CONSERVATION ENGINEERING OUTREACH:

CURRICULUM DEVELOPMENT AND EVALUATION OF

SMART FISHING IN THE BERING SEA

A Thesis

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By

Christine Honan Simpson

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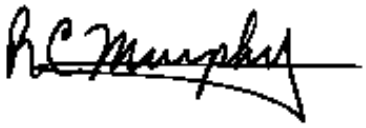
Chairperson Date



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Abstract

The purpose of this project to was to 1) develop, 2) instruct, 3) evaluate, and 4) revise a 5th-12th grade fisheries conservation engineering outreach program entitled *Smart Fishing and the Bering Sea* (SFBS).

Fishery resources are important to Alaska and Alaskans, but present complex conservation challenges include user conflicts and concerns about unsustainable fishing practices. Increasing Alaska residents' environmental literacy will enhance natural resource management decisions regarding fisheries. The intent of the SFBS program is to introduce students to ecological and economical factors that drive conservation engineering in the Bering Sea pollock fishery. I instructed the SFBS program to 93 students from four different public and private institutions in Anchorage, Alaska. My observations and participants' pre- and post-program concept maps were used to evaluate the effectiveness of the SFBS curriculum. Participants gained content knowledge from this fishery outreach program about the Bering Sea and commercial fishing. Program evaluation analysis and results were used to revise the curriculum and make suggestions to SFBS stakeholders.

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Literature Review

The premise of the SFBS project is that if public awareness of marine fishes and fisheries increases, then the likelihood for fisheries to sustainably capture and manage fish resources increases.

Science Research and Public Outreach

The scientific community acknowledges that education efforts are valuable and produce faster outreach results than just publishing scientific papers (Cooke et al., 2013). Education and public outreach (EPO) is a component of the environmental education (EE) process used to produce "*a citizenry that is knowledgeable concerning the biophysical environment and its associated problems, aware of how to help solve these problems, and motivated to work toward their solution*" (Stapp et al., 1969). For a detailed review of EE goals, objectives, methods and barriers please refer to the appendix. EPO is defined as "*efforts to increase awareness and understanding of science. Target audiences can include students, teachers, children, adults, and just about any conceivable subset of these…"* (Franks et. al., 2006). Ray (1999) defined science outreach as:

> *meaningful and beneficial collaboration with partners in education, business, public, and social service. It represents that aspect of teaching that enables learning beyond the campus walls, that aspect of research that makes what we discover useful beyond the academic community, and that aspect of service that directly benefits the public.* (25)

For this project, outreach will refer to the efforts to increase student awareness and understanding of commercial fishing and the Bering Sea. EPO can develop a well-

informed public to engage in regional natural resource management initiatives (Bjorkland and Pringle, 2001; Lane et al., 2006; Ruppert and Dann, 1998; Pomeroy and Rivera-Guieb, 2006; Zahawi, 2010). Outreach activities can be "stand alone, one time activities, or sustained over a long period of time" (Balcom et al., 2009).

EPO barriers. Educating the public about environmental topics is as important and difficult as scientific research (Firth, 1998). Despite a need for EPO, some researchers lack the ability to communicate science successfully to the pubic. Much EE has been carried out by NGOs targeting specific policy outcomes. In turn, some environmental scientists are apprehensive to engage in what might appear to be advocacy thereby compromising their credibility as objective investigators. Although communication does not equate to advocacy, researchers have avoided engaging in public dialogue to ensure "objectivity" (Lackey, 2007; Nelson and Vucetich 2009 as cited in Cooke et al., 2013). Time and economic resources also limit researchers' efforts to educate the public. Academic researchers rely on research and publishing for career advancements, and, in turn, often only dedicate limited time towards EPO (Cooke et al., 2013). Though, most public funding sources only fund projects that include elements of education and outreach (Powers, 2000). Research funding is dependent upon how well the public is informed about the work, study, or project. It can be difficult for scientists to communicate environmental issues to the public because environmental matters are multifaceted and undergo continuous change. The scientific complexities can be difficult to explain to the untrained audience. Failing to effectively communicate research to the public can cause research results to be under utilized or unrecognized (Szaro, 1998).

The foundations of EE can guide science researchers to effectively communicate their knowledge with the public. For example, Monroe et al.'s (2007) EE framework was used to involve the public with inland fishes and fisheries (Cooke at al., 2013). This framework highlights four categories of EE: convey information, build understanding, improve skills, and enable sustainable actions. Other examples of successful science outreach programs using EE approaches include marine systems and sustainable seafood (Jacquet and Pauly, 2007), waste management systems (Taylor and Todd, 1995), and agriculture (Rappole et al., 2003).

EE in Alaska

Formal EE in the state of Alaska is due to statewide community involvement from educators, natural resource managers, private and public resources professionals, and citizen groups. The establishment of formal EE programs in Alaska is credited to Sea Week (ANRELP, 2013). Sea Week began in 1968 in Juneau and is still a statewide program today. Alaska Sea Grant produced, updated and revised Sea Week Curriculum Guides, which are available through Alaska Seas and Rivers curriculum. The Alaska Department of Fish and Game (ADF&G) has also been a leader of EE. In 1983, ADF&G commenced an annual Alaska Wildlife Week, starting the Alaska Wildlife Curriculum. In addition to curriculum materials, ADF&G also offers workshops and resources to educators.

In 1984, Alaska Natural Resource and Outdoor Education Association (ANROE) became the first formal connection between Alaska natural resource bureaus, education

groups and teachers. ANROE serves as Alaska's affiliate to the North American Association for the Environment. Also in 1984, the Alaska Resource Education formed from a partnership between the Alaska Department of Education and Early Development and private industry. The Alaska Resource Education provides education kits pertaining to mining, forestry and energy. In 1995, the Alaska Federation of Natives collaborated with the University of Alaska and rural Alaskan communities to create the Alaska Rural Systemic Initiative (ARSI). The Alaska Native Knowledge Network was one of the outcomes of ASRI and shares information and resources connected to Alaska Native knowledge systems and ways of knowing.

State sponsors have introduced national curriculum guides and resources to Alaska. For example, Project Learning Tree national EE curriculum guide provides educators with resources and training through partnerships with the University of Alaska Fairbanks Cooperative Extension Program and the Alaska Department of Natural Resources. Project WILD and Project WILD Aquatic national EE curriculum guides are managed statewide by ADF&G. In 2008, the National Science Foundation provided funding to launch the Alaska Center for Ocean Sciences Education Excellence (Alaska COSEE). Alaska COSEE aims to connect scientists and educators to increase marine and aquatic science literacy. These types of partnerships and efforts have established a statewide "framework of collaboration" between people with environmental expertise and people who teach about the environment (ANRELP, 2013).

Both the *Constitution of the State of Alaska* (Article 08- Natural Resources) and Alaska state law (AS 14.30.380- Environmental Education) demonstrate the state's

support of EE. Section 8.1 Statement of Policy Natural Resources of the *Constitution* states, "*It is the policy of the State to encourage the settlement of its land and the development of its resources by making them available for maximum use consistent with the public interest*". This article requires Alaskan youth to be prepared to make informed decisions about natural resource management and development. In 1991, the state legislature passed the Alaska Statute 14.30.380 Environmental Education. The statute reads:

> *The board shall encourage each school board to initiate and conduct a program of environmental education for kindergarten through grade 12. The program should include, but is not limited to, education regarding the need to balance resource development with environmental safeguards, the dependence of the state on resource development, and the opportunity for pollution prevention, waste reduction, and recycling. A school board may implement environmental education as a part of regular classroom studies.*

While this law demonstrates the state's support to integrate EE through all schools in Alaska, there are no state education standards targeting environmental literacy and natural resources. However, the Culturally Responsive Schools and Alaska State & Performance Standards are a reference point from which to promote environmental literacy and natural resources in grades K-12 (ANRELP, 2013).

The *Alaska Natural Resource and Environmental Literacy Plan* (ANRELP) was created from 2009-2013 to provide a "road map" to support Alaskan schools in "integrating natural resource and environmental education, including active outdoor learning, as part of the school curricula" (ANRELP, 2013). The working group included educators and natural resource professionals, the Alaska Department of Education &

Early Development and the ADF&G. Individuals, organizations and agencies offered suggestions during a designated six-month period. The vision of ANRELP includes:

> *Alaska's students will graduate from high school with a strong foundation in natural resource and environmental literacy. Students will have personal connections to nature; understand complex relationships between community, culture, economy, and the environment; and be prepared to make informed decisions about the sustainable management and development of our state's rich natural resources for today and future generations.* (ANRELP, 2013, p. 6)

The authors of ANRELP point out that no new state mandates will be required to implement the plan. Additionally, it will not control classroom or outdoor learning activities. Rather, ANRELP aims to empower existing resources and partnerships to increase outdoor and environmental education opportunities for Alaska's K-12 students. ANRELP's intention is for each school and community to adopt the plan's objectives using local expertise and understandings (ANRELP, 2013).

Environmental literacy is important to Alaska's economy and citizen's health. EE fosters the necessary critical thinking skills required for the modern day workforce. These skills are incorporated into STEM subjects: science, technology, engineering, and math. STEM subjects incorporate environmental science and environmental stewardship (Committee of STEM Education, National Science Technology, 2013). Eighty-six percent of the 50 highest growing professions in Alaska require STEM skills. Sixty-six percent of these jobs pay more than $20.00/hour (the state's median wage) (Alaska Department of Labor and Workforce Development as cited in ANRELP, 2013). Although, less than 15% of United States' high school students take enough math and

science to pursue scientific or technical degrees in college (Juneau Economic Development Council, 2010).

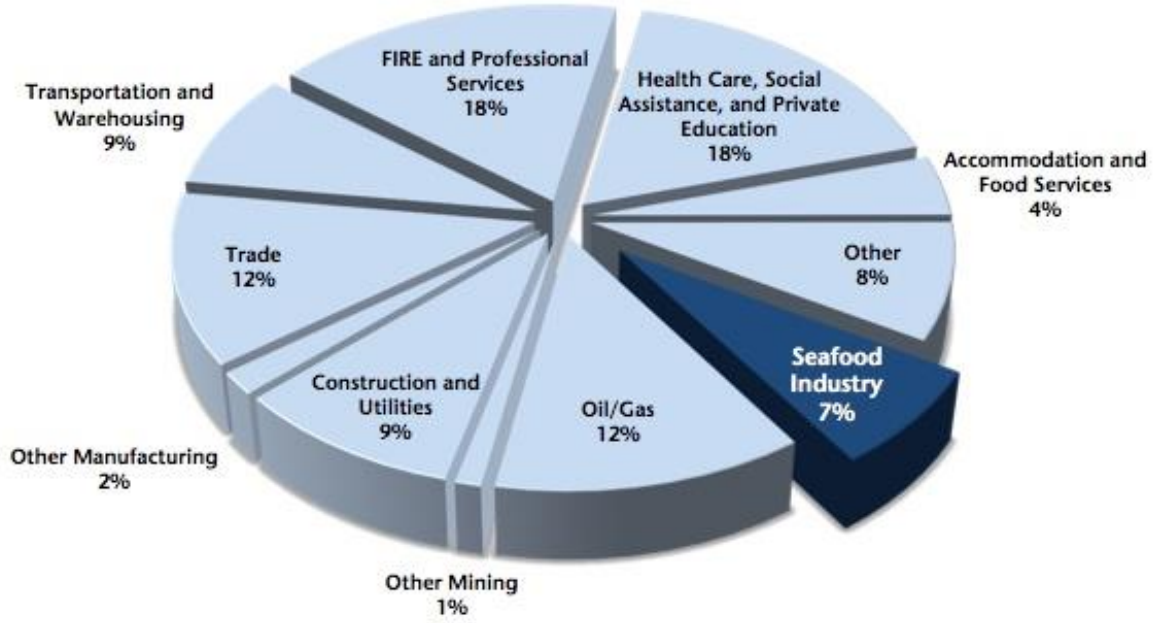
Integrating EE in formal education leads to student achievement in math, science and reading; problem solving; enthusiasm and participation; and leadership and integrity (Ernst, 2007). Hence, EE is one method to increase youth's participation in STEM subjects, leading to a more capable and informed citizenry to manage natural resources.

Alaska Seafood Industry

Alaska is a natural resource-based state, and as such the economy depends upon "*wise stewardship of resources*" (ANRELP, 2013). Alaska's basic industries include oil and gas, tourism, mining, seafood, timber, and federal government. Resource abundance, the international market, regional competition, federal spending, and federal and state government's resource management policies all impact the basic industries (Knapp, 2012; Mc Dowell Group Inc., 2013).

The seafood industry is second to the oil/gas industry in regards to resident earnings among Alaska's basic sectors. In 2011, the seafood industry contributed approximately seven percent of the total private sector resident earnings (Figure 1). While other sectors had higher resident earnings (i.e. health care) than the seafood industry, these sectors are support industries that sell goods/services and provide support services to a basic industry within the state rather than creating value from natural resources.

The *Economic Value of the Alaska Seafood Industry* states, "the commercial seafood industry accounts for 9 percent of all jobs in Alaska [public and private]. In 2011, the industry provided full and part-time jobs to 77,400 people and paid out an estimated $2.2 billion in labor income" (Mc Dowell Group, Inc., 2013, p. 6). The commercial seafood industry is the state's biggest private sector employer and the state's largest industry exporter. In 2011, the Alaska seafood industry created 94,000 jobs, and the total value of Alaska retail value and seafood exports sold in the U.S. was $6.4 billion. Nationally, Alaska contributed 56 percent of the total volume of U.S. commercial fishery harvest in 2011. In 2011, the Alaska seafood industry paid nearly $59 million in state-levied taxes, fees, and self-assessments; and another $90 million to fishing communities as local government taxes (McDowell Group, 2013). The Alaska seafood industry can only provide long term economic benefits if the fisheries resources are carefully managed. The SFBS outreach program introduces students to issues relevant to Alaska's fisheries management and resources.



Note: Data reflects direct earnings for each industry; no multiplier effects are included in these data. Residency is based on eligibility for Permanent Fund Dividend or buying Alaska resident commercial fishing permits. Other Alaska resident sole proprietors are not included in this data.

Figure 1. Alaska Resident Earning, by Private Sector Industry, 2011
(Source: Mc Dowell Group, 2013)

The Bering Sea Alaska Pollock Fishery. The North Pacific Ocean is an exceptionally fertile environment for many species of commercially harvested fish, including halibut, crab, salmon and pollock. The SFBS curriculum includes an introduction to Alaska's current fish capture techniques including trawling, seining, gillnetting, pots and traps, trolling, and long-lining. The SFBS program uses Alaska's commercial pollock industry as a context to explore the state's fisheries in more depth. The Bering Sea pollock fishery creates jobs and revenue for the state, and is a global source of seafood. The Bering Sea pollock fishery is one of the largest sources of wild caught seafood on the planet (MCA, 2011). Walleye pollock (*Theragra chalcogramma*)

is a semipelagic schooling fish. Pollock range from temperate to subartic waters of the North Pacific Ocean and the largest concentrations are in the Bering Sea. Pollock are a fast growing, short-lived fish species and are a key component in the Bering Sea ecosystem (NOAA, 2010).

Since 1988, the US pollock fishery in the Eastern Bering Sea has averaged an annual catch of 1.3 million tons and is the largest U.S. fishery by volume. Alaska pollock products (in order by volume produced) include surimi, fishmeal, fillets, deep skin fillets and roe (NOAA, 2009; NOAA Fisheries Service, 2010). Walleye pollock represents more than 40 percent of the global whitefish production (NOAA, 2009). The American Fisheries Act (AFA) permits 111 catcher vessels and eight shore-based processing plants in the inshore Alaska pollock fishery, and 20 catcher processors in the offshore Alaska pollock fishery. All AFA catchers and catcher processors operating in the Bering Sea and Gulf of Alaska target pollock with pelagic otter trawls. The majority of pollock are caught in the Bering Sea and 90 percent of all catcher vessels' landings are delivered to Dutch Harbor and Akutan. (NPFMC, 2012; NOAA, 2009). From 2000-2007, the state of Alaska collected an average of $10 million per year in tax revenue from the pollock fishery. About 85 percent of this tax revenue was generated from the Bering Sea alone (NOAA, 2009).

Bycatch of non-target species is one challenge faced by the Bering Sea pollock fishery. Prohibited species catch (PSC) limits have been established for non-target species such as halibut and salmon. PSC of chinook and chum salmon is a chief issue for the Alaskan Pollock fleet and salmon harvesters. Several regulations and voluntary

actions have been put in place to minimize salmon bycatch in the Alaska pollock industry (NPFMC, 2012). Conservation engineering is one strategy used by the pollock fishery to reduce salmon bycatch. Conservation engineering, "*as it relates to fisheries science, is the research and development process to bring new and innovative techniques to commercial fishing operations that reduce bycatch and other unintended effects on non-target components of the marine ecosystem*" (Rose et al., 2010). Alaska pollock fishermen, processors and scientists collaborated to design a salmon excluder device (an engineered escapement in the trawl net) that allows Chinook and chum salmon to escape (Rose, 2014).

Alaska Fisheries Education and Outreach. Wise stewardship of the pollock resource is important because of its significance to the Bering Sea ecosystem, the economy, and the global food supply. In turn, existing education and outreach resources related to commercial fishing resources and marine ecosystems are available to Alaskan teachers. ADF&G's K-12 Alaska Wildlife curriculum books include *Alaska's Wetlands and Wildlife*, *Alaska's Forests and Wildlife*, *Alaska's Tundra and Wildlife*, *Alaska's Ecology, Wildlife and the Future* and *Wildlife Ecology Cards*. While these volumes contain detailed, Alaska-specific curricula, a marine based volume (including marine ecosystems and resources) has not been developed. ADF&G does offer *Salmon in the Classroom*, an Alaska specific curriculum to aid primary educators in integrating salmon in the classroom (ADF&G, 2014). The U.S. Fish and Wildlife Service (USFWS) Fisheries and Ecological Services Alaska Region support an education and outreach

program. Their education materials include Cyber Salmon, Fish Kits, Discovering Alaska's Salmon, and Salmon in our lives (USFWS, 2014).

The Bureau of Land Management (BLM) Alaska fisheries program has collaborated with organizations to expand educational watershed and fisheries science events throughout the state. These events include the Ekwok Flyfishing Academy, the Aquatic Education Camp, and a Kid's Ice Fishing Day (BLM Alaska, 2014). The American Fisheries Society (AFS) Alaska Chapter has a Fisheries and Environmental Education Committee. This committee's chief duties include supporting "*fisheries professionals needing assistance with outreach activities*" and to "*develop a communication network among fisheries educators*" (AFS Alaska Chapter, 2014). The Alaska Sea Grant K-8 Curriculum, Alaska Seas and Rivers Curriculum, is an online marine/aquatic curriculum, developed by Alaska teachers. The grade 3-5 resources include lessons on fisheries in the context of human impacts and sustainability. The grade 6-8 curriculum includes lessons on climate change and the Bering Sea (Sea Grant Alaska, 2014).

COSEE Alaska is part of a national network of centers for ocean sciences "*aimed at helping ocean scientists reach broad audiences with their research*." Alaska's regional center theme is "*People, Oceans and Climate Change, focused on weaving together traditional knowledge and western science to share place-based knowledge of ocean climate change in the north*" (COSEE Alaska, 2014). COSEE Alaska connects ocean scientists, teachers, informal educators and the public through programs such as statewide ocean science fairs, teacher workshops, expanded Communicating Ocean Science

Workshops, distance learning and "virtual" field trips. COSEE's website provides K-12 lesson plans, media and collaborative research resources. COSEE Alaska's Polar Trec resource, the *Bering Sea Collection*, is a collection of educational materials "focused on understanding the impacts of climate change and dynamic sea ice cover on the eastern Bering Sea ecosystem" (Polar Trec, 2014). The *Bering Sea Collection* was developed during a workshop attended by teachers who had voyaged to the Bering Sea during researcher programs, Bering Sea community teachers, and project scientists. The collection consists of activities, lesson plans, videos, and presentations about the Bering Sea ecosystem. The collection was created using funding from the National Science Foundation Office of Polar Programs, North Pacific Research Board, COSEE Alaska, Monterey Bay Aquarium Research Institute, and NOAA Teachers at Sea Program (COSEE Alaska, 2014).

The NOAA Fisheries Education Program collaborates with organizations to "*develop and distribute high quality, science-based materials and activities for students and teachers interested in exploring the science behind marine resource management and conservation*" (NOAA Fisheries, 2014). The AFSC, a regional division of NOAA, has developed 12 North Pacific marine science curriculum units for educators. AFSC's six-part activity series, *Sustainable U.S. Seafood: What's science got to do with it?* was developed for educators to introduce the science behind the seafood industry. The curriculum includes topics such as fish population estimates, aging fish, the pollock life cycle, Bering Sea food webs and chains, and U.S. pollock fishery management. The first

five sections were published in *The Seattle Times* and all six sections are available on the AFSC Education and Outreach Activities web page (AFSC, 2014).

EE Program Evaluation

The Joint Committee on Standards for Education Evaluation (1994) defines evaluation as a "*systematic investigation on the worth or merit of an object*" (as cited in Westat, 2010, p. 3). Evaluations provide feedback on how different components contribute to the achievement of program objectives as well as understandings of "*unanticipated consequences*". Weiss (1998) defines evaluation as "*the systematic assessment of the operation and/or outcomes of a program or policy, compared to a set of explicit standards, as a means of contributing to the improvement of the program or policy*" (as cited in Thomson and Hoffman, 2013, p. 12). Weiss's definition explains evaluation components useful for EE programs. "*Systematic assessment*" implies that evaluation of an EE program needs to adhere to a specific, well-designed research proposal. The "*operation and/or outcomes*" emphasize that the activities (i.e. how it is delivered, who delivers it) and/or outcomes for participants (i.e. knowledge, behavior, values, skills change) of a program are the focal point of an evaluation. The "standards" for comparison provides expectations or measures to which a program is evaluated. The program's goals, objectives and mission statements can provide the criteria for comparison. "*Improvement of the program*" specifies

that evaluations provide constructive feedback to make the program progress (Thomson and Hoffman, 2013).

A well-executed program evaluation advances student learning, increases program quality, and helps programs achieve goals and objectives. EE professionals are often specialists in program design and implementation, but do not conduct program evaluations to improve their efficacy (Thomson and Hoffman, 2013). Even novice evaluators can complete a program evaluation and as McNamara (1999) suggests, "*It's better to do what might turn out to be an average effort at evaluation than to do no evaluation at all*" (Thomson and Hoffman, 2013, p. 17). Thus, all EE practitioners should include enough time and resources in their program agendas to complete program evaluations.

Program educators and coordinators can chose from an array of data collection tools to evaluate knowledge, skills attitudes and behaviors (Table 1).

Table 1: Appropriateness of use of specific types of data collection instruments. (Source: American Society for Training and Development, 1989)

Data Collection Instruments	Knowledge	Skills	Attitude	Behavior
Interview	X		X	(X)
Focus Group	(X)		X	
Questionnaire and Survey	X	X	X	(X)
Observation		X		(X)
Literature Review*	X	X	X	X
Test	X	X		
Concept Maps	X		(X)	
Document or product Review	(X)	X	(X)	
Case Study	X	X	X	X

Notes:
X indicates the technique is appropriate to evaluate an indicated type of learning.
(X) indicates that the technique may be, but is not always, appropriate to evaluate the indicated type of learning.
*For comparison from past to initial condition.

Detailed summaries of these data collection instruments are included in *Designing Education Projects: A comprehensive approach to needs assessment, project planning and implementation and evaluation* (Day-Miller and Easton, 2009) and *Measuring the Success of Environmental Education Programs* (Thomson and Hoffman, 2013). First, an evaluation team should decide the reason(s) to conduct an evaluation, who will conduct it, what the focus of the evaluation is, who will be evaluated, and when the evaluation will occur. Each of these determinations identifies the type of evaluation and the appropriate data collection instrument (i.e. focus groups, concept maps, observations, test) (Day-Miller and Easton, 2009; Thomson and Hoffman, 2013).

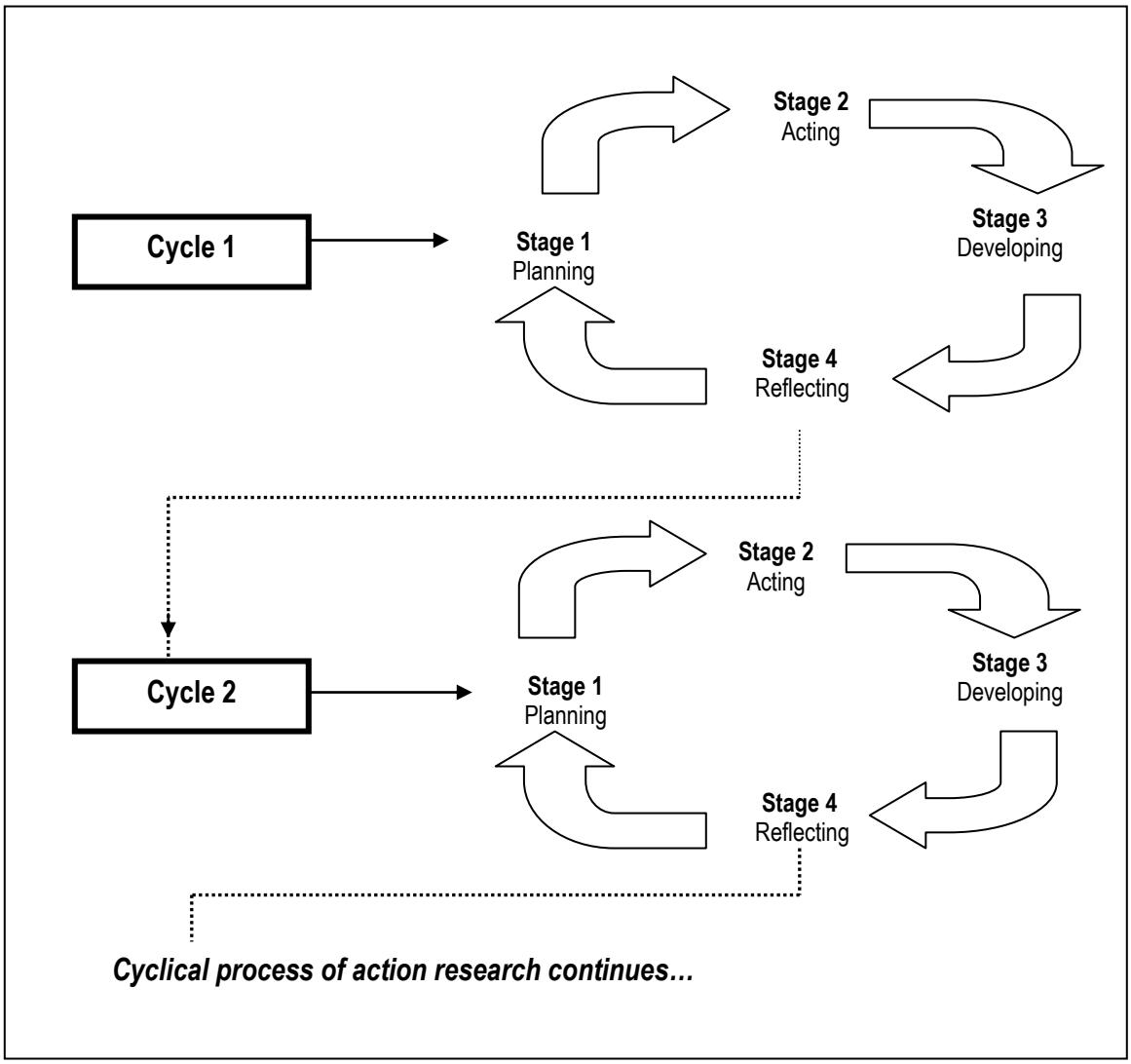
Michael Scriven (1967) presented the terms formative and summative as labels for education curriculum evaluation. A formative evaluation is conducted during implementation, and provides information about the process to make adaptive improvements. A summative evaluation is completed after a program finishes and offers feedback about its effectiveness (Thomson and Hoffman, 2013).

Action Research. Action research is defined as "*any systematic inquiry conducted by teachers… for the purpose of gathering information about how their schools operate, how they teach, and how their students learn*" (Mills, 2007 as cited in Mertler 2009). It is distinguished as research that is "done *by* teachers *for* themselves." This enables teachers to examine their own classrooms to better comprehend them and better their performance (Mertler, 2009, p. 4). Action research includes the following steps:

1. Identify an area of focus
2. Collect data
3. Analyze and interpret data
4. Develop a plan of action (Mills, 2007 as cited in Mertler, 2009).

Many researchers have presented models to describe the action research process. With slight variations, each model illustrates the four steps outlined above (Mertler, 2009). Mertler and Charles' (2008) model, *cyclical process of action research continues* illustrates four steps in each cycle: planning, acting, developing and reflecting (Figure 2)

Figure 2: The process of action research. (Source: Mertler, 2009)



Reflection is a fundamental component to these steps, which are mostly about studying one's own practice. Reflection is "critically exploring what you are doing, why you decided to do it, and what its effects have been" (Mertler, 2009, p. 12). Reflective teaching is a method of creating curriculum or evaluating student learning with careful thought of educational theory, presented research, and experience, combined with the examination of the curriculum's effect on

student learning (Parsons and Brown, 2002). Reflective teaching, followed by active reflection is the essence of action research (Mertler, 2009).

Action research is not a linear process and may flow in any direction. Action research has a clear starting point, but lacks a clear endpoint. Thus, it is considered a cyclical research method (Mertler, 2009).

Concept Maps. Concept maps are "*two-dimensional, hierarchical node-link diagrams that depict the most important concepts and relationships within a knowledge domain*" (Andrews et. al 2008, p. 520). By the 1970s, Novak and his students at Cornell University created the concept map as a means to investigate students' conceptual comprehensions and to encourage meaningful learning (Mintzes, Wandersee and Novak 1998, 2000; Novak, 1998; and Novak and Gowin, 1984 as cited in Andrews et. al, 2008). Concept maps include concepts and relationships between topics represented by a connecting line linking two concepts. Concepts are defined as "*a perceived regularity in events or objects, or record of events*" (Novak and Canas, 2007, p. 1). Linking words specify the relationship between two concepts. Propositions include two or more, concepts associated by linking words to create a statement. Propositions are defined as "*statements about some object in the universe, either naturally occurring or constructed*" (Novak and Canas, 2007, p. 1). Figure 3 provides an example of a concept map to explain the arrangement.

Concepts are organized in a hierarchical manner, with the most broad concepts at the top and the more detailed concepts on the bottom. Hierarchical organization for a field of knowledge hinges on the framework of the knowledge. As such, it is best to

create concept maps using a focus question. Cross-links are another feature of concept maps. Cross-links are defined as "*relationships or links between concepts in different segments or domains of the concept maps*" (Novak and Canas, 2007, p. 2). Cross-links represent how concepts in different spheres of knowledge included on a map are interrelated. Specific examples of events or objects may be included in concept maps to elucidate the meaning of a concept (Novak and Canas, 2007). See Figure 4 for an example of an SFBS participant post-concept map.

