fir)*

*I learned a lot more stuff than I would of by just sitting in a class room, I got to have hands on experience and learn and experience everything for myself. (Dogwood)*

In addition to enjoying the field excursions and practicing scientific techniques, the students felt that their knowledge and interest in the local environment increased.

Students showed a significant increase in how much they felt that they learned about the coastal environment when compared to what they felt they knew before the program.

Prior to instruction half of the students noted that they would have preferred to learn about coral reefs instead of kelp forests; however, after instruction, only one student felt she would have preferred to have studied reefs during the program. This was an encouraging result, as goals of the program included not only educating students about their own environment, but to increase student interest and appreciation of their own temperate marine environment. This supported the theory that the more students learned about their environment through a positive educational experience, the more interested and involved they become. Hopefully this increased interest and knowledge could translate into a stronger “sense of wonder,” leading to responsible environmental action.

### ***Coastal Resources***

Students’ understandings of coastal resources significantly improved during the program. Students showed very strong positive opinions about their understanding of coastal resources after instruction, with a substantial decrease in the variation of their opinions. Understanding BC’s coastal resources was an important area for students to develop their knowledge. The students improved their knowledge of where their food comes from, and the industries along the coast that affect the communities and environment. In this sense, students showed a very large improvement in recognizing the current state of BC’s aquaculture and dwindling fishing industries. Hopefully these students would be able to transfer this knowledge and opinions into their community when, for example, the students shop in the local grocery store, they are able to make

educated decisions in food purchases. Furthermore, this knowledge in resources is important for students of Sooke, as resource extraction was an important part of Sooke's history, and is still a significant part of the community's current economy.

One particular aspect of the students' prior conceptions that was important to address was their understanding of the concept of "conservation." Students understanding of this concept improved significantly, however, there were still 5 students who did not fully understand what conservation meant. As in the pre-instructional knowledge survey, most of the incorrect responses occurred when the students chose the incorrect response "the total protection of all living plants and animals," which reflected a preservationist stance. Although the group of students who, after instruction, did not understand that conservation referred to "using natural resources carefully, so that they are used slowly or replaced" was half the number prior to instruction, this result was disappointing. The concept of conservation is important to understand among the coastal resource based communities of BC, and if students feel that this conservation precludes the use of resources by humans, it could be difficult convincing these students the importance of wise use of resources, without specifically readdressing this concept.

One of the very low scoring questions on the post-instructional knowledge survey asked students which countries still hunt whales. Approximately half of the students understood that Japan still hunted whales, but only a small number understood that both Canada and the United States are also countries still engaged in whaling. Unfortunately, this was a topic that I did not have time to address in the program; however, it is important for students to recognize that whaling occurs in our own country. The recognition that Japan whales was expected, as Japanese consumption of whales is well

documented in the media, but if students are to be able to critically discuss whaling, they need to recognize that whaling can occur in different forms. Although commercial whaling does not occur in Canadian and American waters, subsistence whaling is practiced by the Inuit in the North, and traditional whaling is permitted for the Makah in Washington State. If there had been sufficient time in the program, I would have worked with the students in exploring various aspects of commercial and traditional/subsistence whaling, and the issues around this controversial issue.

### ***Human Impacts***

After instruction, opinions and knowledge about human impacts upon the coast was found to have the smallest improvement of all areas examined, but an improvement nonetheless. One possible reason for this minimal improvement in this area was that prior to instruction, students already held positive opinions and strong knowledge about human impacts. With students already knowledgeable and familiar with this topic, it was hard to further significantly affect their understandings. One considerable improvement was that more students understood that the timber industry could affect the coastal environment, showing that the students recognized the connection between different environments along the coast.

Students also showed good understanding in what types of environments would be more susceptible to human impacts. The students recognized that areas of low water flow would be more heavily impacted by oil or fuel spills, and that this included bays, estuaries and the waters deep within the Sooke Basin. Additionally, all but one student recognized that the ocean is reaching the limits of its ability to absorb the wastes of

humans and is already showing the effects of pollution. In this respect, the students were able to acknowledge the finiteness of the oceans, which would hopefully encourage its respect as a limited resource.

One question in the re-test of the pre-instructional survey resulted in not only no improvement, but showed a noticeably lower score after instruction. This question asked students about the properties of polluted water. It was hoped that students would recognize that you cannot always tell if water is polluted by its physical characteristics. Where 75% of the students recognized this fact prior to instruction, only 53% of the students responded correctly in the post-instructional survey. The most common of the incorrect answers was that students thought that polluted water always looks dirty, smells bad and kills the animals in it. As a class, we had collected water samples in the local river, at the seashore and in the ocean, although we did not address pollution levels. Water turbidity was examined, and some students may have assumed that turbid water meant polluted water; however, as I did not address the other aspects, such as pH, or nitrate levels, students did not have a chance to experience clear, polluted water. This aspect may require testing various water samples showing clean water, turbid clean water, and various levels of polluted water, to address how the appearance of water may not relate to chemical cleanliness.

Although the survey did not reveal the large improvement in opinions and knowledge about human impacts that I was hoping to find, I feel that the program was still a success in this area. During instruction, students' favourable opinions in this topic were supported and encouraged, and hopefully their knowledge and opinions were further engrained through our activities and experiences.

### *Oceanography*

Students' understandings of oceanographic concepts improved significantly after instruction. These improvements were shown through recognition of water conditions around the BC coast, in both the exposed and sheltered environments. Students showed a good understanding of the cold, oxygen and nutrient rich water along the coast, and how these waters were more apt to warm in sheltered bays. Students also had a very good improvement on recognizing how rivers mix with ocean waters. Both of these concepts were strengthened with water sampling excursions that included sampling of water down the Sooke River, to the Basin and offshore. The water was analyzed for turbidity, temperature and salinity, to produce graphs of the trends. Additionally, the highest scoring question after instruction had 100% of students recognize how much of the Earth is covered in oceans.

One of the highest scoring questions involved students' understandings about the primary cause of the tides. It was reassuring that students recognized the influence of the moon on tides, as part of the cross-curricular program was about understanding the causes of the rhythms of the tides on the coast, through the traditional Aboriginal and Western Modern Scientific perspectives. This lesson is described in more detail in Chapter 5: Applying a Cross-Cultural, Experiential Science Curriculum (p. 114).

Although students had a very good grasp of water conditions and tides on the coast two aspects of oceanography that were examined appeared to not be adequately addressed. Students had a very poor understanding of the cause of ocean waves, with only 23.5% of the students recognizing winds, while over half of the students chose the

gravitational pull of the moon. As this question was not presented to the students prior to instruction, I do not know if the tidal lessons may have affected their conception of wave sources.

Student conceptions about the BC coast changed very little, and most students still believed that the BC coast is rocky and surf-swept most of the time. As mentioned previously, this conception is similar to the actual coastal environment west of Sooke and north along the local coast. In the instruction about the coastal environment, the class was not exposed to coastal seashore types (rocky, sandy, muddy, cobblestone) beyond the Sooke Basin and rocky coastal shore, as this was the local environment. Although the Sooke Basin is protected, the students' experiences seemed to revolve mostly around the rocky areas and cobblestone beach of Wiffin Spit. With enough time for the program, a lesson on the diversity of shores in BC would appear to be necessary for students to recognize the vast and diverse protected areas along the coast.

### ***Marine Ecology***

The very strong improvement in students' understanding about marine ecology was noted in both post-instructional knowledge surveys and the seashore sketch. From a basic ecology perspective, students had a good understanding about energy flow in the coastal environment, with almost perfect results recognizing what is represented in an energy flow diagram. This recognition of the energy flow reflected the group activity in building an extensive marine food web with Snively's "Pacific Coast Information Cards" (1999) that was part of the program (p. 116).

Students showed a marked increase in recognition of zonation, habitat and species diversity. In the knowledge survey, students recognized the variance of abiotic factors that effect organisms in different habitats and tidal zones. Students significantly improved their understanding that different beach types would reflect different clam species. Although only about half of the students recognized that barnacles in lower tidal zones were larger in part because they were a different species than barnacles found in higher zones, this was a marked improvement over the three students who answered correctly prior to instruction (which may have been due to random guessing).

The seashore sketches strongly reflected students' improved perceptions of habitat and species diversity. Students' scores increased significantly in all aspects of these drawings, including ecological understanding, species diversity and species naming. Most of the students showed zonation in their diagrams, often with direct labeling of tidal zones. Within these zones, students tended to show the difference in types of species, and where in the intertidal zones the organisms could be found. In addition to showing more types of species located in their tidal zones, students usually used specific common names for the species, such as purple shore crab and acorn barnacles, instead of generic group names, such as crabs and barnacles. Although the accuracy of drawing representations was not scored, as I did not want to judge the artistic skills of students, many organisms were drawn in more specific detail after instruction, indicating that students had experienced and observed the details of various organisms (Figure 24)

## Sketch of seashore

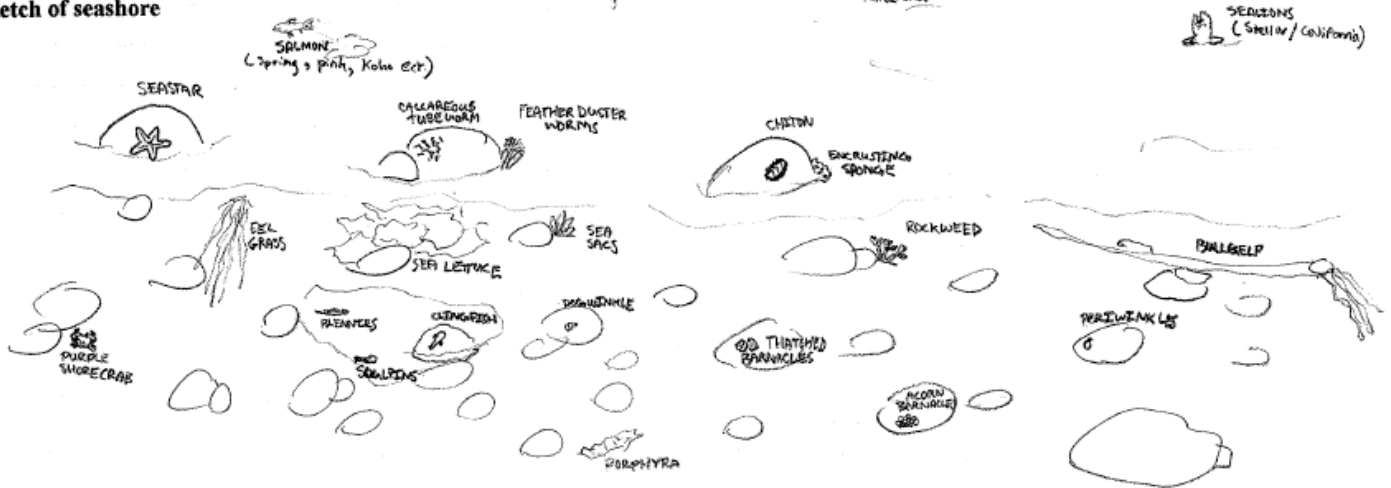


Figure 24. Post-instructional seashore sketch showing improved naming, diversity, and habitat recognition (Dogwood). This sketch scored 12/12 on the seashore sketch rubric, showing excellent diversity, naming and ecological habitat.

Students showed a large improvement in knowledge of seaweeds and kelps. Most students recognized that kelps and seaweeds were marine algae and not vascular plants with over 54% improvement from the pre-instructional survey. Students showed a good improvement, with over 93% of students recognizing that seaweeds do not grow to great depth because of the availability of light. In recognition of the importance of light for marine algae, over 75% of students recognized that groups of seaweeds are differentiated by their photosynthetic pigments. Additionally, students were able to identify and draw various species of kelps in their seashore sketch, where they had only referred to these organisms previously as seaweed, or kelp (Figure 25).

**Part 3: Open-Ended Questions**Personal BC animal or plant code: Alder**1) Seashore Drawing and Identification of Seashore Creatures**

- i. Make a sketch of the local (Sooke) seashore and include as many organisms that you can think of in the sketch.
- ii. Neatly label these animals in your sketch.
- iii. Beneath the picture, include a list of other marine organisms found around Sooke that you were unable to include in the diagram.

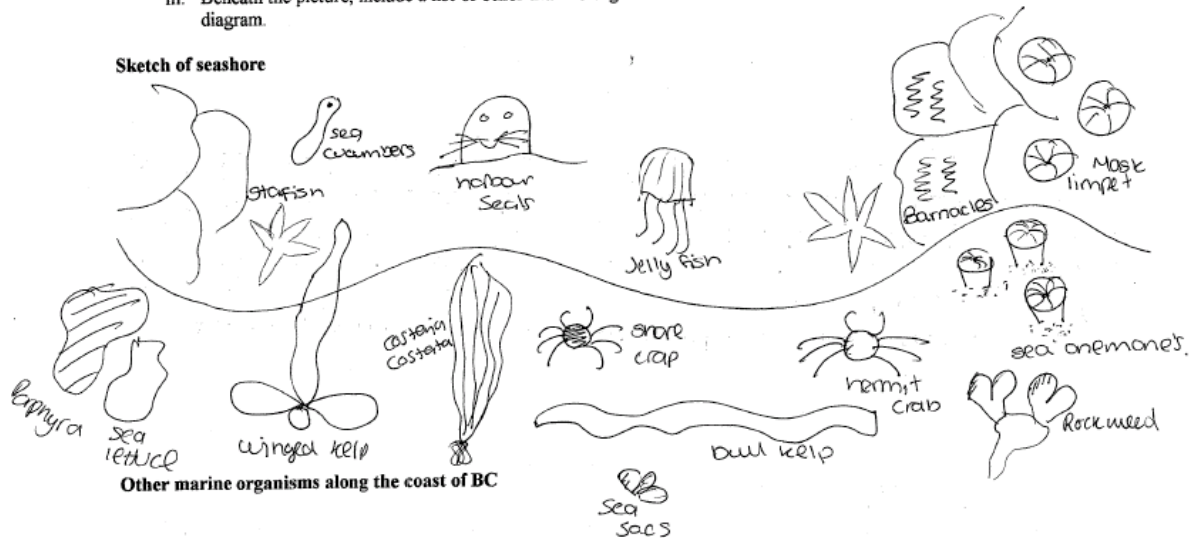


Figure 25. Post-instructional seashore sketch showing improved recognition of seaweeds in naming and diversity. This sketch scored 9/12 on the seashore sketch rubric, with high species diversity (4/4), good species naming (3/4) and satisfactory understanding of habitat (2/4).

The lowest scoring ecology question in the post instructional knowledge survey “B” involved the competition between otters and humans for sea urchins. Students showed almost 87% recognition of the importance of kelp beds for animal habitat, but did not seem to recognize the results of biotic interactions between increasing otter populations and sea urchins. When students were asked to explain the effects of an increasing otter population on the coast, when otters eat sea urchins, which, in turn, eat kelp, 66.7% of students thought that kelp beds would decrease in size and number, while only 29.4% of students realized that humans and otters would both compete for the sea urchins. This was a long worded question, and it may be possible that students had problems with the phrasing or the question. Sea otters and urchins were discussed during the program in both resource exploitation and ecological impacts. The correct answer was expressed as “people and sea otters will compete more for animals like sea urchins,

which both can eat,” may have caused confusion, as these students may not have been aware that humans eat sea urchins. This question may have had different results if the fact that humans eat sea urchins was stated in the question, instead of the answer.

Although students’ appeared to have a good understanding of zonation and habitat, as shown in the seashore sketches and the knowledge surveys, the lowest scoring question in the re-test of the knowledge survey “A” involved analyzing factors that affect zonation. Students were asked about the animals that occur in the spray zone, with the correct response being that there are fewer predators and that they can’t compete for space in the lower zones. This question inquired as to students’ knowledge about biotic and abiotic factors. Only 25% of students answered correctly before instruction and few students changed their answer after instruction. The most common response was that “these animals cannot live in the low tide zones because it is covered with water most of the time.” The students seemed more focused on effects of abiotic factors than effects of predation. The fact that most students believed that these organisms could not survive being covered with water, may reflect personification of organisms with their own experiences, where few humans need to worry about predation, but cold temperatures and drowning seem more immediate influences for survival. This concept may have benefited if it had been taught in the field, emphasizing the competition for space at the lower tidal areas, and above the spray zone, while trying to encourage the students to hypothesize why the spray zone seems the most sparsely inhabited, but still inhabited.

### *Culture of Science, Modern and Traditional*

After instruction, there was much evidence for students' improved understandings of modern science and recognition and respect for traditional ecological knowledge. This understanding of these views of science was reflected in knowledge and opinions surveys, as well as the "Applied Knowledge" open-ended question.

After instruction, students showed an increased understanding in the application modern science tools and techniques. Although few students felt comfortable enough with their level of knowledge and experience to attempt the "Applied Knowledge" question prior to instruction, a significantly higher proportion of students were willing to attempt to devise a research methodology for the effects of a salmon farm in Sooke Basin after the program. Students showed that they had retained knowledge in research methodology and techniques that were discussed and practiced during the program. The improved responses for this research question included students' using water and sediment sampling techniques, seashore quadrat sampling and the use of controls in their methodology.

*Sample the water from near a salmon farm and sample the water from an area of the ocean where there is no salmon farms. This will tell you the pollution created from them. (Lily)*

*Water sampling for salinity and how murky the water is [turbidity test]...organism population and size and amount and health of seaweed. (Moss)*

*We can measure amounts of animals and population using quadrats. This way we can see [whether] populations have been affected and if food chains are the same. (Alder)*

Whereas 8 of 13 responses after instruction utilized modern western science techniques, these techniques were almost completely absent in the pre-instructional responses, except

for general reference to methods by two students who had taken senior level science previously.

Use of TEK in approaching the “Applied Knowledge” problem still posed a problem for most of the students, however, the number using TEK in their response increased from one in the pre-instructional question, to three, after instruction. Although the only student to acknowledge Aboriginal people in their research prior to the program utilized no specifics on the information collected, other than “consult Aboriginal people,” (Oak), after instruction students noted the importance of using TEK to establish baseline, historical data.

*First I would learn about the usual behaviours of salmon from elders.*  
(Sealion)

*I would gather traditional knowledge from elders and base some observations from that point...to compare to the information from the Elders.* (Dogwood)

Although there was not a strong improvement in use of TEK in the “Applied Knowledge” question, the opinion and knowledge surveys showed a marked improvement in the recognition and application of Aboriginal knowledge. Students improved their opinions about the importance of Aboriginal stories for moral lessons, as well as its applicability to modern science, including environmental and resource management. These opinions were very high where all but one opinion reflected “agree” or “strongly agree.” It appeared that the program was very effective in encouraging these positive opinions.

Students’ scores for Aboriginal knowledge and science improved on both versions of the “Coastal Knowledge” surveys. In the re-test of the knowledge survey, the average

student scores increased for every question with very high results recognizing the importance of Aboriginal stories having ecological and moral lessons, and recognizing that Aboriginal communities utilized careful resource management. High results were maintained for where coastal Aboriginals gathered food, and how ancestral boundaries were respected. There was a large improvement of almost 30% in recognizing the moral and potential historical aspects of the Aboriginal flood stories and Noah's Ark, which was important as this, and creation stories were a topic of one of the lessons in the program.

In the "B" version of the post-instructional knowledge test, the questions of similar concepts reflected very good scores. These questions included recognition that Aboriginal resource management was active prior to contact with Europeans (76% correct), how Aboriginal tools and medicines came from the forest and seashore (94%), and how modern science has used TEK in the development of many modern medicines (94%).

Two questions continued to score low after instruction, although their score was improved. Students maintained a poor recognition of the local Aboriginal bands in the Edward Milne Community School catchment area. More students recognized that the Huu-ay-aht were not local, but this improvement could have been a statistical anomaly. Although the local bands were named in passing during the program, there was no emphasis on recognizing these bands, which should have been an important aspect in acknowledging and respecting local Aboriginal groups. Additionally, this acknowledgement could have been promoted had the program discussed how, according

to Aboriginal stories, Aboriginals have always inhabited many of their ancestral lands of the coast, which reflected the other poor scoring question.

The two lowest scoring questions in the knowledge post-test “B” may have been the result of poor definition understanding. The conservationist style of Aboriginal resource management scored only 47%. All students selected either the correct response of “conservationist” or one of the incorrect choices, “preservationist.” No student chose “exploitationist” or “expansionist.” Problems differentiating between “conservationists” and “preservationists” were noted in the pre-instructional survey, and these conceptions may have continued to be held after instruction. Classes did discuss the “wise use” of resources; however, this may not have translated into students’ concepts for redefining these terms.

The other question which involved definition was “A Western equivalent to some Traditional Stories would be...” This question involves the recognition that Western culture’s equivalent to traditional stories may be seen as Aesop’s Fables, where stories contained moral lessons. Only 41% of students recognized this, and many students felt that traditional stories were equivalent to Mother Goose’s Nursery Rhymes. Mother Goose’s rhymes were supposed to represent stories for entertainment purposes only, without true lessons. Students proved through various other post-instructional aspects that they recognized the moral and ecological lessons from Aboriginal stories. However, this suggests that there may be a generation gap and these students may not recognize Mother Goose’s Nursery Rhymes or Aesop’s Fables. Most of the incorrect responses chose that both were similar to Aboriginal stories. I have recently begun to recognize this lack of familiarity in these Western readings since the study group for the program, which

led me to believe that they are not a prevalent reference for today's culture as in the past. Without this familiarity, some of these students may have assumed that both Mother Goose and Aesop both had moral lessons in their stories.

This recognition and appreciation for traditional knowledge was an important goal in the program. Much of this improvement could have been achieved through class activities with Aboriginal stories, such as discussion and comparison of various cultural stories of creation and the flood, and further examining stories for cultural and moral lessons. Additionally, while on field excursions, Aboriginal knowledge and modern science concepts were often discussed interchangeably, as opportunities presented themselves. Hopefully, the recognition of both Aboriginal and Western knowledge in the students' approach to studying the environment would translate into improved cultural appreciation and respect of the Aboriginal students in the community and their everyday lives.

Recognizing science as a sub-culture was also an important aspect of the program. Students increased in agreement that modern western science and the "Scientific Method" were only one culture's approach to learning about the world, and that other cultures had similarly valid methods to study the environment. The strengths in differences and similarities of these approaches to science were noted by the students. The long term knowledge of trends in TEK and the short term analytical power of MWS were examined in the program and after instruction all but two students recognized that a key aspect of both of these approaches was observation.

However, recognition that science and culture were closely connected had only a small improvement from the pre-instructional opinion survey. After instruction, four

students still disagreed with the statement relating science and culture, although this was an improvement, it showed that some of the students were unable to make the connection that the science education they receive in school has a cultural bias. Many of the activities we undertook with TEK was to highlight how different cultures had different valid approaches to “science”. These activities appeared unsuccessful in challenging these four students’ conceptions. I feel that it is important to encourage all students to acknowledge the bias in our current educational system so that students would be more critical in assessing where and how information is gathered. These students, who felt that science and culture are distinct, even after the program, reflect the strength of the science indoctrination to which many students are subject. This strong conception of the students may inhibit a certain amount of critical thinking when students see science from an absolute, and not a relative perspective.

### ***Locus of Control and the Environment***

Among the successes in the program was that after instruction, there were numerous examples of how students felt more confident and empowered when confronted with studying and working with their environment. As noted previously, before instruction, students felt that studying the environment should not be left solely to trained scientists; however, almost all students had little idea of how to approach a study. This lack in confidence was seen prior to instruction with only 13 of the 17 students completing the seashore sketch, and only 8 students attempting the “Applied Knowledge” question. Additionally, in the “A” version of the knowledge survey, the response option

of “I don’t know” was selected a total of 12 times among the 4 questions where this response option was offered.

After instruction, the students expressed their confidence in their knowledge through improvements and attempts in their responses. Students still felt very positively that studying the environment should not only be for trained scientists, and students showed their confidence by increased attempts in answering the open-ended questions. After instruction, of the 17 students to attempt the open-ended questions, 16 of 17 students completed the seashore sketch, with 13 students attempting the “Applied Knowledge” question. The “Applied Knowledge” responses for how to study the effects of a salmon farm in the Sooke Basin had no comments such as “I don’t know” or “Nobody listens to kids,” which were found prior to the program. Finally, when students completed the re-test of the knowledge survey “A,” only one “I don’t know” response was chosen from the whole class, exemplifying how students felt more confident in their learned knowledge.

This increased confidence in their knowledge was important for encouraging students to take control in the studying and protection of their own environment. If the students feel that they have the knowledge and ability to participate in local ecological projects and restorations, local volunteer environmental groups, such as Shorekeepers and Streamkeepers could benefit. Additionally, if students are confident in their knowledge, they may help educate others and increase ecological awareness through social interactions with their community. The student “Mushroom” summed up her opinion of the program, expressing her increased sense of locus of control.

*I thought that [the program] was pretty interesting and gave me a better/different outlook on the way I looked at the marine units. I now know what I can do to help keep our oceans clean and healthy!*  
(Mushroom)

### ***Relational Differences***

A positive result of the program was that after instruction there were few differences in results between any relational groups examined. The total mean score for students who had taken First Nations 12 (M= 68.9, SD= 10.5, N=4) was 20.2% greater than students who had not taken this course (M= 47.2, SD= 16.1, N=9),  $t(11)= 2.42$ ,  $p= 0.034$ . This higher score was not a trend from scoring higher in any one particular aspect of their answers, such as TEK or MWS, as this small sample of four students scored high in different categories that were marked in the rubric.

The only other group that showed a moderate effect from instruction ( $0.05 < p < 0.10$ ) was the students who had taken a senior science. These students represented just over half of the class (56%) and 2-tailed paired  $t$ -test found that the 9 students who had taken a senior science (M= 79.4, SD= 16.1) scored 15.1% higher on the “Ecology” section of the knowledge survey “B,” than the 8 students without experience in senior science (M= 64.3, SD= 17.1),  $t(14.5)= 1.86$ ,  $p= .083$ . These students scored 9.86% (0.296) lower on “coastal resources” (M= 3.33, SD= 0.272, N= 7), than those who had not taken a senior science (M= 3.63, SD= 0.309, N= 9)  $t(13.7)= 2.03$ ,  $p= .062$ . These differences were small, and there was no particular explanation for the slightly lower opinions on coastal resources. The improvement in score for ecology questions could be a result from students’ prior experiences with Biology 11 which may have been reinforced and readdressed in this program. Ecology is an important section in Biology

11, and these students may have not remembered, or understood, some of the concepts prior to instruction, but were more sensitive to being reintroduced to these concepts, with practical experiences.

It was encouraging that, for the most part, there were not any strong effect sizes showing differences in understandings between student relational groupings. Despite gender, cultural heritage, experiences in First Nations 12 or senior science, students all learned to a similar level. This suggests that the program did not make any particular group uncomfortable in the concepts addressed. Of note was how students of Aboriginal heritage had shown lower scores prior to instruction, but these differences were absent after instruction. Students of different cultural backgrounds appeared to learn equally about traditional knowledge and modern western science. This lack of relational differences between cultural backgrounds suggests that students were comfortable learning about other cultural views of science, and were able to include this learning in their own schemas. Had Aboriginal students continued to score low in the sections on TEK and Ecology, it would suggest that the program's presentation of information was similar to the average science class, where WMS is the only acceptable form of science, and continued to suffer from the cultural gap in student learning. Conversely, if non-Aboriginal students showed no improvement in their conceptions of traditional knowledge, this would have also reflected a failure in the cross-cultural learning goals of the program.

### ***Post-Instructional Summary***

The post-instructional surveys found an overall increased knowledge in all topics explored, and a greater proportion of opinions consistent with the goals of the program.

Students' opinions that were found to have positively increased included their interests in studying and exploring the local coastal environment, using scientific equipment, respect and recognition of Aboriginal science, as well as their enjoyment of the marine program. Increased students' knowledge of marine ecology, oceanography, coastal resources and human impacts significantly increased, scoring an overall average of 25% higher in the knowledge survey. Students were able to sketch more accurate representations of their local seashore, with regards to intertidal life and habitat. Students were also much more successful in describing a potential research methodology that could be used in analysis of human impacts within Sooke Basin.

Trends uncovered in this analysis are summarized in accordance to topics covered by the post-instructional chapter:

- ***Student Interest & Experiences in Science and Environmental Education***
  - All students reported either positive or very positive experiences in the marine program, especially in the use of scientific equipment and fieldwork, resulting in a significantly increased opinion mean by 0.4, to 3.5 out of 4.
  - Almost all students reported an increased interest in exploring the local environment more than tropical regions, such as coral reefs (3.2/4).
  
- ***Coastal Resources***
  - Students' opinions about their understandings of coastal resources and resource management were very high at 3.5/4, which was a significant increase of 0.6.
  - The increased opinions reflected in their greater than 33% significantly increased knowledge in these areas.
  - Although improved, the concept of "conservation" remained challenging for a few students, with only 10 of 15 students showing correct understanding.

- ***Human Impacts***
  - Students continued to hold strong positive opinions about human impacts upon the coast, with a small 0.1 overall increase in opinion to 3.5/4.
  - Knowledge about human impacts upon the coast continued to be high, yet there was still an increase in this area.
  - The majority of students recognized that environmental damage in one ecosystem can negatively affect other coastal ecosystems and that nature has a finite ability to buffer these negative impacts.
  - 5 of 15 students did not understand that water turbidity was not an assessment of pollution, but just one descriptor in an aquatic survey while only 8 of 15 students recognized that you cannot always recognize polluted water by looking at it.
  
- ***Oceanography***
  - Overall, students showed at least a 15% improved understanding of oceanographic concepts such as hydrodynamics and tidal fluctuations.
  - 12 of 15 students continued to maintain their conception of BC's coastline as dominated by rocky, surf-swept beaches, possibly as this reflects many areas around Sooke.
  
- ***Marine Ecology***
  - All students showed significant improvement in recognizing species diversity in their local seashores, with a 25% improvement in scoring on the diagram.
  - Almost all students comprehended the concept of habitat and intertidal zonation, although some still misunderstood the biotic and abiotic factors affecting zonation.
  - Most students developed an understanding of the biological and ecological implications of seaweeds and kelps.
  
- ***Sub-culture of Science, Modern and Traditional***
  - Students continued to have a strong respect for, and understanding in TEKW, which showed an overall increase of opinions score by 0.4 to 3.4/4.

- Although there was strong recognition in the validity of TEKW with Western science, only 3 of 13 students were able to show how TEKW can be applied in research and methodology.
  - There was an improvement in recognizing the subjective nature of culture on science, however, 25% of students continued to perceive science as independent from culture.
  - Most students (9 of 13) were able to incorporate their learnings of science and environmental skills in developing an ecological survey methodology. These students utilized techniques such as population analysis with quadrats, comparing findings to a control site and testing water for pH, microorganisms and turbidity. Overall scoring in this area significantly increased over 20%.
- ***Locus of Control and the Environment***
    - Most students showed an increased confidence in attempting all questions, due to improved understandings of ecological understandings and scientific methodology.
    - The majority of students continued to feel that environmental monitoring and research should not be left to only scientists, and that students' opinions, knowledge and skills were relevant in the classroom and community.

### ***Relational Comparisons***

- Students who had taken First Nations 12 showed a strong effect of instruction on their “Applied Knowledge” question, with a 20% higher than average score.
- Lack of significant differences between students' post-instructional surveys suggested that all students, regardless of prior instruction, gender or cultural heritage, were successfully and generally equally engaged in achieving the learning goals of the cross-cultural, marine program.

## **Chapter 7: Implications & Recommendations for Further Research**

The final chapter of the project reflects the major findings and extensions of these findings toward future studies. Firstly, a summary of the findings within this cohort is presented, tracking the changes and trends in opinions and knowledge of the students, before and after instruction. Next, the importance of the key concepts used in this program, such as experiential and cross-cultural education, is discussed in recognizing their potential toward developing similar programs in the future. The future benefits of utilizing these concepts are further explored for the potential to encourage sustainable communities and citizens. The following section discusses how success with Aboriginal students in senior secondary science can have potentially significant impacts in the diverse and independent Aboriginal communities along the coast. Following this, the difficulties faced and restrictions on the findings of the program are addressed in assessing the overall success of this program. Finally, acknowledging these limits of the study, ideas are suggested that could enhance the applicability and reliability of these findings through future research.

### ***Summary of the Study***

The purpose of this research was to develop and evaluate the effectiveness of an experiential, cross-cultural, senior science marine program. Important aspects of this project included encouraging students would recognize the applicability of science within their everyday life, while acknowledging alternative cultural perspectives of science in the environment. The opinions and knowledge of the students, determined through the

various pre- and post-instructional surveys, helped establish the effectiveness of the program, which was seen as the primary causal factor of change.

*Pre-instructional knowledge and opinions.* In addressing the effectiveness of the program, it was important to understand students' prior knowledge and beliefs about local marine ecology and oceanography concepts, such as tidal cycle, ecological energy flow, habitat, human impacts and environmental and resource management. It was found that these students did not have a strong understanding in many areas of ecology and oceanography, even regarding their local seashores. The low knowledge level in these areas agreed with a similar study by Cummins and Snively (2000), which utilized similar knowledge questions as this study. Although both studies found a low level of marine science knowledge, Cummins and Snively's survey was administered to grade 4 students. This similar low scoring of students, despite the grade differences, may suggest that marine education is lacking across multiple grade levels.

When examining gaps in marine ecological understanding among the students in the Environmental Studies program, there were some common trends. Students tended to have poor recognition of specific endemic species found in the intertidal zone, and classified organisms in very general groups, such as crabs, snails and seaweed. In this intertidal zone, students did not recognize specific habitats and how they affect organisms existing within this environment, such as the concepts relevant to zonation within the intertidal seashore.

Students' had a very poor understanding of applications of scientific concepts. All students had previously experienced high school science courses, and over half of

these students had completed senior science classes, however, almost all of the students were unable to transfer their previous science experiences into application of an ecology study. Students were not able to transfer their prior knowledge to suggesting methodology and use of any equipment or scientific tests, such as field guides for identification, water quality tests, use of control sites for comparison and population sampling.

Although students felt that they were knowledgeable in coastal resources and their impacts, they did not show strong evidence of this knowledge. Many students did not understand basic resource management definitions, such as conservation and preservation. Weak understandings in resource management were also shown in the, often incorrect, perceptions of the status of BC's fishing industry, and impacts of this and the timber industry upon coastal ecosystems.

When Aboriginal culture and the concept of TEKW were explored, students appeared to have had some prior experiences with these topics. Students showed positive opinions and respect toward Aboriginal culture, and recognized how stories could be used to transfer knowledge and morals. Students had some general knowledge about Aboriginal culture but it was not locally specific. Additionally, although students had some ideas about TEKW, like scientific theory, they were unable to express any actual application of this knowledge.