Figure 3: A concept map illustrating the key components and ideas that underpin concept maps. (Source Novak and Canas, 2008)

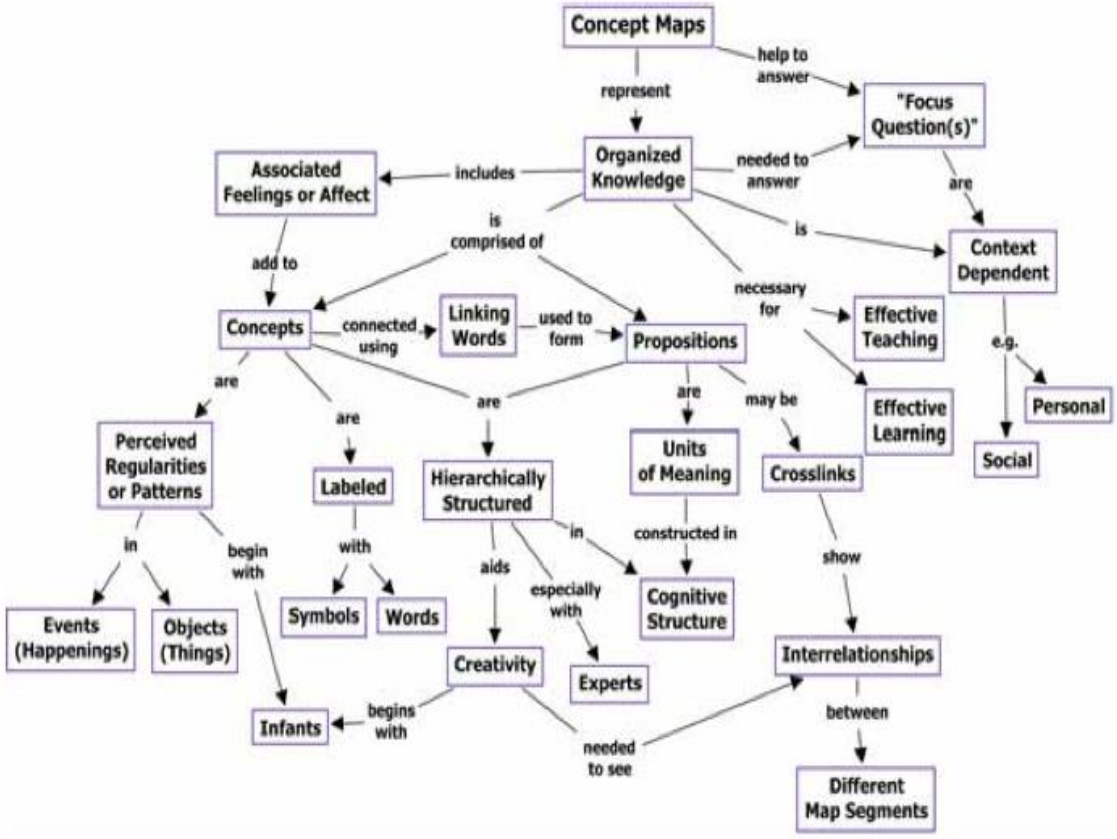
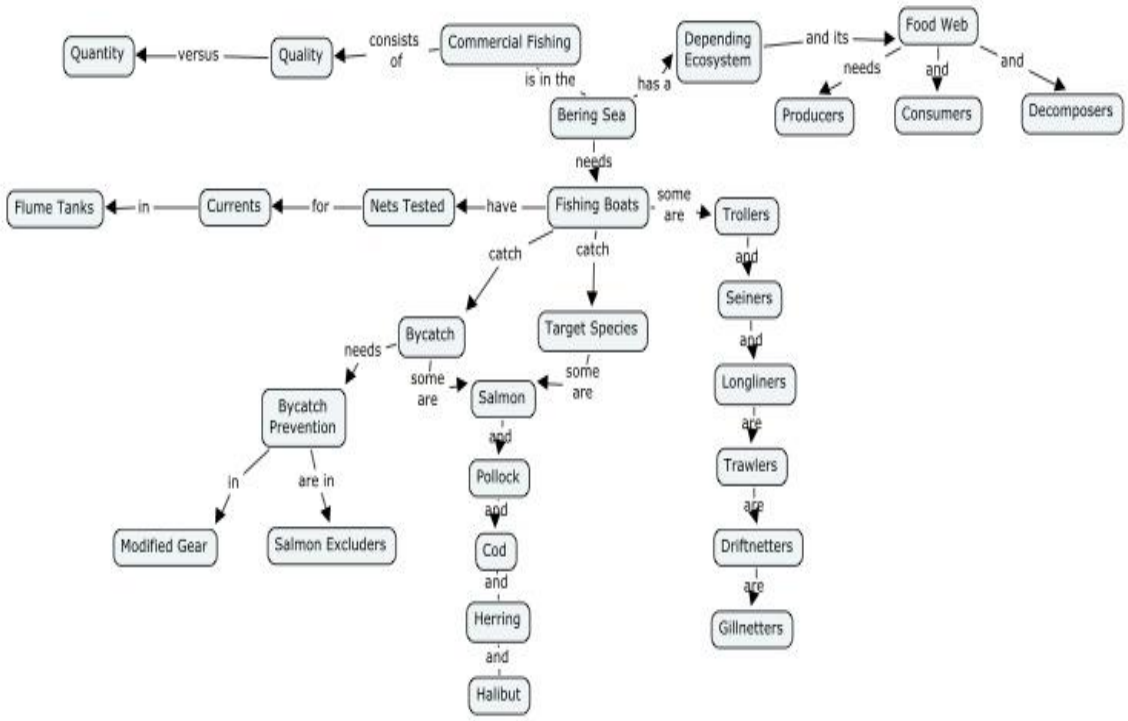


Figure 4: Example SFBS participant post-map (redrawn from original).



The idea of concept maps was based on Ausubel's (1963) theory of assimilation learning (Besterfield-Sacre et al., 2004; Hay and Kinchin, 2006). This theory is based on the premise that new knowledge builds from prior knowledge, and interrelationships between thoughts expand as knowledge grows (Greene et al., 2013). Concept maps can externally communicate the internal processes of learning. Concept maps help students advance critical thinking skills and study subject matter in depth (Bolte, 1999; Briscoe and LeMaster, 1991; Daley et al., 1999; Davis, 1990; Ferry, 1996; Heinze-Fry and Novak, 1990; Kaya, 2007). They are a proven method to provide qualitative and quantitative measures of conceptual understanding in varied academic fields including

sciences, medical training, commerce, and arts (Andrews et al., 2008; Brody, 2005; Hay and Kinchin 2006; Novak and Gowin, 1984).

Concept mapping is a valid and reliable assessment tool of conceptual change and quality of learning (Bourke, 2013; Greene et al., 2013; Gregg and Leinhardt, 2002; Markham et al., 1994; McClure et al., 1999; Rafferty and Fleshner, 1993; Ruiz-Primo and Shavelson, 1996; and Wallace, 1990). The results of Hay and Kinchin's (2008) inspection of 3000 concept maps indicated that concept mapping communicates the *quality* of student learning. Concept mapping is used as a data collection instrument for program evaluation by assembling information about individuals' understanding of a topic (Day-Miller and Easton, 2009). Table 2 summarizes the advantages and challenges of using concept maps as an evaluation tool.

Table 2: Advantages and Challenges of Concept Maps as a Data Collection Instrument for Education Program Evaluation
[Adapted from McNamara (1997-2008) as cited in Day-Miler & Easton, 2009]

Data Collection Instrument: Concept Maps	
Advantages	Challenges
Can offer a more comprehensive and complex view of someone's thinking than a test does	Takes training to complete properly
Could be a better tool for visual learners or test-phobic people	Takes training to administer
Produces qualitative and quantitative data	Can be challenging and time consuming to score
	Can be difficult to analyze

Concept mapping is an "authentic assessment tool with the inherent flexibility needed to assess truly inquiry based learning" (Stoddart et al, 2000 as cited in Green et al., 2013, p. 289). Researchers have affirmed the utility of concept maps as an

assessment tool across subject disciplines (Kinchin and Hay, 2007). Concept maps are difficult to score and compare because final products vary considerably. Recent literature discusses published concept map scoring methods (Besterfield-Sacre et al., 2004; Greene et al., 2013; Stoddard et al., 2000; Yin et al., 2005). Scoring techniques may by quantitative or qualitative. Quantitative methods are based on Novak and Gowin's (1984) original scoring method. Quantitative scoring methods include counting different characteristics of the maps or calculating factors from combinations of those components (Graff 2005 as cited in Greene et al., 2013). Quantitative approaches often tally the links, propositions, and/or nodes and can use weighted point systems for various features (Besterfield-Sacre et al., 2004; Greene et al., 2013; Novak, 2005, Stoddard et al., 2000; Yin et al., 2005). Such methods function best in closed-systems in which the concepts, structures, and linking words are given to the mapper. Overall, the tendency of quantitative scoring methods is to emphasize elaborateness of the map over accuracy (Greene et al., 2013).

Free-ranging styles of maps are more difficult to score quantitatively. In a free-range style of concept mapping (Adameyzk et al., 1994) the concepts, linking words, total number of constructed propositions, and the structure of the map are unknown and unfixed. However, free-range maps can better show incomplete knowledge and disclose misconceptions (Green et al., 2013). Published qualitative methods are available and offer alternatives to quantitative approaches (Besterfield-Sacre et al., 2004; Greene et al., 2013; Stoddart et al., 2000; Yin et al., 2005).

Kinchin et al. (2000) created a holistic scoring method. This method incorporated a qualitative, concise, teacher friendly classification scheme. Kinchin et al.'s (2000) approach classified maps using their morphologies. The holistic scores were explained to represent students' present knowledge and aptitude for upcoming learning (Greene et al., 2013). Later, Besterfield-Sacre et al. (2004) proved the reliability and validity for a qualitative, three-point holistic scoring assessment of concept maps. Besterfield-Sacre et al. (2004) developed the scoring rubric using a sample of industrial engineering students instructed to create concept maps relating to their field of study. Based on their results, Besterfield-Sacre et al. (2004) suggest that their holistic scoring rubric is a useful method for "standardizing the evaluation of concept maps".

Many case studies in the EE literature explain the utility of using concept mapping as a component of program evaluation. Andrew (2005) and Tressler (2008) used concept mapping to assess an EE program, *MarineQuest*. *MarineQuest* is a marine science outreach program run by the University of North Carolina Wilmington. Andrews (2005) and Tressler (2008) examined the effects of the one-week *MarineQuest* summer session on participants' (ages 11-13) knowledge and attitude towards marine life. The researchers used pre- and post-concept maps to evaluate the structural complexity and content validity of participants' knowledge. Tressler's (2008) assessments showed an overall growth in the 113 *MarineQuest* participants' marine science knowledge content and structure. Tressler (2008) used the scoring method described by Thompson and Mintzes (2002), which Markham et al. (1994), Pearsall et al. (1997) and Martin et al. (2000) used in earlier studies.

Thompson and Mintzes (2002) used concept mapping to describe the structural complexity and propositional validity of students' knowledge frameworks about sharks. The researchers analyzed 238 student concept maps on sharks (grades 5 though college level). Maps were scored for non-redundant concepts, scientific relationships, levels of hierarchy, branching, and crosslinks (Thomspon and Mintzes, 2002). Both of these studies concluded that concept mapping is a useful tool for assessing students' knowledge in formal and informal education settings (Thompson and Mintzes, 2002; Tressler, 2008). Tressler (2008) recommends EE educators use concept maps as a pre-assessment tool to evaluate student's existing knowledge framework and to build knowledge from there. Additionally, the *MarineQuest* program evaluation noted the importance of the flexibility of concept maps as an evaluation tool for EE programs as included educational material varies (Tressler, 2008).

Gregg and Leinhardt (2002) used concept maps to document program impacts of student visits to a museum. Their study included 49 undergraduate pre-service teachers' pre- and post-concept maps of the Civil Rights Movement before and after their visit to the Birmingham Civil Rights Institute (Gregg and Leinhardt, 2002). The researchers used concept maps to measure changes in the breadth, depth, complexity and content of students' knowledge about the Civil Rights Movement. Gregg and Leinhardt's systematic analysis of the concept maps showed that students gained a significant amount of information about the Civil Rights Movement after the visit to the Birmingham Civil Rights Institute (2002). Furthermore, the researchers noted that the concept maps "served to 'prime the pump', so that when students were in the museum they would actively seek

to confirm information they had expressed on their webs [concept maps]…" (Gregg and Leinhardt, 2002, p. 561).

Bourke et al. (2013) conducted a "*study to examine the effectiveness of the use of concept maps as a means of documenting student knowledge in the program evaluations of residential environmental education centers*" (p. 1). Bourke et al.'s study examined pre- and post-concept maps created by 60 participants visiting a residential EE center in the Southeastern United States. Participants were 3rd and 6th graders from two elementary schools. The researchers analyzed the concept maps quantitatively to determine the number of unique ideas imparted, and qualitatively to determine changes in depth of understanding (Bourke et al., 2013). Bourke et al. used Gregg and Leinhardt's (2002) method to analyze the concept maps. The researchers' statistical analysis indicated an increase in the mean number of correct and unique ideas shared on the concept maps after completing the EE program. Differences in participant's depth of understanding were ascertained by examining the content of ideas shared on pre- and post-visit maps. Following analysis of individual maps, Bourke et al. (2013) concluded that students vocabulary related to the topics increased and improved their capability to articulate specifics of the topics after the EE experience.

The researchers shared the concept maps and a summary of the analyses results with the EE center stakeholders. Stakeholders included classroom teachers, school principals, the EE center Program Director, and the EE center Program Coordinator. Stakeholders reported in interviews that the maps were useful program assessment tools

(Bourke et al., 2013). Stakeholders identified the following characteristics of concept maps pertaining to their efficacy as an assessment tool:

> 1) The visual nature of the concept maps was considered particularly beneficial.
>
> 2) The quantitative information derived from the maps was considered to be helpful.
>
> 3) The open-ended nature of the concept maps was seen as meeting the needs of the learners, and creating the maps was seen as more engaging for students than typical assessments. (Bourke et al., 2013, p. 9)

Bourke et al. (2013) concluded that "*concept maps can be used effectively to document changes in student knowledge and may contribute to improvement in program evaluations of residential environmental education centers*" (p. 1).

E & O for NPRB's funded project, "Benthic impacts of raised groundgear for the Bering Sea pollock fishery."

The SFBS project is a part of the North Pacific Research Board (NPBR) funded project, "Benthic Impacts of raised groundgear for the Bering Sea pollock fishery." Participating scientists include members of the NOAA Alaska Fisheries Science Center (AFSC) and Alaska Pacific University (APU), sectors of the Alaska pollock fishing industry, and leaders of the fishing gear design and fabrication industry. Researchers are collaborating to address issues confronted by the Bering Sea pollock fishery, including bycatch, fuel consumption and target species catch efficiency (Harris and Rose, 2012). This projects' E & O plan included the development of a hands-on science curriculum to highlight the field of conservation engineering. K-12 public and private school children in the Anchorage, Alaska area were designated as the target audience. The NPRB project

scientists contributed fisheries science expertise and I contributed the ability to translate fisheries science into a 5th-12th grade outreach program.

The NPRB "*supports peer-reviewed scientific research in the Gulf of Alaska, Bering Sea, Aleutian Islands, and Arctic Ocean to inform effective management and sustainable use of marine resources*" (NPRB, 2014). NPRB's efforts include a communication and outreach program to share research with:

> *a broad and diverse audience, including the scientific community of marine researchers; agencies responsible for managing North Pacific marine resources; Alaska residents, including Alaska Native communities, who depend on marine resources for subsistence or employment; teachers and students of all ages and academic levels; and the general public in Alaska and beyond… The objective is to translate detailed scientific information into understandable terms, and package it for maximum accessibility, exposure, and impact*. (NPRB, 2014)

NPRB education and outreach strategies for teachers and students include the NPRB website, which targets secondary and post-secondary students and educators worldwide; the Alaska SeaLife Center (ASLC) K-12 education program; and Alaska Native internship programs such as the Alaska Rural Systemic Initiative through UAF (NPBR, 2014). The ASLC offers K-12 marine science outreach programs to classrooms in South Central Alaska. There are eight outreach programs designed as one-time classroom visits. As of 2014, commercial fishing and the Bering Sea were not offered as topics for classroom outreach programs. The ASLC offers online curriculum related to Alaska salmon education and oil spill recovery. The ASLC has also developed "virtual field trips" for teacher and student use. *Meltdown*, one of the virtual field trips offered, focuses on climate change impacts on the Bering Sea ecosystem.

To help scientists meet the NPRB's education and outreach efforts, the board placed a $500 education and outreach requirement in early request for proposals (RFPs) and has increased this to a $2000 education and outreach requirement for each RFP. "Building and Education and Outreach Program for the North Pacific Research Board" was funded through NPRB projects 403, 537, 802, and 703 from 2004-2008. Project 403 summarized education and outreach efforts on behalf of 88 NPBR projects through the year 2005. Six of the 88 NPRB projects included school classroom presentations (Carrick et al., 2006). A total of 6.8 percent of the NPBR funded projects until 2005 included school presentations. Additionally, only four of the six NPRB projects presented to K-12 schools in Alaska. These one-time presentations provided an overview of topics related to the scientists' expertise (rougheye rockfish, right whales, short-tailed albatross, and salmon) and did not include curriculum development. Examples of recent outreach and education driven by RFPs include "Enhancing rural high school involvement in North Pacific resource issues through participating in Alaska regional National Ocean Sciences Bowl" (2007) and "Pribolof Island Seabird Youth Network" (on-going). Other common education and outreach efforts completed by research teams include symposiums, publications, presentations to scientific and public communities, web pages, funding graduate and undergraduate student research, and press coverage.

I used existing NPRB support for education and outreach to create and teach this program. As noted, it is "*a rare situation… where outside experts are given the opportunity to teach an entire unit… during regular school hours*" (Day-Miller and Easton, 2009). The SFBS was one of these "rare" opportunities for an "expert" fisheries

educator to teach a conservation engineering fisheries unit to multiple classrooms. The SFBS program also increased the percentage of NPRB funded research projects that engage with Alaskan classrooms. At the time of the creation and implementation of the project, no other NPRB fishery research projects were creating, or teaching, multi-session fishery outreach programs in Anchorage classrooms.

METHODS

I developed, instructed and evaluated the SFBS program. The SFBS program was created to teach Alaskan youth about the current topics pertaining to the Bering Sea and Alaska's pollock fishery. The pilot program was taught to 93 students in Anchorage, Alaska. The curriculum included topics about the opportunities and demands of Alaskan fisheries. I used action research to evaluate and improve the effectiveness of the program content. I used observations, pre- and post-concept mapping, and student work to collect data for the action research cycle. I used the results to revise the curriculum and will share all results with SFBS stakeholders.

The SFBS program integrated the EE goals, objectives and characteristics described above and in the appendix. If the SFBS program increases participant knowledge about Alaska fisheries, it may contribute to well-informed management decisions in the future.

Setting

This study assessed the SFBS outreach education program, which took place in formal classroom settings in four schools, with seven student cohorts, over a two-month

period. The schools included the King Career Center (KCC, public institution), the McLaughlin Alternative School/McLaughlin Youth Center (MYC, public institution), Pacific Northern Academy (PNA, private institution), and the Winterberry Charter School (WCS, public institution). All schools were located in Anchorage, Alaska. I was the primary educator of the SFBS program. Classroom teachers were also present during the program and collaborated with me to facilitate learning activities.

KCC is a public school open to all 11th and 12th graders in the Anchorage School District (ASD) and 10th graders are considered on a case-by-case basis. I instructed 43 students from two Natural Resource cohorts. KCC "*prepares students for entry level positions in career fields and/or post-secondary education or training*" and believes that "*KCC has two groups of stakeholders: our students and industry*" (ASD, 2014). The McLaughlin Alternative School is an ASD school serving the educational needs of residents of the MYC, a juvenile detention facility operated by the Alaska Department of Juvenile Justice. "*The mission of the McLaughlin School is to help students become citizens of good character with a range of skills necessary for life success in life*" (ASD, 2014). I taught 18 students from three sections of the MYC high school science classes. PNA is an independent K-8 private school funded by tuition, endowment, private gifts, grants and donations. I instructed 13 students in the 5th grade class. PNA's mission is to "*educate students to be exceptional learners and independent thinkers of vision, courage, and integrity*" (PNA, 2014). PNA embraces a "*student-centered approach to learning*" and is "*committed to maintaining low teacher to student ratios that enable students to have meaningful and personalized interactions with their teachers*" (PNA, 2014). WCS

is a lottery entry public school inspired by the Waldorf methods serving grades K-8. I worked with 17 students in the 8th grade class. "*Winterberry nurtures and promotes the development of healthy, responsible human beings… students actively engage in academic subjects presented through the arts and are encouraged to use their bodies to make learning meaningful*" (ASD, 2014).

Participants

Ninety-three students participated in the program from the four public and private schools described above. The participant pool included minors and persons in residential institutional settings. I offered the outreach program to participating schools and scheduled the program timing and duration to fit the needs of each classroom.

School administrations and classroom teachers granted permission for the classrooms to be part of the study. Signed Institutional Permission Letters were submitted to APU's Internal Review Board (IRB) December 2013 (see appendix for Permission Letter). APU's IRB granted approval for the research project January 2014.

Of the ninety-three students, 33 percent were females, and 67 percent were males. Thirteen were from the 5th grade class of PNA, 17 were from the 8th grade class of WCS, 43 were from two high school natural resource classes at KCC, and 18 were from three high school science classes at MYC.

The schools and classrooms of Anchorage are cross-cultural settings. The Anchorage School District 2011-2012 "Ethnicity Report" recounts the following ethnic composition of Anchorage public schools: African American or Black 6 percent, Alaska

Native or American Indian 9 percent, Hispanic or Latino (of any race) 11 percent, Multi-ethnic 13 percent, Asian or Pacific Islander 15 percent, and White 46 percent Anchorage School District, 2013). To create a "*culturally relevant pedagogy*" it is recommended to use "*the cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students to make learning more relevant and effective [for students]… It teaches to and through the strengths of these students. It is culturally validating and affirming"*" (Gay, 2000, p. 29 as cited in Dutro et al., 2008, p. 272). As a guest teacher, I did not know the cultural background of the participants and could not realistically address the cultural needs of each student. In turn, I tried to attend "*to a range of learning styles by implementing multiple instructional methods and opportunities for interaction*" (Au, 2002, 2006; Gay, 2000 as cited in Dutro et al., 2008, p. 273). I created learning activities by integrating a variety of forms of intelligence such as, aptitudes in linguistic, logical-mathematical, spatial, bodily-kinesthetic, interpersonal and intrapersonal intelligence (Gardiner, 1991). Learning activities are described in detail in the following section and the complete curriculum may be found in the appendix.

There were variations in the program content and activities between each student cohort (no student cohort experienced the same program as any other group). Differences in timing included the total program duration and span of program for each group. Contact time ranged from 6.6 hours to 13.5 hours. The time spans ranged from three weeks to six weeks. I adapted the program to fit the needs of each class and to improve

the learning experiences as needed. This created differences in the included content and subject delivery for each group.

Participants completed pre-concept maps prior to SFBS learning activities and post-concept maps after the SFBS learning activities were complete. However, due to scheduling logistics, the amount of time that lapsed between program completion and post-concept mapping varied between groups, ranging from one day to two weeks. Table 3 summarizes the major program differences between student groups.

Table 3: Summary of SFBS program variation between student groups.

	School Groups	MYC Group A (9th-12th grade)	MYC Group B (9th-12th grades)	MYC Group C (9th-12th grades)	KCC Group A (10th-12th grades)	KCC Group B (10th-12th grades)	PNA (5th Grade)	WCS (8th Grade)
Span/Duration	No. of total program hours	9.5 hrs	9.5 hrs	6.6 hrs	8.25 hrs	8.25 hrs	13.5 hrs	13.5 hrs
	No. of days from start to completions of SFBS program	39	38	39	7	7	36	21
Concept Maps	No. of days concept maps completed after SFBS program	2	1	n/a	14	14	5	3
	Post-Concept Maps	X	X		X	X	X	X
	Pre-Concept Map Training and Maps	X	X	X	X	X	X	X
Lessons	SFBS Flume Tank	X	X	X	X	X	X	X
	NPFMC Role Play				X	X		X
	"What's the Catch?" Group Reading and Discussion	X	X					
	"What's the Catch?" Independent Reading and Questions				X	X		
	Fish Capture Techniques (Group Presentations)						X	X
	Fish Capture Techniques (PowerPoint)	X	X		X	X		
	Bering Seas Food Web Connections						X	X
	Bering Sea Food Web Mural	X	X	X	X	X	X	X
Class Size	No. of students In class group	8	5	5	23	22	13	17

As a new program, routines and systems were lacking. This is inappropriate for an in-depth, systematic evaluation (Thompson and Hoffman, 2013). Thus, I did not establish a control group. My efforts were directed towards collaborating with scientists and teachers to implement the pilot SFBS program. Furthermore, because of the variation among the participant population, a corresponding sample would have been complicated to achieve.

Curriculum Development

The lessons were required to reflect the conservation engineering context of the NPRB funded project. To do so, I used existing curricula and created new resources to teach about the Bering Sea ecosystem, fish capture techniques, conservation engineering, salmon bycatch and the Bering Sea pollock industry. I reviewed available North Pacific fisheries education resources created by scientists, industry, managers, and educators prior to developing the outreach program. The Rural School and Community Trust (2005) states, "*Place-based education is learning that is rooted in what is local- the unique history, culture, economy, literature, and art of a particular place*" (as cited in Smith and Sobel, 2010, p. 23). As a place-based program, not all content could be pulled from a "standardized" resource (Smith and Sobel, 2010).

After joining the fisheries research team, I gained an understanding of the background, context and goals of the "Benthic impacts of raised groundgear for the Bering Sea pollock fishery." I used in-person meetings, e-mails, symposiums, and literature reviews to learn about the pollock fisheries researchers' niche. Next, I examined effective EE pedagogy and program development resources. Additionally, I

was able to bring my professional experience to SFBF's curriculum design process. Prior to collaborating on this project, I had 15 years of international work experience as an outdoor and environmental educator, program director, guide, deckhand and research assistant. My professional background included teaching, developing and managing programs, sailing, and researching in marine environments on boats, coasts, and islands.

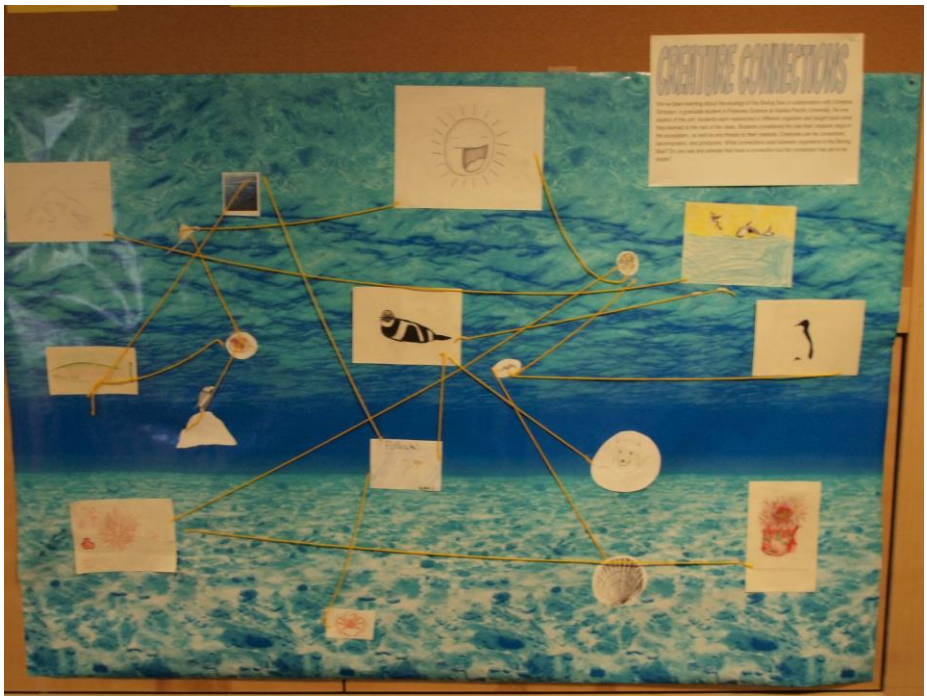
Spring of 2013, I began searching for existing Bering Sea and commercial fishing outreach programs and curriculum materials. I combined original ideas with available curriculum resources from PolarTrec, the ASLC, the Alaska Fisheries Science Center Outreach and Education and the Alice Ferguson Foundation to create the first and successive components of the SFBS program. I introduced the unit with the Bering Sea ecosystem, the foundation of the Alaska pollock fishery, with the, *The Bering Sea Ecosystem: Marine Food Web Mural*. The lesson included a guided overview to the abiotic factors and geography of the Bering Sea using maps and nautical charts. The lesson planned for students to research, organize and present information on organisms found in the Bering Sea; create illustrations of Bering Sea organisms; and combine work to create a Bering Sea mural. I included key ecological concepts such as energy flows, matter cycles, biodiversity, adaptations and food webs. Other learning experiences included in this lesson were singing, exploring specimens that inhabit the Bering Sea, (i.e. fish mounts, fish skeletons, bird mounts, bivalve shells, whale bones), web of life activity, and drawing individual food web diagrams. Figures 5 – 14 are samples from this lesson.

Figures 5 & 6: I used nautical charts as part of a guided overview of the Bering Sea geography.

Fig. 5 (left)
Fig. 6 (Above)

Figure 8: Student cohorts collaboratively created a Bering Sea Food Web mural.

Figures 8 and 9: A sample class Bering Sea food web mural created by students (Fig 8) and posted description of mural written by classroom teacher (Fig. 9) displayed in school's hallway.



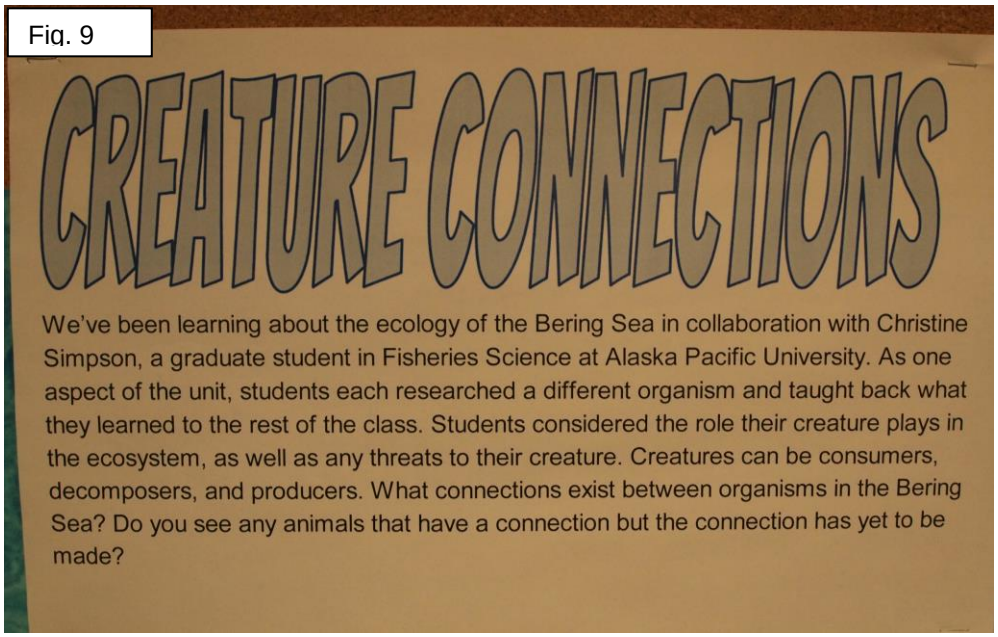


Figure: 10 (below). Some students participated in a Bering Sea "web of life" activity.

Figure: 11 (below). Student illustration of a crab barnacle.

Fig. 11

Figure 12 (below). Student drawing of Walleye pollock, *Theragra chalcogramma*.

Figure 13: Student's drawing of a simplified Bering Sea food web.

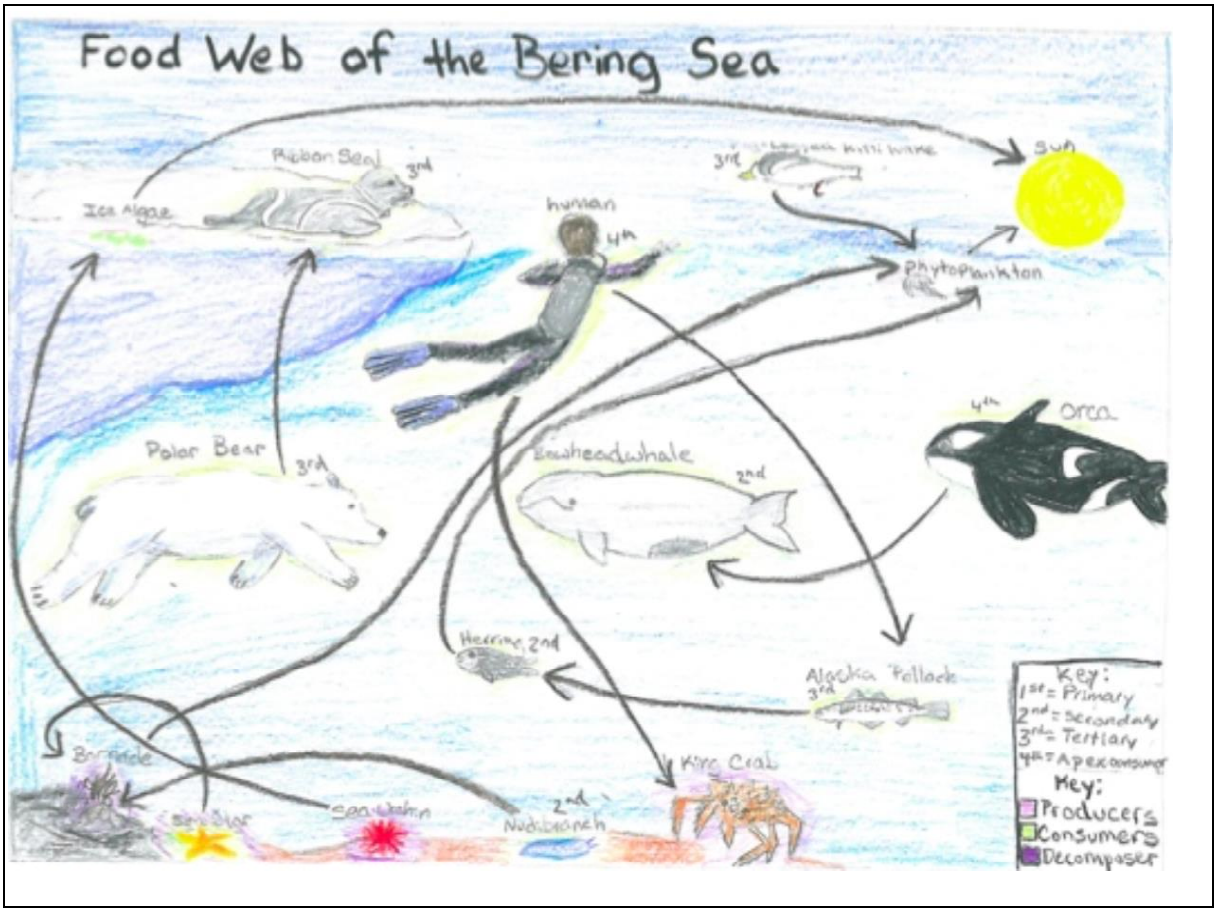


Figure 14 (left): Students handled specimen samples of organisms that inhabit the Bering Sea.

I wanted to present prospective Anchorage teachers and schools enough content to decide if the topics and ideas were worthwhile to include in their daily lessons. I also planned to incorporate teachers' input and ideas into the curriculum. In turn, the curriculum was incomplete prior to initial meetings with prospective teachers. I used the first lesson and other program ideas as a starting point to meet with teachers and schools. In early October 2013, I met with public and private teachers and principals from WCS, PNS, MYC, and KCC. The purpose of these meetings was to collaborate regarding the SFBS context, and to conduct informal needs assessment of the program. Each school responded, "yes," they would like their students to participate in the program and "yes" it would be worthwhile. I gathered information from each teacher to design the program to fit their needs in terms of goals, content, timing, and duration. I inquired if any state, national or other education standards should be included in the lessons. All teachers said "no." Thus, lessons were not designed to teach to particular standards. Instead, National Science Education Standards were selected for each lesson after the program was instructed, evaluated and revised to better reflect which standards were addressed. In December 2013, each school administration formally approved the written evaluation plan for their schools to participate in the SFBS program evaluation (see Appendix for (Sample Institutional Permission Letter).

With teacher and school commitments and an understanding of classroom needs, I completed the program development from October 2013 - January 2014. I decided to use a lecture to "*establish a broad outline of a body of material*" as suggested by Stephen Brookfield (2006) to introduce students to current commercial fish capture techniques

used off the coast of Alaska. I used lecture techniques suggested by Brookfield (2006) and Lemov (2010). To support the lecture, I created a PowerPoint presentation and used guidance from Garber's (2001) article, "Death By PowerPoint" and tips from COSEE's Alaska Marine Science Symposium 2014's Communicating Ocean Science Workshop, "*Translating Science: Taking the Message Home*." The presentation included an overview of the techniques, target species, and bycatch challenges and solutions pertaining to purse seining, trolling, gillnets, nets, pots and traps, longlining, and trolling.

During February, I created an alternative lesson to the fish capture technique PowerPoint presentation for classrooms with more available time. This lesson was not lecture based, but rather used student collaboration as a means for participants to learn about Alaskan commercial fish capture techniques. Student groups were allotted resources, guidelines, and time to organize, prepare and present information to the entire class about one type of fish capture technique. Presentation topics included target species, description of gear and vessels, bycatch challenges and solutions, and landings. Each group was assigned a different fish capture technique. I concluded the group presentations with a brief presentation on the Bering Sea pollock trawlers. I brought samples of pollock products for students to look at in both *Fish Capture Techniques* lessons' formats (Figures 17 and 18). See Figures 15 and 16 for student work relating to *Fish Capture Techniques*.

Figure 15: (Left) One classroom teacher created an extension of the *Fish Capture Techniques* lesson in drawing class.

Figure 16: (Below) Students were instructed to draw an otter trawl. Sample of one student's work is shown below.

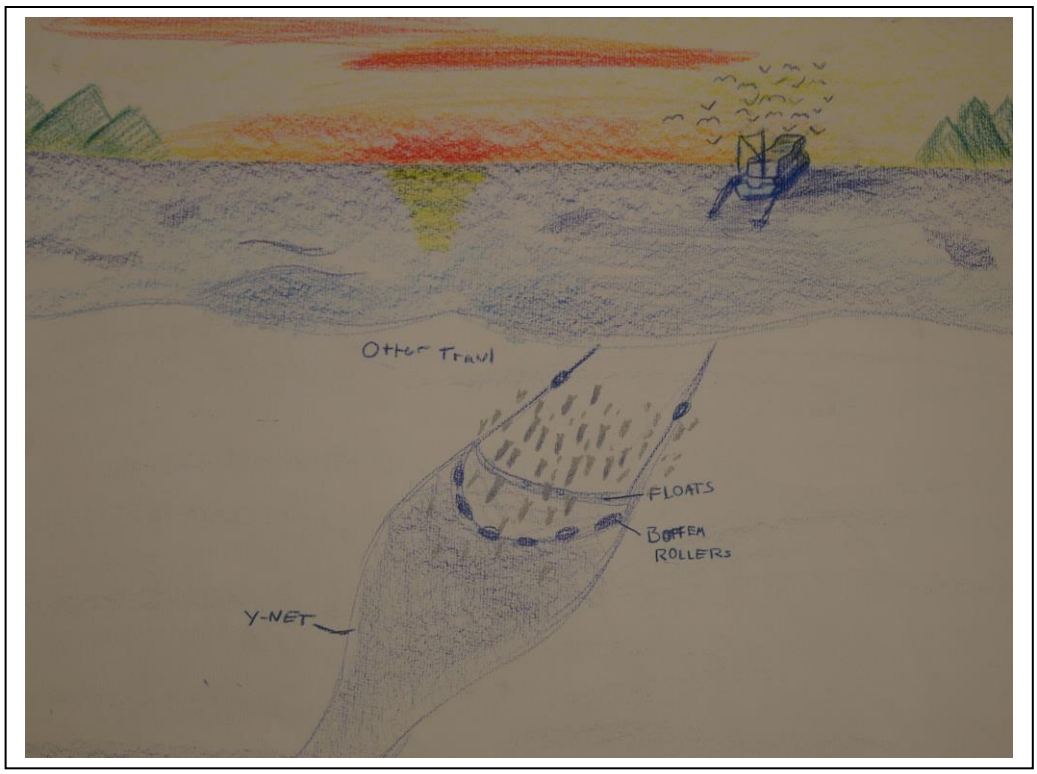


Figure 17 (left) & Figure 18 (bottom right): Students examined sample pollock products.

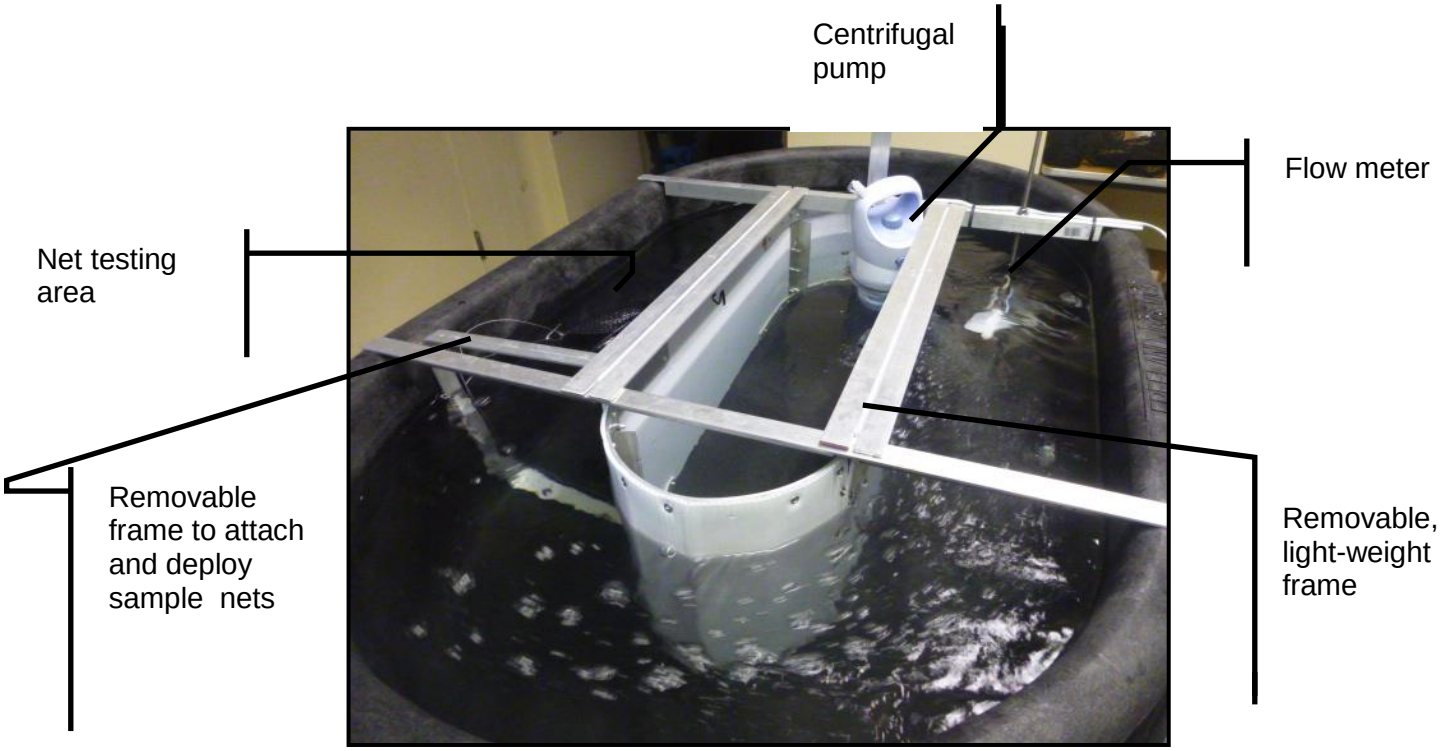
Throughout curriculum development, I met regularly with members of the research team to incorporate relevant topics into SFBS learning activities. Dr. Harris encouraged me to create learning experiences that contributed to a "culture of innovation" because innovation is necessary for conservation engineering. Learning innovation requires students to test ideas, fail and make modifications. In response, I enlisted help to build a small-scale flume tank so students could practice hands-on engineering evaluation and modification with small-scale trawl net models. Flume tanks are used to develop new fishing gear to reduce bycatch, minimize habitat impact, reduce fuel consumption and address challenges faced by fishermen and managers. Gear engineers and fishermen use large flume tanks to test and design new gear. Water circulates through flume tanks, allowing people to observe underwater fishing gear behavior.

It took several months for us to build an operational flume tank. We discussed various designs for the tank before setting on a "race track" approach (Figure 19). The basic tank was a 60-gallon trough purchased at a Missouri feed store. It had rounded

edges, was portable and durable. We fabricated an inner oval shaped partition out of aluminum stock, corrugated plastic and pop rivets. This created a light, strong, inexpensive drop-in frame. We tested several pumps and finally settled on a centrifugal "spa pump," designed to for Jacuzzi tubs. Simple, inexpensive, easily replaceable, powerful, quiet, and with a directable jet, this pump was a perfect fit. Various mounting points were tried in an attempt at minimizing turbulence and eddies. Finally, we mounted the pump in the center of the racetrack opposite the net testing area and installed a flow meter on the side opposite net testing area. A smoother center partition would further reduce turbulence, but performance was overall satisfactory. With the assistance of three undergraduate Environmental Science students, four sample trawl nets were fabricated for students to test and modify in the tank. A removable frame was used to deploy the test nets.

With the tank, SFBS participants learned about Bering Sea pollock trawl practices and focused on current challenges and solutions to salmon bycatch. Students tested and modified different trawl nets in the flume tank as part of this lesson (Figures 20, 21 and 22). Students evaluated net performance based on nets that maximized target species catch, minimized drag, had steady lift (i.e. more fuel efficient), minimized habitat disturbance (did not touch bottom), and minimized bycatch. Objects with different buoyancy were used to represent target species (pollock) and bycatch (herring, salmon, crabs and halibut). A video analysis activity was also created using underwater footage of a salmon excluder device gathered from Bering Sea research.

Figure 19: A small-scale flume tank was developed for students to test and modify sample trawl nets.



Figures 20, 21 & 22: Students using flume tank to test sample nets.


Fig. 20


Fig. 21


Fig. 22

I created lessons to provide a broader context to gear modification. One lesson included an in-class reading of Bruce Barcott's (2010) article, "What's the Catch?" Barcott's (2010) article provides an overview of the Bering Sea pollock stakeholders, pollock fishery management, challenges and solutions to salmon bycatch. The reading was followed by response questions and an in-class discussion and review. The objective of studying "What's the Catch?" was for students to gain an understanding of different Bering Sea stakeholders' perspectives, who manages the fishery and what factors caused the industry to include salmon bycatch excluders.

I developed a role-play activity in which students participated in a mock North Pacific Fisheries Management Council (NPFMC) Meeting. I designed this role-play based on the topic of the Spring 2012 NPFMC Meeting, "Managing Salmon Bycatch in the Bering Sea Pollock Fishery" (Figure 23). I used NOAA's role-play guidelines to facilitate the lesson. The objective of the role-play activity was for students to understand various perspectives of Bering Sea stakeholders in relation to the management of salmon bycatch in the pollock fishery. "Stakeholders" were defined as "*people who have an interest in how resources are used. Stakeholders may include people who do not actively 'use' resources at all*" (NOAA Ocean Service, 2012). Students were assigned the role of a stakeholder (pollock industry, environmental organization, or resident of Western Alaska) and worked in groups to investigate their stakeholders' perspectives on salmon bycatch and the pollock fishery. Students were provided with primary and secondary resources relating to their roles. Students used provided guidelines in preparation to participate in the mock NPFMC meeting as a representative of their

stakeholder. I used real audio and visuals from the 2012 NPFMC meeting during the simulation meeting. The intent of the activity was for students to understand how different interests and perspectives of pollock fishery stakeholders both conflict and overlap with each other. From these overlaps, management solutions and decisions are made. The role-play activity presented challenges and outcomes of the decision-making processes, of which gear modification is one piece.

Figure 23: Some student groups participated in a role-play activity of a mock North Pacific Fishery Management Council Meeting.

Data Collection

Action Research and the Role of the Researcher. My involvement with the program included serving as the lead developer, instructor and evaluator of the learning activities. Fulfilling the role of the SFBS educator provided me with detailed insight into effective and ineffective program operations. I used action research as a formative evaluation to improve the activities and delivery methods during the SFBS program. I adapted learning activities and teaching methods while implementing the pilot program to instruct different student groups. After completing each class session, I reflected on the lessons' theories, methods, and activities to improve subsequent sessions.

While teaching the lessons, I applied the first reflection cycle of action research. I guided students through learning activities, observed the classrooms, reflected, identified problems, and made adjustments to the program as able. I used successive cycles of the action research method each time I repeated a lesson and in post-program reflective critiques. I included personal observations and student concept maps as part of my inquiry. My results were used to revise the SFBS curriculum, make program recommendations, and improve my personal teaching strategies.

Observation Journal. I kept an observation journal to document program operations, student participation, collaboration with classroom teachers, success, failures, student reactions, student comments, student work, student questions, and other information relevant to the SFBS program. I only recorded participant first names when

necessary to distinguish participants. Any observation notes used in the research reports do not include student names.

Concept Mapping. I collected pre and post data in the form of concept maps. Concept maps were used as an open ended, summative evaluation to measure participants' short-term change of conceptual knowledge pertaining to SFBS topics. SFBS participants created free-range concept maps, and a holistic scoring approach was used to evaluate the pre- and post maps. Results were used to evaluate the effectiveness of the SFBS learning activities. I chose concept mapping as an assessment tool because they are "*non-threatening, open-ended enough to all for rich, detailed responses, and manageable for teachers to administer*" (Richhart et al., 2009, p. 148). Furthermore, I shared Ritchhart et al.'s (2009) goals for an evaluation method to:

> 1) feel authentic to the classroom and not a test or exercise done for outsiders,
> 2) be an opening for discussion of thinking [fisheries] with students
> 3) not feel like a test with right or wrong answers
> 4) be relatively transparent so that teachers would come to see themselves as researchers into their students thinking. (p. 148)

Pre- and post-maps were created by students who voluntarily agreed to participate in the study. I made it clear to all students that anyone could decline to participate in the study at any point. Parents/guardians of all participants received and signed a "Consent to Participate" letter and all student participants received and signed an "Assent to Participate" letter (see appendix for samples). Personal information of individual subjects (e.g., last names, address, Email address, etc.) was not collected, and the project did not link individual responses with participants' identities. Each participant wrote

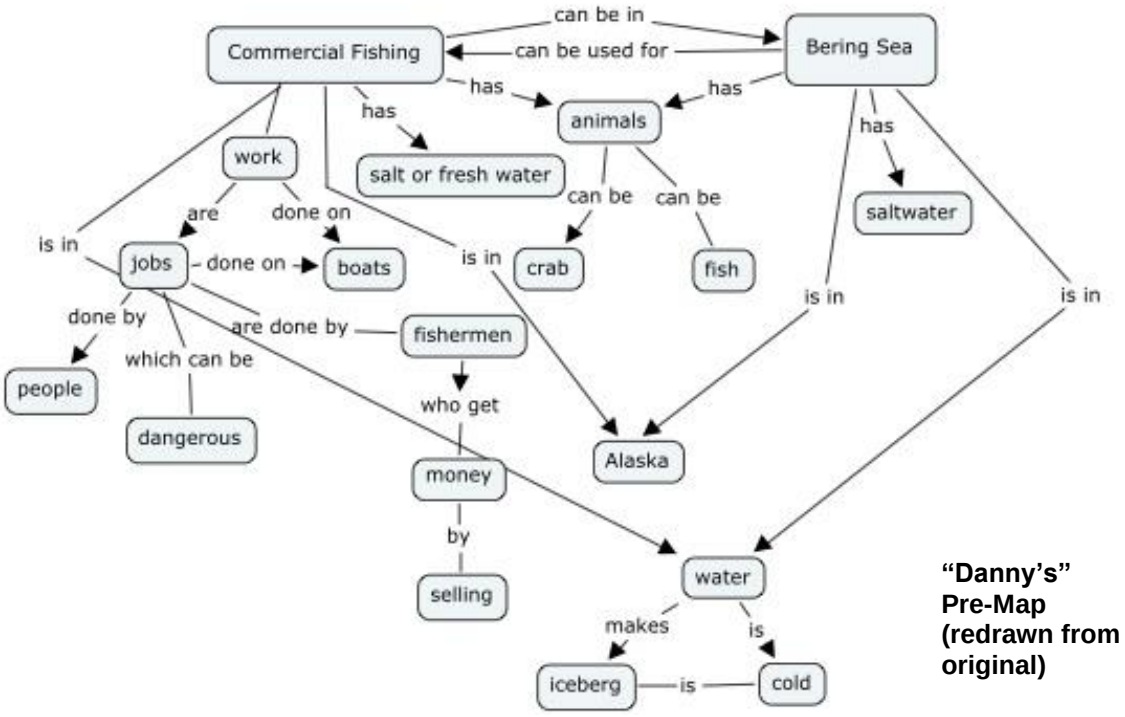
their first name and last initial on each concept map. After concept maps were collected, each map was coded without the use of names and first names were not used in any reports.

Pre-Program Concept Maps. Student concept maps were created and collected at the start of the program to determine participants' understanding of the Bering Sea and commercial fishing prior to SFBS learning activities. I explained that information from the concept maps would be used to evaluate the program's learning activities and make adjustments to the curriculum, *not* as an evaluation of the participants themselves. I trained participants how to create concept maps in accordance to Novak and Gowin's (1984) instructions (see appendix for concept map training outline). Seed concepts and linking words were not provided. To limit the amount of researcher bias, a free-range style of concept mapping was used (Adamecyzk et al., 1994). The training session lasted 1.5 hours and included step-by-step instructions (brainstorming, organizing, layout, revising and finalizing) and explanations of the parts and purposes of concept maps. During the training sessions students created a concept map with a familiar concept, "Food". Students and teachers collaborated throughout the practice concept mapping. Students were encouraged to ask questions about the process of creating concept maps during and after the practice session. Participants were provided with a blank 11" x 17" white piece of paper, pencils, and sticky notes to complete both the practice and pre-program concept maps.

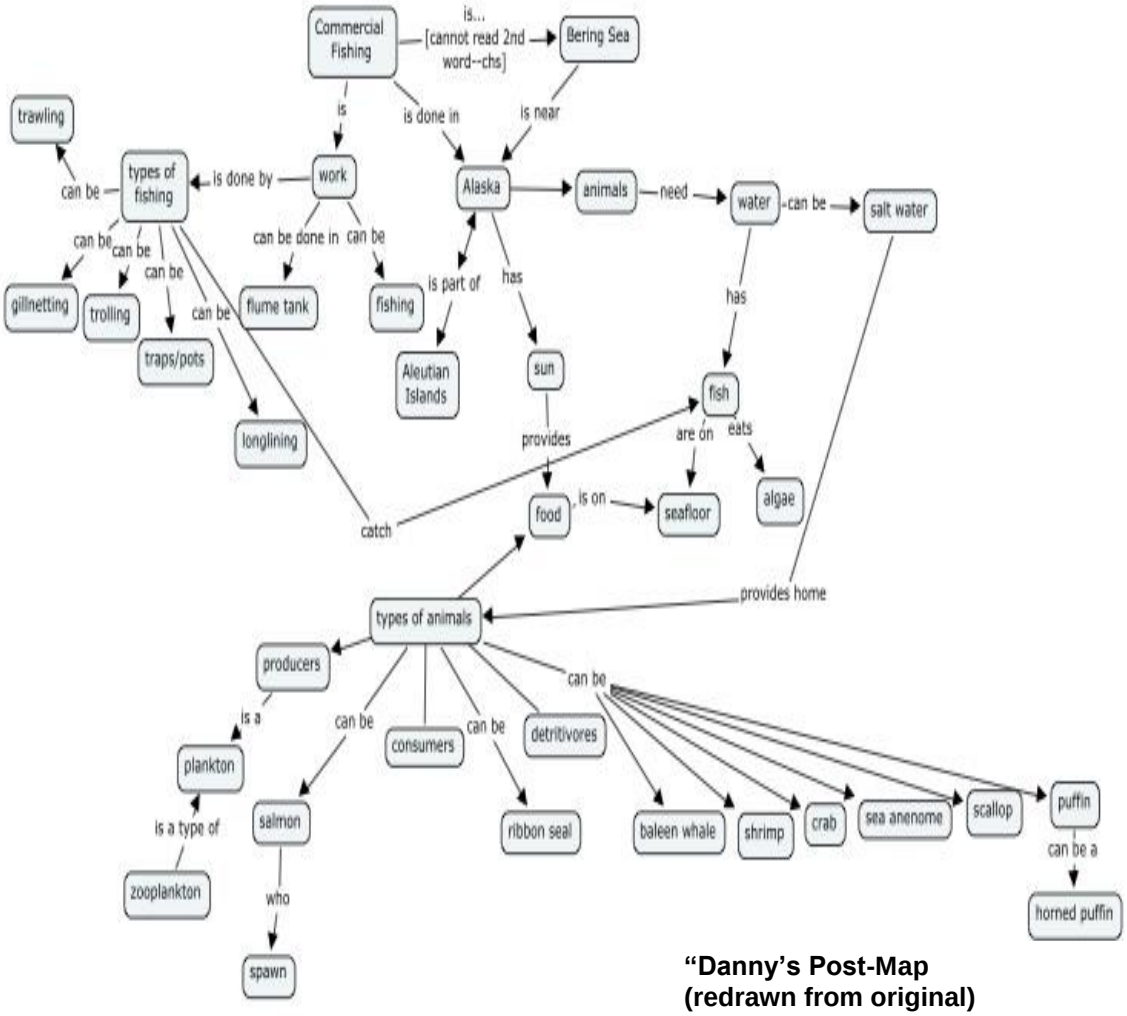
The starting point for creating a concept map is the focus question. To elicit the highest level of response from students, SFBS students were given the focus question,

"*What is the interrelationship between commercial fishing and the Bering Sea*?" I defined the word "interrelationship" and encouraged them to simplify the terms they were unfamiliar with. For instance, if "Bering Sea" and "commercial fishing" were too specific, students were encouraged to brainstorm the interrelationships between the *sea* and *fishing*. The words "sea" and "fishing" were underlined on classroom whiteboards/chalkboards. Students were instructed to complete the concept maps individually and were allotted up to 50 minutes to complete their maps. See Figures 24 and 25 for sample SFBS pre- and post-program map pairs.

Figure 24: Danny's (pseudo name) pre- and post-program concept map.

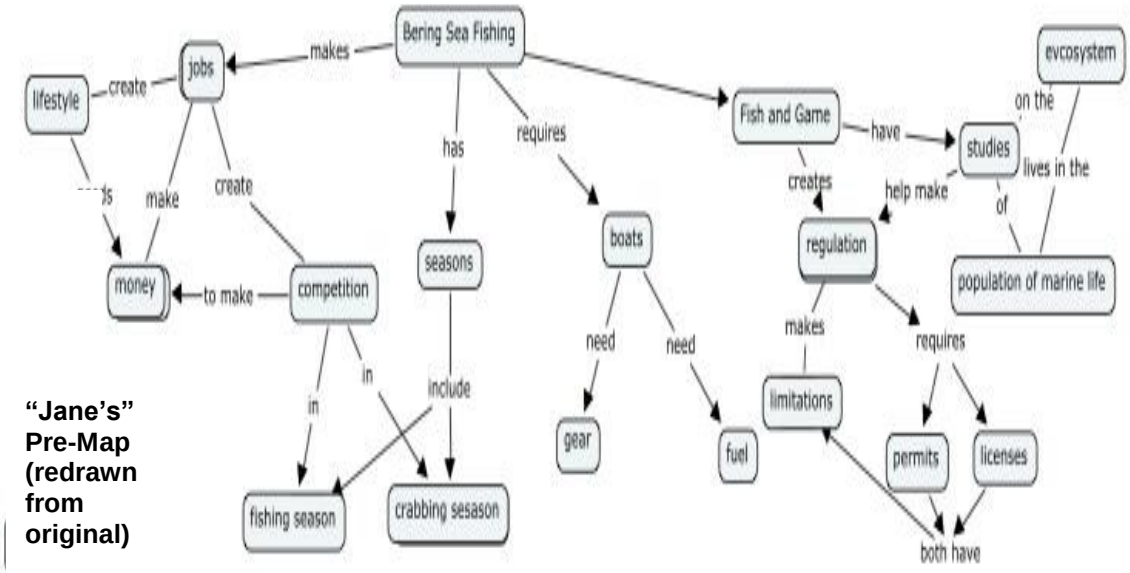


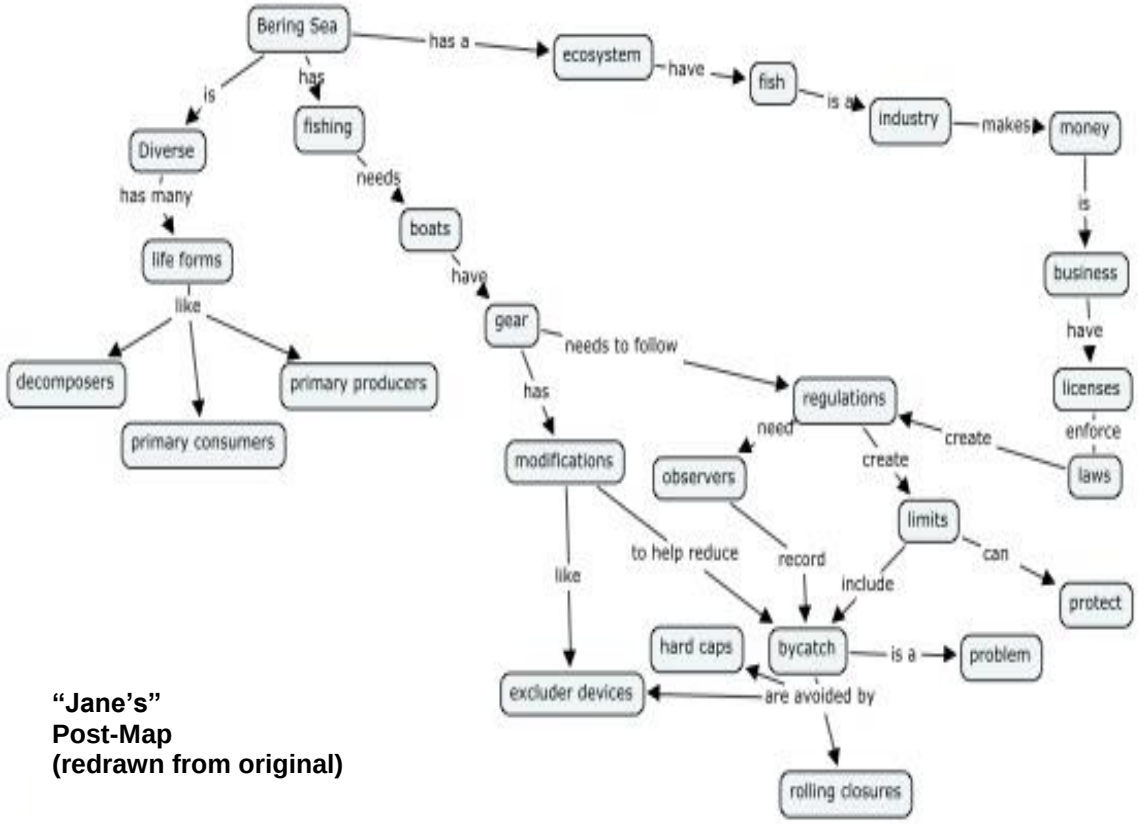
"Danny's" Pre-Map (redrawn from original)



"Danny's Post-Map (redrawn from original)

Figure 25:. "Jane's" (pseudo name) pre- and post-SFBS concept map.