Students' overall opinions about concepts such school science, Aboriginal science, exploring the environment and how humans impacted the environment, were all positive toward the intended goals of this program. Students' science opinions tended to be positive about enjoying past experiences, recognizing a use for science and wanting to

learn how to use scientific tools and methods in exploring their environment. Students' interests in exploring the marine environment were very positive, which agrees with findings by Snively and Sheppy (1991) as well as Cummins and Snively (2000).

Students showed a respect and understanding of general Aboriginal culture and concepts about the environment. However, students did not have a strong sense about the cultural influences that relate to the sub-culture of science, and its subjective nature. In this sense students tended to see science as an absolute, universal concept, reflecting the Western Modern Scientific view.

Overall, students' positive opinions, which were consistent with the goals of the program, suggested that the students' cognitive environmental and scientific worldviews would be receptive to the educational outcomes intended. Many of the students' alternate conceptions which were inconsistent with accepted scientific theory were addressed, through classroom and/or field activities, in order for students to recognize the weaknesses in their conceptions. Because of the students' initial positive opinions, the educational goals of the program were likely to be accepted and synthesized into their scientific and ecological understandings.

***Post-instructional knowledge and opinions.*** After instruction, it was found that the program induced a number of positive changes within the students' knowledge and opinions. Overall, students showed measurable increase in knowledge of all concepts explored. Students were able to understand the biotic and abiotic factors that affected the zonation of organisms in the coastal environment, causing intertidal zonation. Students were able to recognize a greater diversity of species in their local environment and

showed a large improvement in specifically naming these organisms. These organisms included many seaweeds, such as bull kelp, feather boa, rock weed, sea lettuce and *Laminaria sp.*, as well as invertebrates, including black chitons, keyhole limpets, acorn barnacles, periwinkles and purple shore crabs, to name a few. This improved use of proper terminology, though experiential explorations, was similar to the positive results found by Cummins and Snively (2000). Interestingly, the question regarding the appearance of polluted water, which showed a decrease in understanding after instruction, also showed negative results in Cummins and Snively's (2000) post-instructional test with grade 4's.

Students showed a substantial increase in confidence and knowledge in understanding and applying scientific methodology after the program. More students were willing to attempt to describe a possible methodology for an ecological impact survey, and were able to describe methods and tests with which to utilize. Additionally, many students recognized the need to use control sites and samples for comparison with the primary study site.

An understanding of Aboriginal science and other cultural perspectives was found to improve after instruction. Students had a fairly good understanding of these concepts prior to instruction; however, it was evident that after instruction, they had developed a more concrete knowledge and appreciation of other cultural views of science. This concrete knowledge and appreciation was evident as students were able to compare and find complementary strengths between Modern Western Science and Aboriginal science in ecology and resource management. Unfortunately, most students were not able to apply this theoretical knowledge related to TEKW into their own scientific methodology.

Student opinions, which were positive before the program, became even more positive about the program and its goals in interesting students in both Western and Aboriginal science. Students expressed that they very much enjoyed the experiential nature of the program, utilizing scientific equipment in the field and exploring their environment. Students held higher opinions of the importance of Aboriginal science and its applicability with modern techniques. Students' opinions about human impacts changed the least, however, this was an aspect which was very high prior to the program, and only increased slightly afterward. The overall increase in students' opinions agreed with the pre-instructional data. These already positive opinions suggested that their positive opinions toward the goals of the program would be reflected in their willingness to learn and appreciate the concepts of the program.

Overall, this project showed that students were able to effectively learn Western and Aboriginal science in a cross-cultural, marine science program. Students found this program both educational and enjoyable. The cross-cultural nature of the program exposed students to other cultural views of science, and students from all cultures developed an understanding and appreciation for these perspectives. The positive results from this program are encouraging suggesting its potential for developing eco-literate and environmentally active members to support the future of many coastal communities, such as Sooke.

### ***Implications for Program Development***

Many high school science courses rely on a heavy emphasis in theoretical knowledge which appears to disconnect students' understandings of science with their everyday life. These theory driven courses teach students toward standardized provincial exams and provide knowledge with which students may continue their pursuit of science at higher academic levels, such as university. However, this theory driven approach does not recognize that many students will not be entering science as a career field, and for those students who do not see the applicability of science in their lives, these concepts are grudgingly learned, if at all, and too often quickly forgotten. Students frequently memorize the science concepts of interest, yet often don't understand the concept, and can not apply the concept in their everyday life. The connection between the forgetting and misunderstanding of concepts may relate to some students' inability to satisfactorily integrate this new knowledge into their pre-existing knowledge (Sewell, 2002). Through experience and application, students may confront how their current knowledge poorly predicts real world situations, and in recognizing this weakness in knowledge, encourage their mind to accepting the improved explanation of the concept (Colburn, 2000). Additionally, further experience and application of the concept reinforces the new learning for longer retention.

The experiential emphasis and local focus of this program encouraged both academically and non-academically inclined students to participate in, and enjoy science. Students who may not have had a strong interest or background in science were able to participate and be engaged through the various explorations and field studies of the program. These concepts included use of scientific equipment, scientific methodology,

and marine science, in addition to how these concepts can be applied in their own environment and community. Even if these students do not continue with science, they obtained a better understanding of how science functions within their communities, and developed some skills that can be used everyday, such as species identification and recognition at the seashore. For students who may be more academically inclined, these explorations enabled them to experience how some professional scientists work in the field, and how environmental science may be applied, putting theory into practice. This application of theory involved students in experiencing the development of science processes; including observing, questioning, inferring, predicting, measuring and recording and using models to represent ecological and environmental processes.

Additionally, these field-based explorations where students explore several seashores and parks may be used to encourage physical activity within academic classes, which addresses important cross-curricular physical activity goals. This active education is increasingly important in schools as there is a recognized need to increase the daily physical activity of students across Canada (Active Healthy Kids Canada, 2008). Acknowledging this need for activity, the Ministry of Education of BC is implementing initiatives to further encourage physical activity of students in the school and community to a minimum of 150 minutes each week (Ministry of Education, Province of British Columbia, 2007; Ministry of Education, Province of British Columbia, 2008). During this program, these initiatives were partly met in the science class as the students hiked various trails and beaches, such as Whiffin Spit and Mystic Beach, followed waterways to the ocean and were actively engaged in the field explorations. Therefore, in addition to

scientific learning outcomes, the physical activity involved in experiential field explorations provided important school outcomes in themselves.

When considering the application of this, or a similar program in another setting, the educator should recognize a number of factors. The timing of this program would be extremely challenging to implement in a normal high school setting which runs four or five blocks per day. The three week length of this program was possible, as the students had signed up for the Environmental Studies course as a double block, which allowed us two 3-hour blocks and three 2-hour blocks per week. Under normal high school situations, this program would take considerably longer than 3 weeks. For many schools, the accessibility of suitable environments for field trips may cause difficulty, and the experiential nature of the program would require careful pre-organization to make the most field excursions. Additionally, to meet cross-cultural goals, it would be useful to have a pre-existing relationship with the local Aboriginal communities and members. This relationship could encourage participation of Elders and knowledgeable Aboriginal community members to work proactively with the school in achieving cross-cultural goals.

### ***Implications for Environmental Education***

An important finding in this research involved how students' internal locus of control changed regarding their ability to participate in, and affect positive change when confronted with environmental issues. Prior to instruction, students tended to have recognition about numerous negative human impacts upon the coast, yet felt at a loss to actively participate in monitoring and finding solutions to these problems. Despite their

education about environmental issues, students expressed a lack of confidence in knowledge and skills which led to feelings of helplessness in students' ability to contribute to environmental protection. Additionally, some students expressed personal feelings that their opinions were not of significance within the community. These findings suggested that these students had not developed an internal locus of control regarding their environment. Instead these students showed that, despite knowledge of many of the environmental issues, these problems in their environment and community could only be confronted by an outside force, such as the government or professional scientists. This high sense of external locus of control agrees with findings by Twenge, Zhang and Im (2004) who examined how students locus of control has become increasingly externalized since the 1960's.

After instruction, it appeared that students had gained confidence in their skills and knowledge reflecting an increased internal locus of control in environmental issues. With this sense of environmental empowerment through understanding of issues and scientific methods, students felt more confident in the relevance of their opinions on environmental issues. Students were also able to recognize how they could participate in monitoring and providing solutions to the various human impacts upon the environment. The increased internalization of locus of control regarding environmental issues agreed with other research regarding the positive effects of Environmental Studies programs on internalizing locus of control and environmental behavior (Smith-Sebasto, 1995).

Encouraging students to understand environmental issues produces eco-literate citizens, however, as in learning theoretical science, stronger impacts from this learning can be found if students are able to apply and reflect upon this knowledge. This

enhanced learning through application within the community corresponds to what McClaren and Hammond (2005) describe as an action triangle, where students may learn through, learn about and learn from community action and experience (as cited in Zandvliet & Brown, 2006). As educators, it is important to teach students more than just the recognition of the numerous negative impacts that humans have upon the environment, but to nurture a feeling of personal empowerment to address these issues. The influx of negative media about global environmental issues has the potential to make students feel powerless and defeated in the face of overwhelming environmental degradation. Educators need to convince students that there is hope, and that individuals have the potential to make positive differences in protecting the environment. Through hands-on experiences in applying techniques in the field for ecological monitoring, students became aware of the tools and techniques that they could use to help their communities in maintaining a balance between the environment and the needs of the community. Encouraging personal understandings that opinions and actions of students are relevant and do make a difference can develop environmentally literate and ecologically active citizens.

Promoting scientifically and ecologically literate and pro-active community members empowers communities to make educated decisions regarding the direction of environmental and resource management issues within the local community. Scientific participation by educated community members encourages a defensible local management of resources, instead of a government regulated top-down approach. From this bottom-up approach to environmental and resource management, as described by

Budd Hall (personal communication, July, 19, 2004), the community is more likely to benefit from wise decision-making processes that are sensitive to local priorities.

### ***Implications for Cross-Cultural Science Education***

It was felt that the cross-cultural aspects of the program were crucial in encouraging both Aboriginal and non-Aboriginal students to recognize the strengths and similarities between differing cultural approaches to science. Although many students already had positive views of Aboriginal culture prior to instruction, after the program the experiences helped to develop a deeper and more concrete understanding for all students about the importance of this cultural knowledge and how TEKW is important in modern ecological sciences. For example, students may have known that Aboriginal stories held moral and environmental lessons, however after instruction, non-Aboriginal students' experiences included direct examples of the lessons within these stories, while Aboriginal students saw their cultural orations being presented in the standard school environment, along with modern concepts such as tidal movements, intertidal zonation and research methodologies.

The cross-cultural respect and recognition encouraged in the program appeared to successfully address the important Ministry of Education's outcome of equal education of all students (Ministry of Education, Province of British Columbia, 2006a; Ministry of Education, Province of British Columbia, 2006b; Ministry of Education, Province of British Columbia, 2006d). Within recent Integrated Resource Packages, the Ministry of Education recognizes how "The incorporating of Aboriginal science with western science can provide meaningful context for Aboriginal students and enhance the learning

experience for all students” (Ministry of Education, Province of British Columbia, 2006d, p. 12). This incorporation of Aboriginal culture appeared effective with the Aboriginal students within the program as the only strong differences found prior to instruction had been the lower scores of Aboriginal heritage students in the knowledge survey and in opinions of human impacts. This lower scoring in the pre-instructional knowledge survey corresponded with the lower science scores of Aboriginal students recognized by the BC Ministry of Education (2006a). After instruction there were no strong differences between either gender or cultural background of the students. This equality of learning suggests that the culturally inclusive program was equally beneficial and inclusive for all learners. This successful cross-cultural factor is important to recognize, as many regular school science programs do not currently enjoy results that reflect equality in learning. It is important to encourage Aboriginal inclusion and success in all levels of science to increase Aboriginal participation in senior science courses. Ministry of Education data from the Sooke school district describes how Aboriginal students who attempt senior level science in high school often do well (2006c), and positive prior science experiences can increase this participation. Studies such as this project may help encourage other educators to include significant cross-cultural aspects within all science classes to reduce the academic discrepancy found with Aboriginal students, and encourage upper level science participation.

This cross-cultural method of education becomes increasingly important in communities which have a large proportion of Aboriginal students. Recognition that Aboriginal students may have a cultural and scientific worldview different from western non-Aboriginal students acknowledges the need for diverse teaching methodologies.

Through incorporating a more activity based, oral and culturally inclusive model of education, teachers are much more likely to include more learning styles of all students, whether of Aboriginal heritage or not.

### ***Implications for Aboriginal Communities***

Encouraging participation and success of Aboriginal students in science can have numerous benefits for the local Aboriginal communities. Many Aboriginal communities along the coast of BC still utilize many of their traditional natural resources, such as forests and fisheries. These resources, in addition to modern resources, such as coal and minerals, require monitoring and management. Currently the majority of scientists, such as geologists, oceanographers and biologists, used to monitor these resources are non-Aboriginal and often has few, if any, personal relationships with the local community.

Local community management of resources has important implications for Aboriginal communities in the future post-treaty era. Currently groups such as Ecotrust Canada work with Aboriginal communities to aid in mapping and understanding their local resources. Project managers, such as Chris Ashurst (personal communication, July, 2004), note the importance of having properly trained community members who understand the principles of resource management. Increased participation and success of Aboriginal students in math and science allows increased opportunities for these students to directly work with their own communities in resource management and scientific study. Additionally, these Aboriginal professionals are more likely to acknowledge cultural aspects of these resources and incorporate these uses into a management plan.

### *Limitations of the Study*

In the application of the cross-cultural marine program, there were several aspects that could have improved the program's overall effectiveness. Timing was a large obstacle in the program. The goals of this program could have been much more thoroughly addressed if there had been more time. Time pressure led to an inability to address certain topics, such as whaling, and restricted the amount of time that could be spent on completing and reviewing other topics and projects. Time spent on group discussions and reflection of the water analysis and Whiffin Spit projects would have permitted a chance to address issues and areas of confusion that emerged. Additionally, students would have benefited through sharing their own results and findings in a more reflective atmosphere.

Although almost half of the class was of Aboriginal heritage, the participants did not have the experience of interacting with a local Aboriginal elder. Having an Elder on one of the field explorations, or in the class, would have had an important educational impact upon both Aboriginal and non-Aboriginal students. Hearing traditional stories or learning about TEKW from an experienced and knowledgeable elder could have been an important experience for all students. Utilizing and sharing this knowledge in a science class may have encouraged more cultural appreciation from non-Aboriginal students, while increasing a sense of scientific validity and pride in the Aboriginal students. My personal experiences of learning TEKW in the field from Aboriginal community members has been very positive, and I feel students would have enjoyed and benefited from this kind of field experience as a non-Western educational approach. It must be

recognized that this study reflected the early attempts of a non-Aboriginal educator to incorporate Aboriginal learning into a program within the territory of an Aboriginal community with whom there were limited personal experiences. Cultivating an effective co-operative relationship between Aboriginal communities and schools requires time to develop trust and establish mutually beneficial learning outcomes. An established teacher working in a home community over time has an improved potential to interact with Elders and develop the necessary relationships required for effective and on-going cross-cultural program in the local environment and community.

### ***Recommendations for Future Research***

For the purpose in defending this program as a valid part of science 11 curriculum, some extra data collection could be utilized to increase the statistical power of the results. This program only studied the effects and learning outcomes of one class, in one area, during a short period of time. Application of the program, and surveys, to multiple study groups would enable researchers to build up a larger data set. This data set would have more power in determining overall student opinions and trends in knowledge. Additionally, utilizing the surveys on grade 11 and 12 students not enrolled in the EMCS Environmental Studies class would provide comparable baseline data. This data from non- ES students would aid in determining what students' prior opinions and understandings are inherent in the types of students who take ES.

Applying the surveys to schools outside of Sooke, could be used in establishing interesting comparisons. Students in different community structures, such as more urban

schools like Victoria High, could help determine how much, and the type of environmental awareness students gain from their environment.

The long term learnings of the program could be studied through a post-post test, which would be significantly temporally separated from application of the program. An analysis of this information could aid in understanding how effective the environmental and cross-cultural goals of the program were contextualized into student worldviews. If students' opinions and knowledge significantly reverted back toward their pre-instructional understandings over time, then it could be understood that the program's success was likely the result of group thinking dynamics. Janis (1983, as cited in Brownstein, 2003) notes that group thinking occurs through interactions with peers and through student understandings of the educator's goals, where their projected opinions and knowledge may reflect what they feel is expected of themselves, and possibly not their true worldviews. An exploration of this, without the influences of the class, or instructor, may reveal the possibility of the effects of group thinking, or deeper conceptual understandings of the students.

An interesting aspect to follow after the implementation of this cross-cultural program would be to see how students view other science courses. Although about half of the students in this cohort had taken senior science, it would be interesting to see what numbers of students enrolled in an additional science class, and if they saw the Environmental Studies program as complementary to other sciences. This could help understand if cross-cultural and experiential education can encourage science participation.