"Jane's"
Post-Map
(redrawn from original)

Post-Program Concept Maps. After completing the SFBS program activities, the instructor and participants I reviewed concept mapping instructions with participants. I asked participants to complete a second concept map using the same prompt, "What is the interrelationship between commercial fishing and the Bering Sea?" Participants were allotted 50 minutes to complete their map. Due to scheduling restraints, there was variation in how much time lapsed between the end of the program and post-map completion (Table 3).

Scoring Concept Maps. I scored maps qualitatively using an adapted holistic scoring rubric (Table 4) described and validated by Besterfield-Sacre et al. (2004) and Greene et al. (2012). Besterfield-Sacre et al.'s (2004) holistic scoring approach offered a standardized method to evaluate the SFBS program concept maps. The rubric's three sections (comprehensiveness, organization, and correctness) cover a map's quality while omitting concept bias (Besterfield-Sacre et al., 2004). The holistic scoring rubric was more efficient than other scoring techniques. In turn, this methodology was a useful approach to measure participants' conceptual understanding of the SFBS program's subject matter.

Table 4: Concept Map Holistic Scoring Rubric. (Source: Besterfield-Sacre, 2004)

	1	2	3
Comprehensiveness Covering completely/broadly	Lacks subject definition, knowledge simple and limited, Limited breadth of concepts, Barely access qualities of subject area	Adequate subject definition, But knowledge limited in some areas (main aspects missing), Narrow understanding	Map completely defines subject area, Content includes extension areas
Organization To arrange by systematic planning and united effort	Concepts only linearly connected, Few connections in between branches, Concepts not well integrated	Adequate organization with some within branch connections, Some, but not complete integration of branches, Few crosslinks	Map well organized with concept integration and use of crosslinks, Sophisticated branch structure and connectivity
Correctness Conforming to or agreeing with fact, logic, or known truth	Map naïve and contains misconceptions, Inappropriate words or terms about the subject area, Inaccurate understanding of certain subject matter	Few subject matter inaccuracies, Most links are correct	Integrates concepts properly and reflects an accurate understanding of subject matter meaning, Little or no misconceptions

Three researchers scored the pre-and post-test maps and each map was scored by at least two people. All scorers were affiliated with Alaska Pacific University and were members of the Fisheries Aquatic Science and Technology Lab. I was the principal investigator, one assistant was a Master of Environmental Science student, and the second assistant was a senior in the undergraduate Marine Biology program. Each of us had previous experience with concept mapping in at least one component of our student work. I lead a concept map scoring training session for all of us.

Each assistant scored one half of the maps, and I scored all maps. Student names and groups were coded and maps randomly ordered to minimize bias. I compared the two scores for each map and ensured an eighty percent inter-reliability between scores. When a map's scores had less than the eighty percent inter-reliability, I discussed the map's attributes with an assistant scorer until in agreement. Afterwards, scores were converted to a nine-point scale (Table 5).

Table 5: Concept Map Scoring System. (Source: Besterfield-Sacre et al., 2004)

Holistic Score	1-	1	1+	2-	2	2+	3-	3	3+
Conventional Score	1	2	3	4	5	6	7	8	9

Analysis and Results

The overall mean score of pre- maps (*n*= 76) was 2.64 (*sd*= 1.27, Table 6). Individual pre-concept map conventional scores' ranged from 1 to 6. The pre-score median was 2.5. The overall mean score of post-maps (*n*= 66) was 4.0 (*sd*= 2.09, Table

6). The difference in pre and post mean scores was 1.36 (95% CI = 0.794 to 1.926) and is greater than would be expected by chance (t = 4.753 with 140 degrees of freedom) indicating that there is a statistically significant difference between the groups (P = <0.001). Individual post- map conventional scores' ranged from 1.5 to 9. The post-score median was 4. Figure 28 displays the averages for six student cohorts' pre-and post-concept map scores as well as the mean difference between scores. Figures 26 – 37 illustrate the distribution of holistic pre- and post-map scores within each student group. Out of 93 SFBS participants, 76 participants created pre-concept maps. Of these 76 pre-concept maps, 66 participants repeated the process to create post-concept maps. Of these 66 repeat maps, 71 percent improved map scores.

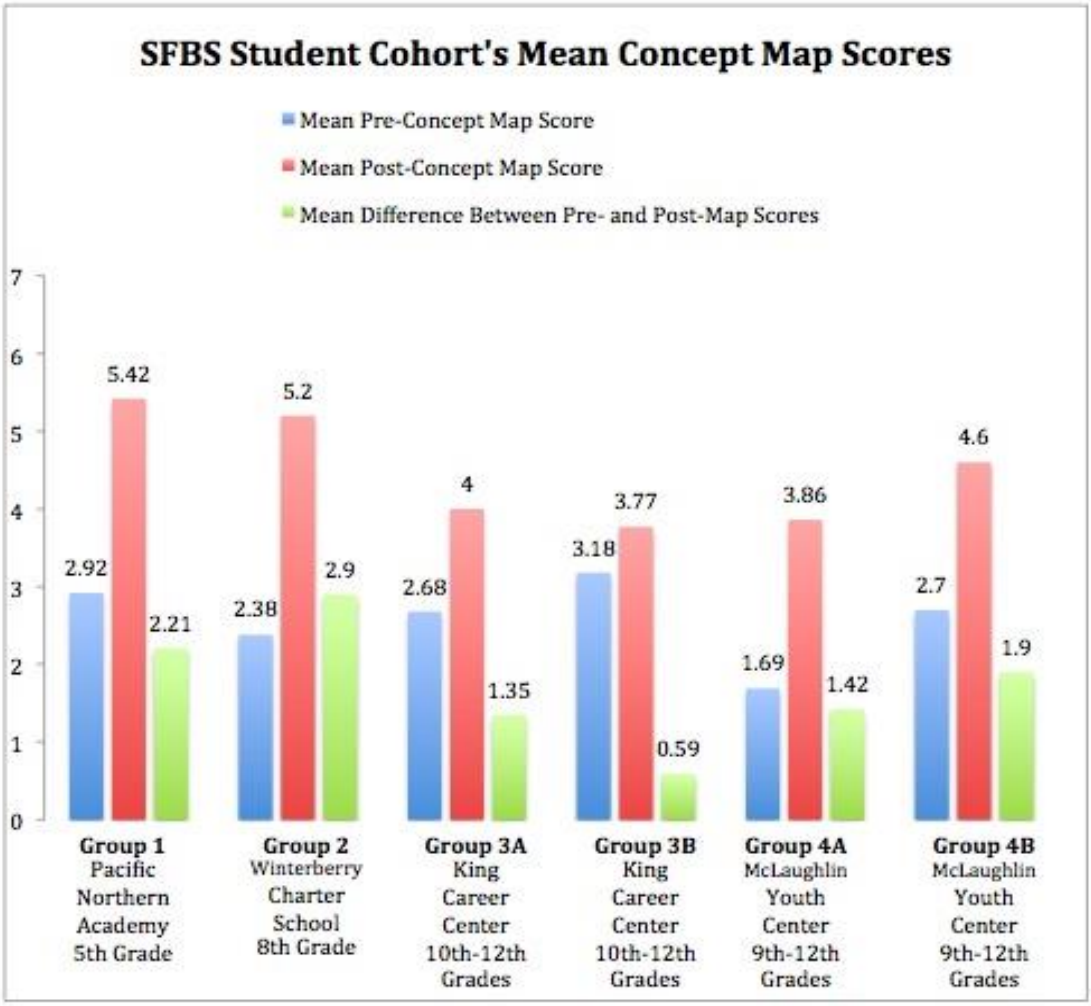


Figure 26: Student groups' mean pre-concept map, post-concept maps.

Table 6: Concept Map Descriptive Statistics for Six Participant Groups

Concept Map Statistics for SFBS Student Cohort Groups						
Group	*n*	*m* Pre-Concept Map Score	*sd*	*m* Post-Concept Map Score	*sd*	*m* Difference Between Pre- and Post-Map Scores
1 PNA, 5th Grade	13	2.92	0.94	5.42	2.49	2.21
2 WCS, 8th Grade	16	2.38	1.12	5.2	1.79	2.9
3A KCC, 10th-12th	17	2.68	1.26	4	1.51	1.35
3B KCC, 10th-12th	17	3.18	1.29	3.77	1.68	0.59
4A MYC, 9th-12th	9	1.69	0.69	3.86	1.07	1.42
4B MYC, 9th-12th	5	2.7	1.29	4.6	2.44	1.9

Figure 27 (below): Holistic scores (converted 9 point scale) of Group 1's Concept Maps.

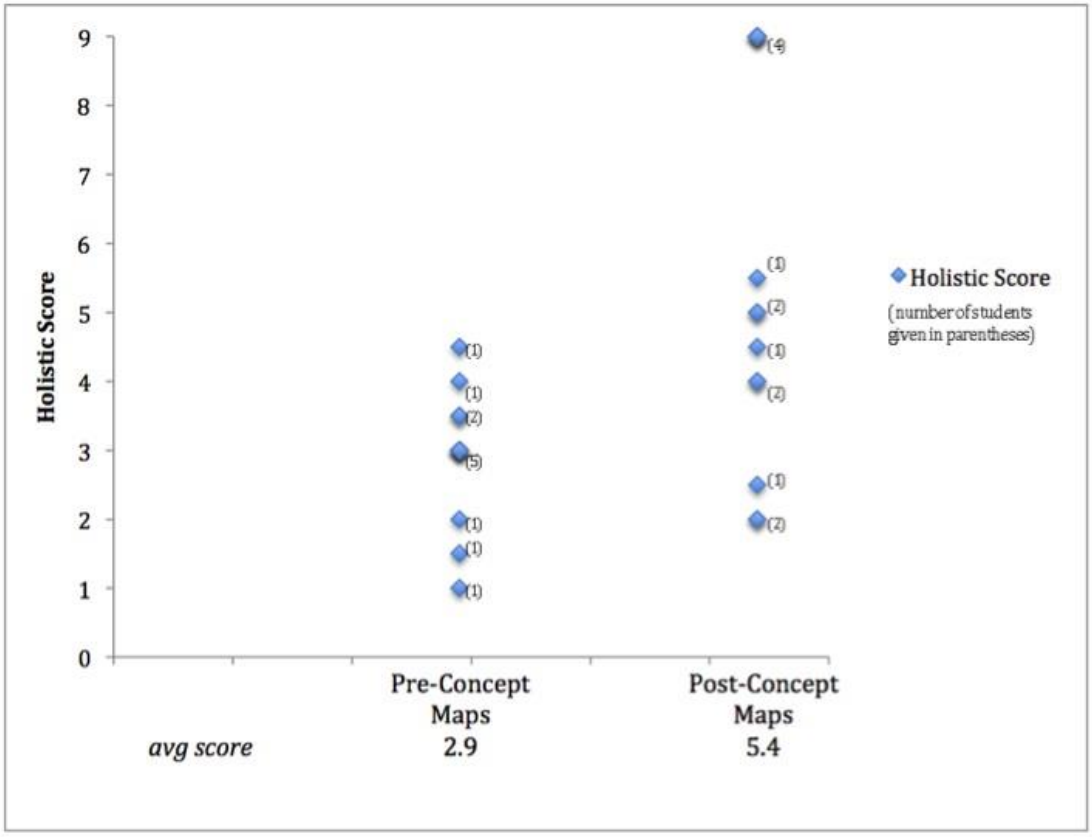


Figure 28 (below). Group 1 repeat students' pre- and post-concept map scores.

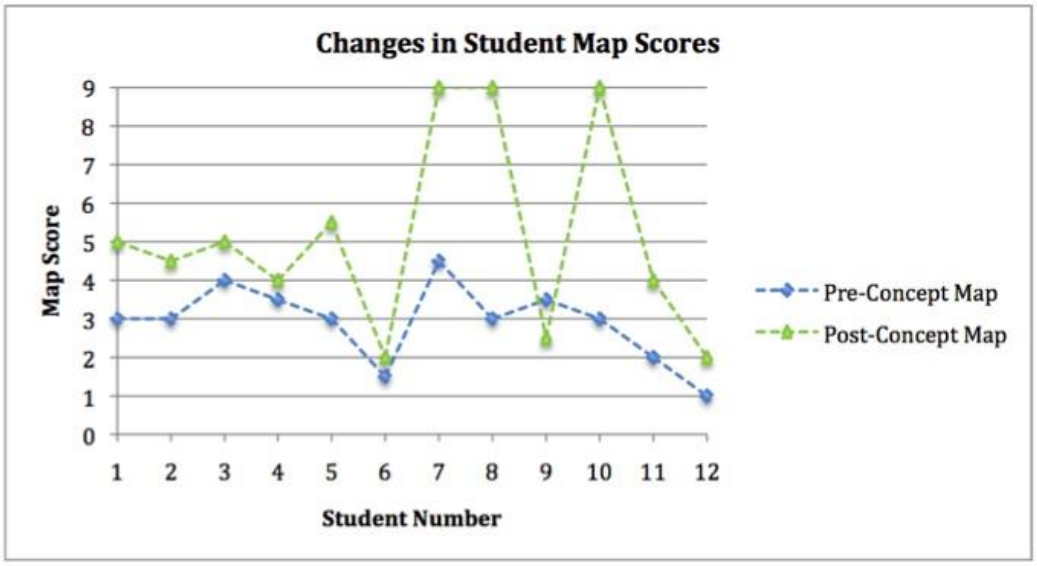


Figure 29 (below). Holistic scores (converted 9 point scale) of Group 2's Concept Maps.

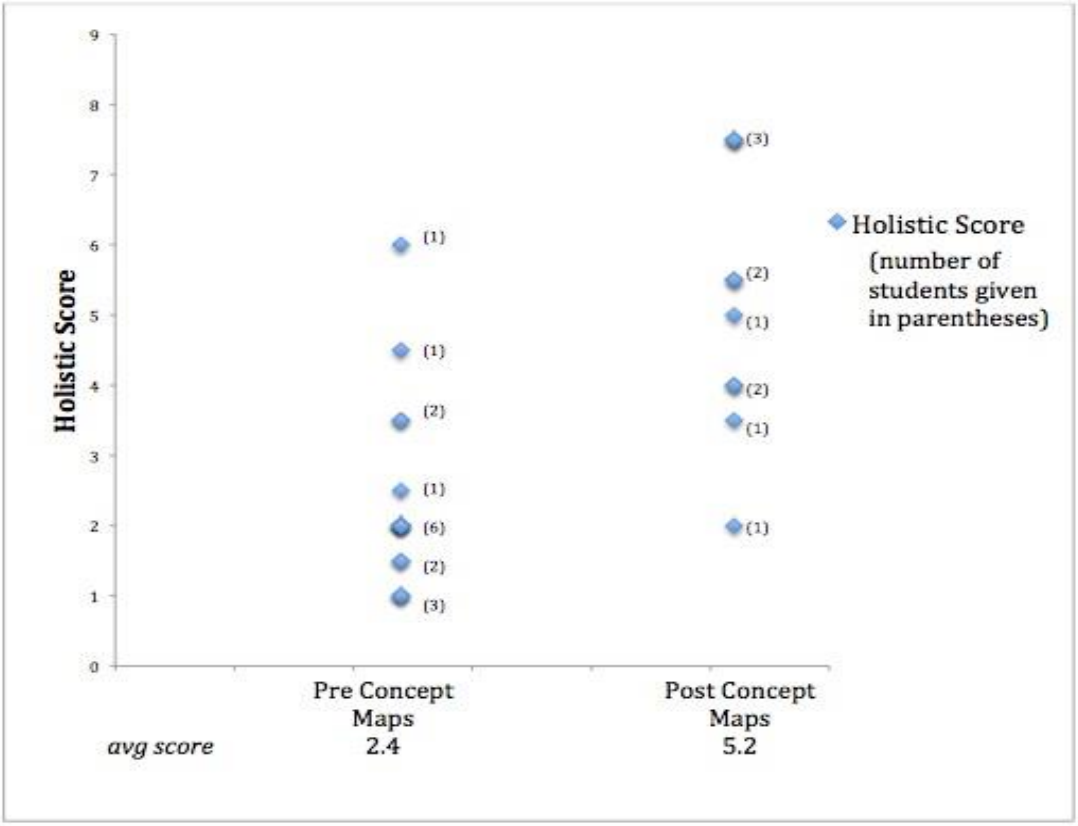


Figure 30 (below). Group 2 repeat students' pre- and post-concept map scores.

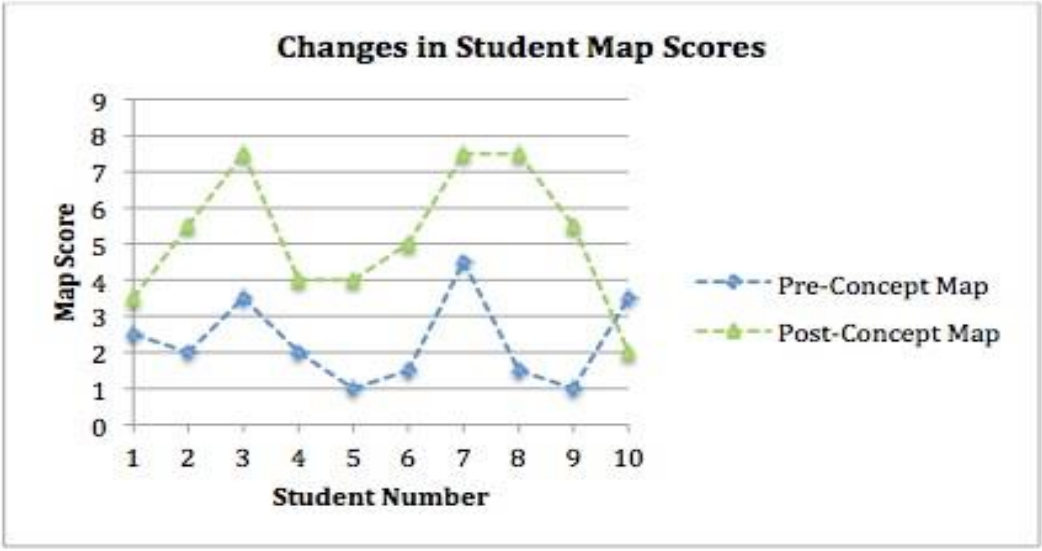


Figure 31 (below). Holistic scores (converted 9 point scale) of Group 3A's Concept Maps.

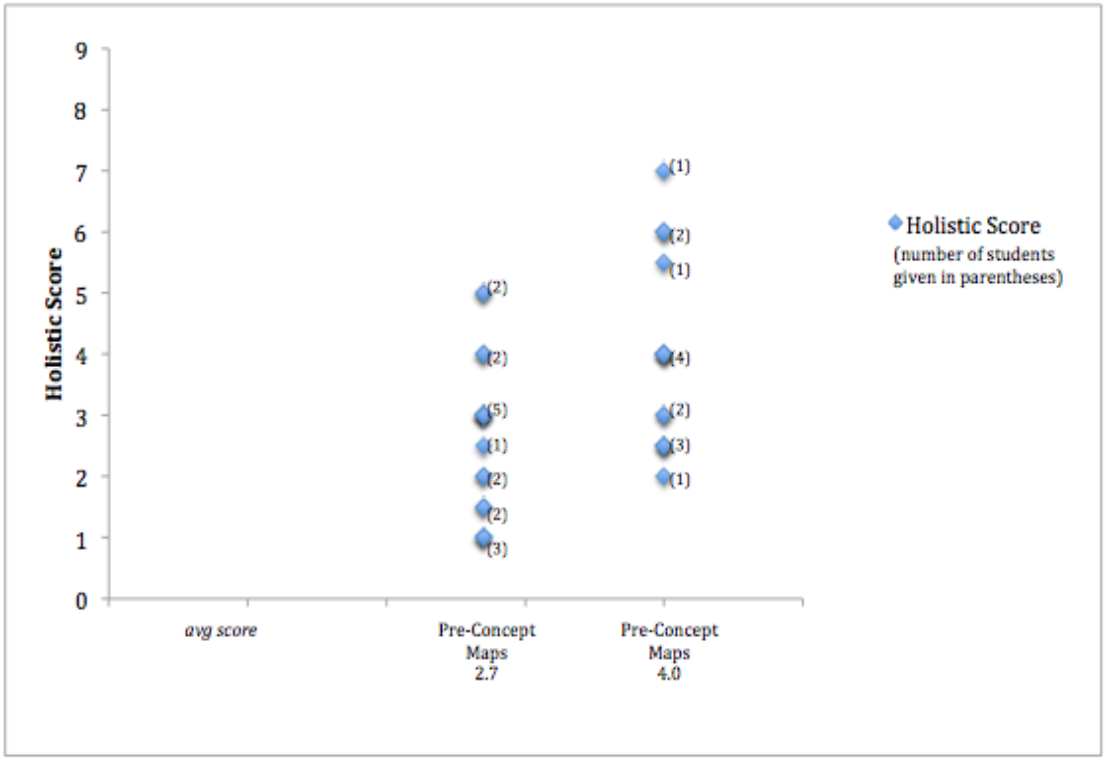


Figure 32 (below). Group 3A repeat students' pre- and post-concept map scores.

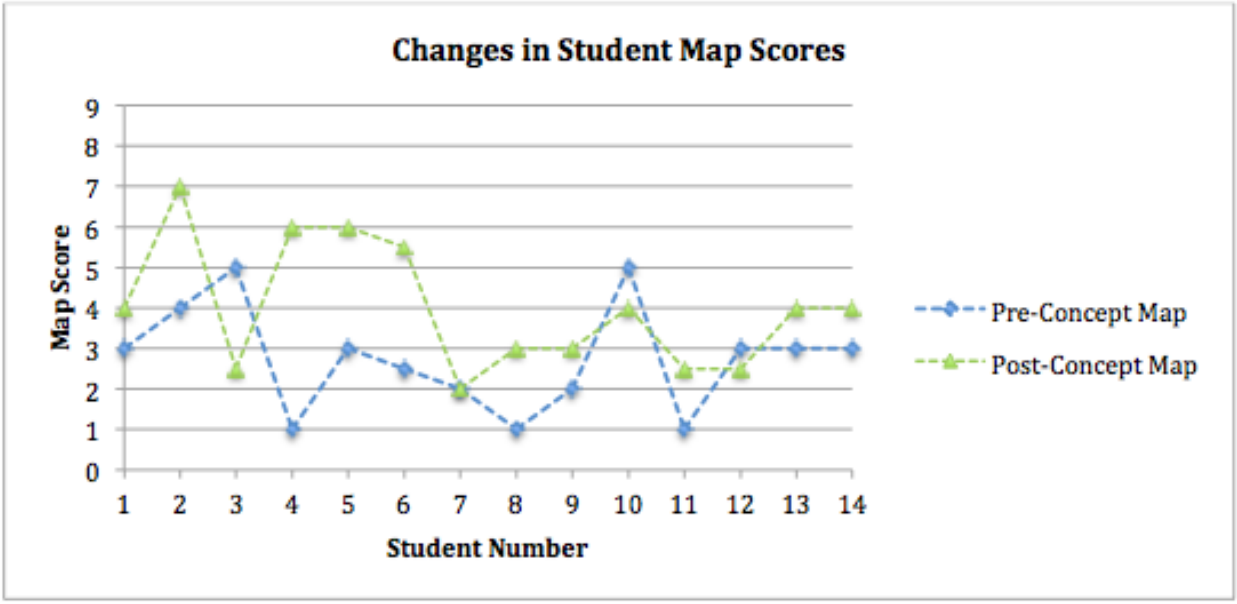


Figure 33 (below). Holistic scores (converted 9 point scale) of Group 3B's Concept Maps.

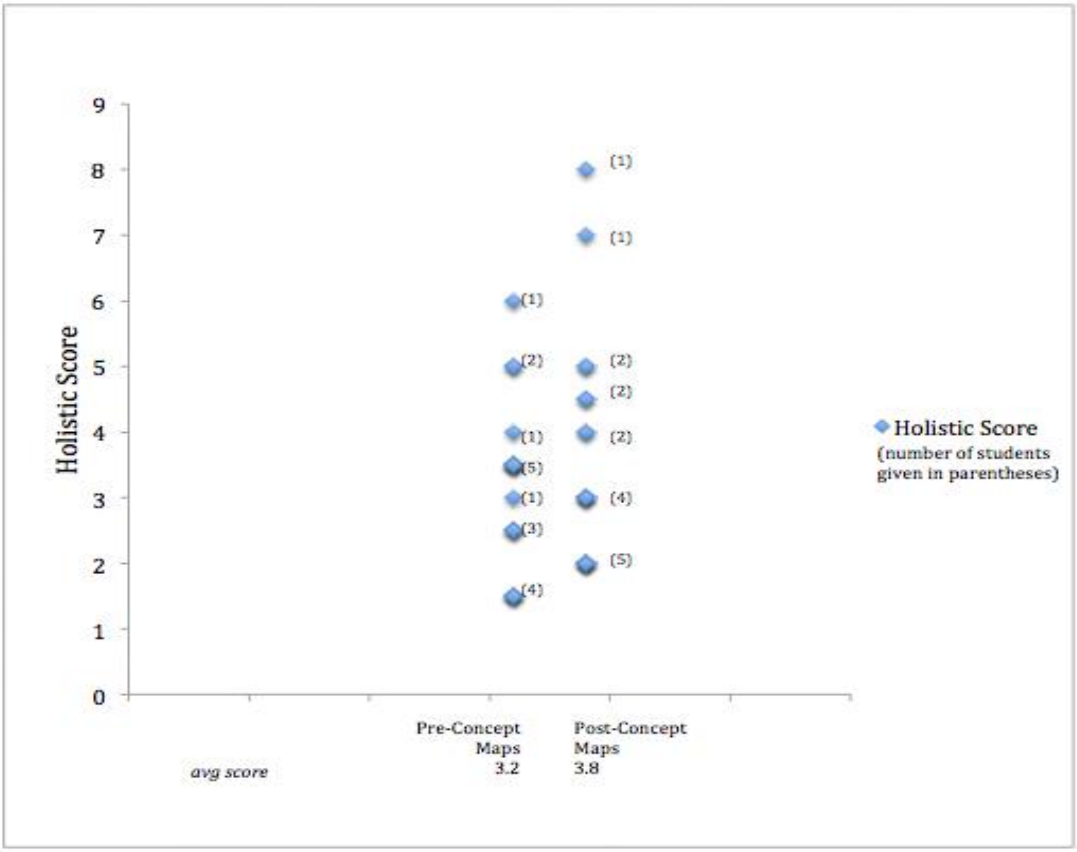


Figure 34 (below). Group 3Brepeat students' pre- and post-concept map scores.

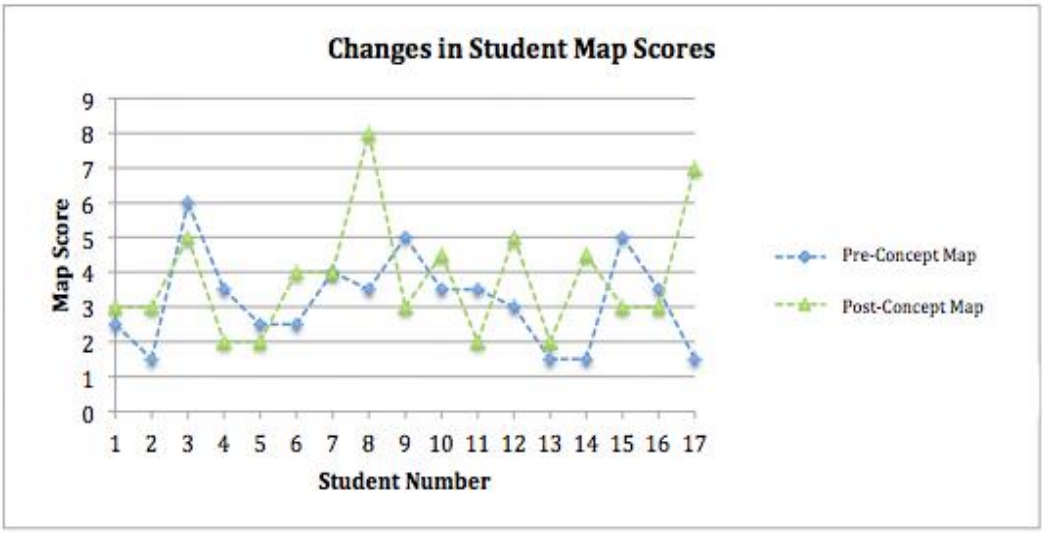


Figure 35 (below). Holistic scores (converted 9 point scale) of Group 4A's Concept Maps.

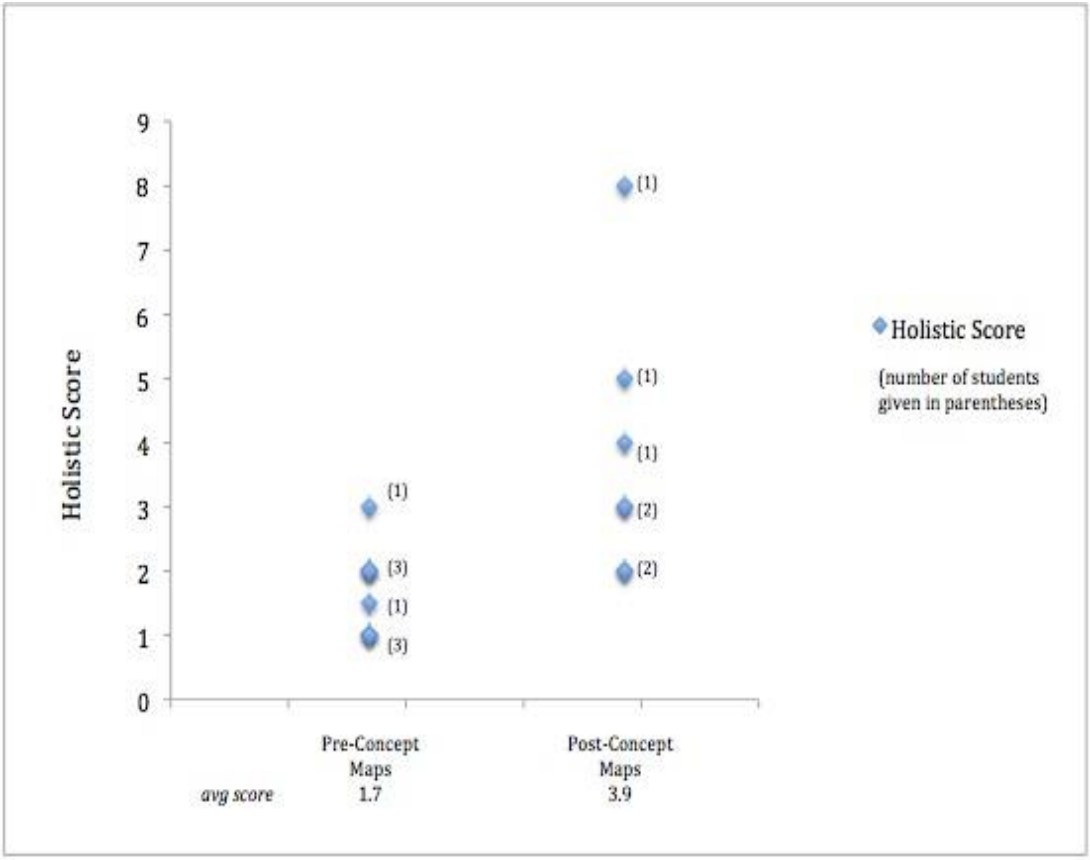


Figure 36 (below). Group 4A repeat students' pre- and post-concept map scores.

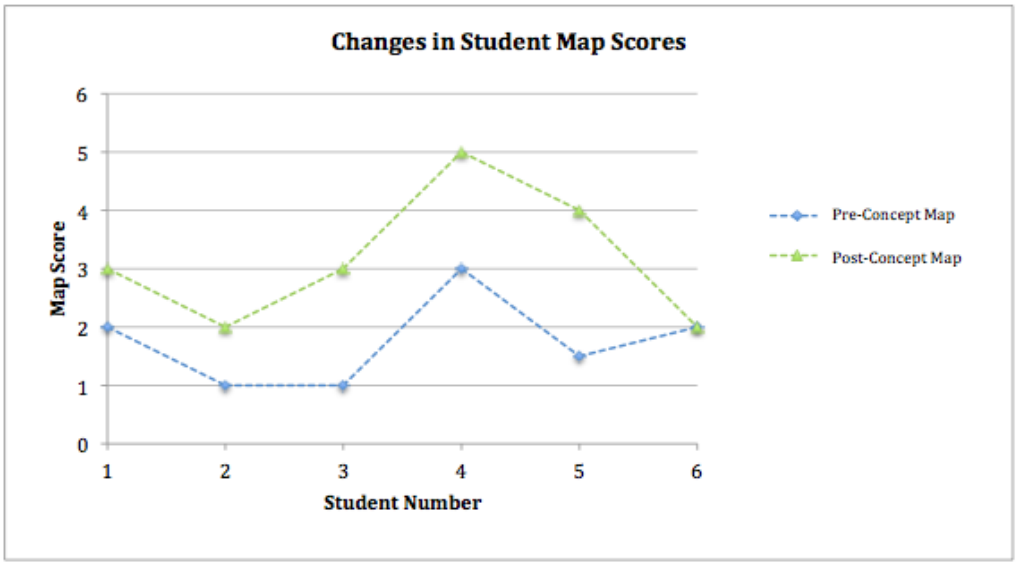


Figure 37 (below). Holistic scores (converted 9 point scale) of Group 4B's Concept Maps.

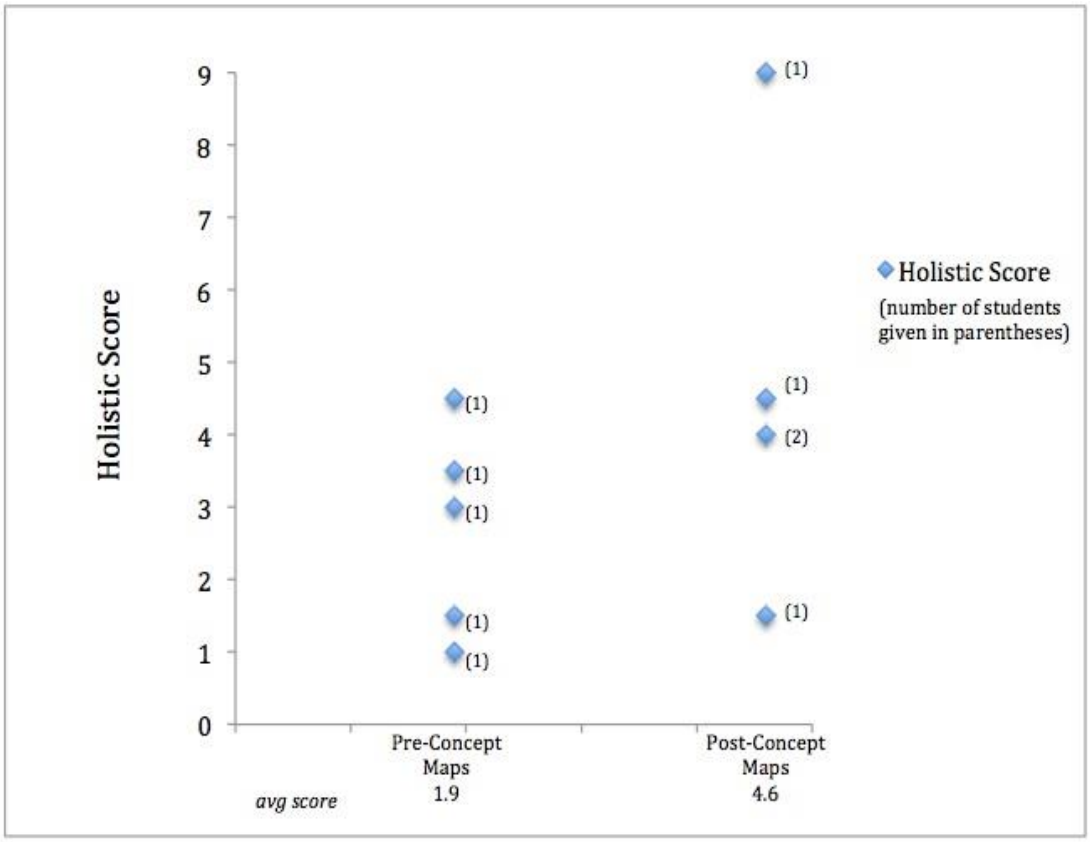
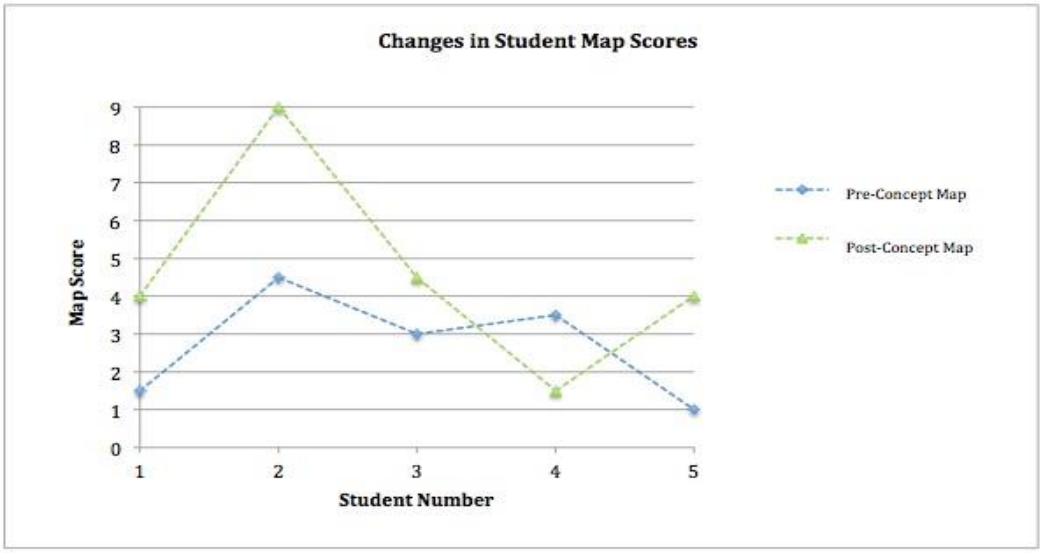


Figure 38 (below). Group 4B repeat students' pre- and post-concept map scores.



Discussion

Results

Analysis of each map showed that participants had an increased capability to express specifics of the subject matter after the SFBS program. The concept map holistic scores (converted to a nine point scale) show that there was an overall gain in understanding of the SFBS topics. A conventional score of 2.5(close to the pre-map mean score) indicates a limited breadth of concepts and barely assess qualities of subject area where students linearly connect concepts with few connections between branches, and reflect an inaccurate understanding of certain subject matter. On average, SFBS pre-maps included few and general concepts relating to the Bering Sea and commercial fishing such as, “fish”, “water”, “boats”, “jobs”, “money” and “weather”. Some maps recognized the Bering Sea ecosystem, or parts of one, existed. Average pre-maps did not interconnect concepts such as “fish,” “water,” and “jobs”. Instead, concept branches were separated from one another. Some pre-maps also incorporated concepts about the Bering Sea ecosystem (*i.e* listing animal species) and fishing regulation agencies (*i.e.* Fish and Game). Concepts were linearly connected to one another and crosslinks between branches were mostly absent. Additionally, pre-maps with an average score either lacked linking words, or were unclear in how concepts were linked. Many pre-maps contained conceptual tangents on topics such as books participant’s read, classmates’ names, holidays, and famous people.

The mean post-map score for participants was 4. A conventional score of 4 indicates an adequate comprehension, but limited or lacking knowledge in some areas.

Maps have adequate organization with some branch connections, but few crosslinks between branches. Concepts are also correct with few subject matter inaccuracies. Average post-maps used specific terminology, showing an increase in comprehension of the topic. For example, the following concepts were commonly included: types of Alaska commercial fishing techniques, targeted Alaska commercial fish species, types of bycatch, ecosystem trophic levels, Bering Sea geography, commercial fishing management, pollock seafood products, and Bering Sea food web components. Intermediate post-maps' organization included limited interconnections between branches. Average post-concept maps constructed clear propositions to define the relationships between concepts. Average post-concept maps' content contained fewer misconceptions, mostly correct links, and excluded tangents.

Post-concept maps with above average scores, particularly ranging from 7 to 9, defined the subject area more completely. They were well organized with concept integration, crosslinks connected branches, and contained little to no misconceptions. Higher scoring post-maps included the basic ecological principals of the Bering Sea, specific commercial fish capture techniques, and causes and prevention of bycatch in the pollock fishery. This content indicated higher levels of comprehension. For example, ecological principals such as "energy transfers" and food webs were illustrated in higher scoring maps. Commercial fish capture techniques such as "gillnetting", "seining", "longlining", "pots and traps", "trawling", and "trolling" were included. Higher scoring maps both recognized bycatch as a component of commercial fishing in the Bering Sea and identified solutions. Lower scoring maps often did not specify solutions to bycatch.

For example, one participant's post-map expressed that bycatch "needs bycatch prevention in modified gear," and "bycatch prevention is in salmon excluders". The same participant also indicated that fishing boats' nets are tested in flume tanks. Another student's stated that commercial fishing decreases bycatch by using "fishing bycatch information to form bycatch hotspots to sustain the fish population while still making revenue". Another participant demonstrated that gear has "modifications like excluder devices to help reduce and avoid bycatch", that "bycatch is avoided by hard caps and rolling closures", and "regulations decrease limits including bycatch to protect the ecosystem". A different participant conveyed that because of bycatch "we need limits, so hard caps were created, which was a contributing factor for the need of salmon excluder devices".

Participants with higher scoring maps also identified different stakeholders in the Bering Sea pollock fishery such as Western Alaskan communities, the commercial fishing industry, non-governmental organizations (*i.e*. "Greenpeace") and government organizations (*i.e.* "North Pacific Fishery Management Council"). In addition, participants' higher scoring post-maps arranged content to show interconnections between ecological, economical, and governmental factors pertaining to the Bering Sea and commercial fishing.

In sum, the pre- and post-maps and scores show an average increase in map quality, indicating an increase in conceptual understanding and knowledge integration following the SFBS program (Bourke 2013; Greene et al. 2013; Ruiz-Primo & Shavelson 1996). According to the assimilation theory of learning, the increase in map quality also

implies that meaningful learning occurred as students linked new knowledge with old knowledge (Besterfield-Sacre et al. 2004; Hay and Kinchin 2006; Greene et al. 2013). The SFBS maps reveal that the average participant completed the program with a basic understanding of Bering Sea ecology and commercial fish capture techniques of Alaska. The post-maps also expose that the average participant recognized bycatch as a problem of commercial fishing in the Bering Sea, but did not acknowledge conservation engineering or management solutions to reduce bycatch.

Six of the seven SFBS student cohorts completed both pre- and post-maps (the seventh student cohort did not). The range of average post- map scores by cohort was 5.42 (Pacific Northern Academy, 5th grade) to 3.77 (King Career Center, 10th-12th grade). Cohort's mean differences between pre- and post-map scores ranged from 2.9 (Winterberry Charter School, 8th grade) to 0.59 (King Career Center 10th-12th grades). Refer to Figure 27 and Table 4.

The variation between cohorts' average map scores reflects the difference in content delivery and knowledge gain of the SFBS topics between each cohort. Groups 3A and 3B (King Career Center, 10th-12th grade) were the first two groups to complete the SFBS program. Thus, I lead all SFBS program activities for the first time with Groups 3A and 3B. As a result, the program was not as effective with Group 3A and 3B as with subsequent student cohorts because I was able to reassess the program following initial instruction. The KCC students did learn how to create concept maps effectively during the training session and it was not adapted for subsequent cohorts.

The first lesson, *Bering Sea Food Web Mural,* proved engaging and useful to cover ecology of the Bering Sea. However, all other lessons were significantly adapted following the KCC instruction. For example, I presented the *Commercial Fish Capture Techniques of Alaska* as a PowerPoint presentation and a supplemental educational Alaska fishery management video. This teaching technique was ineffective. In response, I created a new delivery method including group work and presentations for subsequent students to learn about Alaska's commercial fish capture techniques. Groups that participated in the revised *Fish Capture Techniques* format with group presentations were more successful in defining fish capture techniques. I also modified the "*What's the Catch?"* lesson to become a group reading and discussion, rather than independent reading and written response assignment. While leading a class reading and discussion of the adapted *"What's the Catch?"* lesson with a student cohort from MYC, students were engaged in discussing questions and answers aloud. The modified lesson enabled students to better understand the causes and preventative measures of bycatch in the Bering Sea pollock industry.

Overall, I imposed too many learning activities on the KCC groups. As a result, the quality of student experiences was compromised. For example, the last KCC session (prior to the post-concept mapping) began with a whole group introduction to the NPFMC and role-play activity. After the NPFMC overview I divided the class into three small groups to rotate through learning stations: role-play preparation, knot tying, and the flume tank. I completed the class session with a whole group NPFMC role-play. There were too many different learning tasks in too short of a time. From the reactions of the

students, I learned that they were very engaged with the flume tank and needed much more time to prepare and process for the NPFMC role-play activity (multiple days). Because there were too many activities with KCC students in the time allotted, there was not time to review concepts throughout the program. With subsequent groups, I eliminated lessons from the program as necessary and continued to use observations to modify the lessons and improve the SFBS program.

I found the following concept map attributes useful as part of an assessment:

1) Before the SFBS program began, the pre-concept maps "primed the pump" (Gregg and Leinhardt 2002) so when participants were engaged in SFBS learning activities they could inquire about content included on their concept maps and learn new information. The pre-maps were a good starting point for discussion of the Bering Sea and commercial fishing. Additionally, the pre-maps helped me gain insight on students' prior knowledge of the topic.

2) Concept mapping is not like a test with right or wrong answers, which reduces test anxiety. The concept mapping trainings and sessions felt like a worthwhile, engaging classroom activity and offered an open-ended view of a participant's thinking of SFBS subject matter (Bourke *et al.* 2013; Day-miller and Easton 2009; Ritchhart *et.al* 2009).

3) The "visual nature" of concept maps serves as a brief and precise method to capture change in participant knowledge and a straightforward way to show the change to others (Bourke *et al.*, 2013; Day-Miller and Easton, 2009).

4) Concept maps met my "Feasibility Standard" for an evaluation method. *The Program Evaluation Standards*' are used to advance education evaluations and are organized around characteristics of evaluation: utility, feasibility, propriety, and accuracy. The first "Feasibility Standard" is, "Practical Procedures." The evaluation procedures should be practical, to keep disruption to a minimum while needed information is obtained" (Sanders, 1994). Administering the pre- and post-maps did not disrupt the program and was manageable for me to implement in addition to facilitating the learning activities. The holistic scoring method provided a concise, efficient, and reliable classification scheme to assess individual concept maps (Besterfield-Sacre et al. 2004; Kichin et al. 2000). This method made it possible for me to analyze and score each concept map efficiently.

While concept maps were helpful in measuring the gain in content knowledge during the SFBS program, they were not helpful in documenting student reactions and engagement in learning activities. Based on my observations, the most consistently engaging learning activity was the *Smart Fishing in the Bering Sea*. The focal point of this lesson was the flume tank. When students first saw the flume tank generate flow, initial comments included: “Wow! This is so cool!”, “I wish we had one of these”, and “How does this work?” The hands-on and inquiry based design of this lesson captivated students’ attention and was an effective medium to teach the basic factors driving conservation engineering in the context of reducing bycatch in the Bering Sea pollock fishery. Students were given the opportunity to observe basic principals of gear efficiency and used the small-scale trawl nets to improve the intended results of reducing drag, catching the most target species and catching the least amount of bycatch.

The SFBS program was successful in increasing the knowledge of participants about the Bering Sea environment and commercial fishing challenges and solutions. My revisions are aimed at further increasing the knowledge of future participants and providing more opportunities for conservation engineering skill development. My suggestions include longer and more use of the classroom flume tank.

The results of the program evaluation indicate that the SFBS included the following “Elements of Excellent EE programs” as outlined by Thomson and Hoffman (2013):

* Credible: based on solid facts.

* Create knowledge and understanding about ecological, social, economic, and political concepts, and demonstrate the interdependence between a healthy environment, human well-being and a sound economy.

* Involve a continual improvement that includes the process of design, delivery, evaluation, and redesign.

* Grounded in a real-world context.

* Provide creative learning experiences that are hands-on and learner-centered, where students teach each other and educators are mentors and facilitators.

We successfully met NPRB's mission and outreach priorities as applicable to the SFBS program. The SFBS program shared information relevant to conservation engineering fishery research in the Bering Sea with Anchorage, Alaska students and teachers in grades 5-12. The creation, development and evaluation of the program also involved university students at the undergraduate and graduate level. The follow up from this project will result in a usable curriculum format and materials for interested classroom teachers.

Implications

The following are suggestions for future lessons based on evaluation results.

1) *Smart Fishing in the Bering Sea*: Flume Tank

Students were interested and engaged with the classroom flume tank. For future programs, the flume tank learning activities should follow the *Bering Sea Food Web Mural* lesson. This is a unique, hands-on "hook" (Brookfield, 2006; Lemov, 2010) to introduce basic concepts of conservation engineering, goals of commercial fisheries, and the problems and solutions of bycatch. The other learning activities (*i.e. Current Fish*

Capture Techniques of Alaska, NPFMC Role-Play) would be appropriate lessons to follow the inquiry based flume tank activities.

A flume tank education kit for the state of Alaska should also be developed and made available to educators in Alaska. The flume tank, scaled-down nets and supplies used in the SFBS can be used as a prototype to refine a portable version of a statewide education kit. Working with net-engineers to manufacture small-scale net models will increase the quality and longevity of the flume tank kit.

2) Time Span

The quality of the SFBS program improved with an increase in program time. If possible, plan conservation engineering outreach programs over longer time period rather than shorter ones (*i.e.* 10 hours over five weeks rather than 10 hours in one week). The SFBS programs that had longer delivery times provided more opportunity for processing, inquiry, new ideas, building rapport between the instructor and participants, review, and follow up. Contact over longer time spans made it easier to set a reasonable pace and avoid doing too much during class sessions. If a longer time span is not possible, instructors should minimize the number of learning activities and topics covered. Furthermore, creativity is essential to problem solving and the design process, which are essential aspects of conservation engineering. Teachers need longer time spans with student groups to facilitate how to creatively design output to solve problems (Wong & Siu, 2011).

3) Partnerships

Informal and formal partnerships between APU's FAST Lab and WCS, KCC, MYC and PNA formed as a result of the SFBS outreach program. These partnerships should be maintained in the future so research and relevant scientific topics will continue to be shared in meaningful ways with teachers and students. As participating teachers reported, it is "impossible for teachers to be experts in all topics" and it was "invaluable for their students to participate in "carefully crafted hands-on learning experiences" to explore a real-world context in depth. Co-facilitating the program with a lead classroom teacher and an outreach instructor is also an effective way to modify the program to meet each cohort's needs.

Day-Miller and Easton (2009) state that outreach "*planning team members should also… consider how meaningful partnerships and collaboration can be enhanced through the project*" (p. 34). They further suggest that it is a more efficient use of resources to create long-lasting community partnerships as opposed to creating a one-time event. The SFBS developed "rare" partnerships through which multiple schools and classrooms enabled an entire unit to be taught during school hours. Additionally, at the conclusion of the SFBS program, each school expressed they would like more APU FAST Lab outreach programming to take place in the future. If the relationships between the elementary, high school and university are maintained, students and teachers will increase their environmental literacy pertaining to Alaska's fishery and aquatic sciences. In turn, fostering these partnerships could increase knowledge and skills to address Alaska's fishery environmental problems and solutions.

4) Concept Mapping

The primary costs of the concept maps were student and teacher time. However, concept maps are a reliable and valid assessment tool of conceptual change and quality learning. The literature understated the amount of time required to train students to properly complete concept maps and to create concept maps using a provided prompt. For those planning to use concept maps as an assessment tool, a minimum of an hour and a half should be set aside for a concept map training session. At least one hour should also be used for participants to create pre-concept maps, and one hour for students to create post- maps. If possible, having students create concept maps throughout the program would be useful for them to review and integrate the subject matter.

Limitations

As a pilot program, the conditions were unfavorable to conduct an evaluation because the program had few routines and little stability. It is best for a program to be piloted and established to conduct a systematic evaluation. Thus, the experiences between SFBS groups varied widely as the researcher used action research to improve and modify the program each session. This complicates comparing the outcome of results between student groups. Although, evaluations done during a pilot phase can help identify flaws in learning activities, learning theories, and delivery methods (Thomson & Hoffman, 2013).

The administration of the concept maps was another limitation. All participants required training to create concept maps. If students missed the concept map training, their maps could not be included in the study. Prior to completing post-program concept

maps, the steps to create a concept map were briefly reviewed and students were permitted to ask any questions on how to create a map. This brief review was insufficient to train students who missed the initial training session. There was also variation between groups in how much time lapsed between completing the SFBS program and creating the post-maps. I scheduled the post-mapping session as close to the last day of the SFBS program as possible for each group, but she I had to work around existing classroom schedules. The Natural Resource students from KCC completed the post-maps 14 days after the final day of programming, the 5th graders from PNA completed the post-maps five days later, the 8th graders from WCS completed the post-maps three days after, and the science classes from MYC completed the post-maps between one and two days later. In turn, there was no consistent duration the post-maps were completed. Additionally, as the concept maps were completed close to the end of the program, this study did not measure any long-term outcomes of the program.

Finally, evaluating education processes is complicated and the measurements are often simple, which suggests that the simple concepts are the only real findings with in the EE community. "*The real things, the ways in which environmental education can change someone's life, are much more subtle and difficult to measure*" (Kool, 2002 as cited in Thomson & Hoffman, 2012, p. 31). EE evaluations target measuring multifaceted outcomes and influence, which are problematic to evaluate. While I was able to document some outcomes of the SFBS program, it is difficult to isolate the SFBS program as a primary contributor to these outcomes. Each student's own educational background, learning skills, outside school influences, and demographics influence

his/her learning and change of knowledge. Individual attendance also varied throughout the program; not all 93 participants were present for each SFBS session offered to their class.

Suggestions for Future Research

Findings from this study indicate participants gained content knowledge from a fishery outreach program about the Bering Sea and commercial fishing. As a new outreach program, I recommend that further studies be conducted for future programs. First, future programs should use concept mapping again incorporated with suggestions from this program. If time permits, concept mapping should be used throughout the programming as a way to reinforce the skill, review program content, and spark discussion. A future study could also investigate if and how the use of concept mapping aided in learning of SFBS subject matter. I also suggest limiting the vocabulary of map prompts. If logistically possible, post-program maps should be administered after a time period consistent throughout the participant groups.

Second, if the program establishes more routines and systems, I suggest that future studies compare how variations such as grade level, time span of program, total duration of contact time, and class size influence the outcomes of the SFBS program.

Third, I propose researchers use other evaluation tools to examine information not targeted by concept maps. Concept maps do not provide answers to evaluation questions such as, how extensively was the audience engaged in SFBS program activities? What were participants' reactions to program activities? What were the benefits from

participation in activities? How were participants' attitudes and behaviors impacted? What skills were gained from the SFBS program?

Fourth, I recommend that future studies examine the quality of instruction. Ultimately, the worth of a program is contingent upon the instructor and his/her capabilities. I only received and solicited informal feedback from the classroom teachers in regards to my teaching abilities. A systematic evaluation of instruction could provide useful feedback on what instructional techniques and styles to continue, modify, or professionally develop for the long-term success of educators and EE programs they teach.

Lastly, this project was able to overcome barriers to outreach that allowed "rare" access for an outsider to teach an entire unit in the classrooms. As a result, working partnerships were formed with several different schools and teachers. Future research should examine how more outreach programs can collaboratively teach units with classroom teachers. What makes education and outreach partnerships possible and sustainable?

In conclusion, evaluations offer usable information to stakeholders about the details of project outcomes. In the case of the SFBS, I will share results with funding agencies (NPRB), pollock industry leaders (At Sea Processors Association), supporting institutions (Alaska Pacific University's Fisheries Aquatic Science and Technology Lab), and participating schools. I will share these results to identify areas of improvements, and to determine if stakeholders should continue to support SFBS and similar programs in the future. Specific evaluation results can provide broader insights into outreach and

education. (Friedman, 2008; Westat, 2010). Thus, the SFBS evaluation results, challenges, and successes will be available for future outreach and education efforts.

References

Adamcyzk, P., Wilson, M., Williams, D. (1994). Concept mapping: A multi-level and multipurpose tool. *School Science Review*, pp. 116-124.

Alaska Department of Fish and Game. (2013). *Curricula and Classroom Activities*. Retrieved from http://www.adfg.alaska.gov/index.cfm?adfg=curricula.projectwild

Alaska Fisheries Science Center. (2013). US Seafood Education. *NMFS/AFSC Education and Outreach Activities*. Retrieved from http://www.afsc.noaa.gov/education/activities/seafood_ed.htm

Alaska pollock, *Theragra chalcogramma*. (n.d.) In *Alaska Department of Fish and Game Species Profile* online. Retrieved from http://www.adfg.alaska.gov/index.cfm?adfg=walleyepollock.main

Alaska Statute 14.30.380. (1991). Alaska Statutes- Section 14.30.380.: Environmental Education. Retrieved from http://codes.lp.findlaw.com/akstatutes/14/14.30./08./14.30.380.#sthash.A0AiDSPG.dpuf

American Fisheries Society, Alaska Chapter. (n.d.) Fisheries and Environmental Education Committee. Retrieved from http://www.afs-alaska.org/about-us/committees/fisheries-and-environmental-education-committee

American Society for Trainings and Development. (1989). *Evaluation tool use*. Alexandria, VA: Author.

Anchorage School District. (2013). Schools. *Educational opportunities in the Anchorage School District.* Retrieved from http://www.asdk12.org/aboutschools/

Anchorage School District. (2013). *Demographics-GIS Services, Race and ethnicity report.* Retrieved from https://www.asdk12.org/demographics-gis/ethnicity/

Andrew, K. (2005). *Assessing Marine Quest: Effects of Summer Marine Science Program on Knowledge and Attitudes Toward Marine Life* (Unpublished MS Thesis). University of North Carolina Wilmington, Wilmington, NC.

Andrews, E., Weaver, A., Hanley, D., Shmatha, J., & Melton, G. (2005). Scientists and Public Outreach: Participation, Motivations, and Impediments. *Journal of Geoscience Education* 53 (3), pp. 281-293.

Balcom, N., Payne, D., and Van Patten, P. (2009). *Outreach and Education as an Effective Component of a Research Project*. Connecticut Sea Grant. Retrieved November 19, 2012, from http://web2.uconn.edu/seagrant/funding/fundpdfs /integrate.pdf.

Ball, D.L., and Cohen, D. K. (1996). Reform by the book: What is- or might be- the role of curriculum materials in teacher learning and instructional reform? *Educational Researcher*, 16 (2), 6-18; 14.

Bannan-Ritland, B. (2003). The role of design in research: The integrative learning design framework. *Educational Researcher*, 32 (1), 21-24.

Bartosh, Oksana. (2003). Environmental education: improving student achievement (Unpublished MS Thesis). Evergreen State College; Olympia, Washington.

Bernard, R. (2011). *Research Methods in Anthropology: Qualitative and Quantitative Approaches (Fifth Ed.)*. UK: Alta Mira Press.

Beaucahmp, G.A. (1981). *Curriculum theory*. Itasca, IL: F. E. Peacock Publishers.

Besterfield-Sacre, M., Gerchak, J., Lyons, M.R., Shuman, L.J., & Wolfe, H. (2004). An Integrated-Rubric for Assessing Engineering Education. *Journal of Engineering Education*: volume 93, no. 2 105-115.

Bjorkland, R. and Pringle, C. (2001). Educating our communities and ourselves about aquatic resources through environmental outreach. *Bioscience*; Volume 51, 4; pp. 279-282).

Bogdan, R. and Biklen. (2007). *Research for Education: An Introduction to Theories and Methods (Fifth Ed.).* New Jersey: Pearson Education.

Bourke, Nicholas, Buskist, Connie, and LoBello, Steven. (2013). Documenting Residential Environmental Education Program Impact with Concept Maps. *Electronic Journal of Science Education*: 17, (4) pp. 1-11.

Boyatizis, R. (1998). *Transforming Qualitative Information: Thematic Analysis and Code Development*. Thousand Oaks, CA: Sage Press.

Brewer, C. (2002). Outreach and Partnership Programs for Conservation Education Where Endangered Species Conservation and Research Occur. *Conservation Biology* 16 (1), pp. 4-6.

Brookfield, Stephen. (2006). *The Skillful Teacher: On Technique, Trust, and Responsiveness in the Classroom*. San Francisco, CA: Jossey-Bass.

Brown, A. L., & Campione, J. C. (1996) Psychological theory and the design of innovative learning environments: On procedures, principles, and systems. In R. Glaser (Ed.), *Innovations in learning: New Environments for education* (pp. 289-325). Mahwah, NJ: Lawrence Erlbaum Associates.

Bunce, L., & Pomeroy R. (2003). Socioeconomic monitoring Guidelines for Coastal Managers in Southeast Asia (SocMon SEA). Townsville, Australia: World Commission on Protected Areas and Australian Institute of Marine Science.

Bureau of Land Management Alaska. (2013). Fisheries outreach highlights. Retrieved from http://www.blm.gov/ak/st/en/prog/fisheries/Fisheries_Program_Outreach_Highlights.html

Caduto, M. J. (1985). *A Guide to Environmental Values Education. Environmental Education Series No. 13.*. UNESCO-UNEP International Environmental Education Programme.