In further developing a rigorous cross-cultural, experiential program it would be important to establish what, if any, parts of this program would need to be adapted to be recognized as meeting university entrance requirements for senior science. The skill levels taught in this course could be adjusted to utilize additional mathematical skills and include formulas. One example would be in calculating the volume of water sampled in plankton tows, utilizing geometry and distance or time measurements. Students could utilize more scientific theory in ecology, as well as addressing important concepts of sustainable resource management. Learning outcomes from Geography 12 could easily be incorporated into Environmental Studies, with such concepts as sustainable development, resource management, and traditional Aboriginal land use practices. Additionally, a more in-depth exploration of species and classification systems could be used in conjunction with seashore and forest identification guides, which would reflect Biology 11 learning outcomes. Although these learning outcomes are diverse, this broad range of learning outcomes represents the diverse nature of Environmental Studies.

When addressing the needs for Aboriginal communities, future research could focus on establishing what these communities feel is required to ensure cultural, community and resource sustainability. Determining what Aboriginal students perceive for their career goals and personal aspirations may provide information that could be used to encourage these students to enter and continue with the sciences. Working with community leaders is important to establish what essential sciences are required for their communities, and encourage students toward these community strengthening careers. Research could establish the numbers of communities on the coast that utilize non-Aboriginal scientists, and estimate how many and what types of scientists would be

required for Aboriginal communities to manage local resources themselves. With this information, science programs could include Aboriginal specific components to encourage education for environmental and cultural sustainability. These programs could be used to encourage local, Aboriginal resource and project managers for Aboriginal communities. Finally, the numbers of Aboriginal students who successfully complete science degrees should be analysed to see what they view as important degrees, and what numbers return to their communities to continue in their field. Aboriginal students should feel that they have the option of an education to pursue future careers of their choice, while recognizing that their future goals may be complementary to the needs of their communities.

Providing an applicable, equal and effective education for all students is an important aspect of education at every level. Utilizing cross-cultural science curricula has the potential of including greater numbers of students of our increasingly culturally diverse classes; while active, experiential education encourages the participation of many of the less traditionally academically inclined students. This inclusive, cross-cultural marine program focused upon engaging students in their most important environment—their own locality. This program focused on encouraging scientific participation and enjoyment while acknowledging that not all students will have a future career in science. However, the importance of this program was that students developed an environmental and cultural understanding of their local environment and feel that they have the ability to positively affect the future sustainability of this community and environment.

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## Appendix A

### Student Background Information

\*Note that these questions preceded the pre and post- instructional “Coastal Knowledge” and “Coastal Opinion” surveys. The following version has been adapted for use with a standardized bubble sheet, instead of on-line.

---

#### **Personal Background Information (fill in response on the *bubble sheet* provided)**

1. Write your personal code (BC animal or plant) in the “Name” box on the *bubble sheet*.
  - Leave your response for Q #1 BLANK on the *bubble sheet*
  - Proceed to Q #2
2. I am.....
  - a. Female
  - b. Male
3. I have taken ***at least*** one Grade 11 or 12 Science (Biology, Chemistry, or Physics)....
  - a. Yes
  - b. No
4. I have taken First Nations 12....
  - a. Yes
  - b. No
5. I would consider myself of Aboriginal heritage:

Ⓐ	Ⓑ	Ⓒ	Ⓓ
<b>Strongly Disagree</b>	<b>Disagree</b>	<b>Agree</b>	<b>Strongly Agree</b>

## Appendix B

### Pre-Instructional Coastal Opinions Survey

#### Information on Survey Format

- “Personal Background Information,” “Coastal Opinions,” and “Coastal Knowledge” surveys were completed online at “Surveymethods.com”
- Note: Online, responses were recorded via selecting the appropriate “radio button” next to choice
  - For Example the following question would appear-

1. I have enjoyed the science classes I have taken in the past.
  - Strongly Disagree
  - Disagree
  - Agree
  - Strongly Agree

- Scoring these questions was automated in the on-line program
- However, for the interest in keeping this file as a single paper document that may be hand recorded on a standardized *bubble sheet*, the format was adjusted.

#### Related topics are coded as follows:

(Actual survey did not distinguish topics or separate these topics)

- **Questions about student Science Experience-** (SE)
  - **Questions about Student Interests-** (SI)
  - **Questions about student Environmental Education at school-** (EE)
  - **Questions about Coastal Resources-** (CR)
  - **Questions about Human Impacts on the coast-** (HI)
  - **Questions about Traditional Knowledge and science-** (TK)
-

## Part 1: Pre-Instructional Coastal Opinions Survey

### Instructions:

- Complete the “Student Background Information,” then continue from Q #6.
- Read each statement
- Rate how you feel about the statement as a letter from A-D, using the following scale to rate your opinion
- Record your choice on the *bubble sheet* provided

<div style="border: 1px solid black; border-radius: 50%; width: 30px; height: 30px; margin: 0 auto; display: flex; align-items: center; justify-content: center;">A</div>	<div style="border: 1px solid black; border-radius: 50%; width: 30px; height: 30px; margin: 0 auto; display: flex; align-items: center; justify-content: center;">B</div>	<div style="border: 1px solid black; border-radius: 50%; width: 30px; height: 30px; margin: 0 auto; display: flex; align-items: center; justify-content: center;">C</div>	<div style="border: 1px solid black; border-radius: 50%; width: 30px; height: 30px; margin: 0 auto; display: flex; align-items: center; justify-content: center;">D</div>
<b>Strongly Disagree</b>	<b>Disagree</b>	<b>Agree</b>	<b>Strongly Agree</b>

6. (SE) I have enjoyed the science classes I have taken in the past.
7. (SE) I do not feel that the science courses I have taken in the past are useful outside of school.

8. (SI) I am more interested in coastal BC’s marine life than tropical marine life.
9. (SI) I am interested in learning various ways to study the coastal marine environment.

10. (EE) I often learn about the coastal waters of BC in school.
11. (EE) I often learn about the local plants and animals in school.
12. (EE) I learn about tropical forests more often than the coastal temperate rainforest in school.

13. (CR) I feel that I know of a number of edible seashore plants and animals.
14. (CR) I do not feel that seaweed is a food resource in BC.

15. (HI) I do not feel that my everyday life impacts the ocean.
16. (HI) I feel that farmed salmon have negative impacts upon the coast.

17. (TK) I feel that Aboriginal stories and legends contain important information about the environment and natural resources.
18. (TK) I do not feel that Aboriginal knowledge has contributed much to modern science.
19. (TK) I feel that science should always involve the Scientific Method: observation, question, hypothesis and experimentation to draw accurate conclusions.

20. (SE) I do not feel that the science courses I have taken in the past will help me find a career.
21. (SE) I feel that the science courses I have taken in the past provide me with understanding current events.

22. (SI) I would prefer to learn about life in a different environment than the marine environment.
23. (SI) I would rather learn about a coral reef than a kelp forest.
24. (SI) I feel that knowing how to study the coastal environment should be left to professional scientists.
- 

25. (EE) I often learn about the coastal temperate rainforest in school.
26. (EE) I learn about the coastal waters of BC more often than tropical reefs in school.
27. (EE) I feel that I know more about the local marine environment than tropical forests or reefs.
- 

28. (CR) I feel that I am aware from where most of my seafood comes.
29. (CR) I feel that there are few resources that come from the intertidal and coastal environment.
- 

30. (HI) I feel that the town of Sooke has negative impacts upon the Sooke Basin.
31. (HI) I feel that the timber industry has little impact upon the marine environment.
- 

32. (TK) I feel that Aboriginal stories and legends can pass on important moral lessons.
33. (TK) I feel that the knowledge of Aboriginal people can be useful to modern biologists.
34. (TK) I feel culture and science are not closely connected.
- 

**[END of Survey]**

**Thanks for your participation**

## Appendix C

### Post-Instructional Coastal Opinions Survey

#### Information on Survey Format

- “Personal Background Information,” “Coastal Opinions,” and “Coastal Knowledge” surveys were completed online at “Surveymethods.com”
- Note: On-line responses were recorded via selecting the appropriate “radio button” next to choice
  - For Example the following question would appear-

1. I have enjoyed the science classes I have taken in the past.
  - Strongly Disagree
  - Disagree
  - Agree
  - Strongly Agree

- Scoring these questions was automated in the on-line program
- However, for the interest in keeping this file as a single paper document that may be hand recorded on a standardized *bubble sheet*, the format was adjusted.
- The “Comments” section at the end was typed onto the online survey, and printed out with the response data sheet.

#### Related topics are coded as follows:

(Actual survey did not distinguish topics or separate these topics)

- **Questions about student Science Experience-** (SE)
  - **Questions about Student Interests-** (SI)
  - **Questions about student Environmental Education at school-** (EE)
  - **Questions about Coastal Resources-** (CR)
  - **Questions about Human Impacts on the coast-** (HI)
  - **Questions about Traditional Knowledge and science-** (TK)
-

## Part 1: Post-Instructional Coastal Opinions Survey

### Instructions:

- Complete the “Student Background Information,” then continue from Q #6..
- Read each statement
- Rate how you feel about the statement as a letter from A-D, using the following scale to rate your opinion
- Record your choice on the *bubble sheet* provided

<div style="border: 1px solid black; border-radius: 50%; width: 30px; height: 30px; margin: 0 auto; display: flex; align-items: center; justify-content: center;">A</div>	<div style="border: 1px solid black; border-radius: 50%; width: 30px; height: 30px; margin: 0 auto; display: flex; align-items: center; justify-content: center;">B</div>	<div style="border: 1px solid black; border-radius: 50%; width: 30px; height: 30px; margin: 0 auto; display: flex; align-items: center; justify-content: center;">C</div>	<div style="border: 1px solid black; border-radius: 50%; width: 30px; height: 30px; margin: 0 auto; display: flex; align-items: center; justify-content: center;">D</div>
<b>Strongly Disagree</b>	<b>Disagree</b>	<b>Agree</b>	<b>Strongly Agree</b>

- 
6. (SE) I have enjoyed this science class in the last month.
7. (SE) I **do not** feel that what I learned in this science class in the last month will be useful outside of school.
- 
8. (SI) I am now more interested in coastal BC’s marine life than I was before this last month.
9. (SI) I would have preferred to learn about life in a different environment than the marine environment.
- 
10. (EE) I found learning the various ways to study the coastal marine environment interesting.
11. (EE) I feel I learned much about local seashore plants and animals of BC in the last month.
- 
12. (CR) I feel that I know more edible seashore plants and animals than prior to this last month.
13. (CR) I do not feel that seaweed is a food resource in BC.
- 
14. (HI) I do not feel that my everyday life impacts the ocean.
15. (HI) I feel that farmed salmon have negative impacts upon the coast.
- 
16. (TK) I feel that Aboriginal stories and legends contain important information about the environment and natural resources.
17. (TK) I do not feel that Aboriginal knowledge has contributed much to modern science.
18. (TK) I feel that science should always involve the Scientific Method: observation, question, hypothesis and experimentation to draw accurate conclusions.
- 
19. (SE) I do not feel that the knowledge I learned from the last month in this science course will help me find a career.
20. (SE) I feel that what I have learned in the past month in this science course will provide me with understanding current events.
-

21. (SI) I would rather have learned about a coral reef than kelp forests or the intertidal zone.
22. (SI) I feel that knowing how to study the coastal environment should be left to professional scientists.
- 
23. (EE) I feel that learning about tropical forests is more important than learning about the coastal temperate rainforest in school.
24. (EE) I feel that I know more about the local marine environment than tropical forests or reefs.
- 
25. (CR) I feel that there are few resources that come from the intertidal and coastal environment.
- 
26. (HI) I feel that the town of Sooke has negative impacts upon the Sooke Basin.
27. (HI) I feel that the timber industry has little impact upon the marine environment.
- 
28. (TK) I feel that Aboriginal stories and legends can pass on important moral lessons.
29. (TK) I feel that the knowledge of Aboriginal people can be useful to modern biologists.
30. (TK) I feel culture and modern science are not closely connected.
- 

### **Your Comments**

31. How did you enjoy/ not enjoy practicing with scientific field equipment in the environment?
32. Do you feel that you benefited from our field trips? Why or why not?
33. What would you suggest to improve the marine section of the Environmental Studies program?
34. How did you enjoy your experience in the Environmental Studies program?
35. What parts of the Environmental Studies program did you enjoy/ dislike? Why?
36. Would you recommend the Environmental Studies program to a friend? Why or why not?

## Appendix D

### Coastal Knowledge Survey A

#### Information on Survey Format

- “Personal Background Information,” “Coastal Opinions,” and “Coastal Knowledge” surveys were completed online at “Surveymethods.com”
- Online, responses were recorded via selecting the appropriate “radio button” next to choice, there was no “a, b, c, d”
  - For Example the following question would appear-

1. How much of the Earth is covered by oceans?
  - Less than 40%
  - About 50%
  - About 60%
  - About 75%

- Scoring these questions was automated in the online program.
  - However, for the interest in keeping this file as a single paper document that may be hand recorded on a standardized *bubble sheet*, the format was adjusted.
  - The online format of the knowledge survey *does not contain headings* for related concepts, but is a single continuous form.
-

## Part 2 – Coastal Knowledge Survey A

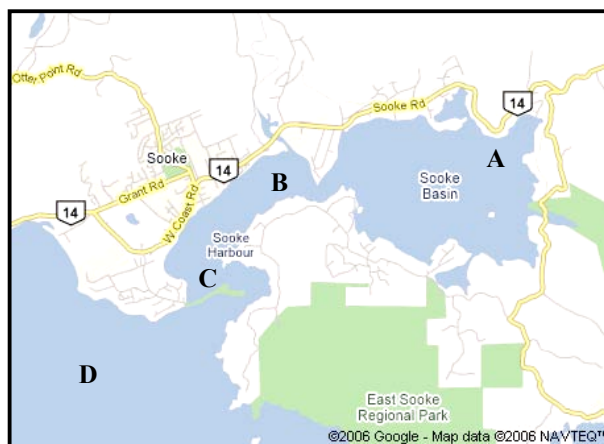
- Complete the “Student Background Information,” then continue from Q #6.
- Read each question *carefully*
- Select ONE response to each question
- Fill in the appropriate letter on the *bubble sheet* completely

### Oceanography

6. How much of the Earth is covered by oceans?
  - a) Less than 40%
  - b) About 50%
  - c) About 60%
  - d) About 75%
  
7. Corals are...
  - a) Only found in cold waters such as Canada’s Pacific Coast
  - b) Only found in warm, tropical waters
  - c) Found in both warm and cold waters
  - d) I don't know
  
8. What happens when a large river like the Fraser River runs into the ocean?
  - a) The fresh water mixes quickly with the salt water near the river’s mouth
  - b) The fresh water sinks to the bottom of the ocean and does not mix
  - c) The fresh water floats on top of the salt water and mixes slowly
  - d) By the time it reaches the ocean, river water is just as salty as ocean water
  
9. Most of British Columbia’s shoreline is ...
  - a) Rocky and surf-swept most of the time
  - b) Protected from the open ocean by islands and peninsulas
  - c) Mostly sandy beaches
  - d) Straight without bays and inlets

The following question refers to this map of the Sooke Basin.

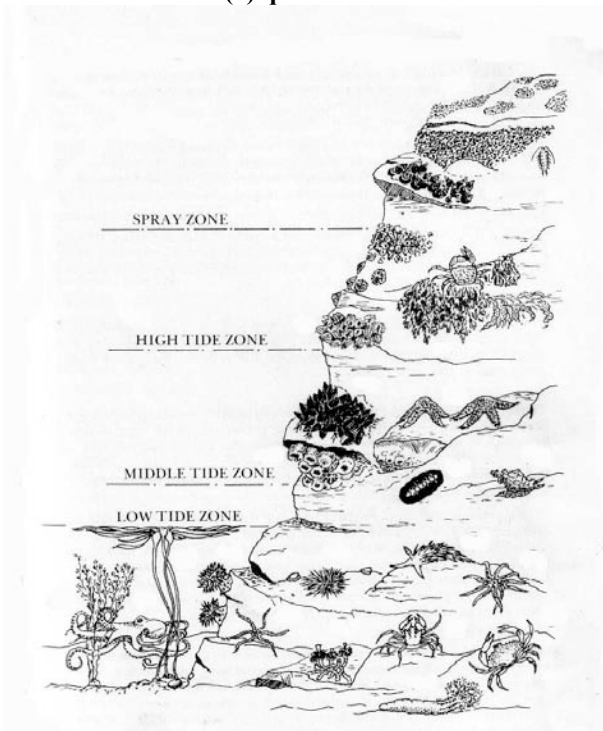
10. In the map of Sooke, the area most likely to have the warmest temperature in summer is:
  - a) A
  - b) B
  - c) C
  - d) D



## Ecology

11. Which one of the following is not a problem at low tide for seashore animals, such as clams, crabs and starfish?
- Subtidal predators
  - Predation by birds and bears
  - Osmoregulation, such as dehydration (drying out)
  - Temperature extremes
12. If we compare the clams on a beach where there is much surf and many big waves with clams on a beach where there is little surf and few big waves, what would we find?
- The same kinds of clams on both beaches
  - Mostly the same kinds of clams, but a few different kinds on the two beaches
  - Almost completely different kinds of clams on the two different beaches
  - No clams on the surf swept beach

Use the following diagram for the next two (2) questions.



13. In the diagram, the barnacles which live in the high tide zone are small, those which live in the middle tide zone are medium sized and those below the low tide are often large. **What is the best reason for this difference?**
- Different kinds (species) of barnacles live in the different zones
  - Young barnacles live in the high tide zones and move to lower zones when they get older
  - The barnacles are all of the same kind, but those lower on the rocks get more to feed on and grow larger
  - The barnacles are all of the same kind, but those in the upper tide zones don't live long enough to grow large

14. In the diagram, the spray zone is almost completely dry, the upper part being only occasionally sprayed, and the lower part covered with water during the highest tides and storms. Animals that occur in the spray zone...
- a) Live mainly in the spray zone, but move to the low tide zone when the tide goes out
  - b) Cannot live in the low tide zone because it is covered with seawater most of the time
  - c) Live only in the spray zone because of fewer predators and they cannot compete for space in the lower tide zones
  - d) Can live in any tide zone
15. Energy for living things in the coastal intertidal environment mostly comes from...
- a) Decomposing plants and animals
  - b) Minerals (such as salt) in the water
  - c) The tides
  - d) The sun
16. Seaweeds do not grow at great depths in the ocean because...
- a) The water pressure is too great
  - b) Sunlight does not penetrate to great depths
  - c) They float around in the ocean
  - d) The water is too cold
17. Seaweeds and kelp, such as sea lettuce and bull kelp, are ...
- a) Types of marine plant
  - b) Types of marine algae
  - c) Neither a plant or algae
  - d) Closely related to eelgrass
18. The most important outcome of the loss of a seaweed forest is...
- a) There is more room for water sports and people
  - b) There is more room for fish and other marine animals to move into the area
  - c) The loss of seaweed for people to harvest
  - d) The loss of habitat for a variety of animals

## Coastal Resources

19. Which one of the following would not be found in B.C.?
- a) A seaweed farm
  - b) A lobster farm
  - c) An oyster farm
  - d) A salmon farm
20. Which statement is true about fishing worldwide?
- a) The total weight of fish caught each year is quickly getting less
  - b) The total weight of fish caught each year is quickly getting more
  - c) The total weight of fish caught each year is staying about the same, but the size of fish is getting smaller
  - d) The total weight of fish caught each year is staying about the same and the size of the fish is getting larger
21. Where are most salmon that are caught in B.C. processed?
- a) Vancouver
  - b) Prince Rupert
  - c) In towns near where the fish are caught
  - d) In a factory ship at sea

22. Which is the best meaning for “conservation”?
- The total protection of all living plants and animals
  - The removal of a kind of plant or animal so that it no longer exists
  - Using natural resources carefully, so that they are used slowly or replaced
  - Capturing an animal for display in a zoo or aquarium
23. Commercial fishing is...
- An important economy in BC
  - A shrinking economy in BC
  - A stable economy in BC
  - The second most important economy, after logging
  - I don't know

## Human Impacts

24. What is the most serious way a fish farm can cause pollution?
- Wastes from fish and wasted fish food add too many nutrients to the water
  - They are noxious
  - Medicines used to control fish diseases get into the water
  - Waste from cleaning fish for market causes pollution
25. Which of the following statements are true about commercial BC coastal logging methods?
- Regulations ensure that it has no effect on the coastal environment
  - It affects inland water systems only
  - It increases the amount of runoff water and silt in coastal habitats
  - Both a & b are correct
26. Household wastes and sewage...
- Do not contain chemicals like wastes from commercial industry
  - Usually contain harmful chemicals from cleaning products
  - Are always treated, so they are not harmful to sea creatures
  - Do not damage the marine environment because of the dilution effects of the ocean
27. Water that is polluted...
- Always looks dirty
  - Always smells bad
  - Always kills the animals in it
  - You can't always tell by smell or looks

## Traditional Knowledge/ Aboriginal Knowledge

28. Which of the following is **not** a local Aboriginal/ First Nation community?
- T'Sou-ke
  - Scianew
  - Huu-ay-aht
  - Pacheed-aht
  - I don't know
29. Many Aboriginal stories...
- Have little value other than entertainment and have no scientific merit
  - Contain ecological and moral lessons
  - Often change from generation to generation
  - Both a & c
  - I don't know

30. Most traditional Aboriginal food along the BC coast was...
- a) Harvested in the ocean
  - b) Harvested in the forest
  - c) Most came from the ocean, but some came from the forest
  - d) Most came from the forest, but some came from the ocean
31. According to the T'Souke, the lands and waters of BC have been inhabited by humans for...
- a) 5,000 years
  - b) 10,000 – 12,000 years
  - c) 100,000 years
  - d) It has always been inhabited by people
32. Stories, such as Noah's Ark and the Aboriginal Flood Story,...
- a) Are similar to many cultures around the world
  - b) Have no scientific relevance
  - c) Has been proven to have occurred by geologists and archeologists
  - d) Is unlikely to have actually happened
  - e) Both a & c are correct
33. A best way to describe how Aboriginal people utilized intertidal resources is...
- a) Sites were over-harvested and new areas nearby were found
  - b) Sites were harvested carefully so that they could always be used
  - c) There were too few people to impact any particular site
  - d) When resources were used up in one area, the community would move to exploit resources elsewhere
34. No single Aboriginal Nation dominated the whole coast because...
- a) There was no way to travel long distances
  - b) Warfare between groups was uncommon
  - c) Aboriginal communities connected to ancestral boundaries
  - d) There were too few resources to expand

**[END OF SURVEY]**

## Appendix E

### Coastal Knowledge Survey B

#### Information on Survey Format

- “Personal Background Information,” “Coastal Opinions,” and “Coastal Knowledge” surveys were completed online at “Surveymethods.com”
- Online, responses were recorded via selecting the appropriate “radio button” next to choice, there was no “a, b, c, d”
  - For Example the following question would appear-

1. How much of the Earth is covered by oceans?
  - Less than 40%
  - About 50%
  - About 60%
  - About 75%

- Scoring these questions was automated in the online program
  - However, for the interest in keeping this file as a single paper document that may be hand recorded on a standardized *bubble sheet*, the format was adjusted.
  - The online format of the knowledge survey does not contain headings for related concepts, but is a single continuous form
-

## Part 2 – Coastal Knowledge Survey B

- Complete the “Student Background Information,” then continue from Q #6.
- Read each question *carefully*
- Select **ONE** response to each question
- Fill in the appropriate letter on the *bubble sheet* completely

### Oceanography

6. Which statement is true about the sea water around Southern Vancouver Island?
  - a) The sea water is cold and high in nutrients, but low in oxygen
  - b) The sea water is relatively warm and low in nutrients
  - c) The sea water is cold, high in oxygen and nutrients
  - d) The sea water is cold and low in nutrients, but high in oxygen
  
7. Most ocean waves are caused by...
  - a) The gravitational pull of the moon
  - b) Strong winds blowing across long distances of ocean
  - c) The movements of water currents along the coast
  - d) The gravitational pull caused by the sun
  
8. What has the most impact upon tides?
  - a) Position of the sun in the sky
  - b) Position of the moon around Earth
  - c) Storms out at sea
  - d) Narrow straits or channels
  
9. The ocean water near the B.C. coast is...
  - a) Nearly freezing in winter and warm in summer
  - b) Warm all year round, but about **7°C cooler** in the winter
  - c) Cold all the year around, but a **7°C warmer** in the summer
  - d) About the same temperature all year round

The following question refers to this map of the Sooke Basin

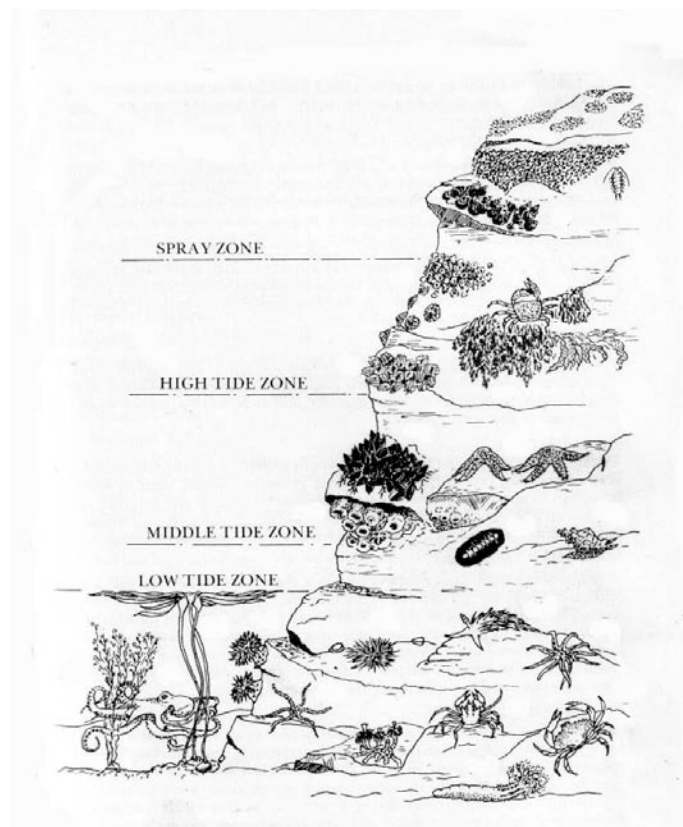
10. In the map of Sooke, which area has the least movement of water?
  - a) A
  - b) B
  - c) C
  - d) D



## Ecology

11. The population of sea otters in British Columbia is increasing and spreading. Sea otters eat sea urchins which, in turn, eat kelp. Which of the following is most likely to happen if the number of sea otters continues to grow?
- Existing food chains along the coast will stay the same
  - The size and number of kelp beds will decrease
  - People and sea otters will compete more for animals like sea urchins, which both can eat
  - The population of animals on which sea otters feed will get larger
12. The barnacles we find in the high tide and middle tide zones
- Are attached to one spot on a rock and feed at high tide.
  - Are attached to one spot on a rock and feed when they are out of seawater at low tide
  - Are attached to one spot on a rock and feed at both low and high tides
  - Move from spot to spot in order to find food

Use the diagram to answer the following question.



13. The diagram shows the arrangement of plants and animals at different heights or in zones, on a rocky shore. When the tide changes from high to low tide, the living conditions of animals in the middle tide zone change a lot. Which of the following is the **greatest** problem they must overcome to survive?
- Predation by seastars
  - The change in temperature and moisture
  - Predation by chitons
  - They may die from hunger because they can't feed at low tide

14. What is plankton?
- Tiny single and multicellular **plants** floating in the ocean
  - Tiny single and multicellular **animals** floating in the ocean
  - Tiny single and multicellular **organisms** floating in the ocean
  - All living things that live in open water in the ocean.
15. What is the importance of the single-celled and microscopic plants and algae which float around the ocean?
- Most fish eat these organisms
  - They are the most important food for people of some countries
  - They provide large quantities of carbon dioxide and oxygen to the atmosphere
  - They are the first stage in almost all food chains in the ocean
16. The main groups of seaweeds can be differentiated by...
- Their different types of photosynthetic pigments shown by their colour
  - Their by-product of photosynthesis
  - The part of the intertidal zone where they are found
  - The habitat they provide for other organisms
17. In the food chain diagram like the one below, what is the most important meaning of the arrows?
- Killer Whales ← Seal ← Salmon ← Herring ← Plankton
- They show which animals are predators
  - They show which animals are prey
  - They show the flow of food energy from prey to predator
  - They show which animal is biggest

## Coastal Resources

18. Aquaculture is best described as...
- The farming of water plants
  - The farming of many aquatic species of algae, plants and animals
  - The farming of fish such as trout and salmon
  - The study of different coastal peoples
19. What is happening to the farming of water organisms worldwide?
- It is getting smaller
  - It is quickly getting larger
  - It is staying the same size
  - It has become as large as it is possible for it to get
20. Commercial salmon fishermen are usually against fish farming. Which of the following is a reason for this opposition?
- Fishermen are afraid that disease and sea lice can spread from fish farms to ocean fish
  - Fishermen think that fish farms cause the price of fish to increase too much
  - Fishermen are afraid that too many ocean fish will be captured and put into fish pens
  - Fishermen are afraid that people will like farm fish better than wild fish
21. Which country is still killing certain types whales for food and oil?
- U.S.
  - Japan
  - Canada
  - All of these countries kill whales
  - No one. An agreement protects all whales from being hunted.

22. Which statement is true about seaweeds?
- Seaweeds are popular dried and eaten
  - Seaweeds taste bad and are tough, so they are rarely eaten by humans
  - Seaweeds are used to produce a thickener for puddings and ice cream
  - None of these are true
  - A and C are true

## Human Impacts

23. Which of the following is true about sea otters?
- There have never been many sea otters in B.C.
  - They are top of the food chain
  - They became nearly extinct in B.C. because of fur trading
  - There have always been large numbers of sea otters in B.C.
24. Man-made changes in the ocean and along our coastline
- Are always helpful to humans
  - Always cause trouble for humans
  - Must be carefully looked at to see what marine life will be affected
  - Never damage the coastline or ocean very much
25. In the diagram opposite, which part of Sooke Basin may have the longest term impacts from a Sooke River fuel spill?

- A
- B
- C
- D



26. Which of the following environments will be most easily damaged by nearby human activities?
- A sandy beach on a surf swept outer coastline
  - Rocky shores on a surf swept outer coastline
  - In protected bays and estuaries
  - The deep sea
27. The oceans...
- Are so big that human and industrial wastes affect them very little
  - Can take very little more waste of any type before we can see the impacts
  - Are already affected by the volume and types of waste humans put in it
  - Are perfect dumps because the garbage and sewage sinks to the bottom

## Traditional Knowledge/ Aboriginal Knowledge

28. Modern Western Science and Traditional Ecological Knowledge both...
- Involve observation
  - Are developed over short periods of time
  - Provide a quick way to analyze the environment
  - Involve a formulated hypothesis

29. To Aboriginal communities, knowledge of the local environment and resource management...
- were first introduced by the European explorers and settlers
  - were not necessary to survive on the plentiful coast
  - were important and commonly practiced along the coast prior to contact
  - held a small importance in everyday life
30. First Nations communities tend to utilize what resource management style?
- Preservationsist
  - Conservationist
  - Exploitationist
  - Expansionist
31. First Nations resources for making tools came from...
- The forest
  - The intertidal zone
  - Trade with the Europeans only
  - Both the forest and the intertidal zone
32. Many modern medicines have been derived from natural plants that were used medically by Aboriginal peoples for hundreds of years or more. This is an example of...
- The success of Modern Western Science
  - Utilizing Traditional Knowledge
  - A coincidence
  - An important area in which to invest money
33. A Western equivalent to some Traditional Stories would be...  
Mother Goose's Nursery Rhymes
- Æsop's Fables
  - A science textbook
  - None of these would be an equivalent
  - All of these would be an equivalent
34. Seaweeds can be used as...
- Food
  - Medicine
  - Tools
  - Both a & b
  - All of the these

[END OF SURVEY]

## Appendix F

### Coastal Open-Ended Questions

**Notes:**

- This part of the survey was handed out to students and completed by hand.
  - Students received a two-sided copy, with one question on each side
  - The same two questions were used both prior to, and after instruction
  - Scoring was completed by a rubrics which are included *after* the questions
  - Students were not aware of the scoring rubric when completing these questions
-

### Part 3: Open-Ended Questions

Personal BC animal or plant code: \_\_\_\_\_

#### 1) Seashore Drawing and Identification of Seashore Creatures

- i. Make a **sketch** of the *local (Sooke) seashore* and include as many organisms that you can think of in the sketch.
- ii. Neatly **label** these animals in your sketch.
- iii. Beneath the picture, include a **list of other marine organisms** found around Sooke that you were unable to include in the diagram.

**Sketch of seashore**

**Other marine organisms along the coast of BC**



### Seashore Sketch Scoring Rubric

<b>Criteria</b>	<b>Mastery (4)</b>	<b>Good (3)</b>	<b>Satisfactory (2)</b>	<b>Non- Achievement (1)</b>
<b>Species Diversity</b>	Student includes a diverse collection of appropriate species (16+)	Student includes many appropriate species (11-15)	Student uses a small number of species (6-10) One or two incorrect species present	Student uses only a limited number of species (<5) May use incorrect species
<b>Ecological Understanding</b>	Student drawing includes an understanding of intertidal zonation- Species placed in specific tidal zones and many are in appropriate ecological niches	Student shows understanding of zonation and some organisms placed in specific niches	Student drawing shows some concept of zonation (shore vs water) Other ecological niches not included	Species are haphazardly placed in drawing, with no demonstration of understanding shoreline zonation or ecological habitat
<b>Species Naming</b>	Student uses almost exclusively species specific common names	Student uses mostly (>50%) species specific names Some generic names used	Student uses mostly generic names for species Some species specific names are used (<50%)	Student uses only generic group names

### Notes:

### Applied Knowledge Scoring Rubric

<b>Criteria</b>	<b>Mastery (4)</b>	<b>Good (3)</b>	<b>Satisfactory (2)</b>	<b>Non- Achievement (1)</b>
<b>Effort</b>	Student provides detailed explanation	Student Provides a basic outline to research the problem	Student attempts question, provides idea of problem but does not provide any clear idea of research	Student Attempts Question
<b>Use of Modern Science</b>	Student mentions multiple western science methods of marine research and includes a control sample	Student notes more than two western science method but doesn't include a control <b>Or</b> mentions one or two techniques and includes a control	Student notes only one or two modern science techniques, no control	Student does not include any specific scientific techniques
<b>Use of Traditional Science</b>	Student notes the use of traditional knowledge, including ideas of how to research and use this information	Student notes traditional knowledge and how to collect this information	Student acknowledges traditional knowledge in research	Student does not address the use of traditional knowledge

#### Notes:

## Appendix G

I. **Title:** **What is Traditional Science & Traditional Ecological Knowledge? (2 one hour classes)**

II. **Grade Level:** 10-12

IIIa. **Key Concepts:**

- “Modern Science” is a cultural perspective from a European base
- Many indigenous groups around the world have a unique knowledge about their environment.
- Traditional Ecological Knowledge involves indigenous people and it has both cultural and spatial connections.
- Traditional Ecological Knowledge is comparable and compatible with Western Science.
- Traditional Ecological Knowledge has Intellectual Property rights

IIIb. **PLO Focus**

*BC Ministry of Education has no specific PLO's in science curriculum at the secondary level, although recent IRP's (2005/2006) suggest Aboriginal/ multicultural recognition and inclusion in the following sections:*

**Rationale**

- developing an understanding of the place of science in society and history and its relationships to other disciplines

**Addressing Local Context**

- educators to plan their programs by using topics and examples that are relevant to their local context

**Student Diversity and Inclusion**

- teachers should ensure that classroom instruction, assessment, and resources reflect sensitivity to diversity and incorporate positive role portrayals, relevant issues, and themes such as inclusion, respect, and acceptance.