Carrick, S., Haddow, A., and Illenberg, M. (March 2006). Building an Education and Outreach Program for the North Pacific Research Board. NPRB Project 403 Final Report and Outreach Plan. *NPRB Project 537 Semi-Annual Report.*

Center for Ocean Sciences Excellence [COSEE] Alaska. (2013). Resources. Retrieved from http://www.coseealaska.net/resources/

COSEE Alaska. (2014, January). Taking the message home. *Alaska Marine Science Symposium*. Symposium conducted at the meeting of the Captain Cook Hotel, Anchorage, Alaska.

Cobb, P., Confrey, J., diSessa, A., Leher, R., & Schauble, L. (2003). Design experiments in educational research. *Educational Researcher*, 32 (1), 9-13.

Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design research: Theoretical and methodological issues. *Journal of the Learning Sciences*, 13 (1), 14-42.

Committee of STEM Education, National Science Technology. (2013). Federal Science, Technology, Engineering, and Mathematics (STEM) Education 5-Year Strategic Plan. Retrieved from http://www.whitehouse.gov/administration/eop/ostp/nstc/committees/costem

Confrey, J. (2000). Improving research and systemic rigor toward equity an quality. In A.E. Kelly & R. A. Lesh (Eds.), *Handbook of research design in mathematics and science education* (pp. 87-106.) Mahwah, NJ: Lawrence Erlbaum Associates.

Confrey, J., & Lachance, A. (2000). Transformative teaching experiments through conjecture-driven research design. In A. E. Kelly & R. A. Lesh (Eds.), *Handbook of research design in mathematics and science education* (pp. 231-265). Mahwah, NJ: Lawrence Erlbaum Associates.

Cooke, S. J., Lapointe, N.W.R., Martins, E.G., Thiem, J.D., Raby, G.D., Taylor, M.K., Beard, T.D., and Cowx, I.G. (2013). Failure to engage the public in issues related to inland fishes and fisheries: strategies for building public and political will to promote meaningful conservation. *Journal of Fish Biology*, 83, pp. 997-1018.

Constitution of the State of Alaska. (1956). Article 08- Natural Resources. Retrieved from http://dnr.alaska.gov/mlw/mining/AK_Consitution_ArticleVIII.pdf

Daley, B. Shaw, C., Balistrieri, T., Glasenapp, K., Piacentine, L. (1999). Concept maps: A strategy to teach and evaluate critical thinking. *Journal of Nursing Education*, 38 (1), pp. 42-47.

Darling-Hammond, L. & Snyder, J. (1992). Curriculum studies and the traditions of inquiry: The Scientific tradition. In P.W. Jackson (Ed.), *Handbook of research on curriculum* (pp. 41-78). New York: Macmillan.

Day-Miller, E. & Easton, J. (2009). *Designing Education Project: A comprehensive Approach to Needs Assessment, Project Planning, and Implementation, and Evaluation.* 2nd Edition. Bridgewater Education Consulting: VA. NOAA.

Diamondstone & Barnhart. (1990) Curriculum Resources for the Alaskan Environment. [CD]

Dutro, Elizabeth; Kazemi, Elham; Balf, Ruth; and Yih-Sheue, Lin. (2008). "What are you and

Where Are You From?" : Race, Identity, and the Vicissitudes of Cultural Relevance.

Urban Education 43 (3), pp. 269-300.

Elder, J.L. (2003). *A field guide to environmental literacy: Making strategic investments in environmental education.* Rock Spring, GA: Environmental Education Coalition.

Elmore, R.F. (1996). Getting to scale with good educational practices. *Harvard Educational Review*, 66 (pp. 1-25).

Erickson, F., & Gutierrez, K. (2002). Culture, rigor, and science in educational research. *Educational Researcher*, 31 (8), pp. 21-24.

Ernst, Julie. (2007). Factors Associated with K-12 Teachers' Use of Environment-Based Education. *The Journal of Environmental Education*, 38 (3), pp. 15-31.

Feuer, M. J., Towne, L., & Shavelson, R.J. (2002). Scientific culture and educational research. *Educational Researcher*, 31 (8), pp. 4-14.

Fien, John. (2002). Exploring Principles of Good Practice: Learning from a Meta-Analysis of Case Studies on Education Within Conservation Across the WWF Network. *Applied Environmental Education and Communication*, 1:3, 153-162.

Firth, P.L. (1998). Fresh water: Perspectives on the integration of research, education and decision making. *Ecological Applications* 8: 601-609.

Franks, S., McDonnell, J., Peach, C., Simms, E., & Thorrold, A. (2006). *Education and Public Outreach: A Guide for Scientists*. The Oceanography Society.

Friedman, A. (Ed.). (2008). Framework for Evaluating Impacts of Informal Science Education Projects. Retrieved on November 27, 2012, from http://insci.org/resources/Eval_Framwork.pdf.

Garber, (2001, April). Death By PowerPoint. *Small Business Computing*. Retrieved from http://www.smallbusinesscomputing.com/print/biztools/article

Gardner, H. (1991). *The Unschooled Mind*: *How Children Think and How Schools Teach*. New York, NY: Basic Books.

Gauvin, John. (January, 2014). When the goal is to get the fishing industry NOT to catch fish: Industry and government working together to reduce salmon bycatch in the Bering Sea pollock fishery. *Alaska Marine Science Symposium*. Symposium conducted at the meeting of Captain Cook Hotel, Anchorage, Alaska.

Greene, B. A., Lubin, I. A., Slater, J. L., and Walden, S. E. (2013). Mapping Changes in Science Teachers' Content Knowledge: Concept Maps and Authentic

Professional Development. *Journal of Science Education Technology*: 22, pp. 287-289.

Gregg, M. & Leinhardt, G. (2002) Learning form the Birmingham Civil Rights Institute: Documenting teacher development. *American Educational Research Journal*: 29, (2) pp. 553-587.

Grorud-Colvert, Kirsten, Lester, S., Airame, S., Neeley, E., and Gaines, S. Levin, Simon editor. Communicating marine reserve science to diverse audiences. (2010). *Proceedings of the National Academy of Sciences*: Volume 107, no. 43, 18306-18311.

Ham, S., & Sewing. D. (1998). Barriers to environmental education. *The Journal of Environmental Education*, 19 (2), pp. 17-24.

Harris, B. & Rose, C. (2012). Benthic impacts of raised groundgear for the Bering Sea pollock fishery. *North Pacific Research Board RFP 2012*.

Hay, D. & Kinchin, I. (2006). Using concept maps to reveal conceptual typologies. *Education and Training*: Volume 48, no. 2/3, 127-142.

Hay, D. B. (2007). Using concept maps to measure deep, surface and non-learning outcomes. *Studies in Higher Education*, 32, pp: 39-57.

Hay, D. & Kinchin, I. (2008). Using concept mapping to measure quality learning. *Education and Training*, 50 (2), pp. 167-182.

Hoffman, J. & Thomson, G. 2003. 2 Hoffman, J. and Thomson, G., 2003

Measuring the success of environmental education programs. Network for Environmental Education. www.cpawscalgary.org/education/evaluation. Accessed September 2013.

Holly, M.L., Arhar, J., Kasten, W. (2001). *Action Research for Teachers. Traveling the Yellow Brick Road (2nd ed.)* Upper Saddle River, NJ: Pearson Education Inc.

Jackson, P. W. (1992). Conceptions of curriculum and curriculum specialists. In P. W. Jackson (Ed.), *Handbook of research on curriculum* (pp. 3-40). New York: Macmillan.

Jacobson, S.K. (2009). *Communication skills for conservation professionals* (2nd ed.). Washington DC: Island Press.

Jacobson, S.K., McDuff, M. D., & Monroe, M. C. (2006). *Conservation and Education Outreach Techniques*. New York, NY: Oxford University Press.

Jacquet, J. L., and Pauly, D. (2007). The rise of seafood awareness campaigns in an era of collapsing fisheries. *Marine Policy* 31, pp. 308-313.

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher*, 33 (7), pp. 14-26.

Juneau Economic Development Council. (2010). Alaska S.T.E.M.: Education and the Economy. Retrieved from http://www.jedc.org/research-library-reports-studies-jedc

Junio-Menez, M.A., Salmo, S., Tamyo, E., Estepa, Bangi, H., & Alino, P. (2000). *'Bugsay': Community Environmental Education: Experiences From Bolinao, Northern Philippines*. Quezon City, Philippines: University of Philippines.

Klimov, A.V. & Ukolov, A. I. (1994). Sistema ekologicheskogo obrazobaniya [The system of ecological education]. In *Problemy sozdaniya edinoy sistemy ekologicheskogo obrazovaniya v Ukraine* [The problems of the development of the universal system of ecological education], ed. V. E. Nekos, V.I. Astakhova et al. pp. 57-58. Kharkov, Ukraine: Kharkov State University.

Kinchin, I. M., & Hay, D. B. (2007). The myth of the research-led teacher. *Teachers and Teaching: Theory and Practice*, 13 (1), pp. 43-61.

Knapp, George. (2012). *Introduction to the Economy of Alaska*. Unpublished PowerPoint lecture, University of Alaska, Anchorage.

Lane, J., & Wilke, R. (1994). Environmental Education in Wisconsin: A teacher survey. *The Journal of Environmental Education*. 21 (1), pp. 36-45.

Lane, R., Lucas, D., Vanclay, F., Henry, S., & Coates, I. (2005). Committing to Place at the Local Scale: the potential for youth education programs for promoting community participation in regional natural resource management. *Australian Geographer* 36 (3), pp. 351-367.

Lauber, T. B., Decker, D. J., & Knuth, B. A. (2008). Social Networks and Community-Based Natural Resource Management. *Environmental Management* 42, pp. 677-687.

Lemov, Doug. (2005). *Teach Like a Champion: 49 Techniques that Put Students on the Path to College*. San Francisco, CA: Jossey-Bass.

Markham, K. M., Mintzes, J. J., & Jones, M. G. (1994). The concept map as a research and evaluation tool: Further evidence of validity. *The Journal of Research in Science Teaching*, 31 (1), pp. 91-101.

Martin, B. L., Mintzes, J. & Clavijo, I. E. (2000). Restructuring knowledge in biology: cognitive processes and metacogntive reflections. *International Journal of Science Education*, 22, pp. 303-323.

Marine Conservation Alliance [MCA]. (2011). The science of Chinook Salmon Avoidance. *Sea Facts*: No 10, May. Retrieved from www.marineconservationalliance.org

McClure, J. R. Sonak, B. & Suen, H. K. (1999). Concept map assessment of classroom learning: Reliability, validity, and logistical practicality. *Journal of Research in Science Teaching*, 35 (4), pp. 475-492.

Mertler, Craig. (2009). *Action Research: Teachers as Researchers in the Classroom (Second Ed.)*. Thousand Oaks, CA: Sage Publications.

Miles, M. & Huberman, M. (1994). *Qualitative Data Analysis: an expanded sourcebook*. Thousand Oaks, CA: Sage Publications.

Milliman, John. (1996). Integrating Research and Education with Public Outreach at Coastal Laboratories. *Biological Bulletin*, 190 (2), pp.278-285.

Monroe, M., Scollo, G., & Bowers, A. (2002). Assessing teachers' needs for environmental education services. *Applied Environmental Education and Communication*, 1, pp. 37-43.

National Environmental Education Act of 1990 (Public Law 10 1-619).

National Environmental Education Advisory Council [NEEAC]. (1996). *Report Assessing Environmental Education in the United States and the implementation of the National Environmental Education Act of 1990.* Submitted to Congress.

National Environmental Education and Training Foundation. (2005). *Understanding Ocean and Coastal Literacy: How Public Opinion and Knowledge Research Helps Inform Ocean and Coastal Science Education Programming at NOAA.*

NOAA [National Oceanic and Atmospheric Administration]. (2009). Final BS Chinook Salmon Bycatch Management Environmental Impact Statement/Regulatory Impact Review (EIS/RIR). Retrieved from http://alaskafisheries.noaa.gov/sustainablefisheries/bycatch/salmon/chinook/feis/

NOAA Fisheries Service. (2010). Fish Watch: *Alaska pollock.* Retrieved from http://www.fishwatch.gov/seafood_profiles/species/pollock/species

NOAA Fisheries Service. (2012). NOAA Fisheries Education Program. Retrieved from http://www.nmfs.noaa.gov/stories/2012/10/noaa_fisheries_education.html

NOAA Fisheries Service. (2014). Fish Watch: Health and Safety. *US Fish Facts.* Retrieved from http://www.fishwatch.gov/eating_seafood/health_and_safety.htm

NOAA Ocean Service Education. I'll Stay Here if it Kills Me! *Lesson Plan Library: Coastal Decision-Making.* Retrieved from http://oceanservice.noaa.gov/education/lessons/if_it_kills_me.html

North America Association for Environmental Education. (1996). *Environmental Education Materials: Guidelines for Excellence*. NAAEE, Rock Spring, GA.

North Pacific Fishery Management Council. (2012). *Fishing Fleet Profiles*. Retrieved from http://www.npfmc.org/summary-reports/

North Pacific Research Board. (2014) . About Us. Retrieved from http://www.nprb.org/nprb/about-us

Novak, J. D. (2005). Results and implications of a 12-year longitudinal study of science concept learning. *Research Science Education*, 35, pp. 23-40.

Novak, J.D. & Canas, A. J. (2007). The Theory Underlying Concept Maps and How to Construct Them. *IHMC Cmap Tools*. Florida Institute for Human Machine Cognition. Retrieved from http://cmap.ihmc.us/Publications/ResearchPapers/TheoryUnderlyingConceptMaps.pdf.

NRC. (2002). *Scientific research in education*. In R.J. Shavelson & L. Towne (Eds.). Washington DC: National Research Council, National Academy Press.

Palmer, J. A. (1998). *Environmental Education in the 21st Century. Theory, practice, progress, and promise*. London: Routledge.

Palmer, J. A. (1997). Beyond Science: Global imperatives for environmental education in the 21st century. In *Environmental education for the 21st Century: international and interdisciplinary perspectives*, ed. P. J. Thomspon pp. 3-11. New York: Peter Lang.

Parsons, R. D., & Brown, K. S. (2002). *Teacher as reflective practitioner and action researcher*. Belmont, CA: Wadsworth/Thomson Learning.

Patton, M. (2002). *Qualitative Research and Evaluation Methods* (3rd Ed.). Thousand Oaks, CA: Sage Press.

Pearsall, N. R., Skipper, J. E., & Mintzes, J. (1997). Knowledge restructuring in the life sciences: A longitudinal study of conceptual change in biology. *Science Education*, 81, pp. 193-215.

Pomeroy, R.S., and R. Rivera-Guieb. (2006). *Fishery Co-Management: A practical Handbook*. UK: International Development Research Center.

Powers, S. E. (2000). Environmental engineering professionals needed for educational outreach. *Journal of Environmental Engineering* 126: p. 891.

Polar Trec. (2013). Bering Sea Ecosystem Collection. Retrieved from http://www.polartrec.com/collections/bering-sea-ecosystem

Rafferty, D. D. & Felschner, L. K. (1993). Concept Mapping: A viable alternative to objective and essay exams. *Reading Research and Instruction*, 32 (3), pp. 25-34.

Rappole, J.H., King, D. I., & Vega Rivera, J.H. (2003). Coffee and conservation. *Conservation Biology* 17, pp. 334-336.

Ray, E. 1999. Outreach, engagement will keep academia relevant to twenty-first century societies. *Journal of Public Service & Outreach* 4, pp. 21-27.

Richhart, R., Tuner, T., & Hadar, Linor. (2009). Uncovering students' thinking about thinking using concept maps. *Metacognition Learning* 4, pp. 145-159.

Riel, M. (2007). *Understanding action research*. Center for Collaborative Action Research. Retrieved from http://cadres.pepperdine.edu/ccar/define.html

Rose, Craig; Munk, Eric; Hammond, Carwyn; and Stoner, Al. (2010). Cooperative Research to Reduce the Effects of Bering Sea Trawling on Seafloor Habitat and Crabs. *AFSC Quarterly Report*. January, February, March.

Ruiz-Primo, M.A., & Shavelson, R. J. (1996). Problems and issues in the use of concept maps in science assessment. *Journal of Research in Science Teaching*, 33 (6), pp. 596-600.

Rupert, J. & Dann, S. (1998). Fishing in the Parks: A Research-based Outreach Program. *Fisheries* 23 (6), pp. 19-27.

Sanders, James A. (1994). *The Program Evaluation Standards.* The Joint Committee on Standards for Educational Evaluation: The Evaluation Center, Western Michigan University, Kalamazoo.

Schwandt, T.A. (2002). *Evaluation practice reconsidered*. New York: Peter Lang

SeaGrant Alaska. (2013). *Alaska Seas and Rivers Curriculum*. Retrieved from https://seagrant.uaf.edu/marine-ed/curriculum/

Smith, J. (1983). Quantitative versus qualitative research: An attempt to clarify the issue. *Educational Researcher*, 12 (3), pp. 6-13.

Smith, G. and Sobel, D. (2010). *Place- and Community-Based Education in Schools*. New York: Routledge.

Snyder, J., Bolin, F., & Zumwalt, K. (1992). Curriculum implementation. In P.W. Jackson (Ed.), *Handbook of research on curriculum* (pp. 402-435). New York: Macmillan.

Stapp, W. B., Bennett, D., Bryan, W. Jr., Fulton, J., MacGregor, J., Nowak, P. et al. (1969). The Concept of Environmental Education. *Journal of Environmental Education*, 1(3): pp. 30-31.

Sterling, S., & Cooper, G. (1992). *In touch: environmental education for Europe*. Surrey, UK: WWF, Panda House.

Stoddard, T., Abrams, R., Gasper, E., Canaday, D. (2000). Concept maps as assessment in science inquiry learning- a report of methodology. *International Journal of Science Education*, 22, pp. 1221-1246.

Szaro, R., Berc, J., Cameron, S., Cordie, S., Crosby, M., Martin, L., Norton, D., O'Malley, R., & Ruark, G. (1998). The ecosystem approach: science and information management issues, gaps and needs. *Landscape and Urban Planning* 40, pp. 89-101.

Taylor, S. & Todd, P. (1995). An integrated model of waste management behavior: a test of household recycling and composting intentions. *Environment and Behavior* 27, pp. 603-630.

The Design-Based Research Collective. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher*, 32 (1), pp. 5-8.

Thompson, T. L. & Mintzes, J J. (2002). Cognitive structure and affective domain: On knowing and feeling in biology. *International Journal of Science Education*, 24 (6), pp. 654-660.

Thomson, G. & Hoffman, J. (2013). *Measuring the Success of Environmental Education Programs* Canadian Parks and Wilderness Society. Retrieved from: http://macaw.pbworks.com/f/measuring_ee_outcomes.pdf

Tressler, K. (2008). *Assessing Marine Quest: A follow-up study on effects of a summer residential marine environmental education program on knowledge and attitudes* (unpublished MS thesis). University of North Carolina Wilmington, Wilmington, NC.

Volk, T.L., & McBeth, B. (1998). *Environmental Literacy in the United States: What should be…what is…getting from here to there*. NAAEE.

UNESCO-UNEP. (1975). The Belgrade Charter: A global framework for environmental education. *UNESCO-UNEP Environmental Education Newsletter*, 1 (1), pp. 1-2.

UNESCO. (1978). Final Report of intergovernmental conference on environmental education. Organized by UNESCO in cooperation with UNEP, Tblisi, USSR, 14-26 October 1977, Paris: UNESCO ED/MD/49.

USFW [United States Fish and Wildlife] Alaska. (2013). Outreach and Education. Retrieved from http://www.fws.gov/alaska/fisheries/fieldoffice/kenai/outreach.htm

Wallace, J.D. (1990). The concept map as a research tool: Exploring conceptual change in biology. *Journal of Research in Science Teaching*, 27 (10), pp. 1033-1052.

Westat, J.F. (2010). The 2010 User Friendly Handbook for Program Evaluation. *Division of Research and Learning in Formal and Informal Settings National*

Science Foundation. Retrieved November 19, 2012, from http://www.westat.com/pdf/projects/2010ufhb.pdf.

Wong, Yi Lin & Siu, Kin Wai Michael. (2012). A Model of Creative Design Process for Fostering Creativity of Students in Design Education. *International Journal of Technology Design Education* 22, pp. 437-450.

Yin, Y., Vanides, J. Ruiz-Primo, M.A., Ayala, C.C., & Shavelson, R.J. (2005). Comparison of two concept-mapping techniques: implications for scoring, interpretation, and use. *Journal of Research Science Teaching* 42, pp. 166-184.

Zahawi, R. & Holl, K. (2010). Bridging the Gap between Scientific Research and Tropical Forest Restoration: A Multifaceted Research, Conservation, Education and Outreach Program in Southern Costa Rica. *Ecological Restoration* 28 (2), pp. 143-146.

Appendix A

Environmental Education Goals and Objectives

EE goals. Environmental education (EE) is a process used to produce "*a citizenry that is knowledgeable concerning the biophysical environment and its associated problems, aware of how to help solve these problems, and motivated to work toward their solution*" (Stapp et al., 1969). EE was formally defined and developed in the 1960s to address a global awareness of environmental concerns. Federal laws, such as the National Environmental Policy Act (NEPA) of 1969, the Magnuson Act, and the ESA empower "people" in the decision making process explicitly and implicitly. Gubernatorial appoints voting council members (MSA) and the mandated public feedback process evaluates NEPA alternatives. Therefore, an educated citizenry has a grip on environmental decision making both via our 3-part government (they can influence the legislative and the executive branches of state and federal government by voting), and via the processes created by these pieces of legislation (so long as they are educated about how to do this). Both NEPA and the National Environmental Education Act (NEEA) of 1970, were ratified to enhance citizens' awareness of complex environmental topics (NEEAC, 1996). In 1990, the US Congress ratified the NEEA of 1990, and asserted that "*effective response to complex environmental problems requires understanding of the natural and built environment, awareness of environmental problems and their origins (including those in urban areas), and the skills to solve those problems*" (NEEA of 1990).

Internationally, the *Belgrade Charter* (UNESCO-UNEP, 1975) and the *Tbilisi Declaration* (UNESCO, 1978) provided the foundation for EE work. The *Belgrade Charter* was enacted in 1975 at the United Nations Educational, Scientific, and Cultural Organization Conference in Yugoslavia, and stated:

> *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.* (UNESCO, 1976)

Subsequently, in 1977, the first Intergovernmental Conference on Environmental Education was held in Tbilisi, Georgia. There, representatives ratified the *Tbilisi Declaration*, which defined EE as "a learning process that increases people's knowledge and awareness about the environment and associated challenges, develops the necessary skills and expertise to address the challenges, and fosters attitudes, motivations, and commitments to make informed decisions and take responsible action" (UNESCO, 1978).

EE Objectives. EE is an on-going, interdisciplinary learning process. It involves the interconnections between human and natural systems, promoting environmental ethics, consciousness and comprehension of environmental problems, critical thinking, and problem-solving abilities. The *Tbilisi Declaration* outlined the objectives of EE as:

> **Awareness:** to help social groups and individuals acquire an awareness and sensitivity to the total environment and its allied problems.
>
> **Knowledge:** to help social groups and individuals gain a variety of experience in and acquire a basic understanding of, the environment and its associated problems.
>
> **Attitudes:** to help social groups and individuals acquire a set of values ad feelings of concern for the environment and the motivation for actively participating in environmental improvement and protection.

> **Skills**: to help social groups and individuals acquire the skills for identifying and solving environmental problems.
>
> **Participation:** to provide social groups and individuals with an opportunity to be actively involved at all levels in working toward resolution of environmental problems. (UNESCO, 1978)

These objectives have been widely adopted by EE educators to meet program goals (Thomson and Hoffman, 2013). Sterling and Cooper (1992) created linear and non-linear models to illustrate how individuals evolve as a result of EE experiences (Figures 38 and 40). Both models incorporate the learning objectives stated in the *Tbilisi Declaration.* The linear model infers that people progress through the phases of EE in a sequential order. The non-linear model demonstrates the relationships between all components of EE. This model suggests that people can be engaged in several phases of EE at any time and develop in no particular order. Regardless of how individuals experience EE, the overall objectives remain the same. The objectives are to cultivate scientific understandings, foster positive attitudes toward the environment, develop an understanding of the importance of conservation, heighten awareness of environmental problems and potential solutions, and shape constructive attitudes towards environmental laws (Bartosh, 2003).

Figure 38: A linear model of EE by Sterling and Cooper (1992).

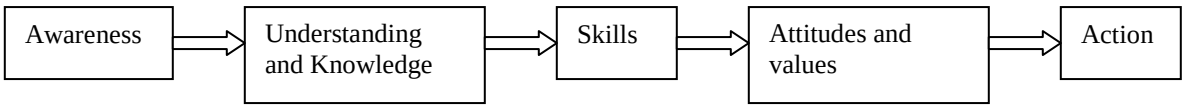
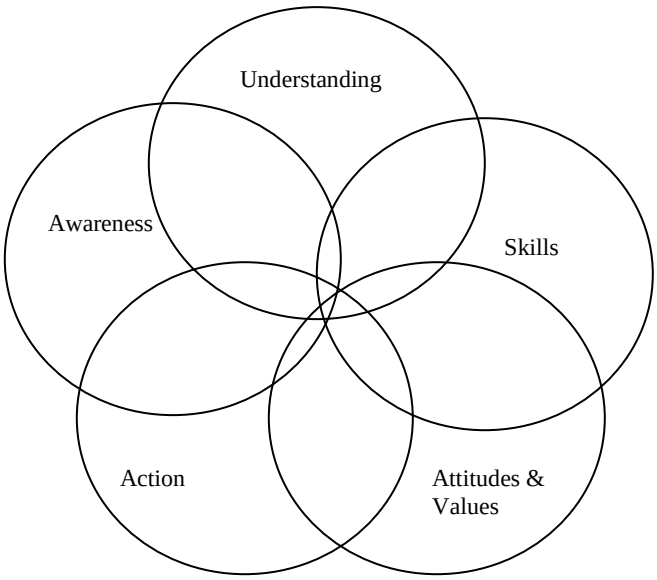


Figure 40 : A non-linear model of EE by Sterling and Cooper (1992).



EE Methods

A variety of EE methods are used for individuals and groups of all backgrounds, genders and ages (Elder, 2003). EE can occur in formal (school) and informal settings (Juinio-Menez et al., 2000). Formal programs may involve credited training sessions, workshops, or lectures. Non-formal trainings could involve exchange visits, performances, discussions, or non-credited after school programs. Other means involve community members in research processes, delivering information via electronic or print

media, developing a school curriculum related to local ecology, or visiting an established nature center (Green, 1997; Pomeroy and Rivera-Guieb, 2006).

Adhering to the goals and objectives of EE, educators create interdisciplinary curricula to promote students' critical thinking skills (i.e. problem solving and decision making) and sense of responsibility. The following characteristics highlighted by the North American Association for Environmental Education's (NAAEE) *Environmental Education Materials: Guidelines for Excellence*, denote an effective EE program:

> -learner centered, providing students with opportunities to construct their own understandings through hands-on investigations
> - involve engaging learners in direct experiences and challenges them to use higher order thinking skills
> -support the development of an active learning community where learners share ideas and expertise, and prompt continued inquiry
> -provide real world contexts and issues from which concepts and skills can be used (1996)

Effective EE can increase the environmental literacy of a community, which is useful for natural resource management decisions (Pomeroy and Rivera-Guieb, 2006). Literacy signifies knowledge. Without an environmental knowledge base, people can make poor resource management decisions.

EE Barriers

Despite the benefits of EE, there are barriers for teachers to incorporate interdisciplinary, student-directed EE learning across core subject areas (Ernst, 2007). A University of Maryland Survey Research Center (2000) national study found that two-thirds of the teachers who included environmental topics did so in less than 50 hours during an academic year (Ernst, 2007). Researchers have cited a lack of pre-service and in-service training as a key barrier for teachers to implement interdisciplinary EE (Lane

and Wilke, 1994). Other reasons teachers have not implemented EE are due to a "conceptual barrier of viewing the environment as a content area, rather than integrating context or instructional method" (Enrst, 2007, p. 17). For example, the University of Maryland Survey Research Center (2000) reported that "lack of relevance to curriculum" and "too much other material to cover" were chief reasons that teachers did not apply EE (Ernst, 2007). Logistical barriers to EE include lack of planning time, administrative support and funding (Ham and Sewing, 1998; Monroe, Scollo and Bowers, 2002). Barriers to EE may contribute to low rates of environmental literacy. The National Environmental Education and Training Foundation (2005) approximated less than 2% of all American adults are environmentally literate. This indicates that the American education system needs to remove the barriers to quality EE.

Appendix B

Bering sea ecosystem

marine food web mural

Overview

Students will research, organize and present information on organisms found in the Bering Sea. Students will create illustrations of Bering Sea organisms. Students will combine work to create a Bering Sea mural.

Learning Objectives

* Students will be able to research, categorize, and share information about an organism's adaptations, habitat, life cycle, trophic level, and niche in the Bering Sea.
* Students will be able to work collaboratively.
* Students will be able to identify interconnections between organisms in the Bering Sea ecosystem, including predator/prey relationships.
* Students will be able to explain the role of producers, consumers and decomposers in the Bering Sea ecosystem.
* Students will become aware of how marine organisms are linked through the processes of energy transfer and nutrient cycling.

Key Concepts

* Biodiversity
* Energy Transfers
* Adaptations
* Food Webs and Interconnections
* Matter Cycles

Required Materials

* Index cards
* Student Journals/Notebooks
* Blank Paper for painting/drawing
* Crayons, Paint, colored pencils, or markers
* Scissors
* Glue/adhesive
* Assorted colors of string
* Bering Sea Resources Materials, Library, or computers with internet access
* Blank Bering Sea Habitat on Poster/Chalkboard/Banner Sized Paper
* World Map
* Map of the Bering Sea

Bering Sea marine food web mural

LESSON PROCEDURES

Introduction

* Students locate Bering Sea on world map.
* Show Bering Sea boundaries and share size [two-million sq km (*775,000 sq mi*), the sea is bordered in the west by Russia and the Kamchatka Peninsula; in the south by the Aleutian Islands, and in the east by Alaska].
* Students complete Bering Sea outline map, labeling large islands, landmarks and political boundaries.

Guided Overview

* Define abiotic factors of the Bering Sea ecosystem.
* Instruct class how to use NOAA marine forecasts to complete Offshore Bering Sea Weather Forecast Log. If internet access available instruct students how to obtain marine forecast from http://www.nws.noaa.gov/om/marine/home.html. If not, provide print out of current marine forecast for offshore Bering Sea.
* Examine NOAA Bering Sea chart to check for depths, latitude and longitude.
* If internet access available, instruct students hot to obtain current sea conditions from NOAA, National Buoy data center, at http://www.ndbc.noaa.gov/maps/Alaska.shtml. If internet access is unavailable, provide a current print out from Bering Sea buoys.
* Time permitting, introduce Bering Sea currents.

Directions

* Discuss organisms students are aware of that inhabit the Bering Sea.
* Assign each student a Bering Sea organism from the critter cards provided.
* Explain that each student will research, organize information and present findings to entire class. Explain that all students will collaborate to create a mural of the Bering Sea.

* Ensure a good proportion of producers, consumers and decomposers are assigned. Teacher can add in more organisms to mural using critter cards provided as necessary.
* Go through the Bering Sea Mural Student Instructions page together. Answer questions and clarify tasks. Provide necessary resources (research journals/ notebooks, index cards, blank drawing/painting paper, and art supplies.)