**Working with the Aboriginal Community**

- the Ministry of Education is dedicated to ensuring that the cultures and contributions of Aboriginal peoples in BC are reflected in all provincial curricula. To address these topics in the classroom in a way that is accurate and that respectfully reflects Aboriginal concepts of teaching and learning.

IV. **Observable Outcomes:**

- ❖ The students will be able to compare several differences between Traditional Science and Western Modern Science.
- ❖ Students will be able to describe Traditional Ecological Knowledge
- ❖ Students will be able to name several areas where Traditional Ecological Knowledge can be used in modern science fields.
- ❖ Students will be able to describe examples of where modern “scientific breakthroughs” have originated from traditional knowledge.

V. **Materials:**

- ❖ white board for brainstorming class ideas
- ❖ Guided notes for instructor
- ❖ “What is Science?” worksheet (What is Science.doc)

- ❖ “Comparing Tradition Ecological Knowledge” worksheet (Comparing Tradition Ecological Knowledge WS.doc)
  - ❖ “Comparing Traditional Knowledge” Worksheet (Comparing Traditional Knowledge.doc)
  - ❖ Articles on Taxol, Neem Tree, Dene Project, Pharmaceuticals and Bioprospecting
- 

## VI. Motivational Activity:

- ❖ Introduce class to the Marine Program and hand out the anticipated itinerary for the next couple of weeks.
    - Introduce why I am interested in the marine environment
    - Go around class having students introduce themselves with a quick statement about what interests them about the marine environment
  - ❖ Begin a **brainstorm on board** about what interests people about the marine environment
    - How do we study the marine environment?
    - How do you learn about the marine environment?
      - When the topic of science arises, question “What is science?”
    - When “**Science**” comes up as a topic of learning or exploring the marine environment, break students into small groups.
- 

## VII. Developmental Activities

### Activity 1. What is Science?

- ❖ Hand out group worksheet “What is Science” (“*What is Science.doc*”)
  - Give students 10 minutes to complete
- ❖ Have each group present its findings, while key ideas are recorded on board
  - Collect worksheets
- ❖ Discuss class findings, focusing on the descriptions that reflect the concepts of “Western Modern Science.”
  - Is this the only way to understand our environment, what have cultures done in the past? Or have we always had *this scientific method*? (As described by Sir Francis Bacon (17<sup>th</sup>) century.
- ❖ Did the WestCoast/ Salish Aboriginals have a way of understanding their environment?
  - How did the T’Sou-ke, or Scianew know what plants they could eat?
  - How were the best materials and methods used for tools and toolmaking found?
  - How did these groups treat illness? How could this be discovered?
  - How did they know when the salmon or herring would be returning?
  - Is this science- studying and understanding our environment?
- ❖ Allow for student input

### Activity 2. Guided notes comparing TEK and WMS

- ❖ Hand out worksheet “Comparing Traditional Knowledge to Western Modern Science”.
  - As a class fill out Modern Western Science side of worksheet, using as many student ideas as possible, but ensuring the basic skeleton
    - Human Placement, Methodology, Transmission, Uses, Time scale, Spatial applicability, etc.
  - As a class discuss generalized systems of Traditional Knowledge and fill out table
  - Which areas are shared by both Knowledge systems (this will be important in the Venn Diagram at end of lesson)?
  - Have students work in groups to come up with uses in the marine environment of traditional knowledge – Question #2 (ecology, navigation, astronomy, medicine, biology, engineering and tool making) (10 minutes)
    - Share results.
  - Develop a working definition of Traditional Knowledge/Science, and Traditional Ecological Knowledge (Question #4)
    - As group, decide on critical aspects and record on worksheet a definition suitable for TK.

### Activity 3. Examples of Utilizing Traditional Knowledge with Western Modern Science

- ❖ Have student groups read and share articles on various subjects including (10 min to read, 15 min to share)
  - The Dene Project
    - The Dene people occupy a large part of the Northwest Territories and consist of several different cultural and linguistic groups. The Dene Project started in 1987 as a co-operative effort by the government of Canada and the Dene people to collect and record the traditional environmental knowledge of the Dene people for future generations. In addition, the documentation and analysis of TEK was to provide information to work with Western science for improved resource management of the whole region. This was the first large scale project in Canada of this kind.

Further information can be found in LORE: Capturing Traditional Environmental Knowledge, edited by M. Johnson, 1992.

- The Western Yew and Taxol
  - The Western Yew (*Taxus brevifolia*) was a traditionally important tree for both its physical and chemical characteristics. The sparse, slow growing, coniferous tree was prized by Aboriginal people along the coast for its dense, durable wood, which could make strong tools, such as harpoons and digging sticks, yet was also flexible enough to make excellent bows and bentwood hooks. The yew was also known for its medicinal value. The chemical compounds found in the seeds, needles and bark were known to be toxic if not used correctly, but was recognized as a powerful medicine when used properly. In Southern Vancouver

Island, it was part of the powerful “four barks medicine,” while the Haida in the Queen Charlotte Islands used its berries as a contraceptive.

- Europeans saw the yew tree as a “junk tree” because of its small size and twisted shape. That is until the anti-cancer compound *taxol* was identified in the bark and to a lesser extent in the needles. This discovery was likely due to the pharmaceutical recognition that the Aboriginal people had used it in medicines. Yew trees were sought out, cut down and stripped of bark and needles, which threatened the slow growing tree population. Little, if any credit was given to Aboriginal people for discovering the medicinal value of the yew. Fortunately, a synthetic version of *taxol* has reduced the need for the natural yew bark.

➤ The Rosy Periwinkle and Neem Tree

- The neem tree (*Azadirachta indica*), is native to India, Burma and western Africa. This unique tree has been known for centuries as having, among other, antibiotic, antifungal and insecticidal properties. It has been used by traditional cultures of these regions for many generations. It can now be found in many commercial pharmaceuticals and other chemical industries. Unfortunately, the peoples who first discovered these properties receive no compensation for their traditional knowledge that attracted modern companies to the neem tree.
- The rosy periwinkle (*Catharanthus roseus*) of Madagascar was traditionally used in medicines by the native population. When the commercial pharmaceutical company, Eli Lilly, found several unique compounds in the plant, they copyrighted the chemicals and sold them commercially, including vincristine, an anti-cancer drug. The Aboriginal peoples, who discovered the medicinal values of the rosy periwinkle, which instigated commercial interest, received no compensation.

➤ Ethnobotany and Biopiracy

- The Western Yew, Neem tree and rosy periwinkle all bring up the concept of utilizing TEK without permission or compensation to those groups who first discovered the medicinal properties of these plants. Lots of information is available and a good root source is Wikipedia- *Biopiracy*.

❖ Use the last articles to briefly touch on concept of “intellectual property rights,” and define it. (Q #6)

- Refer back to traditional ownership of knowledge vs. copyrighting of plants by companies for personal gain. Is it fair for commercial companies to copyright plant chemicals?
- Note that this will be brought up again when using Traditional Stories and Myths

### VIII. Culminating Activity. Comparing Traditional Knowledge to Western Modern Science

- ❖ Hand out ziplock bags filled with separate statements of Traditional Knowledge and Modern Western Science
  - Have student Groups organize statements into **Venn Diagrams** comparing TK and MWS. (10 min)
  - Discuss which statements are shared by both, which are different (Students should have an idea of what MWS concepts are from prior discussion)

### IX. Ongoing Culminating Activity

Throughout this marine program, students will develop a poster on traditional knowledge about the marine environment. They will describe 2 marine animals, 2 marine plants and how they were used by traditional peoples. This will include the aboriginal names, common and scientific names.

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#### References:

Johnson, M. (Ed.). (1992). *Lore: Capturing traditional environmental knowledge*. Hay River, NWT, Canada: International Development Research Centre.

Snively, G., & Corsiglia, J. (2001). Discovering indigenous science; implications for science education. *Science Education*, 85(1), 6-34.

Turner, N., J., Ignace, M. B., & Ignace, R. (2000). Traditional Ecological Knowledge and Wisdom of Aboriginal peoples in British Columbia. *Ecological Applications*, 10(5), 1275-1287.

## What is Science?

Names: \_\_\_\_\_

As a group, complete the following table.

How is it done?	Where can it be applied?	Why do we "do" science?	What controls how we do it?

Name : \_\_\_\_\_

Blk: \_\_\_\_\_ Date: \_\_\_\_\_

Effort/Mark: \_\_\_\_\_

## **Comparing Traditional Knowledge to Western Modern Science**

1) Contrast Traditional Knowledge to Western Modern Science in the following categories:

	<b>Traditional Knowledge</b>	<b>Western Modern Science</b>
Human Place in Environment		
Worldview (holistic/ reductionistic)		
Methodology -timescale  - type of knowledge (qualitative/ quantitative)  - biological classification system		
Application of Knowledge		
Transmission of Knowledge		
Ownership of Knowledge		

2) What aspects of science do both Traditional Science and Modern Western Science share?

3) Describe some ways in which each science can contribute to marine science.

**Traditional Science**

**Western Modern Science**

4) **Traditional science** can be defined as: \_\_\_\_\_

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5) Briefly describe how these examples show Traditional Science and Western Modern Science working together.

**The Dene Project** \_\_\_\_\_

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**The Western Yew (*Taxus brevifolia*)** \_\_\_\_\_

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**The Neem Tree** \_\_\_\_\_

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**Rosy Periwinkle** \_\_\_\_\_

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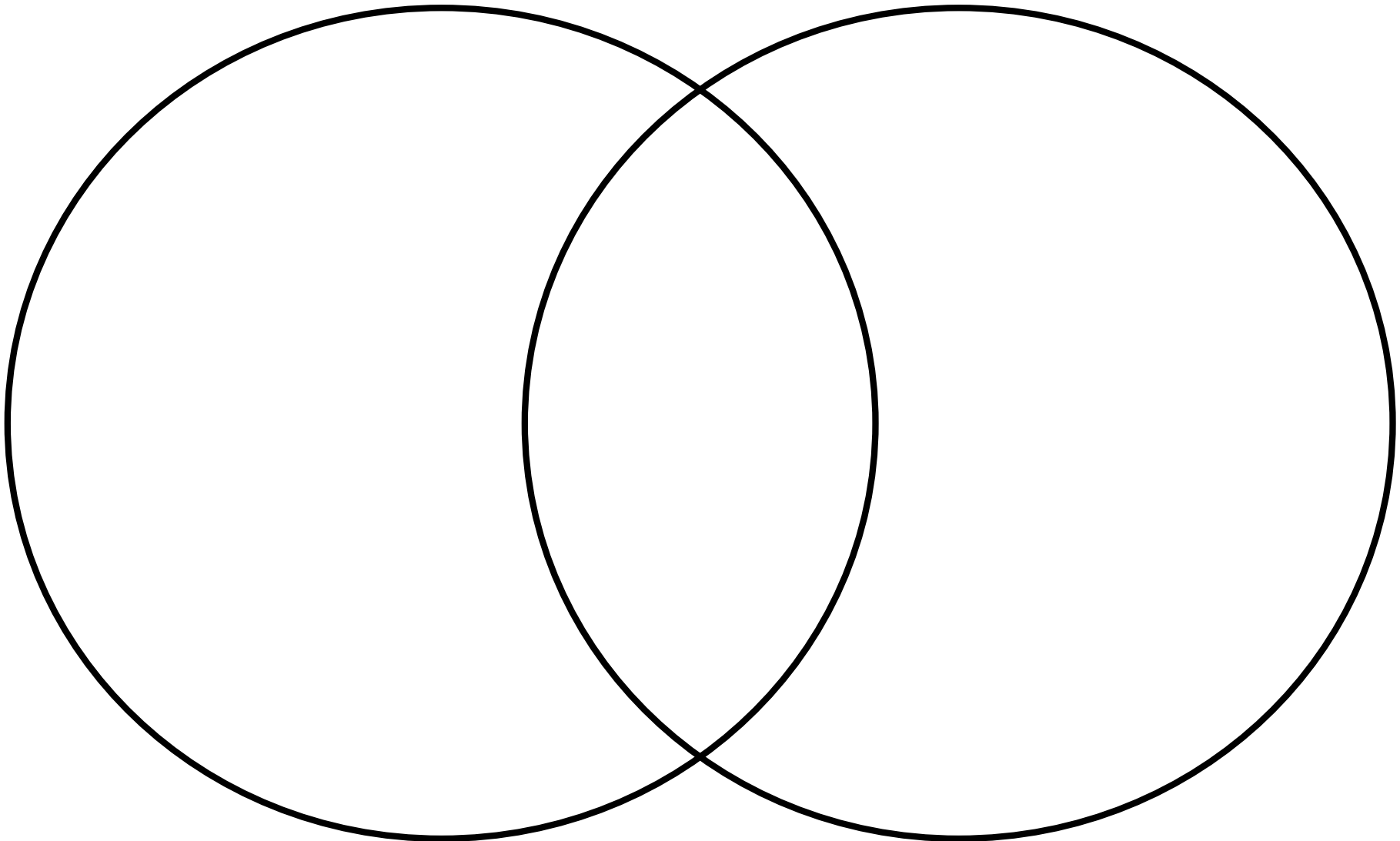
6) What are "intellectual property rights" and how does this apply to traditional knowledge.

**Comparing Traditional Knowledge & Modern Western Science**

Place Statements in Appropriate Area, where the circles overlap, statements are true for both

**Traditional Knowledge**

**Modern Western Science**



**Place the Following Statements in the appropriate part of the diagram:**

Humans are controllers over nature	Transmitted by written word and tends to be removed from experience	Medicine
Humans are part of nature	Examines nature in pieces (reductionist)	Aeronautics
All organisms are depend on each other	Quantitative	Architecture
Transmitted orally and through experience	Theoretical	Botany
Holistic	The universe is rational and objective	Food
Qualitative	Owned by a person	Copyright
Practical	Protected by laws	Often developed from short term observations
Developed over long term observations	Wisdom oriented	Very specific
Locally valid	Fact oriented	
Culture	Ecology	
Spirituality	Resource management	
Communally held	Money	
Used to make suitable decisions for community and environment	Weather	
	Mathematics	

## Appendix H

I. **Title:** **Traditional Stories and their use in Traditional Ecological Knowledge?**  
(2 one hour classes)

II. **Grade Level:** 10-12

IIIa. **Key Concepts:**

- Aboriginal cultures orally transferred ecological and cultural knowledge through stories.
- Traditional stories often contain useful information and/or moral teachings.
- Cultures all over the world have, and still do, use stories for the transfer of ideas.
- These stories pertain to specific cultures within a spatial context.
- Learning oral traditions is a cultural skill, not easily understood by “Western” people.
  - Note: this lesson involves lots of listening and students will probably become restless (a good teaching moment about cultural methods of teaching)
- Many of these stories are protected by intellectual property rights.

IIIb. **PLO Focus**

*In addition to the Multicultural PLO focus of the previous lesson, this lesson incorporates cross curricular aspects into the science class from English and Aboriginal Studies:*

IV. **Observable Outcomes:**

- ❖ Students will be able to describe how Aboriginal stories are more than myths used for entertainment.
- ❖ Students will be able to extract learning concepts from an Aboriginal Story.
- ❖ Students can make connections between cultures through historical stories such as “The Great Flood” or moral stories.
- ❖ Students will be able to create their own story with an ecological or moral aspect.

V. **Materials:**

- ❖ white board for brainstorming class ideas
  - ❖ Guided notes for instructor
  - ❖ Creation Stories from <http://www.dreamscape.com/morgana/uranus.htm>
  - ❖ Aesop’s Fables
  - ❖ “Keepers of the Animals” Book
    - “Octopus and Raven” (p. 73)
    - “Salmon Boy” (p. 95)
  - ❖ “Indian Fishing” Book
    - “How the Fish Came Into the Sea” (p.13)
  - ❖ Worksheets:
    - “Examining Traditional Stories.doc”
  - ❖ “Who owns the stories” Reading from <http://www.eldrbarry.net/rabb/rvn/whoowns.htm>
- 

VI. **Motivational Activity:**

- ❖ Read long and technical quote from ecology textbook
  - Ask students how much they retained of the knowledge, through specific questions.