Research & Creation

* Students research organisms.
* Students organize information and prepare for presentations.
* Students create a visual representation of an organism using provided art materials.
* See appendix for suggested student research resources.

Presentations

* Each student presents a concise oral report (set maximum time) to class about organism and attaches their drawing to mural in appropriate location.
* Students submit index card to teacher.
* Teacher can add additional organisms to mural from critter card collection and provide brief summary for each component added.

Connections

* Review that energy in a food web flows from the sun. Use one color of string, start at the sun and ask students to select one producer represented on mural. The student who researched the selected producer attaches string to mural adjacent to organism and makes a connection with another organism that consumes it/is its predator. The path of the string represents the flow of energy in the ecosystem.
* Continue with same color string until the flow stops with a decomposer.
* Discuss the flow of energy is one direction. Energy is used to maintain the structured chemical state of all living organisms (differentiates living organisms from non-living accumulations of similar materials). After string ends with a decomposer connect is to top of mural and label top of string with an upward pointed arrow, "Waste Heat." If time permits and appropriate for class, discuss amounts of energy available passed from one trophic level to the next. See appendix for resources on trophic levels.

* Discuss the cyclical flow of matter in the Bering Sea ecosystem. Matter is necessary for growth, repair, and reproduction. Draw lines with arrows to illustrate the path of "Nutrient Return" on the mural.
* Repeat the process with a different colored string, starting from the sun, as many times as necessary. Continue to include "Waste Heat" and "Nutrient Return" with each path.

Independent Explanations

Individual Diagram

* Students draw a simplified food web that focuses on their organism.
* Student diagrams need to illustrate how energy is transferred through the food web and how matter is cycled.
* Students need to label producers, consumers and decomposers.

Written Responses

* Students complete written responses in student journals to explain concepts of adaptations, niche, and biodiversity.

Bering Sea marine food web mural : APPENDIX

Bering Sea Organism Cards

* Assign a variety of organisms and roles to provide an overview of the Bering Sea food web. The following are possible choices. Unassigned organisms can be included on mural once students complete their portion.

-Whales:
Bowhead whale, Orca, Gray Whale, Beluga Whale
-Polar Bear
-Walrus
-Seals:
Bearded Seal, Ringed Seal, Ribbon Seal, Spotted Seal
-Humans:
Commercial Fishing Vessels, Native Alaskan subsistence hunters, Shipping containers
-Birds
Puffins, Gulls, Spectacled Eiders, Kittiwake, Cormorant, Fulmar, Petrel, Murre Albatross, Auk, Shearwater, Tern
-Fish
Bering Sea Flounder, sculpin, Arctic cod, Pacific herring, Alaska Pollock
-Crabs
king crab, snow crab
-Cnidarians
sea anemone, sea whips
-Echinoderms
sea urchin, sea stars, brittle stars. basket stars
-Predatory marine snails
-Arctic Whelk, Artic moon snail, nudibranch
-Algae grazing mollusks
Bering chiton
-Filter feeding mollusks
mussels, nut clams, chalk clams
-Phytoplankton
-Zooplankton
-Ice Algae
-Annelida
-polychaete worms

Useful Terms Defined

ADAPTATION a characteristic body part, shape or behavior that helps a plant or animal survive in its environment

APHOTIC ZONE the portion of the water column, usually deeper than 1000 m,
where sunlight is absent

AUTOTROPH any organism that synthesizes its own organic nutrients from inorganic raw materials

BACTERIUM (PL. BACTERIA) one-celled organisms so small they can only be seen with a microscope. Some bacteria cause diseases, like pneumonia and tuberculosis, but others are necessary to all life on Earth because they break down dead organic material

BENTHIC pertaining to the seafloor and the organisms that live there

BENTHOS marine organisms that live in or on the sea bottom

BIODIVERSITY the variety, distribution and abundance of living things and ecological processes in an ecosystem

CHEMOSYNTHESIS bacterial synthesis or organic material from inorganic substances using chemical energy

CONSUMER an organism that consumes and digests other organisms to satisfy its energy and material needs

CONVECTIVE MIXING the vertical mixing of water masses driven by wind stresses or density changes at the sea surface

DECOMPOSER an organism that consumes and breaks down dead organic material, recycling the nutrients to be used within an ecosystem

DETRITUS particulate dead organic matter, including excrement and other waste products, shed body parts (such as exoskeletons, skin, hair, or leaves) and minute dead organisms

ECOLOGY the scientific study of the relationships between plants, animals and their environment

ECOSYSTEM the system of living organisms, their physical environment, and all their interactions and relationships; the area in which these interactions occur

EPIFAUNA benthic animals that crawl about on the seafloor or are firmly attached to it

ENERGY used to maintain the structured chemical state of all living organisms (differentiates living organisms from non-living accumulations of similar materials), flows in one direction and is transferred

FOOD CHAIN a diagrammatic representation of trophic relationships, the sequence of transfers of food energy from one organism to another (i.e. producer, consumer, decomposer)

FOOD WEB a diagrammatic representation of the complete set of trophic relationships of an organism, interconnected food chains

HABITAT a place organisms need to feed, breed, seek shelter and raise young, has the minimum required amounts of resources (food, water, shelter, and space) for a particular species

HETEROTROPHIC an organism that is unable to synthesize its own organic food from inorganic substances and must consume other organisms and organic compounds for nourishment

LATITUDE a geographic coordinate that specifies the north-south position of a point on the Earth's surface. Latitude is an angle which ranges from 0° at the Equator to 90° (North or South) at the poles. Lines of constant latitude, or parallels, run east–west as circles parallel to the equator. Latitude is used together with longitude to specify the precise location of features on the surface of the Earth.

LONGTITUDE Lines of longitude, or meridians, run between the North and South Poles. They measure east-west position. The prime meridian is assigned the value of 0 degrees, and runs through Greenwich, England. Meridians to the west of the prime meridian are measured in degrees up to −180° westward and those to the east of the prime meridian are measured to by their number of degrees east, up to 180° eastward.

MATTER necessary for growth, repair, and reproduction, matter cycles, anything that has mass and volume

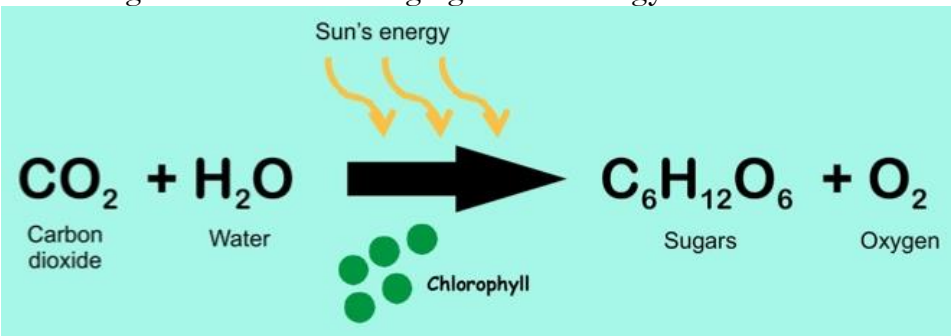
NICHE the functional role of an organism in the ecology of an environment, as well as the suite of physical and chemical factors that limit its range of existence

NUTRIENT REGENERATION any of several mechanisms that transport nutrient-rich water from the sea floor up to the photic zone, such as upwelling and convective mixing

PELAGIC pertaining to the ocean's water column and the organisms that live there, live in the open sea, away from the coast or seafloor

PHOTIC ZONE the upper sunlit ocean layers to 350 feet deep (107 meters), the portion of the ocean where light intensity is sufficient to enable gross primary production (photosynthesis) to at least meet a cell's respiratory needs

PHOTOSYNTHESIS the biological synthesis of organic compounds from inorganic substances using light as an energy source



PHYTOPLANKTON photosynthetic members of the plankton community

PLANKTON plants and animals (mostly tiny) that swim weakly, or not at all, and drift with ocean currents

PREDATOR an animal that obtains food primarily by killing and consuming other animals

PREY an animal taken by a predator as food

PRIMARY PRODUCER autotrophic organisms that synthesize organic compounds via photosynthesis or chemosynthesis

PRIMARY PRODUCTION the synthesis of organic compounds from inorganic substances

PRODUCER an organism, usually photosynthetic, that contributes to the production of organic compounds for a community

SECONDARY CONSUMER an organism that largely feeds on primary consumers, for instance, carnivores feeding on herbivores and detritivores

SCAVENGER an animal that feeds on the dead remains of other animals and plants

SEA Seas are smaller than oceans and are usually located where the land and ocean meet, in terms of geography, a sea is part of the ocean partially enclosed by land

TERTIARY CONSUMERS an organism that largely feeds on secondary and primary consumers, for instance, carnivores that feed on other carnivores

TIDAL RANGE vertical distance between high and low tides

TIDE a long-period wave noticeable as a periodic rise and fall of the sea surface along coastlines

TROPHIC pertaining to feeding or nutrition

TROPHIC LEVEL the position of an organism or species in a food web or food chain

UPWELLING the process that carries nutrient rich deep waters upward to the photic zone

ZOOPLANKTON heterotrophic members of the plankton community

Research resources

North Pacific Ocean Theme Page
http://www.pmel.noaa.gov.np/pages/seas/bseamap.html

NOAA National Data Buoy Data Center
http://www.ndbc.noaa.gov/

World Register of Marine Species
http://www.marinespecies.org/

NOAA, Alaska Fisheries Science Center
http://www.afsc.noaa.gov/RACE/media/photo_gallery/fish_by_family.htm

Alaska Department of Fish and Game
http://www.adfg.state.ak.us.special/esa/esa_home.php

National Academies Press, Bering Sea Ecosystem
http://books.nap.edu/openbook.php

Smithsonian Museum of Natural History, North American Mammals
http://www.mnh.si.edu/mna/main.cfm

What Bird
www.whatbird.com

Monterey Bay Aquarium
http://www.montereybayaquarium.org/

Books

Eschmeyer, W., Herald, O. W., Mammann, H., Gnagy, J. (1983). *Pacific Coast Fishes.* New York: Houghton Mifflin Company.

Folkens, Pieter. (2002). *Guide to Marine Mammals of the World.* New York: Alfred A. Knopf.

Gotshall, Daniel. (2005). *Guide to Marine Invertebrates: Alaska to Baja California (Second Edition).* Hong Kong: Sea Challengers.

Harrison, Peter. (1992). *Seabirds: an identification guide*. Houghton Mifflin Harcourt.

Hoelzel, Russ (Ed.). (1986). *Gentle Giants of the Sea by the Whale Museum (Second Ed.)*. Washington: Moclips Cetological Society.

Jensen, Gregory. (1957). *Pacific Coast Crabs and Shrimp*. Hong Kong: Sea Challengers.

Kaufman, K. 2001. Birds of North America. Houghton Mifflin Co., Boston, MA.

Lamb, A. & Hanby, B. (2005) *Marine Life of the Pacific Northwest: A Photographic Encyclopedia of Invertebrates, Seaweeds and Selected* Fishes. Harbour Press.

Morrissey, J. F. & Sumich, J. (2012). *An Introduction to the Biology of Marine Life (Tenth Edition)*. Sudbury, MA: Jones and Bartlett Learning.

Ocean Futures Society. (2009). Whale Adaptations. *Jean-Michel Cousteau Ocean Adventures*. Retrieved from http://www.pbs.org/kqed/oceanadventures/educators/

Parsons, E. C. M., Bauer, A., McCafferty, D. Simmonds, M., and Wright, A. (2013). *An Introduction to Marine Mammal Biology and Conservation*. Burlington, MA: Jones and Bartlett Learning.

Russo, R. & Olhausen, P. (1981). *Pacific Intertidal Life*. Nature Study Guild Publishers.

Ricketts, E. & Calvin, J. (1985). *Between Pacific Tides: Fifth* Edition. Stanford University Press.

Schreiber, E. A. & Burger, J. (2002). *Biology of Marine Birds*. CRC.

Sibley, D. A. 2000. The Sibley guide to birds. Alfred A. Knopf, New York.

Wrobel, D. & Mills, C. (2003). *Pacific Coast Pelagic Invertebrates: a guide to the common gelatinous animals*. Hong Kong: Sea Challengers.

Wynne, K. & Folkens, P. (1992). *Guide to Marine Mammals of Alaska*. Fairbanks, AK: Alaska University Sea Grant College Program.

References

This lesson was adapted from "Ecosystem Food Web Mural," Hard Bargain Environmental Center, www.alicefergunsonfoundation.org and "Bering Sea Buffet- A Foodweb Activity," *PolarTrec Learning Resources*, http://www.polartrec.com/learningresources.

National Science Education Standards

Content Standards, Grades 5-8

CONTENT STANDARD B: Physical Science
a. Properties and changed of properties in matter
c. Transfer of energy

CONTENT STANDARD C: Life Science
d. Populations and ecosystems
e. Diversity and adaptations of organisms

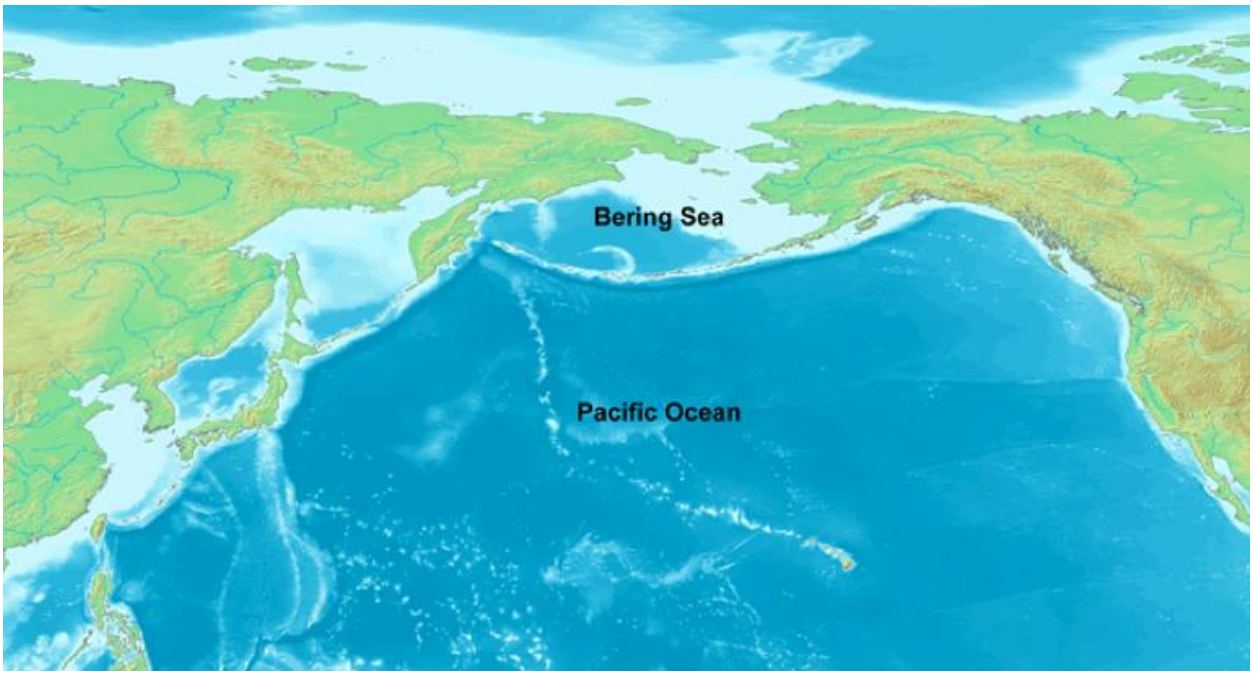
CONTENT STANDARD F: Science in Personal and Social Perspectives
b. Populations, resources, and environments

Content Standards, Grades 9-12

CONTENT STANDARD C: Life Science
d. Interdependence of organisms
e. Matter, energy, and organization in living systems

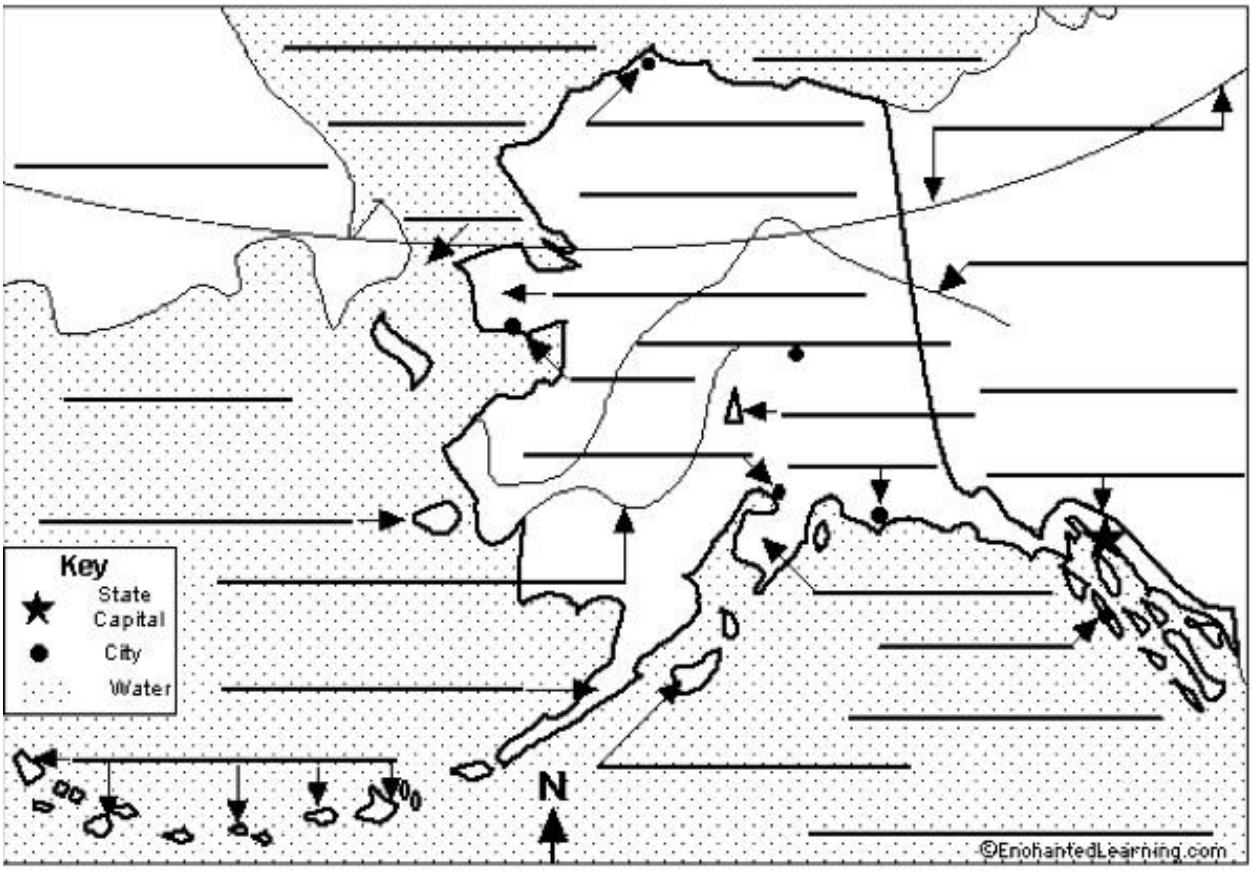
Bering Sea marine food web mural : Student Resources and Instructions


Bering Sea
Ilike2learn.com


Bering Sea
Pacific Ocean


BERING SEA
WorldAtlas.Com
Arctic Ocean
East Siberian Sea
Chukchi Sea
Barrow
Beaufort Sea
Russia
Alyatki
Kotzebue Sound
Alaska (U.S.)
ARCTIC CIRCLE
SIBERIA
Anadyr
Gulf of Anadyr
Nome
Norton Sound
Fairbanks
St. Lawrence Island
BERING STRAIT
Anchorage
Kamchatka Peninsula
INTERNATIONAL DATE LINE
St. Matthew Island
Nunivak Island
Bering Sea
Pribilof Islands
Bristol Bay
Gulf of Alaska
Kodiak Island
300 mi
300 km
Aleutian Islands
North Pacific Ocean
©GraphicMaps.com

ALASKA STATE MAP: LABEL



Word Bank:

Alaska	Bering Strait	Nome
Alaska Peninsula	Canada	Nunivak Island
Aleutian Islands	Chukchi Sea	Pacific Ocean
Anchorage	Fairbanks	Russia
Arctic Circle	Gulf of Alaska	Seward Peninsula
Arctic Ocean	Juneau	Sitka
Barrow	Kenai Peninsula	Valdez
Beaufort Scale	Kuskokwim River	Yukon River
Bering Sea	Mt. McKinley/Denali	

STUDENT PRESENTATIONS & FOOD WEB MURAL

OVERVIEW

You will research, organize and present information on organisms found in the Bering Sea and create a visual representation of a selected organism to collaboratively create a Bering Sea Food Web mural.

OBJECTIVES

* To research, categorize, and share information about an organism's adaptations, habitat, life cycle, trophic level, and niche in the Bering Sea.
* To work collaboratively.
* To identify interconnections between organisms in the Bering Sea ecosystem, including predator/prey relationships.
* To explain the role of producers, consumers and decomposers in the Bering Sea ecosystem.
* To become aware of how marine organisms are linked through the processes of energy transfer and nutrient cycling.

RESEARCH

You will be assigned a specific organism to learn about that lives in the Bering Sea. You will be responsible for researching the information listed below, which you will present to your class. You will submit your information cards after your oral presentation.

Information Card

Please research, organize, summarize and write the following information about your Bering Sea organism on your card(s).

~ ***Habitat***

Where in the ecosystem does it live?

~ ***Size***

Average size of the adult

~ ***Diet/Food***

How does it obtain its energy and nutrients?

~ ***Predators***

What consumes the organism?

~ ***Reproduction***
Location and means of reproduction

~ ***Adaptation and survival***
Share at least one adaptation for the organism. Explain how the adaptation helps it survive in its habitat.

~ ***Role in food chain: producer/consumer/decomposer?***
Explain why and how it is this role.

~ ***Classification***
What is the taxonomic classification of your organism and why?

~ ***Other relevant or interesting information***
Anything else unique or fascinating about your organism you think is worthwhile to share.

Visual Representation
Use the materials provided in your classroom to create an image of your organism. These images will be attached to a larger class mural to depict a Bering Sea Food Web.

PRESENTATIONS

~ Share your research with your classmates.
~ Show what your organism looks like
~ Clearly and concisely explain your research findings
~ Put your visual representation of your organism in a correct place on the mural (i.e. put your organism in a place on the mural it would be found in real life)

CONNECTIONS

* Together with your classmates, you will connect all of the organisms on the mural into food webs. The food web mural will show how some Bering Sea organisms get energy to live.

~ **FOOD CHAIN:** a diagrammatic representation of trophic relationships, the sequence of transfers of food energy from one organism to another (i.e. producer, consumer, decomposer).

~ **FOOD WEB:** a diagrammatic representation of the complete set of trophic relationships of an organism, interconnected food chains.

* When your organism is selected, go to the mural and connect it to another organism that consumes it for energy. You will connect the organisms using string. The string represents energy moving from one organism to one that consumes it.

INDEPENDENT WORK

Please complete the following work on your own.

- Draw a food chain (recall difference between food chain and food web) that includes your organism. Your food chain needs to:
  - Illustrate how energy is transferred through the food chain
  - Label producers, consumers, and decomposers on the illustration.
  - Below the illustration explain why organisms are considered as producers, consumers and decomposers.

- List the primary, secondary, and tertiary consumers in your food chain

- Identify a food chain from the completed class Bering Sea Food Web mural where there is a terrestrial/marine connection

- Answer the following questions:
  - Choose a pair of organisms that live in close proximity to one another in the Bering Sea. How do they have different **niches** (the functional role of an organism in the ecology of an environment, as well as the suite of physical and chemical factors that limit its range of existence) and share the same space?

  - Choose any organism from the Bering Sea food web. Imagine something occurred that resulted in this organism to die off. How would the loss of this organism affect others in the food web? How does greater biodiversity lead to a healthier ecosystem ?

Commercial Fish Capture Techniques in Alaska

Overview

Students will be introduced to fish capture techniques of the Alaska commercial fishing fleet. Students will work in small groups to prepare a class presentation about an assigned commercial fish capture technique used off of the coast of Alaska.

Learning Objectives

* Students will be able to collaboratively research, organize and share information about the target species, gear and vessels, bycatch, and landings of an Alaskan commercial fish capture technique.
* Students will be able to identify longlining, purse seining, gillnetting, trolling, traps and pots, and trawling as Alaskan commercial fish capture techniques.
* Students will handle actual parts of trawling gear.
* Students will identify possible impacts fish capture techniques have on the Alaskan marine environment.
* Students will be introduced to bycatch challenges and solutions associated with commercial fish capture techniques.

Key Concepts

* Fish Capture Technology
* Bycatch
* Target species & non-target species
* Human connections to ocean.
* Design: form and function.

Required Materials

* Index cards
* Student Journals/Notebooks
* Blank presentation paper and drawing supplies, or computers and projectors
* Commercial fish capture technique resources materials, such as books and articles, and/or computers with internet access

Commercial Fish Capture Techniques

Lesson Procedures

Introduction

* Review Bering Sea or other Alaskan marine ecosystem.
* Discuss how humans are a part of the ecosystem.
* Highlight fishing resources humans use.

Guided Overview

* Define **fish capture technology**.
* Discuss Alaskan fish species and fish capture techniques students are aware of.

Directions

* Assign each student a Fish Capture Technique group from the following:
    - -trolling
    - -longlinging
    - -gillnetting
    - -purse seining
    - -traps and pots
    - -trawling (optional: teacher may want to present this technique)
* Explain that each group will research, organize and present information to the whole class about their assigned fish capture technique.
* Explain visual aids are required for presentations.
* Lead students through the Fish Capture Techniques student instruction page. Answer questions. Provide necessary resources.

Group Work: Research & Preparation

* Students research fish capture techniques.
* Student groups organize information and prepare class presentations on index cards.
* Student groups create a visual aid for their fish capture technique presentation.
* See appendix for suggested research resources.

PRESENTATIONS

* Each group presents an oral report with visual aids to class about their fish capture technique.
* Student groups submit index cards to teacher.
* Teacher can choose to present one of the types of fish capture techniques to class as an example, or to explore a technique in more depth.
* Sample commercial fishing gear is available in Commercial Fish Capture Technique kit to share with students.

Commercial Fish Capture Techniques in Alaska : APPENDIX

Useful Terms

* Target Species/Non-target Species
* Fish Capture Technology
* Bycatch
* Landings
* Purse Seining
* Trawling
* Trollling
* Traps and Pots
* Gillnetting
* Longlinging
* Bycatch Reduction Device

Research Resources

Alaska Department of Fish and Game
http://www.adfg.alaska.gov

Boats of Alaska
Paul Denton (1998)

Cetacean Bycatch Organization
http://cetaceanbycatch.org

FAO Fisheries and Aquaculture Department
http://www.fao.org/fishery

Monteray Bay Aquarium: Fishing Methods Fact Cards
www.seafoodwatch.org

NOAA Fisheries
http://www.fisheries.noaa.gov

North Pacific Fisheries Management Council
Fleet Profiles (2012)

*For additional target and bycatch species information please refer to reference books listed in Bering Sea Food Web Mural Appendix.

* Teachers can use the education kit for students to handle sample part of commercial fishing gear.
* See the following page for a sample visual aid used in presentation on trawling.

Sample Visual Aid

NATIONAL SCIENCE EDUCATION STANDARDS

Content Standards, Grades 5-8
CONTENT STANDARD C: Life Science
d. Population and ecosystems
e. Diversity and adaptations of organisms.

CONTENT STANDARD E: Science and Technology
b. Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives
b. Populations, resources, and environments
e. Science and Technology in society

Content Standards, Grades 9-12
CONTENT STANDARD C: Life Science
d. Interdependence of organisms

CONTENT STANDARD E: Science and Technology
b. Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives
b. Population growth
c. Natural Resources
d. Science and technology in local, national and global challenges

Fish Capture Techniques in Alaska: Student Instructions

OVERVIEW

You will work in a small group to prepare a class presentation about an assigned commercial fish capture technique used off of the coast of Alaska.

OBJECTIVES

* To collaboratively research, organize and share information about the target species, gear and vessels, bycatch, and landings of an Alaskan commercial fish capture technique.
* To be able to identify longlining, purse seining, gillnetting, trolling, traps and pots, and trawling as Alaskan commercial fish capture techniques.
* To handle actual parts of fishing gear.
* To identify possible impacts fish capture techniques have on the Alaskan marine environment.
* To be introduced to bycatch challenges and solutions associated with commercial fish capture techniques.

RESEARCH

Your job is to prepare a group presentation to your class about a commercial fish capture technique used off of the coast of Alaska.

Your group will be responsible for presenting and sharing information about the following:

- **Target Species**
  - What species are targeted off of the coast of Alaska using your fish capture technique?
  - Provide an overall description of your target species. Where are they found?
  - Fishing season?

- **Description of Gear and Vessels**
  - Explain, or demonstrate, how your gear works to catch your target species.

- **Bycatch**
  - Provide a brief overview of some of the bycatch problems and solutions associated with your fishing method.

- **Landings**
  - Summarize the annual estimated catch by volume and economic value of your target species in the Alaska fishery.

PRESENTATIONS

* Clearly and concisely present your research findings with your peers.
* You are required to create visual aids to use during your class presentation
* Presentation notes and visual aids will be collected after your group presentation.

"WHAT'S THE CATCH?"

OVERVIEW

Students will read and discuss Bruce Barcott's article, "What's the Catch?" The reading and discussion provides an overview of the Bering Sea pollock fishery stakeholders, pollock fishery management, challenges and solutions to salmon bycatch.

LEARNING OBJECTIVES

* Students will be able to identify Bering Sea pollock fishery stakeholders and managers.
* Students will comprehend different Bering Sea Pollock fishery stakeholders' perspectives.
* Students will be able to explain contributing factors causing the Bering Sea Pollock fishery to employ salmon excluder devices.

KEY CONCEPTS

* Fisheries management and bycatch reduction
* Supply and demand
* "Catch shares" management scheme

REQUIRED MATERIALS

* Bruce Barcott's article, "What's the Catch?" (*On Earth Magazine*, May 27, 2010)
* Student Notebooks
* Discussion Questions

INTRODUCTION

* Students research products sold as pollock, or made with pollock. Students share findings with class.
* Teacher brings in sample pollock products to class.
* Students look at pie graph showing that the Bering Sea pollock fishery is the largest U.S. fishery by volume.

DIRECTIONS

* Review commercial fish capture techniques' bycatch challenges and solutions
discussed in student presentations.
* Provide each student a copy of the article, "What's the Catch?"

* Either provide time for students to read article on their own, or read the article aloud as a class.
* Discussion questions can be used as prompts for oral or written responses from students. Use comprehension questions as an aid for students to interactively read the article.
* Answer questions and clarify misunderstandings in regards to article topics.

NATIONAL SCIENCE EDUCATION STANDARDS

Content Standards, Grades 5-8
CONTENT STANDARD C: Life Science
d. Population and ecosystems

CONTENT STANDARD E: Science and Technology
b. Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives
b. Populations, resources, and environments
e. Science and Technology in society

Content Standards, Grades 9-12
CONTENT STANDARD E: Science and Technology
b. Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives
a. Personal and community health
b. Population growth
c. Natural Resources
d. Science and technology in local, national and global challenges

"What's the catch?" Student Instructions

OVERVIEW

You will read and discuss Bruce Barcott's article, "What's the Catch?" The reading and discussion provides an overview of the Bering Sea pollock fishery stakeholders, pollock fishery management, challenges and solutions to salmon bycatch.