## VII. Developmental Activities

### Activity 1. What are Traditional Stories?

- ❖ Most, if not all, cultures have their own versions of Traditional stories. These may be known variously as stories, folktales, fables, epics, myths and legends as well as many other terms.
  - **Brainstorm** traditional stories with which students are familiar, such as “The tortoise and the hare,” “The ant and the grasshopper,” “Goldilocks,” or some students with non-Western backgrounds may come up with a number of other cultural stories.
    - Engage students in asking if any of these stories have purposes, such as entertainment, moral lessons or historical importance.
- ❖ Traditional stories are often transferred orally, and often referred to as “orations,” instead of “stories.”
  - Learning complicated information orally is a difficult skill; however, oral cultures had specialists in remembering oral stories. In addition, the people were already enculturated into oral traditions where younger generations were accustomed to listening closely to stories presented by their elders.
- ❖ Introduce examples of creation myths and read beginnings the of samples from <http://www.dreamscape.com/morgana/uranus.htm>
  - Japanese, Salish, and Judeo-Christian
- ❖ Discuss similarities and differences of these stories, focusing upon cultural perspectives and purposes
  - The exact details of comparison are not important, except to recognize that all these cultures had stories to explain the beginnings of life and the universe, and that these stories reflect the culture as it is present today. For example, Judeo-Christian creation involves a single, all powerful, male-like entity, reflecting the male dominated, power hierarchy of Western culture, such as kings and emperors. However, many Aboriginal cultures often involve multiple characters in an interactive creation of the world through various events, which reflects the importance of the interconnectedness of man, spirit and the environment.

### Activity 2. Traditional Stories Can Be Used For Historical References

- ❖ Have students read various Flood stories from <http://www.dreamscape.com/morgana/uranus.htm>
  - Read examples of the Flood stories.
    - Greco-Roman, Salish, Judeo-Christian
  - Discuss similarities and differences between these stories.
    - Rise of water for different reasons, and all cultures had a safe place in which to wait out the lowering of the waters to expose new land.
  - Discuss how the similarities between stories from around globe may be used to complement geological records of a widespread flood around 10,000 years ago.
    - This corresponds to the last major retreating of an ice age where sea levels rose over 100m to their present levels, and can be verified with various topographical charts geological data along the coast. Other flood stories may represent retreating of minor glaciations or localized geological events.

- Traditional stories can be used for historical purposes such as discovering, or verifying records of global, or widespread climate change.

### Activity 3. Traditional Stories Can Be Used As Moral and Ecological Lessons

- ❖ Give examples and purpose of Aesop’s Fables in Western Culture.
  - These fables provide learning for moral and cultural lessons.
  - Traditional stories from Aboriginal cultures can teach and provide moral lessons.
- ❖ Explain to students how many coastal Aboriginal stories incorporate animals and natural objects in their spirit form, which is similar to that of a person.
- ❖ Have students read “Octopus and Raven” and answer questions.
  - What is the moral lesson that Raven learns?
    - Raven learns that when learning from elders, one needs to observe carefully and with respect. From a social perspective, constantly asking questions is rude and annoys others. This corresponds to one of the common methods that Aboriginal children learned the skills and knowledge of the elders, by accompanying them and watching and listening. This is also present in the expected behaviour during storytelling.
  - What other information can we learn from this story?
    - Clams are collected at low tide using sturdy yew sticks, woven baskets are carried on the back, so both hands are free, and that one must be aware that when collecting foods from the tide zones, the tide will eventually return.
- ❖ Have students read “Salmon Boy” and answer the questions on the worksheet.
  - Discuss student responses noting the ecological importance of returning wastes to the river and respect aspects.
    - Recycling of nutrients feed spring fry, salmon return to home rivers utilizing smell, reducing garbage in village, respecting the waste shows intrinsic respect for the resource (the more you waste, the more you have to deal with).
- ❖ Have students read “How the fish came into the sea” and answer questions.
  - What information can we learn from this?
    - The order of the fish released by Raven is the order in which the fish are found to harvest throughout the year.
  - Why is it important to remember this story accurately?
    - The order of the fish corresponds to the order they can be caught throughout the season, if you have the order wrong, you will be fishing for the wrong fish and have a poor catch.
    - Although, this isn’t the biological explanation as to what fish are present and/ or ready to harvest during any particular season, the concept of the order of the fish allows the community to prepare properly, to make the resource collection as efficient as possible.

Fishing for herring, when they are not around in large numbers would be a waste of effort, especially if another fish would be more plentiful.

- ❖ Read “Who owns the stories” and discuss with students the concept of Intellectual Property Rights with stories.
  - This letter brings up the concept of intellectual property rights (IPR). This was discussed in the TEK lesson, however, this letter describes to students how IPR can belong to less tangible elements of a culture. These stories may have quantifiable monetary value, or may be owned by sheer respect and partitioning of knowledge throughout a community (one person cannot be expected to know all the stories of a nation).
    - Stories belong to the storyteller and the original community and family.
    - These stories can be passed along with inherited rights or with marriage.

#### VIII. Culminating Activity. Examples of Utilizing Traditional Knowledge with Modern Western Science

- ❖ Students will develop their own story to remember facts about their traditional marine knowledge project
  - Myth needs to describe interrelationships between at least 2 organisms, and refer to the others.
  - Temporal and spatial descriptions are required.
  - Information about tools is required (Yew stick, basket material, etc.)
- ❖ This will be added to their project.

#### References:

- Caduto, M. & Bruchac, J. (1991). *Keepers of the Animals*. Saskatoon: Fifth House Publishers.
- Caduto, M. & Bruchac, J. (1997). *Keepers of the Earth*. Fulcrum, Inc.: Golden, CO.
- Corsiglia, J., & Snively, G. (1997). Knowing home. *Alternatives Journal*, 23(3), 22-27.
- Kimmerer, R. (2002). Weaving traditional ecological knowledge into biological education: A call to action. *Bioscience*, 52(5), 432-438.
- Snively, G., & Corsiglia, J. (2001). Discovering indigenous science: Implications for science education. *Science Education*, 85(1 (January)), 6-34.
- Stewart, H. (1977). *Indian Fishing*. Douglas and McIntyre, Ltd.: Vancouver, BC.

Name: \_\_\_\_\_ Blk: \_\_\_\_\_ Date: \_\_\_\_\_  
Effort/Mark: \_\_\_\_\_

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### Examining Traditional Stories

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- 1) How were Aboriginal stories transferred traditionally?
  
- 2) How are various creation stories similar? Different?
  
- 3) How can the flood stories be used to confirm geological data?
  
- 4) Read "Octopus and Raven."  
How were clams collected?

What material was used for the digging stick?

What lesson did Raven learn?

What safety lesson can children learn about exploring the seashore?

- 5) Read "Salmon Boy"  
What does this story tell us about the life cycle of salmon?

What does this story tell us about respecting nature?

Why would it be important to return the fish remains to the river? Give at least three reasons.

Both the Salmon Boy and the Salmon have a form similar to humans, what can this be said about the people's connection to salmon?

6) Read "How the fish came into the sea."  
Who releases the fish?

This character is often referred to "the Trickster" with coastal Aboriginal cultures. Why would he be used in many stories as the main character, and often causing trouble?

What is the important lesson for fishermen in the story?

How would you remember this order?

What aspects of the story suggest that it is not universally valid, but only useful on the West coast of BC, Alaska?

Is this similar with these other stories?

7) Name three ways in which traditional stories can be used?

8) How do Intellectual Property Rights apply to Traditional stories?

## Appendix I

- I. **Title:** **Rhythm of the Tides- Two Perspectives**  
(2 one hour classes)
- II. **Grade Level:** 10-12
- IIIa. **Key Concepts:**
- Aboriginal stories have their own way to explain the tides.
  - The tides are caused by the combined gravitational forces of the moon and sun and Earth's spin.
  - We have 2 sets of tides a day.
  - Tides vary through the month because of the position of the moon.
  - Tides have a significant impact on the coastal environment and the organisms.
  - Aboriginal people have learned to take advantage of the movement of tides in order to collect resources.
- IIIb. **PLO Focus**
- BC Ministry of Education has no specific PLO's in secondary science curriculum, although recent IRP's (2005/2006) suggest Aboriginal/ multicultural recognition.*
- IV. **Observable Outcomes:**
- ❖ Students can draw/ explain what celestial conditions cause high tides.
  - ❖ Students can name geographical features that affect tidal movement.
  - ❖ Students can read a tide table to predict the tidal changes and heights, as well as predicting current movement.
  - ❖ Students can describe how humans are affected by tidal changes.
  - ❖ Students can explain ways that Aboriginal people utilized the tidal changes to collect food resources.
- V. **Materials:**
- ❖ white board
  - ❖ Student "What causes the Tides?" worksheet
  - ❖ Copy of Barry McWilliams' "Raven and the Man who sat on the tides"
  - ❖ Overhead of Worksheet
  - ❖ Overhead of Tide Tables for Sooke
  - ❖ Overheads of wooden weir traps and stone weir formations from "Indian Fishing"
  - ❖ Overhead of Sooke Basin
- 
- VI. **Motivational Activity:**
- ❖ Guided brainstorm on board, utilizing leading questions.
    - Are the changes in tides important to us now?
      - Accessibility for collecting seafood, water safety with coastal currents.
    - Were they important to Aboriginal cultures?
      - Foods, transportation, tool materials.
    - What causes the tides?
      - Wind? Current? Sun & Moon!
    - How would you explain the tidal rhythm if you didn't know about the effects of the sun and moon?
      - How would you make a connection?

## VII. Developmental Activities

### Activity 1. What causes the tides in a Traditional story?

- ❖ Read “Raven and the Man who sat on the Tides” by Barry McWilliams story aloud.
  - From- [http://www.eldrbarry.net/rabb/rvn/r\\_tide.htm](http://www.eldrbarry.net/rabb/rvn/r_tide.htm)
  - This story is from the BC coast, however, the exact Aboriginal source is not known.
    - In this version of Raven and the tides, Raven is hungry and knows that there is plenty of food in the sea that he can’t access. He goes to find Fog Man and ask him how to move the water away from the shore. The Fog Man tells Raven about the Man who sits on the Tides and Raven goes off in search of this Man, taking Fog Man’s hat with him. Eventually Raven finds the Man who sits on the Tides and asks him if he will let the water recede. The giant, being unwilling to help, is encouraged to stand up by some “convincing” from Raven’s beak, and when he stands, the water drains out in a hole upon which he is normally sitting. When the giant sits again, the waters return to their normal level. Raven decides to “encourage” the giant to stand twice a day to let the tides go out, but not after an initial battle that results in a great storm that washes seashells into the mountains. Raven comes at different times each day to take the giant by surprise. Eventually the giant begins standing twice a day on his own, allowing two tides per day, but at different times each day.
- ❖ Discuss what we learned from the story.
  - Who was the main character (again)?
    - Raven is a common impetus for myths.
  - Why was Raven the main character?
    - Probably because Aboriginal people recognized the intelligence and curiosity of ravens.
  - What food items could the people collect from the seashore, if the tide were out?
    - Crabs, clams, mussels...
  - Why did the tide not go out?
    - The giant sat on the hole in the ocean.
  - What does the story say about the intelligence of “The Man Who Sits on the Tide.”
    - He is a man of habit, who does things as they are always done, just because.
  - How many times a day does Raven want the giant to “stretch”?
    - How does this correspond to our tides?
      - Twice a day, at different times each day.
  - Why did the giant begin to get up off the tide on his own?
    - It became his new habit and he had forgotten his old habit.
  - How is this information important to people?
- ❖ The Aboriginal perspective was not correct, according to Western modern science, but it was functionally correct for teaching children about the tidal cycle.

### Activity 2. Guided notes of tidal rhythm

- ❖ The force of gravity causes the movements of the ocean’s waters.
  - Force of gravity was first described by Newton in the 1700’s.
- ❖ Which object in the sky affects the tides the most?
  - The moon, the sun, although larger, is further away.
  - Combined with the Earth’s rotation, creates a tidal bulge.
- ❖ We have about 4 tides each day, in two cycles.
  - HH, HL, LH and LL
- ❖ The tidal period is just over 24 hours, by 52 mins.
  - Caused by the Earth’s rotation relative to moon.
- ❖ Neap and Spring tides are caused by the combined effects of moon and sun.
  - Spring at new and full moons when moon in line with sun.
  - Neap when moon at right angles to sun.

**Activity 3. Tide tables**

- ❖ Show overhead of BC tide tables
  - Show how to find Sooke and how to read table
- ❖ Use *Standard Time*
  - What happens to the time in the Summer?
- ❖ How can we find the total tidal range?
- ❖ How can I use this information to predict local currents?
- ❖ Note that tidal times are different between nearby areas
  - Why?
- ❖ What geographic features affect the tidal rhythms?

**Activity 4. Taking Advantage of the Tidal Rhythm**

- ❖ Aboriginal coastal people used, and continue to use, the intertidal zone extensively for food and resources, much as we do now.
- ❖ Examples included clam beds, mussels, seaweeds, fish, sea urchins, sea cucumbers, and chitons.
  - We will learn more about how these were utilized during the intertidal explorations.
- ❖ These sites were not randomly and haphazardly used, the coast was well populated so everything was managed to some extent.
  - Clam beds were owned and maintained by families.
  - Semi permanent wooden *weirs* were set up and maintained.
  - Stone weirs were used near creeks and streams as they opened onto tidal flats.
  - These weirs would catch fish swimming in the shallows at high tide, or those moving upstream.
  - Weirs were a sustainable form of fish management as most included some escapement in the design. This escapement would ensure that whole genetic schools of fish were not wiped out. In addition, weirs (and hooks) were designed with certain fish species and sizes in mind. Undersized fish, or non target fish had a decreased chance of being caught.
- ❖ Show various forms of weirs and remnant stone weirs along the coast (“Indian Fishing”)
  - Note that modern East coast fishing still relies on weir technology developed by Aboriginals.
- ❖ Complete Worksheet.

**VIII. Culminating Activity. Resource gathering in the Sooke Basin?**

- ❖ In groups of 2 or 3:
  - Sketch the Sooke Basin and nearshore (from overhead)
  - If you were to utilize the resources where would you place weirs (stone or wooden), where would you collect shellfish, and what types of fish could you catch?
  - What material would you use for your clam digging sticks?
  - Draw your weirs.
  - **How might the current use of the Sooke Basin differ from 300 years ago?**
    - The Sooke people would have intimate knowledge of the tides and currents. Not only would this affect when they could collect intertidal life in and around Sooke Basin and other bays and inlets, but the strong currents passing the headlands and at the entrance to Sooke harbour would affect canoe travel. This knowledge would include anticipating the tidal times and relative heights (according to the moon cycle).
- ❖ **Share ideas as a group, and emphasize on last question.**

**References:**

Snively, G. (2003). *Beach Explorations; a curriculum for Grades 5-10*, Kingfisher Press: Sooke, BC .

Stewart, H. (1977). *Indian Fishing*. Douglas and McIntyre, Ltd.: Vancouver, BC.

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Tidal WS.doc 28/08/2009 dashurst

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## Tidal Rhythms

What force causes tides?

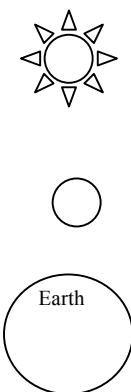
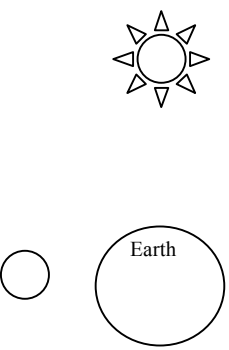
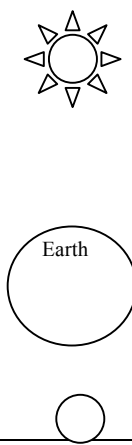
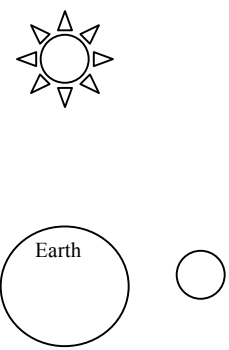
Which object in the sky has the largest impact upon the tides?

Why does the other object not affect the tide as much?

How many tides do we have each day? Label and draw the different tides on the graph?

What is the period of the daily tidal cycle? Why?

Draw the tidal bulge and the type of moon throughout the month.

<b>Spring Tide</b>			
			
<b>New Moon</b>			

What is the difference between a "neap tide" and a spring tide?"

**Reading a tide table.**

Using this table, when is the:

high high tide? \_\_\_\_\_

high low tide? \_\_\_\_\_

What is the total tidal range (in feet)?

\_\_\_\_\_

2006-12-13	02:22	PST	4.75	feet
2006-12-13	10:02	PST	7.88	feet
2006-12-14	00:09	PST	5.45	feet
2006-12-14	09:44	PST	8.13	feet
2006-12-14	18:04	PST	5.05	feet

How would we calculate the times in the summer?

What geographic features can affect the local tides?

Sketch the Sooke basin and indicate what feature has the most affect on tides?

Design a fishing weir for a spot in the Sooke basin? What type of weir is it? What would you catch and where would you put it? How does this target a particular species?

How might the story of "The Raven and the Man Who Sits on the Tide" change more toward the equator? (check on number of tides and their movement)

## Appendix J

### Food Web Activity

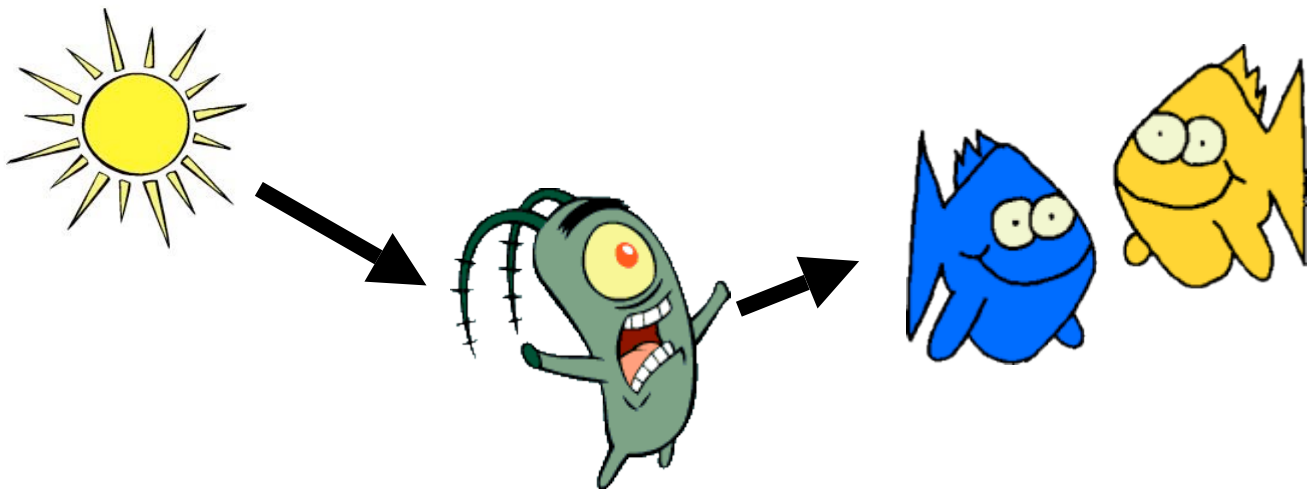
#### The Activity

1. Place the students in small groups and supply them with set of arrows, a sun and a deck of Gloria Snively's "Pacific Coast Information Cards."
2. Have students create a model of an ecosystem with the sun in the center and marine plants and animals radiating from the sun. Instruct students to read the back of cards to determine "who eats who," predator/prey relations, and, thus, the flow of energy from Sun to top predators.
3. Have students make the food web as complex as they are able with many organisms connected to many others.

#### Circulate and ask students:

- Are all the elements of the web connected?
- What would happen if we removed or changed one element?
- Can one element be removed without affecting the others?
- What happens when one species is abundant or scarce?
- Who is affected in the food chain?
- What role do humans play?
- Different levels of the food chain
- We may not always understand the links and importance of a species, but each has their place in the web of life

Have Students draw Food Web in their Journal and discuss some of the above issues.



## Appendix K

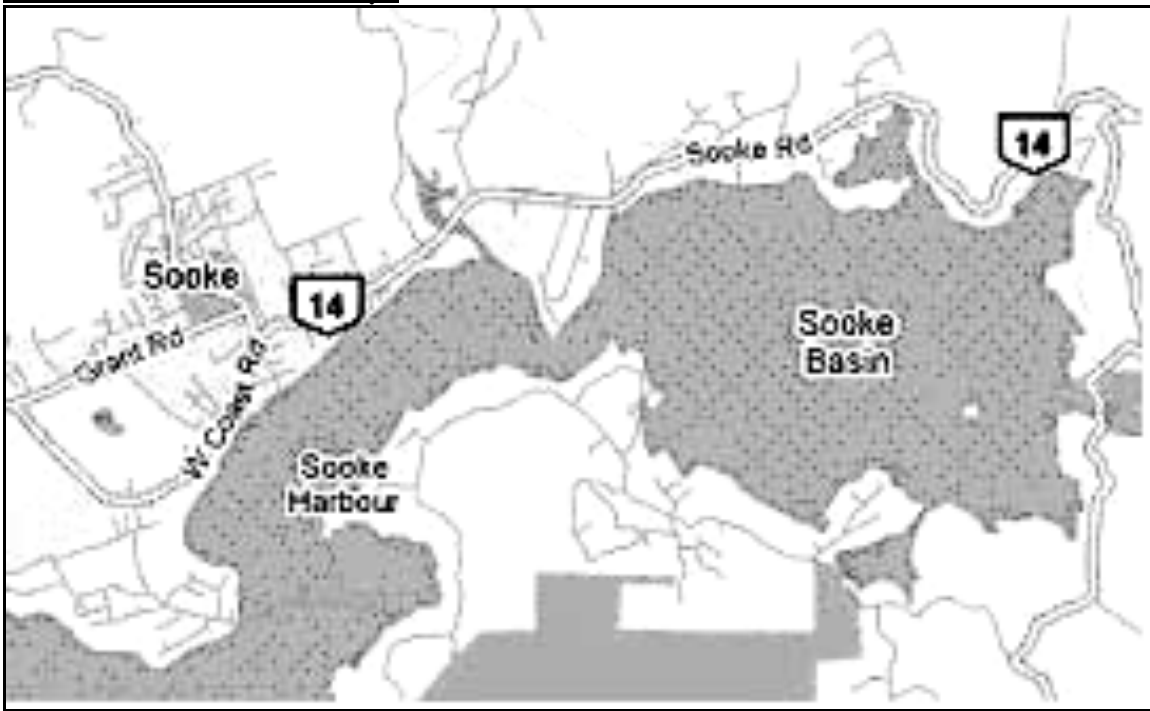
**Marine Water Sampling: Individual Data**

Date: \_\_\_\_\_

Name: \_\_\_\_\_

Location (description): \_\_\_\_\_

GPS Location: \_\_\_\_\_ " N \_\_\_\_\_ " W

**Indicate location on map.**

Weather Conditions: \_\_\_\_\_

Wind Direction and Speed: \_\_\_\_\_

Wave Height: \_\_\_\_\_

Surface Salinity (ppt): \_\_\_\_\_

Surface Temperature (°C): \_\_\_\_\_

Water Clarity (Turbidity) Description: \_\_\_\_\_

**Secchi Disc Visibility (if possible) on:**

**Trial 1**

Descent (m): \_\_\_\_\_

Ascent (m): \_\_\_\_\_

Average (m): \_\_\_\_\_

**Trial 2**

Descent (m): \_\_\_\_\_

Ascent (m): \_\_\_\_\_

Average (m): \_\_\_\_\_

**Questions:**

**At this sampling site, what factors may be affecting each of the following tests.**

**Water Temperature:** \_\_\_\_\_  
\_\_\_\_\_

**Turbidity:** \_\_\_\_\_  
\_\_\_\_\_

**Salinity:** \_\_\_\_\_  
\_\_\_\_\_

**Which factors are natural and which may be a result of, or related to human impacts?** \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

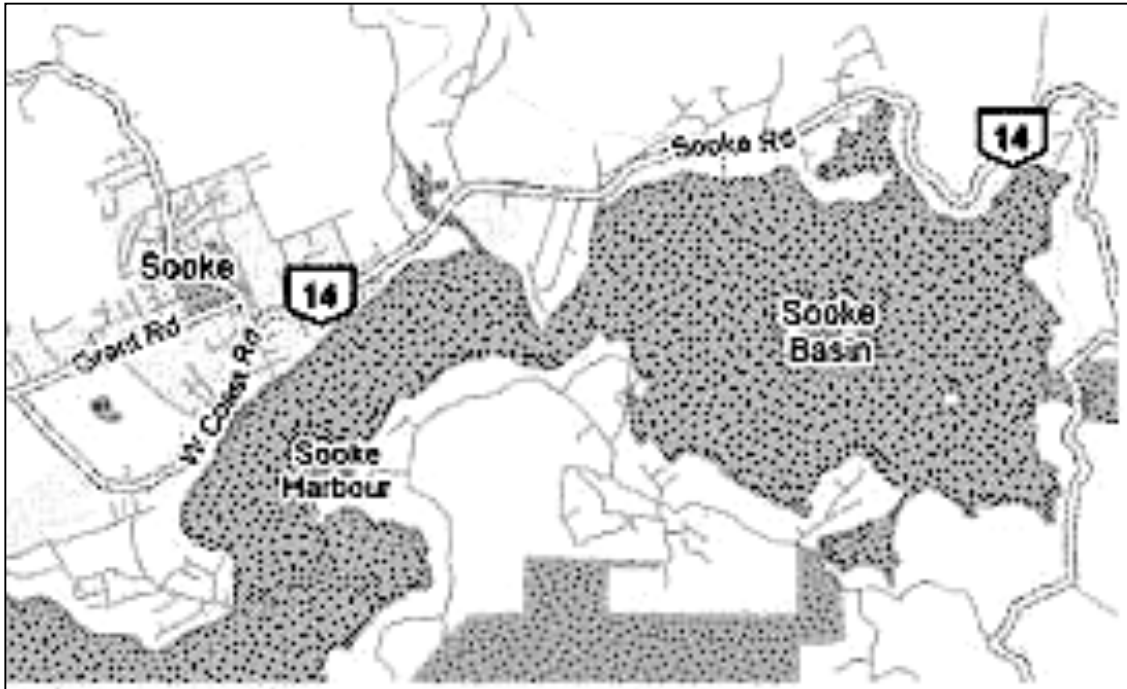
**How may marine organisms, be affected by these factors?** \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

## Sooke Marine Water Sampling: Group Data

Date: \_\_\_\_\_

Name: \_\_\_\_\_

Indicate locations on map.

Data Table:

Site #	Temperature (°C)	Salinity	
		Refractometer (%)	Hydrometer (ppt)
6- Exposed Bay	13	30	26.5
7- Offshore	12	33	

**Graph:****Temperature AND Salinity Vs Site Distance Toward Sea****Questions:****Which instrument was more accurate for reading salinity at low levels? Why?**

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**None of our water samples had a salinity reading of 0%. What are some possible explanations of this?**

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**What happened to temperature of the water as we approached open water? Would this be a good measure to estimate salinity? Why or why not?**

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**What factors may be affecting each of the following tests.**

**Water Temperature:** \_\_\_\_\_

\_\_\_\_\_

**Turbidity:** \_\_\_\_\_

\_\_\_\_\_

**Salinity:** \_\_\_\_\_

\_\_\_\_\_

**Which factors are natural and which may be a result of, or related to human impacts?**

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**How may marine organisms, be affected by these factors?**

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_



## Appendix L

## Whiffin Spit Ecology Project



Group Members:

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**You will work in groups of 3 or 4.**

- Each member of the group will hand in their own copy of this project.
- You will do 3 quadrats, one in each tidal zone- low, mid and high.
- Choose these quadrats in a straight line from the water (a *transect*)
- *Do not wander away, we will work in our teams together to minimize the impact on the beach!*

**Field Work**

1. Divide your research team up into the following four roles:
  - a. Recorder
  - b. Organism identifier
  - c. Quadrat setup and sampler
  - d. Habitat restorer/
2. The size of your quadrat is \_\_\_\_\_
3. **Photograph** each quadrat with your group names in the bottom right corner.
4. **Plants/ Algae-** record the species and percentage cover of each in your quadrat.
5. **Animals-** record number and name of organisms found in your quadrat. *You may want to find the scientific name later*

You may want to count a few random samples within the quadrats and average it for the whole quadrat. . (Don't forget the existence of phytoplankton d zooplankton in the seawater.) Be VERY careful and gentle when disturbing the animals and their habitat. Make sure that rock homes are replaced.

**Low Tide Zone****Plants**

Common name	% cover

**Animals**

COMMON NAME	SCIENTIFIC NAME	sample number

**Major Biotic and Abiotic Factors** – list the *MAJOR* factors in your quadrat. Do any of them vary throughout the seasons? Day? With weather? Predators? (eg. Salinity, coverage, dessication, temperature etc.)

Biotic Factors	Abiotic Factors

**Mid Tide Zone****Plants**

Common name	% cover

**Animals**

COMMON NAME	SCIENTIFIC NAME	sample number

**Major Biotic and Abiotic Factors** – list the *MAJOR* factors in your quadrat. Do any of them vary throughout the seasons? Day? With weather? Predators? (eg. Salinity, coverage, dessication, temperature etc.)

Biotic Factors	Abiotic Factors

## High Tide Zone

### Plants

Common name	% cover

### Animals

COMMON NAME	SCIENTIFIC NAME	sample number

**Major Biotic and Abiotic Factors** – list the *MAJOR* factors in your quadrat. Do any of them vary throughout the seasons? Day? With weather? Predators? (eg. Salinity, coverage, dessication, temperature etc.)

Biotic Factors	Abiotic Factors

**Human impact** – list as many sources of human impact on your *transect* as you can think of.

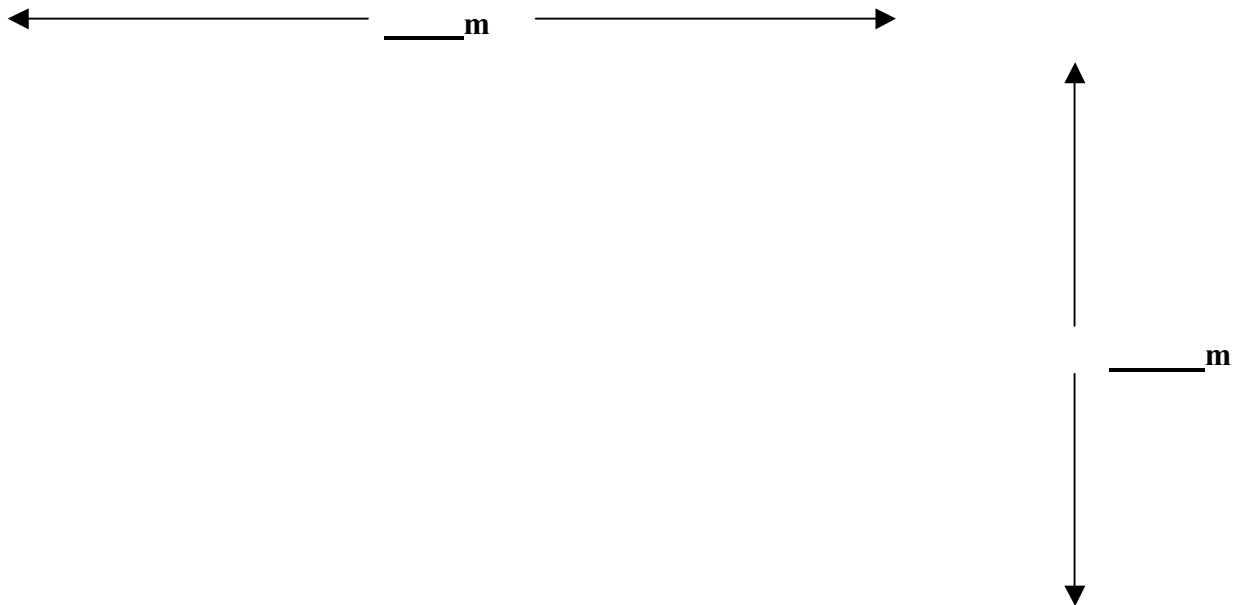
Explain how these sources will affect the organisms.

\*\*\*\*Think of the tests we could do- pH, temperature, turbidity, salinity, dissolved oxygen, chemical pollutants, bacteria and viruses and invasive species.

SOURCE/ IMPACT	HOW IT AFFECTS ORGANISM

6. Sketch ONE quadrat, *draw and label* the various organisms. (artistic ability is not important!)

**(Low/Mid/High) Tide Zone**



## Report Preparation

**In your good copy report, you must include:**



**Ecological Understandings:**

1. **Field Work:** A good copy presentation of your field work, including the plant and animal charts, biotic & abiotic factors, human impact list and your quadrat sketch.
2. **Adaptations:** Choose three organisms from your quadrats. For each organism list five major adaptations. Adaptations may help it find food, escape predators, move, find shelter, or reproduce.
3. **Seashore Sketch:** *Sketch and label* a cross section of the seashore on a spare blank piece of paper. Include as many organisms as you can. Make sure you place these organisms in their appropriate tidezone & environment (tidepool, under kelp, on rock...). Make sure your labels are neat! Use common, *or* scientific names.  
*You may use symbols to represent organisms in your sketch, if you do use symbols, include a key for what each represents.*

**Intrinsic/Experiential Understandings:**

4. Choose one marine plant or animal that you saw at Whiffin Spit (not necessarily in your quadrat) and imagine being that organism. Write, in the first person, a moment in time. Can you hear/see/smell/taste/feel anything? How do you perceive your world? Perhaps, you can write about an interaction with another organism or a connection with natural elements.
5. How do you think the loss of species on Whiffin Spit would impact you?

**Answer the following questions on human impact:**

6. **Salmon farms** are springing up on various parts of the west coast. These farms tend to introduce excess nutrients, biological matter, and chemicals (such as antibiotics) into the environment. Explain how introducing a salmon farm might affect populations of plankton, kelps, crabs, starfish, nudibranchs and barnacles. Keep in mind their places in the food web.
7. **Global warming** or the greenhouse effect is caused by too much carbon dioxide in our atmosphere. As we release more carbon dioxide from our cars, homes and industries, the planet's temperature increases and the polar ice caps melt. How do you think that an increase in global temperature might even affect the organisms at Whiffin Spit?

**Marking Criteria:**

1. Field Work
  - a. Plant and animal charts
  - b. Biotic/ Abiotic factors
  - c. Human impact list
  - d. Quadrat sketch /20
2. Seashore cross-section sketch /10
3. Adaptations /15
4. Experiential /5
5. Intrinsic /5
6. Salmon farms /5
7. Global Warming /5

**/ 65**