OBJECTIVES

* To identify Bering Sea pollock fishery stakeholders and managers.
* To comprehend different Bering Sea Pollock fishery stakeholders' perspectives.
* To be able to explain contributing factors causing the Bering Sea Pollock fishery to employ salmon excluder devices.

DISCUSSION QUESTIONS

Read article, "What's the Catch?" and prepare responses for discussion questions.

1. Identify the role of the following organizations/institutions AND write what the acronyms stand for when applicable:

   a. UN FAO
   b. US NMFS
   c. Center for Marine Conservation
   d. Marine Stewardship Council
   e. United Catcher Boats
   f. Green Peace
   g. Oceana
   h. Sea Share
   i. Marine Conservation Alliance
   j. North Pacific Fisheries Management Council
   k. At Sea Processors Association
   l. Sea State
   m. Westward Seafoods

2. Fisheries Observers:
   a. What are their duties and responsibilities?
   b. Who manages and pays observers?

3. Alaska pollock:
    a. What food products are made with pollock?
    b. What is the estimated annual catch by weight and economic value?
    c. What percentage of the world's whitefish catch is the Alaska pollock?

4. Bycatch:
Summarize the rates, problems and solutions (both government and industry driven) of the Bering Sea Pollock industry.

5. What is the global demand for fish?

6. Describe a catch share's management scheme? How has it changed the pollock industry?

7. How does pollock support the biodiversity of the Bering Sea?

8. What are some of the consequences of catching small Pollock?

9. What did the Magnuson-Stevens Fishery Conservation Act of 1976 set? What have been some of the effects of the act?

10. What do regional fisheries councils decide? How many are there? According to the author, how does the North Pacific Fisheries Management Council's decision making process compare to other fishery councils?

11. What is the length overall of the *Pacific Prince*? How many days did it take to fill its fish hold and with how many pounds of fish?

12. Do you think that the "catch shares" management scheme will prevent the pollock fishery from over fishing? Why or why not?

13. How is the information in this article useful in explaining the Bering Sea pollock industry to you?

14. What do you like or dislike about this article?

North Pacific Fisheries Management Council Role-Play

Overview

Students will use role a role-play to explore the human part of fishery management decision-making. Students will participate in a mock North Pacific Management Council (NPFMC) Meeting based on the Spring 2012 NPFMC Meeting, "Managing Salmon Bycatch in the Bering Sea Pollock Fishery." Each student will assume the role of a stakeholder of the pollock fishery (*i.e.* pollock industry, conservation organization, or resident of Western Alaska). Students will work in groups to investigate their stakeholders' perspectives on salmon bycatch and the pollock fishery. Teachers will provide students with primary and secondary resources pertaining to their assigned role. Students will use the role-play guidelines to prepare for the mock NPFMC meeting. Students will be challenged to partake in a complex challenge that does not have a pre-selected correct solution.

Learning Objectives

* Students will be able to distinguish and discuss different perspectives and driving factors that exist among stakeholders regarding salmon bycatch in the pollock fishery.
* Students will understand how stakeholders' viewpoints and driving factors conflict, overlap, and make pollock fishery management decisions.
* Students will be able to explain how gear-modification is one piece of the pollock fishery management.
* Students will know the role of the NPFMC.

Key Concepts

* Stakeholders
* Role-playing
* Fishery management
* Gear-Modification
* Rolling Hotspot Closure (voluntary/regulatory)
* Bycatch Reduction Device / Salmon Excluder Device
* Hard Cap
* Public Input

Required Materials

* Student Notebooks/Journals
* Role-Play Student Guidelines
* NPFMC PowerPoint "Presentation on Bering Sea chum salmon bycatch alternatives" (February 24, 2012).
* NPFMC audio recording of February 24, 2012 meeting.
* Computer, projector, and speakers.
* Primary and secondary resources pertaining to each stakeholder group (pollock industry, conservation organization, and Western Alaskan residents).
* Species and ecosystem information pertaining to pollock.

Guided Overview

* Hold a discussion session about the idea of fishery resource management.
* Ask students to list Alaska fishery resources, who uses them, and what possible issues exist relating to the use of these resources. Encourage students to include different types of users.
* Introduce the concept of stakeholders (people who have an interest in how resources are used, including people who do not actively use the resources).
* Lead a discussion about how the interests and perspectives of stakeholders both conflict and overlap with each other. Ask students to list how different perspectives introduce challenges to the decision-making process about how to use and conserve natural resources (use example students are familiar with).
* Ask students to list factors that contribute to different people's perceptions, decision-making, and response to change(s).

Directions

* Inform students that they are going to participate in a role-play to explore the human part of fishery management decision-making. Tell students everyone will participate in a mock North Pacific Management Council (NPFMC) Meeting based on the Spring 2012 NPFMC Meeting, "Managing Salmon Bycatch in the Bering Sea Pollock Fishery."
* Explain that each student will assume the role of a stakeholder of the pollock fishery (*i.e.* pollock industry, conservation organization, or resident of Western Alaska).
* Use PowerPoint slides from the NPFMC meeting 1) what the NPFMC is and does and 2) the topic of the meeting.
* Review the objectives of the role-play, for students to investigate the perspectives and viewpoints of Bering Sea pollock fishery stakeholders.

* Review the context and setting of the NPFMC meeting (salmon bycatch in the Bering Sea pollock fisheries).
* Assign roles and groups to each student (pollock industry, conservation organization, or resident of Western Alaska). Explain their personal viewpoints and perspectives might vary from their assigned role-play role.
* Explain expectations for each student and amount of time available for preparation.
* Provide students with primary and secondary resources for their assigned roles (see appendix for resource suggestions).
* Hold the NPFMC mock meeting, with teacher as moderator. Use NPCMC PowerPoint slides as visuals and select audio portions of 2012 meeting. All prepared statements will be collected following the meeting.
* Follow up role-play with group discussion and assessment of work.

Answer student questions about the NPFMC and pollock fishery management process. Discuss importance of public input. Discuss role of gear modification in pollock fishery management.

North Pacific Fisheries Management Council Role-Play
Appendix

Primary & Secondary Student Role-Play Resources

The following are possible primary and secondary resources to provide students with in preparation for the mock NPFMC meeting. Select relevant resources to provide each student depending upon their assigned role. See Bering Sea Food Web Mural Appendix for pollock species and ecosystem resources. Note: Greenpeace is used as an example of a non-government conservation organization.

* *Bering Sea Chinook Salmon Bycatch: Final Environmental Impact Statement.* December 2009.
* *Bering Sea Chinook Salmon Bycatch: Final RIR.* December 2009.
* "By-catch": Problems and solutions." *Marine Pollution Bulletin.* 2000.
* "CDQ's bring millions in fishing profits- and jobs- to poor western Alaska villages." *Alaska Dispatch.* August 18, 2013.
* "Cooperative management facilitates salmon bycatch reduction." www.noaa.gov.
* "Eastern Bering Sea 2012 Report Card." *NOAA*
* "Federal fisheries managers take another look at Bering Sea salmon bycatch." *Fishermen's News Online.* October 11, 2013.
* "Final Report for the EFP 08-02 to explore the potential for flapper-style salmon excluders for the Bering Sea pollock fishery." 2010.
* "Fisheries council votes for salmon bycatch cap." *Anchorage Daily News.* April 6, 2009.
* "For fur seals and fish sticks – protect the Bering Sea Canyons!" *Greenpeace Blog.* November 26, 2012.
* "Full Nets –Empty Seas." *Progressive Magazine.* November 1997.
* "Greenpeace seeks ban on trawlers- Industry denies it's depleting North Pacific Fisheries." *Seattle Times.* August 15, 1999.
* "Hungary, forgotten and alone." *Greenpeace Blog.* July 1, 2009.
* Letter to Secretary Locke, "Fisheries Disaster Declaration." *Alaska Federation of Natives.* April 8, 2009.
* "McDonald's marketing a boon for wild Alaska pollock." *Alaska Dispatch.* February 3, 2013.
* National Marine Fisheries Services letter and agreement: "Approval of Non-Chinook Salmon Bycatch Reduction

Intercooperative Agreement." *NOAA, Alaska Region.* December 28, 2010.
* "New salmon bycatch cap is too high." *Anchorage Daily News.* April 8, 2009.
* *News and Notes.* NPFMC. October 2013.
* *News and Notes.* NPFMC. December 2013.
* "North Pacific Groundfish Observer Program – Frequently Asked Questions." *NOAA Alaska Fisheries Science Center.*
* "Panel votes for salmon bycatch limit." *Seattle Times.* April 7, 2009.
* "Participation and resistance: Tribal involvement in Bering Sea fisheries management and policy." *Fishing People of the North.* 2012.
* "Protecting Alaska salmon for subsistence." *National Congress of American Indians.* 2013.
* Rally against bycatch laws, for Bering Sea canyon protection reaches Juneau." *Juneau Empire.* June 12, 2013.
* "Report to the NPFMC on the 2012 Bering Sea Intercooperative Salmon Avoidance Agreement." April 1, 2012.
* "Seattle, Shatner, and saving the Bering Sea." *Greenpeace Blog.* February 7, 2014.
* "Seattle trawlers may face new limits on pollock fishery." *Seattle Times.* October 10, 2008.
* "State sold out Western Alaska on salmon bycatch issue." *Greenpeace Blog.* August 25, 2009.
* "Subsistence Fishing in the Yukon River Delta: A Case Study of Alakanuk Subsistence Fishery and the Use of Local/Traditional Ecological Knowledge." *Scripps Institution of Oceanography.* 2011.
* "Summary of public comments submitted to the National Marine Fisheries Services prior to 2008." *Alaska Intertribal Council.*
* "The Northern Bering Sea: Our Way of Life." *Bering Sea Elders Advisory Group.* 2011.
* "Time for action: Bering Sea salmon bycatch at the October council meeting." *Delta Discovery.* September 25, 2013.
* Trident job posting descriptions.
* " We are all Bering Sea stakeholders." *Greenpeace Blog.* February 3, 2014.

Websites

* www.greenpeace.org
* www.alaskaseafoodcooperative.org
* www.atseaprocessorsassociation.org
* www.marineconservationalliance.org

* www.fakr.noaa.gov
* www.alaskafisheries.noaa.gov
* www.alaskafisheries.noaa.gov/npfmc

TEACHER RESOURCES

* Science Education Resource Center at Carleton College web site: http://serc.carleton.edu/introgeo/roleplaying/index.html
* "Chinook Salmon Bycatch Management in the Bering Sea Pollock Fishery." NPFMC PowerPoint. 2010.
* "Presentation on Bering Sea chum salmon bycatch alternatives." NPFMC PowerPoint. February 2012.
* NPFMC meeting audio recordings downloads.

REFERENCES

"I'll Stay Here if it kills me!" *NOAA Ocean Education Service*

NATIONAL SCIENCE EDUCATION STANDARDS

* **Content Standards, Grades 9-12**

CONTENT STADARD A: Science as Inquiry
- b. Understandings about scientific inquiry

CONTENT STANDARD C: Life Science
- d. Interdependence of organisms
- f. Behavior of organisms

CONTENT STANDARD D: Earth and Space Science
- a. Energy in the Earth System

CONTENT STANDARD E: Science and Technology
- b. Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives
- a. Personal and community health
- b. Population growth
- c. Natural Resources
- f. Science and technology in local, national and global challenges

North Pacific Fisheries Management Council Role-Play
Student Instructions

Spring 2012
North Pacific Fisheries Management Council Meeting

TOPIC: Managing Salmon Bycatch and the Bering Sea Pollock Fishery

STAKEHOLDERS' STATEMENTS:

A stakeholder is a person with an interest in the way a resource is used. Different stakeholders sometimes disagree, depending upon their perspectives.

In class, we are simulating a North Pacific Fisheries Management Council meeting that took place in Alaska in 2012. Each student of the class will attempt to persuade the Council to follow his or her recommendations on the best way to face the challenge of salmon bycatch in the Bering Sea pollock fishery.

EACH STAKEHOLDER STATEMENT MUST INCLUDE:

Part 1) Begin with an introduction of your perspective's ethos.

- Who are you?
- In what way do you have stake in pollock fishery?
- What experience/connection do you have with the Bering Sea?
- What experience/connection do you have with fishing?
- Why do you care about this fishery?
- What are your opinions about commercial fishing?

Part 2) State a **THESIS**, in which you write your recommendation and mention two to four reasons why this recommendation is accurate/important.

Part 3) Go into detail about each of the reasons you provided, proving with facts or examples that you are speaking the truth.

Part 4) Conclude by restating, strongly, your recommendation.

Statements should take no longer than one and a half minutes to read.

You will have until _____ to research as much as you can about your stakeholder. Primary and secondary resources relating to your stakeholder will be provided to you.

You will be assigned to a small group to help research and prepare your Council meeting statement. Use the worksheet below to prepare for writing your statement. You may use a separate piece of questions.

PART 1) Answer the following questions about your stakeholder:

"Who" are you?

In what way do you have stake in pollock fishery?

What experience/connection do you have with the Bering Sea?

What experience/connection do you have with fishing?

Why do you care about this fishery?

What are your opinions about commercial fishing?

PART 2)

a) Come up with a recommendation to the Council that addresses the bycatch issue, based on what you believe your stakeholder would think was best.

b) Briefly list 2-4 reasons why this is the best:

1.

2.

3.

4.

PART 3) Go into detail about each of the 2-4 reasons:

1.

2.

3.

4.

PART 4) Restate, strongly, your recommendation.

Commercial Fishing in the Bering Sea: Smart Fishing in the Bering Sea

Overview

Students will explore ways that new technologies can help fisheries scientists and managers address conservation challenges. Students will learn and apply basic principals used to quantify and compare the impact of different types of fishing gear used by the Bering Sea pollock industry. Students will use a portable flume tank to practice hands-on groundgear evaluation and modification with small-scale models.

Learning Objectives

* Students will understand that US managed fisheries need to minimize bycatch and maintain commercially viable catch of target species, like the Alaska pollock industry.
* Students will collaborate with classmates in the modification processes to foster creative thinking.
* Students will be able to compare bottom and pelagic trawls.
* Students will be able to identify components of trawl nets.
* Students will be aware that Alaska Pollock, *Theragra chalcogramma*, is the largest U.S. fishery by volume.
* Students will identify possible impacts trawl nets have on the Bering Sea benthic environment.
* Students will understand the function of bycatch reduction devices (BRD) in Bering Sea Pollock trawls.

Key Concepts

* Pelagic Trawling
* Bottom Trawling
* Non-target species, Bycatch & non-target species
* salmon excluder device
* drag
* bycatch reduction devices
* Design: form and function.
* conservation engineering
* fuel efficiency

Required Materials

* Flume tank kit (includes portable flume tank with instruction booklet, small scale nets, video clips of flume tanks testing gear, flow meter, trawl net design visuals, salmon excluder design visuals, flow calculation table, objects with different buoyancies, video clips from *FV Pacific Prince* test hauls, *Pacific Prince* video analysis table)
* fresh water source
* large table for flume tank
* computer and projector

Introduction

* Review that the Alaska Pollock, *Theragra chalcogramma*, is the largest U.S. fishery by volume.
* Review the geography and food webs of the Bering Sea.
* Review trawling (the fish capture technique used to catch pollock) methods, challenges and advantages.
* Review, or provide an overview, to the goals and interests of pollock fishery stakeholders. Draw a Venn diagram to represent interests and illustrate how different stakeholders' interests overlap. Explain that from this overlap management decisions are made.
* Discuss how reducing bycatch is a goal shared by different stakeholders.
* Discuss ways to reduce bycatch (see previous lessons for specific resources on this topic).
* Define conservation engineering.
* Define bycatch reduction device.

Directions

* If large class size, it will be best to divide class into smaller groups and rotate through stations.
* Set up all stations and supplies before students arrive. Use flume tank instruction booklet provided with kit.
* Discuss role and goals of pollock trawl net designers.
* Define flume tank. Explain purpose and function of flume tanks to pollock fishery and net designers. Show video of net designers testing gear in flume tank.
* Gather group around portable flume tank. Turn pump on and explain how tank functions.
* Explain to group that they will use the flume tank to evaluate and modify three different small-scale trawl nets.
* Ask students to imagine that they are pollock trawl net designers. As the designers they are challenged with the task of creating nets that
    1) maximize catch efficiency
    2) minimize bycatch
    3) minimize drag (fuel efficiency)

As net designers, they will evaluate and modify the small-scale trawl nets to meet the above criteria.
* Review catch efficiency, bycatch, and drag in the context of the Bering Sea pollock fishery.

* Use trawl net diagram to review parts of the trawl net.
* Show students the flow meter. Explain how it works. Ask what it can be used to measure in the flume tank (drag = fuel efficiency).
* Instruct the group how to calculate flow with the flow meter. Use provided table. Measure flow without anything extra in tank, with small size object in testing area and with large size object in testing area. Have students complete table to calculate flow each time.
* Introduce small-scale trawl nets.
* Demonstrate how net testing deployment works (see flume tank instruction booklet with kit).
* Objects with different buoyancies will be used to represent target species (pollock) and bycatch (chum salmon, chinook salmon, halibut, crab, herring. Key included in flume tank instruction booklet.
* Explain to group that their task is to evaluate and modify each net to best:
    1) maximize catch efficiency
    2) minimize bycatch
    3) minimize drag (fuel efficiency).
* During each net deployment students will need to keep track of total target species caught, total bycatch caught, and calculate flow before and during net deployment. This data will be used as part of their evaluation and comparison of each net. (Flume tank kit provides explanations of each nets' different attributes).
* Based on their evaluations of each net's performance, student groups will need to modify the nets, and/or rigging, to try to increase the net's performance.
* Demonstrate importance of steady lift and decrease in net's drag.
* After all trials and modifications student groups will present their findings and select one net they think best meets the criteria of a pollock trawl.
* Teacher can decide if student groups should each work on all nets, or task groups can be assigned to different nets.
* Ask students to continue to imagine that they are net engineers. Now that they have designed and selected an efficient net using a flume tank, it is time to deploy the net from a real boat and further test the net's performance.
* Use the diagram to review the design of a salmon excluder device.
* Tell students (net engineers) that they are going to use video analysis as feedback on their net performance.

* Select clips from the underwater video footage from *FV Pacific Prince* for students to complete video analysis table. Video clips in flume tank kit.
* Compare student analysis results and share summary of *FV Pacific Prince* results of target and bycatch species caught and escaped with use of salmon excluder device. (Results summary in flume tank kit).
* Have students calculate salmon escape rate:

$$\text{Salmon escape rate} = \frac{\text{Total Salmon Escapes}}{(\text{Total Salmon Caught} + \text{Total Salmon Escapes})}$$

* Lead students to discuss the solutions bycatch reduction devices like salmon excluder devices offer to pollock fishery stakeholders. What challenges of the pollock fishery do the students think are being addressed by conservation engineering? What challenges are not being addressed by conservation engineering?
* What did they learn about the conservation engineering during their experience with the flume tank?
* Do they have any suggestions for the pollock fishery?

TEACHER RESOURCES

See appendices in "Bering Sea Food Web Mural," "Fish Capture Techniques in Alaska," "What's the Catch?" and "North Pacific Fishery Management Council Role Play" for lists of possible resources to use as background information for this lesson.

NATIONAL SCIENCE EDUCATION STANDARDS

Content Standards, Grades 5-8

CONTENT STANDARD A: Science as inquiry
- a. Abilities necessary to do scientific inquiry
- b. Understandings about scientific inquiry

CONTENT STANDARD C: Life Science
- d. Populations and ecosystems
- e. Diversity and adaptations of organisms

CONTENT STANDARD E: Science and Technology
- a. Abilities of technological design
- b. Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives
b. Populations, resources, and environments
e. Science and technology in society

*** Content Standards, Grades 9-12**
CONTENT STADARD A: Science as Inquiry
a. Abilities necessary to do scientific inquiry
b. Understandings about scientific inquiry

CONTENT STANDARD C: Life Science
d. Interdependence of organisms
f. Behavior of organisms

CONTENT STANDARD D: Earth and Space Science
a. Energy in the Earth System

CONTENT STANDARD E: Science and Technology
a. Abilities of technological design
b. Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives
c. Natural Resources
f. Science and technology in local, national and global challenges

SMART FISHING IN THE BERING SEA
STUDENT HANDOUTS

Flume Tank Flow

Initial	Final	Difference	Product	Distance	Speed	Net d^2	Volume m/s

Formulas
Product = difference X 26873
Distance = product 999999
Speed = disgancex100 0 120
Volume = (net^2 x 3.14) 4 x distance

FV Pacific Prince Test Haul Video Analysis									
Haul	Camera	File #	Time	Intervals	Chinook	Chum	Salmon	Pollock	Herring

Appendix C

Sample Institutional Permission Letter

INSTITUTIONAL PERMISSION LETTER: King Career Center

To: Mr. Lou Pondolfino
King Career Center
2650 E Northern Lights Blvd
Anchorage, AK 99508

From: Christine Simpson
Alaska Pacific University
MSOEE Department
4101 University Drive
Anchorage, AK 99508
csimpson@alaskapacific.edu

December 5th, 2013

Dear Mr. Lou Pondolfino,

I am a graduate student at Alaska Pacific University (APU) conducting a curriculum evaluation for my master's thesis project over the coming January – March 2014. I am requesting your approval to include King Career Center students in my thesis project, "Conservation Engineering Outreach: Curriculum Development and Evaluation of *Smart Fishing in the Bering Sea*." The development, implementation and evaluation of my thesis project is funded by a North Pacific Research Board grant and is supported by Alaska Pacific University's Fisheries, Aquatic, Science and Technology Laboratory and the Masters of Science of Outdoor and Environmental Education program.

The purpose of the "Smart Fishing in the Bering Sea" outreach program is to increase ecological knowledge of the Bering Sea, enhance awareness of current commercial fishing trawl practices, and improve students' ability to creatively solve problems. An outcomes-based evaluation will be conducted to investigate the following research questions: What do participants gain from the program? What is the impact of the program on participant knowledge of relevant topics? What do participants learn about the Bering Sea ecosystem? What do participants learn about commercial fishing in the Bering Sea? What do participants learn about problem solving?

I am requesting voluntary student participation in my research. Participants may choose to stop their participation at any time without penalty. I expect that maximum participation will take approximately three hours, over four sessions, to complete (one

hour dedicated to concept mapping and two hours dedicated to focus group interviews). My research plan is subject to approval by Alaska Pacific University's IRB and I will share all changes in research plans requested by the IRB.

Collected data will be used to evaluate if the "Smart Fishing in the Bering Sea" learning activities achieve the specified outreach goals. Data from concept maps and focus group interviews will be analyzed to identify patterns, relationships and themes among participant responses and changes in knowledge and skills to assess the effectiveness of the curriculum. This analysis will be used to make adjustments to the curriculum to improve the overall program quality and to better achieve the program's educational goals.

I will keep all data confidential, and I will *not* use any students' names in any

research reports. I will only use your school's name upon written approval, otherwise I will *not* use your school's name. Any information that I present will *not* be linked to any personal information that could be used to identify individual students. I will take the necessary steps to ensure that my research will be conducted in ways that meet ethical standards. I have attached the consent letters that I wish to give to the students and guardians, my research plan subject to approval by APU's IRB, my approved thesis proposal, and the approved North Pacific Research Board research grant.

Please sign below and return a copy of this letter to me, via e-mail, or request a pick up by me, indicating whether or not you give me permission to conduct this research project with students in Mr. Mike Woods' Natural Resources class. If approved, I will submit your signed letter as part of my application materials to APU's IRB.

Please contact me with any questions. Thank you for your time and consideration.

Sincerely,

Christine Simpson

❑ I give permission to you to conduct the graduate research project described above and further explained in attached documents.

If permission is given please select one of the following:

❑ I give permission to you to use the King Career Center name in research reports.

❑ I do **not** give permission to you to use the King Career Center name in research reports.

❑ I do **not** give permission to you to conduct the graduate research project described above and

further explained in attached documents.

Name of Principal Lou Pondolfino	
Signature of Principal	**Date**
Name of Natural Resources Teacher Mike Woods	
Signature of Natural Resources Teacher	**Date**

Sample Letter of Consent to Participate

LETTER OF CONSENT TO PARTICIPATE

Conservation Engineering Outreach: Curriculum Development and Evaluation of "Smart Fishing in the Bering Sea"

I am a graduate student at Alaska Pacific University (APU) conducting a curriculum evaluation for my master's thesis project over the coming January –March 2014. I am requesting your voluntary participation in my research. You may choose to stop your participation at any time without penalty. I expect that your participation will take approximately two hours, over two sessions, to complete.

The purpose of the "Smart Fishing in the Bering Sea" outreach program is to increase ecological knowledge of the Bering Sea, enhance awareness of current commercial fishing trawl practices, and improve students' ability to creatively solve problems. An Outcomes-Based Evaluation will be conducted to investigate the following research questions: What do participants gain from the program? What is the impact of the program on participant knowledge of relevant topics? What is learned about the Bering Sea ecosystem? What is learned about commercial fishing in the Bering Sea? What is learned about problem solving?

Concept maps will be the primary methods to collect data for this research project. Concept maps are two-dimensional diagrams that illustrate the most important concepts and relationships of a topic. The researcher will train all participants in a concept mapping strategy session. Instructions will include oral and written training on concept mapping. Participants will complete a pre- and post-program concept map on their understanding of the Bering Sea marine ecosystem, current fishing practices in the Bering Sea and conservation engineering. Concept mapping sessions will take place in participants' classrooms and are expected to take one hour each. Each participant will write an assigned number and first name on each of their concept maps. No other identifying information will be collected with each concept map. Individual names will not be used in any research reports.

The researcher will keep an observation journal during outreach programs. The researcher will only record participant first names when making hand written notes in journal. The use of first names will only be used as an aid for the researcher to distinguish participants throughout the program. Any observation notes used in the research report will not include student names. Individual names will be replaced with numbers in any research reports.

All data will be used to evaluate if the "Smart Fishing in the Bering Sea" program activities achieve the specified outreach goals. Data will be analyzed to identify patterns,

relationships and themes among participant responses and changes in knowledge and skills to assess the effectiveness of the curriculum. This analysis will be used to make adjustments to the curriculum to improve the overall program quality and to better achieve the program's educational goals.

At the end of the study, materials that will include identifying information of individuals will include concept maps and the researcher's observation journal. All sources will only contain first names and an assigned participant number. Beyond first names, no identifying information of individual subjects (e.g., last names, address, Email address, etc.) will be collected and the project will not link individual responses with participants' identities. The concept maps will be returned to the participants. Again, **no individual participants will be identified in any research reports.**

This project has been reviewed and approved by APU's Institutional Review Board. **Written permission to conduct this research project has been granted by Shanna Mall, Winterberry Charter School Principal and Diana Johnson, Winterberry Charter School eighth grade teacher.** This investigation does not involve risk to the participants and the researcher will adhere to all risk management policies of the Winterberry Charter School.

A copy of this letter is yours to keep. If you have any questions about how this investigation is to be conducted please contact me, **Christine Simpson by e-mail csimpson@alaskapacific.edu** and **mail Alaska Pacific University, MSOEE Department, 4101 University Drive, Anchorage, AK 99507.**

You may also contact my Faculty Advisor, Brad Harris, Ph.D., by phone 907-564-4672, e-mail bharris@alaskapacific.edu, and mail Alaska Pacific University, 4101 University Drive, Anchorage, AK 99507.

_____ _____

Investigator (print and sign) Date

I agree to participate in the project as described above.

_____ _____

Participant Name (if 18 years of age or older print and sign) Date

I give permission to the participant to participate in the project as described above.

_____ _____

Participant Guardian [if participant under 18 years of age] (print and sign) Date

Assent to Participate in Research

ALASKA PACIFIC UNIVERSITY
ASSENT TO PARTICIPATE IN RESEARCH

Study title: Conservation Engineering Outreach: Curriculum Development and Evaluation of
"Smart Fishing in the Bering Sea"

Person in Charge of Study: Christine Simpson, Masters of Science of Outdoor and Environmental Education Graduate Student

We are doing a research study. A research study is a way to learn more things. We are trying to learn about what students learn during the outreach program, "Smart Fishing in the Bering Sea." We are going to use this research to improve the education program.

If you decide that you want to be part of this study, you will be asked to complete a concept map before and after the "Smart Fishing in the Bering Sea" education activities. You will be trained in what concept maps are and how to create one. Concept mapping sessions will take place in your classroom and are expected to take one hour each. Each participant will write an assigned number and name on each of concept map. We will not collect any other information from you and will not use your name in any research reports.

The researcher will keep an observation journal during outreach programs. Any observation notes used in the research report will not include student names. Individual names will be replaced with numbers in any research reports.

There are some parts of the study that may frustrate you. For example, you will be learning new things and asked to complete tasks that might not be easy for you to complete.

We do not know if this study will help you, but we hope to learn something that will improve the learning activities for future students.

You do not have to be in this study. It is up to you and no one will be upset. You can also change your mind. If you say, "yes" now and decide to say "no" later that is okay. You can just let the researcher know.

When we are finished with this study we will write a report about what was learned. This report will not include your name or that you were in the study.

If you decide you want to be in this study, please print and sign your name.

I, _____, want to be in this research study.
(Print your name here)

_____ _____
(Sign your name here) (Date)

Principal Investigator (or Designee)
I have given this research subject information on the study that is accurate and sufficient for the subject to fully understand the nature, risks and benefits of the study.

_____ _____
Printed Name of Person Obtaining Consent Role on Study

_____ _____
Signature of Person Obtaining Consent Date

Media Release Form

Media Release Form

Project Title: _____ North Pacific Research Board Outreach Program, "Smart Fishing in the Bering Sea" ___

I, the undersigned, hereby authorize **Christine Simpson** (outreach educator and researcher) to use photographic representations of me for written reports, public presentations, publications, and educational media deemed appropriate by **Christine Simpson** pertaining to the "Smart Fishing in the Bering Sea" program.

Agreed and accepted by:

Print Name _____

Signature & Date _____

PARENTAL/GUARDIAN CONSENT

I certify that I am the parent or guardian of the individual above,

_____, a minor under the age of eighteen years. I hereby

assume responsibility for his/her authorizations referred to in this Media Release.

_____ _____

Signature of Applicant's Parent/Guardian **Date**

Appendix D

Concept Map Training Outline

I. Definition of Concept Map
   a. Concepts
   b. Relationships between concepts

II. Concepts
   a. Objects
   b. Events
   c. Mental image activity

III. Linking Words
   a. Function
   b. Difference between concept words and linking words
   c. Short sentence activity

IV. Meanings and Understandings of Concepts
   a. Meanings- not fixed
   b. Understandings: grow and change

V. Purposes for Concept Mapping
   a. Brainstorming
   b. Design complex structures
   c. Communicate ideas
   d. Integrate new and old knowledge
   e. assess understandings or find out misunderstandings

VI. Review
   a. Concepts
   b. Linking Words
   c. Sample concept map

VII. Steps to Create a Concept Map
   a. Brainstorm
   b. Organize
   c. Layout
   d. Link
   e. Revise
   f. Finalize

VIII. Create individual concept maps
   a. Main Concept: Food

b. Share final concept maps in small groups
c. Share specific maps or parts of maps with class

IX. Question/Answer and Review Session

X. Create individual concept maps
a. Prompt: What is the interrelationship between commercial fishing and the Bering Sea?